Unit 26 · Frog

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Faunal Diversity (Units 22–26 together): 19 of 75 marks, 1 MCQ, 2 short and 1 long; in one group with Evolutionary Biology, Units 18–21 (28 marks)
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:**
  - MCQ: what the frog's **vocal sacs** do (make the croak louder)
  - short (2 + 3): the **pancreas**; its part in intestinal digestion
- **MCQ (1 mark)**
  - why near water; tadpole; mucous glands; cutaneous respiration; why males croak; hibernation
  - teeth; enzymes not from the pancreas; bile emulsifies fats; glycogen; duodenum; gullet; enterokinase; micelles
  - pericardium; sinus venosus; truncus arteriosus; opening with no valve; nucleated red cells; agranulocytes
  - sternohyal, petrohyal; glottis; no bronchioles in the lung; bicarbonate; oxyhemoglobin; chloride shift
  - middle piece; acrosome; Bidder's canal; oogenesis; mesolecithal, telolecithal; vitelline membrane; Leydig cells
- **Short and long (in parts)**
  - habit, habitat, seasons; parts of the body; sexual dimorphism
  - alimentary canal; digestion part by part; gastric digestion; absorption
  - **draw** the **buccal cavity**; teeth; liver; pancreas (compound gland)
  - heart and how it works; **draw** the heart's **inside**; blood vessels; capillaries; blood; granulocytes vs agranulocytes
  - bucco-pharyngeal, cutaneous, pulmonary breathing; why the lungs are less efficient; how a frog makes sound; gas transport
  - **draw** the **male** and **female** systems, the **sperm**, **T.S. of the testis**; the egg; why "urinogenital duct"

Key terms

Poikilothermic: body temperature follows the surroundings.

Hibernation (winter sleep) · **aestivation** (summer sleep).

Amplexus: male clasps female behind her front legs; no true copulation.

Spawn: eggs in jelly; **milt**: male's fluid with sperms.

Bucco-pharyngeal cavity: mouth and pharynx together (no neck).

Homodont · pleurodont · polyphyodont: teeth alike · on the jaw's inner side · replaced for life.

Myogenic heart: beat starts in its own muscle.

Positive-pressure breathing: air pushed into the lungs by the mouth floor.

Chloride shift: Cl^- into red cells as HCO_3^- leaves.

Mesolecithal · telolecithal: moderate yolk · gathered at the vegetal pole.

Urinogenital duct: male's ureter carrying urine and sperms.

Hoplobatrachus tigerinus

- Chordata · Vertebrata · Gnathostomata · Tetrapoda · **Amphibia** · *Rana tigrina* (now *Hoplobatrachus tigerinus*)
- **Indian bullfrog**; family Ranidae in old books, **Dicroglossidae** since 2006
- Nepal: the Terai's ponds and paddy fields
- large; olive to brown, **dark blotches**; pointed snout; pale **mid-dorsal line**
- why studied: common, cheap, harmless; good size; short life cycle; built like higher vertebrates

Habitat and habit

- near **fresh water**: moist skin for breathing; escape by diving; food; breeding
- **solitary**, **mostly nocturnal**; **carnivorous**, **cannibalistic**
- **locomotion**: leaps (hind legs in a **Z**); swims with **webbed** feet
- **feeding**: flicks a sticky tongue; swallows **whole**; moving prey only; stores **glycogen**, **fat** before winter
- **hibernation**: mouth, nostrils shut; no feeding; slow metabolism; **skin breathing only**; lives on glycogen and fat
- **aestivation**: same, in hot dry summer
- **croaking**: male's **mating call**; **vocal sacs** make it louder
- **breeding**: monsoon (June–September); male turns **lemon yellow**; **nuptial pad**; **amplexus**; fertilization **external**; **tadpole**, **metamorphosis**
- **camouflage**: **chromatophores** in the dermis (pigment spread: dark; gathered: pale)

- **protection**: color change, squirting urine, slippery mucus, diving

External features

- **spindle-shaped**, flat, bilateral; up to ~17 cm
- skin: moist, slimy, **no scales**; **never drinks** (water through the skin)
- **head** and **trunk**: **no neck**, **no tail**
- head:
  - wide **mouth**; **external nostrils**
  - bulging **eyes**: fixed upper lid, movable lower lid, **nictitating membrane**
  - **brow spot** (lost pineal eye)
  - **tympanum** behind each eye; no external ear
  - male: **vocal sacs** on the throat
- trunk: **sacral prominence** (hump); **cloacal aperture**
- **forelimb**: **4 fingers**, no web; **nuptial pad** on the first finger (breeding male)
- **hind limb**: thigh, shank, ankle, foot with **5 webbed toes**; **subarticular tubercles**

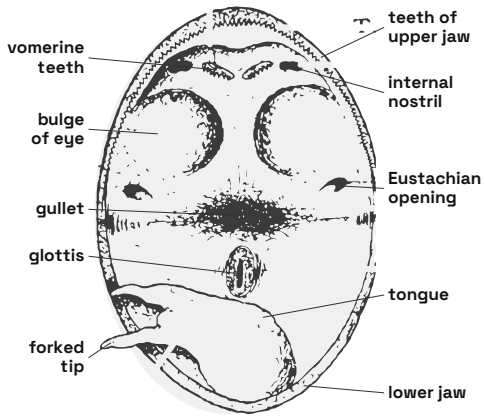
Male	Female
smaller	larger
bright yellow in breeding season	olive or brown
nuptial pad	none
vocal sacs; croaks	none; silent
slim	belly swollen with eggs

Toad	Bullfrog
mostly on land	near water
parotoid poison gland	not poisonous
dry, **warty** skin	moist, smooth
short legs, little web	long legs, full web
hops, walks	leaps, swims
no teeth	teeth on upper jaw
eggs in **strings**	eggs in **clusters**

Digestive system

Alimentary canal: mouth → bucco-pharyngeal cavity → esophagus → stomach → duodenum → ileum → rectum → cloaca

- **mouth**: wide; lower jaw moves; lips can't move
- **bucco-pharyngeal cavity**: food and air; ciliated epithelium, **goblet cells**; **no salivary glands**
  - **teeth**: **maxillary**, **premaxillary** (upper jaw), **vomerine** (roof); **none on the lower jaw**; **hold** prey, don't chew
  - **internal nostrils** beside the vomerine teeth
  - **tongue**: fixed in front, free and **bifid** behind; **protrusible**; sticky (lingual, intermaxillary glands)
  - **bulges of the orbits**: eyes pressed down push food back
  - **Eustachian openings** (to middle ears)
  - **vocal sac openings** (male)
  - **glottis** (to lungs) and **gullet** (to esophagus)
  - **fossae** and **prelingual elevations** seal the mouth



The frog's mouth opened wide, tongue flipped forward.

- **tooth**: base and crown; **dentine** with **canaliculi**; **enamel** cap (ameloblasts); **pulp cavity** (odontoblasts)
- **esophagus**: short; folds; goblet cells; some **pepsinogen**
- **stomach**: **J-shaped**, left side; **mesogaster**; **cardiac** and **pyloric** parts
  - **gastric glands** (pepsinogen), **oxyntic cells** (HCl), goblet cells
  - **pyloric sphincter**
- **small intestine** (on a **mesentery**): **duodenum** (U with stomach; **common bile duct** opens) and **ileum** (folds, **no true villi**)
- **rectum**: absorbs water, stores feces
- **cloaca**: also ureters, oviducts; **cloacal aperture**

Wall of the gut (outside in)

1. **serosa** (adventitia round the esophagus)
2. **muscularis**: outer longitudinal, inner circular; **peristalsis**
3. **submucosa**
4. **mucosa**: lamina propria, muscularis mucosae, columnar epithelium

Liver

- **largest gland**; three lobes; **gall bladder** stores bile
- hepatic ducts + **cystic duct** → **common bile duct** → through the pancreas → duodenum
- **lobules** of **hepatic cells**; bile canaliculi; **hepatic artery** and **hepatic portal vein**
- functions:
  - **bile**: neutralizes chyme; **emulsifies** fats
  - **glycogenesis**, **glycogenolysis**, **gluconeogenesis**
  - **deamination**: ammonia → **urea**
  - removes **bilirubin**, **biliverdin**
  - destroys old red cells; **Kupffer cells** eat microbes
  - stores iron, copper, fat-soluble vitamins
  - makes **fibrinogen**, **prothrombin** (not heparin)

Pancreas: a **mixed (compound) gland**

- in the loop of stomach and duodenum; pancreatic ducts join the bile duct: **hepato-pancreatic duct**
- **exocrine**: **acini** of secretory cells → **pancreatic juice**
- **endocrine**: **islets of Langerhans**
  - **alpha**: **glucagon** (raises blood sugar)
  - **beta**: **insulin** (lowers it)
  - **delta**: **somatostatin**
- in intestinal digestion:
  - **secretin** makes it pour out juice
  - **trypsinogen** → **trypsin** (by **enterokinase**); trypsin activates chymotrypsinogen (**autocatalyst**)
  - **trypsin, chymotrypsin**: proteins, peptones → polypeptides, amino acids
  - **amylase** (amylopsin): starch → maltose
  - **lipase** (steapsin): emulsified fats → fatty acids + glycerol

Physiology of digestion

- **ingestion**: tongue catches; teeth hold; mucus, cilia, **eyeballs** push it back; no chewing
- **mouth, esophagus**: **no digestion**
- **stomach** (gastric): **gastrin** → gastric juice; HCl: pepsinogen → **pepsin**, kills bacteria; proteins → **peptones, proteoses**; **chyme**
- **intestine**: acid chyme → **secretin** (pancreas) and **cholecystokinin** (gall bladder)
  - **bile**: no enzymes; $NaHCO_3$, glycocholate, taurocholate; neutralizes, emulsifies
  - **pancreatic juice** (above)
  - **succus entericus**: enterokinase, **peptidases** (erepsin), lipase, **maltase**, **sucrase**, **lactase**, nucleases

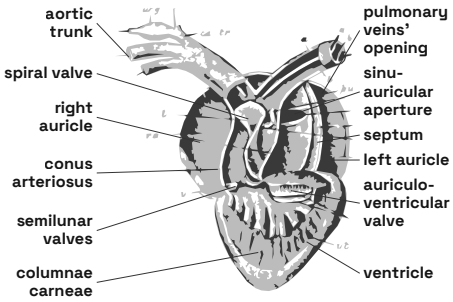
Enzyme	Acts on	Gives
maltase	maltose	glucose + glucose
sucrase	sucrose	glucose + fructose
lactase	lactose	glucose + galactose
peptidases	polypeptides	amino acids
nucleases	nucleic acids	nucleotides

- **absorption**: duodenum, ileum (folds)
  - sugars, amino acids → blood → **hepatic portal vein** → liver
  - fatty acids + bile salts → **micelles** → rebuilt into fats → **chylomicrons** → **lymph**
- **assimilation**; **egestion** by the cloacal aperture

Blood vascular system

Heart

- in the **pericardium** (parietal, visceral; **pericardial fluid**)
- **3 chambers**: 2 **auricles**, 1 **ventricle**; plus:
  - **sinus venosus** (dorsal): 2 **precavals** + **postcaval** → right auricle
  - **truncus arteriosus** (ventral, from the right of the ventricle) → **carotid**, **systemic**, **pulmocutaneous** arches each side
- inside:
  - **inter-auricular septum**; right auricle larger
  - **sinu-auricular aperture**: valve of **2 flaps**
  - pulmonary vein into left auricle: **no valve**
  - **auriculo-ventricular aperture**: valve of **4 flaps**, **chordae tendineae** (not contractile)
  - ventricle: thick, spongy; **columnae carneae**
  - **3 semilunar valves** into the truncus; 3 more between **conus** and **bulbus**
  - **spiral valve** in the conus: **cavum aorticum**, **cavum pulmocutaneum**



A frog's heart cut open from the front.

Working

- **myogenic**; systole, diastole
- sinus venosus → right auricle; lungs → left auricle; auricles together → ventricle → truncus
- **old view** (Brücke, 1852): little mixing; deoxygenated to lungs and skin, mixed to body, oxygenated to head
- **modern view** (Foxon, 1950s): blood mixes in the ventricle
- measured since: **partial separation**; less oxygen in blood to lungs and skin

Blood vessels

Artery	Capillary	Vein
away from the heart	between arterioles and venules	to the heart
thick, muscular, elastic	one layer of endothelium	thin walls
narrow lumen	exchange with tissues	wide lumen
no valves	—	**valves**
doesn't collapse	sinusoids in liver, spleen	collapses

- frog: most arteries and veins carry **mixed** blood

Blood: liquid connective tissue, slightly alkaline

- **plasma**: water; **albumin** (osmotic pressure), **globulins** (antibodies), **fibrinogen** (clot)
- **red cells**: **oval, biconvex, nucleated**; large, few (4–13 lakh/mm^3); **hemoglobin**; made in bone marrow, spleen
- **white cells**: nucleated; **diapedesis**; phagocytosis

Granulocytes	Agranulocytes
granules in cytoplasm	clear cytoplasm
lobed nucleus	round or kidney-shaped
bone marrow	spleen, lymphoid tissue
eosinophil (red, 2 lobes; parasites), **basophil** (blue; histamine, heparin), **neutrophil** (many lobes; phagocyte)	**lymphocyte** (antibodies), **monocyte** (phagocyte)

- **thrombocytes**: spindle-shaped, **nucleated**; clotting (no platelets)
- functions: **transport**, **regulation**, **protection** (clotting, antibodies)

Respiratory system

- tadpole: **gills** (3 pairs external, then internal)
- adult: **cutaneous**, **bucco-pharyngeal**, **pulmonary**

Cutaneous

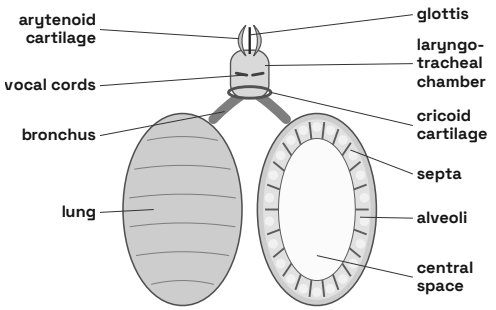
- all the time; **only** way in hibernation, aestivation
- skin **thin, moist** (mucous glands), **full of capillaries**
- O_2 dissolves in the water film → diffuses in; most CO_2 leaves by the skin

Bucco-pharyngeal (nostrils open; mouth and glottis shut)

- **hyoid** in the mouth floor
- **sternohyal** (to sternum): floor **down** → pressure falls → air in (**inspiration**)
- **petrohyal** (to skull): floor **up** → air out (**expiration**)

Pulmonary: nostrils → nasal chambers → internal nostrils → bucco-pharyngeal cavity → **glottis** → **laryngo-tracheal chamber** → **bronchi** → **lungs**

- **laryngo-tracheal chamber**: **arytenoid** and **cricoid** cartilages; **vocal cords** vibrate → voice; **vocal sacs** make it louder
- **lungs**: thin, elastic, pinkish; help floating; **alveoli** lined by **thin, flat cells**
- less efficient: **no bronchioles**, **few alveoli**, small surface



Glottis to lungs, one lung cut open.

- **positive-pressure** (buccal pump); **no diaphragm, no ribs**
- **inspiration**: floor down (sternohyals), air in; nostrils shut (**mentomeckelian** bones push the **premaxillae**); floor up (petrohyals); **glottis opens**, air forced into lungs; glottis closes
- **expiration**: lungs' elasticity and body wall; glottis opens; air to mouth; out by nostrils
- X-ray films (de Jongh and Gans, 1969): stale air out, then fresh air pumped in

Gas transport

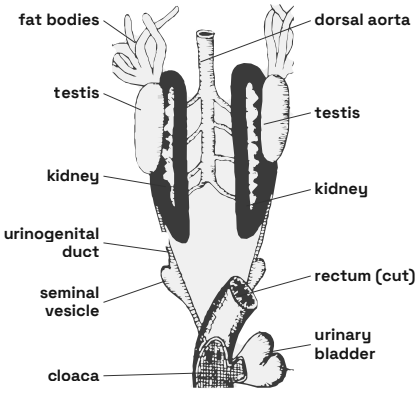
- **O_2**: 1–3% in plasma; **97–99%** as **oxyhemoglobin** (Hb + $4O_2$)
- **CO_2**:
  - ~7% dissolved (carbonic acid)
  - **~70%** as **bicarbonate** (**carbonic anhydrase** in red cells; **chloride shift**, Hamburger)
  - ~23% as **carbaminohemoglobin**

Reproductive system

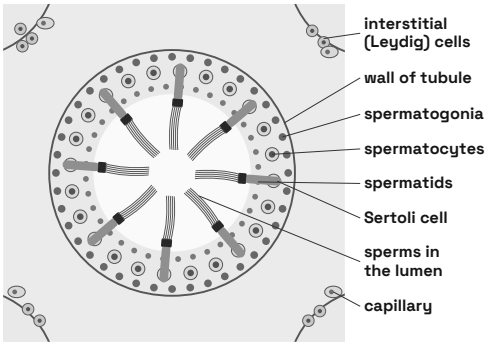
- **unisexual**; **urinogenital system**

Male

- **testes** on the kidneys, by **mesorchium**
- **seminiferous tubules**: germinal epithelium → sperms (**spermatogenesis**); **Sertoli cells** feed them
- **Leydig (interstitial) cells**: **testosterone** → nuptial pads, vocal sacs, yellow color
- **fat bodies**: stored fat for hibernation, breeding
- **vasa efferentia** (10–12) → kidney → **Bidder's canal** → transverse tubules → longitudinal tubule → **urinogenital (Wolffian) duct** → **seminal vesicle** → cloaca
- sperms pass **through the kidney**; male's duct carries urine and sperms
- **no penis**

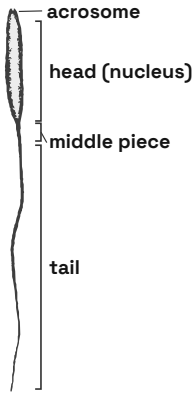


Male urinogenital organs, from below.



T.S. of a piece of the testis.

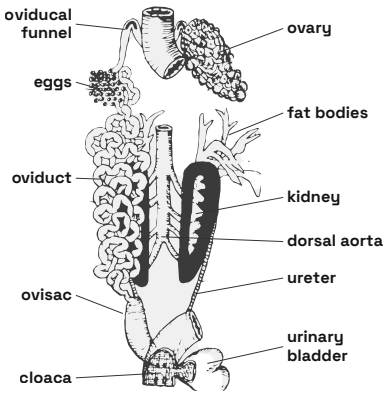
- **sperm**:
  - **head**: nucleus, **acrosome** (sperm lysins dissolve egg coverings)
  - **middle piece**: **mitochondria** (energy), centrioles
  - **tail**



A frog's sperm.

Female

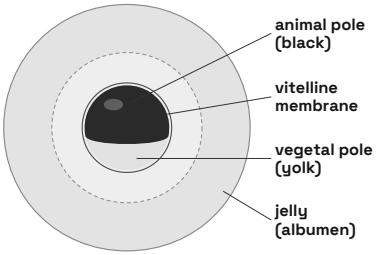
- **ovaries**: lobed, **mesovarium**; **no link with kidneys**; fill the body in the breeding season
- **theca externa**, **theca interna**; **follicles**; **oogenesis**; **ovulation** into the body cavity
- **oviducts**: **funnel** (**ostium**) near the heart; coiled glandular tube (jelly); **ovisac**; open separately into the cloaca
- several thousand eggs at a time



Female urinogenital organs, from below.

The egg

- 1.5–2 mm; **vitelline membrane** (jelly added in the oviduct)
- **animal pole**: black, nucleus; **vegetal pole**: yolk
- **mesolecithal**, **telolecithal**



A frog's egg just laid, in its jelly.

Amplexus

- **testosterone**: nuptial pads, vocal sacs, sperms
- male croaks, climbs on, clasps **behind her front legs** (**axillary**); hours
- female lays **spawn**; male sheds **milt** over it
- fertilization **external**; development **indirect** (tadpole)

COMMON MISTAKES

✗ The frog is diurnal
✓ **mainly nocturnal**.

✗ The male grips the abdomen
✓ **behind the front legs**.

✗ Frog's teeth chew food
✓ they **hold** prey; food is swallowed whole.

✗ Teeth are acrodont
✓ **pleurodont** (inner side of the jaw).

✗ Toad's "parotid" gland
✓ **parotoid** gland.

✗ Chordae tendineae contract
✓ tough cords; they don't contract.

✗ The liver makes heparin
✓ it makes **fibrinogen**, **prothrombin**.

✗ Alveoli lined by ciliated columnar cells
✓ **thin, flat** cells.

✗ The frog copulates
✓ **amplexus** only; fertilization external.

✗ The egg has jelly at ovulation
✓ only the **vitelline membrane**; jelly added in the oviduct.