Unit 27 · Applications of Zoology

STUDY NOTES

WHAT NEB'S GRADE 12 EXAM ASKS

- **CDC's grid (2078):** Applied Biology (Units 27–29 together): 9 of 75 marks; 1 MCQ (knowledge) and 1 long question (8 marks: knowledge 1, understanding 3, application 2, higher ability 2)
- **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
- **CDC's model paper:** short OR question on poultry farming
- **Our model papers:** Paper 2 long question (composite fish culture; how six carps use all the pond's food; stocking 5,000 fingerlings by percent; silver carp alone gives a smaller harvest, why); Paper 3 MCQ (Ranikhet, Newcastle, the viral poultry disease)
- **MCQ (1 mark)**
  - amniotic fluid; test-tube baby = IVF; PGT screens inherited disorders; amniocentesis from ~15 weeks; its ethics (sex, disability)
  - IVF for blocked tubes; isograft; heart recipient avoids crowds (infections); tissue (HLA) typing; rejection; immunosuppressants
  - microinjection; transgenic = gene from another species; first in the mouse
  - Leghorn lays; culling; vaccinating instead of antibiotics; pullet; folding unit
  - silver carp exotic; liming corrects acidity
- **Short and long (in parts)**
  - a female couple with a donor's sperm (IVF); transplant types, preventing rejection
  - IVF's pros, cons, ethics; amniocentesis (what, how, pros, cons)
  - poultry in Nepal; fish farming in Nepal; transgenic animals

Key terms

Applied zoology: knowledge of how animals (people too) are built, reproduce and grow, put to work.

In vivo fertilization: inside the body (fallopian tube).

In vitro fertilization (IVF) (*in vitro*, in glass): egg and sperm joined **outside the body**, embryo returned to the **uterus**; a "test-tube baby".

ART: assisted reproductive technologies, for **infertility**.

ICSI: one sperm injected straight into the egg.

Surrogate (substitute) mother: carries and bears a baby for another; in gestational surrogacy **no genes** of hers.

Organ transplantation: a damaged organ replaced by a healthy **donor**'s; the **recipient** receives it.

Rejection: recipient's immune system destroys the graft as foreign.

Amniocentesis: amniotic fluid drawn and tested; a **prenatal diagnostic test**.

GMO: DNA altered in a laboratory; **transgenic** when it carries a **transgene** from another organism (**transgenesis**).

Poultry: domesticated birds kept for eggs, meat (chickens, ducks, turkeys, geese, pigeons, quails, ostriches).

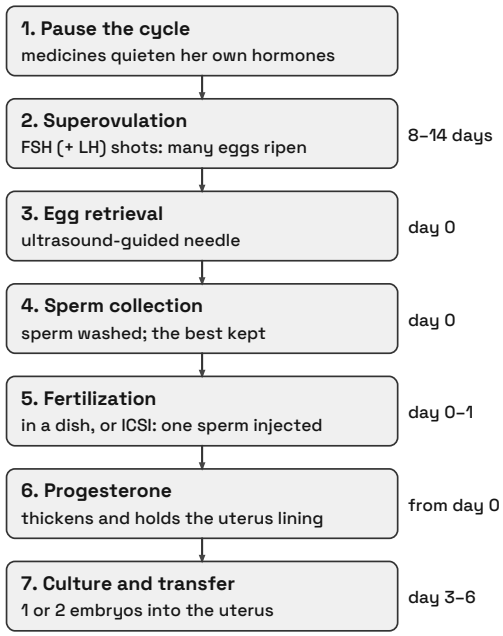
Aquaculture: rearing aquatic organisms; **pisciculture**: fishes only.

In vitro fertilization

- infertility: woman (blocked tubes, no ovulation, endometriosis), man (few sperm, poor swimmers), both, unknown
- first IVF baby **Louise Brown, 1978** (Edwards and Steptoe); Nepal's first **Om Mani Tamang**, 3 March **2005**, Om Hospital
- surrogate mother when: no uterus or it can't hold a pregnancy (**repeated miscarriages**); pregnancy unsafe (heart, kidney disease); a single man or male couple (where allowed); raises questions of payment and rights

Procedure (2–3 weeks)

1. **suppress** the natural cycle
2. **superovulation**: daily **FSH** (with LH) 8–14 days → several follicles; ultrasound, blood tests; last **hCG** injection
3. **egg retrieval**: ~1½ days later; needle through the vaginal wall, by **ultrasound**, light anesthesia
4. **sperm collection**; **sperm washing** picks the healthiest
5. **insemination**: eggs + sperm in nutrient medium; or **ICSI**; next day **two pronuclei**
6. **progesterone** (± hCG) from retrieval: uterine lining thick, ready
7. **embryo culture** 3–6 days (8 cells day 3, **blastocyst** day 5) → **1–2** embryos by **catheter** into the **uterus**; spares frozen; pregnancy test ~2 weeks later



The seven steps of an IVF cycle.

- **IVF-ET** puts the embryo in the **uterus**; **ZIFT** (rare) puts a zygote or $\leq$ 8-cell embryo in the **fallopian tube**
- female couple: IVF with one partner's egg and a donor's sperm

Merits	Demerits
infertile couples have a baby	**costly**
bypasses **blocked tubes**; ICSI for **low sperm count**	success **far below 100%** (< half even when young; falls after 40)
PGT: a cell of the embryo tested for a genetic disorder (thalassemia) before transfer	**multiple births** (avoid: one embryo)
donor eggs or sperm	physical, emotional **stress**; ovarian hyperstimulation
spare embryos **frozen**	ethical, religious issues

- **ethical issues**: conception apart from intercourse · spare embryos discarded · choosing **sex** (forbidden in Nepal) or non-disease traits · identity, parental rights · **poor women exploited** (surrogates, egg donors) · reproduction a **business** · right to know genetic origin

Organ and tissue transplantation

- **donor**: **living** (one kidney, part of the liver) or **deceased** (**circulatory death**; **brain death**: heart kept beating, all organs usable)
- most transplanted: **kidney** (by far), liver, heart, lungs, pancreas, intestine
- first kidney: Boston **1954**, identical twins, **Joseph Murray** (Nobel 1990); first heart: Cape Town **1967**, **Christiaan Barnard**
- tissues: **skin** grafts (burns; first grown in the lab from the 1980s), **bone**, **blood transfusion** (commonest), **cornea**, heart valves, veins
- no brain transplant: the brain is the person; nerve connections can't be rejoined
- Nepal: first kidney **2008** (TU Teaching Hospital); **Shahid Dharmabhakta National Transplant Centre, Bhaktapur** (2012; kidney 2013; first **liver 2016**; first brain-dead donor 2017); living donors only to **close family** (stops kidney selling)

Graft	Donor → recipient	Rejection	Examples
autograft	same person	**none**	thigh skin to a burnt arm; leg (saphenous) vein for a **coronary bypass**
isograft	**identical twins**	**none**	kidney, skin between identical twins
allograft (homograft)	another person, same species	**yes** (less if related)	kidney, liver, heart, cornea, bone marrow
xenograft (heterograft)	**another species**	**highest**	treated pig heart valves; pig skin on burns

Challenges

1. **rejection**: foreign **HLA** (human leukocyte antigens) → **T lymphocytes** attack, **antibodies** made
2. **immunosuppressants** for life → **infections** (avoid crowds), some cancers
3. drugs harm kidneys, raise BP and cholesterol, weaken bones
4. **cost**
5. disease passed with the organ
6. **organ trafficking**: a crime

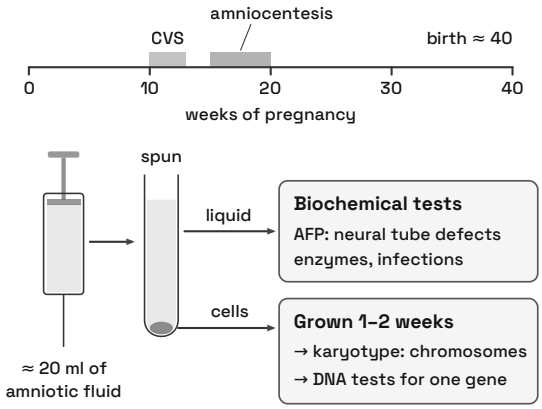
Preventing rejection

1. **immunosuppressive drugs**: **tacrolimus**, **cyclosporine**, **mycophenolate**
2. **tissue typing**: **HLA** and blood groups matched
3. **family donors** (a sibling: 1 in 4 an identical HLA match)
4. bone marrow: recipient's marrow destroyed first by **chemotherapy**, **radiation**
5. training **tolerance** (research)
6. **artificial** parts (no HLA): vessels, valves, skin, corneas, tracheas
7. hoped for: artificial heart, liver, wearable kidney; organs from the patient's **stem cells**; gene-edited **pig** organs

Amniocentesis

- **amniotic fluid** holds fetal cells and chemicals
- for **chromosomal**, **genetic**, some **developmental** disorders; **15th–20th week** (earlier, more miscarriage; at 10–13 weeks **chorionic villus sampling** instead)
- **procedure**:
  1. **ultrasound** locates fetus, placenta, fluid
  2. **thin needle** through the **abdomen** and uterus into the **amniotic sac**

3. **~20 mL** drawn (made again in a day or two)
4. **centrifuged**: cells settle; cells **cultured** 1–2 weeks
5. analysis:
   - **karyotype** (extra chromosome 21: Down syndrome; and the **sex**)
   - **biochemical**: **alpha-fetoprotein (AFP)** high in open **neural tube defects** (spina bifida); missing enzymes (**Tay–Sachs**)
   - **DNA** tests: sickle cell anemia, thalassemia, hemophilia, cystic fibrosis

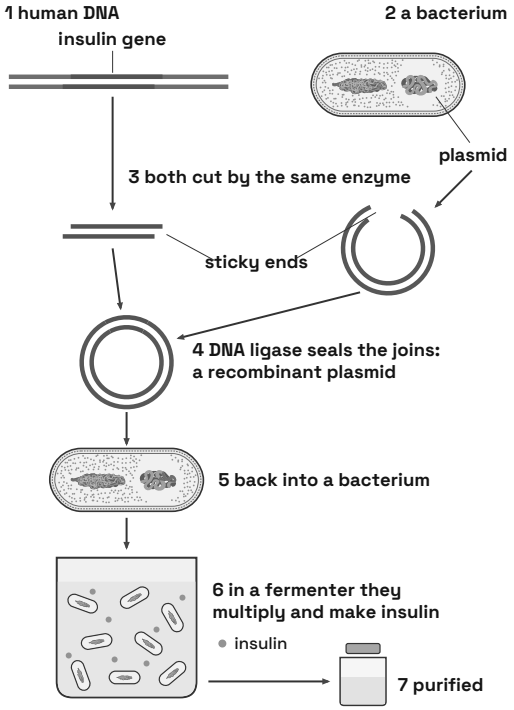


When the tests are done, and what the laboratory does with the sample.

- **purposes**: genetic testing (Down, cystic fibrosis, Tay–Sachs, thalassemia) · infections in the uterus; fetal **anemia** in **Rh sensitization** · **amnioreduction** (excess fluid) · **paternity** · **neural tube defects** (AFP) · **lung maturity** late in pregnancy
- **risks**: **miscarriage** ~1 in 300–1,000 (0.1–0.3%) · infection · fluid leaking · needle injury · mother's hepatitis C, HIV, toxoplasmosis passed on · **sex revealed and misused**
- Nepal bans **identifying the sex** of a fetus and abortion for it (Safe Motherhood and Reproductive Health Act **2075**, Section 17), not the test itself; serious defect: ending allowed with consent up to 28 weeks

Transgenic animals

- **selective breeding**, crossbreeding: slow, many generations; **genetic engineering**: direct, specific, one generation, across species
- tools: restriction enzymes cut, ligase joins, plasmids, viruses carry (Unit 5)



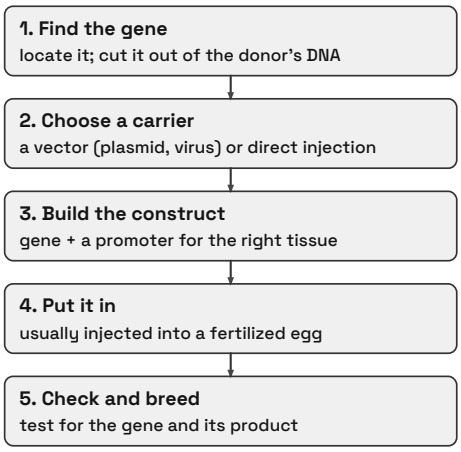
Making recombinant DNA.

Examples

- **goats** ("pharm" animals): human **antithrombin** in milk (first approved, Europe **2006**); a promoter working only in the **mammary gland**
- **rabbits**: interleukin-2, growth hormone, **tissue plasminogen activator** in milk
- **Rosie** (1997), first transgenic **cow**: human **alpha-lactalbumin**, 2.4 g/L
- **mice** with human disease genes: models; **first transgenic animals were mice**
- **fish**: carp, trout, salmon, catfish, goldfish, zebrafish; **AquAdvantage salmon** (Chinook growth hormone gene; first GM animal food, USA 2015)
- **chickens**: resisting bird flu; eggs with medicines
- **Dolly** (1996, Roslin): first mammal **cloned** from an **adult cell**, **not transgenic**; **Polly** (1997) both cloned and transgenic
- transgenic **plants**: Bt cotton, Bt brinjal, **Golden Rice** (beta-carotene), **Flavr Savr** tomato (1994, first GM food sold), protein potatoes; *nif* genes in cereals not yet achieved

Making one (recombinant DNA technology)

1. **identify, isolate** the gene
2. choose a **vector** (plasmid, harmless virus) or direct injection
3. join gene + vector, with a tissue **promoter**
4. introduce it: **microinjection** into the **male pronucleus** of a **fertilized egg** → foster mother
5. check **expression** (gene, protein); breed carriers



The five steps of making a transgenic animal.

- microinjection: random place; few in a hundred eggs carry it; **knockout mouse** (one chosen gene, ES cells, Nobel 2007); **CRISPR** edits in the egg

Advantages

1. **biological products**: α_1**-antitrypsin** (sheep milk), tPA, antithrombin (goats), **lactoferrin** (cows); Rosie's milk
2. **vaccine safety** testing (polio) in mice
3. **toxicity testing**
4. how genes are **regulated**
5. how genes cause **disease** (cancer, cystic fibrosis, Alzheimer's)
6. pigs as **organ** sources (xenotransplantation)
7. farm animals grow faster, more milk, meat, disease resistance

- related, not transgenesis: **cloning**; tissues from **stem cells**

Risks

1. **gene flow** to wild relatives (pollen, escaped fish)
2. less **genetic diversity**
3. **superweeds**, **superpests**
4. new **allergens**, toxins, unknown long-term effects
5. antibiotic-resistance **marker genes**
6. **animal welfare**, ethics

Poultry farming

- **eggs** (**layers**), **meat** (**broilers**) or both
- Nepal: village birds to large farms; cheap **protein**, **income**; demand rising; fights **malnutrition**, **poverty**

Indigenous (free-roaming; 40–60 eggs a year; hardy, disease-resistant, high price as *lokal*)

- **Sakini**: commonest, dual purpose
- **Ghanti Khuile**: **naked neck**, copes with heat
- **Pwakh Ulte**: **frizzle**, feathers curl out
- **Giriraj** (improved Indian, Karnataka): dual purpose

Class	Breeds	For
American	**Rhode Island Red**, **New Hampshire**	eggs and meat
	White Plymouth Rock	meat (broiler parent)
Mediterranean	**White Leghorn** (Italy)	**eggs**: best layer, ~300 white a year
	Black Minorca (Spain)	eggs
English	**Australorp**	eggs and meat
Asiatic	**Brahma**, **Cochin**	meat, heavy
Indian	**Aseel** (fighting), Busra, Chittagong, Ghagus	meat

- **broiler**: hybrid (Cornish × White Plymouth Rock), ~2 kg in 6 weeks; commercial layers hybrids (Leghorn white eggs; Rhode Island Red-type brown)
- White Leghorn: **Mediterranean** by origin (some books say American)

Management

- **incubation**: fertilized, clean, uncracked eggs from healthy vaccinated birds, $\leq$ ~1 week old, stored at **13–18 °C**; incubator **37.5 °C**, 55–60% humidity, **turned** several times a day; hatch in **21 days**
- **brooding**: new chicks kept **warm** (32–35 °C in week 1, less each week), fed, watered, protected; heat lamps, gas brooder
- **rearing**: feed hoppers, water, **laying boxes**; **sexing** (vent, wing feathers, comb, **spur**); **vaccinated** (Newcastle, fowl pox)
- **housing**: ventilated, spacious, lit, fenced, drained, quiet, **safe from predators**; **ages apart**; a **coop**
- **feeding** by age and type: maize, wheat, rice (energy); mustard cake, soybean, **fish meal** (protein); bone meal, shells (Ca, P); salt, vitamins; layers need **calcium**, protein
- **pullet**: young female < 1 year · **cockerel**: young male · **rooster** (cock) · **hen**

System	How	Notes
extensive (free range)	roam by day, shut in at night	little investment, hardy; predators, disease
semi-intensive	small fenced **run** by day, house at night	moderate cost
intensive: **battery cage**	layers in wire **cages**, eggs roll out	most eggs per space; welfare concerns
intensive: **deep litter**	on **15–30 cm** of rice husk, sawdust, straw	litter absorbs droppings, moisture; usual for **broilers**
folding unit	movable pen (**ark**) on **pasture**, moved **daily**	fresh ground, lower feed cost, manure spread, predator-safe; small farms

Diseases

- **viral**: **Newcastle (Ranikhet)**, **bird flu**, **fowl pox**, Gumboro, **Marek's**
- **bacterial**: **fowl cholera**, **pullorum** (white diarrhea of chicks), salmonellosis, TB
- **fungal**: **aspergillosis** (brooder pneumonia, moldy litter)
- **protozoan**: **coccidiosis** (bloody diarrhea)
- parasites: worms; mites, lice, ticks, fleas; nutritional deficiencies
- prevention: clean, spacious, ventilated house; good feed, clean water; no ectoparasites, predators; **vaccination**; **biosecurity**
- **culling**: removing **sick, weak, unproductive** birds; whole flock for **bird flu**

Advantages: protein, vitamins, minerals · income · **jobs** (hatcheries, feed, vets, transport) · droppings a **fertilizer** (N, P, K) · **quick return** (broilers 6–8 weeks, layers from ~5 months) · **feathers** · small space, small investment

Fish farming

- **fishery**: farming + catching, processing, selling
- Nepal: **~187 native**, **~17 exotic** species; ~8 lakh ha of water: rivers ~3,95,000; lakes ~5,000; reservoirs ~1,500; village ponds ~6,500; swamps ~12,500; **irrigated rice fields ~3,98,000**
- Terai warm water: carps; cold hill streams: **asla** (*Schizothorax*), **sahar** (golden mahseer, *Tor putitora*; *Tor tor*), **katle** (*Neolissochilus*): mahseers threatened (dams, overfishing, poisoning)
- jobs, business, steady rural income; demand rising

Term	Meaning
aquaculture	rearing **aquatic organisms** (fish, prawns, crabs, mollusks, plants)
pisciculture	rearing **fishes** only
riverine / lacustrine	fishing in rivers / lakes
inland	fresh water: **capture** (wild) and **culture** (ponds, tanks)
marine	seas, oceans
monoculture	**one** species
polyculture (composite)	**several** species, different foods

- **native**: rohu (*Labeo rohita*), naini/mrigal (*Cirrhinus mrigala*), bhakur/catla (*Catla catla*), asla, sahar, hile (*Channa punctata*), tengra (*Mystus tengara*)
- **exotic** (first: **common carp**): common carp (*Cyprinus carpio*; India 1950s, Israel) · **grass carp** (*Ctenopharyngodon idella*; India) · **silver carp** (*Hypophthalmichthys molitrix*; Japan) · **bighead** (*H. nobilis*; Hungary) · **Nile tilapia** (Thailand) · **rainbow trout** (*Oncorhynchus mykiss*; Nuwakot, Rasuwa) · African catfish (*Clarias gariepinus*)

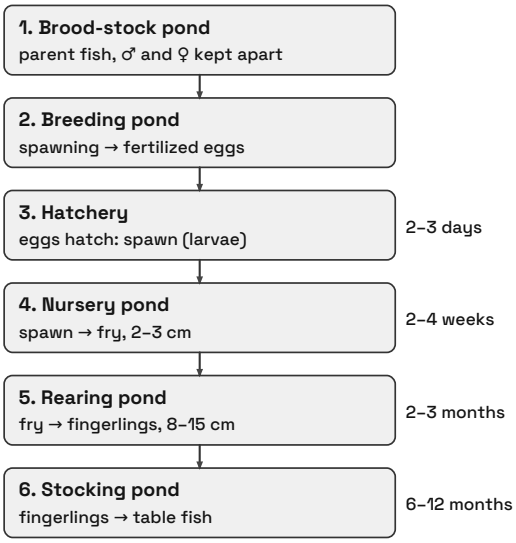
Composite fish culture (six carps, sometimes catla too)

Fish	Feeds on	Level
silver carp	**phytoplankton**	surface
bighead, **catla**	**zooplankton**	surface
grass carp	**water weeds**, grass thrown in	weeds
rohu	mid-water food	middle
mrigal	**detritus**	bottom
common carp	worms, insect larvae in the mud	bottom

- different foods → little competition, no food unused → more fish; one species alone (silver carp only) → competes for one food, others wasted, **smaller harvest**
- stocking by percent: share × total (30% of 5,000 = 1,500)

Ponds

1. **brood-stock**: male and female **brooders** apart, well fed, spawn when wanted
2. **spawning (breeding)**: monsoon; ~1 female : 2 males; **gentle water flow** triggers spawning; eggs to the hatchery
3. **hatchery**: shallow, **slow continuous flow** (oxygen); **spawn** live on yolk
4. **nursery**: **fry** → **fingerlings** (8–15 cm); rectangular, **~90 cm** deep, ≤ ~3 months, ≤ ~40 g (or a separate **rearing pond**)
5. **stocking (grow-out)**: large, permanent, **> ~2 m** deep, to market size



The ponds of a complete fish farm.

Building a pond: **topography** (bowl-shaped land) · **clay** soil, pH ~7–8 · water supply · roads · **layout** (**restricted**: buy fingerlings; **complete**: breed to market)

Managing a pond

1. control **vegetation**; empty, dry, clean after harvest
2. **liming** (quicklime CaO, limestone): **corrects acidity**, kills parasites, weeds, frees nutrients
3. **manuring** (dung, droppings, fertilizer) → **phytoplankton bloom**, zooplankton
4. **artificial feeding**: rice bran, oil cake, kitchen waste, fish meal

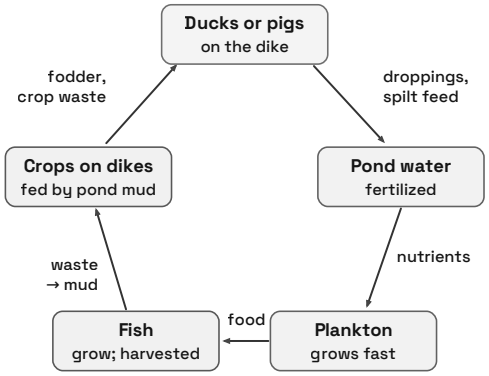
5. remove **predatory** (snakeheads, *Channa*) and **weed fishes** (small barbs, *Puntius*)
6. **physico-chemical**: depth, temperature, light, turbidity, pH, **dissolved oxygen** (aeration)
7. **harvest**: drain, net

Cage culture: floating or submerged cages (40–10,000 m^3; nylon net on steel, bamboo, pipe; drums) in lakes, reservoirs, rivers

- **Pokhara lakes** (Phewa, Begnas, Rupa; 1970s); **Kulekhani** (Indrasarobar, 1982 dam; government + Canada's IDRC); **silver, bighead** on plankton, little feed
- advantages: all water used · **small investment** · easy management · predators, disease controlled · **movable** in emergencies · easy harvest

Integrated fish farming: **paddy-**, **pig-**, **duck-**, **poultry-**, **livestock-cum-fish**; one's waste another's food

- efficient resources · **nutrients recycled** (manure → plankton; fish eat rice pests, droppings feed rice) · more total production · sustainable · varied income, food security · lower costs · less pollution



Duck- or pig-cum-fish farming as a cycle.

Breeding

1. **natural**: ripe females, males (~1 : 2) in a **hapa** (mosquito-net box on bamboo) near fresh inflow
2. **semi-artificial** (common carp, sticky eggs): **cement tanks** with **kakabans** (palm, coconut-fiber mats; Indonesian); **pituitary extract** injection; spawn **~12 hours** later
3. **induced breeding** (**hypophysation**): ripe male gives **milt** when pressed; ripe female soft, swollen belly, **reddish** swollen vent; **pituitary extract** (~3 mg/kg female, ~1 mg/kg male) or synthetic hormone; ~12 hours → **stripping** (belly pressed head to tail), eggs and milt mixed

- why it works: pond carp ripen but don't spawn; monsoon floods make their **pituitary** release the spawning hormones; another fish's pituitary supplies them

Importance: income, economy · fish: protein, **vitamins A and D**, minerals, **iodine**, **omega-3** · **fish oil**, liver · **fish meal**, manure · skin leather · **angling**, tourism (mahseer) · research

COMMON MISTAKES

✗ The IVF embryo is placed in the fallopian tube
✓ in standard IVF, the **uterus**; only rare **ZIFT** uses the tube.

✗ A surrogate mother is the baby's genetic mother
✓ in gestational surrogacy she gives **no genes**.

✗ An isograft is between any two people
✓ between **identical twins**; between others it is an **allograft**.

✗ Immunosuppressants protect against infection
✓ they make **infections** more likely.

✗ Amniocentesis is banned in Nepal
✓ its misuse for **sex selection** is banned; tests for disease are allowed.

✗ Dolly was the first transgenic animal
✓ Dolly was a **clone**; the first transgenic animals were **mice**.

✗ White Leghorn is an American breed
✓ **Mediterranean** (Italy); kept for **eggs**.

✗ Ranikhet is bacterial
✓ it is **viral** (Newcastle disease); fowl cholera is bacterial.

✗ Liming adds food for fish
✓ it **corrects acidity**, kills parasites and weeds; manuring adds food.

✗ Silver carp feed on the bottom
✓ on **phytoplankton** at the surface; mrigal and common carp feed at the bottom.