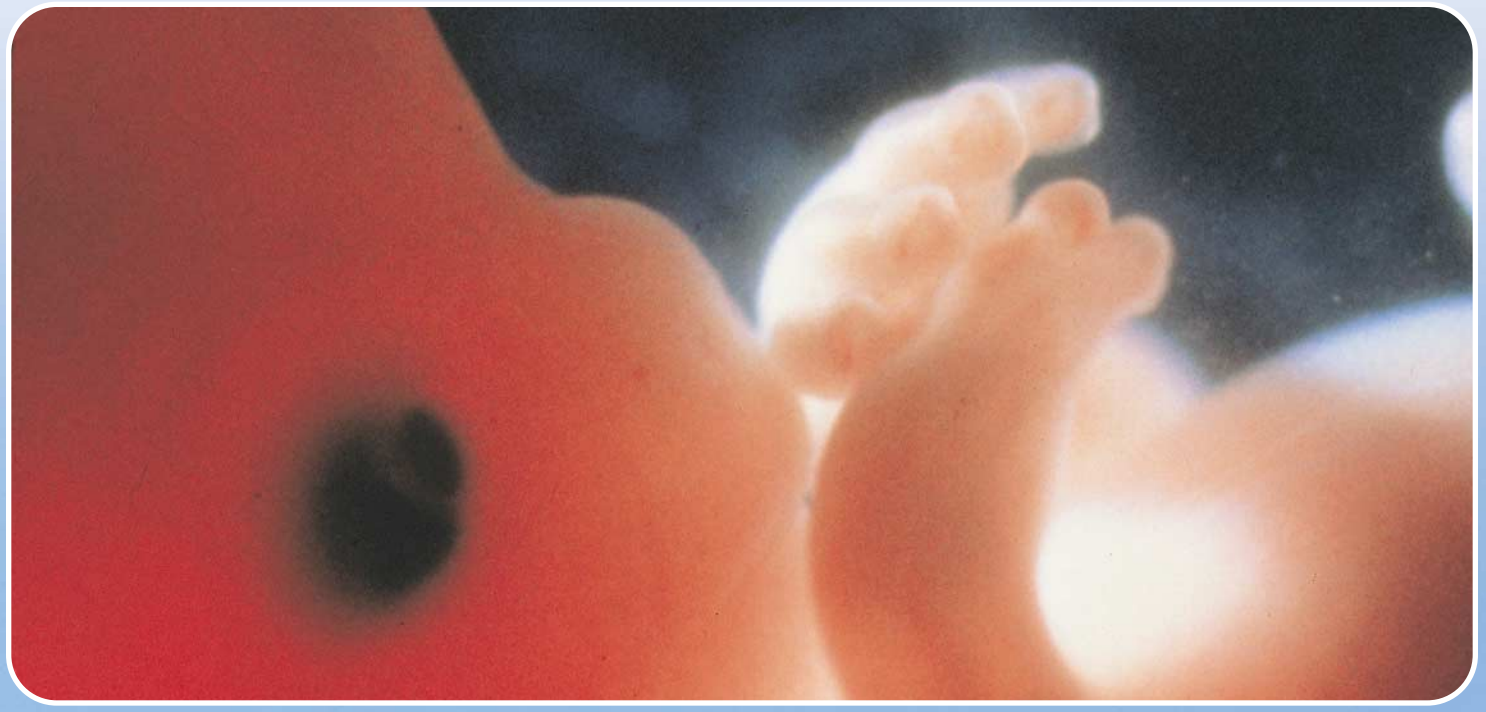
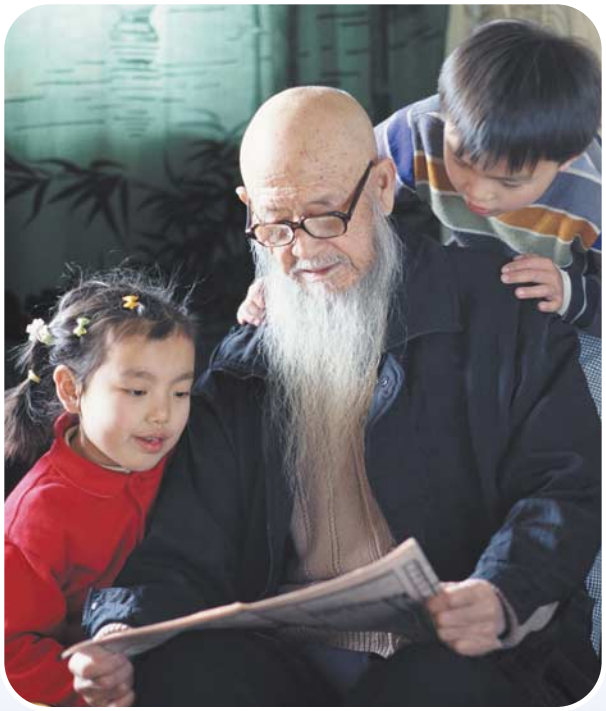
Section 2
Beginnings

What endless questions vex the thought, of whence and whither, when and how.

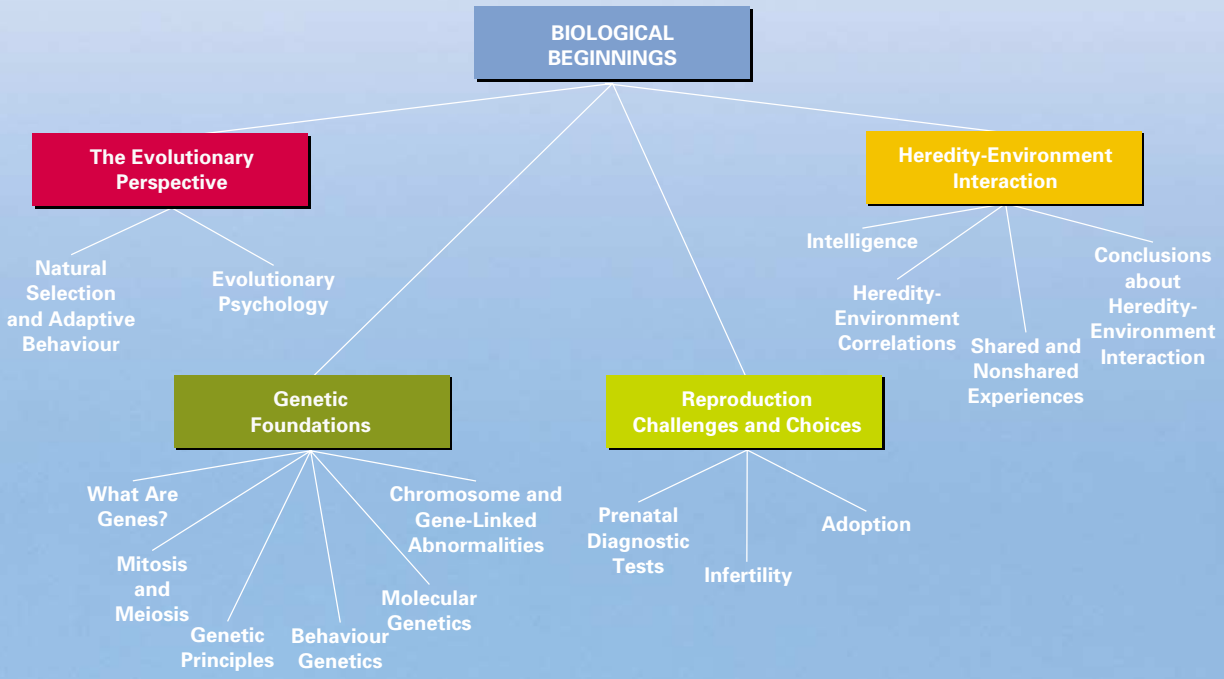
Sir Richard Burton, English Explorer, 19th Century

The rhythm and meaning of life involve beginnings. Questions are raised about how, from so simple a beginning, endless forms develop and grow and mature. What was this organism, what will this organism be? Section 2 contains two chapters: "Biological Beginnings" (Chapter 3) and "Prenatal Development and Birth" (Chapter 4).





Chapter 3
Biological Beginnings



There are one hundred and ninety-three living species of monkeys and apes. One hundred and ninety-two of them are covered with hair. The exception is the naked ape, self-named Homo sapiens.

Desmond Morris, Contemporary British Zoologist

Images of Life-Span Development

Your Genetics versus Your Environment

The Human Genome Project and privately owned Celera Genomics announced in the summer of 2000 that a first draft of the genetic code for humans had been worked out. The potential for improved quality and length of life is being offered as the main reason for pursuing the fully accurate genetic map for humans. If the genes which triggered cancer cells brought the onset of Alzheimer's or caused heart disease were known, then perhaps we could turn them off, or alter them in some fashion, to avoid the illness. Perhaps the same might be true for social concerns, such as criminal behaviour. If we knew the full code, we could construct the "perfect" human. To date, though, scientists have cloned sheep, a few pigs and cows, a mule, and several dozen mice. Each cloning has been done using slightly different methods. All involved many attempts before the method worked. Most cloned animals appear to develop serious defects, from enlarged organs to circulatory and respiratory problems, and show a tendency to die young. Cloning humans is currently not a possibility.

Farm worker Marc Noel attends to Canada's first cloned calf, Starbuck II.

But what if we could choose the genetic character of a person, making her/him attractive, intelligent, and strong? Some suggest this would be morally unthinkable; others see a reduction in health and social care costs and perceive the idea of a perfect world. Would a genetically created human be able to escape cancer, Alzheimer's, or criminal behaviour? Certainly, there are environmental factors which lead to the first two, and the third is really defined by laws, which are created on the basis of the values of those in government. Perhaps we could select those people who fit the ideal type (for now we will leave out the argument about who decides what the ideal type would be). If we cloned these people and created an exact physical copy of them, would that copy also be psychologically identical? The "new" copies would have the genetic make-up of the original, but not the life history or environmental experiences of the original. What difference would this make?

One way in which psychologists currently study these last two questions is through research on twins. Thomas Bouchard and his colleagues address these questions as part of the Minnesota Study of Twins Reared Apart. They bring identical twins (identical genetically because they come from the same fertilized egg) and fraternal twins (dissimilar genetically because they come from different fertilized eggs) from all over the world to Minneapolis to investigate their lives. The twins are given a number of personality tests and detailed medical histories are obtained, including information about diet and smoking, exercise habits, chest X-rays, heart stress tests, and EEGs (brain-wave tests). The twins are interviewed and

Critical Thinking

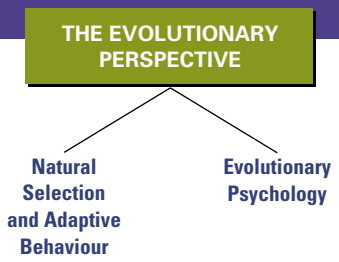
Bill C-13 prohibits cloning humans in Canada. Create a list of advantages and a list of disadvantages to cloning humans. Now, create a third list of things that would be interesting to discover with cloning but would be neither positive nor negative. Discuss with a fellow student your "interesting" list or, if you could not create one, the difficulty in generating such a list.

asked more than 15,000 questions about their family and childhood environment, personal interests, vocational orientation, values, and aesthetic judgments. They also are given ability and intelligence tests (Bouchard & others, 1990).

Critics of the Minnesota identical twins study point out that some of the separated twins were together several months prior to their adoption, that some of the twins had been reunited prior to their testing (in some cases, a number of years earlier), that adoption agencies often place twins in similar homes, and that even strangers who spend several hours together and start comparing their lives are likely to come up with some coincidental similarities (Adler, 1991). Nevertheless, the Minnesota study of identical twins indicates that scientists recently have shown an increased interest in the genetic basis of human development and that we need further research on genetic and environmental factors (Bouchard, 1995).

The possibility of human cloning stimulates us to think about our genetic heritage and the biological foundations of our existence. Organisms are not like billiard balls, moved by simple, external forces to predictable positions on life's pool table. Environmental experiences and biological foundations work together to make us who we are. Our coverage of life's biological beginnings in this chapter focuses on theories and research about evolution, genetic foundations, reproduction challenges and choices, and the interaction of heredity and environment.

The Evolutionary Perspective



In evolutionary time, humans are relative newcomers to Earth, yet we have established ourselves as the most successful and dominant species. If we consider evolutionary time as a calendar year, humans arrived here in the last moments of December (Sagan, 1977). As our earliest ancestors left the forest to feed on the savannah, and finally to form hunting societies on the open plains, their minds and behaviours changed. How did this evolution come about?

Natural Selection and Adaptive Behaviour

Human Genome Project

Natural selection is the evolutionary process that favours individuals of a species that are best adapted to survive and reproduce. To understand natural selection, let us return to the middle of the 19th century, when Charles Darwin was travelling around the world, observing many different species of animals in their natural surroundings. Darwin, who published his observations and thoughts in *On the Origin of Species* (1859), observed that most organisms reproduce at rates that would cause enormous increases in the population of most species, and yet populations remain nearly constant. He reasoned that an intense, constant struggle for food, water, and resources must occur among the many young born each generation because many of the young do not survive. Those that do survive pass on their genes to the next generation. Darwin believed that those who do survive to reproduce are probably superior in a number of ways to those who do not. In other words, the survivors are better adapted to their world than are the nonsurvivors (Raven & others, 2002). Over the course of many generations, organisms with the characteristics needed for survival would comprise a larger percentage of the population. Over many, many generations, this could produce a gradual modification of the whole population. If environmental conditions change, however, other characteristics might become favoured by natural selection, moving the process in a different direction (Zubay, 1996).

Evolution
Evolution and Behaviour

To understand the role of evolution in behaviour, we need to understand the concept of adaptive behaviour. In evolutionary conceptions of psychology, *adaptive behaviour* is behaviour that promotes an organism's survival in the natural habitat. Adaptive behaviour involves the organism's modification of its behaviour to include its likelihood of survival (Cosmides & others, 2003). All organisms must adapt to particular places, climates, food sources, and ways of life. Natural selection designs adaptation to perform a certain function. An example of adaptation is an eagle's claws, designed by natural selection to facilitate predation. In the human realm, attachment is a system designed by nat-

ural selection to ensure an infant's closeness to the caregiver for feeding and protection from danger.

Evolutionary Psychology

Although Darwin introduced the theory of evolution by natural selection in 1859, his ideas about evolution only recently have emerged as a popular framework for explaining behaviour (Silverman, 2003). Psychology's newest approach, **evolutionary psychology**, *emphasizes the importance of adaptation, reproduction, and "survival of the fittest" in explaining behaviour*. Evolution favours organisms that are best adapted to survive and reproduce in a particular environment. The evolutionary psychology approach focuses on conditions that allow individuals to survive or to fail. In this view, the evolutionary process of natural selection favours behaviours that increase organisms' reproductive success and their ability to pass their genes to the next generation (Bjorklund & Bering, 2001; Caporael, 2001; Durrant & Ellis, 2003).

David Buss's (1995, 1999, 2000) ideas on evolutionary psychology have ushered in a whole new wave of interest in how evolution is involved in explaining human behaviour. He believes that just as evolution shapes our physical features, such as body shape and height, it also pervasively influences how we make decisions, how aggressive we are, our fears, and our mating patterns.

Evolution and Life-Span Development According to life-span developmentalist Paul Baltes (1996; Baltes, Staudinger, & Lindenberger, 1999), the benefits of evolutionary selection decrease with age. As a result, older adults have a higher number of deleterious genes and dysfunctional gene expressions.

Why do the later years of life benefit less from the optimizing power of evolutionary selection pressure than the younger years? The main reason is reproductive fitness, which generally extends from conception through the earlier part of adulthood. As a consequence, says Baltes, selection operates mainly during the first half of life. Also, given the much shorter life span in early human evolution, selection pressure could not function as often in the later years of life. Most individuals died before possible negative genetic attributes were activated or their negative consequences appeared.

A concrete example of a decrease in evolutionary selection benefits in older adults involves Alzheimer's disease, a progressive, irreversible brain disorder characterized by gradual deterioration. This disease typically does not appear until age 65 or older. Possibly, such diseases as Alzheimer's emerge in later life because evolutionary pressures based on reproductive fitness were not able to select against it.

While Baltes believes that the benefits of evolutionary selection decrease following the decline in reproductive capacity, he argues that the need for culture increases (see figure 3.1). Some of the cultural factors needed are cognitive skills, motivation, socialization, literacy, and medical technology. That is, as older adults weaken biologically, they need culture-based resources (material, social, economic, psychological). For example, for cognitive skills to continue into old age at comparable levels of performance to earlier in adulthood, cognitive support and training are needed (Hoyer, Rybash, & Roodin, 1999). And, as we indicated in Chapter 1, Baltes also stresses that a life-span shift in the allocation of resources takes place away from growth and toward maintenance and the regulation of loss.

Evaluating Evolutionary Psychology Albert Bandura (1998), whose social cognitive theory was described in Chapter 2, recently addressed the "biologizing" of psychology and evolution's role in social cognitive theory pp. 49–50. Bandura acknowledges the important influence of evolution on human adaptation and change. However, he rejects what he calls "one-sided evolutionism," which sees social behaviour as the product of evolved biology. In the bi-directional view, evolutionary pressures created changes in biological structures for the use of tools, which enabled organisms to manipulate, alter, and construct new environmental conditions. Environmental innovations of

Humans, more than any other animal, adapt to and control most types of environments. Because of longer parental care, humans learn more complex behaviour patterns, which contribute to adaptation. *What are some other adaptive aspects of human behaviour that might be tied to evolution?*

evolutionary psychology
A contemporary approach that emphasizes that behaviour is a function of mechanisms, requires input for activation, and is ultimately related to survival and reproduction.

Evolutionary Psychology
Handbook of Evolutionary Psychology
Evolutionary Psychology Resources

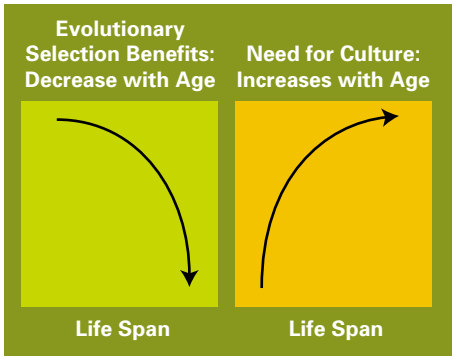


FIGURE 3.1
Baltes's View of Evolution and Culture across the Life Span

increasing complexity produced, in turn, new selection pressures for the evolution of specialized biological systems for consciousness, thought, and language.

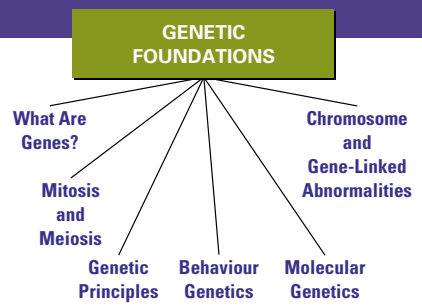
Human evolution gave us bodily structures and biological potentialities, not behavioural dictates. Having evolved, advanced biological capacities can be used to produce diverse cultures—aggressive, pacific, egalitarian, or autocratic. Steven Jay Gould (1981) concluded that in most domains of human functioning, biology allows a broad range of cultural possibilities. Theodore Dobzhansky (1977) reminds us that the human species has been selected for the ability to learn and plasticity—for the capacity to adapt to diverse contexts, not for biologically fixed behaviour. Bandura (1998) points out that the pace of social change shows that biology does permit a range of possibilities.

To this point, we have studied a number of ideas about the evolutionary perspective. A review of these ideas is presented in summary table 3.1.

SUMMARY TABLE 3.1 The Evolutionary Perspective

Concept	Characteristics/Description
Natural Selection and Adaptive Behaviour	• Natural selection is the process that favours the individuals of a species that are best adapted to survive and reproduce. • The process of natural selection was originally proposed by Charles Darwin.
	• In evolutionary theory, adaptive behaviour is behaviour that promotes the organism's survival in a natural habitat. • Biological evolution shaped human beings into a culture-making species.
	• The view that adaptation, reproduction, and "survival of the fittest" are important in explaining behaviour.
Evolutionary Psychology	• According to Baltes, the benefits of evolutionary selection decrease with age mainly because of a decline in reproductive fitness. • While evolutionary selection benefits decrease with age, cultural needs increase.
Evaluating Evolutionary Psychology	• Social cognitive theorist Albert Bandura acknowledges evolution's important role in human adaptation and change, but argues for a bi-directional view that enables organisms to alter and construct new environmental conditions. • Biology allows for a broad range of cultural possibilities.

Genetic Foundations



chromosomes
Threadlike structures that come in 23 pairs, one member of each pair coming from each parent. Chromosomes contain the genetic substance DNA.

DNA
A complex molecule that contains genetic information.

genes
Units of hereditary information composed of DNA. Genes act as a blueprint for cells to reproduce themselves and manufacture the proteins that maintain life.

Every species must have a mechanism for transmitting characteristics from one generation to the next. This mechanism is explained by the principles of genetics. Each of us carries a genetic code that we inherited from our parents. This code is located within every cell in our bodies. Our genetic codes are alike in one important way—they all contain the human genetic code. Because of the human genetic code, a fertilized human egg cannot grow into an egret, eagle, or elephant.

What Are Genes?

Each of us began life as a single cell weighing about one-fifty-millionth of a gram! This tiny piece of matter housed our entire genetic code—information about who we would become. These instructions orchestrated growth from that single cell to a person made of trillions of cells, each containing a perfect replica of the original genetic code.

The nucleus of each human cell contains 46 **chromosomes**, *which are threadlike structures that come in 23 pairs, one member of each pair coming from each parent. Chromosomes contain the remarkable genetic substance deoxyribonucleic acid, or DNA.* **DNA** *is a complex molecule that contains genetic information. DNA's "double helix" shape looks like a spiral staircase.* **Genes**, *the units of hereditary information, are short segments composed of DNA. Genes act as a blueprint for cells to reproduce themselves and manufacture the proteins that maintain life.* Chromosomes, DNA, and genes can be mysterious. To help you turn mystery into understanding, see figure 3.2.

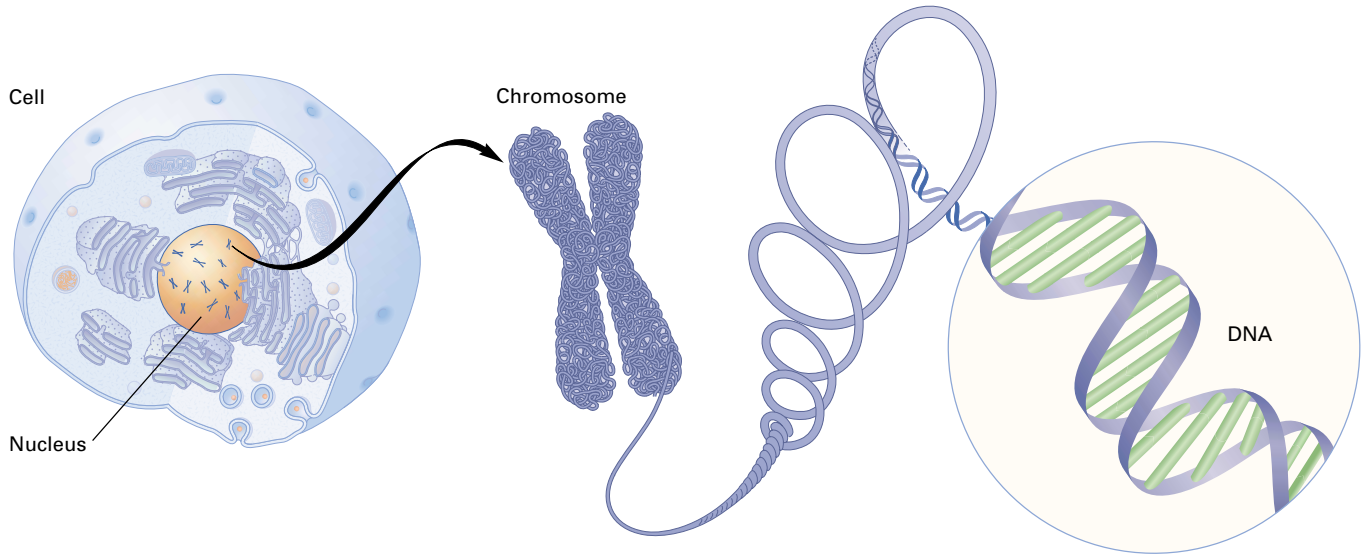


FIGURE 3.2
Cells, Chromosomes, Genes, and DNA

(*Left*) The body contains trillions of cells, which are the basic structural units of life. Each cell contains a central structure, the nucleus. (*Middle*) Chromosomes and genes are located in the nucleus of the cell. Chromosomes are made up of threadlike structures composed of DNA molecules. (*Right*) A gene, a segment of DNA that contains the hereditary code. The structure of DNA is a spiralled double chain.

Mitosis and Meiosis

Mitosis and meiosis are biological processes that are important to understanding how genes function.

Mitosis is the term applied to the division of autosomal (body) cells. It requires that the chromosomes be duplicated before the cell divides so that each new cell will have the correct number of chromosomes. Each of our body cells has 23 pairs or 46 individual chromosomes. This number includes 22 autosomal (body) pairs and one pair of sex chromosomes. In mitosis, two daughter cells are formed, each with 23 pairs of chromosomes.

Meiosis is the process that reduces the number of chromosomes in a sex cell to half the normal number. One phase of meiosis is a reduction division, and when it is completed each of the cells produced will have only 23 chromosomes. Reduction division is necessary so that when the ovum and sperm join they will each contribute 23 chromosomes to the zygote for a total of 46 individual or 23 pairs of chromosomes. In meiosis four daughter cells are formed, each with 23 individual strands of chromosomes (see figure 3.3).

The sperm and the ovum are referred to as gamates, and because of the activities in meiosis, they each have 23 unpaired chromosomes. When a cell has half the normal complement of chromosomes, it is referred to as haploid. During **reproduction**, the **zygote**, a single cell, is formed by the fertilization of the ovum by the sperm. The zygote has 46 individual or 23 pairs of chromosomes.

mitosis
The process of cell division during which cellular material is duplicated and two daughter cells are formed.

meiosis
The process of cellular division that divides sex cells and produces four daughter cells, each with 23 single chromosomes.

reproduction
The process that, in humans, begins when a female gamete (ovum) is fertilized by a male gamete (sperm).

zygote
A single cell formed when an ovum is fertilized by a sperm.

Genetic Principles

Genetic determination is a complex affair, and much is unknown about the way genes work (Lewis, 2003). But a number of genetic principles have been discovered, among them those of dominant-recessive genes, sex-linked genes, polygenically inherited characteristics, reaction range, and canalization.

According to the *dominant-recessive genes principle*, if one gene of a pair is dominant and one is recessive, the dominant gene exerts its effect, overriding the potential influence of the other, recessive gene. A recessive gene exerts its influence only if both genes of a pair are recessive. If you inherit a recessive gene for a trait from both your parents, you

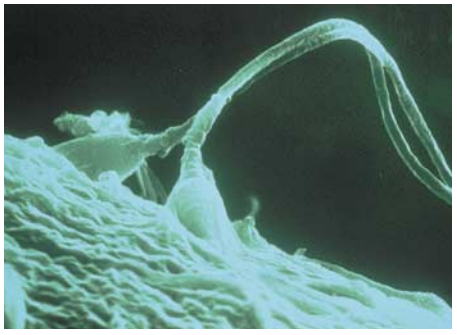


FIGURE 3.3
Union of Sperm and Egg

will show the trait. If you inherit a recessive gene from only one parent, you may never know you carry the gene. Brown eyes, farsightedness, and dimples rule over blue eyes, nearsightedness, and freckles in the world of dominant-recessive genes. Can two brown-eyed parents have a blue-eyed child? Yes, they can. Suppose that in each parent the gene pair that governs eye colour includes a dominant gene for brown eyes and a recessive gene for blue eyes. Since dominant genes override recessive genes, the parents have brown eyes, but both are carriers of blueness and pass on their recessive genes for blue eyes. With no dominant gene to override them, the recessive genes can make the child's eyes blue. Figure 3.4 illustrates the dominant-recessive genes principles.

For thousands of years, people wondered what determined whether we become male or female. Aristotle believed that the father's arousal during intercourse determines the offspring's sex. The more excited the father was, the more likely it would be a son, he reasoned. Of course, he was wrong, but it was not until the 1920s that researchers confirmed the existence of human sex chromosomes, two of the 46 chromosomes human beings normally carry. Ordinarily, females have two X chromosomes, and males have an X and a Y. (Figure 3.5 shows the chromosomal makeup of a male and a female.)

Genetic transmission is usually more complex than the simple examples we have examined thus far (Weaver & Hedrick, 1999). *Polygenic inheritance* is the genetic principle that many genes can interact to produce a particular characteristic. Few psychological characteristics are the result of single pairs. Most are determined by the interaction of many different genes. There are about 30,000 to 35,000 genes in the human genome, so you can imagine that possible combinations of these are staggering in number. Traits produced by this mixing of genes are said to be polygenically determined.

No one possesses all the characteristics that our genetic structure makes possible. A **genotype** *is the person's genetic heritage, the actual genetic material*. However, not all of this genetic material is apparent in our observed and measurable characteristics. A **phenotype** *is the way an individual's genotype is expressed in observed and measurable characteristics*. Phenotypes include physical traits (such as height, weight, eye colour, and skin pigmentation) and psychological characteristics (such as intelligence, creativity, personality, and social tendencies).

For each genotype, a range of phenotypes can be expressed. Imagine that we could identify all of the genes that would make a person introverted or extroverted. Would measured introversion-extroversion be predictable from knowledge of the specific genes? The answer is no because even if our genetic model were adequate, introversion/extroversion is a characteristic shaped by experience throughout life. For example, parents may push an introverted child into social situations and encourage the child to become more gregarious.

To understand how introverted a child is, think about a series of genetic codes that predispose the child to develop in a particular way, and imagine environments that are

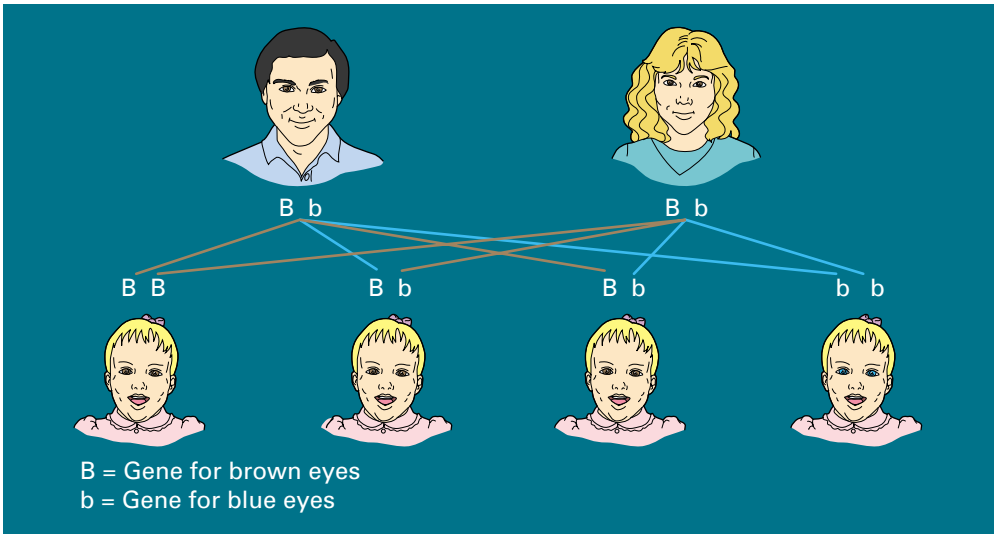
Landmarks in the History of Genetics
Heredity Resources
Genetic Journals and News

genotype
A person's genetic heritage; the actual genetic material.

phenotype
The way an individual's genotype is expressed in observed and measurable characteristics.

FIGURE 3.4
How Brown-Eyed Parents Can Have a Blue-Eyed Child

Although both parents have brown eyes, each parent can have a recessive gene for blue eyes. In this example, both parents have brown eyes, but each parent carries the recessive gene for blue eyes. Therefore, the odds of their child having blue eyes is one in four—the probability the child will receive a recessive gene *(b)* from each parent.

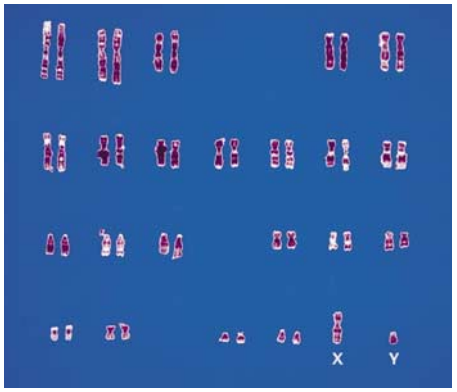


responsive or unresponsive to this development. For instance, the genotype of some persons may predispose them to be introverted in an environment that promotes a turning inward of personality, yet, in an environment that encourages social interaction and outgoingness, these individuals may become more extroverted. However, it would be unlikely for the individual with this introverted genotype to become a strong extrovert. The **reaction range** *is the range of possible phenotypes for each genotype, suggesting the importance of an environment's restrictiveness or richness* (see figure 3.6).

Sandra Scarr (1984) explains reaction range this way: Each of us has a range of potential. For example, an individual with "medium-tall" genes for height who grows up in a poor environment may be shorter than average; however, in an excellent nutritional environment, the individual may grow up taller than average. No matter how well fed the person is, though, someone with "short" genes will never be taller than average. Scarr believes that such characteristics as intelligence and introversion work the same way. That is, there is a range within which the environment can modify intelligence, but intelligence is not completely malleable. Reaction range gives us an estimate of how modifiable intelligence is.

Although some traits have a wide reaction range, others are somewhat immune to extensive changes in the environment. These characteristics seem to stay on a particular developmental course, regardless of the environmental assaults on them (Waddington, 1957). **Canalization** *is the term chosen to describe the narrow path, or developmental course, that certain characteristics take. Apparently, preservative forces help protect, or buffer, a person from environmental extremes.* For example, Jerome Kagan (1984) points to his research on Guatemalan infants who had experienced extreme malnutrition as infants, yet showed normal social and cognitive development later in childhood.

Although the genetic influence of canalization exerts its power by keeping organisms on a particular developmental path, genes alone do not directly determine human behaviour. Developmentalist Gilbert Gottlieb (1991, 2000; Gottlieb, Wahlsten, & Lickliter, 1998) points out that genes are an integral part of the organism but that their activity (genetic expression) can be affected by the organism's environment. For example, hormones that circulate in the blood make their way into the cell, where they influence the cell's activity. The flow of hormones themselves can be affected by environmental events, such as light, day length, nutrition, and behaviour.



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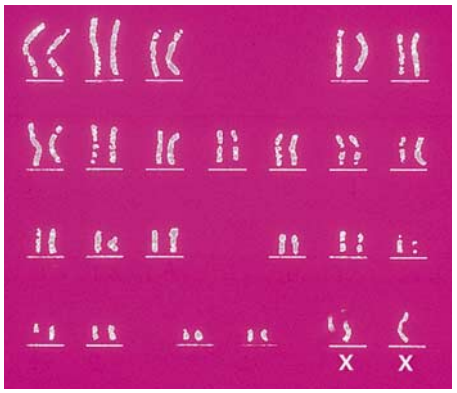


b

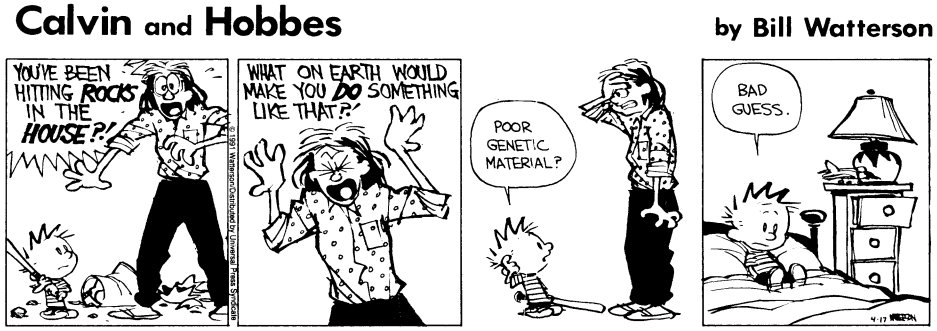
FIGURE 3.5
The Genetic Difference between Males and Females

Set (*a*) shows the chromosome structure of a male, and set (*b*) shows the chromosome structure of a female. The last pair of 23 pairs of chromosomes is in the bottom right box of each set. Note that the Y chromosome of the male is smaller than the X chromosome of the female. To obtain this kind of chromosomal picture, a cell is removed from a person's body, usually from the inside of the mouth. The chromosomes are stained by chemical treatment, magnified, and then photographed.

Behaviour Genetics

Comparing twins reared apart is one of a number of methods used to examine heredity's influence on behaviour. **Behaviour genetics** *is the study of the degree and nature of behaviour's hereditary basis.* Behaviour geneticists assume that behaviours are jointly determined by the interaction of heredity and environment (Goldsmith, 1994; Rowe, 2001; Wahlsten, 2000).

To study the influence of heredity on behaviour, behaviour geneticists often use either twins or adoption situations. In the most common **twin study**, *the behavioural similarity of identical twins is compared with the behavioural similarity of fraternal twins. Identical twins* (called monozygotic twins) develop from a single fertilized egg that splits



reaction range
The range of possible phenotypes for each genotype, suggesting the importance of an environment's restrictiveness or richness.

canalization
The process by which characteristics take a narrow path or developmental course. Apparently, preservative forces help protect a person from environmental extremes.

behaviour genetics
The study of the degree and nature of behaviour's basis in heredity.

twin study
A study in which the behavioural similarity of identical twins is compared with the behavioural similarity of fraternal twins.

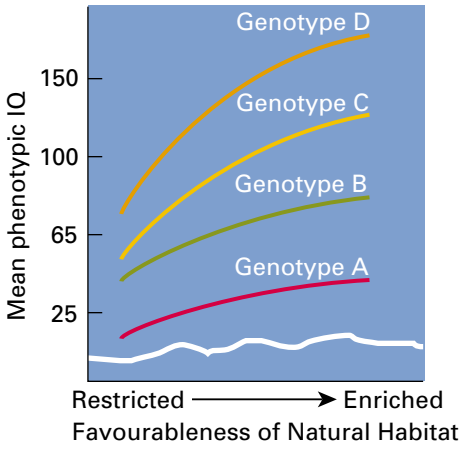


FIGURE 3.6
Responsiveness of Genotypes to Environmental Influences

Although each genotype responds favourably to improved environments, some are more responsive than others to environmental deprivation and enrichment.

Behaviour Genetics
Twin Research

adoption study
A study in which investigators seek to discover whether, in behaviour and psychological characteristics, adopted children are more like their adoptive parents, who provided a home environment, or more like their biological parents, who contributed their heredity. Another form of the adoption study compares adoptive and biological siblings.

Down syndrome
A chromosomally transmitted form of mental retardation, caused by the presence of an extra chromosome.

Paul (centre) was best man at his sister's wedding. He is seen here with wedding guests and friends.

into two genetically identical replicas, each of which becomes a person. *Fraternal twins* (called dizygotic twins) develop from separate eggs and separate sperm, making them genetically no more similar than ordinary siblings. Although fraternal twins share the same womb, they are no more alike genetically than are nontwin brothers and sisters, and they may be of different sexes. By comparing groups of identical and fraternal twins, behaviour geneticists capitalize on the basic knowledge that identical twins are more similar genetically than are fraternal twins (Mitchell, 1999; Plomin & DeFries, 1998; Scarr, 1996). In one twin study, 7,000 pairs of Finnish identical and fraternal twins were compared on the personality traits of extroversion and neuroticism (psychological instability) (Rose & others, 1998). On both these personality traits, the identical twins were much more similar than the fraternal twins, suggesting the role of heredity in both traits. However, several issues crop up as a result of twin studies. Adults might stress the similarities of identical twins more than those of fraternal twins, and identical twins might perceive themselves as a "set" and play together more than fraternal twins. If so, observed similarities in identical twins could be environmentally influenced.

In an **adoption study**, *investigators seek to discover whether, in behaviour and psychological characteristics, adopted children are more like their adoptive parents, who provided a home environment, or more like their biological parents, who contributed their heredity. Another form of the adoption study compares adoptive and biological siblings.* In one investigation, the educational levels attained by the biological parents were better predictors of the adopted children's IQ scores than were the IQs of the children's adopted parents (Scarr & Weinberg, 1983). The implication is that heredity influences children's IQ scores.

Molecular Genetics

Studies of behaviour genetics do not focus on the molecular makeup of genes. Rather, behaviour geneticists study the effects of heredity at a more global level by such methods as comparing the behaviour of identical and fraternal twins.

Today, there is a great deal of enthusiasm about the use of molecular genetics to discover the specific locations of genes that determine an individual's susceptibility to many diseases and other aspects of health and well-being.

The term *genome* is used to describe the complete set of instructions for making an organism, the master blueprint for all cellular structures and activities for the life span of the organism. The human genome consists of tightly coiled threads of DNA.

As noted in this chapter's opening vignette, the Human Genome Project, begun in the 1970s, has made stunning progress in mapping the human genome. For example, genes have been located for Huntington disease (which causes the central nervous system to deteriorate), some forms of cancer, and many other diseases. Once these genetic markers are found, what next? One strategy is to find a healthy copy of the missing gene and transplant it into the affected cells. Another is to develop drugs that will alter the genetic makeup of the affected cells.

Chromosome and Gene-Linked Abnormalities

Let us examine some abnormalities that can occur in chromosomes and genes. As you will see, some of these abnormalities involve chromosomes, others harmful genes.

Chromosome Abnormalities

When gametes are formed, the 46 chromosomes do not always divide evenly. In this case, the resulting sperm and ovum do not have their normal 23 chromosomes. The most notable instances when this occurs involve Down syndrome and abnormalities of the sex chromosomes (see figure 3.7).

Down Syndrome

Down syndrome *is a chromosomally transmitted form of mental retardation, caused by the presence of an extra chromosome* (number 21). The syndrome is also referred to as Trisomy 21. An individual with Down syndrome has a round face, a flattened skull, an extra fold of skin over the eyelids, a protruding tongue, short limbs, and retardation of motor and mental abilities. It is not known why the extra chromo-

Name	Description	Treatment	Incidence
Down syndrome	Extra or altered 21st chromosome causes mild to severe retardation and physical abnormalities.	Surgery, early intervention, infant stimulation, and special learning programs	1 in 1,900 births at maternal age 20 1 in 300 births at maternal age 35 1 in 30 births at maternal age 45
Klinefelter syndrome	An extra X chromosome causes physical abnormalities.	Hormone therapy can be effective	1 in 800 males
Fragile X syndrome	An abnormality in the X chromosome can cause mental retardation, learning disabilities, or short attention span.	Special education, speech and language therapy	1 in 1,500 males 1 in 2,500 females
Turner syndrome	A missing X chromosome in females can cause mental retardation and sexual underdevelopment.	Hormone therapy in childhood and puberty	1 in 3,000 female births
XYY syndrome	An extra Y chromosome can cause above-average height.	No special treatment required	1 in 1,000 male births

FIGURE 3.7
Some Chromosome Abnormalities

some is present, but the health of the sperm or ovum may be involved (Davison, Gardiner, & Costa, 2001; MacLean, 2000). Women between the ages of 18 and 38 are less likely to give birth to a child with Down syndrome than are younger or older women. The overall prevalence rate is 14.4 per 10,000 births in Canada (Health Canada, 2002). The risk of giving birth to a child with Down syndrome rises with the age of the mother but has no relation to the father's age. The Alberta Congenital Anomaly Surveillance System reported that between 1990 and 1998, the incidence of a child being born with Down syndrome was 7.2 per 10,000 for women aged 25 to 29 and 28.3 per 10,000 for women aged 35 to 39.

Genetic Disorders
Prenatal Testing and Down Syndrome

Sex-Linked Chromosome Abnormalities Genetic disorders can be inherited through the chromosomes which determine the sex of the child. The Y chromosome is not known to carry any disease-causing genes; therefore, the X chromosome appears to be responsible for sex-linked chromosomal abnormalities. Since males receive only one X chromosome, a recessive gene will cause disease in the male, but a female requires a recessive gene on each of her two X chromosomes or only one X chromosome with the recessive gene (missing the other altogether) for the disease to appear. Thus, males are more likely to be affected by sex-linked chromosome abnormalities. Approximately one in every 500 infants either is missing a second X chromosome or has an X chromosome that is combined with two more sex chromosomes. Three such sex-linked chromosomal disorders are Klinefelter syndrome, fragile X syndrome, and Turner syndrome (Baum, 2000).

Klinefelter syndrome *is a genetic disorder in which males have an extra X chromosome, making them XXY instead of XY.* The extra X chromosome occurs during the formation of either the sperm or the egg or during the early fetal development. Males with this disorder have underdeveloped testes, and they usually have enlarged breasts and are above average in height. Testosterone can be given to promote appropriate secondary sexual characteristics. Men with Klinefelter syndrome will have normal sexual function but may not produce sperm and thus could be infertile (Fagerstrom, Himes, & Olson, 1999). Klinefelter syndrome occurs approximately once in every 500 live male births.

Klinefelter syndrome
A chromosomal disorder in which males have an extra X chromosome, making them XXY instead of XY.

Spotlight on Social Policy

Bill C-13: An Undecided Question

The *Assisted Human Reproduction Act* (Bill C-13) was passed by the House of Commons on October 28, 2003. Sent to the Senate for consideration, the Bill "died" with the end of the Parliamentary session in November 2003, having only received two of the necessary three readings in the upper chamber. With the resumption of Parliament in February 2004, the new Liberal leader Paul Martin reactivated the legislation, which continued its way through the legislative process. Bill C-13 prohibits the following: human cloning; creating an in vitro embryo for any other purpose than creating a human being or enhancing our knowledge of assisted reproduction procedures; maintaining an embryo outside the body of a female for more than 14 days (except when development is suspended); to affect in any way the sex of an embryo or identify the sex of an embryo (other than for diagnosis of sex-linked disorders); any merging of or implantation between human and nonhuman life forms; surrogate mothers receiving any money for the surrogate service (other than particular expenses outlined under the "controls" section of the Bill); counselling or arranging of surrogate services; purchase of sperm or ova; the taking of human reproductive material without consent; and sperm and ova donations from people under 18 years of age, except for purposes of assisted reproductive procedures for that person for a child they will raise.

The Bill offers controls through regulation and licence of the following: collecting, handling, storing, and manipulation of any human reproductive material and in vitro embryo; who is able to engage in these activities and who may combine in any form the human genome with other specified genomes; the reimbursement of donors or surrogate mothers for very specific expenditures; and where all this will occur.

This is not the first piece of legislation on reproductive technologies that a Canadian government has considered. The Royal Commission on New Reproductive Technologies reported in 1993 on numerous serious problems with clinics, their procedures to collect and handle genetic material, and the inadequate screening of diseases among donors (such as AIDS). The Commission recommended the regulation of assisted reproductive technology and the outright banning of certain procedures. In 1995, the government declared a moratorium on human cloning, the selling of sperm and eggs, and stem cell research on human embryos. Bill-47 was introduced in 1996 to continue these bans and add others. The Bill "died" when a spring election was called in 1997. The next effort was from Quebec Bloq Quebecois MP Pauline Picard, who introduced a private members bill (Bill C-247) criminalizing human cloning. In was withdrawn in committee and more extensive legislation sought. In May 2002, *An Act Respecting Assisted Human Reproduction* (Bill C-56) was tabled for consideration in the Commons, but "died" when Parliament adjourned. The Liberal Government reintroduced the bill in October 2002, as Bill C-13.

Some have suggested that the bill goes too far in limiting research that may have had positive impact on the treatment of such diseases as Alzheimer's, Parkinson's, and diabetes (especially research with stem cells from embryos). Others criticize the protection of donor's anonymity, fearing that children created through assisted reproductive technology employing donor sperm or ova will not be able to access critical genetic health data from their biological parent. Some worry that not paying surrogate mothers will result in fewer women volunteering for the activity and thus driving the parents seeking a child by this means to use "underground" services. Not even all the Liberals (the party that put the bill forward) supported the Act, and a small group of back-benchers objected to the allowing of cloning for therapeutic purposes, even regulated. Still others reject any element of genetic manipulation as a commodification and/or a dehumanizing of human life, which they feel is sacred and above such activity.

As we write this edition of the text, Bill C-13 is before the Senate, and after a second reading it has been referred to the Standing Senate Committee on Social Affairs, Science and Technology (February 13, 2004). The Senate has not guaranteed a blind acceptance of Bill C-13, which could be sent back to the House for further amendment, or if parliament closes or an election called, it, too, like its predecessors could "die" on the table.

At this time, the moratoriums are still in place and people seeking technical assistance to become pregnant are entering into a largely unregulated, unlicensed world.

fragile X syndrome
A genetic disorder involving an abnormality in the X chromosome, which becomes constricted and, often, breaks.

Turner syndrome
A chromosome disorder in females in which either an X chromosome is missing, making the person XO instead of XX, or the second X chromosome is partially deleted.

Fragile X syndrome *is a genetic disorder that results from an abnormality in the X chromosome, which becomes constricted and often breaks.* Mental deficiency often is an outcome, but its form may vary considerably (mental retardation, learning disability, short attention span) (Lewis, 1999). This disorder occurs more frequently in males than in females, possibly because the second X chromosome in females negates the disorder's negative effects (see figure 3.7).

Turner syndrome *is a chromosome disorder in females in which either an X chromosome is missing, making the person XO instead of XX, or the second X chromosome is partially deleted.* These females are short in stature and have a webbed neck. Cardiovascular anomalies are common, as is a higher risk of osteoporosis, and a late-starting or no

puberty. Ninety-eight percent of pregnancies where Turner syndrome is present abort spontaneously (Habib, 1998). They might be infertile and have difficulty in mathematics, but their verbal ability is often facilitated. Turner syndrome occurs in approximately one of every 3,000 live females births.

The **XYY syndrome** *is a chromosomal disorder in which the male has an extra Y chromosome.* The extra Y chromosome could have been within the sperm which fertilized the egg or generated in the early stages of fetal development. The only physical difference in males with the extra Y chromosome is that they tend to be above average in height. There may be a link with learning disabilities, but with a supportive home and school environment, the difficulties can be dealt with successfully (Pacific Northwest Regional Genetics Group, 2002). Early interest in this syndrome involved the belief that if a male had an extra Y chromosome he would likely be extremely aggressive and possibly develop a violent personality. However, researchers subsequently found that XYY males are no more likely to commit crimes than are XY males (Witkin & others, 1976).

XYY syndrome
A chromosomal disorder in which males have an extra Y chromosome.

Gene-Linked Abnormalities

Not only can abnormalities be produced by an uneven number of chromosomes, they also can result from harmful genes (Croyle, 2000). Apart from the single pair of sex chromosomes, the 22 other pairs of chromosomes are referred to as autosomes and account for most of the genetic disorders. The inheritance of the disorders follow one of two paths: either autosomal-dominant or autosomal-recessive. In the autosomal-dominant pattern, one parent will usually be affected with the disorder. If only one parent has the dominant gene, then half the children will exhibit the disorder. If both parents have the gene, then all the children will have the disorder. Examples of disorders generated by the autosomal-dominant gene include: achondroplasia, a bone growth disorder; hereditary colon cancer; and neurofibromatosis I, which causes light brown birthmarks and soft skin lumps over peripheral nerves. In the autosomal-recessive pattern, if both parents are carriers, but not affected by the disorder, each offspring will have a one-in-four chance of being affected. If both parents are affected, then all their children will be as well. If one is affected and the other not at all (not a carrier), then their children will be unaffected but carriers. If one parent is affected and the other is a carrier, then half their offspring will be affected. Phenylketonuria, sickle-cell anemia, Tay-Sachs disease (all discussed below), and cystic fibrosis are autosomal-recessive disorders. In both patterns, male and female babies are equally affected. More than 7,000 such genetic disorders have been identified, although most of them are rare.

phenylketonuria (PKU)
A genetic disorder in which an individual cannot properly metabolize an amino acid. PKU is now easily detected but, if left untreated, results in mental retardation and hyperactivity.

sickle-cell anemia
A genetic disorder that affects the red blood cells and occurs most often in people of African descent.

Phenylketonuria (PKU) *is a genetic disorder in which the individual cannot properly metabolize an amino acid. Phenylketonuria is now easily detected, but if it is left untreated, mental retardation and hyperactivity result*. The disorder is treated by diet to prevent an excess accumulation of phenylalanine, an amino acid. Phenylketonuria occurs about once in every 12,000 live births. Phenylketonuria accounts for about one percent of institutionalized mentally retarded individuals, and it occurs primarily in Caucasians. If women with phenylketonuria do not maintain their dietary restrictions during pregnancy, it is estimated that their infants will be affected by the presence of maternal hyperphenylalaninemia, resulting in an increase in PKU-related mental retardation. This increased incidence could match the levels seen prior to the PKU screening programs, which have helped all but eliminate this form of mental retardation in North America (Feldman, 1994).

Sickle-cell anemia, *which occurs most often in North Americans of African descent, is a genetic disorder affecting the red blood cells*. A red blood cell is usually shaped like a disk, but in sickle-cell anemia, a change in a recessive gene modifies its shape to a hook-shaped "sickle." These cells die quickly, causing anemia and early death of the individual because of their failure to carry oxygen to the body's cells. About one in 400 North American babies of African descent is affected. One in 10 North Americans of African

FIGURE 3.8
Sickle-Cell Anemia

During a physical examination for a college football tryout, Jerry Hubbard, 32, learned that he carried the gene for sickle-cell anemia. Daughter Sara is healthy, but daughter Avery (in the flowered dress) has sickle-cell anemia. *If you were a genetic counsellor, would you recommend that this family have more children? Explain.*

Name	Description	Treatment	Incidence
Cystic fibrosis	Glandular dysfunction that interferes with mucus production; breathing and digestion are hampered, resulting in a shortened life span.	Physical and oxygen therapy, synthetic enzymes, and antibiotics; most individuals live to middle age.	1 in 2,000 births
Diabetes	Body does not produce enough insulin, which causes abnormal metabolism of sugar.	Early onset can be fatal unless treated with insulin.	1 in 2,500 births
Hemophilia	Delayed blood clotting causes internal and external bleeding.	Blood transfusions/ injections can reduce or prevent damage due to internal bleeding.	1 in 10,000 males
Huntington disease	Central nervous system deteriorates, producing problems in muscle coordination and mental deterioration.	Does not usually appear until age 35 or older; death likely 10 to 20 years after symptoms appear.	1 in 20,000 births
Phenylketonuria (PKU)	Metabolic disorder that, left untreated, causes mental retardation.	Special diet can result in average intelligence and normal life span.	1 in 14,000 births
Sickle-cell anemia	Blood disorder that limits the body's oxygen supply; it can cause joint swelling, sickle-cell crises; heart and kidney failure.	Penicillin, medication for pain, antibiotics, and blood transfusions.	1 in 400 North American children of African descent (lower among other groups)
Spina bifida	Neural tube disorder that causes brain and spine abnormalities.	Corrective surgery at birth, orthopedic devices, and physical/medical therapy.	2 in 1,000 births
Tay-Sachs disease	Deceleration of mental and physical development caused by an accumulation of lipids in the nervous system.	Medication and special diet are used, but death is likely by five years of age.	One in 30 North American Jews is a carrier.

FIGURE 3.9
Some Gene-Linked Abnormalities

Tay-Sachs disease
A fatal genetic disorder that starts in the fetus during pregnancy, becomes clinically apparent when the child is several months old, and causes death, usually by age five.

descent is a carrier, as is one in 20 Latin Americans. According to Goldbloom (1994), the carrier rate among Canadians may be higher than that found in the United States. He suggests that the larger number of Canadians with Caribbean heritage (where the carrier rate is 10 to 14 percent) and West African heritage (where the carrier rate is between 20 to 25 percent) might lead to an increased carrier rate in Canada (see figure 3.8).

Tay-Sachs disease (TSD) *is a fatal genetic disorder that starts in the fetus during pregnancy, becomes clinically apparent when the child is several months old, and causes death, usually by age five.* TSD results from the lack of an enzyme called hexosaminidase A (Hex-A). In the absence of Hex-A, a lipid called GM2 ganglioside builds up inside the cells, especially inside nerve cells in the brain. The child progressively loses his/her eyesight, becomes unable to coordinate motor activity, sit up, or turn over, and eventually to breathe on his/her own. The gene for TSD is found significantly more often in people of eastern European (Ashkenazi) Jewish descent. In Canada, about one in 30 Ashkenazi Jews are carriers of the TSD gene. There is also a high incidence of TSD in non-Jewish French Canadians living near the St. Lawrence River and in the Cajun community of Louisiana. Genetic counselling has reduced the occurrence of TSD in groups seen to be

at significant risk. The greatest number of new cases occurs in people who have not previously been linked to a group at significant risk. One in 250 people in the general population is a carrier of the disease. Since the gene is recessive, both parents must be carriers, and even then there is only a 25-percent chance that the child will receive both recessive genes and develop TSD.

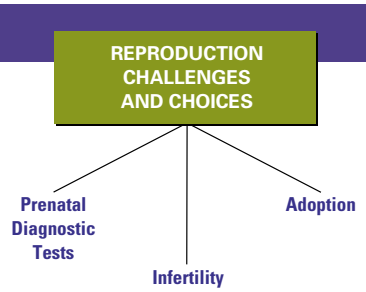
Other genetic abnormalities include cystic fibrosis, diabetes, hemophilia, Huntington disease, and spina bifida. Figure 3.9 provides further information about the genetic abnormalities we have discussed.

To this point, we have explored a number of ideas about genetic foundations. To review these ideas, see summary table 3.2.

SUMMARY TABLE 3.2 Genetic Foundations

Concept	Characteristics/Description
Chromosomes, DNA	• The nucleus of each human cell contains 46 chromosomes, which are composed of DNA. • Genes are short segments of DNA and act as a blueprint for cells to reproduce and manufacture proteins that maintain life.
Mitosis and Meiosis	• Mitosis is the process of cell division.
	• Genes are transmitted from parents to offspring by gametes, or sex cells. • Gametes are formed by the splitting of cells, a process called "meiosis." • Reproduction takes place when a female gamete (ovum) is fertilized by male gamete (sperm) to create a zygote.
Dominant-Recessive to Canalization	• Genetic principles include those involving dominant-recessive genes, sex-linked genes, polygenic inheritance, genotype-phenotype influences, reaction range, and canalization.
Behaviour Genetics	• Behaviour genetics is the field concerned with the degree and nature of behaviour's hereditary basis.
	• These include twin studies and adoption studies.
The Human Genome Project	• The field of molecular genetics seeks to discover the precise locations of genes that determine an individual's susceptibility to various diseases and other aspects of health and well-being. • The Human Genome Project has made stunning progress in mapping the human genome.
Chromosome and Gene-Linked Abnormalities	• These occur when chromosomes do not divide evenly. • Down syndrome is the result of a chromosomal abnormality caused by the presence of an extra chromosome 21. • Sex-linked chromosomal abnormalities include Klinefelter syndrome, fragile X syndrome, Turner syndrome, and XYY syndrome.
	• These involve harmful genes. • Gene-linked disorders include phenylketonuria (PKU) and sickle-cell anemia.

Reproduction Challenges and Choices



Prenatal Diagnostic Tests

Scientists have developed a number of tests to determine whether a fetus is developing normally, among them amniocentesis, ultrasonography, chorionic villus sampling, and the maternal serum screening.

Amniocentesis is a prenatal medical procedure in which a sample of amniotic fluid is withdrawn by syringe and tested to discover if the fetus is suffering from any chromosomal or metabolic disorders (Tercyak & others, 2001). Amniocentesis is performed between the 15th and 16th weeks of pregnancy. The later amniocentesis is performed, the better is its diagnostic potential. The earlier it is performed, the more useful it is in deciding whether a pregnancy should be terminated. There is a small risk of miscarriage when amniocentesis is performed, between 5 and 1 percent.

FIGURE 3.10
Ultrasonography

A six-month-old infant poses with the ultrasonography record taken four months into the baby's prenatal development. *What is ultrasonography?*

Ultrasonography is a prenatal medical procedure in which high-frequency sound waves are directed into the pregnant woman's uterus. The echo from the sounds is transformed into a visual representation of the fetus's inner structures. This technique has been able to detect such disorders as microencephaly, a form of mental retardation involving an abnormally small brain. Ultrasonography is often used in conjunction with amniocentesis to determine the precise location of the fetus in the mother's uterus (see figure 3.10). When ultrasonography is used five or more times, the risk of low birth weight may be increased.

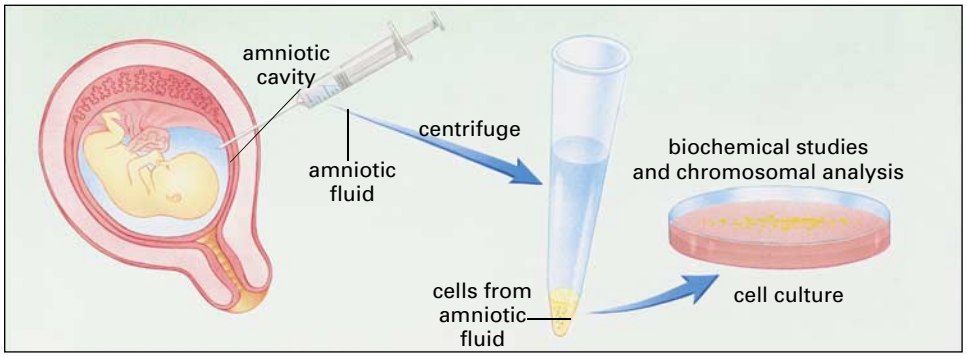
Chorionic villi sampling is a prenatal medical procedure in which a small sample of the placenta is removed at some point between the 10th and 12th weeks of pregnancy (Health Canada 2002). Diagnosis takes approximately 10 days. Chorionic villi sampling is usually performed between the 10th and 12th weeks in Canada. Chorionic villi sampling has a slightly higher risk of miscarriage than amniocentesis and is linked to a slight risk of limb deformities. These techniques provide valuable information about the presence of birth defects, but they also raise issues pertaining to whether an abortion should be obtained if birth defects are present. The International Clearinghouse for Birth Defects Monitoring Systems (2001) surveyed a number of countries and reported that due to prenatal tests diagnosing Down syndrome, 53.2 percent of pregnancies were terminated. The lowest percentage of aborted pregnancies due to the possible presence of Down syndrome was 26.7 in Alberta, Canada, while the highest (84%) was found in Paris, France. Figure 3.11 shows how the procedures of amniocentesis and chorionic villi sampling are carried out.

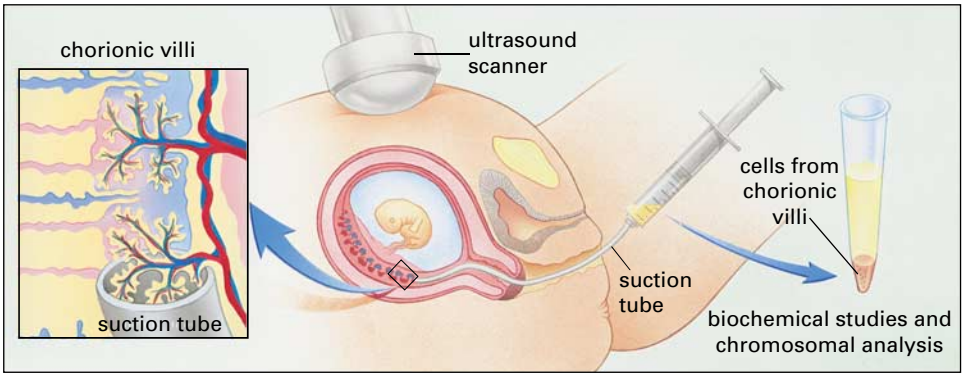
The *maternal serum screening (alpha-fetoprotein—AFP)* is a prenatal diagnostic technique that is used to assess blood alpha-fetoprotein level, which is associated with neural-tube defects. The blood test is the first level of screening for possible fetal abnormalities and may be administered in the first trimester. If it is, there is a one-in-10 to one-in-20 chance of a false-positive reading, depending on maternal age (Health Canada, 2002). This test is administered to women 14 to 20 weeks into pregnancy only when they are at risk of bearing a child with defects in the formation of the brain and spinal cord.

See the OLC! WWW.COM

Amniocentesis
Obstetric Ultrasonography
Chorionic Villi Sampling
Genetic Counselling

FIGURE 3.11
Amniocentesis and Chorionic Villi Sampling





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Infertility Resources

Infertility

The first national assessment of infertility in Canada was conducted in 1991 by the Royal Commission on New Reproductive Technologies (Baird, 1993). Approximately 8.5 percent of couples in Canada (nearly 300,000 couples) experience infertility, which is defined as the inability to conceive a child after 12 months of regular intercourse without contraception. The figure drops to 7 percent (approximately 250,000 couples) if infertility is defined as being a 24-month period with no pregnancy after regular intercourse without contraception. Thus, one in five couples, considered infertile under the 12-month definition, achieve a pregnancy within the next year (Baird, 1993). The Royal Commission on New Reproductive Technologies concluded that the use of a two-year time frame was more appropriate for assessing infertility but noted that many international studies use a one-year time frame.

The cause of infertility can rest with the woman or the man, but the myth that infertility is a women's problem has persisted. Twenty-four percent of couples seen in fertility clinics at the beginning of the 1990s were "infertile because of a diagnosed problem in the male partner" (Baird, 1993, 402). The woman may not be ovulating, she may be producing abnormal ova, her fallopian tubes may be blocked, or she may have a disease that prevents implantation of the ova. The man may have a seminal problem, either too few sperm (a condition called oligospermia), or no sperm (a condition called azoospermia), the sperm may lack motility (the ability to move adequately), or the man may have a blocked passageway. (See figure 3.12.) William Buckett, of McGill University, suggests

The McCaughey septuplets, born in 1998. *Why has there been such a dramatic increase in multiple births?*

FIGURE 3.12
Fertility Problems, Possible Causes, and Treatments

MEN		
Problem	**Possible Causes**	**Treatment**
Low sperm count	Hormone imbalance, varicose vein in scrotum, possibly environmental pollutants Drugs (cocaine, marijuana, lead, arsenic, some steroids and antibiotics) Y chromosome gene deletions	Hormone therapy, surgery, avoiding excessive heat
Immobile sperm	Abnormal sperm shape Infection Malfunctioning prostate	None Antibiotics Hormones
Antibodies against sperm	Problem in immune system	Drugs
WOMEN		
Problem	**Possible Causes**	**Treatment**
Ovulation problems	Pituitary or ovarian tumour Underactive thyroid	Surgery Drugs
Antisperm secretions	Unknown	Acid or alkaline douche, estrogen therapy
Blocked fallopian tubes	Infection caused by IUD or abortion or by sexually transmitted disease	Surgical incision, cells removed from ovary and placed in uterus
Endometriosis (Tissue buildup in uterus)	Delayed parenthood until the thirties	Hormones, surgical incision

that without treatment, women who ovulate infrequently might take up to a decade or more to become pregnant (Buckett, 2004). In the past, this time line was not a major issue in a marriage that could begin at age 18 or 20. But with women today waiting longer to get married and start a family (possibly into their early thirties), this period of time would place them in the age range where fertility normally declines, thus not giving them enough time to successfully conceive. Other causes for fertility problems noted by Buckett include tubal disease (related to sexually transmitted diseases) and obesity-related infertility.

In some cases of infertility, surgery may correct the problem. The Royal Commission on New Reproductive Technologies examined three forms of infertility treatment: fertility drugs, assisted insemination (AI), and in vitro fertilization (IVF). The most common form of fertility treatment in Canada is the use of fertility drugs. Baird found that many of the drugs in use do not have research that clearly supports their effectiveness.

The oldest form of assisting a woman to become pregnant when she or her partner are subfertile, or her partner infertile, or when a woman wishes to have a baby without a male partner, is AI. In this procedure, the sperm of either the women's partner or that of a donor is placed in the vagina, near the cervix, or in the uterus. AI is the most common fertility procedure available in Canada. Baird and her fellow commissioners found AI to have "the potential to be a safe, inexpensive, and relatively low-tech" method to treat infertility. Yet, they had concerns for the storage and handling of sperm, the definition of success, and the variations in procedural technique employed across the country.

The third form of infertility treatment studied by Baird has received the most media coverage. The use of high-tech IVF procedures has the image of advanced science at work to correct infertility problems. The basic idea of IVF is that the egg and sperm are removed from the couple, and both egg and sperm (or one of them) are subjected to one of several procedures to enhance the likelihood of fertilization. Then, the egg and sperm (or a zygote) are placed inside the women. In the procedure known as gamete intrafallopian transfer (GIFT), if the women has a functional fallopian tube, the egg and sperm will be placed inside the tube, where it is hoped fertilization will occur. In direct oocyte sperm transfer (DOST), the egg and sperm are placed in the uterus. Another technique involves placing the treated egg and sperm in a medium. If fertilization occurs, the viability of the resulting zygote will be decided, and it then may be placed in the uterus or fallopian tube. The zygote intrafallopian transfer (ZIFT) technique was developed to transfer the zygote to the fallopian tube. However, the success rate for IVF methods is far from clear. The Canadian Fertility and Andrology Society (CFAS, 2002), in examining 19 of the 23 Canadian centres for in vitro fertilization, found that in 2000 "the overall live birth rate was 20 percent per" attempts made. In 2001, the overall pregnancy rate climbed to 28 percent. The Royal Commission found that the definition of success varied widely across facilities and among doctors, institutions, and patients. The standard of practice with IVF procedures also was found to vary greatly across Canada. The Commission's recommendation that the federal government create a National Reproductive Technologies Commission to oversee fertility and reproductive technology has not yet been acted upon.

The Canadian Government responded with Bill C-13, "an Act respecting assisted human reproduction and related research" (Health Canada, October 2003). (See Spotlight on Social Policy box on p. 74.) The Bill sets the restrictions that will regulate the form and practice of activities to help people with infertility problems and conduct research in the area of reproduction and reproductive technology. It prohibits cloning and the buying and selling of human sperm and eggs. Strict regulations and procedures are set out for the research using in vitro human embryos. This research goes beyond the issue of infertility, as it may benefit those with spinal-cord injuries, cancer, and Alzheimer's, among others. At the time of writing this text, Bill C-13 had been passed by the House of Commons and was before the Senate.

The creation of families by means of new reproductive technologies raises important questions about the psychological consequences for children. In one study, the family relationships and socio-emotional development of children were investigated in four types of families—two created by the most widely used reproductive technologies (in vitro fertilization and donor insemination) and two control groups (families with natu-

rally conceived children, and adoptive families) (Golombok & others, 1995). There were no differences among the four types of families on any of the measures of children's socio-emotional development. The findings of Golombook and others (1995) indicate that the picture of families created by the new technologies remains positive. However, more research is needed, not only to verify their results but also to explore the many ethical issues that arise from using these technologies.

One consequence of fertility treatments is an increase in multiple births. According to the Multiple Births Association of Canada (2001), 15 to 17 percent of multiple births result from infertility treatments. Specifically, they estimate that 90 percent of quadruplets and 99 percent of quintuplets are the outcome of infertility treatments. Though parents may be thrilled at the prospect of having children, they also face serious risks. Multiple births make up only 2 percent of the total annual births in Canada, but constitute 16 percent of infants with extremely low birth weight. Nearly 50 percent of twins and more than 90 percent of triplets, quadruplets, and quintuplets are born prematurely and/or with low birth weight. Multiple-birth children are five times likelier to have birth defects or disabilities.

Although multiples are likely to result from fertility treatments, two-thirds of pregnancies employing assisted reproduction technology are singletons (CFAS, 2002). Helmerhorst, Perquin, Donker, and Keirse (2004) reviewed studies examining the perinatal outcome after assisted conception and found that singletons were significantly more at risk for preterm birth, for a caesarean birth, admissions to neonatal intensive care units, and possibly low birth weight than were singletons conceived naturally. The same study, however, pointed out that twins who were conceived with assisted conception were more similar in outcome to naturally conceived twins, with some slight advantages, including a 40-percent lower perinatal mortality rate. This difference between singleton and twin assisted reproduction birth outcomes may be a result of the implantation procedures favouring the carrying to term of a multiple birth over the natural conception of twins.

Adoption

Although surgery and fertility drugs can solve the infertility problem in some cases, another choice is to adopt a child. Adoption is the social and legal process by which a parent–child relationship is established between persons unrelated by birth. Researchers have found that adopted children and adolescents often show more psychological and school-related problems than nonadopted children (Brodzinsky & others, 1984; Brodzinsky, Lang, & Smith, 1995). Adopted adolescents are referred to psychological treatment two to five times as often as their nonadopted peers (Grotevant & McRoy, 1990). The increased number of adopted children in counselling may be because their adoptive parents belong to a higher socio-economic group and are more aware and willing to make use of mental health services (Warren, 1992; Haugaard, 1998).

In one recent large-scale study of 4,682 adopted adolescents and the same number of nonadopted adolescents, adoptees showed slightly lower levels of adjustment (Sharma, McGue, & Benson, 1996). However, adoptees actually showed higher levels of prosocial behaviour. Also, the later adoption occurred, the more problems the adoptees had. Infant adoptees had the fewest adjustment difficulties; those adopted after they were 10 years of age had the most. Other research has documented that early adoption often has better outcomes for the child than later adoption. At age six, children adopted from an orphanage in the first six months of their lives showed no lasting negative effects of their early experience. However, children from the orphanage who were adopted after they were six months of age had abnormally high levels of cortisol, indicating that their stress regulation had not developed adequately (Chisholm, 1998; Ambert, 2003).

These results have policy implications, especially for the thousands of children who are relegated to the foster care system after infancy. Most often, older children are put up for adoption due to parental abuse or neglect. The process of terminating the birth parents' parental rights can be lengthy. In the absence of other relatives, children are turned over to the foster care system, where they must wait for months or even years to be adopted.

York University professor Anne-Marie Ambert (2003) suggests that the position of the adopted person in our society is a socially constructed one and that it is most often

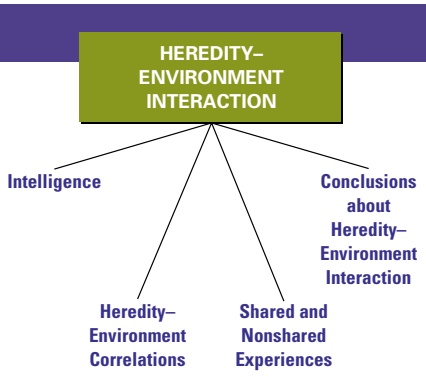
not a positive position. She notes our society's orientation toward a "genetic consciousness," where genetic lineage is portrayed as critical for a positive sense of self and personal completeness, places the adopted person in an awkward position, and possibly elicits negative responses to their circumstances. This social construction is seen in the language used to describe both adoption and the relationship between adopting parent and child. Further, our society seems to have assumed that adoptive parents will not feel as close to their adopted children as biological parents. Ambert reports that adoptive parents are usually equally attached to their adopted children and their biological children, if they have one. Yet, Ambert cites several examples where the adoptive parents were clearly confronted by society's refusal to accept their uncompromised attachment to their children.

A question that virtually every adoptive parent wants answered is, "Should I tell my adopted child that he or she is adopted? If so, when?" Most psychologists believe that adopted children should be told that they are adopted because they will eventually find out anyway. Many children begin to ask where they came from when they are approximately four to six years of age. This is a natural time to begin to respond in simple ways to children about their adopted status. Clinical psychologists report that one problem that sometimes surfaces is the desire of adoptive parents to make life perfect for the adoptive child and to present a perfect image of themselves to the child. The result, too often, is that adopted children feel that they cannot release any angry feelings or discuss problems openly in this climate of perfection (Warshak, 1997).

To this point, we have discussed a number of ideas about reproduction challanges and choices. A review of these ideas is presented in summary table 3.3. In our discussion of adoption, we indicated that children who are adopted later in their development often show more difficulties than those who are adopted very early in their lives. This finding suggests that the environment plays an important role in children's development.

SUMMARY TABLE 3.3 Reproduction Challenges

Concept	Characteristics/Description
Prenatal Diagnostic Tests	• Amniocentesis, ultrasonography, chorionic villi sampling, and the maternal blood test are used to determine the presence of defects once pregnancy has begun.
	• Genetic counselling has increased in popularity because couples desire information about their risk of having a child with defective characteristics.
Infertility	• Some infertility problems can be corrected through surgery or fertility drugs.
	• Methods include in vitro fertilization and other more recently developed techniques.
Adoption	• Adopted children and adolescents have more problems than their nonadopted counterparts.
	• When adoption occurs very early in development, the outcomes for the child are improved.



Heredity–Environment Interaction

Heredity and environment interact to produce development (McGuire, 2001). To explore this interaction, we will focus on an important area of development—intelligence—and then explore many other aspects of heredity–environment interaction.

Intelligence

Arthur Jensen (1969) sparked a lively and, at times, hostile debate when he presented his thesis that intelligence is primarily inherited. Jensen believes that environment and culture play only a minimal role in intelligence. He examined several studies of intelligence, some of which involved comparisons of identical and fraternal twins. Remember that identical twins have identical genetic endowments, and so their IQs should be similar. Fraternal twins and ordinary siblings are less similar genetically, and so their IQs should

be less similar. Jensen found support for his argument in these studies. Studies with identical twins produced an average correlation of 0.82; studies with ordinary siblings produced an average correlation of 0.50. Note the difference of 0.32. To show that genetic factors are more important than environmental factors, Jensen compared identical twins reared together with those reared apart; the correlation for those reared together was 0.89 and for those reared apart was 0.78 (a difference of only 0.11). Jensen argued that if environmental influences are more important than genetic influences, then siblings who were reared apart and experienced different environments should have IQs much further apart.

Many scholars have criticized Jensen's work. One criticism concerns the definition of intelligence itself. Jensen believes that IQ as measured by standardized intelligence tests is a good indicator of intelligence. Critics argue that IQ tests tap only a narrow range of intelligence. Everyday problem solving, work, and social adaptability, say the critics, are important aspects of intelligence not measured by the traditional intelligence tests used in Jensen's sources. A second criticism is that most investigations of heredity and environment do not include environments that differ radically. Thus, it is not surprising that many genetic studies show environment to be a fairly weak influence on intelligence.

University of Western Ontario's J. Phillippe Rushton (1985, 1990) entered the debate with a declaration that a thorough review of all sources revealed that genetic differences existed between racial groups for the heritable nature of such factors as intelligence, family size, spacing of births, incidence of DZ twinning, parental care, altruism, law-abiding behaviour, and sex drive. He stated that people of the Mongoloid race (Asians and Amerindians) were superior on all these traits to Caucasians (whites of European ancestry), who, in turn, were superior to blacks of African origin. These alleged genetic differences were also found between people of the upper socio-economic class versus those of the lower socio-economic class. Examining magnetic resonance imaging (MRI) scans, Rushton and Ankney (1996) suggested that evidence revealed a difference in brain size between the three racial groupings which paralleled the other findings: Mongoloids had larger brains than Caucasians, who had larger brains than blacks. He noted that brain size is highly related to intelligence, that is, the larger the brain, the higher is the intelligence. He believes that this accounts for the higher IQ scores of Asians over Caucasians and blacks of African decent.

Rushton makes use of an ecological theory called the r/K Model, concerning the effect of population density on heritable traits within the species. According to the theory, when population density is not a problem (there is little competition for resources) an r-selection takes place, favouring those who produce many young at one time and do not expend much energy raising them. At the opposite end of the continuum is a state of high population density, with much competition for survival. In this latter case, a K-selection is preferable, with a limited number of well-spaced offspring and high parental involvement to ensure survival.

Critics attacked Rushton on several levels (Weizmann, Wiener, Wiesenthal, & Ziegler, 1990; Anderson, 1990; Peters, 1995; and Flynn, 1989, 1999a, 1999b). Weizmann et al., at York University, criticized Rushton's assignment of traits to either the r or K end of the continuum. They suggested he arbitrarily assigned positive aspects (altruism, high intelligence, rule following, and so on) to the K end and negative aspects (aggression, criminality, and so on) to the r end. Weizmann et al. attacked Rushton's use of 19th century sources for brain size and anatomical descriptions of "white versus black" racial differences as being untrustworthy in their methods of analysis and biased toward their intended European audience. Weizmann et al. noted that comparison of genetic material across the human species finds so much similarity that two people selected "from two races can be expected to differ only by about 0.04 percent more than two people of the same race". Furthermore, they found more genetic variation within the sub-Saharan African population than between it and other groups. Thus, the idea of a single "African" race is not supported.

Judith L. Anderson (1991), of Simon Fraser University, reviewed Rushton's use of the r/K Model and found it wanting. Her key criticism is that the theory was created to specifically examine a well-defined local population. But the human race is not a local population, nor are the racial subgroups well defined. Anderson also noted that the the-

Socio-cultural Worlds of Development

The Abecedarian Project

EACH MORNING a young American mother waited with her child for the bus that would take the child to school. The unusual part of this is that the child was only two months old and "school" was an experimental program at the University of North Carolina at Chapel Hill. There the child experienced a number of interventions designed to improve her intellectual development—everything from bright objects dangled in front of her eyes during her infancy to language instruction and counting activities when she was a toddler (Wickelgren, 1999).

This child was part of the Abecedarian Intervention Program conducted by Craig Ramey and his associates (Ramey & Campell, 1984; Ramey & Ramey, 1998; Ramey, Ramey, & Lanzi, 2001). They randomly assigned 111 young children from low-income, poorly educated families either to an intervention group, which experienced full-time, year-round day care along with medical and social work services, or to a control group, which got medical and social benefits but no day care. The day care program included gamelike learning activities aimed at improving language, motor, social, and cognitive skills. The success of the program in improving IQ was evident by the time the children were three years old, at which time the children in the experimental group showed normal IQs averaging 101, a 17-point advantage over the control group. Recent follow-up results suggest that the effects are long-lasting. More than a decade later, at age 15, children from the intervention group still maintained an IQ advantage of five points over the control group children (97.7 to 92.6) (Ramey & others, in press; Ramey, Campbell, & Ramey, in press). They also did better on standardized tests of reading and math, and they were less likely to be held back a year in school. The greatest IQ gains were in the children whose mothers had especially low IQs—below 70. At age 15, these children showed a 10-point IQ advantage over a group of children whose mothers had IQs below 70 but did not experience the daycare intervention.

Abecedarian Project

James Flynn has been one of several researchers who have doggedly critiqued Phillipe Rushton's work. An Emeritus Professor from the University of Otago, New Zealand, James Flynn also studies the political and moral grounds for "justifying human ideals."

ory cannot be used to examine groups outside the area in which the r/K factors were believed to have affected them (for example, all North Americans of European descent live outside of Europe where the r/K factors were influential).

Michael Peters (1995), of the University of Guelph, challenged Rushton's findings concerning brain size and intelligence. Rushton's sources examine the brain from several perspectives: brain weight, cerebrospinal fluid volume, density of the neural development, and brain size. Peters says the findings indicate that there is more variation within each "racial" grouping than between them. Rushton proposed that men's larger brain size explained why they achieved higher intelligence test scores than women. Peters suggests that there is more to the brain and its functioning than simply its size, however measured. He notes that women can improve test scores by 30 to 50 percent after one experience with the area in which men had previously been better. These gains cannot be accounted for by different brain sizes.

One of Rushton's most ardent opponents, James Flynn (1999), of New Zealand, states that intelligence test score differences between "races," cited by both Jensen and Rushton, can be accounted for by environmental differences and are not genetic qualities. Colom, Juan-Espinosa, and Garcia (2001) support Flynn's conclusion by finding generation gaps in intelligence scores which match the observed contemporary gaps between "races." Colom et al. believe that this finding rules out evidence suggesting a genetic cause and that we ought to focus our attention instead on environmental conditions that influence intelligence test scores.

Most experts today agree that the environment plays an important role in intelligence (Brody, 2000; Ceci & others, 1997; Di Lalla, 2000; Patrick, 2000; Sternberg, 2001; Sternberg & Grigorenko, 2001). This means that improving children's environments can raise their intelligence. Consider the experiences of 20 children in France who had been abandoned in infancy by their parents of low socio-economic status and subsequently adopted by parents of upper-middle socio-economic status (Schiff & others, 1982). These children all had biological siblings who remained with their biological mothers and were reared in impoverished circumstances. No factors that might have made the children who were adopted more genetically promising could be found. When tested in the elementary school years, the adopted children's IQs averaged 14 points higher than the IQs of their biological siblings. Children who remained with their biological mothers

in impoverished conditions were four times more likely to do poorly in school. These results are consistent with other research that reveals that adoption into well-functioning homes with middle socio-economic status improves the cognitive functioning of children who previously have lived in impoverished environments (Skodak & Skeels, 1949; Scarr & Weinberg, 1978). To read further about the importance of environment in children's intelligence, see the Socio-cultural Worlds of Development box on page 84.

According to Sandra Scarr, what are three ways that parents can contribute to genotype–environment correlations?

Heredity–Environment Correlations

The notion of heredity–environment correlations involves the concept that individuals' genes influence the types of environments to which they are exposed. That is, individuals inherit environments that are related or linked to their genetic propensities (Plomin & others, 1994). Behaviour geneticist Sandra Scarr (1993) described three ways that heredity and environment are correlated: passively, evocatively, and actively.

Passive genotype–environment correlations *occur when biological parents, who are genetically related to the child, provide a rearing environment for the child*. For example, the parents might have a genetic predisposition to be intelligent and read skilfully. Because they read well and enjoy reading, they provide their children with books to read. The likely outcome is that their children, given their own inherited predispositions, will become skilled readers.

passive genotype–environment correlations
Correlations that exist when the natural parents, who are genetically related to the child, provide a rearing environment for the child.

Evocative genotype–environment correlations *occur because a child's genotype elicits certain types of physical and social environments*. For example, active, smiling children receive more social stimulation than passive, quiet children do. Cooperative, attentive adolescents evoke more pleasant and instructional responses from the adults around them than uncooperative, distractible adolescents do. Athletically inclined youth tend to elicit encouragement to engage in school sports. As a consequence, these adolescents tend to be the ones who try out for sport teams and go on to participate in athletically oriented environments.

evocative genotype–environment correlations
Correlations that exist when the child's genotype elicits certain types of physical and social environments.

Active (niche-picking) genotype–environment correlations *occur when children and adolescents seek out environments they find compatible and stimulating*. Niche-picking refers to finding a niche or setting that is suited to one's abilities. Adolescents select from their surrounding environment some aspect that they respond to, learn about, or ignore. Their active selections of environments are related to their particular genotype. For example, attractive adolescents tend to seek out attractive peers. Adolescents who are musically inclined are likely to select musical environments in which they can successfully employ their skills.

active (niche-picking) genotype–environment correlations
Correlations that exist when children seek out environments they find compatible and stimulating.

Scarr believes that the relative importance of the three genotype–environment correlations changes as children develop from infancy through adolescence. In infancy, much of the environment that children experience is provided by adults. Thus, passive genotype–environment correlations are more common in the lives of infants and young children than they are for older children and adolescents who can extend their experiences beyond the family's influence and create their environments to a greater degree.

Shared and Nonshared Environmental Experiences

Behaviour geneticists also believe that another way the environment's role in heredity–environment interaction can be carved up is to consider the experiences of children that are in common with those of other children living in the same home as well as experiences that are not shared (Feinberg & Hetherington, 2001; Finkel, Whitfield, & McGue, 1995; Perusse, 1999; Turkheimer & Waldron, 2000). Behaviour geneticist Robert Plomin

(1993) has found that common rearing, or shared environment, accounts for little of the variation in children's personality or interests. In other words, even though two children live under the same roof with the same parents, their personalities often are very different.

shared environmental experiences
Children's common environmental experiences that are shared with their siblings, such as their parents' personalities and intellectual orientation, the family's social class, and the neighbourhood in which they live.

nonshared environmental experiences
The child's own unique experiences, both within the family and outside the family, that are not shared by another sibling. Thus, experiences occurring within the family can be part of the "nonshared environment."

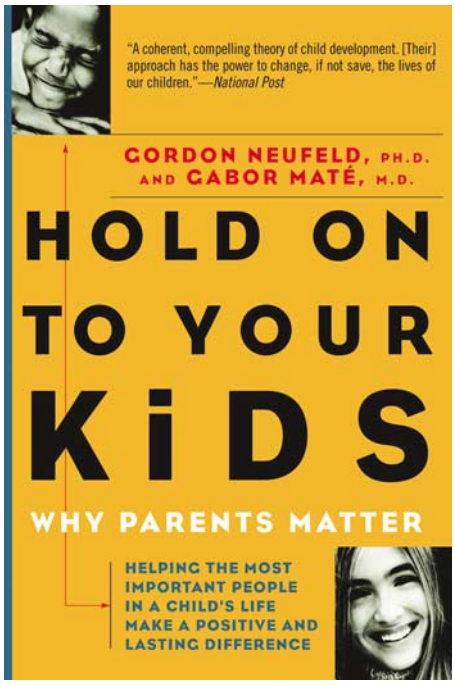
Shared environmental experiences *are children's common experiences, such as their parents' personalities and intellectual orientation, the family's social class, and the neighbourhood in which they live.* By contrast, **nonshared environmental experiences** *are a child's unique experiences, both within the family and outside the family, that are not shared with another sibling. Thus, experiences occurring within the family can be part of the "nonshared environment."* Parents often interact differently with each sibling, and siblings interact differently with parents (Hetherington, Reiss, & Plomin, 1994; Reiss & others, 2000). Siblings often have different peer groups, different friends, and different teachers at school.

Conclusions about Heredity–Environment Interaction

In sum, both genes and environment are necessary for a person even to exist. Without genes, there is no person; without environment, there is no person (Scarr & Weinberg, 1980). Heredity and environment operate together—or cooperate—to produce a person's intelligence, temperament, height, weight, ability to pitch a baseball, ability to read, and so on (Gottlieb, Wahlsten, & Lickliter, 1998; Kallio, 1999). Because the environment's influence depends on genetically endowed characteristics, we say the two factors *interact* (Mader, 1999).

The relative contributions of heredity and environment are not additive, as in such-and-such a percentage of nature, such-and-such a percentage of experience. Nor is it accurate to say that full genetic expression happens once, around conception or birth, after which we take our genetic legacy into the world to see how far it gets us. Genes produce proteins throughout the life span, in many different environments. Or they do not produce these proteins, depending on how harsh or nourishing those environments are.

The emerging view is that many complex behaviours likely have some genetic loading that gives people a propensity for a particular developmental trajectory (Plomin & others, 2001). But the actual development requires more: an environment. And that environment is complex, just like the mixture of genes we inherit (Sternberg & Grigorenko, 2001). Environmental influences range from the things we lump together under "nurture" (such as parenting, family dynamics, schooling, and neighbourhood quality) to biological encounters (such as viruses, birth complications, and even biological events in cells) (Greenough, 1997, 1999).



Imagine for a moment that there is a cluster of genes somehow associated with youth violence (this is hypothetical because we do not know of any such combination). The adolescent who carries this genetic mixture might experience a world of loving parents, regular nutritious meals, lots of books, and a series of masterful teachers. Or the adolescent's world might consist of parental neglect, a neighbourhood where gunshots and crime are everyday occurrences, and inadequate schooling. In which of these environments are the adolescent's genes likely to manufacture the biological underpinnings of criminality? Also note that growing up with all of the "advantages" does not necessarily guarantee success. Adolescents from wealthy families might take their opportunities for granted and fail to develop the motivation to learn and achieve. In the same way, "poor" or "disadvantaged" does not equal "doomed"; many impoverished adolescents make the best of the opportunities available to them and learn to seek out advantages that can help them improve their lives.

The most recent nature–nurture controversy erupted when Judith Harris (1998) published *The Nurture Assumption*. In this provocative book, she argued that what parents do does not make a difference in their children's and adolescents' behaviour. Yell at them. Hug them. Read to them. Ignore them. Harris says it will not influence how they turn out. She argues that genes and peers are far more important than parents in children's and adolescents' development.

Harris is right that genes matter and she is right that peers matter, although her descriptions of peer influences do not take into account the complexity of peer contexts

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Genes and Parenting

and developmental trajectories (Hartup, 1999). In addition to not adequately considering peer complexities, Harris is wrong that parents do not matter. To begin with, in the early childhood years parents play an important role in selecting children's peers and indirectly influencing children's development (Baumrind, 1999). There is a huge parenting literature with many research studies documenting the importance of parents in children's development (Collins & others, 2000, 2001; Maccoby, 2000). We will discuss parents' important roles throughout this book.

Canadian psychologist Gordon Neufeld and physician Gabor Mate (2004) voice the opposite opinion to Judith Harris in their book *Hold On to Your Kids: Why Parents Matter*. They find that some parents distance themselves from their children during the early years, allowing the children to spend most of their time with other children. Neufeld and Mate say this results in a stronger attachment with peers than with parents for these children. The results are often a complete rejection of parental authority, influence, and connection during adolescence, a time when parental attachment might prevent or at least soften some of the problems teenagers can encounter. Thus, for Neufeld and Mate, a strong and nurturing attachment with their parents is critical for adolescent's positive experience of life.

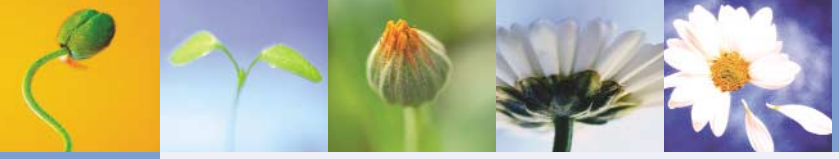
To this point, we have discussed a number of ideas about heredity–environment interaction. To review these ideas see summary table 3.4.

Critical Thinking

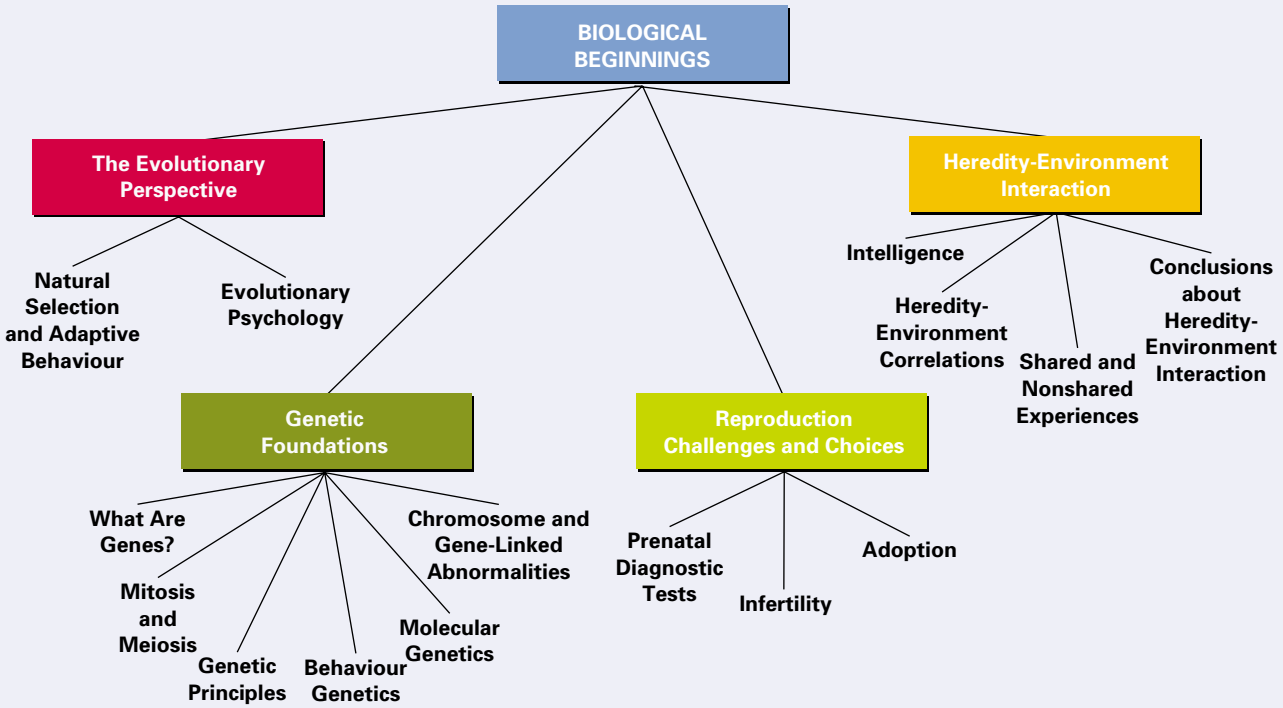
Harris as well as Neufeld and Mate represent two extremes in the argument about how important parents and peers are in shaping personality and life experience. From your own experiences, which do you believe is more correct? What features of your experience lead you to this opinion? What would have had to be different for you to hold the opposite view?

SUMMARY TABLE 3.4 Heredity–Environment Interaction

Concept	Characteristics/Description
Intelligence	• Jensen argues that intelligence is mainly due to heredity. • Most experts today accept that the environment plays an important role in intelligence.
Heredity–Environment Correlations	• Sandra Scarr argues that the environments parents select for their children depend on the parents' genotypes.
	• Passive genotype–environment, evocative genotype–environment, and active (niche-picking) genotype–environment are three correlations. • Scarr believes the relative importance of the these three genotype–environment correlations changes as children develop.
Shared and Nonshared Environmental Experiences	• These refer to siblings' common experiences.
	• These refer to the child's unique experiences.
Complexity: Conclusions about Heredity–Environment Interaction	• Many complex behaviours have some genetic loading that gives people a propensity for a particular developmental trajectory. • Actual development also requires an environment, and that environment is complex. • The interaction of heredity and environment is extensive.



Chapter Review



To obtain a detailed review of this chapter, study these four summary tables:

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Taking It to the Net

1. Ahmahl, a biochemistry major, is writing a psychology paper on the potential dilemmas that society and scientists may face as a result of the decoding of the human genome. What are some of the main issues or concerns that Ahmahl should address in his class paper?
2. Brandon and Katie are thrilled to learn that they are expecting their first child. They are curious about the genetic makeup of their unborn child and want to know (a) what disorders might be identified through prenatal genetic testing, and (b) which tests, if any, Katie should undergo to help determine this information.
3. Greg and Courtney wish to adopt a child. What issues will they face in adopting a child in Canada? Are there particular policies for your province? What would you tell them about the long-term impact of adopting a child?

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