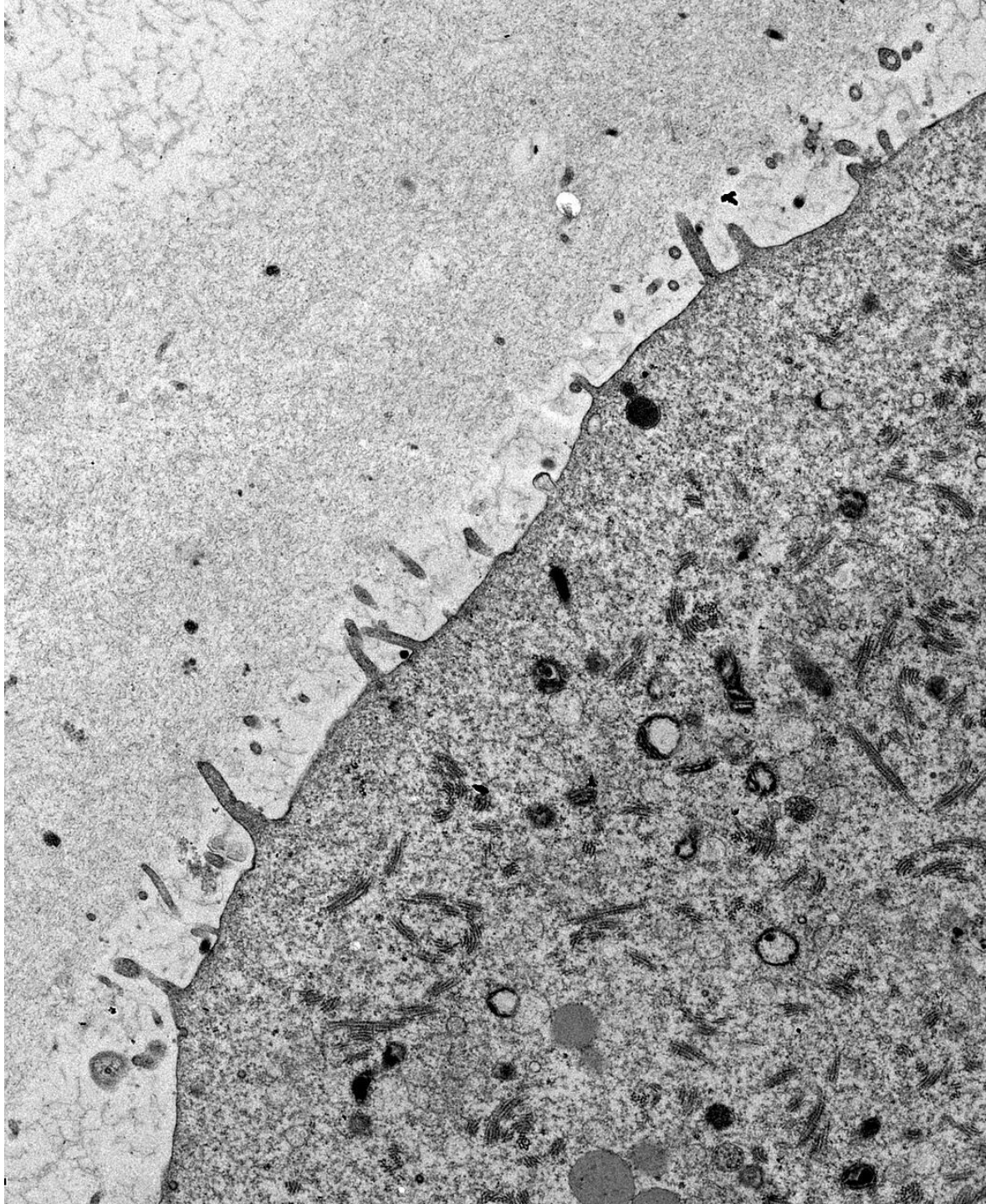
DP Biology – D3.1

Reproduction

- What does sexual or asexual reproduction show about change and continuity?
- How must organisms change in order to reproduce?

Statements D3.1.1–7, SL and HL. Textbook pp. 693–702. Plants are in Plant Systems.
Image: the surface of an egg and its outer coat, electron micrograph. Prue Talbot, CC0.



Objectives for each class

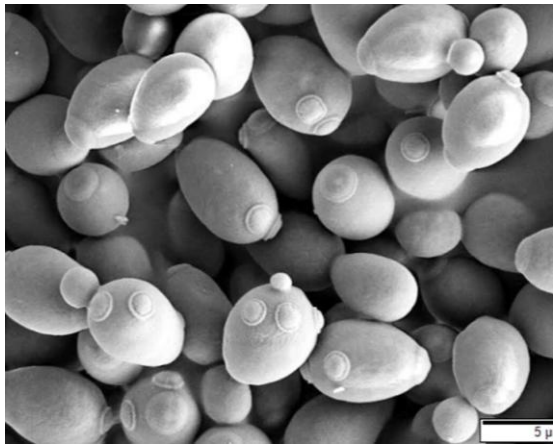
Class	Statements	By the end of the class, you can…
1	D3.1.1–3	Compare sexual and asexual reproduction, and explain how meiosis, fusion and gamete differences matter
2	D3.1.4	Draw and annotate the male-typical and female-typical reproductive systems
3	D3.1.5	Explain the ovarian and uterine cycles, including the four hormones and feedback
4	D3.1.6–7	Outline fertilization, and explain how hormones are used in IVF

Overview of this chapter

Part	Statements	What it covers
Two ways to reproduce	D3.1.1	Sexual and asexual, with their advantages
New combinations	D3.1.2	Meiosis and the fusion of gametes
Two sexes	D3.1.3	Why male and female gametes differ
Human anatomy	D3.1.4	Male-typical and female-typical systems
The menstrual cycle	D3.1.5	Four hormones, and feedback
Fertilization and IVF	D3.1.6–7	Fusion of gametes; hormones used in treatment

Asexual reproduction: one parent

D3.1.1



Yeast cells budding



Hydra budding



Plantlets on Kalanchoe



Spider plant runners

Images, left to right: M.D. Murtey and P. Ramasamy, CC BY 3.0; A. Gomez-Colunga, CC0; Cookie, CC BY 2.5; Mokkie, CC BY-SA 3.0.

- No gametes and no fertilization: cells divide by mitosis
- Offspring are **genetically identical** to the parent, apart from any mutations
- No partner needed, and numbers can rise quickly

Advantage

Identical offspring are as well adapted as their parent, while the environment stays the same.

Sexual reproduction: two parents

D3.1.1



Trout spawning: gametes are released into water, for external fertilization. Parker Montgomery, CC BY-SA 3.0.

- **Meiosis** makes haploid gametes
- **Fertilization** forms a diploid zygote
- Each offspring has a **new combination of genes**
- Needs more time and energy, and usually a partner

Advantage

Variation among the offspring means that some may be better adapted if the environment changes.

Sexual and asexual compared

D3.1.1

	Asexual	Sexual
Parents	One	Usually two
Gametes	None	Yes, haploid
Offspring	Genetically identical	Genetically varied
Best suited to	An existing, stable environment	A changing environment
Examples	Bacteria, yeast, hydra, many plants	Most animals and plants



Example

Aphids reproduce asexually in spring and summer, when conditions are stable, and sexually in autumn. Image: Lucis, public domain.

Meiosis and fusion in the life cycle

D3.1.2



- **Meiosis** halves the chromosome number, so gametes are **haploid**
- **Fertilization**, the fusion of gametes, restores the **diploid** number
- Without meiosis, the chromosome number would double in every generation

Common mistake

The numbers 23 and 46 are for humans only. Other species have different numbers of chromosomes, so do not define haploid as having 23 chromosomes. Define it as having one set of chromosomes.

How new combinations arise

D3.1.2

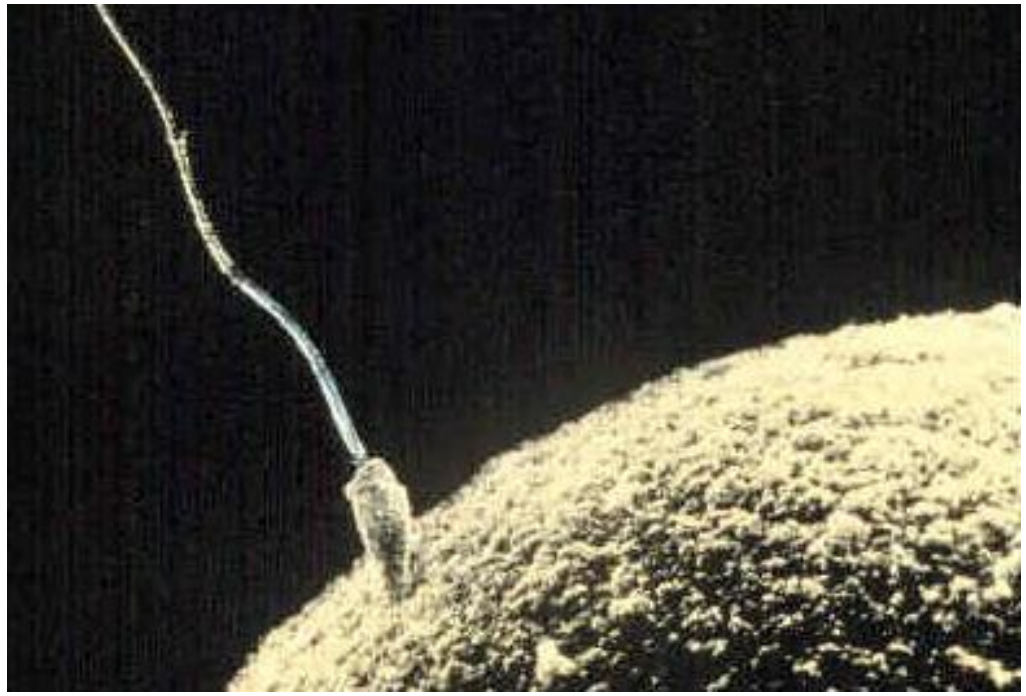
Stage	What it does to alleles
Meiosis	**Breaks up** parental combinations: gametes have allele combinations not found in either parent
Fusion of gametes	**Produces new** combinations: any sperm may fertilize the egg, and each gamete is unique

Key idea

This is the theme of change and continuity. Genes pass from one generation to the next, which gives continuity. Meiosis and random fusion shuffle them, which provides variation for evolution.

Male and female gametes differ

D3.1.3



A sperm reaching the surface of an egg, micrograph. Public domain.

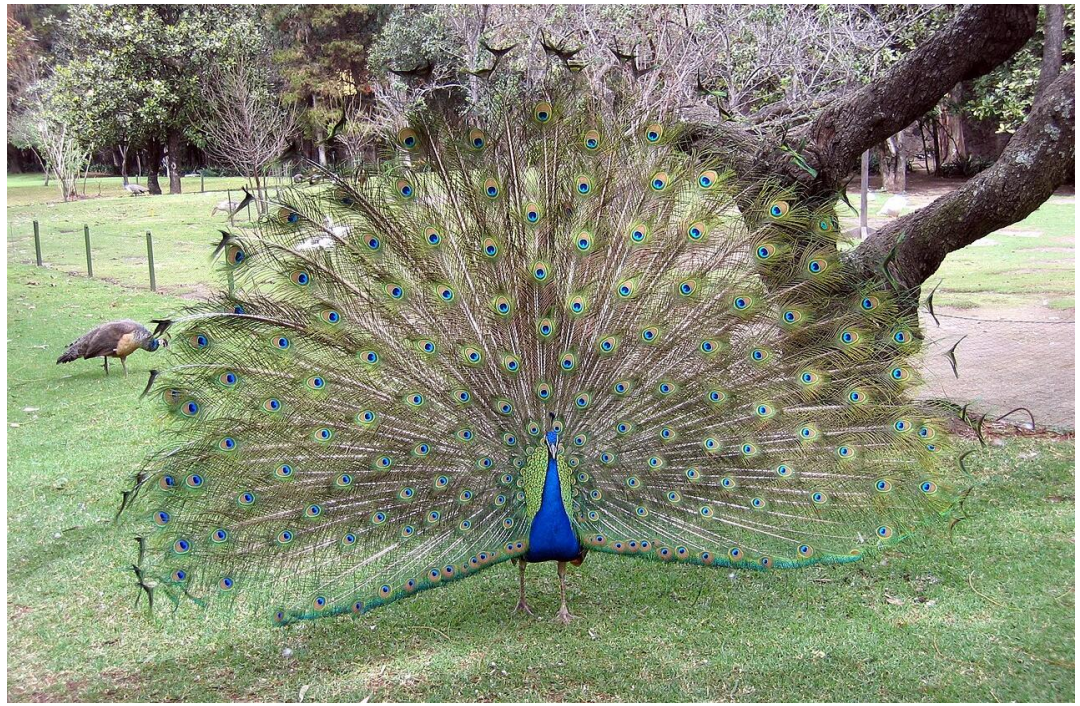
	Male gamete	Female gamete
Movement	Travels	Does not travel
Size	Very small	Much larger
Food reserves	Few	Many
Number	Very many	Few

Key idea

The prime difference is that the male gamete travels to the female gamete. Everything else follows: it must be small and light; few complete the journey, so many are made; and the egg carries the food reserves.

Different reproductive strategies

D3.1.3



Peacock display: a male competing to be selected by females. Peter Andersen, CC BY 2.5.

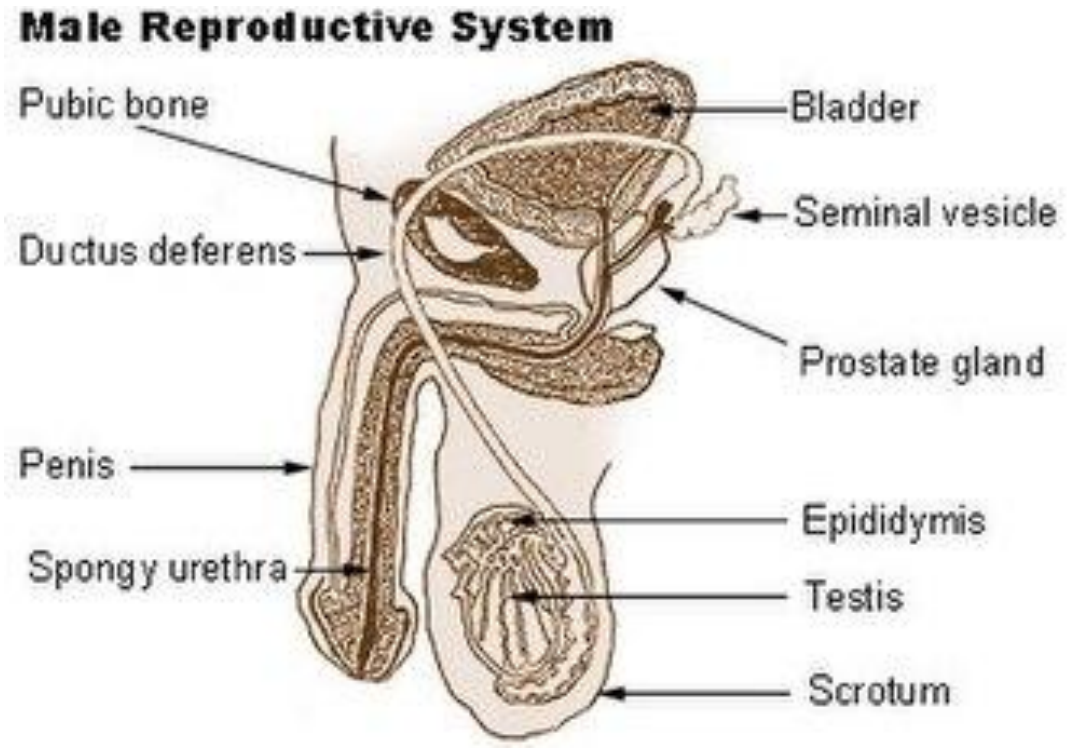
- In many animals, males produce huge numbers of gametes and can mate often
- Many females produce fewer, larger gametes and invest more in each offspring
- So in many species, males compete and females choose
- These are patterns across species, and vary widely

Discussion

Can you think of species that do not follow these patterns? What can biology say about animal behaviour, and what can it not say about human choices or roles?

The male-typical reproductive system

D3.1.4

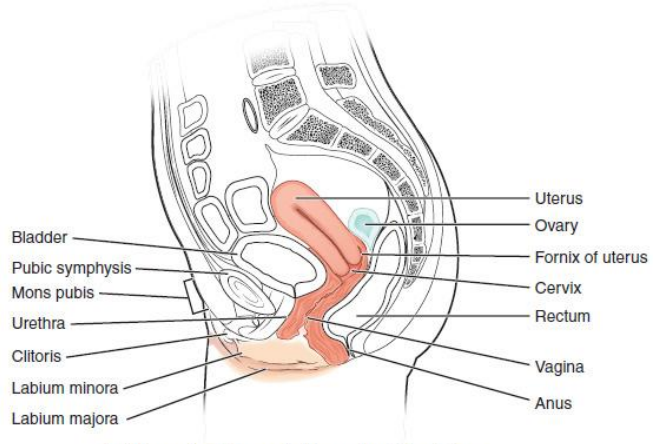


Male reproductive system, side view. National Cancer Institute, public domain.

Structure	Function
Testes	Make sperm and testosterone
Scrotum	Keeps testes a little below body temperature
Epididymis	Stores sperm
Sperm duct	Carries sperm to the urethra
Seminal vesicles, prostate	Add fluid with nutrients and alkali
Urethra	Carries semen, and also urine
Penis	Erectile tissue allows intercourse

The female-typical reproductive system

D3.1.4



Female reproductive system, side and front views. OpenStax College, CC BY 3.0.

Structure	Function
Ovaries	Make eggs, oestradiol and progesterone
Oviducts	Carry the egg; site of fertilization
Uterus	Thick muscular wall; embryo develops here
Endometrium	Lining with many blood vessels, built up each cycle
Cervix	Connects uterus to vagina
Vagina	Muscular tube to the outside

Exam note

When you draw this, each oviduct must open into the space inside the uterus, not into its wall.

Four hormones control the cycle

D3.1.5

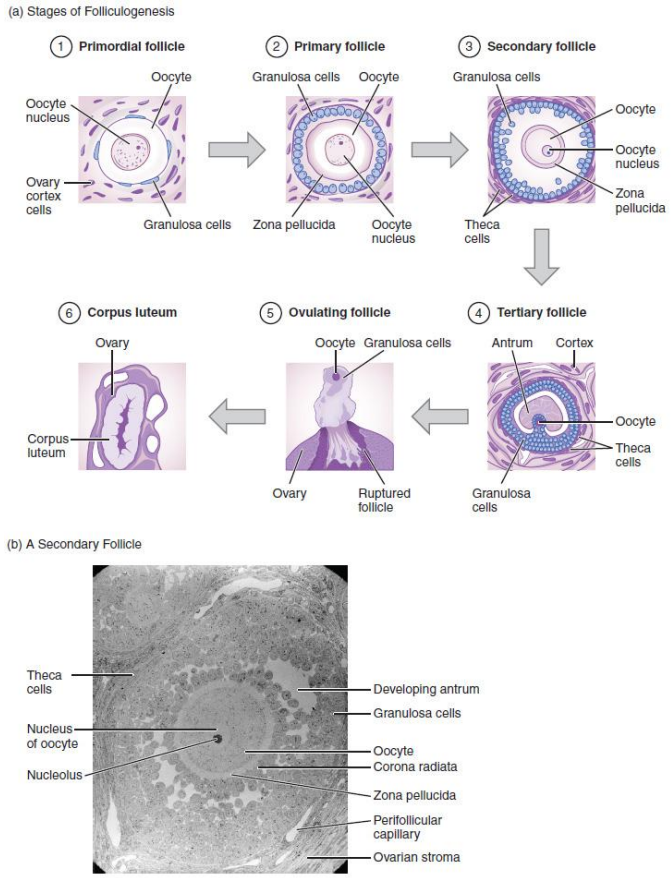
Hormone	Secreted by	Main role
FSH	Pituitary gland	Stimulates follicles to develop, and to secrete oestradiol
LH	Pituitary gland	Triggers ovulation; turns the follicle into a corpus luteum
Oestradiol	Developing follicle	Builds up the endometrium; regulates FSH and LH
Progesterone	Corpus luteum	Maintains the endometrium; inhibits FSH and LH

Key idea

The menstrual cycle is two linked cycles, each about 28 days. The ovarian cycle prepares and releases an egg. The uterine cycle builds up the lining and then sheds it if no embryo implants.

First half: preparing an egg

1. Day 1 is the start of **menstruation**, when the lining is shed
2. **FSH** stimulates several follicles; usually one matures fully
3. The follicle secretes **oestradiol**, which rebuilds the endometrium
4. Oestradiol increases FSH receptors in the follicle, so it makes more oestradiol: **positive feedback**
5. High oestradiol inhibits FSH, so no more follicles develop: **negative feedback**
6. High oestradiol stimulates a surge of **LH**, which triggers **ovulation** at about day 14



Stages of follicle development in the ovary. OpenStax College, CC BY 3.0.

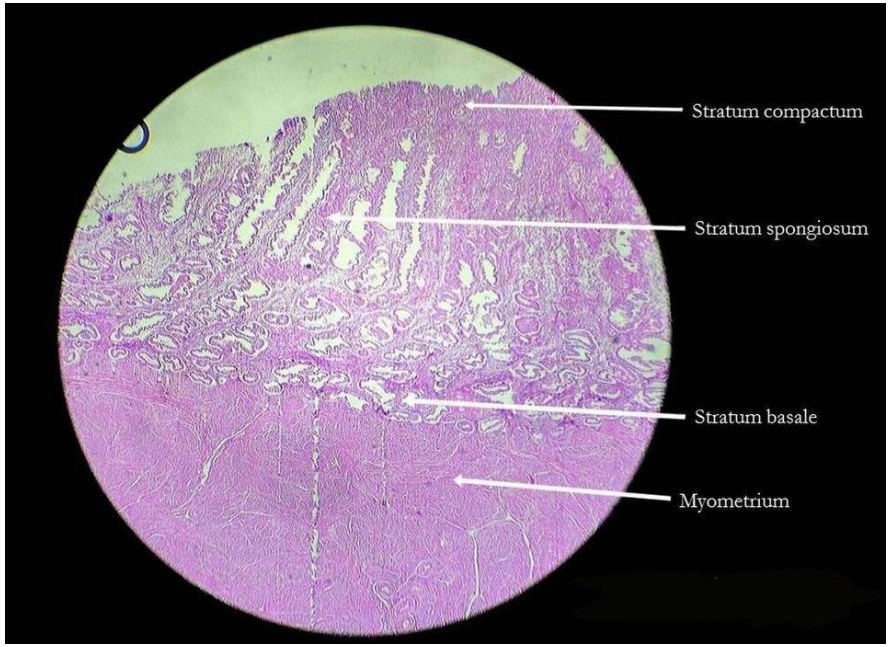
Common mistake

Follicle development is stimulated by FSH. Ovulation is triggered by LH. Do not swap them.

Second half: preparing for implantation

D3.1.5

1. LH turns the empty follicle into the **corpus luteum**
2. The corpus luteum secretes **progesterone** and some oestradiol
3. Progesterone continues to build the endometrium
4. Progesterone inhibits FSH and LH: **negative feedback**
5. Low FSH and LH allow the corpus luteum to break down
6. Progesterone and oestradiol fall, the endometrium breaks down and a new cycle begins

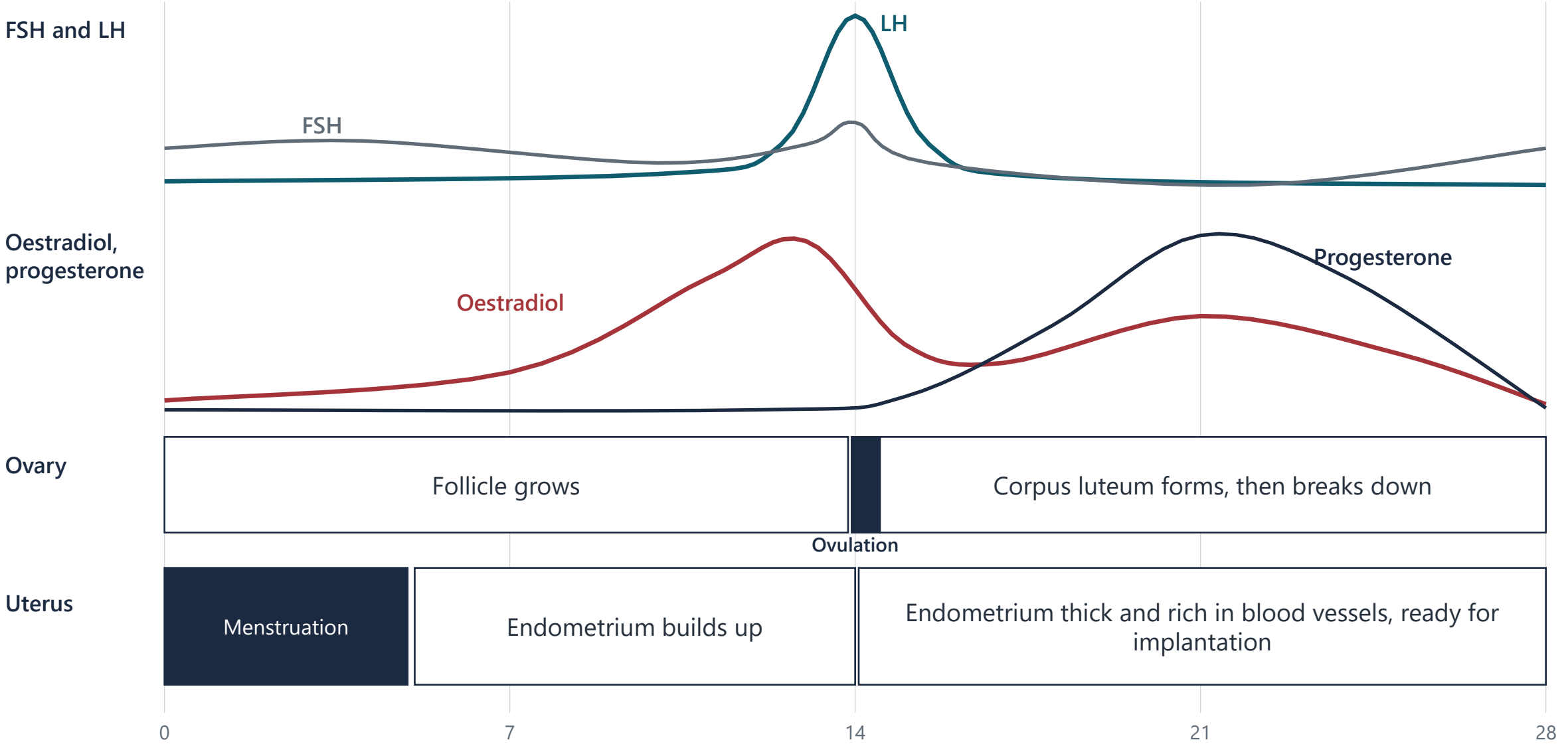


Endometrium in the second half of the cycle, stained section. Dr. Roshan Nasimudeen, CC BY-SA 3.0.

If fertilization occurs

The embryo secretes a hormone that maintains the corpus luteum, so progesterone stays high. Later the placenta takes over.

The cycle in one picture



Positive and negative feedback

D3.1.5

Type	Example	Effect
Positive	Oestradiol increases FSH receptors on the follicle	Oestradiol secretion rises further
Negative	High oestradiol inhibits FSH	No more follicles develop
Negative	Progesterone inhibits FSH and LH	No further ovulation; corpus luteum is not maintained

Key idea

Positive feedback amplifies a change, and negative feedback reverses it. When progesterone falls, FSH can rise again. Be careful: that is the removal of negative feedback, not positive feedback.

Fertilization in humans

1. Usually happens in the upper part of the **oviduct**
2. The sperm cell membrane **fuses** with the egg cell membrane
3. The sperm nucleus enters the egg
4. The sperm tail and mitochondria are destroyed
5. Nuclear membranes of both nuclei break down
6. Chromosomes condense and join in a shared **mitosis**
7. Two diploid nuclei are produced



Human embryo, at the eight-cell stage. RWJMS IVF Program, public domain.

Common mistake

The two nuclei do not simply fuse into one. Their membranes break down and the chromosomes take part in a joint mitosis. All of the mitochondria in the new cell come from the egg.

In vitro fertilization



Injecting a sperm into an egg, one form of IVF, seen through a microscope. Eugene Ermolovich, CC BY-SA 3.0.

- **In vitro** means in glass, outside the body. **In vivo** means in the body
- Used when natural fertilization is not possible
- Causes include too few or slow-moving sperm, blocked oviducts, or eggs that fail to mature
- The first IVF baby was born in 1978

Key idea

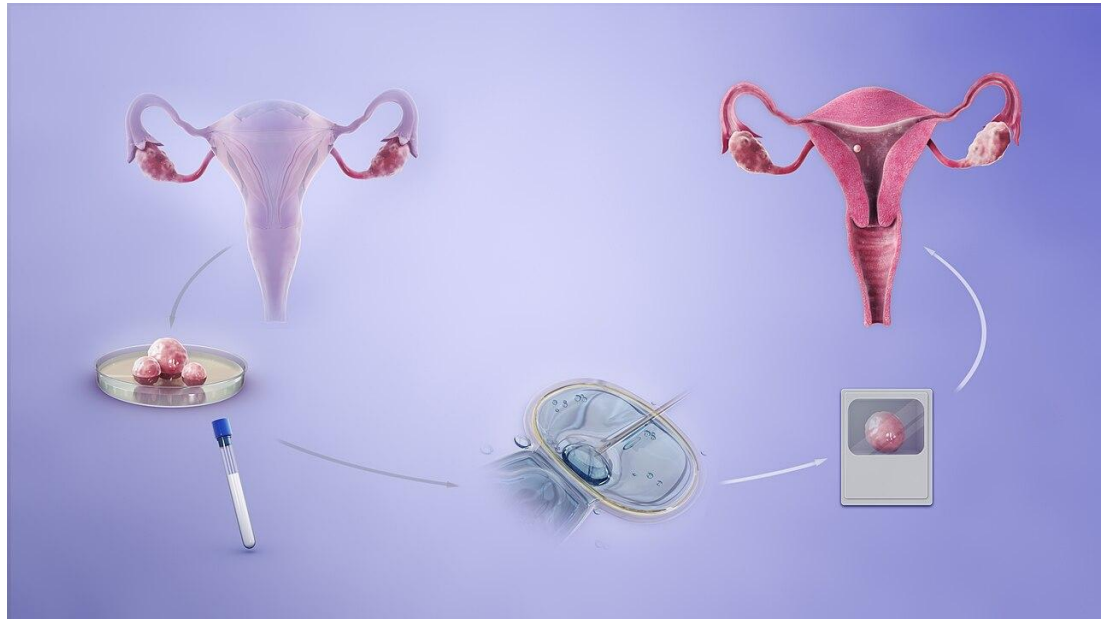
IVF depends on hormones. Normal secretion is suspended, then artificial doses produce many eggs at a time chosen by doctors.

How hormones are used in IVF

Stage	What is given	Why
Down-regulation	A drug, often a nasal spray, for about two weeks	Stops pituitary and ovarian hormones, so timing can be controlled
Superovulation	High doses of FSH, for about ten days	Many follicles develop at once
Maturation	Injection of hCG	Eggs mature; collected about 36 hours later
Fertilization	No hormone	Eggs mixed with sperm; embryos are incubated
Implantation	Progesterone	Maintains the endometrium

Early embryos are placed in the uterus. Success rates are limited, and transferring several embryos raises the risk of a multiple pregnancy.

Evaluating IVF



- Not every treatment leads to a birth, and success falls with age
- Treatment can be physically and emotionally demanding
- Multiple pregnancies carry greater risks
- Spare embryos raise ethical questions, and access varies

Stages of in vitro fertilization. scientificanimations.com, CC BY-SA 4.0.

Discussion

Which of these questions can science answer? Which ones need other ways of thinking?

Check that you can explain

1. The advantages of each type of reproduction
2. How meiosis and fusion create variation
3. Why male and female gametes differ
4. The anatomy of both systems, with functions
5. What each of the four hormones does
6. What triggers ovulation and menstruation
7. Positive and negative feedback in the cycle
8. How the graph of the cycle links to events
9. The events of fertilization
10. How hormones are used in IVF

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Give one advantage of asexual reproduction and one of sexual reproduction.

2. Which hormone triggers ovulation? Which structure secretes progesterone after ovulation?

3. Why does the endometrium break down at the end of a cycle with no pregnancy?

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