Unit
2B

Chapter 15
Healthy pregnancy

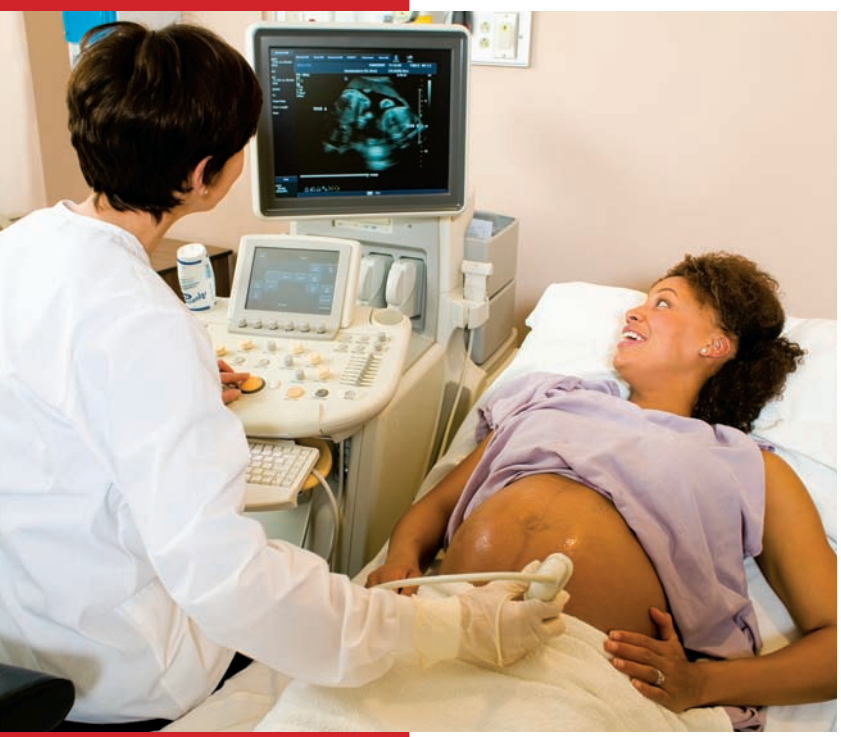

Figure 15.1 A pregnant woman, close to full term, being examined by ultrasound

Unit content

Body systems
Environmental factors can influence human development from implantation to infancy.

Environmental factors:

- care of the unborn child, e.g. risks associated with smoking, alcohol and other drug use
- the effect of various types of teratogens.

Reproductive technologies related to:

- maintenance of pregnancy including ultrasound, foetal monitoring and hormonal intervention.

Variation and evolution
The changing environment influences survival of genetic variations.

Variations and the environment:

- teratogens: the range of actions and their effects.

The relevance of human biology to everyday life
The rate of change in human biology means that there is a range of alternative treatments available. Each treatment has its risks, ethical concerns and benefits based on individual variations and the condition being treated. Health choices can be based on myths and misconceptions about human biology.

Health choices:

- pregnant women, e.g. warnings on food labels, drugs, alcohol and smoking

Throughout pregnancy, all women hope that the developing child will be born healthy. To help achieve this goal, a woman wishing to have a child needs to ensure that she takes care of her own body so that if she does become pregnant, her developing child will then have the best chance for a healthy life. Women wishing to become pregnant, or who are already pregnant, can make lifestyle choices that will reduce the risk of damage to the baby. This chapter discusses some of the important matters relating to pregnancy that people may need to consider when deciding to have a child.

Maintaining a healthy pregnancy

While the embryo, and later the foetus, develops in the uterus, changes occur in the mother's body to allow her to adjust to the needs of pregnancy. These changes start very early in pregnancy, and most of them take place ahead of the demands that the foetus will place on its mother for oxygen, nutrients and waste removal. During the embryonic period, when the organ systems are developing, the woman easily supplies the oxygen and nutrients that the embryo requires. In the later weeks of foetal development, when large amounts of oxygen and nutrients are needed, adjustments are required in the functioning of the woman's body. Her own functions slow down, allowing nutrients to stay in the blood for a longer period of time. This enables them to be more easily diffused across the placenta for use by the foetus.

Slowing of body functioning has some disadvantages for the mother. As her alimentary canal is less active, her stomach empties more slowly, and constipation is therefore common. As the concentration of nutrients in the bloodstream is higher, more tend to be filtered out by the kidneys and are lost in the urine. This loss is easily compensated for by a well-balanced diet.

For the developing foetus to obtain the nutrients it requires, a large quantity of blood needs to flow through the placenta. This is met by a gradual increase in the volume of the mother's blood and a faster rate of circulation through her blood vessels. This results from an increase in both the rate at which the heart beats and the amount of blood pumped with each beat. By the end of pregnancy the mother's blood volume will have increased by 40%.

Diet is an important aspect of prenatal care but its importance should not be overstressed because, provided the diet is balanced, its influence on the birth weight and survival of the baby is minimal. The average pregnant woman needs an increase in her energy intake of about 850 kJ per day, especially in the second half of her pregnancy. Pregnancy also requires an increased protein intake to ensure that the developing foetus is adequately supplied. The diet should contain at least 65 g of protein each day. Other important dietary requirements for a pregnant woman are an increased intake of calcium, iron and folic acid (folate). In areas where fluoride is not added to the drinking water, fluoride tablets after the twentieth week of pregnancy will help to protect the foetus from future dental problems.

Weight gain can be a problem for some women during pregnancy. Obviously the mother will gain weight as her pregnancy progresses, especially from the contribution of the foetus, the placenta and the amniotic fluid. Increases in blood volume and in the size of the breasts and uterus also contribute to weight gain (see Table 15.1). The hormonal changes involved in

Table 15.1 Distribution of weight gain during pregnancy

Foetus	3.0 kg
Placenta, foetal membranes and amniotic fluid	1.8 kg
Blood and tissue fluid	2.7 kg
Fat	1.4 kg
Uterus	0.9 kg
Breasts	0.9 kg
Total	**10.7 kg**

Source: Table 28.3 in Saladin KS. *Anatomy & Physiology*. 3rd edn. New York: McGraw-Hill, 2004.

pregnancy promote the conversion of energy to fat and the retention of water in the body, both of which make a further contribution to weight increase. It is best if the mother can keep her weight gain to about 0.5 kg a week during the second half of pregnancy. Excessive weight gained during pregnancy is very hard to lose after the child is born, particularly if the mother is not breastfeeding.

Pregnant women need to be very careful about exposure to chemical substances. For the benefit of the developing baby they should not smoke, consume alcohol or other drugs.

If a pregnant woman is used to regular exercise she should maintain her exercise program. Women who are not used to exercise should not suddenly start a program just because they are pregnant, although walking regularly is a good habit to establish and maintain. There is increasing medical evidence to show that exercise, even a vigorous workout, is healthy during pregnancy. A number of studies have found that exercise is usually safe, and that women who exercised vigorously during pregnancy were more likely to carry their babies to full term compared with women who exercised less or not at all.

A good exercise program during pregnancy will also help a woman maintain her stamina during labour. And, after the birth of her child, a woman who has exercised regularly will regain her pre-pregnancy shape more quickly than a woman who has not exercised.

As pregnancy continues, the placenta becomes a major source of progesterone (see Chapter 12), a hormone that is essential for maintaining pregnancy. Rising progesterone levels prevent the premature shedding of the uterine lining. If progesterone levels drop due to inadequate progesterone production, then a premature delivery could result, or bring about a miscarriage. Mothers at risk of giving birth too soon can be given a synthetic form of the hormone progesterone (called **progestin**). This hormonal intervention helps ensure the mother retains the foetus until it is full term.

Disruptions to normal foetal development

Congenital disorders are defects or diseases that are present at birth. Sometimes defects occur because the child inherits a defective gene, or genes, from the parents. Others are caused through mutations—spontaneous changes that occur to a gene or chromosome. (Mutations are discussed in Chapter 19.) Environmental factors affecting the foetus during uterine development may also cause defects. If, during pregnancy, a woman smokes, consumes alcohol or other drugs, or suffers dietary deficiencies, the developing foetus may be adversely affected. Many chemicals and drugs have been shown to be toxic and teratogenic to a developing foetus. A **teratogenic agent** (or **teratogen**) is one that causes physical defects in the developing embryo. There is a wide range of potential teratogens, including some hormones, antibiotics, oral anticoagulants, anticonvulsants, antitumour drugs, thyroid drugs, thalidomide, LSD (lysergic acid diethylamide) and marijuana.

Teratogens are usually identified after an increased prevalence of a certain birth defect. For example, the increased prevalence of cerebral palsy in babies born to mothers living around Minamata Bay in Japan led to researchers identifying methyl mercury as the offending agent. A local factory was discharging this chemical into the water in the bay and contaminating the fish. After pregnant women ate the contaminated fish, the methyl mercury passed across the placenta and affected the developing foetus. Affected babies were born suffering convulsions, intellectual disabilities and general brain damage.

Many agents can cause physical defects in the developing embryo. The range of actions and the effects of teratogens vary significantly. For example, the dose of a particular agent

often determines the severity of the damage and the type of defect that occurs. In most cases, the greater the dose, the greater the effect. The time of exposure is also important, as certain stages of embryonic and foetal development are more vulnerable than others. In general, the embryonic stage is more vulnerable than the foetal period.

Environmental factors may cause malformations in babies but do not necessarily involve any change in the genes or chromosomes. Consequently, such changes can not be inherited by later generations. The placenta allows many dangerous organisms and chemicals to pass from the mother to the foetus. For example, viruses easily pass across the placenta. All of these have the potential to cause serious problems for a developing baby.

Infections

Some viruses are known to cause birth defects, while others are suspected of contributing to congenital disorders.

Rubella is a viral infection that was frequently contracted by school-aged children. It is a fairly mild disease although highly infectious. However, if contracted by a pregnant woman it can have disastrous consequences for the child, who may be born deaf, blind or with heart malformations. In 1941, an Australian doctor, Norman Gregg, first made the connection between rubella and a high risk of birth abnormalities.

The rubella virus prefers to grow in tissues that are just forming. Nine out of 10 babies infected during the first 10 weeks of pregnancy have a major problem such as deafness, blindness, heart defects or brain damage. The risk of damage decreases as the pregnancy progresses. The risk is 61% if infection occurs in the fourth month, and 10% towards the end of the pregnancy.

One of the vaccines recommended in the Australian Standard Immunisation Schedule for children from birth to 4 years of age is MMR—measles, mumps, rubella. The vaccine, injected under the skin, at 12 months and again at 4 years gives lifelong protection against the disease. MMR vaccination began in Australia in 1989, and during the 1990s the number of rubella cases in Australia fell by more than 80% due to high rates of immunisation.

A definite link between viral infections and birth defects is often difficult to establish. Influenza, infectious hepatitis and mumps are all thought to have adverse effects on the foetus. There is some evidence to suggest that the influenza virus may be linked with brain damage to the foetus if contracted by the mother during early pregnancy.

Maternal diet

The mother's diet is another important factor in normal foetal development. Folic acid (folate) is essential for normal cell division and for the manufacture of protein. Lack of folic acid before and during pregnancy can also contribute to spina bifida and other neural tube defects. In this condition the bony arch of the vertebrae around the spinal cord does not develop. Mothers can help to protect their babies from problems like spina bifida by increasing their folic acid intake at least one month before pregnancy and for the first three months of pregnancy. Foods rich in folic acid are wholegrain breads and cereals, green leafy vegetables and legumes.

Adequate amounts of calcium are necessary for normal bone growth and deficiencies in vitamin A or folic acid can cause deformities. Vitamin A is required for the normal growth of cells and, as little is stored in the body, a steady intake is necessary. During pregnancy the demand increases considerably, especially in the last 10 weeks, and the level of this vitamin in the woman's blood tends to fall. However, if the pregnant woman has a balanced diet, with good quantities of green and yellow vegetables, there should be no need for concern.

Listeria infection, or **listeriosis**, is a very mild illness caused by eating food contaminated with the bacteria *Listeria monocytogenes*. Infection in pregnant women has the potential to cause miscarriages or stillbirths. To guard against *Listeria* infection pregnant women should eat food that has been freshly prepared or cooked. Foods to avoid are salads from salad bars, pre-packaged salads, soft cheeses, pâté and raw or smoked seafoods. Pregnant women should also carefully read any warnings on food labels to ensure there is no risk to their developing child.

Alcohol

Alcohol was a suspected teratogen for hundreds of years. It is only relatively recently that a relationship between maternal alcohol intake and characteristic malformations in the foetus has been recognised. **Foetal alcohol syndrome (FAS)** is the term used to describe the effects of foetal exposure to alcohol. It appears that 1 in every 1000 births may be affected by FAS. While it is unlikely that an alcoholic drink now and then causes harm to the mother's developing baby, health authorities advise pregnant women, and those planning pregnancy, not to drink alcohol. Excessive alcohol intake, especially 'binge drinking' early in pregnancy, definitely has a marked effect on the child. The most obvious effect is a lower-than-normal birth weight. Other symptoms include slow growth before and after birth, a small head, irregularities of the face such as narrow eye slits and sunken nasal bridge, defects of the heart and other organs, malformed arms and legs, and mental retardation. Besides such physical abnormalities the child may have behavioural problems, such as hyperactivity, extreme nervousness and a poor attention span.

Smoking

Smoking during pregnancy has an adverse effect on the developing foetus. The birth weight of babies born to women who smoke during pregnancy is significantly lower than that of babies born to women who do not smoke. In addition, there is evidence of an increased risk of abortion. Children of mothers who smoke and breastfeed their babies are more likely to suffer from gastrointestinal problems than other children. Children of smoking mothers also have a higher incidence of respiratory problems, including bronchitis and pneumonia, during the first year of life. There is a strong association between smoking during pregnancy and sudden infant death syndrome (SIDS). If the mother resumes smoking after giving birth there is still an increased risk of SIDS in the child.

Find out more about sudden infant death syndrome by going to http://www.choice.com.au/viewArticleAsOnePage.aspx?id=101343

Chemicals

Besides alcohol and the ingredients of cigarette smoke, many other chemicals are known to be teratogenic agents. One is **thalidomide**, a chemical that was originally developed for use in sleeping pills. It was found to be effective in the prevention of morning sickness during the first months of pregnancy. Two years after it went on sale in 1958 a sharp rise in the incidence of certain limb malformations was noticed. The malformations were of a type that is normally very rare, and this was a major factor in the discovery of the teratogenic action of thalidomide. If the malformations had been less conspicuous, they may not have aroused medical attention so quickly. Two doctors, Widikund Lenz in Germany and William McBride in Sydney, were responsible for linking these malformations to thalidomide. By the time thalidomide was taken off the market in November 1961, an estimated 7000 babies had been affected.

Thalidomide is a good example of where the time of exposure to the teratogen determines the type of defect. Thalidomide acts on the embryo between the twenty-

eighth and forty-second days of development, a time when the future limbs are forming. After 10 days of development the limbs start to appear, first as microscopic buds, then gradually developing into readily recognisable forms by the forty-second day. The arms are the first to develop, followed by the legs, which may be the reason why thalidomide affects the arms more frequently than the legs (Fig. 15.2).

It is interesting to note that, after 40 years as a banned drug, thalidomide is now being used for the treatment of leprosy and for a type of blood cancer. It is available in Australia but only for very restricted use.

Illegal drugs such as heroin and LSD as well as many medicinal drugs can cause damage to the foetus when taken during pregnancy. Most doctors are extremely careful when prescribing drugs to women of child-bearing age, as most drugs cause the greatest harm early in pregnancy, when a woman may not even know she is pregnant. Any sexually active woman who is not using contraception should be very careful about using drugs of any kind without first seeking medical advice. The labels on most medicinal products now have clear warnings about possible side effects and a pregnant woman should carefully read such labels to ensure there is no risk to her developing child.

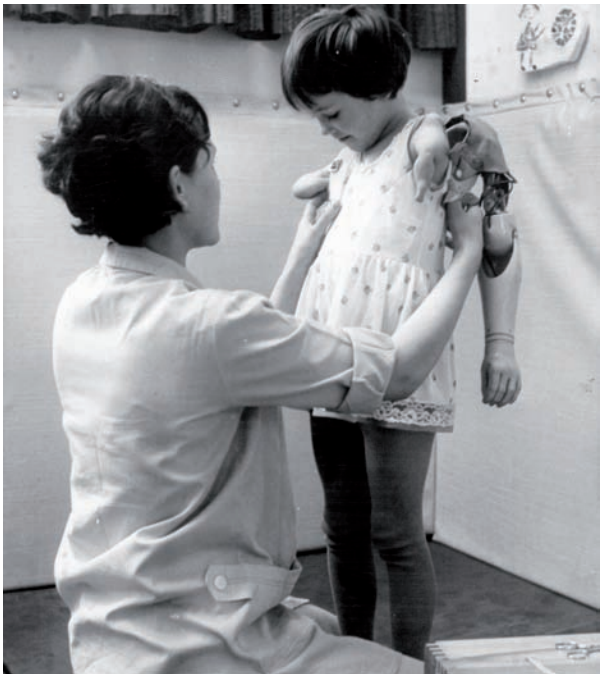

Figure 15.2 The children of women who took the drug thalidomide during pregnancy in the 1950s had malformed limbs

Diagnosis of foetal health

To maintain a healthy pregnancy, a woman needs to ensure that she has regular medical checks with her doctor or other heath care professional. In this way the health of the foetus can be monitored. If there is concern at any stage a range of technologies is available for testing the foetus. Two of these techniques allow an image of the foetus to be seen, whereas others provide an analysis of the chromosomes or of some of the chemicals from the foetus. Table 15.2 provides a list of the techniques available and the year in which general use of the test began. In addition, counselling is available for couples concerned about the risks of producing a baby with a birth defect.

Ultrasound

Ultrasound uses inaudible, high-frequency sound waves to produce an image of the foetus (Fig. 15.3). A probe is placed on the abdomen of the pregnant woman (Fig. 15.1), and the sound waves are reflected by the foetal tissues to obtain a visual

Table 15.2 History of foetal diagnosis

Technique	Year when general use began
Ultrasound	1957
Amniocentesis	1970
Amniocentesis with ultrasound guidance	1972
Fetoscopy	1973
Foetal blood sampling	1983
Chorionic villus sampling	1983

Figure 15.3 Ultrasound image of a 12 week old foetus; the distance between the two green crosses on this image is known as the crown-rump length; on this foetus it is 5.4 cm.

'echo' of what is inside the uterus. The doctor feeds these reflected sounds, or echoes, into a computer to produce a screen image for study. By careful examination of the image, malformations of the brain and head, or malformed or defective limbs, can be detected. In addition, many cases of spina bifida can be diagnosed.

Chromosome analysis

The chromosomes of cells from a foetus can be examined to detect defective, missing or additional chromosomes. A photograph, or drawing, of the chromosomes displayed in order is called a **karyotype**. The karyotype for Down syndrome, with an additional chromosome 21, is shown in Figure 20.6 on page 273. Foetal cells can be obtained for analysis using either amniocentesis or chorionic villus sampling.

Amniocentesis is carried out during the sixteenth to twentieth week of pregnancy, by which time the foetus is floating in about 130 mL of amniotic fluid. It involves the removal of about 10–20 mL of the fluid (Fig. 15.4). Floating in the fluid are living cells from the foetus, which can be examined for biochemical defects and for abnormalities in the number of chromosomes or in the chromosome structure. Amniocentesis is only performed on women who are thought to be at higher risk of delivering a child with a birth defect. Some of the disorders that can be detected by this procedure are Down syndrome, cystic fibrosis, neural tube defects, such as spina bifida, and a wide range of genetic disorders, including phenylketonuria, Tay-Sachs disease, Duchenne muscular dystrophy and sickle cell disease.

Chorionic villus sampling (CVS) obtains a specimen of foetal cells from the chorion, one of the foetal membranes (Fig. 15.5). The cells are then examined in a similar way to those gained by amniocentesis. CVS has an advantage over amniocentesis, however, in that testing can take place at 9–19 weeks of pregnancy. In addition, the foetal tissue gained through CVS can be tested more quickly than the specimen of amniotic fluid, thus reducing the time between the testing procedure and examination of the results. This is especially important if a birth defect that may require termination of the pregnancy is involved. A disadvantage of CVS is that the risk of miscarriage following the procedure is 1 in 100. CVS can be used to detect genetic disorders and biochemical abnormalities but it cannot diagnose spina bifida.

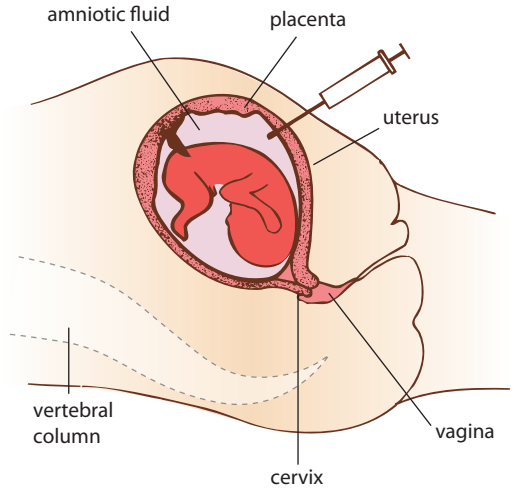

Figure 15.4 Amniocentesis in which amniotic fluid (carrying foetal cells) is sampled

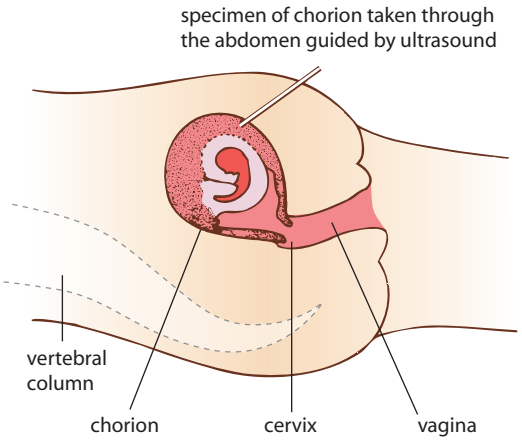

Figure 15.5 Chorionic villus sampling, in which a specimen of foetal cells is taken from the chorion

Blood tests of the mother's blood have also been devised to detect genetic disorders in a foetus. Such tests can detect genetic abnormalities six weeks after conception. These are far simpler than amniocentesis and CVS and only involve taking a sample of blood from the arm of the pregnant woman. The sample is treated with special antibodies that adhere only to the few foetal cells contained within the mother's blood. The antibodies have magnetic beads attached to them to enable the foetal cells to be isolated from the other cells in the blood by use of a magnet. The foetal cells can then be cultured and the chromosomes examined for genetic abnormalities.

In July 2003, scientists at the University of Queensland announced that they had developed a pap smear-type test that collects cells from the woman's cervix between the eighth and the twelfth week of pregnancy. This test obtains cells from the placenta that trickle down to the cervix, which can be used to diagnose genetic abnormalities. With this test results are available after two to three days. However, it is not yet widely available, but when it is, it could replace invasive diagnostic tests such as amniocentesis or CVS. This would remove the risk of miscarriage or other complications that are associated with invasive techniques.

Fetoscopy

Fetoscopy involves looking directly at the foetus through a small, telescope-like instrument with a diameter about the size of a large hypodermic needle. This instrument, a **fetoscope**, is introduced into the uterus through the abdominal wall. Examination of the outward appearance of the foetus may enable such conditions as cleft lip and palate, missing or abnormal ears, deformed or absent limbs, and spinal abnormalities (e.g. spina bifida) to be detected. If detection takes place early in the pregnancy, a decision about termination can then be made.

Foetal blood sampling

The fetoscope was first used to obtain foetal blood samples from the placenta. More recently, foetal blood has been directly obtainable. Having foetal blood for chromosomal analysis enables results to be provided far more quickly than with the other techniques: some biochemical disorders can be diagnosed on the day the foetal blood sample is

obtained. The benefits of a fast diagnosis for early treatment where possible, or quicker action if the pregnancy requires termination, are obvious.

Foetal monitoring

Foetal monitoring is the regular recording of a baby's heart rate in order to detect indicators of stress (Fig. 15.6). This monitoring usually takes place during labour and birth using ultrasound and electrocardiography. **Electrocardiography** is a procedure for recording electrical changes in the heart. The record, which is called an **electrocardiogram (ECG)**, shows the series of waves that relate to the electrical impulses that occur during each beat of the heart. The results are printed on paper or displayed on a monitor.

The aim of foetal monitoring is to identify any risk of injury to the foetus so that appropriate action can be taken. A foetal monitor may be used during labour and birth to record a baby's heart rate, and sometimes the mother's contractions. A detailed foetal heart rate analysis enables medical staff to check if there is any chance of oxygen deficiency occurring. Oxygen deficiency during birth may result in brain damage, or even a stillbirth.

Biochemical analysis

The **assessment of marker proteins** occurs with all newborns in Australia and in many other countries. This technique is used to detect phenylketonuria (PKU) either by testing the blood for excessive amounts of phenylalanine, or by analysing the urine for phenylpyruvic acid. Another marker protein is alpha-fetoprotein (AFP), which can be measured in samples of amniotic fluid. The concentration of this protein is very high when the foetus has a malformation of the spinal cord, such as spina bifida.

DNA probes

DNA probes are a more recent innovation that enables the detection of a range of genetic disorders, such as Duchenne muscular dystrophy and thalassaemia. These

Figure 15.6 Foetal monitoring allows continuous evaluation of a foetus. It can give early warning of foetal distress and allows precise management of labour

probes are based on recombinant DNA technology. A segment of DNA is used that is structurally identical to the gene being tested. Some of the units in the DNA segment are 'labelled' with a dye or radioisotope. This DNA probe is then joined to the gene in question. If the gene is normal, the DNA probe joins with the DNA segments with which it is structurally identical and shows them up. If it is an abnormal gene it does not show up, and is identifiable as a gap in the DNA being tested.

Working scientifically

Activity 15.1 Pregnancy and exercise

Some observations have indicated that mothers who exercise during pregnancy seem more likely to avoid a premature birth than those who do little or no exercise.

1. Propose a hypothesis that states a relationship between the two variables, exercise during pregnancy and time of birth (see page 16 for the characteristics of a good hypothesis).
2. Your task is to compile a questionnaire that could be given to mothers after the birth of their babies. The questions should be designed so that the answers will either support or disprove your hypothesis. In making up your questions, keep the following points in mind.
   - Make sure the questions are concise and clear. The respondents should not have to interpret what the question means.
   - Try to frame questions that require a yes/no answer or one response to several choices (multiple choice). If respondents are required to write a sentence answer you may then have to interpret the answer.
   - Keep your questionnaire as brief as possible but make sure the answers will give you enough information to reach a conclusion about your hypothesis.

   There are many websites that give advice on making up questionnaires—use a search engine to look for 'questionnaire design'. Much of the advice is concerned with marketing surveys but the principles can be applied to your questionnaire.
3. If you know a mother with a baby you may like to try out your questionnaire. If necessary, you could then modify your questionnaire.
4. What pattern of answers to your questions would support your hypothesis?
5. How would you go about conducting your survey? In particular, how would you select participants?
6. How many participants would be necessary to enable you to decide whether your hypothesis was supported or disproved?

REVIEW QUESTIONS

1. To meet the requirements of the developing foetus a large quantity of blood needs to flow through the placenta. Describe the changes in the mother's body that make it possible for a lot of blood to flow through the placenta.
2. **(a)** Make a list of factors that a pregnant woman should consider in her diet.
   (b) Women gain weight during pregnancy. In addition to the growing foetus, what else contributes to the weight gain?
3. List the benefits of exercise for a pregnant woman.

4. What is a congenital disorder? Explain your answer with an example.
5. Why should pregnant women be particularly careful about smoking, consuming alcohol and taking other drugs?
6. **(a)** Define the term 'teratogen' (or teratogenic agent).
   (b) List examples of teratogenic agents.
7. What environmental factors can affect the development of the foetus? Give examples to illustrate how the environmental factors you have mentioned can affect development.
8. Why should a pregnant woman read the labels of prepared foods and medicinal products?
9. Briefly describe five techniques that are available to check the embryo, foetus or newborn for congenital disorders.
10. What is foetal monitoring and why is it used?

APPLY YOUR KNOWLEDGE

1. Study the items listed in Table 15.1. Which of these do you think the mother has some control over? List ways she could exert this control.
2. There are differing views on the benefits of exercise during pregnancy. Research the latest information and put forward what you consider is a balanced exercise regimen for a woman over the nine-month gestation period.
3. Since the introduction of vaccination for rubella the incidence of the disease has dropped, significantly reducing birth defects due to this disease. Find out what other vaccination programs could help reduce harm to the developing foetus.
4. Thalidomide was not as widespread a tragedy in Australia as in European countries; however, a number of people were affected. There are sometimes stories in the media on how these people have coped with their handicaps. Use research to discover the occupations and lifestyles of some of these thalidomide victims.
5. In what situations would a doctor advise a female patient that genetic screening or counselling was advisable? What testing procedures could the doctor suggest?
6. Amniocentesis and chorionic villus sampling are both invasive diagnostic tests that have complications associated with them that may cause harm to the foetus. A pap smear-type test is being developed to diagnose genetic abnormalities. Find out the progress being made on developing such a test and how long it is likely to be before it comes into general use. Are there other non-invasive techniques being developed?
7. Design a leaflet that could be given to women hoping to become pregnant. The leaflet should set out, in simple terms, the positive steps that a pregnant woman can take to help ensure the health of her baby.
8. Explain why amniocentesis is offered to mothers aged 37 or over but is not routinely offered to mothers in their 20s.