Chapter 18 – Reproduction in Humans

Subject content

Content

- Sexual Reproduction in Humans
- Sexually Transmitted Diseases

Learning outcomes

(a) define sexual reproduction as the process involving the fusion of nuclei to form a zygote and the production of genetically dissimilar offspring
(b) identify on diagrams, the male reproductive system and give the functions of: testes, scrotum, sperm ducts, prostate gland, urethra and penis
(c) identify on diagrams, the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina
(d) briefly describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and the fertile and infertile phases of the cycle with reference to the effects of progesterone and estrogen only
(e) describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells which becomes implanted in the wall of the uterus
(f) state the functions of the amniotic sac and the amniotic fluid
(g) describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (structural details are not required)
(h) discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled

Use the knowledge gained in this section in new situations or to solve related problems.

Definition

Phrase	Definition
Sexual reproduction	Process involving fusion of nuclei of male + female gametes → produce genetically dissimilar offspring
Fertilisation	Fusion of nuclei of male + female gametes → zygote
Ejaculation	Release of semen from penis into vagina
Puberty	Stage of human growth and development in which person becomes physically mature
Menstrual cycle	Cycle of events taking place in female reproductive organs every month
Menstruation	Monthly discharge of blood + uterine lining from uterus
Menopause	Ovaries stop releasing ova → menstrual cycle stop (aging)
Ovulation	Release of ovum from ovary

18.0 Reproduction

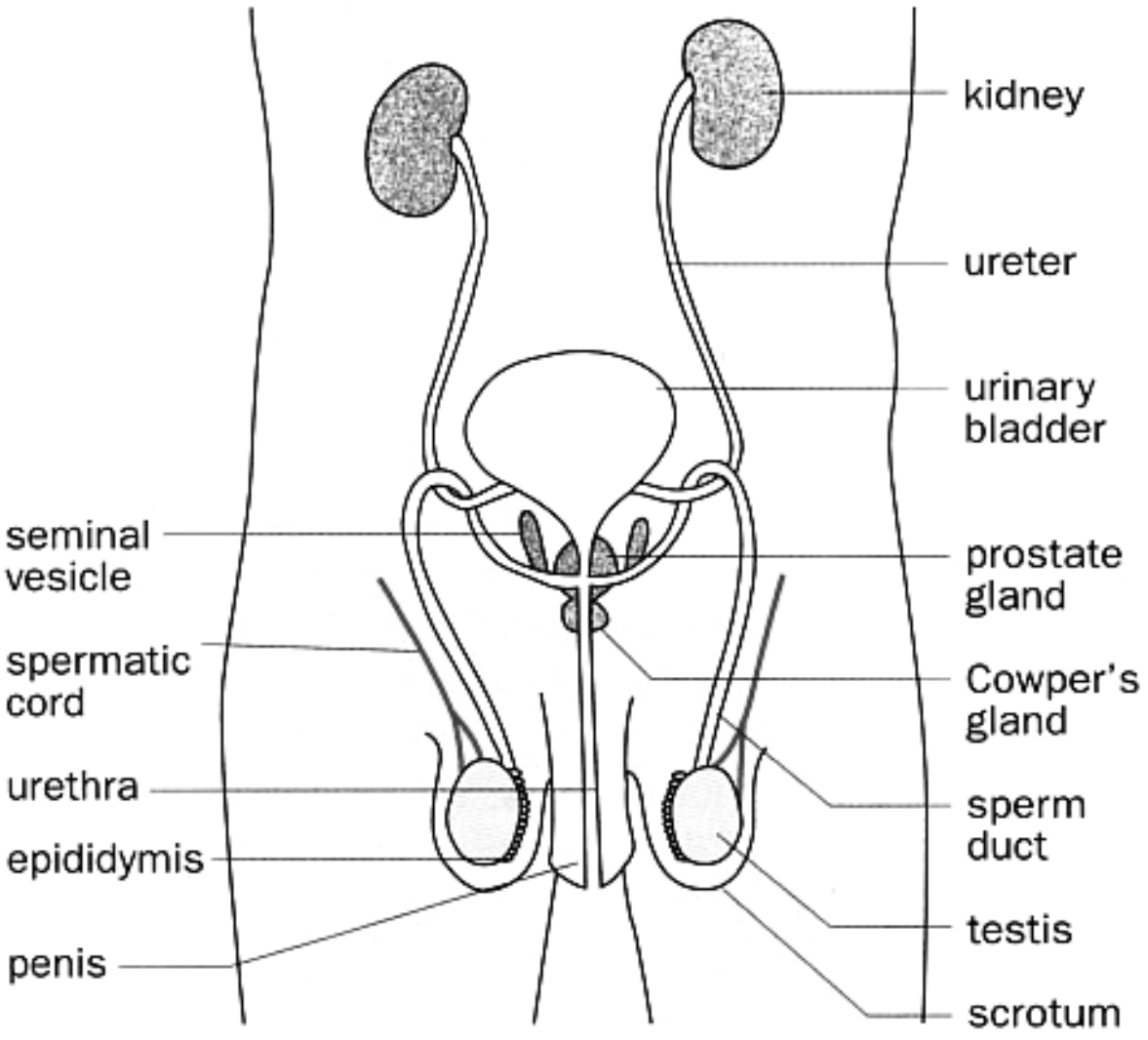
Differences b/w asexual & sexual reproduction

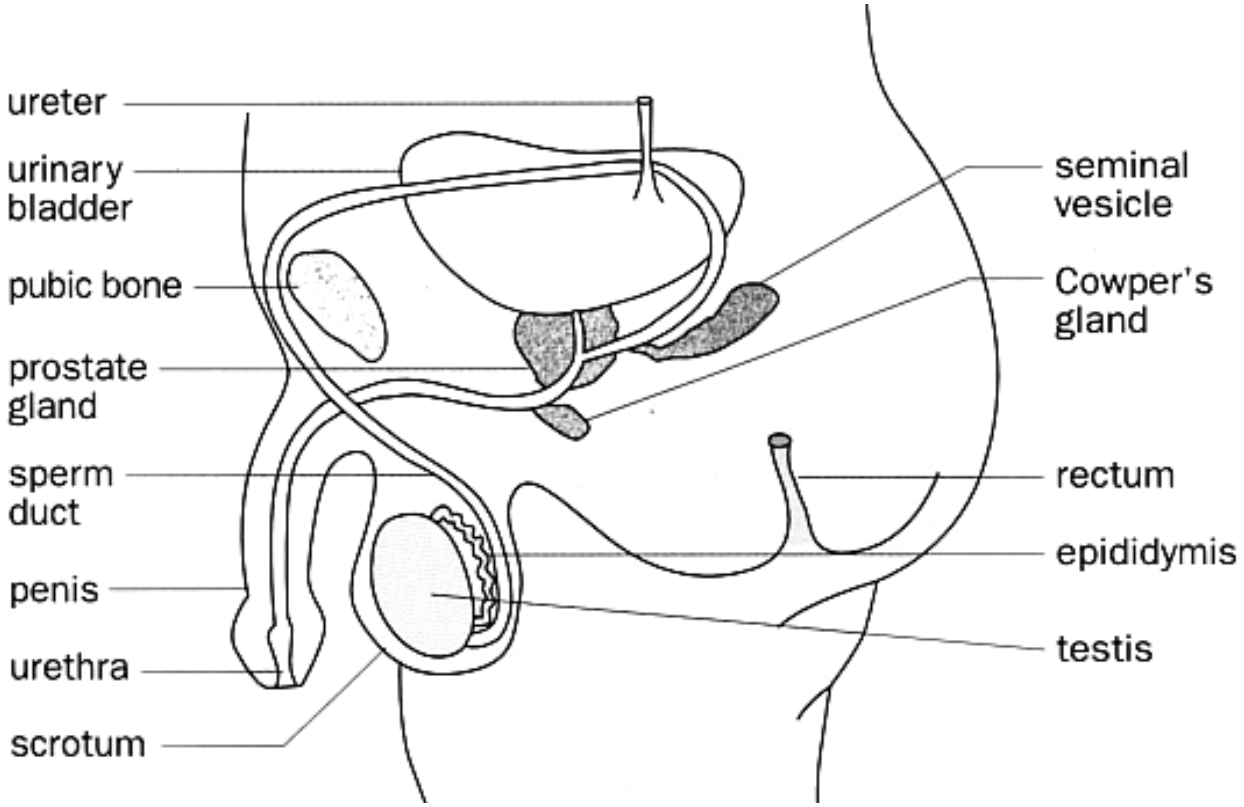
Asexual reproduction	Sexual reproduction
Does not involve fusion of gametes	Involves fusion of male + female gametes → zygote
Only one parent required	Two parents required
Offspring are genetically identical	Offspring are genetically dissimilar

Sexual > asexual reproduction

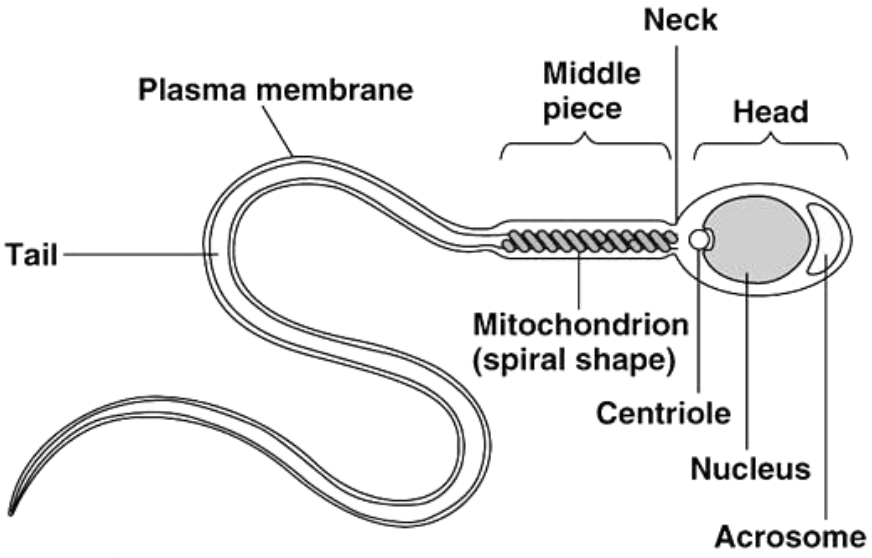
Sexual	Asexual
Mixing of genes → more varieties produced	No mixing of genes → little variation
Offspring more adaptable to changes in environment + ensure survival of species	Offspring less adaptable

18.1 The Male Reproductive System





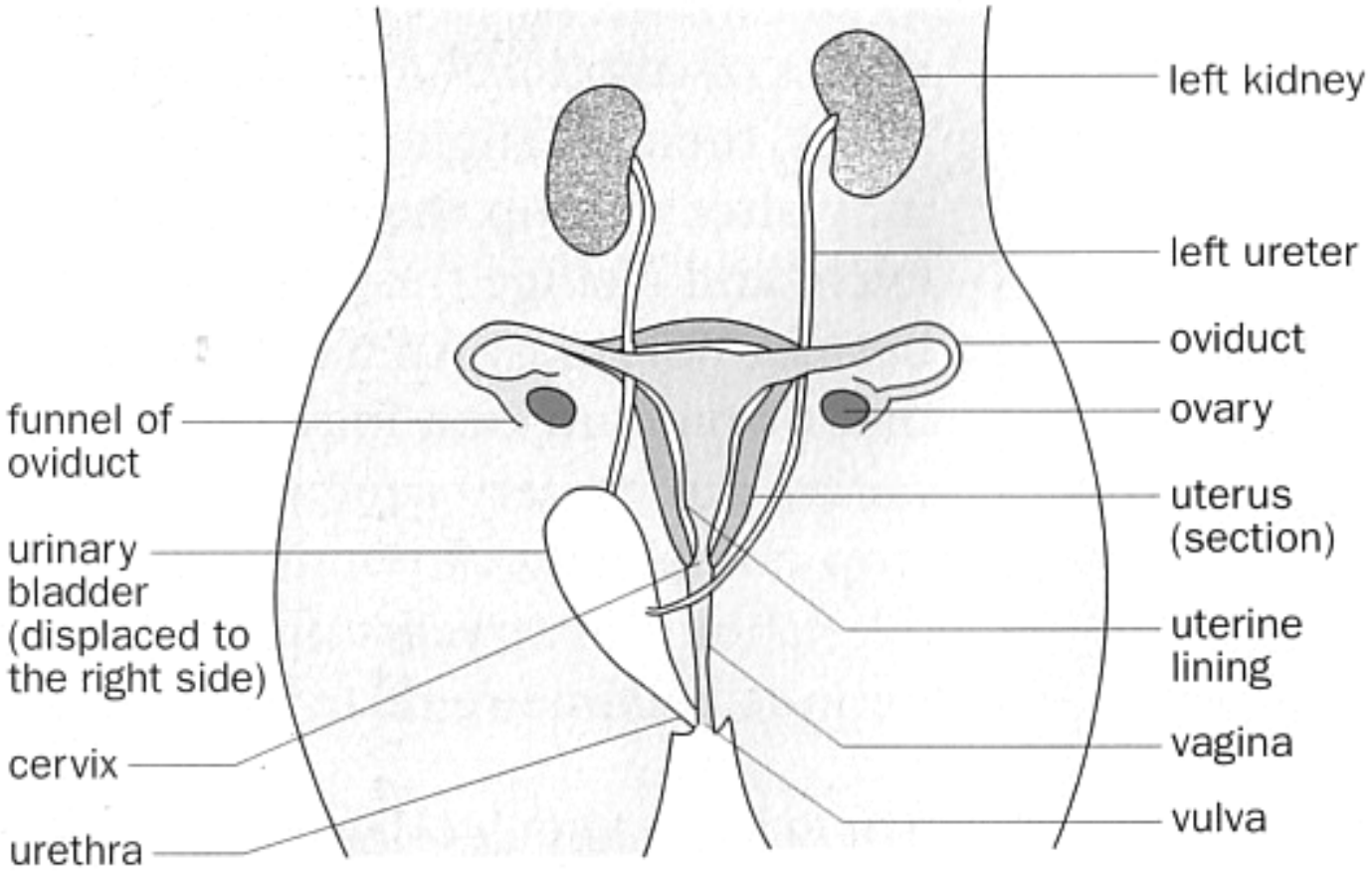
Structure	Function	Description
1. **testis**	1) Produce sperms 2) Produce male sex hormones (testosterone)	● Receive blood from blood vessels in **spermatic cord** ● **Epididymis**: store inactive sperms from testis before entering sperm duct
2. **scrotum**	Sacs containing testes	Outside main body cavity → <u>lower temperature</u> (sperms develop properly)
3. **sperm duct**	Travel of sperms from testis → urethra	Loops over ureter before opening into urethra
4. **prostate gland**	Secrete fluid ● nutrients + enzymes ○ nourish sperms ○ stimulate → swim actively ● **Semen**: mixture of fluid + sperms	Base of urinary bladder
5. **Cowper's gland**		Beneath prostate gland
6. **seminal vesicle**		Open into sperm duct
7. **penis**	Erectile organ	Enter vagina during sexual intercourse → deposit semen (containing sperms)
8. **sphincter muscle**	Contract → prevent urine from coming out of urinary bladder during **ejaculation** (release of semen)	Circular band of muscle at base of urinary bladder

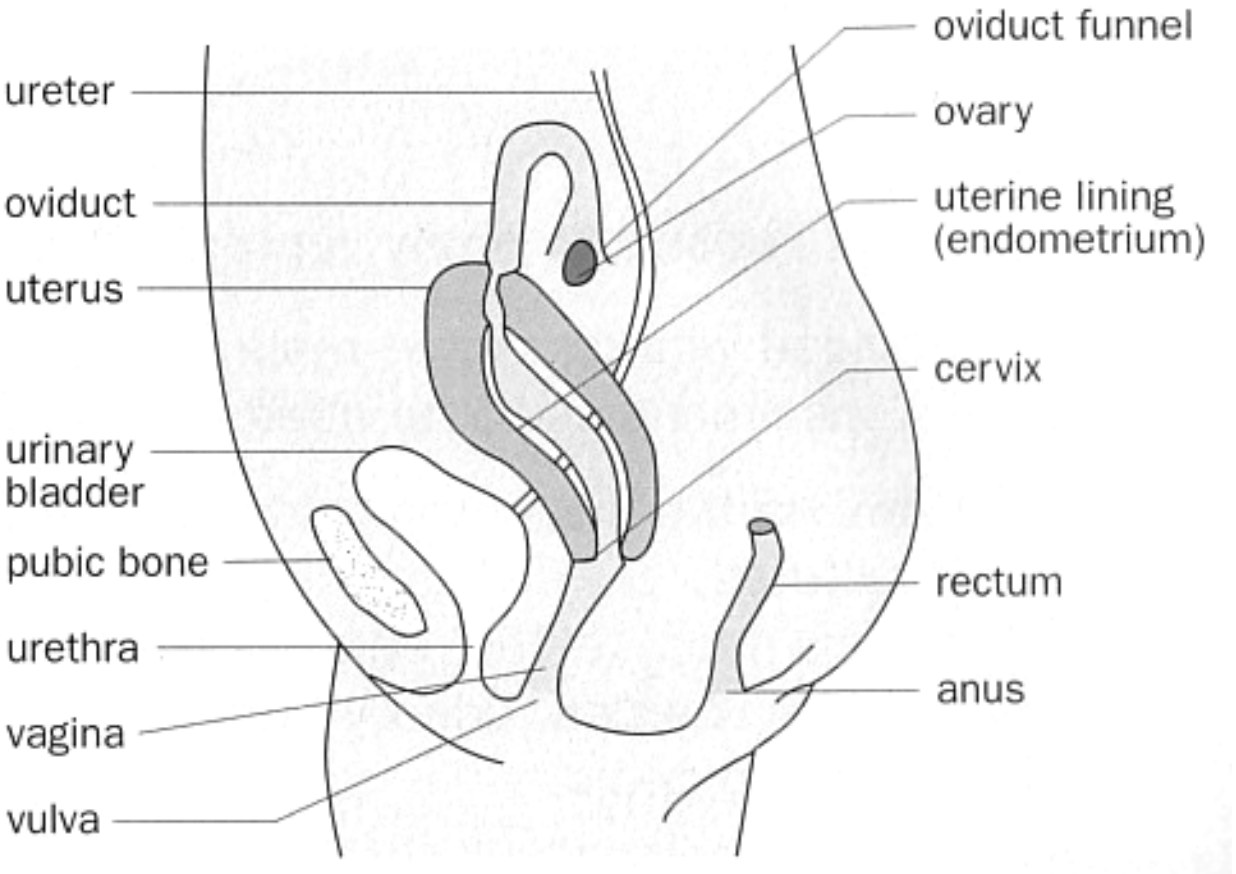


Sperm - 60 μm long
(Hundreds of millions in each ejaculate → increase chance of fertilisation)

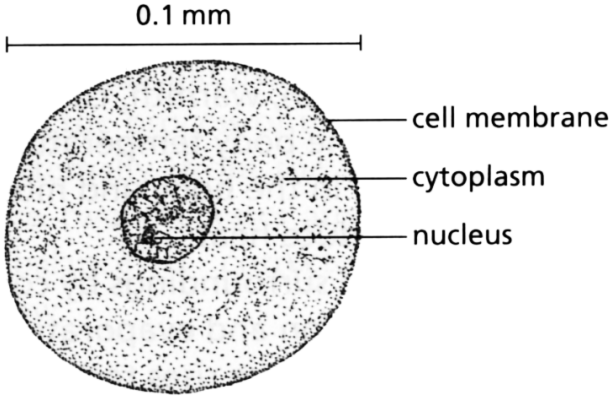
Parts	Structure
Head	Extremely small (2.5 μm wide) ● Large nucleus (haploid set of chromosomes – 23) ● Small amount of cytoplasm ● **Acrosome**: vesicle containing enzymes ○ break down part of ovum membrane ○ sperm penetrate ovum during fertilisation
Middle piece	Numerous **mitochondria** ● cellular respiration → release energy ● muscle contraction → sperm swim towards ovum
Tail	**Flagellum**: beating movement of tail ● propel sperm forward → swim towards ovum ● sperm is **motile** (move on its own)

18.2 The Female Reproductive System





Structure	Function	Description
1. **ovary**	1) Produce ovum 2) Produce female sex hormones (regulate menstruation)	
2. **oviduct**	1) Carry ovum forward (i) beating action of cilia on inner surface (ii) muscular contraction of oviduct 2) Fertilisation occurs	Funnel-like opening close to ovary → easier for ovum to enter
3. **uterus**	1) Development of fetus during pregnancy 2) Thick muscular walls → contract during childbirth to push baby out	pear-shaped 7.5 cm long
4. **uterine lining** (endometrium)	Shed during menstruation	soft inner smooth lining of uterus
5. **cervix**	Opening allows menstrual blood to flow out → vagina (menstruation)	circular ring of muscle just below uterus
6. **vagina**	Semen deposited during sexual intercourse	● continuation of cervix ● **vulva**: opening of vagina



Ovum

Part	Description
1. **Nucleus**	● large ● 1 haploid set of chromosomes (23)
2. **Cytoplasm**	● abundant ● small amount of yolk (no need much nutrients)
3. **Membrane**	● surrounded by CSM → surrounded by outer membrane

Differences b/w male & female gamete:

Feature	Male gamete (**sperm**)	Female gamete (**ovum**)
Size	0.05 mm long	0.1 mm diameter
Structure	Head + middle piece + tail Nucleus contains X / Y chromosome	Spherical in shape Nucleus contains X chromosome
Mobility	Motile (tail → swim towards oviduct)	Non-motile (passive movement along oviduct → cilia on oviduct + peristalsis of oviduct wall)
Quantity	• Numerous produced throughout life since puberty • Large no. per ejaculation	• No. determined at birth • 1 per month (both all together 500)
Lifespan	3 ~ 4 days	1 ~ 2 days
Food reserves	Nutrients in seminal fluid	Food reserves in cytoplasm

Puberty

Secondary sexual characteristics

- Reproductive system begins to function
- Sex organs mature → produce gametes
- Brought about by sex hormones

Male	Female
testes	ovaries
testosterone	**oestrogen** **progesterone**

- Characteristics

Male	Female
○ Hair in pubic region, under armpits + face ○ Penis & testicles increase in size ○ Larynx enlarge, voice deepen ○ Production of sperms start	○ Hair in pubic region, under armpits ○ Breasts & uterus enlarge ○ Hips broaden ○ Menstruation + ovulation start

18.3 Menstrual Cycle

Natural variation

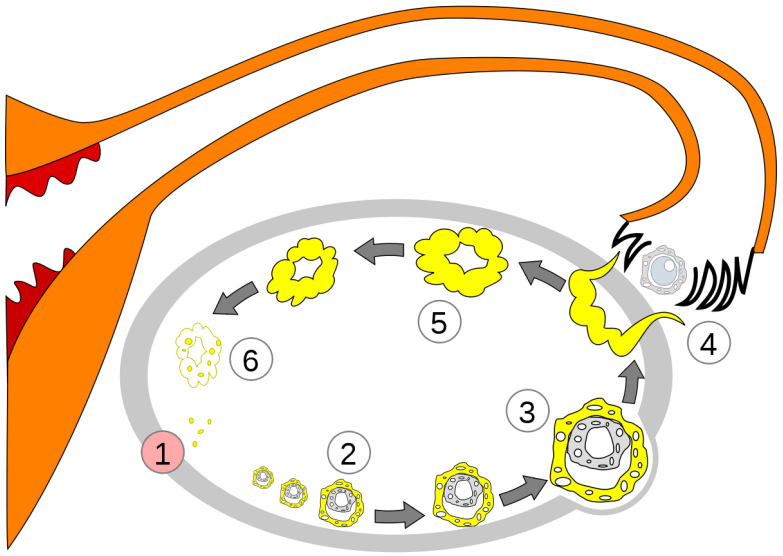
Natural variation in length of menstrual cycle

- Causes:
  - stress
  - tiredness
  - illness
  - unbalanced diet
  - malnutrition
- Result:
  - stop
  - change interval b/w periods

Fertile and infertile periods

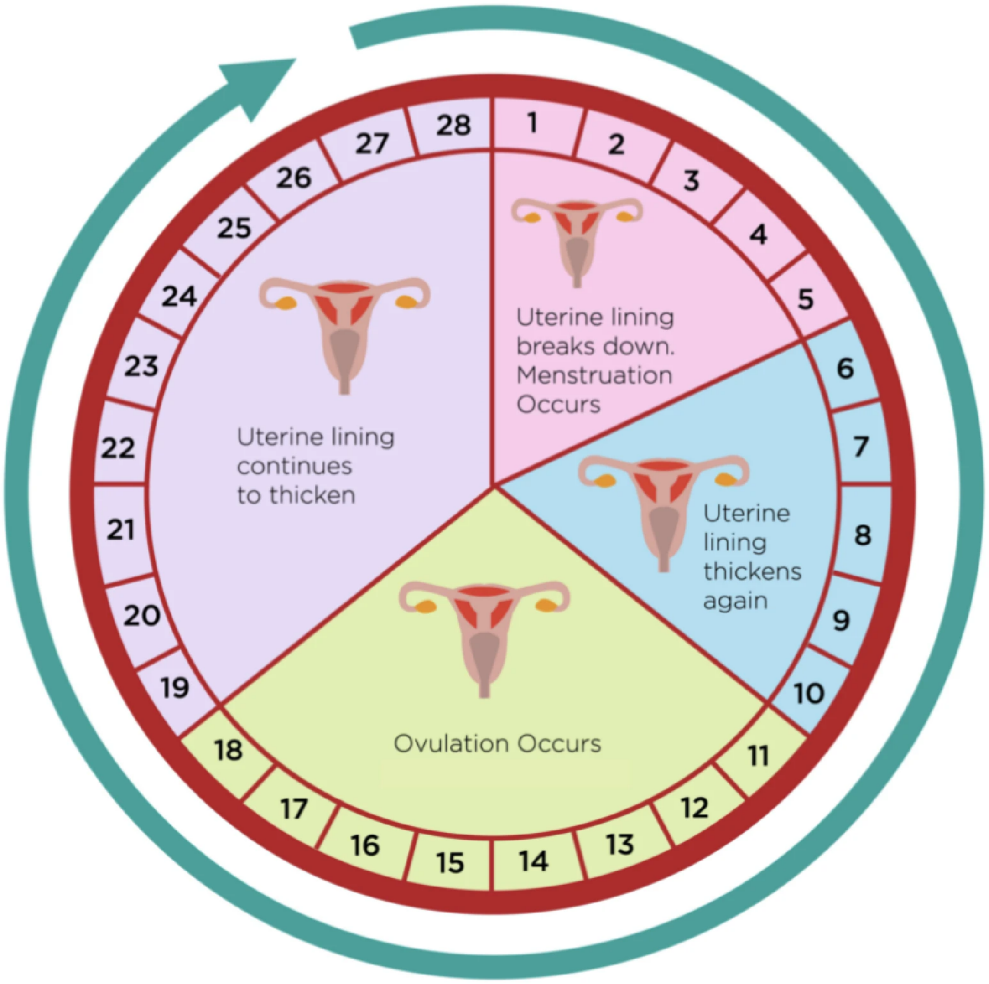
Fertile period	Infertile period
days 11 ~ 15 (calculate based on qn)	rest of the days
fertilisation possible	low chance of fertilisation

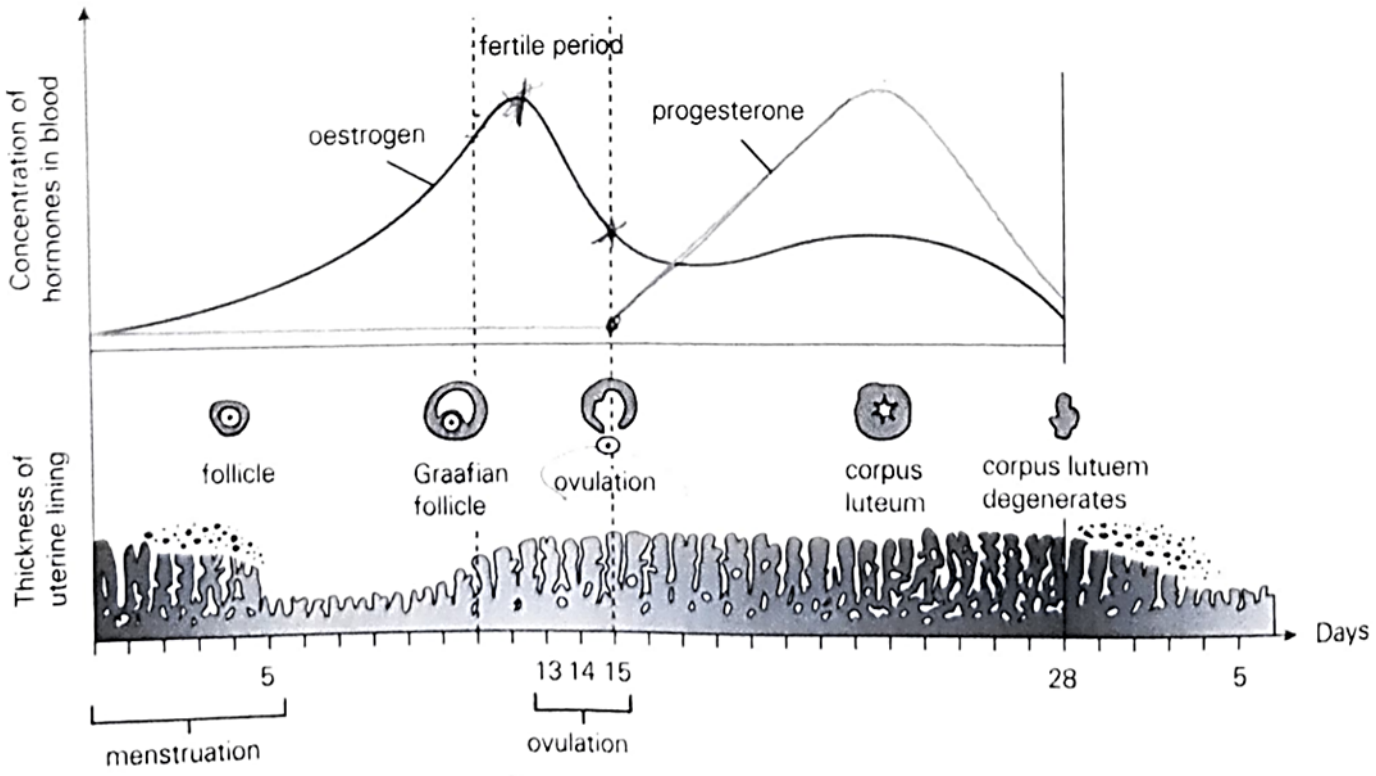
Changes in follicle



Event	Explanation
1. **Primary follicle**	• Consist of 1) 1 potential ovum cell 2) surrounding layer of follicle cells
2. **Graafian follicle**	• Consist of 1) ovum surrounded by follicle cells 2) fluid-filled space • Ovum: haploid no. of chromosomes (1 per month)
3. **Ovulation**	• Graadian follicle rupture → release ovum into oviduct • **Ovulation**: release of ovum from ovary
4. **Corpus luteum**	• Develop from Graafian follicle • Produce hormones → prepare body for pregnancy • Break down if no fertilisation

Stages in menstrual cycle





Day	Stage	Hormone	Explanation
1 ~ 5	**Menstrual flow stage**		● Uterine lining break down + flow out of body through vagina ● Pituitary gland: secrete FSH
6 ~ 13	**Follicle stage**	FSH	● stimulate development of follicles in ovaries ● stimulate follicles in ovaries → secrete oestrogen
		oestrogen	● repair + growth of uterine lining → thick + spongy with blood vessels ● (high conc) inhibit FSH production → prevent maturation + development of more follicles ● (high conc) stimulate pituitary gland → secrete **luteinising hormone** (LH)
14	**Ovulation**	LH	● stimulate ovulation ● stimulate formation of corpus luteum from remains of Graafian follicle ● corpus luteum secrete progesterone
15 ~ 28	**Corpus luteum stage**	progesterone	● maintain uterine lining → thicken further + richly supplied with blood capillaries → prepare for implantation ● inhibit ovulation ● inhibit FSH production

Pituitary hormones

Pituitary hormone	Effects	Period of highest conc
1. **Follicle-stimulating hormone (FSH)**	● Stimulate maturation of follicles in ovaries (primary → Graafian) ● Stimulate follicles → secrete **<u>oestrogen</u>**	Follicle stage
2. **Luteinising hormone (LH)**	● Trigger ovulation (rupture of Graafian) ● Stimulate formation of corpus luteum → secrete **<u>progesterone</u>** + oestrogen	Ovulation

Sex hormones

Sex hormone	Effects	Period of highest conc
1. **Oestrogen**	• Stimulate repair + growth of uterine lining after menstruation • High conc: stimulate secretion of FSH + LH Low conc: inhibit FSH production (prevent maturation of more follicles)	Follicle stage
2. **Progesterone**	• Promote further thickening of uterine lining + well-supplied with blood capillaries → prepare to receive embryo • Inhibit ovulation + contraction of uterus • Inhibit FSH + LH production	Corpus luteum stage

Fertilisation

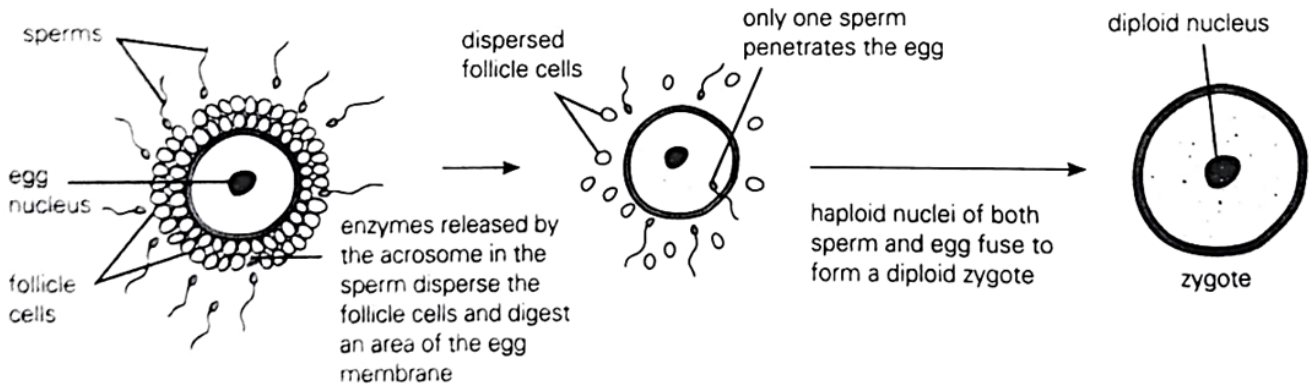
✘	✓
• Ovum break down • LH production inhibited by high conc of progesterone → corpus luteum break down → no progesterone → cannot maintain thickened uterine lining → break down → + blood flow from uterus through vagina (beginning of menstruation) • FSH produced again by pituitary gland → cycle repeat	• Fertilised ovum → zygote → embryo • Embryo embeds itself in uterine lining • Embryo secretes hormone → prevent corpus luteum from breaking down until placenta is formed • Corpus luteum continue to secrete progesterone + oestrogen until placenta able to produce progesterone + oestrogen

18.4 Sexual Reproduction in Humans

Sexual intercourse

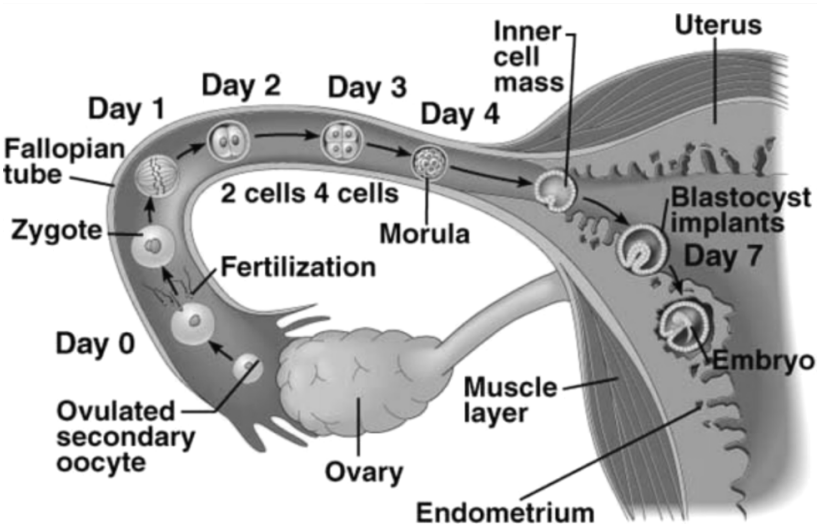
1. Male sexually stimulated → blood pumped into penis faster than it returns to bloodstream via veins → blood fill spaces in spongy tissues of penis
2. Penis becomes stiff and erect → enter vagina of female
3. Semen containing sperms: ejaculated → vagina
4. Sperms swim up oviduct (sperm tail beat to propel along oviducts)
5. Sperm meet ovum → fertilisation

Fertilisation



Stage	Explanation
1. Acrosome release enzyme → disperse follicle cells + break down ovum membrane	● Ovum from ovary: surrounded by layers of follicle cells
2. 1 sperm nucleus enter ovum	● Fusion: haploid sperm nucleus + haploid ovum nucleus ● Form diploid zygote (fertilised ovum)
3. Sperm entered ovum	● Ovum membrane change → no other sperms enter ● Remaining sperms (do not fertilise ovum) → die

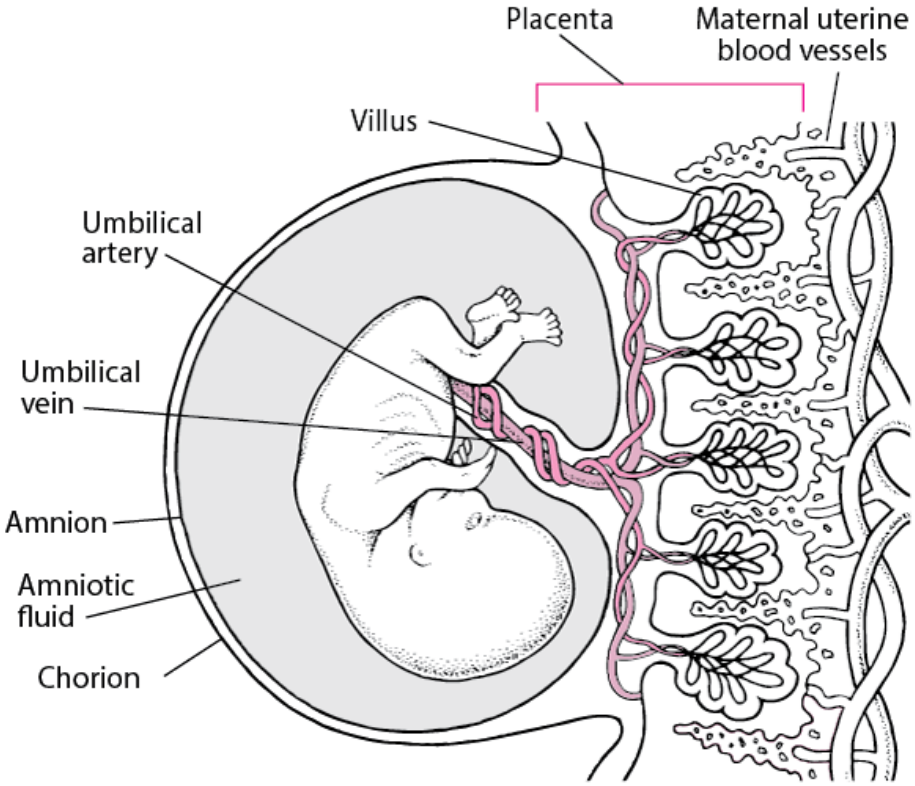
<u>Development of embryo</u>

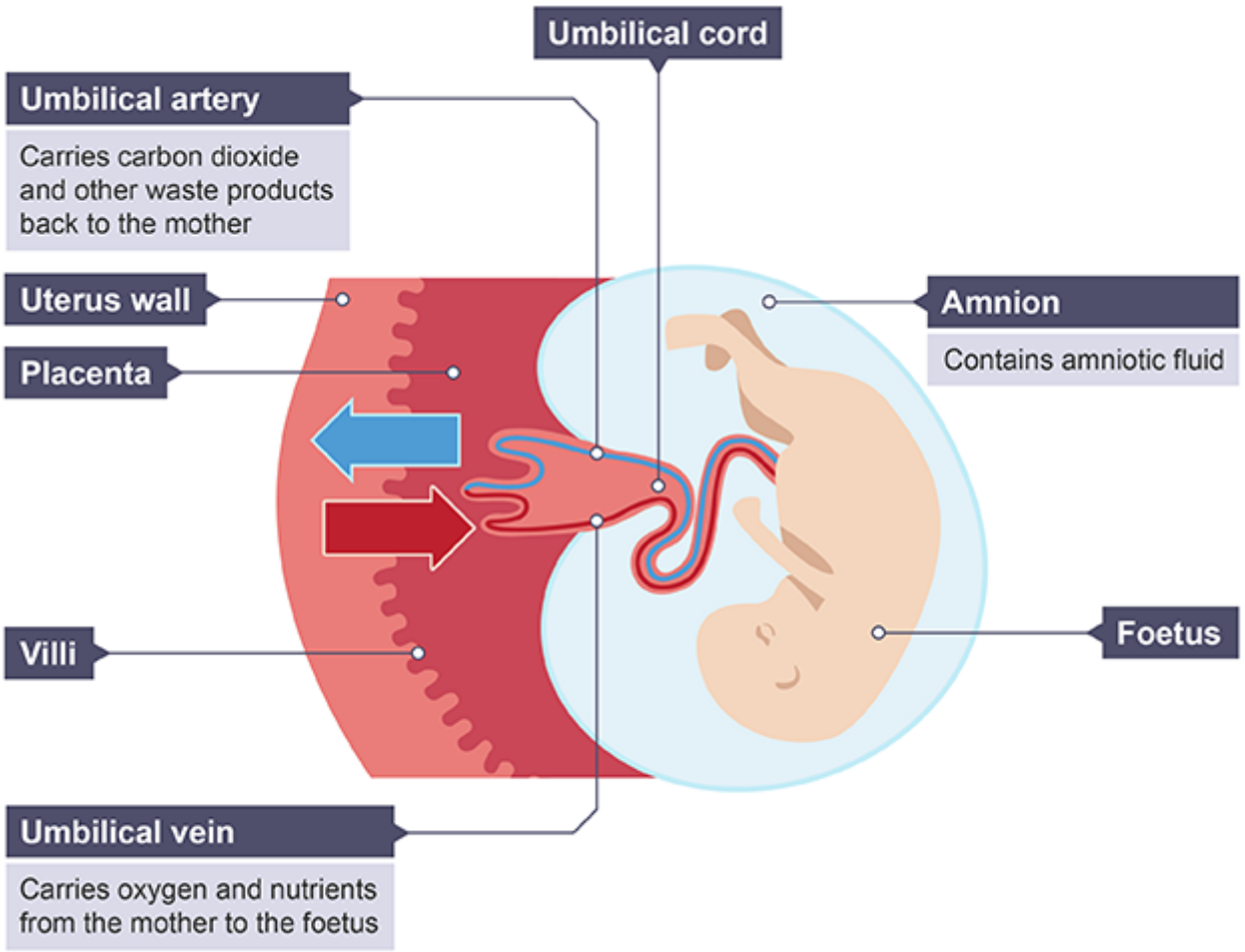


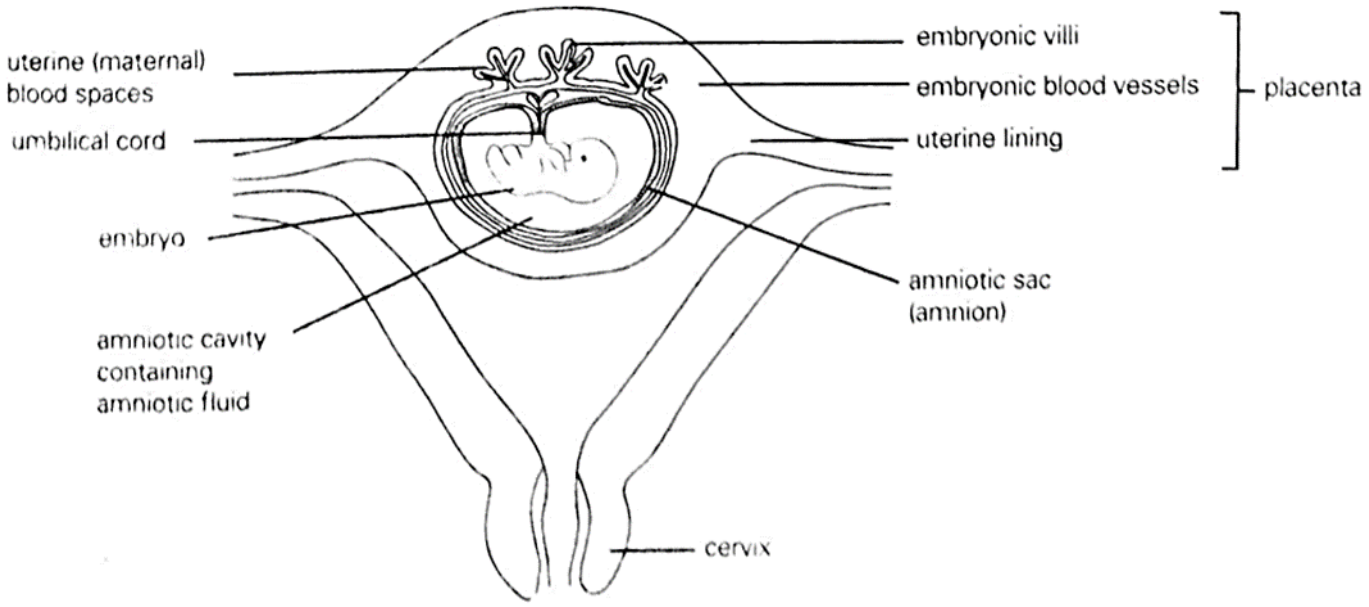
Stage	Explanation
1. **Implantation**	● Zygote (fertilised ovum): oviduct → uterus [5 days] 1) Sweeping of cilia lining inner surface of oviduct 2) Peristaltic movement in wall of oviduct ● Zygote divides (<u>mitosis</u>) → embryo (ball of cells) ● Embryo embedded in uterine lining [2 days of floating freely]
2. **Development of placenta**	● Villi grow from embryo into uterine lining (contain blood capillaries of embryo) ● **Placenta**: villi + uterine lining ● **Umbilical cord**: tube attach embryo → placenta
3. **Development of amniotic sac**	**Amniotic sac** develop simultaneously with placenta ● **Amniotic cavity**: fluid-filled space where embryo is enclosed by amniotic sac ● **Amniotic fluid**: fluid in amniotic cavity

Sperm + ovum → zygote → embryo → fetus → baby

Fetus


Placenta
Maternal uterine blood vessels
Villus
Umbilical artery
Umbilical vein
Amnion
Amniotic fluid
Chorion


Umbilical cord
Umbilical artery
Carries carbon dioxide and other waste products back to the mother
Uterus wall
Placenta
Amnion
Contains amniotic fluid
Villi
Foetus
Umbilical vein
Carries oxygen and nutrients from the mother to the foetus

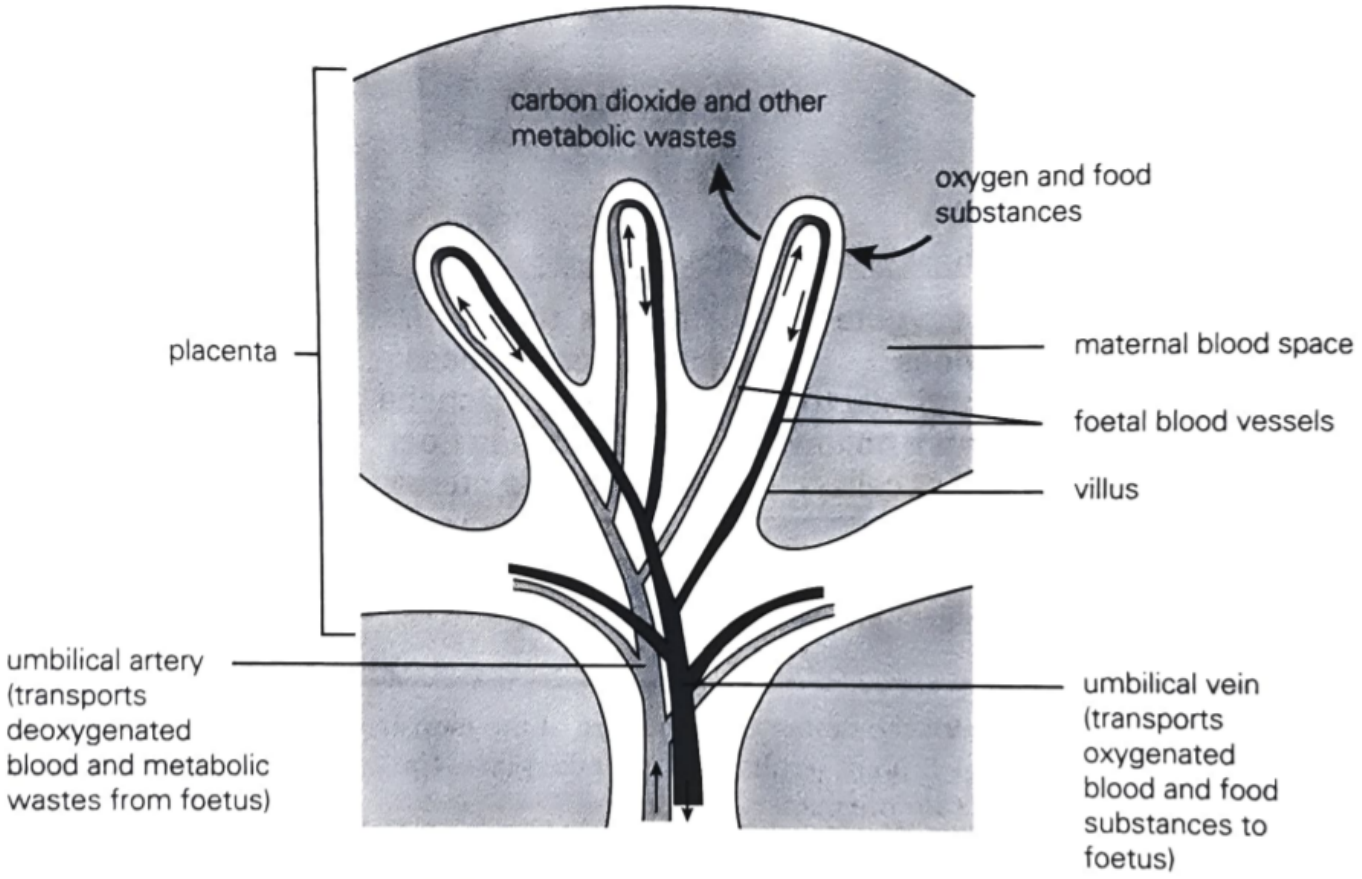


Fetal blood system: not continuous with mother's blood system

Reason	Explanation
1. **Blood pressure**	much higher → kill fetus
2. **Different blood group**	diff blood groups mix: antibodies in mother's blood → fetal blood cells agglutinate

Functions of placenta

Function	Direction	Explanation
1. **Transport**: oxygen + dissolved food substances	mother → fetus	(a) glucose (b) amino acids (c) dissolved mineral salts
2. **Transport**: metabolic waste + excretory products	fetus → mother	(a) urea (b) carbon dioxide
3. **Protective antibodies**	mother → fetus	Protect fetus against diseases (e.g. German measles)
4. Produce **progesterone**	mother	Maintain uterine lining in healthy state during pregnancy



Functions of umbilical cord (attach fetus → placenta)

2 umbilical arteries	**1 umbilical vein**
fetus → placenta (away from fetus heart)	placenta → fetus (towards fetus heart)
• **deoxygenated** blood • metabolic waste products	• **oxygenated** blood • dissolved food substances

Functions of amniotic fluid

1. Support + cushion fetus before birth
2. Shock absorber
3. Protect fetus against physical injury (cannot be compressed)
4. Promote muscular development of fetus (allow certain degree of movement)
5. Lubricate + reduce friction in vagina (during birth)

Gestation: period from fertilisation → birth (38 weeks)

18.5 Sexually Transmitted Infection

Sexually transmitted infection (STI): disease spread / transmitted through sexual intercourse
Mode of transmission: **exchange of body fluids**

- semen: into contact with mucous membrane in vagina
- fluid in vagina: into contact with mucous membrane of urethra
- blood from infected person: into bloodstream of uninfected person

Acquired Immune Deficiency Syndrome (AIDS)

Caused by **Human Immunodeficiency** (HIV): destroy lymphocytes → destroy immune system

- body X produce sufficient antibodies to protect against diseases
- mild infections → fatal

Signs and symptoms

- chronic / persistent fever
- severe diarrhoea lasting for months
- pneumonia
- Kaposi's sarcoma (blood vessel cancer)
- brain infection
- widespread tuberculosis (lung disease) affecting many organs

Modes of transmission
(exchange of body fluids)

1. Sexual intercourse with infected person
2. Sharing of infected hypodermic needles
3. Blood transfusion with blood from infected person
4. Infected mother to fetus during pregnancy

Prevention and control

1. Keep to 1 sex partner
2. Use condom during sexual intercourse
3. Do not abuse drugs / share instruments that break skin
4. Sterilised / disposable instruments (acupuncture, ear-piercing, tattooing)

Typical questions

Multiple choice questions

1 What is an advantage of the testes being held in the scrotum, outside the body cavity?

(N2011/P1/Q29)

A More sperms can be stored in an external scrotum.
B Sperm development is more efficient at temperatures below 36℃.
C Testes are better protected in the scrotum than in the body cavity.
D There is more time for prostate secretions to be added to sperm.

2 Which structures are found in a human sperm cell? (N2012/P1/Q2)

	diploid nucleus	haploid nucleus	mitochondria	nuclear membrane
A	✔	✖	✔	✔
B	✔	✖	✖	✖
C	✖	✔	✔	✔
D	✖	✔	✖	✖

3 Which row shows the effects of estrogen and progesterone?

(N2012/P1/Q29 / N2016/P1/Q30)

	high level needed for ovulation	high level needed to stop development of more ova	maintains the uterus lining	repairs the uterus lining
A	oestrogen	progesterone	oestrogen	progesterone
B	oestrogen	progesterone	progesterone	oestrogen
C	progesterone	oestrogen	oestrogen	progesterone
D	progesterone	oestrogen	progesterone	oestrogen

4 Some constituents of the blood are listed.

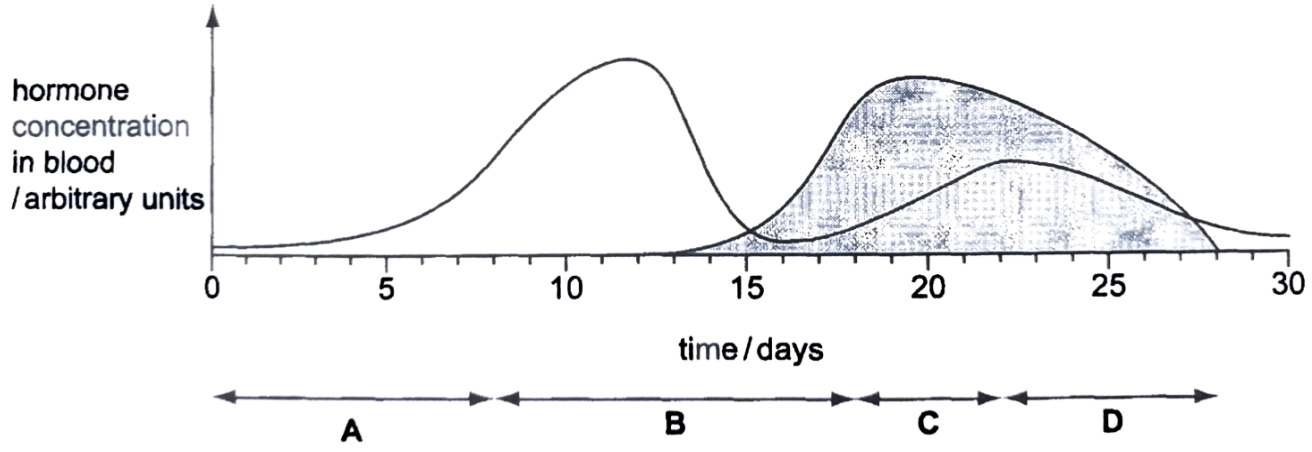
1 amino acids
2 antibodies
3 carbon dioxide
4 glucose
5 minerals
6 oxygen
7 red blood cells
8 urea

Which constituents pass from baby to mother across the placenta and which pass from mother to baby? (N2012/P1/Q30)

	baby to mother	mother to baby
A	2 and 3	1 and 8
B	3 and 4	5 and 7
C	3 and 8	1 and 2
D	5 and 6	3 and 4

5 The graph shows the concentrations of two reproductive hormones in the blood of an adult female.

During which period is she most likely to become pregnant if she has sexual intercourse? (N2013/P1/Q30)

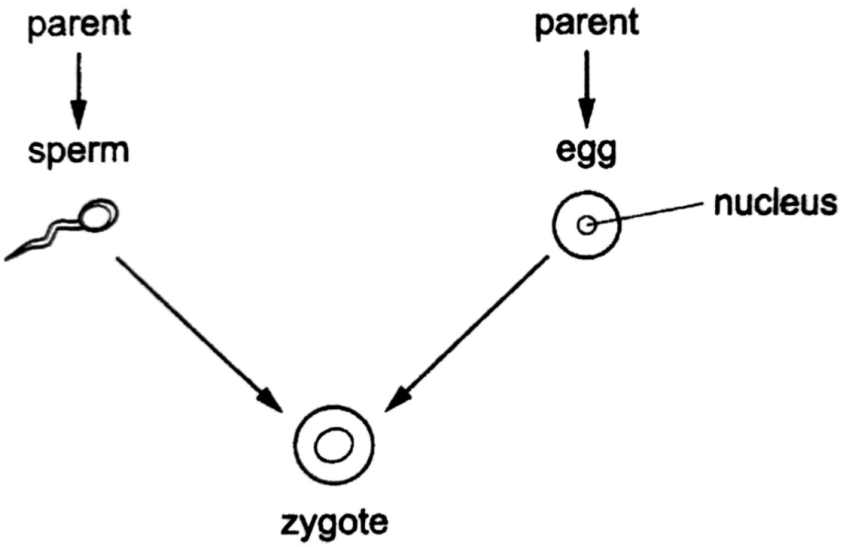


6 Which row gives the correct comparison of blood passing from the fetus to the placenta compared to the composition of the blood flowing from the placenta to the fetus?

(N2014/P1/Q30)

	blood from fetus to placenta			
	amino acids	oxygen	urea	water
A	less	less	more	more
B	less	same	same	same
C	more	less	more	less
D	same	same	less	more

7 The diagram shows a human zygote being formed.

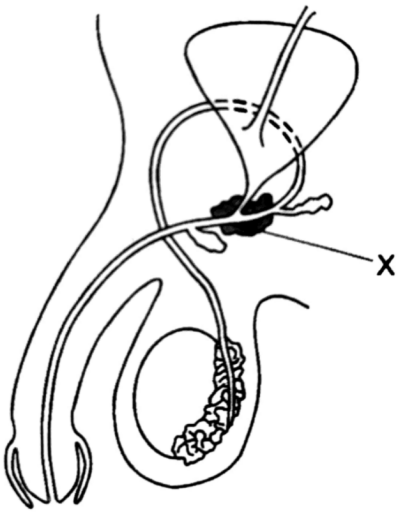


What describes the zygote?

(N2015/P1/Q29)

	homologous chromosomes present	produced by mitosis	sex determined by the father
A	✔	✖	✔
B	✔	✖	✖
C	✖	✔	✔
D	✖	✔	✖

8 The diagram shows a section through the male reproductive system.



What will be the effect if gland X is removed? (N2015/P1/Q30)

A Fewer sperms are formed.
B Fewer sperms can be stored.
C Less testosterone is produced.
D Sperms are less active.

9 Some possible functions of the amniotic fluid are listed.

1 It keeps the fetus cool.
2 It protects the fetus from mechanical shocks.
3 It supplies the fetus with oxygen.
4 It supports the fetus during development.

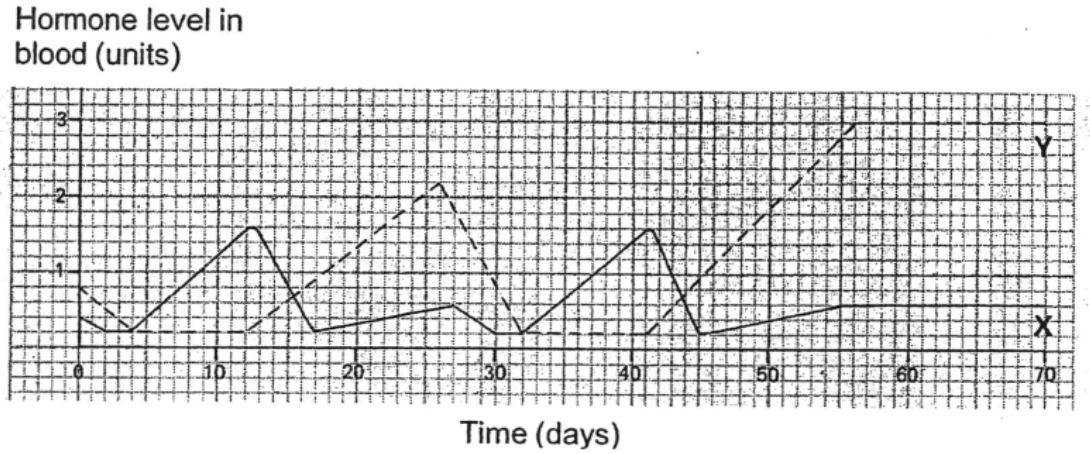
Which functions are correct? (N2017/P1/Q30)

A 1 and 2
B 1 and 3
C 2, 3 and 4
D 2 and 4

10 Which change occurs just before menstruation? (N2019/P1/Q29)

A a decrease in the concentration of oestrogen and progesterone
B an increase in the concentration of oestrogen and progesterone
C a decrease in the concentration of progesterone and an increase in the concentration of oestrogen
D an increase in the concentration of progesterone and a decrease in the concentration of oestrogen

11 The graph below shows the changes in the level of oestrogen (represented by X) and progesterone (represented by Y) in blood.



With reference to the graph, what are the approximate dates on which ovulation occurred?

A Day 4 and 32

B Day 13 and 42

C Day 17 and 45

D Day 26 and 56

Structured questions

1 Suggest why

(a) ovum is much larger in size than the sperm cell [2]

- A large ovum has a large amount of cytoplasm which contains more nutrients / food nutrients
- for the developing zygote before it is implanted and obtains food from placenta.

(b) the sperm has flagellum but not in the ovum [1]

After its deposition at the cervix, the sperm needs to swim up the female reproductive tract with the help of its flagellum to the oviduct to fertilise the ovum.

(c) the sperm contains mitochondria but few other cytoplasmic organelles and the advantage of this feature [3]

- Numerous mitochondria for increased rate of cellular respiration to release more energy. This propels the sperm from vagina to oviduct for fertilisation.
- Few organelles are present so that more space can be given to pack mitochondria
- and also decreases the mass of sperms to speed up their mobility.

2 Describe the importance of corpus luteum. [2]

Corpus luteum secretes progesterone to maintain uterine lining, keeping it soft and vascularised to prepare for implantation and the initial stages of pregnancy.

3 Describe the sequence of events that occur after a human ovum cell is fertilised which enable it to develop and survive in the uterus. [5]

(N2017/P2/A5b)

- After a human ovum cell is fertilised, it is known as a zygote. The zygote divides repeatedly by mitosis to develop into an embryo. The cilia lining the oviduct and peristaltic movements transport the embryo from the oviduct to the uterus from implantation in the uterine lining.
- The embryo secretes a hormone that prevents the corpus luteum from breaking down until the placenta is formed. the corpus luteum continues to secrete progesterone and estrogen until the placenta is ready to produce the two hormones. Progesterone maintains the uterine lining during pregnancy.

- The amniotic sac encloses the embryo in the amniotic cavity which contains amniotic fluid. Villi containing the blood capillaries of the embryo grow into the uterine wall. The embedded villi and the part of the uterine wall form the placenta. Fetal blood capillaries are separated from the maternal blood by a thin layer of tissue.
- The placenta allows useful substances such as glucose, oxygen, amino acids and mineral salts to diffuse from the maternal blood into the fetal blood. It also allows metabolic waste products such as carbon dioxide and urea to diffuse from the fetal blood into the maternal blood to be excreted. The placenta allows antibodies in the maternal blood to diffuse into the fetal blood so that the fetus is able to defend itself against diseases.
- The amniotic fluid supports the fetus and prevents it from suffering physical injury. It also allows the fetus to move freely.

4 (N2018/P2/B10 OR)

(a) Describe the process of fertilisation and outline the early development of the embryo. [6]

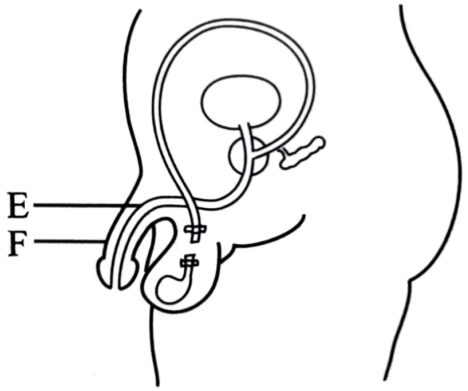
- Millions of sperms are released during ejaculation and deposited in the vagina. The sperms travel from the vagina, up through the cervix and uterus, to the oviduct.
- Fertilisation takes place in the oviduct. One mature ovum is released by the ovary every month. The ovum contains a nucleus and an abundant cytoplasm with stored nutrients. One of the sperms reaches the ovum and fuses with it. The nucleus of the sperm fuses with the nucleus of the ovum to form a zygote. The nutrients in the ovum are used by the developing zygote. The zygote divides repeatedly by mitosis to develop into an embryo.
- The embryo is made up of a hollow ball of cells. The cilia lining the oviduct and peristaltic movements transport the embryo from the oviduct to the uterus for implantation in the uterine lining. The embryo may float freely in the uterus before implantation, which usually occurs about seven days after fertilisation.

(b) Describe the function of the placenta during pregnancy. [4]

Villi containing blood capillaries of the embryo grow into the uterine wall. The embedded villi and this part of the uterine wall form the placenta. Fetal blood capillaries are separated from the maternal blood by a thin layer of tissue. The placenta

1. allows useful substances such as glucose, oxygen, amino acids and mineral salts to diffuse from the maternal blood into the fetal blood.
2. allows metabolic waste products such as carbon dioxide and urea to diffuse from the fetal blood into the maternal blood to be excreted.
3. allows antibodies in the maternal blood to diffuse into the fetal blood so that the fetus is able to defend itself against diseases.
4. produces progesterone to maintain the uterine lining during pregnancy.

5 The following shows the male reproductive system of a male who has recently undergone surgery.



(a) Identify the structures labelled E and F. [2]

E: urethra

F: penis

(b) State the functions of structure E in the urinary and reproductive systems. [2]

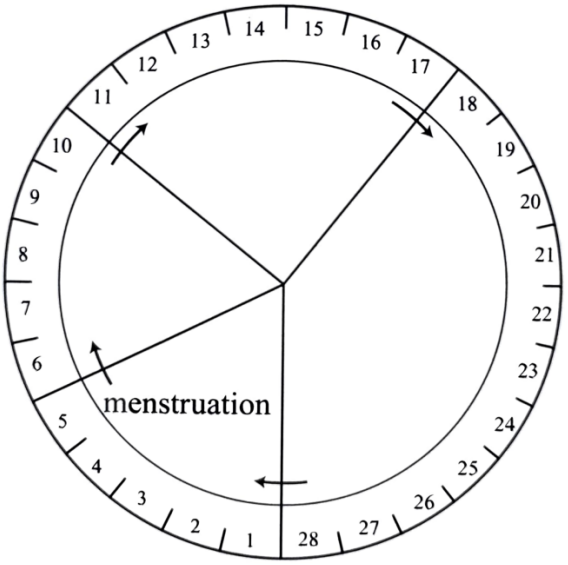
- Allows urine to pass from the bladder to the outside of the body.
- Allows semen to pass through during ejaculation.

(c) Suggest the purpose of the surgery and why it has to be performed on both sides of the reproductive system of the male. [3]

Purpose: the male no longer ejaculates semen that contains sperms

Performed on both sides: both the left and right testes are able to produce sperms, so surgery is performed on both left and right sperm ducts to prevent any sperms from being ejaculated

6 Describe the effects of the female sex hormones from day 6 to the start of a new cycle. [8]



Days	Effects of sex hormones
6 – 13	● Oestrogen is secreted by the ovaries to stimulate the repair of the uterine lining. ● High levels of oestrogen inhibit the activity of follicle-stimulating hormone (FSH) such that only 1 primary follicle could mature in each menstrual cycle. ● Secretion of luteinising hormone (LH) by the pituitary gland is also stimulated by high levels of oestrogen.
14	● LH stimulates ovulation and the formation of a corpus luteum from the remnants of the Graafian follicle.
15 – 28	● The corpus luteum secretes progesterone and some oestrogen. ● Progesterone helps to thicken the uterine lining and ensures that the uterine lining receives a rich supply of blood to prepare it for embryo implantation if fertilisation takes place. ● Progesterone also inhibits ovulation and secretion of FSH. ● If fertilisation does not take place, the oestrogen and progesterone levels decrease, leading to the breakdown of the uterine lining and the start of a new cycle.