Compare These with Those These children seem ideal for cross-sectional research—they are schoolchildren of both sexes and many ethnicities. Their only difference seems to be age, so a study might conclude that 6-year-olds raise their hands but 16-year-olds do not. But any two groups in cross-sectional research may differ in ways that are not obvious—perhaps income, national origin, or culture—and that may be the underlying reason for any differences by age.

Studying Development over the Life Span

In addition to conducting observations, experiments, and surveys, developmentalists must measure how people *change or remain the same over time*, as our definition stresses. Remember that systems are dynamic, ever-changing. To capture that dynamism, developmental researchers use one of three basic research designs: cross-sectional, longitudinal, or cross-sequential.

CROSS-SECTIONAL VERSUS LONGITUDINAL RESEARCH The quickest and least expensive way to study development over time is with **cross-sectional research,** in which groups of people of one age are compared with people of another age. You saw that at the beginning of the chapter: With every decade of age, the proportion of obese people increases.

cross-sectional research
A research design that compares groups of people who differ in age but are similar in other important characteristics.

longitudinal research
A research design in which the same individuals are followed over time, as their development is repeatedly assessed.

Cross-sectional design seems simple. However, it is difficult to ensure that the various groups being compared are similar in every way except age. Because most women now in their 50s gained an average of a pound every year throughout their adulthood, does this mean that women now aged 20 who weigh 140 pounds will, on average, weigh 170 pounds at age 50? Not necessarily.

To help discover whether age itself rather than cohort causes a developmental change, scientists undertake **longitudinal research.** This requires collecting data repeatedly on the same individuals as they age. It is only through longitudinal research that we learned that a third of overweight children become normal weight adults.

However, longitudinal research has several drawbacks. Over time, participants may withdraw, move to an unknown address, or die. These losses can skew the final results if those who disappear are unlike those who stay, as is often the case. Another problem is that participants become increasingly aware of the questions or the goals of the study—knowledge that could affect their behavior over time.

For example, you saw in Figure 1.2 that most overweight children who became normal-weight adults were actually healthier than adults who had never been overweight. How could that be? Perhaps the fact that they knew they had been heavy and that they were now repeatedly measured caused them to eat more fruits and vegetables than they otherwise would have. That is a wonderful result, but it is also a flaw of longitudinal research.

Probably the biggest problem comes from the historical context. Science, popular culture, and politics alter life experiences, and those changes limit the current relevance of data collected on people born decades ago. Results from longitudinal studies of people born in the early twentieth century, as they made their way through childhood, adulthood, and old age, may not be relevant to people born in the twenty-first century.

Six Stages of Life These photos show Sarah-Maria, born in 1980 in Switzerland, at six stages of her life: infancy (age 1), early childhood (age 3), middle childhood (age 8), adolescence (age 15), emerging adulthood (age 19), and adulthood (age 30).

OBSERVATION QUIZ

Longitudinal research best illustrates continuity and discontinuity. For Sarah-Maria, what changed over 30 years and what didn't? **(see answer, page 41)** **▲**

Many recent substances are thought to be harmful by some people but advocated as beneficial by others, among them *phthalates* and *bisphenol A* (BPA) (chemicals used in manufacturing) in plastic baby bottles, *hydrofracking* (a process used to get gas for fuel from rocks), *e-waste* (from old computers and cell phones), and more. Some nations and states ban or regulate each of these; others do not, because verified, longitudinal data are not yet possible.

One example that is directly developmental is *e-cigarettes*, which are less toxic (how much less?) to the heart and lungs than combustible cigarettes. Some (how many?) adult smokers reduce their risk of cancer and heart disease by switching to e-cigs (Bhatnagar et al., 2014). But for some teenagers (how many?) vaping introduces them to using more damaging substances that they otherwise would never use.

Until we know rates of addiction and death for all those e-cig smokers, 10 or 20 years from now, we cannot be sure whether the harm outweighs the benefits (Ramo et al., 2015; Hajek et al., 2014; Dutra & Glantz, 2014). Forty U.S. states have restricted e-cig sales. A spokesman for the Utah Department of Health said, "while we wait for the science on long-term effects . . . thousands of teens in Utah are starting a nicotine addiction via e-cigarettes . . . it's imperative that we get one finger in the dam until we know more" (Bramwell, quoted in McGill, 2015, p. 12).

cross-sequential research A hybrid research design in which researchers first study several groups of people of different ages (a cross-sectional approach) and then follow those groups over the years (a longitudinal approach). (Also called *cohort-sequential research* or *time-sequential research*.)

CROSS-SEQUENTIAL RESEARCH Scientists have discovered a third strategy, combining cross-sectional and longitudinal research. This combination is called **cross-sequential research** (also referred to as *cohort-sequential* or *time-sequential research*). With this design, researchers study several groups of people of different ages (a cross-sectional approach), follow them over the years (a longitudinal approach), and then combine the results.

A cross-sequential design lets researchers compare findings for a group of, say, 16-year-olds with findings for the same individuals at age 1, as well as with

CROSS-SECTIONAL
Total time: A few days, plus analysis

age 1	age 16	age 31	age 46	age 61
Time 1	Time 1	Time 1	Time 1	Time 1

Collect data once. Compare groups. Any differences, presumably, are the result of age.

LONGITUDINAL
Total time: 61 years, plus analysis

age 1 — [15 years later] — age 16 — [15 years later] — age 31 — [15 years later] — age 46 — [15 years later] — age 61

Time 1 — Time 1 + 15 years — Time 1 + 30 years — Time 1 + 45 years — Time 1 + 60 years

Collect data five times, at 15-year intervals. Any differences for these individuals are definitely the result of passage of time (but might be due to events or historical changes as well as age).

CROSS-SEQUENTIAL
Total time: 61 years, plus double and triple analysis

age 1 — [15 years later] — age 16 — [15 years later] — age 31 — [15 years later] — age 46 — [15 years later] — age 61

age 1 — [15 years later] — age 16 — [15 years later] — age 31 — [15 years later] — age 46

age 1 — [15 years later] — age 16 — [15 years later] — age 31

For cohort effects, compare groups on the diagonals (same age, different years).

Time 1 — Time 1 + 15 years — Time 1 + 30 years — Time 1 + 45 years — Time 1 + 60 years

Collect data five times, following the original group but also adding a new group each time. Analyze data three ways, first comparing groups of the same ages studied at different times. Any differences over time between groups who are the same age are probably cohort effects. Then compare the same group as they grow older. Any differences are the result of time (not only age). In the third analysis, compare differences between the same people as they grow older, *after* the cohort effects (from the first analysis) are taken into account. Any remaining differences are almost certainly the result of age.

FIGURE 1.14 Which Approach Is Best? Cross-sequential research is the most time-consuming and complex, but it yields the best information. One reason that hundreds of scientists conduct research on the same topics, replicating one another's work, is to gain some advantages of cohort-sequential research without waiting for decades.

findings for groups who were 16 long ago, and who are now ages 31, 46, and 61 (see Figure 1.14). Cross-sequential research is complicated, in recruitment and analysis, but it lets scientists disentangle age from history.

One well-known cross-sequential study (the *Seattle Longitudinal Study*) found that some intellectual abilities (vocabulary) increase even after age 60, whereas others (speed) start to decline at age 30 (Schaie, 2005/2013), confirming that development is multi-directional. This study also discovered that declines in adult math ability are more closely related to education than to age, something neither cross-sectional nor longitudinal research could reveal.

A more recent cross-sequential study looked at self-esteem in late adulthood. The results were surprising: Self-esteem varied markedly from one person to another, but was quite stable over the decades. Elders with high self-esteem were social and self-sufficient, characteristics that often continued from age 70 to 105 (Wagner et al., 2015).

Cross-sequential research is useful for young adults as well. For example, drug addiction (called *substance use disorder, SUD*) is most common in the early 20s and decreases by the late 20s. But one cross-sequential study found that the origins of SUD are much earlier, in adolescent behaviors and in genetic predispositions (McGue et al., 2014).

ANSWER TO OBSERVATION QUIZ (from page 39) Of course, much changed and much did not change, but evident in the photos is continuity in Sarah-Maria's happy smile and discontinuity in her hairstyle (which shows dramatic age and cohort changes). ●

Cautions and Challenges from Science

The scientific method illuminates and illustrates human development as nothing else does. Facts, consequences, and possibilities have all emerged that would not be known without science—and people of all ages are healthier, happier, and more capable than people of previous generations because of it.

For example, infectious diseases in children, illiteracy in adults, depression in late adulthood, and racism and sexism at every age are much less prevalent today than a century ago. Science deserves credit for all these advances. Even violent death is less likely, with scientific discoveries and education likely reasons (Pinker, 2011).

Developmental scientists have also discovered unexpected sources of harm. Video games, cigarettes, television, shift work, asbestos, and even artificial respiration are all less benign than people first thought.

As these examples attest, the benefits of science are many. However, there are also serious pitfalls. We now discuss three potential hazards: misinterpreting correlation, depending too heavily on numbers, and ignoring ethics.

CORRELATION AND CAUSATION Probably the most common mistake in interpreting research is confusing correlation with causation. A **correlation** exists between two variables if one variable is more (or less) likely to occur when the other does. A correlation is *positive* if both variables tend to increase together or decrease together, *negative* if one variable tends to increase while the other decreases, and *zero* if no connection is evident.

correlation
A number between +1.0 and −1.0 that indicates the degree of relationship between two variables, expressed in terms of the likelihood that one variable will (or will not) occur when the other variable does (or does not). A correlation indicates only that two variables may be somehow related, not that one variable causes the other to occur.

To illustrate: From birth to age 9, there is a positive correlation between age and height (children grow taller as they grow older), a negative correlation between age and amount of sleep (children sleep less as they grow older), and zero correlation between age and number of toes (children do not have more or fewer toes as they grow older).

Expressed in numerical terms, correlations vary from +1.0 (the most positive) to −1.0 (the most negative). Correlations are almost never that extreme; a correlation of +0.3 or −0.3 is noteworthy; a correlation of +0.8 or −0.8 is astonishing.

Many correlations are unexpected. For instance, first-born children are more likely to develop asthma than are later-born children, teenage girls have higher rates of mental health problems than do teenage boys, and counties in the United States with more dentists have fewer obese residents. That later study controlled for the number of medical doctors and the poverty of the community. The authors suggest that dentists provide information about nutrition that improves health (Holzer et al., 2014).

At this point, remember that *correlation is not causation*. Just because two variables are correlated does not mean that one causes the other—even if it seems logical that it does. It proves only that the variables are connected somehow. Many mistaken and even dangerous conclusions are drawn because people misunderstand correlation.

QUANTITY AND QUALITY A second caution concerns how heavily scientists should rely on data produced by **quantitative research** (from the word *quantity*). Quantitative research data can be categorized, ranked, or numbered and thus can be easily translated across cultures and for diverse populations. One example of quantitative

quantitative research
Research that provides data that can be expressed with numbers, such as ranks or scales.

research is the use of children's school achievement scores to compare the effectiveness of education within a school or nation.

Since quantities can be easily summarized, compared, charted, and replicated, many scientists prefer quantitative research. Statistics require numbers. Quantitative data are easier to replicate and less open to bias, although researchers who choose this method have some implicit beliefs about evidence and verification (Creswell, 2009).

However, when data are presented in categories and numbers, some nuances and individual distinctions are lost. Many developmental researchers thus turn to **qualitative research** (from *quality*)—asking open-ended questions, reporting answers in narrative (not numerical) form.

qualitative research
Research that consider qualities instead of quantities. Descriptions of particular conditions and participants' expressed ideas are often part of qualitative studies.

Qualitative researchers are "interested in understanding how people interpret their experiences, how they construct their worlds . . ." (Merriam, 2009, p. 5). Qualitative research reflects cultural and contextual diversity, but it is also more vulnerable to bias and harder to replicate. Both types of research are needed.

ETHICS The most important caution for all scientists, especially for those studying humans, is to uphold ethical standards. Each academic discipline and professional society involved in the study of human development has a *code of ethics* (a set of moral principles) and specific practices within a scientific culture to protect the integrity of research.

Ethical standards and codes are increasingly stringent. Most educational and medical institutions have an *Institutional Review Board* (IRB), a group that permits only research that follows certain guidelines.

Although IRBs often slow down scientific study, some research conducted before they were established was clearly unethical, especially when the participants were children, members of minority groups, prisoners, or animals. Some argue that serious ethical dilemmas remain (Leiter & Herman, 2015).

Researchers must ensure that participation is voluntary, confidential, and harmless. In Western nations, this entails the *informed consent* of the participants—that is, the participants must understand and agree to the research procedures and know what risks are involved. A dilemma occurs when severe consequences might follow either participation or non-participation.

Many ethical dilemmas arose in the Ebola epidemic (Rothstein, 2015; Gillon, 2015). Among them: Is it fair to use vaccines that have not been proven safe, when such proof would take months and the death rate from Ebola would increase? What kind of informed consent is needed to avoid both false hope and false fears? Is it justified to keep relatives away from sick people who might have Ebola, even though


JOHN MOORE/GETTY IMAGES

Science and Ebola Ebola halted as much because of social science as medicine, which has not yet found an effective vaccine. Fortunately, social workers taught practices that were contrary to West African culture—no more hugging, touching, or visiting from one neighborhood to another. Psychologists advised health workers, like this one from Doctors Without Borders, to hold, reassure, and comfort children as much as possible. This girl was *not* among the 5,000 Liberians who died.