Unit 15 · Gametogenesis

STUDY NOTES

WHAT NEB'S GRADE 12 EXAM ASKS

- **CDC's grid (2078):** Developmental Biology (Units 15–16 together): 4 of 75 marks; 1 short question (4 marks: understanding 1, application 2, higher ability 1); no MCQ by the plan
- **The paper:** Botany 37 + Zoology 38; each part: MCQs × 1 (5 Botany, 6 Zoology) · 4 short × 4 · 2 long × 8; one OR in each short and long group; 3 hours; 1 mark per expected point
- **Our model papers:** Paper 1's short question is on this unit (4 marks in three parts)
- **MCQ (1 mark), from the exercise**
  - final product of spermatogenesis: four sperms
  - acrosome: to penetrate the egg
  - yolk at the vegetal pole
  - LH brings on ovulation
  - follicle cells round the oocyte
  - sperm entry completes oogenesis
- **Short (in parts)**
  - why 1 ovum but 4 sperms
  - count gametes and chromosomes from n primary cells
  - are laid frog eggs mature ova? (no: secondary oocytes)
  - spermatogenesis with a chart
  - oogenesis in a frog, briefly

Key terms

Gametogenesis: making of gametes in the **gonads** (primary reproductive organs): **spermatogenesis** in testes, **oogenesis** in ovaries.

Diploid (2n): two sets of chromosomes (frog body cell 2n = 26); **haploid (n)**: one set (frog gamete n = 13).

Spermatogonia: diploid sperm mother cells; **oogonia**: diploid egg mother cells.

Spermiogenesis (spermateleosis): a spermatid **changes shape** into a sperm; no division.

Spermiation: release of sperms into the **lumen** of the seminiferous tubule.

Sertoli cells: nurse cells of the tubule wall; hold and feed developing sperms.

Leydig (interstitial) cells: between tubules; make **testosterone**.

Polar body (polocyte): tiny cell cut off by each unequal division of an oocyte; degenerates.

Non-cleidoic: egg with no hard shell (frog); **cleidoic**: with a shell (hen).

Mesolecithal: moderate yolk; **telolecithal**: yolk gathered towards the vegetal pole.

Gray crescent: gray band in the fertilized egg, **opposite the sperm's entry**; future dorsal side.

Gametogenesis

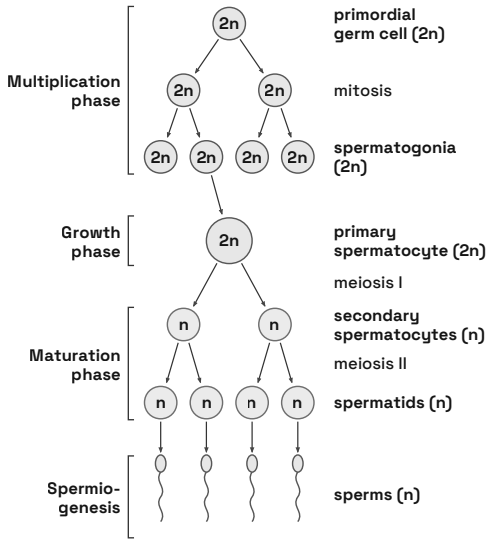
- zygote = fusion of sperm + ovum → divides into the many-celled body
- **meiosis** is the key step: halves chromosomes (26 → 13)
- fertilization: n + n → 2n; keeps the species' number constant
- without halving: number doubles every generation
- **von Baer** (1826): mammal's ovum in a dog's ovary; **father of embryology**

Spermatogenesis

- in **seminiferous tubules** of the testes; wall = **germinal epithelium** + Sertoli cells
- control: pituitary **FSH**, **LH** (→ Leydig cells → **testosterone**); frog: speeds up as the rains near

Phases

1. **Multiplication**: primordial germ cells (2n) → by **mitosis** → many **spermatogonia** (2n)
2. **Growth**: spermatogonium grows a little (food from Sertoli cells) → **primary spermatocyte** (2n); **DNA replicated**, proteins made
3. **Maturation** (meiosis):
   - **meiosis I** (first maturation division): 1 primary spermatocyte → **2 secondary spermatocytes** (n)
   - **meiosis II** (second maturation division): each → 2 **spermatids** (n)
   - ∴ 1 primary spermatocyte → **4 spermatids**, equal size
4. **Spermiogenesis**: spermatid → sperm



Spermatogenesis: the chart to draw.

Spermiogenesis: what changes

- **Golgi body** → **acrosome** (cap over the nucleus)
- **nucleus** condenses; narrow, long

- **centrioles** behind the nucleus; distal → **axial filament** → **tail**
- **mitochondria** round the tail's start → **middle piece**
- most **cytoplasm** thrown off (**residual body**, eaten by Sertoli cells)
- frog: sperms in bundles, heads in a Sertoli cell → released (**spermiation**) → vasa efferentia → kidney → urinogenital duct

Structure of a sperm

1. Head (broadest part)

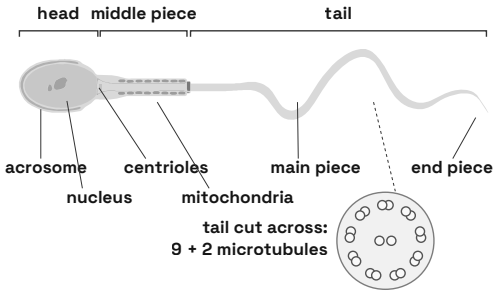
- almost all **nucleus**, haploid, DNA packed tight
- **acrosome** (from Golgi): **sperm lysins** (protein-digesting); mammals also **hyaluronidase**
- enzymes digest a path through the egg's coverings

2. Middle piece ("power house", energy chamber)

- **proximal centriole**: enters the egg; organizes the spindle of the first cleavage
- **distal centriole**: forms the **axial filament**
- **mitochondria** in a spiral → ATP for the tail

3. Tail (flagellum)

- many times longer than the head; beats → swims
- axial filament **9 + 2** microtubules
- **main piece** + thin **end piece**
- frog's sperm: long, narrow head; very short middle piece; swims in pond water



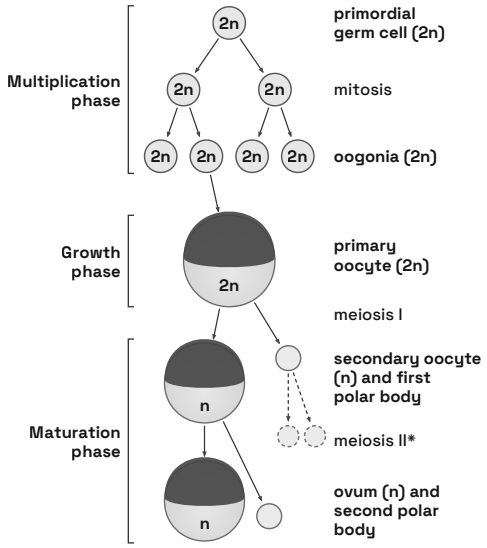
A sperm (a mammal's, as most diagrams draw it).

Oogenesis

- in the **ovaries**; **FSH** grows follicles, **LH** brings on **ovulation**

Phases

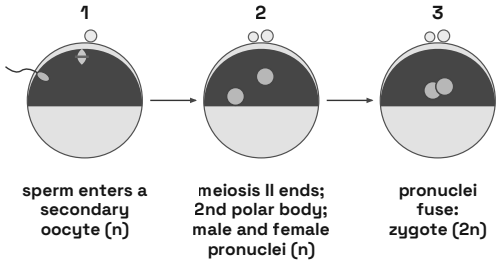
1. **Multiplication**: germinal epithelium (cuboidal) → primordial germ cells → by **mitosis** → many **oogonia** (2n)
2. **Growth**: oogonium enters meiosis → **primary oocyte** (2n); meiosis **pauses in prophase I**; grows for **months**
   - **yolk** (proteins, fats): yolk protein (vitellogenin) made in the **liver** → blood → oocyte
   - wrapped in **follicle cells** (feed it, make hormones)
   - frog: from a few hundredths of a mm to **1.5–2 mm**; > 10,000 × volume
   - **lampbrush chromosomes**: loops of genes read into RNA
3. **Maturation**: **unequal** divisions
   - **meiosis I**: large **secondary oocyte** (n, keeps cytoplasm and yolk) + tiny **first polar body**
   - **meiosis II**: large **ovum** + tiny **second polar body**; first polar body may divide
   - ∴ 1 primary oocyte → **1 ovum + 2 or 3 polar bodies** (degenerate; they carry off extra chromosome sets, egg keeps the food)



Oogenesis: the chart to draw.

In a frog

- meiosis I done in the ovary just before **ovulation**; meiosis II stops at **metaphase II**
- ∴ frog **lays secondary oocytes**, not mature ova
- **sperm entry** → meiosis II completed → second polar body out → 13 chromosomes form the **female pronucleus**
- male + female pronuclei fuse → diploid zygote



Fertilization brings on the second maturation division.

- e.g. 50 primary spermatocytes → 200 sperms; 50 primary oocytes → 50 ova; each n = 13 (frog)
- **Hogben test** (1930s–60s): pregnant woman's urine (hCG, acts like LH) → *Xenopus* lays eggs

Spermatogenesis vs oogenesis

	Spermatogenesis	Oogenesis
where	testes (seminiferous tubules)	ovaries
growth phase	short; little growth	long (months); huge, stores yolk
meiotic divisions	equal	unequal: big cell + polar body
from 1 primary cell	4 sperms	1 ovum + 2–3 polar bodies
extra step	spermiogenesis	none; frog: meiosis II after sperm entry
gamete	small, motile, little cytoplasm, no yolk	large, non-motile, much cytoplasm, yolk
numbers	millions	a few thousand a season

The frog's egg

- laid as a **secondary oocyte**; round, **1.5–2 mm**; **non-cleidoic**
- **mesolecithal + telolecithal**
- laid in water, stuck together by jelly: **spawn**

Coverings (inside → out)

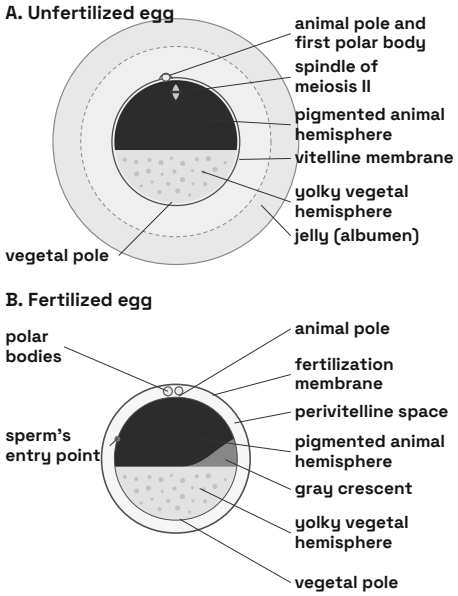
- **plasma membrane**
- **vitelline membrane** (made in the ovary); with the plasma membrane looks double
- **jelly** ("albumen"), added in the oviduct; swells in water

Jelly's jobs

- stops drying out
- keeps off germs, fungi
- cushions knocks
- holds eggs in a mass
- keeps eggs a little warmer
- tastes bad → not eaten

Two hemispheres

- **animal** (top, **animal pole**): **black** (melanin); chromosomes just under the pole; most organelles; little yolk; pigment absorbs sunlight (warmth), shields from UV
- **vegetal** (bottom, **vegetal pole**): **creamy white**, heavy with **yolk**
- "nucleus" in a laid egg's diagram = the meiosis II spindle under the animal pole



A frog's egg: A unfertilized, in its jelly; B fertilized, with the gray crescent.

After fertilization

- fluid under the vitelline membrane → it lifts off → egg turns freely
- yolk sinks → **animal hemisphere up** (black from above, pale from below)

Gray crescent

- on the side **opposite the sperm's entry**, between black and white halves
- cortex (pigmented) turns ~30° towards the entry point → band of lightly pigmented cytoplasm uncovered
- marks the **dorsal lip of the blastopore** → future **dorsal side**
- egg: radially symmetrical → **bilaterally symmetrical**

COMMON MISTAKES

✗ One primary oocyte gives four ova
✓ **one ovum** + 2 or 3 polar bodies; four sperms come from a spermatocyte.

✗ Spermiogenesis is the whole making of sperms
✓ that is **spermatogenesis**; spermiogenesis is only spermatid → sperm, with no division.

✗ Chromosomes are halved in meiosis II
✓ halved in **meiosis I**; meiosis II separates chromatids.

✗ A frog lays mature ova
✓ it lays **secondary oocytes**; meiosis II ends only when a sperm enters.

✗ The gray crescent forms where the sperm entered
✓ **opposite** the entry point.

✗ The acrosome gives energy
✓ the **middle piece's mitochondria** do; the acrosome's enzymes enter the egg.

✗ The animal hemisphere holds the yolk
✓ yolk is in the **vegetal** hemisphere.