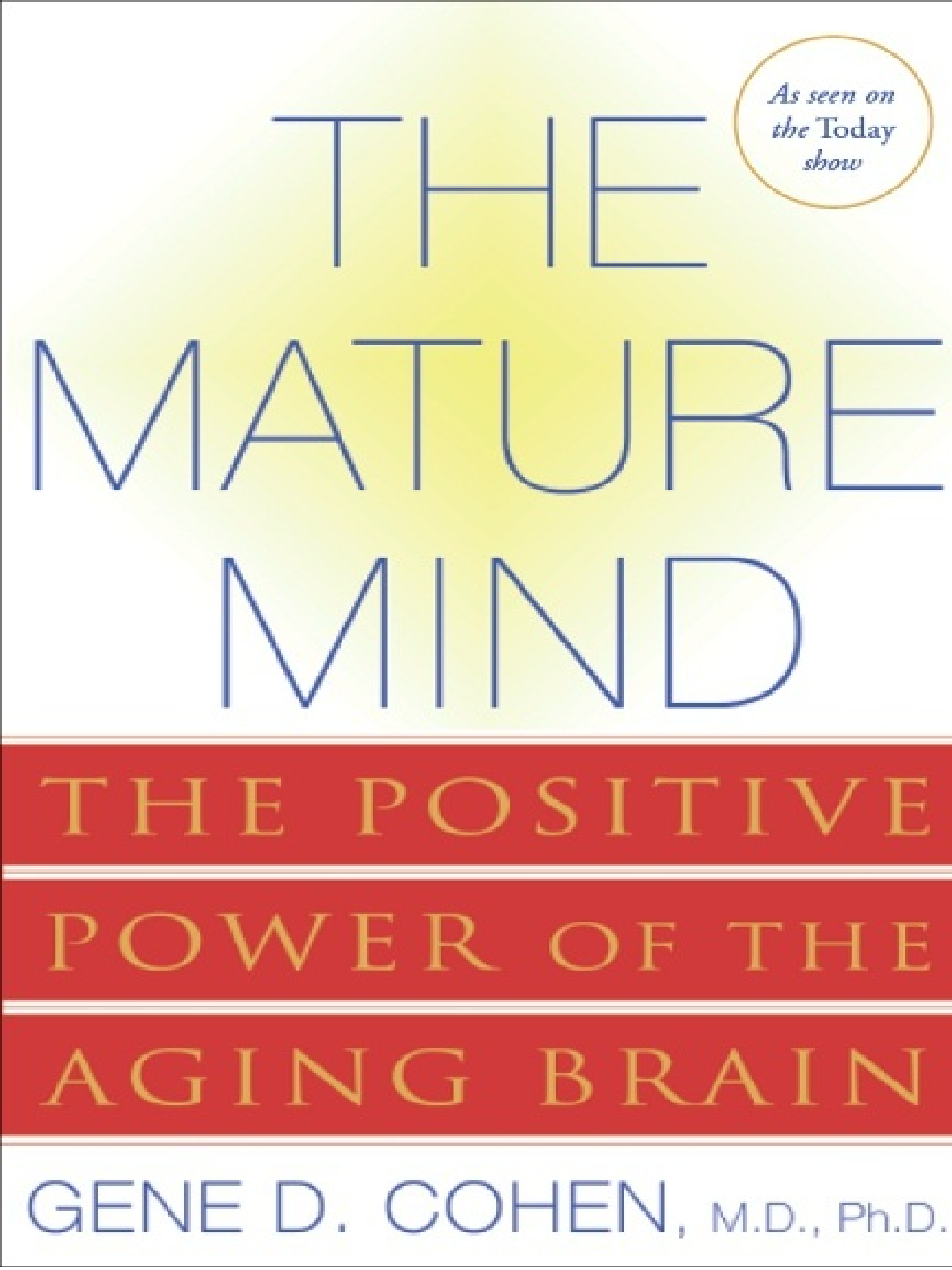
As seen on the Today show
THE MATURE MIND
THE POSITIVE POWER OF THE AGING BRAIN
GENE D. COHEN, M.D., Ph.D.

THE MATURE MIND

ALSO BY GENE D. COHEN, M.D., PH.D.

The Creative Age: Awakening Human Potential in the Second Half of Life

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The Positive Power of the Aging Brain

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To the elders of my family,
in deep appreciation
for the nurturing and wisdom
they have provided to our family
and to the community.

Contents

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being on a dream team.

Introduction

The greatest obstacle to discovery is not ignorance—
it is the illusion of knowledge.

—Daniel J. Boorstin

"Over the hill."
"Out to pasture."
"Twilight years."
"Retired."
These words reflect a stubborn myth—that aging is a negative experience and that "successful aging amounts to nothing more than slowing the inevitable decline of body and mind. Rubbish. Some life's most precious gifts can *only* be acquired with age: wisdom, for example, and mastery hundreds of different spheres of human experience that requires decades of learning. Growing old ca be filled with positive experiences, and "successful" aging means harnessing and manifesting th enormous positive potential that each one of us has for growth, love, and happiness.

Of course, aging brings challenges and losses. As actress Bette Davis once famously quippe "Getting old isn't for sissies." Sight may blur, hearing may dull, friends may die or become disable All of this is true, but it's not the *whole* truth. Historically, both science and culture in Weste societies have focused exclusively on the negative sides of aging and ignored the positive. It's tim for a better, truer, and more motivating paradigm—not a rosy, everything-is-wonderful perspectiv but a clear-eyed view that acknowledges the hard realities of growing old while at the same tim celebrating its benefits, pleasures, and rewards. With this book I want to shatter the illusions "knowledge" about aging that are based on faulty reasoning, insufficient research, and a preoccupatio with disease and pathology. My picture of positive aging is based on cutting-edge scientific researc as well as my personal experience as a psychiatrist who has treated older adults and their families f more than thirty-five years.

The latest research findings are encouraging and important. Denying or trivializing the positiv potential of aging prevents people from realizing the full spectrum of their talents, intelligence, an emotions. But when we come instead to *expect* positive growth with age, such growth can be nurture We are still a long way from fully realizing this shift in perspective, but I hope this book will be forceful catalyst for change in that direction.

New Science, New Horizons

Some of the most exciting research supporting the concept of positive aging comes from rece studies of the brain and mind. Much of aging research conducted during the twentieth centu emphasized improving the health of the aging body. As a result of this research, life expectancy an

overall health did in fact improve dramatically. Aging research at the beginning of the twenty-fir century, in contrast, has expanded with a strong focus on improving the health of the aging *min* Dozens of new findings are overturning the notion that "you can't teach old dogs new tricks." It tur out that not only can old dogs learn well, they are actually better at many types of intellectual tas than young dogs.

The big news is that the brain is far more flexible and adaptable than once thought. Not only do the brain retain its capacity to form new memories, which entails making new connections betwe brain cells, but it can grow entirely new brain cells—a stunning finding filled with potential. We'v also learned that older brains can process information in a dramatically different way than young brains. Older people can use both sides of their brains for tasks that younger people use only one si to accomplish. A great deal of scientific work has also confirmed the "use it or lose it" adage: th mind grows stronger from use and from being challenged in the same way that muscles grow strong from exercise.

But the brain isn't the only part of ourselves with more potential than we thought. O personalities, creativity, and psychological "selves" continue to develop throughout life. This mig sound obvious, but for many decades scientists who study human behavior did not share this view. fact, until late in the twentieth century, psychological development in the second half of life attracte little scientific attention, and when attention was paid, often the wrong conclusions were drawn. F example, Sigmund Freud, whose influence on psychological theory was profound, had this to sa about older adults: "About the age of fifty, the elasticity of the mental processes on which treatme depends is, as a rule, lacking. Old people are no longer educable."

Ironically, Freud wrote this statement in 1907, when he was fifty-one, and he wrote some of h greatest works after the age of sixty-five. Furthermore, Sophocles's *Oedipus Rex*, the masterpiece which Freud based his pioneering psychoanalytic theory, was written when the Greek playwright wa seventy-one years old.

Freud wasn't the only pioneer to get things wrong when it came to aging. Jean Piaget, who mad an extraordinary contribution to our understanding of cognitive development, ended his description intellectual development with what he called "formal operations," the kind of abstract thinking th matures during the teenage years. As far as Piaget was concerned, development stopped in your adulthood and then began a slow erosion.

Even the great developmental psychologist Erik Erikson, one of my teachers at Harvard, gave on limited attention to development in older age. Erikson delineated eight stages of psychosoci development and defined each one in terms of an issue or conflict that must be resolved. Yet only on of his stages refers to development after the onset of adulthood—mature age, which, these day amounts to a single stage that can last fifty years! His classic work *Identity and the Life Cyc* included only one page on each of the two last stages of human life. To his credit, Erikson was one the first influential thinkers to assert that some kind of psychosocial development continu throughout the life cycle. He acknowledged that his work on aging was incomplete, and he invited h students to continue in this area. This book is, in part, my response to the challenge Erikson mad decades ago.

FOUR PHASES

In this book I present a new account of psychological development in the second half of life. This ne

view explains many things about older age and is fundamentally forward-thinking and optimist about our potential for lifelong growth, creativity, and emotional fulfillment. Based on my studies more than 3,000 older adults, using in-depth interviews and questionnaires conducted multiple tim over the years, I have identified the following four distinct developmental phases of late life: midli reevaluation, liberation, summing up, and encore.

People enter and pass through these phases under the impelling force of inner drives, desires, ar urges that wax and wane throughout life. I call these drives the "Inner Push" and have witnessed it thousands of older adults who have participated in my research projects and clinical practice. Th Inner Push is the fuel motivating development; it works in concert with the changes in the aging bra that I explore in chapter 1. My conception of phases is more fluid and dynamic than Erikson's stag because I recognize that by later life people vary widely in every conceivable way, and no rig system will be accurate for everyone. The phases I propose are real—I've seen them manifested tim after time—but people experience them in different ways and sometimes in a slightly differe sequence than the one I present.

The first phase, midlife reevaluation, is a time for exploration and transition. It is not at all th same thing as a "midlife crisis"—which modern research has shown has been overreported and largely a cultural myth. Only 10 percent of people I interviewed reported having a midlife crisis. Wh I found, instead, was that in this period, from roughly ages forty through sixty-five, people undergo profound reevaluation, asking themselves: Where have I been? Where am I now? Where am I going Most people experience this period not as a crisis but as a quest—a desire to break new groun answer deep questions, and search for what is true and meaningful in their lives.

The midlife reevaluation phase is followed by what I call the liberation phase: a time when w feel a desire to experiment, innovate, and free ourselves from earlier inhibitions or limitations. Th desire often overlaps with midlife reevaluation and then comes on strong throughout the late fifti and sixties and into the seventies. As this shift is happening, our brains undergo significa physiological changes, including the sprouting of new connections between brain cells and a mo balanced use of the two brain hemispheres. This is a time when people express the sense of "If n now, when?"

The summing up phase, from the late sixties through the seventies and eighties, can be a time recapitulation, resolution, and review. One of the common outcomes of this autobiographic summing up process is a desire to give back—to family, friends, and society. Volunteerism an philanthropy, prominent among older people well into their eighties, are two tangible manifestatio of this phase.

For the final phase I use "encore" in the French sense of "again," "still," and "continuing." Th phase is not a swan song, but a variation on a theme: the desire to go on, even in the face of adversi or loss. This need to remain vital can lead to new manifestations of creativity and social engageme that make this period full of surprises.

When people come to understand these phases of later life and the mechanisms at work behi them, I have seen them become powerfully motivated and energized. Released from overly negati illusions about aging, people are often stirred by new energy, direction, or purpose.

DEVELOPMENTAL INTELLIGENCE

In this book I introduce a novel concept, developmental intelligence, which I see as the greate

benefit of the aging brain/mind. Developmental intelligence is the degree to which a person h manifested his or her unique neurological, emotional, intellectual, and psychological capacities. It also the process by which these elements become optimally integrated in the mature brain. Mo specifically, developmental intelligence reflects the maturing synergy of cognition, emotion intelligence, judgment, social skills, life experience, and consciousness. We are all developmentall intelligent to one degree or another, and, as with all intelligence, we can actively promote its growt As we mature, developmental intelligence is expressed in deepening wisdom, judgment, perspectiv and vision. Advanced developmental intelligence is characterized by three types of thinking ar reasoning that develop later than Piaget's "formal operations" and hence are referred to a "postformal operations": relativistic thinking (recognizing that knowledge may be relative and n absolute); dialectic thinking (the ability to uncover and resolve contradictions in opposing ar seemingly incompatible views); and systematic thinking (being able to see the larger picture, distinguish between the forest and the trees).

These three types of thinking are "advanced" in the sense that they do not come naturally youth; we prefer our answers black or white, right or wrong. And we usually prefer *any* answer to no at all. It takes time, experience, and effort to develop more flexible and subtle thinking. Our capaci to accept uncertainty, to admit that answers *are* often relative, and to suspend judgment for a mo careful evaluation of opposing claims is a true measure of our developmental intelligence. In th book I'll show you how you can cultivate your developmental intelligence and thereby reap i rewards.

TWO NEW STUDIES

I've had the privilege of directing two groundbreaking studies of older age since 2000, one looking the new face of retirement and the other at the positive benefits of creativity in older adults. Bo studies have generated surprising—and encouraging—results. My retirement study shows just ho outmoded the word "retirement" really is. For most people these days, the years after age sixty-fiv are anything but "retiring." It's not that everyone is a dervish or that people don't relax and enjo themselves, but most people I interview see this life stage as a great opportunity to pursue activiti and interests for which they previously didn't have time. Far from being a time of social and cultur withdrawal (as was postulated by early influential research), "retirement" can usher in *great* engagement, more satisfying relationships, new intellectual growth, and more fun.

My other study explores the mental, physical, and emotional effects of participating in community arts program. Again, my colleagues and I have made surprising discoveries. Contrary societal myths, creativity is hardly the exclusive province of youth. It can blossom at any age—and fact it can bloom with more depth and richness in older adults because it is informed by their va stores of knowledge and experience. As I will explain more fully later, taking part in any kind of a program, including the nonvisual arts of music, dance, and theater, can improve your health, yo outlook, and your resilience.

Important implications flow from these two studies, both for private citizens and for tho responsible for supporting the health and well-being of older adults. Outcomes from our creativi study, for example, should be invaluable for program directors of senior centers. Similarly, the findi from the retirement study that many older people are seeking part-time work should interest huma resources directors in corporations and nonprofit institutions. In reporting the findings from m

research, I hope to provide a road map for improving the social supports and educational opportuniti
for all older adults.

MY HOPE

In 1971, when I entered the field of gerontology, it was a relatively new area of study, underfunde
and hobbled by stereotypes and misconceptions. As recently as the 1960s and 1970s, many exper
still viewed old age as a disease: the mind and body, they believed, naturally fell apart, like a car aft
many years of use.

By the mid-1970s, these views began to change as evidence accumulated about the realities
aging and as the population of older adults began to surge. The federal government started spendi
millions of dollars on new research through two major programs: the National Institute on Aging a
the Center for Studies of the Mental Health of the Aging, the latter of which I was fortunate enough
be the first director. Researchers began to understand that aging is not a medical condition in and
itself; it is simply a time of life in which many medical conditions become manifest—the so-call
age-associated problems. This new focus fueled the field of geriatrics and provided a more balanc
view of old age. Healthy adults, researchers found, retain sound mental and emotional faculties a
typically decline only gradually in their physical resources.

Over the next thirty years, funding for aging research grew from $50 million a year to more tha
$1 billion today. Yet despite this infusion of time and money, studies still tend to focus on th
problems of older age. Even the recent and important book *Successful Aging*, by John Rowe a
Robert Kahn, presents the goal as minimizing decline rather than recognizing the huge potential f
positive growth in later life. Although Rowe and Kahn rightly emphasize the importance
maintaining health, mental functioning, and active engagement in life, they don't present th
possibilities for *improving* these areas with age.

The Mature Mind presents a new paradigm of aging, one that I hope will eventually displa
today's negative views and assumptions. It recognizes the potential beyond the problems associate
with aging. It reframes the aging process as a set of developmental phases that support real growth
opposed to the view of aging as an inevitable decline. This book shows how we can support a
cultivate our natural capacity for positive change. I sincerely hope it will help redirect public dialog
on this topic by delivering a promising message about the value and capacities of the maturing mind.

1

The Power of Older Minds

Your brain never stops developing and changing.
It's been doing it from the time you were an embryo,
and will keep on doing it all your life.
And this ability, perhaps, represents its greatest strength.
—James Trefil, physicist and author

MY IN-LAWS, HOWARD AND GISELE MILLER, both in their seventies, were stuck. They had just emerge from the Washington, D.C., subway system into a driving snowstorm. They were coming to our hous for dinner and needed to catch a cab because it was too far to walk—but it was rush hour, and no cal stopped. Howard tried calling us to get a lift, but my wife and I were both tied up in traffic ar weren't home yet.

As his fingers began to turn numb from the cold, Howard noticed the steamy windows of a pizz shop across the street. He and Gisele marched through the slush, entered the shop, stepped up to th counter, and ordered a large pizza for delivery. When the cashier asked where to deliver it, Howar gave him our address, and added, "Oh, there's one more thing."

"What's that?" the cashier asked.

"We want you to deliver us with it," Howard said.

And that's how they arrived—pizza in hand—for dinner that night.

This favorite family story perfectly illustrates the sort of agile creativity that the aging mind ca produce. Would a younger person have thought of this solution? Possibly. Creativity knows no ag limits. But in my experience, this kind of out-of-the-box thinking is a learned trait that improves wi age. Sherry Willis, of the Human Development and Family Studies program at Pennsylvania Sta University, calls it pragmatic creativity in everyday problem solving, a capacity that her research ha found to be very strong in later life. Age allows our brains to accumulate a repertoire of strategi developed from a lifetime of experience—part of what has been referred to by other researchers crystallized intelligence. Howard hadn't done the pizza parlor routine before, but the accumulate experience of other successful strategies helped stimulate the thinking that produced his creativ solution.

Howard's solution reflects not only the experience of years and a certain agility of thought b also a mature psychological development that is prevalent among people in their sixties and seventie With age can come a new feeling of inner freedom, self-confidence, and liberation from soci constraints that allows for novel or bold behavior. Howard wasn't afraid to make an unusual request perfect strangers, and that was a key part of his success that night.

In Howard's story we have a picture of a healthy aging mind at work: clear, creative, resourcefu

and powerful. But how does such a mind develop? On what does it depend for its existence? The sho answer is the brain.

It's been said that the mind is what the brain does. The mind is often described as "softwar running on the "hardware" of the brain. But this analogy is too simple. The brain is far more malleab and flexible than any computer chip. And the mind, although it seems almost ghostlike, ca powerfully influence the brain and, by extension, the body. Mind and brain are really two sides of single coin—mind/brain. This chapter explores the brain side of this equation and looks at rece discoveries in brain science that illuminate the positive potential of the aging mind.

You may have learned the following "facts" about the brain:

- The brain cannot grow new brain cells.
- Older adults can't learn as well as young people.
- Connections between neurons are relatively fixed throughout life.
- Intelligence is a matter of how many neurons you have and how fast those neurons work.

All these "facts" are wrong, as we will see. And that's good news for all of us. The brain is mo resilient, adaptable, and capable than we long thought. Research in the past two decades h established four key attributes of the brain that lay the foundation for an optimistic view of huma potential in the second half of life:

- The brain is continually resculpting itself in response to experience and learning.
- New brain cells *do* form throughout life.
- The brain's emotional circuitry matures and becomes more balanced with age.
- The brain's two hemispheres are more equally used by older adults.

Now, let's be clear. I am not suggesting that the brain is immune to age-related changes. The bra is made of cells, like every other part of the body, and cells can and do "wear out" with age. Certa aspects of brain function do decline with age, such as the raw speed with which complicated ma problems are solved, reaction times, and the efficiency of short-term memory storage. But the "negatives" are by no means the whole—or even the most important—story about the aging brai Unfortunately, because much brain research has focused on age-related *problems*, negative aspects aging have been emphasized and the positive implications of research have been overlooked. Indee one of the most important findings of all is still not widely known; namely, that much of the decline mental abilities formerly associated with aging is *not* caused by aging per se but by specific diseas such as "microstrokes," Alzheimer's disease, and mental illnesses such as depression. Healthy old brains are often as good as or better than younger brains in a wide variety of tasks.

Understanding more about how your brain works is important because understanding can sp motivation. If you learn how memory works and see the connections between the health of yo neurons and the choices you make in diet, exercise, sleep, social activity, and how you challenge yo mind, you'll be more likely to harness your brain's latent potential.

THE POTENTIAL OF OLDER BRAINS

The most important difference between older brains and younger brains is also the easiest to overloo

older brains have learned more than younger brains. Many aspects of life are simply too complicate and subtle to learn quickly, which is why experience counts in so many spheres of life. Huma relationships, for example, are notoriously complicated, and it can take decades to acquire the dee knowledge and understanding it takes to be a truly effective therapist, pastor, manager, or politicia There is simply no substitute for acquired learning in such fields as editing, law, medicine, coachin and many areas of science. In these and many others fields, age generally trumps youth. Of course, ag alone is no guarantee of excellence, but excellence in many fields can be achieved only after mar years of hard work and experience.

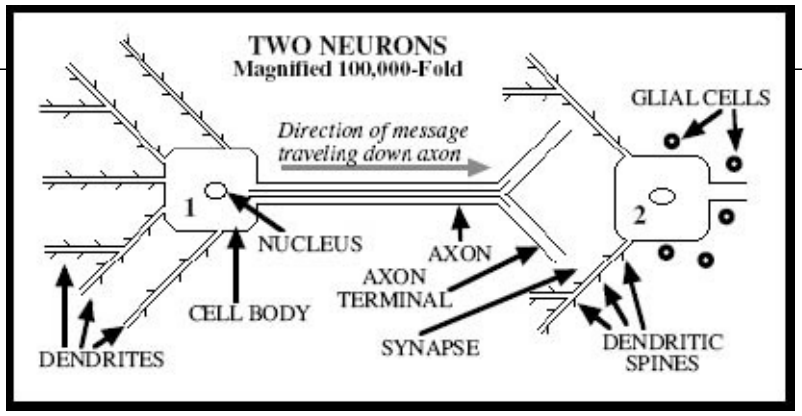
We now know that learning actually causes physical changes in the brain. An older adult's brai magnified tremendously, would look distinctly different from a young person's brain. The brain cel (called neurons) in the parts of the brain that an older person has used continuously would look like dense forest of thickly branched trees, compared with the thinner and less dense forest of a youn brain. This neural density is the physical basis for the skills of accomplished older adults.

Let's take a closer look at learning and how it sculpts the brain.

To learn, we must remember. Memories, in turn, are created when clusters of hundreds o thousands of neurons fire in a unique pattern. Whenever you perceive anything, whether it's a whiff o cinnamon, a catchy song, or a visual image, a flood of signals lights up particular constellations neurons in certain parts of your brain. If conditions are right (that is, if you are paying attention), th connections between these neurons are automatically strengthened. If this particular pattern neurons is stimulated later in exactly the same way—say, by another whiff of cinnamon—the netwo "lights up" more easily than it did previously and you "remember" the smell. The original sensation stored in these discrete patterns of primed connections. The more often a particular pattern stimulated, the more sensitive and permanent are the connections between the neurons in the patter This process of memory formation is summarized by the phrase "neurons that fire together, wi together."

Not only does learning link neurons in new patterns, it also stimulates neurons to grow *ne* connections (known as synapses) through tiny branchlike extensions called dendrites.

The idea that the brain physically changes as a result of learning—a phenomenon called plastici —emerged in the mid-1960s from animal studies conducted by Marion Diamond, a professor anatomy at the University of California, Berkeley. Diamond found that when rats were placed in more stimulating environment, their neurons sprouted new dendrites and produced higher levels of a important brain chemical called acetylcholine. The age of the rats made no difference. The brains older rats showed the same kind of robust response to a stimulating environment as the brains younger rats. A great deal of research conducted since those pioneering experiments has proven th the same phenomenon occurs in all animals, including human beings. In short, the brain active grows and rewires itself in response to stimulation and learning.



Two neurons magnified 100,000-fold showing dendrites, cell body, axon, and synapse(s) with postsynaptic neuron(s). Regardless age, a stimulating environment with challenging activities prompts an increased production of dendrites, dendritic spines, glial cel and synapses (contact points between different neurons), enhancing brain capacity and communication among neurons.

For example, brain imaging studies have found that London taxi drivers have an enlarged regio in the hippocampus—the part of the brain used for navigating in three-dimensional space. The driver experience of negotiating the complex London streets "exercised" that part of their brains, which gre as a result. (And the oldest drivers in the study showed no hippocampal decline compared with th younger drivers.) Similar findings were reported in a study of musicians, who were found to hav significantly increased functioning in the parts of the brain associated with hearing and th discrimination of tone and pitch.

I suspect that a brain scan of my neighbor, Lorraine Kennedy, would reveal similar kinds of robu growth in certain parts of her brain. Kennedy, who just turned ninety, is legendary for her knowledg of local history. She is an infallible resource on who lived where, and when, in the Victorian house lining our street. Whenever some clarification is needed about a historical fact, people turn to he and, without a computer, digital assistant, or notes, she retrieves the information from memory– sometimes along with plenty of additional detail. The part of her brain where all this knowledg resides would look far richer and more complicated than the corresponding part in the brain of young person.

The complex neural architecture of older brains, built over years of experience, practice, and dai living, is a fundamental strength of older adults. And the more complex the architecture, the more resists degradation by injury or disease.

Of course, the brain and its architecture are not static. Our brains are a bit like Monticello, th home that Thomas Jefferson built and then proceeded to modify during the many years he lived ther By continuing to learn and have new experiences, we can actively maintain, build, and remodel ou brains for more effective and creative tasks. Doing so involves avoiding certain things as well. Stres excessive alcohol and drug use, inactivity, smoking, obesity, malnourishment, and social isolation a weaken the brain's neural superstructure. In fact, these are some of the real culprits behind age-relate mental decline, not aging itself.

One aspect of brain development is frequently misunderstood, to the detriment of people's view about their own mental capacities. Some people have the false belief that mental ability is "all in th genes" and that anything that has a genetically determined component, such as eye color or the shap of one's nose, can't be changed. Genes, of course, are very powerful, and, broadly speaking, the gene we inherit do set some limits on what we can achieve mentally or physically. No matter how har some people train, they'll simply never be Olympic runners, for example. But genes are not al powerful—not by a long shot. Rather than constituting an immutable blueprint for our bodies an behavior, genes, it turns out, are highly sensitive to our environment, what we are exposed to, what w

perceive, the emotions we feel, the stress we are under, and a host of other factors in our lives. Mar genes include "switches" for their activity—they can be turned on or off, or their activity levels can b dialed up or down like a volume control.

Thousands of genes are involved in the growth and maintenance of the brain. In fact, the bra uses up a larger portion of the human genome than any other organ. Many of these genes respond the neural stimulation of learning. By challenging our brains, we not only actively shape existi neurons and stimulate their growth, we also switch on the key genes for making the cellular ra materials needed for mental development. The relationship between us and our genes is much mo like a dance than most people think, which is a hopeful situation indeed.

ESTELLE'S STORY

The potential of the healthy older brain is beautifully epitomized in Estelle Jansen, age seventy-one, participant in my study of retirement-age adults. Estelle lives independently in a retireme community, where she moved after her husband's death.

Estelle's life has been rich and full. Her husband, to whom she was married for forty-one year was a foreign service officer, and his career took them to many countries around the world. Estel loved the experience of living abroad and always tried to learn the local language wherever the landed.

After recovering from her husband's death, Estelle began again to feel the desire for fres challenging experiences. She decided to earn a master's degree in history, despite some reservatio about not having computer skills and fears about whether she could keep up with classmates in the twenties. But she dove into the challenge, starting off by taking a computer course for older adul who were new to the technology. She said it was "like learning a foreign language," and she quickl learned what she needed for her course work.

In her history courses, she found that her younger colleagues enjoyed her contributions to cla discussions. And because of her focus on the work—including her habit of spending more time o assignments by choice, rather than need—she was very successful in her classes. When I met her, sh had just completed her first semester and earned solid grades. "I kept up just fine after all, thank you she said.

You might think that Estelle's brain, so able and open to learning at seventy, is exceptional. But i fact all older adults, unless they are afflicted with injury or disease, have the same capacity to lear grow, and derive satisfaction and pleasure from new accomplishments. Indeed, the fastest-growin group of graduate students are those over age fifty, a trend that supports an optimistic view of th potential of the aging brain.

NEW BRAIN CELLS, NEW POTENTIAL

For decades, one of the most unshakable axioms of neuroscience was that nerve cells cannot regro and the brain does not create new neurons. Then, in the early 1960s, Joseph Altman, at th Massachusetts Institute of Technology, made the startling discovery that new neurons *can* form— least in rats. Specifically, he found new cells growing in the hippocampus of adult rats, a part of th brain that is critical for new memory formation. In 1998, scientists showed that the adult human bra produces new neurons as well, a process called neurogenesis. It turns out that many regions of th

brain have primitive cells that, under certain conditions, can mature into either fully functionin neurons or brain cells called glia, which provide mechanical and nutritional support for the neuron (It's probably not coincidental that, at autopsy, Einstein's brain was found to have significantly mor glial cells than average.)

These remarkable findings were rich with implications, not only for the treatment of brai decaying diseases such as Parkinson's disease and Alzheimer's disease, but for anyone interested i preserving or improving their mental capacity. The findings threw open the possibility that we ca actually build (or rebuild) our brains.

We now know that new brain cells can form in other important regions of the brain. In 1999, team of scientists at Princeton University led by psychologist Elizabeth Gould found that, in monkey new neurons can grow in several regions of the cerebral cortex, the region responsible in huma beings for many of our "higher" functions, such as reflection, planning, decision-making, an emotional control.

Researchers are beginning to home in on what triggers new neuronal growth, although much abo the process remains unknown. Challenging mental activity certainly stimulates neuronal growth, b so does another activity that few would have suspected: vigorous physical exercise. Exercise seems "juice" the brain by stimulating the production of chemicals called brain growth factors. The compounds, in turn, provoke the primitive brain cells to mature into neurons. Prolonged stress, on th other hand, seems to dramatically suppress new neuron production. Studies have shown that bo physical and psychological stress reduce the growth of new cells in the hippocampus. Patients wi depression or posttraumatic stress disorder also show reduced hippocampal volume, while treatme reverses this trend.

The discovery that new brain cell growth can occur in adulthood has transformed views of th aging brain and the potential for enhancing brain functioning in older adults. For example, Ge Kempermann, of the Department of Experimental Neurology at Humboldt University in Berlin, say that studies conducted in his department suggest that neurogenesis enables the aging brain " accommodate continued bouts of novelty." In other words, neurogenesis may have played a role in m father-in-law's pizza delivery inspiration and Estelle Jansen's success in a graduate program at ag seventy.

Fred Gage, at the Laboratory of Genetics at the Salk Institute, who is one of the co-discoverers neurogenesis in the mature brain, notes that "the stage has now been set for a new understanding of th adult brain" and emphasizes that even a damaged adult brain very likely retains some capacity to he and recover. Of course, since memories are stored in patterns of connection between existing neuron new neurons will not mean the recovery of memories lost to disease or injury. But the brain's abilit to grow new neurons is one of the most exciting discoveries in neuroscience and a dramatic reason f optimism about the brain's potential in the second half of life.

EMOTIONS IN BALANCE

George Barker was a smart, scrappy son of a housepainter. When World War II broke out, he enliste in the Air Force and became a bomber pilot. Like many veterans, the experience of war and the re possibility of being killed affected him deeply—although in the decades following his comb experience he rarely talked about it. He returned from the front, began a career in journalism, marrie and raised a family. Then, when he was in his sixties, he was diagnosed with leukemia, a cancer

white blood cells that weakens the immune system.

His doctors advised him to avoid travel and any interactions that would expose him to pathogen such as playing with his grandchildren. He rejected the advice.

"I went through a war being shot at every day," he says. "I'm not going to start living in fear no because I might catch a cold."

Taking some appropriate cautions, he continued to travel, see his family, and engage in a full ar loving life. A disease that might have caused a younger person to become depressed or withdrav became a challenge, but not an obstacle.

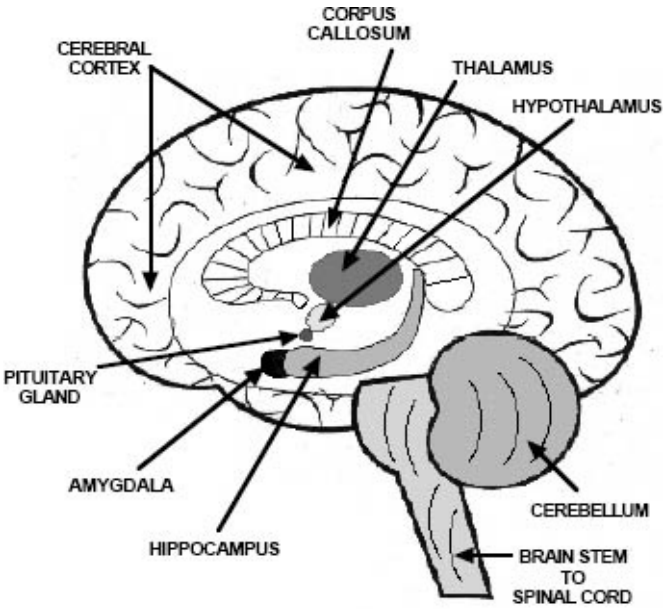
Among the myriad negative stereotypes and myths about aging is the view that many older peop are depressed by the physical ills that, admittedly, become more common with age. In fact, howeve research shows that the incidence of depression in later life is no higher than in early adulthood. Mar studies have reported high morale in older adults, even among those who are frail. The positiv outlook of people like Estelle Jansen and George Barker isn't the exception—it's the rule. I recall on day saying, "Have a lovely day!" to a seventy-four-year-old woman participating in one of my studie

"I'll *make* it a lovely day!" she shot back with a smile.

Many factors play into the high morale and positive outlook of so many older persons, includin such things as a greater acceptance of life's realities, a greater sense of self, and a long-ter perspective that makes it easier to accept the inevitable slings and arrows of daily life. In addition such psychological factors, however, new evidence shows that changes in the older brain itself play a important role in the emotional aplomb and equanimity of many older adults.

Human emotional responses are produced and regulated by a set of structures deep in the bra called the limbic system. These structures have been shaped by millions of years of natural selectio to provide both a carrot and a stick to guide behavior in ways that favor survival and reproductio Positive emotions such as feelings of affection, bonding, love, pleasure, and happiness arise fro electrical and chemical activity in the limbic system in response to external cues such as th proximity of potential mates; success in obtaining food, status, and security; and, in human beings, th satisfaction of higher drives such as curiosity and artistic or musical expression.

SIDE VIEW OF THE INNER BRAIN AND THE LIMBIC SYSTEM



Side view of the inner brain and the limbic system. The limbic system is a group of anatomical structures, including the hippocampu

amygdala, parts of the cortex, and parts of the hypothalamus, that functions as the motivation and emotional center of the brain.

Negative emotions such as fear, anger, envy, disgust, and depression arise in response to events o situations that threaten our survival, well-being, or sense of fair play. Some negative emotions a inborn. Anger, for example, is a nearly universal response to the perception of unfairness against u And some fears, such as fear of snakes, spiders, and heights, have a genetic component to them. B fear, anger, and other negative emotions can also be learned, such as when a hypochondriac moth engenders a constant fear of illness in her children, or when a chronically angry father unconscious transmits the message that anger is an expected or appropriate reaction to life's difficulties.

A particularly important aspect of the human emotional system is how these systems a connected to the neocortex, the thick layer of brain tissue overlaying the limbic system. The neocort performs many functions, among them giving us our sense of self-awareness as well as "highe attributes of consciousness such as morals, beliefs, intentions, goals, and aspirations.

Many more nerve fibers run from the limbic system up to the cortex than run from the cortex bac down to the limbic system. If neural activity were water, the limbic system would have a firehos connection to the cortex and a straw from the cortex. This fundamental imbalance in connectivi means that emotions can easily overwhelm and overrule the thinking, deliberating parts of our brain From an evolutionary standpoint, this makes perfect sense: animals that respond quickly an unthinkingly to perceived threats have a much better chance of survival than animals that ponder th situation before reacting.

For human beings, however, this basic brain imbalance between our reason and our emotion leads to all sorts of trouble. Indeed, our universal tendency to be pulled between what we know is rig and what we want to do is at the core of much great art and literature. Our frequent inability to contr our emotions and cravings is one of the defining features of our species. Our ability to control ou emotions and modulate our behavior appropriately, however, is a hallmark of maturity.

The capacity to ride out emotional storms more flexibly and resiliently is one of the great fruits aging. This is partly due to learning, experience, and practice, which stimulate the growth of ne dendrites and sometimes entirely new neurons. This may mean that we can actually begin to equali the out-of-balance connections between the limbic system and the cortex. In a real sense, we can bui more control wires connecting our "higher" selves to our emotional centers.

But that's not all. The limbic system itself appears to grow calmer with age. One focus of curre research is the amygdalae, two almond-shaped structures in the limbic system that generate some our most intense emotions. The amygdalae are positioned to intercept sensory information streamin in from our eyes, ears, and noses; if that information contains a potential threat, the amygdala immediately fire off volleys of impulses that can change our behavior even before the signals hav been fully processed and interpreted by our neocortex. That's why your heart starts pounding at th vague shape of two men approaching you on a dark sidewalk. The men may or may not be a threat, b your amygdalae don't care and are preparing you for the worst.

People vary widely in the vigor with which their amygdalae respond. Brains are as unique faces, and that goes for specific brain structures as well. Some people have very reactive, sensitiv amygdalae—they startle easily, are "hot tempered," or feel intense bodily reactions to frightenin situations. Others have relatively quiet amygdalae and are therefore more apt to be "cool," rationa unreactive, and unemotional. But for almost everyone, the amygdalae are notoriously difficult control—and the younger you are, the harder they are to rein in.

This is where some recent research on the aging brain comes into play. Studies using bra

imaging techniques such as positron-emission tomography (PET) scanning find that activity in th amygdalae decreases with age, specifically in response to negative emotions such as fear, anger, an hatred.

A study by Mather Canli and his colleagues in the psychology department at the University o California, Santa Cruz, found that as adults age, they:

- Experience less intense negative emotions
- Pay less attention to negative than to positive emotional stimuli
- Are less likely to remember negative than positive emotional materials

As the study's authors summed it up, "This profile of findings suggests that, with age, th amygdalae may show decreased reactivity to negative information while maintaining or increasin their reactivity to positive information."

In short, older people are usually calmer in the face of life's challenges. As one of the subjects i my retirement study put it, "I'm less up in arms about things and less of a perfectionist. Minor thing don't upset me, and I make better judgments about things." We now know that this positive aspect o aging is the result not just of experience and learning but also of fundamental changes in bra function.

EXTREME MAKEOVER OF THE AGING BRAIN

As human beings evolved and developed the capacity to devise new strategies for survival, such a tool use and language, the human brain increased in size. But Nature had a problem: the head couldn simply keep getting larger, because eventually it wouldn't fit through the birth canal. The fema pelvis could only enlarge so far without the entire body becoming unstable. What to do?

Conveniently, the brain, like some other organs such as eyes, ears, lungs, and kidneys, is a du structure. We actually have two brains, left and right, connected by a kind of broadband neural lin called the corpus callosum. Nature's solution to the problem of ever-increasing demands fo specialized brain processing areas was to use a division of labor: some capacities would be handle primarily by the left hemisphere, others by the right. Hence, in most people (there are som interesting exceptions) speech, language, and mathematical and logical reasoning are handled by th left hemisphere. The right hemisphere tends to specialize in such functions as face recognition, visua spatial comprehension, and intuitive/holistic operations, such as those underlying artistic creativity.

Much has been made of these differences in hemispheric function, not all of it well grounded i science. Some talk of "left-brained people" and "right-brained people" or of women being mo "right-brained" and men being more "left-brained." This is mostly metaphor, however. Healthy me and women need both sides of their brains and use both sides fluidly and continuously throughout lif Although people certainly vary in the relative strength of the activity of their hemispheres, to ascrib things like career choices to one side of the brain or the other is a misrepresentation of curre knowledge.

At the level of specific brain functions, however, we can correctly speak of right/left difference It turns out that throughout early life the brain typically uses predominantly only one side at a time f things like decoding written language, generating speech, or recognizing patterns. Use of one side the brain is referred to as unilateral hemisphere involvement; use of both sides is referred to

bilateral hemisphere involvement.

In the course of conducting studies with PET scans and magnetic resonance imaging, scientis noticed something unexpected going on in the brains of older adults. When, for example, young adul retrieve a specific word from memory, they usually use mostly the left side of their brain. Older adul doing the same task, however, often use both hemispheres. This phenomenon has been found wi other tasks too, such as face recognition, working memory, and certain types of perception. The part the brain examined in these studies is the prefrontal cortex in both hemispheres, a region that lies ju behind the forehead. Much of this work has been described by Roberto Cabeza, of the Center f Cognitive Neuroscience at Duke University. He calls the phenomenon "hemispheric asymmet reduction in older adults"—dubbed HAROLD for short.

These findings were puzzling. Did the bilateral hemisphere involvement in older people refle some kind of impairment? Was it a desperate attempt by an aging brain to draw on greater brai power to solve problems? Or was it something positive—perhaps a way for the brain to create mo "redundancy"—a backup system, so to speak?

To compare these two hypotheses, Cabeza measured brain activity during a set of memory tasl being performed by three groups: younger adults, low-performing older adults, and high-performi older adults. He found that the low-performing older adults used right prefrontal cortex regio similar to those used by the young adults, but the high-performing older adults used both hemisphere These findings suggest that although the low-performing older adults and the young adults recruit similar networks of brain cells, the older subjects used them inefficiently (hence their lo performance), whereas the high-performing older adults counteracted age-related neural decline b reorganizing their neural networks.

This is stunning news. Although we don't yet understand exactly how the brains of older adul remodel themselves in this more efficient and powerful way, they clearly do. This phenomenon ma be related to another one of older age: an interest in making sense of one's life by writing and talki about it.

CHARLES'S STORY

Charles Pugh, now ninety-two, was seventy-two when he retired from a long career as an IRS age He moved easily into a less pressured life that included a lot of the things he'd loved but never ha time for: fishing, reading, bowling with friends, and more relaxed time with his wife. One day in th kitchen, his wife remarked that she was frustrated because she had loaned a roaster oven to someo but couldn't remember to whom. Charles excused himself for a moment, disappeared into his stud and soon returned with the name of the friend who had borrowed the roaster—and the date.

Amazed, his wife asked how he could possibly know. Charles took her into his study and pointe to the bottom shelf of a bookcase that ran the length of the room. There, in a neat row of identic volumes, were Charles's accumulated diaries covering the years since his retirement. With th increased free time of retirement, Charles had decided to keep a diary. He began by noting details life as minute and mundane as the roaster's migration. But he eventually expanded his notes to inclu more thoughtful observations and reflections on life. What had begun as a simple accounting—whi for Charles was a familiar way to relate to the world—had evolved into a more textured account of h life, colorful, and with meticulous (and often helpful) detail.

Autobiographical writing and storytelling among older adults is common, and it stems from