1 STUDYING GROWTH AND CHANGE ACROSS THE LIFE SPAN

You know the stereotypes. Older women are judgmental and like to gossip. Old men are grumpy, like Carl Fredricksen in the movie *Up*. But how does an adult move from being an awesome person like *you* toward that caricature of aging? The short answer is: they don't! In this book, we take a life span approach to adult development and aging. That means that we will focus on the ways in which adults stay the same across adulthood, as well as the ways in which they change. We will also highlight many of the factors that influence such stability and change. Of course, we will apply these themes to many of the important areas of life, including biology and health, cognition, emotions, coping and resilience, social relationships, work, leisure and retirement, disabilities, and psychopathology. A unique feature of this textbook is that we also will carry some examples across the various chapters and return to the basic underlying principles of development as they apply to the specific content within each chapter. See Box 1.1 for an introduction to the idea that the opioid crises, including the fentanyl abuse, as a life span issue.

BOX 1.1: THE OPIOID CRISIS AS A LIFE SPAN ISSUE

Opioid dependence has grown to the level of a national crisis. The CDC estimates that between the year 2000 and 2015, ninety-one Americans died each day from opioid overdoses. Contrary to stereotypes about illegal drugs, the CDC states that the driving factor for the increase in mortality is prescription abuse and misuse. Despite widespread prevention and intervention programs, deaths from opioid overdose have increased in the past fifteen years. In fact, drug overdose deaths doubled among men in the United States from 2009 to 2019, from 14.8 deaths per 100,000 to 29.6 deaths per 100,000. For women, the pattern of drug overdose deaths was moderated by age, with increases in deaths per 100,000 for females ages fifteen through fifty-four years, stability for women ages fifty-five to seventy-five years, and decreases for women over the age of seventy-five years. However, across all ages younger than seventy-five years, drug overdose deaths have increased in the past fifteen years (CDC, 2024).

Opioid addiction poses other threats as well. Among infants whose mothers are opioid dependent, risks include preterm birth, Hepatitis C, and neonatal abstinence syndrome (NAS). NAS is a constellation of problems evident in neonates as a consequence of exposure to opioids during gestation. Nationwide, about 6 out of every 1,000 births involves NAS.

In general, babies born with NAS remain in the hospital for about two weeks longer than neonates without NAS, putting a strain on mothers, the family, and health care system. In addition to the vulnerable physical state at birth, infants born with NAS may experience persistent learning and developmental challenges throughout childhood.

The strains on American families as a result of opioid abuse are well known. Mothers with opioid dependence may be estranged from their families. Others may have rich and supportive ties. Understanding the ways that families support or increase the burdens of mothers is an important knowledge gap. Better understanding these processes can inform interventions and support services for women and families.

Of the 56 million American grandparents, 5.7 million live with their young grandchildren. In more than 40 percent of these coresident dyads, the grandparent has primary responsibility for the grandchild's basic needs (U.S. Bureau of the Census, 2005). Compared to noncustodial grandparents, those raising grandchildren report more chronic health problems and more psychological distress (Hayslip & Patrick, 2006; Patrick & Tomczewski, 2007). Despite data showing that custodial grandparents reside in a variety of urban, suburban, and rural locations, research has focused on large metropolitan areas (Kohn & Smith, 2006). Yet significant differences exist across geographies. Grandparents in rural areas may encounter a variety of unmet needs and geographic isolation (Cohen & Pyle, 2000). With their relation to pain, addiction, and comorbid health conditions, opioid-related deaths are largely responsible for the decrease in life expectancy in the United States (Bohnert & Ilgen, 2019).

PRINCIPLES OF LIFE SPAN DEVELOPMENT

When researchers and clinicians began studying adult development, they faced resistance from the scientific community. As you may have learned in previous classes, many early theories of human development took the view that very few interesting changes happened after puberty. Some even claimed that after one had reproduced, there was only decline. Physicians and other researchers held many stereotypes. Take a look at the questions in Box 1.2. These items were introduced by Erdman Palmore (1977) in what is commonly called the Facts on Aging Quiz. Many people, including families, health professionals, and older adults themselves, hold a variety of positive and negative aging-related stereotypes like these. These negative attitudes are harmful to older adults and hinder the study of adult development and aging.

Whereas the study of childhood as a unique and important period of development began in the mid-1700s, it can be argued that gerontology and the scientific study of adult development and aging did not begin until the 1940s, after the end of World War II. Although many scientists contributed to the growth of the new field of gerontology, Paul Baltes is recognized as a true pioneer in the field of aging. His work continues to shape the field of aging in many ways, but one of his most enduring contributions is summarized in the Principles of Life Span Development, listed below (Baltes et al., 1980).

Development is lifelong: That is, changes and adaptations occur throughout the life span, and there is no one "supreme" period in the life span. You have probably heard people say that the first three years of a child's life are the most important. You might have heard it said that if you do not learn a foreign language or how to play a musical instrument before age twelve years, it is much harder to do so later. It is true that events that occur early in the life span may have long-reaching effects. It is also true that our brains might be more or less able to learn new skills at different points in the life span. But development is possible throughout all the years of our lives.

BOX 1.2: AGE STEREOTYPES

Although there are several brief quizzes and checklists about age stereotypes, the most well-known is probably that by Erdman Palmore (1977). He advanced this area of inquiry by publishing a brief measure that was fact-based, the Facts on Aging Quiz. His results showed that most adults, including those with advanced training in the helping professions, hold both negative and positive stereotypes about older adults. Although originally offered in a True-False format, other researchers have adapted different response formats and updated items. Even with these changes, for more than forty years, its results have been replicated: We hold many age stereotypes. Below are just a few of the original items.

A. True or False: Most old people are senile/ have dementia.
B. True or False: Most old people are set in their ways and unable to change.
C. True or False: Most old people take longer to learn something new.
D. True or False: Most old people are pretty much alike.
E. True or False: Older workers have fewer job-related accidents than younger workers.

For a more recent version, scholars at the University of Missouri-Kansas City have updated the Facts on Aging Quiz and invite you to view it at: http://cas.umkc.edu/cas/AgingFactsQuiz.htm.

You might be surprised to learn that when Palmore published his quiz, his data showed that most people realized that dementia was not a usual part of the aging process. Thus, the answer to item A is false. As we will cover in subsequent chapters, dementia is a disease. Although prevalence does increase with advanced age, most older adults do not have dementia. As more adults live into late adulthood, and thus have increased risks for dementia, some researchers are calling for less stigmatizing language, including referring to those with dementia using person-first language (person with dementia, pwd) and suggest reframing discussions of dementia as a disability rather than a disease.

In his early results, Palmore reported that 47 percent of undergraduates and 9 percent of graduate students incorrectly thought that most older people are unable to change. In fact, although many attitudes held by older adults are stable, they do change and adapt. As you will learn later in this book, older adults also respond well to psychotherapy. Thus, the correct answer to item B is false.

Palmore (1977) reported that 47 percent of undergraduates and 30 percent of graduate students incorrectly responded to item C, stating that there were no age differences in how long it takes older and younger adults to learn new information. Thus, the correct answer to item C is true. As you will learn in Chapter 3, the answer to this question is complicated. Older adults do require more time to learn new information, but if given enough time to process the information, older adults often do learn (Hayslip & Chapman, 2007). Moreover, older adults may demonstrate larger vocabularies and richer knowledge bases than younger adults (NIA, 2022). You will learn much more about normal cognitive aging, super cognitive agers, and cognitive impairments in chapter 3.

Late life is marked by heterogeneity. That is, older adults are more different from each other than are people at earlier ages in the life span. Most newborns are pretty much alike, but most seventy-five-year-olds have been shaped and influenced by a range of different genetics, varying environmental conditions, including health behaviors, and some idiosyncratic life events. Thus, the correct response to item D is false. Most of Palmore's undergraduates (91 percent) and graduate students (98 percent) got that item correct.

Approximately two to three workers out of every one hundred experience an on-the-job injury. That equates to 2.6 million nonfatal injuries and millions of days off work or in job reassignment (OSHA, 2023). More injuries are sustained by younger workers. About 42 percent of Palmore's undergraduates and 18 percent of the graduate students answered this one incorrectly. Item E is true. There are many explanations for why older workers have fewer on-the-job accidents compared to younger workers. As we will discuss in later chapters, older workers' experience and use of safety procedures may help reduce their accidents and injury rates. However, it is also likely that younger workers may be asked to perform the more dangerous tasks. The Occupational Safety and Health Administration (OSHA) put new reporting guidelines in place for 2024, so we may see dramatic changes in these numbers as the data become more standardized across employers (OSHA, 2023).

How do our attitudes and stereotypes develop? Most research suggests that these are formed from a combination of personal experiences and inaccurate information. If you hold some incorrect views about older adults, this textbook and your course should help! There is good evidence that focused course work in aging can reduce knowledge deficits (e.g., Snyder, 2008). In chapters 2 and 7, we will discuss ways in which age-related stereotypes harm the health and well-being of older adults.

Development is multidimensional and multiply caused: From a developmental perspective, we are not a collection of different systems, such as bones and strength and vision. Each person is a single, integrated unit. Thus, each system of our being ages. But, as we will discuss, different factors may influence different systems of our body and person differently. For example, aging is associated with an increased risk for cognitive impairment. But we know that some nutritional deficits or sleep issues also influence memory problems. Thus, there are multiple causes for developmental changes, including biology, psychology, and lifestyle.

Development is multidirectional and involves both gains and losses: At all ages, our growth is multidirectional; different areas of development may show growth or decline across the life span. For example, although older adults may approach certain decision-making and problem-solving tasks differently than younger adults, older adults often use a more sophisticated or efficient approach. Thus, they may compensate for declines in one area by applying new approaches to a problem (Patrick et al., 2013; Salthouse, 1980).

The importance and frequency of biological and cultural factors shift over time: For example, infants and toddlers have many biological pushes, but the role of biology may be less important for a person in her 70s or 80s. The notion that different factors may exert stronger or weaker influences on development depending on when these factors occur is an exciting area of research. Early research in this area was conducted by Glen Elder (1979) and

Caspi and Elder (1986). Their collective work suggests that large-scale events, like the Great Depression, exerted different influences on a child's future, depending on the child's gender, the family economic situation, and other factors. Similarly, other social movements may have exerted fewer effects for older adults, as opposed to adolescents and emerging adults (Stewart & Healy, 1989).

Development involves a change in the allocation of biological resources: That is, early in life, much of our biological reserve is used for growth and repair. This is illustrated by the observation that young children recover quickly from the flu or a broken bone. As we reach midlife, our bodies begin to use more energy for maintenance. There may be even fewer available resources in late life. By the time we are old, most of our biological energy is used for maintenance, and relatively little is left for repair. That's why one in three older adults who experience a fall die within a year. They simply may not have the biological capacity to repair and recover.

Development is plastic: Specifically, throughout our lives, we are capable of growth and change. With enough training and practice, even an old dog can learn new tricks! This is a critical idea for those who work with older adults. For example, physical and occupational therapy can help older adults. Even adults with dementia can demonstrate growth and adaptation (Camp, 2010).

Development is influenced by historical period and culture: Although development is a universal process, there are significant interindividual and intraindividual differences. In fact, it has been said that older adults are more different from each other than is a group of infants or children. The older adults have had more opportunities to be changed by history and culture. Three specific types of factors that influence heterogeneity among older adults are non-normative events, history-normative events, and age-normative influences. Non-normative influences are those idiosyncratic events that occur for people, including such influences as an early illness, experiencing the death of a parent early in life, experiencing a religious conversion, or winning the lottery. These influences change the way a person approaches the rest of their life.

History-normative influences are those large, cultural events that may influence a group of people differently. For example, the Great Depression research by Elder (1979) and Caspi and Elder (1986) show good examples of the ways in which an historical event may influence a generation. In more recent history, the terrorist attacks in September 2001 continue to influence the development of Americans. Evidence suggests that younger adults in 2001 experienced stronger negative effects of those attacks on psychological well-being compared to older adults (Holman et al., 2016).

Finally, age-normative influences are those that are related to a person's chronological age. In the United States, the average age of a first-time grandmother is about forty-seven years. However, there are some grandmothers as young as twenty-seven years. It is considered atypical or age non-normative to be a grandparent so young, but if one has their first child as a young teenager and that child also has offspring at a young age, the generations are narrow. This idea of age-normative influences speaks to the importance of historical time and culture as determinants of what is considered to be on-time or off-time.

GENERATIONAL COHORTS

Age-normative influences often differ across generational cohorts and may interact with history-normative and non-normative influences. A **generational cohort** is a group of people who are born in the same historical period and who experience many of the same cultural and historical events in similar ways but often differently than those who are older or younger. You have probably heard a lot about the Baby Boom generation. Following the end of World War II, America and the world experienced a significant increase in the number of babies born. In the United States, this was accompanied by a rise in factory jobs and the middle class and increased access to education for many. As those born between 1946 and 1964 aged, more elementary schools were needed. As they became teenagers, their tastes pushed music, entertainment, fashion, and food choices in the nation. This Baby Boom generation has continued to push the politics and culture of the nation. Now that all of the Boomers are middle-aged and older adults, they continue to influence politics, health, and recreation services. See Table 1.1 for descriptions and comparisons across different cohorts.

TABLE 1.1 ■ Generational Cohorts

Name	Birth Years and Estimated Number of US Births	Special Concerns/ Description/ Effects
Gen Z	1996– ? 84.8 million	Immigration, Social Security; value flexibility in the workforce
Millennials	1981–1996 62 million	Immigration; worldwide media, varied definitions of "family," busy children with many structured activities; value work-life balance
Gen X	1965–1980 55 million	Value independence, having been among the first "boomerang" generation; deliberate with their purchases
Baby Boomers	1946–1964 76 million	The American Dream, ambitious, growth of the suburbs and a teen culture; Hippies, Woodstock, Vietnam War
The Silent Generation	1925/1928–1945 47 million	Children of the Great Depression, rise of factories and corporations
The Greatest Generation*	1910–1925/1928 47+ million	Tend to be frugal with their money, believed in merit and hard work as a means to success

If you were born between 1980 and 1996, you are counted among the Millennials. If you were born after 1997, you are likely part of the Gen Z cohort. Cohorts generally do not get their ending year or name until the members have reached working age. That is why there is no listed end date for Gen Z. Membership in a generational cohort has important implications for many areas of our lives (Fry, 2018).

Three big factors influence the numbers and proportions of older adults in a society: births, deaths, and immigration/emigration. If you examine Table 1.1, you will see that, like the Baby Boom generation, the Millennials and Gen Xers are also large cohorts in terms of the numbers of births. With increasing longevity, we will soon have a society with a large number of middle-aged Millennials and Gen Xers and a large number of late Baby Boomers still living. As these cohorts continue to age, their needs will begin to influence policy and services, too. But cohorts also grow as a function of immigration. Most immigrants to the United States are between the ages of twenty and fifty-four years; thus, they are part of the Gen X, Millennial, and Gen Z cohorts. When people migrate to the United States, often they are accompanied by parents or other members of older cohorts. Finally, many older immigrants die here, and others return to their native countries. Thus, migrants are contributing to a growth in non-Baby Boomer cohorts (Holzer, 2019).

Although we are still learning about the defining characteristics of Gen Z, the Pew Institute states that Gen Z is the most racially and ethnically diverse cohort in US history (Fry & Parker, 2018). In addition to racial and ethnic differences across cohorts, members of Gen Z are more likely than previous generations to be native-born Americans, but they are also more likely than Millennials to have at least one foreign-born parent. Gen Z members are more highly educated and come from more highly educated families, as well. These trends matter because they speak to the need for more inclusive services and policies for all adults, including older adults. When COVID-19 impacted the education and employment sectors in the USA, Gen Z may have been especially disadvantaged. These cohort differences in education and employment are likely to have downstream repercussions for programs like Social Security.

However, an interesting trend is happening within research on cohorts. After consulting with experts in adult development and acquiring more sophisticated statistical analysis tools, the Pew Research Center is moving away from reporting average differences across cohorts (Parker, 2023). Instead, Pew has committed to only reporting results from **cohort sequential designs**, provided that there is sufficient historical data to permit such examinations. When a true cohort analysis is not feasible, Pew will take a more balanced view of reporting age differences identified in cross-sectional studies. In addition, Pew will focus more on **period effects** in order to disentangle cultural effects that influence all members of a society. Finally, reflecting the limits of using only birth year as an index, Pew will explore additional indices of development besides chronological age (Parker, 2023).

THE MULTIDIMENSIONAL NATURE OF AGE

Just as development is multidimensional, age is multifaceted. Despite its nearly eighty-year history as a field, the term "gerontology" remains difficult to define (Achenbaum & Levin, 1989). We will loosely define **gerontology** as both the study of older people as a group and as the study of aging as a developmental process. When we examine older adults as a distinct group of people, issues related to attitudes and stereotypes, preferences, and group averages are important. When we focus on aging as a developmental process, we consider the kinds of factors that influence the different ways in which people age. Each approach has its own assumptions and research methods.

One reason that it is difficult to define gerontology is that we have different ways to define age. Most people first think of **chronological age** when thinking about aging. Chronological age is easy to define as the length of time one has been alive. Chronological age can be a useful index when we are making rough estimates or broad generalizations. For example, few Americans younger than age fifteen years are married, although most people over age thirty-five years have been married at least once (Census, 2019). Thus, we would be surprised to meet a twelve-year-old who is someone's spouse, and we are sometimes surprised to meet a fifty-year-old person who has never married. Chronological age thus guides our thinking about whether some event or behavior is typical.

We often use chronological age as an index to categorize adults at different points in the life span. It is important to note, however, that any such categorization is somewhat arbitrary and is likely to be revised as new information is provided by newer cohorts. Daniel Levinson (1978, 1986, 2011) proposed a detailed sequence of developmental periods. He broadly defined childhood as ages birth to twenty-two years, early adulthood from ages seventeen to forty-five years, middle adulthood from ages forty to sixty-five years, and late adulthood from ages sixty to eighty-five years. He argued that the different periods of adulthood were marked by structure-building experiences and structure-changing ones in which adults seek to form a coherent life structure. Each structure-building phase lasts about five to seven years, with transitional periods between phases of building new structures. Within each structure-building phase, we make specific choices based on our values and goals. As we reach stability, we may begin to question whether those goals are still valued for us. It is at that point that we may enter into a transition or structure-changing period. Levinson (1978) argues that these periods are closely age-graded, with adults entering into each phase at about the same age:

1. From ages seventeen to twenty-two years, we are engaged in the Early Adult transition, a bridge between pre-adulthood and early adulthood (Levinson, 1986). More recent conceptualizations refer to this period as emerging adulthood (Arnett, 2000).
2. From ages twenty-two to twenty-eight years, we begin to build and maintain our initial approach to adulthood in the Entry Life Structure for Early Adulthood period.
3. From ages twenty-eight to thirty-three years, we are engaged in the Age Thirty Transition, which provides an opportunity to reevaluate and modify goals to be pursued in the next stage.
4. From ages thirty-three to forty years, we use the Culminating Life Structure for Early Adulthood period to complete the goals of our youth. Newer conceptualizations of ages thirty to forty-five years, termed Established Adulthood, are redefining this period of the life span (Mehta & Arnett, 2023).
5. A brief Midlife Transition from ages forty to forty-five years allows us to finalize those early goals and pivot toward middle age (Levinson, 1986). As we will discuss in later chapters, much has been learned about this midlife transition through the work of the Midlife in the United States (MIDUS) research group (Brim, Ryff, & Kessler, 2004).

6. Ages forty-five to fifty years mark the Entry Life Structure for Middle Adulthood, during which one begins to identify new goals.
7. The Age Fifty Transition, at ages fifty to fifty-five years, allows an adult to continue to modify and refine this life structure.
8. From ages fifty-five to sixty years, one works within the Culminating Life Structure for Middle Adulthood. Here, we complete our midlife goals and turn our focus to the next period.
9. During ages sixty to sixty-five years, we bridge from midlife to late adulthood in the Late Adult Transition.

Although there are some limitations to Levinson's approach, as there are with any framework, Levinson's later work (2011) suggested that these structures were similar for men and women and across different economic groups. One notable limitation extends from his focus on employment goals and transitions. Although he did acknowledge late life, Levinson's purpose was not to fully understand post-retirement years.

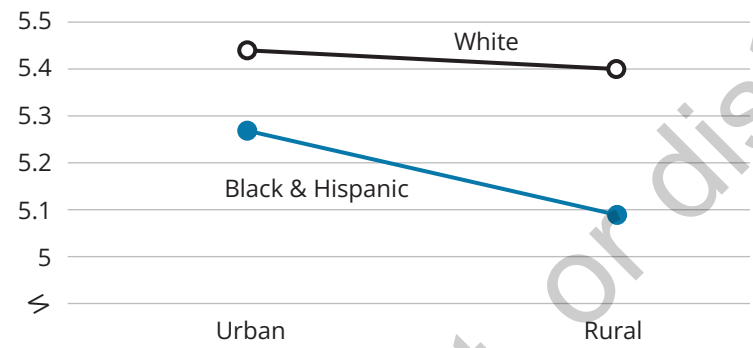
Noting that age sixty-five years is a marker of economic late life, Bernice Neugarten (1974) further divided late life into the period of young-old, from ages fifty-five to seventy-five years, and old-old, aged seventy-five and over. In more recent years, scholars also address the oldest-old, referring to those over age eighty-five years, noting similarities and differences across the more fine-grained age groups (Cohen-Mansfield et al., 2013).

Chronological age may not be a useful index for many areas, however. For example, knowing that someone is twenty-five years old may tell us little about their physical abilities, emotional health, or occupational status. So, too, there are many differences among older adults. Because of the limited utility of chronological age, we often make use of other indices. Thus, we sometimes rely on measures of biological age, functional age, social age, and psychological age. Although we only briefly define these concepts in this chapter, we will return to them in subsequent discussions throughout the book.

Biological age, also termed physiological age, relates to the multidimensional aspect of life span development. That is, different systems may age at different rates. Thus, we can use a variety of biomarkers to estimate how well an organism is adapting and functioning (Karasik et al., 2005). Biological age is affected by genetics, environment, and the interaction between the two (Holliday, 2006; Scheidt, 2015). **Functional age** refers to how well a person is able to live independently in the community based on whether they are able to complete basic activities of daily living (BADLs) and instrumental activities of daily living (IADLs). BADLs relate to hygiene and personal care, including bathing, dressing, grooming, and transferring. IADLs include higher order tasks that are needed to live independently in the community, such as managing medications, doing housework, and preparing meals. IADLs may rely on either physical health and strength (e.g., housework, shopping) or on complex cognitive skills (e.g., taking medication, managing finances; Patrick et al., 2004). As researchers begin to adopt a focus on intersectionality, a new area of research shows that functional ability may show dramatic differences for men versus women, urban versus rural, and white non-Hispanic adults versus others. For example,

one recent study showed that among women ages 80+ years, race and place interacted to influence functional ability (Patrick et al., 2024). As shown in Figure 1.1, Black and Hispanic women residing in rural areas reported especially low functional ability. As more research examines such intersectionality, we may need to develop a broader variety of services and programs to serve the increasingly heterogenous community of older adults.

FIGURE 1.1 ■ Functional Ability Differences Among Women Over Age Eighty Years by Race and Place



Patrick, J. H., Spencer, S. M., & Gouge, C. (2024). Race and Place: Influences on Functional Ability Among Women Ages 80+ Years. *Women & Therapy*, *47*(4), 428–438.

Social age acknowledges the cultural and age-normative expectations that one faces (Hayslip et al., 2011). Throughout our lives, we take on and relinquish roles. Some of these are considered to be on-time or age appropriate. Other behaviors are considered to be off-time or age inappropriate. Think back to some of the stereotypes that Palmore (1977) investigated in his Facts on Aging Quiz. Many dealt with social age stereotypes. There is strong evidence that being the recipient of others' negative stereotypes can have negative effects on a person's health and well-being (Ory et al., 2003). Work by Levy (1996) showed that others' negative stereotypes influenced an older person's actual memory performance and physiological functioning. Negative stereotypes resulted in poorer performance on memory tasks and higher cardiovascular reactivity.

More recent examinations of social age extend to a person's own assessment of their perceived age. This self-assessment of how old one feels based on their thoughts and behaviors is sometimes described as **psychological age**. Perceived age is a subjective estimate of how old one feels. It combines what one knows about their current health; social activities, within the context of their vitality; illness; and family predispositions (Patrick et al., 2018). For example, Shinan-Altman and Werner (2019) recently examined perceived age among both middle-aged and older adults. Across the age groups, people reported feeling younger than their chronological age, although middle-aged adults reported feeling closer to their desired age than did the older adults! Adults who felt closer to their desired age reported better emotional well-being.

DEVELOPMENTAL RESEARCH METHODS: DISENTANGLING CHRONOLOGICAL AGE, HISTORICAL PERIOD, AND GENERATIONAL COHORT

Gerontology is the study of older adults as a specific group, but it also encompasses aging as a process. Thus, depending on which definition one uses, the emphasis differs. To address these different questions, gerontologists use a variety of research techniques. In fact, the kinds of questions we ask directly influence the kinds of research methods we use, which in turn influence the conclusions we can draw.

We have already discussed chronological age and linked it to generational cohort. For example, the youngest Baby Boomers turned sixty in 2024. Their chronological age is naturally tied to their birth cohort but also to the historical time or period in which we examine them. Look at Table 1.2 to get a better idea of how age, cohort, and time of measurement are directly related to one another. Because age, cohort, and time of measurement are confounded, gerontologists rely on specific research designs to disentangle these effects from each other.

For scholars who are most interested in the ways that younger adults differ from middle-aged and older adults, the simplest research method to use is a **cross-sectional** method. A cross-sectional design compares groups of different ages at a single point in time. Cross-sectional studies are useful for when we want to gauge **average interindividual differences**. For example, a medical institution might want to better understand its clients' needs. The reproductive health services used by twenty-year-olds might be very different from those used by adults in their fifties or eighties. For example, men and women in their twenties might be particularly interested in contraception (e.g., birth control pills, implants), whereas men and women in their fiftiess might be less concerned with birth control but still interested in detecting sexually transmitted infections (STIs) and cancers of the reproductive system (Graf & Patrick, 2015). Thus, conducting a cross-sectional study would provide the medical center with useful information that it could use to target specific groups and frame public health messages.

The following table shows how age, cohort, and time of measurement are confounded or intertwined. The numbers within the table represent the age ranges for specific birth cohorts at each time of measurement.

TABLE 1.2 ■ Age, Cohort, and Time of Measurement

Cohort	Time of Measurement			
	2025	2015	2005	1995
Baby Boomers (1945–1964)	60–80	50–70	40–60	30–50
Gen X (1965–1980)	45–60	35–50	25–40	15–30
Millennials (1981–1996)	29–44	19–34	9–24	0 to 14
Gen Z (1996–?)	?–29	?–19	?–9	Not born

If a researcher wanted to compare different age groups at a single point in time, she would conduct a **cross-sectional study**. Thus, she could sample participants from within a single column to make those age group comparisons. However, when she compares age groups, the birth cohort also varies.

If she wanted to examine change over time, she would sample from within a single row, using a **longitudinal design**. Here, she could track the same people across many decades. However, when we study age changes, we are examining only a single cohort.

We could remedy the problem of studying only a single cohort by explicitly examining the changes associated with historical time by sampling from adults along the diagonal. Here, we could study thirty-year-olds in 1995, thirty-year-olds in 2005, and thirty-year-olds in 2015. Sometimes called a **time-lag design**, in this approach, time of measurement is confounded with birth cohort.

Cross-sectional studies have many benefits. They can be completed in a relatively short period of time. They can be useful for illuminating average age differences and similarities. Compared with other designs, cross-sectional studies may have lower costs in terms of study personnel. They are also highly flexible. Researchers can collect cross-sectional data via face-to-face or telephone interviews, web-based surveys, and lab-based quasi-experimental designs. However, cross-sectional designs have limitations. The chief limitation related to age is that cross-sectional studies can only address age differences. They are not able to detect reasons for age differences, and as noted, age is confounded with cohort and time of measurement. Cross-sectional studies may overestimate the magnitude of age differences. Moreover, if we conduct a cross-sectional test comparing twenty-year-olds with forty-year-olds today, it is likely that these age differences will not characterize differences between twenty-year-olds and forty-year-olds in the future. Moreover, we cannot even conclude that today's twenty-year-olds will respond like today's forty-year-olds in the future.

Many gerontologists are interested in examining change over time. To do so, they rely on a longitudinal design. Following the same group of people across a row in Table 1.2, one would be using a longitudinal design that could answer questions about age changes and stability. Thus, they examine **average intraindividual change**. Longitudinal designs are a powerful means of considering growth and change over time. However, they are expensive in terms of research effort and participant burden. Moreover, longitudinal designs are limited by their confounds with both age and historical time of measurement. Thus, they may underestimate the true effect of age change. Historical time can influence the results of longitudinal studies in several ways. For example, one of the largest studies of middle-aged adults, the Midlife in the United States (MIDUS), began in 1995/1996. The study is currently housed at the University of Wisconsin (http://midus.wisc.edu/). Life in the United States in the 1990s was very different than it is today. For example, in 1997, only 36.6 percent of Americans had a computer in the home. Now, more than 80 percent of us carry smart phones in our pockets! When the MIDUS study began, it included a few questions about technology use, including this one: "How often do you use a computer (such as to send e-mail or search the internet)?" Answers included Daily, Several times a day, Once a week, Several times a month, Once a month, and Never. Although that item might have been appropriate for a time when only about one-third of Americans had a computer in the home, the historical changes make that question less useful for understanding

how technology use by adults changed over the past twenty-five years. We will return to this issue of newer technologies and older adults in later chapters. For now, however, it is clear that one limitation to longitudinal studies is that the earlier measures may no longer be appropriate for subsequent waves of data collection.

We could remedy some of the limitations of a longitudinal study by explicitly examining the changes associated with historical time. Using Table 1.2, we could examine cohort differences by sampling adults along the diagonal, studying thirty-year- olds in 1995, in 2005, and in 2015. When a design holds age constant and samples across time of measurement and generational cohort, it is a time-lag design. Time-lag designs can add important insights to our understanding of historical changes in a society. For example, a recent study by Oosterhoff et al. (2019) used data from 110,000 adolescents over a forty-year period from 1976 to 2015. The research team examined selected social concerns, including crime, hunger and poverty, race relations, and others. Using sophisticated statistical procedures, they learned that the social concerns noted by adolescents followed historical trends related to specific sociopolitical occurrences. For example, adolescents' concerns about race relations were higher in the 1990s, a time when racial tensions and crime rates were particularly high. Similarly, adolescents' views on economic and employment outlooks mapped closely to the prevailing economic landscape in the country, with less optimistic outlooks during times of economic recession. Given that adolescence is an important time during which political and social consciousness are formed, these cohort-sensitive analyses may be informative for future policy debates when these adolescents are in the workforce. For another example of cohort changes, see Box 1.3 about changes in attitudes about legalizing marijuana. Although time-lag designs are useful for understanding changes in society over time, age and time of measurement are confounded.

Other designs have been proposed to separate these confounds (Schaie, 1965, 1970). Theses designs are extensions of cross-sectional, longitudinal, and time lag designs. Science, including the behavioral sciences like gerontology, progresses when researchers are able to ask and answer interesting questions. Changes in research methodology support the acquisition of scientific knowledge (Schaie, 1992). For example, Schaie (1992) advocated designing studies which would allow us to counter the inherent weaknesses of the three more traditional research designs. In fact, his most efficient design would include a series of longitudinal and cross-sectional designs. Returning to Table 1.2, imagine conducting a longitudinal study for each row. By default, we would also have cross-sectional studies for each column. Of course, over time, we would have sufficient data to examine differences and similarities along the diagonals.

BOX 1.3: COHORT CHANGES IN ATTITUDES ABOUT LEGALIZING MARIJUANA USE

Students sometimes find the ideas underlying age differences, history-graded effects, and cohort changes difficult to grasp. Campbell et al. (2017) provide a good example of these concepts. Using data from more than nine million high school seniors from 1968 to 2015, they examined cohort differences in attitudes toward legalizing marijuana.

An age effect would be seen in a longitudinal change in attitudes from adolescence through emerging adulthood through mid and late life. If we consistently saw that youth favor legalizing marijuana but become less positive across adulthood, this would be evidence for an age effect. In contrast, history or period effects reflect systemic changes in attitudes, in which after some specific point in history, an entire culture becomes more or less positive toward legalization, regardless of age group. Finally, generational differences or cohort effects would be observed if current twenty-year-olds are more positive than prior groups of twenty-year-olds.

Using this large data set, Campbell et al. (2017) found evidence for a general increase in support for legalizing marijuana from 1972 to 2014, controlling for age and birth cohort. They noted a trend toward more positive attitudes beginning in the early 1990s with a large increase around 2006.

In terms of age effects, there was evidence of age differences. When asking whether they would favor legalization of marijuana use, about 37 percent of twenty-year-olds, 25 percent of mid-forty-year-olds, and about 13 percent of eighty-year-olds favored legalization.

But the most important finding was that despite some age differences and some cohort effects, the general public seems to have become more favorable toward marijuana legalization. When an entire society or culture changes in the same way, we have evidence for period effects. Campbell and colleagues report an increase overall in the early 1970s, a dip in favorable attitudes in the 1980s, with a renewed positive view emerging after the year 2000.

A **time-sequential design** is similar to conducting multiple cross-sectional studies at different points in time. Thus, using Table 1.2, a researcher could compare different age groups within the 1995 column and then replicate that study in 2015, with a new sample. Doing so would allow the researcher to examine age and time of measurement across different cohorts. Similarly, if the researcher wanted to examine both age and cohort effects, she could use a **cohort sequential design** to sample from two or more different birth cohort rows over time. Finally, a researcher who was interested in examining cohort and time of measurement effects could sample from multiple diagonals, thereby conducting a **cross-sequential study**.

THEORETICAL FRAMEWORKS

Research designs are important tools for asking and answering questions about adult development and aging. So, too, are the theoretical frameworks that can guide our questions and help us to interpret the findings of our studies. Although several theories try to help us to understand adult development, we will discuss only two well-supported theories in this chapter.

Socioemotional Selectivity Theory (SST), formulated and investigated by Laura Carstensen and her colleagues (Carstensen et al., 1999), is among the leading theories in the study of adult development and aging. We will continue to discuss SST throughout this textbook because it has a broad range of applications. In its most simple version, SST proposes that humans are unique in our ability to ponder time and our own limited life span

(Carstensen, 1993). Knowing that our time is limited, we prioritize different goals at different points in our lives. For example, younger adults value knowledge and seek out social partners from whom they can learn about themselves and the world. In contrast, middle-aged adults already have a solid sense of who they are and the world; they want social partners who maximize their emotional well-being (Carstensen, 1993). According to SST, our time horizon—whether we view our time left as expansive or very constricted—influences with whom we spend our time, whether we pursue health-promotion behaviors, how we spend and invest our money, to which information we attend and remember, and what kinds of marketing ads appeal to us. Note that although time horizon is correlated with chronological age, it is not identical. In fact, early studies demonstrated that young men with AIDS, whose life expectancies were shortened by disease, often preferred social partners with whom they could enjoy maximal emotional connection, similar to the choices of much older adults (Carstensen & Fredrickson, 1998).

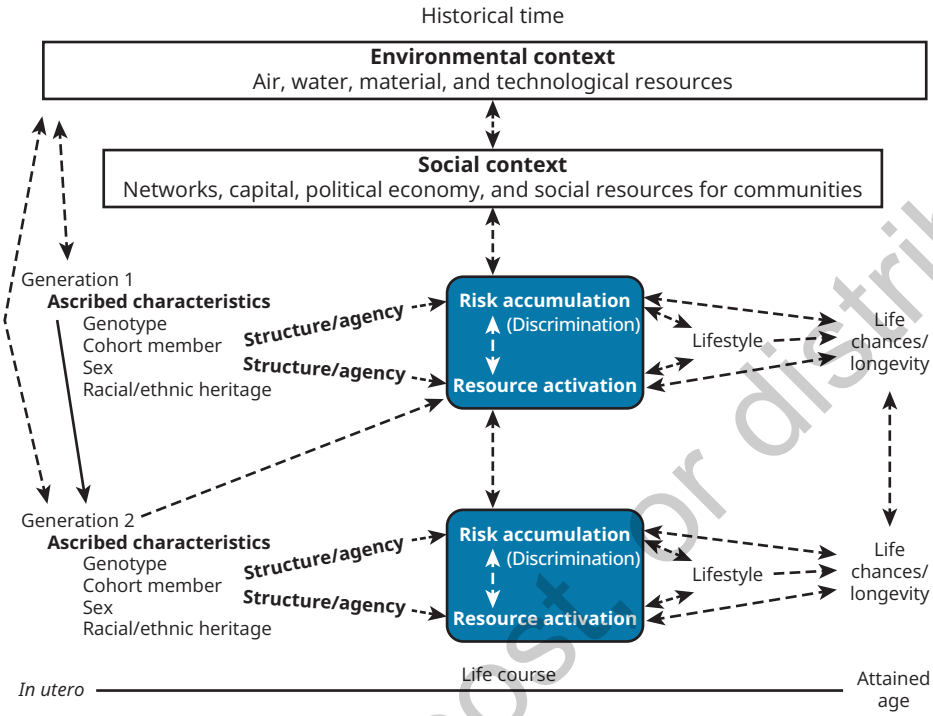
CUMULATIVE DIS/ADVANTAGE

This approach is rooted in a much earlier sociological framework known as Double Jeopardy, the idea that some social structures disadvantage certain groups of people and make adaptation to aging especially challenging. When researchers began to examine this idea, they focused initially on African American and white adults. In terms of age differences, both African American and white older adults reported more chronic health conditions than younger peers. However, researchers also noted that at the same chronological age, many African Americans had more chronic health problems and fewer supportive resources than their white age peers. As research expanded to examine a variety of disadvantaging factors, multiple frameworks emerged. We will discuss these group differences in more detail in chapter 2.

The tenets of **Cumulative Dis/Advantage Theory** state that **health disparities** observed between older racial, ethnic, and other members of underrepresented groups are the result of the accumulation of risks and exposures across the life span (Ferraro, et al. 2017). Moreover, the majority of the factors that influence these disparities and those that contribute the most to these group differences are preventable. Among the factors disproportionately associated with racial and ethnic minority status and that lead to more chronic health conditions and more severe symptoms are exposure to environmental hazards, poverty, unhealthy or high-risk health behaviors, and limited access to affordable and high-quality health care (Ferraro et al., 2017). We are now learning that the stresses and accumulated disadvantages experienced by an individual may continue to be observed in their offspring.

As shown in Figure 1.2, Ferraro and his colleagues propose an interactive and cumulative effect of various environmental, social, and health effects that act upon an individual across time. Based on this model and the implications, they argue for increased attention to models that focus on the life span, an increased attention to individual differences within groups, and a sharper focus on the environmental context in which aging occurs. These are themes to which we will return frequently in subsequent chapters.

FIGURE 1.2 ■ Possible Pathways of Transgenerational Health Disparities



Ferraro, K. F., Kemp, B. R., & Williams, M. M. (2017). Diverse aging and health inequality by race and ethnicity. *Innovation in Aging, 1*(1).

SUMMARY AND CONCLUSIONS

Aging is a life span phenomenon that includes biological, psychological, and sociohistorical influences. As you engage in the research presented in this textbook, keep an open mind, be attentive to ways in which you can improve your own health and aging, and be ready to identify ways in which you can contribute to applying your own expertise to the problems of aging.

KEY TERMS

Average interindividual difference
Average intraindividual change
Biological age
Chronological age
Cohort sequential design
Cross-sectional study
Cross-sequential study
Cumulative Dis/Advantage Theory
Functional age
Generational cohort

Gerontology
Health disparities
Longitudinal design
Psychological age
Social age
Socioemotional Selectivity Theory (SST)
Time sequential design
Time-lag design

EVALUATE YOUR UNDERSTANDING

1. What are the Principles of Life Span Development?
2. Why is chronological age insufficient for explaining adult behavior?
3. What are some of the major research designs used in the study of adult development?
4. What are some of the contributors to heterogeneity among older adults?
5. What does the framework of Cumulative Dis/Advantage contribute to the field of adult development and aging?
6. In what ways is the construct of "cohort" useful? In what ways is it no longer applicable?

2 BIOLOGICAL AGING, HEALTH, AND LONGEVITY

Why do we age, and what can we do to ensure a longer, healthier life? Most Americans over age sixty-five years would be pleased to live to be one hundred years old, if they could be assured that they had good health and sufficient financial resources (Kiger, 2018). In this chapter, we will discuss theories regarding biological aging and factors that influence the quantity and quality of our later years.

As mentioned in chapter 1, there are many different kinds of aging. In this chapter, we will focus on **biological aging**, the changes in the body's structure and function over time. Although these changes may include growth or decline, when we speak of biological aging in mid to late adulthood, most of those changes are declines. However, the location, rate, and timing of those declines are often the result of nature, nurture, and their interaction. Thinking back to Baltes's (1987) principles of life span development, you may recall that as we age, biology becomes *less* important in our development, whereas culture or nurture becomes more salient. This is true, in part, because biological forces and sociocultural influences have been acting on an aging individual since before birth. Remember, however, that Baltes was primarily addressing functional and psychological aging. In this chapter, we will highlight some of the mechanisms of biological aging, their relation to health and longevity, and some newer research that suggests that we might be able to alter the course of aging and health for many people.

WHY DO WE AGE? THEORIES OF BIOLOGICAL AGING

Early research with cardiac cells from chickens led Leonard Hayflick to state that cells are not immortal but have a limited number of replications. For humans, Hayflick (1965) demonstrated that normal human cells divide and replicate forty to sixty times, then begin the process of dying. These fifty or so replications are known as the **Hayflick Limit**. But why do our cells stop dividing and replicating after about fifty such divisions? As a science, we do not have a single, definitive answer to that question. We do, however, have useful theories to help us understand the phenomenon of biological aging.

People often misuse the term "theory" in everyday language, suggesting that a guess or suspicion is the same as a theory. For example, imagine that you are making plans to go see a movie with a group of your friends. One of these friends is disorganized and rarely makes notes in their calendar. When the day of your movie arrives, your disorganized friend is late. When you are asked why the friend is late, you might be tempted to say, "Well, I have a theory about that."

In science, however, theories are more than mere hunches or educated guesses. They are useful tools that enable us to make sense of a large body of information and that guide future scientific explorations. To be properly termed a theory, the idea must meet specific criteria. To be viewed as a theory, the topic being studied must entail specific definitions. There must be an awareness of the limitations of the theory and the domains to which it can be applied. It should help us to see additional relationships among domains. Theories also lead to testable predictions. Additional characteristics help determine whether a theory is good. Among those qualities of a good theory is **parsimony**, the preference for simple explanations rather than overly complicated or convoluted ones. A good theory offers **heuristic value** or fecundity. Heuristic value is defined as usefulness for inspiring or producing additional insights. A good theory is also **generalizable**, in that it can be used to explain a wide range of findings (Wacker, 1998).

Over the past centuries, many theories have been proposed to explain why we age. As shown in Table 2.1, although some scholars prefer to group theories by whether the theory focuses on a specific organ system or at the cellular level, non-biologists generally divide theories of biological aging into two main groups: **genetic-programming theories** and **variable-rate** or **error** theories of aging (Hayflick, 1985; Jin, 2010). There are several programmed theories of aging, and each has some strong support. It is likely that as we continue to learn more about aging, some of these theories will be combined. Others may be discarded in favor of better or more parsimonious theories. For the purposes of this chapter, however, we will present each as a unique theory.

TABLE 2.1 ■ Theories of Biological Aging

	Description/Hallmark
Genetic-Programming Theories	
Immunological	The MHC is the site of biological aging
Neuroendocrine Theory	Hormones are the "master clock"
Programmed senescence	Telomeres are the "master clock"
Error/Variable Rate Theories	
Wear-and-tear	Biological resources cannot repair sustained damage
Oxygen-free radicals	Free radicals cause damage within the body, which builds up over time
Autoimmune failures	Immune system falsely recognizes healthy tissue as pathogenic

Adapted from Hayflick, 1985; Jin, 2010; Weinert & Timiras, 2003.

Genetic programming theories rest on the idea that there is a biological limit to the integrity of our bodies—it is built into our genetics. Different theories, listed in Table 2.1, propose different sites or mechanisms for the onset of aging. The **immunological theory** attributes biological aging to decreases in the efficiency of our immune system and its production of antibodies. The

master genetic control for the immune system is known as the Main Histocompatibility Complex (MHC), and systems associated with it and the thalamus are the sites of decline (Hayflick, 1985). Critics of this approach note that declines in immune system functioning are not universal, but all humans do age. Critics of the immunological approach point out that the immune system comprises cells, and these cells are aging. Thus, the mechanism of age-related decline may be more general, at the cellular level, rather than at the level of the immunological system. Finally, critics note that much of the immune system is regulated by hormones, and aging may relate to declines in hormones, rather than the immune system, per se (Hayflick, 1985).

The **neuroendocrine theory** focuses on the roles of hormones in the aging process and recognizes the importance of the **hypothalamic-pituitary-adrenal (HPA) axis** as a "master clock." The HPA is involved with coordinating communication within and across body systems, coordinating physiological responses to external stimuli, and maintaining a homeostatic balance of resources across reproductive and repair functions in the body. Thus, changes in the HPA axis have profound effects on the entire body in terms of homeostasis and resilience (Weinert & Timiras, 2003). Human menopause, the cessation of menstruation and ovulation in adult females, is often cited as evidence for the neuroendocrine theory of aging. As a consequence of menopause, women experience a reduction in both estrogen and progesterone, which are associated with decreases in immune function (Ghosh et al., 2014).

A third preprogrammed theory links the rate and timing of aging to **programmed senescence**, which is under the control of telomeres (Anderson et al., 2018). **Telomeres** are the protective ends on chromosomes that prevent loss of genetic information during cell division and replication. As the cell divides and replicates, a small piece of the telomere is cut or lost. In addition to age, other factors can shorten the length of a telomere, including poor nutrition, high levels of stress, obesity, cigarette smoking, and physical inactivity (Shammas, 2011). The length of telomeres and the rate at which they shorten are important **biomarkers** of aging. Shorter telomeres are associated with increased risks of cancers in the lung, bladder, renal cells, digestive system, and head (Shammas, 2011).

In addition to these preprogrammed theories, there are several variable rate or error theories of aging. Variable-rate or error theories share the common assumption that aging occurs because of damage to the organism over time. Among the earliest error theory was that of **Wear-and-Tear** (Jin, 2010). The wear-and-tear approach states that our bodies age as a function of use and lack of proper repair or maintenance. This approach further suggests that if we had unlimited biological resources, we could continually renew and repair our bodies. But, as Baltes's Principles of Life Span Development state, we experience a decrease in biological resources, and more resources are needed for maintenance in late life, leaving fewer resources available for repair. The classic example of wear-and-tear concerns an automobile. With unlimited effort and resources, a person could maintain their favorite vehicle indefinitely. But, as a car ages, its systems require more frequent and often more expensive attention. At some point, the owner may decide that the costs of repairing the vehicle exceed the wisdom of doing so.

Perhaps the most popular error theory today is the **free radical theory** of aging. During normal metabolic processes, an unpaired oxygen molecule is released in the body. This free radical sets off a chain reaction of damage throughout the body, as it searches for an available electron

with which to pair. The free radical can cause damage to collagen and DNA, and it can cause a buildup of waste materials that weaken the cell walls (Hayflick, 1985). We have long known that antioxidants, like those found in certain foods, can help limit the free radical damage. Newer research is demonstrating that an increase in dietary antioxidants results in increased life expectancy among mice, rats, and fruit flies (Kennedy et al., 2014). Hekimi et al. (2011) argue that although free radicals are strongly linked to the rate of aging, their role in aging may be broader than solely a cause of oxidative damage. They suggest that free radicals may also play a role in mediating the body's response to stress and age-dependent damage. Thus, there is much still to be learned about the role of free radicals and aging.

A third error theory is the **autoimmune** approach. As the immune system declines, the body fails to appropriately recognize pathogens, and it falsely identifies healthy tissue as infectious. Thus, due to these errors, certain chronic health conditions occur, such as rheumatoid arthritis and diabetes (Hayflick, 1985). We will discuss these health conditions in more depth in the next sections.

Sensory Aging

Recall that a good theory must account for a broad range of findings in different domains. Thus, it is necessary to understand how aging looks in different systems of the body. Now that you have some understanding of the different kinds of theories related to biological aging, we turn our attention to the broad domain of **sensory aging**. Sensory aging refers to age-associated changes in the structure and functioning of our sense organs, especially in terms of our ability to see (**vision**), hear (**audition**), smell, (**olfaction**) taste (**gustation**), and feel (**somesthesis**). The effects of biological aging can be seen in every system of the body, including sensory systems. The rate, location, severity, and timing of these changes depend on both genetics and environment, and their interaction (National Institute on Aging [NIA], 2016). It is important to note that there are robust gender and race differences in the ways in which sensory aging affects Americans.

Moreover, these sensory changes do not occur in isolation; rather, adults often experience multiple sensory declines across mid and late adulthood. Research from the National Social Life, Health, and Aging Project (NSHAP) shows that 94 percent of older Americans experience at least one sensory deficit, 38 percent experience two sensory deficits, 28 percent report having three or more sensory deficits. Not surprisingly, having multiple sensory deficits is more common with advanced age, especially in vision and hearing. Men report better corrected vision than do women, but men experience more frequent and more severe losses in hearing, smell, and taste. Older Hispanic adults report better gustatory senses but perform more poorly on tests of vision, touch, and olfaction. Finally, older African American adults score lower on all senses except audition (Pinto et al., 2014).

AGE-RELATED CHANGES IN VISON

Peak visual functioning occurs during late adolescence or emerging adulthood and remains stable through midlife. However, a number of age-related changes occur in the visual system that can contribute to impaired vision (Besdine, 2016). By 2050, it is anticipated that

approximately two million people will be classified as legally blind, nearly seven million will have a visual impairment (VI) equal to seeing at twenty feet what most people can see at two hundred feet, and more than sixteen million will have a VI due to uncorrected refractive errors associated with myopia, hypermetropia, astigmatism, and presbyopia (Varma et al., 2016). Many of these vision impairments are associated with age-normative changes, including (1) a thickening, yellowing, and increased opacity of the lens, resulting in less light being projected onto the retina; (2) a weakening of the ciliary muscles which alters the ability of the lens to focus; (3) a thickening of the aqueous humor, which limits metabolic support for the lens and cornea and possibly increases intraocular pressure associated with **glaucoma**; and (4) a decrease in the pupil's resting diameter, known as senile miosis, which results from weakening muscles and contributes to less light on the retina. These structural changes result in decreased visual abilities or functions, which have consequences for the person's behavior and functioning (Kline & Scialfa, 1997; Schieber, 2006). For instance, problems with eyesight represent the leading reason given by both older men and women to limit or avoid driving (Ragland et al., 2005).

In addition to these structural changes, the visual system experiences functional changes, too. As we age, we require more light to perform daily activities like reading or using our cell phones. This increase in **absolute threshold**, the minimum level of stimulus energy or intensity required to see an object, increases with age (Kline & Scialfa, 1997). If you are concerned about the safety of an adult with possible VI, you can make safety-related changes to the environment, as described in Table 2.2.

Accommodation is the process whereby the eye adjusts its focus both near and far in order to gain clarity. With aging, there is a decrease in the ability of the eye to focus and/or refocus on objects at varying distances (Panek, 1997). Age-associated problems with visual accommodation is known as **presbyopia**, which is a decline in the eye's ability to focus on near objects and is due to a loss of elasticity of the lens. This is why many individuals in middle age need glasses for reading or for working with objects that are close to them.

Visual acuity is the ability to resolve detail. It is equated with the accuracy of distance vision compared with that of a hypothetical normal person, which is measured by means of a Snellen chart, consisting of a standardized series of letters, numbers, or symbols that must be read from a distance of twenty feet. The ability to read this chart is termed **static visual acuity**. If an individual with normal vision can read a designated letter on the Snellen chart at a distance of twenty feet, this is called 20/20 vision. A person who can distinguish at only twenty feet a letter that a person of normal vision can distinguish at one hundred feet is said to have a visual acuity of 20/100.

Visual acuity tends to be relatively poor in young children, but improves in young adulthood, and shows a slight decline from the mid-twenties to the fifties. Beyond this point, the rate of decline is accelerated. The average static visual acuity for adults aged sixty-five years and older is 20/70. Decreased visual acuity creates difficulties in reading, watching television, and reading labels on medicine bottles. Providing more ambient light or making objects larger and more distinct (termed contrast sensitivity) are relatively easy environmental supports for persons with static visual acuity problems (Long & Crambert, 1990; Schieber, 2006).

TABLE 2.2 ■ Environmental Interventions to Support Sensory Declines

Specific Sensory Issues	Behavioral Challenge	Environmental Solution
Visual System		
Senile miosis Higher absolute threshold	Less light is available to the retina, so an increase in light is needed.	Replace light bulbs early and use higher intensity bulbs.
Decreased adaptation	Eye responds more slowly to changes in lighting	Place lighting at the top and bottom of staircases to ensure a steady level of illumination.
Glare from headlights of oncoming traffic	To minimize effects of glare, look to the right side of the road, not directly at the light; slow your own driving to match that of the distance that your headlights illuminate.	New technologies enable more light for drivers without adding to the glare for oncoming vehicles/
Auditory System		
Higher volume threshold	Difficulty hearing speech, especially in noisy areas	Speaker should face the person with hearing loss, speaker should speak slightly louder but without exaggeration
Hair cells break	High frequencies are lost (difficulty hearing women or children)	Speaker should enunciate clearly, speaker should use a slightly lower register
Gustation		
Fewer and smaller taste buds	Lower sensitivity to taste; food may not be appealing	Avoid using excess salt, but experiment with other spices
Less saliva is produced	Dry mouth	Sips of water may help
Olfaction		
The number of neurons in the olfactory bulb are stable, but there may be fewer synapses	Decreased sensitivity	Use safety devices, like smoke detectors; maintain good nutrition (link between gustation and olfaction)
Touch		
Less blood and fewer strong signals from spinal cord	Difficulty feeling temperature change and regulating own temperature	Rely on thermometers to help decide how to dress; decrease temperature on water heater; be vigilant about scratches/ injuries

Adapted from Barry, 2019; Lutz et al., 2018; MedLine Plus, 2019.

There are also age decrements in **dynamic visual acuity** (Long & Crambert, 1990), which is the ability to accurately identify a moving target, such as a television message, a weather warning, or a street sign seen from a moving car. The more quickly the target is moving, the more older people are disadvantaged. The decrement with age in dynamic visual acuity appears to be related to changes in the thickness of the lens and the size of the pupil. Dynamic visual acuity is especially critical when driving. When searching for a specific street, many older drivers must be much closer to the street sign in order to read it relative to an emerging adult. By the time the older can read the sign, they may not have sufficient time to brake and signal before turning.

Regarding **color vision**, with increased age there is increased difficulty in discriminating among the blues, blue-greens, and violets—the low to middle range of the visible light spectrum—and much better successes in discriminating among the reds, oranges, and yellows, the upper middle to high range of the visible light spectrum (Kausler, 1991). Color vision deficits are more apparent when levels of illumination are low and when fine discriminations in shades of a particular color are being made (Fozard, 1990). The consequences of distortions in color vision can range from minor, such as choosing two different colored socks, to severe, such as an inability to differentiate medication tablets by color.

Adaptation refers to the sensitivity of the eye to adjust to changes in levels of illumination. **Dark adaptation** is increased sensitivity to light in a dark environment. For example, when you enter a dark movie theater, your pupils will expand to increase the amount of light entering your eyes (dark adaptation). This process takes about thirty seconds for adults, but older eyes may require more time to adjust. The reverse happens when you leave the theater, that is, your pupils will automatically contract to cut down the amount of light entering your eyes (light adaptation). This process requires a shorter time than does dark adaptation (Hayslip et al., 2011). Think for a moment about the eye's adaptation to changes in illumination. If you exit a dark theater and move into bright sunshine, you may feel blinded. If you continue to move in that space, it is possible that you will not be able to see changes in elevations, like from a sidewalk to a parking lot.

These issues with adaptation also play a role when dealing with **glare**. Glare is the relatively bright light that results in unpleasantness or discomfort and/or interferes with optimum vision. We experience glare when light rays are diffused via a change in the composition of the vitreous humor. An example of this process occurs during night driving when you view the headlights of oncoming autos. The negative effects of glare on performance increases with age from age forty on. For middle-aged and older drivers, this temporary blindness resulting from glare can easily cause an accident. In a recent study with older drivers, Kimlin et al. (2017) found that nighttime glare and a decreased sensitivity to detect motion were significantly associated with driving impairments, especially for the detection of a pedestrian.

Glare is not a problem only for older drivers. Bright sunlight and the headlights of oncoming traffic can create glare problems for all drivers. Newer automobiles are using much brighter headlamps than before. Drivers are able to see much more of the road ahead of them, but the glare caused by these lights may exacerbate glare problems for other drivers. However, automobile manufacturers are also developing technologies that allow the driver to continue to benefit from increased illumination, while decreasing some of the glare for oncoming drivers (Barry, 2019).

Visual field is the total extent of physical space visible to an eye in a given position—the whole area you see when your head is in a fixed position. For emerging adults, visual field is typically 180 degrees, but by age seventy, it decreases to approximately 140 degrees. The **peripheral field** is the outer area of your overall visual field and shrinks several degrees per decade after age forty-five (Kline & Schieber, 1985; Schieber, 2006). The more your visual field is restricted, the more you must turn your head to see what you used to see out of the corner of your eye, with your peripheral vision. This decline is significant since a great deal of important information from the environment comes to us from the peripheral visual field. Karlene Ball and her associates have developed and validated a measure of the **useful field of view** (UFOV; Ball et al., 1993; Edwards et al., 2006). The UFOV assesses the amount of information that one can obtain from a visual array. Evidence shows that the size of the UFOV accurately predicts which drivers have a history of automobile accidents. Older adults with an especially narrow UFOV were six times more likely to have had an automobile accident in the previous five years. We will return to the UFOV in chapter 3, when we discuss applied cognitive aging and the interactions among sensory and biological aging with cognitive performance.

Vision-related disorders are not considered to be part of normal aging, but they may increase with advanced age. Four common disorders are of special significance:

Cataracts are a clouding of the lens of the eye, interfering with our ability to focus, producing halos around objects, and increasing problems with glare. Cataracts can be caused by a variety of environmental factors, such as smoking or eye injury, but there may also be a familial influence. The clouding begins around age sixty but may not cause noticeable vision difficulty until age seventy-five years. By age seventy-five, most people will have cataracts. Treatment includes environmental changes, such as increased lighting, but the cataract can only be removed by surgery (MedLine Plus, 2019).

Glaucoma refers to a group of eye diseases that result in damage to the optic nerve. Pressure inside the eye increases, causing damage to the optic nerve and reducing peripheral vision and giving the experience of tunnel vision. Over time, even this tunnel vision may decrease until the person has no vision remaining. Glaucoma is the leading cause of blindness in the United States and is more common among African Americans over age forty years, Mexican American adults over age sixty years, and those with a family history of glaucoma. Currently, there is no cure for glaucoma, but eyedrops and surgery may be helpful (MedLine Plus, 2019).

A third common eye disease is **Age-Related Macular Degeneration** (AMD). With age, some people experience a decreased blood supply to the macula, within the retina of the eye. The macula is responsible for sharp focus. With a reduced blood supply, the macula and the entire retina are damaged. AMD results in a loss of sharp, central-field vision, making reading and other detail-oriented tasks difficult. Although the causes of AMD are not yet certain, white adults, women, people with a family history of AMD, adults who eat a high-fat diet, and cigarette smokers are at a higher risk (MedLine Plus, 2019). See Box 2.1 for new research highlighting a new treatment for AMD.

By 2050, it is expected that more than fourteen million Americans will have **diabetic retinopathy**. Diabetic retinopathy is caused when diabetes damages the blood vessels in the retina. This damage leads to blurry vision, floaters that appear as splotches obstructing the visual field, halos around lights, loss of central vision, and loss of color vision. Adults with type 1 or type 2 diabetes, especially if poorly controlled, are at high risk. Women who experienced gestational diabetes during pregnancy are at high risk as well. Surgery and medications may help (MedLine Plus, 2019).

BOX 2.1: NEW STEM CELL TREATMENTS FOR AMD

Age-Related Macular Degeneration is a leading cause of vision impairment among adults over age fifty years. Such visual impairment affects one's ability to perform basic Activities of Daily Living (ADLs), such as feeding oneself, Instrumental Activities of Daily Living (IADLs), such as getting around town, and many leisure time activities. Thus, AMD has the potential to significantly reduce one's quality of life.

Researchers have attempted to develop treatments for AMD that involved human stem cells. Stem cells, as you likely know, are a bit like a blank slate, having the potential to become any specialized cell in the body. Two critical issues with human stem cell research have prevented advances in stem cell research with AMD. First, when a stem cell strain is donated from another person, the recipient's body may reject those cells. Second, early stem cell research has shown that these cells have a higher likelihood of becoming cancerous. But new research from the National Eye Institute at the NIH is showing promising results.

Researchers are testing the effectiveness of using a person's own stem cells to become retinal pigment epithelium (RPR) cells. These RPE cells could then be grown into a patch that can be introduced to the retina affected by AMD. Studies with rats and pigs are showing that these patches can be integrated into the eye and that the cells continue to develop into mature stem cells, which should be able to help keep the photoreceptors in the eye healthy. Of note, these new cells do not show any signs of becoming cancerous, as was noted in previous stem cell trials. The researchers are now planning to test the safety of this treatment in people.

Source: Sharma et al., 2019.

AGE-RELATED CHANGES IN AUDITION

You probably learned in an elementary school class about how the human auditory system works: Sound travels through the air in waves that are converted to electrical signals. As the waves travel through the ear canal, the eardrum vibrates. This vibration is carried by the three bones in the middle ear through the fluid in the cochlea of the inner ear. When the vibrations from the fluid reach the basilar membrane, hair cells begin to move, which stimulate the production of chemicals. These chemicals rush into the cells, creating an electrical signal which

is carried by the auditory nerve to the brain. The brain then interprets that signal as sound (National Institute on Deafness and Other Communication Disorders [NIDCD], 2018). Aging interferes at each step of the process, from receiving incoming sound waves through the conversion of electrical signals into sound.

Several structural and functional changes in the auditory system occur with age. These contribute to hearing loss in older adults: an accumulation of fluid in the middle ear, thickening of fluid in the ear, atrophy and degeneration of hair cells in the cochlea, loss of auditory neurons, and wax buildup (NIDCD, 2018). Typical age-related changes in hearing, termed **presbycusis**, include an increase in the absolute threshold for detecting sound, such that sounds must be louder in order to be detected; difficulty distinguishing between certain sounds (e.g., "s" versus "th"); and a loss of ability to hear high-frequency sounds, such as speech by women or children (NIDCD, 2018). Presbycusis is bilateral (i.e., occurs in both ears) and progressive so that a person is often not aware of the gradual loss in hearing.

Globally, hearing loss affects about one third of older adults, with between 50 percent and 80 percent of adults aged eighty years and older having significant hearing loss (World Health Organization, 2013). Hearing loss is associated with both genetic and environmental factors, as well as their interaction. The ability to hear decreases quite dramatically across the life span, potentially compromising performance on a variety of daily tasks. Older adults may experience difficulty engaging in normal conversation, hearing the telephone, hearing verbal instructions regarding the use of medications, or participating fully in therapy and geriatric assessments (Lutz et al., 2018). We know that men tend to experience hearing loss at much younger ages than do women: Most men notice some decrease in hearing around age thirty years, whereas women notice declines around age fifty years. Moreover, men's hearing loss progresses more quickly than it does for women (Sharashenidze et al., 2007). In addition to these gendered differences, environmental factors such as occupational noise, pharmaco-therapeutic agents, industrial chemicals, rapid changes in ambient pressure, and chronic health conditions, such as diabetes, ear infections, and cardiovascular disease, affect hearing (Strawbridge et al., 2000).

AGE-RELATED CHANGES IN GUSTATION

The most common sensory loss identified in the NSHAP study was a decrease in gustation, with 74 percent of adults reporting a decreased sense of taste (Pinto et al., 2014). Your mouth produces less saliva as you age. This can cause dry mouth, which can affect your sense of taste. **Taste buds**, the sensory receptors on the tongue, also change with age. Adults have about ten thousand taste buds, but we experience a decrease in the number and size of taste buds as we age. Although many adults are able to identify a range of tastes, their sensitivity to the five (or six) tastes (see Box 2.2) often declines after age sixty (Saxon et al., 2014). This decreased sensitivity to taste is termed **hypogeusia**.

BOX 2.2: GUSTATION

We are able to detect four basic taste qualities: sweet, salty, bitter, sour, and the controversial taste quality termed umami (Mojet, Christ-Hazelhof, & Heidema, 2001). An example of umami is monosodium glutamate (MSG), which is described as salty with a greasy aftertaste. The receptors for taste are the taste buds, which are on the tongue, and the taste buds for each of the four basic taste qualities tend to be clustered on specific locations on the tongue. The taste buds become fully developed in early adolescence and remain relatively unchanged until the mid-forties, when signs of atrophy begin to appear. The specific age-related changes in the taste system include a gradual decrease in the number of taste buds, a loss of elasticity in the mouth and lips, a decrease in saliva, and fissuring of the tongue.

To assess gustation and potential hypogeusia, the NSHAP researchers (Correia et al., 2016) used paper strips that were infused with sour, bitter, sweet, and salty tastes. These were placed on the tongue, and adults were asked to identify the taste. Only 26 percent were able to correctly identify all four tastes. Another 26 percent correctly identified three of the four tastes. Nearly half of the middle-aged and older adults, 48 percent, had poor gustatory ability, making between two and four errors when identifying the four tastes.

Deficits in taste sensitivity may reduce the pleasure and comfort from food and thus represent risk factors for nutritional deficiencies. This decreased sensitivity may also present challenges to adhering to specific dietary regimens. The age-related decline in taste sensitivity is more pronounced for men compared to women.

AGE-RELATED CHANGES IN OLFACTION

Age-related decreases in our sense of smell, olfaction, are also known as **presbyosmia**. Age-related changes in olfaction, like changes in gustation, may result as a consequence of biological aging, disease states (such as Alzheimer's and Parkinson's disease), medications, surgical interventions, and environmental exposure (Pinto et al., 2015). Although the sense of olfaction and gustation are closely linked, most studies suggested that the sense of smell is even more impaired than the sense of taste. Using data from the Sniffin' Sticks, the NSHAP study shows that olfaction declines at a rate of about one error for every twenty years. Racial differences exist, with African Americans' olfaction declining more rapidly than whites' sense of olfaction. Gender, too, plays a role. Olfaction in men declines more rapidly than for women. It is important to note that these differences persisted, even when prior or existing socioeconomic status, health conditions, cognition, mental health, alcohol use, and smoking were considered. Researchers are continuing to examine the role of olfaction in cognitive disorders, as discussed in Box 2.3.

BOX 2.3: OLFACTION, PEANUT BUTTER, AND DEMENTIA

The popular media outlets were excited. The general public was excited. A simple Internet search of "peanut butter" and "dementia" brings up more than 1.2 million hits. Here we discuss the original study that sparked the media attention, the solid science that prompted them to conduct that study, and additional research that helps to answer the question: Can a peanut butter sniff test help us to diagnose dementia?

It has long been known that persons with dementia, such as Alzheimer's Disease (AD), exhibit sensory declines along with the hallmark cognitive challenges. In fact, disruptions in the sense of smell, hyposmia, might be among the very earliest warning signs. Although most older adults experience decreased olfactory sensitivity, these declines are even greater among persons with dementia (Albers et al., 2015; Murphy et al., 1990). The left olfactory structures are physically closer to the parts of the brain most affected by dementia. Thus, in addition to general decrease in olfaction, it might be true that persons with dementia show differences in olfaction between the left and right nostril. This finding, along with other facts about the way that dementia influences cognitive processing, led a group of researchers to examine olfaction among persons with dementia and other forms of cognitive impairment, with the goal of developing an inexpensive but useful test to evaluate the presence of dementia.

Specifically, Stamps et al. (2013) examined olfaction among eighteen adults with AD, twenty-four adults with Mild Cognitive Impairment (MCI), twenty-fix adults with non-AD dementia, and twenty-six controls without dementia. The materials were simple: fourteen grams of peanut butter in a one-ounce container. Adults closed their eyes and mouth and were asked to hold one of their nostrils closed from the side, using their index finger. The container of peanut butter was placed on a thirty cm ruler (about one foot long) and moved toward the person's nostril in increments of one cm. The adult indicated at what distance they could smell the peanut butter. This procedure was repeated for the opposite nostril. The reported results were uniformly consistent: Each person with dementia showed a higher threshold for olfaction, meaning that the peanut butter needed to be closer to the nose before it could be detected. More importantly, the researchers reported that all of the persons with dementia showed a clear discrepancy between the left and right nostril before they could detect the odor. The left-right difference for persons with AD was more than twelve cm. About a five cm difference was present between the left and right nostrils for persons with non-AD dementia. People with MCI differed between nostrils by less than two cm and controls showed no left-right difference! The authors suggested that the peanut butter sniff test could be a reliable and inexpensive test for dementia.

Dramatic research results often capture the attention of the general public. The scientific community also takes notice when reported results are dramatic. Other research teams began the work of attempting to replicate the Stamps et al. (2013) finding. For example, Doty et al. (2014) repeated the Stamps et al. study using the exact procedures with fifteen adults with AD. Even though these adults were more impaired than the adults in the Stamps et al. sample, none exhibited the left-right discrepancy for identifying peanut butter. To rule out the possibility that asking a person to close their own nostril contributed to these results, Doty and colleagues used medical tape, rather than the index finger, to close off the nostril. Again, no left-right discrepancy was observed. Doty and colleagues then recruited an additional twenty adults with dementia to examine the possibility of a left-right difference in detecting up to twenty odors. Again, no such discrepancy was observed.

Doty et al. (2014) consider several important implications of the failure of the Stamps et al. (2013) results to replicate. First, they improved the procedures in several ways—they included persons who were more impaired than those participating in the Stamps et al. study. If there really is a left-right difference, one might expect larger discrepancies among the most impaired. But that did not occur. Second, Doty et al. expanded to other odors—no discrepancy was observed.

A recent examination added the scent of coffee to the test (Trapp et al., 2023). These researchers report high correlations among the ability to identify peanut butter versus coffee and suggest that these "everyday" tasks may help families to know when to seek medical assessment. It is important to note, however, that many other issues in addition to dementia may influence our sense of olfaction. For example, it is estimated that as many as 60 percent of people who had COVID-19/SARS-CoV-2 also experienced loss of taste and smell for some period of time (Aziz et al., 2021).

Because the fear of dementia is especially high among the general public, the idea of an inexpensive assessment is attractive. Although the peanut butter sniff test is not likely to change the way we diagnose or assess dementia, scientific labs across the world are actively identifying new diagnostic tests, new pharmacological and behavioral treatments, and new supports for individuals and families of persons with dementia. Individuals and families who have concerns about possible dementia should seek a good geriatric health assessment.

AGE-RELATED CHANGES IN SOMESTHESIS

Sensitivity to touch, vibration, temperature, kinesthesis, and pain are collectively known as **somesthesis** (Hayslip et al., 2011). Age-related changes in such sensitivity can be attributed to a decreased number of sensory receptors for each sense and vary by the part of the body involved. For example, sensitivity of the feet starts to decrease at an earlier age than does that of the forearm.

Regarding touch, sensitivity appears to remain relatively stable throughout midlife. However, we experience an increase in absolute threshold, resulting in decreased sensitivity to some forms of touch, around age fifty to fifty-five years (Whitbourne, 1985). An especially important aspect of age-related change in our sense of touch is **thermal perception**, our sensitivity to heat and cold. Older adults are less able to regulate their own body temperatures and less able to respond to changes in ambient temperature. Thus, older adults may be especially susceptible to frostbite, heatstroke, burns, and other conditions related to temperature fluctuations (Saxon et al., 2014).

Finally, somesthesis also involves the **vestibular system**, with includes our sensitivity to balance and movement, sometimes referred to as kinesthesis. Age-related changes in the vestibular system can result in dizziness, vertigo, and other balance problems. Moreover, changes in our sense of balance may result in injuries and falls. Injuries can occur when we move too quickly or sharply through our environment. You may have noticed that when you are especially stressed, you might bump into walls or turn too quickly.

For older adults, that kind of dysregulation is likely to result in injury (Saxon et al., 2014). Older adults who fall are especially likely to experience severe bruising and broken ankles and

hips. Falling is the leading cause of traumatic brain injury in older adults, and falls represent the most common cause of accidental death in older adults worldwide (WHO, 2018).

Age is a primary factor associated with both injuries and deaths from falls, with very young children and adults over age sixty-five years at a high risk. With the aging of the Baby Boomers, it is no surprise that the number of deaths from falls among older adults has increased. Estimates suggest that among adults aged sixty-five years and older, deaths from falls have increased by 30 percent over the past decade. If this trend continues, it is estimated that by the year 2030, seven older adults per hour will die from a fall (CDC, 2019b)! But there are many preventative efforts that one can enact to reduce falls: regular medication checkups to avoid side effects like dizziness, removing trip hazards like throw rugs, installing handrails in bathrooms, and maintaining adequate lighting. Good health habits, including eating nutritious foods and engaging in strength training, especially for the lower torso, can also help. Preventing falls is such an important public health issue that the Centers for Disease Control and Prevention (CDC) has developed a special initiative to help health care providers to screen, assess, and intervene for fall risks. This program, Stopping Elderly Accidents, Deaths, & Injuries (STEADI) Initiative, provides many informational resources for physicians and the general public.

SPECIFIC CHRONIC HEALTH CONDITIONS

Most older adults live with one or more **chronic health conditions**, with about 77 percent having at least two. According to the National Council on Aging (NCOA; 2024), the ten most common chronic health conditions experienced by adults ages sixty-five and older include: hypertension (60 percent), high cholesterol (51 percent), obesity (42 percent), arthritis (35 percent), coronary heart disease (29 percent), diabetes (27 percent), chronic kidney disease (25 percent), heart failure (15 percent), depression (16 percent), and dementia (12 percent). The Centers for Disease Control and Prevention (CDC, 2024) also highlights cancer. We will briefly discuss each of these chronic health conditions.

Stroke and **hypertension** are especially prevalent in the United States, with 90 percent of those over age fifty-five years being at risk and nearly 60 percent of older adults in treatment for hypertension (NCOA, 2024). Hypertension relates to both how much blood the heart pumps and how well the arteries are able to deal with that blood flow. Hypertension is often called the "silent killer," because people may have the condition for years before it comes to their attention. Gender differences are apparent, with 77 percent of women and 64 percent of men aged seventy-five years and older having hypertension (NIA, 2016). Hypertension is linked to both heart disease and stroke. Stroke occurs when the brain experiences a sudden lack of blood, through either blockage or ruptures. As the fourth leading cause of death, strokes lead to more long-term disabilities than any other chronic health condition in the United States (NIA, 2016).

High cholesterol is common, with more than half of older adults being treated for high cholesterol (NCOA, 2024). High cholesterol is related to stroke and heart disease because high cholesterol occurs when the body has too many fats in the blood stream, which clogs the arteries (NCOA, 2024).

Obesity, a chronic health condition characterized by excess body fat, is especially common in the United States. In fact, about 20 percent of American children, 33 percent of emerging adults ages seventeen to twenty-four years, and more than 40 percent of American adults, including those over age sixty-five years, are obese (CDC, 2024). Obesity is linked to more than two hundred other chronic health conditions (NCOA, 2024).

Arthritis is an umbrella term for inflammatory conditions affecting the joints of about 20 percent of Americans, in general (CDC, 2024) and 35 percent of older Americans, in particular (NCOA, 2024). It is a leading cause of disability and chronic pain. **Osteoarthritis** is a specific type of arthritis common among older adults in which the cushion between joints breaks down over time. Joints that are especially likely to be affected are those in the hands, lower back, neck, knees, hips, and feet (NIA, 2022).

Heart disease is responsible for one in three deaths among American adults, with nearly 945,000 deaths each year (CDC, 2024). Coronary heart disease, experienced by 29 percent of older adults, is caused by the accumulation of fatty plaques in the walls of the coronary arteries, a condition known as **atherosclerosis**. These fatty deposits impair blood flow and oxygen supply in the heart, which weakens the heart muscle. This blockage may also lead to chest pain (angina), blood clots, or heart attack (NIA, 2016).

Diabetes is a disease characterized by excessive levels of blood glucose. There are different types of diabetes, but in terms of aging, **type 2 diabetes (T2D)** and prediabetes are of special concern. More than twelve million adults aged sixty years and older have T2D, and another 57 million adults over age twenty years have prediabetes, increasing Americans' risks for heart disease, stroke, kidney disease, and diabetic retinopathy (National Institute of Diabetes and Digestive and Kidney Diseases [NIDDK], 2016). Lifestyle interventions involving maintaining a healthy body weight and engaging in regular physical activity are especially effective for reducing risk of developing T2D. Evidence shows that these health promotion behaviors can reduce T2D risk by more than 70 percent in adults over age sixty years (NIDDK, 2016).

Chronic kidney disease involves a loss of kidney function over time, which may lead to other chronic health conditions such as kidney failure and heart disease (NCOA, 2024). Almost 25 percent of older Americans are being treated for chronic kidney disease,

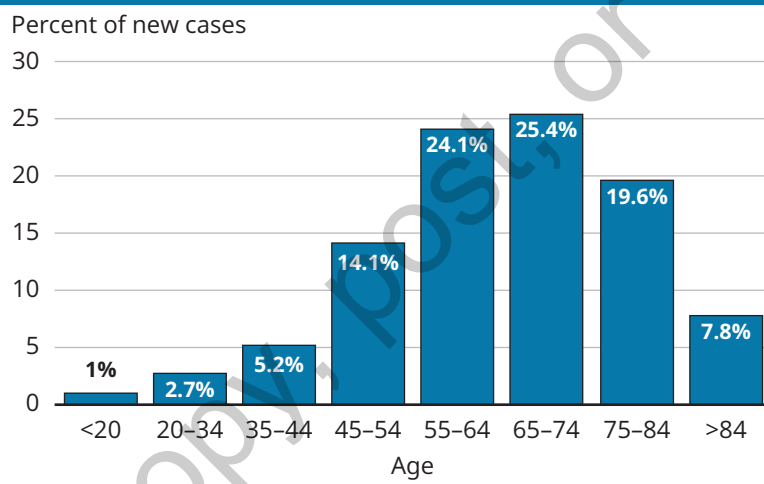
Heart failure, affecting about 5 percent of older adults, occurs when the heart is no longer able to supply adequate blood and oxygen to the organs of the body. Adults with heart failure may feel fatigued, light-headed, nauseous, or confused, or have a lack of appetite as side effects of the heart becoming enlarged and pumping faster as a way to deliver more blood throughout the body (NCOA, 2024).

Depression is a treatable health condition that is *not* part of normal aging (NCOA, 2024). About 16 percent of older adults are in treatment for depression. You will learn more about depression in later chapters of this book.

Similarly, **dementia** is not a part of normal aging. Dementia is an umbrella term that refers to disorders in thinking, memory, and problem solving. It is more common among older adults, affecting 12 percent of adults over age sixty-five years. Deaths from dementia have more than doubled in the past twenty years, at a cost of more than $360 billion in care in 2024 (CDC, 2024). Chapter 3 includes more information about dementia.

Cancer refers to a collection of diseases in which the cells of the body fail to stop dividing and replicating (National Cancer Institute [NCI], 2015). In addition to specific environmental risk factors, advanced age is associated with an increase in cancer. Across all types of cancer, half occur in people older than age sixty-six years. Some cancers are more likely to be diagnosed at mid or late life, as shown by the median age of diagnosis. Figure 2.1, reprinted from the National Cancer Institute, shows the relation between age and site of new cancer diagnoses. The **median age** is the cut-point at which half of the diagnoses occur younger than and half occur at ages older than the stated age. Half of all diagnoses for breast cancer occur after age sixty-one years. For colorectal cancer, the median age of diagnosis is sixty-one years. Age sixty-six years is the median for prostate cancer diagnoses. Half of all lung cancer diagnoses occur after age seventy (NCI, 2015). For all cancers, regardless of age, good health habits and regular visits to health care providers can reduce risk and aid in early detection.

FIGURE 2.1 ■ Percent of New Cancers by Age Group: All Cancer Sites



"Age and Cancer Risk," National Cancer Institute, 2015, https://www.cancer.gov/about-cancer/causes-prevention/risk/age.

EVERYDAY EXPERIENCE OF BIOLOGICAL AGING

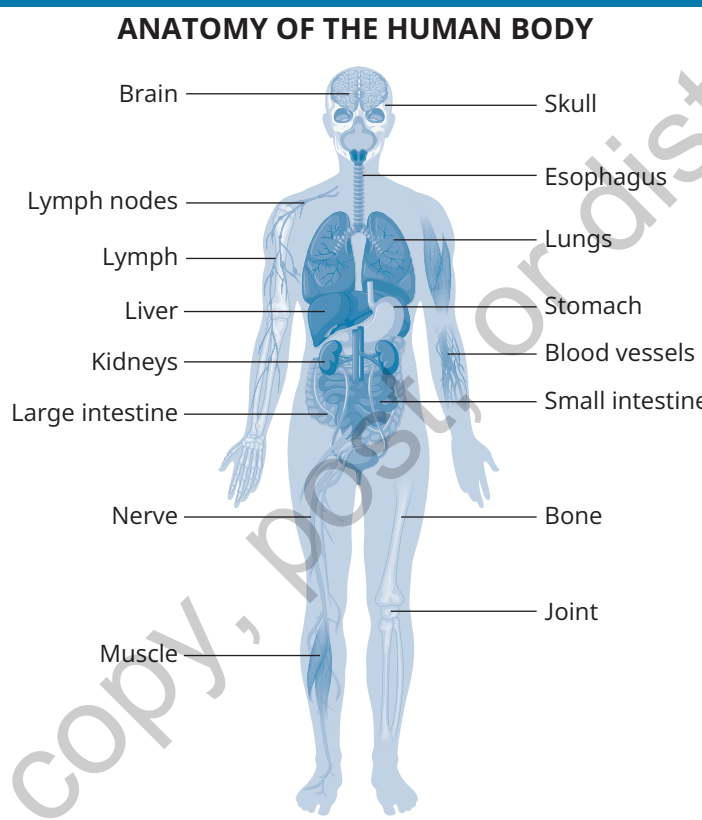
So far, we have discussed a variety of theories regarding why we age and effects of aging on various sensory systems, and we have discussed a few of the most common chronic health conditions at mid and late life. In the remaining sections of this chapter, we turn our attention to issues of longevity and the multiple causation mentioned by Baltes (1987) in his principles of life span development.

Typical Biological Aging in the Human Body

As stated at the beginning of this chapter, across development, biological aging may include both growth and decline. In mid to late adulthood, however, most of those changes are declines.

But there are wide individual differences in the location, rate, and timing of those declines. Below, we briefly summarize normative biological changes in the organs of the human body, while highlighting the influences of Nature (biology), Nurture (environment behaviors), and their interactions. For ease of this discussion, we will refer to the Figure 2.2, below and discuss the various organ systems from the brain to the lymph nodes and continuing in a counterclockwise fashion.

FIGURE 2.2 ■ Human Anatomy



Source: Vecteezy.com

Although chapter 3 includes detailed information about cognitive aging and the brain, we want to highlight some of the normative structural and functional brain changes that adults experience in late life. It is important to note that structural and functional changes may not always translate to behavioral deficits. With that said, there is evidence that overall brain volume shrinks as young as one's thirties or forties and continues to show small decreases through the sixties. The site of this shrinkage is not uniform across the brain. In some areas of the brain, chemical and electrical impulses may be weaker across the cells, interfering with neuron communication. Blood flow and glucose may be lower than during younger age periods. Inflammation and injuries may accumulate, which also interfere with brain functions (NIA, 2023).

Age-related normative changes occur in the lymphatic system, as well. The lymphatic system includes a variety of organs and tissues, and it is critical to healthy immune system functioning. As we age, the tissues in the lymphatic system may become thinner and the system may drain fluid more slowly (NIA, 2023). The lymphatic system may play a key role in removing waste materials like beta amyloid plaques from the brain (NIA, 2021).

About the liver, Lindenmeyer (2022) states that it acts, "…as the body's chemical factory, performing many vital functions, from regulating the levels of chemicals in the body to producing substances that make blood clot (clotting factors) during bleeding." With age, the liver becomes smaller, and blood flow is reduced. It metabolizes drugs and other substances more slowly, reaffirming the old adage that with medicines and older adults, one should "go low and go slow." Additionally, the liver becomes less resilient with age, repairing more slowly and sustaining damage with smaller insults.

The kidneys and bladder work together to filter and remove waste materials and extra fluid from the body. In healthy adults, kidney function declines very slowly with age. However, kidney tissue decreases, including the number of nephrons which filter wastes. Blood flow may also be reduced, causing the kidneys to filter the blood more slowly. The bladder also experiences age-related changes, with a thinning of the bladder walls and muscle weakening. For both older men and women, the urethra may become blocked in mid- to late life (Brodkey, 2022b).

The digestive system includes the esophagus, the stomach, small and large intestines, and the pancreas, each of which experiences age-related changes in structure or function. The esophagus weakens with age, but this generally is not problematic for adults, and food is able to move through the system easily. In Chapter 3, we will briefly discuss some techniques that can be used with adults with dementia, who may have difficulty with swallowing behaviors. With age, the stomach lining may become less resilient, especially for adults who ingest aspirin and other NSAIDs. This may result in peptic ulcers for many older adults. The stomach decreases in elasticity, so is not able to hold as much food as in earlier periods of the lifespan. The rate of digestion may also slow. Most adults do not notice these small changes. However, changes in stomach fluids and acid secretions may result in problems with vitamin deficiencies and bacterial overgrowth in the small intestine. The small and large intestines experience minor age-related changes. Adults may experience sensitivity to lactase or develop lactose intolerance as absorption rates slow in the small intestine. Similarly, movement of contents through the large intestine may slow with age.

Bones, muscles, and joints experience age-related changes, but the extent and site vary as a function of genetic, lifestyle, and combined factors. For example, some bone loss is normal with aging, especially for post-menopausal women. When this bone loss occurs in the spine and the arch of the foot, older adults lose height. Vertebrae may lose minerals, becoming thinner. This leads to spinal compression and possible curvature of the spine. Fluid in the joints may decrease, leading to painful cartilage wear and calcification in the joints. These changes in the joints may lead to inflammation, pain, and stiffness. Lean body mass decreases with age. Muscle changes may begin as early as the 20s for men and 40s for women. Strength and endurance changes occur (Brodkey, 2022a).

The lungs and respiratory system experience normative age-related changes. Lungs reach maturity around ages twenty to twenty-five years and some decline in function may begin as early as age thirty-five years (American Lung Association, 2024). The changes are gradual, however. By late life, adults may experience changes in how quickly one can exhale, decreases in the maximum amount of air one can exhale, general weakening of the respiratory muscles, and less

resistance to pneumonia, infections, and influenza. Vaccines against these conditions is recommended for older adults and all those with decreased respiratory functioning (Dezube, 2023).

Although not explicitly highlighted in the figure, there is one additional organ that merits discussion: human skin. The appearance of our skin relates to our own and others' perceptions of vitality and attractiveness. As a normal part of aging, skin wrinkles, exhibits inconsistent pigmentation, and has less volume, especially facial skin. Skin aging is a function of intrinsic factors (e.g., genetics, chronological age, hormones) and extrinsic factors (e.g., exposure to ultraviolet radiation, cigarette smoking, other behavioral and environmental factors; Norton, 2023). Thus, many factors influence the appearance of our skin, including race and ethnicity. A recent study suggests that white non-Hispanic women show most of the signs of skin aging between ages forty and fifty-nine years. Black non-Hispanic women, however, do not exhibit these facial aging signs until they are ages sixty to seventy-nine years (Alexis et al., 2019). But skin is much more than merely being an outward indicator of youthful appearance. Skin is our largest organ and serves several important functions. Skin helps to regulate our body's temperature, provides protection from chemical and radiation damage, and is an important component of the microbiome (Norton, 2023).

We have been discussing the various organs of the body as if they were unique entities rather than parts of a whole. But of course, we inhabit a single body, and these organs are aging together. Changes in one organ system may effect changes in other systems. One such example is the microbiome. The human body is a host to "…bacteria, fungi, protozoa, and viruses" (Melby et al., 2023, p. 46) that exist in a symbiotic relationship to promote optimal health and functioning. Although these microbiomes can become pathogenic with age, they generally continue to facilitate functions in digestion, in the immune system, and in the control of inflammation. Changes in the relation between the microbiome with other systems may result in age-related challenges. Specifically, changes in the gut-brain axis may result in neurodegenerative and inflammatory diseases. Changes in the relation between the microbiome and the bones (gut-bone axis) has been implicated in osteoporosis and increased bone fractures (Melby et al., 2023). Ways to strengthen the microbiome include the same good health practices suggested for other individual organ systems: Eat well, hydrate with water, engage in physical activity, and enjoy social connections.

BOX 2.4: MENOPAUSE AND "MANOPAUSE"

Humans who menstruate (referred to as women for the rest of this discussion), as part of their reproductive cycle, experience a monthly shedding of the tissue and blood which line the uterus during cycles in which conception does not occur. For most women, this reproductive cycle begins in adolescence and women stop menstruating in their late forties to mid-fifties. The cessation of menstruation is termed menopause and is merely the transition from active reproductive capability to post-reproductive capability. Generally, we can ask women when their last menstrual period occurred. When a woman reports the absence of a menstrual period for one year, we consider her as having completed the menopause transition. Idiosyncratic accounts and marketing researchers often suggest that menopause is a physically and emotionally tumultuous time. Symptoms may include hot flushes and night sweats (Rulu & Sievert, 2023). These and other vasomotor symptoms (VMS) are

experienced by many women, but the extent to which they are disruptive varies greatly and is influenced by other health behaviors (i.e., smoking, alcohol), heavier body weight, physical exercise, and even culture. The differential experience of such VMS is a good example of the interaction between nature and nurture.

Until very recently, it was thought that only humans and a few species of toothed whales experienced menopause. The argument was that humans were unique in continuing to live beyond the period of reproductive potential. However, conducting research with mammals who can't self-report is difficult. Other mammals, such as cats and dogs, do not have monthly menstrual cycles, but rather experience an estrus cycle during which the lining is reabsorbed and not shed (Winkler & Goncalves, 2023). Thus, other measures of detecting the last reproductive cycle are needed. Finally, there may be important differences between non-human mammals living in the wild versus those living in captivity.

Recent research provides a new understanding of menopause beyond humans and whales, however. Using indirect physiological measures, including hormone levels in urine, we can assess whether a mammal has ceased ovulating, a transition termed oopause. Winkler and Goncalves (2023) reported on a variety of mammals, including laboratory rodents, domestic cattle and horses, and chimpanzees raised in captivity. Using indirect measures of oopause, such as the levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), the team discovered that as many as 80 percent of mammalian species do experience the cessation of ovulation. Similarly, and at the same time, a second research team reported findings related to menopause among chimpanzees living in the wild in Uganda (Wood et al., 2023). This team had twenty-five years of data on female chimpanzees, including measures of five different hormones. Based on these hormone levels and observation, they discovered that fertility did decrease after age thirty years and no births occurred after age fifty years. However, some of these females lived another 20 percent of their lifetime post-menopause.

This new evidence is compelling and suggests that menopause may be more broadly experienced across female mammals than previously thought. But what about men? We hear a lot about "man-opause," a colloquial term for andropause, the decrease in hormones that occurs with age among male humans. From about the age of forty years, men exhibit a decrease in the levels of testosterone circulating in the blood, at about a rate of 1 percent decrease per year. Over time, men may experience decreased sex drive, lack of energy, decreased muscle strength, sadness, and loss of height (NIA, 2022). Although men do not experience the cessation of reproductive capacity like women do, there are changes with age (Martins da Silva & Anderson, 2022). Men continue to produce semen well into their eighties, but the quality and quantity decrease. This may have implications for the health of offspring fathered in late life (Martins da Silva & Anderson, 2023).

LIFE EXPECTANCY AND LIFE SPAN

How old is old? It seems like a simple question, but as chapter 1 points out, the answer depends on historical period, social context, and individual perceptions. Because it defines upper limits, life span is an important contributor to our definitions of "younger" versus "older." **Life span** can be defined as the maximum age that a member of a species can survive. Few members reach that limit, and different species have markedly different life spans (Hayflick, 2007). For example, humans are thought to have a maximum life span of around 125 years. The common house fly has a life span of about five weeks. For other variations in life span across species, see Table 2.3.

TABLE 2.3 ■ Life Span Across Species

Species	Maximum Life Span
Actinobacteria[1]	500,000 years
Glass sponges[2]	11,000 years
Humans[3]	125 years
Dog[3]	12 years
Horse[3]	25 years
House fly[3]	1 day

Sources: [1]Sample, 2010; [2]Max-Planck-Gesellschaft, 2012; [3]Shock, 1977. (Superscript numbers of different species correspond to source citations listed below.)

One factor that influences our view of "how old is old" is **life expectancy**. Life expectancy is defined as the average age a person can expect to live, based on environmental characteristics, lifestyle and behavioral choices, and genetic factors. Using empirical evidence, we can estimate an individual's life expectancy. There are a lot of life expectancy calculators available, but one of the best such calculators was developed by Dr. Thomas Perls.

As a physician, Perls approaches life expectancy using the same techniques that one uses to identify the precursors to disease, using a Patient Zero approach. Perls focused on **centenarians**, adults who reached their one hundredth birthday. By speaking with many people who were especially long-lived, Perls and his team were able to identify patterns in their family history and lifestyle habits (Andersen et al., 2012).

You may have noticed that the Perls's life expectancy calculator used your current age to determine your estimated life expectancy. That is because life expectancy differs for different birth cohorts. In 1901, life expectancy at birth in the United States was forty-nine years; in 1950 it was around sixty-eight years; in 2011, it was about seventy-eight years; and in 2014, a baby born in the United States was expected to reach age seventy-nine years. However, there are marked discrepancies in life expectancy within the United States. For example, an infant born on the Pine Ridge Indian Reservation in 2014 was expected to reach age sixty-six years. Infants born in Colorado could expect to live eighty-six years or more (Dwyer-Lindgren et al., 2017). Some of the lowest life expectancies in the United States can be found among residents of rural Appalachia, especially in eastern Kentucky, southwest West Virginia, parts of Alabama, and western Mississippi. These **place-based health disparities** are the result of multiple influences that challenge the economic, physical, and emotional well-being of adults (Allen & Roberto, 2016; Krout & Hash, 2015; Patrick et al., 2020).

TRY IT NOW

Take Dr. Perls's empirically based life expectancy calculator at https://www.livingto100.com/ to learn about the factors that influence your life expectancy.

See Box 2.5 for a discussion of cohort differences in life expectancy at birth.

BOX 2.5: COHORT AND LIFE EXPECTANCY

Human life expectancy has shown a significant increase from the time of the ancient Greeks to the present. Life expectancy at birth in ancient Greece in 500 B.C. was eighteen years, twenty-five years in ancient Rome (A.D. 100), and thirty-five years in thirteenth-century England. From 1775 to 1900 in the United States, the increase in life expectancy was from about fifteen years to thirty-five years. The most significant increases in life expectancy in the United States occurred between 1900 and 1940; increases have been relatively minor since then. For example, for white males, during the fifty-year period from 1900 to 1950, predicted life expectancy at birth increased by approximately twenty years (46.6 to 66.5 years). The increase in life expectancy since 1900 was due to improvements in housing, sanitation and hygiene (especially handwashing), antiseptics and antibiotics, public health laws, immunization for diseases, and nutrition. However, from 1950 to 1990, predicted life expectancy at birth increased by only about five and a half years (66.5 to 72 years). This relatively smaller increase relates to the primary causes of death among middle-aged and older adults. The primary causes of death for both men and women are chronic diseases, such as cardiovascular diseases and cancer, which, generally speaking, currently do not have a cure. These two diseases account for three fourths of all the deaths of older adults (Hayslip et al., 2011; Kastenbaum, 2006).

However, a new trend is emerging. For the first time, the current generation of children might expect to have shorter life expectancies than their parents. Three major contributors to this decrease in life expectancy are deaths from drug overdoses, chronic liver disease, and suicide (CDC, 2019a). These three diseases of despair are responsible for increasing numbers of deaths among those twenty-five to sixty-four years, especially in rural areas (Meit et al., 2017).

Racial and ethnic differences are also present in life expectancy at birth. For example, African Americans have an average life expectancy at birth equal to 74.6 years. Native Americans/American Indians have a mean life expectancy of 76.9 years. White non-Hispanic Americans have an average life expectancy at birth of 78.9 years. In contrast, Latinx Americans have a mean of 82.8 years, and Asian Americans have a mean life expectancy at birth of 86.5 years (SimplyInsurance.com, 2019).

In addition to birth cohort and geographic location, gender differences exist for life expectancy. But these gendered differences in life expectancy do not occur in isolation. That is, gender interacts with a host of other factors, including education and race. People who finish college generally live longer than those who do not complete high school. Across educational levels, women outlive men. When we factor in race, white women tend to live longer than Black/African American women, at least until age eighty-five. After age eighty-five years, Black women show a slight longevity advantage. In contrast, Hispanic adults born in the United States tend to outlive their white and African American peers. It is important to remember, however, that just as there are many ethnic and cultural variations within white or Black groups, Hispanic Americans are also a diverse group. For example, recent Hispanic immigrants to the United States may expect to obtain a significantly lower life expectancy than US-born Hispanic adults (Olshansky et al., 2012). As you read through Table 2.4, identify the public health, political, and other social conditions that influence the changes in life expectancy across race, gender, and birth cohort.

TABLE 2.4 ■ Changes in US Life Expectancy at Birth

	All Races			White Adults			Black/African Americans			Hispanic Adults		
Birth Year	Both	Men	Women	Both	Men	Women	Both	Men	Women	Both	Men	Women
1900	47.3	46.3	48.5	47.6	46.6	48.7	33.0	32.5	33.5	–	–	–
1950	68.2	65.6	71.1	69.1	66.5	72.2	60.8	59.1	62.9	–	–	–
2000	76.8	74.1	79.3	77.3	74.7	79.9	71.8	68.2	75.1	–	–	–
With a consideration for Hispanic/Latinx ethnicity												
2012	78.8	76.4	81.2	78.9	76.5	81.2	75.1	71.9	78.1	81.9	79.3	84.3
2013	78.8	76.4	81.2	78.8	76.5	81.2	75.1	71.9	78.1	81.9	79.2	84.2
2014	78.9	76.5	81.3	78.8	76.5	81.2	75.3	72.2	78.2	82.1	79.4	84.5
2015	78.7	76.3	81.1	78.7	76.3	81.0	75.1	71.9	78.1	81.9	79.3	84.3
2016	78.7	76.2	81.1	78.6	76.2	81.0	74.9	71.6	78.0	81.8	79.1	84.3
2017	78.6	76.1	81.1	78.5	76.1	81.0	74.9	71.5	78.1	81.8	79.1	84.3

Adapted from Arias & Xu, 2019; SimplyInsurance, 2019; Woolf & Schoomaker, 2019.

FROM THEORY TO APPLICATION: LIFE EXTENSION AND HEALTH SPAN

Americans face an obesity problem, with overweight and obese adults and children experiencing a range of chronic health conditions that shorten life expectancy (NCOA, 2022). Maintaining a healthy body weight and muscle mass would decrease the number and severity of chronic health conditions experienced. But *what* we eat may be as important as *how much* we eat. The US Department of Agriculture and the Department of Health and Human Services publish a guideline for healthy caloric intake and dietary patterns. They suggest a range between 1600 and 3000 calories daily. But choosing foods high in nutritional content and avoiding high fat and high sodium foods has additional benefits than mere calories (USDA, 2020). We have known for more than eighty years that **caloric restriction (CR)** increases life expectancy in short-lived animals (Anderson et al., 2018). Focusing on highly nutritious foods and staying at the lower end of the suggested calorie range may result in health benefits. Studies of whether CR increases life expectancy in primates have found that CR may be associated with a compression of disease but might not increase the number of years that one survives (Hayslip, Patrick, & Panek, 2011).

Health Span

At the start of this chapter, we posed the question, "How old is old?" Your answer is important because it reflects your knowledge and attitudes about aging in general, and it influences how long you might want to live. An emerging construct, **health span**, may also influence your answer. Although there is no agreed-upon definition, or indeed even a scientifically sound way to measure it, health span can be defined as the period of time in which one lives (relatively) disease free and functions at optimal levels (Kaeberlein, 2018). Using this definition, the individuals over one hundred years old studied by Perls and his team often showed great similarity between their life expectancy and their health span— they were living relatively healthy lives until the last few years (Andersen et al., 2012). Compression of disease may be an important component of health span.

Most Americans in the United States and Canada say that they do not want to live beyond age eighty or eighty-five years, and few have knowledge about current life extension science (Pew Research Center, 2013). Donner et al. (2016) asked one thousand adults about whether they would like to live to ages eighty-five years, one hundred twenty years, one hundred fifty years, or indefinitely. If conditions were such that an individual could be guaranteed mental and physical youthfulness and vitality, almost 80 percent responded that they would prefer to live to age one hundred twenty years or longer. More than half (53.1 percent) said that with sustained vitality, they would choose to live indefinitely. Adults who previously identified a preference for a lower life expectancy changed their responses to 120+ years when the option of sustained vitality was mentioned. Health span seems to matter to adults in North America. Not surprisingly, adults who were more scientifically minded were especially likely to prefer a long and vital life.

However, there are difficulties related to translating lab studies with rats, mice, worms, and flies to humans. Notably, human CR usually is not initiated until adulthood, whereas animal studies may begin much earlier in life, even before birth. Humans live 75+ years, much longer than

rats (three years) or flies (a few weeks). Human ethics procedures also include the right to decline invitations to participate in research, as well as the right to withdraw one's consent to participation. Animal models do not include those particular aspects. Finally, although there are many similarities between different animal species and humans, there are important differences, as well.

Possible benefits of CR for humans first came to the public's attention more than three decades ago, with a 1983 book, *Maximum Lifespan*, and other writings by noted researcher and physician Roy Walford. Walford was part of the Biosphere Project and was able to gather evidence that CR, reduced caloric intake accompanied by high nutritional value, could result in improved health among humans (Walford, 1986). Even though Walford was a recognized expert, his small sample size observations included humans who wanted to try CR; thus, they might have differed in many dimensions from other adults, including being science-minded and having high self-control.

More modern research in CR is following clinical trial protocols. In these protocols, people are randomly assigned to different conditions, and they are evaluated many times over longer periods, using a variety of methods and assessments. Ravussin et al. (2015) reported results from the first two years of human trials with CR. This study follows more than two hundred normal-weight adults, aged twenty-one to fifty years, who were randomly assigned to one of two conditions: a control group who ate their normal caloric intake across the two-year period, referred to as the ad litum group, and the Caloric Restriction (CR) group, who consumed 25 percent fewer calories than their preferred intake (e.g., preferred 2500 kcal but at 1875 kcal daily), with careful attention to the nutrition intake of that reduced calorie diet. In the first two years, adherence was impressive, with 82 percent of those in the CR group and 95 percent who were in the Control group completing the study. Adults in the CR group lost and maintained a weight loss around 10 percent, equivalent to about sixteen pounds, most of which was fat. No such changes were observed for the Control group. Of course, it is not surprising that adults who eat less than they prefer to eat will lose weight. Other health changes were observed, however. At year one, but not year two, those in the CR group had lower resting metabolic rates and lower body temperatures than the Control group. Although the study continues, it is among the best-designed studies to demonstrate that CR is feasible in typical adults.

Other researchers argue that additional factors contribute to the benefits of CR beyond simply reducing caloric intake while maintaining high nutrient density. These researchers focus on *when* one ingests calories. For example, Di Francesco et al. (2018) and Mattson (2014) lay out convincing evidence regarding the mechanism whereby CR influences health and argues that the benefits can be increased through **Intermittent Fasting (IF)**. IF, in which one restricts the number of hours per day in which one eats (e.g., eating between eight a.m. and five p.m. only), increases health span by decreasing our risks of inflammatory-related diseases, such as Alzheimer's, Parkinson's, and cardiovascular diseases. Reducing the preferred number of calories while maintaining high nutrient density is associated with a host of benefits that increase the quantity (life expectancy) and quality (health span) of life. These benefits are not merely due to the effects of reduced caloric intake on obesity, cardiovascular disease, diabetes, and hypertension, however (Di Francesco et al., 2018). Specific systems of the body are healthier when

adults engage in CR and IF. Benefits are seen in the blood, liver, intestine, brain, cardiovascular system, pancreas, and a decrease in adipose tissue.

Benefits related to energy expenditure also contribute to the improved health and functioning. Specifically, Di Francesco and colleagues (2018) highlight systemic benefits of IF that include the following:

1. Improved tissue repair and reduced damage from oxidative stress (free radical damage)
2. Improved function due to decreased inflammation
3. Improved metabolic homeostasis via improved protein synthesis
4. Healthier mitochondria

INTEGRATING ACROSS TOPICS

Many of the early explanations of biological aging did not address the group differences we observe in life expectancy or health span. Early sociological theories (see Table 2.5) examined the social context of health and longevity, noting that Black Americans experienced the onset of age-related diseases about ten years earlier than their white peers.

Thus, it was not surprising that Black adults had shorter life expectancies relative to White adults. Take another look at Table 2.4. Although in the United States, Black life expectancy has

TABLE 2.5 ■ Early Theories Regarding Race Differences in Longevity and Racial Health Disparities

Theory	Summary
Multiple Jeopardy	Being a member of a racial or ethnic minority (and lower socioeconomic status; and female) and old combine in an additive or multiplicative way to create health disparities
Age-as-Leveler	The effects of aging are so profound that race differences are evened out
Persistent Inequality	The racial differences in health are observed in earliest childhood and simply continue into old age
Age-as-Survival	Older minorities may be healthier than older whites because only the healthiest minorities survive to late life and because older minorities have gained coping strategies to deal with a lifetime of discrimination
Cumulative Dis/Advantage	As stated in chapter 1, the idea that a lifetime of stresses and discrimination result in health challenges that persist and decrease one's reserve capacity

Adapted from Dowd & Bengtson, 1978; Ferraro & Farmer, 1996.

increased dramatically in the past sixty years, there is still room for progress. Drawing across different disciplines and integrating the social and applied sciences' focus on social and environmental resources and biology's focus on geroscience, we have a better understanding of the how **socioeconomic position (SEP)** factors influence health across the life span. For example, Glymour et al. (2009) pose five models describing how the **timing of risk exposure** may influence development:

1. The immediate effect model looks to identify immediate causes for effects, with the assumption that once a risk factor is removed, symptoms or functioning should change. Scientists can test this model by using designs in which a person serves as her own statistical control. For example, if we were interested in studying how caffeine leads to an increase in blood pressure, we could test blood pressure before, during, and after ingestion of caffeine. We assume that once the caffeine was out of person's system, their blood pressure would return to its baseline measure.
2. A social trajectory model suggests that exposure to certain factors creates a persistent pathway of exposure to other risk factors. For example, Glymour and colleagues discuss the influence of lower educational attainment. Lower education levels are associated with lower paying jobs, which in turn affect the foods one eats, where one lives, and the general environmental conditions, such as pollution and crowding. Thus, the effects on health under a social trajectory model may persist across the life span or may be able to be disrupted at some point.
3. Cumulative models adhere to the idea that risk exposure at each stage of development may cause a cascading of effects because not only are social trajectories altered but the risks directly alter the physiological hardiness of the person. Thus, early exposure may weaken a person's **reserve capacity** such that they are less able to deal with future illnesses or diseases.
4. Sensitive Period models suggest that the effects of exposure to specific risks may be magnified or minimized depending on when a person experiences the exposure. For example, Ingber and Pohl (2016) present data with lab animals' exposure to methylmercury (MeHg) which highlight the need to distinguish effects based on the timing of exposure, dose of exposure (including doses for specific systems), differences in effects across species, and the effects' specific mechanisms of action (i.e., genetic mutations, chromosome damage, chemical imbalances).
5. Physiological effects of trajectory models focus explicitly on how the *changes* in risk factors that are present in the environment lead to later disparities. These kinds of models examine how the magnitude and direction of risk exposure influences health over time. Thus, they focus on the severity of adverse events, not just their mere presence.

SUMMARY AND CONCLUSIONS

Biological aging is a rich and active area of geroscience. Good theories help us to understand the complexities of aging as we continue to discover the mechanisms by which aging influences the systems and cells of our bodies. A focus on the specific sensory changes and chronic health conditions experienced by older adults prompts us to focus on solutions to these issues and prevention of early disability. Moreover, good theory and data are helping us to understand differences in racial, ethnic, and place-based health disparities that may help to even out differences in life expectancy.

KEY TERMS

Absolute threshold
Accommodation
Adaptation
Age-Related Macular Degeneration (AMD)
Atherosclerosis
Audition
Autoimmune theory
Biological aging
Biomarkers
Caloric restriction (CR)
Cancer
Cataracts
Centenarians
Chronic health conditions
Color vision
Dark adaptation
Dementia
Depression
Diabetic retinopathy
Dynamic visual acuity
Error theories
Free radical theory
Generalizable
Genetic-programming theories
Glare
Glaucoma
Gustation
Hayflick Limit
Health span
Heart disease
Heuristic value
Hypertension
Hypogeusia
Hypothalamic-pituitary-adrenal (HPA) axis
Immunological theory
Intermittent fasting (IF)
Life expectancy
Life span
Median age
Neuroendocrine theory
Olfaction
Parsimony/ parsimonious
Peripheral field
Place-based health disparities
Presbycusis
Presbyopia
Presbyosmia
Programmed senescence
Reserve capacity
Sensory aging
Socioeconomic position (SEP)
Somesthesis
Static visual acuity
Stroke
Taste buds
Telomeres
Thermal perception
Timing of risk exposure

Type 2 diabetes (T2D)
Useful Field of View (UFOV)
Variable-rate theories
Vestibular system
Vision
Visual field
Wear-and-tear

EVALUATE YOUR UNDERSTANDING

1. What are the two major theories to explain why we age at a biological level?
2. List some ways to counter oxygen-free radical damage in the human body.
3. What are some of the major age-related changes in the sensory systems?
4. What are five chronic health conditions that many older adults experience?
5. Differentiate among life span, life expectancy, and health span.
6. List several factors that increase/decrease life expectancy.
7. Define menopause, andropause, and oopause.
8. Describe how early life experiences might limit health at mid- and late-life.