DP Biology – D3.1 (HL extension)

From gametes to birth

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

HL statements D3.1.13–20. Textbook pp. 709–725.
Image: a sperm meeting an egg, electron micrograph. Public domain.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	D3.1.13–14	Explain how hormones start puberty, and compare spermatogenesis with oogenesis
2	D3.1.15–16	Explain how polyspermy is prevented, and how a blastocyst forms and implants
3	D3.1.17–18	Explain pregnancy tests for hCG, and the role of the placenta
4	D3.1.19	Explain how hormones keep a pregnancy going and bring about birth
5	D3.1.20	Evaluate the evidence about hormone replacement therapy and heart disease

Hormones start puberty

D3.1.13

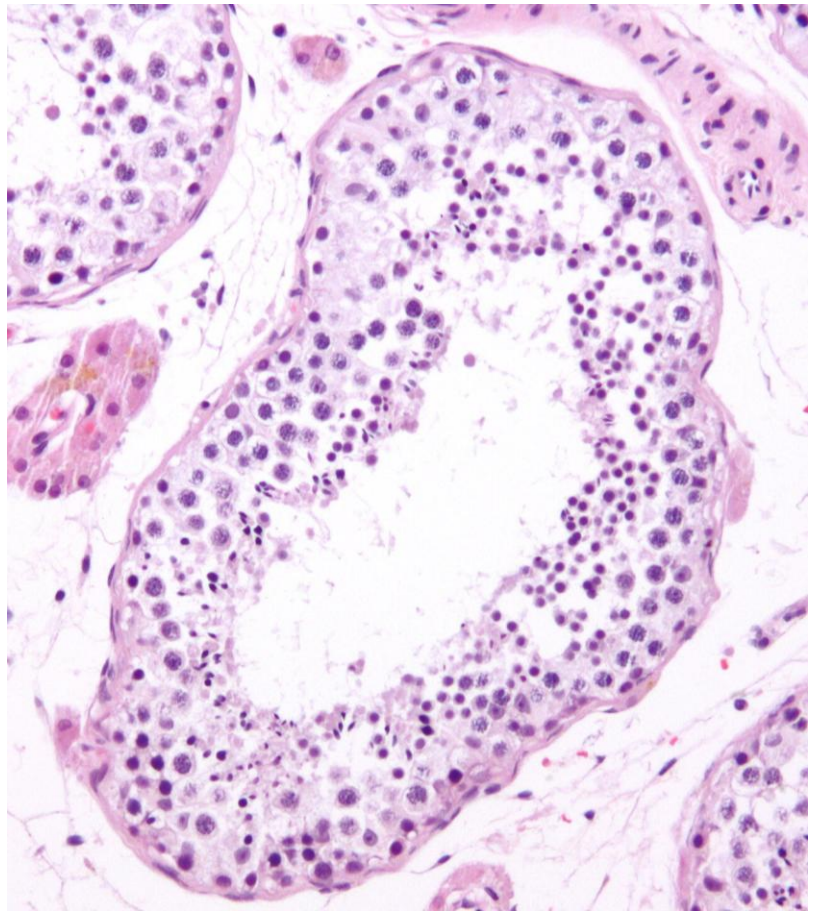


Male changes (testosterone)	Female changes (oestradiol)
Sperm production begins	Menstrual cycles begin
Growth of penis and testes; deeper voice	Breast development; wider hips
Growth of facial and body hair; more muscle	Growth of body hair; growth spurt

Key idea

The trigger is the rise in GnRH: the pituitary and gonads were ready earlier.

Spermatogenesis



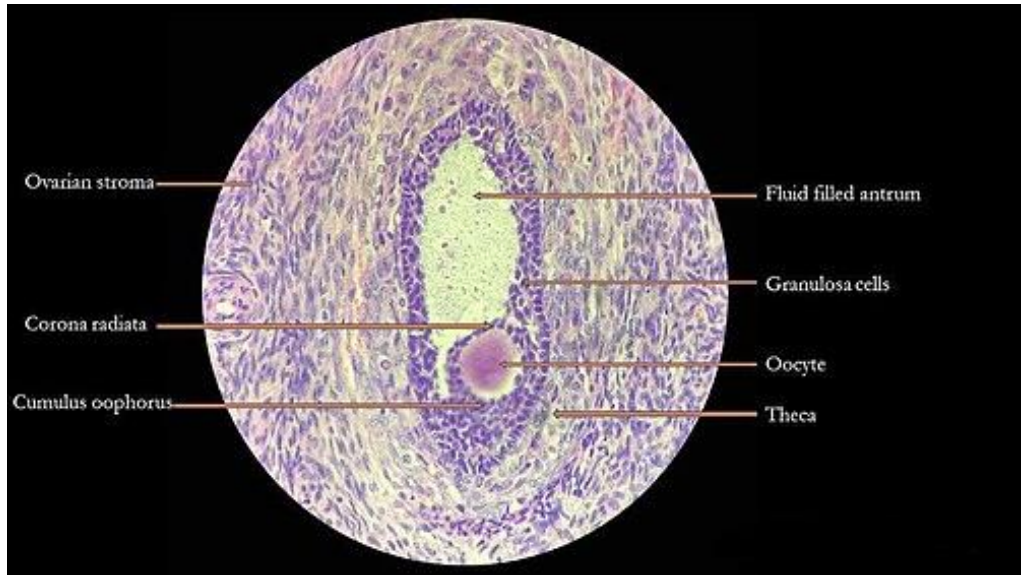
Seminiferous tubule in section; sperm tails in the centre. Nephron, CC BY-SA 3.0.

1. **Mitosis**: spermatogonia (2n) in the tubule wall divide again and again
2. **Growth**: some enlarge into primary spermatocytes (2n)
3. **Meiosis I**: each gives two secondary spermatocytes (n)
4. **Meiosis II**: each gives two spermatids (n)
5. **Differentiation**: spermatids develop tails and lose most cytoplasm, fed by Sertoli cells
6. Result: four sperm from each primary spermatocyte, millions a day

Hormones

FSH and testosterone keep sperm production going.

Oogenesis



A mature follicle with its oocyte. CC BY-SA 3.0.

1. **Mitosis**: oogonia divide in the ovaries of the female foetus
2. **Growth**: they enlarge into primary oocytes, which start **meiosis I** and stop
3. From puberty, one each cycle finishes meiosis I, dividing **unequally**: a large secondary oocyte and a small polar body
4. Meiosis II starts but stops; it is completed only if a sperm enters
5. Result: one large egg with much cytoplasm from each primary oocyte

Why unequal?

The egg keeps nearly all the cytoplasm: food reserves, mitochondria and ribosomes for the early embryo. Polar bodies break down.

Spermatogenesis and oogenesis compared

D3.1.14

	Spermatogenesis	Oogenesis
Same stages	Mitosis, growth, meiosis I and II, differentiation	Mitosis, growth, meiosis I and II, differentiation
Gametes per meiosis	Four sperm	One egg (plus polar bodies)
Cytoplasm	Very little	A great deal
Numbers	Millions a day, from puberty for life	About one a month, from puberty to menopause
Timing of meiosis	Continuous	Paused twice; finished at fertilization

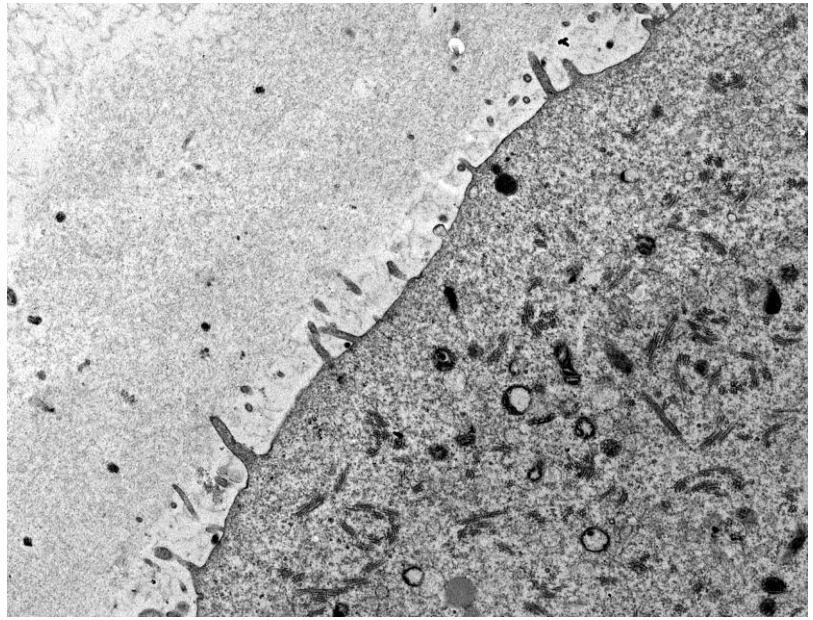
Try it

Explain why a man makes millions of gametes but a woman releases only about 400 in a lifetime.

Only one sperm gets in

D3.1.15

Sperm reaches the zona pellucida, a glycoprotein coat → **Acrosome reaction**: enzymes released from the sperm head digest a path → Membranes of sperm and egg fuse; the sperm nucleus enters → **Cortical reaction**: granules release enzymes by exocytosis → Zona pellucida hardens: other sperm cannot pass



Edge of an egg: zona pellucida (left), electron micrograph. CC0.

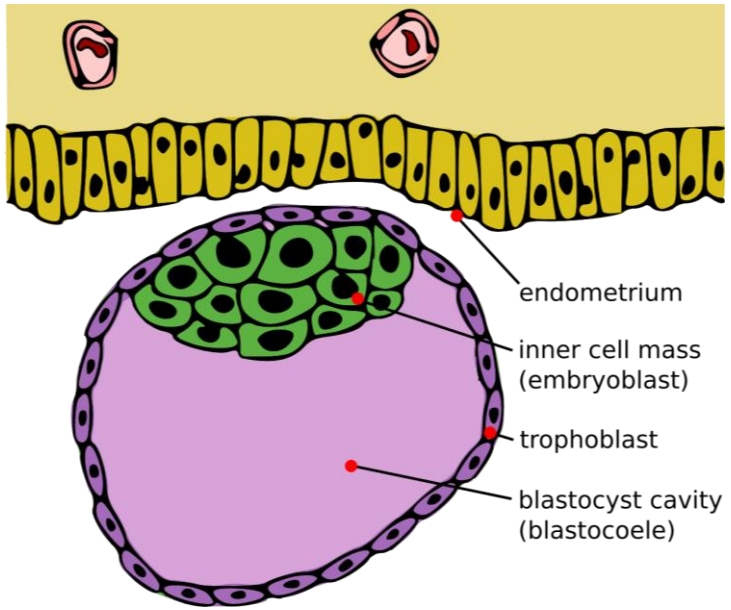
Why prevent polyspermy?

A zygote with two sperm nuclei would have three sets of chromosomes and could not develop normally. Blocking further entry quickly keeps the zygote diploid.

The blastocyst



Eight-cell embryo, about day 3. Public domain.



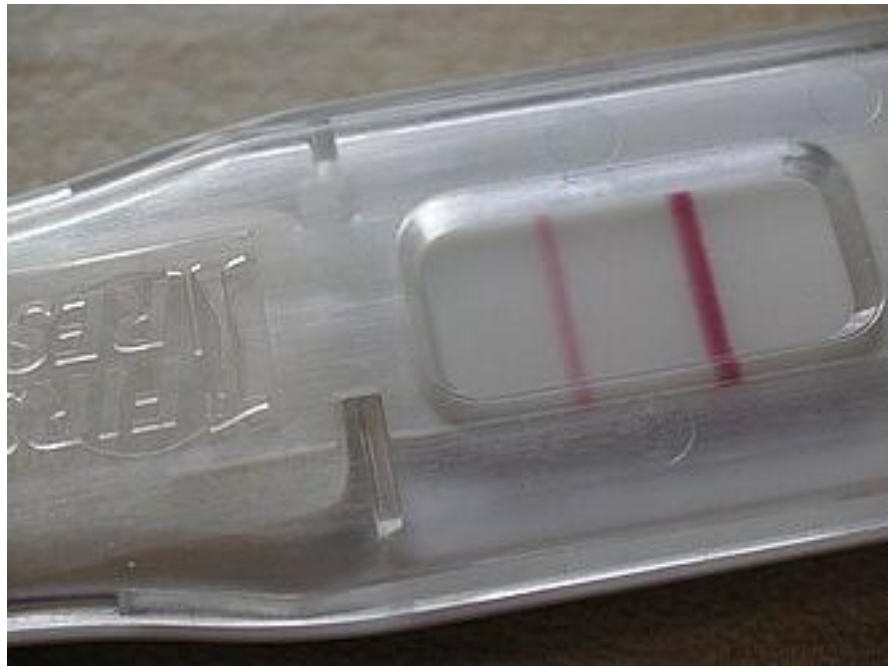
Blastocyst implanting. CC BY-SA 3.0.

- The zygote divides by mitosis as it moves along the oviduct
- By about day 5 it is a **blastocyst**: a hollow ball of about 100 cells
- Outer layer: becomes part of the placenta
- Inner cell mass: becomes the embryo

Implantation

About 7 days after fertilization the blastocyst sinks into the thick endometrium, which progesterone has prepared. It then takes food and oxygen from the mother's tissues.

Pregnancy tests detect hCG



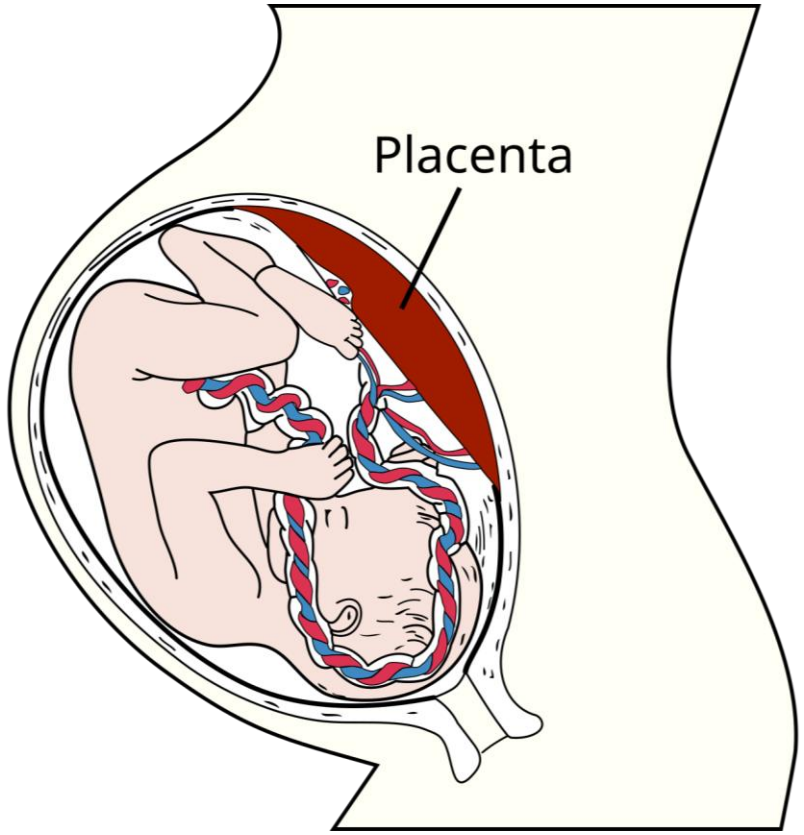
A positive pregnancy test: two lines. Klaus Hoffmeier, public domain.

- The embryo, and later the placenta, secretes **human chorionic gonadotropin** (hCG)
- hCG passes into the mother's blood and urine
- Tests use **monoclonal antibodies** that bind only to hCG

Urine soaks up the strip → Mobile antibodies with dye bind any hCG → At the test line, fixed antibodies trap the hCG complexes: a line → At the control line, fixed antibodies trap mobile antibodies: always a line

The placenta

D3.1.18



The placenta and umbilical cord. Public domain.

Mother to foetus	Foetus to mother
Oxygen	Carbon dioxide
Glucose, amino acids, lipids	Urea
Ions, vitamins, water	Water
Some antibodies	

- **Placental villi** give a large surface area, close to maternal blood
- The two bloods do not mix

Why a placenta?

It lets the foetus stay in the uterus and grow to a much later stage than in mammals without a placenta, such as kangaroos, whose young are born tiny.

Keeping the pregnancy going

D3.1.19

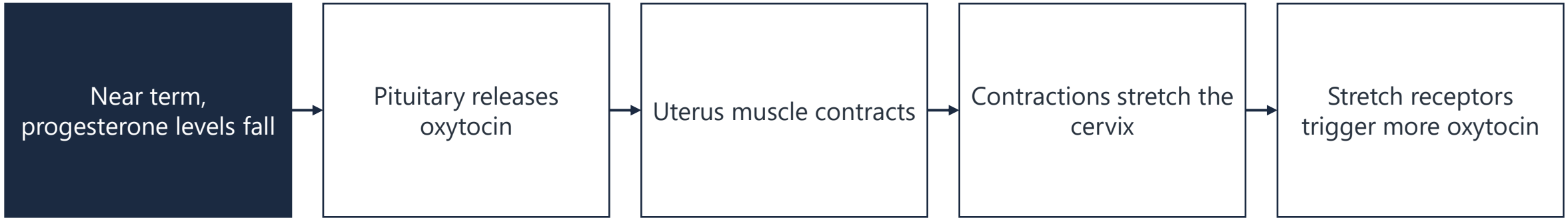
Weeks	Source of progesterone	Why it matters
0–2	Corpus luteum, as in every cycle	Builds and keeps the endometrium
2–12	Corpus luteum, kept alive by hCG from the embryo	No menstruation; endometrium kept
12 onwards	Placenta	Corpus luteum is no longer needed

Key idea

Progesterone keeps the pregnancy going: it maintains the endometrium and stops the uterus muscle contracting. A failure to switch from the corpus luteum to the placenta can lead to miscarriage.

Childbirth and positive feedback

D3.1.19



Positive feedback

Each contraction causes more oxytocin, which causes stronger contractions. The loop speeds up until the baby is born, then stops because the stretching stops.

Compare

Most hormone systems use negative feedback, which keeps a variable steady. Positive feedback is used when a fast, complete change is needed.

HRT and heart disease

D3.1.20

	Early studies	Later trials
Type	Observational: compared women who chose HRT with those who did not	Randomized controlled trials: women randomly given HRT or a placebo
Finding	Less coronary heart disease in HRT users	A small increase in coronary heart disease with HRT
Why they differ	HRT users were wealthier, with healthier lives: a confounding variable	Randomizing balances such variables between groups

Correlation is not causation

Socioeconomic status caused both more HRT use and less heart disease. The early link was real, but HRT was not the cause. Only a controlled trial could separate the two.

Check that you can explain

1. How GnRH, LH and FSH start puberty
2. The stages of spermatogenesis and oogenesis, and why they give different numbers and sizes of gametes
3. How the acrosome and cortical reactions prevent polyspermy
4. How a blastocyst forms and implants
5. How a pregnancy test uses monoclonal antibodies to hCG
6. What the placenta exchanges, and why it matters
7. How progesterone and oxytocin control pregnancy and birth
8. Why early HRT studies were misleading

Exit activity: 5 minutes

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

1. State two differences between spermatogenesis and oogenesis.
2. Explain the role of the cortical reaction.
3. Explain why childbirth involves positive feedback.

Image credits

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