Reproduction

D3.1 · SL and HL

A runner and a flower offer different reproductive routes

Explain the process and its consequences for inherited combinations

Shared D3.1 covers reproduction, chromosome sets, human structures and cycles, fertilization, IVF, flowers, crossing and seeds.

AHL: puberty, gametogenesis, early development, pregnancy, childbirth and evaluation of HRT evidence.

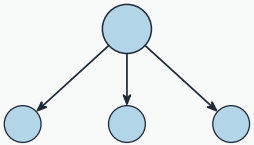
Diagrams and datasets are invented teaching models unless a published investigation is named. A model cycle is not a personal fertility prediction.

An advantage depends on the environment and mechanism

Route	Benefit and limit
Asexual	No gamete fusion; rapid propagation without a mate can preserve a successful genotype
Asexual limitation	Shared susceptibility can be harmful after change; mutation can still introduce variation
Sexual	Meiosis and gamete fusion create allele combinations that may suit changed conditions
Sexual limitation	Gamete transfer costs resources; new combinations are not necessarily improvements

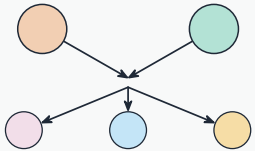
Asexual or sexual?

asexual - one parent



offspring are **identical** clones

sexual - two parents



gametes join → **varied** offspring

Sexual offspring vary

Chromosome reduction and restoration have different roles

1. **Invented species.** 2n $= 12$; normal gametes n $= 6$; fertilization restores twelve chromosomes.
2. **Replication.** DNA is copied before meiosis, without doubling the chromosome sets. I separates homologues; II separates sisters.
3. **Variation.** $2^6 = 64$ possible whole-chromosome combinations across gametes when crossing over is ignored; one meiosis still gives four nuclei.

Plant gametes are produced within a more complex life cycle

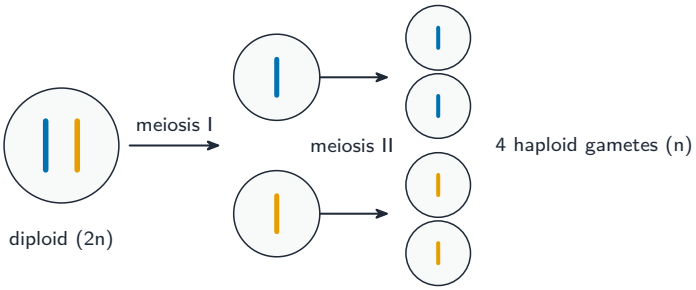
Pollen is not one naked sperm

Animals use meiosis as part of gamete formation. Flowering plants have haploid stages developing after meiosis.

Those haploid lineages produce gametes by mitosis. Pollen contains the lineage that supplies male gametes.

Fertilization restores two sets. Recombination reshuffles alleles; it does not create every new allele.

Meiosis halves the chromosome number

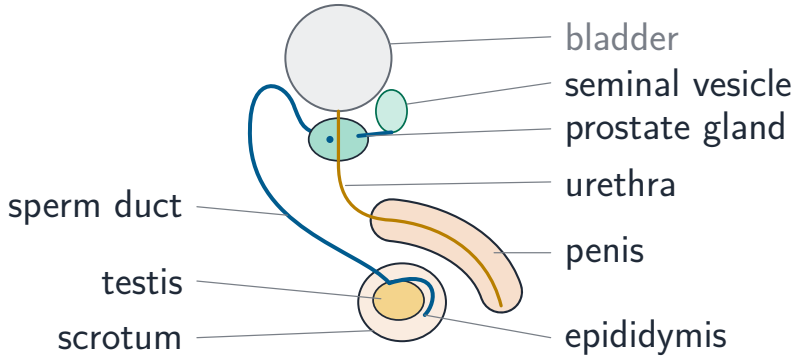


Fertilisation restores the diploid number

Compare gametes without equating number with reproductive success

Feature	Connection
Male role	Smaller gametes, relatively few reserves; animal sperm commonly travel toward eggs
Female role	Larger gametes retain cytoplasm and resources
Plant transfer	Pollen tube delivers male gametes; sperm do not fly naked through air
Hermaphroditic flower	Can supply both roles; gamete fusion remains sexual
Outcome	Transfer, fertilization, development and survival constrain offspring number

Identify the pathway before adding gland functions

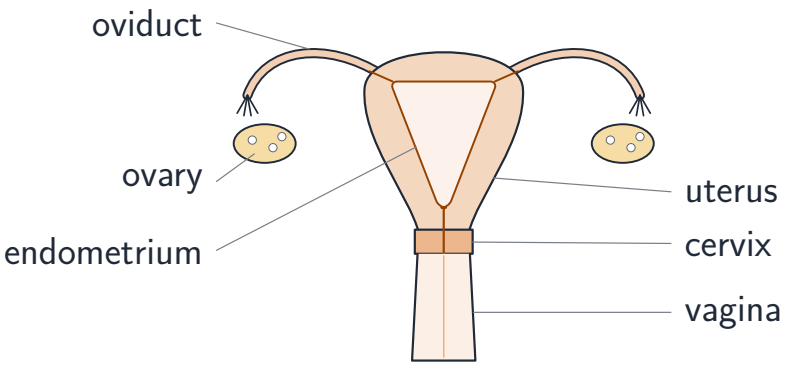


Sperm and gland secretions contribute different parts of semen.

Connect male structures with production, storage and transfer

Structure	Function
Testis / scrotum	Sperm development and testosterone; external position supports a suitable temperature
Epididymis	Further sperm maturation and storage
Sperm duct	Transfers sperm toward the urethra
Seminal vesicle / prostate	Add secretions contributing to semen
Urethra / penis	Route and organ of semen transfer; bladder stores urine, not sperm

Place the endometrium inside the uterus

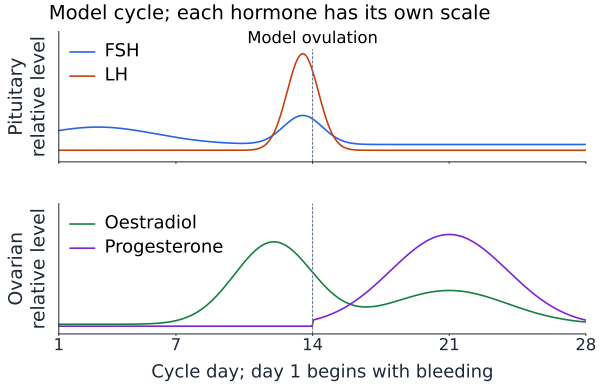


Fertilization usually occurs in an oviduct; implantation in uterus.

Name structures and the distinct processes they support

Structure	Function
Ovary	Oocyte development/release and ovarian hormones
Oviduct	Receives released oocyte; usual fertilization site; cilia and muscle aid movement
Uterus / endometrium	Muscular organ; lining supports implantation and pregnancy
Cervix	Narrow uterine neck connecting to vagina
Vagina	Receives semen and forms part of birth canal; urinary outlet is separate

Read hormone timing before claiming a cause



Follicle → oestradiol → LH surge → ovulation → progesterone.

Follow the follicular phase to the ovulatory signal

1. **Follicle.** Pituitary FSH promotes development; follicular oestradiol supports endometrial rebuilding.
2. **Feedback.** Negative feedback operates for much of the phase. Sustained high pre-ovulatory oestradiol can produce positive feedback.
3. **Transition.** The LH surge triggers ovulation and corpus-luteum development. A later progesterone maximum cannot cause an earlier LH surge.

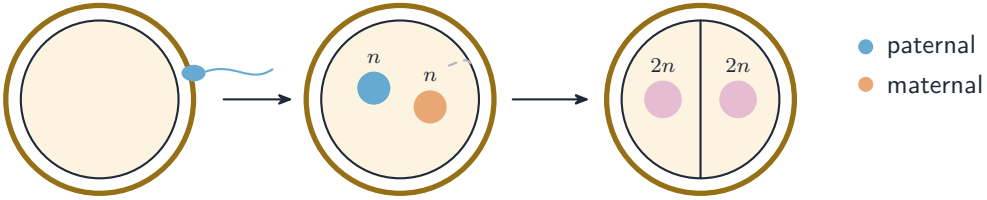
Explain maintenance and shedding using the corpus luteum

1. **After ovulation.** Corpus luteum produces progesterone and oestradiol; progesterone supports secretory endometrium.
2. **Feedback.** Ovarian hormones inhibit further gonadotropin signalling in this phase.
3. **No pregnancy support.** Corpus luteum declines; ovarian hormones fall and endometrium sheds. Day 1 begins with bleeding; cycle timing varies.

Distinguish the two membranes and the first joint division

1. **Entry.** Sperm and oocyte membranes fuse; the paternal nuclear contribution enters. Tail and mitochondria are normally broken down.
2. **Chromosomes.** Pronuclear envelopes break down; both **haploid** complements participate in a joint mitosis, yielding diploid nuclei.
3. **Location and time.** Fertilization normally occurs in an oviduct. Later embryo development and uterine arrival precede implantation.

Human fertilisation



1. sperm membrane fuses with oocyte

2. two haploid pronuclei; tail broken down

3. first joint mitosis: two diploid nuclei

The first mitosis gives two diploid nuclei

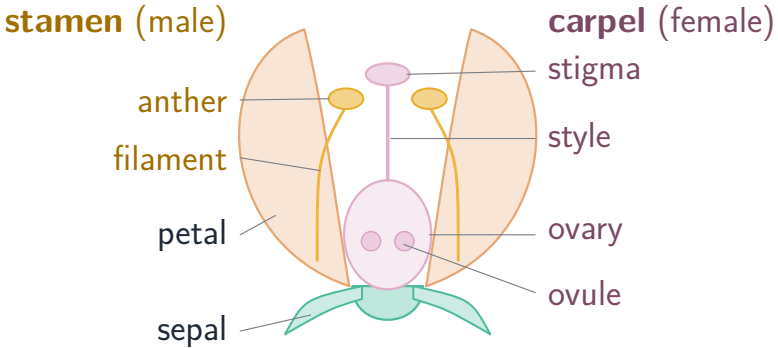
Hormones support stages but do not guarantee later outcomes

1. **Control.** Suppress or control the natural cycle, then use administered gonadotropins to stimulate several follicles.
2. **Procedure.** Monitor maturation and collect oocytes; fertilize and culture in the laboratory, then transfer an embryo with suitable endometrial support.
3. **Limits.** Regimens vary. Collection, fertilization, implantation and live birth are different outcomes with different denominators.

Define the denominator before reporting a success percentage

1. **Invented sequence.** 10 collected oocytes → eight fertilized → four at a stated later embryo stage.
2. **Ratios.** $8/10 = 80\%$ fertilized. Later stage: $4/8 = 50\%$ of fertilized, or $4/10 = 40\%$ of collected.
3. **Boundary.** No live-birth outcome was supplied. These percentages cannot be labelled a live-birth rate.

Distinguish a stamen from a carpel and an ovule from an ovary



Anther makes pollen; compatible stigma receives it.

Annotate the section with a function per structure

Structure	Function
Anther / filament	Pollen production / support
Stigma / style	Pollen reception / route for pollen-tube growth
Ovary / ovule	Ovary contains ovules; the egg occurs within the embryo sac in an ovule
Petal	Can attract animal visitors; scent and nectar can also contribute
Sepal	Protection of developing bud

Follow the transferred structure through the life cycle

1. **Pollination.** Pollen moves anther → compatible stigma; germinating pollen produces a tube delivering male gametes toward an ovule.
2. **Fertilization.** One male gamete fuses with egg to give zygote and embryo; a second fertilization produces endosperm.
3. **Afterwards.** Ovule becomes seed; ovary commonly becomes fruit. Seed dispersal moves a formed seed, not pollen to a stigma.

Pollen arrival does not guarantee self-fertilization

Process / mechanism	Consequence
Self-pollination	Same flower or another flower on the same plant
Cross-pollination	Transfer between different plants of the same species
Different maturation times	Can reduce self-pollination
Separate sexes / pollen transport	Separate male/female plants and animal/wind movement can promote crossing
Self-incompatibility	Genetic recognition can reject incompatible pollen before fertilization

Inbreeding effects depend on the alleles and environment

Increasing homozygosity can reveal harmful recessives

Repeated selfing can reduce heterozygosity and expose harmful recessive alleles, contributing to reduced vigour.

Some species regularly self; not every selfed individual is unfit. Genetic background and environment affect outcomes.

An insect visiting several flowers on one plant does not necessarily cross between plants. Outcrossing changes combinations rather than creating every new allele.

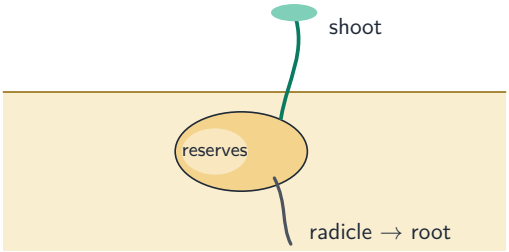
Connect conditions to metabolism and growth

1. **Start.** A viable seed needs suitable conditions and any dormancy requirements met. Water supports rehydration and metabolism.
2. **Resources.** Oxygen supports aerobic respiration; suitable temperature supports enzymes. Light requirements vary by species.
3. **Growth.** Enzymes mobilize food reserves for respiration and biosynthesis; radicle and shoot develop before photosynthesis supplies sufficient new organic material.

A germination percentage is an outcome, not a unique explanation

1. **Invented result.** 18 of 24 seeds germinate: $18/24 \times 100 = 75\%$.
2. **Design.** Use comparable viable seeds, independent replicate groups, controlled other conditions and a consistent time and criterion.
3. **Inference.** Poor germination can reflect viability, dormancy or several environmental conditions; one poor group identifies no unique cause.

What germination needs



water: rehydrates, activates enzymes

oxygen: aerobic respiration

suitable temperature: enzyme activity

enzymes hydrolyse stored starch, protein and lipid to soluble products for respiration and growth

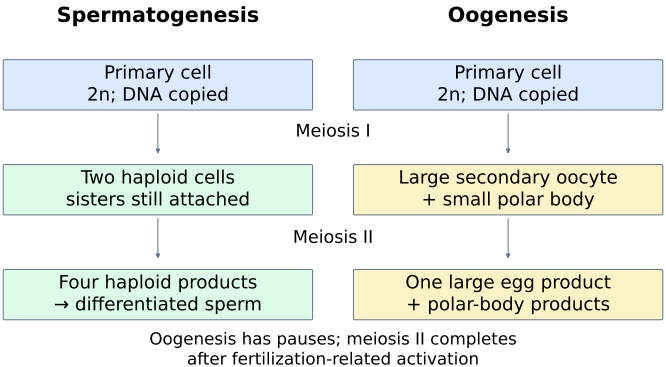
light: needed by some species only

> Light is needed only by some species

Trace the signal from hypothalamus to responsive gonadal tissues

1. **Initiation.** Increased pulsatile GnRH stimulates anterior-pituitary LH and FSH release.
2. **Gonads.** Gonadotropins support reproductive maturation and increased sex-steroid production.
3. **Effect and limit.** Steroids contribute to secondary sexual characteristics; feedback regulates the axis and timing varies. Hormones do not physically become gametes.

Both routes halve sets but allocate cytoplasm differently



Four sperm products differ from one large egg product.

Compare the processes as well as the final products

Feature	**Spermatogenesis / oogenesis**
Shared stages	Precursor mitosis, growth, meiosis I and II, differentiation
Sperm products	Four **haploid** products can differentiate; acrosome, flagellum and mitochondrial midpiece
First oocyte pause	Primary oocyte begins meiosis before birth and pauses in prophase I
Unequal divisions	Most cytoplasm retained in the oocyte; small polar bodies
Second pause	Secondary oocyte pauses in metaphase II; completion follows fertilization-related activation

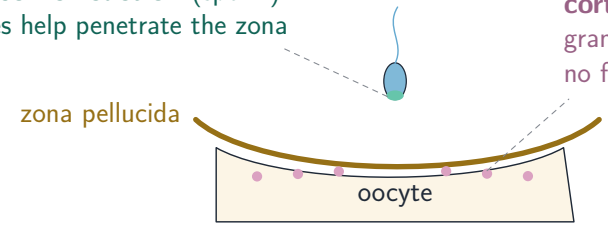
Place each transition in the correct cell and stage

Event	Mechanism
Acrosome reaction	Sperm components help penetration of zona pellucida
Cortical reaction	Oocyte granules modify zona to limit further penetration / polyspermy
Blastocyst	Develops after early mitoses; implantation requires interaction with endometrium
hCG	Produced by developing trophoblast/placental tissues; supports corpus luteum early
Pregnancy test	Monoclonal antibodies bind hCG; timing and threshold affect detection

Blocking extra sperm

acrosome reaction (sperm):
enzymes help penetrate the zona

cortical reaction (oocyte):
granules released, zona modified:
no further sperm (no polyspermy)



The zona changes and blocks further sperm

Exchange does not require normal free mixing of blood

Feature	Function
Placental villi	Large exchange area with maternal/fetal circulations closely apposed
Toward fetus	Oxygen and nutrients
Toward maternal circulation	Carbon dioxide and other metabolic wastes
Umbilical vein	Placenta $\rightarrow$ fetus
Umbilical arteries	Fetus $\rightarrow$ placenta; direction defines the vessel names

Progesterone support changes source before its inhibitory effect is lost

Human functional withdrawal is not simply a required blood-level fall

Corpus luteum supplies progesterone initially; the placenta later becomes the main source. Progesterone supports endometrium and uterine quietness.

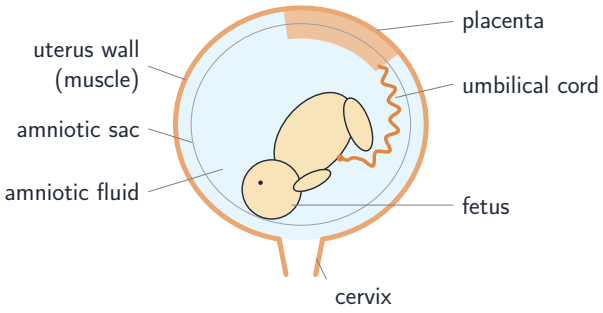
Near human labour, altered tissue responsiveness contributes to functional loss of inhibition even when circulating progesterone has not fallen.

Placental exchange and hormonal support allow continued fetal development; the placenta is not a perfect barrier to every harmful substance.

Positive feedback amplifies contraction toward delivery

1. **Stimulus.** Cervical stretch promotes posterior-pituitary oxytocin release.
2. **Amplification.** Oxytocin increases uterine contractions, causing more stretch and further release.
3. **End and contrast.** Delivery removes the major stretch stimulus. Negative feedback instead opposes a deviation to stabilize a variable.

The fetus in the uterus



Amniotic fluid cushions the fetus

Use randomization to test an earlier protective association

1. **Observational problem.** HRT users and non-users can differ in socioeconomic conditions, behaviours and access to care.
2. **Named comparison.** The 2002 WHI trial tested one combined oral regimen versus placebo in 16,608 postmenopausal women aged 50–79.
3. **Conclusion and limit.** The tested regimen did not support the simple CHD-protection claim. Findings do not automatically generalize to every regimen, route, population or purpose.

Attempt the handout practice before revealing the checks

Name the process, location, hormone source and denominator

Compare reproduction routes and chromosome sets; annotate both human systems and explain cycle feedback and fertilization.

Evaluate IVF percentages, flower structures, pollination, incompatibility, dispersal and germination evidence.

AHL: explain gametogenesis, early development, pregnancy and childbirth, then evaluate the historical HRT comparison.

Check the shared numerical answers

1. **Chromosomes.** 2n = 8 gives gamete four and zygote eight; $2^4 = 16$ possible whole-chromosome combinations, four nuclei from one meiosis.
2. **IVF.** $9/12 = 75\%$ fertilized; $3/9 \approx 33.3\%$ of fertilized or $3/12 = 25\%$ of collected reach the stated later stage.
3. **Germination.** $21/28 \times 100 = 75\%$. Define the observation time and criterion; control viability, dormancy and other conditions.

AHL answers: products and population exposure time

1. **Gamete model.** Eight normally completing primary spermatocytes can yield 32 sperm; eight primary oocytes yield eight large egg products.
2. **Rate example.** Seven excess events per 10,000 person-years corresponds to fourteen over 20,000 person-years if the rate stays constant.
3. **Limit.** An excess population rate is not a personal probability or 7% of all women. Interpret the tested regimen and retain uncertainty.

Check yourself

Do not exchange neighbouring processes or structures

Pollination, fertilization, implantation and dispersal transfer different structures or occur at different locations and times.

State hormone sources, targets and feedback direction. For every rate, identify the outcome and denominator.

AHL: distinguish acrosome/cortical reactions, chromosome reduction/cytoplasm allocation, exchange/blood mixing and tissue responsiveness/blood concentration.