SAMPLE TEXTBOOK ANSWERS

Chapter 17 Development of a human embryo

The following are sample answers only. Other answers to the same questions may also be correct.

Science inquiry

Activity 17.1 Examination of a pregnant rat

Studying your observations

1 Check with others in the class and ensure that you agree on the identification of the various reproductive structures.

2 Draw a diagram of your dissection, labelling all the structures you have identified.

Answer: Students should have a diagram similar to Figure 17.16 on page 239.

3 How many pairs of mammary glands were present on your specimen? Were there sufficient nipples for the number of offspring being produced?

Answer: Rats have five to seven pairs of mammary glands.

The answer to the second part of this question will depend on the number of embryos present.

4 Describe the appearance of the placenta and umbilical cord.

Answer: The placenta is dark red in colour, disc-shaped and about 1 cm in diameter. It is attached to the umbilical cord, which is very fine (approximately 1 mm across) and transparent, or it may contain some blood so that parts of it are red.

5 How is the colour of the placenta related to its function?

Answer: The red colour indicates that the placenta is full of blood. This is expected, because its function is to allow exchange of materials between the two blood supplies: the foetal blood and the mother's blood.

6 Describe the appearance of the amnion and the amniotic fluid that it contained.

Answer: The amnion is a clear membrane covering each rat foetus. When the amnion is broken, clear amniotic fluid runs out.

7 What is the purpose of the amniotic fluid?

Answer: Amniotic fluid provides support for the developing embryo/foetus and cushions it from bumps as the mother moves around.

8 Compare the female rat with the human female in Figure 18.15 (on page 245). List the similarities and differences between the pregnant rat and a pregnant human.

Answer:

Rat	Human
Five to seven pairs of mammary glands	One pair of mammary glands
Two uteri – each containing many embryos	One uterus – usually only one embryo, but possibly two or more
Similarities	
Both will nourish offspring using milk from mammary glands.	
In both cases foetuses are surrounded by an amnion and are nourished by a placenta that is attached to each foetus by an umbilical cord.	
Contraction of the uterus will push the foetus/foetuses out through the vagina.	

Activity 17.2 Developments in stem cell research

Answer: Student answers will vary, but some of the points that should be covered include:

- The lines of research that are currently being carried out:
  - Cell-based therapies: cells induced to produce specific cells that are required to repair or replace damaged cells or tissues
  - Growing replacement organs
  - Screening drugs and toxins
  - Growing nerve stem cells to transplant and cure paralysis
  - Human cloning
- The latest information on the use of adult stem cells includes investigation into:
  - How many kinds of adult stem cells exist, and in which tissues do they exist?
  - How do adult stem cells evolve during their development?
  - How are adult stem cells maintained in an adult individual?
  - Why do adult stem cells remain in an undifferentiated state when all the cells around them have differentiated?
  - What are the factors that stimulate adult stem cells to relocate to sites of injury or damage? How can this process be enhanced to enable better healing of injuries?
  - Do adult stem cells have the capacity to transdifferentiate; that is, to differentiate into cell types seen in organs or tissues other than those expected from the cells' predicted lineage?
  - If adult stem cells have the ability to transdifferentiate, is it possible to control this process to improve its reliability and efficiency?

    Students may also mention research that has been done with the treatment of leukaemia and related bone/blood cancers through bone marrow transplants. They may also mention experiments where scientists have demonstrated that certain adult cell types can be 'reprogrammed' into other cell types in the body using a process of genetic modification. This approach may offer a way to reprogram available cells into other cell types that have been lost or damaged due to disease. For example, one experiment showed how pancreatic beta cells, the insulin-producing cells that are lost or damaged in diabetes, could possibly be created by reprogramming other pancreatic cells.

- What diseases could potentially be cured or alleviated as a result of the research:
  - leukaemia
  - ALS (amyotrophic lateral sclerosis or Lou Gehrig's disease)
  - Alzheimer's disease
  - autism
  - cancers
  - cystic fibrosis
  - diabetes
  - heart disease
  - HIV/AIDS
  - lupus
  - multiple sclerosis
  - Parkinson's disease
  - pulmonary fibrosis
  - lymphoma
  - inherited blood disorders.

  It is also possible that injuries could be repaired using stem cells.
- Arguments against stem cell research include the following:
  - Religious belief that destruction of embryos is the same as killing potential humans
  - Use of embryonic stem cells requires the embryo to be destroyed
  - Better to spend the money on the living and the many other problems that are already in the world

Review questions

1 a What is implantation?

Answer: Implantation is the process where the blastocyst embeds in, and attaches to, the endometrium of the uterus.

b Describe where, when and how implantation occurs.

Answer: Implantation occurs in the uterus by the blastocyst sinking into the soft endometrium then attaching to the wall. This occurs 6–12 days after ovulation with an average of approximately 9 days.

2 a What is a blastocyst?

Answer: A blastocyst is a fertilised egg that has divided to form a hollow ball of cells. The interior of the ball is filled with fluid.

b At what stage of embryonic development does a blastocyst occur?

Answer: The blastocyst occurs at about five days after fertilisation when the dividing cells have reached the uterus.

3 a What are the three embryonic germ layers?

Answer:

i Endoderm

ii Mesoderm

iii Ectoderm

b Give two examples of tissues that develop from each of the germ layers.

Answer:

Germ layer	Examples of tissues that develop (any two of each)
Endoderm	Epithelium of • the alimentary canal • respiratory system • urinary bladder • urethra • gall bladder • tonsils • thyroid • thymus • vagina

Mesoderm	• Skeletal, smooth and cardiac muscles
	• Cartilage, bone, blood and connective tissues
	• Endothelium of the blood vessels and lymphatics
	• Epithelium of:
	  • the body cavities and joint cavities
	  • kidneys
	  • ureters
	  • ovaries
	  • testes
	  • adrenal cortex
	• Dermis of the skin

Ectoderm	• Epidermis of the skin • Hair • Nails • Glands of the skin • Receptor cells of the sense organs • Epithelium of the mouth, nostrils, sinuses and glands of the mouth • Epithelium of anal canal • Enamel of the teeth • The entire nervous system • The anterior lobe of the pituitary and the adrenal medulla • Lens, cornea and muscles of eye

4 Distinguish between the terms 'embryo' and 'foetus'.

Answer: An embryo is the term given to the new individual in the uterus for the first two months of pregnancy. From two months on, until birth, the developing individual is referred to as a foetus.

5 a What is the placenta?

Answer: The placenta is the organ that supplies nutrients to and removes wastes from the foetus. It results from a combination of maternal and foetal tissues. It also produces hormones to maintain pregnancy and is attached to the foetus via the umbilical cord. The placenta is fully developed by the end of the third month of pregnancy. In the placenta the mother's blood is very close to the blood capillaries of the foetus and this allows for the ready diffusion of materials between the two circulations.

b From which of the embryonic tissues does the placenta develop?

Answer: The placenta develops from part of the chorion, which is one of the embryonic membranes.

c Describe the functions performed by the placenta.

Answer: The placenta supplies nutrients and oxygen to and removes wastes (including carbon dioxide) from the foetus. It also produces hormones to maintain pregnancy. It allows for the transfer of antibodies from mother to foetus (see also Table 17.3 on page 227).

6 Describe how blood from the embryo/foetus gets to and from the placenta.

Answer: The blood travels to the placenta from the embryo/foetus via two umbilical arteries in the umbilical cord. The blood travels from the placenta to the embryo/foetus via the umbilical vein in the umbilical cord.

7 Briefly describe the function of the following embryonic membranes:

a amnion

Answer: The amnion surrounds the embryo and secretes amniotic fluid. This fluid gives protection to the embryo/foetus, because it acts as a shock absorber. It also maintains a stable temperature and allows room for the embryo/foetus to move freely.

b chorion.

Answer: The chorion completely surrounds the embryo and the other embryonic membranes. Part of the chorion develops into the foetal part of the placenta, allowing exchange of materials between the mother and the embryo/foetus.

8 How does amniotic fluid help the development of the foetus?

Answer: The amniotic fluid aids foetal development by helping prevent injury, allowing the growing and developing limbs to move, supporting the tissues as they grow and develop, and maintaining a stable environment.

9 Describe the main features of the 8-week-old embryo.

Answer: At 8 weeks, the embryo has a recognisably human form. All organs are present, but not all are functioning. It is now 3 cm long and weighs 1 g. It has an enlarged head (about half the size of the embryo), slit-like eyes, a nose, small earlobes and a jaw that is almost fully formed. There are arms, legs, hands, fingers and toes. The external sex organs are present so that sex can be determined.

10 Distinguish between proliferation and differentiation.

Answer: Proliferation is when cells make new cells.

Differentiation is when cells develop into different types of cells; that is, when *unspecialised* cells develop into *specialised* cells.

11 Explain the difference between the three types of stem cells: totipotent, pluripotent and multipotent.

Answer: Totipotent stem cells can differentiate into any of the cell types that make up the human body. They are also able to differentiate into any of the cell types that make up the embryonic membranes.

Pluripotent cells are stem cells that develop into any of the specialised cells that make up the human body, but not the membranes around the embryo.

Multipotent cells are stem cells that can develop into more than one type of cell but not all cell types.

12 What are three sources of stem cells?

Answer:

a Umbilical cord blood and placental stem cells

b Embryonic stem cells, from the inner cell mass of embryos

c Adult stem cells, from various body tissues

13 a In what ways do stem cells differ from ordinary body cells?

Answer: Stem cells are not specialised, but have the ability to become specialised cells (to differentiate). They can also undergo repeated mitosis.

b What are the differences between embryonic and adult stem cells?

Answer: Embryonic stem cells are from an embryo or foetus, while adult stem cells come from tissues from an adult's body. Embryonic stem cells are pluripotent, meaning that they can differentiate into most tissue types. In contrast, adult stem cells are multipotent, meaning that they can differentiate into cells with a particular type of function.

14 What are cell-based therapies? How could they be used to treat certain diseases?

Answer: Cell-based therapies use stem cells that can differentiate into different tissues to treat diseases. These tissues are used as replacement tissues to treat diseases and injuries such as strokes, heart disease, arthritis and spinal cord injuries.

15 Explain how a stem cell line is created.

Answer: From the blastocyst, the inner cell mass is removed and cultured in a nutrient solution. Once the cells have proliferated, subculturing begins by removing cells and placing them in fresh culture dishes. The process of subculturing can be repeated as often as required. Cells cultured in this way are known as a stem cell line.

16 What is therapeutic cloning? How could therapeutic cloning be used to treat disease?

Answer: Therapeutic cloning is when a nucleus from a person's body cell is inserted into a donor ovum (the nucleus of the ovum has been removed) and is allowed to develop into a blastocyst. Stem cells are removed from the blastocyst and allowed to develop into tissues that are genetically identical to the person from whom the nucleus of the body cell was originally taken. Because the tissues grown are genetically identical to the person, the tissues will be accepted by their body and not rejected. The tissues that could one day be therapeutically cloned and used include skin for burns victims, organs for transplants, and nerve cells to treat diseases such as Parkinson's and Alzheimer's diseases.

Apply your knowledge

1 Explain how a blastocyst can consist of many more cells than a zygote yet be only slightly larger in size.

Answer: The cells in a blastocyst are thinner and smaller than those of a zygote. The two original cells that form a zygote are a sperm and an egg. These then divide multiple times to form a blastocyst, so the blastocyst's cells are smaller and in thin layers. The cells that make up the blastocyst divide many times without increasing in size between divisions.

2 Explain how the structure of the placenta is related to the functions that it performs.

Answer:

Placental structure	Placental function
Umbilical cord: long and thin, and connects foetus to mother	Allows materials to travel back and forth between mother and foetus
Foetal capillary network: sits in mother's blood	Increased surface area for exchange of materials; for example, oxygen, carbon dioxide, wastes
Maternal blood spaces: bathe the foetal capillary network	More efficient exchange of materials between mother's and foetal blood
Chorionic villi	Increased surface area for exchange of materials
Umbilical artery and vein	Separate tubes, so that the flow is one way ensuring that required materials and wastes do not mix
Mother and foetal blood are separate	Prevents infection and unwanted exchange of materials; also prevents reaction between bloods if mother and foetus have different blood groups

3 The categorisation of stem cells is based on the potency, or ability, of that cell to produce a range of other cells. Look at the three types and describe how the name fits the range of cells it is able to produce.

Answer:

- Totipotent cells: 'toti' means wholly or entirely (a bit like 'total'). Totipotent cells can give rise to all of the cell types that make up the whole human body and the membranes surrounding the developing embryo.
- Pluripotent cells: 'pluri' means more than one or several (a bit like 'plural'). Pluripotent cells can give rise to all cell types that make up the foetus, but not those of the embryonic membranes.
- Multipotent cells: 'multi' means many or much and gives rise to words such as multiple. Multipotent cells may give rise to many different types of cells, but not all types.

4 Which source of stem cell is likely to be most useful in developing therapies for diseases?

Answer: Embryonic stem cells are most useful because they are pluripotent.

5 An umbilical cord blood bank was established in Australia in 1995. Parents can voluntarily have a sample of their baby's cord blood stored for later use. What would be the advantages of such a bank?

Answer:

- It doesn't harm or kill embryo or baby.
- The process is painless.
- It is easy to collect cord and then the cells.
- Cells can differentiate into red blood cells and cells of the immune system.
- Stored cells can be used for therapeutic cloning if the child later becomes ill.
- Cord stem cells are easier to tissue-match than stem cells from bone marrow.
- Cells in the cord blood are available for any patient who needs them.
- The more samples that are stored, the greater the chance there is of finding a match for someone who needs adult stem cells.

6 Research into cell-based therapies using stem cells is occurring in many laboratories around the world, with new advances being made all the time. Find out the latest information available, with particular reference to which diseases are the most likely to benefit from such research.

Answer: Stem cells may be used in the future to help cure brain tumours, spinal injuries, heart disease and many more. Refer to http://en.wikipedia.org/wiki/Stem_cell_treatments for more information.

Stem cell therapies are being used to replace retinal cells when the patient has suffered from degenerative eye diseases. Refer to www.nature.com/news/2011/110406/full/news.2011.215.html for more information. A more recent discovery of special stem cells in the eye could lead to better treatments for blindness. See http://www.medicalnewstoday.com/releases/283366.php

Understanding the behaviour of stem cells may lead to preventative measures for bowel cancer. For more information refer to http://www.medicalnewstoday.com/releases/280795.php

Stem cell therapies may be able to be used to treat muscular dystrophy in the future. Refer to www.sciencedaily.com/releases/2012/05/120504110554.htm for more information. Read more about some recent stem cell research at www.medicalnewstoday.com/sections/stem_cell/.

7 '*The rate of change in human biology can cause tensions requiring individuals to make decisions that will have consequences for individuals and society.*'

Discuss this statement with particular reference to research on embryonic and adult stem cells.

Answer: This answer involves individual research so answers will vary. However, students should mention the impact from governments who make decisions that will affect society by allowing certain research to take place while prohibiting other lines of research.

8 It was reported in the media in late 2007 that several top Australian sporting teams were considering storing their players' stem cells so that they could be helped to recover quickly from serious injury. Stem cells would be taken from the bone marrow in a player's spine, cultured in the laboratory and then stored. The cells could be transplanted to the player should an injury occur. What kinds of injuries could be treated using such a technique?

Answer: Stem cells taken from the bone marrow in a player's spine, cultured in the laboratory and then stored, could be used to treat spinal injuries, replace blood cells and help increase the player's immunity to infections. If the cells were cultured in the right conditions, they could be used to grow replacement tissues for any part of the body that might be injured while playing sport.