THE TELOMERE EFFECT

A REVOLUTIONARY APPROACH TO **LIVING YOUNGER, HEALTHIER, LONGER**

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INTRODUCTION

A Tale of Two Telomeres

It is a chilly Saturday morning in San Francisco. Two women sit at an outdoor café, sipping hot coffee. For these two friends, this is their time away from home, family, work, and to-do lists that never seem to get any shorter.

Kara is talking about how tired she is. How tired she *always* is. It doesn't help that she catches every cold that goes around the office, or that those colds inevitably turn into miserable sinus infections. Or that her ex-husband keeps "forgetting" when it's his turn to pick up the children. Or that her bad-tempered boss at the investment firm scolds her—right in front of her staff. And sometimes, as she lies down in bed at night, Kara's heart gallops out of control. The sensation lasts for just a few seconds, but Kara stays awake long after it passes, worrying. *Maybe it's just the stress*, she tells herself. *I'm too young to have a heart problem. Aren't I?*

"It's not fair," she sighs to Lisa. "We're the same age, but I look older."

She's right. In the morning light, Kara looks haggard. When she reaches for her coffee cup, she moves gingerly, as if her neck and shoulders hurt.

But Lisa looks vibrant. Her eyes and skin are bright; this is a woman with more than enough energy for the day's activities. She feels good, too. Actually, Lisa doesn't think very much about her age, except to be thankful that she's wiser about life than she used to be.

Looking at Kara and Lisa side by side, you would think that Lisa really *is* younger than her friend. If you could peer under their skin, you'd see that in some ways, this gap is even wider than it seems. Chronologically, the two women are the same age. Biologically, Kara is decades older.

Does Lisa have a secret—expensive facial creams? Laser treatments at the dermatologist's office? Good genes? A life that has been free of the difficulties her friend seems to face year after year?

Not even close. Lisa has more than enough stresses of her own. She lost her husband two years ago in a car accident; now, like Kara, she is a single mother. Money is tight, and the tech start-up company she works for always seems to be one quarterly report away from running out of capital.

What's going on? Why are these two women aging in such different ways?

The answer is simple, and it has to do with the activity inside each woman's cells. Kara's cells are prematurely aging. She looks older than she is, and she is on a headlong path toward age-related diseases and disorders. Lisa's cells are renewing themselves. She is living younger.

WHY DO PEOPLE AGE DIFFERENTLY?

Why do people age at different rates? Why are some people whip smart and energetic into old age, while other people, much younger, are sick, exhausted, and foggy? You can think of the difference visually:

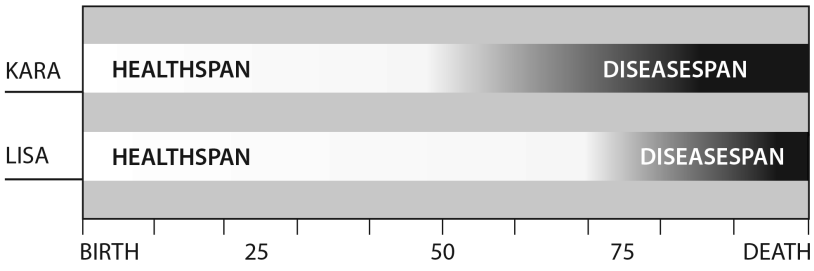

Figure 1: Healthspan versus Diseasespan. Our healthspan is the number of years of our healthy life. Our diseasespan is the years we live with noticeable disease that interferes with our quality of living. Lisa and Kara may both live to one hundred, but each has a dramatically different quality of life in the second half of her life.

Look at the first white bar in figure 1. It shows Kara's healthspan, the time of her life when she's healthy and free of disease. But in her early fifties, the white goes gray, and at seventy, black. She enters a different phase: the diseasespan.

These are years marked by the diseases of aging: cardiovascular disease, arthritis, a weakened immune system, diabetes, cancer, lung disease, and more. Skin and hair become older looking, too. Worse, it's not as if you get just one disease of aging and then stop there. In a phenomenon with the gloomy name *multi-morbidity*, these diseases tend to come in clusters. So Kara doesn't just have a run-down immune system; she also has joint pain and early signs of heart disease. For some people, the diseases of aging hasten the end of life. For others, life goes on, but it's a life with less spark, less zip. The years are increasingly marred by sickness, fatigue, and discomfort.

At fifty, Kara should be brimming with good health. But the graph shows that at this young age, she is creeping into the diseasespan. Kara might put it more bluntly: she is getting old.

Lisa is another story.

At age fifty, Lisa is still enjoying excellent health. She gets older as the years pass, but she luxuriates in the healthspan for a nice, long

time. It isn't until she's well into her eighties—roughly the age that gerontologists call "old old"—that it gets significantly harder for her to keep up with life as she's always known it. Lisa has a diseasespan, but it's compressed into just a few years toward the end of a long, productive life. Lisa and Kara aren't real people—we've made them up to demonstrate a point—but their stories highlight questions that are genuine.

How can one person bask in the sunshine of good health, while the other suffers in the shadow of the diseasespan? Can you choose which experience happens to *you*?

The terms *healthspan* and *diseasespan* are new, but the basic question is not. *Why do people age differently?* People have been asking this question for millennia, probably since we were first able to count the years and compare ourselves to our neighbors.

At one extreme, some people feel that the aging process is determined by nature. It's out of our hands. The ancient Greeks expressed this idea through the myth of the Fates, three old women who hovered around babies in the days after birth. The first Fate spun a thread; the second Fate measured out a length of that thread; and the third Fate snipped it. Your life would be as long as the thread. As the Fates did their work, *your* fate was sealed.

It's an idea that lives on today, although with more scientific authority. In the latest version of the "nature" argument, your health is mostly controlled by your genes. There may not be Fates hovering around the cradle, but the genetic code determines your risk for heart disease, cancer, and general longevity before you're even born.

Perhaps without even realizing it, some people have come to believe that nature is *all* that determines aging. If they were pressed to explain why Kara is aging so much faster than her friend, here are some things they might say:

"Her parents probably have heart problems and bad joints, too."

"It's all in her DNA."

"She has unlucky genes."

The "genes are our destiny" belief is, of course, not the only position. Many have noticed that the quality of our health is shaped by the way we live. We think of this as a modern view, but it's been around for a long, long time. An ancient Chinese legend tells of a raven-haired warlord who had to make a dangerous trip over the border of his homeland. Terrified that he would be captured at the border and killed, the warlord was so anxious that he woke up one morning to discover that his beautiful dark hair had turned white. He'd aged early, and he'd aged overnight. As many as 2,500 years ago, this culture recognized that early aging can be triggered by influences like stress. (The story ends happily: No one recognized the warlord with his newly whitened hair, and he traveled across the border undetected. Getting older has its advantages.)

Today there are plenty of people who feel that nurture is more important than nature—that it's not what you're born with, it's your health habits that really count. Here's what these folks might say about Kara's early aging:

"She's eating too many carbs."

"As we age, each of us gets the face we deserve."

"She needs to exercise more."

"She probably has some deep, unresolved psychological issues."

Take a look again at the ways the two sides explain Kara's accelerated aging. The nature proponents sound fatalistic. For good or for bad, we're born with our futures already encoded into our chromosomes. The nurture side is more hopeful in its belief that premature aging can be avoided. But advocates of the nurture theory can also sound judgmental. If Kara is aging rapidly, they suggest, it's all her fault.

Which is right? Nature or nurture? Genes or environment? Actually, both are critical, and it's the interaction between the two that matters most. The real differences between Lisa's and Kara's rates of aging lie in the complex interactions between genes, social relationships and environments, lifestyles, those twists of fate, and

especially how one responds to the twists of fate. You're born with a particular set of genes, but the way you live can influence how your genes express themselves. In some cases, lifestyle factors can turn genes on or shut them off. As the obesity researcher George Bray has said, "Genes load the gun, and environment pulls the trigger."[1] His words apply not just to weight gain but to most aspects of health.

We're going to show you a completely different way of thinking about your health. We are going to take your health down to the cellular level, to show you what premature cellular aging looks like and what kind of havoc it wreaks on your body—and we'll also show you not only how to avoid it but also how to reverse it. We'll dive deep into the genetic heart of the cell, into the chromosomes. This is where you'll find **telomeres (tee-lo-meres)**, repeating segments of noncoding DNA that live at the ends of your chromosomes. Telomeres, which shorten with each cell division, help determine how fast your cells age and when they die, depending on how quickly they wear down. The extraordinary discovery from our research labs and other research labs around the world is that the ends of our chromosomes can actually lengthen—and as a result, aging is a dynamic process that can be accelerated or slowed, and in some aspects even reversed. Aging need not be, as thought for so long, a one-way slippery slope toward infirmity and decay. We all will get older, but how we age is very much dependent on our cellular health.

We are a molecular biologist (Liz) and a health psychologist (Elissa). Liz has devoted her entire professional life to investigating telomeres, and her fundamental research has given birth to an entirely new field of scientific understanding. Elissa's lifelong work has been on psychological stress. She has studied its harmful effects on behavior, physiology, and health, and she has also studied how to reverse these effects. We joined forces in research fifteen years ago, and the studies that we performed together have set in motion a whole new way of examining the relationship between the human

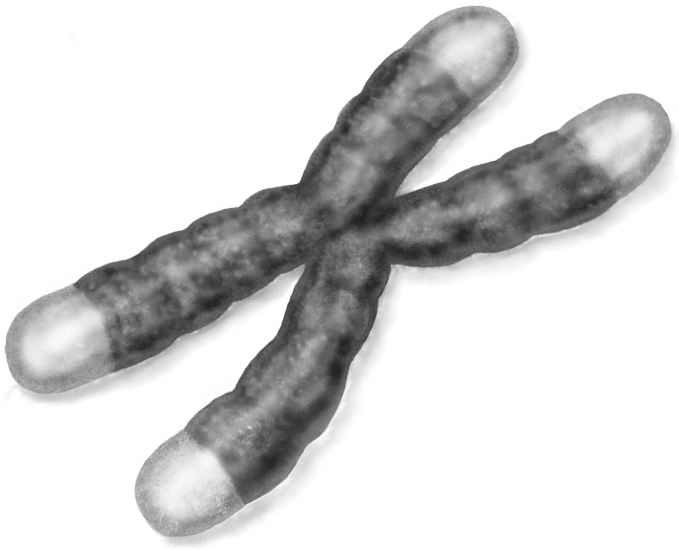

Figure 2: Telomeres at the Tips of Chromosomes. The DNA of every chromosome has end regions consisting of DNA strands coated by a dedicated protective sheath of proteins. These are shown here as the lighter regions at the end of the chromosome—the telomeres. In this picture the telomeres are not drawn to scale, because they make up less than one-ten-thousandth of the total DNA of our cells. They are a small but vitally important part of the chromosome.

mind and body. To an extent that has surprised us and the rest of the scientific community, telomeres do not simply carry out the commands issued by your genetic code. Your telomeres, it turns out, are listening to you. They absorb the instructions you give them. The way you live can, in effect, tell your telomeres to speed up the process of cellular aging. But it can also do the opposite. The foods you eat, your response to emotional challenges, the amount of exercise you get, whether you were exposed to childhood stress, and even the level of trust and safety in your neighborhood—all of these factors and more appear to influence your telomeres and can prevent premature aging at the cellular level. In short, one of the keys to a long healthspan is simply doing your part to foster healthy cell renewal.

HEALTHY CELL RENEWAL AND WHY YOU NEED IT

In 1961 the biologist Leonard Hayflick discovered that normal human cells can divide a finite number of times before they die. Cells reproduce by making copies of themselves (called mitosis), and as the human cells sat in a thin, transparent layer in the flasks that filled Hayflick's lab, they would, at first, copy themselves rapidly. As they multiplied, Hayflick needed more and more flasks to contain the growing cell cultures. The cells in this early stage multiplied so quickly that it was impossible to save all the cultures; otherwise, as Hayflick remembers, he and his assistant would have been "driven out of the laboratory and the research building by culture bottles." Hayflick called this youthful phase of cell division "luxuriant growth." After a while, though, the reproducing cells in Hayflick's lab stopped in their tracks, as if they were getting tired. The longest-lasting cells managed about fifty cell divisions, although most divided far fewer times. Eventually these tired cells reached a stage he called **senescence**: They were still alive but they had all stopped dividing, permanently. This is called the Hayflick limit, the natural limit that human cells have for dividing, and the stop switch happens to be telomeres that have become critically short.

Are all cells subject to this Hayflick limit? No. Throughout our bodies we find cells that renew—including immune cells; bone cells; gut, lung, and liver cells; skin and hair cells; pancreatic cells; and the cells that line our cardiovascular systems. They need to divide over and over and over to keep our bodies healthy. Renewing cells include some types of normal cells that can divide, like immune cells; progenitor cells, which can keep dividing even longer; and those critical cells in our bodies called stem cells, which can divide indefinitely as long as they are healthy. And, unlike those cells in Hayflick's lab dishes, cells don't always have a Hayflick limit, because—as you will read in chapter 1—they have telomerase. Stem cells, if kept healthy, have enough telomerase to enable them to keep dividing throughout our life spans. That cell replenishment, that *luxuriant growth*, is one

reason Lisa's skin looks so fresh. It's why her joints move easily. It's one reason she can take in deep lungfuls of the cool air blowing in off the bay. The new cells are constantly renewing essential body tissues and organs. Cell renewal helps keep her feeling young.

From a linguistic perspective, the word *senescent* has a shared history with the word *senile*. In a way, that's what these cells are—they're senile. In one way it is definitely good that cells stop dividing. If they just keep on multiplying, cancer can ensue. But these senile cells are not harmless—they are bewildered and weary. They get their signals confused, and they don't send the right messages to other cells. They can't do their jobs as well as they used to. They sicken. The time of luxuriant growth is over, at least for them. And this has profound health consequences for you. When too many of your cells are senescent, your body's tissues start to age. For example, when you have too many senescent cells in the walls of your blood vessels, your arteries stiffen and you are more likely to have a heart attack. When the infection-fighting immune cells in your bloodstream can't tell when a virus is nearby because they are senescent, you are more susceptible to catching the flu or pneumonia. **Senescent cells can leak proinflammatory substances that make you vulnerable to more pain, more chronic illness. Eventually, many senescent cells will undergo a preprogrammed death.**

The diseasespan begins.

Many healthy human cells can divide repeatedly, so long as their telomeres (and other crucial building blocks of cells like proteins) remain functional. After that, the cells become senescent. Eventually, senescence can even happen to our amazing stem cells. This limit on cells dividing is one reason that there seems to be a natural winding down of the human healthspan as we age into our seventies and eighties, although of course many people live healthy lives much longer. A good healthspan and life span, reaching eighty to one hundred years for some of us and many of our children, is within our reach.[2] There are around three hundred thousand centenarians

worldwide, and their numbers are rapidly increasing. Even more so are the numbers of people living into their nineties. Based on trends, it is thought that over one-third of children born in the United Kingdom now will live to one hundred years.[3] How many of those years will be darkened by diseasespan? If we better understand the levers on good cell renewal, we can have joints that move fluidly, lungs that breathe easily, immune cells that fiercely fight infections, a heart that keeps pumping blood through its four chambers, and a brain that is sharp throughout the elderly years.

But sometimes cells don't make it through all their divisions in the way they should. Sometimes they stop dividing earlier, falling into an old, senescent stage before their time. When this happens, you don't get those eight or nine great decades. Instead, you get premature cellular aging. Premature cellular aging is what happens to people like Kara, whose healthspan graph turns dark at an early age.

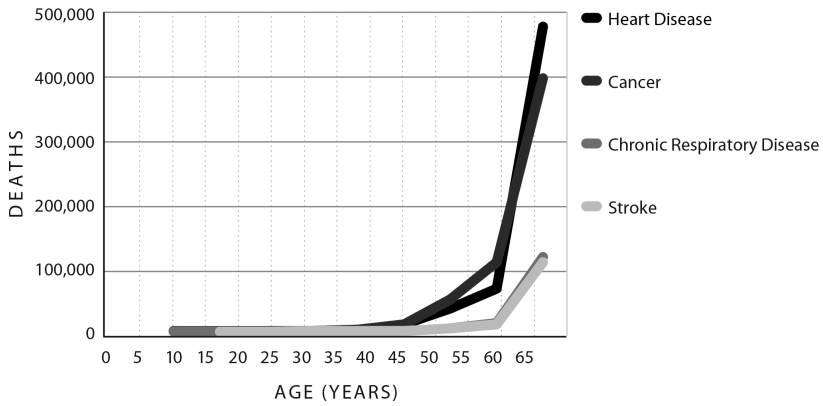

Figure 3: Aging and Disease. Age is by far the largest determinant of chronic diseases. This graph shows the frequency of death by age, up to age sixty-five and older, for the top four causes of death by disease (heart disease, cancer, respiratory disease, and stroke and other cerebrovascular diseases). The death rate due to chronic diseases starts to increase after age forty and goes up dramatically after age sixty. Adapted from U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, "Ten Leading Causes of Death and Injury," http://www.cdc.gov/injury/wisqars/leadingCauses.html.

Chronological age is the major determinant of when we get diseases, and this reflects our biological aging inside.

At the beginning of the chapter, we asked, *Why do people age differently?* One reason is cellular aging. Now the question becomes, *What causes cells to get old before their time?*

For an answer to this question, think of shoelaces.

HOW TELOMERES CAN MAKE YOU FEEL OLD OR HELP YOU STAY YOUNG AND HEALTHY

Do you know the protective plastic tips at the ends of shoelaces? These are called aglets. The aglets are there to keep shoelaces from fraying. Now imagine that your shoelaces are your chromosomes, the structures inside your cells that carry your genetic information. Telomeres, which can be measured in units of DNA known as base pairs, are like the aglets; they form little caps at the ends of the chromosomes and keep the genetic material from unraveling. They are the aglets of aging. But telomeres tend to shorten over time.

Here's a typical trajectory for the life of a human's telomere:

Age	**Telomere Length (in base pairs)**
Newborn baby	10,000 base pairs
35 years old	7,500 base pairs
65 years old	4,800 base pairs

When your shoelace tips wear down too far, the shoelaces become unusable. You may as well throw them away. Something similar happens to cells. When telomeres become too short, the cell stops dividing altogether. Telomeres aren't the only reason a cell can become senescent. There are other stresses on normal cells that we don't yet understand very well. But short telomeres are one of the primary reasons human cells grow old, and they are one mechanism that controls the Hayflick limit.

Your genes affect your telomeres, both their length when you're born and how quickly they dwindle down. But the wonderful news is that our research, along with research from around the globe, has shown you can step in and take some control of how short or long—how *robust*—they are.

For instance:

- Some of us respond to difficult situations by feeling highly threatened—and this response is linked to shorter telomeres. We can reframe our view of situations in a more positive way.
- Several mind-body techniques, including meditation and Qigong, have been shown to reduce stress *and* to increase telomerase, the enzyme that replenishes telomeres.
- Exercise that promotes cardiovascular fitness is great for telomeres. We describe two simple workout programs that have been shown to improve telomere maintenance, and these programs can accommodate all fitness levels.
- Telomeres hate processed meats like hot dogs, but fresh, whole foods are good for them.
- Neighborhoods that are low in social cohesion—meaning that people don't know and trust one another—are bad for telomeres. This is true no matter what the income level.
- Children who are exposed to several adverse life events have shorter telomeres. Moving children away from neglectful circumstances (such as the notorious Romanian orphanages) can reverse some of the damage.
- Telomeres on the parents' chromosomes in the egg and sperm are directly transmitted to the developing baby. Remarkably, this means that if your parents had hard lives that shortened their telomeres, they could have passed those shortened telomeres on to you! If you think that might be the case, don't panic. Telomeres can build up as well as shorten. **You can still take action to keep your telomeres stable. And this**

news also means that our own life choices can result in a positive cellular legacy for the next generation.

MAKE THE TELOMERE CONNECTION

When you think about living in a healthier way, you may think, with a groan, about a long list of things you ought to be doing. For some people, though, when they have seen and understood the connection between their actions and their telomeres, they are able to make changes that last. When I (Liz) walk to the office, people sometimes stop me to say, "Look, I'm biking to work now—I'm keeping my telomeres long!" Or "I stopped drinking sugary soda. I hated to think of what it was doing to my telomeres."

WHAT'S AHEAD

Does our research show that by maintaining your telomeres you will live into your hundreds, or run marathons when you're ninety-four, or stay wrinkle free? No. Everyone's cells become old and eventually we die. But imagine that you're driving on a highway. There are fast lanes, there are slow lanes, and there are lanes in between. You can drive in the fast lane, barreling toward the diseasespan at an accelerated pace. Or you can drive in a slower lane, taking more time to enjoy the weather, the music, and the company in the passenger seat. And, of course, you'll enjoy your good health.

Even if you are currently on a fast track to premature cellular aging, you can switch lanes. In the pages ahead, you'll see how to make this happen. In the first part of the book, we'll explain more about the dangers of premature cellular aging—and how healthy telomeres are a secret weapon against this enemy. We'll also tell you about the discovery of telomerase, an enzyme in our cells that helps keep the protective sheaths around our chromosome ends in good shape.

The rest of the book shows you how to use telomere science to

support your cells. Begin with changes that you can make to your mental habits and then to your body—to the kinds of exercise, food, and sleep routines that are best for telomeres. Then expand outward to determine whether your social and physical environments support your telomere health. Throughout the book, sections called "Renewal Labs" offer suggestions that can help you prevent premature cellular aging, along with an explanation of the science behind those suggestions.

By cultivating your telomeres, you can optimize your chances of living a life that is not just longer but better. That is, in fact, why we've written this book. In the course of our work on telomeres we've seen too many Karas—too many men and women whose telomeres are wearing down too fast, who enter the diseasespan when they should still feel vibrant. There is abundant high-quality research, published in prestigious scientific journals and backed by the best labs and universities, that can guide you toward avoiding this fate. We could wait for those studies to trickle down through the media and make their way into magazines and onto health websites, but that process can take many years and is piecemeal, and, sadly, information often gets distorted along the way. We want to share what we know now—and

THE HOLY GRAIL?

Telomeres are an integrative index of many lifetime influences, both the good, restorative ones like good fitness and sleep, and also malign ones like toxic stress or poor nutrition or adversities. Birds, fish, and mice also show the stress-telomere relationship. Thus it's been suggested that telomere length may be the "Holy Grail for cumulative welfare,"[4] to be used as a summative measure of the animals' lifetime experiences. In humans, as in animals, while there will be no one biological indicator of cumulative lifetime experience, telomeres are among one of the most helpful indicators that we know of right now.

we don't want more people or their families to suffer the consequences of unnecessary premature cellular aging.

When we lose people to poor health, we lose a precious resource. Poor health often saps your mental and physical ability to live as you wish. When people in their thirties, forties, fifties, sixties, and beyond are healthier, they will enjoy themselves more and will share their gifts. They can more easily use their time in meaningful ways—to nurture and educate the next generation, to support other people, solve social problems, develop as artists, make scientific or technological discoveries, travel and share their experiences, grow businesses, or serve as wise leaders. As you read this book, you are going to learn a lot more about how to keep your cells healthy. We hope you're going to enjoy hearing how easy it is to extend your healthspan. And we hope you're going to enjoy asking yourself the question: *How am I going to use all those wonderful years of good health?* Follow a bit of the advice in this book, and chances are that you'll have plenty of time, energy, and vitality to come up with an answer.

RENEWAL BEGINS RIGHT NOW

You can start to renew your telomeres, and your cells, right now. One study has found that people who tend to focus their minds more on what they are currently doing have longer telomeres than people whose minds tend to wander more.[5] Other studies find that taking a class that offers training in mindfulness or meditation is linked to improved telomere maintenance.[6]

Mental focus is a skill that you can cultivate. All it takes is practice. You'll see a shoelace icon, pictured here, throughout the book. Whenever you see it—or whenever you see your own shoes with or without laces—you might use it as a cue to pause and ask yourself what you're thinking. Where are your thoughts right now? If you're worrying or rehashing old problems, gently remind yourself

to focus on whatever it is you're doing. And if you are not "doing" anything at all, then you can enjoy focusing on "being."

Simply focus on your breath, bringing all of your awareness to this simple action of breathing in and out. It is restorative to focus your mind inside (noticing sensations, your rhythmic breathing), or outside (noticing the sights and sounds around you). This ability to focus on your breath, or your present experience, turns out to be very good for the cells of your body.

Figure 4: Think of Your Shoelaces. Shoelace tips are a metaphor for telomeres. The longer the protective aglets at the ends of the laces, the less likely the shoelace will fray. In terms of chromosomes, the longer the telomeres, the less likely there will be any alarms going off in cells or fusions of chromosomes. Fusions trigger chromosome instability and DNA breakage, which are catastrophic events for the cell.

Throughout the book, you will see a shoelace icon with long aglets. You can use that as an opportunity to refocus your mind on the present, take a deep breath, and think of your telomeres being restored with the vitality of your breath.

PART II

YOUR CELLS ARE LISTENING TO YOUR THOUGHTS

ASSESSMENT: Your Stress Response Style Revealed

Part Two, "Your Cells Are Listening to Your Thoughts," offers insights into how you experience stress and how you can shift that experience to be healthier for your telomeres and more beneficial in your daily life. To get you started, here's a quick self-test. It assesses your underlying sources of stress reactivity and stress resilience, some of which have been linked to telomere length.

Think of a situation that bothers you a great deal and that is ongoing in your life. (If you cannot think of a current situation, think of your most recent difficult problem.) Circle your numerical response to each question.	
1. When you think about dealing with this situation, how much do you feel hope and confidence vs. feelings of fear and anxiety?	**0** hopeful, confident **1** **2** same amount of each **3** **4** fearful, anxious
2. Do you feel you have whatever it takes to cope effectively with this situation?	**4** not at all **3** **2** somewhat **1** **0** extremely
3. How much are you caught up in repetitive thoughts about this situation?	**0** not at all **1** **2** somewhat **3** **4** extremely
4. How much do you avoid thinking about the situation or try not to express negative emotions?	**0** not at all **1** **2** somewhat **3** **4** extremely
5. How much does this situation make you feel bad about yourself?	**0** not at all **1** **2** somewhat **3** **4** extremely
6. How much do you think about this situation in a positive way, seeing some good that could come from it, or telling yourself statements that feel comforting or helpful, such as that you are doing the best you can?	**4** not at all **3** **2** somewhat **1** **0** extremely
TOTAL SCORE (Add up the numbers; notice questions 2 and 6 are positive responses so the scale is reversed.)	

The point of this informal test (not a validated research measure) is to raise awareness of your own tendencies to respond in a certain way to chronic stress. It is not a diagnostic scale. Also know that if you're dealing with a severe situation, your response style score will naturally shift to be higher. This is not a pure measure of response style, because our situations and our responses inevitably get a bit mixed together.

Total score of 11 or under: Your stress style tends to be healthy. Instead of feeling threatened by stress, you tend to feel challenged by it, and you limit the degree to which the situation spills over into the rest of your life. You recover quickly after an event. This stress resilience is positive news for your telomeres.

Total score of 12 or over: You're like most of us. When you're in a stressful situation, the power of that threat is magnified by your own habits of thinking. Those habits are linked, either directly or indirectly, to shorter telomeres. We'll show you how to change those habits or soften their effects.

★ ★ ★

Here's a closer look at the habits of mind associated with each question:

Questions 1 and 2: These questions gauge how threatened you feel by stress. High fear combined with low coping resources turn on a strong hormonal and inflammatory stress response. **Threat stress** involves a set of mental and physiological responses that can, over time, endanger your telomeres. Fortunately, there are ways to convert threat stress into a feeling of challenge, which is healthier and more productive.

Question 3: This item assesses your level of **rumination**. Rumination is a loop of repetitive, unproductive thoughts about something that's bothering you. If you're not sure how often you ruminate, now you can start to notice. Most stress triggers are short-lived, but we humans have the remarkable ability to give them a vivid and extended life in the mind, letting them fill our headspace

long after the event has passed. Rumination, also known as brooding, can slip into a more serious state known as depressive rumination, which includes negative thoughts about oneself and one's future. Those thoughts can be toxic.

Question 4: This one's about **avoidance and emotion suppression**. Do you avoid thinking about the stressful situation or avoid sharing feelings about it? Is it so emotionally loaded that the thought of it makes your stomach clench? It's natural to try to push difficult feelings away, but although this strategy may work in the short term, it doesn't tend to help when the situation is chronic.

Question 5: This question addresses "**ego threat**." Does it feel as if your pride and personal identity could be damaged if the stressful situation doesn't go well? Does the stress trigger negative thoughts about yourself, even to the extent that you feel worthless? It's normal to have these self-critical thoughts sometimes, but when they are frequent, they throw the body into an overly sensitive, reactive state characterized by high levels of the stress hormone cortisol.

Question 6: This question asks whether you're able to engage in **positive reappraisal**, which is the ability to rethink stressful situations in a positive light. Positive reappraisal lets you take a less than ideal situation and turn it to your benefit or at least take the sting out of it. This question also measures whether you tend to offer yourself some healthy **self-compassion**.

If the assessment revealed that you struggle with your stress responses, take heart. It's not always possible to change your automatic response, but most of us can learn to change our responses *to our responses*—and that's the secret sauce of **stress resilience**. Now let's get to work understanding how stress affects your telomeres and cells, and how you can make changes that will help protect them.

CHAPTER FOUR

Unraveling: How Stress Gets into Your Cells

We explore the stress-telomere connection, explain toxic stress versus typical stress, and show how stress and short telomeres affect the immune system. People who respond to stress by feeling overly threatened have shorter telomeres than people who face stress with a rousing sense of challenge. Here, you'll learn how to move from harmful stress responses to helpful ones.

Nearly fifteen years ago, my husband and I (Elissa) were driving across the country. We had just finished graduate school at Yale and were taking on postdoctoral fellowships in the Bay Area. San Francisco is an expensive city, and so we had arranged to live with my sister and her family. We expected that when we arrived in San Francisco, we would meet our new nephew, who was supposed to be born at any moment. In fact, he was quite overdue. I called every day for news, but I'd had trouble reaching anyone in the family for days.

About halfway through the trip, just after we'd passed Wall Drug Store in South Dakota, my cell phone finally rang. Tearful voices wavered on the other end. The baby had been born, but something had gone terribly wrong during an induced delivery. The baby was on life support and being fed through a gastric tube to his stomach.

He was a beautiful healthy boy, but an MRI showed his brain had been profoundly damaged. He was paralyzed, blind, and wracked with seizures.

Eventually, after several months, the baby left the intensive care ward and came home. We joined the family team to help take care of this little guy, who had extraordinary needs. We became intimate with both the demands and sorrows that come with a life of caregiving. We were accustomed to pressure and hard work, but this had nothing in common with the types of stresses we had known. Now there were new feelings of constant vigilance, intermittent urgency, worry about the future, and most of all, a heavy weight on the heart. One of the hardest parts was seeing and feeling the pain my sister and brother-in-law were experiencing every day. On top of the emotional suffering there was, all of a sudden, a new, unexpected, and demanding life centered around medical caregiving.

Caregiving is one of the most profound stresses a person can experience. Its tasks are emotionally and physically demanding, and one reason caregivers get so worn out is that they don't get to go home from their caregiving "jobs" and recover. At night, when we all need to biologically check out and refresh body and mind, caregivers are on call. They may be repeatedly woken from sleep to respond to someone in need. Caregivers rarely have time to take care of themselves. They skip their own doctor appointments as well as opportunities for exercise and going out with friends. Caregiving is an honorable role that is taken on out of love, loyalty, and responsibility, but it is not supported by society or recognized for its value. In the United States alone, family caregivers perform an estimated $375 billion in unpaid services each year.[1]

Caregivers often feel unappreciated and become isolated. Health researchers have identified them as one of the most chronically stressed groups of people. This is why we often ask caregivers to volunteer for our studies on stress. Their experiences can tell us a lot about how telomeres react to serious stress. In this chapter, you'll

learn what our groups of caregivers have taught us—that chronic, long-lasting stress can erode telomeres. Fortunately for all of us who cannot escape chronic stress (and for all of us who scored higher than 12 on the stress assessment on page 71), we've also learned that we can protect our telomeres from some of stress's worst damage.

"LIKE THERE IS AN ASSAILANT, WAITING FOR ME": HOW STRESS HURTS YOUR CELLS

In our very first study together we looked at some of the most highly stressed caregivers of all: mothers who were taking care of their chronically ill children. This is the study we've told you about. It's the one that first revealed a relationship between stress and shorter telomeres. Now we want to show you a close-up look at the extent of that damage. More than ten years later we still find it sobering.

We learned that the years of caregiving had a profound effect, grinding down the women's telomeres. The longer a mother had been looking after her sick child, the shorter her telomeres. This held true even after we took into account other factors that might affect telomeres, like the mother's age and body mass index (BMI), which are related to shorter telomeres themselves.

There was more. The more stressed out the mothers felt, the shorter their telomeres. This was true not just for the caregivers of sick children, but also for *everyone* in the study, including the control group of mothers who had healthy children at home. The high-stress mothers also had almost half the levels of telomerase than the low-stress mothers, so their capacity to protect their telomeres was lower.

People experience stress in many different ways: "like a fifty-pound weight on my chest," "like a knot in my stomach," "like a vacuum in my lungs that doesn't let me take a full breath," "my heart pounds like there is an assailant, waiting for me." These metaphors are grounded in the body, because stress is as present in the body as

in the head. When the stress-response system is on high alert, the body produces more of the stress hormones cortisol and epinephrine. The heart beats faster and blood pressure increases. The vagus nerve, which helps modulate the physiological reaction to stress, withdraws its activity. That's why it's harder to breathe, harder to stay in control, harder to imagine that the world is a safe place. When you suffer from chronic stress, these responses are on a low but constant alert, keeping you in a state of physiological vigilance.

In our caregivers, several aspects of the physiological stress response, including lower vagus activity during stress, and higher stress hormones while sleeping, were linked to shorter telomeres or to less telomerase.[2] These responses to stress appeared to be accelerating the biological aging process. We had discovered a new reason that stressed-out people look haggard and get sick: their heavy stresses and cares are wearing down their telomeres.

SHORT TELOMERES AND STRESS: CAUSE OR EFFECT?

When a scientific finding suggests a cause-and-effect relationship, you have to ask whether the relationship really runs in the direction you think it does. For example, people used to think that fevers caused sickness. Now we know that the relationship is the reverse: sickness causes fevers.

As the results of our first study of caregivers came in, we were careful to ask ourselves *why* shorter telomeres appeared in people with higher stress. Does stress really lead to short telomeres? Or can short telomeres somehow predispose a person to feeling more stress? Our caregiving mothers provided the first convincing data about this question. The relationship between the years of caregiving stress and telomere length is a strong indicator that the stress exposure happens over time, causing telomeres to shorten.

Short telomere length (after correcting for age) could not have determined how many years a mother had been a caregiver, so it had to be the other way around—that the years of caregiving were the cause of the shorter telomeres. We also tested whether an older age of the child was related to shorter telomeres. If the years of difficult caregiving were wearing down telomeres more than the years of parenting by the control mothers, we would see the relationship between the child's age and the mother's telomeres in the caregivers but not in the control moms. Indeed, this was what we found. Now there are animal studies showing that inducing stress can actually cause telomere shortening.

The depression story is more complicated. The findings above were not enough to rule out the possibility that cell aging could cause depression. In humans, depression runs in families. Not only are girls whose mothers have depression more prone to depression themselves, but even before any depression has developed, these girls have shorter blood telomeres than girls who are not depressed.[3] Also, the more stress reactive the girls are, the shorter the telomeres. So the arrow likely points in both directions with depression—short telomeres may precede depression, and depression may speed up telomere shortening.

HOW MUCH STRESS IS TOO MUCH?

Stress is unavoidable. How much of it can we handle before our telomeres are damaged? A consistent lesson from the past decade of studies—and a lesson that echoes what the caregivers taught us—is that stress and telomeres have a dose-response relationship. If you drink alcohol, you're familiar with dose and response. An occasional glass of wine with dinner is rarely harmful to your health and may even be beneficial, as long as you're not drinking and driving. Drink

several glasses of wine or whiskey, night after night, and the story changes. As you "dose" yourself with more and more alcohol, the poisonous effects of alcohol take over, damaging your liver, heart, and digestive system and putting you at risk for cancer and other serious health problems. The more you drink, the more damage you do.

Stress and telomeres have a similar relationship. A small dose of stress does not endanger your telomeres. In fact, short-term, manageable stressors can be good for you, because they build your coping muscles. You develop skills and confidence that you can handle challenges. Physiologically, short-term stress can even boost your cells' health (a phenomenon called hormesis, or toughening). The ups and downs of daily life are usually not wearing to your telomeres. But a high dose of chronic stress that wears on for years and years will take its toll.

We now have evidence that links particular kinds of stress to shorter telomeres. These include long-term caregiving for a family member and burnout from job stress. As you may imagine, more serious traumas, both recent and in childhood, have also been linked to damaged telomeres. These traumas include rape, abuse, domestic violence, and prolonged bullying.[4]

Of course, it's not the situations themselves that produce the short telomeres; it's the stress responses that many people feel when they're in these situations. And even under these stressful circumstances, dose matters. A monthlong crisis at work can be stressful, but there's no reason to think your telomeres will take a hit. They are more robust than that; otherwise, we'd all be falling apart. (A recent review showed that there is a relationship between short-term stress and shorter telomeres, but that effect is so tiny that we don't think it will have a meaningful effect on an individual person.[5] And even if short-term stress shortens your telomeres, the effect is likely temporary, with telomeres quickly recovering their lost base pairs.) But when stress is an enduring, defining feature of your life, it can act

as a slow drip of poison. The longer the stress lasts, the shorter your telomeres. It is vitally important to get out of long-term, psychologically toxic situations if it's at all possible.

But fortunately for the many of us who live with stressful situations we cannot change, that's not the whole story. **Our studies have shown that being under chronic stress does not *inevitably* lead to telomere damage.** Some of the caregivers we've studied were weathering enormous burdens without losing telomere length. These stress-resistant outliers have helped us understand that you do not necessarily have to escape difficult situations to protect your telomeres. Incredible as it sounds, you can learn to use stress as a source of positive fuel—and as a shield that can help protect your telomeres.

DON'T THREATEN YOUR TELOMERES—CHALLENGE THEM

When we looked at the data for our first caregiver study, we realized we had a mystery on our hands. Some of the caregiving mothers in the group reported less stress, and these mothers had longer telomeres. We wondered: *Why* would they feel less stress? After all, they had been caregiving for just as long as the other mothers in the group. They had a similar number of daily duties and spent just as many hours in the day performing those duties (appointments, administering injections and other treatments, managing tantrums, having to hand- or tube-feed, diaper, and bathe older disabled children).

To understand what was protecting these mothers' telomeres, we wanted to see people respond to stress in real time, before our eyes. We decided to bring more women into the lab and, essentially, stress them out. Research volunteers who arrive at our stress lab are told something like, "You're going to perform some tasks in front of two evaluators. We want you to try hard to do your best. You are going to prepare a five-minute speech and then deliver it, and perform

some mental arithmetic. You can make some notes for your speech, but you will have to do all the math in your head." Sound easy? Not really, and especially not in front of an audience.

One by one, the volunteers are escorted into a testing room. Each study volunteer stands at the front of the room and faces two researchers sitting at a desk. The researchers look at the volunteer in a manner best described as stony-faced. No smiling, no nodding, no encouragement. Technically, a stony-faced expression is neutral, neither positive nor negative, but most of us are used to seeing other people smile at us, nod as we talk, or at least make an effort to seem pleasant. When compared to our usual interactions, a stony expression can come across as disapproving or strict.

The researchers explain the task, saying something like, "Please take the number 4,923 and subtract the number 17 from it, out loud. Then take your answer and subtract 17 from it, and so on, as many times as you can in the next five minutes. It is important that you perform this task quickly and accurately. We will judge you on various aspects of your performance. The clock starts now."

As each volunteer begins the math task, the researchers stare at her, pencils poised to record her answer. If she fumbles (and almost everyone fumbles), the researchers turned toward each other and whisper.

Then the volunteer goes on to her five-minute speech with the same researchers evaluating her and behaving in a similar way. If she finishes before the five minutes are up, the researchers point to the timer and say, "Please continue!" As she talks, the researchers glance at each other and slightly furrow their brows and shake their heads.

This lab stressor test, developed by Clemens Kirschbaum and Dirk Hellhammer, is a staple of psychology research, and its point is definitely *not* to test math and speech skills. Instead, it's designed to induce stress. What makes it so stressful? Mental math and on-the-fly public speaking are tricky to perform well. The most stressful element, though, is what's called social evaluative stress. Anyone

who tries to perform a task in front of an audience will probably feel increased stress about their performance. When that audience appears judgmental, the stress is intensified. Even though our volunteers' physical survival was not at risk and they were safe in a clean, well-lighted university lab, this test was capable of eliciting a full-blown stress response.

We've put caregivers and noncaregivers through this protocol. We assessed their thoughts at two different times during the lab stressor: just after they'd learned what they were going to do, and just after they'd finished the two tasks. What we found was that although all the women felt *some* stress, not everyone had the *same* type of stress response. And only one kind of stress response went hand in hand with unhealthy telomeres.[6]

The Threat Response: Anxious and Ashamed—and Aging

Some of the women had what's known as a threat response to the lab stressors. The threat response is an old, evolutionary response, a kind of switch to be flipped in case of dire emergency. Basically, the threat response was designed to surge when we are face-to-face with a predator who is probably going to eat us. The response prepares our body and mind for the trauma of being attacked. As you might guess, if it keeps on happening without letup, this is *not* the response associated with telomere health.

If you already suspect that you have an exaggerated threat response to stress, don't worry. In a moment, we'll show you some lab-tested ways to convert a habitual threat response into one that is healthier for your telomeres. First, though, it's important to know what a threat response looks and feels like. Physically, the threat response causes your blood vessels to constrict so that you'll bleed less if you're wounded, but also less blood flows to your brain. Your adrenal gland releases cortisol, which gives you energizing glucose. Your vagus nerve, which runs a direct line from your brain to your viscera and normally helps you feel calm and safe, withdraws

its activity. As a result, your heart rate accelerates, and your blood pressure increases. You may faint or even release your bladder. A branch of the vagus innervates the muscles of facial expression, and when that nerve isn't active, it becomes even harder for someone to interpret your facial expressions accurately. If others are wearing a similarly ambiguous expression, one that leaves lots of room for your interpretation, you in turn may view them as more hostile. You tend to freeze, you are unable to run or fight—and your hands and feet get colder, making movement more difficult.

A full-throttle threat response unleashes some uncomfortable physical reactions, but there are psychological ones, too. As you might expect, the threat response is associated with fear and anxiety. Shame, too, if you're worried about failing in front of other people. People with a strong habitual threat response tend to suffer from anticipatory worry; they imagine a bad outcome to an event that hasn't happened yet. That was exactly what happened to many of the caregivers in our lab. They felt high levels of threat—not just after they had finished the tasks but *before* the tasks had even begun. This group of caregivers became fearful and anxious when they heard the somewhat vague information about having to give a speech and do mental math. They anticipated a bad outcome, and they felt failure and shame.

As a group, our caregivers had a stronger threat response. The chronic stress of being a caregiver had made them more sensitive to a lab stressor. The ones with the strongest threat responses also had the shortest telomeres. The noncaregivers were less likely to have an exaggerated threat response, but those who did had shorter telomeres, too. Having a large anticipatory threat response—meaning that they felt threatened at the mere thought of the lab stressor before it even happened—was what mattered most.[7] Here was some vital information about how stress gets into our cells. **It's not just from experiencing a stressful event, it's also from feeling threatened by it, even if the stressful event hasn't happened yet.**

Excited and Energized: The Challenge Response

Feeling threatened is not the only way to respond to stress. It's also possible to feel a sense of challenge. People with a challenge response may feel anxious and nervous during a lab stressor test, but they also feel excited and energized. They have a "bring it on!" mentality.

Our colleague, Wendy Mendes, a health psychologist at the University of California, San Francisco (UCSF), has spent over a decade examining the body's responses to different types of stressors in the lab, and has mapped out the differences that occur in the brain, in the body, and in behavior during "good stress" compared to "bad stress." Whereas the threat response prepares you to shut down and tolerate the pain, the challenge response helps you muster your resources. Your heart rate increases, and more of your blood is oxygenated; these are positive effects that allow more blood to flow where it's needed, especially to the heart and brain. (This is the opposite of what happens when you're threatened. Then, the blood vessels constrict.) During the challenge response, your adrenal gland gives you a nice shot of cortisol to increase your energy—but then your brain quickly and firmly shuts off cortisol secretion when the stressful event is over. This is a robust, healthy kind of stress, similar to the kind you may have when you exercise. The challenge response is associated with making more accurate decisions and doing better on tasks, and is even associated with better brain aging and a reduced risk of developing dementia.[8] Athletes who have a challenge response win more often, and a study of Olympic athletes has shown that these highly successful folks have a history of seeing their life problems as challenges to be surmounted.[9]

The challenge response creates the psychological and physiological conditions for you to engage fully, perform at your best, and win. The threat response is characterized by withdrawal and defeat, as you slump in your seat or freeze, your body preparing for wounding

Figure 14: Threat versus Challenge Responses. People tend to have many thoughts and feelings when facing a stressful situation. Here are two different types of responses: One is characterized by feeling threatened, by a fear of losing, or possibly being shamed. The other is characterized by feeling challenged and confident about achieving a positive outcome.

and shame as you anticipate a bad outcome. A predominant habitual threat response can, over time, work itself into your cells and grind down your telomeres. A predominant challenge response, though, may help shield your telomeres from some of the worst effects of chronic stress.

People don't generally show responses that are *all* threat or *all* challenge. Most experience some of both. In one study, we found that it was the proportion of these responses that mattered most for telomere health. The volunteers who felt more threat than challenge had shorter telomeres. Those who saw the stressful task as more of a challenge than a threat had longer telomeres.[10]

What does this mean for you? It means you have reason to be hopeful. We do not mean to trivialize or underestimate the potential that very tough, difficult, or intractable situations have for harm

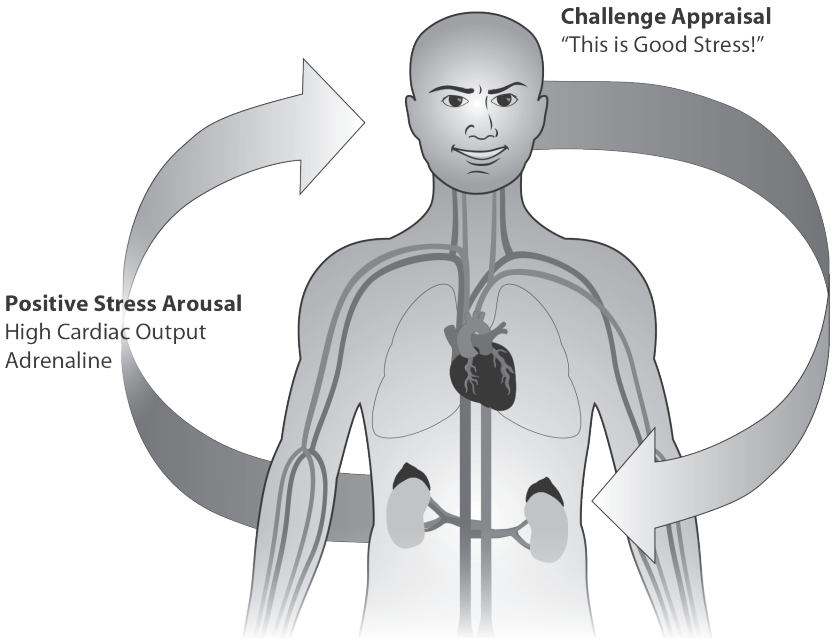

Figure 15: Positive Stress (Challenge Stress) Energizes. Our body automatically reacts to a stressful event within seconds and also reacts to our thoughts about the event. When we start to notice the stress response in our muscle tension, heart rate, and breathing, we can relabel it by saying, "This is good stress, energizing me so I can perform well!" This can help shape the body's response to be more energizing, bringing more dilation to the vessels and more blood to the brain.

to your telomeres. But when you can't control the difficult or stressful events in your life, you can still help protect your telomeres by shifting the way you view those events.

WHY DO SOME PEOPLE FEEL MORE THREAT THAN OTHERS?

Reflect on incidents in your life that have been difficult. Ask yourself: Do you tend to respond by feeling more threatened or challenged? Do you borrow trouble, feeling anticipatory threat about events that haven't happened yet—and that may not ever happen?

When you're stressed, do you feel ready for action, or do you feel like diving under the covers and hiding?

If you tend to feel more of a threat response, don't waste your time feeling bad about it. Some of us are simply wired to be more stress reactive. It has been critical to human survival for some of us to respond in a robust way to changes in our environment, and for others to be more sensitive. After all, someone's got to alert the tribe to dangers and warn the more gung-ho members against taking foolhardy risks.

Even if you weren't strongly wired at birth to feel threat, conditions in your life may have altered your natural response. Teenagers who were exposed to maltreatment when they were children respond to stressful tasks with blood-flow patterns characteristic of a threat response, experiencing vasoconstriction rather than strong blood flow out of the heart.[11] (On the other hand, people who experienced moderate adversity in childhood tend to show more of a challenge response than people who had it easy as children—more evidence that small doses of stress can be healthy, provided that resources are available to help you cope.) As we described earlier, prolonged stress can wear down emotional resources, making people more prone to feeling threatened.[12]

Either by birth or by the circumstances of your life, you may have a strong threat response. The question is: Can you learn to feel challenged instead? Research says the answer is *yes*.

DEVELOPING A CHALLENGE RESPONSE

What happens as an emotion arises? Scientists used to believe it was a more linear process—that we experience events in the world, our limbic system reacts with an emotion, like anger or fear, which causes the body to respond with an increased heart rate or sweaty palms. But it's more complicated than that. The brain is wired to *predict things ahead of time*, not just *react after things have happened*.[13] The

brain uses memories of past experiences to continually anticipate what will happen next, and then corrects those predictions with both the current incoming information from the outside world, and from all the signals within our body. *Then* our brain comes up with an emotion to match all of this. Within seconds, we patch all this information together, without our awareness, and we feel some emotion.

If our "database" of past experience has a lot of shame in it, we are more likely to expect shame again. For example, if you feel high arousal and jittery, maybe from that morning's strong coffee, and if you see two people who could be talking about you, your mind may quickly cook up the emotions of shame and threat. Our emotions are not pure reactions to the world; they are our own fabricated constructions of the world.[14]

Knowing how emotions are created is powerful. Once you know this, you can have more choice over what you experience. Instead of feeling your body's stress responses and viewing them as harmful, a common experience in your brain's database, you can think about your body's arousal as a source of fuel that will help your brain work quickly and efficiently. And if you practice this enough, then eventually your brain will come to predict feelings of arousal as helpful. Even if you're one of those people whose brain is hardwired to feel more threat, you can feel that immediate instinctive survival response—and then revise the story. You can choose to feel challenged.

Sports psychologist Jim Afremow, PhD, who consults with professional and Olympic athletes, was once approached by a sprinter who was struggling with her hundred-meter time. She had already diagnosed the reason she wasn't running as well as she wanted to. "It's the stress," she said. "Before every race, my pulse races. My heart is about to jump out of my chest. You've got to help me stop it!"

Afremow laughed. "Do you really want to stop your heart?" The worst thing athletes can do, he says, is try to get rid of their stress.

"They need to think of stress as helping them get ready to perform. They need to say, 'Yes! I need this!' Instead of trying to make the butterflies in their stomach go away, athletes need to make those butterflies line up and fly in formation." In other words, they need to make the stress work for them.

The sprinter took Afremow's advice. By viewing her physical responses as tools that would help her rise to the challenge of a race, she was able to shave milliseconds off her time (a big deal for a hundred-meter runner) and set a personal record.

It sounds unbelievably simple, but research backs up this efficient method of converting threat to challenge. When research volunteers are told to interpret their body's arousal as something that will help them succeed, they have a greater challenge response. One study found that students who are encouraged to view stress in this way score higher on their GREs.[15] And when researchers put people through lab stressors, the ones who are told to think of stress as useful are able to maintain their social equilibrium. Instead of looking away, playing with their hair, or fidgeting—all signs of feeling somewhat threatened—the challenge participants make direct eye contact. Their shoulders are relaxed, and their bodies move fluidly. They feel less anxiety and shame.[16] All these benefits happened simply because people were told to think of their stress as good for them.

A challenge response doesn't make you less stressed. Your sympathetic nervous system is still highly aroused, but it is a positive arousal, putting you in a more powerful, more focused state. To channel your stress so that it gives you more good energy for an event or performance, say to yourself, "I'm excited!" or "My heart is racing and my stomach is doing cartwheels. *Fantastic*—those are the signs of a good, strong stress response." Of course, if you are under the kind of emotionally depleting stress that our caregiving mothers experienced, this language could feel too glib. Instead, talk to yourself in a gentler way. You could say, "My body's responses are trying to help me. They're designed to help me focus on the

tasks at hand. They're a sign that I care." The challenge response is not a falsely chipper, gee-I'm-so-happy-that-stressful-things-are-happening-to-me attitude. It is the knowledge that even though times may be very difficult, you can shape stress to your purpose.

For those who feel addicted to "good stress"—the achievement stress involved in the constant excitement of, for example, working in a start-up company and never having downtime, know that even good stress can be overdone. It's healthy to have times when your cardiovascular system is mobilized and your psyche is primed for action. But our bodies and minds aren't built to sustain this kind of high stimulation on a consistent basis. Being able to relax, although it's been overrated as a sole source of stress management, is still necessary. We recommend that you regularly engage in an activity that brings you deep restoration. There is high-quality evidence that meditation, chanting, and other mindfulness practices can reduce stress, stimulate telomerase, and perhaps even help your telomeres to grow. See page 153 to learn more about these cell-protecting strategies.

Even in chronically stressful situations like caregiving, the stress is not a monolith or a blanket of darkness that cannot be lifted. Stress and stressful events do not live in each little moment, although they can visit. There is some freedom in each moment, because we can have a choice about how we spend this moment. We can't rewrite the past and we can't dictate what happens in the future, but we can choose where to place our attention in the moment. And although we can't always choose our immediate reactions, we can shape our subsequent responses.

Some clever studies have shown that merely anticipating a stressful event has almost the same effect on the brain and body as experiencing the stressful event.[17] When you worry about events that haven't happened yet, you're letting stress flow over its time boundaries the way a river can overflow its banks, flooding the minutes, hours, and days that could otherwise be more enjoyable. It is almost

OUR FEATHERY FRIENDS: STRESSED BIRDS, STRESSED TELOMERES

Is the stress-telomere relationship really causal? To test this, researchers have done experiments on birds. When wild European shag chicks were given water laced with the stress hormone cortisol, or were stressed out by being held, they developed shorter telomeres compared to controls.[18] Not good, since in this species, short telomeres early in life predict early death! When parrots are housed alone and can't have their usual social chats with each other, they develop shorter telomere length.[19] We know humans are sensitive to their social environments, and it seems birds are, too.

always possible to find something to worry about and therefore possible to keep the stress response engaged on an almost constant basis. When you anticipate a bad outcome before an event has even begun, you increase your dose of threat stress, and that's the last thing you need. But rather than avoiding thinking about stressful things, it's how we think about them that matters.

A SHORT PATH TO A LONG DISEASESPAN: STRESS, AGING IMMUNE CELLS, AND INFLAMMATION

It never fails. Just after you've met an important work deadline, or as you're boarding a plane for a long-overdue beach vacation, you come down with the mother of all colds: sneezing, runny nose, sore throat, fatigue. Coincidence? Probably not. While your body is actively fighting stress, your immune system can be bolstered for a time. But that effect can't last forever. Chronic stress suppresses aspects of the immune system, leaving us more vulnerable to infections, causing us to produce fewer antibodies in response to vaccinations, and making our wounds heal more slowly.[20]

There is an unsavory relationship between stress, immune suppression, and telomeres. For years, scientists were unsure just how stress, which lives in the mind, could damage the immune system. Now we have an important part of the answer: telomeres. People with chronic stress have shorter telomeres, and short telomeres can lead to prematurely aging immune cells, which means worse immune function.

Shorter Telomeres, Weaker Immune System

Certain immune cells are like SWAT teams that fight viral infections. These cells are known as T-cells, because they are stored in the thymus gland, which sits under the sternum bone in the chest. Once T-cells mature, they leave the thymus and circulate continuously throughout the body. Each T-cell has a unique receptor on its surface. The receptor acts like a searchlight on a police helicopter, sweeping the body and looking for "criminals"—cells that are either infected or cancerous. Of particular interest to aging is the type of T-cell called a CD8 cell.

But it isn't enough for the T-cell to simply spot a villainous cell. In order to complete the job, the T-cell needs to receive a second signal from a surface protein, called CD28. When the T-cell kills its target, the cell develops "memory" so that if the same virus infects the body again in the future, the T-cell can multiply into thousands and thousands of progeny cells just like itself. Together they can mount a rapid, efficient immune response against that specific virus. This is the basis of vaccination. The vaccine is typically a piece of a viral protein or a killed virus; the immunity lasts for years, since the T-cells that have responded to the initial vaccination remain in the body for a long time (sometimes for life) and are available to fight off an infection if the virus should work its way into the body again.

We have a tremendously large repertoire of T-cells, each with the capacity to recognize just one particular antigen or virus. Because we have such a huge variety of different T-cells, when we

become infected with a particular virus, the few T-cells that have the correct receptor for the virus must create many progeny in order to combat the infection. During this massive process of cell division, telomerase is ratcheted up to high levels. However, it simply can't keep up with the speedy rate of telomere shortening, and eventually the telomerase response weakens to a whisper, and the telomeres in those responding T-cells keep getting shorter. So they pay for those heroic responses. When a T-cell's telomeres grow short, the cell becomes old, and it loses the CD28 surface marker that is necessary for mounting a good immune response. The body becomes like a city that's lost its budget for police helicopters and searchlights. The city looks normal from the outside, but lies vulnerable to criminal infestation. The antigens on bacteria, viruses, or cancerous cells are not cleared from the body. That's a reason people with aging cells—including the elderly and the chronically stressed—are so vulnerable to sickness, and why it's hard for them to weather diseases like the flu or pneumonia. It's partly why HIV progresses to AIDS.[21]

When telomeres in these aging T-cells are too short, even young people are more vulnerable. Sheldon Cohen, a psychologist at Carnegie Mellon University, asked young, healthy volunteers to live isolated in hotels so he could study the effects of giving them a noseful of the virus that causes the common cold. First, he measured their telomeres. The people with shorter telomeres in their immune cells, and especially in their near-senescent CD8 cells, developed colds faster, with more severe symptoms (which were measured by weighing their used tissues).[22]

What's Stress Got to Do with It?

Our CD8 T-cells (the fighters in the immune system) appear to be especially vulnerable to stress. In another of our family caregiver studies, we took blood samples from mothers who had a child with autism living at home. We found that these caregiving mothers had lower telomerase in their CD8 cells that had lost the critical CD28

surface marker, suggesting they would be in danger of developing critically short telomeres over the years. Rita Effros, an immunologist from University of California, Los Angeles, and a pioneer in understanding aging immune cells, has created "stress in a dish"—she has shown that exposing immune cells to the stress hormone cortisol dampens their levels of telomerase.[23] A compelling reason to learn how to respond to stress in a healthier way.

Shorter Telomeres, More Inflammation

Unfortunately, the news gets worse. When the telomeres of aging CD8 cells wear down, the aging cells send out proinflammatory cytokines, those protein molecules that create systemic inflammation. As the telomeres continue to shorten and the CD8 cells become fully senescent, they refuse to die and they accumulate in the blood over time. (Normally CD8 T-cells gradually die by a natural type of cell death called apoptosis. Apoptosis rids the body of old or damanged immune cells so they do not overwhelm the body or develop into the types of blood cancers called leukemias.) These senescent T-cells are the rotten apples in the barrel, with their bad effects spreading outward. They pump out slightly more inflammatory substances each year like a slow drip. If you have too many of these aging cells in your bloodstream, you're at risk for rampant infections *and* all the diseases of inflammation. Your heart, your joints, your bones, your nerves, and even your gums can become diseased. When stress makes your CD8 cells grow old, you grow old, too—no matter what your chronological age is.

Experiencing stress and pain is unavoidable. It is part and parcel of being involved with life, of loving and caring for people, caring about issues, and taking risks. Use the challenge response to protect your cells while you engage fully with life. The Renewal Lab at the end of this chapter offers some specific techniques to help you cultivate this response. The challenge response is not the only

tool in your box, though. For powerful stress-relievers that are great for your telomeres, check out "Stress-Reducing Techniques Shown to Boost Telomere Maintenance" at the end of Part Two. And if stress tends to lead you into destructive thinking patterns—maybe you suppress painful thoughts or ruminate excessively about them, or perhaps you begin to anticipate negative responses from other people—turn to the next chapter. We'll help you protect your telomeres from this harmful thinking.

TELOMERE TIPS

- Your telomeres don't sweat the small stuff. Toxic stress, on the other hand, is something to watch for. Toxic stress is severe stress that lasts for years. Toxic stress can dampen down telomerase and shorten telomeres.
- Short telomeres create sluggish immune function and make you vulnerable even to catching the common cold.
- Short telomeres promote inflammation (particularly in the CD8 T-cells), and the slow rise of inflammation leads to degeneration of our tissues and diseases of aging.
- We cannot rid ourselves of stress, but approaching stressful events with a challenge mentality can help promote protective stress resilience in body and mind.

RENEWAL LAB

REDUCE "EGO THREAT" STRESS

If you feel that an important aspect of your identity is on the line, you are probably going to feel a strong threat response. This is why a final exam can be so stressful if your main identity is as a "good student," or why a sports competition can feel terrifying if you strongly identify as an athlete. If you do poorly, you don't just suffer a bad grade or a loss. The experience takes a bite out of your sense of self-worth. A challenge to your identity leads to threat stress, which can lead to poor performance, which can wound your identity. It's a vicious cycle, one that may have a negative effect on your telomeres. Break the cycle by reminding yourself that your identity runs wide and deep:

> *Instructions for defusing ego threat:* Think of a stressful situation. Now in your mind or on a piece of paper, make a list of the things that you value (it's best to choose things unrelated to the stressful situation). For example, you may think about some social roles that are important to you (being a parent, good worker, community member, etc.) or values you believe are particularly important (such as your religious beliefs, community service). Next, think about a specific time in your life when one of these roles or values was particularly salient for you.

There are many studies documenting this effect; typically in these studies, volunteers are asked to write for ten minutes about their personal values. This small manipulation (called value affirmation) reduces stress responses in the lab, and in real life, and helps people engage in stressful tasks with a challenge mind-set.[24] Identifying values translates into better performance and higher grades on science tests.[25] It activates the reward area of the brain that may help buffer stress reactions.[26]

The next time a threat looms, pause and list what's most important to you. One caregiving mother we know stops and reminds herself that one of her highest priorities is helping her son who has autism, which seems to absorb her tension and protect her from caring about what other people think. When he has a meltdown in a public space, she ignores the judgmental stares from other people and simply does what her son needs. "It's like I'm in a protective bubble," she says. "It's a lot less stressful in there." When you see just how broad your values run, you validate your sense of self-worth, so there's less of your identity riding on the outcome of a single event.

DISTANCING

Create some space between your feeling self and your thinking self. Researchers Ozlem Ayduk and Ethan Kross and their colleagues have conducted several lab studies to manipulate the emotional stress response, in order to see what amps it up and what allows emotions to dissipate quickly. They've discovered that by distancing your thoughts from your emotions, you can convert a threat response into a positive feeling of challenge. Below are the methods Ayduk and Kross have identified to create this distance:

Linguistic self-distancing. Think about an upcoming stressful task using the third person, as in "What is making Liz nervous?" Thinking in the third person "puts you in the audience," so to speak, or makes you a fly on the wall. You don't feel so caught up in the

drama. Moreover, research shows that frequent self referencing ("I," "me," and "mine") is a sign of being self-focused and is related to feeling more negative emotions. Ayduk and Kross have found that thinking in the third person and not using "I" leads people to feel less threatened, anxious, and ashamed, and to engage in less rumination. They perform better at stressful tasks, and raters view them as more confident.[27]

Time distancing. Think about the immediate future, and you will have a bigger emotional response than if you take a longer-term view. Next time you are in the grip of a stressful event, ask yourself, *In ten years, will this event still have an impact on me?* In studies, people asked to pose this question to themselves had more challenge thoughts. Recognizing the impermanence of an event helps you get over it faster.

Visual self-distancing. Distancing is a trick you can play on the threat response after the fact. If you have experienced a stressful event that you still feel emotional about, visual distancing allows you to emotionally process it in a way that will help put it to rest. Rather than just relive the event straight up, which can induce the same emotions you felt in those moments, *step back and view the event from afar, as if it's happening in a movie that you're watching.* That way, you won't reexperience the event in your emotional brain. Instead, you'll view it with greater separation and clarity. Distancing takes some of the power away from a negative memory. This technique is also known as cognitive defusion, and it's been shown to immediately reduce the brain's neural stress response,[28] probably because it activates the brain's more reflective, analytical areas instead of its emotional ones. Here is a modified version of the script Ayduk and Kross use to help their research volunteers create distancing (we combined visual, linguistic, and time distancing):[29]

> *Instructions for distancing:* Close your eyes. Go back to the time and place of the emotional experience and see the scene in

> your mind's eye. Now take a few steps back. Move away from the situation to a point where you can now watch the event unfold from a distance and see yourself in the event, the distant you. Now watch the experience unfold as if it were happening to the distant you all over again. Observe your distant self. As you continue to watch the situation unfold for your distant self, try to understand his [or her] feelings. Why did he [or she] have those feelings? What were the causes and reasons? Ask yourself, "Will this situation affect me in ten years?"

If you suffer from retrospective stress—if you feel a lot of negative emotions and shame after an event is over—the visual distancing strategy can be especially useful. You can also try this strategy while you're actually in the stressful moment. By mentally stepping outside your body, you can bypass its sense of imminent threat and attack.

PART IV

OUTSIDE IN: THE SOCIAL WORLD SHAPES YOUR TELOMERES

CHAPTER ELEVEN

The Places and Faces That Support Our Telomeres

Like the thoughts we think and the food we eat, the factors beyond our skin—our relationships and the neighborhoods we live in—affect telomeres. Communities where people do not trust one another, and where they fear violence, are damaging to telomere health. But neighborhoods that feel safe and look beautiful—with leafy trees and green parks—are related to longer telomeres, no matter what the income and education level of their residents.

When I (Elissa) was a graduate student at Yale, I routinely worked late into the evening. By the time I walked back home from the psychology building, it was dark. I had to pass a church where someone had been murdered a few years earlier, and even though the area was usually quiet when I walked by at around 11:00 p.m., my heart would beat faster. Next, I turned down my street, where the rent was quite affordable on a student stipend. It was a long street, known for occasional muggings. As I walked, I listened carefully for steps behind me. I could feel my heart thump more powerfully. It is a good bet that my blood pressure went up and that glucose was recruited from its stores in my liver, giving me energy to run if needed. Every night, my body and mind mobilized themselves for danger. That experience lasted for just ten minutes each evening.

Imagine how stressful it would feel if the risk was much worse, the duration was longer, and you couldn't afford to move away.

Where we live affects our health. Neighborhoods shape our sense of safety and vigilance, which in turn affects levels of physiological stress, emotional state, and telomere length. Besides violence and lack of safety, there is another critical aspect that makes neighborhoods potent influences on health, and that is the level of "social cohesion"—the glue, the bond, among people who live in the same area. Are your neighbors mutually helpful? Do they trust one another? Do they get along and share values? If you were in need, could you rely on a neighbor?

Social cohesion is not necessarily a product of income or social class. We have friends in a beautiful gated neighborhood, where the houses sit on acres of rolling hills. There are positive signs of social cohesion, including Fourth of July picnics and holiday dances. But there's also mistrust and infighting, and it's not free of crime. It's a neighborhood full of doctors and lawyers, but if you live there you might wake up in the morning to the sound of a police helicopter hovering over your house, searching for an armed robbery suspect who has jumped over the gate. When you take out the trash, a neighbor who is unhappy about your plans for remodeling might accost you. Check your messages, and you could find that your neighbors are in a heated e-mail fight about whether to hire a security patrol and who will pay for it. You may not even know the person who lives next door. There are also neighborhoods that are poor but have people who know each other and have a strong sense of community and trust. While income plays a role, a neighborhood's health goes way beyond income.

People in neighborhoods with low social cohesion and who live in fear of crime have greater cellular aging in comparison to residents of communities that are the most trusting and safe.[1] And in a study in Detroit, Michigan, feeling stuck in your neighborhood—wanting to move but not having the money or opportunity to do

so—is also linked to shorter telomeres.[2] In a study based in the Netherlands (known as the NESDA study), 93 percent of the sample rated their neighborhood as generally good (or higher). Despite that these neighborhoods were good environments, the more specific ratings of quality—including levels of vandalism and perception of safety—were associated with telomere length.

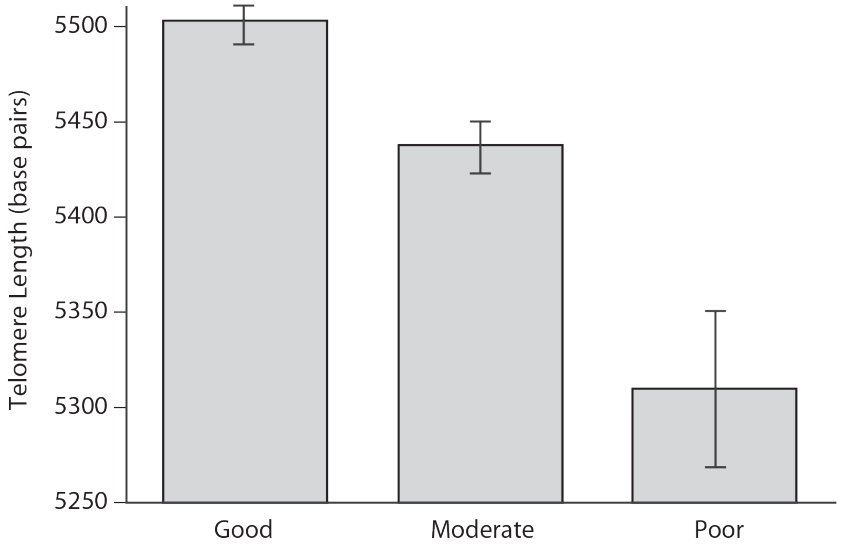

Figure 25: Telomeres and Neighborhood Quality. Here in the NESDA study, residents of neighborhoods with higher quality had significantly longer telomeres than those with moderate or poor quality.[3] This is even after adjusting for age, gender, demographic, community, clinical, and lifestyle characteristics.

Maybe the people living in lower quality neighborhoods have more depression. Was that a possibility that occurred to you? It makes sense that people who live in neighborhoods with low social cohesion would feel worse psychologically. And we know that depressed people have shorter telomeres. The NESDA researchers tested this—and found that the emotional stress of living in an unsafe neighborhood has an effect independent of how depressed or anxious its residents are.[4]

Exactly how does low social cohesion penetrate to your cells and

telomeres? One answer has to do with vigilance, that sense of needing to be on high alert to maintain your safety. A group of German scientists performed a fascinating study of vigilance that pitted country folks against city dwellers. People from both groups were invited to take one of those nerve-wracking math tests that are designed to elicit a stress response, the kind where volunteers perform complex mental math while researchers give instant feedback. In this case, the participants were hooked up to a functional MRI, which allowed the researchers to watch their brain activity, and so the researchers gave their feedback over headphones, saying things like "Can you go faster?" or "Error! Please start from the beginning." When the city dwellers took the math test, they had a bigger threat response in their amygdala, a tiny brain structure that is the seat of our fear reactions, than the people who lived in the country.[5] Why the difference between the two groups? Urban living tends to be less stable, more dangerous. People in cities learn to be more vigilant; their bodies and brains are always prepared to mount a big, juicy stress response. This ultrapreparedness is adaptive but is not healthy, and it may be part of the reason that people in threatening social environments have shorter telomeres. (It's interesting, and a source of relief to us city dwellers, that the noise and crowds of urban living are *not* associated with shorter telomeres.)[6]

Some neighborhoods may shorten telomeres because they are places where it's harder to maintain good health habits. For example, people tend to get less sleep when they live in neighborhoods that are disorderly and unsafe, with low social cohesion.[7] Without adequate sleep, your telomeres suffer.

I (Liz), who also lived in New Haven for a time, experienced firsthand another way that a neighborhood can inhibit health habits. Prior to moving to New Haven, I had studied in Cambridge, England. With its flat terrain, Cambridge is a bicycling haven, and I rode my bike everywhere. When I arrived in New Haven to start

postdoctoral research at Yale, I noticed that its geography was ideal for cycling. One of the first questions I asked my new lab mates was, "Where can I get a bike to ride to and from work?"

A short silence followed. Someone said, "Well, maybe biking home in the evening is not such a good idea. Bikes tend to be stolen."

Airily I replied that when that had happened in Cambridge, I simply bought a cheap, secondhand bike to replace it. Another silence, and then someone kindly explained that when their colleague said "stolen," he had meant "stolen while the person was still riding the bike." So I didn't bike in New Haven.

Other residents of low-trust, high-crime neighborhoods may draw similar conclusions. It's hard enough for many of us to fit exercise into our schedules, or to resist the call of the easy chair—and for people in unsafe neighborhoods, certain kinds of exercise may be too dangerous to even contemplate. Safety is only one barrier. Another is a lack of parks and other places to exercise. The social and "built environment" of poor neighborhoods stacks the deck against exercise. Without exercise, telomeres are shorter.

LITTERED OR LEAFY?

San Francisco is one of the world's great cities. Its citizens live within walking distance of museums, restaurants, and theaters; they can hike to spectacular views of the hillsides and bay. But as with many cities, parts of San Francisco are also quite dirty. They have a litter problem. This is not good for the residents, especially the young ones. Children who live in a neighborhood that is physically disorderly, with vacant buildings and trash in the streets, have shorter telomeres. The

presence of litter or broken glass right outside the house is an especially strong predictor of telomere trouble.[8]

Have you ever been to Hong Kong? There is a stark contrast between the densely populated bustle, bright neon lights, and chaos of Kowloon, the city's downtown, and the sprawling green hills of the New Territories, which are located just outside the city. There, the citizens enjoy trees, parks, and rivers. A 2009 study looked at nine hundred elderly men; some lived in Kowloon and others lived in the lush New Territories. Guess who had shorter telomeres? The men who lived in the city. (The study controlled for social class and health behaviors.) While other factors could be responsible for the association, this study suggests that there's a role for green space in telomere health.[9]

When you're in the thick of a forest, breathing the crisp, clean air, it's not hard to believe that telomeres could benefit from exposure to nature. We're intrigued by this possibility because it's supported by what we already know about nature and a phenomenon called psychological restoration. Being in nature provides a dramatic change in context. It can inspire us with beauty and stillness. It takes us out of small thinking about small problems. It can also relieve us of the moving, blinking, wailing, shuddering, shaking, noisy urban stimuli that keep our arousal systems jacked up. Our brains get a break from registering dozens of simultaneous sensations, any of which could mean danger. Exposure to green spaces is associated with lower stress and healthier regulation of daily cortisol secretions.[10] People in England who are economically deprived have almost double (93 percent) the early mortality of the wealthiest in their country—*except* when they live in neighborhoods surrounded by greenery. Then their relative mortality dips, so that they are only 43 percent more likely to die early from any cause.[11] Nature halves their comparative risk. It's still a sad statistic about poverty, but it leads us to believe that the greenery-telomere connection deserves more exploration.

CAN MONEY BUY LONGER TELOMERES?

You don't need to be rich to have long telomeres, but having enough money for basic needs does help. One study of around two hundred African American children in New Orleans, Louisiana, found that poverty was associated with shorter telomeres.[12] Once you have basic needs met, having more money doesn't seem to help further—there are no consistent relationships between gradients of how much money you make and your telomere length. But with education, there does appear to be a dose-response gradient—the more education, the longer the telomeres.[13] Educational level is one of the most consistent predictors of early disease, so these results aren't too surprising.[14]

In a UK study, occupation mattered more than other indicators of social status: White-collar jobs (versus manual labor) were associated with longer telomere length. This was true even among twins who were raised together but as adults had different occupational status.[15]

CHEMICALS THAT ARE TOXIC TO YOUR TELOMERES

Carbon monoxide: It's odorless, flavorless, and colorless. Deep underground, in coal mines, it can build up without detection, especially after an explosion or fire. At high enough levels, it can cause a miner to asphyxiate. So in the early 1900s, miners began carrying caged canaries down into the mines with them. The miners considered them friends and would sing to the birds as they worked. If there was carbon monoxide in the mine, the canaries would show distress by swaying, reeling, or falling off their perches. The miners would know that the mine was contaminated, and they would either exit or use their breathing apparatuses.[16]

Telomeres are the canaries in our cells. Like those caged birds, telomeres are captive inside our bodies. They are vulnerable to their chemical environment, and their length is an indicator

of our lifelong exposure to toxins. Chemicals are like litter in our neighborhoods—they are a part of our physical surroundings. And some are silent poisons.

Let's start with pesticides. So far, seven pesticides have been linked to significantly shorter telomeres in agricultural workers who apply them to crops: alachlor; metolachlor; trifluralin; 2,4-dichlorophenoxyacetic acid (also known as 2,4-D); permethrin; toxaphene; and DDT.[17] In one study, the greater the cumulative exposure to the pesticides, the shorter the telomeres. It wasn't possible to determine whether one type of pesticide alone was worse or better for telomeres than any others; the study looked at an aggregate of all seven. Pesticides cause oxidative stress—and oxidative stress, when it accumulates, shortens telomeres. This study is supported by another finding, in which agricultural workers who are exposed to a mixture of pesticides while working in tobacco fields have been found to have shorter telomeres.[18]

Fortunately some of these chemicals have been banned in parts of the world. For example, there is a worldwide ban on the agricultural use of DDT (although it is still used in India). Once released, however, these chemicals don't just disappear. They live on and on in the food chain ("bioaccumulation"), so any hope to live completely free of chemicals is impossible. There are probably many toxic chemicals in small amounts in each of our cells. They end up in breast milk as well, although the benefits of breast-feeding are thought to far outweigh the exposure to chemicals. Unfortunately, many compounds on the toxic list (alachlor; metolachlor; 2,4-D; permethrin) are still used in farming and gardening and are still being produced at high levels.

Another chemical, cadmium, is a heavy metal with weighty effects on our health. Cadmium is found mostly in cigarette smoke, though we all carry low but potentially toxic levels around in our bodies because of our contact with environmental contributors such as house dust, dirt, the burning of fossil fuels such as coal or oil, and the incineration of municipal waste. Cigarette smoking has

been linked to shorter telomeres—no surprise there, given the other dangerous effects of smoking.[19] Some of that relationship is due to cadmium.[20] Smokers have twice the levels of cadmium in their blood compared to nonsmokers.[21] In some countries and industries, people are exposed to cadmium through factory work. In an electronic waste-recycling town in China with known high cadmium pollution, higher cadmium levels in blood were linked to shorter telomeres in placentas.[22] In a large study of U.S. adults, those with the worst cadmium exposure have up to eleven additional years of cellular aging.[23]

Lead is another heavy metal to watch out for. Lead is found in some factories, some older homes, and developing nations that do not yet regulate lead paint and still use leaded gasoline, and it is another potential culprit in telomere shortening. Although the study of the electronic waste-recycling plant found no association between lead levels and telomere length, another study of Chinese battery factory workers who were exposed to lead as part of their work environment found some striking relationships.[24] In this study of 144 workers, almost 60 percent had lead levels high enough to meet the definition of chronic lead poisoning, and they had significantly shorter immune cell telomere length than those with normal or lower lead levels. The only difference between groups was that the group with poisoning had worked at the factory longer. Fortunately, once the lead poisoning was discovered, victims were hospitalized and given treatment (lead chelation therapy). During treatment, urine was assessed for how much lead was excreted, a measure called the "total body burden" of lead. Body burden indicates long-term lead exposure. The greater the body burden of lead, the shorter the telomeres. The correlation was .70, which is very high (the highest a correlation can be is 1). This relationship was so strong that the usual relationships of telomere length with age, sex, smoking, and obesity were not detectable in those exposed to lead. Lead exposure overrode all these factors.[25]

While severe occupational hazards have the strongest effects, it is alarming that households can also carry genotoxic hazards. Older homes may still have lead paint, which can be a danger if the paint is peeling. Many cities still use lead pipes, and the lead can travel into our homes and drinking water. Consider the tragic and shameful crisis in Flint, Michigan, in which the water supply is so corrosive that lead was leached from the pipes. The water became highly contaminated—and so did the residents' blood. While this disturbing drama has unfolded publicly on our screens, the same problem is silently taking place in many other cities that use old pipes. Particularly troublesome is that children are more sensitive to lead than adults. In one study, eight-year-old children with lead exposure had telomeres that were shorter than those of children without lead exposure.[26]

One category of chemicals, **polycyclic aromatic hydrocarbons (PAHs)**, is airborne, which makes it especially hard to avoid. PAHs are by-products of combustion and can be breathed in from fumes from cigarette and tobacco smoke, coal and coal tar, gas stoves, wildfires, hazardous waste, asphalt, and traffic pollution. You can also be exposed to PAHs if you eat foods grown in affected soil or that have been cooked on a grill. Beware. Higher exposure to PAHs has been shown to be associated with shorter telomere length in several studies.[27] An investigation of PAHs offered a caution for pregnant women: the closer a pregnant mother lived to a major roadway, and the fewer trees and plants in her neighborhood (which can reduce air pollution levels), the shorter were the telomeres of her placenta, on average.[28]

CHEMICALS, CANCER, AND *LONGER* TELOMERES

Some chemicals are associated with *longer* telomeres. This may sound good, but remember that very long telomeres in some cases are associated with uncontrolled cell growth—in other words, cancer. So when genotoxic chemicals get into our bodies, we are more likely to

get mutations and cancerous cells, and if the telomeres of those cells are long, they are more likely to divide and divide and divide into cancerous tumors. This is one reason we are so concerned about the widespread use and marketing of supplements and other products that claim to lengthen your telomeres.

We are concerned that chemical exposures and telomerase activating supplements may damage cells, or that they may increase telomerase and change telomeres in radical or inappropriate ways that our bodies have not learned to cope with. But when you practice naturally healthy habits such as stress management, exercise, good nutrition, and good sleep, your telomerase efficiency increases slowly, steadily, and over time. This natural process protects and maintains your telomeres. In some cases, lifestyle changes may even help your telomeres grow a bit longer, but in a way that won't trigger uncontrolled cell growth. Healthy lifestyle factors that have been correlated with longer telomeres have *never* been shown to increase cancer risk. Lifestyle changes influence telomeres through mechanisms that are different from and safer than chemical exposures or supplements.

Which chemicals might unnaturally lengthen telomeres too much? Exposure to **dioxins and furans** (toxic by-products that are released through various industrial processes and that are commonly found in animal products), **arsenic** (common in drinking water and some foods), **airborne particulate matter**, **benzene** (exposure occurs via tobacco smoke as well as gasoline and other petroleum products), and **polychlorinated biphenyls** (or PCBs, a class of banned compounds that is still found in some high-fat animal products) is associated with longer telomere length.[29] What is so interesting is that some of these chemicals have also been linked to cancer risks. Some have been linked to higher rates of cancer in animals; others have been studied in labs, where heavy doses are put into cells and create cancer-promoting molecular changes. It is possible that chemicals can both create fertile ground for mutations

and cancerous cells, and create high telomerase or longer telomere length, promoting greater likelihood the cancerous cells might be replicated. We speculate that telomeres thus may be one link in the chemical-cancer relationship.

To put this into perspective, the American Association for Cancer Research Cancer Progress Report of 2014 informs us that 33 percent of the relative contribution to overall risks of developing cancer is from tobacco use alone, and about 10 percent is attributable to occupational and environmental exposures to pollutants.[30] But that low percentage is for the United States; it is not known how much higher it is in countries and regions of the world where environmental pollution and exposures at work are much less well controlled. Furthermore, a 10 percent increase in risk may seem small, but since there are over 1.6 million new cases of cancers every year in the United States alone, that 10 percent translates into 160,000 new

Telomere Toxins

Chemicals Linked to Shorter Telomeres	**Chemicals Linked to Longer Telomeres** *(Long telomeres in these conditions indicate a possible risk of uncontrolled cell growth and some forms of cancer.)*
Heavy metals, such as cadmium and lead	Dioxins and furans Arsenic Particulate matter Benzene PCBs
Agricultural pesticides and lawn products: alachlor metolachlor trifluralin 2,4-dichlorophenoxyacetic acid (also known as 2,4-D) permethrin Mostly no longer produced but still present in the environment: toxaphene DDT	
Polycyclic aromatic hydrocarbons (PAHs)	

cancer cases per year. Think about it. Every year, 160,000 additional people and their families have their lives irrevocably changed by a diagnosis of cancer. And that's just in the United States; the World Health Organization estimates that there are 14.2 million new cases of cancer around the globe each year, so we could estimate that 1.4 million new cases of cancer each year come from environmental pollution.[31]

PROTECT YOURSELF

What can you do? More research is needed to fully understand the connection between these chemicals and cell damage, but in the meantime it is reasonable to take all the precautions you can. I have always had a preference to use natural products—but only when it was convenient for me to buy them. After realizing that so many of our household cleaners and cosmetics contained genotoxic and telomere-damaging chemicals, I now actively seek out natural products.

You may also want to change the way you eat and drink. Arsenic is naturally found in wells and groundwater, so you can either have your water tested or use a filter. Avoid plastic drinking bottles and cookware. Even BPA (Bisphenol A)–free plastic bottles may not be free of other harmful chemicals. BPA substitutes may be as unsafe; they just haven't been studied to the same extent (plus, we may soon have more plastic in the ocean than fish if we don't reduce our reliance on plastic bottles). Try not to microwave plastics, even the ones that say they are microwavable. It's true that microwaveable plastics won't warp when you heat them, but there are no promises that you won't get a dose of plastics in your food.

How can you reduce your exposure to smoke, air, and traffic pollution? Avoid living near major roadways if possible. Don't smoke (yet another good reason to quit), and avoid passive smoke. Greenery—trees, green space, and even house plants—can help

reduce the levels of air pollutants inside your home and in a city, including volatile organic compounds. There is no direct evidence that living with more plants leads to longer telomeres, but there are correlations to suggest that increasing your exposure to greenery can be protective. Try to walk in parks, plant trees, and support urban forestry.

For more ways to protect yourself, see the Renewal Lab on page 276.

FRIENDS AND LOVERS

Long ago, when most of humanity lived in tribes, each group would delegate a few of its members to keep watch at night. The folks on watch would remain alert for fires, enemies, and predatory animals, and everyone else could sleep soundly, knowing that they were protected. In those perilous days, belonging to a group was a way to ensure your safety. If you couldn't trust your night watchmen, you weren't going to get your much-needed sleep. Our ancestors' version of poor social capital and lack of trust!

Flash-forward to contemporary life. When you lie down in your bed at night, you probably don't worry very much about panthers dropping on you from above, or enemy warriors skulking behind the drapes. Nevertheless, the human brain hasn't changed much since tribal days. We're still wired to need someone around who "has our backs." Feeling connected to others is one of the most basic human needs. Social connection is still one of the most effective ways to soften the danger signal; its absence will amplify it. That's why it feels so good to belong to a cohesive group. It feels good to be in connection with others—to give or receive advice, borrow or lend something, work together, or share tears and feel understood. People with relationships that allow for this kind of mutual support tend to have better health, whereas people who are socially isolated are more stress reactive and depressed, and are more likely to die earlier.[32]

In animal research, even rats, who are social animals, suffer when they are caged solo. Little did we know how stressful isolation is for this social animal. Now we know that when rats are caged alone, they don't receive the safety signals from being in close proximity to others and feel more stressed out. They get three times more mammary tumors than the rats who live in a group.[33] The rats' telomeres weren't measured. But a similar experiment found that parrots caged alone have faster telomere shortening than when they are with a mate.[34]

Aside from my bicycling disappointment, I (Liz) was generally happy as a postdoctoral fellow at Yale. But as it became time to think about finding a job, I began to worry. I'd wake up in the night in a cold sweat of anxiety, wondering how on earth I would ever become employed. One of the hurdles I had to overcome was preparing a job seminar, a lecture that I'd deliver when interviewing for academic positions. Feeling insecure, I overdid it. Desperate to convince a skeptical world about the validity of my scientific conclusions, I poured every bit of my data into the text. When I practiced the talk in front of my colleagues, the reaction was . . . muted, to say the least. The lecture was so dense that it was unintelligible. I went back to my shared office and succumbed to despairing tears. The head of the lab, Joe Gall, came by and offered kind, encouraging words. That helped. Then Diane Juricek (later Lavett), dropped in. Diane was a visiting junior professor working in a neighboring lab, and she and I shared group meetings and lunch tables. Diane volunteered to help me work my talk into shape, taking out the excessive quantities of data description and forming it into a more coherent whole. Then she helped me rehearse the lecture in the big, old-fashioned hall near the building where we worked. This enormous generosity to a younger, less experienced colleague—Diane didn't even know me well—made a huge impression on me. I realized what an academic scientific community could be about.

At the time, I was simply grateful for Diane's help. I didn't know

then that my cells were likely responding to the support. Good friends are like the trusted night watchmen; when they're around, your telomeres are more protected.[35] Your cells beam out fewer C-reactive proteins (CRPs), proinflammatory signals that are considered a risk factor for heart disease when they appear in high levels. [36]

Do you have someone in your life who is close to you but also causes unease? About half of all relationships have positive qualities with less helpful interactions, what researcher Bert Uchino calls "mixed relationships." Unfortunately, having more of these mixed-quality relationships is related to shorter telomeres.[37] (Women with mixed friendships have telomeres that are shorter; both women and men have shorter telomeres when the mixed relationship is with a parent.) That makes sense. These mixed relationships are characterized by friends who don't always know how to offer support. It's stressful when a friend misunderstands your problems or doesn't give you the kind of support you really want. (For example, a friend may decide you need a long pep talk when what you really need is a shoulder to cry on.)

Marriages come in all flavors, and the better the quality of the marriage the better the health benefits, although these are what we consider statistically small effects.[38] Put someone from a satisfying marriage into a difficult situation, and they'll likely have more resilient patterns of stress reactivity.[39] Happily married people also have a lower risk of early mortality. Marriage quality has not been examined with telomere length yet, but we do know that married people, or people living with a partner, have longer telomeres.[40] (This was a surprise finding from a genetic study of 20,000 people, and the relationship was stronger in the older couples.)[41]

Sexual intimacy in marriage may matter for telomeres, too. In one of our recent studies, we asked married couples if they had been physically intimate during the previous week. Those who answered yes tended to have longer telomeres. This finding applied to both women and men. This effect could not be explained away by the

quality of the relationship or other factors relating to health. Sexual activity declines less in older couples than stereotypes would have us believe. Around half of married thirty- to forty-year-olds, and 35 percent of sixty- to seventy-year-olds, engage in sexual activity anywhere between weekly and a few times a month. Many couples remain sexually active well into their eighties.[42]

Couples in unhappy relationships, on the other hand, suffer from a high level of "permeability"—they pick up on each other's stress and negative moods. If one spouse's cortisol rises during a fight, so does the cortisol of the other spouse.[43] If one spouse wakes up in the morning with a big stress response, the other is more likely to as well.[44] Both are operating at a high level of distress, leaving no one in the relationship who can put the brakes on the tension, no one who can say, "Whoa, wait. I see you're upset. Let's take a breath here and talk about it, before things get out of control." It's easy to imagine that these relationships are wearying and depleting. Our physiological responses moment to moment are more synced with our partner's than we may realize. For example, in one study examining couples having both positive and stressful discussions in the lab, heart rate variability followed the pattern of the other partner with a slight lag.[45] We suspect the next generation of research on relationships is going to reveal many more ways that we are connected physiologically to people we are close to.

RACIAL DISCRIMINATION AND TELOMERES

One Sunday morning, thirteen-year-old Richard decided to attend a friend's church in a town a few miles outside his Midwestern city. "I guess there weren't too many black people at the church to begin with," says Richard, who is black, "and I guess the two of us were dressed differently." Richard sat quietly with his friend in the reception area, waiting for the service to begin. As a minister's son, Richard had grown up in churches; he had always known them to be

places where he felt welcomed, accepted, and safe. Then a woman who ran one of the church programs walked up to them.

"What are you guys doing here?" she asked in a pointed tone. They explained that they were planning to attend the Sunday service.

"I don't think you're in the right place," she said, and told them to leave.

"I felt so uncomfortable," Richard recalls now of the incident. "She kind of convinced me that I actually didn't belong there. We ended up leaving the church and not going to the service. I almost couldn't believe it had happened, but then my dad e-mailed the minister, and he confirmed that the details were correct. The woman really had said all those things. It seems inhuman that people would go to such lengths to get me out of a church."

Discrimination is a serious form of social stress. Discriminatory acts of any kind, whether they target sexual orientation, gender, ethnicity, race, or age, are toxic. Here we're zeroing in on race, because that is where telomere research has been focused. In the United States, being black, and especially being a black man, means you are more vulnerable to encounters like the one Richard had. He says, "When I talk about racism, people think I mean something extreme. But it can be small, like when a white mother grabs her child's hand when an African American teenager walks by. It hurts."

Unfortunately, racism in its extreme form is also common. African American men are more likely to be accused of a crime and attacked by the police. Now, given dashboard cameras and iPhones, we see these painful scenes on our TVs often. Police officers are like every other human: they make automatic judgments about people from a visibly different social group. Meet someone new, and within milliseconds your brain is assessing whether the person is "same" or "other." Does the person look like me? Is he or she familiar in some way? When the answers are yes, we instinctively judge the person as

being warmer, more friendly, and more trustworthy. When the person seems different from us, our brains judge them to be potentially hostile and dangerous.[46]

As we said, this is an instant, unconscious reaction. It is a reason that skin color can set off automatic judgments—but it's not an excuse for acting on those judgments. All of us have to consciously work to counter this internal bias. Tim Parrish, who was raised in a close-knit but racist community in Louisiana during the 1960s and '70s, is now an adult in his fifties. Tim, who is white, admits that sometimes racist assumptions pop into his head, even though he doesn't want them there and no longer believes them to be true. But, as Parrish explained in a opinion piece for the New York *Daily News*, "What gets injected into us as beliefs is not fully our choice. What is our choice is to be constantly vigilant, to deconstruct the assumptions we make, to combat impulses we may have that lead us in the direction of thinking we are somehow the generalized victim and the more civilized color."[47] In a relatively low-stress situation, this mental work against bias may be easier to accomplish than in fast-moving, tense situations. It is a reason that "driving while black" means you are more likely to be pulled over. If you're a black man in America and your behavior seems dangerous, or is hard to interpret, you are more likely to be shot. My (Elissa's) husband, Jack Glaser, a public policy professor at the University of California, Berkeley, works on training police officers to reduce racial bias. He is helping to adapt police procedures so that they are not so heavily influenced by automatic judgments that can lead to racial discrimination. Although he and his academic colleagues categorize this as policy work, I think of it as stress reduction at a societal level, and possibly telomere relevant!

The amount of suffering people experience when they are targets of discrimination runs very deep. African Americans tend to develop more chronic diseases of aging. For example, they have

higher rates of stroke than other racial and ethnic populations in the United States. Poor health behaviors, poverty, and lack of access to good medical care may explain some of these statistics, but so does a lifetime of greater stress exposure. In a study of older adults, African Americans who experience more daily discrimination had shorter telomeres, and this relationship did not hold up for whites (who experience less discrimination in the first place).[48] But this is probably not a simple, straightforward relationship; it may depend on attitudes we are not even aware of within ourselves.

David Chae at the University of Maryland performed a fascinating study that looked at low-income, young black men living in San Francisco. He wanted to know what happens to telomeres when people internalize the common societal bias, meaning that they come to believe society's negative opinions of them at an unconscious level. Discrimination alone had a weak effect. The men who had been discriminated against *and* internalized the disparaging cultural attitudes toward blacks had shorter telomeres.[49] Internalized bias toward blacks is tested by a computer task using reaction times to see how quickly people pair the word *black* with negative words. You can test your own bias at this website: https://implicit.harvard.edu/implicit/user/agg/blindspot/indexrk.htm. Just don't berate yourself for having automatic biases; most of us do. We suspect we will see more data on discrimination and telomeres in the coming years.

Knowing how places and faces affect your telomere health can be reassuring, or it can be unsettling. It all depends on your situation—where you live, the quality of your relationships, and how much you've internalized discrimination (discrimination toward any aspect of yourself—race, sex, sexual orientation, age, disability). But *all* of us can take steps to reduce toxic exposures, improve the health of our neighborhoods, become more aware of our biases toward other groups, and create positive social connections. The Renewal Lab at the end of this chapter offers some ways to get started.

TELOMERE TIPS

- We are interconnected in ways we cannot see, and telomeres reveal these relationships.
- We are affected by the toxic stress of discrimination.
- We are affected by toxic chemicals.
- We are affected in more subtle ways, by how we feel in our neighborhood, by the abundance of green plants and trees nearby, and by the emotional and physiological states of those around us.
- When we know how we are affected by our surroundings, we can begin to create healthful, supportive environments in our homes and our neighborhoods.

RENEWAL LAB

REDUCE YOUR TOXIC EXPOSURES

We've already described some basic precautions against plastics and pollution that could shorten—or dangerously lengthen—your telomeres. Here are some more advanced moves:

- **Eat less animal and dairy fat.** The fatty parts of meat are where certain bioaccumulative compounds collect and concentrate. The same goes for the fat in large, long-lived fish, except that there is a balancing issue to weigh. Fatty fish such as salmon and tuna also contain omega-3s, which are good for your telomeres, so eat in moderation.
- **Think about the air when you turn up the heat with meat.** If you cook meat on a grill or on a gas stove, use ventilation. Try to avoid exposing the food directly to open flames, and try not to eat the charred portions, no matter how tasty they are. A good idea for any food.
- **Avoid pesticides in your produce.** Eat foods that are free of pesticides when possible; at the very least, wash your produce thoroughly before consuming. Purchase organic fruits, vegetables, and meats, or grow your own. Consider growing lettuce, basil, herbs, and tomatoes in pots on your balcony. Safe alternatives for dealing with pesky critters can be found here: http://www.pesticide.org/pests_and_alternatives.

- **Use housecleaning products containing natural ingredients.** You can make many of these products yourself. We like the housecleaning "recipes" found at http://chemical-free-living.com/chemical-free-cleaning.html.
- **Find safe personal-care products.** Carefully read the labels on personal-care products such as soap, shampoo, and makeup. You can also visit http://www.ewg.org/skindeep to identify which chemicals are in your beauty products. When in doubt, buy products that are organic or all natural.
- **Buy nontoxic house paints.** Avoid paints that contain cadmium, lead, or benzene.
- **Go greener.** Buy more house plants: two per one hundred square feet is ideal for keeping your air filtered. Good choices include philodendrons, Boston ferns, peace lilies, and English ivy.
- **Support urban forestry** with your money or your labor. Green spaces offer so many benefits to mind and body, as well as to healthy communities. **One newer idea can be considered in dense urban megacities, where one cannot plant enough trees to rid the air of toxins.** If you live in a city, consider lobbying your municipal government to install air-purifying billboards. These billboards do the work of 1,200 trees, cleaning a space of up to 100,000 cubic meters by removing pollutants such as dust particles and metals from the air.[50]
- **Stay up to date about toxic products by downloading the "Detox Me" app by Silent Spring:** http://www.silentspring.org/.

INCREASE THE HEALTH OF YOUR NEIGHBORHOOD: SMALL CHANGES ADD UP

To brighten a corner of your own neighborhood, follow the example of our San Francisco neighbors and place a few benches and tables on

a bare cement sidewalk, along with a little greenery. These "parklets" attract neighbors and promote socializing and peaceful lounging. Or consider one of these:

- **Add art.** A mural or even a beautiful poster can infuse a drab area with hope, truth, faith, and positivity. Residents in a Seattle neighborhood painted boarded-up shop windows with pictures of the businesses they hoped to attract: an ice-cream parlor, a dance studio, a bookshop, and so on. The paintings helped entrepreneurs see the potential of the neighborhood. They brought their small businesses to the block, revitalizing the area and bringing economic growth to the community.[51]
- **Get greener**, especially if you are a city dweller. More green space in a neighborhood is associated with lower cortisol and lower rates of depression and anxiety.[52] Turn a vacant lot into a sustainable community fruit or vegetable patch, or plant trees and flowers in a small park space. "Greening" a vacant lot has been associated with a decrease in gun violence and vandalism and an increase in the residents' general feeling of safety.[53]
- **Warm your neighborhood tone.** Social capital is an invaluable resource that predicts good health. It's defined by the level of community engagement and positive activities and resources that exist in a neighborhood, and one of its most important ingredients is trust. So be the one to make the first move. Cook or bake a little extra and drop it off at your neighbors' house on a small plate. Share vegetables or flowers from your garden. Help out by shoveling snow, giving a ride to an elderly person, or starting a neighborhood watch. Leave a welcoming note for newcomers to the neighborhood, or plan a block party. You could also join the trend of opening a Little Free Library in front of your house by putting out a wooden cabinet where books are shared. (See https://LittleFreeLibrary.org.)

- **Smiles matter.** Acknowledge people you pass on the street. As social animals, we are exquisitely sensitive to social cues, noticing signs of acceptance and especially rejection. Each day, we interact with strangers or acquaintances, and we can either feel separate from them—or we can connect with them in a small way that has a positive effect. Give people an "air gaze" (looking past the face, with no eye contact) and they will tend to feel more disconnected from others. Give them a smile and eye contact, and they feel more connected.[54] Plus, when people are given a smile, they are more likely to help someone else in their next moments.[55]

STRENGTHEN YOUR CLOSE RELATIONSHIPS

Then there are the people we wake up to almost every day—our family, and colleagues we work with. The quality of these relationships is important to our health. It is easy to be neutral, to take those we see all the time for granted. Investigate what it is like to really acknowledge your close ones in a significant way:

- Show gratitude and appreciation. Say, "Thanks for doing the dishes" or "Thanks for supporting me at the meeting."
- Be present. This means not looking at a screen or around the room. Give your full, sincere attention. That is a gift you can give another person, and it doesn't cost a dime.
- Hug or touch your loved ones more often. Touch releases oxytocin.

Your Renewed Day

Each day you have an opportunity to forestall, maintain, or accelerate the aging of your cells. You can stay in balance or maybe even forestall unnecessary acceleration of biological aging by eating well, getting enough sleep for restoration, being active and maintaining or building fitness, and sustaining yourself through meaningful work, helping others, and social connection.

Or you can do the opposite—consume junk food or too many sweets, get too little sleep, and stay sedentary or decondition the fitness you have. Throw high stress into the mix of a vulnerable body, and you'd have a day of wear and tear on your cells. It's possible that you might even lose a few base pairs of telomere length. We don't *really* know how responsive telomeres are on a daily basis, but we do know that chronic behavior over time has important effects. We can all strive to have more days of renewal rather than wear and tear. Begin by making small changes. There are suggestions for telomere-healthy change throughout the book, and we've created an example of how you can build some of these behaviors into your day. Circle any you might like to try.

We've also included a blank Renewed Day schedule that you can customize with the telomere-healthy changes you'd like to make. You can copy it, or print it from our website, and stick it to your refrigerator or mirror to help remind you of easy ways to promote healthy cell renewal. Fill in several new behaviors you'd like to add to your day. What do you want to say to yourself when you wake up? Do you want to fit in a few minutes of a morning renewal

Your Renewed Day

Time	Telomere-Shortening Behavior	Telomere-Supporting Behavior
Waking up	Anticipatory stress or dread. Mentally rehearse your to-do list. Check phone immediately.	**Reappraise your stress response** (page 120). Wake with joy. "I am alive!" Set an intention for the day. Look forward to any positive aspects.
Early morning	Regret that there's no time for exercise.	Perform a **cardio or interval workout** (page 186). Or do energizing **Qigong** (page 156)
Breakfast	Sausage and bagel.	Oatmeal with fruit; fruit smoothie with yogurt and nut butter; vegetable omelet.
Morning commute	Rush, hostile thoughts, maybe a little road rage.	Practice the **three-minute breathing break** (page 149).
Arrival at work	Play catch-up from the moment you arrive. Anticipate, worry about the workday.	Give yourself a ten-minute window of habituation and settling before work begins. Meet situations as they arise.
Workday	Self-critical thoughts. Multitask to deal with work overload.	Notice your thoughts. Take a **self-compassion break** (page 122) or **manage your eager assistant** (page 123). Focus on one task at a time. (Can you turn off your e-mail and ringer for an hour?)
Lunch	Eat fast food, deli meats. Eat quickly.	Enjoy a lunch made from fresh, whole foods. Practice **mindful eating** (page 222). Connect with someone. Have lunch or walk with a partner; text, call, or e-mail someone you have a supportive relationship with.
Afternoon	Give in to cravings for a sugared drink, baked goods, or candy.	**Surf the urge** (page 220). Have a **telomere-friendly snack** (page 240). **Stretch.**
Evening Commute	Ruminate. Negative mind wandering.	**Mentally distance yourself** (page 97). Take a **three-minute breathing break** (page 149).
Dinner	Eat processed food. Look at screens.	Have a whole-foods dinner (see our website for ideas). Give the gift of focused attention to others.
Evening	Run through your evening activities and chores without a break. Suffer from a head buzzing with the aftereffects of a busy nonstop day.	**Exercise**, or try a **stress-reducing technique** (page 153). Ask, "Did I live my intentions today?" Review your day; try a **challenge reappraisal** (page 87). Savor the things that made you happy. Engage in a **relaxing sleep ritual** (page 203).