

Prenatal Development and the Newborn Period



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Prenatal Development | Hazards to Prenatal Development
The Birth Experience | The Newborn Infant

THEMES

NATURE AND NURTURE ■ THE ACTIVE CHILD ■ THE SOCIOCULTURAL CONTEXT

INDIVIDUAL DIFFERENCES ■ CONTINUITY/DISCONTINUITY

RESEARCH AND CHILDREN'S WELFARE

Picture the following scenario: a developmental psychologist is investigating a very young research participant's ability to learn. First, she plays a recording of a nonsense word for the young participant (*tatata*). The participant hears this word multiple times a day, for several months. The psychologist wants to use brain responses to find out whether the participant has learned the novel word. But before the psychologist can measure the participant's brain waves, something very important has to happen: the participant has to be born!

This scenario is not at all fanciful. Indeed, as you will discover later in this chapter, it describes one of many studies that has revolutionized our understanding of prenatal development (Partanen, Kujala, Tervaniemi et al., 2013). Fetuses can detect and learn from a range of stimuli coming from both the outside world and inside the mother's body, and they are affected by these stimuli after birth.

This chapter will examine prenatal development—a time of astonishingly rapid and dramatic change. We will also consider some of the ways in which these processes can be disrupted by environmental hazards. Then, we will explore the birth process and some of the most salient aspects of neonatal behaviour. Finally, we will outline issues associated with low birth weight and premature birth.

Most of the themes described in Chapter 1 play prominent roles in our discussion of the earliest periods of development. The most notable will be *nature and nurture*, because prenatal development relies on the continual interplay of biological and environmental factors. The *active child* theme will also be featured: the activity of the fetus contributes in numerous vital ways to its development. Another theme we will highlight is the *sociocultural context* of prenatal development and birth. There is substantial cultural variation in how the birth process unfolds. The theme of *individual differences* comes into play throughout prenatal development and early postnatal life. *Continuity/discontinuity* is also prominent: despite the dramatic contrast between prenatal and postnatal life, the behaviour of newborns shows clear connections to their experience inside the womb. Finally, the theme of *research and children's welfare* is central to our discussion of how poverty can affect prenatal development and birth outcomes, as well as to our description of intervention programs designed to foster healthy development for preterm infants.

Prenatal Development

Hidden from view, the process of prenatal development has always been mysterious and fascinating, and beliefs about the origins of human life and development before birth are an important part of the lore and traditions of all societies. (Box 2.1 describes one set of cultural beliefs about the beginning of life that is quite unlike those of Western societies.)

In the fourth century B.C.E., Aristotle posed a fundamental question that influenced Western thought for the next 15 centuries: Does prenatal life start with a fully formed individual, composed of a full set of tiny parts, or do the many

BOX 2.1 A CLOSER LOOK Beng Beginnings


Few topics have generated more intense debate and dispute in Canada in recent decades than the issue of when life begins—at the moment of conception, the moment of birth, or sometime in between. The irony is that few who engage in this debate recognize how complex the issue is or the degree to which societies throughout the world have different views on it.

Consider, for example, the perspective of the Beng, a people in the Ivory Coast of West Africa. According to the Beng, every newborn is a reincarnation of an ancestor (Gottlieb, 2004). In the first weeks after birth, the ancestor's spirit, its *wru*, is not fully committed to an earthly life and therefore maintains a double existence, traveling back and forth between the everyday world and *wrugbe*, or “spirit village.” (The term can be roughly translated as “afterlife,” but “before-life” might be just as appropriate.) It is only after the umbilical stump has dropped off that the newborn is considered to have emerged from *wrugbe* and become a person. If the newborn dies before this point, there is no funeral, for the infant's passing is perceived as a return to the *wrugbe*.

These beliefs underlie many aspects of Beng parenting practices. One is the frequent

application of an herbal mixture to the newborn's umbilical stump to hasten its drying out and dropping off. In addition, there is the constant danger that the infant will become homesick for its life in *wrugbe* and decide to leave its earthly existence. To prevent this, parents try to make their babies comfortable and happy so they will want to stay in this life. Among the many recommended procedures is elaborately decorating the infant's face and body to elicit positive attention from others. Sometimes diviners are consulted, especially if the baby seems to be unhappy; a common diagnosis for prolonged crying is that the baby wants a different name—the one from its previous life in *wrugbe*.

So when does life begin for the Beng? Because each infant is a reincarnation of an ancestor, in one sense, an individual's life begins well before birth. In another sense, however, life begins sometime after birth, when the *wru* commits to life and the individual is considered to have become a person.

 Beng Infant Caretaking Practices



COURTESY OF ALMA GOTTLIEB

The mother of this Beng baby has spent considerable time painting the baby's face in an elaborate pattern. She does this every day in an effort to make the baby attractive so other people will help keep the baby happy in this world.

parts of the human body develop in succession? Aristotle argued in favour of the latter, which he termed **epigenesis**—the emergence of new structures and functions during development (we will revisit this idea in Chapter 3 in its more modern form, *epigenetics*). Seeking support for his idea, he took what was then a very unorthodox step: he opened chicken eggs to observe organs in various stages of development.

Conception

Each of us originated as a single cell that resulted from the union of two highly specialized cells—a sperm from our father and an egg from our mother. These **gametes**, or germ cells, are unique not only in their function but also in the fact that each one contains only half the genetic material found in other cells. Gametes are produced through **meiosis**, a form of cell division in which the eggs and sperm receive only one member from each of the 23 chromosome pairs contained in all other cells of the body. This reduction to 23 chromosomes in each gamete is necessary for reproduction, because the union of egg and sperm must contain the normal amount of genetic material (23 *pairs* of chromosomes).

The process of reproduction starts with the launching of an egg (the largest cell in the human female body) from one of the woman's ovaries into the adjoining fallopian tube (see Figure 2.1). As the egg moves through the tube toward the uterus, it emits a chemical substance that acts as a sort of beacon, a “come-hither” signal that attracts sperm toward it. If an act of sexual intercourse takes place near

epigenesis the emergence of new structures and functions in the course of development

gametes (germ cells) reproductive cells—egg and sperm—that contain only half the genetic material of all the other cells in the body

meiosis cell division that produces gametes

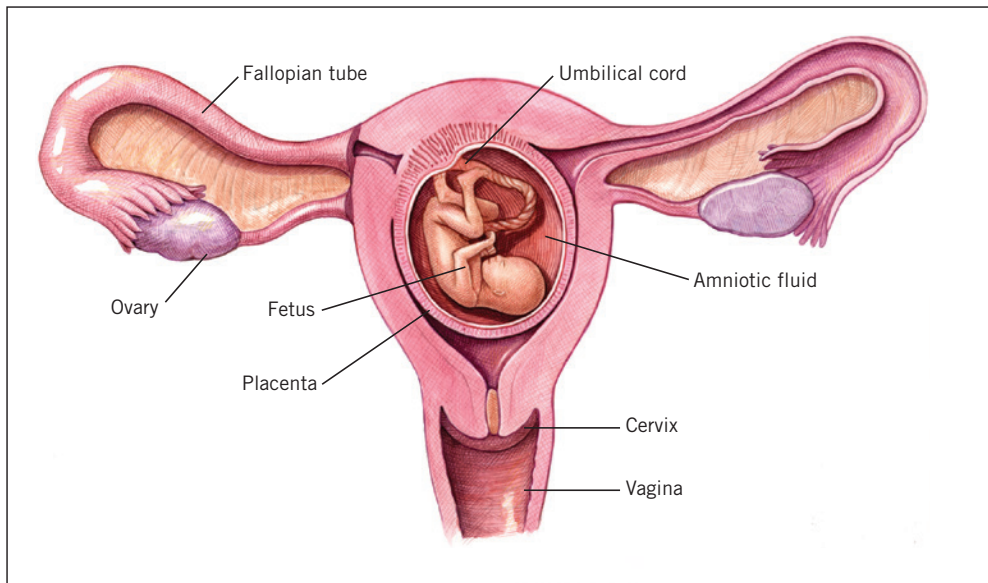


FIGURE 2.1 Female reproductive system A simplified illustration of the female reproductive system, with a fetus developing in the uterus (womb). The umbilical cord runs from the fetus to the placenta, which is burrowed deeply into the wall of the uterus. The fetus is floating in amniotic fluid inside the amniotic sac.

the time the egg is released, **conception**, the union of sperm and egg, is possible. In every ejaculation, as many as 500 million sperm are pumped into the woman's vagina. Each sperm, a streamlined vehicle for delivering the man's genes to the woman's egg, consists of little more than a pointed head packed full of genetic material (the 23 chromosomes) and a long tail that whips around to propel the sperm through the woman's reproductive system.

conception the union of an egg from the mother and a sperm from the father

To be a candidate for initiating conception, a sperm must travel for about 6 hours, journeying 15 to 18 centimetres from the vagina up through the uterus to the egg-bearing fallopian tube. The rate of attrition on this journey is enormous: of the millions of sperm that enter the vagina, only about 200 ever get near the egg (see Figure 2.2). Many of the sperm get tangled up with other sperm milling about in the vagina; others wind up in the fallopian tube that does not currently

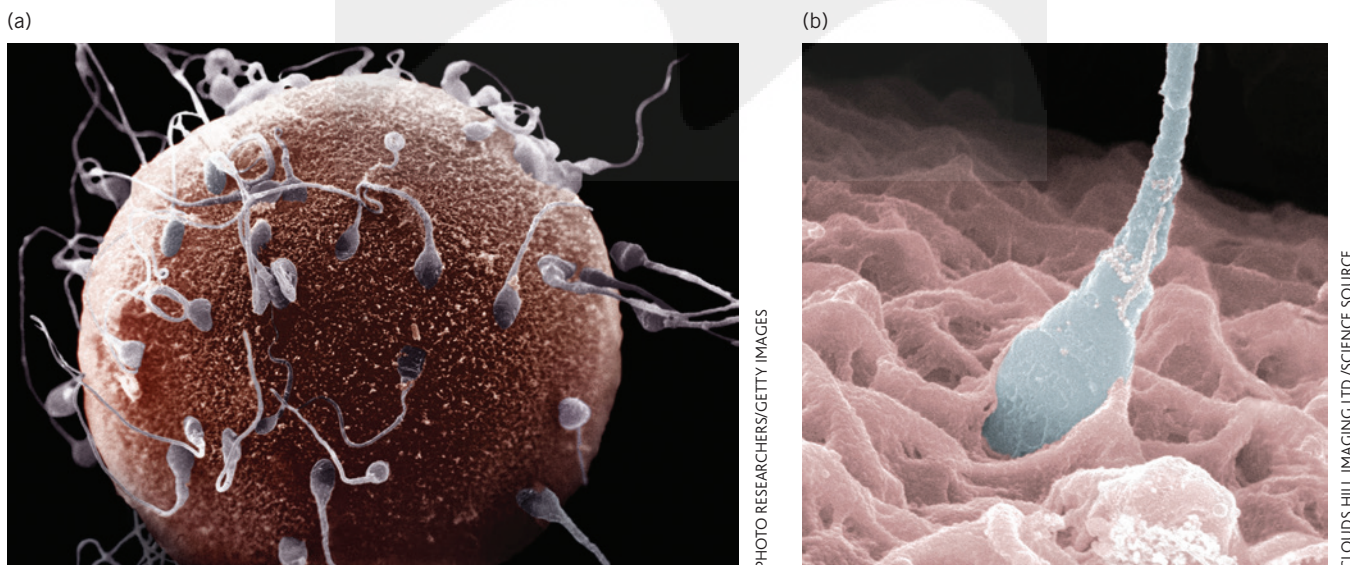


FIGURE 2.2 (a) Sperm nearing the egg Of the millions of sperm that enter the vagina, only a few ever get near the egg. The egg is the largest human cell (the only one visible to the naked eye), but sperm are among the smallest. **(b) Sperm penetrating the egg** This sperm is whipping its tail around furiously to drill itself through the outer covering of the egg.

BOX 2.2 INDIVIDUAL DIFFERENCES

Do Girls Outnumber Boys?

Do girls outnumber boys? Because the answer to that question depends on the various forces that influence development and survival, it ultimately depends on when in the lifecycle you ask. There are slightly more male newborns (51.3%) across generations and around the world. This is the case, despite the fact that male fetuses are more susceptible to spontaneous abortion than females in both the 1st week and last several weeks of pregnancy (though it is worth noting that female fetuses are more susceptible in weeks 10–15) (Orzack et al., 2015).

The apparent frailty of male fetuses, paired with the fact that males outnumber females at birth, would seem to imply that male embryos must significantly outnumber female embryos (Austad, 2015). In fact, conception is equally likely to result in male and female embryos (Orzack et al., 2015). Researchers took advantage of the increased use of reproductive technologies and prenatal genetic tests to determine the sex of nearly 140,000 3- to 6-day-old fetuses, and they found an almost exact 50-50 split between males and females. It appears that female fetuses are actually less likely than male fetuses to survive early gestation, resulting in the slight male bias at birth.

Females win the next big competition—birth. During labour and delivery, males are more likely to experience fetal distress than females, even controlling for the males' larger size and head circumference (DiPietro, Costigan, & Voegtline,

2015). Indeed, for decades, and across many cultural contexts, infant mortality rates have been higher for boys than for girls (Drevenstedt et al., 2008). Male fetuses are more sensitive than females are to teratogens (harmful external agents), including opioids and alcohol, which affects their viability and ability to thrive after birth (e.g., DiPietro & Voegtline, 2017). Male infants' heightened vulnerability is not limited to the immediate postnatal period. Males are also more likely than females to die from sudden infant death syndrome (SIDS, discussed in more detail in Box 2.3; Mage & Donner, 2014) and have higher rates of incidence of a wide range of developmental disabilities, including attentional disorders and autism spectrum disorders.

Societal and cultural forces also play a role, sometimes to devastating effect. In many societies, both historically and currently, male offspring are more highly valued than female offspring, and parents resort to infanticide to avoid having daughters. For example, Inuit families in Canada's North traditionally depended on male children to help in the hunt for food, and in former times, Inuit girls were often killed at birth. Until 2015, the Chinese government strictly enforced a "one-child" policy, a measure designed to reduce population growth by forbidding couples to have more than one child. This policy resulted in many parents killing or abandoning their female babies (or giving them up for adoption to Western families) in order to make room for a male child.

A more technological approach is currently practiced in some countries that place a premium on male offspring: prenatal tests are used to determine the gender of the fetus, and female fetuses are selectively aborted. These cases dramatically illustrate the socio-cultural model of development described in Chapter 1: cultural values, government policy, and available technology all affect developmental outcomes. Though not addressed in the studies cited here, it is important to note that not every individual can be categorized as male or female, and that an infant's designated sex at birth may differ from their eventual gender identity. These issues are addressed more fully in Chapter 15.

It is important to remember that our understanding of the effects of environmental forces on developmental outcomes is far from complete. New research is exploring the impact of climate change on sex ratios—both in terms of higher temperatures, which may increase the ratio of boys conceived compared to girls, and stress-related teratogens as a result of extreme weather events and subsequent environmental effects, which may negatively affect the number of male fetuses that survive through birth (Fukuda et al., 2014). Evidence at this point does not support definitive statements about the impact of climate change on birth sex ratios, but emerging research in this area reminds us of the complex network of forces at play.

harbour an egg. And a substantial portion of the sperm have serious genetic or other defects that prevent them from propelling themselves vigorously enough to reach and fertilize the egg. Thus, any sperm that do get to the egg are likely to be healthy and structurally sound, revealing a Darwinian-type "survival of the fittest" process operating during conception. (Box 2.2 describes the consequences of this selection process for the conception of males and females.)

As soon as one sperm's head penetrates the outer membrane of the egg, a chemical reaction seals the membrane, preventing other sperm from entering. The tail of the sperm falls off, the contents of its head gush into the egg, and the nuclei of the two cells merge within hours. The fertilized egg, known as a **zygote**, now has a full complement of human genetic material, 23 chromosomes from the egg and 23 chromosomes from the sperm.

Developmental Processes

Four major developmental processes underlie the transformation of a zygote into an **embryo** and then a **fetus**. The first is *cell division*, known as **mitosis**. Within about 12 hours after conception, the zygote divides into two equal parts, each

zygote a fertilized egg cell

embryo the developing organism from the 3rd to 8th week of prenatal development

fetus the developing organism from the 9th week to birth

mitosis cell division that results in two identical cells

containing a full complement of genetic material. These two cells then divide into four, those four into eight, those eight into sixteen, and so on. Through continued cell division over the course of 38 weeks, the barely visible zygote becomes a newborn consisting of trillions of cells.

A second major process is *cell migration*, the movement of newly formed cells away from their point of origin. Among the many cells that migrate are the neurons that originate deep inside the embryonic brain and then, like pioneers settling new territory, travel to the outer reaches of the developing brain.

The third process in prenatal development is *cell differentiation*. Initially, all of the embryo's cells, referred to as **embryonic stem cells**, can give rise to any of the more than 200 possible cell types in the human body. (It is this unique flexibility that makes embryonic stem cells the focus of a great deal of research in regenerative medicine.) After several cell divisions, however, these cells start to specialize. Since all cells in the body share an identical set of genes, what factors determine which type of cell a given stem cell will become? While much about this process remains unknown, it is clear that the cell's location influences its future development via chemical and cell-to-cell contact with neighbouring cells, and that gene expression—which genes in the cell are switched on—distinguishes one type of cell from another.

The fourth developmental process is something you would not normally think of as developmental at all—*death*. The role of this genetically programmed “cell suicide,” known as **apoptosis**, is readily apparent in hand development: the formation of fingers depends on the death of the cells in between the ridges in the hand plate, as seen in Figure 2.3. In other words, death is preprogrammed for the cells that disappear from the hand plates. Apoptosis has been referred to as a “ticking death timer” because it follows a specific timeline, programmed into the cells themselves.

Finally, hormones have a major influence throughout prenatal development. For example, hormones play a crucial role in sexual differentiation. All human fetuses, regardless of the genes they carry, can develop either male or female genitalia. The presence of *androgens*, a class of hormones that includes testosterone, leads to the development of male genitalia. If androgens are absent, female genitalia develop. The source of androgens is the male fetus itself, at around the 8th week after conception. This is just one of the many ways in which the fetus influences its own development. Other important hormones include steroids such as glucocorticoids, which limit fetal growth and help fetal tissues mature. Toward the end of gestation, the fetus increases production of these hormones in order to facilitate maturation of key organs, such as the lungs, that are needed for life outside the womb. Later in this chapter, we will discuss the role played by glucocorticoids in the influence of maternal stress on the fetus.

We now turn our attention to the general course of prenatal development.

Early Development

On its journey through the fallopian tube to the womb, the zygote doubles its number of cells roughly twice a day. By the 4th day after conception, the cells arrange themselves into a hollow sphere with a bulge of cells, called the *inner cell mass*, on one side.

embryonic stem cells embryonic cells, which can develop into any type of body cell

apoptosis genetically programmed cell death

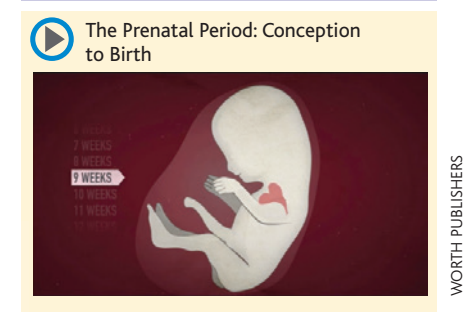
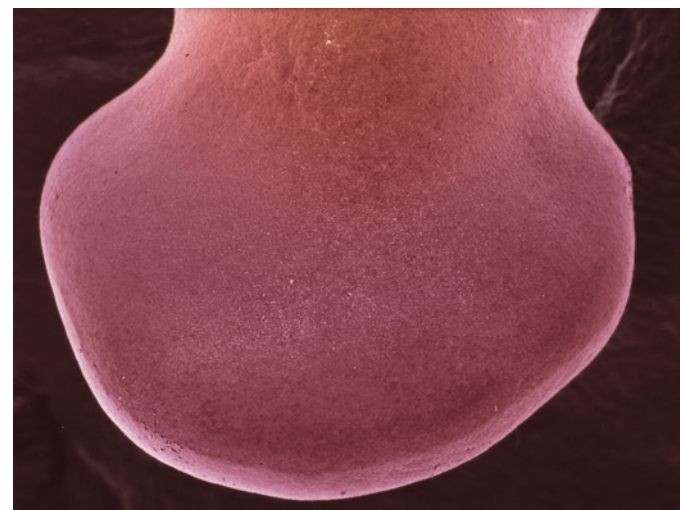


FIGURE 2.3 Fetal hand plate The role of apoptosis, or cell death, is clearly seen in the development of the hand, which requires the death of the cells in between the ridges of the hand plate in order for the fingers to separate.



identical (monozygotic) twins twins that result from the splitting in half of the zygote, resulting in each of the two resulting zygotes having exactly the same set of genes

fraternal (dizygotic) twins twins that result when two eggs happen to be released into the fallopian tube at the same time and are fertilized by two different sperm; fraternal twins have only half their genes in common

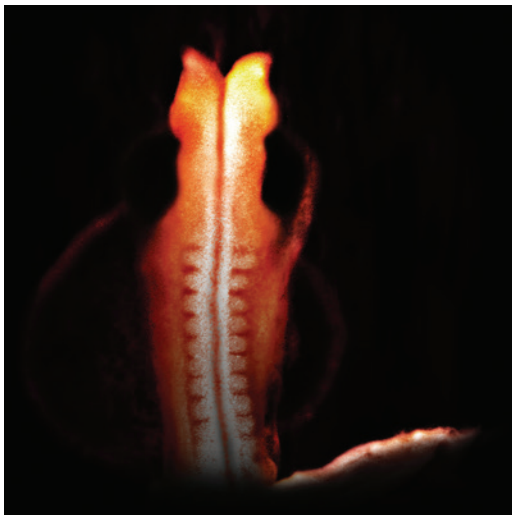
neural tube a groove formed in the top layer of differentiated cells in the embryo that eventually becomes the brain and spinal cord

amniotic sac a transparent, fluid-filled membrane that surrounds and protects the fetus

placenta a support organ for the fetus; it keeps the circulatory systems of the fetus and mother separate, but a semipermeable membrane permits the exchange of some materials between them (oxygen and nutrients from mother to fetus, and carbon dioxide and waste products from fetus to mother)

umbilical cord a tube containing the blood vessels connecting the fetus and placenta

FIGURE 2.4 Neural tube In the 4th week, the neural tube begins to develop into the brain and spinal cord. In this photo, the neural groove, which fuses together first at the centre and then outward in both directions as if two zippers were being closed, has been “zipped shut” except for one part still open at the top. Spina bifida, a congenital disorder in which the skin over the spinal cord is not fully closed, can originate at this point. After closing, the top of the neural tube will develop into the brain.



ANATOMICAL TRAVELOGUE/SCIENCE SOURCE

This is the stage at which **identical (monozygotic) twins** most often originate. They result from a splitting in half of the inner cell mass, thus they have exactly the same genetic makeup. In contrast, **fraternal (dizygotic) twins** result when two eggs happen to be released from the ovary into the fallopian tube and both are fertilized. Because they originate from two different eggs and two different sperm, fraternal twins are no more alike genetically than non-twin siblings with the same parents.

By the end of the 1st week following conception, if all goes well (which it does for less than half the zygotes that are conceived), the zygote embeds itself in the uterine lining and becomes dependent on the mother for sustenance. The embedded ball of cells then starts to differentiate. The inner cell mass becomes the embryo, and the rest of the cells become an elaborate support system—including the *amniotic sac* and *placenta*—that enables the embryo to develop. The inner cell mass is initially a single layer thick, but during the 2nd week, it folds itself into three layers, each with a different developmental destiny. The top layer becomes the nervous system, the nails, teeth, inner ear, lens of the eyes, and the outer surface of the skin. The middle layer becomes muscles, bones, the circulatory system, the inner layers of the skin, and other internal organs. The bottom layer develops into the digestive system, lungs, urinary tract, and glands. A few days after the embryo has differentiated into these three layers, a U-shaped groove forms down the centre of the top layer. The folds at the top of the groove move together and fuse, creating the **neural tube** (Figure 2.4). One end of the neural tube will swell and develop into the brain, and the rest will become the spinal cord.

The elaborate support system that develops along with the embryo is essential to the embryo's survival. The **amniotic sac** is a membrane filled with a clear, watery fluid in which the fetus floats. The amniotic fluid operates as a protective buffer for the developing fetus, providing it with a relatively even temperature and cushioning it against jolting. The **placenta** is a rich network of blood vessels, weighing roughly one pound, that extends into the tissues of the mother's uterus. While we might assume that the placenta comes from the mother, 90% of the cells in the placenta come from the fetus itself. Far from just being afterbirth, the placenta is a complex organ that plays a critical role in the healthy development of the fetus.

Crucially, the placenta is semipermeable: it permits the exchange of materials carried in the bloodstreams of the fetus and its mother, but it prevents the blood of the mother and fetus from mixing. Oxygen, nutrients, minerals, and some antibodies—all of which are just as vital to the fetus as they are to you—are transported to the placenta by the mother's circulating blood. They then cross the placenta and enter the fetal blood system. Waste products (e.g., carbon dioxide and urea) from the fetus cross the placenta in the opposite direction and are removed from the mother's bloodstream by her normal excretory processes. The placental membrane also serves as a defensive barrier against a host of dangerous toxins and infectious agents that can inhabit the mother's body but would be harmful or even fatal to the fetus. Unfortunately, being semipermeable, the placenta is not a perfect barrier, and, as you will see shortly, a variety of harmful elements can cross it and attack the fetus. These support system structures are illustrated in Figure 2.1.

The amniotic sac is connected to the placenta via the **umbilical cord**, which is a tube containing the blood vessels that run to the fetus.

An Illustrated Summary of Prenatal Development

The course of prenatal development from the 4th week post-conception on is illustrated in Figures 2.5 through 2.11, and significant milestones are highlighted in the accompanying text. Notice that earlier development takes place at a more rapid pace than later development and that the areas nearer the head develop earlier than those farther away (e.g., head before body, hands before feet)—a general tendency known as **cephalocaudal development**.

Figure 2.5: At 4 weeks after conception, the embryo is curved so tightly that the head and the tail-like structure at the other end are almost touching. The round area near the top of the head is where the eyes will form, and the round gray area near the back of the “neck” is the primordial inner ear. A primitive heart is visible; it is already beating and circulating blood. An arm bud can be seen in the side of the embryo; a leg bud is also present but less distinct.

Figure 2.6: (a) In this 5½-week-old fetus, the nose, mouth, and palate are beginning to differentiate into separate structures. (b) Just 3 weeks later, the nose and mouth are almost fully formed. Cleft palate, one of the most common birth defects worldwide, involves malformations of this area and originates sometime between 5½ and 8 weeks prenatally, as these structures are developing.

Figure 2.7: The bulging forehead of this 9-week-old fetus reflects extremely rapid brain growth. Rudimentary eyes and ears are forming. All the internal organs are present. Sexual differentiation has started. Ribs are visible, fingers and toes have emerged, and nails are growing.

Figure 2.8: This image of an 11-week-old fetus clearly shows the heart, which has achieved its basic adult structure. You can also see the developing spine and ribs, as well as the major divisions of the brain.

Figure 2.9: During the last 5 months of prenatal development, the growth of the lower part of the body accelerates. At this age, the external genitalia are substantially developed, and a different camera angle would have revealed the sex of this fetus.

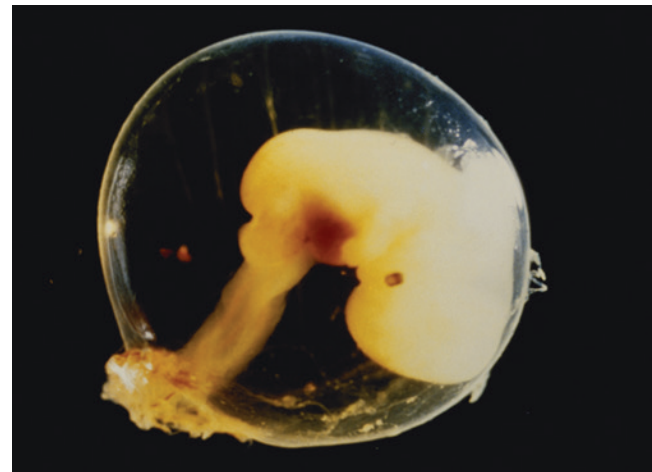


FIGURE 2.5 Embryo at 4 weeks.

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cephalocaudal development the pattern of growth in which areas near the head develop earlier than areas farther from the head



DR G. MOSCOSO/SCIENCE SOURCE



STEVE ALLEN/THE IMAGE BANK/GETTY IMAGES

FIGURE 2.6 Face development from (a) 5½ to (b) 8½ weeks.



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FIGURE 2.7 Fetus at 9 weeks.



ANATOMICAL TRAVELOGUE/SCIENCE SOURCE

FIGURE 2.8 Fetus at 11 weeks.

Figure 2.10: This 18-week-old fetus is covered with very fine hair, and a greasy coating protects its skin from its long immersion in liquid. The components of facial expressions are present—the fetus can raise its eyebrows, wrinkle its forehead, and move its mouth.

Figure 2.11: The brain and lungs of a 28-week-old fetus are sufficiently developed that it would have a chance of surviving on its own, without medical intervention. The eyes can open, and they move, especially during periods of rapid eye movement (REM) sleep. The auditory system is functioning, and the fetus reacts to a variety of sounds.

During the last 3 months of prenatal development, the fetus grows dramatically in size, essentially tripling its weight. It also develops a wide repertoire of behaviours and learns from its experiences, as described in the next section. Table 2.1 summarizes the major milestones in prenatal development.



ANATOMICAL TRAVELOGUE/SCIENCE SOURCE

FIGURE 2.9 Fetus at 16 weeks.



ARNO MASSEE/SCIENCE SOURCE

FIGURE 2.10 Fetus at 18 weeks.

TABLE 2.1 Milestones in Prenatal Development		
Trimester	Weeks	Major Milestones
1	1	Zygote travels from fallopian tube to womb and embeds in uterine lining; cells arrange into a ball and begin to form embryo and support system.
	2–3	Embryo forms three layers, which will become the nervous system and skin; muscles, bones, and circulatory system; and digestive system, lungs, and glands; neural tube also develops.
	4	Neural tube continues to develop into the brain and spinal cord; primitive heart is visible, as are leg and arm buds.
	5–9	Facial features differentiate; rapid brain growth occurs; internal organs form; fingers and toes emerge; sexual differentiation has started.
	10–12	Heart develops its basic adult structures; spine and ribs develop more fully; brain forms major divisions.
2	13–24	Lower body growth accelerates; external genitalia are fully developed; body develops hairy outer covering; fetus can make basic facial expressions; fetal movements can be felt by mother.
3	25–38	Fetus triples in size; brain and lungs are sufficiently developed at 28 weeks to allow survival outside of womb; visual and auditory systems are functional; fetus is capable of learning and behaviours begin to emerge.

Fetal Experience and Behaviour

Is the womb a haven of peace and quiet? Although the uterus and the amniotic fluid buffer the fetus from much of the stimulation impinging on the mother, the fetus still experiences an abundance of sensory stimulation and is capable of learning and developing behaviours.

Studies of fetal behaviour reveal many results consistent with the themes laid out in Chapter 1. Prenatal experiences shape the developing fetus (*nature and nurture*). The fetus participates in, and contributes to, its own development: the formation of organs and muscles depends on fetal activity, and the fetus rehearses the behavioural repertoire it will need at birth (*the active child*). There is also evidence for both *continuity and discontinuity*. To give just one striking example, 32-week-old fetuses whose heart rates were generally slower and who moved less were more behaviourally inhibited at 10 years of age (DiPietro et al., 2018). Despite their very different environments (discontinuity), fetuses and children show surprising similarities (continuity).

Movement

From 5 or 6 weeks after conception, the fetus moves spontaneously. One of the earliest distinct patterns of movement to emerge (at around 7 weeks) is, remarkably enough, hiccups. Although the reasons for prenatal hiccups are unknown, one theory posits that they are a *burping* reflex, preparing the fetus for eventual nursing by removing air from the stomach to make more room for milk (Howes, 2012).

Swallowing is another important reflex that helps to prepare the fetus for survival outside the womb. Fetuses swallow amniotic fluid, most of which is excreted back out into the amniotic sac. The tongue movements associated with swallowing promote the normal development of the palate. In addition, the



FIGURE 2.11 Fetus at 28 weeks.

MEDI-MATION/SCIENCE PHOTO LIBRARY



FIGURE 2.12 Fetal arm and hand movements.

passage of amniotic fluid through the body helps the digestive system mature properly.

Another form of fetal movement anticipates breathing after birth. For breathing to occur, the respiratory system must be mature and functional. Beginning as early as 10 weeks after conception, the fetus promotes its respiratory readiness by exercising its lungs through “fetal breathing,” moving its chest wall in and out. No air is taken in, of course; rather, small amounts of amniotic fluid are pulled into the lungs and then expelled. Fetal breathing is initially infrequent and irregular but then increases in rate and stability. By the third trimester, fetuses “breathe” roughly once per second (Ulusar, Sandhal, & Mendilcioglu, 2017).

Touch

The fetus experiences tactile stimulation as a result of its own activity. Fetuses have been observed not only grasping their umbilical cords but also rubbing their face and sucking their thumbs. Indeed, the majority of fetal arm movements during the second half of pregnancy result in contact between their hand and mouth (Myowa-Yamakoshi & Takeshita, 2006), as the fetus in Figure 2.12 demonstrates. Remarkably, fetuses’ choice of thumb to suck predicts later handedness; fetuses who suck their right thumb are more likely to be righthanded adolescents, whereas fetuses who suck their left thumb are more likely to be lefthanded adolescents (Hepper, Wells, & Lynch, 2005).

As the fetus grows larger, it bumps against the walls of the uterus increasingly often. By full term, fetal heart rate responds to maternal movements, suggesting that their vestibular systems—the sensory apparatus in the inner ear that provides information about movement and balance—is also functioning before birth (Cito et al., 2005; Lecanuet & Jacquet, 2002).

Sight

Although it is not totally dark inside the womb, the visual experience of the fetus is minimal. Despite minimal stimulation, fetuses can process visual information by the third trimester of pregnancy, and, much like newborn infants, fetuses have visual preferences. In a recent study, researchers used 4-D ultrasound to measure what third-trimester fetuses preferred to look at by projecting light patterns onto pregnant women’s abdomens (see Figure 2.13; Reid et al., 2017). Fetuses preferred light displays that are top-heavy (resembling correctly oriented faces) over those that are bottom heavy (resembling inverted faces). These data suggest that infants’ predispositions to look toward face-like stimuli may not require postnatal experience (though see Scheel et al., 2018, for an alternative view). We continue the discussion of face perception and preference in infants in Chapter 5, Box 5.1.

Taste

The amniotic fluid contains a variety of flavours, and fetuses like some better than others. Indeed, the fetus has a sweet tooth. The first evidence of fetal taste preferences came from a study performed more than 60 years ago (described by Gandelman, 1992). A physician named DeSnoo (1937) devised an ingenious treatment for women with excessive amounts of amniotic fluid. He injected saccharin into their amniotic fluid, hoping that the fetus would help the mother out by ingesting increased amounts of the sweetened fluid, thereby diminishing the excess. And, in fact, tests of the mothers’ urine showed that the fetuses

ingested more amniotic fluid when it had been sweetened, demonstrating that flavour preferences exist before birth.

Smell

Amniotic fluid takes on odours from what the mother has eaten. Obstetricians have long reported that during birth they can smell scents like curry and coffee in the amniotic fluid of women who had recently consumed them. Smells can be transmitted through liquid, and amniotic fluid comes into contact with the fetus's odour receptors through fetal breathing, providing fetuses with the opportunity for olfactory experience. Prenatal scent learning plays an important role in many species' early developmental processes, demonstrating the principle of **phylogenetic continuity**: humans share many characteristics and developmental processes with nonhuman animals due to our shared evolutionary history. For example, during the birth process in rats, the nipples on the underside of the mother rat's belly are smeared with amniotic fluid. The scent of the amniotic fluid is familiar to the rat pups from their time in the womb, and it lures the pups to the mother's nipples for nursing. When the mother rat's nipples are washed immediately after birth, newborn rats fail to attach to her nipples (Teicher & Blass, 1977). This classic finding clearly demonstrates that nurture begins prenatally: experiences before birth play an important role in post-natal developmental processes.

Hearing

The prenatal environment is surprisingly noisy. Fetuses float in a soundscape dominated by their mother's heartbeat, blood flow, and breathing. From the fetuses' vantage point, digestive sounds occur roughly 5 times per second (Parga et al., 2018)! The noise level in the uterus ranges from about 70–95 decibels (roughly the noise level of a vacuum to a lawnmower). The mother's voice is particularly prominent. We know that the fetus hears its mother because its heart rate changes when the mother starts speaking (Voegtline et al., 2013).

During the last trimester, external noises elicit changes in fetal movements and heart rate as well, suggesting that the fetus also perceives sounds outside the mother's body. For instance, Canadian researchers found that fetal heart rate increases when recordings of the mother's or father's voices are played near the pregnant mother's abdomen (Lee & Kisilevsky, 2014). Similarly, changes in heart-rate patterns suggest that fetuses can distinguish between music and speech played near the mother's abdomen (Granier-Deferre et al., 2011).

The uterine auditory experience appears to be particularly well-suited to early brain development. In a study by Webb and colleagues (2015), a group of hospitalized preterm infants spent several hours each day listening to recordings of their mothers' uterine sounds (including voices and heartbeats). At 1 month of age, their brain development was compared to another group of preterm infants who were only exposed to regular hospital sounds. The preterm

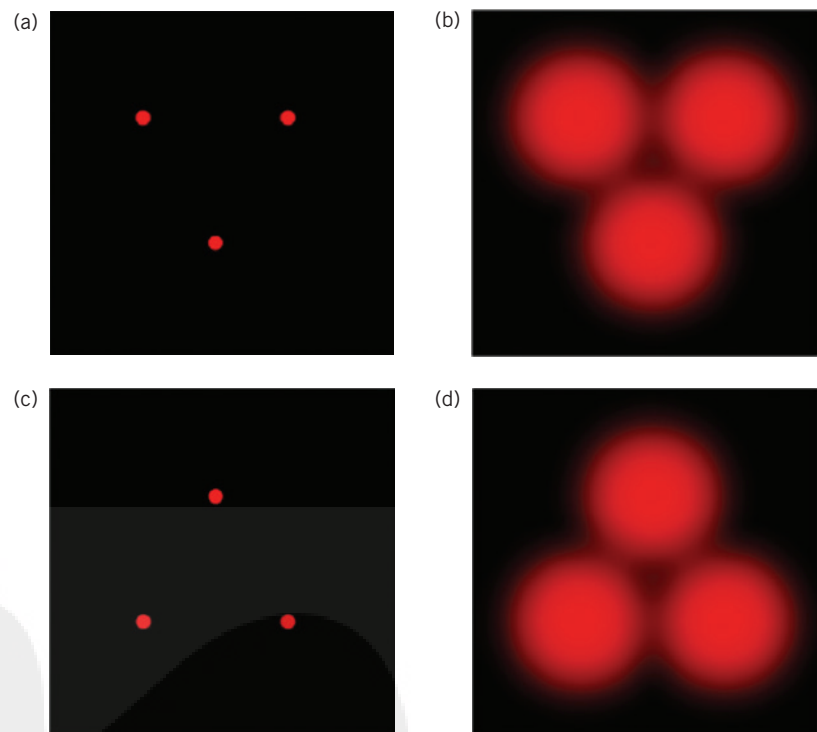


FIGURE 2.13 Light-pattern projection

Fetuses prefer light displays that are top-heavy, resembling correctly oriented faces (a, b) over bottom-heavy displays (c, d). The images on the left show the unobstructed light display, and the images on the right illustrate how this display would look to the fetus.

FIGURE 1 FROM THE HUMAN FETUS PREFERENTIALLY ENGAGES WITH FACE-LIKE VISUAL STIMULI BY REID ET AL. CURRENT BIOLOGY, JULY 10, 2017. © 2017 THE AUTHORS. PUBLISHED BY ELSEVIER LTD. CREATIVE COMMONS ATTRIBUTION (CC BY 4.0)

phylogenetic continuity the idea that because of our common evolutionary history, humans share many characteristics, behaviours, and developmental processes with non-human animals, especially mammals

habituation a simple form of learning that involves a decrease in response to repeated or continued stimulation

dishabituation the introduction of a new stimulus rekindles interest following habituation to a repeated stimulus

infants exposed to womb sounds had larger auditory cortexes than the control group, suggesting that maternal sounds may facilitate brain development before full gestation.

Because sound is such a prevalent feature of the fetal environment, it plays a major role in prenatal learning, as we discuss next.

Fetal Learning

To this point, we have emphasized the impressive behavioural and sensory capabilities of the fetus. Even more impressive is the extent to which the fetus learns from its experiences in the last 3 months of pregnancy, after the central nervous system is adequately developed to support learning.

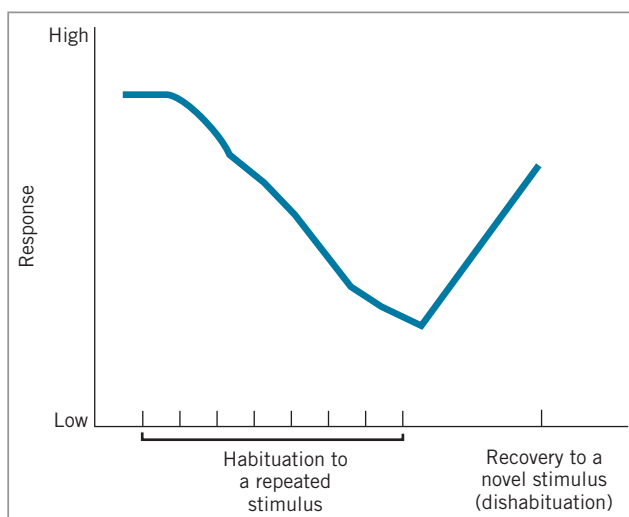
In the example of fetal learning that opened this chapter, infants remembered specific prenatal auditory experiences that were presented via audio speakers adjacent to the mother's abdomen, such as repetitions of a single nonsense word (Partanen, Kujala, Tervaniemi et al., 2013) or a melody like *Twinkle Twinkle Little Star* (Partanen, Kujala, Näätänen et al., 2013). More direct evidence for fetal learning comes from studies of habituation, one of the simplest forms of learning. Much like adults and children, fetuses grow bored if a stimulus is repeated over and over again. This process is called **habituation**: a decrease in response to repeated or continued stimulation (see Figure 2.14). Habituation provides evidence of learning and memory: the stimulus loses its novelty (and becomes boring) only if the stimulus is remembered from one presentation to the next. When a perceptible change in the stimulus occurs, it becomes interesting again—a process known as **dishabituation**. Fetuses as young as 30 weeks gestation show habituation to both visual and auditory stimuli, indicating that their central nervous systems are sufficiently developed for learning and short-term memory to occur (Matuz et al., 2012; Muenssinger et al., 2013).

Fetuses also learn from their extensive experience with their mother's voice. To test this idea, Queens University's Barbara Kisilevsky and her colleagues (2003) tested term fetuses in one of two conditions. Half of the fetuses listened to a recording of their mother reading a poem, played through speakers placed on their mother's abdomen. The other half listened to recordings of the same poem read by another woman. Fetal heart rate increased in response to the mother's voice but

decreased in response to the other woman's voice. These findings suggest that the fetuses recognized (and were aroused by) the sound of their own mother's voice relative to a stranger's voice. For this to be the case, fetuses must be learning and remembering the sound of their mother's voice.

After birth, do newborns remember anything about their fetal experience? The answer is a resounding yes! They still prefer to listen to their own mother's voice rather than to the voice of another woman (DeCasper & Fifer, 1980). Furthermore, newborns prefer to listen to a version of their mother's voice that has been filtered to sound the way it did in the womb, rather than to another woman's filtered voice (Moon & Fifer, 1990; Spence & Freeman, 1996). Newborns prefer to listen to the language they heard in the womb over another language (Mehler et al., 1988; Moon, Cooper, & Fifer, 1993). Finally, newborns remember the sounds of specific stories heard in the

FIGURE 2.14 Habituation Habituation occurs in response to the repeated presentation of a stimulus. As the first stimulus is repeated and becomes familiar, the response to it gradually decreases. When a novel stimulus occurs, the response recovers. The decreased response to the repeated stimulus indicates the formation of memory for it; the increased response to the novel stimulus indicates discrimination of it from the familiar one, as well as a general preference for novelty.



womb (DeCasper & Spence, 1986). Figure 2.15 describes the technique these researchers used to study prenatal learning.

Fetuses also learn from the tastes and smells they encounter in the womb. Like the rat pups discussed earlier, newborn humans remember the scent of amniotic fluid. They orient to their own amniotic scent and prefer scents reflecting flavours that their mother ate while she was pregnant, like anise (licorice) or garlic (for a review, see Anzman-Frasca et al., 2018). Long-lasting taste preferences have also been observed. In one study, pregnant women drank carrot juice for three weeks near the end of their pregnancy (Mennella, Jagnow, & Beauchamp, 2001). When tested at around 5½ months of age, their babies reacted more positively to cereal prepared with carrot juice than to the same cereal prepared with water. These flavour preferences suggest a *persistent* effect of prenatal learning that may shed light on the origins and strength of cultural food preferences. A child whose mother ate a lot of chili peppers, ginger, and cumin during pregnancy, for example, might be more favourably disposed to Indian food than would a child whose mother's diet lacked those flavours.

Does this evidence of fetal learning suggest that there is a benefit to “prenatal education” programs, where specific music, languages, voices, or other experiences can be used to enhance cognitive abilities after birth? Probably not. In the first place, the fetal brain is unlikely to be sufficiently developed to process much about language meaning. In addition, the liquid environment in the womb filters out detailed speech and music sounds, leaving only pitch contours and rhythmic patterns. In short, the fetus learns about general sounds but not any specific content.

REVIEW QUESTION

Fetal development includes periods of rapid change, as well as periods of slower growth. Throughout the gestation process, the fetus goes through phases during which different organs and systems develop. How do the different periods of fetal development illustrate aspects of continuity and discontinuity? ■

Hazards to Prenatal Development

Regrettably, prenatal development is not always free of error or misfortune. The most dire, and by far the most common, misfortune is *spontaneous abortion*—commonly referred to as *miscarriage*. Most miscarriages occur before the woman even knows that she is pregnant. The majority of embryos that are miscarried very early have severe defects, such as a missing chromosome or an extra one, that make further development impossible. In Canada and the United States, between 6% and 15% of clinically recognized pregnancies end in miscarriage (Arck et al., 2008; Rai & Regan, 2006). This number is similar to the rate in a very different culture, rural Kenya (18.9%), suggesting that the factors that influence miscarriage are present across a wide range of life circumstances (Dellicour et al., 2016).

Across their childbearing years, at least 25% of women—and possibly as many as 50%—experience at least one miscarriage. Few women realize how common this experience is, making it all the more painful if it happens to them. Yet more



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FIGURE 2.15 Prenatal learning This newborn can control what he gets to listen to. His pacifier is hooked up to a computer, which is in turn connected to an audio player. If the baby sucks in one pattern (predetermined by the researchers), he will hear one recording. If he sucks in a different pattern, he will hear a different recording. Researchers have used this technique to investigate many questions about infant abilities, including the influence of fetal experience on newborn preferences.

teratogen an external agent that can cause damage or death during prenatal development

sensitive period the period of time during which a developing organism is most sensitive to the effects of external factors

dose–response relation a relation in which the effect of exposure to an element increases with the extent of exposure (prenatally, the more exposure a fetus has to a potential teratogen, the more severe its effect is likely to be)

Challenges During Pregnancy



This young artist exhibits the harmful prenatal effects of exposure to thalidomide. It seems likely that his mother took the drug in the 2nd month of her pregnancy, when the arm buds are developing—an unfortunate example providing clear evidence of the importance of timing in how environmental agents can affect the developing fetus.



agonizing is the experience of the approximately 1% of women who experience *recurrent miscarriages*, or the loss of three or more consecutive pregnancies. Encouragingly, though, many women who have had recurrent miscarriages successfully carry subsequent pregnancies to term (Cohain, Buxbaum, & Mankuta, 2017).

For fetuses that survive the danger of miscarriage, there is still a range of factors that can lead to unforeseen negative consequences. Here, we consider some of the many environmental risk factors. Genetic factors will be discussed in Chapter 3.

Teratogens

A vast number of environmental agents, called **teratogens**, have the potential to harm the fetus. The effects of potential teratogens are heavily influenced by timing (one of the basic developmental principles discussed in Chapter 1). Many teratogens cause damage only if they are present during a **sensitive period** in prenatal development. The major organ systems are most vulnerable to damage at the time when their basic structures are being formed. Because the timing is different for each system, the sensitive periods are different for each system, as shown in Figure 2.16.

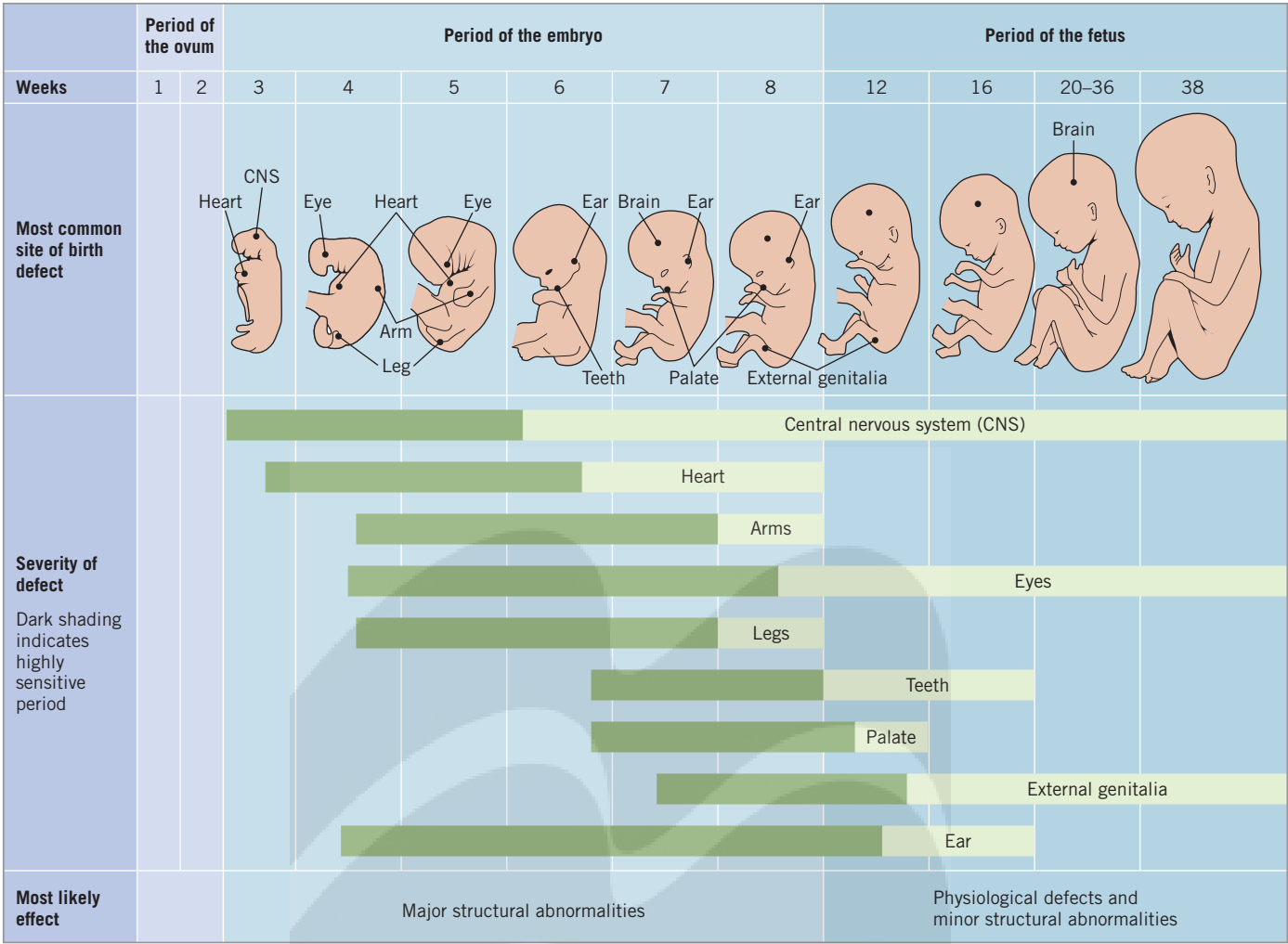
The most dramatic illustration of the importance of timing comes from the use of the drug thalidomide in the early 1960s. Thalidomide was prescribed to treat morning sickness (among other things) and was considered to be so safe that it was sold over the counter in numerous countries, including Canada (the last country to withdraw thalidomide from the market). At the time, it was believed that such medications would not cross the placental barrier. However, many pregnant women who took this new, presumably safe drug gave birth to babies with major limb deformities; some babies were born with no arms and with flipperlike hands growing out of their shoulders. In a striking illustration of sensitive period effects, serious defects occurred only if the pregnant woman took the drug between the 4th and 6th week after conception—the time when her fetus's limbs were emerging and developing (look again at Figures 2.5 to 2.11).

Taking thalidomide either before the limbs started to develop or after they were basically formed had no harmful effect.

As you can see in Figure 2.16, the sensitive periods for many organ systems occur before the woman might realize she is pregnant. Because a substantial number of pregnancies are unplanned, sexually active people of childbearing age should be aware of factors that could compromise the health of a child they might conceive.

Another crucial factor influencing the severity of teratogenic effects is the amount and duration of exposure. Most teratogens show a **dose–response relation**: the greater the fetus's exposure to a potential teratogen, the more likely it is that the fetus will suffer damage and the more severe any damage is likely to be.

Teratogens frequently occur in combination, making it difficult to separate out their effects. For families living in poverty, for example, it is hard to tease apart the effects of poor maternal nutrition, exposure to pollution, inadequate prenatal care, and psychological stress. The presence of multiple risk factors can have a *cumulative* impact on development, as we discuss further at the end of this chapter in the section on multiple-risk models.



Negative effects of prenatal experience may not be immediately evident. *Fetal programming* refers to the belated emergence of effects of prenatal experience that “program the physiological set points that will govern physiology in adulthood” (Coe & Lubach, 2008). For instance, in the case of inadequate prenatal nutrition, the fetus’s metabolism adjusts to the level of nutritional deficiency experienced in the womb and does not reset itself after birth. In a postnatal environment with abundant food, this programming sets the stage for the development of overweight and obesity issues.

Evidence comes from studies of individuals who were conceived in the Netherlands in 1944, during what was known as the Dutch Hunger Winter (Schulz, 2010). At this point in World War II, the German occupying force in the Netherlands limited rations to as little as 400 to 800 calories per day. Women in the earlier stages of pregnancy during the famine had babies of normal birth weights. However, these infants grew up to have high rates of obesity. The fetuses’ metabolisms were apparently set prenatally, while they were experiencing undernutrition, and were not reset when nutrition reached normal levels. Thus, the physiology of these individuals was a poor match for the food-rich environment available later in their lives, leading to an increased risk of obesity.

The effects of teratogens can also vary according to *individual differences* in genetic susceptibility (probably in both the mother and the fetus). Thus, a substance

FIGURE 2.16 Sensitive periods of prenatal development The most sensitive or critical period of prenatal development is the embryonic period. During the first 2 weeks, before implantation in the uterus, the zygote is generally not susceptible to environmental factors. Every major organ system of the body undergoes all or a major part of its development between the 3rd and the 9th week. The dark green portions of the bars in the figure denote the times of most rapid development when major defects originate. The light green portions indicate periods of continued but less rapid development when minor defects may occur. (Information from Moore & Persaud, 1993)

that is harmless to most people may trigger problems in individuals whose genes predispose them to be affected by it. Identifying teratogens is further complicated by the existence of *sleepers effects*, in which the impact of a given agent may not be apparent for many years. For example, between the 1940s and 1960s, the hormone diethylstilbestrol (DES) was commonly used to prevent miscarriage and had no apparent ill effects on babies born to women who had taken it. However, in adolescence and adulthood, these offspring turned out to have elevated rates of cervical and testicular cancers. An enormous number of potential teratogens have been identified, but we will focus only on some of the most common ones.

Drugs

In Canada, 6.7% of women reported using illegal drugs in the three months before becoming pregnant or before realizing that they were pregnant, while about 1% of women reported using drugs after recognizing that they were pregnant (Public Health Agency of Canada, 2009). Almost all drugs of abuse—both legal and illegal—have been shown to be, or are suspected of being, dangerous for prenatal development. And though many prescription and over-the-counter drugs are perfectly safe for pregnant women, some are not. Pregnant women (and women who have reason to think they might soon become pregnant) should take medications only under the supervision of a physician. Some prescription drugs that are in common use by women of childbearing age, such as the acne medication isotretinoin (Accutane), are known human teratogens that cause severe birth defects or fetal death. Indeed, because of the unambiguous relationship between Accutane and birth defects, physicians require women to comply with multiple contraceptive measures and ongoing pregnancy tests before prescribing the drug.

Antidepressants Antidepressant medications raise particularly challenging issues for women contemplating pregnancy. These medications can be hugely beneficial for individuals experiencing depression. Treatment for depression during pregnancy can help reduce the risk of postpartum depression, which affects 10% to 30% of new mothers, and which is especially likely for women with previous histories of depression (Brummelte & Galea, 2016). In Canada, roughly 3% to 5% of pregnant women take antidepressant medication (Bérard & Sheehy, 2014; Smolina et al., 2015). Evidence regarding whether or not these medications are harmful to the fetus is inconclusive (Lusskin et al., 2018), raising difficult questions for pregnant women who are depressed. Should they choose a pharmaceutical intervention for their depression and risk negative outcomes from the medication? Or should they choose not to treat their mood disorder and risk negative outcomes from the depression itself?

One potential solution to this issue is the use of non-pharmaceutical treatments for depression, which many pregnant women say they would prefer (Dimidjian & Goodman, 2014). Behavioural interventions, including cognitive behaviour therapy and mindfulness-based cognitive therapy, hold promise as ways to treat perinatal depression without the use of medication (e.g., Dimidjian et al., 2017).

Opioids Another issue of increasing concern is the use of prescription opioid medications (e.g., Vicodin, Percocet, Oxycodone, Fentanyl) and the related use of illicit opioids, such as heroin. Because they are designed to mimic the effects of neurotransmitters, they have the potential to wreak havoc on the developing brain. Prescribed for pain management or used illegally, opioids can be highly damaging to fetuses, who can become addicted themselves. Neonatal abstinence syndrome (NAS) is a form of drug withdrawal seen when fetuses exposed to opioids in the

womb are born. In Canada, prevalence of NAS has continued to rise (Brogly et al., 2017); for example, between 1992 and 2011, the rate of NAS increased 0.28 per 1000 live births to 4.29 per 1000 live births (Turner et al., 2015).

Common effects of NAS include low birth weight, problems with breathing and feeding, and seizures. Treatment for these newborns often requires medications such as methadone or morphine to manage withdrawal symptoms. As we mentioned earlier, teratogens often occur in clusters. In the case of opioids, the co-presence of other maternal drug use (e.g., antidepressants or marijuana) increases the likelihood that the newborn will have NAS (Sanlorenzo, Stark, & Patrick, 2018).

Marijuana Marijuana is of particular interest to researchers because it is so frequently used by women of reproductive age, and its usage may increase in Canada now that cannabis has been legalized. Even prior to legalization, which occurred in October 2018, marijuana use among pregnant women was on the rise; in Ontario, marijuana use during pregnancy grew from 1.2% in 2012 to 1.8% in 2017, with the highest rate (6.5%) among 15- to 24-year-olds (Corsi et al., 2019). Data on the effects of marijuana on fetal development are inconclusive because many users of marijuana also smoke cigarettes and/or use alcohol, and the effects of each drug are difficult to tease apart; some studies suggest that the combination of marijuana and tobacco is particularly problematic (Ryan et al., 2018). Prenatal exposure to marijuana is also associated with a range of problems involving attention, impulsivity, learning, and memory in older children (Behnke et al., 2013).

The effects of opioids and marijuana on fetal development can be devastating, but the two drugs that wreak the most widespread havoc on fetal development are cigarettes (nicotine) and alcohol, which we turn to next.

Cigarette smoking When a pregnant woman smokes a cigarette, both she and her fetus get less oxygen. Indeed, the fetus makes fewer breathing movements while its mother is smoking, and the fetuses of smokers metabolize some of the cancer-causing agents contained in tobacco. Secondhand smoke has an indirect effect on fetal oxygen as well, through the mother's intake of cigarette gases when someone is smoking nearby.

The main developmental consequences of maternal smoking are slowed fetal growth and low birth weight, both of which compromise the health of the newborn. In addition, smoking is linked to increased risk of sudden infant death syndrome (SIDS) (discussed in Box 2.3) and a variety of other problems, including lower IQ, hearing deficits, ADHD (see Box 9.3), and cancer. As with other teratogens, there is a dose-response relationship: greater smoking intensity (as measured in the number of cigarettes per day) predicts worse outcomes, including stillbirths (e.g., Marufu et al., 2015). And, as with other teratogens, timing matters: the effects of smoking are greatest early in gestation (e.g., Behnke et al., 2013). However, in spite of the well-documented and widely advertised negative effects of maternal smoking on fetal development, approximately 12% of pregnant women in Canada continue to smoke during pregnancy (Lange et al., 2015).

E-cigarettes (e-cigs) are becoming increasingly prevalent as an alternative to conventional cigarettes. Many pregnant women believe that vaping is healthier for their fetuses than cigarette smoking (Wagner, Camerota, & Propper, 2017). While e-cigs

| Smoking endangers the health of the fetus.



GABBY JONES/BLOOMBERG VIA GETTY IMAGES

BOX 2.3 APPLICATIONS Sudden Infant Death Syndrome

For parents, nothing is more terrifying to contemplate than the death of their child. New parents are especially frightened by the specter of **sudden infant death syndrome (SIDS)**. SIDS refers to the sudden, unexpected, and unexplained death of an infant younger than 1 year. The most common SIDS scenario is that an apparently healthy baby, usually between 2 and 5 months of age, is put to bed for the night and found dead in the morning. In Canada, SIDS accounts for 21.3% of post-neonatal deaths, making it the leading cause of infant mortality between 28 days and 1 year of age (Public Health Agency of Canada, 2013). Furthermore, infants from socioeconomically disadvantaged and Indigenous populations have higher incidences of SIDS than do other populations in Canada (Collins et al., 2012; Gilbert et al., 2013).

The causes of SIDS are not well understood, but they likely involve an interaction between an underlying biological issue that places the infant at risk and an environmental stressor—for example, limited access to oxygen due to an obstruction of the nose and mouth. Recent research suggests that at least some infants who succumbed to SIDS had altered levels of serotonin, a neurotransmitter (Haynes et al., 2017). Decreased serotonin may make it more difficult for young infants to detect and respond to a lack of oxygen by turning their head away from bedding or other soft materials, especially during sleep.

A subset of cases result from a rare genetic mutation in the breathing muscles that puts infants at greater risk of respiratory challenge in situations that impair breathing (Männikkö et al., 2018). Researchers studying SIDS hope to identify biomarkers, like neurotransmitters or genetic mutations, that will help physicians flag infants at heightened risk for SIDS (Bright, Vink, & Byard, 2018).

To decrease the risk of SIDS, the most important steps that parents can take entail removing any barriers to their baby's breathing. First, putting infants to sleep on their backs reduces the possibility of breathing obstructions. Sleeping on the stomach increases the risk of SIDS more than any other single factor. A campaign encouraging parents to put their infants to sleep on their back—the “back to sleep” movement—contributed to a dramatic reduction in the number of SIDS victims. Second, parents should not smoke because it decreases the oxygen available in the infant's environment. If they do smoke, they should not smoke around the baby. Third, bedding should be firm; soft bedding can trap air around the infant's face, causing the baby to inhale carbon dioxide instead of oxygen. For more recommendations, the Public Health Agency of Canada posts resources for parents and caregivers.

One unanticipated consequence of the “back to sleep” movement has been that North American infants are now beginning to crawl slightly later than those in previous generations,



In Canada, death from SIDS declined by more than 71% between 1981 and 2009, likely due to Safe Sleep campaigns supported by the Public Health Agency of Canada and the Canadian Pediatric Society.

presumably because of reduced opportunity to strengthen their muscles by pushing up off their mattress. Parents are encouraged to give their babies supervised “tummy time” to exercise their muscles during the day.

avoid some of the issues related to smoke exposure, the use of nicotine in any form is a risk factor for fetal development and can affect fetal cardiac, respiratory, and nervous systems. In addition, because e-cigs are largely unregulated, they range greatly in the amount of nicotine they contain, with some brands containing far more nicotine than cigarettes do (Jiang et al., 2018). Thus, the perception of the benefits of e-cigs relative to traditional cigarettes may lead pregnant women to overlook the risks.

Alcohol Maternal alcohol use is the leading cause of fetal brain injury and is generally considered to be the most preventable cause. In Canada, 1 in 10 pregnant women report using alcohol during their pregnancies (Popova et al., 2017b). This rate is similar to the worldwide estimate of the prevalence of alcohol use during pregnancy, but there are substantial cultural differences (Popova et al., 2017a). Rates are highest in European countries (25% overall, with the highest rate in Ireland at 60%), and lowest in countries in the Middle East, where Saudi Arabia, Qatar, and Oman report rates of 0% (though it is worth noting that stigma may lead women in some countries to underreport alcohol use). These data suggest

sudden infant death syndrome (SIDS)

the sudden, unexpected death of an infant less than 1 year of age that has no identifiable cause

that alcohol use during pregnancy reflects broader cultural views about the use of alcohol, especially by women.

When a pregnant woman drinks, the alcohol in her blood crosses the placenta into both the fetus's bloodstream and the amniotic fluid. Thus, the fetus gets alcohol both directly—in its bloodstream—and indirectly, by drinking an amniotic-fluid cocktail. Concentrations of alcohol in the blood of mother and fetus quickly equalize, but the fetus has less ability to metabolize and remove alcohol from its blood, so it remains in the fetus's system longer.

Maternal drinking can result in **fetal alcohol spectrum disorder (FASD)**, which comprises a continuum of alcohol-related birth defects. Babies born to alcoholic women often exhibit extreme negative outcomes, known as *fetal alcohol syndrome (FAS)*. The most obvious symptoms of FAS are characteristic facial structures, like the eyes, nose, and lips shown in Figure 2.17. Other forms of FAS can include varying degrees of intellectual disability, attention problems, and hyperactivity. Recent analyses suggest that the rates of FAS in Canada are much greater than previously suspected, with a prevalence estimated to be between 2% and 3% based on a study of 7- to 9-year-olds tested in the Greater Toronto area (Popova et al., 2018).

Even moderate drinking during pregnancy (i.e., less than one drink per day) can have both short- and long-term negative effects on development. So can occasional drinking if it involves binge drinking (four drinks or more on a single occasion). In Canada, it is estimated that 1% to 2% of pregnant women engaged in at least one incident of binge drinking during the previous month (Lange et al., 2017). The negative effects can include low birth weight, increased risk for ADHD, and delays in cognitive development and school achievement (e.g., Behnke et al., 2013). Given the research to date, the Society of Obstetricians and Gynaecologists of Canada recommends that pregnant women avoid alcohol altogether (Carson et al., 2017).

Environmental Pollutants

The bodies and bloodstreams of most Americans (including women of childbearing age) contain a noxious mix of toxic metals, synthetic hormones, and various ingredients of plastics, pesticides, and herbicides that can be teratogenic (Moore, 2003). These substances often have significant negative effects on the fetus. For instance, the infants of Inuit mothers, whose diets are high in Arctic fish, are exposed to lead, mercury, and polychlorinated biphenyls (PCBs) both prenatally and postnatally. This type of exposure has been associated with later difficulties in attention, cognition, and neuromotor development (Boucher et al., 2014; Boucher et al., 2012; Deprés et al., 2005). Air pollution from the burning of fossil fuels is associated with low birth weight and neurotoxicity and disproportionately affects low-income populations, both in North America and around the world (Perera, 2016). Often, different forms of pollution act in combination. For example, China's rapid industrialization has led to a dramatic increase in pollution-related birth defects due to the unregulated burning of coal, water pollution, and pesticide use (e.g., Ren et al., 2011).

While progress has been made nationwide in eradicating some pollutants, the situation in Grassy Narrows and White Dog First Nations provides clear evidence that environmental hazards continue to pose risks. In the 1970s, peoples from the Grassy Narrows and White Dog First Nations, who lived near Dryden, Ontario, began experiencing symptoms consistent with methylmercury poisoning



RICK'S PHOTOGRAPHY/SHUTTERSTOCK

FIGURE 2.17 Facial features of FAS This child displays the three primary diagnostic facial features of fetal alcohol syndrome: small eyes (as measured across); the absence of, or flattening of, the vertical groove between the nose and the upper lip (smooth philtrum); and a thin upper lip. This facial phenotype is one of the diagnostic criteria for FAS.

fetal alcohol spectrum disorder (FASD)

the harmful effects of maternal alcohol consumption on a developing fetus. Fetal alcohol syndrome (FAS) involves a range of effects, including facial deformities, intellectual disabilities, attention problems, hyperactivity, and other defects. Fetal alcohol effects (FAE) is a term used for individuals who show some, but not all, of the standard effects of FAS.



Decades after the English–Wabigoon River System was originally contaminated by mercury dumping, the First Nations peoples who live and fish there are still suffering the effects.

(Takaoka et al., 2014). A chemical and pulp mill was dumping mercury into the English–Wabigoon River System and poisoning the fish that were the First Nations' main source of food and income. Four decades after the mill stopped dumping mercury into the river system, mercury levels in fish remain above safe levels, and people are still developing the symptoms of Minamata disease (named after a coastal town in Japan that suffered a similar case of factory-related methylmercury poisoning); these symptoms include numbness in the limbs, difficulty walking a straight line, vision and hearing impairments, headaches, and exhaustion. Such incidents highlight the impact that decisions by individuals, groups, and local governments can have on environmental factors, which can in turn have significant and sometimes disastrous consequences on fetal and child development. And these issues are not easily remedied; only in 2017 did the Ontario government pledge funds to remediate the river system.

Maternal Factors

Because the mother-to-be provides the most immediate environment for her fetus, some of her characteristics can affect prenatal development. These characteristics include age, nutritional status, health, and stress level.

Age

A pregnant woman's age is related to the outcome of her pregnancy. Infants born to girls 15 years or younger are 3 to 4 times more likely to die before their 1st birthday than are those born to mothers who are between 23 and 29 (Phipps, Blume, & DeMonner, 2002). However, the rate of teenage pregnancy in Canada is declining, and in 2014, the teen birth rate for teenagers under 17 years old fell to the lowest recorded level (5.4 births per 1000 females younger than 17; Public Health Agency of Canada, 2017).

The increasing age at which many women become pregnant is also cause for concern. In recent decades, many women in industrialized countries wait until their 30s or 40s to have children. Techniques to treat infertility have continued to improve, increasing the likelihood of conception for older parents. Like many other risk factors, there is a dose–response relationship, with risk of negative outcomes for both mother and fetus increasing with maternal age. For example, children born to older mothers and/or older fathers are at heightened risk for developmental disorders such as autism spectrum disorder (ASD; Sandin et al., 2016).

The causal pathways linking older mothers and fathers to their infants' developmental outcomes are likely different, since only mothers contribute to prenatal environments and birth circumstances (Lee & McGrath, 2015). Fathers' contributions may lie more in mutations and other chromosomal abnormalities, as we will discuss in Chapter 3.

Nutrition

The fetus depends on its mother for all its nutritional requirements. If a pregnant woman has an inadequate diet, her unborn child may also be nutritionally deprived. An inadequate supply of specific nutrients can have dramatic consequences. For instance, women who get too little folic acid (a form of B vitamin) are at high risk for having an infant with a neural-tube defect such as spina bifida (see Figure 2.4). While prenatal vitamins are frequently used to address these concerns, many women do not know they are pregnant during the crucial early

periods of gestation. Many processed foods, such as breakfast cereals, are fortified with folic acid to help ensure that women receive adequate nutrition during the early weeks of pregnancy.

Because malnutrition is more common in impoverished families, it often coincides with the host of other risk factors associated with poverty, making it difficult to isolate its effects on prenatal development. However, one unique study of development in extreme circumstances made it possible to assess certain effects of malnutrition *independent of socioeconomic status*. As we discussed earlier, people of all income and education levels suffered severe famine in parts of the Netherlands during World War II. Children conceived during the Dutch Hunger Winter have been followed into adulthood. In late middle age, individuals who had experienced malnutrition as fetuses showed impaired performance on attentional tasks and had prematurely aged brains, compared with those who had not (de Rooij et al., 2010; Franke et al., 2018).

Disease

Although most maternal illnesses that occur during a pregnancy have no impact on the fetus, some do. For example, if contracted early in pregnancy, rubella (also called the 3-day measles) can have devastating developmental effects, including major malformations, deafness, blindness, and intellectual disabilities. The Society of Obstetricians and Gynaecologists of Canada recommends that women who do not have immunities against rubella be vaccinated before becoming pregnant (Dontigny et al., 2018).

Sexually transmitted infections (STIs) are also quite hazardous to the fetus. Cytomegalovirus (CMV), a type of herpes virus that is present in 50% to 70% of women of reproductive age in North America, is the most common cause of congenital infection (affecting 1% to 5% of births; Manicklal, 2013). CMV can damage the fetus's central nervous system and cause a variety of other serious defects, including hearing loss. Genital herpes can also be very dangerous: if the infant comes into contact with active herpes lesions in the birth canal, blindness or even death can result. HIV infection is sometimes passed to the fetus in the womb or during birth, but the majority of infants born to women who are HIV-positive or who have AIDS do not become infected themselves. HIV can also be transmitted through breast milk after birth, but research suggests that breast milk contains a carbohydrate that may actually protect infants from HIV infection (Bode et al., 2012).

Zika, a mosquito-borne viral infection, burst onto the world scene in 2016. While the illness itself is mild and often goes undetected, it can cause a serious birth defect called microcephaly, a condition in which the baby's head is much smaller than expected. Depending on the severity of the problem, issues can range from hearing and vision loss to seizures and intellectual disability. Microcephaly occurs in roughly 6% of fetuses whose mothers were infected by Zika (Honein et al., 2017). Consistent with our earlier discussion of sensitive periods, higher rates of microcephaly are observed for women whose Zika infections occurred during the first trimester of pregnancy. The virus appears to infect fetuses' cortical-neural progenitor cells, resulting in stunted brain growth (Tang et al., 2016). The only preventative option is to avoid mosquito bites in areas where the virus has spread. Women of reproductive age should also take heed of the fact that Zika can be transmitted sexually and through body fluids (Kim et al., 2018).



This expectant mother, living in an evacuation camp in the Philippines, is being examined by a Doctors Without Borders medical worker. She worries about how she is going to feed her child. Whether caused by displacement due to war or natural disaster, pervasive poverty, or some other factor, concern for maternal nutrition is a situation all too common throughout the world.



This Brazilian infant suffers from microcephaly, likely due to her mother's Zika infection during pregnancy.

Maternal Emotional State

Effects of maternal stress during pregnancy have been observed on myriad aspects of infant and child development, ranging from infant cognitive development to later psychiatric diagnoses (for review, see Van den Bergh et al., 2017). Brain-imaging studies with infants and young children reveal both structural and functional effects of prenatal maternal state on the developing brain (Van den Bergh, Dahnke, & Mennes, 2018). For example, Alberta researchers showed that maternal prenatal depression was associated with changes in brain structure in children aged 2 to 5 years (Lebel et al., 2016). A primary mechanism for these effects is alternations in the hypothalamic–pituitary–adrenal (HPA) axis and the hormone cortisol, a glucocorticoid which helps regulate stress in both the mother and the fetus. As discussed earlier in this chapter, glucocorticoids slow the growth of the fetus. The concept of *fetal programming*, also discussed previously, shapes research in this area and suggests that the altered hormonal environment for the fetus may lead to long-term changes in how children and adults cope with stress via disrupted HPA axis functioning.

In some wealthy countries, including the United States, pregnant women from minority ethnic groups report greater rates of prenatal stress than do women in majority ethnic groups (Liu et al., 2016). Pregnant women in less wealthy countries report even greater levels of stress (Glover et al., 2018). Their anxiety may relate to scarcity of resources, as in cases of high food insecurity, or to war or domestic violence. Women in developing countries may also have increased fears about the outcomes of their pregnancies due to high rates of infant and maternal mortality where they live. For instance, researchers in rural Nigeria found that in a group of 262 women giving birth, 5 women died and 52 experienced severe complications (Mbachu et al., 2017). These sorts of statistics, combined with their firsthand knowledge about the dangers of childbirth, likely add yet another layer of stress for many women in developing countries.

Like other types of teratogens, it is difficult to tease apart the specific effects of maternal stress from other factors that often co-occur with stress. For example, expectant mothers who are stressed during pregnancy are likely to still be stressed after giving birth. Genetic factors may also link both maternal stress and postnatal outcomes. One clever study took advantage of the increased use of assistive reproductive technology—*in vitro* fertilization (IVF)—to attempt to tease apart these factors (Rice et al., 2010). In this study, mothers were either genetically related or unrelated to their fetuses. The results revealed effects of maternal stress on birth weight and later antisocial behaviour, in both related and unrelated mother–fetus pairs, suggesting that the prenatal environment, not shared genetics, was the strongest predictor of later outcomes. However, for measures of child anxiety, the results suggest that postnatal maternal stress, not prenatal maternal stress, was the strongest predictor of later outcomes.

This area of research reveals a complex interplay between prenatal and postnatal factors in developmental outcomes. It also points to the importance of finding ways to help minimize maternal stress both pre- and postnatally. The increased popularity of prenatal yoga and meditation classes suggests that there may be straightforward ways to reduce at least some aspects of pregnancy-related stress, with potential benefits for both mother and fetus.

Prenatal exercise classes, as well as yoga or meditation classes, may help reduce pregnancy-related stress.



MANGO PRODUCTIONS/GETTY IMAGES

REVIEW QUESTION

A wide variety of environmental agents can have a negative impact on prenatal development, from drugs to pollution to maternal factors like stress, illness, or nutrition. How can research into these hazards be used to influence public policy aimed at reducing their prevalence and impact? ■

The Birth Experience

Approximately 38 weeks after conception, contractions of the muscles of the uterus begin, initiating birth. Typically, the fetus has already contributed to the process by rotating into the normal head-down position. In addition, the maturing lungs of the fetus may release a protein that triggers the onset of labour. Uterine contractions, as well as the baby's progress through the birth canal, are extremely painful for the mother.

Is birth as painful for the newborn as for the mother? Actually, there is good reason to believe that birth is not particularly painful for the baby. Compare how much pain you feel when you pinch and pull on a piece of skin on your forearm versus when you wrap your hand around your forearm and squeeze as tightly as you can. The stretching is painful, but the squeezing is not. The mother's pain comes from her tissues being greatly stretched, but the baby experiences squeezing.

The squeezing that the fetus experiences during birth serves several important functions. First, it temporarily reduces the overall size of the fetus's disproportionately large head, allowing it to pass safely through the mother's pelvic bones. This is possible because the skull is composed of separate plates that can overlap one another slightly during birth (see Figure 2.18). The squeezing of the fetus's head during birth also stimulates the production of hormones that help the fetus withstand mild oxygen deprivation during birth and help regulate breathing after birth. The squeezing of the fetus's body forces amniotic fluid out of the lungs, in preparation for the newborn's first, crucial gasp of air.

Diversity of Childbirth Practices

Although the biological aspects of birth are pretty much the same everywhere, childbirth practices vary enormously. All cultures pursue the dual goals of (1) safeguarding the *survival and health* of both mother and baby and (2) ensuring the

The Birth Experience



REGINE MAHAUX AND ERIC DAEM/GETTY IMAGES

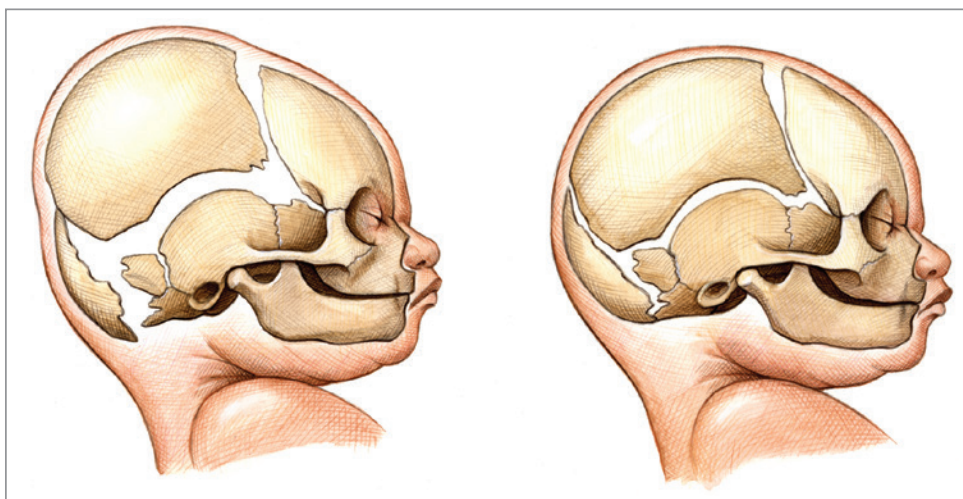


FIGURE 2.18 Head plates Pressure on the head during birth can cause the separate plates of the skull to overlap, resulting in a temporarily misshapen head. Fortunately, the condition rapidly corrects itself after birth. The “soft spot,” or fontanel, is simply the temporary space between separate skull plates in the top of the baby's head.

social integration of the new person. Groups differ, however, regarding the relative importance they give to these goals. An expectant mother on the South Pacific island of Bali assumes that her husband and other kin, along with any children she may already have, will all want to be present at the joyous occasion of the birth of a new child. Her female relatives, as well as a midwife, actively help her throughout the birth, which occurs in her home. Having already been present at many births, the Balinese woman knows what to expect from childbirth, even when it is her first child (Diener, 2000).

A very different scenario unfolds in twenty-first century North America, where the woman in labour usually withdraws almost totally from her everyday life. In most cases, she enters a hospital to give birth, typically attended by a small group of family or close friends. The birth is supervised by a variety of medical personnel, most of whom are strangers. Unlike her Balinese counterpart, the first-time Canadian mother has probably never witnessed a birth, so she may not have very realistic expectations about the birth process. Also, unlike her counterparts in most societies, a Canadian woman in labour has a 28% chance of having a surgical delivery by cesarean (also called C-section)—a rate that is high relative to other countries but has been in decline for the past few years (Canadian Institutes for Health Information, n.d.; Martin, Hamilton, & Osterman, 2018).

C-sections are intended to assist infants and mothers facing birth complications, and indeed they have saved untold numbers of lives. However, there are other reasons for the high number of surgical deliveries in Canada, including a vastly increased rate of multiple births (discussed in the next section), scheduling convenience for the physician and/or the parents, maternal obesity, prior C-sections (which may necessitate future C-sections), and physicians' attempts to decrease risk of lawsuits concerning medical malpractice should problems arise from a vaginal birth (e.g., Yang et al., 2009). Indeed, one study found that among a sample of American women who had a C-section, nearly half did not appear to have any pregnancy complications (Witt et al., 2015).

The Balinese approach to childbirth emphasizes the social goal of immediately integrating the newborn into the family and community—hence the presence of many kin and friends to support mother and baby. In contrast, the belief that childbirth is safer in a hospital setting outweighs the resulting social isolation of mother and baby. And indeed, while the rates of home births are increasing in North America, it is unclear whether home births are riskier than hospital births.

The medical model of childbirth prevails in Canada.



ABK / BSIP / THE IMAGE WORKS

One recent study found that in the United States, infant mortality in hospital births attended by certified midwives was significantly lower than infant mortality in home births attended by certified midwives (Grünebaum et al., 2016). It is worth noting, however, that in Ontario where home births are more common (20% of all births) and well-integrated into the healthcare system, the mortality rates for home and hospital births are equivalent, possibly because it is standard practice to transfer home-birthing mothers to the hospital when complications arise (as was the case for 25% of home births in this Canadian sample; Hutton et al., 2015).

The practices in both Canada and Bali have been changing to some degree. In Canada, the social dimensions of birth are increasingly recognized by doctors and hospitals, which often now employ certified midwives for

expectant parents who prefer a less medicalized birth plan. As in Bali, various family members—sometimes even including the parents' other children—are encouraged to be present to support the labouring mother and to share a family experience. Another increasingly common practice in Canada is the use of *doulas*, individuals trained to assist women in terms of both emotional and physical comfort during labour and delivery. This shift has been accompanied by decreased use of delivery drugs, enhancing the woman's participation in childbirth and her ability to interact with her newborn, including engaging in activities such as skin-to-skin contact, which promotes stabilization of physiological processes in the transition from the womb to the outside world (e.g., Rutgers & Meyers, 2015).

In addition, many expectant parents attend childbirth education classes through their birth centre or educational organizations like Lamaze, where they learn some of what their Balinese counterparts pick up through routine attendance at births. Social support is a key component of these programs; the pregnant woman's partner, or some other supportive person, is trained to assist her during the birth. Such childbirth programs are generally beneficial, and obstetricians routinely advise expectant couples to enroll in them. At the same time that these changes are occurring in Canada, Western medical practices are being increasingly adopted in societies like Bali, in an effort to improve newborn survival rates.

As a final example of alternate birthing practices, let's consider the Ju/'hoansi women of rural Botswana and Namibia, who often give birth outdoors and alone despite the dangers posed by animal predators, including lions. This practice is deeply intertwined with spiritual and cultural beliefs that have endured for centuries and reflects a specific view of individual development that sees the birth experience as a key event in a person's maturation (Bieseke, 1997). Though extreme when viewed from other cultural perspectives, and dangerous from a modern medical standpoint, the birthing traditions of the Ju/'hoansi illustrate the complex ways that childbirth, among other aspects of child development, are linked to the greater social and cultural context.

Similar to Balinese practices, this childbirth in South Sudan is quite different from the norm in Canada. The baby was born at home, with the help of a grandmother, great aunt, and a qualified birth attendant.



DESIRUS BENEDICTE/SIPA/NEWS.COM/SIPA PRESS/JUBA REPUBLIC OF SOUTH SUDAN

REVIEW QUESTIONS

The diverse range of birthing practices highlights the influence of sociocultural context, and these practices can have a direct impact on the newborn. Consider the birth experiences that you have encountered: In what ways did these experiences reflect cultural practices that are beneficial to the newborn and mother? What alternate practices should have been implemented for the benefit to the newborn and mother? ■

The Newborn Infant

Healthy newborns begin interacting with their new environment right away, exploring and learning about newfound physical and social entities. Newborns' exploration of this uncharted territory is very much influenced by their state of arousal.

state level of arousal and engagement in the environment, ranging from deep sleep to intense activity

rapid eye movement (REM) sleep an active sleep state characterized by quick, jerky eye movements under closed lids and associated with dreaming in adults

non-REM sleep a quiet or deep sleep state characterized by the absence of motor activity or eye movements and more regular, slow brain waves, breathing, and heart rate

FIGURE 2.19 Newborn states This figure shows the average proportion of time, in a 24-hour day, that Western newborns spend in each of the six states of arousal. There are substantial individual and cultural differences in how much time babies spend in the different states.

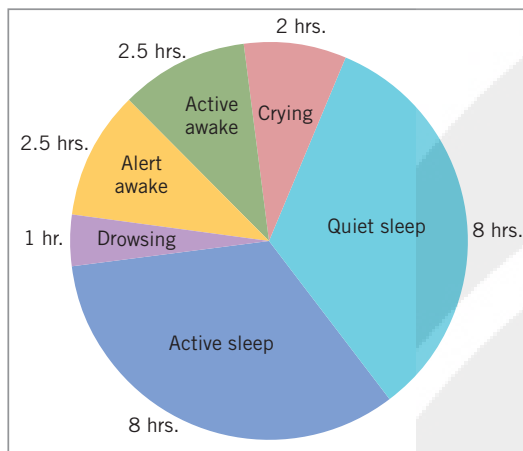


FIGURE 2.20 Quiet-alert state The parents of this quiet-alert newborn have a good chance of having a pleasurable interaction with the baby.



ROY HSU/GETTY IMAGES

State of Arousal

State refers to a continuum of arousal, ranging from deep sleep to intense activity. As you well know, your state dramatically affects your interaction with the environment—with what you notice, do, learn, and think about. It also affects the ability of others to interact with you.

Figure 2.19 depicts the average amount of time in a 24-hour period that newborns typically spend in each of six states, ranging from quiet sleep to crying. Within this general pattern, however, there is a great deal of individual variation. To appreciate how these differences might affect parent–infant interactions, imagine yourself as the parent of a newborn who cries more than the average baby, sleeps little, and spends less time in the awake–alert state. Now imagine yourself with a baby who cries relatively little, sleeps well, and spends an above-average amount of time quietly attending to you and the rest of his or her environment (see Figure 2.20). Clearly, you would have many more opportunities for pleasurable interactions with the second newborn.

The two newborn states that are of particular concern to parents—sleeping and crying—have both been studied extensively.

Sleep

Two facts about sleep and its development are of particular importance. First, the average newborn sleeps twice as much as young adults do. Second, the pattern of two different sleep states—*REM sleep* and *non-REM sleep*—changes dramatically with age. **Rapid eye movement (REM) sleep** is an active sleep state associated with dreaming in adults; it is characterized by quick, jerky eye movements under closed lids, a distinctive pattern of brain activity, body movements, and irregular heart rate and breathing. **Non-REM sleep**, in contrast, is a quiet sleep state characterized by the absence of motor activity or eye movements and more regular, slow brain waves, breathing, and heart rate. REM sleep constitutes fully 50% of a newborn's total sleep time. The proportion of REM sleep declines quite rapidly to only 20% by 3 or 4 years of age and remains low for the rest of life.

Why do infants spend so much time in REM sleep? Some researchers believe that it helps develop the infant's visual system. Because newborns spend so much time asleep, they do not have much opportunity to amass waking visual experience. The high level of internally generated brain activity that occurs during REM sleep may help to make up for the natural deprivation of visual stimulation, facilitating the early development of the visual system in both fetus and newborn.

Another way in which REM sleep may be adaptive for neonates is that the natural jerking movements (called *myoclonic twitching*) that occur exclusively during REM sleep may give infants opportunities to build sensorimotor maps (Blumberg, 2015). These twitching movements are most frequent during early development and may help the infant with the difficult problem of linking motor patterns with the specific sensations that they evoke.

Another distinctive feature of sleep in the newborn period is that neonates' slumbering brains do not become disconnected from external stimulation to the same extent that the brains of older individuals do. This stimulation allows newborns to learn during sleep. In one study, infants were exposed to recordings of foreign vowel sounds while they slumbered in the newborn nursery. When tested in the morning, their brain activity revealed that they recognized the sounds they had heard while asleep (Cheour et al., 2002).

Although newborns are likely to be awake during part of their parents' normal sleep time, they gradually develop the more mature pattern of sleeping through the night. Nighttime awakenings typically diminish over the course of the first postnatal year. However, there is a subset of infants who continue to wake regularly. Roughly one-third of parents of 6-month-olds in the United States report that their infants continued to wake up at least once every night (Weinraub et al., 2012). Even by 12 months of age, only about half of the infants in a Canadian study slept for at least 8 hours at a stretch (Pennestri et al., 2018).

A number of sleep techniques have been proposed to help parents and infants who are struggling with sleep. A recent randomized-control study was designed to determine whether behavioural sleep interventions work and whether they cause undue stress for parents and infants (Gradisar et al., 2016). The results suggest that, compared with a sleep-education control group, infants in a graduated-extinction group—in which parents slowly increased their delays in responding to their crying infant—showed greater improvement in sleep behaviours, with no negative effects on infant stress (cortisol levels) or infant–mother attachment. The study also demonstrated successful effects of another behavioural method, bedtime fading, in which the infant's bedtime is shifted later to ensure sleepiness, and then gradually moved earlier. Both groups showed large decreases in nocturnal wakefulness, with concomitant positive effects on maternal stress.

In contrast with Canadian parents, Kipsigis parents in rural Kenya are relatively unconcerned about their infants' sleep patterns. Kipsigis babies are almost always with their mothers. During the day, infants are often carried on their mother's back as she goes about her daily activities; at night they sleep with her and are allowed to nurse whenever they awaken. As a consequence, these babies distribute their sleeping throughout the night and day for several months (Harkness & Super, 1995; Super & Harkness, 1986). Thus, cultures vary not only in terms of where babies sleep, as you learned in Chapter 1, but also in terms of how strongly parents attempt to influence when their babies sleep.

Crying

Infants cry for many reasons—including illness, pain, and hunger—that require the attention of caregivers. As unpleasant as it is, crying is a normal behaviour. Rather than diminishing over the first few months, as many new parents expect, it actually increases, peaking around 6 to 8 weeks of age. Crying behaviour tends to decrease in frequency around 3 to 4 months of age, potentially because infants now have somewhat more control over their environment. During this period, crying bouts tend to increase in the late afternoon and evening, a phenomenon familiar to most caregivers of young infants.

Parents, especially first-timers, are often puzzled and anxious about why their baby is crying, and especially why their infants' crying bouts increase in frequency—and sometimes intensity—over the first 2 months. In extreme cases, caregivers may react with a form of child abuse known as *shaken baby syndrome*, which can result in severe head trauma or death (e.g., Barr et al., 2015). Relatively minimal parental education can play an important role in demystifying infant crying. For example, the Period of PURPLE program, developed by Ron Barr at the University of British Columbia in conjunction with the National Centre on Shaken Baby Syndrome, is provided in hospitals after birth and via public-educational outreach programs.

Sleep in Infancy and Toddlerhood



LIM CHEWHOW/SHUTTERSTOCK



GARY S. CHAPMAN/GETTY IMAGES

Most Canadian parents want to avoid the 2 A.M. fate of this young father. They regard their baby's sleeping through the night as a developmental triumph—the sooner, the better.

This baby is sleeping in a baby box provided to new parents as part of a recent study funded by the Alberta government.



KAREN BENZIES

swaddling a soothing technique, used in many cultures, that involves wrapping a baby tightly in cloths or a blanket

colic excessive, inconsolable crying by a young infant for no apparent reason

This informational intervention can be highly effective in decreasing emergency room visits based on parental concerns about crying (Barr et al., 2015). More significantly, the intervention decreased the number of infants admitted to the hospital in British Columbia for abusive head trauma (Barr et al., 2018). Understanding that crying is a normal developmental process can significantly decrease parental stress and—in extreme cases—parent-caused injury to infants.

Soothing What are the best ways to console a crying baby? Most of the traditional standbys—rocking, singing lullabies, stroking the baby, holding the baby up to the shoulder, giving the baby a pacifier, distracting the baby—work reasonably well. Many effective soothing techniques involve moderately intense and continuous or repetitive stimulation. One very common soothing technique is **swaddling**, which involves wrapping a young baby tightly in cloths or a blanket, thereby restricting limb movement. The tight wrapping provides a constant high level of tactile stimulation and warmth. This technique is practiced in cultures as diverse and widespread as those of the Navajo and Hopi in the American Southwest (Chisholm, 1983), the Quechua in Peru (Tronick, Thomas, & Daltabuit, 1994), and rural villagers in Turkey (Delaney, 2000). It is also increasing in popularity in North America; numerous popular baby-carrying devices compress the infant close to the caregiver's body, leaving the caregiver's hands free for daily activities.

One question that often concerns parents is whether or not to respond to their infant's signals of distress. Will quick and consistent supportive responses reward the infant for fussing and crying and hence increase these behaviours? Or will a rapid response give the infant a sense of security that leads to less fussing and crying? The literature suggests that both perspectives are valid. In one classic study, Bell and Ainsworth (1972) found that prompt responding to infant cries predicted less crying several months later. Yet in another classic study, Hubbard & van IJzendoorn (1991) found that infants whose cries were ignored during the first 9 weeks cried less during the next 9 weeks.

While most research in this area has focused on Western families, there are substantial cultural differences in parental responding that may influence these patterns. For example, mothers in the rural island communities of Fiji are more likely to rapidly respond to their infant's negative facial displays of affect than are urban mothers in the United States (Broesch et al., 2016). As with many aspects of parenting, there is likely not one “right” answer to the question of how and when to respond to infant distress. Cultural norms and individual differences among infants jointly influence families' preferred responses to parenting challenges.

Colic No matter how or how much their parents try to soothe them, some infants are prone to excessive, inconsolable crying for no apparent reason during the first few months of life, a condition referred to as **colic**. Indeed, one of your authors was a colicky baby who resisted being held. The causes of colic are unknown and may include allergic responses to the mother's diet (ingested via breast milk), formula intolerance, immature gut development, and/or excessive gassiness. Unfortunately, colic is not a rare condition: around 18% of young Canadian infants—and their parents—suffer



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ANDREY BURKOV / DREAMTIME

Carrying infants close to the parent's body results in less crying. Many North American parents are now emulating the traditional carrying methods of societies like the Quechua in Peru. Swaddling should be avoided when babies are lying on their stomachs or sides, due to increased risk for SIDS (Pease et al., 2016).

from it (Wolke et al., 2017). Fortunately, it typically ends by about 3 months of age and has no long-term effects. One of the best things parents with a colicky infant can do is seek social support, which can provide relief from the stress, frustration, and sense of inadequacy they may feel because they are unable to relieve their baby's distress.

Negative Outcomes at Birth

Neonatal caregivers worldwide use an evaluation tool called the **Apgar score** to quickly assess the health of newborn infants immediately following birth. A cumulative score is derived from ratings on skin tone, pulse rate, facial responses (typically grimacing), arm and leg activity, and breathing strength. Perfect scores are rare, reflecting the traumatic effect that even a normal birth can have on the newborn, but a consistently low score can indicate serious health problems.

Although most clinically recognized pregnancies in an industrialized society result in the full-term birth of a healthy baby, sometimes the outcome is less positive. The worst result, obviously, is the death of an infant. A much more common negative outcome is low birth weight, which can have long-term consequences.

Infant Mortality

Infant mortality—death during the first year after birth—is now relatively rare in the industrialized world, thanks to decades of improvements in public health and general economic levels. In Canada, the 2018 infant mortality rate was estimated to be 4.5 deaths per 1000 live births (Central Intelligence Agency [CIA], 2018).

Although the Canadian infant mortality rate is declining over time in absolute terms, it is high compared with that of other industrialized nations. The *relative* ranking of Canada has generally gotten worse over the past several decades, partially because the infant mortality rates in many other countries have had a higher rate of improvement and partially because of a wide variation in birth registration practices across countries. In Canada, the United States, Wales, and England, a live birth is registered if the infant shows any signs of life at birth, regardless of birth weight or gestational age. In contrast, other countries use other criteria to register a live birth, such as gestational age (e.g., >22 weeks), birth weight (e.g., >500 g), or length of survival (e.g., at least 24 hours after birth; Deb-Rinker et al., 2015).

The rates of infant mortality in Canada are starkly different for different provinces and territories. For instance, infants born in Nunavut and the Northwest Territories (NWT) are two to three times more likely to die before their first birthday as infants born in British Columbia and Nova Scotia. Indeed, the infant mortality rate for Nunavut and NWT is similar to the rates observed in many developing countries. Why do so many babies die in the Canadian North, given that we are a highly developed country? There are many reasons having to do with limited access to health care, a greater prevalence of *macrosomic births* (births of very large babies), and higher rates of poverty (Luo et al., 2012).

In less developed countries, especially those suffering from a breakdown in social organization due to war, famine, or persistent extreme poverty, the infant mortality rates can be staggering. In Afghanistan and Somalia, for example, roughly 1 of every 10 infants dies before age 1 (CIA, 2018).

Low Birth Weight

Most Canadian newborns weigh between 2500 grams and 4500 grams. Infants who weigh less than 2500 grams at birth are considered to be of **low birth weight (LBW)**. Many LBW infants are **premature**, or preterm; that is, they are born

Coping with Colic

Julie Schneiderman
Mom



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Parenting in Infancy and Toddlerhood



WORTH PUBLISHERS

Apgar score method for evaluating the health of the newborn immediately following birth based on skin tone, pulse rate, facial response, arm and leg activity, and breathing

infant mortality death during the first year after birth

low birth weight (LBW) a birth weight of less than 2500 grams

premature any child born at 37 weeks after conception or earlier (as opposed to the normal term of 38 weeks)

Afghanistan has the highest infant mortality rate in the world (CIA, 2018). Among the causes are extreme poverty, poor nutrition, and poor sanitation. The great majority of the population lacks access to clean water, leading to a great many infant deaths related to dysentery, severe diarrhea, and other illnesses.



EMILIO MORENATTI/AP IMAGES

Low Birth Weight in India



UNICEF

small for gestational age babies who weigh substantially less than is normal for whatever their gestational age

at 37 weeks or earlier after conception. About 7.8% of babies born in Canada between 2015 and 2017 were premature (Statistics Canada, 2019a). Other LBW infants are referred to as **small for gestational age**: they may be either preterm or full-term, but they weigh substantially less than is normal for their gestational age, which is based on weeks since conception.

In 2017, 6.5% of babies born in Canada were LBW (Statistics Canada, 2019a). As a group, LBW newborns have a heightened level of medical complications, as well as higher rates of neurosensory deficits, more frequent illness, lower IQ scores, and lower educational achievement. *Very LBW* babies (VLBW; those weighing less than 1500 grams) are particularly vulnerable; these infants accounted for around 1% of live births in Canada (Statistics Canada, 2019b).

There are numerous causes of LBW and prematurity, including several discussed in the section on teratogens: smoking, alcohol, and environmental pollutants such as lead and mercury. In some rapidly developing countries, such as China, high levels of airborne pollution have been linked to both LBW and preterm birth, likely due to impaired oxygen transport across the placenta (Fleischer et al., 2015). Another cause is the skyrocketing rate of twin, triplet, and other multiple births as a result of the development of increasingly successful treatments for infertility. (The use of fertility drugs typically results in multiple eggs being released during ovulation; the use of in vitro fertilization [IVF] usually involves the placement of multiple laboratory-fertilized embryos in the uterus.) Between 1991 and 2017, the rate of multiple births in Canada increased from 2% to 3.1% (Statistics Canada, 2019c). This is a concern because the rates of LBW among multiples are quite high: 53.8% of multiples weigh less than 2500 grams (Statistics Canada, 2019b). The numbers for higher-order births (triplets and up) have also increased dramatically in recent years. This is a concern because the rates of LBW among multiples are quite high: 55% for twins and higher than 95% for triplets and above (Martin, Hamilton, Osterman et al., 2018).



BETTMANN/CONTRIBUTOR/GETTY

The Dionne quintuplets, born in 1934 in a farmhouse in Ontario, are the first known quintuplets to have survived infancy. The identical sisters were born two months prematurely. During infancy, the government removed them from their family and placed them in a specially built hospital with an observation area for tourists. In the 1930s, they were the biggest tourist attraction in Canada. In 1998, the Ontario government formally apologized to the surviving sisters.

Long-term outcomes As a group, children who were LBW infants have a higher incidence of developmental problems: the lower their birth weight, the more likely they are to have persistent difficulties. For example, 8-year-old Australian children who were born LBW showed a greater incidence of sensory impairments, poorer academic achievement, and more behaviour problems than their term-birth peers (Hutchinson et al., 2013). Other studies suggest links between VLBW and childhood psychiatric issues, especially those involving inattention, anxiety, and social difficulties (e.g., ADHD, autism; Johnson & Marlow, 2011). The hypothesized pathways between LBW and these negative outcomes include white-matter reduction, ventricular enlargement, and other abnormal brain development outcomes.

However, it is important to note that these comparisons often confound SES with birth-weight status. For example, in the aforementioned study by Hutchinson and colleagues (2013), the sample of term-birth families had higher educational attainment and employment status than the preterm sample. Indeed, a German study demonstrated that the strongest predictor of outcomes for VLBW infants is maternal education (Voss et al., 2012). The authors concluded that special services and additional support may be especially important for families of at-risk infants with less educational background.

The good news is that for the *majority* of LBW children, the negative effects of their birth status gradually diminish, generally ending up within the normal range on most developmental measures. Figure 2.21 depicts a particularly striking example (Teoh et al., 2006). Indeed, one follow-up study of extremely LBW infants (<1000 grams) found that by 18 to 22 months of age, 16% were unimpaired and 22% were only mildly impaired (Gargus et al., 2009).

FIGURE 2.21 Small miracles Rumaisa and Hiba Rahman, shown here shortly after their birth in Chicago in 2004, were born 15 weeks premature. Rumaisa weighed just 260 grams at birth, making her the world's smallest surviving infant. Her sister was slightly heavier, at 567 grams. Despite the significant challenges these sisters faced in their early lives, they both reached appropriate developmental milestones in motor and language abilities, perhaps because they were able to reach 25 weeks in the womb (Rochman, 2011).



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FIGURE 2.22 Infant massage Everybody enjoys a good massage, including infants (Badr et al., 2015). Hospitalized newborns may particularly benefit from massage (e.g., Field, 2017). As an added bonus, parents also benefit from massaging their infants (Vicente, Veríssimo, & Diniz, 2017).

Intervention programs Supporting LBW newborns and their families is a prime example of our theme about the role of research in improving the welfare of children. Until relatively recently, hospitals minimized parents' contact with their LBW infants, mainly because of fear of infection. Parents are now encouraged to have as much physical contact and social interaction with their hospitalized infant as the baby's condition allows. Indeed, *kangaroo care*—a variant of the skin-to-skin care discussed earlier, in which caregivers act as incubators to help maintain infants' skin temperature and to promote breast-feeding—decreases mortality and increases growth, breast-feeding, and attachment (Conde-Agudelo & Díaz-Rossello, 2014). Recent data suggest that breast milk, in and of itself, promotes healthy brain development in preterm infants (Blesa et al., 2019); we will return to the topic of breast-feeding in Chapter 3.

Being touched—cuddled, caressed, and carried—is a vital part of a newborn's life. Many LBW infants experience little stimulation of this kind because of the precautions that must be taken with

them, including keeping them in special *isolettes* where they are hooked up to life-support machines. Because LBW infants are often premature, they may spend weeks or months in the neonatal intensive care unit (NICU). For these infants, their exposure to touch in the hospital affects how they respond to touch later on. As one study showed, babies who experienced more gentle touching by caregivers in the NICU later showed stronger neural responses to touch than did babies who had less experience with gentle touching in the NICU. In contrast, babies who experienced more painful experiences in the NICU later showed decreased brain responses to touch than did babies who experienced less pain in the NICU (Maitre et al., 2017). Thus, early atypical experiences in the NICU can shape infants' later responses to something as ubiquitous as touch, as shown in Figure 2.22.

Hospitals have designed education programs to help parents of preterm infants learn about the revised timetable of their baby's early development: developmental milestones will be delayed, often linked more tightly to gestational age at birth than to chronological age after birth. For example, their preterm infant will not begin to smile at them at around 6 weeks of age, the time when full-term infants usually reach this milestone. Instead, they may have to wait several more weeks for their baby to look them in the eye and break into a heart-melting smile. Thus, preterm infants are potentially more challenging to care for while being less rewarding to interact with.

One consequence of these challenges is that children who were born preterm are more likely to be victims of parental child abuse than are full-term infants. Indeed, a recent study of infant hospitalizations due to child abuse found that the two strongest predictors were preterm birth and extended stay in the NICU (Mason et al., 2018). Interventions that provide parents with training in child development, and/or focus on helping parents to become more responsive to their LBW infants, have yielded numerous positive effects, including improved behavioural outcomes, greater weight gain, higher IQs, and myriad other improved outcomes relative to their LBW peers (Nordhov et al., 2012; Wassenaar-Leemhuis et al., 2016). Successful intervention programs also include support sessions, in the hospital and during home visits, designed to encourage parents to talk about their experiences and express their feelings.

Though these interventions can improve outcomes for specific conditions, it is important to note the impact of cumulative risk: the more risks the infant endures,

the lower the chances of a good outcome. Because this principle is so important for all aspects of development, we examine it in greater detail in the following section.

Multiple-Risk Models

Risk factors tend to occur together. For example, a pregnant woman who engages in substance abuse is also likely to be under a great deal of stress and unlikely to eat well, take vitamins, seek prenatal care, have a strong social support network, or take good care of herself in other ways. Furthermore, whatever the cumulative effects of these prenatal risk factors, they will likely be compounded after birth if the mother continues her unhealthy lifestyle.

As you will see repeatedly throughout this book, a negative developmental outcome—whether in terms of prenatal or later development—is more likely when multiple risk factors are involved. In a classic demonstration of this fact, Michael Rutter (1979) reported a heightened incidence of psychiatric problems among English children growing up in families with four or more risk factors (including marital distress, low SES, paternal criminality, and maternal psychiatric disorder; Figure 2.23). Thus, the likelihood of developing a disorder is slightly elevated for the child of parents who fight a lot; but if the child's family is also poor, the father engages in criminal behaviour, and the mother suffers from emotional problems, the child's risk is multiplied nearly tenfold. Across numerous developmental domains, there are cumulative effects of risk factors: the more risk factors, the worse the potential outcomes. These cumulative risk effects impact aspects of child functioning, ranging from attachment to language development to well-being (Evans, Li, & Whipple, 2013).

Consider some of the risk factors for fetal development that we have discussed: inadequate prenatal care, poor nutrition, illness, emotional stress, cigarette smoking, drug abuse, and exposure to environmental and occupational hazards. All these factors are more likely to be experienced by a woman living below the poverty line than by a middle-class woman. It is no wonder, then, that on the whole, the outcome of pregnancy is less positive for infants of lower-SES parents than for babies born to middle-class parents. This is not just the case in Canada. In Japan, which has less income disparity than Canada, there is a link between income and birth outcomes (Fujiwara, Ito, & Kawachi, 2013).

Structural racism—which describes behaviours and beliefs that harm specific racial and ethnic groups and can result in residential segregation, uneven access to healthcare, and high rates of incarceration—also impacts fetal and newborn health (Bailey et al., 2017). For example, hospitalization rates in Quebec are significantly higher in both First Nations and Inuit infants as compared to non-Indigenous infants (He et al., 2017). In the United States, consistent with research on the role of maternal stress in fetal development, pregnant women in minority communities who report higher levels of concern about racial discrimination are more likely to have preterm infants than those who report lower levels of concern (Braveman et al., 2017). Improving the quality of hospitals and other medical facilities that serve minority communities is one promising approach currently being taken to address pregnancy-related health disparities (Howell, 2018). We will return to these issues in Box 3.4: Poverty and Health Disparities.

Much of the discussion in this chapter has focused on the many ways in which early developmental processes can go wrong. There are, of course, individuals who, faced with multiple and seemingly overwhelming developmental hazards, even beginning before birth, nevertheless do well. In studying such children, researchers

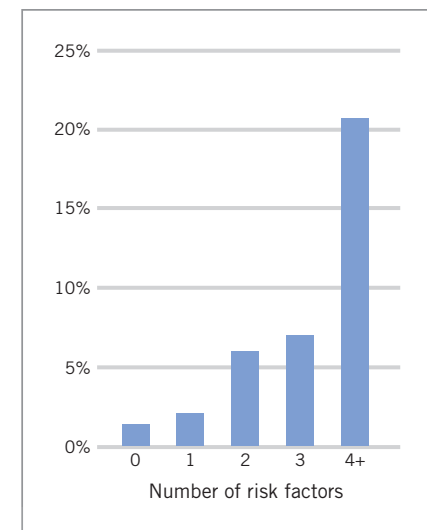


FIGURE 2.23 Multiple risk factors

Children who grow up in families with multiple risk factors are more likely to develop psychiatric disorders than are children from families with only one or two problematic characteristics. (Data from Rutter, 1979)

developmental resilience successful development in spite of multiple and seemingly overwhelming developmental hazards

employ the concept of **developmental resilience** (Masten, Best, & Garmezy, 1990; Sameroff, 1998). Resilient children—like those in the Kauai study discussed in Chapter 1—often have two factors in their favour: (1) certain personal characteristics, especially intelligence, responsiveness to others, and a sense of being capable of achieving their goals; and (2) responsive care from someone. Returning to our theme of *individual differences*, personal traits combined with a supportive environment can help us understand remarkable successes in the face of developmental challenges.

REVIEW QUESTION

A central theme in child development is the ways in which nature and nurture work together to shape developmental processes. How do nature and nurture interact in experiences such as newborn sleep patterns, crying, and the effects of multiple risks that an infant might face? ■

CHAPTER SUMMARY

Prenatal Development

- Nature and nurture combine forces in prenatal development. Much of this development is generated by the fetus itself, making the fetus an active player in its own progress. Substantial continuity exists between what goes on before and after birth in that infants demonstrate the effects of what has happened to them in the womb.
- Prenatal development begins at the cellular level with conception, the union of an egg from the mother and a sperm from the father to form a single-celled zygote. The zygote multiplies and divides on its way through a fallopian tube.
- The zygote undergoes the processes of cell division, cell migration, cell differentiation, and cell death. These processes continue throughout prenatal development.
- When the zygote becomes implanted on the uterine wall, it becomes an embryo. From that point, it is dependent on the mother to obtain nourishment and oxygen and to get rid of waste products through the placenta.
- Fetal behaviour begins 5 or 6 weeks after conception with simple movements, undetected by the mother, that become increasingly complex and organized into patterns. Later, the fetus practices behaviours vital to independent living, including swallowing and a form of intrauterine “breathing.”
- The fetus experiences a wealth of stimulation both from within the womb and from the external environment. The fetus learns from this experience, as demonstrated by studies showing that both fetuses and newborns can discriminate between familiar and novel sounds, especially in speech, and exhibit persistent taste preferences developed in the womb.

Hazards to Prenatal Development

- There are many hazards to prenatal development. The most common fate of a fertilized egg is spontaneous abortion (miscarriage).
- A wide range of environmental factors can be hazardous to prenatal development. These include teratogens from the external world and certain maternal characteristics, such as age, nutritional status, physical health, behaviour (especially the use of legal or illegal drugs), and emotional state.

The Birth Experience

- Approximately 38 weeks after conception, the baby is ready to be born. Usually, the behaviour of the fetus helps to initiate the birth process.
- Being squeezed through the birth canal has several beneficial effects on the newborn, including preparing the infant to take his or her first breath.
- Cultural practices surrounding childbirth vary greatly and are in part related to the goals and values emphasized by the culture.

The Newborn Infant

- Newborns’ states of arousal range from deep sleep to active crying.
- The amount of time infants spend in the different arousal states varies greatly, both across individuals and across cultures.

- REM sleep seems to compensate for the lack of visual stimulation that results from the darkness of the womb, and for the fact that newborns spend much of their time with their eyes shut, asleep.
- The sound of a baby crying can be very aversive, and adults employ many strategies to soothe distressed infants.
- The infant mortality rate in Canada is high relative to that of other developed countries. It is much higher for babies born to low-SES parents.
- Infants born weighing less than 5½ pounds (2500 grams) are referred to as being of low birth weight. LBW infants are at risk for a variety of developmental problems, and the lower the birth weight, the greater the risk of lasting difficulties.
- A variety of intervention programs have been designed to improve the course of development of LBW babies, encompassing time in the hospital as well as after the infant returns home.
- The multiple-risk model refers to the fact that infants with a number of risk factors have a heightened likelihood of continued developmental problems. Poverty is a particularly insidious risk to development, in part because it is associated with numerous negative factors.
- Some children display resilience even in the face of substantial challenges. Resilience seems to result from certain personal characteristics and from responsive care from someone.

Test Yourself

1. The single cell that forms when two gametes merge during conception is called the
 - a. zygote.
 - b. ova.
 - c. sperm.
 - d. embryo.
2. Which process of prenatal development is critical to the specialization of cells?
 - a. Cell division
 - b. Synaptogenesis
 - c. Cell differentiation
 - d. Apoptosis
3. Harry and Ron are genetically identical twins and are referred to as _____. Althea (a genetic female) and Stephen (a genetic male) are also twins but are clearly _____ twins.
 - a. monozygotic; identical
 - b. dizygotic; fraternal
 - c. dizygotic; monozygotic
 - d. monozygotic; dizygotic
4. Which of the following systems protects the developing embryo from dangerous toxins?
 - a. Amniotic sac
 - b. Placenta
 - c. Umbilical cord
 - d. Neural tube
5. The disproportionately large head of a 5-month-old fetus is a typical result of the normal process of
 - a. cephalocaudal development.
 - b. proximal–distal development.
 - c. lateral development.
 - d. bottom-up development.
6. Which of the following senses is the least active while the fetus is in the womb?
 - a. Hearing
 - b. Smell
 - c. Taste
 - d. Sight
7. Logan's dad is thrilled as Logan laughs each time he shows him a new toy: a monkey that squeaks when he pushes on its belly. After repeated exposure to the squeaking monkey, Logan becomes bored and no longer laughs. This process is known as
 - a. habituation.
 - b. dishabituation.
 - c. classical conditioning.
 - d. operant conditioning.
8. The DeCasper and Spence study, in which pregnant women read aloud twice a day from the same book during their last 6 weeks of pregnancy, was designed to assess
 - a. fetal attention.
 - b. fetal learning.
 - c. infant attention.
 - d. infant learning.
9. Which of the following does *not* influence the severity of the effect of a teratogen on a developing fetus?
 - a. Timing of exposure
 - b. Quantity of exposure
 - c. Duration of exposure
 - d. Number of previous pregnancies of the mother
10. Which is *not* a symptom of fetal alcohol syndrome?
 - a. Facial deformities
 - b. Intellectual disability
 - c. Underactivity
 - d. Attention problems

11. Studies suggest that the squeezing that a fetus experiences during delivery serves several important functions. Which of the following is *not* one of them?
 - a. It temporarily reduces the size of the infant's head, allowing it to pass safely through the pelvic bones.
 - b. It squeezes fluid from the ear canals, allowing the baby to hear.
 - c. It stimulates the production of hormones that help the fetus withstand mild oxygen deprivation.
 - d. It forces amniotic fluid out of the lungs, in preparation for the baby's first breaths.
12. Which of the following is a characteristic of non-rapid eye movement (non-REM) sleep?
 - a. Irregular heart rate
 - b. Irregular breathing
 - c. Quick, jerky eye movements
 - d. Slow brain waves
13. Which of the following describes an infant who is most likely suffering from colic?
 - a. Vivian cries for several hours a day for unexplained reasons.
 - b. Jeremy cries loudly when he is hungry.
 - c. LaTosha cries when she is placed in her crib.
 - d. Emelie rarely cries.
14. What intervention program, involving direct skin-to-skin contact, are parents of low-birth-weight infants encouraged to use to support development and promote survival?
 - a. Swaddling care
 - b. Massage care
 - c. Kangaroo care
 - d. Pouch care
15. What does the multiple-risk model suggest about negative developmental outcomes?
 - a. Each risk factor will produce a unique negative outcome.
 - b. The presence of one risk factor increases the likelihood that another risk factor will emerge in the future.
 - c. The more risk factors that are present, the more likely and worse the potential outcomes will be.
 - d. The presence of more risk factors increases the likelihood that a child will develop resilience.



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Critical Thinking Questions

1. A recent cartoon showed a pregnant woman walking down a street carrying an MP3 player with a set of very large headphones clamped around her protruding abdomen. What point was it making? What research might have provided the basis for the woman's behaviour, and what assumptions is she making about what the result might be? If you or your partner were pregnant, do you think you would do something like this?
2. We hear a great deal about the terrible and tragic effects that illegal drugs like cocaine can have on fetal development. In this chapter, tobacco and alcohol use are identified as two of the most common harmful behaviours. How do the effects of these various substances differ from each other, and should that influence how we as a society perceive their use by pregnant women?
3. Suppose you were in charge of a public-health campaign to improve prenatal development in Canada and you could focus on only one factor. What would you target and why?
4. Pick a country or culture that you are not very familiar with and research the common beliefs and practices with respect to conception, pregnancy, and childbirth. Do their practices appeal to you more than the practices with which you are familiar? Are there beliefs or practices that could be used beneficially with the ones that you are familiar with?
5. Speculate on why the infant mortality rate in Canada has steadily gotten worse compared with that of other countries. Suggest some potential policy changes or healthcare initiatives that might help to address these causes.
6. Explain the basic idea of the multiple-risk model and how it relates to poverty in terms of prenatal development and birth outcomes.

Key Terms

amniotic sac, p. 46	fetal alcohol spectrum disorder (FASD), p. 59	phylogenetic continuity, p. 51
Apgar score, p. 69	fetus, p. 44	placenta, p. 46
apoptosis, p. 45	fraternal (dizygotic) twins, p. 46	premature, p. 69
cephalocaudal development, p. 47	gametes (germ cells), p. 42	rapid eye movement (REM) sleep, p. 66
colic, p. 68	habituation, p. 52	sensitive period, p. 54
conception, p. 43	identical (monozygotic) twins, p. 46	small for gestational age, p. 70
developmental resilience, p. 74	infant mortality, p. 69	state, p. 66
dishabituation, p. 52	low birth weight (LBW), p. 69	sudden infant death syndrome (SIDS), p. 58
dose–response relation, p. 54	meiosis, p. 42	swaddling, p. 68
embryo, p. 44	mitosis, p. 44	teratogen, p. 54
embryonic stem cells, p. 45	neural tube, p. 46	umbilical cord, p. 46
epigenesis, p. 42	non-REM sleep, p. 66	zygote, p. 44

Answers to Test Yourself

1. a, 2. c, 3. d, 4. b, 5. a, 6. d, 7. a, 8. b, 9. d, 10. c, 11. b, 12. d, 13. a, 14. c, 15. c