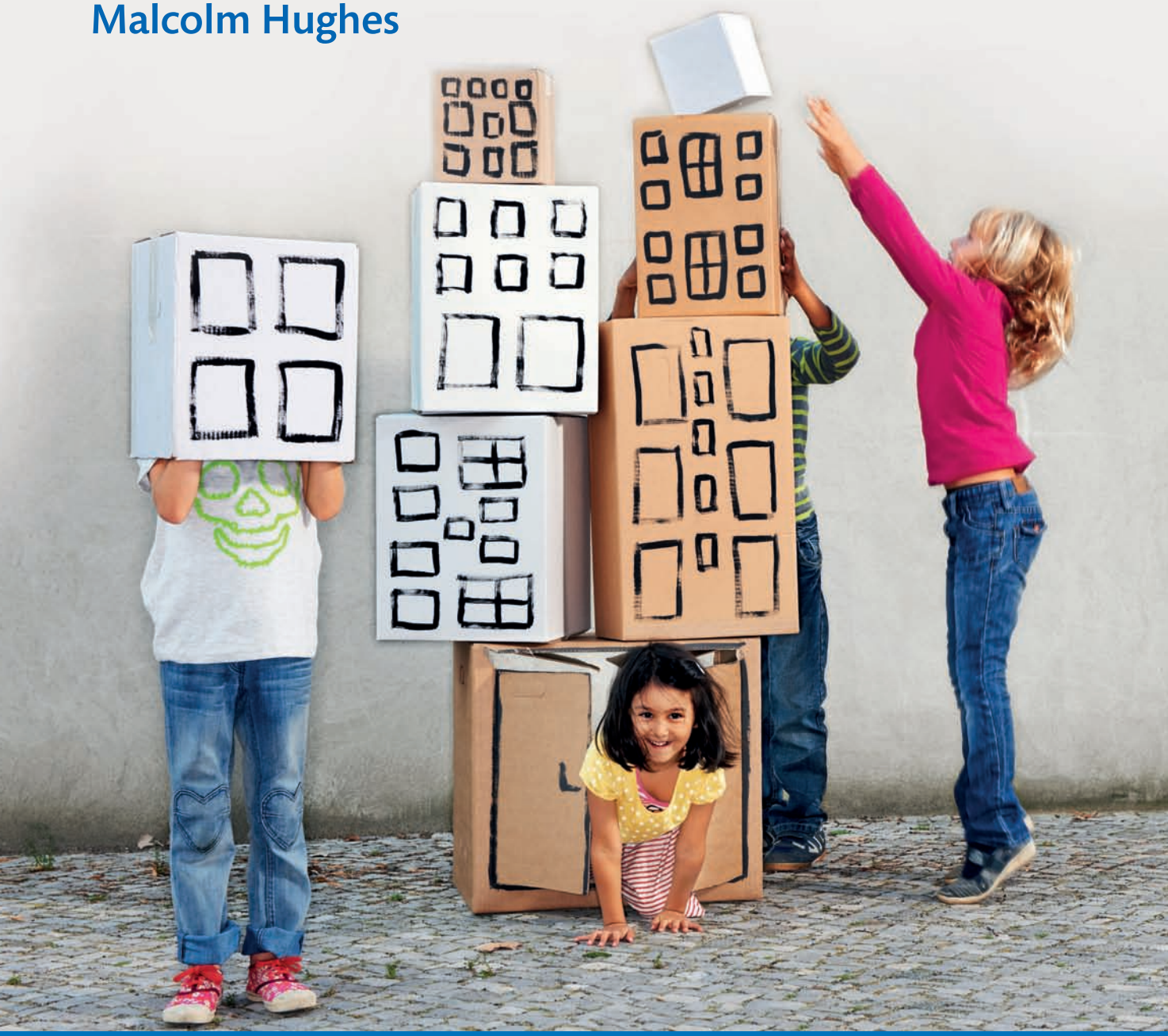
# Child Development

## Theory and Practice 0–11

Second Edition

Jonathan Doherty
Malcolm Hughes



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# Child Development

# Chapter 5
## Prenatal Development

### Overview


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# Introduction

In Chapter 4 we explained that our genetic map is set down at the precise moment of our conception and continues with the multiple divisions of cells. We learned a good deal about cells, chromosomes, DNA and genes, and how characteristics, traits, appearance and behaviour are transferred from one generation to another, including genetic differences between girls and boys. The link between genetic and environmental factors was presented and highlighted with evidence from recent research studies on twins.

We now turn to what happens after conception. First there are the all-important first few divisions of the zygote cell, then the development of the human embryo into a viable foetus and finally into a fully formed unborn infant. Before getting too involved in the biology of this development, let us share in the reactions of two people, Jeevan and Sahana, who have just discovered that Sahana is expecting their first child. First of all they can hardly believe that it is happening to them. They check and check again the pregnancy test result. They even take photographs of the test result. This is so exciting for both of them and such good news that they can hardly wait to tell their families and friends.

Sahana had been experiencing some headaches, breast tenderness and backache, similar to those she usually experienced before her period. However, missing her period was a sign that something was different and so Sahana had rushed out to buy a pregnancy test kit. The test identified the hormone *human chorionic gonadotropin* (better known as hCG) which is produced during pregnancy. Traces of this hormone are found in Sahana's blood and urine and at the time of the test the presence of hCG was about the only sign that Sahana and Jeevan had of their new baby. (At 4 weeks, an embryo is still very small – about 1 mm long.) Nevertheless, Sahana and Jeevan decided to tell everybody straightaway.

Of course, family and friends were full of advice about Sahana's pregnancy; about being careful now about what Sahana ate and things she should avoid. She was warned about morning sickness and the headaches and tiredness but everyone agreed it would all be worth it. Her sister said, 'You wouldn't want to do anything to harm your baby or to interfere with development and when baby is born you'll be so glad of this.' Sahana listened to everyone's advice but decided to do what felt natural and right for her. Both she and Jeevan couldn't help wondering what was going on inside her. How was their baby growing? Was this growth as it should be? Could their baby taste what Sahana ate, and hear what she and Jeevan were saying? When would she feel the baby move? Would their baby be healthy?

This chapter will explore child development before babies are born – the period before childbirth. To answer some of Sahana and Jeevan's questions and many others about how babies develop in their mother's womb, we will focus on the three periods of pregnancy and the main milestones of prenatal development. Next, we will explore how factors in the external environment can negatively influence foetal health and capacity. Finally, we will explore the link between early brain development, and the behaviour and learning of the foetus.

**Chapter Objectives**

By the time you have completed this chapter you should be able to answer the following questions:

- What are the three phases of pregnancy and what happens during each of them?
- What are teratogens?
- What are Wilson's six principles and why are they important?
- Which teratogens have (or had) the most effect upon embryonic and foetal development?
- Which processes characterise prenatal brain development?
- How do foetuses behave?
- What learning takes place in the womb?
- Does 'hot-housing' using music work?

# Conditions for development

## Growth in the womb

**Gestation**
The process of being carried in the womb between conception and birth.

**Prenatal development**
The progress of maturity of a baby prior to birth.

**Foetus**
An unborn human, more than 8 weeks after conception.

**Germinal period**
The first period of prenatal development, in the first 2 weeks after conception.

**Blastocyst**
A hollow ball formed by cells in the first 4–10 days after fertilisation.

**Embryo**
A human offspring in the first 8 weeks from conception.

The human **gestation** period lasts 38 weeks (265 days). Although these 9 months of pregnancy are a time of great joy and anticipation for the parents, they are also a vitally important time in the development of the new being, the time in which genetic patterning takes place and stages in our **prenatal development** unfold. Prenatal development is often divided into three phases (germinal, embryonic and foetal) and a brief summary of each phase is given below. In each description we refer to foetal weeks rather than weeks of pregnancy, because a woman is considered pregnant from the first day of her last menstrual period – a recordable physical event. This means that at conception, around the end of the second week of a cycle, a woman is considered to be 2 weeks pregnant. Her pregnancy lasts for 40 weeks; the gestation period of a **foetus** is 38 weeks.

This first phase or **germinal period** lasts for approximately 14 days. Within a few hours of conception, cell division starts by a process of mitosis described in Chapter 4. (Remember, this dividing process continues until the original single cell becomes the billions of cells that form the complete human.) The fertilised egg (called a zygote) divides into two cells which continue to divide and divide again. New cells do not float away but stick tightly together in a cluster forming the **blastocyst**, a ball-like structure of between 60 and 80 cells (Figure 5.1). Deep inside it is the **embryo**, supported on the outside by cells that protect and nourish.

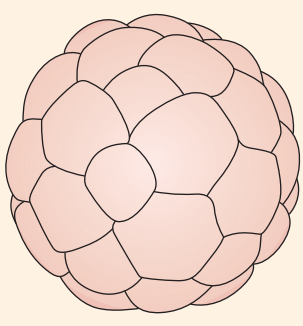


**Figure 5.1** The blastocyst is a ball-like structure of 60 to 80 cells

In the germinal period the blastocyst travels down the Fallopian tube towards the uterus. As it approaches the **uterus** or **womb**, the blastocyst produces a number of small tendrils which burrow into the **uterine** wall and implant themselves into the mother's blood supply. Roughly half of all fertilised eggs implant successfully. If implantation is successful, the outer layers of the blastocyst continue to protect and nourish the other cells inside a thin but tough membrane called the **amnion**, containing **amniotic fluid**. This fluid provides a protected environment and allows the embryo to move and grow. At this stage the blastocyst is only an 'embryo' in a very technical sense. It's just a ball of cells, with all the cells pretty much the same.

The second phase or **embryonic period** is from the third to the eighth week after implantation is complete. During this time three layers of cells form – the **ectoderm**, **mesoderm** and **endoderm**. These three layers will form the baby's organs and tissues. The ectoderm will become the nervous system (which includes the brain), and the skin, hair, nails, mammary glands, sweat glands and enamel for the teeth. The mesoderm will become the heart, circulatory system, skeleton, connective tissues, blood system, urinogenital system and the muscles. The endoderm will house the lungs and develops into the lining of the gastrointestinal tract, the liver, pancreas and thyroid. The placenta has also begun to form and is producing some important hormones, including hCG. Earlier we explained that it is during this period that pregnancy can be confirmed using a test that identifies the presence of this hormone in the blood or urine of the mother.

In the embryonic period the embryo takes on a more human appearance: limbs start to grow; skin and muscles form; sense receptors, nerve cells and internal organs develop. Facial features of a mouth, nose and ears can just be discerned using an ultrasound scan. The photograph below shows the ultrasound scan image of Niamh at foetal age 8 weeks (Edd and Ella's baby girl who we have 'met' several times in earlier chapters). Niamh's first scan shows her as a tiny foetus just a few millimetres in length. The womb (a sausage-shaped darker area) is small. Edd remembers seeing Niamh's tiny heart beating. For Edd and Ella, seeing their baby for the first time was an amazing moment. However, it was not possible to see whether they should be thinking about girls' or boys' names at 8 foetal weeks despite the embryonic period being a time of accelerated sexual development. In males, a gene on the Y chromosome triggers a chemical reaction resulting in the production of testes. In females, there is no such reaction and ovaries are produced. So although Niamh is already Niamh and not Nigel it is impossible to tell this from the ultrasound scan image.

The image of Niamh's first scan is very blurred and grainy. It is created by projecting very high frequency sound waves into Ella's tummy and forming images from the distortions of the sound waves that bounce back to the receiver. Despite their 'blurriness', trained operators can detect sufficient evidence that allows doctors to measure and assess the growth of the foetus, and to make a judgement that all seems well and Niamh is developing normally.

The **foetal period** (9–38 foetal weeks) or third phase takes place over the last 30 weeks of pregnancy. After 8 foetal weeks, the embryo is medically renamed a foetus and is a much more recognisable human being. Now begins a period of rapid growth and development. By the third month, co-ordination of nervous and muscular systems facilitates many movements; the foetus can stretch, kick and leap around the womb – well before the mother can feel any movement. The digestive and excretory systems are working to allow swallowing and urination. Development is so fast that by the end of the third month, the sex of the foetus can be detected by ultrasound. In the ultrasound image taken of Niamh at foetal age 12 weeks, her head, body and legs are visible (the head is on the left). The dark

Niamh's first scan, at about 8 foetal weeks.
*Source:* Edward and Ella Hogan.

**Uterus**
Another name for the womb.

**Womb**
The organ in which a baby is carried between conception and birth.

**Uterine**
Of or belonging to the womb.

**Amnion**
The innermost membrane that encloses the embryo.

**Amniotic fluid**
Forms inside the amnion to protect the embryo.

**Embryonic period**
The second period of prenatal development, 3–8 weeks after conception.

**Ectoderm**
One of the three layers of cells in the embryo, which will develop into the nervous system, skin, hair, nails, mammary glands, sweat glands and tooth enamel.

**Mesoderm**
One of the three layers of cells in the embryo, which will develop into the heart, circulatory system, skeleton, connective tissues, urinogenital system and muscles.

**Endoderm**
One of the three layers of cells in the embryo, which will develop into the lungs, the lining of the gastrointestinal tract, liver, pancreas and thyroid.

## Connect and Extend

For information about embryonic stem cells development – an area of great interest and controversy – connect to **www.eurostemcell.org/** and a videoclip which explains where stem cells come from at **www.eurostemcell.org/films/a-stem-cell-story/English**

**Foetal period**
The third and final period of prenatal development, taking place 9 weeks after conception and extending until the end of the pregnancy.

### Connect and Extend

There are now some excellent images available of the very first few days and weeks of life on the Internet. Take some time to find a site using an image search. We found some stunning pictures at **bio.m2osw.com**. At what stage do you think does the embryo first start to look 'more human'? Caution: some pro-life websites that you might access include disturbing images in relation to campaigns against abortion.


Niamh's second scan, at 12 foetal weeks.

*Source*: Edward and Ella Hogan.


Niamh's third scan, at about 20 weeks.

*Source*: Edward and Ella Hogan.

### Connect and Extend

There is reliable evidence that preterm births are increasing, especially births before 28 weeks' gestation. Improvements in neonatal care have substantially increased the survival of pre-term infants during the past 15 years. Papers on this subject are technical by nature but it is interesting to read about some of the reasons for pre-term delivery. For example, maternal asthma is a risk factor for pre-term birth which in turn predisposes to childhood asthma. Read: Koshy, G., Akrouf, K., Kelly, Y., Delpisheh, A. & Brabin, B. (2012). Asthma in children in relation to pre-term birth and fetal growth restriction. *Maternal and Child Health Journal*, Preprints 1–11.

half-moon area around Niamh is the womb. She is 9 cm long and weighs 45 grams (equivalent to 2 AA batteries). Her eyes are slowly 'moving' to the front of her face, her nose is more pronounced and her ears are fully developed.

At 20 foetal weeks Niamh has grown to 28 cm long and weighs over 450 grams (almost half a bag of sugar). Her weight gain has increased to around 70 grams a week – just think how many new cells that is. The lower photograph shows Niamh's developed facial profile, chest and the different densities of her rib cage. Her eyebrows and eyelids are fully developed and finger nails cover her finger tips. By now she is developing sleeping and waking patterns, and reacts to loud sounds and sudden movements by her mother, Ella.

In the last 3 months of pregnancy all the organs and nervous systems mature quickly and are capable of continuing to function if the foetus is born prematurely. In fact, between 22 and 26 foetal weeks, a point is reached where the foetus is capable of survival outside the womb. This is known as the **age of viability**. In the last 10 foetal weeks the heart rate is more predictable, there is an increase in activity (ask any expectant mother!) and clear sleeping and waking cycles. In the final month, much of the earlier activity diminishes. Sleep is increased and the baby curls up in the classic foetal position at the base of the uterus in preparation for birth. A summary of the major events throughout pregnancy appears in Table 5.1.

**Age of viability**
The point when the baby is able to survive outside the womb. The period is between 22 and 26 weeks.

## The external environment

We may have given the impression that a foetus is always cocooned in a safe and protective environment inside mother, immune from the world outside. This is not quite the case. After the thalidomide disaster of the 1960s – see below for more details – it became apparent and more accepted that a developing embryo could be highly vulnerable to certain environmental agents that have negligible or non-toxic effects on adults. So, the safety and future health of the foetus that the mother's womb affords can be adversely affected by external influences known as **teratogens** (from Greek, meaning 'the making of monsters').

**Teratogen**
An environmental factor or agent that can cause harm to the embryo or foetus.

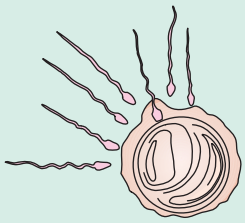
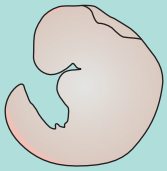
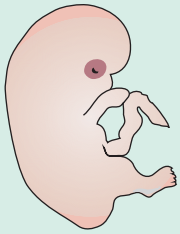
**Reflect**

**Most estimates of the incidence of congenital abnormalities in Britain are around 2 per cent of live births but we have no idea of the true incidence of foetal abnormality. Why is this? If you are not sure at the moment, make a note to return to this question at the end of the chapter.**

Teratogens are environmental factors or agents (something that produces an effect) capable of harming or malforming a developing embryo or foetus (Holmes, 2011). Typically these are drugs or diseases that cause a host of functional defects, **congenital** abnormalities and even death. Teratogal susceptibility is influenced by the quality of the uterine environment

**Congenital**
Existing from birth.

**Table 5.1** Milestones in prenatal development

| Periods of development | Aspects of development |
|---|---|
| **Germinal period (first 2 weeks)**<br>First 2 weeks  | Cells divide, cluster and move towards the uterus<br>Blastocyst becomes implanted onto the uterine wall |
| **Embryonic period (3–8 weeks)**<br>3–4 weeks  | Brain and central nervous system begin forming<br>Blood vessels formed<br>Heart beat established<br>Digestive and urinary systems appear<br>Head, eyes, ears and mouth form<br>Limbs appear as buds<br>Umbilical cord functioning |
| 5–8 weeks  | Formation of thyroid, pituitary and adrenal glands<br>Blood cells produced in the liver<br>Limbs continue to grow<br>Elementary brain functions<br>Eyes open<br>Main body structures form<br>Hands and feet form webs |
| **Foetal period (9 weeks to birth)**<br>9–12 weeks  | All major body organs now formed<br>Sex organs differentiated<br>Fingers and toes fully formed<br>Muscles that support limbs are formed |
| 13–16 weeks  | Fingernails and toenails grow<br>Cerebrum area of brain expands<br>Skin forms as translucent layer<br>Sweat glands appear<br>Reflexes present |