

ZOOLOGY

+2 2nd Year (Class XII) · Study Notes

6 chapters · theory in simple words · key terms · exam Q&A

Contents

1. Human Reproduction
2. Reproductive Health
3. Evolution
4. Human Health and Disease
5. Biotechnology: Principles and Processes
6. Biotechnology and its Applications

How to use: read the box "In simple words" first, then the main points. Learn the key terms, then try each exam question yourself before reading the model answer. Diagrams named in the notes should be practised from your textbook.

Chapter 1. Human Reproduction

In simple words: Humans reproduce sexually. Testes make sperm and ovaries make eggs (ova). Fertilisation happens inside the female body, and the baby develops in the uterus, nourished through the placenta.

Male reproductive system

- A pair of **testes** in the scrotum, kept 2–2.5 °C below body temperature, which is needed for sperm formation.
- Each testis has many **seminiferous tubules**. Their **Sertoli cells** nourish developing sperm; **Leydig (interstitial) cells** between the tubules make testosterone.
- Ducts: rete testis → vasa efferentia → epididymis → vas deferens → ejaculatory duct → urethra.
- Accessory glands: seminal vesicles, prostate and bulbourethral glands. Their secretions with sperm form **semen**.

Female reproductive system

- A pair of **ovaries** (make ova and the hormones oestrogen and progesterone), **fallopian tubes** (oviducts: infundibulum with fimbriae, ampulla, isthmus), **uterus**, cervix and vagina.
- Uterine wall: perimetrium, myometrium (smooth muscle, strong contractions in labour) and **endometrium** (lining that changes in each cycle).
- Mammary glands produce milk after childbirth.

Gametogenesis

- **Spermatogenesis** starts at puberty. Spermatogonia (2n) → primary spermatocytes (2n) → meiosis I → secondary spermatocytes (n) → meiosis II → spermatids (n) → sperm (spermiogenesis). One primary spermatocyte gives **four sperm**.
- Hormones: GnRH from the hypothalamus → LH (acts on Leydig cells, testosterone) and FSH (acts on Sertoli cells).
- **Oogenesis** begins before birth. Oogonia → primary oocytes, which stay arrested in prophase I until puberty. One primary oocyte gives **one ovum** and polar bodies.
- A sperm has a head (nucleus and acrosome with enzymes), middle piece (mitochondria for energy) and tail.

Menstrual cycle (about 28 days)

- **Menstrual phase** (days 1–5): the endometrium breaks down and bleeding occurs because the egg was not fertilised.
- **Follicular phase**: FSH and LH make follicles grow; oestrogen rebuilds the endometrium.
- **Ovulation** (about day 14): an **LH surge** makes the Graafian follicle release the secondary oocyte.
- **Luteal phase**: the empty follicle becomes the **corpus luteum**, which secretes progesterone to keep the endometrium ready. Without fertilisation it degenerates and the next period starts.
- Menarche is the first menstruation; menopause (around 50 years) is when cycles stop.

Fertilisation and development

- Fertilisation happens in the **ampulla** of the fallopian tube. The sex of the baby is decided by the sperm: X sperm gives a girl (XX), Y sperm gives a boy (XY).
- The zygote divides (cleavage) → morula → **blastocyst**, which implants in the endometrium.

- The **placenta** connects mother and foetus: it supplies food and oxygen, removes wastes, and makes hormones — hCG, hPL, oestrogen and progesterone.
- Pregnancy lasts about 9 months. The heart forms by the end of the first month; limbs and fingers by the end of the second; most organs by the end of the first trimester.
- **Parturition** (birth) is triggered by the foetal ejection reflex; **oxytocin** causes strong uterine contractions. **Colostrum**, the first milk, contains antibodies (IgA).

Exam questions

Q. Why are the testes located outside the abdomen?

Sperm formation needs a temperature 2–2.5 °C lower than normal body temperature. The scrotum keeps the testes at this lower temperature.

Q. What is the role of the corpus luteum?

It secretes progesterone, which keeps the endometrium ready for implantation and maintains pregnancy in its early stage.

Q. Who decides the sex of the child, and how?

The father. The ovum always has an X chromosome. If an X-carrying sperm fertilises it, the baby is a girl (XX); if a Y-carrying sperm does, the baby is a boy (XY).

Q. What are the functions of the placenta?

It supplies oxygen and nutrients to the foetus, removes CO₂ and wastes, and works as an endocrine gland making hCG, hPL, oestrogen and progesterone.

Chapter 2. Reproductive Health

In simple words: Reproductive health means a healthy reproductive system and responsible behaviour — including awareness, safe birth control, prevention of sexually transmitted infections (STIs) and help for infertile couples.

Programmes and awareness

- India started a national family-planning programme in 1951 — among the first in the world. Today it is the Reproductive and Child Health Care (RCH) programme.
- Amniocentesis** tests the amniotic fluid for genetic disorders. Its misuse for sex determination (female foeticide) is banned by law in India.

Population and birth control

- The legal marriage age in India is 18 years for females and 21 for males.

Natural methods	Periodic abstinence (avoiding days 10–17 of the cycle), withdrawal, lactational amenorrhoea (up to 6 months after birth).
Barrier methods	Condoms (also protect against STIs and HIV), diaphragms, cervical caps and vaults.
IUDs	Copper-releasing (CuT, Cu7, Multiload 375), hormone-releasing (LNG-20, Progestasert) and non-medicated (Lippes loop).
Oral pills	Progestogens or progestogen–oestrogen combinations; stop ovulation. Saheli is a weekly non-steroidal pill (made by CDRI, Lucknow).
Surgical methods	Vasectomy (in males, vas deferens cut and tied) and tubectomy (in females, fallopian tube cut and tied). Highly effective but hard to reverse.

- MTP (medical termination of pregnancy)** is legal in India under the MTP Act (amended 2017); it is safest in the first trimester.

Sexually transmitted infections (STIs)

- Examples: gonorrhoea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis B and HIV/AIDS.
- Hepatitis B, genital herpes and HIV infections are not completely curable.
- Prevention: avoid unknown or multiple partners, always use condoms, get early diagnosis and full treatment.

Infertility and ART

IVF–ET	In vitro fertilisation followed by embryo transfer ("test-tube baby").
ZIFT	Zygote (or early embryo up to 8 cells) transferred into the fallopian tube.
IUT	Embryo with more than 8 cells transferred into the uterus.
GIFT	An ovum from a donor is transferred into the fallopian tube of a female who cannot make ova.
ICSI	A sperm is injected directly into the ovum.
AI / IUI	Artificial insemination — semen from the husband or a donor placed in the vagina or uterus (intra-uterine insemination).

Exam questions

Q. Why is a condom considered a good contraceptive?

It is a barrier that stops sperm reaching the ovum, and it also protects against STIs and HIV/AIDS. It is cheap, easy to use and has no side effects.

Q. How do copper IUDs prevent pregnancy?

The copper ions released reduce the movement of sperm and their ability to fertilise the ovum.

Q. What is the difference between ZIFT and IUT?

In ZIFT the zygote or early embryo (up to 8 blastomeres) is placed in the fallopian tube. In IUT an embryo with more than 8 blastomeres is placed in the uterus.

Chapter 3. Evolution

In simple words: Life on Earth changed slowly over millions of years from simple to complex forms. Darwin explained this by natural selection: individuals better suited to their environment survive and reproduce more, passing on their useful traits.

Origin of life

- The Earth formed about 4.5 billion years ago; life appeared about 4 billion years ago.
- **Oparin and Haldane:** the first life arose from non-living organic molecules in the early oceans (chemical evolution).
- **Miller's experiment (1953):** CH_4 , NH_3 , H_2 and water vapour with electric sparks in a closed flask at 800 °C produced amino acids — supporting chemical evolution.

Evidence for evolution

- **Fossils** in rock layers show that different organisms lived at different times.
- **Homologous organs:** same basic structure, different functions — forelimbs of whale, bat, cheetah and human. They show **divergent evolution**.
- **Analogous organs:** different structure, same function — wings of a butterfly and a bird; eye of an octopus and a mammal. They show **convergent evolution**.
- **Biochemical evidence:** similar proteins and genes across organisms.
- **Natural selection seen today:** industrial melanism in the peppered moth (England), and resistance of bacteria to antibiotics and insects to pesticides.

Theories

- **Lamarck:** use and disuse of organs; acquired characters are inherited (giraffe's long neck). This is not accepted now.
- **Darwin:** variation exists; organisms produce many offspring; there is a struggle for existence; the fittest survive (**natural selection**) and over time new species arise. He studied finches of the Galapagos Islands.
- **Hugo de Vries:** worked on the evening primrose; proposed that **mutations** (sudden large changes) cause evolution — saltation.

Hardy–Weinberg principle

- In a large population with no mutation, gene flow, genetic drift, natural selection or non-random mating, allele frequencies stay constant: $p^2 + 2pq + q^2 = 1$.
- A change in these frequencies means the population is evolving.
- **Genetic drift:** a chance change in allele frequency; strong in small populations (founder effect).

Adaptive radiation and human evolution

- **Adaptive radiation:** many forms evolve from one ancestor to fill different habitats — Darwin's finches, Australian marsupials.
- Human evolution (simplified): Dryopithecus and Ramapithecus → Australopithecus (East African grasslands) → Homo habilis (first tool-maker, brain about 650–800 cc) → Homo erectus (about 900 cc, ate meat) → Neanderthal man (about 1400 cc, buried the dead) → Homo sapiens (arose in Africa).

Exam questions

Q. Distinguish between homologous and analogous organs.

Homologous organs have the same basic structure and origin but different functions (forelimbs of whale and bat). Analogous organs have different structure and origin but the same function (wings of insect and bird).

Q. What did Miller's experiment show?

Simple organic molecules like amino acids can form from inorganic gases (methane, ammonia, hydrogen, water vapour) under conditions like the early Earth, supporting chemical evolution.

Q. State the Hardy–Weinberg principle.

In a large, randomly mating population with no evolutionary forces, the allele and genotype frequencies remain constant from generation to generation: $p^2 + 2pq + q^2 = 1$.

Q. What is industrial melanism?

In industrial England, soot darkened tree trunks, so dark-coloured peppered moths were hidden from birds and became more common than light moths — natural selection in action.

Chapter 4. Human Health and Disease

In simple words: Health is a state of complete physical, mental and social well-being. Diseases can be caused by pathogens (germs), by faulty body functions, or by harmful habits. The immune system protects us, and vaccines train it in advance.

Common diseases caused by pathogens

Typhoid	Bacterium <i>Salmonella typhi</i> ; contaminated food and water; high fever. Widal test confirms it.
Pneumonia	Bacteria <i>Streptococcus pneumoniae</i> and <i>Haemophilus influenzae</i> ; infects the alveoli of the lungs.
Common cold	Rhinoviruses; nose and respiratory passage; droplets.
Malaria	Protozoan <i>Plasmodium</i> (<i>P. vivax</i> , <i>P. falciparum</i> — most serious); spread by female <i>Anopheles</i> mosquito. Haemozoin toxin causes chill and high fever.
Amoebiasis	Protozoan <i>Entamoeba histolytica</i> ; houseflies carry it; affects the large intestine.
Ascariasis	Roundworm <i>Ascaris</i> ; contaminated food and water.
Filariasis (elephantiasis)	Worm <i>Wuchereria</i> ; spread by <i>Culex</i> mosquito; swelling of the lower limbs.
Ringworm	Fungi (<i>Microsporum</i> , <i>Trichophyton</i> , <i>Epidermophyton</i>); dry scaly lesions on skin, nails, scalp.

- Prevention: clean drinking water, proper sewage disposal, hygiene, and control of mosquitoes (removing stagnant water, *Gambusia* fish that eat larvae).

Immunity

- **Innate immunity** (present from birth): physical barriers (skin, mucus), physiological barriers (stomach acid, saliva, tears), cellular barriers (neutrophils, monocytes, NK cells) and cytokine barriers (interferons).
- **Acquired immunity**: specific and has memory. The first response is slow (primary), and the later response is fast and strong (secondary).
- **B-lymphocytes** make **antibodies** (humoral immunity). **T-lymphocytes** fight directly (cell-mediated immunity) — this also causes graft rejection.
- An antibody is Y-shaped, with two heavy and two light chains (H_2L_2). Types: IgA, IgM, IgE, IgG, IgD.
- **Active immunity**: the body makes its own antibodies (infection or vaccine). **Passive immunity**: ready-made antibodies are given (colostrum, anti-tetanus serum, snake antivenom).
- **Vaccination**: a weakened or killed pathogen (or its parts) makes memory cells; on later infection the body reacts quickly.
- **Allergy**: an exaggerated response to allergens like pollen or dust; IgE and histamine are involved. **Autoimmunity**: the body attacks its own cells (rheumatoid arthritis).
- Lymphoid organs: primary — **bone marrow** and **thymus**; secondary — spleen, lymph nodes, tonsils, Peyer's patches, MALT.

AIDS and cancer

- **AIDS** is caused by **HIV**, a retrovirus. It spreads by unsafe sex, infected blood, shared needles, and from mother to child. HIV attacks **helper T-cells**, so immunity falls. Diagnosis: **ELISA** test. Antiretroviral drugs prolong life but do not cure it.

- **Cancer:** uncontrolled cell division due to loss of contact inhibition. Benign tumours stay in one place; malignant tumours spread (**metastasis**). Causes (carcinogens): X-rays, UV rays, tobacco smoke, oncogenic viruses. Detection: biopsy, CT, MRI. Treatment: surgery, radiotherapy, chemotherapy, immunotherapy (α -interferon).

Drugs and alcohol abuse

- Opioids (heroin/smack from morphine — a depressant), cannabinoids (charas, ganja, marijuana — affect the heart), coca alkaloids (cocaine — stimulant, hallucinations).
- Tobacco contains **nicotine**; smoking causes cancers of lung, mouth and throat, bronchitis and emphysema. Alcohol damages the liver (cirrhosis).
- Prevention: avoid peer pressure, get help from parents, teachers and counsellors, and seek medical help early.

Exam questions

Q. Name the vector and causative organism of malaria.

Malaria is caused by the protozoan Plasmodium and spread by the bite of an infected female Anopheles mosquito.

Q. Distinguish between active and passive immunity.

In active immunity the body makes its own antibodies after infection or vaccination; it is slow but long-lasting. In passive immunity ready-made antibodies are given; it is quick but short-lived.

Q. Which cells does HIV attack?

Helper T-lymphocytes. As their number falls, the person cannot fight even common infections.

Q. What is metastasis?

The spread of cancer cells from a malignant tumour through blood to other parts of the body, where they form new tumours.

Chapter 5. Biotechnology: Principles and Processes

In simple words: Biotechnology uses living organisms or their parts to make useful products. Its two core techniques are genetic engineering (changing DNA, making recombinant DNA) and growing microbes in large, sterile containers (bioreactors).

Basic steps of making recombinant DNA

- 1. Find and cut out the desired gene from DNA.
- 2. Join it into a **vector** (carrier) DNA, such as a plasmid.
- 3. Put the recombinant DNA into a host cell (e.g. *E. coli*) — **transformation**.
- 4. Grow the host so the gene is copied and the product is made.
- The first recombinant DNA was made in 1972 by Stanley Cohen and Herbert Boyer, using a plasmid of *Salmonella typhimurium*.

Tools of genetic engineering

Restriction enzymes	"Molecular scissors" that cut DNA at specific palindromic sequences. EcoRI (from <i>E. coli</i> RY13) cuts at GAATTC, giving sticky ends.
DNA ligase	"Molecular glue" that joins DNA fragments.
Vectors	Carriers such as plasmids and bacteriophages. A vector needs ori (origin of replication), selectable markers (e.g. ampicillin resistance) and cloning sites. pBR322 is a common plasmid vector.
Ti plasmid	From <i>Agrobacterium tumefaciens</i> ; used to carry genes into plants.
Competent host	Cells treated with calcium ions (and heat shock) so they take up DNA.

Other key techniques

- **Gel electrophoresis:** DNA pieces are separated by size in agarose gel; DNA (negatively charged) moves towards the positive end; smaller pieces move farther. Stained with ethidium bromide and seen under UV light.
- **Insertional inactivation:** a gene inserted inside the lacZ gene stops β -galactosidase; recombinant colonies stay white while non-recombinants turn blue with a chromogenic substrate (blue–white screening).
- **Other ways to insert DNA:** microinjection (into animal cell nucleus), gene gun / biolistics (into plant cells), disarmed pathogen vectors.
- **PCR (polymerase chain reaction):** makes millions of copies of a DNA piece. Three steps repeated: denaturation (heat), annealing of primers, extension by **Taq polymerase** (heat-stable, from *Thermus aquaticus*).

Bioreactors and downstream processing

- Large vessels (100–1000 litres) giving the best temperature, pH, oxygen and nutrients. The stirred-tank bioreactor is common.
- **Downstream processing:** separation and purification of the product, then formulation with preservatives and clinical trials for medicines.

Exam questions

Q. What are restriction enzymes? Why are they called molecular scissors?

They are enzymes that recognise specific base sequences (palindromes) in DNA and cut it there. Because they cut DNA at exact places, they are called molecular scissors.

Q. Why is Taq polymerase used in PCR?

It is heat-stable, so it is not destroyed at the high temperature used to separate DNA strands in each cycle.

Q. What is a selectable marker?

A gene in the vector that helps to identify and select the cells that have taken up the vector, e.g. genes for resistance to ampicillin or tetracycline.

Chapter 6. Biotechnology and its Applications

In simple words: Biotechnology has given us pest-resistant crops, cheaper medicines like human insulin, new ways to treat genetic disease, and fast tests for diseases. It also raises ethical questions that need rules and care.

In agriculture

- **GM (genetically modified) crops:** more tolerant to stress, less need for pesticides, less post-harvest loss, more nutritious (Golden rice rich in vitamin A).
- **Bt cotton:** has cry genes from the bacterium *Bacillus thuringiensis*. The Bt toxin is inactive in the bacterium but becomes active in the alkaline gut of insects, killing bollworms. cryIAc and cryIIAb control cotton bollworms; cryIAb controls corn borer.
- **RNA interference (RNAi):** used to protect tobacco plants from the nematode *Meloidogyne incognita*; the nematode's own mRNA is silenced.

In medicine

- **Human insulin:** Eli Lilly (1983) made the A and B chains separately in *E. coli* and joined them with disulphide bonds. Called Humulin.
- **Gene therapy:** a normal gene is put into a patient's cells. The first case (1990) was a 4-year-old girl with **ADA deficiency**, given lymphocytes carrying a functional ADA gene.
- **Molecular diagnosis:** PCR, ELISA and DNA probes detect diseases early, even when pathogen numbers are low (e.g. HIV).

Transgenic animals

- Animals with a foreign gene, used to study diseases, to make biological products and for testing vaccines and chemical safety.
- **Rosie** (1997) was a transgenic cow whose milk contained human alpha-lactalbumin, more balanced for human babies.

Ethical issues

- **GEAC** (Genetic Engineering Appraisal Committee) in India decides on the safety of GM research and release of GM organisms.
- **Biopiracy:** using biological resources or traditional knowledge of a country without permission or fair payment — e.g. attempts to patent Basmati rice and products of turmeric and neem.

Exam questions

Q. Why does the Bt toxin not kill the bacterium itself?

The toxin exists in an inactive form (protoxin) inside the bacterium. It becomes active only in the alkaline gut of the insect.

Q. What is gene therapy? Give the first example.

Correcting a genetic defect by inserting a normal gene into the patient's cells. The first gene therapy (1990) treated ADA deficiency in a 4-year-old girl.

Q. What is biopiracy?

Using bio-resources or traditional knowledge of a nation (such as Basmati rice, turmeric or neem) by others without proper permission and compensation.