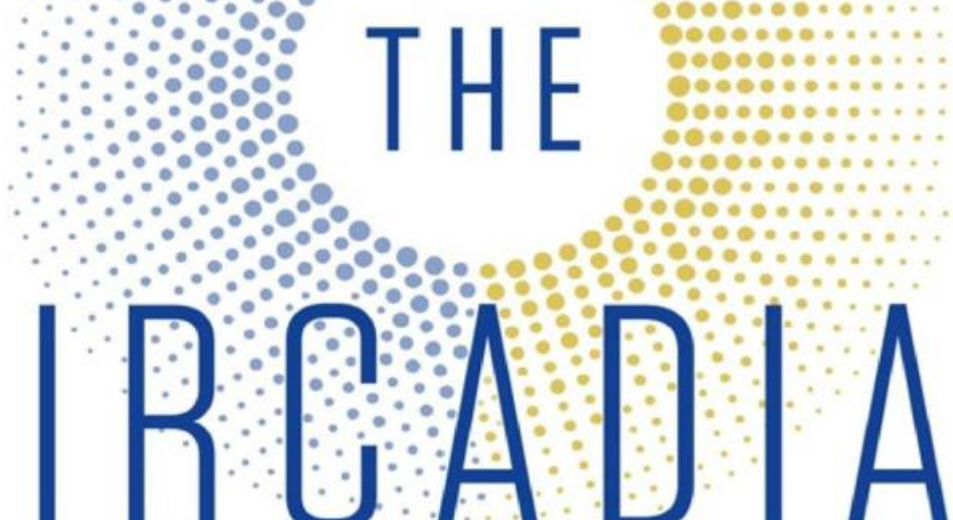



LOSE WEIGHT,  
Supercharge Your Energy,  
and Transform Your Health  
from Morning to Midnight



THE  
CIRCADIAN  
CODE

SATCHIN PANDA, PHD



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To my loving grandparents,  
Banchhanidhi and Urbashi Panda,  
Kalpataru and Leelabati Otta

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# Preface

*To have rhythm, to be in sync, is to be healthy.  
But not just any rhythm will do.*

Germ theory—and its related breakthroughs of sanitation, vaccination, and antibiotics—was the groundbreaking health development of the past century. It prevents infectious disease and led to the most dramatic rise in longevity in any century in human history. Yet living longer does not always mean living healthier. In fact, we are now witnessing a rapid increase in chronic diseases of both the mind and the body beginning in early childhood and stretching through old age. Luckily, we are beginning to understand the cause: Our modern lifestyle is disrupting a deeply ingrained, primordial, and universal code to being healthy.

The observations that I have made over the past twenty years, along with my colleagues and other researchers in the tiny field of circadian biology, are radically changing the way we understand how both the body and the mind optimally function. The science of circadian rhythms is actually a multidisciplinary field that includes biologists, exercise physiologists, mathematicians, psychologists, sleep researchers, nutritionists, endocrinologists, ophthalmologists, geneticists, oncologists, and more. Working together, we have found that simply adjusting the timing of how we live—and making easy lifestyle changes—is the secret to restoring our rhythm, and it will surely be the next revolution in health care. I invite you to learn what I have uncovered through my own research and through working with the best minds in each of these fields. I call this the *circadian code*, and by adopting these lessons you will make small changes to the way you sleep, eat, work, learn, exercise, and light up your home that will make a profound difference in every aspect of your health. In fact, the benefits you'll reap can be far more effective and long-lasting than any medication or special diet.

You may have heard about circadian rhythms before; a 2017 Nobel Prize recognized this field of research for its impact on human health. But if you haven't heard of circadian rhythms, don't worry; the concept is very simple. The term *circadian* comes from the Latin *circa*, meaning "around" (or

“approximately”), and *diēm*, meaning “day.” Circadian rhythms are real biological processes that every plant, animal, and human exhibits over the course of a day. These rhythms are actually interconnected among species and are governed by internal circadian or biological clocks, which are very different from the “ticking biological clock” you might think about if you’re worried about having kids by a certain age. As you’ll learn, almost each and every one of our cells contains one of these clocks, and each is programmed to turn on or off thousands of genes at different times of the day or night.

These genes influence every aspect of our health. For instance, when we are healthy, we can have a good night’s sleep. In the morning, we wake up feeling fresh and energetic and ready to get to work. Our gut function is perfectly normal. We have a healthy hunger and a clear mind. In the afternoon, we have the energy to exercise. At night, we are tired enough to go back to sleep without much effort. Yet when these daily rhythms are disturbed for as little as a day or two, our clocks cannot send out the right messages to these genes, and our body and mind will not function as well as we need. If this disruption continues for a few days, weeks, or months, we may succumb to all types of infections and diseases, ranging from insomnia to attention deficit hyperactivity disorder (ADHD), depression, anxiety, migraine, diabetes, obesity, cardiovascular disease, dementia, and even cancer.

Luckily, it’s easy to get back in sync. We can optimize our clocks in just a few weeks. By restoring our circadian rhythms, we can even reverse some of the diseases or accelerate cures, returning us to better health.

## **My Journey: Discovering the Secrets of the Biology of Time**

I was lucky to be born (in 1971) and raised in India during a unique time in history. I experienced firsthand how a rapidly evolving modern society disrupts the interconnectedness of life, including our own biological rhythms. Throughout my early childhood, I lived in a small town near my maternal grandparents. My grandfather worked as a goods clerk at the local train station, where he often worked the night shift. My grandparents lived in a house with a large jasmine tree near their front gate. To me, that tree was magical: It bloomed profusely at night and would shed its flowers right

before dawn, as if laying a beautiful carpet to welcome my grandfather home each morning.

During summer and winter breaks, we visited my father's family, who lived on a farm in a rural part of the country. The contrast between my maternal grandfather's shift work at the train station and my paternal grandfather's life on the farm, in sync with nature, seemed like it was at least a century apart, although it was only a 2-hour road trip to get from one place to the other. For most of my childhood their village did not have electricity, so as you can imagine, life on the farm was very different from life at my home. My relatives raised almost everything they ate. Although I don't remember my grandfather ever wearing a watch, their daily routine happened with clockwork precision that was in sync with the sun and the stars. At the crack of dawn roosters sounded the alarm clock that woke everyone up. The whole day was spent tending to plants and animals and preparing meals. We picked fruits and vegetables or helped my uncle catch fish from the farm pond. Breakfast and lunch were the main meals, and they were feasts prepared with freshly picked vegetables and fish. Dinner was always before sunset and was mostly leftovers from lunch, as it was impossible to store any cooked food overnight. The evenings were also very different. The only light we had available came from kerosene lanterns. In those days kerosene was expensive and rationed by the government. My grandparents had a relatively large house with six bedrooms. We were only allowed to use the lanterns for a couple of hours in the evening, except for two lanterns that were placed at the ends of the verandah that flickered all night. After dinner all of the kids would huddle around a lantern, and my mother—who was a schoolteacher—would quiz us. Sometimes our aunts would join to tell us stories or my uncle would take us to the backyard to teach us the phases of the moon.

I remember asking for certain fruits or vegetables I liked to eat at home and being met with a strange look from my cousins. To them, I was a dumb town kid who didn't know which fruits and vegetables grow in what season. But what they didn't know was that my father, who had a college degree in agriculture, had introduced many high-yielding trees, vegetables, and rice varieties to my grandfather's farm. Some of these new rice strains could even grow in both the summer and winter, essentially doubling the return from the same piece of land. In this instance, disrupting the natural order of things didn't seem like such a bad idea.

When I was in junior high school, I lost my father to a road accident. A truck driver who was most likely sleep-deprived lost control of his vehicle.

Years later I learned a sleep-deprived brain is more dangerous than a brain under the influence of alcohol. Yet even today, driving after a sleepless night is not illegal.

After high school, I went to an agriculture school like my father had, which at the time was the fastest path to a secure job in government or banking. Whenever I visited my grandparents' rural village, my grandfather would tease me and ask if I could crack the code of nature so that he could grow any fruit or vegetable in any season. That is how I developed an interest in understanding how all living things connect to daily and seasonal time.

I would also visit my maternal grandfather, who by then had retired from his job. It was only a few years after retirement that he started showing signs of dementia. My grandmother took care of him like he was a baby. I visited him almost every weekend in my senior year: I was one of only three or four people he recognized. He lost sense of day and night; he would feel hungry, sleepy, or could stay wide awake at random times. I began to notice how important the simple code of time is in our daily life. A few days after I completed college, he passed away at the age of 72.

I had done well in college with a major in plant breeding and genetics. My natural next step would have been to go for a master's degree in these same subjects, but I was lucky to secure a scholarship for a master's degree in molecular biology, which in India is called *biotechnology*. Molecular biology was at the time a new branch of science, and it introduced me to the genetic code.

Afterward, I landed a nice research job in the city of Chennai with Bush Boake Allen (now International Flavors and Fragrances), which makes flavoring agents and fragrances for almost every major food company in the world. My first assignment was to figure out the chemistry of how vanilla beans get their flavor. I visited the vanilla farms in the Nilgiri Hills in southern India, where my host would wake me up around 2:00 a.m. to drive to the fields to show me how the workers pollinated each vanilla flower by hand as soon as it would open in the wee hours of morning. Although the job paid well, the workers hated waking up in the middle of the night for a couple of months, and by the end of the season they were very sick. I wondered whether their sickness was some type of reaction to stuff in the field, or if it was due to losing sleep for 2 months. The field of circadian



rhythm research was beginning to make headlines in top scientific journals as Jeffrey C. Hall, Michael Rosbash, and Michael W. Young (who together won the Nobel Prize in Physiology or Medicine in 2017) were publishing their groundbreaking work.

I soon left India for graduate school in Winnipeg, Manitoba, Canada. It was a profound shock on many levels, the least of which was moving from 98°F weather in India to Winnipeg, where 0°F temperatures during winter were not uncommon. The nights were so long in winter, and my brain was disoriented: Was it culture shock, temperature shock, or the lack of light? Almost half of my classmates in the immunology department were feeling quite low, and they called it the “winter blues.” The effect of long Winnipeg nights on my circadian rhythm and mood rekindled my interest in the field. After just one winter, I managed to move to San Diego. That’s where I put all of my life’s questions and experiences into one field of research. I began to formally study circadian rhythms.

For the past 21 years, I’ve devoted my life to this research. As a graduate student at the Scripps Research Institute in La Jolla, California, I worked on understanding how plants measure time. The most exciting part was being in a lab that was at the forefront of the field. This was when we first discovered that there were clock genes in both plants and animals. Our work involved uncovering the mystery of how these clocks work. Every day was thrilling, almost like sitting in the front row of your favorite Broadway show every night. I was part of the team that discovered how specific plant clock genes work together to tell plants when to photosynthesize and absorb carbon dioxide for fuel, and when to sleep or repair themselves. One of the plant genes I discovered allowed us a better understanding of how the circadian clock, metabolism, and DNA repair may be connected.

In 2001, I was invited to do my postdoctoral research at the newly founded Genomics Institute of the Novartis Research Foundation (GNF), where I would be working on animal clocks. This premier institute squarely focused on using the newly described human and mouse genome to understand biology. I was there to solve mysteries in circadian biology.

My first breakthrough came in the first year. I was able to explain how our circadian rhythms adjust to different seasons or different types of light. My team discovered an elusive blue light sensor in the eye’s retina that sends light signals to the brain clock to tell it when it is morning and when it is night. Having a handle on the light sensor helped us figure out how much light—of which color, for how long, and at what time of the day— we

need to advance or delay our clock. That was a huge discovery because for almost 100 years, scientists had known that there was a light sensor in the eye, but they didn't have any idea where it was or what it did. This discovery was cited among the top ten breakthroughs of 2002 by the prestigious *Science* magazine, and it is the reason why your smartphone or tablet lets you change its background color from bright white to a dimmer orange a few hours before your scheduled sleep time.

It took us almost 8 years to determine how this light sensor worked, how it transfers information from the eye to the brain, and which brain regions receive that information in order to regulate sleep, depression, circadian rhythm, and pain. Even today, I am still trying to figure out the full extent to which light affects circadian rhythm and how modern lighting affects this process. Yet it's been very gratifying to see how our discovery went from simple observation to adoption, enabling more than a billion people to be aware of the impact of light on their health in just 15 years.

A second point of inquiry was to determine how our internal clocks transmit their timing information and how our organs read time and do different tasks at specific times. We started using very modern genomic technology to monitor which genes turn on and off at different times in different organs. This research began in 2002, and since then we have had another big breakthrough: the discovery that hundreds to thousands of genes in both the brain and liver turn on and off at specific times. We are still extending these experiments to different organs, tissues, brain centers, and glands. We are finding that almost every organ has its own clock, and in each organ genes turn on or off, affecting protein production levels at predictable times of the day.

After starting my own lab at the prestigious Salk Institute for Biological Studies, I continued my clock research in collaboration with outstanding colleagues. We now know that to have predictable circadian rhythms is to have healthy organs. Just like a mutation in the genetic code can lead to disease, living in opposition to the circadian code can push us toward disease. Over the past few years I have had the good fortune to work with some of the great minds in the fields of cardiovascular and metabolic diseases, and together we have found that animals that lack a normal clock are highly predisposed to these diseases. Slowly it became clear that a disrupted clock is the mother of all maladies, and, conversely, in most chronic diseases, clock function is compromised.

Finally, in 2009, these two areas of my research—light and time—came together. Extending the research of two prior studies, we created a simple experiment where we kept mice in a specific light-dark cycle.<sup>1,2</sup> Mice are usually nocturnal and eat at night. But in the experiment, we gave them food during the daytime and then watched to see what happened with their internal clocks. Surprisingly, we found that almost every liver gene that ever turns on and off within a 24-hour period completely ignored the light signal and instead were synced to when the mice ate and fasted. We also learned from this experiment that a daily eating–fasting cycle drives almost every rhythm in the liver. Instead of thinking that all timing information comes from the outside world through the eye’s blue light sensor, we learned that just like the first light of the morning resets our brain clock, the first bite of the morning resets all other organ clocks.

Then, in 2012, we pushed the envelope even further. We wanted to see if disease was not only linked to diet but also to the breakdown of the circadian code. Thousands of research papers had shown that when mice are given free access to fatty and sugary foods, they become obese and diabetic within a few weeks. We compared one set of mice having free access to the fatty diet to a second group that had to eat all their food within an 8- to 12-hour period. What we found was startling: Mice that eat the same number of calories from the same foods within 12 hours or less every day are completely protected from obesity, diabetes, liver, and heart disease. More surprising, when we put sick mice on this scheduled feeding, we could reverse their disease without medication or change in diet.

Initially, the scientific community was skeptical of our discovery. The conventional wisdom was that what and how much we eat determined our health. But slowly, similar observations began to pour in from laboratories around the world, including from human studies. Now we know that in addition to what and how much we eat, when we eat matters. Many important medical groups have taken note of our findings and have done their own literature review to find if timing of food intake matters. For instance, the National Institutes of Health, the American Heart Association, and the American Diabetes Association, among others, believe as I do that resetting the circadian clock is our next, best hope to prevent or to accelerate the cure of chronic diseases. In 2017, the American Heart Association released their first recommendation on meal timing and frequency in almost 70 years that corroborates our research, showing how

eating patterns might be used as a way to prevent or reduce cardiovascular disease.<sup>3</sup>

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This book, based on my research, is meant to give you the tools you can use to optimize your clock by making simple lifestyle changes. The stakes have never been higher. Today, almost one-third of all adults suffer from at least one chronic disease, such as obesity, diabetes, cardiovascular disease, hypertension, respiratory disease, asthma, or chronic inflammation. By the time of retirement, adults in the United States typically have two or more chronic diseases. And the truth about chronic disease is that there is rarely a cure. There aren't many people with diabetes who go completely back to normal. A person with cardiovascular disease rarely goes back to normal. We just have better ways to manage and live with these diseases.

That changes now. In this book I offer you very simple ideas and practices you can use on a daily basis that have been proven in vigorous laboratory research to prevent or delay the onset of disease.

Here's just one more thing you need to know about me: My science is supported by the U.S. government and thrives because of honest taxpayers and philanthropists like you. If this research can inspire a million people to make these small changes and delay one chronic disease by just one year, it can provide an estimated savings of at least \$2 billion annually to the U.S. economy. This research is my gift to you because I feel so deeply indebted to this country. In 2001, I was a foreign national having just finished my PhD with an F-1 visa. I was very excited to continue my postdoc research at GNF and had just applied for an H-1B visa. Any foreign national knows the gut-wrenching anxiety of waiting for your work visa.

Then 9/11 happened. At about 5:00 p.m. on September 12, 2001, the human resource director of GNF walked toward my desk with a piece of paper in her hand. My worst fear came to my mind: that the government must have rejected my H-1B visa. But instead, I learned that it had been approved earlier that day. It was then I realized that this country, my new home, must be awesome, because on September 12, when I could not focus on my work in the lab, being completely overcome with the previous day's events, somebody on the East Coast actually went to work, looked at my application, and approved it. That was the day I decided to stay in this

country forever and pay it forward. This is why I'm sharing my research with you, and I hope that you can benefit from it.

## How This Book Works

Addressing your circadian clock is more than a diet. In fact, it's not a diet at all. It's a lifestyle. It begins with knowing when to eat and when to turn off the lights. Just paying attention to those small parts of your day will go a long way toward preventing and delaying disease.

As you'll learn, we are easily vulnerable to disrupting our circadian rhythm. All it takes is the slightest upset from an overnight flight, a poor night's sleep, illness, or a disruptive work schedule. *The Circadian Code* can be a powerful tool to manage your waking day, whether you are a parent or a child (especially a teenager), millennial or retired; regular workers, shift workers, working moms, and health enthusiasts can all benefit. If you are dealing with one or more chronic diseases, you need to read this book. No matter who you are, you'll learn when is the best time for you to eat, work, and exercise during the day, and how to manage the evening hours so that you can get the best, most restful sleep.

First and foremost, this book is about prevention, but you can also use this information to live better now. Part I focuses on identifying how the circadian clocks in the body work and why maintaining perfect timing is of utmost importance for both children and adults. The first step on the road to health is to recognize if you are in fact unwell, and this section includes a simple quiz to see how your health is currently affecting your rhythm. You will also start tracking your timing so you can see where adjustments need to be made.

Part II features complete instructions on how to best use your day to maximize your internal rhythms. You will learn exactly when (and what) to eat, but not how much. There is no calorie counting on this program, but I can say that if you do follow the guidelines I suggest, weight loss is almost inevitable. You'll learn when is the optimal time of day to work and be productive, as well as when is the best time to exercise. You'll also discover new techniques for getting a better night's sleep, as well as technology that can enhance and track your total experience.

As we age, disruptions to our circadian rhythm affect us more than when we are young. I believe that most of the diseases that affect us in adulthood

can be traced back to circadian disruption. Part III addresses specific ailments and how they relate to our circadian rhythms. This section covers cancers and other immune-system issues, the components of metabolic syndrome (heart disease, obesity, and diabetes), and neurological health including depression, dementia, Parkinson's disease, and other neurodegenerative issues. You'll also learn how the gut's microbiome is influenced by your internal rhythms and how conditions like acid reflux, heartburn, and inflammatory bowel disease can be addressed.

I'm not a medical doctor, so I cannot prescribe medications. The scientist in me reminds me every day how little we really know about how the body works. But I can share with great certainty what I know about this powerful, primordial inescapable rhythm we have, including my best advice for optimizing your daily routines. Please share this information about daily habits that optimize our circadian rhythms with your doctor or other health practitioner so that he or she can make better decisions about treatment options or courses of action. With the tools given inside this book, it's very likely that you'll be able to get your health back on track.



# The Circadian Clock

## CHAPTER 1

# We Are All Shift Workers

If you are a card-carrying shift worker who wakes up in the middle of the night to go to work, returns from work late at night, or stays awake all night, you know how it feels to be living against a primitive, primordial drive to sleep at night and stay awake during the day. But even if you're not, I'm sure you can remember a time when you were fighting against your internal clock. The truth is, we are all shift workers. There are times in life when we go through chronic sleep disruption, and for many, those habits linger. If you pull an all-nighter at school or work, stay up late studying for a test, have a bad night's sleep, travel across several time zones, stay awake late into the night to tend to a sick relative, or wake up a few times to feed and change a baby, then you too are a shift worker. A full-time job with long commutes combined with a regular home routine is like working two shifts and going to bed past midnight. Even one late night of partying can be just as disruptive as traveling from one time zone to another: That's why we call it *social jet lag*.

The statement that "we are all shift workers" isn't just an idea. Data points to this fact. For example, Professor Till Roenneberg, a researcher in Munich, surveyed more than 50,000 people in Europe and the United States and found that the majority of people either go to bed after midnight or wake up early with insufficient sleep.<sup>1,2</sup> Similarly, people also follow different bedtime schedules on weekdays and weekends. At the 2017 World Sleep Congress, Roenneberg presented his data showing that roughly 87 percent of adults have social jet lag and go to bed at least 2 hours later on the weekend.

About 6 years ago, my lab started monitoring the activity and sleep patterns of close to 200 college students, and we found the same pattern that Roenneberg has reported. So far, there's been only one person in the whole group who actually went to bed every day at the same time, within half an hour, including on weekends. There has been only one other student who went to bed before midnight for at least two days in a week.



We also monitor pregnant women and working moms with babies, and their patterns are also very erratic. In fact, their patterns are most similar to firefighters, who expect to be awoken a few times every night. For many women, the hardest part of motherhood is working against your clock to stay awake at night and trying to catch up on sleep at odd hours of the day. The only time new moms actually got good sleep, not surprisingly, was when they had some help beyond their spouse/partner, like in-laws or parents who could share some of the work at night.

Working mothers have the roughest time syncing their lives to a daily rhythm because their day is affected by everyone else in the home. Typically, working mothers wake up very early to get breakfast ready for the family, prepare the kids, pack the lunch bags and backpacks, get the kids to school or day care, and then get themselves to work. After dinner, they oversee homework, exercise, or work at home late into the night. As the week goes on, their circadian disruption becomes more severe. For instance, when my daughter was an infant, by Friday my wife would literally fall ill, and it would take her all weekend to recover.

No matter what the cause, we all know how it feels the day after a particularly rough night. You feel sleepy, yet you cannot sleep. Your stomach may feel upset, your muscles are weak, your mind is foggy, and you are certainly not in the mood to hit the gym. It's as if your body and mind are confused—half of your brain may be telling you that it is time to catch up on lost sleep, but the other half is insisting that it's daytime and you should not sleep. You may resolve to push on and reach for a strong cup of coffee or energy drink to stamp out the urge to sleep or try to get back into your regular routine as quickly as possible.

A brain on shift work cannot make rational decisions. According to a recent article in *Popular Science* magazine,<sup>3</sup> a single night shift has cognitive effects that can last a week. These lapses in memory or attention can also make us vulnerable to bad habits. A few days of reduced sleep can change our appetite, both for the kinds of foods we crave and how much we want to eat when we stay awake at night. Often, we are prone to eat more calorie-dense junk food late at night when our stomach is meant to rest and repair.

Living in the shift-work zone can also cause difficulty in getting to sleep. Some turn to alcohol or sleeping pills, both of which can trigger depression. But more important, they are addictive remedies that create bad habits

that continue even when our lifestyle does not demand us to be awake at night.

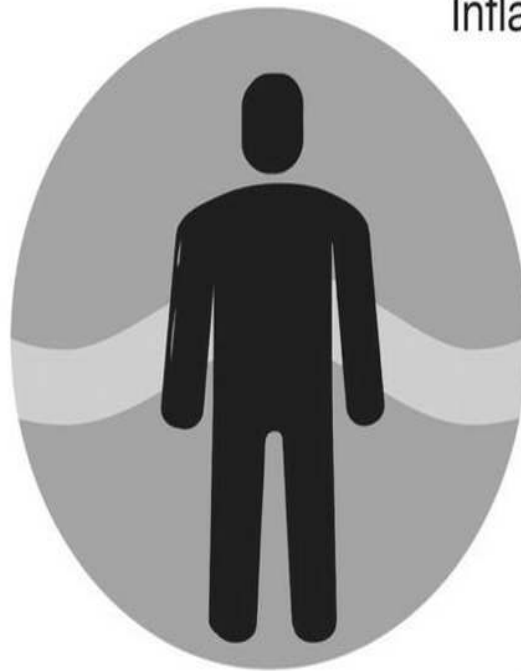
And if it weren't bad enough that a shift-work lifestyle affects the way we feel the next day, our family members are in essence secondhand shift workers, as we may inadvertently disrupt their sleep as they wake up early or stay awake late to match our crazy schedules and keep us company. The effects on their health are equally troubling. For instance, in a 2013 analysis of published papers on the topic, researchers found that children of shift workers not only had more cognitive and behavioral problems as compared to children raised by non-shift workers, they also had a higher incidence of obesity.<sup>4</sup>

While a day or two of staying awake late into the night, or a couple of days after traveling through a few time zones, may be uncomfortable, repeatedly disrupting your circadian clock can have adverse health consequences, as every system in your body starts to malfunction. It makes the immune system so weak that germs and bugs that don't usually cause any trouble can upset your stomach or even cause flulike symptoms. It has been well documented that shift workers experience more health problems than non-shift workers, particularly gastrointestinal diseases, obesity, diabetes, and cardiovascular diseases.<sup>5,6,7,8,9,10,11,12,13,14,15,16</sup> Surprisingly, the number one cause of death and work disability for active-duty firefighters is not fire or accident—it is heart disease, which is now thought to be linked to a disruption of the circadian rhythm.<sup>17,18</sup> In many studies, shift work increases the risk for certain types of cancer to such an extent that, in 2007, the World Health Organization's International Agency for Research on Cancer classified shift work as a potential carcinogen.<sup>19</sup>

If we are all shift workers, then we will all suffer. This is why we have to understand how our circadian clock works, and how to optimize our lifestyle to nurture the natural rhythm of the body.

# What Happens When Circadian Rhythms Break Down?

ADHD	Polycystic ovarian syndrome	Leaky gut
Autism	Irregular menstrual cycle	Indigestion
SAD	Post-partum depression	Heart burn
Anxiety	Inability to conceive	Stomach pain
Panic attack	Morning sickness	Crohn's disease
Depression	Miscarriages	Ulcerative colitis
Compromised learning		Inflammatory bowel syndrome
Nocturnal epilepsy		Inflammatory bowel disease
Bipolar syndrome		Metabolic syndrome
ICU Delirium		Weight gain/Obesity
Migraine		Childhood obesity
PTSD		Type 2 Diabetes
Seizure		Prediabetes
Mania		Stroke
Psychosis		Dyslipidemia
Multiple Sclerosis		Hypertension
Huntington Disease		Heart Arrhythmia
Alzheimer's Disease		Chronic Kidney Disease
Parkinson's Disease		Fatty Liver Disease (NAFLD)
Bacterial Infection	Insomnia	Steatohepatitis (NASH)
Sleeping sickness	Prader-Willie syndrome	Ovarian cancer
Malaria	Smith-Magenis syndrome	Breast cancer
Arthritis	Obstructive Sleep Apnea	Liver Fibrosis
Asthma	Delayed sleep phase syndrome	Colon cancer
Allergy	Non-24-hour sleep-wake syndrome	Liver cancer
Lymphoma	Familial advance sleep phase syndrome	Lung cancer



## Which Kind of Shift Worker Are You?

A person who stays awake for more than 3 hours between 10:00 p.m. and 5:00 a.m. for more than 50 days in a year fits the official European definition of a shift worker. Yet I believe we are all shift workers simply due to the way we live our lives. Which kind of shift work do you experience?

- *Traditional shift work:* Roughly 20 to 25 percent of the nonmilitary workforce in any developing or developed country is involved in shift work. This includes emergency responders (firefighters, emergency dispatchers); police; workers in health services (nurses, doctors), manufacturing, construction, utility services, air transportation (pilots, flight attendants, ground staff), ground transportation, and food services; custodial staff; and call center customer support workers.
- *Shift-work-like lifestyle:* This includes high school and college students, musicians, performing artists, new mothers, in-home caregivers, and spouses of shift workers.
- *Jobs in the gig economy:* This includes part-time drivers for ride-share services and food delivery services, flexible workers, and freelancers.
- *Jet lag:* This occurs when you travel across two or more time zones within a day. Nearly 8 million air travelers take to the air each day,<sup>20</sup> and half of them travel over at least two time zones.
- *Social jet lag:* This occurs when someone sleeps late and wakes up at least 2 hours later on the weekends. More than 50 percent of the population in modern society experiences social jet lag.