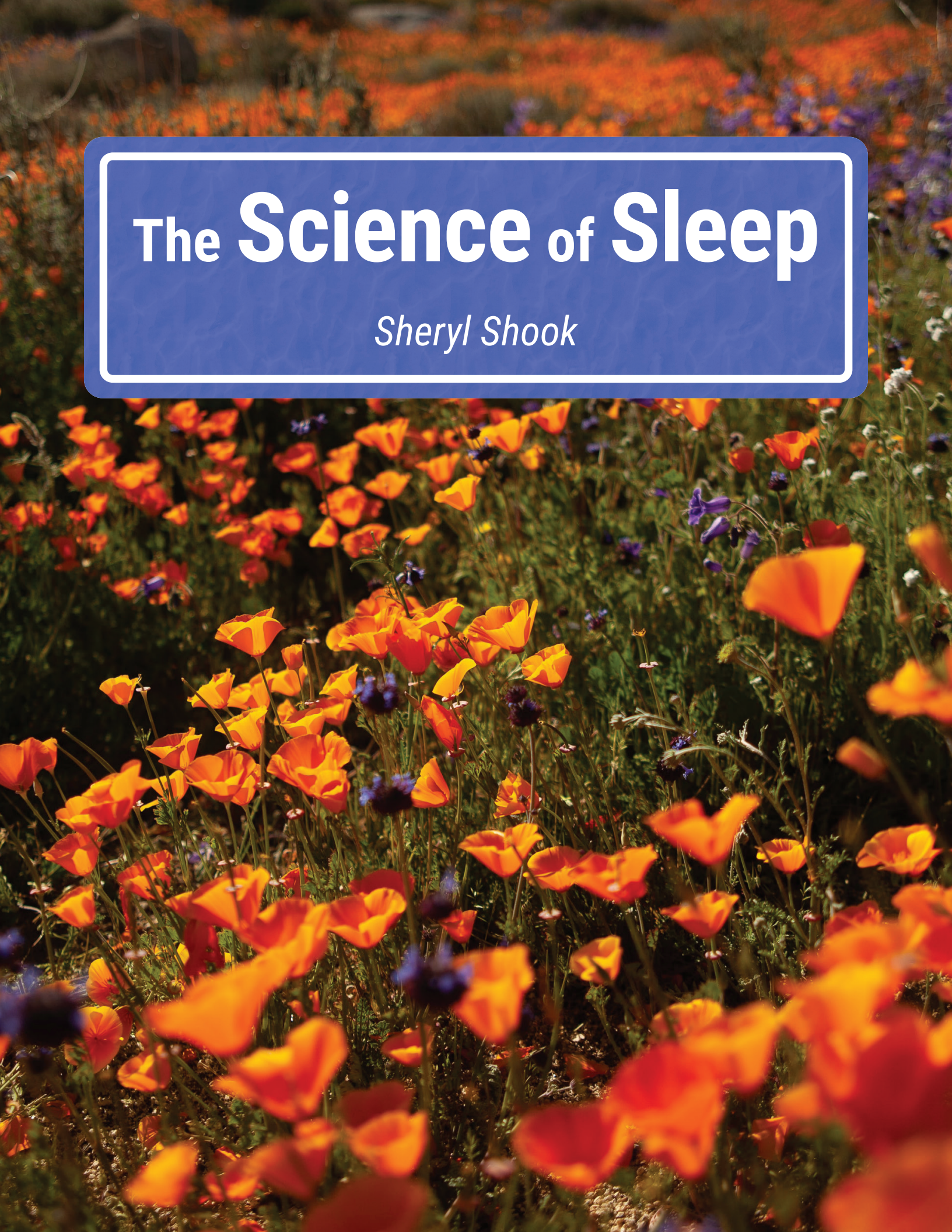

The Science of Sleep

Sheryl Shook

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To my dear students.
You continue to inspire me.

Contents

Acknowledgments

This book and my deep dive into open educational resources (OER) are thanks to Sunny Pai. I fondly recall the moment by Lama Library when she opened my eyes to the social justice impact of OER and the myriad benefits of zero-cost textbooks. From that time on, her heroic efforts have been instrumental to this project and my growth as an OER advocate.

I am tremendously grateful for Jason Ford who, with Sunny Pai's collaboration, took on the quest to find over one hundred open-access images to bring my manuscript to life. In addition to lending his artistic vision, Jason also tuned in to my aesthetic for the book, and that is testimony to his brilliance and intuition. Not only could I have never found all those images; the book would surely be another year in the making without Jason's genius. Nicholas Wong also deserves some of the appreciation, as he found several images during the early phase of this project. I am thankful to the artists who created all those meaningful images and made the choice to share with no paywall so my readers will have the pleasure of seeing their work. Special thanks to Stéphane Granzotto for his generosity in giving us permission to use his whale photo that Jason, Sunny, and I were in awe of when we saw it in *National Geographic*.

My profound thanks to Anya Dimitrijevic, Somer Rickards, ʻIwalani Clayton, Malia Hasegawa, Tiare Sabellano-Tsutsui, Mary Shook-Starsinic, Hikialani Guzman, and Joyce Tokuda for creating imaginative artwork that is nowhere else to be found. I am inspired by their generosity, providing these images with open-access attribution licenses so others will be able to benefit from their creations. Additional thanks to ʻIwalani Clayton for verifying ʻŌlelo Hawaiʻi (Language of Hawaiʻi) throughout the book.

One of the many reasons I dedicated this book to my students is because of their wholehearted requests, year after year, that I create it. Every semester I teach my class on the science of sleep, I feel deeply blessed to meet all these courageous, talented, compassionate, humorous students, who are eager to explore every imaginable dimension of sleep and even willing to laugh at my jokes!

Thank you to my mom and dad, Coy and Sherry Shook, for giving me so much unconditional love and acceptance. The opportunities they created for me were such treasures and an enormous part of who I am today.

Through her graceful combination of strength, humor, and wisdom, my daughter Mary provided me with insights and meaningful conversation, especially around social justice and antiracism, that impacted this book and beyond. My son, Doug Jr., brought the best stories, laughs, and music exactly when I needed them. Time after time, my daughter Angie gave me caring and comfort in her home, especially during those long hours I spent writing during "breaks" at the semester's end. I am enormously grateful for all three of my children for providing the inspiration, good times, and hope I needed to get this book written.

My muse, surfer boy, and man of my dreams, Doug Fetterly, deserves my warmest appreciation for being by my side while writing and surfing and dancing and nurturing me so I could write and write and write. I also send admiration to Doug for teaching me how to show up in Washington, DC, and lobby Congress, and for the many ways he models civic engagement.

I send heartfelt gratitude to my dear grandchildren, who provided me with the spark and vitality to write this book by bringing me joy, love, and a sense of belonging that are beyond my wildest dreams.

Guide to the Textbook

1. Student Learning Objectives
2. Ready to Move On?
3. Retrieval Practice
4. ʻŌlelo Hawaiʻi (Language of Hawaiʻi)
5. Your Next Actions for Justice

1. Student Learning Objectives

This is an Adinkra symbol that represents knowledge and the potential to learn anything that you do not yet know. It is called "Nea Onnim," which means "the one who doesn't know" in Akan. It refers to the proverb that states, "The one who doesn't know can know through learning." Adinkra symbols appear often in parts of Ghana as art, jewelry, and even bumper stickers! The philosophies found throughout West Africa are infinitely profound and deserve just as much attention as any other world-renowned philosophies.

This narrative and image were created by Mary Shook-Starsinic (an Africana studies graduate from San Francisco State University), and the picture accompanies each chapter's student learning objectives. The Adinkra symbol at the beginning of each chapter is a reminder to consider some of the things you will learn and be able to do after reading the chapter.

2. Ready to Move On?

In Native American culture, power animals are spirit guides that teach, lead, and protect. Many tribes have a group of power animals called "tribe totems" that are emblems of their people and lineage. Particularly in Cherokee culture, the wolf is an important tribe totem, and it has been regarded by many Native American tribes as a teacher or pathfinder. The wolf often symbolizes intelligence, guidance, intuition, and perseverance.

This narrative and image were created by Anya Dimitrijevic (of Cherokee ancestry). The wolf was chosen as a reminder to take time and reflect on what you learned. When you see the wolf, follow the instructions to engage with the content and reinforce the concepts before moving on to the next section.

3. Retrieval Practice

The image of the dog retrieving the toy is to let you know it is time for some retrieval practice. You will find detailed directions for an activity that will reinforce learning. Neuroscience research suggests that retrieval practices are one of the most effective ways to learn content. The photo of the dog is from Brixiv on Pexels.

4. ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

The honu (Hawaiian green sea turtle) holds a sacred place among Hawaiians as an ʻaumakua (family or personal god). The honu symbol represents many things in Polynesian culture, including longevity, safety, mana (spiritual energy), and protective wisdom (that comes with age). It is a bearer of good luck, peace, health, rest, endurance, and perseverance as well as a navigator. The honu is one of the last remaining indigenous reptiles living on the Hawaiian Islands.

The kākau or kākau kaha is a form of tattooing in Hawaiʻi. Tattoos were considered protective talismans or personal representations in Polynesian culture. In this image, the two outer vertical rows of waves represent ola (life, continuity, change) and ʻaoʻao mau o ka honua (afterlife). The vertical marks located in the center row are of the interlocking manō (shark) teeth representing protection, strength, guidance, and adaptability.

The honu and kākau images are on a backdrop of the Hawaiian kapa (the beaten thing) or tapa cloth, like the kīhei (cape), symbolizing home and protection. In bringing all three together, the image here is one of peace, rest, and protection. Mālama pono.

This narrative and image were created by ʻIwalani Clayton (of Native Hawaiian ancestry), who also verified the use of Hawaiian words throughout the book. This image is incorporated to emphasize some of the ʻŌlelo Hawaiʻi that appears in each chapter.

5. Your Next Actions for Justice

Maat is the Egyptian goddess of justice, truth, harmony, and balance. She is seen comparing the weight of a feather to the heart of a person's soul to determine if they had lived in an ethically balanced manner. The heart is the symbol for the person's conscience.

Somer Rickards (eighth-grade teacher and artist) created this image. Please consider the suggestions that accompany this image. They provide ideas for the next steps you can take toward social justice as it relates to sleep wellness.

Yawning and an Introduction to Sleep

Yawn. There, I said it. And I even provided an image (figure I.1). Now you will likely be yawning for the next few minutes, and if anyone sees you reading my book, they will say, "I'm not going to pick up that book! Boring, eh?" But hopefully, you will find sleep science irresistible enough that you will join me in engaging people in conversations about sleep, its truths as well as its myths—such as boredom being the cause of yawning.

Why am I so passionate about sleep—talking about it, teaching college lecture and lab courses about it, giving workshops around the world about it? It goes way beyond how fascinating some things about sleep are, such as

- the meaning of dreams and nightmares (figure I.2)
- animal sleep and behaviors like sleeping while swimming or flying
- disorders such as teeth grinding, sleepwalking, and sleep paralysis

Yes, these are compelling topics, and I cover them all and much more. But my passion? It comes from my fierce commitment to helping people determine how they can do two things:

1. Improve their sleep and enjoy the associated health benefits
2. Find their place in creating a revolution so more people will understand sleep's importance and have the opportunity to get enough of it

Figure I.1 Yawning

Figure I.2 Dreams

Sleep quality is one of the strongest predictors of how long you will live and how good you will feel, mentally and physically. In most circumstances, sleep quality can be a stronger predictor of longevity than diet, blood pressure, cigarette use, or genetics (figure I.3). Healthy sleep changes which of your genes are expressed. Combine this with the fact that good sleep causes changes in brain physiology that make it easier to create healthy habits such as quitting smoking, improving food choices, and getting exercise and the case for prioritizing sleep becomes even clearer.

While you sleep, there are changes in your brain, cardiovascular system, and metabolism as well as your body's healing pathways. Most of us have noticed the slow thinking and crankiness associated with poor sleep, but did you know your brain is taking out the garbage while you sleep? During sleep, a set of structures that comprise the glymphatic system flush out toxins and waste associated with an array of neurologic problems.

To keep your heart and blood vessels healthy, your body will also need sleep. It is essential to blood pressure regulation. Sleep reduces the risk of cardiovascular disease and stroke. Many people, hoping to avoid a myocardial infarction (heart attack), try to manage their health with foods, and that is a good idea, but they would be wise to

Figure I.3 105 year old woman

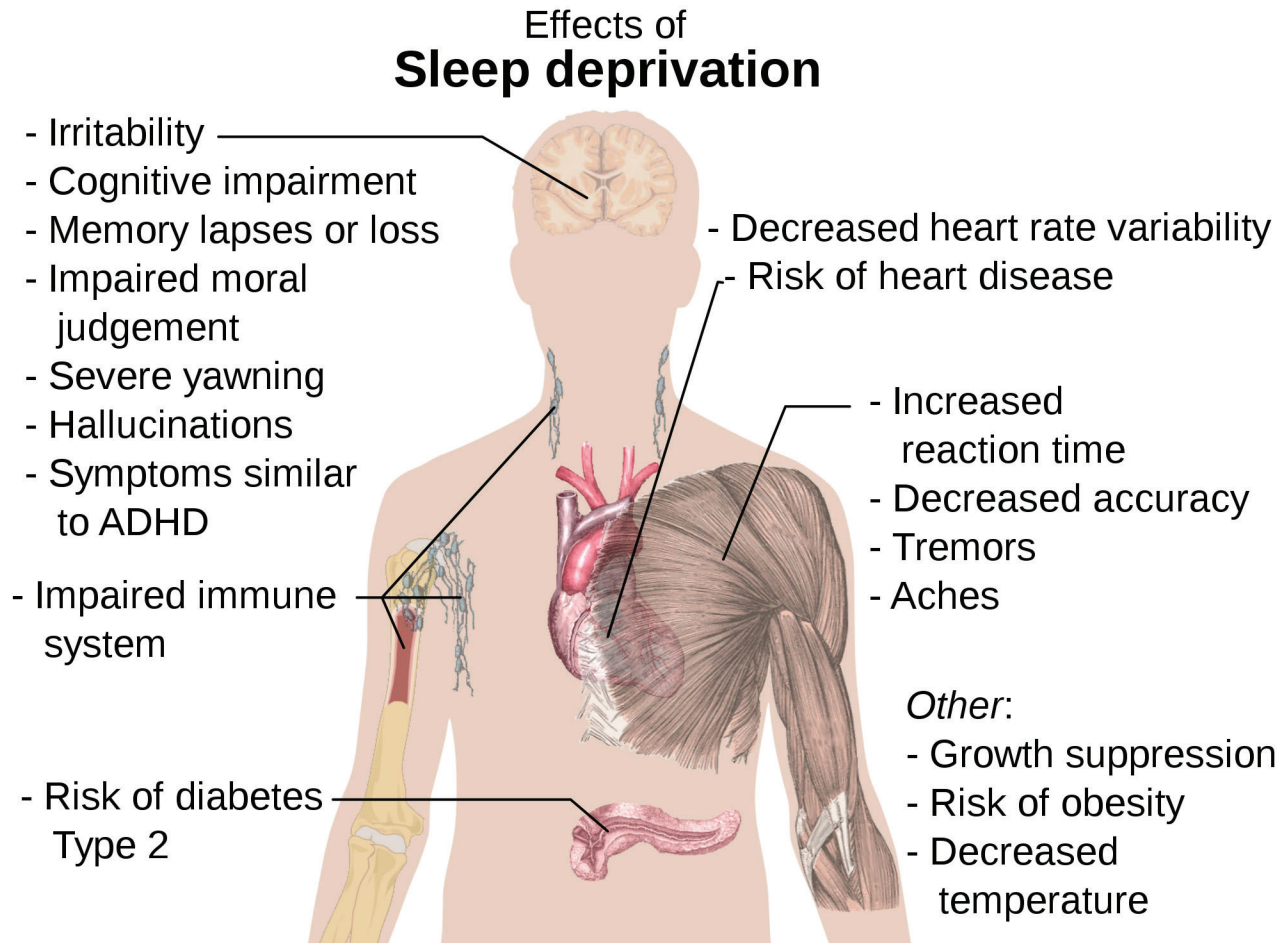


Figure I.4 Some of the effects of sleep deprivation

also address their sleep as if their lives depend on it—because they might.

Sleep is crucial for maintaining a balanced metabolism and managing appetite, blood sugar, and diabetes. This is related to poor sleep's effect on hormones, which can make you feel as though you are starving even though you have eaten plenty. Insulin sensitivity (related to diabetes) also takes a drastic turn for the worse if someone is not getting enough sleep.

Inflammation and oxidation, recognized more commonly in relation to injuries and healing, are also underlying mechanisms in many diseases, including several neurologic disorders. We will see that sleep is essential for reducing oxidation and inflammation and promoting healing, reducing pain, and lowering risk for neurologic disorders (figure I.4).

We know that sleep provides a spark for creativity and problem solving as well as laying down the physiological changes for learning and memory. While there are numerous stories such as how the melody of "Yesterday" came to Paul McCartney in a dream, that type of inspiration translates to most of us as solutions to the previous day's problem that become apparent after "sleeping on it" (figure I.5). This common (and wise) expression alone, and its existence across cultures, points to the now scientifically based fact that sleeping and dreaming help us create solutions and solve problems.

There is a tragic catch. Who has the luxury of putting into practice the recommendations of the numerous healthy sleep articles going around? Who of those in society can carve out eight hours each night in a quiet, dark, comfortable, temperature-controlled room? It is painful to see the studies

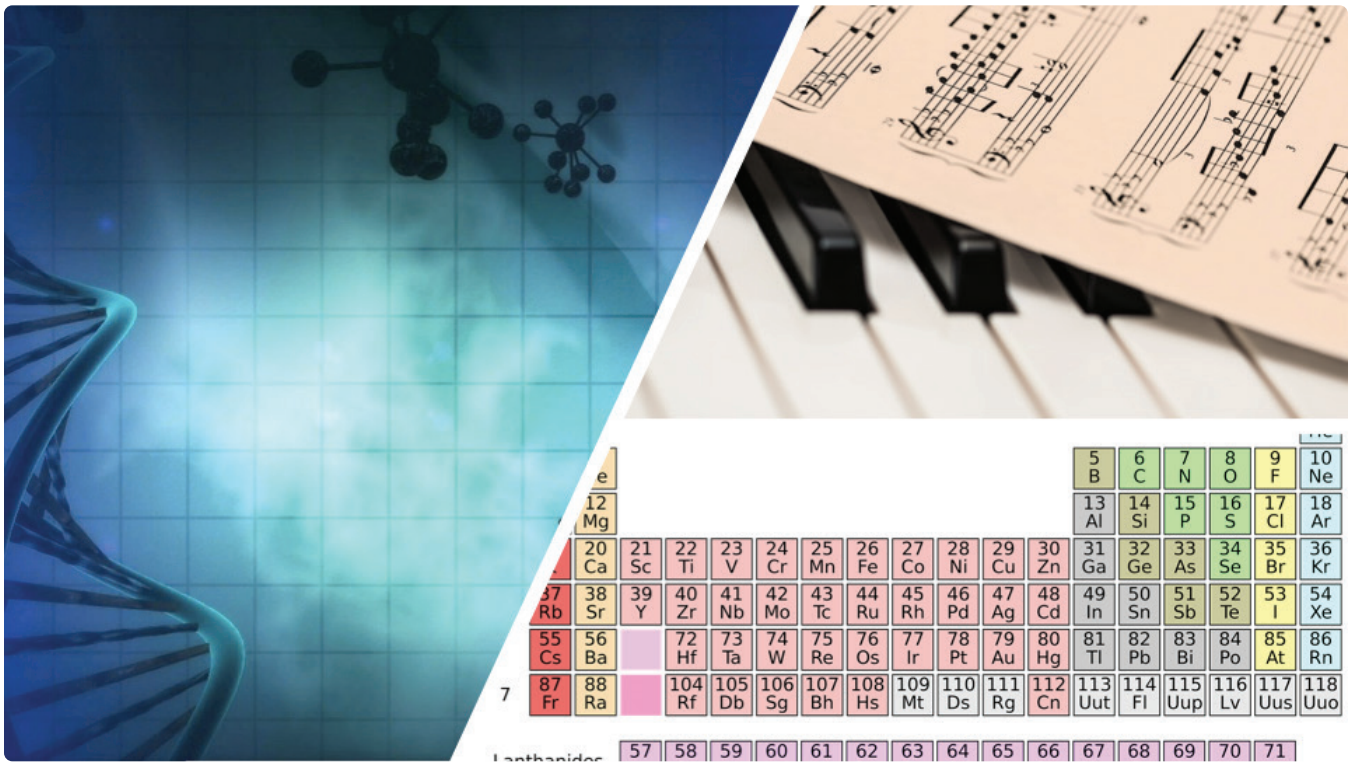


Figure I.5 Sleeping on it

showing correlations between poor sleep and race, sexual orientation, economic group, and education level.

The majority of those who get good sleep are already at an advantage based on race, sexual orientation, economics, and education. If the research continues to pile up showing the connection between good sleep and being smarter, faster, stronger, and more successful, we must take responsibility and address the sleep wellness gap. There is an essential element of social justice, antiracism, and inclusion work in sleep science, so in each chapter, we will discuss this and provide ideas for how you can have an impact in your community and beyond. I have also dedicated a chapter to equity, politics, and sleep. As Zoë Heller has asserted in her *New Yorker* article, "The fact that some of the leading indicators for poor sleep and sleep loss are low household income, shift work, food insecurity, and being African-American or Hispanic suggests that the quest for rest is not so simple."* Let's get together, put the information from this book in motion, and create a sleep wellness revolution. I invite you to work with me to achieve that dream.

But what about yawns? Oh, there you go again. Yawning at my book. The good news is, if you catch yawns, that it is an indication you are empathic. Empathy is the ability to share and understand another person's feelings, so it is a treasured quality—one that is correlated with the contagiousness of yawns. To back this claim up with the behavioral evidence, brain imaging studies show that the areas of the brain activated during yawning are associated with understanding others' feelings. Yawning is typically not contagious in children under five years old, as they are still building their capacity for empathy with each year. Yawning's contagiousness may be valuable as a signal among animals to coordinate behavior—for example, as a way to say, "It is time for all of us to go to sleep."

* Zoë Heller, "Why We Sleep, and Why We Often Can't," *New Yorker*, December 3, 2018, https://www.newyorker.com/magazine/2018/12/10/why-we-sleep-and-why-we-often-cant.

Figure I.6 Yawning is not just for humans

Contagious yawning could also help a group react quickly to a sudden increase in temperature. Disproving earlier theories that yawning is a response to low oxygen, the current research suggests yawning's purpose is to cool the brain. So when one animal yawns, others nearby might begin yawning too because if one of them is getting warm, the rest will soon be in need of the brain-cooling benefit of a yawn too (figure I.6).

But how does yawning accomplish this cooldown effect? As we suck in air, it moves across the moist mucous membranes of the nasal and oral passageways, cooling the blood in the numerous tiny blood vessels just below the surface. The effect of this is that the blood flow in the head is cooled, and scientists speculate that coolness is transferred to the brain. Have you ever noticed how unsatisfying it is when someone interrupts your yawn? Why do we feel the need to complete it? It turns out the full stretching of the jaw brings blood flow to several muscles too, thus increasing the volume of blood that is cooled due to the radiator effect of the air movement over the nearby mucous membranes.

The research studies that led to this conclusion involved having participants place warm or cool packs to the head while watching films of people yawning. Scientists observed that participants yawned significantly less with the cool pack on their heads. There are also times during the twenty-four-hour day that people yawn more often, and there are explanations that can be related to brain cooling. Right before bed, body temperature is usually at its highest, which could trigger yawning. Upon awakening, body temperature is quite low but increasing at its fastest rate, prompting a reflex for cooling—morning yawns. However, there are other times during the day when the body increases to or even sustains a higher temperature, so there are clearly complicating factors involved in understanding the complete picture. Months or decades from now, another scientist—perhaps you—will come along and turn this theory upside-down with fresh insight.

This is one of the satisfying aspects of studying sleep science right now: The frontiers of knowledge are expanding. Today's genius postulate may be tomorrow's balderdash. Join me in the wilderness!

1

Sleep Wellness

Student Learning Objectives

After you read this chapter, you will be able to

- determine sleep need
- discuss the benefits of napping
- describe the habits that fix problematic sleep and support healthy sleep
- explain the concept of a sleep diary
- guide, in the role of a layperson, someone through cognitive behavioral therapy for insomnia
- address pregnancy-related sleep challenges
- describe the values and safety of the family bed

Introduction

The previous chapter likely convinced you of the importance of sleep, but how do you get that sleep? Identifying and establishing the behavioral changes necessary to improve sleep can be elusive, so I will guide you through a simple methodical approach for success. Rest assured, most people start sleeping better after making a few small adjustments to their routines or environment. This chapter will help you create habits for boosting your sleep.

To begin, identify your current level of sleep wellness with the SATED questionnaire, published by Daniel Buysse in 2014.* (In the article, scroll down to figure S1 for the questionnaire.) Part of the motivation in the development of SATED was to help researchers and clinicians move away from a sleep disorder–centric model of thinking and provide a way to assess and promote sleep health. This is because if we view wellness as an absence of disease, we are missing opportunities to increase health in our communities. By defining, and thus being able to evaluate, a person's sleep health, we have a better opportunity to prevent disease, maximize wellness, and have an impact on entire communities. Concerns can be addressed, and educational interventions taken, to prevent the tragic effects of sleep debt. If, in addition to the traditional programs focused on disease treatment, political and health-care policies support health practitioners in assessing the well-being of individuals and communities to determine educational targets, we could take a significant leap toward increasing vitality and preventing disease.

In his article, Buysse stresses the difficulty of conducting meaningful research and making health policy changes without a clear understanding of *sleep health*, pointing to the lack of a clear definition of this term in the scientific literature and the field of sleep medicine. The SATED questionnaire is part of his attempt to provide a better understanding of what constitutes healthy sleep. He considers sleep health to have five dimensions:

* Daniel J. Buysse, "Sleep Health: Can We Define It? Does It Matter?," *Sleep* 37, no. 1 (January 2014): 9–17, https://doi.org/10.5665/sleep.3298.

- Satisfaction with sleep
- Alertness during waking hours
- Timing of sleep
- Efficiency of sleep
- Duration of sleep

Determining Sleep Need

Before diving into detail about how to get good sleep, let's agree on how much is enough. For most adults, it is around eight hours, and for many adults, a little more than eight. Even if you get that much, you may wonder how to verify if it is of good quality. That is easier to ascertain than you might imagine.

Here are questions to ask to determine if you are getting adequate sleep:

1. After being up for two hours in the morning, if you were to go back to bed, would you be able to fall asleep?
2. If you did not set your alarm, would you wake up automatically at the desired time, feeling refreshed?
3. Without caffeine or nicotine during the day, would you easily stay awake and alert?

Figure 1.1 Nap

4. When you go to bed at night, do you fall asleep "when your head hits the pillow"?
5. Do you doze off during a boring meeting, conversation, or TV show? (figure 1.1).

Answers to these simple questions reveal if you're getting enough good-quality sleep. If it is adequate, your answer to questions 2 and 3 would be yes but no to questions 1, 4, and 5. Question 4 is the only one that may not be obvious: some of you likely believe it is a healthy sign to fall asleep immediately upon getting in bed, but that in fact is a sign of an extreme lack of quality sleep. It should take about fifteen minutes to fall asleep if a person is getting enough good sleep each night. Similarly, regarding question 5, a person might assume they are getting ample sleep and that it is normal to doze off if they had an exhausting day and are watching a TV show in the early evening. However, these situations are actually unmasking sleep debt and are a signal that more sleep is needed.

What about sleeping too much? This concern can often be traced to a misinterpretation of research showing a correlation between nine or more hours of sleep a night and a shorter life-span. However, there is no evidence that more good-quality sleep is the cause. Rather, having a disorder such as obstructive sleep apnea (OSA) can cause a person to stay in bed nine or more hours a night (see chapter 6). In this case, they will report they are "sleeping" nine or more hours, but unbeknownst to them, they are not actually getting quality sleep during those nine hours, and that is why they end up staying in bed so long. After the eighth hour in bed, their body is still trying to get sleep because they may have been awakened, without knowing it, hundreds of times during the night due to breathing issues. So untreated OSA is what increases the risk of an earlier death, not excessive sleep. Someone without OSA who spends nine hours each night going through healthy sleep cycles and feels refreshed throughout the day would not have an increased risk of an earlier death. Please use this content to deliberate with a classmate about correlation versus causation.

Ready to Move On?

Before moving on, be sure you are clear about the difference between correlation and causation.

Correlation: a connection between things
Causation: one thing plays a part in making another thing happen

Just because there is a correlation between things, it does not mean one thing causes the other. It is important when you are reading about science that you are able to tease out the difference between correlation and causation. If someone is trying to convince you of something, they may make it difficult to tell the difference.

Engage a classmate in a conversation and respond to each of the three prompts below. You may draw on simple things from your own life, something from your imagination, or even science:

1. Describe a situation where there is a *correlation* between two things. For example, if I surf in the morning, I am happier the rest of the day. There is a connection between my happiness and surfing.
2. Describe a situation where one thing obviously causes another. For example, while riding a wave, if I stand too far forward on my surfboard, I will pearl (a.k.a., nosedive—as in, "Hey sistah, you looked like you were diving for pearls!"). Standing near the front of my surfboard plays a part in making the nose of my surfboard dive underwater. That is *causation*.
3. Describe a situation where there is a correlation between two things but there is obviously *not* causation. For example, on the days I surf, I gain a little weight. Does this mean surfing causes me to gain weight? That does not make sense, does it? So if I wrote an article telling people to avoid surfing if they were trying to lose weight, I hope you would read it critically and try to find out other explanations for the correlation. Perhaps after I go surfing, I always go eat double loco moco, a popular dish in Hawai'i that includes two scoops of rice, two fried eggs, a hamburger patty, and gravy. What do you think?

One factor that must be included in discussions of the ideal amount of sleep is sleep opportunity. Going to bed at 11:00 p.m. and arising at 7:00 a.m. does not mean a person has slept eight hours. This means the person was providing themselves a sleep opportunity of eight hours (the time they spent in bed) with the time of actual sleep still to be determined. This is often an area of confusion in interpreting population studies of sleep. In questionnaires, people likely report that they sleep eight hours if they are in bed from 11:00 p.m. to 7:00 a.m. However, if you have those same individuals wear an actigraphy device or polysomnography equipment, the results may show that during those eight hours, they sleep less than four hours or, under the best of circumstances, seven and a half hours (see chapter 2 for a discussion of actigraphy and polysomnography). You may be wondering why, under the best of circumstances, eight hours of sleep would not be obtained after eight hours in bed. This is because it is normal to take fifteen minutes to fall asleep (as mentioned at the start of this chapter) and to have a few tiny awakenings during the night (most of which we are

Figure 1.2 Kalahari ǂKhomani San Bushman

usually unaware). If we recommend a person get eight hours of sleep, we are referring to *actual sleep*, which requires being in bed for eight hours plus the time it takes to fall asleep and any additional time for awakenings during the night. This means most people need to give themselves a little over eight hours in bed each night.

One fascinating study that received considerable press—press that misrepresented the scientists' conclusions—was regarding hunter-gatherer tribes and their sleeping less than seven hours a night. Understanding this study will help you comprehend the difference between sleep efficiency and sleep opportunity as well as encourage you to think critically when hearing news stories. Consider, for example, how a headline in popular media that tells people "You do not really need 8 hours of sleep" will sell magazines. Even though that was likely not the intention of the scientists who conducted the study, this distortion of the results made for profitable press. But what actually happened?

The researchers studied people from three tribes: the Hadza (Tanzania), Tsimané (Bolivia), and San (Kalahari; figure 1.2). The idea was that since these are preindustrial tribes, the way they sleep is how we city dwellers should too. The members of the tribes wore actigraphy devices that showed an average of 6.75 hours of sleep per night for the duration of the study. A layperson's interpretation of this could be that the tribal member was in bed for 6.75 hours; consequently, that layperson may believe they achieve optimal sleep health if they go to bed at 1:15 a.m. and get up at 8:00 a.m. However, for a sleep efficiency of 85 percent (the low end of the healthy range), a person would have to be in bed 7.9 hours to get 6.75 hours of sleep (see chapter 2 for a discussion of sleep efficiency).

But wait—how long does it take the person to fall asleep? Under ideal circumstances, a person falls

asleep in 15 minutes (0.25 hour), so add 0.25 hours to the 7.9 hours to get 8.15 hours (8 hours and 9 minutes). This means that if a person has both healthy sleep efficiency and sleep latency (time to get to sleep), they need to be in bed 8.15 hours to get 6.75 hours of sleep. It is doubtful that most people interpreted the popular-press headlines (boasting we need less than 7 hours of sleep) of this research as guidance to be in bed for over 8 hours; rather, many people probably ended up getting less than 6 hours a night, thinking they were on track because they allowed themselves 6.75 hours of time in bed as their new healthy goal. The actual study supports this as well: the tribespeople were giving themselves between 7 and 8.5 hours of sleep opportunity a night.*

As a science student, the lesson for you in this is to think critically when reading news stories, ask yourself if the reporter has an agenda, and most importantly, look for the source of the data and find the original article. See if that article is in a peer-reviewed scientific journal, and read the article itself critically as well.

In his book *Why We Sleep*, Matthew Walker, PhD, adds further fuel to the argument that these tabloid headlines are harmful and misguided. He points out that the life expectancy for people in these tribes is fifty-eight years, a number very close to the projected sixty-year life-span of an adult in an industrialized country who gets 6.75 hours of sleep a night. He also refers to animal studies indicating that the cause of death in sleep-deprived animals is the same lethal intestinal infection that is the cause of death for many of the tribespeople of the study. He reasons that the tribespeople may be sleeping 6.75 hours, but they might live longer if they were to sleep more. He then postulates that the reason they sleep less is due to a lack of sufficient calories; they border on starvation for a significant part of each year. There are physiological cascades that shorten sleep if the body needs to spend more time acquiring food. This is clearly not the goal for a person looking for the ideal amount of sleep to get each night for the sake of health optimization and longevity.

Napping

Napping makes us stronger, faster, smarter, and happier, and it helps us sleep better at night. From the prophet Muhammad, who recommended a midday nap (qailulah), to the Mediterranean concept of a siesta, napping has spanned cultures and the ages (figure 1.3). The word *siesta* derives from Latin: *hora sexta*, meaning "sixth hour." Here is why that makes sense: the day begins at dawn, around six in the morning; consequently the sixth hour would be around noon—siesta time! Only recently have modern North Americans, on a larger scale, embraced the practice of napping, thanks to extensive research showing the mental and physical health benefits of a brief amount of sleep shortly after midday. This is the time we have a genetically programmed dip in alertness—the signal to nap—that is a function of our human circadian rhythm, regardless of ancestry.

If we take the sleep wellness advice, adjust our routines, and start getting eight hours of sleep a night, it can feel disappointing to still feel drowsy in the afternoon. However, it is time to create a new habit of celebrating that afternoon slump as a healthy response in the body, even after sleeping well the night before. Drowsiness at this time is a valuable reminder to take a ten- to twenty-minute nap. Remember to set an alarm to train the body to limit the nap's duration, and with practice, you will wake up just before the alarm sounds. The groggy feeling upon awakening from a nap might be a deterrent for even an ardent napper. This is sleep inertia, and with a more regular napping routine, it will be easily managed. Knowing you will have that sensation and that it will pass, usually within ten minutes, will make it easier to settle down for the nap. Some people who enjoy caffeine, and have

* Gandhi Yetish et al., "Natural Sleep and Its Seasonal Variations in Three Pre-industrial Societies," *Current Biology* 25, no. 21 (November 2015): 2862–68, https://doi.org/10.1016/j.cub.2015.09.046.

Figure 1.3 Siesta

tested to be sure it is not affecting their nighttime sleep, might want to have some right before their nap or immediately upon waking to help manage sleep inertia, but this isn't always necessary. The quality of clear and relaxed energy that takes you well into the evening, as opposed to the energy crash from not napping and using caffeine or nicotine in place of a nap, is usually enough to motivate someone to maintain a napping habit. Since the body has not been on a roller coaster of drowsiness during the day, thanks to the missed nap and possibly the use of stimulants, it approaches bedtime in a more even and restful state, and a better night's sleep should follow.

Students hoping to optimize their study efforts would be wise to close the book and take a short nap (figure 1.4). Naps increase memory performance, and scientists have documented particular types of brain activity that are associated with enhanced learning during naps, including sleep spindles (see chapter 2). When working on a homework set, the skill of restructuring—viewing a problem from various perspectives and creating a novel vision—is an ingredient for success that can be obtained via a brief afternoon snooze. Combine this with the amplification of creativity after napping and we see why students at colleges around the world are finding ways to get a nap on campus (see chapter 7).

When trying to avoid a cold or the flu, people are willing to spend a lot of money on immune support supplements and vitamins, but one of the strongest ways to provide powerful immune support is free (figure 1.5). After a night of poor sleep, antiviral molecules such as interleukin-6 drop and reduce immune system power. However, a nap can bring those levels back to normal. Researchers have also found increased levels of norepinephrine, the "fight or flight" molecule, after reduced nighttime sleep. Sustained high levels of norepinephrine, associated with the stress response, have harmful effects on blood glucose balance and cardiovascular health. Napping brought the norepinephrine levels back within their normal range. Similarly, since one in three adults in the US have high blood pressure, it is welcome news

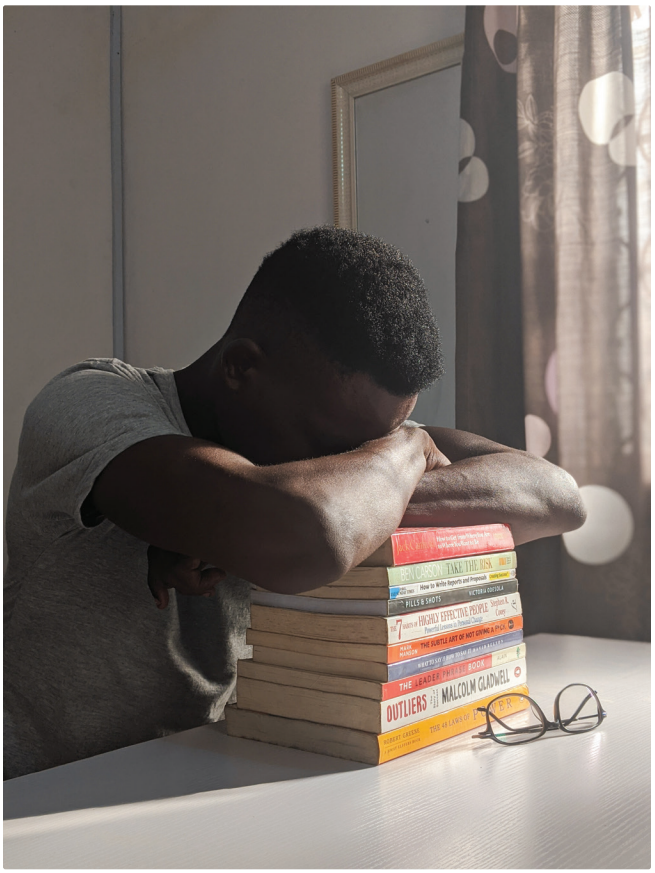


Figure 1.4 Napping boosts learning

Figure 1.5 Skip the side effects and choose napping

that a daily nap can bring that down as effectively as medications and other lifestyle changes.

Athletes have been converting en masse to napping based on research showing the benefits it has for athletic performance as well as increased motor learning, even after a nap as short as ten minutes (figure 1.6). Athletes, such as sprinter Usain Bolt, have shared stories of napping earlier in the day before a record-breaking performance. Adam Silver, National Basketball Association commissioner, cautions those who want to contact athletes during siesta time, "Everyone in the league office knows not to call players at 3 p.m. It's the player nap."

If you are still not convinced of the importance of napping, consider the distressing consequences when many healthy Greeks gave up napping. This occurred when business owners in many Greek communities began deciding to keep the businesses open rather than shut down for a siesta as they always had. Around that time, Harvard researchers examined over twenty thousand Greek adults with no cardiovascular disease. When they followed up after several years, the individuals who had given up napping had seen a 37 percent increase in their risk of dying from heart disease. For working men, it was an over 60 percent increase. A more hopeful way to view this is that the risk of dying was *reduced* by these significant amounts for those who continued napping.

Sleep Wellness Guidelines: Daytime, Before Bed, In Bed

Refer to the Sleep Wellness Guide below and take inventory, noting areas that you need to address. Prioritize each of those problem areas based on the *significance* of its impact on sleep, the *feasibility* of making change, and the *value* its implementation would have for the individual. This increases success by helping people see the flexibility of the approach and how they can control the process.

- *Significance:* If a person is having caffeine late in the day and it is keeping them awake, the caffeine is having a significant impact on their sleep. Therefore, avoiding caffeine—or having it earlier—may solve the problem without the need to address less significant areas. Putting the effort toward changing behavior in less significant areas while continuing something significantly disruptive, such as caffeine intake, might not result in any improvement. In addition to being ineffective, it is frustrating because you feel like you are putting in effort and not getting results.
- *Feasibility:* All items on the Sleep Wellness Guide are not feasible for everyone. If someone is a shift worker or caring for a family member, it may not be possible to get to bed at the same time every night. Determine a way to address this item that

Figure 1.6 Power naps for power athletes

recognizes the reality of the situation. For example, could you go to bed and get up at the same time four days a week and maintain a different sleep schedule the other three days.

- *Value:* Do you really enjoy that bowl of ice cream when watching a movie right before bed? Sleep wellness is not about giving up life's pleasures. One sleepless client I worked with told me he had addressed all the items in his sleep wellness inventory but was still not getting quality sleep. We went over his daytime and evening routines, and I found out he truly treasured his ice cream, a generous serving of it, shortly before bed. I did not want him to deprive himself of this pleasure. He agreed to instead switch from a large to a small bowl to reduce the serving size. I asked him to choose an artistically pleasing little bowl, hoping to tap into an additional pathway to the reward center of his brain. We discussed the concern of heightened sugar levels right before bed and decided to offset this by, in addition to reducing the portion, rolling up a piece of sliced turkey and eating it while he scooped his ice cream into the bowl. This would help balance out the sugar-to-protein ratio of his late-night snack. Now, he still gets to sit and enjoy his bowl of ice cream, but thanks to those adjustments, his sleep is now satisfactory.

Sleep Wellness Guide

During the Day

- Get a little sunlight on your face first thing in the morning to set your circadian rhythm.
- Exercise, taking at least a brisk twenty-minute walk each day.
- After noon, avoid caffeine, guarana, and other stimulants (e.g., chocolate, black or green tea, coffee, soda, energy drinks).
- Avoid alcohol within five hours of bedtime—alcohol disrupts brain activity critical for healthy sleep.
- Quit cigarettes/nicotine because nicotine at any time of day disrupts sleep; get support from a local smoking cessation program.
- If you are not quitting smoking, avoid cigarettes/nicotine within five hours of bedtime.
- Take a ten-to-twenty-minute nap around 2:00 p.m.—our bodies are meant to sleep two times a day.
- If you are awakening to urinate at night, then during the day, elevate your legs often and also do heel/toe raises to absorb fluid (accumulated in legs) that would be processed by kidneys at night.
- Ask your doctor about the effects any medications you take might have on sleep—healthy sleep can be disrupted by some prescription and over-the-counter medications (even some "sleep" medications).
- Keep a sleep diary*—many people are surprised by what they find out at the end of a week.

Before Bed

- Practice a ritual (e.g., take a bath, read a relaxing book, meditate, sing). See the UCLA Mindful Awareness Research Center, marc.ucla.edu, for guided meditations.
- Eat a light snack with minimal sugar (e.g., milk and cereal, fruit and yogurt, nuts and crackers).
- Avoid light from lamps, computers, televisions, and cell phones within one hour of bedtime. This light disrupts melatonin production and thus circadian rhythm. Alternatively, use blue light–filter glasses or apps.
- If nighttime urination is a problem, minimize water intake—consider no fluids within ninety minutes of bedtime. Try no herbal tea at least five hours before bed to determine if that is a factor. Urinate immediately before going to bed.
- Start a relaxation practice before bed—begin with three minutes of quieting your mind, sitting still.
- Practice slow breathing. Gently push out the belly as you inhale, hold, then slowly exhale, relaxing the belly back to a neutral position.

While in Bed

- Keep the room completely dark—no streetlights or night-lights unless very dim or orange.
- If you do not fall asleep within what feels like twenty minutes, get out of bed and do something relaxing (e.g., read a calming book, listen to an audiobook).
- Keep the room cool, around 65–68 degrees Fahrenheit (18–20 degrees Celsius).
- Use the bed only for sex, sleep, and gentle reading / audio files (no emailing, television, working, etc.).
- Make the room quiet or use white noise (recordings of the ocean, a fan, rain, etc.) to mask disruptive sounds.
- Position your clock so it is not visible during the night, and do not check the time if you wake up.
- If you need to get up to urinate, use dim and orange lighting just bright enough for safety.
- Go to bed and get up at the same time every day, even on weekends.
- Sleep approximately eight hours.

Before making any changes to your routine, consult your physician.

* Shook, Sheryl, "Sleep Diary," Google, accessed December 3, 2021, https://docs.google.com/document/d/1zigrkIEwmCLq5oMAkZ-bQIajdwhA9mQezfNAervgIoE/copy.

Sleep Wellness: Beyond the Guide

After reviewing each of the items in the Sleep Wellness Guide, synthesize the content with a deeper understanding of the science behind the practices.

Light

Chapter 3 provides elucidation about the role of light in regulating your sleep-wake cycle, while this section provides details about how to use the timing and quality of light exposure to improve sleep health. Sunlight or bright indoor light on the face in the morning is helpful to correct the circadian rhythm of someone who is not sleepy until late at night—a night owl—or has a difficult time waking up at the desired hour. Then, in the evening, establish a routine with reduced (or preferably, no) blue/white light exposure two hours before bedtime. This light so close to bedtime disrupts the circadian rhythm and interferes with sleep quality. In the evening, use solely amber- or orange-colored lights for illumination (figure 1.7). For the phone, computer, and TV, utilize apps that filter blue light (the display will appear slightly orange). Alternatively, donning a pair of amber eyeglasses that block blue light will carry you into the bedtime hours, reassured that your melatonin secretion will not be disrupted by, for instance, preparing tomorrow's lunch in a well-lit kitchen (figure 1.8). Consider switching to an orange night-light, in place of bright vanity lights, to use while brushing your teeth before bed. When sleeping, keep the bedroom as dark as possible for the soundest sleep.

Figure 1.7 Cozy amber lighting

If someone is a lark, we use an alternate approach. Falling asleep early in the evening and awakening before sunrise, a lark is often an elder, although a small percentage of younger people fit this rhythm. Light therapy is used with a different schedule to shift the lark circadian rhythm. Upon arising, the light levels are kept low, including filtering blue light, thus sustaining melatonin levels for those predawn hours. If the lark engages in early morning outdoor activities or a morning commute, sunglasses are essential. Late in the afternoon and into the early evening, bright light is used to keep melatonin levels from building. This will often shift the lark's schedule closer to the desired rhythm.

Exercise

A commitment to movement, especially if it is enough to get a little sweaty or elevate the heart rate—even slightly—helps us sleep better. Consider something that you can make a regular part of almost every day for twenty to thirty minutes. Movement and consistency, more so than the time of day or type of activity, are key. If gardening is pleasurable, let that be your sport. If the convenient time is in the evening, it is better for most to have the evening workout than to skip it due to worries that it is too close to bedtime. It may take several weeks to have an impact on sleep, but research suggests exercise increases sleep quality.

Nighttime Urination

There are several possible ways to eliminate nighttime urination. (This refers to people who interrupt their sleep to get up to urinate, as opposed to bedwetting, a different problem discussed in chapter 6.) Maybe you are thinking, "I only get up once during the night to urinate and go right back to sleep, so it isn't a problem." However, when we understand sleep architecture, the importance of its components, and how our eight hours of sleep must be uninterrupted in order to get the proper balance of each stage, we will see how even just one interruption each night can be a significant problem (see chapter 2). Let's help people eliminate nighttime urination so they get the benefits of a full night's sleep.

During the day, fluid accumulates in the legs in varying amounts depending on physical activity

Figure 1.8 Looking cool while blocking blue light

Figure 1.9 Elevate your legs

level. By elevating the legs during sitting and taking breaks to get movement in the legs, some of this fluid is moved from the legs up toward the kidneys to be urinated out during the day. Otherwise, upon lying down in bed at night, the fluid in the swollen legs, now elevated, moves up into the kidneys, producing more urine than the bladder can contain during the night. When working on a computer or watching television, prop up your legs above the level of your hips, being sure to provide support for the lower back (figure 1.9). If sitting for long periods, get up occasionally, and while standing, lift the heels to put weight on the toes, then lift the toes so weight is on the heels. (Hold on to something if support is needed.) Repeating this several times helps move fluid out of the legs.

Fluid intake during the day and the evening has an impact on sleep. Stop drinking fluids ninety minutes before bed to give the kidneys time to filter the excess water from your blood. Then urinate immediately before bed to empty your bladder. For some people, herbal tea causes increased urination; however, in other people, it is no different than water. If you enjoy herbal tea before bed, determine if this is an influence by not drinking it within five hours of bed. After your nighttime urination is resolved, reintroduce the evening herbal tea and, if sleep is sound and uninterrupted, enjoy your tea (as long as it contains no caffeine). Alcohol also increases urination and is best avoided five hours before bed for this reason (and also due to its

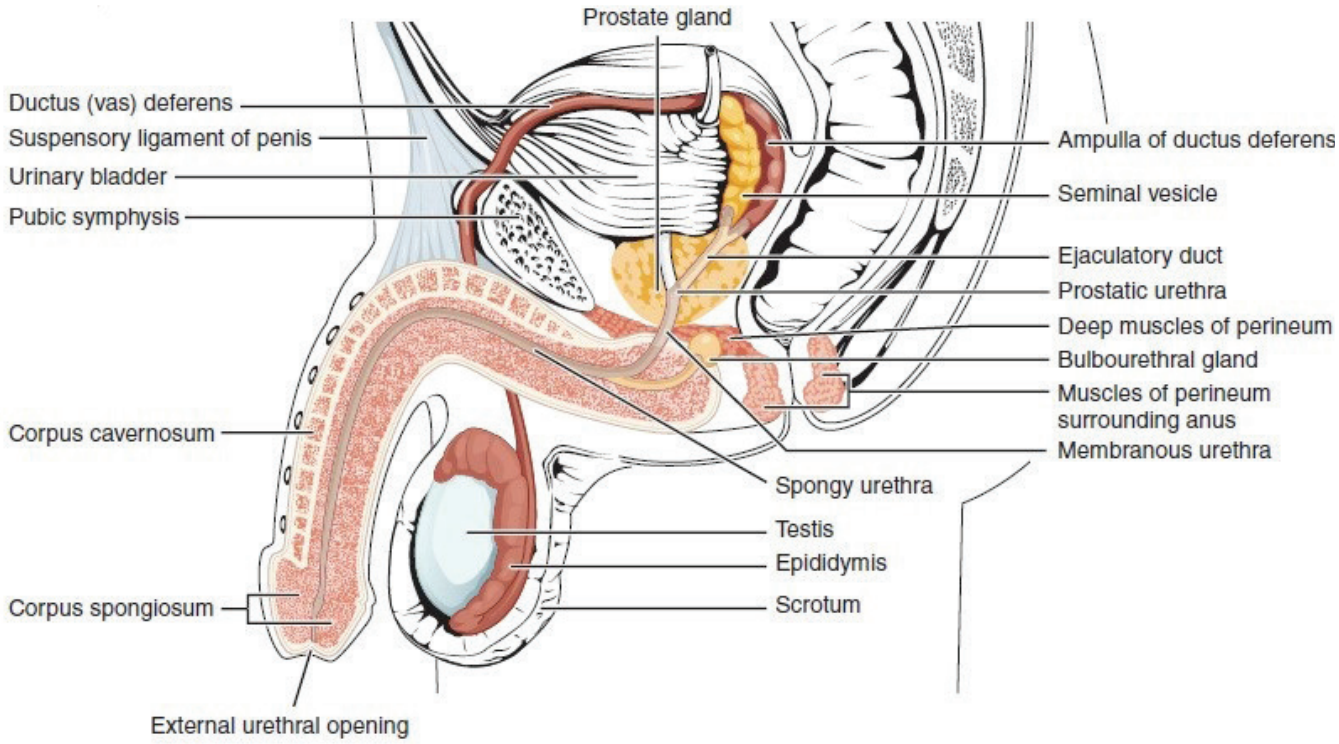


Figure 1.10 Mid-section view of the male reproductive system

sleep architecture–disrupting properties). Eliminate caffeine entirely after noon, as it is a bladder irritant. Also examine nutritional supplements and any protein or workout powders to check for ingredients with diuretic effects.

An enlarged prostate is associated with nighttime urination. This is a gland surrounding part of the male urethra, the tube that carries urine and semen (figure 1.10). As men age, there is normal age-related prostate enlargement that squeezes the urethra to varying degrees. This makes it difficult to completely empty the bladder before bed, making it crucial to put all the other strategies in place to minimize the need to disrupt sleep for urination. Some men also decide to talk to their medical doctor regarding various prescription medications or surgical procedures to treat the symptoms.

If a person addresses the various concerns and is practicing all these strategies to eliminate nighttime urination but finds they are still getting up to urinate, there is a possibility that the nervous system is responding to a trigger of awakening—a snoring partner, an outdoor noise, a warm room—and perceiving a need to urinate even though the bladder is not full. Depending on a range of factors, including age, the bladder holds around two cups of urine and, for most people, even more at night. An easy way to determine if the bladder truly needs emptying is to collect the urine and measure the output. Upon arising in the middle of the night, urinate into a container such as a pitcher placed in the bathroom. In the morning, determine the volume of urine. If it is a small amount of urine, just a few ounces, perhaps the body and mind need to be trained to go back to sleep and not respond to the trigger to get up and urinate. However, if well over a cup of urine is produced after putting in place all the strategies mentioned, take this information to a doctor and discuss what could be causing the urine production. Knowing the amount of urine produced during the night will be helpful in the course of diagnostics.

If you still must urinate at night, be safe by lighting the way, and at the same time, preserve melatonin levels by using orange lights for illumination from bedside to the toilet.

Caffeine and Stimulants

Individual responses to caffeine vary widely, but if someone is getting poor sleep, advice about when to end consumption remains standard. Avoid caffeine in all its forms after noon until healthy sleep is achieved and sustained for at least a week. The same is true for guarana, a stimulant found in a range of sources, including energy drinks (figure 1.11). Some folks need to give up caffeine, guarana, and any other stimulants (e.g., theobromine, which is found in chocolate) entirely until they get good sleep. After a satisfying sleep rhythm is maintained for a week, you could consider reintroducing stimulants. However, many will find getting good sleep for a week without stimulants provides such an increase in vitality that there is no need for any stimulants. If you are still craving a boost from caffeine or another stimulant, first reintroduce it before noon and notice if there are changes to sleep quality or the refreshed feeling upon awakening in the mornings. From there, determine the latest time in the day your body can clear out the caffeine/stimulant and allow you to sleep well at night.

Alcohol

Under the influence of alcohol, the brain is not able to construct a proper night's sleep. Being relaxed and falling asleep is not the same as creating health-promoting sleep architecture (see chapter 2). For example, having as little as one serving of wine, beer, or spirits close to bedtime can cause increased awakenings during sleep (even though the person may not be aware of them), decreased rapid eye movement (REM) sleep in the first half of the night, and disturbing REM sleep rebound in the latter half. Alcohol on its own is not the challenge to sleep; rather it's the timing of its consumption. Avoid alcohol at least five hours prior to bed so the sleep-disrupting chemicals get mostly metabolized out of the body before it's time to tuck yourself in for the night. This is a wiser

Figure 1.11 Think about your sleep before reaching for an energy drink

approach than the close to bedtime "nightcap" that is sure to hijack a sound night's sleep.

Nicotine

The double bind of nicotine is that it is a stimulant that will keep us awake if used too close to bedtime, but if a person stops nicotine earlier in the evening, they will have subtle awakenings during the night due to nicotine withdrawals. However, the latter is preferable, so cease nicotine use at least five hours before bed.

To support sleep wellness and overall health, seek a local or online smoking cessation program, preferably one with scientifically proven mindfulness training, which has shown significant success. During the process of quitting, practice self-compassion for two reasons. The first is that smoking is one of the most difficult habits to change, so it is important to be kind to yourself throughout. The second is that neuroscience has proven that self-compassion is an effective component of habit-changing. Many communities have a resource such as the Hawai'i Quitline.* Nationally in the US, there is also smokefree .gov or 1-800-QUIT-NOW (1-800-784-8669).

Nap

In the early afternoon, take a ten-to-twenty-minute nap. (See the napping section for details)

Medications

Sleep is disrupted by many medications, such as some antidepressants, over-the-counter sleep aids, pain medications, antihistamines, and even prescriptions marketed to promote sleep. Just because a medication puts someone to sleep does not mean it creates natural restorative sleep. Check with your health-care provider to determine whether any medications you take may impact your sleep and for guidance about pros and cons associated with sleep disruption and each course of treatment.

Sleep Diary

A sleep diary's purpose goes well beyond keeping track of how you sleep. By keeping a good sleep diary, you will notice how daytime habits—exercise, alcohol, caffeine, TV viewing—and their timing have an impact on sleep. By keeping track of your sleep habits along with how you feel during the day, you will also establish a connection between sleep quality and daytime mood and performance. Record your data in a sleep diary for two weeks. In addition to providing clear motivation to make changes, this type of biofeedback also fuels the brain for habit-changing behavior. Use this fillable sleep diary† created by one of my sleep science students at Kapi'olani Community College. You may also try one of the many phone apps for tracking daytime activities and sleep quality. Daytime activity and mood data are essential to the process, so be sure whatever you use also tracks that information. People are often surprised by their findings after making use of a sleep diary. It shines a light on several potential areas for change to improve sleep.

Ritual

The brain can be rewired to associate behaviors and sensory input with falling asleep. Decide on a before-bed ritual, such as taking a shower, using a soothing naturally scented lotion, reading a book you read only at bedtime, meditating, singing, practicing a relaxing breathing technique, or listening to an audio book or podcast (figure 1.12).

Leg Cramps

If you experience leg cramps at night, talk with your health-care practitioner to determine if you have any electrolyte imbalances or if they can suggest any supplements, vitamins, or electrolyte drinks. Maintain sufficient hydration. Incorporate daily exercise. Gentle early evening stretching, from head to toe, helps relieve lower leg cramps because they can be triggered by tension elsewhere (including up much

* "Hawai'i Tobacco Quitline," accessed December 3, 2021, https://hawaii.quitlogix.org/en-US/.
† Shook, Sheryl, "Sleep Diary," Google, accessed December 3, 2021, https://docs.google.com/document/d/1zigrkIEwmCLq5oMAkZ-bQIajdwhA9mQezfNAervgIoE/copy.

Figure 1.12 Bedtime story

higher) in the body. Consider a warm bath with Epsom salts (magnesium sulfate) before bed. During the cramp, applying an ice or heat pack or standing and holding a stretch might alleviate some of the pain.

Snack

Our tūtū (the way we say "grandparents" in Hawai'i) and tias (Spanish for "aunts") knew what they were talking about when they advised us to have warm milk with honey before bed. Although there is a small amount of tryptophan in milk, which is associated with the cascade that puts us to sleep, and the carbohydrates in honey clear the way to allow more of the tryptophan to get into the brain, our sound sleep is probably more due to the calming ritual and the balanced nutrition of that bit of nourishment. The general guideline is to have a little snack close to bedtime and to include a small amount of fat and protein and balance that with carbohydrates, but no high-sugar items, which cause a stress response that keeps you awake. Examples of healthy bedtime snacks would be milk (can be dairy, almond, etc.) with whole-grain cereal (low in sugar) or nut butter with crackers (figure 1.13). A small serving is best because digestion slows down with sleep. If you have gastroesophageal reflux disease, it is best to skip having food too close to lying down. Time it so it does not aggravate your symptoms.

Sleep in Bed

Use your bed only for sleeping, having sex, reading, or listening to a relaxing audio file. Avoid emailing, engaging in social media, or watching television in bed, all of which condition the brain to associate the bed with a different level of alertness, interfering with sleep. If you have spent what feels like twenty minutes trying to fall asleep, get out of bed, do something relaxing like reading a book on the couch or listening to a relaxing audiobook until sleepy, and then return to bed.

Figure 1.13 Healthy snack for healthy sleep

Temperature

While most people can sleep in a range of temperatures, I have had several clients find cooling the bedroom was the one thing needed to fix their sleep. Research shows the ideal sleeping temperature is a surprisingly cool 65–68 degrees Fahrenheit (18–20 degrees Celsius). In the wild, the natural drop in temperature each evening triggers the hypothalamus (see chapter 2) to launch the cascade that ultimately releases melatonin, telling our bodies it is time to sleep. Taking a warm bath or shower before bed promotes this cooling by bringing the blood flow to the skin in response to the heat. Then, after stepping out of the bath, the blood on the skin surface works like a radiator to cool the body temperature and send you into a relaxing sleep. To investigate this phenomenon, researchers developed a bodysuit with a layer containing a mesh of tiny tubes of water, precisely controlled for temperature and region of flow. When wearing the suit, participants' skin surface was exposed to heat, yet remained dry. These experiments showed bringing blood flow to the body surface via temporary superficial warmth provided core-temperature body cooling and thus reduced the time participants needed to fall asleep and improved their sleep quality.* Warming the feet and/or hands with a warm soak or heating pad is also a quick trick if taking a shower or bath is too time-consuming or not practical.

Timing

Most adults need around eight hours of sleep every night, and it is best to go to bed and get up in the morning at the same time each day, even on weekends.

Clocks

Do not have a clock within view of the bed; being aware of the time triggers a loop of thinking that keeps you awake. When awakening in the middle of the night, resist the urge to look at the clock or your phone (both of which should not be near your bed or visible) and train your brain to let go of the curiosity about the time.

Noise

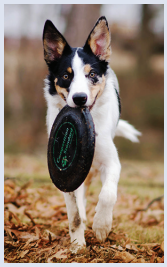
If it is not possible to make the bedroom quiet, use noise-reducing earplugs. There are also phone apps and audio files that create relaxing white noise, such as rain sounds. Running a fan in the room is sometimes enough to mask intrusive noises. However, the brain still processes white noise information, so minimizing it is preferable when outside noises are low enough that you can still sleep.

Cognitive Behavioral Therapy for Insomnia

Cognitive behavioral therapy for insomnia (CBTI) involves meeting with an individual or a group once a week for four to eight weeks. The client is advised on how to change thoughts and behaviors to increase healthy sleep. The National Institutes of Health (NIH) claims CBTI is safe and effective.† Many insurance companies cover CBTI, and research shows it is more effective than sleep

* Roy J. E. M. Raymann, Dick F. Swaab, and Eus J. W. Van Someren, "Cutaneous Warming Promotes Sleep Onset," *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology* 288, no. 6 (June 2005): 1589–97, https://doi.org/10.1152/ajpregu.00492.2004.

† "NIH State-of-the-Science Conference Statement on Manifestations and Management of Chronic Insomnia in Adults," *NIH Consensus and State-of-the-Science Statements* 22, no. 2 (June 2005): 1–30, https://consensus.nih.gov/2005/insomniastatement.htm.



Retrieval Practice

Review all the items on the Sleep Wellness Guide along with the details in the Sleep Wellness Beyond the Guide section. Get a clear understanding of each item, as if you were going to explain it to someone to help them improve their sleep. Take a blank piece of paper or create a blank file on your computer. Divide the document into three large columns with these three headings across the top: "During the Day," "Before Bed," "While in Bed." Put away this textbook and your notes and list as many Sleep Wellness Guide items as you can, along with details, under each heading. When you are done, open up the textbook, look at the Sleep Wellness Guide, and correct any errors on your document and add in any of the items you missed.

medications. CBTI does not have medications' harmful side effects and also has been shown to have beneficial effects extending beyond the treatment period, which is not the case with medications. One of the paradigms for CBTI involves five pillars: sleep wellness, sleep restriction, stimulus control, sleep diary, and actigraphy.

1. *Sleep wellness:* Refer to the Sleep Wellness Guide for instructions on this step.
2. *Sleep restriction:* Research shows this works better than medications and has longer-lasting effects. In general, the concept is to be in bed only when sleeping and not to spend hours lying there trying to sleep. Here are the steps:
   a. Spend only five hours in bed. Figure out what time you have to get up and count back five hours. Go to bed at the same time every night.

      Example: Do you have to get up at 7:00 a.m.? Then go to bed at 2:00 a.m.
   b. After five days, you will be very tired in the evening due to sleep deprivation, but your circadian rhythm is closer to being set, so you can go to bed fifteen minutes earlier on that fifth night.
   c. After five more days, go to bed fifteen minutes earlier, and continue with this adjustment every five days until you are going to bed around eight hours before having to wake up.

   During the program, a person may feel worse because they are so tired. Pay extra attention to light. Use dim or orange light at night and bright light in mornings.

   Be safe. Put help in place before beginning. Do not do dangerous work, drive, take care of children, or anything else that requires your full attention to do safely in the early days of the program due to the high level of sleep debt.
3. *Stimulus control:* A stimulus is something that causes a specific reaction. If you hear your phone (sound from phone = stimulus), you walk toward it (walking = response). Stimulus control involves separating sleep-related activities in the bedroom from wakeful activities in the rest of the home. For example, not watching TV, emailing in bed, or sleeping part of the night on the living room couch. Here are the instructions:
   a. If you are not sleepy, do not go to bed.
   b. If you cannot fall asleep within what feels like twenty minutes, leave the bedroom.
   c. Listen to an audiobook or do some gentle reading by a dim or blue light–filtered light in a chair or on the couch. Do not fall asleep there. When you start to fall asleep, move to your bed.
   d. Use the bed only for sleep, sex, and gentle reading or relaxing audio books.
4. *Sleep diary:* Refer to the sleep diary section in this chapter for instructions on this step. This helps pinpoint areas from the sleep wellness list that need to be addressed. For example, someone could report in their sleep diary that they were texting in bed or having a glass of wine before bed, but they did not realize those things could affect sleep.

5. *Actigraphy:* This is not necessary but can be helpful. Some clinicians use medical actigraphy devices, while laypersons might use mobile phone apps that monitor sleep. If using a phone app, temper your connection to the results and do not become fixated on the data, especially given the significant limitations of such phone apps as of the writing of this textbook. I have met people who became obsessed with their phone app sleep data to the point that it caused them anxiety and poor sleep. Also keep in mind that the movement of a sleeping partner may appear as your movement during a night's recording, depending on the placement of your device and how easily movement is translated across your mattress. Both actigraphy and sleep-related phone apps use an accelerometer to detect changes in velocity, providing a record of physical activity. The movement patterns are processed by a computer algorithm that translates those movements as a state of sleep or waking. All this is in an attempt to verify four things:
   a. *Circadian rhythmicity:* Going to bed between 9:00 and 11:00 p.m. and getting out of bed early in the morning or around midmorning. These times are part of a healthy circadian rhythm.
   b. *Consolidation:* One major block of sleep, as opposed to something like three hours at midnight and three hours in the afternoon.
   c. *Sleep schedule regularity:* Going to bed and getting out of bed at the same every day.
   d. *Napping:* When and for how long the nap is taken.

Additional Support during Pregnancy

The National Sleep Foundation's "Women and Sleep" poll in 1998 showed that 78 percent of women had more difficulty with sleep during pregnancy than any other time. Their 2007 follow-up survey indicated that the primary factors disturbing women's sleep during pregnancy were getting up to urinate; back, neck, or joint pain; leg cramps; heartburn; and/or dreams. Even with all these challenges, there is good news, because most women can mitigate pregnancy-related sleep problems by implementing strategies listed in the Sleep Wellness Guide along with the following advice. This section will address the importance of sleep during pregnancy, and how to improve sleep by addressing challenges particular to pregnancy.

There are a range of reasons pregnant women are driven to be concerned about their sleep. Kathy Lee—a University of California, San Francisco, nursing professor and specialist on pregnancy and sleep—advises pregnant women to remember that in addition to "eating for two," they are also "sleeping for two." One of her studies reported that pregnant women who get less than six hours of sleep a night have more difficult labors and are over four times more likely to need a cesarean. A study by another group, which controlled for other factors associated with preterm birth, indicated that poor sleep during pregnancy is associated with a higher incidence of preterm birth (when a baby is born too early). Scientists suggest that preterm labor and births may be related to the increase in prostaglandins found in people getting inadequate sleep.

One of the disruptions to sleep in pregnancy is snoring. Because even a small increase in weight multiplies the chance of snoring, a woman who never snored could begin snoring during pregnancy, even with the minimal weight gain required. University of Michigan researchers recommend screening and treatment for this, as they found snoring that begins during pregnancy is associated with a higher risk of developing high blood pressure during the pregnancy (gestational hypertension) and preeclampsia. Hypertensive disorders during pregnancy can have serious consequences, so we must make an effort to educate people about the importance of screening pregnant women for snoring.

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

Hāpai is Hawaiian for "pregnant." It also means "to support and carry" (figure 1.14).

Figure 1.14 Pele emerging from lava

Polls show that a small percentage of pregnant women drink alcohol before bed in hopes of improving their sleep, even though there is solid research on alcohol's damaging effects to the fetus. Additionally, as stated earlier, while alcohol induces what feels like sleep, it is not healthy, normal sleep. It is essential for women to seek support to eliminate alcohol during pregnancy and lactation due to the damaging impact of alcohol on fetal and infant development. Infant sleep is significantly disrupted by even small amounts of alcohol in breast milk. If giving up alcohol during the breastfeeding months/years is not feasible, some people use different strategies like considering the timing of alcohol consumption and "pumping and dumping" breast milk until it is clear of alcohol before nursing. Please contact a lactation consultant or health-care provider for guidance.

Strategies for healthy sleep during pregnancy begin with the list of items on the Sleep Wellness Guide combined with these additional practices: Sleeping on the side, compared to on the back, reduces lower-back strain and takes the weight of the enlarging uterus off the large blood vessels vital to baby's and mom's circulation. This also is helpful for the digestive system, freeing it from the pressure of being beneath the uterus. As often as is comfortable, sleep on the left side, which is slightly preferred as it takes the weight of the uterus off the liver, which is on the right side of the body. Left-side sleep also provides the best position for blood flow to the heart and the rest of the body. Early in the pregnancy is a time to practice building the habit of sleeping on the side. However, sleeping all night on the side, especially the same side, is not necessary and likely would cause discomfort in the hips and shoulders. Remember that while this is the optimal position theoretically, the position itself is not something for the pregnant woman to worry about. The priority is to get sleep. During the night, you may awaken to find yourself on your back, or when falling asleep, you might feel better in something other than this prescribed side-sleeping position. Get comfortable as you wish, and rest assured that your body will give you a sign when a move is in order.

Here are some suggestions for increasing your comfort when side sleeping. Lying on your side, place a pillow between your bent knees and extend that pillow to the feet (figure 1.15). The cushion between the knees squares the hip alignment, and its placement between the feet prevents the rotation of the top of the thigh bone (femur) in the hip socket. All this diminishes back strain. As the uterus increases in size, a cushion beneath the abdomen in this position is often comforting. Body-length pillows may also be a satisfying

Figure 1.15 Put a pillow between your legs

luxury. If you experience heartburn, use pillows to slightly elevate the head and shoulders in addition to following your health practitioner's general heartburn treatments.

Regarding other common pregnancy-related sleep disturbances, see, for example, previous sections on treatment for frequent nighttime urination, leg cramps, and unsettling dreams. If there are still challenges, seek out a cognitive behavioral therapy for insomnia (CBTI) practitioner. CBTI is the most effective proven technique for insomnia and does not have the risks and side effects of medications.

Family Sleep and Bed Sharing

The baby has arrived—but now, where do they sleep? Babies sleeping in the same bed with parents is normal in a vast array of cultures all over the world, yet in the US, there continues to be fervent debate (figure 1.16). Could it be our litigious society, where legal advisors caution medical groups against suggesting cosleeping on the off chance that something could go wrong, or are there legitimate safety and medical concerns? In the following discussion, the terms *family sleep*, *family bed*, *bed sharing*, and *cosleeping* will be used to refer to the practice of having a baby or child in the bed or in the immediate sleeping space of the parent.

Using research from the fields of medicine and anthropology, Dr. James McKenna, at the University of Notre Dame, provides resources to guide families in safe cosleeping practices. He emphasizes the need for an infant to be in contact with the mother's body during sleep in order to properly regulate itself, as it did when in the womb. He is also very clear that bed sharing involves much thought, discussion, and a commitment from the parent and also the additional parent—if there is one—and that bed sharing is not suitable for everyone. A misperception associated with family sleep is that the child will grow to be clingy and more dependent, but sociologists and psychologists explain the opposite to be true. When a child senses the strong emotional bond of a parent, the child more easily grows to be independent and emotionally secure. One concept behind cosleeping is that it fosters an environment where a child more confidently differentiates from the parent.

Safe family sleeping requires certain precautions and arrangements such as these:

- Infants should sleep on their back.
- The sleeping surface must be firm and not a pillow.
- The mattress should be as close to the floor as possible, preferably on the floor.
- There must be no potential for a covering, such as a blanket or sheet, to fall over their face.
- There must be no exposure to cigarette smoke or nicotine in utero or as an infant.
- There must be no stuffed animals, pillows, or sheepskins (fluffy items).
- Do not use water beds, beanbags, couches.
- There must be no gap between the mattress and frame or the mattress and wall.
- Parents must not use alcohol, drugs, or medication that may interfere with their ability to easily awaken.
- Parents with long hair need to fix it so it cannot wrap around the baby's neck.

Figure 1.16 Sleeping together

- Parents should ensure that they still experience a good night's sleep. For parents who do not feel they will sleep well with the baby in the bed, there are certified-safe cosleeping bed attachments to consider.
- Breastfeeding helps reduce death from SIDS (sudden infant death syndrome) and other diseases and is highly recommended in conjunction with cosleeping. If the baby is not sleeping with their breastfeeding parent or if the parent is extremely obese, it is safer for the baby to be on a separate surface from the parent's bed, but still adjacent to it (such as in a cosleeping bed attachment).

Social Justice and Sleep Wellness

Who has the luxury of putting these sleep wellness practices in place? Who is able to dedicate eight hours each night to sleep when we have work and family responsibilities; go to school or work somewhere we can take a nap; make time for exercise; sleep in a comfortable bed in a dark, quiet room at the desired temperature? By now, you are likely clear on the importance of good sleep and its connection to how healthy you will be, how good you feel emotionally, and even how long you will live. But due to economic injustices and lack of equity around things like race and sexual orientation, many people cannot get adequate sleep. Please consider your part in working to help yourself and everyone get better sleep by reading "Your Next Actions for Justice" and chapter 7.

Your Next Actions for Justice

Think of someone in your community who may not have the economic luxury of creating the conditions for optimal sleep. Perhaps they have to work two jobs to afford food. Look over the Sleep Wellness Guide and consider how you can meet this person where they are in terms of what is feasible for them to change in order to get better sleep. It might not be possible for them to set aside eight hours at night to sleep, but maybe there is a safe place at their work where they can take a ten-minute nap during one of their breaks if they pack a pāreu or sarong in their bag. Get creative with how you can advise those with less privilege so they can improve their sleep and have more opportunities for health and success.

2

The Sleeping Brain

Neuroanatomy, Polysomnography, and Actigraphy

Student Learning Objectives

After you read this chapter, you will be able to

- provide an introductory overview of neuroanatomy
- identify and describe functions of sleep-related brain structures
- illustrate both directions of the shift between sleep and waking states
- list the components of polysomnography (PSG)
- describe rapid eye movement (REM) sleep and non-REM (NREM) sleep
- determine sleep stages from PSG data
- construct a diagram of healthy sleep architecture for eight hours of sleep
- explain actigraphy, including its limitations compared to PSG

Introduction

Thanks in part to the availability of phone apps claiming to measure and analyze sleep, as well as an epic assortment of sleep analysis devices for the layperson to wear, we are experiencing a much-needed increase in the desire to deconstruct and explore our own sleep. To help understand the intricacies of sleep, let's first get a fundamental understanding of the brain, at least in the context of how it functions when it's awake versus sleeping. This will also be valuable in later chapters, which will make reference to assorted brain structures.

Brain Anatomy and Physiology

What molecules in your brain had to be released for you to make the decision to study this chapter? And how are you managing to hold your head up or read the words on the page? The nervous system carries signals through the body via neurons.* These signals cause activity in muscles, glands, and other neurons. Some of the neurons are in the brain and the spinal cord, which together make up the central nervous system. Others travel throughout the rest of your body and comprise the peripheral nervous system (figure 2.1). Sensory information from things we see, hear, feel, taste, or smell flows into the body and is processed by the central nervous system. After the brain has put us to sleep, it has a simple way of keeping most of that sensory information from awakening us. And while we are sleeping, the brain is actively creating the elaborate sleep architecture that carries us through the different stages and cascades necessary to secure the myriad benefits of a healthy night's sleep.

* Gordon J. Betts et al., *Anatomy and Physiology* (Houston: OpenStax, 2013), 12, available at https://openstax.org/books/anatomy-and-physiology/pages/12-introduction.

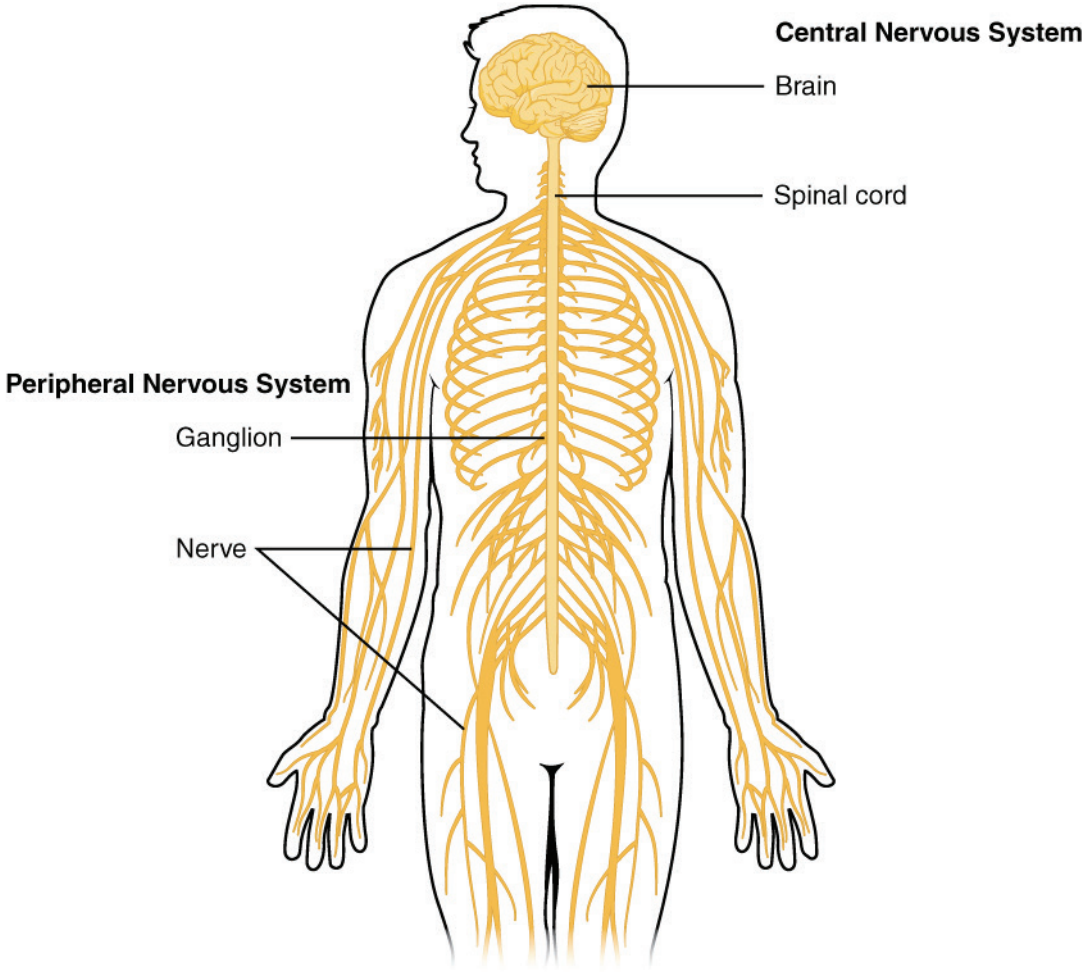


Figure 2.1 Central and peripheral nervous systems

Note to reader: A more comprehensive review of brain anatomy and physiology is beyond the scope of this book, but this chapter will provide enough context and detail to give an understanding of sleep-related brain structures and functions. For additional brain anatomy and physiology, see *The Brain from Top to Bottom*, a website developed by Bruno Dubuc, hosted by McGill University in Canada, and labeled "copyleft" as a part of their desire to encourage people to freely copy and use their site's content.*

The nervous system has two classes of cells: glial cells and neurons. Glial cells provide metabolic (metabolism = chemical reactions of the body) and physical support, while neurons carry the nervous system's signals. *Glial* comes from the Greek for "glue." Scientists chose this term when they noticed how numerous these cells were in the brain and mistakenly thought they had no purpose other than holding the neurons together. Later, it became clear that these cells are much more than brain glue and play a crucial role in preventing neurologic disorders through their sleep-related housekeeping activities. The misinformation surrounding glial cells did not end with their name. For ages, scientists believed glial cells immensely outnumbered neurons in the brain. Several studies suggested glial

* Bruno Dubuc, *The Brain from Top to Bottom* (blog), last modified May 4, 2021, https://thebrain.mcgill.ca/index.php.

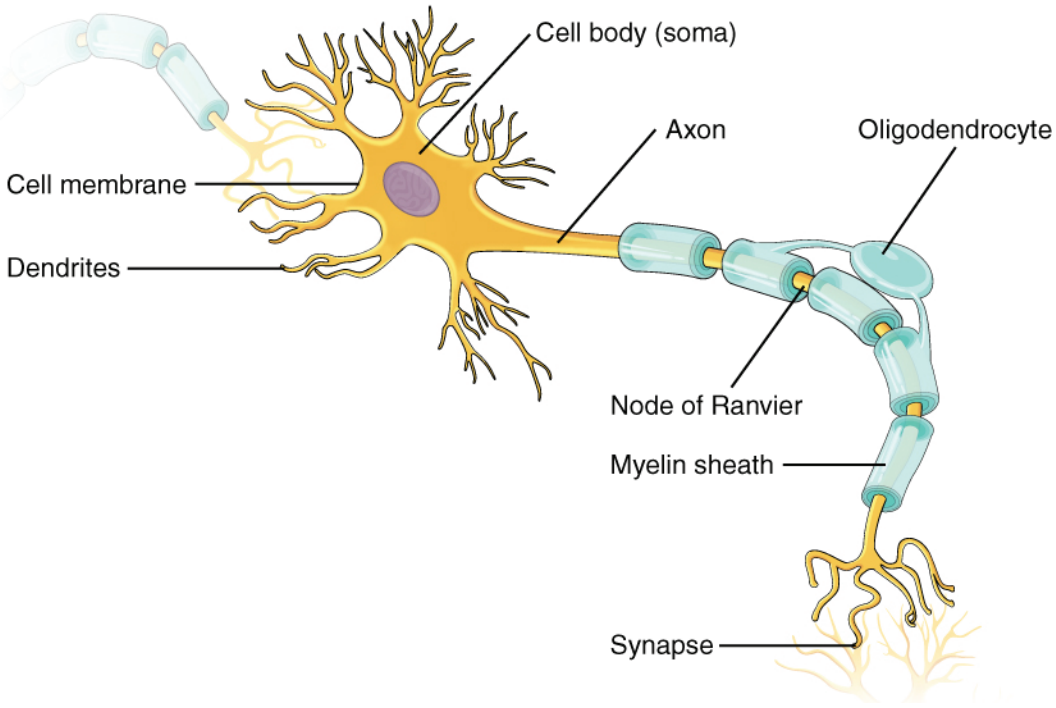


Figure 2.2 Neuron and synapse

cells were ten times more numerous than neurons. However, in 2016, researchers from the Universidade Federal do Rio de Janeiro and University of Nevada School of Medicine used a new counting method and proposed that there are actually fewer glial cells than neurons in the brain. In their paper, they also provided a history of the techniques used to count glial cells, along with a discussion of the problems with the methods used that led scientists to the wrong conclusions for so many years.* However, there are still some neuroscientists who debate this conclusion.

In contrast to glial cells, neurons use electrical activity and chemicals to carry signals throughout the body. The basic parts of a neuron are the dendrites, cell body, and axon (figure 2.2). Dendrites carry information toward the cell body. From there, the signal travels to the axon to be transmitted to a muscle, gland, or another neuron. The functional connection between the neuron and the cell of its destination is called a synapse. Here, chemicals (neurotransmitters) or sometimes charged particles (ions) move from the first cell (presynaptic) to the second cell (postsynaptic). In this way, a signal, such as one triggered from the aroma of your roommate's cooking, can make you aware of a delight to come. Meanwhile, another pathway, triggered by that same aroma, may cause you to salivate and activate your muscles to get you moving swiftly toward the kitchen so you can eat and fuel your brain for further studying.

The four major parts of the brain are the brainstem, cerebellum, diencephalon, and cerebrum (figure 2.3). The brainstem is continuous with and superior to (above) the spinal cord. Within the brainstem are the medulla oblongata, pons, and midbrain. Posterior to (behind) the brainstem is the cerebellum. The diencephalon—which includes the thalamus, hypothalamus, and epithalamus—sits on top of the brainstem. The cerebrum, the largest part of the brain, rests on top of the diencephalon.

* Christopher S. von Bartheld, Jami Bahney, and Suzana Herculano-Houzel, "The Search for True Numbers of Neurons and Glial Cells in the Human Brain: A Review of 150 Years of Cell Counting," *Journal of Comparative Neurology* 524, no. 18 (June 2016): 3865–95, https://doi.org/10.1002/cne.24040.

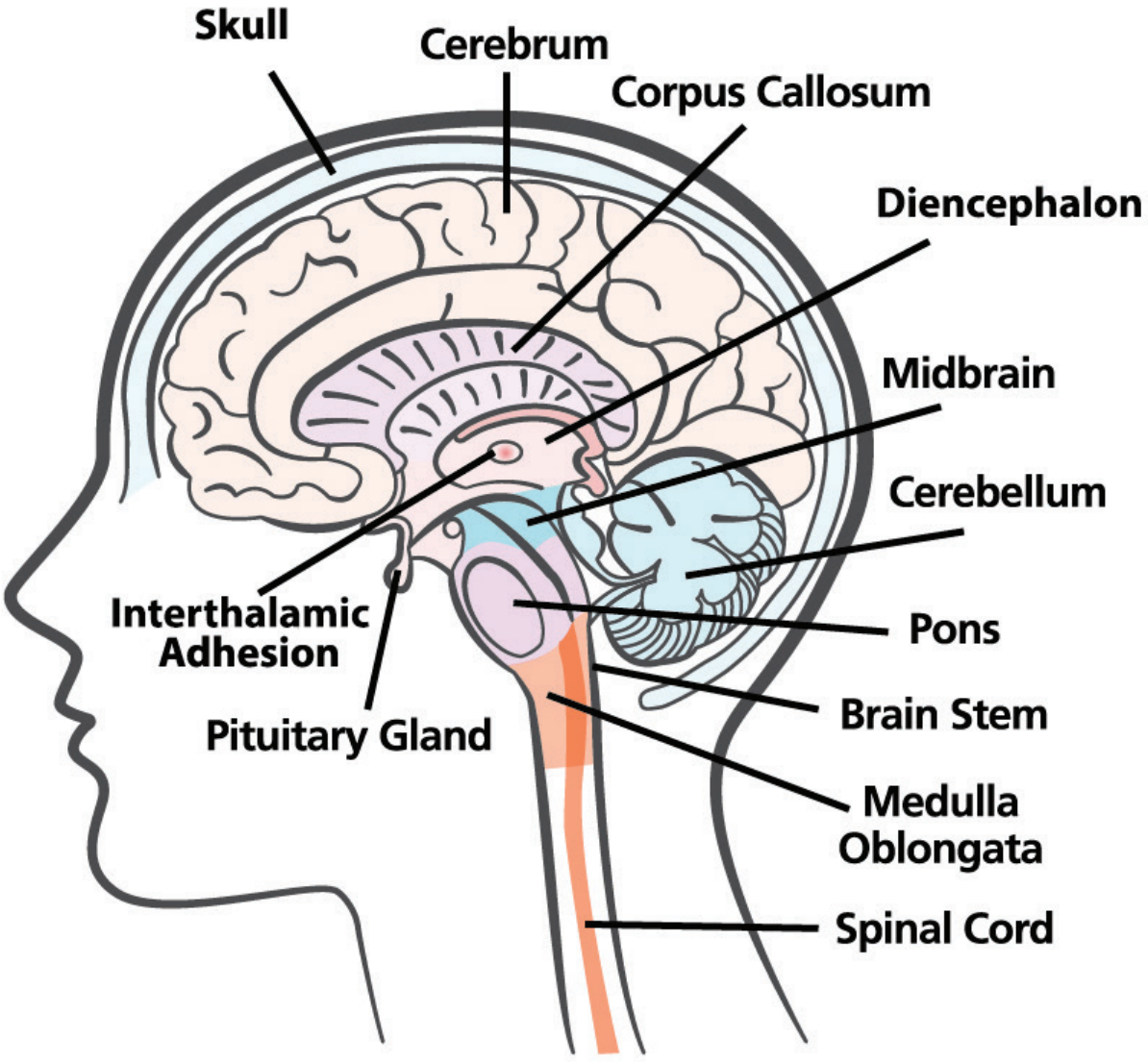


Figure 2.3 The brain

Brainstem

With groups of neurons that control breathing, heart rate, and blood vessel diameter, the brainstem coordinates movements such as swallowing, coughing, sneezing, and much more. Pathways of sensory and motor information pass through and sometimes make connections in various regions of the brainstem. The reticular activating system (RAS)—a network of connections, primarily originating in the reticular formation—contains brainstem circuits that send signals to the cerebral cortex directly and also via the thalamus to contribute to consciousness (figure 2.4). Sensory signals along this pathway keep you alert and oriented to your surroundings. The RAS is activated during awake states and is inactivated as part of initiating and maintaining sleep. However, when someone is sleeping, a strong enough sensory stimulus,

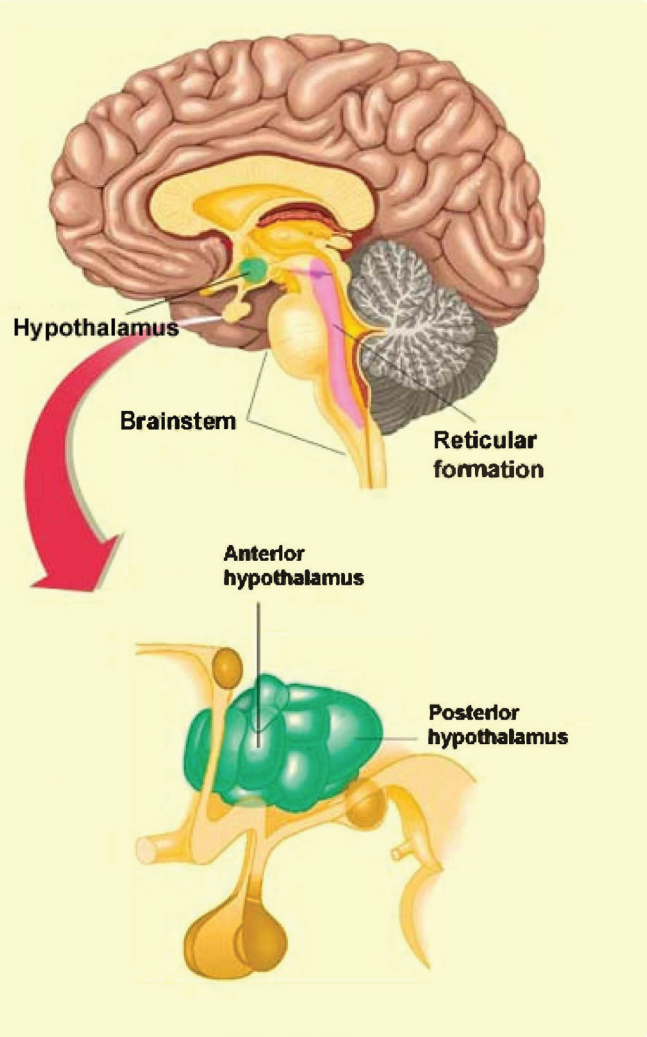


Figure 2.4 The brainstem

such as a loud noise, will awaken the person via RAS activation. People differ from one another in the threshold required to activate the RAS during sleep: thus there are "heavy" and "light" sleepers. Signals from the eyes, the ears, and most of the rest of the body (e.g., temperature, touch, pain) travel through the RAS, but odors do not. This is why smoke detectors are important in sleeping areas. A person may die inhaling smoke from a fire while they are sleeping because the smell of smoke will not travel through the RAS and awaken them. If a person is unable to hear a fire alarm, they may consider smoke detectors that utilize extremely bright flashing lights or strong pillow vibrations to activate RAS pathways and increase their chances of awakening.

Cerebellum

Although the cerebellum is only one-tenth of the weight of the brain, it contains almost half of the brain's neurons. Many of these neurons are dedicated to coordinating and optimizing movement, as well as maintaining posture and balance. While the preliminary motor signal to make a move, such as throwing a ball or saying a word, originates in the motor area of the cerebral cortex, that signal will loop into the cerebellum and back to the cerebral cortex. The benefit of the cerebellar input is that the movement will be smoother and more precise. There are also nonmotor functions of the cerebellum, such as learning and information processing, and a number of sleep-related functions. Research shows cerebral cortex and cerebellar interactions are crucial for memory consolidation, and some of these interactions occur particularly during sleep.* Cerebellar activity also changes depending on the specific stage of sleep. Scientists continue to debate the exact role of the cerebellum in sleep, but it is clear that its dysfunction can cause sleep problems. In the presence of abnormal cerebellar function due to damage or a neurologic disorder, the sleep-wake cycle can be disrupted, and sleep disorders may be present. Of interest is that clock genes—regulators of the circadian rhythm—are expressed by cerebellar cells, but their function in this region remains to be elucidated.

Diencephalon

The thalamus—the largest part of the diencephalon—is a relay station, transmitting sensory information from the spinal cord and brainstem up into the sensory areas of the cerebral cortex (figure 2.5). Additionally, by conveying information from the cerebellum and other brain structures up to the motor regions of the cerebral cortex, the

* Cathrin B. Canto et al., "The Sleeping Cerebellum," *Trends in Neurosciences*, regular ed., 40, no. 5 (May 2017): 309–23, https://doi.org/10.1016/j.tins.2017.03.001.

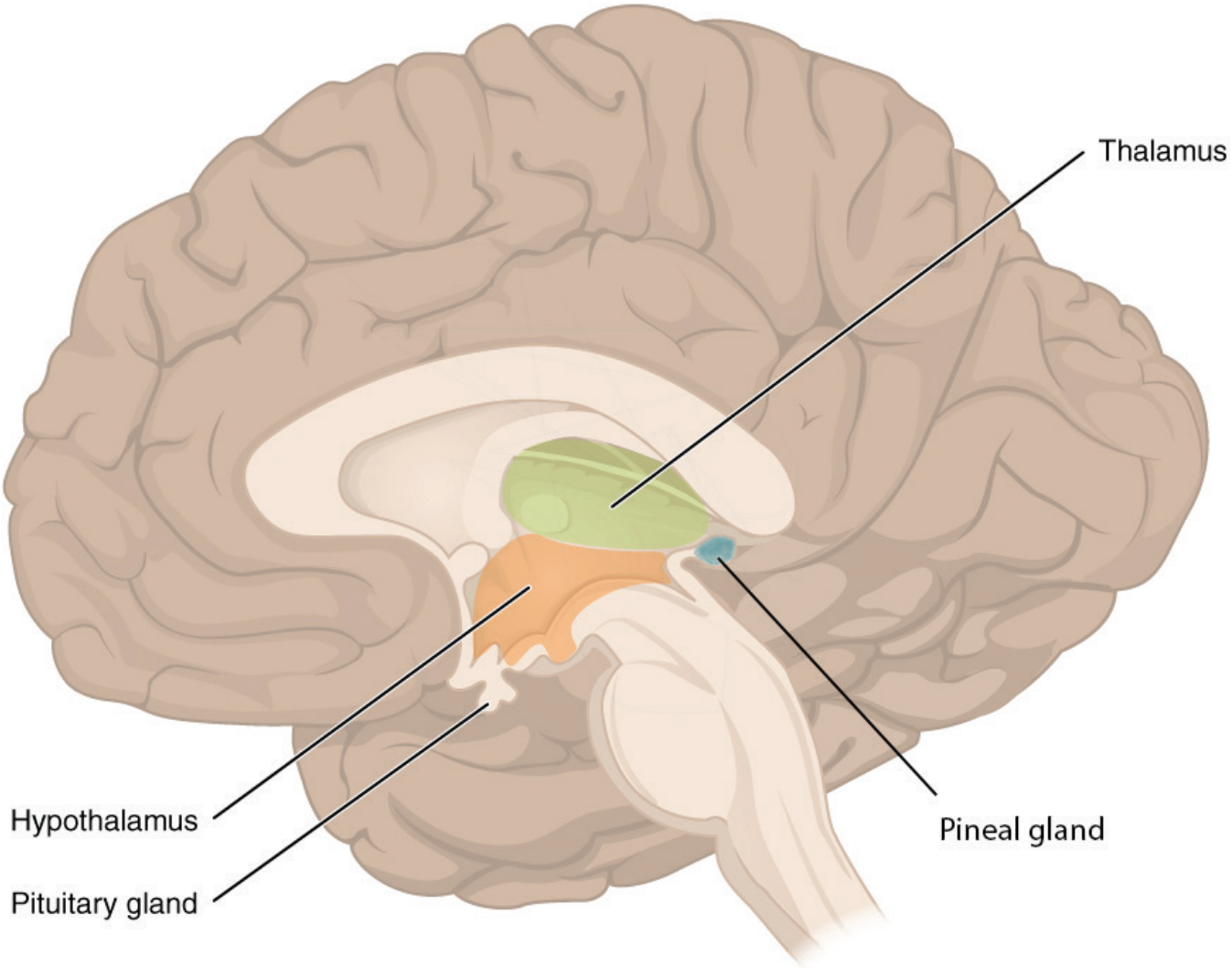


Figure 2.5 The diencephalon shown in a mid-section view of the brain

thalamus is instrumental in creating coordinated movement. There are also thalamic functions associated with learning, memory, emotions, and consciousness. This consciousness is maintained in part by the thalamus transmitting some of the RAS signals up to the cerebral cortex. In contrast, during some components of sleep, the thalamus sends oscillatory signals to a large area of the cerebral cortex, in effect interfering with the cerebrocortical reception of sensory input that would normally travel up from the RAS. Oscillatory signals in this setting refer to neuronal electrical activity that is regular and synchronized, as opposed to neuronal sensory activity while awake, which would be irregular and not synchronized in a widespread manner.

Posterior and superior to the thalamus, the epithalamus contains the habenular nuclei, which associate emotions with smells—for example, the reaction you may have to the fragrance of your ipo (Hawaiian for "sweetheart").

The other structure in the epithalamus is the pineal gland, a pea-sized structure that releases the hormone melatonin. Hormones are molecules

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

Ipo is Hawaiian for "sweetheart" (figure 2.6).

Figure 2.6 Ipo

that flow through the blood to their target structure, where they have an effect. This is the mechanism of action of the endocrine system.* Therefore, the pineal gland, though it is in the brain, is a part of the endocrine system. During the darkness of night, the pineal gland releases its highest levels of melatonin, thereby regulating the circadian rhythm (see chapter 3).

The hypothalamus (hypo = under) is made up of several nuclei with a vast array of functions. You may be familiar with the nucleus (plural, nuclei) as the part of a cell that contains the genetic material. However, in the brain, *nucleus* refers to a group of neuronal cell bodies such as those comprising the hypothalamus (figure 2.7). To get a sense of the range of functions of the hypothalamus, they include—but are not limited to—regulating body temperature, generating the feeling of being satisfied after eating, being sexually aroused, changing heart rate, and controlling the circadian rhythm.

Of the many nuclei in the hypothalamus, the suprachiasmatic nucleus (SCN) is the one that orchestrates the circadian rhythm. As covered in chapter 3, the light- and dark-dependent signals from the eyes are one of the driving forces of the SCN, which regulates the pineal gland's release of melatonin.

The posterior hypothalamus (posterior hypothalamic nucleus) is a nucleus that contributes to an elaborate network of structures involved with maintaining the awake state. One of the molecules the posterior hypothalamus releases to sustain wakefulness is histamine. This explains, in part, the drowsiness experienced when taking an antihistamine, found in many allergy medications, which blocks the effects of histamine. In fact, one of the

* Betts, Gordon J., Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix. *Anatomy and Physiology*. (Houston: OpenStax, 2013), 17, https://openstax.org/books/anatomy-and-physiology/pages/17-introduction.

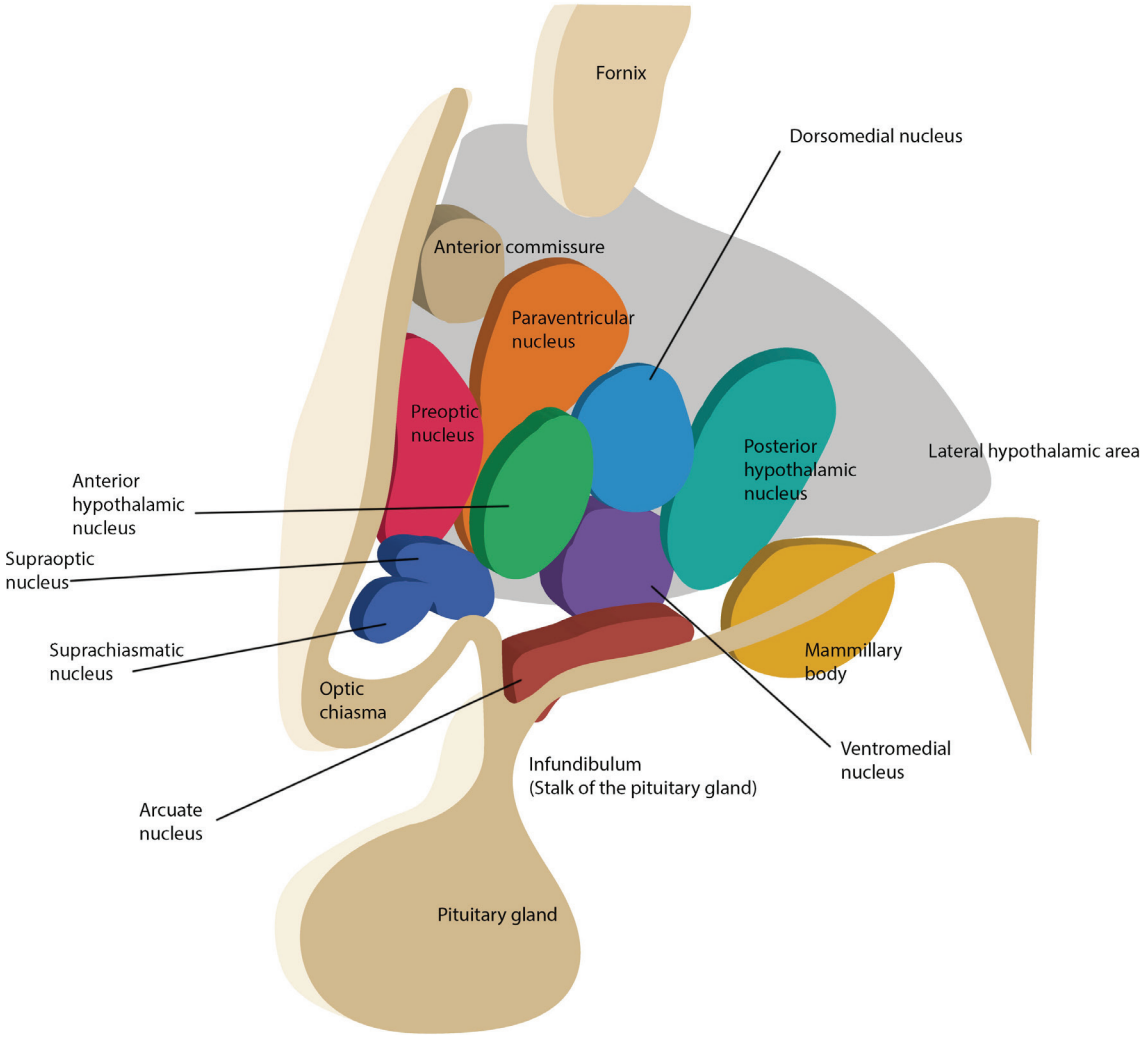


Figure 2.7 Nuclei of the hypothalamus

wake-producing pathways of caffeine is associated with activating the release of histamine from these neurons. The posterior hypothalamus also releases gamma-aminobutyric acid (GABA) to maintain wakefulness. It does this by inhibiting neurons that would normally inhibit cerebral cortex activity. If you are thinking, "That sounds like a double negative," you are correct. Think of it this way: The awake cerebral cortex is actively processing information, but that processing can be inhibited by neural pathways, thus resulting in sleep or drowsiness. But if those drowsiness-inducing pathways are inhibited by GABA from the posterior hypothalamus, then the brain will remain alert.

To understand one of the mechanisms for falling asleep, let's consider what would happen if the posterior hypothalamus, and its wake-promoting effects, were inhibited. Since one of the posterior hypothalamus' roles is to facilitate the transmission of information up to the cerebral cortex, then inhibiting the posterior hypothalamus would support sleep onset by reducing cerebrocortex information processing. The *anterior* hypothalamus (anterior hypothalamic nucleus) pulls this off via GABA. When the anterior hypothalamus is activated by the neurotransmitter serotonin, and if the timing is right in terms of circadian rhythm, the posterior hypothalamus is inhibited by the anterior hypothalamus, helping bring about the sleep state. The RAS is also inhibited from the anterior hypothalamus' GABA activity, further reducing the likelihood that sensory information will have alerting effects on the cerebral cortex. Now the brain can fall asleep, mostly uninterrupted from the outside experience.

Ready to Move On?

Before moving on, explain how the brain puts you to sleep. Address the roles of the anterior hypothalamus, posterior hypothalamus, reticular activating system (RAS), histamine, serotonin, and GABA. Combine this explanation with a rough sketch of the brain structures involved as well as arrows showing the flow of molecules (histamine, etc.).

Cerebrum

Singing a song, writing a story, playing a sport, and planning the day are made possible by our cerebrum. It is divided in half, with discrete regions that connect the left and right hemispheres. Deep inside the cerebrum are structures associated with an array of functions including memory, emotions, and motor control. The more superficial neurons of the cerebrum comprise the cerebral cortex, which is divided into four lobes: frontal, parietal, occipital, and temporal (figure 2.8). The insula is another section of the cerebral cortex but is best visualized by creating a space between the meeting of the frontal and temporal lobes (figure 2.9).

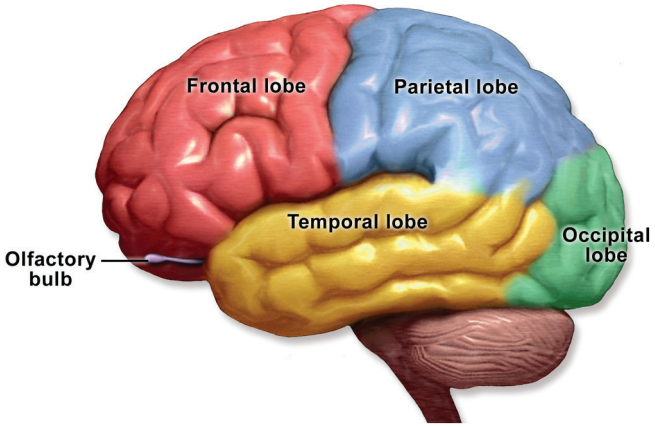


Figure 2.8 Lobes of the human brain

The frontal lobe contains areas for motor control, speech generation, odor identification, reasoning, personality, judgment, understanding consequences, learning complicated concepts, and more.

The parietal lobe receives sensory information, such as touch, temperature, pain, and itch. It also associates sensory data with other information, enabling you to identify a previously encountered item, such as your favorite fruit, entirely by touch. Part of the ability to understand language is also in the parietal lobe.

The occipital lobe processes visual information, including giving meaning to images. For example,

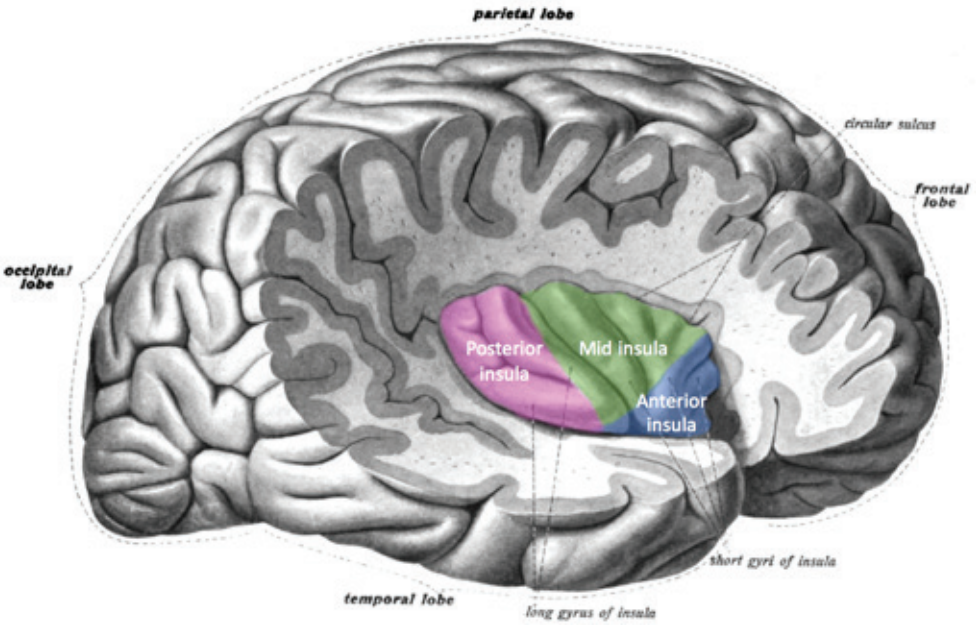


Figure 2.9 The insula

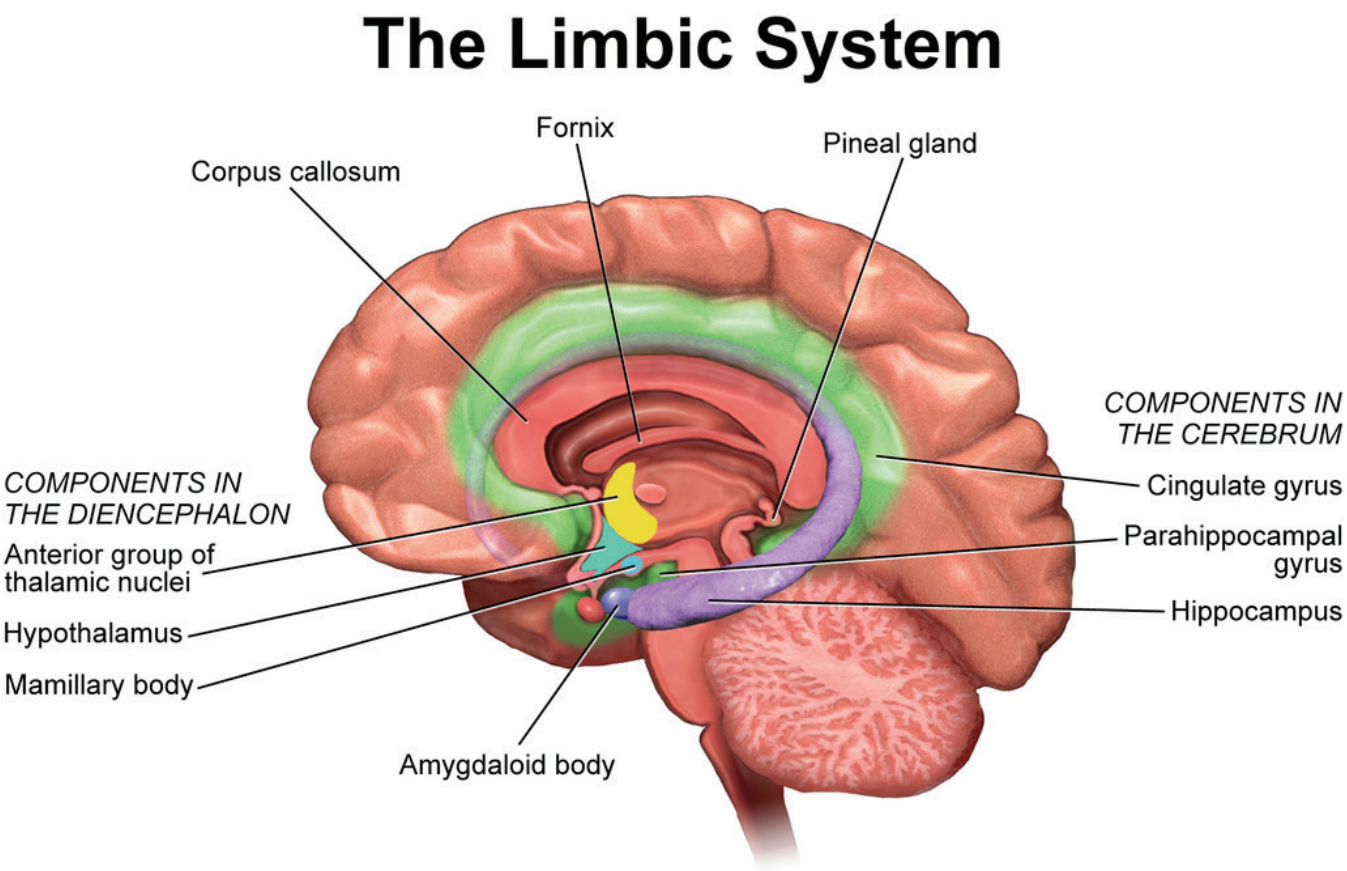


Figure 2.10 The limbic system

image shapes coming from the eyes are combined in the occipital lobe in a manner that allows you to recognize your shoes solely by looking at them.

The temporal lobe receives and processes sounds and has areas for recognizing faces and perceiving smells.

The insula, previously one of the least understood brain regions, is now known to process taste, smell, sound, visceral and body surface sensations, and emotional responses such as empathy.

The limbic system includes part of the cerebral cortex and contains groups of neuronal cell bodies and pathways that interconnect cerebral cortex regions and other brain structures (figure 2.10). It creates emotions such as pleasure, anger, and rage while also sparking drives for hunger and sex. The hippocampus, a vital structure for memory, is in the limbic system. The hippocampus has received more attention in recent decades because studies have suggested that the adult hippocampus produces new neurons, something previously deemed impossible anywhere in the adult brain. However, with further research, neuroscientists began questioning the existence of hippocampal neurogenesis. The debate has continued, with 2019 research swinging the view back in favor of neurogenesis in adult humans up to ninety years of age.*

In later chapters, we will revisit assorted aspects of brain anatomy, such as when learning about the creation and qualities of different types of dreams or how dreams can help us heal from trauma. For now, our discussion of brain activity will turn to how its characteristics are used to classify different waking and sleep states.

* Elena P. Moreno-Jiménez et al., "Adult Hippocampal Neurogenesis Is Abundant in Neurologically Healthy Subjects and Drops Sharply in Patients with Alzheimer's Disease," *Nature Medicine* 25, no. 4 (March 2019): 554–60, https://doi.org/10.1038/s41591-019-0375-9.

Figure 2.11 Polysomnogram

Polysomnogram

The polysomnogram (PSG) is the scientific tool for verifying sleep and is also used clinically to analyze sleep for disorders. While phone apps and actigraphy (see Actigraphy section) are commonly used to report sleep data of varying value, the scientific community has agreed to physiologically define sleep in humans as a set of stereotypical electrical signals from the brain, eyes, and skeletal muscles. Together, these three measurements—electroencephalogram, electrooculogram, and electromyogram—comprise the polysomnogram (poly = many, somno = sleep, gram = recording; figure 2.11).

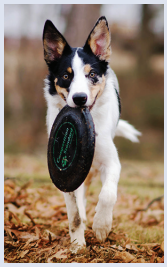
Electroencephalogram

During an electroencephalogram (EEG; electro = electricity, en = inside, cephalo = head, gram = recording), electrical activity in the brain travels through the skull and skin and can be detected by pasting tiny electrodes to the scalp (figure 2.12). Viewing the voltage changes across time gives an indication of sleep onset and offset as well as the stage of sleep (such as REM or NREM, covered in the following section). The voltage change is

Figure 2.12 Baby connected to EEG

measured vertically along the *y* axis, and the time change is measured horizontally along the *x* axis. This axis orientation is typical for all three types of polysomnogram recordings (electroencephalogram, electrooculogram, and electromyogram), but the scale on the *y* axis may vary.

The PSG electrical wave characteristics are amplitude, frequency, and morphology (figure 2.13). Wave amplitude is exactly what it sounds like: the size of the wave—a *y* axis measurement of voltage. Frequency describes how fast the waves are coming, so will be measured by looking along the *x* axis, at timing (figure 2.14). The units for frequency are measured in hertz, also known as "cycles per second," with a cycle being an entire wave. So this refers to how many whole waves are arriving every second. (The term *hertz* [Hz] was named after a person who studied electromagnetic waves.) Morphology (morph = form) is a way to look along the recording for unique shapes, such as a sleep spindle or K-complex, which are discussed in relation to



Retrieval Practice

Put away the book and all your notes. Make some very rough sketches of the brain, including all the parts covered in this chapter. This will take more than one sketch because some of the regions are on the outer areas and some are deep inside the brain. For example, one sketch should show the major lobes of the cerebral cortex (outer regions), while another sketch should show the details of the diencephalon (deep regions), and there will be additional sketches as well. After you have sketched as many parts as you can recall, add arrows with words describing the functions of each of the regions. Take a moment to congratulate yourself for all you were able to create, and then go back to the chapter and add in any missing structures and functions on your sketches while also correcting any of your errors. You may find you need to make additional sketches to include all the structures you find on that second pass through the chapter.

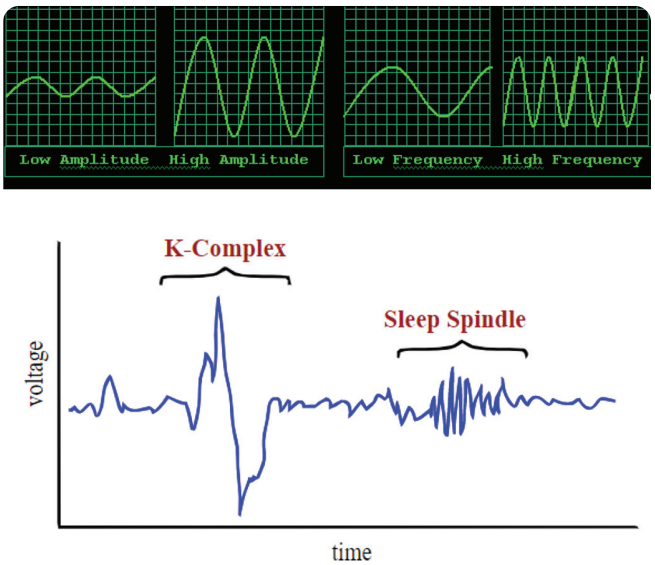


Figure 2.13 Wave amplitude and frequency as well as a K-complex and sleep spindle

Figure 2.14 Waves in Hawai'i

Figure 2.15 Riding the perfect wave

NREM 2 in the Sleep Stages section (figure 2.15). Different physiological states, such as sleeping or thinking, can be identified by EEG (figure 2.16).

Beta: awake, alert, thinking; 14–40 Hz

Alpha: awake, resting the mind, eyes closed; 8–13 Hz

Theta: drowsiness, daydreaming, sleep; 4–7 Hz

Delta: sleep; 1–4 Hz

Electrooculogram

Different parts of the sleep cycle have particular eye movements that can be recorded by pasting electrodes on the skin beyond the outer corner of

What happens when we're asleep?

In the Brain

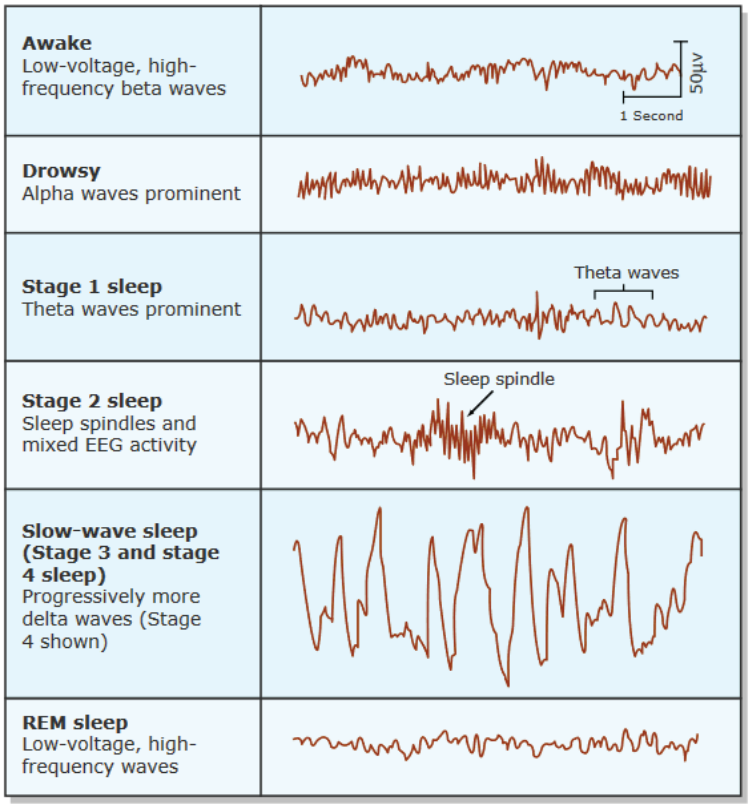


Image by MIT OpenCourseWare.

Figure 2.16 EEG recordings

each eye for an electrooculogram (EOG; electro = electricity, oculo = eye, gram = recording). The anterior (front) region of the eyeball is positively charged compared to its posterior (back) region. This charge difference is utilized to generate a voltage trace for each eye, indicating if the eye is moved toward or away from the electrode, as well as the speed and size of the movements (figure 2.17).

Electromyogram

Body movement during sleep can be categorized to determine sleep stages. Electrodes are typically placed below the chin and on the leg for an electromyogram (EMG; electro = electricity, myo = muscle, gram = recording). If you are sitting up reading this chapter and start to fall asleep, your head would fall slightly forward because the postural muscles below the chin relax. This change in muscle tone is picked up by an EMG. During a night's sleep, it is normal to change position, twitch, and even have periods of paralysis. The EMG displays the type and timing of this movement (or lack of movement) so that data can be combined with the EOG and EEG to provide details about a person's sleep.

Additional Clinical Measures

The EEG, EOG, and EMG are useful in research, but a clinical sleep study relies on additional physiological data. The sleep technician will connect the patient to devices to measure heart activity (electrocardiograph), blood oxygen (pulse oximeter), breathing effort (chest and abdominal expansion measurement instruments), and breath movement at the mouth and nose (oral/nasal airflow sensors). See the Apnea section of chapter 6 for a further discussion of these clinical measures.

Your Next Actions for Justice

Who can afford a clinical sleep study? Polysomnography and its interpretation require dedicated resources, but there is an enormous return on investment. Most importantly, a clinical sleep study could save your life, especially if you have something like sleep apnea, discussed in chapter 6. From a business standpoint, making these studies accessible could save insurance companies and taxpayers money. We know poor sleep can cause diabetes, cardiovascular disease, neurologic disorders, and more. These are expensive diseases that can require decades of treatment for each patient. If a clinical sleep study determines there is a sleep disorder and it is treated, that patient will reduce their odds of getting other diseases that could cost insurance companies and taxpayers more money than treating a sleep disorder. Since clinical sleep studies make sense in terms of saving lives and dollars, thankfully insurance usually covers them. However, lack of access to affordable insurance can be an obstacle for someone who needs one of these studies. In your community, where can someone go for medical care if they do not have health insurance? Your homework is to check the internet and ask around to find out what open-access resources are available for health care in your neighborhood? Make a note on your phone or on a piece of paper in your wallet so if you are sharing sleep wellness information with someone who cannot afford medical care, you can tell them where to find it in your area. In Hawai'i, we have Waikīkī Health,* which provides medical services to everyone, regardless of their ability to pay.

* "Waikiki Health," accessed on December 3, 2021, https://waikikihc.org/.

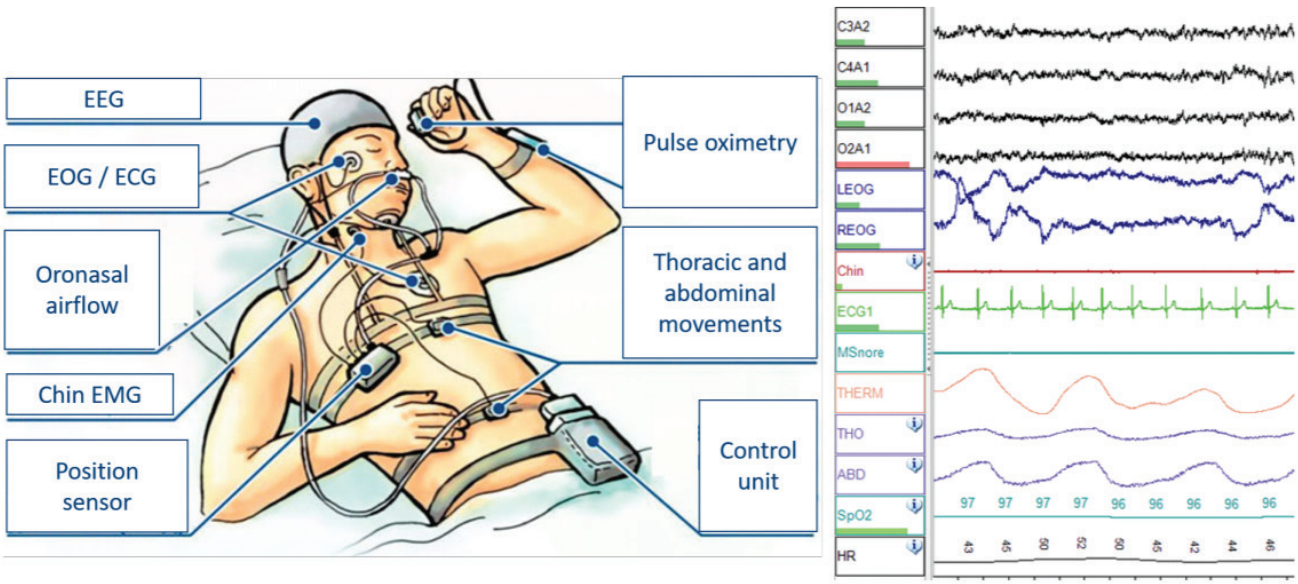


Figure 2.17 Polysomnography set-up and data

Sleep Stages: REM Sleep and Non-REM Sleep

Sleep is divided into five major stages, each with an assortment of characteristics that distinguishes one stage from the other. However, they are named simply in reference to the presence or absence of rapid eye movement (REM). Curiously, REM sleep has only brief periods of rapid eye movement, but that name has persisted through the decades. Non-REM (NREM) sleep is further divided into four stages: NREM 1, 2, 3, and 4. Each of the five sleep stages occurs and repeats during different parts of a night's sleep, comprising the full sleep cycle. The order, timing, and duration of the stages are referred to as sleep architecture. We will see that the brain has quite a job to do if it is to build a healthy night's sleep according to the sleep architectural blueprint, which has been perfected over millennia.

REM Sleep

During REM sleep, we have vivid and emotional dreams while the body is paralyzed and not apparently regulating several physiological functions such as body temperature, heart rate, and blood pressure. REM sleep is composed of phasic and tonic components. Phasic REM sleep is easily recognized due to the "phases" when the eyes are darting back and forth. Tonic REM sleep, while still considered REM sleep, does not have eye movements but has similar brain activity to phasic REM sleep. Unless otherwise noted, in this textbook, REM will refer to REM in general without differentiating between phasic or tonic.

The purpose of those rapid eye movements may surprise you, especially if, like many others, you assumed the movements were associated with dream content (which they are not). Research by a Columbia University ocular physiologist suggests that rapid eye movement during sleep may be a way to keep the aqueous humor in the eyeball swirling in order to transport oxygen from the blood vessels of the iris to the cornea, which lacks blood vessels.* During sleep, if the eyes did not move, the lack of aqueous fluid movement could result in corneal suffocation and cell death. When a person is awake, with the eyes open, there is a temperature difference on either side of the cornea that creates convection currents, causing the aqueous humor to move and transport the oxygen (figure 2.18). The story gets more interesting when we try to understand why periods of REM sleep get longer throughout the night. The Columbia researcher's group theorized that this lengthening of the REM sleep periods is necessary for oxygen transport, as the cumulative time (NREM + REM) the closed eye remains motionless increases from the first to the last hour of sleep.

Looking at the EEG of a person in REM sleep may lead you to believe they are awake because the electrical activity is asynchronous—it looks messy. This asynchronous activity is typical of the waking state, when the brain is processing myriad sensory input and thoughts.

The flaccid paralysis of skeletal muscles during REM sleep leaves the person motionless except for breathing, rapid eye movement, and the occasional twitch, perhaps in a leg, finger, or facial muscle. There are also tiny skeletal muscles in the middle ear—providing protection from loud noises—that

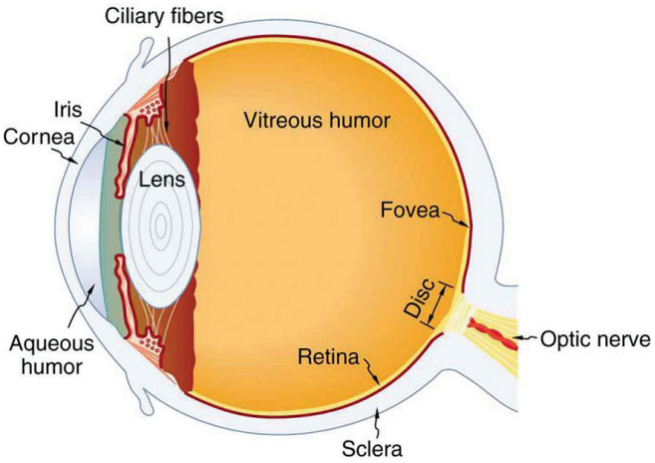


Figure 2.18 The eye

* "New Research Suggests REM Is about Eyes Not Dreams," Columbia University Irving Medical Center, Columbia, accessed May 5, 2021, https://www.cuimc.columbia.edu/news/new-research-suggests-rem-about-eyes-not-dreams.

are not paralyzed during REM sleep, but this is certainly not observable to the casual viewer. Figure 2.19 shows the EEG, EOG, and EMG of the waking state and different stages of sleep: S1 (NREM 1), S2 (NREM 2), SWS (slow-wave sleep; NREM 3 and NREM 4), and REM.

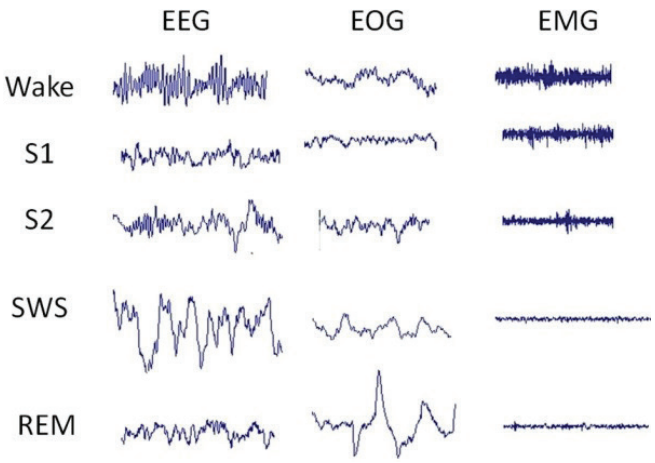


Figure 2.19 EEG, EOG, and EMG

NREM Sleep

NREM 1 is how you enter sleep and is a light stage of sleep. Light sleep means a person is easily awakened. Many of us have been on one end of this experience: You wake up your friend, who is obviously sleeping, and you thoughtfully mention, "Sorry to wake you, but—" and they interrupt, "I was not sleeping!" and look at you like you said something ludicrous. If your friend happened to be hooked up to PSG, you would be able to show them they were in fact asleep. They may report they could not have been asleep because they were thinking about something, although usually something quite mundane. These "thoughts" are in fact the dull dreams of NREM 1. Another experience of NREM 1 can be when we lie down to sleep, and after a few moments, wonder why we were thinking something slightly absurd or illogical. We likely fell into NREM 1, easily awakened with no impression of being asleep, and then recalled the NREM 1 dream as a "thought."

Here are some more facts about NREM 1 sleep:

- The EEG of NREM 1 is characterized by theta activity, with its lower frequency compared to the awake state.
- Although you may freak out your roommate by staring at them while they fall asleep (the sleep scientist's folly), you can note when they drift into NREM 1 as their closed eyes have easily observed slow rolling movements.
- Occasionally, we see someone lying down, gently readjusting their position, and we conclude they are not sleeping. We may say something to them, to find they startle a bit and ask why we awakened them. These seemingly wakeful movements are normal in NREM 1 and are seen in the EMG. This stage can also include hypnic jerks, where the entire body or body parts have a large twitch, and there is often a sensation of falling. There is speculation that hypnic jerks are a vestigial response that prevented our ancestors who slept in trees from falling to the ground.

The term *light sleep* often refers to NREM 1 and NREM 2, but NREM 2 sleep, where you will spend almost half of your night, is more difficult to awaken from than in NREM 1. This is when things in the body start to slow down:

- The unique EEG morphology—sleep spindles and K-complexes—of NREM 2 makes it easy to differentiate this stage of sleep from the others (figure 2.20). Sleep spindles may be associated with learning, and transferring information

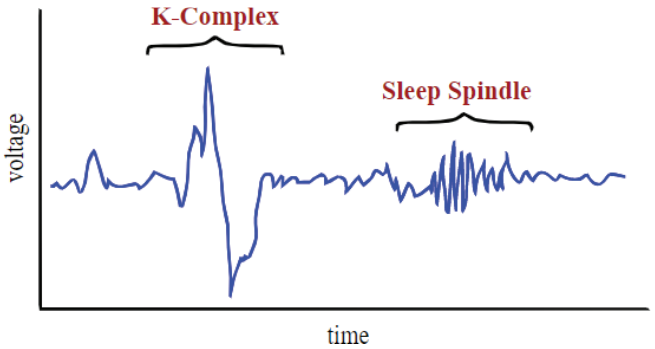


Figure 2.20 NREM 2 EEG

from short-to-long-term memory. K-complexes are generated in response to a stimulus, such as touch or sound, and may help us stay asleep during those potential disruptions.
- The eyes do not have any noticeable movements during NREM 2.
- There may still be some body movements during NREM 2, such as shifting position.

NREM 3 and NREM 4 together are often referred to as "deep sleep" because awakening from these stages is difficult and results in a fierce feeling of grogginess.

- The EEGs for NREM 3 and NREM 4 both contain large amplitude, slow waves—delta waves—giving both of these sleep stages the name "slow-wave sleep." NREM 4 consists almost entirely of these slow waves, while NREM 3 has intermittent periods of the slow waves. Because this percentage of slow-wave sleep is the most noticeable difference between NREM 3 and NREM 4, many scientists have abandoned use of *NREM 4*, stating that NREM has only three stages, 1, 2, and 3. For simplicity and clarity in this text, we will use slow-wave sleep (SWS) to refer to NREM 3 and NREM 4 collectively, collapsing NREM 4 into NREM 3 when discussing the NREM stages.
- The eyes do not have any noticeable movements during SWS.
- Some body movement may occur during SWS, but it is minimal.

Some researchers debated the use of the word *deep* when referring to slow-wave sleep, so occasionally an article may seem contradictory to the convention. Which would you consider deep sleep: SWS, during which the body may be moving slightly and is still regulating many of its physiological functions, such as temperature and blood pressure, or REM sleep, when the body is paralyzed and not highly regulating some physiological functions, such as temperature and blood pressure? Ultimately, most have landed on considering SWS deep sleep due to the synchronous slow-wave brain activity and the difficulty of awakening a person from this stage, compared to the asynchronous brain activity of REM sleep and the relative ease of awakening from REM sleep.

Sleep Architecture

Sleep architecture is the timing and order of each of the sleep stages: REM and NREM 1, 2, and 3. Your brain and body are building something complex while you are lying there, and even something seemingly minor like a glass of wine shortly before bed is enough to disrupt your brain's ability to create all the elements of sleep. Alcohol, a central nervous system depressant, is one of the many substances that can prevent the brain from generating some of the sleep stages, such as REM, and can wreak havoc on the body's ability to organize the stages in a manner necessary to receive the benefits of a healthy night's sleep.

Sleep begins with NREM 1 and then moves through NREM 2 and 3 before going into the first period of REM, and this completes the first sleep cycle. On the way from NREM 3 to that first REM period, there may be some time in NREM 2 and 1. This first cycle takes about ninety minutes and will repeat throughout the night around five times, resulting in around 7.5 hours of sleep (consider

Retrieval Practice

After viewing the sleep architecture figure and studying the discussion of how sleep stages progress through the night, set aside the content and do not let yourself look at it. On a piece of paper or using your computer, create a rough sleep architecture sketch of an eight-hour night's sleep. Then open up the book and your notes and make corrections to your drawing.

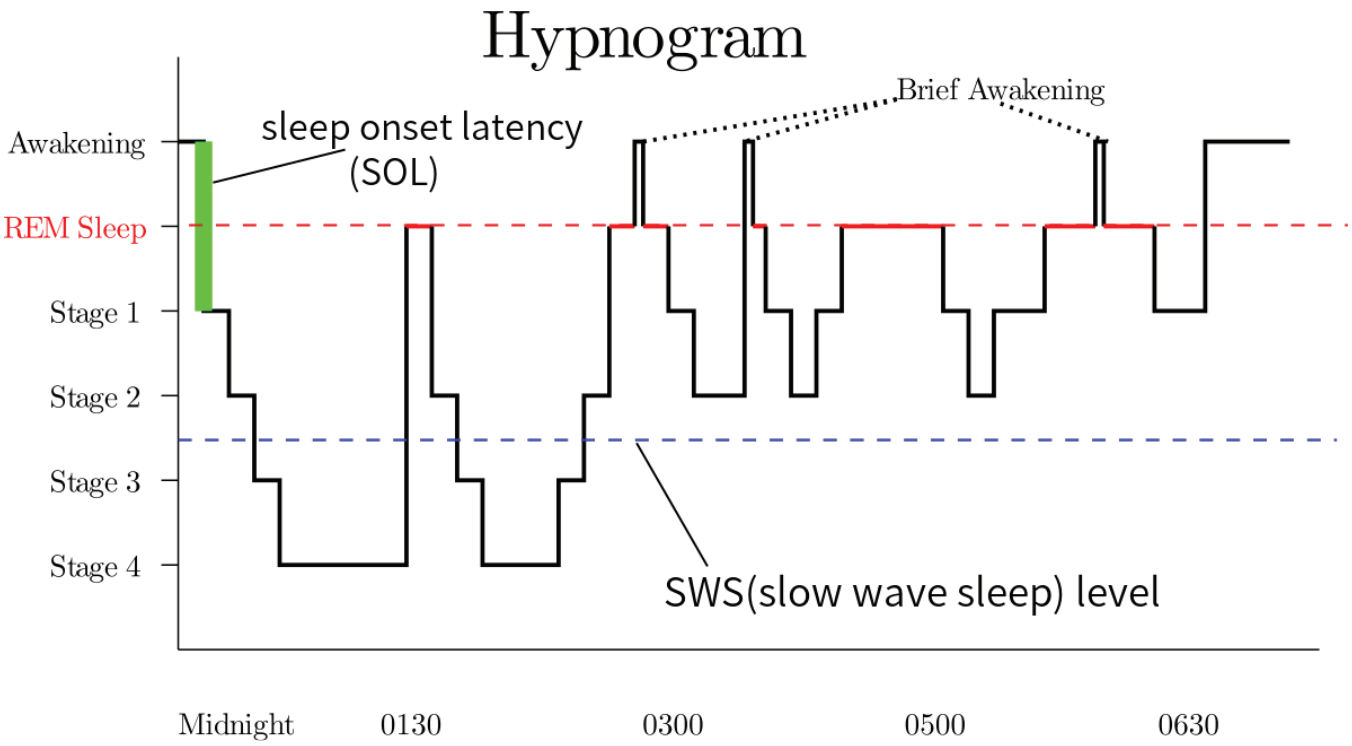


Figure 2.21 Hypnogram of sleep between midnight and 6:30 am

doing that math to convince yourself it makes sense). The hypnogram in figure 2.21 shows sleep architecture. Around midnight, this person took a few minutes to fall asleep (sleep-onset latency), went into NREM 1 (stage 1), and then went through each of the night's sleep cycles before ultimately awakening fully at 6:30 a.m.

Within each ninety-minute cycle, as it repeats during the night, REM increases and NREM 3 and 4 decrease. Another way to think of this is that during the beginning of the night, you are getting more NREM 3 and 4, and during the last part of the night, you are getting more REM. Putting it all together, we also see that almost half the night is spent in NREM 2. (Note how the example hypnogram differentiates between NREM 3 and NREM 4 [as stages 3 and 4], while in this textbook, those two stages are typically merged into NREM 3.)

Actigraphy

Cell phones contain a tiny instrument, an accelerometer, that changes the view on the phone display—the screen rotation—depending on how the phone is being held. In general, an accelerometer detects a change in the speed, direction, and size of a movement. Actigraphy utilizes accelerometers in small, watch-like devices to record a person's physical activity, and consequently, in combination with computer algorithms, can be used to examine sleep in clinical and research studies (figure 2.22).

The idea behind actigraphy is that during long enough periods of inactivity, a person must be sleeping, so that period would be labeled as sleep. Usually, the device will have a button that can be pressed when the person goes to bed and awakens. That context is helpful because sitting for two hours watching television could also seem a lot like sleep to an accelerometer. Polysomnography, with the three physiological measures of EEG, EOG, and EMG, has been used to validate actigraphy. However, it is important to understand actigraphy's limitations. In actigraphy, we are using a device to measure movements and then making a leap utilizing computer programming to label different periods as sleep, while PSG is measuring the actual elements (EEG, EOG, and EMG) used in defining sleep.

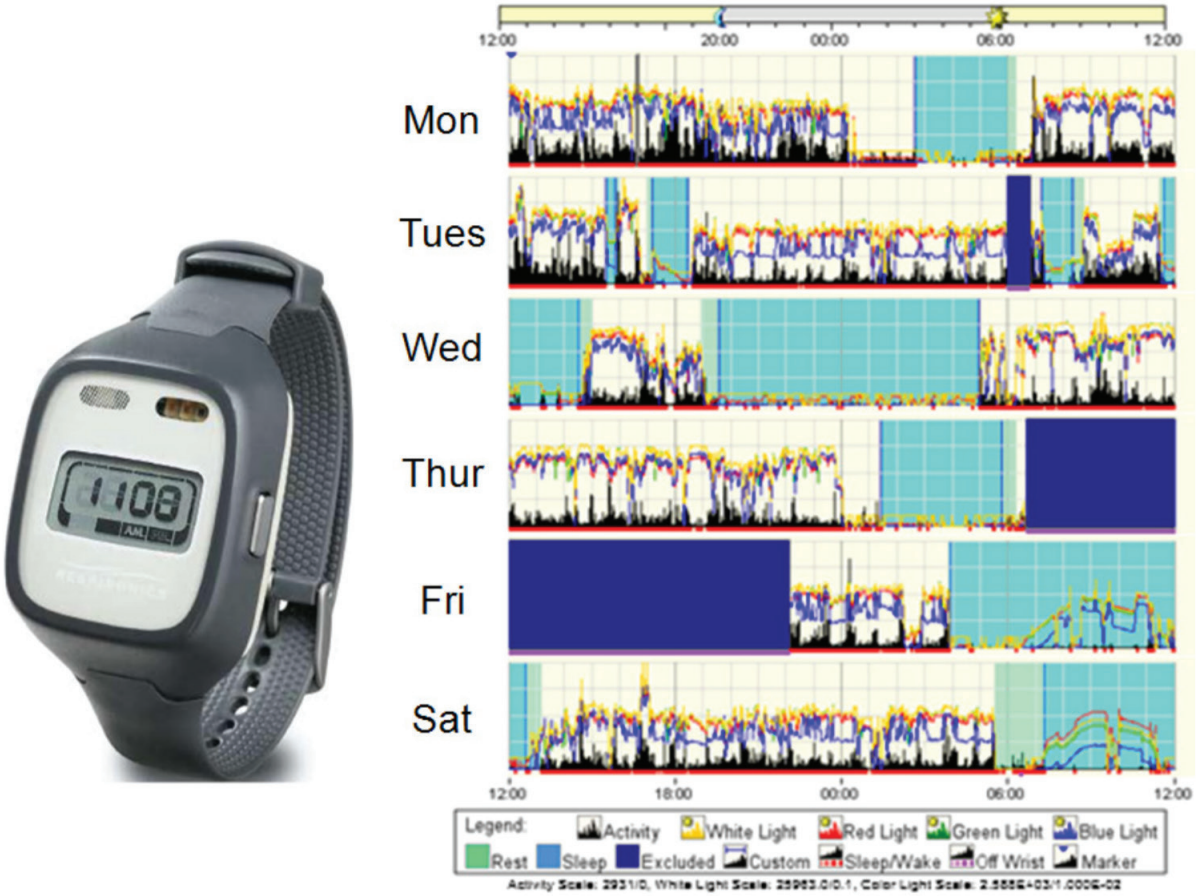


Figure 2.22 Actigraphy device and data from a college student

The different measures and derivatives from actigraphy are as follows:

Sleep latency: how long it takes to fall asleep

Wake after sleep onset (WASO): how much time, after falling asleep, was spent awake

Total sleep time: from sleep onset to final awakening, with WASO subtracted

Sleep efficiency: total sleep time divided by the total time between sleep onset and final awakening; often referred to as sleep quality

Sleep latency should be at least fifteen minutes, as discussed in chapter 1, but certainly, much beyond that can begin to be frustrating. Sleep efficiency should be between 85–95 percent. To make this relatable, imagine that during the eight hours between falling asleep and waking up in the morning, you were awake for a few minutes enough times in the night that it added up to one hour of being awake (one hour of WASO). That would equate to seven hours of sleep during that eight-hour period. Dividing seven by eight gives a healthy sleep efficiency of 88 percent. Upon seeing their actigraphy data for the first time, many of my sleep science lab students are shocked by how many times they woke up during the night and even more surprised that it is considered normal and healthy. We are rarely aware of any of these awakenings.

What about a sleep efficiency of 100 percent—and why is that not included in the healthy range? With normal sleep architecture and a reasonable amount of sleep debt, a person would still occasionally awaken, as noted previously. However, if a person has a sleep disorder or an extreme amount of sleep debt, they may not awaken at all during their night's sleep and have a sleep efficiency close to 100 percent.

3

Circadian Rhythm

Student Learning Objectives

After you read this chapter, you will be able to

- explain the difference between circadian rhythm and sleep pressure
- illustrate the actions of structures and molecules that generate the circadian rhythm
- describe the effects of light, shift work, jet lag, and caffeine on the circadian rhythm
- compare polyphasic sleep with biphasic sleep

Introduction

Why are you lying awake, staring at the ceiling? It's 10:00 a.m. and you stayed up all night to study for an exam, arrived at your early morning class thinking about nothing more than how quickly you could get back to your bed, completed the exam in spite of the occasional head bob, then rushed home to at last jump into bed (figure 3.1). Yet there you are, not only having flashbacks from the exam pages but also criticizing yourself for something silly you said to your crush as you were leaving the classroom. In other words . . . you are wide awake! You can thank your circadian rhythm.

Circadian Rhythm and Sleep Pressure Don't Always Agree

There are brain cells that drive your body to go through an activity cycle that is roughly twenty-four hours in duration. The cycle is your circadian rhythm, and those brain cells are like a clock inside your body. Almost every creature on earth has a similar cycle; even plants and insects exhibit these rhythms.

The 2017 Nobel Prize was awarded to researchers who figured out how genes in the fruit fly create a rhythm of cell activity that is approximately twenty-four hours. They also clarified how similar mechanisms are utilized in human cells to create our biological clock. The internal clock provides the daily timing for sleep, body temperature, blood pressure, mental clarity, bowel movements, hormones, athletic performance, and more (figure 3.2). And while light and dark have a significant impact on this circadian rhythm, the cycle

Figure 3.1 Nodding off

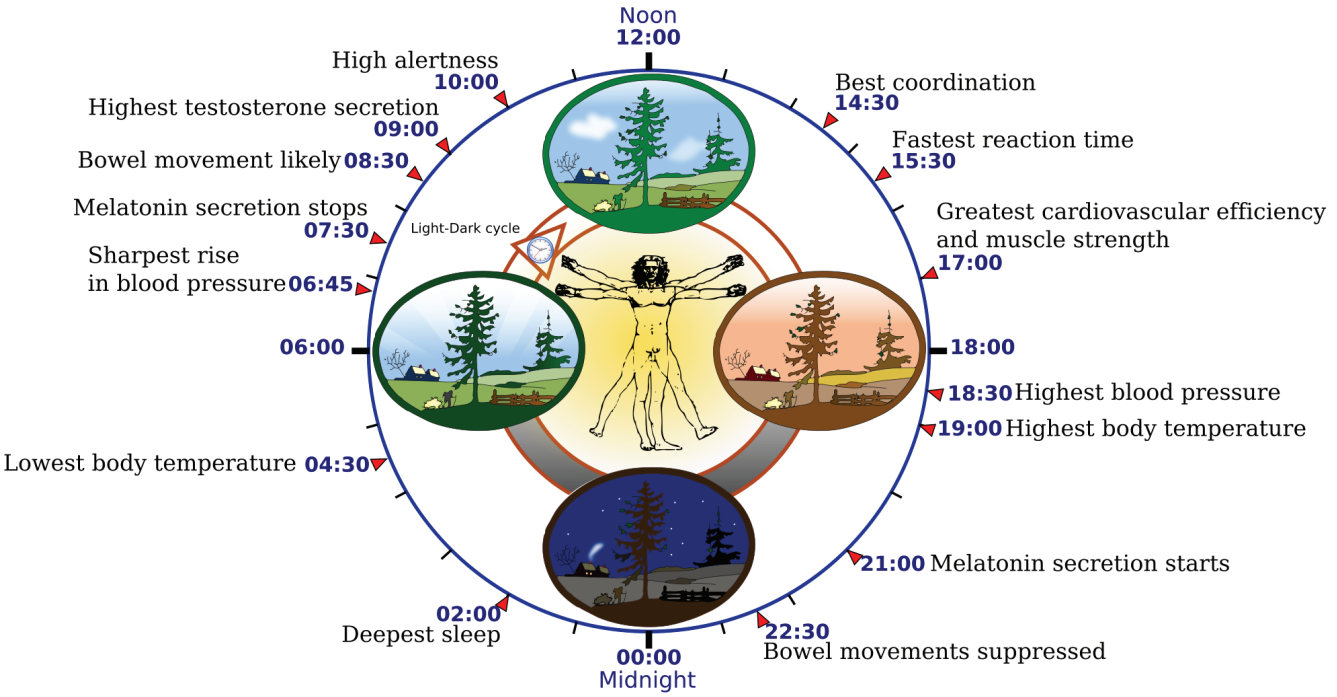


Figure 3.2 Circadian rhythm

will persist even if a creature is in total darkness for days.*

Your body has another process that controls whether or not you are sleepy: sleep pressure, the drive to sleep depending on how long you have been awake. Your brain breaks down adenosine triphosphate (ATP) to get energy (figure 3.3). This reaction causes an accumulation of adenosine. Every hour you are awake, adenosine builds up, binds to adenosine receptors, and activates sleep-promoting regions of the brain, while at the same time, adenosine inhibits alert-promoting brain regions. Through these pathways, adenosine puts "pressure" on the brain to go to sleep. During sleep, adenosine will get broken down, recycled, and removed from the brain, so your sleep pressure drops to its lowest point during the final minute of your sleep. Then with each waking moment, sleep pressure continues to build, and the cycle continues.

As you likely guessed from our all-nighter scenario that left you wide awake at 10:00 a.m., circadian rhythm and sleep pressure have an interaction. By staying up all night, sleep pressure builds continuously until we have to struggle heartily to stay awake. But circadian rhythm drives the brain and body to be alert in the midmorning hours, even if we are sleep deprived. You likely have also experienced this circadian rhythmicity on a day when, after a perfectly sound night's sleep, you find yourself feeling quite drowsy around 2:00 p.m. This is the internal clock of your circadian rhythm giving you the healthy body signal that it is nap time (figure 3.4).

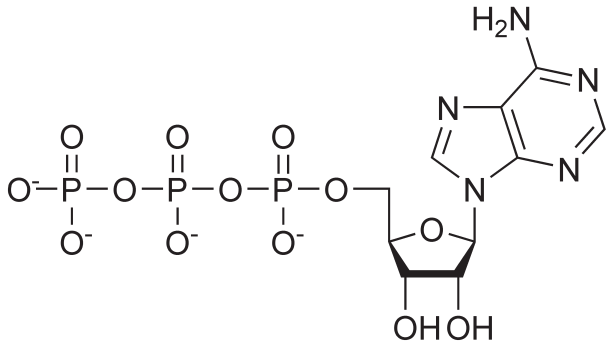


Figure 3.3 ATP chemical structure

* "The 2017 Nobel Prize in Physiology or Medicine—Press Release," Nobel Prize, accessed May 28, 2021, https://www.nobelprize.org/prizes/medicine/2017/press-release/.

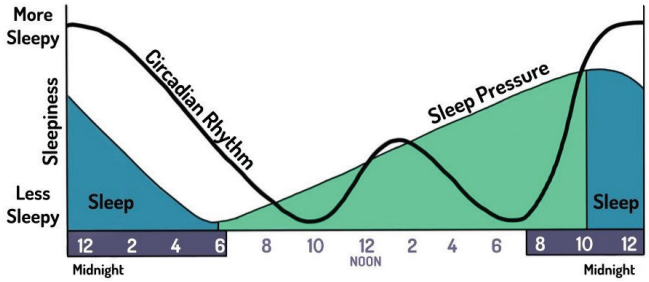


Figure 3.4 Circadian rhythm vs. sleep pressure

How Many Hours Are in a Day?

In 1938, two sleep science pioneers were so intrigued by the sleep-wake cycle that they spent a month 140 feet (over 42 meters) below ground in Mammoth Cave in Kentucky. There was no outside light, and the temperature remained at 54 degrees Fahrenheit (12 degrees Celsius) in the ana (Hawaiian for "cave").

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

Ana is Hawaiian for "cave" (figure 3.5).

One of their primary interests was what we now call the circadian period—the time it takes to complete one cycle of the circadian rhythm. In other words, away from the influence of light and other cues that tell us when a day begins and ends, how long would it take for the body to go through a cycle of its natural biological rhythms before starting over for the next "day." These University of Chicago researchers, Professor Nathanial Kleitman and his student Bruce Richardson,

Figure 3.5 The cave behind Waiānuenue Falls

recorded, among other things, fluctuations in body temperature, hoping to gain insight into the body's internal connection to the twenty-four-hour day (figure 3.6). "Internal" in this case refers to something that would drive the circadian cycle without any external cues, such as daylight. Based on sleep-wake cycles and body temperature fluctuations, they found their biological rhythms were in fact longer—by one to four hours—than twenty-four hours. We now know they were on track with this conclusion, as given a setting not influenced by external cues such as light, the human circadian period is about twenty-four hours and fifteen minutes. This means that left to our own devices, each night, we would fall asleep fifteen minutes later. After just eight days of this, rather than falling asleep at midnight and arising at 8:00 a.m., those times would shift to 2:00 a.m. and 10:00 a.m. The time shift would continue this way forever. Eventually, you would be falling asleep in the late afternoon and awakening several hours before sunrise. We will turn our attention to sunlight to explain why we are saved from that daily shift in our schedule.

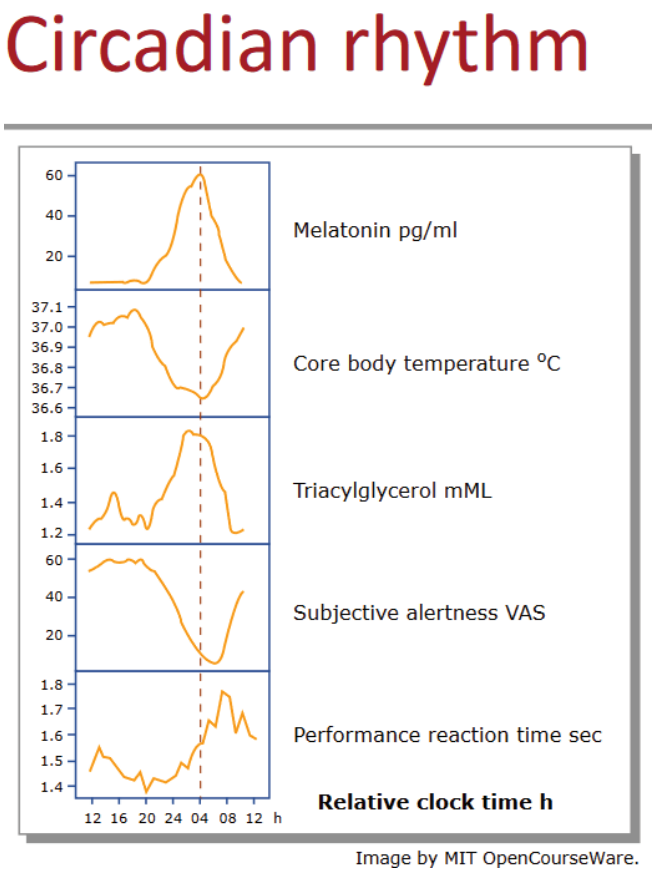


Image by MIT OpenCourseWare.

Figure 3.6 Circadian rhythm of physiological measures

Sunlight, Larks, and Night Owls

Thankfully, sunlight has a strong influence on our circadian rhythm. Exposure to light in the morning synchronizes it with our planet's solar cycle, thus trimming those fifteen minutes off our circadian period. Even artificial light, social activity, noise, temperature, and food impact our internal clock (figure 3.7). These cues are called zeitgebers, from the German for "time givers." Part of the success of Kleitman and Richardson's work in the cave was due to their being away from major zeitgebers, so they could experience what the internal clock would do in the absence of most external influences. Being isolated from zeitgebers puts a person in a "time-free" environment. They do not know the time of day or night or even how many days have passed.

In the decades since Kleitman and Richardson, circadian rhythm studies have often emphasized the importance of time-free settings in order to substantiate the theory of the internal clock working on its own. In some protocols, male participants are directed to shave their faces at varied intervals so their "five-o'clock shadow" will not provide any clues about the time of day or number of days passing. In the absence of these types of zeitgebers, numerous investigations have verified that our clock signal is generated inside of us (endogenous), but where exactly is its control center?

Animal studies have demonstrated that the suprachiasmatic nucleus (SCN), a tiny structure in the brain, is necessary and sufficient to create the circadian rhythm (see chapter 2). Scientists removed the SCN from animals that previously exhibited healthy circadian rhythms, and their rhythmicity disappeared, suggesting the SCN is necessary to generate the circadian rhythm. Another procedure involved transplanting the SCN from one animal to another. The SCNs from animals with long circadian periods (more than twenty-four hours) were

Figure 3.7 How many zeitgebers do you see in this photo?

transplanted into animals with short circadian periods (less than twenty-four hours), and vice versa. Consequently, the animals' circadian rhythms shifted to be aligned with their new SCN, implying the SCN is sufficient for generating circadian rhythm. But the SCN is only one structure along the pathway of signals that keeps the body on the approximately twenty-four-hour rhythm.

In the dark, a signal from the paraventricular nucleus of the hypothalamus (PVH) activates a circuitous pathway to the melatonin-releasing cells of the pineal gland (figures 3.8 and 3.9). The signal travels from the PVH, down into the upper thoracic region of the spinal cord, through the superior cervical ganglion (a little ball of neurons in the neck), and finally up to the pineal gland, causing it to release melatonin, which is a circadian rhythm–setting molecule that tells your brain it is time to sleep. Then when light shines on the eyes, an electrical signal travels along the optic nerve to the SCN—our internal clock—which is also a part of the hypothalamus. In the presence of light, especially sunlight and blue light, the SCN sends a signal to the PVH and inhibits the melatonin-producing pathway. This lets our brain know it is time to be awake. We are diurnal (active during the day), so this pathway keeps us alert during the daytime hours. In a nocturnal (active at night) animal, the melatonin release/inhibition pathway is similar to ours, except opposite in one regard: the response to light is to induce sleep and the response to dark is to bring about alertness and activity.

Since this pathway of disrupting melatonin secretion begins with light shining on the eye, it can be surprising to find that some blind people do have their circadian rhythm entrained to the sunlight. It is because not all the cells in the retina, a layer of tissue lining the inside of the back of the eye, transmit visual signals: some ganglion cells carry light-signal information from other retinal cells to the brain for processing visual images. But another type of retinal ganglion cell contains melanopsin, a light-sensitive pigment, and in addition to responding to light themselves, these cells

Ready to Move On?

In philosophy, law, math, and more you may encounter comparisons of necessity and sufficiency. Before moving on, consider the necessity and sufficiency of the SCN to produce the circadian rhythm. Then explore some educational websites to help you create—in your mind—a scenario you could use to explain to someone the relationship between necessity and sufficiency. Also consider how understanding the difference will help you think more critically when reading someone's claims about causation.

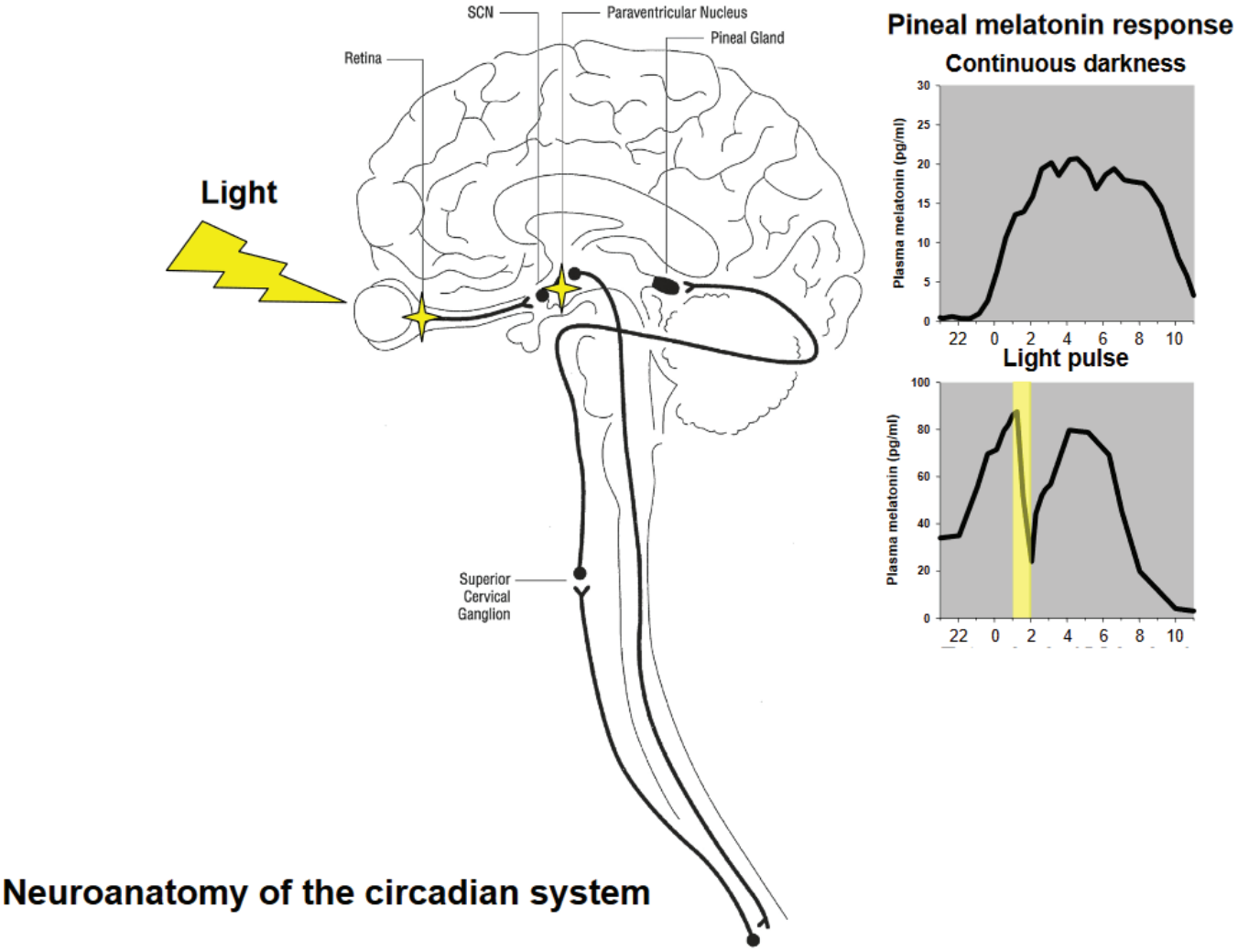


Figure 3.8 Neuroanatomy of the circadian system

carry the light information to the SCN for circadian rhythm light entrainment.

In other words, there are different types of retinal ganglion cells, which perform different functions. If a person's blindness was caused by something that left the melanopsin-containing ganglion cells functioning, they will be able to maintain their circadian rhythm in sync with the sun. However, it is important for these individuals to wear dark sunglasses in daylight because they will not have the pupillary constriction (the shrinking of the pupil) that would protect their retina from the sun's damaging rays. For some blind people, their melanopsin-containing ganglion cells do not function, so sunlight does not regulate their circadian rhythm and thus they struggle more with maintaining a twenty-four-hour circadian rhythm. The US Food and Drug Administration and the European Medicines Agency have approved a drug that activates melatonin receptors as a treatment, and some research also suggests that melatonin supplements, when dosing and timing are appropriate, improve circadian rhythmicity in blind people.

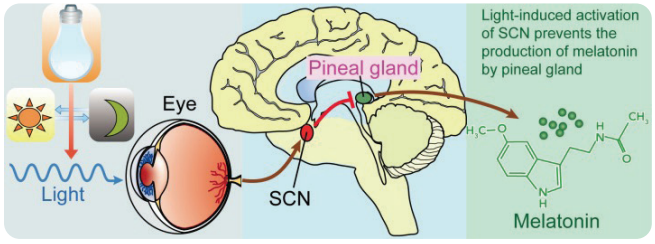


Figure 3.9 Light and dark impact the pineal gland's release of melatonin

Figure 3.10 During the winter, the sun does not rise at all in Tromsø, Norway

In some parts of the world with short periods of daylight in winter, circadian rhythm disruptions are understandably more common and are often associated with poor sleep quality (figure 3.10). Complicating the situation is seasonal affective disorder (SAD), a type of depression that most often begins when the weather becomes cloudier (blocking the sun) and/or daylight periods get shorter. There are interactions between the circadian rhythm pathway and pathways that involve the release of molecules like thyroid and serotonin, which affect mood. The association of depression with poor sleep further compounds the challenge of SAD. In these regions with darker days, it is helpful to incorporate various forms of light therapy, including working in front of light boxes and installing classroom lights that simulate a bright spring day at noon (figure 3.11).

Regardless of where they live, some people find their circadian rhythm is naturally shifted so they fall asleep in the early evening and wake up before dawn. These folks are sometimes referred to as larks ("morning people"), while their counterparts, the night owls ("night people"), fall asleep after midnight and wake up much later in the morning, maybe as late as noon (figure 3.12). These are two different chronotypes (a word that comes from *khronos*, the Greek word for time). While sometimes these bedtime patterns are age-related, such as the elderly lark or teenage night owl, chronotype is also a gene-based timing pattern for when a person naturally feels sleepy. The genetically determined chronotype usually persists regardless of age.

Figure 3.11 Bright lighting in the classroom

Figure 3.12 Lark and owl

About 40 percent of humans are larks, about 30 percent are night owls, and the remaining 30 percent fall in the middle. This genetic variation within our species is quite inconvenient in our modern world, which operates mostly around a nine-to-five workday. It is especially difficult for the night owls, who have to start engaging their brain several hours before they are metabolically ready every morning. It is unfortunate that our society does not accommodate different chronotypes, especially considering the health consequences (increased heart disease, diabetes, brain disorders) and accidents associated with disrupting a person's natural circadian rhythm. Considering all this may make you wonder why the different chronotypes exist. Yet looking to our tribal ancestors, these different chronotypes make perfect evolutionary sense. If it is time for the tribe members to sleep, the safer outcome in terms of avoiding attack during sleep would be to have a few members awake late at night and a few alert and functioning before dawn. Thus the larks and owls were the revered sentinels (figure 3.13).

This is not much solace for night owls who have to catch the bus at 6:30 a.m. to get to an 8:00 a.m. class, but there are coping strategies. Chapter 6 contains a discussion of these circadian rhythm disorders, referred to as advanced sleep-wake phase (in larks) and delayed sleep-wake phase (in night owls). Tips for working with each of these disorders are in chapter 1, which also includes details about orange versus blue light (such as from a computer screen) and their effects on the circadian rhythm.

Derailing the Circadian Rhythm

For those who are neither larks nor night owls, there still are plenty of challenges to maintaining the circadian rhythm. And deviating from the earth's rotational rhythm and natural daylight hours comes at a great cost. Even a once-a-year shift forward in the clocks can be deadly, as seen in the US with the significant increase in deaths from heart attacks and accidents on the Monday after the beginning of daylight savings time. Russian researchers also claim their country had an enormous increase in heart attacks and suicide rates on that day, and for that reason, Russia and many countries are abandoning the daylight savings time shift. But if it causes so much harm, why and where did it begin?

This shifting of the clock time—in the US, setting it ahead by an hour in March and then returning to standard time in November—originated in

Your Next Actions for Justice

If your community still practices daylight savings time, consider writing your congressperson or a letter to the editor in your local newspaper and start a conversation to make health the priority and discard daylight savings time.

Figure 3.13 Storytelling

different periods of history, and independently in many countries for varied reasons. For example, a New Zealand entomologist in the late 1800s wanted more evening hours to find insects, and the Germans during World War I hoped it would help their war effort. Currently, only a little more than a third of countries in the world engage in this practice. Many nations—based on science and as a reflection of their value of health, safety, and productivity—are making the move to ditch the practice of shifting the clock.

Regardless of time zone, many people have to live by a different clock because of their work hours. While some have the luxury of a 9:00 a.m. to 5:00 p.m. workday, a shift worker may have to work through the middle of the night (figure 3.14). More challenging still, some shift workers have weekly rotations in their shifts, from daytime to nights to mornings. A night shift might be from 5:00 p.m. to 1:00 a.m., with the morning shift from 1:00 a.m. to 9:00 a.m. Shift work is associated with devastating health problems such as increased rates of cardiovascular disorders, depression, diabetes, and cancer. The World Health Organization has listed shift work as a probable carcinogen, as it is associated with cancer. They state this is due to the health damage that comes with disrupting the circadian rhythm.

One of the recommendations to help shift workers is to eliminate the weekly rotation between shifts so the body does not have to experience the equivalent of traveling through eight time zones every week and never settling on any circadian rhythm. Science indicates that if rotation is necessary, the shifts should be rotated clockwise: from day shift, to night shift, to morning shift. This movement, while not at the same magnitude, is at least in the same direction as our internal circadian rhythm, which is fifteen minutes longer each day,

Figure 3.14 Shift workers

making us naturally want to go to bed and wake up later each day. The other advice is to rotate every three weeks, not every week. Protecting the eyes from sunlight and blue light with tinted glasses in the two hours before sleep is also helpful for shift workers, especially those driving through bright sunlight as they head home for their much-needed sleep.

The time zone change experienced with airline travel has some difficulties in common with shift work (figure 3.15). Scientists have shown how jet lag can cause digestion problems, menstrual cycle irregularities, feelings of depression, and foggy thinking. Left to its own, the SCN adjusts to a new time zone by only an hour a day, so thankfully, there are several effective jet lag strategies. One of the most surprising protocols is fasting to reset our internal clock. Studies have shown that if an animal is not getting enough food, light takes a back seat as the strongest zeitgeber. The driving factor for circadian rhythm becomes all about the best time to get food. See chapter 6 for approaches to minimize jet lag.

Figure 3.15 Flying into a different time zone

Figure 3.16 Caffeine impacts the circadian rhythm

Jet lag and demanding work and school schedules motivate many people to turn to caffeine in an attempt to forestall the circadian rhythm (figure 3.16). But we pay for that short-term boost. The adenosine activity that creates sleep pressure gets intercepted by caffeine, which blocks adenosine receptors in the brain, so they are not able to be activated. Theobromine, a constituent of chocolate, works in a similar manner to caffeine as it also blocks adenosine receptors. Having the adenosine receptors blocked, whether it is via caffeine or theobromine, creates a short-term illusion that we are not sleepy. However, adenosine is still building up at its normal rate. Then, when the caffeine (or theobromine) is broken down and the adenosine receptors are available again, there is an extra high level of adenosine in the brain, and the adenosine receptor activation is substantial, causing the typical crash experienced several hours after caffeine use. For some, the next step is another cup of coffee, continuing the cycle—which will have disastrous effects on sleep that night. Depending on factors such as age and genetics, caffeine is metabolized at different rates: it may take around thirty minutes for caffeine to kick in, but it can still be in the system eight to ten hours later.

Polyphasic versus Biphasic

If there is a group of people with the resources and will to hack the circadian rhythm and reduce the hours of sleep needed, it would be the National Aeronautics and Space Administration (NASA). Every hour an astronaut is in space is expensive, and every hour they are sleeping is an hour they could be working (figure 3.17). Yet even NASA scientists have not figured out a way to get around the fact that most of us need around eight hours of sleep and a ten-minute nap every day. This is biphasic sleeping: two sleep periods every twenty-four hours. Solo sailors are also interested in finding a way to sleep less and still perform optimally, as they may be at sea for days and must keep their sailboat safe and on course.

Consequently, Claudio Stampi, a sleep specialist and expert round-the-world sailor, was a leader in the development of polyphasic sleeping for sailors, athletes, and others in extreme situations, including outer space. One form of polyphasic sleeping is taking a thirty-minute nap every four hours, for a total of three hours' sleep in a twenty-four-hour

Retrieval Practice

After studying the paragraph about caffeine and adenosine receptors, go back to the beginning of the chapter and review the role of adenosine triphosphate (ATP) breakdown in making you sleepy. Set aside the content and do not let yourself look at it. On a piece of paper or using your computer, create a rough sketch and explanation of how caffeine works to keep you awake and why there is a crash several hours later. Include adenosine receptors in your sketch. Then open up the book and your notes and make corrections to your drawing and explanation.

Figure 3.17 Sleeping in space

period (figure 3.18). However, even Stampi himself, a self-proclaimed biphasic sleeper, is clear that polyphasic sleeping is only for extreme events and is an unhealthy practice long-term.

Despite this, the concept of gaining additional waking hours each day became irresistible for laypeople, who see it as a way to potentially add years of awake time to a person's life. Based on sleep debt research, however, the health damage caused by this sleep schedule would likely actually take several years *off* a person's life and lessen the quality of their living years by diminishing cognitive function, lowering mood, reducing physical abilities, and more. In spite of the contradiction, the practice has taken off and gained a following. It is an unfortunate misinterpretation of Stampi's research.

Another probable misinterpretation related to circadian rhythm research is regarding news of a bygone sleeping pattern. In the past, this theory purports, the schedule was to sleep several hours at night, awaken at midnight for a couple of hours, and return to sleep for several more hours. Some reported that this is the biphasic sleeping pattern we are all meant to follow. This practice seemed to originate around the 1700s among a group of Western Europeans: after sleeping several hours, they would wake up for singing, sex, praying, or storytelling, then finish the rest of their slumber until morning.

While it made popular headlines, evidence indicates this was an isolated practice and that there is no biological justification for it. The jury is in: based on the scientific examination of human circadian rhythm over the ages and in current times, we have indeed evolved to be biphasic sleepers—that is, sleeping around eight hours each night with a ten-to-twenty-minute nap in the afternoon.

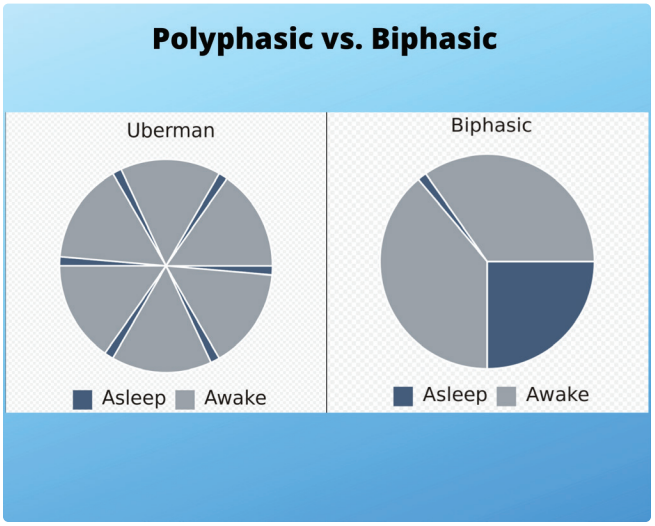


Figure 3.18 Sometimes polyphasic sleeping is referred to as the uberman schedule. This figure compares polyphasic to biphasic sleep. The circle represents time in the 24-hour day, so the small dark blue sectors in the uberman (polyphasic) schedule are the six thirty-minute naps. On the biphasic image, the large dark blue sector is eight hours of nighttime sleep and the small sector is the twenty minute afternoon nap.

4 Animals

Student Learning Objectives

After you read this chapter, you will be able to

- compare and contrast sleep in various insects, fish, and mammals
- explain how understanding unique sleep characteristics from animals provides insight into human sleep
- discuss the significance of sleep's persistence throughout evolution

Introduction

Animals, such as lions, that eat many pounds of meat in a single meal can spend fifteen hours a day sleeping. Compare this to plant-eating animals, like giraffes, which sleep an hour or less each day (figure 4.1). If you were to make a hasty survey, it appears predators sleep more than other animals. However, there are exceptions to that generalization and others like it (such as that smaller animals sleep less than larger ones). There are a multitude of theories about the sleep duration differences between animals, but currently, there is no clear front-runner. Even within groups of animals that are similar genetically, there are sometimes more pronounced sleep duration differences than between vastly dissimilar animals. We do know all creatures studied so far have a period of something similar to sleep. Even unicellular organisms have stretches of time, linked to the earth's light-dark cycle, when they barely move and have a decreased reaction to stimuli.

Since it is not possible to hook up a bug to EEG, EOG, and EMG to verify sleep physiologically, for many life-forms, we must rely on this more behavioral definition of sleep—for example, a stereotypical resting posture combined with reduced response to the external environment. And let's be sure to add that sleep is a reversible state—one of the hallmarks of sleep, thank goodness. In the absence of polysomnography, an additional factor to add to the equation for verifying sleep is to note the strong drive the organism exhibits to return to that "sleeping" state when deprived of it. But how would you know a sleep-deprived insect is trying harder to sleep? Scientists record the baseline level of stimulation required to awaken the sleeping creature when it is left to its normal rhythm for a few days. Then the creature is kept awake during what would be its sleeping time. In this sleep-deprived condition, more intense stimulation is required to rouse the creature from sleep. Imagine your roommate awakening you by softly tapping you on the arm after you've had several nights of full and comfortable sleep. Compare that to the jab required if you have at long last dozed off after pulling an all-nighter. This exemplifies one aspect of sleep rebound: sleeping more deeply after being kept awake too long. The other aspect is falling asleep during what are normally waking hours.

In lieu of physiological measurements to verify that an organism is sleeping, the behavioral definition proves helpful. Upon observation of behaviors, even insects will provide additional clues—beyond just a resting posture—to let us know they are sleeping.

Figure 4.1 Delicious

Insects

Like humans, fire ants have different stages of sleep. They start with their mouths open and antennae retracted or drooping (figure 4.2). Then the antennae begin quivering as the fire ant moves into rapid antennal movement (RAM) sleep. Might they be dreaming? Could RAM sleep be an equivalent to REM sleep—even though much research suggests that insects have no equivalent to REM? At this point, it remains an enigma, motivating further investigations.

Another insect, the fruit fly, often examined when there is a need for deciphering genetics, is a favorite for sleep research. Fruit flies have many genetic and physiological similarities to humans, including getting a buzz from caffeine that keeps drowsy flies awake. As with humans, if fruit flies do not get sufficient sleep they have poor memory, have reduced learning function, and die earlier. They have also been used to demonstrate the reduction in sleep associated with starvation. If a creature is not getting enough calories, the body, much to its detriment, will reduce the time spent sleeping to instead seek food. One of the most compelling sleep-related findings in this research was the discovery of a gene that controls circadian rhythm (see chapter 3). These scientists were awarded the 2017 Nobel Prize in Physiology or Medicine for their work.*

Fish

For ages, scientists believed that sharks do not sleep because their eyes are open when they settle into

* "The 2017 Nobel Prize in Physiology or Medicine—Press Release," Nobel Prize, accessed May 28, 2021, https://www.nobelprize.org/prizes/medicine/2017/press-release/.

Figure 4.2 Red ant

their quiet resting posture. Upon further investigation, it became apparent that sharks were sleeping, but they do not close their eyelids during sleep (figure 4.3). Some sharks have a clear membrane covering their eyes, and others have eyelids partially covering them. The purpose of shark eyelids is not sleep related; it is to protect their eyes when fighting or attacking. Great white sharks, which do not have eyelids, have to roll their eyes back to protect their eyes when attacking. This Discovery Channel video captured a great white shark sleeping.* You may have heard that some sharks need to move while sleeping to get oxygen across their gills, and this is true. But other sharks have spiracles that draw in water and move it over their gills so they do not need to move during sleep.

Reptiles

As late as 2016, many believed that reptiles have NREM sleep but not REM sleep. However, when researchers at the Max Planck Institute for Brain Research in Frankfurt began to study the Australian dragon—a type of lizard that is a popular pet in Germany—a surprising story emerged (figure 4.4). The scientists set out to study visually guided behaviors and were continuously recording

* Discovery, "Great White Naps for First Time on Camera," YouTube video, 2:33, June 28, 2016, https://www.youtube.com/watch?v=B7ePdi1McMo.

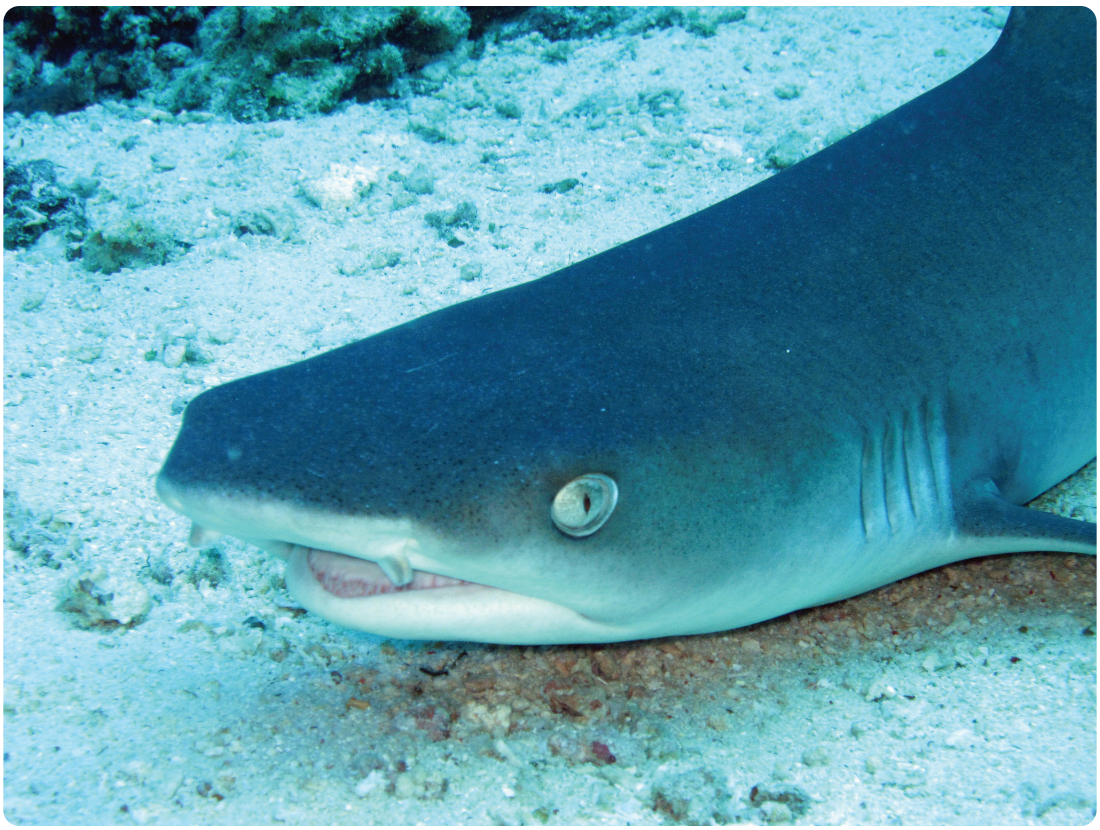


Figure 4.3 Shark

Figure 4.4 Australian dragon

the lizards' brain activity using electrodes. They did this for several days at a time, also using infrared cameras to record nighttime behavior. Although sleep was not the focus of the study, they found the lizards had the typical NREM slow-wave sleep activity—and also REM brain activity, combined with tiny twitches in the eyelids during the REM phases. Part of the significance of this finding is related to how REM sleep is also found in birds and mammals, creatures that evolved separately and much later than reptiles. Until this Australian dragon research, the conventional wisdom was that evolutionary pressure along two isolated evolutionary pathways (those of birds and mammals) resulted in the emergence of REM sleep—people thought REM sleep did not exist before birds and mammals. Now it is clear that REM sleep existed much earlier in the evolutionary line and was likely handed down to both birds and mammals.

REM sleep in other reptiles remains to be examined, but reptilian behavioral sleep patterns have been observed for ages. The beloved honu (green sea turtle of Hawai'i) sleeps in the ocean for several hours, usually close to the surface, holding its breath (figure 4.5). Near the shore, they doze several feet under water, cozy under the edge of a coral reef.

Figure 4.5 Honu

It can be difficult to determine if snakes are sleeping or simply not moving. Since the thin membrane covering their eyes is clear, they appear to sleep with their eyes open.

Some geckos do actually sleep with their eyes open, but they constrict their pupils down to protect the retina. Other geckos are fortunate enough to have eyelids they close, just as humans do when sleeping.

Birds

Birds have evolved to sleep with one hemisphere of their brain at a time, keeping an eye on things while they snooze. This leaves the awake half of the brain alert and able to process information coming from its associated eye, which remains open during sleep. Ducks and many other birds use this skill not just for their own self-preservation but also that of their community. Sleeping in a row, sentinels on each end of the row keep one eye open, sleeping with only one hemisphere of their brain. The birds in between the sentinels enjoy a completely restful night of shut-eye, with both hemispheres sleeping at once (figure 4.6). At either end, each sentinel bird's open eye faces out, so after a period of sleep in this position, the bird arises and turns around to face the opposite direction, opening the closed eye, and letting the previously active brain hemisphere and eye get some sleep. Even though they are processing information with only half of their brain, it takes less than a fifth of a second for the guard birds to react to a predator. Although REM sleep is normal for birds, it seems both hemispheres must be engaged in sleeping to generate REM. Consequently, these vigilant guardians on the end of the row are only able to get NREM sleep when on duty.

Figure 4.6 Safe sleeping with sentinels

Humans have a rather subtle version of sleeping with one hemisphere for the sake of vigilance. Have you ever noticed you sleep a little lighter on the first night staying over at a friend or family member's home? And then if you stay with them for a few more nights, you notice your sleep feels more satisfying. During NREM in new surroundings, half of our brain will have a lighter version of deep sleep; the other half will have its normal restorative depth. This allows us to keep watch, ever so slightly, in our less-than-familiar setting until we have settled in for a few more nights and feel entirely comfortable.

Birds have another fascinating sleep-related adaptation. Due to their need to migrate thousands of miles over the ocean, they have evolved to safely fly nonstop for hours and hours, seemingly without sleep . . . or are they sleeping while flying? Yes, they are, and it is a unique sleep pattern. Frigate birds (ʻiwa in Hawaiian) fly for months straight and so will sleep about ten seconds at once, in flight, getting less than half an hour of sleep each day.

Some birds, such as the white-crowned sparrow, have even attracted attention from groups such as the US Department of Defense. This sparrow

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

ʻIwa is Hawaiian for "frigate bird" (figure 4.7).

can stay awake for two weeks at a time during its migratory period and apparently not suffer the usual deleterious consequences of sleep deprivation. During these phases, the bird also remains capable of proficiently responding to stimuli. The US military, with its history of pressuring troops to use various forms of stimulants such as amphetamines (with deadly consequences), is highly motivated to determine a way to keep people such as pilots awake for long stretches at a time without not compromising their judgment or damaging their health. At this point, the science suggests it is not possible. Let's hope for the sake of the troops, their families, and the world community that there are also researchers actively investigating revolutionary and innovative solutions to minimize the need to put people in harm's way.

Mammals

Imagine swimming through the ocean with half of your brain asleep, or catching z's while dangling like a ripe mango from a tree (figures 4.8 and 4.9). The unihemispheric sleep of dolphins allows them to swim and communicate—during sleep—with other dolphins. Up in the trees, bats, with their unique wing structure, are unable to create the rapid vertical takeoff mastered by birds. The best way for a sleeping bat to escape a hungry raccoon lumbering toward its roost is for the bat to drop from the tree and take flight midair. In the sea, dozens of sea otters come together and wrap themselves in seaweed, creating a sea otter raft for safety in numbers and to keep from drifting

Figure 4.7 Frigate bird

away while snoozing. Occasionally, they even hold hands (figure 4.10). In open grassy areas, cows, horses, zebras, and elephants can sleep standing up, able to quickly flee if attacked. They have a "stay apparatus" that allows them to essentially lock their legs, minimizing muscular effort to remain standing. At times, these big mammals also lie down to sleep in order to complete their sleep architecture.

Noticing the range of adaptations and behaviors that make it possible for animals to sleep and survive, we see that sleep has persisted even in the face of environments where it seems it would have been simpler to just eliminate it from the mix. As Alan Rechtschaffen, a sleep science trailblazer, has said, "If sleep does not serve an absolutely vital function, then it is the biggest mistake the evolutionary process has ever made."* Then

Figure 4.8 Dolphins

* E. Mignot, "Why We Sleep: The Temporal Organization of Recovery," *PLoS Biology* 6, no. 4 (April 2008), https://doi.org/10.1371/journal.pbio.0060106.

Figure 4.9 Bat

how can we resist the question, "*Why* is sleep so vital?" Let's further investigate animal sleep and get some answers.

Although they live and sleep in the water, whales, seals, and dolphins are mammals and so must breathe in the air. If they fell fully asleep underwater, they would drown, so like some birds, only half of their brain sleeps at a time. When one hemisphere is sleeping, the other hemisphere guides the animal to the surface and activates the body to take a breath. The visual system of the awake hemisphere is vigilant for danger and stays connected to other animals in its group, such as companions or offspring. These elaborate evolutionary adaptations suggest that sleep must provide a crucial function, since sleep does not make it to the bargaining table when evolutionary pressure looks for behaviors to remove. At first blush, it seems it would be easier to evolve to not sleep than to evolve the mechanisms necessary to sleep while swimming. In other words, sleep is indispensable!

Figure 4.10 Sea otters

Ready to Move On?

Before moving on, establish that you have a clear understanding of Rechtschaffen's statement, "If sleep does not serve an absolutely vital function, then it is the biggest mistake the evolutionary process has ever made." In your own words, explain what he meant.

Getting back to unihemispheric sleep in aquatic mammals, there are exceptions: seals have bihemispheric sleep underwater (they hold their breath) and sperm whales sleep with both hemispheres too, seemingly dangling in the water, tail down, until they awaken to swim to the surface to take a breath (figure 4.11).

Dolphins and some whales do not show obvious signs of REM sleep, but scientists speculate that they may experience transient REM sleep or REM brain activity in deeper structures than the cortex. This motivation to not rule out dolphin and whale REM sleep is partially due to observed muscle twitching, penile erections, and eyelid movements during dolphin sleep. These behaviors are associated with REM sleep in land mammals but also occur during waking states, so REM sleep in dolphins remains an area of active research. Dolphins are so highly evolved that maybe we will see they have a unique form for REM that provides additional survival benefits beyond those given to us humans during REM sleep.

Fur seals do clearly have REM sleep, but they add a unique variation to its predictability. On land, the fur seal sleeps with both hemispheres at once and goes through REM and NREM stages, similar to most mammals (figure 4.12). However, when a fur seal sleeps in the water, its sleep is similar to

Figure 4.11 Sleeping sperm whales

a dolphin's: it sleeps with one hemisphere at a time, and NREM is the only obvious sleep stage. Because fur seals spend weeks at a time in the sea, they go for long stretches without REM. But why would a seal have two different patterns of sleep, depending on whether or not it was sleeping in the water?

A current theory about REM is it increases brain metabolism and warms the brain and brainstem, balancing out the lower metabolic rate and brain temperature of NREM. When fur seals, dolphins, and whales sleep in the water, one hemisphere at a time, and exclusively in NREM, the theory is they would not need REM to warm up the brain, since half of the brain is always awake and warm. Then when the fur seal is sleeping on land, it reverts to the typical land mammal pattern of bilateral NREM interspersed with REM. We humans feel much more alert if we wake up shortly after or even during an REM period, as opposed to when our alarms go off in the middle of deep NREM sleep, when our brains are cool and sluggish.

If REM sleep did not provide an essential benefit, then it seems the fur seal would continue its unihemispheric NREM sleep when snoozing on land. However, it has evolved to incorporate REM sleep whenever it returns to its terrestrial home. With the

Figure 4.12 Hawaiian monk seal

Your Next Actions for Justice

Did you know that some organizations conduct sonar and explosives testing in identified habitats of whales, dolphins, and porpoises, furthering the real possibility of their extinction?* In addition to disrupting their sleep, this testing causes grave harm, even death, to ocean creatures. Whales, dolphins, and porpoises are so affected that in Guam, eight senators created a resolution, with strong backing from the community, to stop such testing in that region. Of course, the people of Guam fought for this because they care about the animals, but they also did it because Guam is an island nation, where their cultural identity, social fabric, and economy are linked to the health of their region's sea life. Your next step for action is to investigate sonar and/or explosives testing in the ocean. Find out where it is happening, in what parts of the world, and more details about the communities affected and the environmental impact. Based on your research, select the information that is most meaningful to you and post on social media (or send an email to several friends if you don't use social media) to share a brief and factually accurate synopsis of your findings.

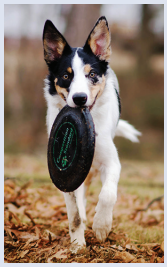
* Ocean Conservation Research: Sound Science Serving the Sea, last modified May 2021, https://ocr.org/.

myriad REM sleep–associated benefits—including emotional healing, cardiovascular system regulation, and more—it is tempting to believe REM sleep would be incorporated into a creature's sleep cycle if at all possible.

Let's look way back in time to compare variations in mammalian sleep. During the early stages of mammalian evolution, monotremes branched off from placentals and marsupials. Monotremes (e.g., platypuses) are egg-laying mammals. This is in contrast to placentals (e.g., humans), which carry the fetus in the uterus until a relatively late developmental stage, and marsupials (e.g., kangaroos), which give birth before the animal is completely developed, so after birth, it is usually carried in a pouch on the mother's body (figure 4.13). Although for decades, scientists believed monotremes do not experience REM sleep, there are now studies showing that platypuses not only have REM sleep but have a higher rate of it than placentals or marsupials.* During REM, the platypus has rapid eye movements and twitches its bill. Its REM EEG is similar in many ways to newborn placental mammals, which have high rates of REM too. The brainstem EEG of a platypus shows that REM occurs at the same time as cerebrocortical slow-wave sleep, explaining why early investigators may have miscategorized its sleep pattern.

Figure 4.13 Monotreme, placental, and marsupial mammals

* J. M. Siegel et al., "Monotremes and the Evolution of Rapid Eye Movement Sleep," *Philosophical Transactions of the Royal Society B: Biological Sciences* 353, no. 1372 (July 1998): 1147–57, https://doi.org/10.1098/rstb.1998.0272.



Retrieval Practice

Look up the meaning of *adaptation* in the context of organisms. When you are clear on its meaning, start at the beginning of the chapter and skim the content, making note of all the adaptations and behaviors animals make in order to sleep and/or survive while sleeping. Then set aside the content and your notes and do not let yourself look at that material. Relying only on your memory, make a list of all the adaptations and behaviors you noted. After you are done honoring that you were able to retrieve some of the content from your mind, open the book and your notes and make additions and corrections to your retrieval practice list. Remember to have a sense of humor and be kind to yourself if you made mistakes or could not recall some of the facts. The brain learns better with kind criticism than with harsh words. This is also an opportunity to see if the way you are reading and taking notes is working for you. If it is not, make a change to how you approach studying the textbook. It may be helpful to stop more often while reading and do tiny retrieval practices like this one. It will save you time in the long run.

Hibernators

A common myth is that hibernation, which can last a few hours or as long as several months, is the same as sleep. However, although hibernation has evolved from sleep, there are fundamental differences between the two. In fact, some animals will bring themselves out of deep hibernation in order to get sleep and then return back to hibernation after a satisfying snooze. Also, sleep is easily and rapidly awoken from, but it takes an hour (or more, depending on the animal) to rouse from hibernation. And what about the function of hibernation compared to sleep? A fundamental purpose of hibernation is to save energy. If sleep and hibernation had energy conservation as a common goal, it would not make sense to expend energy to warm up the body during hibernation in order to create conditions necessary for true sleep. Yet some animals, even in frosty conditions, do exactly that.

Ground squirrel body temperature can remain close to zero degrees Celsius, the temperature at which water freezes, during hibernation, which could last the entire winter (figure 4.14). However, once a week, for around twenty-four hours, they bring themselves out of hibernation. It takes a while, and a lot of energy, for them to speed up their metabolism and activate their brain. When they are hibernating, their EEG is practically a flat line, as though they were not alive. Remember learning about dendrites in chapter 2? During the first day of hibernation, ground squirrels lose about one-fourth of their dendrites. Then, within hours of coming out of hibernation, the dendrites are restored. Other physiological functions, such as urine production, come to almost a halt during hibernation as well. But after rousing from their week of hibernation, during that twenty-four-hour period at their normal body temperature, they eat, pass waste, and sleep before returning to another week of hibernation.

Figure 4.14 Ground squirrel

Figure 4.15 Bear

If I say "hibernating animal," what creature comes to your mind? If it is a bear, you are in good company, as this is the typical response (figure 4.15). You may find it surprising that some scientists argue that bears are not true hibernators; others suggest that theirs is just a different form of hibernation. A bear's body temperature will drop only a few degrees, even when outside temperatures are below freezing. This closer-to-normal body temperature allows bears to generate NREM and REM sleep during hibernation. They also stay in their state of torpor for the entire winter, not bothering to invest energy in the weekly rousing practiced by the ground squirrel. Lastly—and this is a significant difference from the ground squirrel, as intrepid hikers will tell you—a hibernating bear can be roused quickly and easily.

5 Dreams

Student Learning Objectives

After you read this chapter, you will be able to

- discuss theories about several different dream functions, including emotional healing, memory consolidation, problem-solving, and emotional intelligence development
- explain the role of dreaming in posttraumatic stress disorder recovery
- describe how dreams are created
- compare and contrast several theories about dream interpretation
- discuss dream significance from the perspective of different cultures
- teach someone how to lucid dream
- provide instruction for conducting a dream group

Introduction

In the early moments of trying to fall asleep, we may experience a stunning hallucination that startles us back to reality, leaving us to wonder, "What was that?!" It is disorienting because we feel we were not yet sleeping. These hypnagogic hallucinations occur around sleep onset (figure 5.1). They are a type of dream—if you define dreaming as something going through your mind while you are asleep—but some people refer to hypnagogic hallucinations as "sleep thinking." We dream in all stages of sleep, NREM and REM, but during REM sleep, our dreams become more intense in their content and often bizarre in nature. Conversely, if awakened from NREM dreams, many report that it feels as though they were simply thinking about something rather boring. We know dreams occur throughout the night, but in this chapter, dreaming refers, unless

Figure 5.1 Under the covers

stated otherwise, to the dreaming state associated with REM sleep. Let's begin with a discussion of the importance of dreams to our mental well-being, because in the words of Nobel laureate Elias Canetti, "All things one has forgotten scream for help in dreams."*

Emotional Healing

Dreams help us cope with, and better understand, our emotions. During the day, emotional events happen, but we rarely pause for reflection because we are pressed to continue with the business of the moment. When we are dreaming, it is an opportunity to take the emotions of the day and relate them to memories—even those from long ago—to see if we can make sense of the situation and be better prepared for the next time something similar occurs.

Imagine an emotional event during the day, such as a group activity in class in which you felt socially uneasy, like you did not fit in (figure 5.2). Maybe you said something that was poorly received or were given a disapproving look by one of your classmates, but you had to continue with the work at hand. You may or may not have forgotten about it by the time you went to bed. Either way, that night, your dream might have an emotional theme of social rejection, but in a scene involving people you haven't seen in years rather than your current classmates. Through dreams, your brain can create a mash-up of current and previous experiences to optimize your future behavior—the perfect harm-free dress rehearsal.

While our dreams are synthesizing such relationships between recent emotions and distant memories, the brain experiences its lowest levels of stress hormones over the course of twenty-four hours. One of these hormones, norepinephrine (also called noradrenaline), is present in the brain at various levels throughout the day and night—except during REM sleep. During our vivid

Figure 5.2 We've all been there

emotional dreams, we can replay events without the stress response triggered by norepinephrine. Matthew Walker, a sleep scientist at the University of California, Berkeley, has led brain imaging research in this area to show how the brain takes advantage of this zero-norepinephrine condition to relate clear recollections of crucial events to previous memories without engaging the flight-or-fight brain circuits that would distract us from calm introspection. The result is that we are able to shed the emotionally painful layer of the memory and still retain details of the situation to help us be better prepared to face another day . . . or that judgy classmate!

Dreaming about emotional events brings us to a place where we are more comfortable with the situation. Psychologist Rosalind Cartwright, also a world-renowned sleep specialist and expert on dreaming, has published extensive research showing the benefit of dreaming for emotional recovery. Dreams mentally evolve us to a point where our daily activities, as well as our sleep, are less disturbed by feelings associated with challenging life events. She says a part of the purpose of dreaming is so that "negative mood [can be] down-regulated

* Deirdre Barrett, ed., *Trauma and Dreams* (Cambridge, MA: Harvard University Press, 2001), 282.

Figure 5.3 Staying together

overnight."* Although, she is quick to clarify that recovery from difficult life events will take many nights, maybe months, of dreaming about them. Cartwright has done brilliant research and clinical work with patients experiencing despair at the time of an upsetting life event, such as a breakup with a partner (figure 5.3). She found people who dreamt of the event, especially around the time of its occurrence, experience a significant amelioration of depression compared to those who did not dream of the event (even if they did still dream of other things).

This progression to recovery has a more complicated path for individuals faced with trauma and nightmares. If someone experiences a frightening or dangerous event, and feelings of being scared or stressed remain strong long after the danger has passed, they may have posttraumatic stress disorder (PTSD; figure 5.4). People with PTSD have increased levels of norepinephrine in their brains during REM sleep. This is the opposite of the norepinephrine-free condition responsible for emotional healing during REM dreams, which is experienced by those without PTSD. For folks suffering from PTSD, the presence of norepinephrine during REM sleep disrupts the ability for dreams to reduce the emotional intensity associated with disturbing events. But because the mind still wants to work out the problem while dreaming, it will repeatedly attempt to do so with a dream, sometimes every night, resulting in recurring nightmares—one of the most common symptoms of PTSD.

Imagery rehearsal therapy (IRT) has been used successfully to help people with PTSD work with a

* R. D. Cartwright et al., "REM Latency and the Recovery from Depression: Getting Over Divorce," *American Journal of Psychiatry* 148, no. 11 (November 1991): 1530–35, https://doi.org/10.1176/ajp.148.11.1530.

Figure 5.4 Soldier

therapist to transform nightmares into less disturbing dreams. The concept is to create a more comfortable version of the nightmare and retain enough nightmare details so the mind will slip into this new version. For example, if a person has a nightmare of being attacked by a shark, the new version will still have water splashing, a fin in the water, and the feeling of a strong bump against the body of an animal. However, in this new version, the splashing is from a dolphin playing nearby, not a shark thrashing; the fin is a dolphin fin, not a shark fin; and the bump to the body is gentle, from the friendly dolphin (figure 5.5). People write out the new version of the dream, create an art piece depicting it, and tell the new dream as a story to another person. They meditate on the new dream before sleep to train the mind to shift over to this new set of details. Harvard psychologist Deirdre Barrett has written extensively about the benefit of working with dreams as a part of the recovery process for PTSD. She explains that dreams provide a "barometer" of a person's mental state, delivering insight into a patient's progress.*

Memory and Learning

Through dreams, our brains create connections between recent experiences and long-term memories. This equips us with new perspectives, allowing us to better respond to similar situations in the future. Our sense of self or identity also changes through dreams as we see our role in a recent situation through the lens of a memory from our distant past. Procedural memories—those for things like playing a song on the guitar or making your favorite cookies—are also processed and stored through dreaming. When we are learning a new procedure, let's say a dance routine, we will notice the first time we try it after a night of dreaming, we will do much better than on the previous day. NREM and REM dreams both play a role in memory formation, but there is a difference. NREM dreams serve more to strengthen memories, and REM dreams restructure them, marrying fresh experiences to earlier ones.

Taking a deep look at how dream content has an impact on learning and memory, sleep science experts Erin Wamsley and Robert Stickgold studied navigation in a virtual maze (figures 5.6a and 5.6b). Human participants trained on the virtual maze and then were allowed to sleep overnight. In prior animal studies on the subject, researchers had already

Figure 5.5 Transforming the nightmare

* Barrett, *Trauma and Dreams*, 282.

Your Next Actions for Justice

Think of someone you know who may have nightmares and ask them if you can share what you know about imagery rehearsal therapy (IRT). Since you are a layperson, skip this next step if the person is experiencing trauma, but if not, find out if they would like to share their nightmare with you so you can guide them, in your role as a student, through your understanding of IRT. If they have experienced trauma or if the nightmares are significant, you may suggest that they instead ask their mental health–care practitioner for help with IRT, since your advising them would be beyond the scope of your experience. If in these conversations you meet someone with suicidal feelings, contact the US National Suicide Prevention Lifeline* 1-800-273-8255. Another way to help would be if you know of a veteran or someone who works with veterans, in which case you could tell them what you know about IRT and suggest they consider looking further into it to help their clients and/or fellow veterans.

* "National Suicide Prevention Lifeline," accessed on December 3, 2021, https://suicidepreventionlifeline.org/.

shown that the animals' brain firing patterns during sleep closely matched the patterns seen when they were learning a maze, but how could we know what the animals were dreaming about? Previous studies on animals and humans also provided evidence of improved performance being associated with sleeping after attempting a task. The novelty of Wamsley and Stickgold's research was in asking participants about their dreams' content during the night and establishing the clear relationship between maze-themed content in dreams and success in navigating the maze the next morning. They also found that the participants who did not perform well during practice sessions with the maze were more likely to see the maze in their dreams that night.* If something is challenging for us, our brain knows we will be more likely to overcome the challenge if we dream about it. This fits well with Antti Revonsuo's "threat simulation theory," which posits that dreams help us develop better skills to behave successfully in the midst of difficult situations. He states that through dreams, we are able to rehearse threatening scenarios, with the result being improved outcomes in our next waking encounter with similar challenges.†

Figure 5.6a Virtual reality goggles

Figure 5.6b Maze

* Erin J. Wamsley and Robert Stickgold, "Memory, Sleep, and Dreaming: Experiencing Consolidation," *Sleep Medicine Clinics* 6, no. 1 (March 2011): 97–108, https://doi.org/10.1016/j.jsmc.2010.12.008.

† Antti Revonsuo and Katja Valli, "Dreaming and Consciousness: Testing the Threat Simulation Theory of the Function of Dreaming," *Psyche* 6 (October 2000), https://www.researchgate

Knowing sleep has such a powerful influence on storing memories, University of California, Los Angeles, neuroscientist Gina Poe proposed a solution to help people with PTSD. The background for her theory is work from an assortment of scientists studying the relationship between sleep/dreams and memory. When trying to learn something, one way to increase memory capacity and accuracy is to sleep, and thus dream, shortly after exposure to the content. It turns out the timing of the sleep matters for optimal memory creation: the sooner, the better. This knowledge about timing is used to schedule sleep for someone who has experienced a traumatic event. Poe suggests it is beneficial to hold off—for around eight hours after the event—before sleeping.* Delaying sleep onset diminishes the brain's ability to store traumatic event details, so the person is less likely to create vivid and lasting memories that would haunt them.

With so much focus on dreams helping us create memories, we could overlook a theory from the 1980s stating one of the functions of dreaming is to "unlearn" information. Scientists Francis Crick and Graeme Mitchison present a model of dreams as a mechanism for sorting through information in order to discard unnecessary memories from the day. Consider when you are ready to leave campus: it is important you remember where you parked your car or locked up your bike. The next day, it is best if the parking information is not crowding up your memory space, but you still need to remember how to get to class; dreams, in this theory, are a way that parking information is culled while the route to class is maintained.

Problem Solving and Creativity

Stories of creative inspiration arriving through dreams are pervasive: Dmitri Mendeleev's periodic table of elements, Mary Shelley's idea for *Frankenstein*, Elias Howe's design of the needle for the sewing machine, Friedrich Kekulé's vision of benzene ring structure, Keith Richards' guitar riff in *Satisfaction*, and more all are said to have come from dreams (figure 5.7). Rather than take space here to provide the details of these worn-out stories, you may Google the topics—and when you do, you will find Google itself was born in a dream!

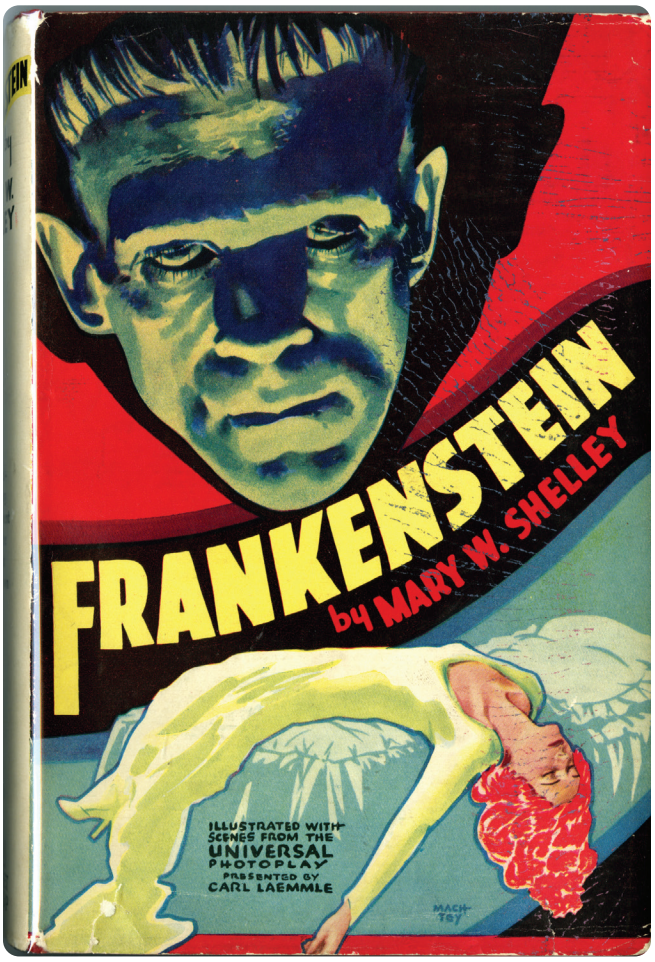


Figure 5.7 Frankenstein

There is one story worth telling here. It is about an inspiring role model, Sarah Breedlove Walker (a.k.a. Madam C. J. Walker), who was a civil rights activist and philanthropist up through the early 1900s (figure 5.8). The wealth she built to provide the financial resources to support herself and her philanthropy came in small part from a hair-loss remedy recipe that came to her in a dream. I say "small part" because most of her success is likely

.net/publication/232499090_Dreaming_and_consciousness_Testing_the_threat_simulation_theory_of_the_function_of_dreaming.

* "Faculty: Gina Poe," UCLA: Integrative Biology & Physiology, accessed June 6, 2021, https://www.ibp.ucla.edu/faculty/gina-poe/.

Figure 5.8 Madam C.J. Walker

due to her fortitude. She started life as the daughter of freed slaves, living in financial poverty in Louisiana, and spent years working as a single mother, since her parents and husband died by the time she was twenty. Then after a hard day of work as a washerwoman, she had a dream where a recipe came to her, including ingredients she ultimately had shipped from Africa, for a product to help her restore her hair, which had fallen out. She ultimately became a successful businessperson and multimillionaire, dedicating herself to helping others. W. E. B. DuBois said of Walker, "It is given to few persons to transform a people in a generation. Yet this was done by the late Madam C. J. Walker."*

With scores of stories about dreams providing creative solutions, it is no surprise there is a bounty of research that shows sleeping and dreaming on a problem makes us more likely to gain insight into a solution. Psychologist Ullrich Wagner and his colleagues scheduled cognitive testing sessions so that one group of participants would sleep in between their first and second testing sessions, while the other would not. The test consisted of tiresome math problems. Rules were provided for generating the solutions, but it was still a tedious and prolonged experience. But there was a secret shortcut that could be used if the participant had an epiphany about an abstract rule. Such epiphanies, in which the solution to a seemingly unsolvable problem suddenly becomes clear, happen more often if we dream about our problems. Wagner's team found that the people who slept between their first and second attempts had significantly more revelations that led them to the secret shortcut than those without the opportunity to sleep.†

But what if the participants' epiphanies about the secret shortcut were due simply to the fact that they'd slept and had nothing to do with the brain restructuring memories of the test problems during their dreams? To factor this in, they needed to do additional data collection on participants who took the test only once. They divided participants who had not yet seen the test into two groups, those who slept before the test and those who did not. There was no difference between the two groups in terms of discovery of the hidden rule: the sleepers and nonsleepers had the same rate of epiphanies upon taking the test for the first time. In other words, a participant had to have seen the test problems before sleep (as in the protocol with people taking the test twice) in order for the rate of epiphanies to increase (as they did when those participants saw the problems again). Notice how the researchers included this essential part of the scientific method: seek to disprove your hypothesis and look for alternate explanations, even if it seems you have proven the hypothesis you were seeking to prove.

* W. E. Burghardt Du Bois, "A Great Woman," *Crisis* 18, no. 3 (July 1919): 131, https://modjourn.org/issue/bdr512386/.
† Ullrich Wagner et al., "Sleep Inspires Insight," *Nature* 427, no. 6972 (January 2004): 352–55, https://doi.org/10.1038/nature02223.

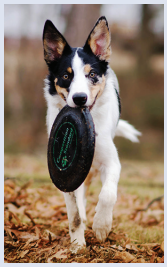
Ready to Move On?

Before moving on, consider this statement: "If you try only to prove your hypothesis, you will." Take a moment to think about something clearly and obviously true. Now propose a hypothesis that is ridiculous and untrue about the item you are thinking about. Can you see that if you look *only* for reasons your ridiculous hypothesis is true, it is very likely you could find at least one reason and decide to conclude that your hypothesis is true? What is missing? If you want to uncover the truth, you must also seek to disprove your hypothesis.

Emotional Intelligence

One of the pillars of healthy interpersonal relationships is emotional intelligence, which includes the capacity to understand and control one's own emotions and to recognize and interpret the emotions of others (figure 5.9). One aspect of this is being able to distinguish different facial expressions, such as for fear, anger, or joy. Without the benefit of time in our dream state, this ability drastically deteriorates to the point where not only do we lose the ability to tell the difference between a friendly or angry expression on someone's face but also our tendency is to assume the more threatening option. This was discovered in Matthew Walker's University of California, Berkeley, lab. Regarding how misinterpreting neutral facial expressions as threatening could cause harm, Andrea Goldstein, lead author on the study, urges, "Consider the implications for students pulling all-nighters, emergency-room medical staff, military fighters in war zones and police officers on graveyard shifts." One of the fascinating aspects of the study was that they studied the participants in an MRI scanner, so in addition to having the evidence reported by the subjects themselves, the scientists could also see how well (or poorly in the case of less REM sleep) their brain structures were doing in terms of distinguishing between the different expressions.

Figure 5.9 Facial expressions



Retrieval Practice

Start at the beginning of the chapter and skim the content through to the end of this section, noting all the reasons we dream. Then set aside the content and your notes and do not let yourself look at that material. Relying only on your memory, make a list of all reasons for dreaming. After you are done honoring that you were able to retrieve some of the content on your own, open the book and your notes and make additions and corrections to your retrieval practice list. Now if someone asks you, "Why do we dream?" do you feel like you are ready with a concise and interesting answer? Retrieval practices are one way to memorize fascinating content so you can gift it to others during your next conversation.

How and Where Dreams Are Created

In the 1970s, Harvard medical doctors J. Allan Hobson and Robert McCarley postulated a neurobiological model of dreams. They described REM-associated bursts of electrical activity in cats as originating in the pons (a part of the brainstem), traveling through the thalamus, and arriving at the cerebral cortex (figure 5.10). Along with this neuronal activity came twitches in whiskers and muscles, as well as jerky eye movements not typical of a cat tracking something visually, which therefore seemed random. The brainstem's electrical activity patterns were not similar to those seen in animals processing real sensory information either; however, the cortex, influenced by this chaotic activation, was still trying to make sense of the activity and synthesizing the brainstem activity into a dream. This is the premise of Hobson and McCarley's activation-synthesis model of dream creation. For some people, the activation-synthesis model makes a case for dreams being meaningless, since they are based on seemingly random activity. However, if we consider that the dreamer interprets dream content based on its relationship with their waking experiences, interpretations of dreams generated according to this model still provide an opportunity for personal insight.

Debate about the activation-synthesis model continues, but there is no debate about how the advent of magnetic resonance imaging (MRI) has increased awareness of many additional brain regions that are active during dreaming. Contemporary research has utilized MRIs to provide a window into dream-related brain activity, showing high levels of activation in brain regions associated with feeling emotions, creating movements, and comprehending visual scenery (figure 5.11). Surprisingly, some of the brain structures, such as the amygdala, anterior cingulate gyrus, and hippocampus—parts of the "emotional brain" or limbic system—are even more active during dreaming than when we are processing information in our waking state.

In sharp contrast to the activation-synthesis model, neuropsychologist Mark Solms proposes that dreams are created in the cerebral cortex, specifically the ventromedial prefrontal cortex (figure 5.12). This part of the brain is involved in a range of functions such as goal-seeking, regulating challenging emotions, recognizing facial expressions, and processing risk. It also provides connections between the limbic system and the frontal cortex. In the early half of the twentieth century, this was one of the brain regions destroyed in attempts to treat mental illness. Solms found

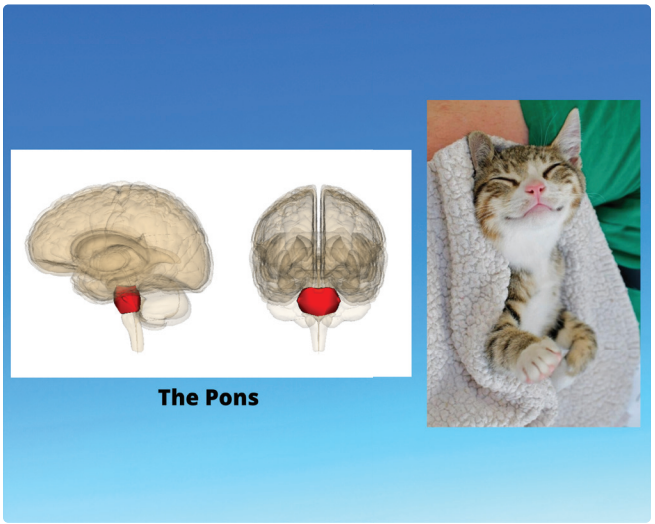


Figure 5.10 The pons is highlighted in red

Figure 5.11 In the MRI

that patients with damage to this area, whether from surgeries or other injuries, did not dream.

In this chapter, we are focused primarily on REM dreams, but let's briefly consider the activity of the limbic system during NREM dreams, which we know are bland and lacking in emotion. So it follows that the limbic system is quite mellow during NREM dreams.

On the other hand, it turns out, if we look further, that there are brain areas that become inactive during REM dreams as well. When we consider the bizarre and sometimes embarrassing things we do in REM dreams, the deactivation of one of these brain regions in particular makes perfect sense: the prefrontal cortex, which guides you to use good judgment and be sensible and socially appropriate, has exceptionally low activity during dreaming (figure 5.13). Another area that seems to almost drop out of the game during REM dreaming is the primary visual cortex. This region of your brain is involved in consciously detecting visual stimuli from your eyes, so it is logical that, since your eyes are closed while dreaming, the primary visual cortex has almost no activity at that time. The brain is still able to generate visual content for dreams, as it still relies on the visual association cortex—the part of the brain that processes more complex visual information.

Rather than looking at particular brain structures for the source of dreams, Harvard Medical School sleep researcher Robert Stickgold asked participants to look at the events and emotions of their days for the source of dream content. Participants kept diaries of their daytime activities and their dreams. The dreams were not a replay of daytime events. However, the worries and emotional themes of the day were often incorporated into the dreams. If we leave the activation-synthesis model behind in favor of theories such as Stickgold's, suggesting dreams contain meaningful information, then it's time to move to the next section for a discussion of how to interpret dreams.*

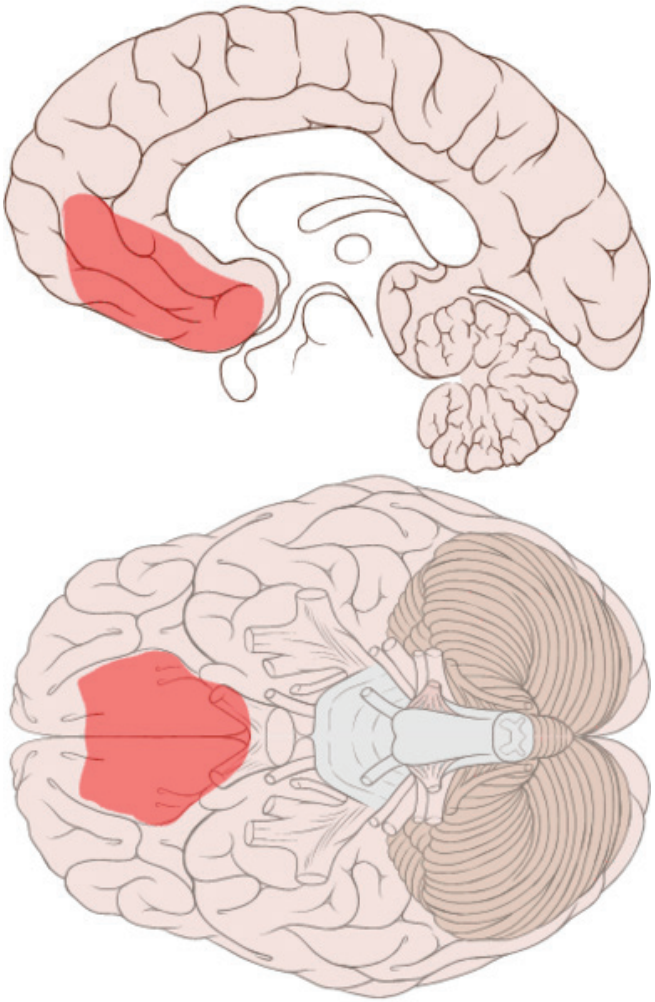


Figure 5.12 Ventromedial prefrontal cortex

* Magdalena J. Fosse et al., "Dreaming and Episodic Memory: A Functional Dissociation?," *Journal of Cognitive Neuroscience* 15, no. 1 (January 2003): 1–9, https://www.researchgate.net/publication/10896475_Dreaming_and_Episodic_Memory_A_Functional_Dissociation.

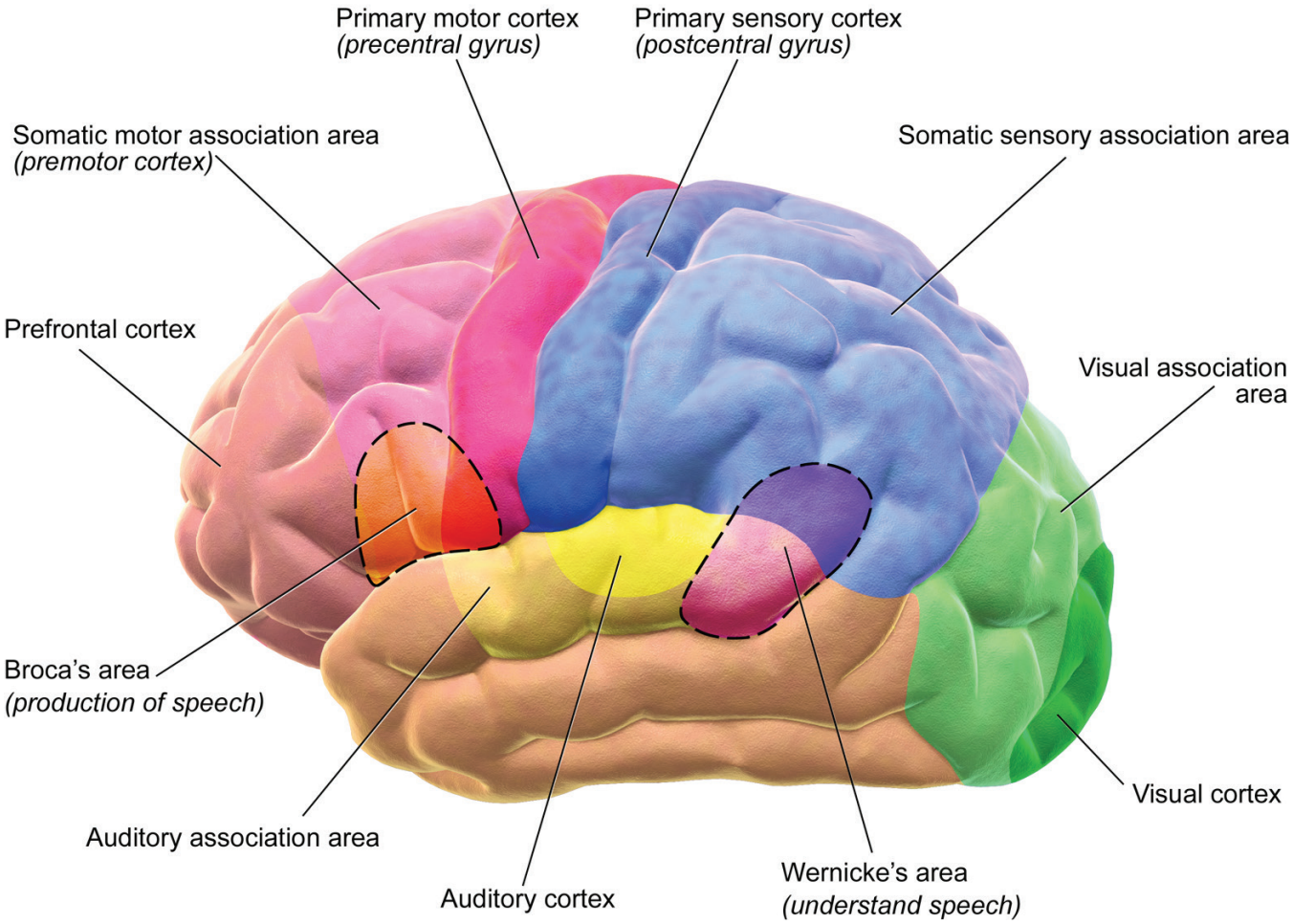


Figure 5.13 Motor and sensory regions of the cerebral cortex

Interpretation of Dreams

Over five thousand years ago in Mesopotamia, people were having their dreams interpreted and looking to them for divine guidance (figure 5.14). Throughout the years and around the world, dream interpreters and sometimes priests have been trusted to translate dream content into something meaningful for the dreamer. With the emergence of the discipline of psychology in the nineteenth century, the practice began to include psychologists as interpreters as well.

Sigmund Freud, an Austrian neurologist, believed dreams contained symbolic information requiring interpretation by an expert. He thought dream content would be too disturbing for the dreamer. For example, the dreamer may feel too ashamed to admit to a fantasy they are having, so the content has to come to the dreamer in symbols. (It was convenient for Freud that he, as a self-proclaimed expert, could charge people money for these interpretations.) According to his approach, dreams contain two categories of content: manifest and latent. Manifest content is the obvious material from the dream—the way the dreamer would describe the dream. Latent content is the hidden material that indicates the dreamer's secret desires and fears. These repressed feelings, once revealed in a dream analysis session, could be used to identify and treat a person's problems. There is great value in exploring and analyzing dream content, but

Figure 5.14 Mesopotamia

Freud's particular method of dream interpretation has been put to the test by scientific studies that have shown that different experts using his technique will come up with vastly different conclusions about the meaning of the same dream. These studies suggest a lack of reliability in his approach to dream analysis.

A psychiatrist colleague of Freud's, Carl Jung, disagreed with Freud on the need for dreams to be deciphered. Jung was convinced that the same symbol means something different to each person, so there was no use in trying to create a book of dream symbols that could be applied as a part of dream analysis. Instead, Jung thought our instincts convey wisdom to our rational mind via dreams. He said we were disconnected from nature and our instincts because of modern society, so we should use our dreams to reconnect and be transformed.

At around the same time that Freud and Jung were placing emphasis on the deep psychological meaning of dreams, Mary Whiton Calkins, a pioneer in psychology, was developing an opposing theory. As a part of her project at Clark University in Massachusetts, she examined over two hundred dream reports and concluded that dream content is closely related to recent experiences, almost like a related replay of the day's events and sensations, and that dreams do not contain hidden meaning. She said, "In fact, my study as a whole must be rather contemptuously set down by any good Freudian as superficially concerned with the mere 'manifest content' of the dream." Calkins must have been courageous not only for challenging conventional wisdom about dreams but because she was attending psychology seminars at Harvard with special permission, since women were not often allowed at the then all-male

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

ʻAumākua is Hawaiian for "ancestral guardian spirits" (figure 5.15).

college. She even fulfilled all the requirements for a doctorate in psychology at Harvard, receiving high recommendations from professors, including William James, but the institution still refused to grant her the degree since she was a woman. However, she went on to Wellesley College, where she created a psychology lab—one of the first in the nation—and became the first woman to serve as president of the American Psychological Association, soaring beyond Harvard's discriminatory policy.

Dreams in Different Cultures

Looking around the world to consider diverse attitudes about dreams, a common theme is that many view dreaming as an opportunity to connect with the divine. In the Quran, one type of dream is called ru'ya. Rather than being created by the dreamer's mind, a ru'ya comes from God or the angels, and therefore a ru'ya is believed to have a purpose and meaning. There is a parallel in Hawaiian culture in that dreams from spirits are thought to have significance, in contrast to dreams the dreamer created, which are thought to be meaningless and pupule (crazy). In Hawaiian tradition, dreams are part of the bond between the spirits of those who are living and those who have passed. While a living person is dreaming, the spirit leaves the body through the luaʻuhane ("pit for the spirit," which is our tear duct) and travels to receive guidance from ʻaumākua (ancestral guardian spirits) and akua (gods).

Ancient Egyptians also used dreams to travel in their dream body and connect with gods and the spirits of the departed. People would visit the temple of a god or goddess, such as the goddess

Figure 5.15 Green sea turtle

Isis (who has nothing to do with the Islamic State terrorist group) for dream interpretation or incubation (figure 5.16). The dreamer might spend days preparing for dream incubation—a time to encourage dreams rich in guidance—by purifying themselves through ritualistic bathing, fasting, and praying before sleeping in a temple. After awakening from the dream, an oracle would be available to interpret the dream, which was especially valuable, since one of the strategies was to interpret dream content as the exact opposite of its literal meaning. The temples were also available for visitors who had slept and dreamt at home to consult with priests on dream interpretation.

Figure 5.16 Temple of Isis

Lucid Dreaming

Bringing awareness that we are dreaming into the middle of a dream, opens another world for learning, creativity, resolving trauma, and more. Lucid dreaming refers to the conscious realization that we are dreaming while still remaining asleep and deep in the dream. Taking things one step further, a person who is lucid dreaming can learn to control the content and progression of the dream. This control is particularly beneficial when working with persistent nightmares because dream scenery and outcomes can be resolved and transformed into something pleasant.

Here are some steps to take if you would like to learn to lucid dream:

1. Develop skill at remembering dreams and keep a dream journal. If remembering dreams is difficult for you, one strategy is to set an alarm for two hours before you are supposed to wake up in the morning. After the alarm goes off, remain in bed, eyes closed, and still. Try to recall the last feeling or thought in your mind. After you have that setting established, then go slowly backward in your mind, trying to recall any other impressions. In general, to help improve your dream recall, sleep at least eight hours, because then you will be more likely to awaken after a long REM period with the vivid dreams that are associated with that stage of sleep.
2. Take stock numerous times during the day to notice you are not dreaming. Increase your awareness of the nondreamlike qualities of your waking state: Every time you look at your phone or your watch, the color and shape remain the same. If you are talking to someone, they do not spontaneously turn into someone else. Doing this several times during the day trains your brain to notice the details that indicate the waking state. This task is in contrast to the next step.
3. Notice things about your dreams you do *not* experience in your waking state. The idea is to become intimately familiar with your dreams. During dreams, people *do* turn into other people spontaneously, and your phone or your watch *may* change shape or color if you look away and then look immediately back at them. You might also experience repeating elements, such as the appearance of a friend you have not seen in years or how you are able to fly if you run fast enough. For example, I am a surfer, and in my dreams, water is colossal and defies the laws of physics (figure 5.17).
4. Combine the previous two steps to increase awareness of whether you are dreaming. Tell yourself ahead of time that if you see your friend from kindergarten or if you notice you can fly when you flap your arms, you will know you are dreaming.

Figure 5.17 The wave

5. Set an alarm to awaken in the middle of the night. After it goes off, keep your eyes closed and hold still, recalling the recent dream. Meditate on the dream and tell yourself you are going to fall back asleep into the same dream and you will be aware you are dreaming. Hopefully, you will drift into a pleasant lucid dream.

Figure 5.18 Stretching together before the discussion

Conducting a Dream Group

This is best done in a group of four to six people seated in a circle but is still satisfying and productive in groups of different sizes (figure 5.18). It is reassuring to state at the beginning that nothing shared in the group will be discussed outside of the group. Everyone is responsible for keeping the group on track with the steps, but it is helpful to designate a leader to take that responsibility. A different person takes over the role of leader when the group finishes all the steps and

Dreamer Tells the Group the Entire Dream

Everyone writes down the dream as brief notes in preparation to later read it back to the group.

Group Members Ask Questions

Go around the circle and ask the dreamer about their recent experiences (or those close to the time they had the dream, if it is not a recent dream). This is to establish emotional context. Sample questions might include the following:

> Anything on your mind, like a book or something else you read, a TV show or movie, a phone call? Anything going on at work/school? What's happened lately with friends/family?

Avoid asking "Why do you think you had _____ in your dream?" This is too direct. Rather, ask "Do you have any recent experiences with _____?"

Group Members Read the Dream Out Loud

Go around the circle, with each person reading a small part of the dream, in order, from the notes they created when the dreamer shared their dream in the first step. In this way, the dream is retold by group members with the dreamer listening. This often prompts the dreamer to recall more details from the dream.

During the retelling, the dreamer is encouraged to add in details and share thoughts or theories as they arise.

At any time, group members may ask additional open-ended questions, similar to those in the second step.

Group Member Projections

Go around the circle, with each group member projecting their ideas as if the dream were their own. For example,

> "If I dreamt about _____, it might mean _____."

Each group member is not meant to guess what it means to the dreamer; rather they are projecting what it would mean to themselves.

The dreamer shares any epiphanies as they come up during the projections. Even if the dreamer finds a projection completely unrelatable to their own experience, that is also helpful, as it rules out possibilities on the way to gaining insights.

Open and Unstructured Conversation

Freely discuss and continue to analyze the dream until the group is ready to move on to the next person and their dream. At the end, everyone thanks the dreamer for sharing.

finishes the analysis of one dream before moving on to the next person's dream. Revelations about each dream's meaning will arise throughout the process, usually in pieces, and the interpretation discussion can continue without structure after the final step. The group should work on one dream at a time, going through all the steps and including the final open discussion about interpretation before moving on to the next person and their dream.

6

Sleep Disorders

Student Learning Objectives

After you read this chapter, you will be able to

- differentiate between poor sleep due to unhealthy habits and that which is caused by a sleep disorder
- describe several sleep disorders as well as their etiology and potential treatments, including holistic approaches

Introduction

While a disorder such as obstructive sleep apnea—not breathing during the night—is very serious and has lethal consequences, it is also essential that other, seemingly more subtle sleep disorders, such as periodic limb movements, get diagnosed and treated. For example, if someone has daytime sleepiness, and sleep apnea has been ruled out, the person still needs to find out what is leading to their sleepiness. In chapter 1, we have covered sleep debt and its serious consequences, such as depression, stroke, heart attack, obesity, diabetes, and more. Therefore, we must not take lightly any condition that disrupts sleep. In my workshops, I have met people all over the world who tell me they had undergone sleep studies in which, after apnea was ruled out, they were sent on their way with no further investigation or advice. Or worse still, they were given a prescription for sleeping pills, which are not meant as a long-term solution and can lead to countless other problems with no benefit or, at most, perhaps twenty additional minutes of sleep a night. We need to advocate for ourselves and loved ones to get health-care practitioners to persevere until we know what is causing daytime drowsiness and get it treated. Our lives depend on it.

Insomnia

Many people who suffer from poor sleep think they have a disorder called insomnia. However, most people who believe this actually have a particular factor causing their poor sleep, and such factors can usually be addressed—the sleep is improved and insomnia goes away. It is rare for a person to have insomnia not caused by something else, such as stress, physical pain, medication, a psychiatric disorder, a physical illness, or poor sleep-health habits. These are what I mean by "factors" causing insomnia.

The most straightforward factors to address are poor sleep-health habits. Refer to chapter 1 to identify and determine strategies to attend to habits disturbing your sleep. That chapter also has detailed instructions for several techniques to alleviate insomnia as well as recommendations for effective treatments; the gold standard is cognitive behavioral therapy for insomnia. For many people, following the guidelines in chapter 1 will fix their sleep. If not, a sleep specialist can determine what other factors need to be addressed and develop a treatment approach. Once all these factors have been addressed, if the person is still not sleeping well, then a clinical sleep study may be necessary to identify an underlying sleep disorder causing

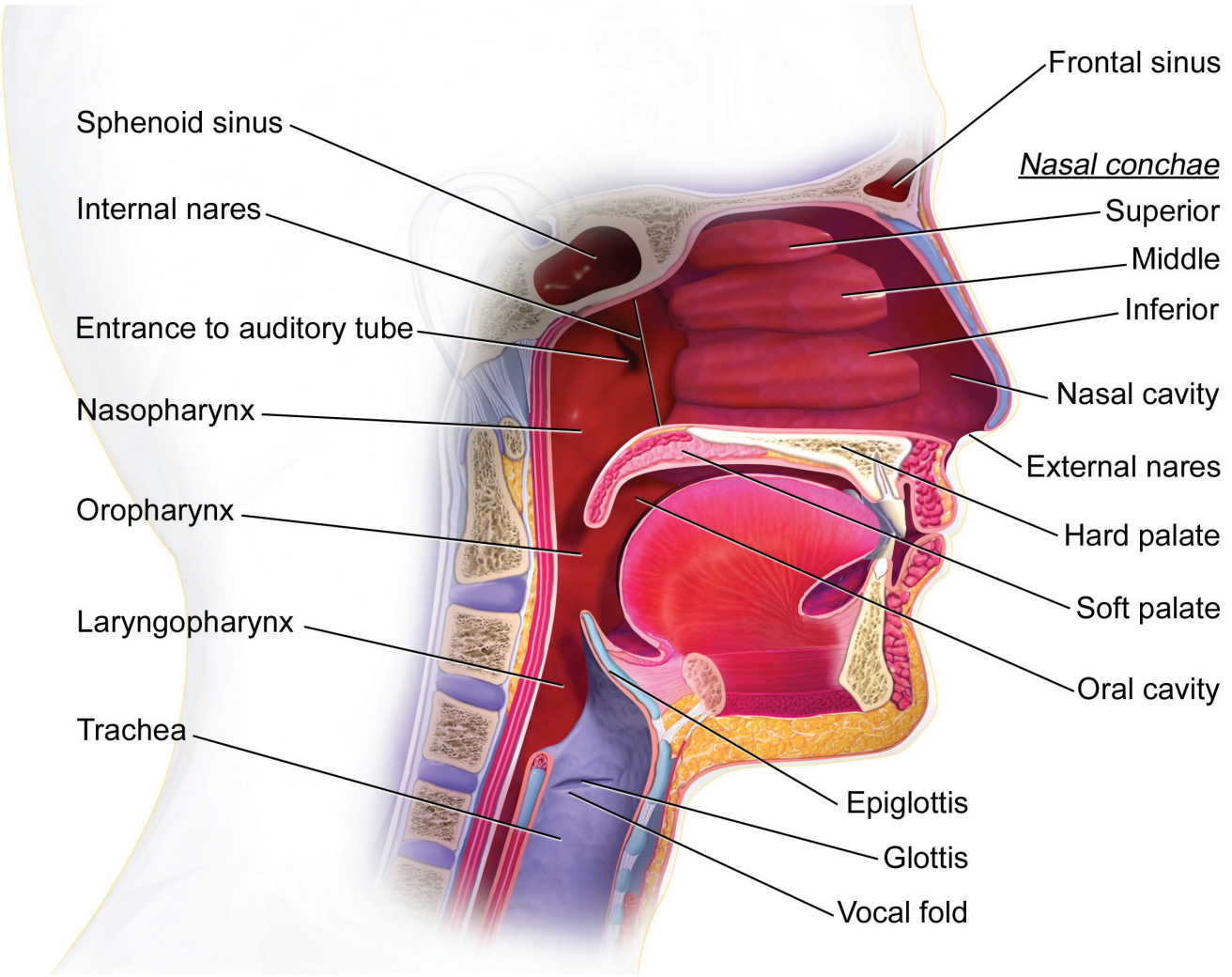


Figure 6.1 Mouth and pharynx

the insomnia. But for most people, their sleep will be restored before they get to that stage.

Snoring

Have you ever noticed that if a snoring person rolls on their side, it sometimes brings even the most skull-shattering sound to a halt? Snoring can be caused by the architecture and muscle tone of the structures in and around the pharynx, which is made up of the nasopharynx, oropharynx, or laryngopharynx (figure 6.1).* During sleep, the waking-state muscle tone is lost and this tissue closes in to varying degrees and vibrates as the breath moves past. There are other locations, such as the nasal passageway or between the lips, that can cause snoring. It often occurs during inhalation but also happens with exhalation. Consuming alcohol, smoking cigarettes, or having nasal congestion from a cold worsens snoring, as can being overweight or pregnant. While some snorers have no idea they are snoring and will swear, "I never snore," others will awaken themselves with the noise. Heavy snoring might be an indication of obstructive sleep apnea, but not always. Because of the potentially lethal consequences of obstructive sleep apnea, if a heavy snorer is also sleepy during the day, it is important to consider a sleep study to rule out apnea. This path of preventative medicine may save the snorer's life.

* See also Capital Otolaryngology Head and Neck Surgeons, "What Causes Snoring and Obstructive Sleep Apnea?," YouTube video, accessed May 5, 2021, https://www.youtube.com/watch?v=i5p0I-Jvtss.

Treatments for snoring include side sleeping, losing weight (if overweight), eliminating nicotine, and avoiding or reducing alcohol. There are also many devices that can help, from inexpensive over-the-counter gadgets to costly oral appliances designed by dentists trained in sleep medicine. The range of efficacy of these devices is broad, with the same device working well for one person and not at all for another.

One of the populations overlooked in regard to sleep disorder–related breathing is children, even though up to 15 percent of them may have it. It is disconcerting that 90 percent of such cases are undiagnosed. It can be associated with headaches, irritability, bedwetting, and of course, daytime sleepiness. Causes range from problems with tonsils to irregular facial bone development, so engaging a pediatric otolaryngologist (ear, nose, and throat physician) can be impactful.

Obstructive Sleep Apnea

The statistics surrounding obstructive sleep apnea (OSA) are alarming when we consider it occurs in more than one in four adults between thirty and seventy years old, with over 80 percent of cases undiagnosed. If a risk factor such as having post-traumatic stress disorder or being overweight is added to the equation, the likelihood of having OSA increases dramatically. OSA can cause diabetes, weight gain, stroke, heart attack, high blood pressure, and depression, so we must increase education and screening for OSA. But what is OSA exactly? The airway is obstructed during sleep, and the oxygen levels in the body and brain drop, with associated damage to tissue depending on the severity of the disorder. If oxygen levels drop low enough, small parts of the brain and the heart could die each night. The reason airflow gets blocked is usually because the tissue of the throat or the weight of the tongue closes off the opening in a manner more extreme than snoring. Snoring allows the air to pass through, despite the vibration of the tissue. In contrast, with OSA, the air is blocked for a varied amount of time, happening a few or hundreds of times each night, often without the sleeper having any idea. Heavy snoring can be an indication of OSA, but also people who do not snore at all might still have OSA. Waking up with headaches, feeling sleepy during the day, and having cognitive decline or unexpected weight gain are all OSA symptoms. OSA is diagnosed with a sleep study, and now there is also at-home equipment that can be used in many cases, making it even easier to take this crucial step to improve health.

Once OSA is diagnosed, there is an assortment of choices for treatment, including weight loss (if a person is overweight), quitting smoking and/or drinking alcohol, sleeping with an apparatus to keep the person on their side, and using oral appliances or devices that keep the airway open with air pressure. Continuous positive airway pressure (CPAP) consists of a piece that goes over the mouth and/or nose connected to a hose that supplies a flow of air to keep the airway open. There is an array of shapes and sizes, so if a patient is not comfortable wearing what they are given, it is important that they advocate for themselves to get a more comfortable device (figure 6.2). There are also oral appliances that can hold the tongue or move the jaw forward, and these do not rely on an airflow machine. Some patients resort to surgeries, but they are typically not as effective as CPAP. Visit this Harvard Medical School website* for apnea resources and a video of retired basketball player Shaquille O'Neal going through the process of being diagnosed and treated for his OSA.†

Central Sleep Apnea

Central sleep apnea (CSA) is a rare disorder compared to OSA and is associated with the brain not sending the signal to breathe.

Some cases of CSA are caused by problems with the heart or kidneys or from taking opioids

* Division of Sleep Medicine, "Apnea: Understanding and Treating Obstructive Sleep Apnea," accessed on December 3, 2021, http://healthysleep.med.harvard.edu/sleep-apnea.
† Harvard Medical School, "Shaq Attacks Sleep Apnea," YouTube video, 4:16, May 5, 2011, https://www.youtube.com/watch?v=4JkiWvWn2aU.

Figure 6.2 Continuous positive airway pressure (CPAP) consists of a piece that goes over the mouth and/or nose

for longer than two months. The concept of CSA is similar to OSA in that the person will be tired during the day because they are not receiving enough oxygen when sleeping, but treatments will vary depending on the cause.

Sudden Infant Death Syndrome

Sudden infant death syndrome (SIDS) is not a sleep disorder per se, but it is worthy of discussion in this chapter. SIDS is the sudden, unexplained death of an infant younger than one year old and is the leading cause of death in children one to eleven months old. The highest rates are in babies two to four months old. Research suggests it is linked to an abnormality in the brainstem. Studies are underway to further investigate the possibility of a hearing screening test to identify babies at increased risk of SIDS. The connection may be the hearing pathway traveling through the brainstem. While the cause of SIDS is not known, certain practices increase the risk and so are best avoided: inhaling secondhand smoke, sleeping on soft surfaces, overheating, or sleeping on the stomach. The current advice is to put babies on their backs to sleep, use a firm mattress, and put babies in sleep clothing or a sleep sack so covers are not necessary (figure 6.4). Breastfeeding has also been shown to dramatically reduce the risk of SIDS.

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

Hā is Hawaiian for "breathing" (figure 6.3).

Restless Legs Syndrome

Having restless legs might not sound too bad, but with an increased risk of depression and anxiety, as well as the myriad consequences of poor sleep, restless legs syndrome (RLS) has far-reaching repercussions on a person's life. This arises from what is often an indescribable sensation—perhaps tingling or itching—that triggers an overwhelming urge to move the legs. The sensations tend to disrupt daily activities, such as riding in a car or sitting in a classroom, and they are deleterious to sleep.

Sometimes the cause is unknown, but anemia, diabetes, or pregnancy could give rise to RLS or make it worse. Medications such as antidepressants, allergy medications, over-the-counter sleep

Figure 6.3 Hā

Figure 6.4 Back to sleep

drugs, and antinausea medications can cause and aggravate RLS.

Exercise may relieve the symptoms of RLS, but interestingly, exercising with too much intensity can increase them. Stress-reducing and muscle-relaxing practices such as yoga, meditation, warm baths, and massages mitigate the symptoms and promote sleep. Eliminating nicotine, alcohol, and caffeine is crucial.

Periodic Limb Movements

Occasionally people confuse periodic limb movements (PLM) with RLS, but they are separate disorders. While RLS sensations cause the *urge* to move the legs, PLM is an unconscious and uncontrollable movement itself. The big toe or leg moves a couple of times a minute for up to an hour. Sometimes, though rarely, movements are also in the arms. These common leg movements often do not disrupt the sleeper and, if that is the case, would not be considered a disorder. In fact, a sleeping partner is the one who may have their sleep disrupted, while the person with PLM is snoozing peacefully. If the movements do disrupt the sleep of the person with PLM, at that point, it is considered a disorder and will have all the consequences of poor sleep.

Sleep Leg Cramps

Almost everyone will experience sleep-related leg cramps at least once in their life, but some individuals have several of these intense and painful muscle contractions every night. Both the cramp itself and the lingering pain make it difficult to sleep. Sleep leg cramps are more likely in the presence of diabetes, dehydration, electrolyte imbalance (including potassium, calcium, or magnesium), diuretics, and some medications. While strenuous exercise is sometimes listed as an aggravating factor, the association might be more about a lack of rehydration, stretching, or electrolyte replacement after the strenuous exercise rather than the exercise itself. In most cases, daily exercise, including stretching, helps prevent leg cramps (figure 6.5). In addition to a daytime exercise program, light exercise—like a walk or gently riding a stationary bike—for a few minutes before bed can fend off cramps. During the cramp itself, stretching, walking, massaging, and heat provide relief. Healthcare practitioners are able to determine if there are imbalances (such as an electrolyte imbalance) or other medical conditions that, when treated, will resolve the leg cramps.

Bruxism

Strongly clenching the jaw or grinding the teeth during sleeping or waking states is called bruxism. As a sleep disorder, the episodes happen from a few to hundreds of times each night. Depending on its severity, bruxism can damage teeth, disrupt sleep, and lead to headaches or pain similar

Figure 6.5 Stretching

to an earache. In many instances, people who have bruxism are wholly unaware. Risk factors are stress, anxiety, anger, frustration, extreme competitiveness, hyperactivity, medications (including antidepressants), nicotine, alcohol, caffeine, and some mental and physical health disorders (such as gastroesophageal reflux disease). To aid in resolving bruxism, consider cognitive behavioral therapy (for anxiety, stress, etc.) and relaxation strategies such as mindfulness, meditation, and yoga, as well as addressing the risk factors. Oral appliances—similar to mouth guards—protect the teeth during sleep but do not address the disorder.

Sleep Paralysis

Since it is normal to be paralyzed during REM sleep, "sleep paralysis" does not sound like a disorder, but it is. Perhaps it should be called "presleep paralysis" or "postsleep paralysis" because those are the times it occurs. An episode of a few seconds or minutes may happen several times a year or only once in a lifetime. A person is unable to speak and cannot move except to breathe and move their eyes. Most of the people I have worked with who have sleep paralysis have reported visual hallucinations, such as seeing a person at the foot of the bed, and also feelings of anxiety during the episode (figure 6.6). Being sleep deprived or stressed or having an irregular sleep schedule increases the likelihood of having sleep paralysis. It is also associated with particular medications, narcolepsy, and psychiatric conditions, including bipolar disorder. Other than ruling out and addressing mental or physical health problems and narcolepsy, the treatment usually involves attending to stress and getting regularly scheduled eight-hour sleep sessions each night. To reduce their anxiety, I have coached people on meditation and breathing techniques to use during the paralysis. They have all reported to me that the

Figure 6.6 Sleep paralysis hallucination

practice makes them feel less aversive and fearful of the episodes, and consequently, their sleep quality improved.

REM Sleep Behavior Disorder

When the normal paralysis of REM sleep does not take over, a person will act out their dreams by jumping, shouting, swinging their arm, or whatever happens to be taking place in the dream (figure 6.7). This is REM sleep behavior disorder (RBD). Unlike sleepwalking, a person with RBD will usually have their eyes closed and rarely walk. Upon awakening, they swiftly become alert and are able to report their dream, which will contain activities that match their observed movements. This can happen four times a night, every night, or as rarely as once a month. The sleeper does not have awareness of the episode. Alcohol use (and withdrawal), certain medications, and sleep debt exacerbate RBD. Because more than one in three people with Parkinson's disease also have RBD, health-care practitioners recommend monitoring RBD patients for signs of Parkinson's so early treatments to slow the course of the disease can begin immediately. RBD patients are also at greater risk of experiencing other sleep disorders, such as narcolepsy and sleep apnea, so they require regular sleep studies so these other disorders can be diagnosed and treated. RBD itself is usually treated with medication.

Figure 6.7 Falling asleep

Sleep-Related Eating Disorder

Getting up in the middle of the night for a snack might sound harmless, but that is not the only thing happening with sleep-related eating disorder (SRED). In this case, the person will typically binge eat quite rapidly and, since they are not completely alert, could cut or burn themselves cooking. The foods they eat are also sometimes inedible items such as raw meat, coffee grounds, or even cleaning supplies (figure 6.8). Unlike a sleepwalker, who will likely be scared if you awaken them, a person with SRED tends to be angry and hostile when aroused from an episode. They may or may not have any memory of the event, so it can be frightening to arise in the morning to a messy kitchen and a stomachache. Using antidepressants, sleep prescriptions, and other drugs can cause SRED. Getting poor sleep increases the frequency of these episodes. Typically, a doctor will prescribe medication to treat the symptoms.

Sleepwalking

During slow-wave sleep in the first half of the night, a person may walk, or sometimes run, out of bed, with glazed-over and open eyes (figure 6.9). They talk or engage in other behavior, sometimes elaborate and/or inappropriate. Episodes can occur just a few times in a year or several times each night, or even during a nap. Awakening someone from sleepwalking can be very scary and disorienting to the sleepwalker. While it is a myth that it is dangerous to awaken a sleepwalker because they may die from the fright, it is in fact dangerous to awaken a sleepwalker too suddenly because, in their confusion, they may attack and hurt you or themselves. If you feel completely comfortable, gently guide the person back to bed, touching them as little as possible, coaxing them in the right direction until they get into bed themselves. That approach is risky, so the other option is to get a safe distance away and make a noise, gradually increasing in volume, until the person awakens. They will startle, but at least you are out of harm's way. Then gently explain to them that they are all right and were sleepwalking.

Figure 6.8 Midnight snack

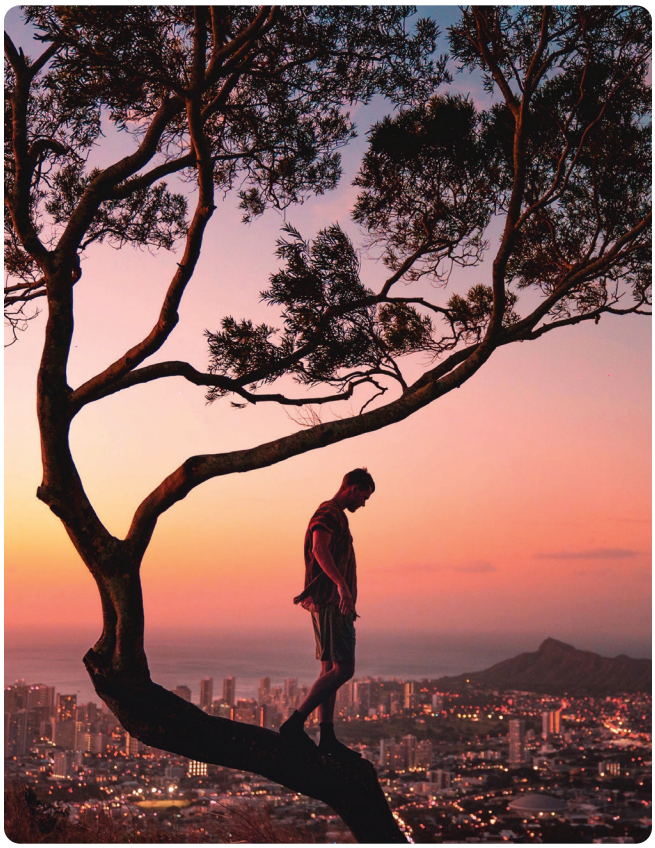


Figure 6.9 Sleepwalking can be dangerous

Alcohol, sleep prescriptions, stress, irregular sleep schedule, posttraumatic stress disorder, asthma, premenstrual syndrome, fever, certain drugs, and sleep debt can cause sleepwalking. Mindfulness, meditation, hypnosis, and stress-reduction strategies can treat it. It is also important to do a safety check in the bedroom and home to minimize the harm that may come during an episode. For example, make sure the sleepwalker will not have easy access to prescription drugs, scissors, or car keys, and put gates across stairways.

Now that you are familiar with sleepwalking, take a moment to compare it to REM sleep behavior disorder.

Bad Dreams, Nightmares, and Night Terrors

It is normal to have an occasional "bad dream," slightly distressing in its feeling. However, when a dream is so upsetting that it causes you to wake up, it is called a nightmare (figure 6.10). On their own, nightmares are not a sleep disorder unless they occur so often that they are making you lose sleep. One of the difficulties is that since nightmares occur during REM sleep, the dream is vivid, so upon awakening, and even throughout the next day, it can be a challenge to clear it from the mind.

In contrast, when aroused from a night terror, which usually occurs during slow-wave sleep, with its associated dull dreams, there is usually no memory of the dream. However, there is nothing dull about the physiological response to night terrors. A person awakens from a night terror with an overpowering sense of fear and a pounding heart, shaking and perhaps even screaming, jumping out of bed, or striking out at someone. They are also usually disoriented and slow to respond to someone trying to soothe them. Night terrors are typical during the first third of the night, when we have the most slow-wave sleep, while nightmares usually occur during the latter third of the night, during our longer periods of REM.

Nightmares and night terrors have a range of causes including antidepressants, high blood pressure prescriptions, alcohol, posttraumatic stress disorder, exhaustion, mental disorders, and inconsistent sleep schedules. Treatments include addressing these factors as well as implementing stress-reduction and mindfulness practices. Imagery rehearsal therapy is a promising treatment as well and has also helped reduce daytime trauma symptoms (see chapter 5).

Bedwetting

A child might not be able to control their bladder during sleep until they are five years old, so unless there is bedwetting twice or more a week in a child over five years old, it is not considered a disorder. It is crucial that if a child wets the bed, their self-esteem is considered in the parent's handling of it. In addition to being harmful to the child's emotional health, shaming them for it is also known to make the bedwetting more severe and take longer to resolve.

Figure 6.10 Nightmares

If a child has gone six or more months without bedwetting and then suddenly begins again, it could be due to stress, a urinary tract infection, constipation, or another disorder. In elderly adults, bedwetting may occur with dementia, depression, or obstructive sleep apnea. Some forms of diabetes also cause bedwetting. Rarely, hormonal imbalances could cause bedwetting at any age. Normally, antidiuretic hormone (vasopressin) levels rise during sleep to keep the amount of urine produced low enough so the bladder holds it all night. If these levels are too low, the bladder may fill multiple times during the night, so the person would need to wake up repeatedly to go urinate in the bathroom and might eventually be too tired to awaken. Once mental and physical health issues have been ruled out, treatment should focus on minimizing any shame associated with bedwetting combined with behavioral therapies such as enuresis alarms and positive reinforcement.

Jet Lag

Traveling across time zones can be ruinous to your sleep schedule. You may find yourself waking up in the middle of the night, wide awake and with no ability to go back to sleep, and during the daytime, you may get hit with a strong and sudden wave of uncontrollable sleepiness (figure 6.11). For many people, it takes one day for their circadian rhythm to shift one hour, so in the days

before a trip, try shifting your bedtime closer to that of your destination. Stay hydrated and avoid or have only minimal caffeine and alcohol during the flight. Consider incorporating bright light in the morning or early evening, depending on the direction of the shift; daily exercise; and scheduled fasting. Some people find melatonin supplementation shortly before bedtime on the night of arrival or at the beginning of a red-eye flight to be helpful. Be cautious, and seek advice from your health-care practitioner regarding melatonin because it interacts with some medications and natural remedies. Also, researchers have found that some melatonin supplements carry dangerously high levels of the hormone (many times higher than what is stated on the bottle), and some products labeled "melatonin" contained no melatonin at all.*

Short Sleeper

Research suggests there is a genetic difference that changes the sleep need of a rare few—less than 1 percent of the population—so they need less than six hours of sleep a night. They never sleep longer than six hours, even on weekends, and they do not need naps. Every morning, they wake up feeling refreshed; they do not have any drowsy periods during the day and so do not need caffeine or any stimulants to stay alert. This sleep pattern begins in childhood, lasts throughout life, and tends to be accompanied by other characteristics like a generally upbeat mood, less of a reaction to painful stimuli, and a somewhat manic personality. It is not possible to teach yourself to be a short sleeper, and if you need to sleep in on weekends, wake up less than revitalized, feel drowsy during the day, or need caffeine to stay alert, you are not

* Madeleine M. Grigg-Damberger and Dessislava Ianakieva, "Poor Quality Control of Over-the-Counter Melatonin: What They Say Is Often Not What You Get," *Journal of Clinical Sleep Medicine* 13, no. 2 (February 2017): 163–65, https://doi.org/10.5664/jcsm.6434.

Figure 6.11 Can't sleep

Ready to Move On?

Most of us have met someone who says, "I do not need eight hours of sleep. I am fine with six hours!" Maybe you even say that! Before moving on in this chapter, rehearse how to engage someone in a dialogue to help them determine if they are one of the rare few with this genetic difference. In addition to sharing the likelihood that someone is a short sleeper (which is less than 1 percent), what questions could you ask the person? It is really quite simple: your goal is to find out if they have sleep debt. Remember, many people are unaware they have sleep debt, and it can be masked by stimulants such as caffeine and nicotine. In the section on determining sleep need in chapter 1, there is a list of questions to figure out if someone is getting enough sleep:

1. After being up for two hours in the morning, if you were to go back to bed, would you be able to fall asleep?
2. If you did not set your alarm, would you wake up automatically at the desired time, feeling refreshed?
3. Without caffeine or nicotine during the day, would you easily stay awake and alert?
4. When you go to bed at night, do you fall asleep "when your head hits the pillow"?
5. Do you doze off during a boring meeting, conversation, or TV show?

If six or fewer hours of sleep a night is truly adequate for the person you are talking to, then the answer would be "yes" to questions 2 and 3 and "no" to questions 1, 4, and 5. Question 4 is the only one that is not obvious in terms of a "no" answer indicating adequate sleep. While some of you believe it is a healthy sign to fall asleep immediately upon getting in bed, that in fact is a sign of an extreme lack of quality sleep. It should take about fifteen minutes to fall asleep if a person is getting enough good sleep each night. Regarding question 5, a person could assume they are getting ample sleep and that it is normal to doze off if they had an exhausting day and are watching a TV show in the early evening. However, these doze-promoting situations are simply unmasking sleep debt, providing a signal that more sleep is needed.

Remember to also ask the person if they sleep in on weekends. A short sleeper would not do that. I think you will be surprised how many putative short sleepers you will help by being able to connect with them in this conversation and help them see that they need to get more sleep.

a short sleeper. Most people who sleep less than eight hours a night are sleep deprived and are causing harm to their bodies and minds.

Delayed or Advanced Sleep-Wake Phase

There are two separate disorders, delayed sleep-wake phase (DSP) and advanced sleep-wake phase (ASP), categorized as circadian rhythm disorders (see chapter 3). Someone with DSP might refer to themselves as a "night owl" or "night person" because their tendency is to stay up late and get up late. A "lark" and "early bird" refers to those with ASP, who go to bed early and are up before dawn (figures 6.12a and 6.12b). If someone with either DSP or ASP is able to follow their natural rhythm and still sleep eight hours peacefully each night, their disorder may not cause problems in their life and require no treatment.

If the person's schedule does have to be changed—for example, due to school, family, or work commitments—research indicates that the

Figure 6.12a Owl

Figure 6.12b Lark

use of melatonin, guided by a sleep specialist, is effective in shifting the sleep schedule. Bright-light therapy is also effective for both DSP and ASP, though with inverse timing. For DSP, bright lights and blue light from devices should be avoided in the two hours before one's desired bedtime, and bright-light exposure (sunlight, if available) should be sought at the time one wishes to wake up. For ASP, light should be avoided in the morning, and sunglasses are recommended for those commuting in the bright morning sun. Then, in the afternoon and early evening, exposure to bright light is important. Because sleep quality is disrupted if DSP and ASP schedules are shifted, cognitive behavioral therapy for insomnia is helpful (see chapter 1).

Narcolepsy

Some films use narcolepsy as a joke, depicting those afflicted as having a sleep attack, suddenly falling asleep midconversation. I try to counter this in my classroom by humanizing narcolepsy, showing students interviews with people who have this disorder to demonstrate that it is debilitating and difficult, not funny at all. At my campus of around eight thousand students, I tell those in my classroom to look at the faces of their fellow students and know there could be four students on our campus suffering from narcolepsy, which affects one in every two thousand people. I have had several students with narcolepsy in my classes, and their stories inspire me. They have shared how they have coped and become outstanding students, pursued their academic dreams, and helped people in our communities.

The most notable symptom of narcolepsy is extreme daytime sleepiness—indeed, sometimes sleep attacks (sudden onset of sleep)—that may be accompanied by cataplexy, a loss of muscle tone. Cataplexy can be subtle, such as difficulty with speech, or as severe as total paralysis, causing the person to drop to the ground, sometimes causing serious injury. A person with narcolepsy might not be completely alert when they are going through their day—for example, while in the classroom, talking to someone, or reading a book—and thus may face memory problems as well.

Treatments for narcolepsy involve various medications and prescribed sleep schedules, including naps at regular times during the day. Exercising

Retrieval Practice

Start at the beginning of the chapter and skim the content through to the end of this section, making brief notes of all the sleep disorders and treatments mentioned. Then set aside the content and your notes, and do not let yourself look at that material. Relying only on your memory, make a list of as many sleep disorders and treatments as you can. After you are done honoring that you were able to retrieve some of the content from your mind, open the book and your notes and make additions and corrections to your retrieval practice list. The next time someone talks to you about how sleepy they are, you can provide some insight about relevant sleep disorders and treatments and perhaps encourage them to consider talking to their health-care provider.

Your Next Actions for Justice

Everyone reading this book can do something to help those with sleep disorders. Share what you know about sleep debt and how to fix it, increase awareness of sleep disorders, and write a letter to a newspaper or your congressperson to ask for increased sleep wellness initiatives. Read the next chapter for more on how to get moving and make a change!

and avoiding alcohol, nicotine, and drugs are also helpful strategies.

Clinical Sleep Study

Once a person has gone through the Sleep Wellness Guide (see chapter 1) and put in place as many of its strategies as they can, if they are still experiencing daytime drowsiness, it is vital that they consider a clinical sleep study to rule out a sleep disorder. As we've seen throughout this chapter, untreated sleep disorders can lead to serious mental and physical health consequences. Thankfully, most insurance companies cover sleep studies, and the experience itself is not unpleasant: most places have created comfortable and private sleeping spaces that feel like a nice hotel (other than the tiny wires placed on your head and in a few places on your body).

That being said, there is one especially troubling thought: Who has insurance, and of those who do, who can afford the copay? If we know sleep debt causes strokes, heart attacks, Alzheimer's, diabetes, obesity, depression, and more, then whoever cannot afford to fix their sleep is at a huge disadvantage in terms of their health, which should be a basic human right—especially in countries like the United States, where there is access to excellent medical treatment . . . for those who can afford it. I encourage you to consider how you can help bring sleep wellness education and access to clinical sleep studies to everyone who needs it.

7

Politics, Sleep, and You

Student Learning Objectives

After you read this chapter, you will be able to

- discuss the significance of sleep debt as a community and global issue
- explain the social justice implications of sleep debt demographics
- describe various approaches to reducing sleep debt on local and national levels, including business, school, and health-care settings
- determine a feasible way to have an impact on sleep debt in your community
- participate in an activity focusing on the intersection between sustainability and sleep

Introduction

How would you react if you saw your bus driver, your surgeon, or your pilot drinking cocktails while performing their job? You would be appalled. Yet sleepiness can be worse than drunkenness in terms of its likelihood of causing an accident (figure 7.1). Researchers have shown that sleep-deprived individuals drive more recklessly (hit more cones in driving courses) and have worse coordination and reaction time than those who are drunk. Sleepiness in fact causes as many deaths and injuries from car accidents as drunk driving. Those numbers are probably lower than they should be, since highway patrol officers do not have a test for sleep debt and also because people are often unaware of their degree of sleepiness. People can experience four seconds of sleep while driving, performing surgery, flying a plane—you name it—and not realize they are asleep. It is chilling to combine this information with the fact that one in three Americans admits that at least once in the previous month, they have put themselves in the driver's seat even though they were finding it challenging to keep their eyes open. More than 40 percent of adults report that they rarely or never get enough sleep on weeknights. If legislators could see the deadly effects of drowsiness the same way they see those of drunk driving, perhaps we could motivate them to support an effective educational and health-care movement to address our national sleep debt emergency.

Figure 7.1 Sleepy driving causes as many deaths as drunk driving

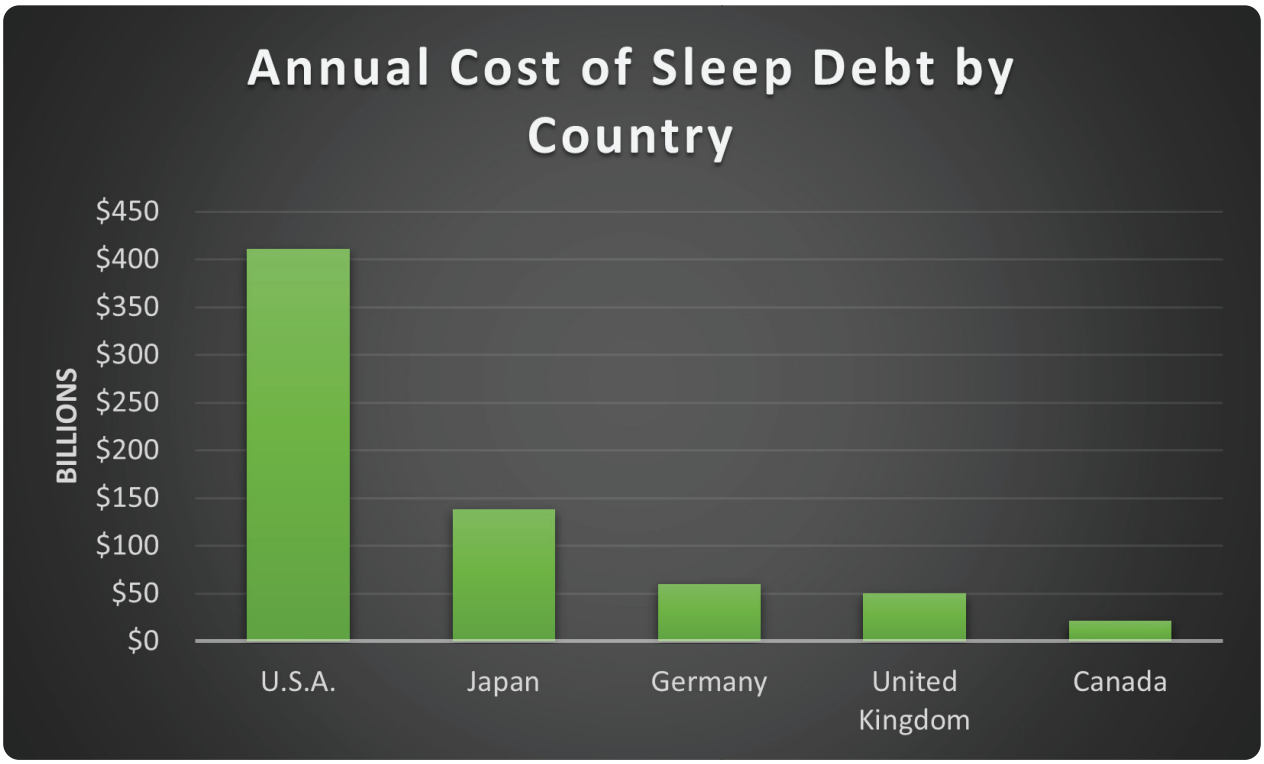


Figure 7.2 Sleep debt by country

Economics

An effective approach may be to talk to people about the financial cost of sleep debt. One of my mentors in social justice and antiracism work told me, "We do this work because we know it is the right thing to do, but if we can show leaders how making these changes is a way for them to save or make money, then we get their attention." What is the financial cost of sleep debt? $411 billion annually for the US. This comes from a RAND Corporation 2016 report that also listed the annual cost of insufficient sleep for Japan ($138 billion), Germany ($60 billion), the United Kingdom ($50 billion), and Canada ($21 billion) (figure 7.2).* If loss of life is not enough reason to justify the allocation of resources for sleep wellness education, saving hundreds of billions of dollars each year should do it.

Valiant efforts have been made to help change attitudes toward sleep in the US. William Dement, known as the father of sleep medicine, dedicated decades to the cause, in particular from 1991–94, when he served as chair of the US Congress–mandated National Commission on Sleep Disorders Research. Yet still, we find our country to be, in the words of US senator Mark Hatfield, a "vast reservoir of ignorance about sleep, sleep deprivation and sleep disorders" (figure 7.3). It may surprise you to know that Hatfield made this remark all the way

Figure 7.3 US Capitol

* Marco Hafner et al., "Why Sleep Matters—the Economic Costs of Insufficient Sleep: A Cross-Country Comparative Analysis," *Rand Health Quarterly* 6, no. 4 (2017): 11, https://doi.org/10.7249/RR1791.

back in 1993, and yet sleep debt–related tragedies have been multiplying ever since.

Antiracism

As we consider the need for action to address the issue of sleep debt, we should keep in mind race-associated inequities in sleep wellness. Is healthy sleep a luxury, afforded only to "non-Hispanic whites"?

Before moving on, it is important to clarify that race is a social construct. There is no biological or anthropological evidence that humans come from different races. We are one race: the human race (figure 7.4). But race labels, such as Black, are a part of this discussion due to the research, in which they are used to create groups for data analysis. Sometimes, these groups have to do with ancestry, such as in the case of Alaska Natives, so some of these terms are mixed into this section, depending on the studies being cited.

The US Centers for Disease Control and Prevention analyzed data from over four hundred thousand adults and found the prevalence of healthy sleep duration to be significantly lower in Native Hawaiians / Pacific Islanders, non-Hispanic Black people, multiracial non-Hispanics, and American Indians / Alaska Natives compared to non-Hispanic whites, Hispanics, and Asians. This study is just one of several that have provided evidence that there is racial inequality in sleep wellness. Harvard researchers reported that Black participants are five times more likely to have insufficient sleep compared to other groups. Even when socioeconomic status is factored out, the Black participants still get less sleep.* This has enormous implications

* Yong Liu et al., "Prevalence of Healthy Sleep Duration among Adults—United States, 2014," *Morbidity and Mortality Weekly Report* 65, no. 6 (February 2016): 137–41, http://dx.doi.org/10.15585/mmwr.mm6506a1.

Figure 7.4 One race: The human race

when we consider which groups have the highest rates of diabetes, obesity, high blood pressure, and other sleep debt–related disorders. For example, if Blacks and Native Hawaiians, two groups with higher rates of those disorders, are getting poor sleep, and we know poor sleep can cause these disorders, we have an extra layer of responsibility to address the racial inequalities around sleep health.

It is important to point out that the scientific community agrees that there are no innate biological reasons for the sleep differences based on race. Researchers suggest the experience of racism, even in its subtlest forms, impacts a person's ability to sleep well and, in particular, to enter the deep and restorative sleep of NREM 3. This likely plays a role in the poor sleep reported by those experiencing discrimination based on sexual orientation as well, so consideration for sleep equity must go beyond race, to all groups experiencing discrimination and oppression. It makes sense that sleeping deeply would require the mind to be in a state of ease, knowing we are safe and free. The situation is exacerbated by the reported connection between lack of sleep and reduced opportunity for civic engagement, such as being able to safely and conveniently vote. Insufficient sleep is associated with reduced political participation and decreases in other measures of social capital (figure 7.5).

Thus sleep inequality research adds one more justification, on top of the mountain of reasons, for fighting racism. It also illustrates the importance of developing targeted sleep wellness education and health services for these groups.

Figure 7.5 Kapu Aloha. Find your cause and speak out!

Ready to Move On?

Another one of my passions is environmental conservation. My campus, Kapiʻolani Community College, a part of the University of Hawaiʻi, has a strong history of action around sustainability. Mālama i ka honua means "to take care of the earth" in Hawaiian (figure 7.6). Years ago, I chose to incorporate a sustainability designation into my sleep science course. Why? Because I believe sustainability, just like social justice, should be woven into the fabric of what we do, rather than as an add-on. My goal was to challenge students, through a classroom activity, to consider how they can relate sleep to sustainability. The point is, we find opportunities for action if we look hard enough.

Figure 7.6 Hawaiʻi standing with Standing Rock #NoDAPL

Here are the guidelines in case you would like to try it:

In small groups (or you can do it on your own), create consensus on a definition of *sustainability*. Do not look one up; this is about sharing what sustainability means to you. Remember, sustainability can be social, cultural, environmental, and economic.

When all groups have agreed on one definition, share it with the class.

After sharing those definitions, here are some others to consider:

- something that will remain diverse and produce indefinitely
- endurance of systems and processes
- a way to continue something indefinitely and remain healthy

The next step in the activity is to work within your group to create a concept relating sleep to sustainability. Use any definition of sustainability. When your group is finished, create a title for your concept and write it large and in color on the board. When all the groups have titles on the board, each group shares their concept. Before you get to work on creating your concept, consider these examples:

- *Gardening:* If you garden, you get exercise and more nutritious food, both things that will help you sleep. By gardening for sleep wellness, you are also taking care of the planet because you are not polluting the air and using gasoline driving to get that food, and you are not purchasing the food in plastic packaging that would increase plastic waste.
- *Going to bed earlier:* If you stay up late at night rather than getting up early, you are using electric lights for your activities instead of doing those activities in the early morning sunlight. By going to bed earlier, you use less electricity and spend more time in natural sunlight. This is sustainable because it reduces energy usage.

Business

Company leaders are in a strong position to make their mark, and increase profits, by addressing employee sleep debt. One study of four large companies in the US determined sleepiness was costing them—in lost productivity alone—around $3,000 annually per employee. For the four companies in the study, the yearly capital loss was over $50 million. On a national level, poor sleep causes on average, per person, eleven days of lost productivity in the US. In the United Kingdom, one in five workers report that they had recently arrived late to work or skipped work due to insufficient sleep. More than one in four employees in Canada take sick days because of sleepiness. Sometimes the reason we don't get enough sleep is because we are staying at our jobs late into the evening in hopes of completing more work. The irony is that if we are low on sleep, it will take us longer to finish the work because of decreased cognitive and physical functioning. We, and our companies, would be better served to call it a day, get a good night's sleep, and start new in the morning. But first, a company must develop a prosleep culture that supports this wise decision-making.

In Japan, as part of a response to survey results indicating that 90 percent of adults do not get enough sleep, some companies are paying their employees to sleep. One Japanese company uses a phone app to record hours of sleep, and if the employee reaches the target, they earn points to use for cafeteria purchases. In the US, Ben and Jerry's, Google, Huffington Post, and Nike have places where staff can sleep while at work (figure 7.7).

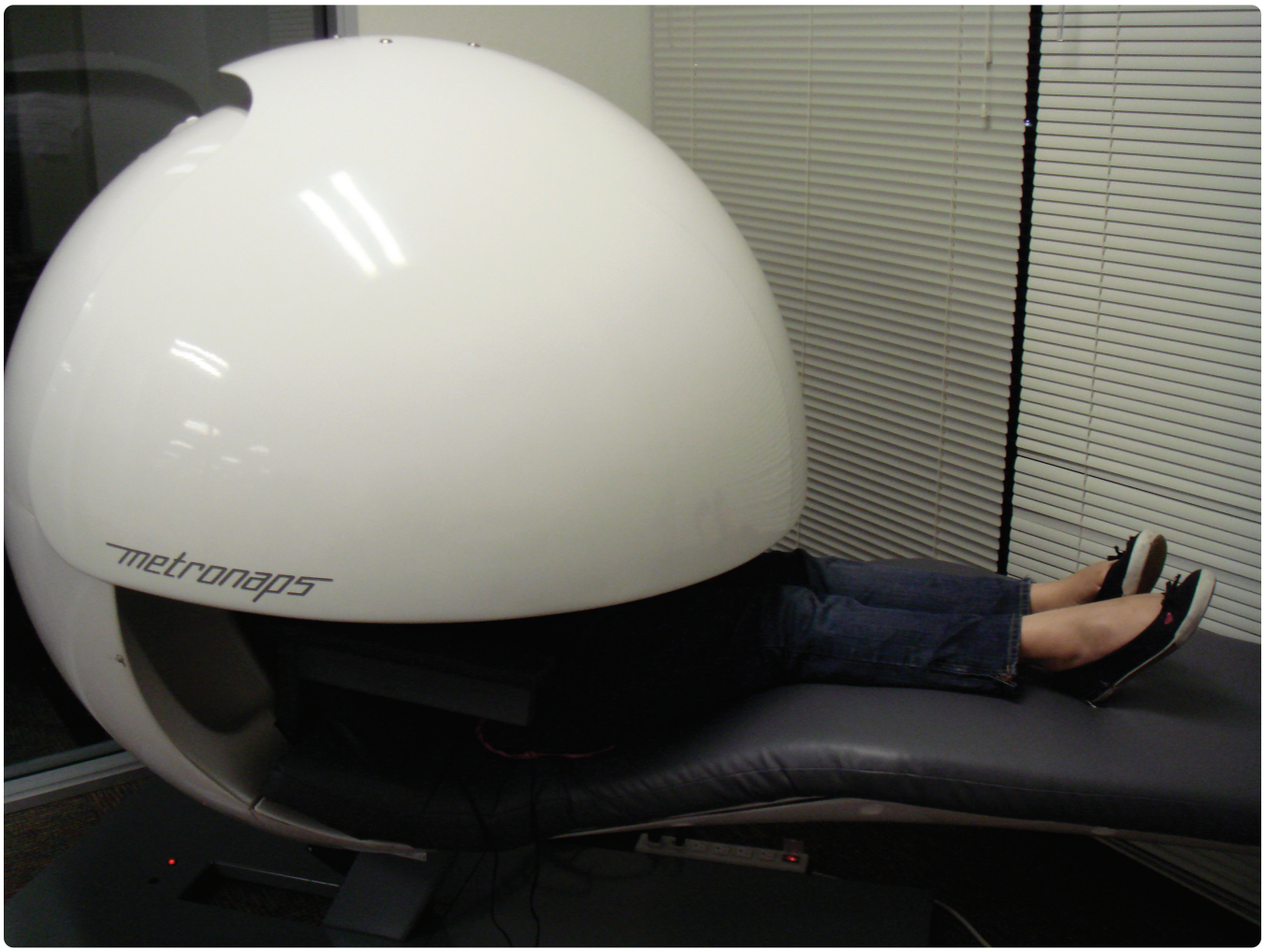


Figure 7.7 Nap pod

Reboot, a marketing company in London, provides a peaceful room for napping. Many companies around the world are seeing the benefit of allowing their employees to work the hours better matched to their chronotype: for example, letting the night owls start their shift later in the morning. Considering the impact of poor sleep on cognitive function, productivity, accidents, and illness, companies could get an enormous return on their investment by supporting healthy sleep for their employees.

Figure 7.8 Sleeping in class

High Schools and Colleges

An international comparison found that among the fifty countries studied, the US has the most sleep-deprived students. One in three high school students fall asleep in class, and although teenagers need nine hours of sleep each night, most are sleeping around seven or fewer; less than 10 percent of them are getting enough sleep (figure 7.8). African American and Hispanic students, as well as those from low-income households, get even less. In Japan, half of high school students are sleeping six or fewer hours on weeknights.

Adolescent sleep deprivation is an alarming epidemic. The American Academy of Pediatrics, the American Association of Sleep Medicine, and the American Medical Association have all identified insufficient sleep in adolescents as a serious public health issue and recommend that high schools should not start before 8:30 a.m., even though most of them still begin much earlier. Consider the short- and long-term impact of insufficient sleep on teenage mental and physical health, such as increased rates of depression, anxiety, high blood pressure, obesity, and diabetes. Research suggests teen suicide, violence, and accidents are reduced if teens are given the opportunity to get a healthy amount of sleep. In addition to educating families about the importance of sleep, convincing school districts to move to later start times would start a revolution with tremendous and far-reaching impact. Along with higher academic achievement, school officials could boast about reductions in their students' rates of illness, depression, tardiness, and suicide.

If the traditional school start time is 8:00 a.m. and a student awakens at 6:30 a.m. to get ready and catch a bus, it is almost impossible that the teen

Your Next Actions for Justice

Consider the range of topics covered so far in this chapter. Did any of these resonate with you or spark motivation to get involved? Take a moment to reflect and make a mental note: What is a simple next step you could take to move this sleep wellness revolution forward? It could be reaching out to your favorite high school teacher, asking if they would consider adding a tiny module on sleep wellness to their curriculum, or maybe connecting with a small group to address sleep debt on your college campus. Whether large or small, imagine taking that next step and get in touch intuitively with where you see yourself having an impact.

could have gotten enough sleep: to get the nine hours most teens need, they would have to be sleeping by 9:30 p.m. Add to the equation their delayed circadian rhythm, a normal physiological part of being a teen, and it is even more unlikely they would be able to pull this off, even under the best of circumstances. For their bodies, the experience of getting up at 6:30 a.m. would be like an adult getting up at 4:30 a.m. every day for work. So it comes as no surprise that schools that shift to a later start time report a reduction in mental and physical health problems, alcohol and drug use, and traffic accidents, as well as increased academic success.

In Japan, Australia, New Zealand, England, and Finland, they have had later school start times for decades, and each of these countries has higher achievement rates than the US on standardized exams. In the fall of 2019, California became the first US state to mandate later high school start times, reflecting its value for its children's health. Since studies have shown that bus scheduling, after-school programs, student jobs, and sports activities are not affected by later start times, hopefully more states will follow California's lead (figure 7.9).

Get involved in your community by having discussions with local school administrators about the American Academy of Pediatrics 2014 policy statement* and the Society of Behavioral Medicine position statement,† which are calls to action, with compelling scientific evidence, for delaying school start times. You can also contact wise politicians such as US congresswoman Zoe Lofgren, who in 2017 introduced the ZZZ's to A's Act as a House Bill to "direct the Secretary of Education to conduct a study to determine the relationship between school start times and adolescent health, well-being, and performance." An easy step for getting involved, and a way to find a range of resources, would be to visit startschoollater.net.

When you were in school, do you remember having lessons about healthy foods and sex

* Au, Rhoda, et al. "School Start Times for Adolescents." Pediatrics 134, no. 3 (2014): 642-649, https://publications.aap.org/pediatrics/article/134/3/642/74175/School-Start-Times-for-Adolescents.
† Trevorrow, T., E.S. Zhou, J.R. Dietch, B.D. Gonzalez. "Start Middle and High Schools 8:30 a.m. or Later to Promote Student Health and Learning." *Society of Behavioral Medicine*, (November 2017): https://www.sbm.org/UserFiles/file/late-school-start-statement-FINAL.pdf.

Figure 7.9 Golden Gate Bridge, San Francisco, California

education, as well as classes emphasizing the importance of physical fitness? Most people in the US would answer yes. However, what about lessons on the importance of sleep? Let's encourage our teachers and school administrators to incorporate lessons on the importance of healthy sleep for academic and athletic performance, stable mood, safe driving, and physical health. Getting children and teens motivated to sleep well is a wise place to build momentum for this much-needed sleep revolution.

Students fortunate enough to make it to college are faced with further challenges. With the high cost of tuition and textbooks, there is considerable pressure on college students to work long hours and take too many credits at once to finish school early so they can get a job, leaving only a small amount of time for sleep. In a survey of industrialized nations, with the adult population sorted by age, college-age people get the worst sleep. In Korea, college students sleep on average 6.7 hours per night, and I imagine many college students reading this book wish they could get six hours. The connection between depression and poor sleep, along with the high rates of depression and suicide on college campuses, adds more urgency to the issue. Surveying college students about their sleep is one way to start conversations and increase awareness about sleep debt. This opens the door for us to share resources about how to improve sleep. Illinois State University students made up their faces to look like zombies and walked around campus handing out sleep kits as a part of their "Don't Become a Zombie" campaign (figure 7.10). Stanford University has a Refresh program that has been modified and implemented on many other campuses as well, including Dartmouth, the University of Chicago, and the University of Iowa. These programs teach students about the importance of sleep health and provide successful strategies for getting healthy sleep. Several campuses in the US, the United Kingdom, and Japan have also created napping spaces for students. Some have beanbags and others have cots in areas where students sign up for a napping timeslot. Students can reach out to their student government organizations and student health centers for opportunities to provide sleep wellness education activities and find resources to create napping spaces.

Figure 7.10 Zombies

Health-Care Providers

The issue around sleep debt and health-care providers has three components. The first one is foundational: the lack of education on sleep wellness and sleep disorders provided to our doctors and nurses. Studies report that the total amount of time dedicated to sleep education in our doctors' preclinical training is only fifteen minutes. If they received more education, we could expect a decrease in the current rate of sleep disorders that are left undiagnosed (95 percent).

ʻŌlelo Hawaiʻi (Language of Hawaiʻi)

Kahuna lapaʻau is Hawaiian for "health-care practitioner" (figure 7.11).

Figure 7.11 Wana (sea urchin) are a source of healing food in Hawai'i

The second component is the lack of sleep-health education and screening provided by health-care practitioners (kahuna lapa'au in Hawaiian) to their patients.

Primary care physicians should administer a sleep-quality questionnaire and screen patients for sleep problems like how they screen everyone for high blood pressure (figure 7.12). If a physician sees a patient for something as minor as a splinter, they still have the medical assistant slap on a blood pressure cuff to screen for hypertension (high blood pressure). We need to approach sleep-health screening in the same manner. Every patient should get surveyed; then the survey data should be used as talking points to emphasize the importance of sleep and address any problem areas. Drowsiness should be discussed and pursued. Patients should be asked to keep ten-day sleep diaries and submit those in follow-up appointments. A primary care clinic in Idaho surveyed a little over 1,200 patients who were coming to the clinic for a variety of reasons (besides sleep disorders) and found over 60 percent of them also had sleep disorder symptoms. At that point, all but two of the patients had not been diagnosed. Imagine if we could generalize this type of care and reduce illness, accidents, and deaths related to sleep debt and sleep disorders.

The third and final component is the demanding shift work required of our health-care providers and hospital workers. We must change the guidelines for this because there are too many deaths and accidents clearly documented and linked to health-care provider sleep debt. For example, physicians in their residency (the two to seven years they practice while learning their specialty) are working with such high sleep debt that one in twenty report that they have killed a patient due to errors they made because they had not gotten enough

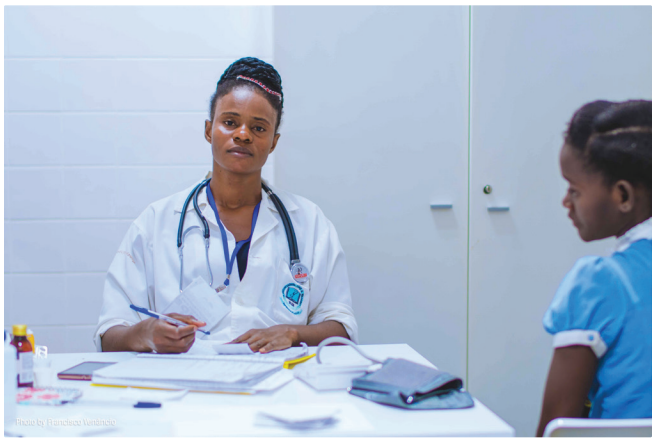


Figure 7.12 Physicians have the potential to play a critical role in sleep wellness

sleep (figure 7.13). In a survey of residents in a San Francisco hospital, over 40 percent of residents disclosed killing at least one patient due to sleepiness. Stanford University researchers have used the multiple sleep latency test for years on numerous residents and nurses, and according to them, of all those respondents, only one person "was not in the twilight zone of extreme sleepiness."* Johns Hopkins released a study in 2016 stating medical errors are the third-highest cause of death in the US, making medical errors the reason for 10 percent of all US deaths.† Knowing how sleep-deprived medical workers are, it is not a leap to consider lack of sleep playing a part in those medical errors and therefore deaths.

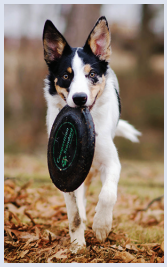
The medical establishment needs to be held accountable and revise the work schedules of our health-care providers. The National Academies of Science, Engineering, and Medicine gathered a group of medical and scientific experts to examine evidence and propose revised work schedules for medical residents. For example, with these revisions, they would get a five-hour break for sleeping after working sixteen of their thirty hours in a shift. However, the Accreditation Council for Graduate Medical Education (ACGME) has done too little to have much impact, and way too many sleep debt–related accidents and deaths continue to occur. To put it in perspective, in the US, the ACGME mandates that the maximum number of hours a resident can work per week is eighty, but many European countries, whose medical programs still have excellent success rates and train physicians in a similar number of years, set the maximum at forty-eight.‡ We need to increase awareness of the tragic number of preventable deaths and injuries associated with the sleep deprivation imposed on our health-care providers and pressure the medical establishment to change.

Your Next Steps

The World Health Organization says we are in the midst of a "global epidemic of sleeplessness." The Centers for Disease Control and Prevention report that over 40 percent of adults said they had fallen asleep during the day unintentionally at least once in the past month. In the US and Japan, more than 65 percent of adults are not getting enough sleep. The problem is not limited to industrialized societies. A study of people living in rural, low-income communities without the trappings of industry in eight African and Asian countries found that a

Figure 7.13 MedGlobal volunteer performs surgery at Al-Shifa hospital in Gaza Strip

* Rafael Pelayo, C. William Dement, and Krystle Singh, *Dement's Sleep and Dreaming* (self-published, 2016), 430.
† Johns Hopkins Medicine, "Study Suggests Medical Errors Now Third Leading Cause of Death in the U.S.—05/03/2016," *Johns Hopkins Medicine-News and Publications*, May 2016, https://www.hopkinsmedicine.org/news/media/releases/study_suggests_medical_errors_now_third_leading_cause_of_death_in_the_us.
‡ Pelayo, Dement, and Singh, *Dement's Sleep and Dreaming*, 428.



Retrieval Practice

Start at the beginning of the chapter and skim the content through to the end of this section, making brief notes of a few of the most compelling facts in each section. Then set aside the content and your notes and do not let yourself look at that material. Relying only on your memory, make a list of as many of the facts you can recall. After you are done honoring that you were able to retrieve some of the content from your mind, open the book and your notes and make additions and corrections to your retrieval practice list. Finally, look over that list and select one of the topics that you find to be the most interesting. Rehearse two talking points on the topic so you can share them in a conversation that may give rise to someone taking action.

large number of adults were not getting enough sleep. The authors used their study's results to urge people to see the global nature of the sleep debt epidemic.*

There are many approaches to resolving this problem and decreasing its associated catastrophes. One place to start is to address the lack of awareness about sleep debt and the dearth of public policies promoting healthy sleep.

Let's take a glance at previously successful campaigns that had impacts on public health. Thanks to scientific evidence about the dangers of cigarette smoking, we saw the rise of consumer warnings added to packaging as well as designated nonsmoking areas. After learning more about automobile accidents, we went from cars not even having seat belts to passing laws requiring that all passengers wear them. Vaccine awareness and access helped eradicate smallpox and almost eradicated polio and other diseases. Research on death in infants led to the Back to Sleep campaign to reduce the incidence of sudden infant death syndrome. Widespread distribution of posters provided education about reducing the spread of disease through handwashing. We know we can have an impact, and now is the time to act to increase sleep-health education.

After completing my course on the science of sleep, or simply reading this book, you are likely a sleep expert compared to most of the people in your community, so I ask you to take that knowledge and use it to make an impact on your community. You can read the previous sections for ideas, but here are a few more:

- Choose some sleep wellness and sleep disorders information (for potential content, see chapters 1 and 6 in this book) and put it in a format you like—a flyer, brochure, poster, or sheet of talking points—and go with a friend to do targeted sleep-health education in underserved neighborhoods. You might consider visiting a beauty salon, barbershop, church, or school to share your expertise (figure 7.14). A good way to start the conversation is by asking people to tell you about their sleep and their early evening routines. People usually like to share their stories. Your first step is to encourage dialogue about sleep.
- Get resources from, or provide support to, a nonprofit such as Pajama Program† and help children get sleep.
- Reach out to educate leaders in occupations known to have increased levels of sleep debt: health-care workers, airline employees, bus drivers, truck drivers, police officers, first responders, and military.

* Saverio Stranges et al., "Sleep Problems: An Emerging Global Epidemic? Findings from the INDEPTH WHO-SAGE Study among More Than 40,000 Older Adults from 8 Countries across Africa and Asia," *Sleep* 35, no. 8 (August 2012): 1173–81, https://doi.org/10.5665/sleep.2012.

† "Pajama Program," accessed on December 3, 2021, https://pajamaprogram.org/our-programs/.

Figure 7.14 Start a sleep wellness conversation at the barbershop

- Visit your campus health center and ask them to consider providing sleep wellness screenings and to discuss snoring, insomnia, apnea, and daytime drowsiness.
- Talk to colleagues at work about their sleep. Identify things at your workplace that could change to support healthy sleep. Approach an ally in a leadership role in your company and discuss the financial gains likely achieved if they adopted a prosleep culture. Ask them to consider creating a safe napping space, providing sleep disorder and insomnia screening, starting a healthy sleep awareness program, and adjusting shift hours based on chronotype.
- Start a petition or grassroots effort to eliminate daylight savings time.

Consider the successful business leaders, school administrators, and politicians mentioned earlier in this chapter, who have chosen to make healthy sleep a priority for large groups of people and achieved much along the way. Please find an arena where you have a natural interest—perhaps a school, a local political group, a veterans club, an eldercare facility, a health clinic for the underserved, your workplace or college campus—and begin a conversation with someone about how to raise consciousness about sleep wellness. Let's work together to help people get the sleep they deserve so we can bring more equanimity, health, and peace to our communities and beyond.

Image Credits

Image caption	Attribution phrase	Source/link
Figure I.1 Yawning	Yawning little girl by truthseeker08 / Pixabay	https://pixabay.com/photos/yawning-little-girl-yawn-child-1895561/
Figure I.2 Dreams	Dreams by Rogier Hoekstra / Pixabay	https://pixabay.com/photos/dreams-fantasy-art-surreal-2904682/
Figure I.3 105-year-old woman	This woman is 105 years old by Joe Green / CC BY-ND 2.0	https://www.flickr.com/photos/82552101@N00/3133747764
Figure I.4 Some of the effects of sleep deprivation	Effects of sleep deprivation by Mikael Häggström «Medical gallery of Mikael Häggström 2014» / CC0 1.0	https://commons.wikimedia.org/wiki/File:Effects_of_sleep_deprivation.svg
Figure I.5 Sleeping on it	Sleeping on it by Sheryl Shook / CC0 1.0	https://drive.google.com/file/d/1dAUcc5EekSgRlrz9dizd6HggVZGGm981/view?usp=sharing
Figure I.6 Yawning is not just for humans	Yawn . . . by Tancread / CC BY-NC 2.0	https://www.flickr.com/photos/69446921@N00/83525962
Figure 1.1 Nap	Nap by Bery1_snw / CC0 1.0	https://www.flickr.com/photos/beryl_snw/14894872130/in/photolist-oGd7yb https://drive.google.com/file/d/1jP4qUdYAP-lumBIHo-xDozD7j4I4FebY/view?usp=sharing
Figure 1.2 Kalahari ǂKhomani San Bushman	Arri Raats, Kalahari Khomani San Bushman, Boesmansrus camp, Northern Cape, South Africa by South African Tourism from South Africa / CC BY 2.0	https://upload.wikimedia.org/wikipedia/commons/a/a4/Arri_Raats%2C_Kalahari_Khomani_San_Bushman%2C_Boesmansrus_camp%2C_Northern_Cape%2C_South_Africa_%28199195443 04%29.jpg
Figure 1.3 Siesta	Woman Lying Down by Hy Aan / Pexels	https://www.pexels.com/photo/woman-lying-down-1768968/
Figure 1.4 Napping boosts learning	Man Napping on Books by Oladimeji Ajegbile / Pexels	https://www.pexels.com/photo/man-napping-on-books-3564013/
Figure 1.5 Skip the side effects and choose to nap	Medication Pills Isolated on Yellow Background by Anna Shvets / Pexels	https://www.pexels.com/photo/medication-pills-isolated-on-yellow-background-3683098/
Figure 1.6 Power naps for power athletes	Womens Wheelchair Basketball by Audi Nissen / Unsplash	https://unsplash.com/photos/u1CAj5HJzO4

Image caption	Attribution phrase	Source/link
Figure 1.7 Cozy amber lighting	Lighting Ceiling Lights by WaltiGoehner / Pixabay	https://pixabay.com/da/photos/lys-belysning-loftlamper-orange-459236/
Figure 1.8 Looking cool while blocking blue light	Man Wearing White Crew-neck shirt by Pedram Normohamadian / Unsplash	https://unsplash.com/photos/QchkCq3w_UE
Figure 1.9 Elevate your legs	Person Sitting on Couch While Using Laptop Computer by Pixabay / Pexels	https://www.pexels.com/photo/apartment-comfortable-contemporary-couch-269129/
Figure 1.10 Midsection view of the male reproductive system	Male Reproductive System by Openstax / CC BY 4.0	https://openstax.org/books/anatomy-and-physiology/pages/27-1-anatomy-and-physiology-of-the-male-reproductive-system
Figure 1.11 Think about your sleep before reaching for an energy drink	man getting can in beverage cooler by NeONBRAND / Unsplash	https://unsplash.com/photos/OGlhEkaMot0
Figure 1.12 Bedtime story	Bedtime Story 2 by Michael Gabelmann / CC BY-NC 2.0	https://www.flickr.com/photos/97411961@N00/26397372635
Figure 1.13 Healthy snack for healthy sleep	Maple Granola by QuintanaRoo / CC BY-NC-SA 2.0	https://www.flickr.com/photos/84143785@N00/3470512747
Figure 1.14 Pele emerging from lava	Hawaii Volcanoes National Park by Jasperdo / CC BY-NC-ND 2.0	https://www.flickr.com/photos/66733752@N00/6059308503
Figure 1.15 Put a pillow between your legs	Put a pillow between your legs by wikiHow / CC BY-NC-SA 3.0	https://www.wikihow.com/Improve-Your-Sleeping-Position#/Image:Improve-Your-Sleeping-Position-Step-1.jpg
Figure 1.16 Sleeping together	sleeping together by Frerieke / CC BY-NC 2.0	https://www.flickr.com/photos/frerieke/6268206497/in/album-72157627892036730/
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Figure 2.17 Polysomnography setup and data	The Meaning of Sleep Quality: A Survey of Available Technologies - by Unknown / CC BY 4.0	https://www.researchgate.net/figure/A-graphical-representation-of-the-polysomnography-technology-from-the-user-point-of-view_fig3_337243463 [accessed February 23, 2021]

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Figure 3.7 How many zeitgebers do you see in this photo?	Smiling coworkers in aprons using laptop together by Ketut Subiyanto / Pexels	https://www.pexels.com/photo/smiling-coworkers-in-aprons-using-laptop-together-4353605/
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Figure 3.17 Sleeping in space	Sleeping in Space by NASA / PD	https://www.nasa.gov/image-feature/sleeping-in-space
Figure 3.18 Sometimes polyphasic sleeping is referred to as the uberman schedule. This figure compares polyphasic to biphasic sleep. The circle represents time in the twenty-four-hour day, so the small dark blue sectors in the uberman (polyphasic) schedule are the six thirty-minute naps. On the biphasic image, the large dark blue sector is eight hours of nighttime sleep and the small sector is the twenty-minute afternoon nap.	Collage by Jason Ford using Uberman Polyphasic Sleep Pie Chart and Biphasic Sleep Pie Chart by Master Uegly / CC0 1.0	https://drive.google.com/file/d/1QfIn-0L1Ai2KTIidDrjOQGu2Py-n6nOo/view?usp=sharing

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