

Chapter 11: Reproduction — How Life Continues

1. What is Reproduction?

- **Reproduction** is the biological process by which living organisms produce new individuals of their own kind.
- It is one of the **fundamental characteristics of all living organisms**. Every organism has a definite life span — it is born, grows, matures, reproduces, and eventually dies.
- Without reproduction, a species would become **extinct**. It ensures the **continuity of life on Earth**.

2. Why is Reproduction Important?

- **Continuity of life** — without it, species die out.
- **Transfer of genetic information** from one generation to the next through genes (instructions inside every cell that direct how an organism grows and functions).
- **Creates variation** (in sexual reproduction) — small differences between parents and offspring. This variation helps species **adapt to changing environments**.
- Variation accumulated over many generations can even give rise to **new species** (evolution).

3. Two Main Types of Reproduction

Feature	Asexual Reproduction	Sexual Reproduction
Parents involved	One parent	Two parents
Gametes (sex cells)	No fusion of gametes	Male and female gametes fuse
Offspring	Genetically identical to parent (clones)	Inherit a mix of characteristics (variation)
Cell division	Mitosis (DNA copied exactly)	Meiosis (chromosome number halved) + fertilisation
Examples	Bacteria, amoeba, yeast, hydra, many plants	Flowering plants, most animals, humans

4. Asexual Reproduction — Detailed

4.1 What is Asexual Reproduction?

- A **single parent** produces offspring **without the fusion of gametes**.
- It involves repeated **mitotic divisions** — the DNA is copied exactly, so offspring are **genetically identical** to the parent. These identical offspring are called **clones**.

- Seen mostly in **lower and unicellular organisms** (bacteria, amoeba, yeast) and in some multicellular organisms (hydra, fungi, many plants).

4.2 Vegetative Propagation in Plants

- **Definition:** A type of asexual reproduction in plants where new plants arise from the **vegetative parts** (roots, stems, or leaves) of the parent plant, producing genetically identical offspring.
- Only **one parent** is involved → all offspring are **clones** of the parent.

Natural Examples:

Plant Part Used	How It Works	Example
Underground stem (tuber)	Eyes of potato sprout new plants	Potato
Rhizome (underground stem)	Sprouts new plants without seeds	Ginger
Stem cutting	Stem pieces grow into new plants	Money plant, sugarcane
Leaf	Tiny plantlets (buds) grow on leaf margins	Bryophyllum

Artificial Methods of Vegetative Propagation:

1. Cutting

- Cut a shoot (about 10–15 cm long) with **2–3 nodes** from a healthy parent plant.
- Remove leaves from the lower half of the cutting.
- Insert the cutting at a **45–60° angle** into soil mixed with compost.
- Water regularly — new roots and shoots grow from nodes.
- Examples: rose, sugarcane, money plant, bougainvillea.
- The cutting should always have at least **one node** from which new roots sprout.

2. Grafting

- Take a healthy rooted plant (**Plant A = rootstock**, e.g., wild rose).
- Take a stem piece from another plant (**Plant B = scion**, e.g., yellow rose).
- Create a slit/wound on Plant A's twig.
- Insert Plant B's stem cutting into Plant A's slit and tie with cloth/tape.
- Cut the other branches of Plant A so Plant B gets all nutrients.
- Water regularly — Plant B grows on Plant A's roots.

- **Why useful:** Combines the **strong roots** of one plant with the **desirable fruits/flowers** of another. Widely used for mango, apple, and rose.

3. Layering

- Select a **flexible, thin twig** of a plant (e.g., lemon, jasmine, guava).
- Bend the middle part of the twig and **bury it under the soil** surface.
- Water regularly — new roots develop at the buried part after 10–15 days.
- Once roots develop, **cut the twig** from the parent plant.
- The rooted twig now grows as a **new independent plant**.
- **Advantage:** The developing plant continues to receive nutrients from the parent until it can survive on its own.

4. Tissue Culture (Micropropagation)

- A **modern laboratory technique** where tiny pieces of plant tissue (often from **shoot tips / apical meristem**) are grown on special **nutrient media** to produce thousands of new plants.
- Produces **disease-free, high-yielding plantlets**.
- **Real-world impact:** Revolutionised banana farming in India — farmers get mass-produced, virus-free plantlets, ensuring high yields.

Advantages of Vegetative Propagation in Agriculture:

- Produces **genetically identical plants** — desirable characters are preserved.
- Plants **grow faster** than those from seeds — begin flowering/fruiting sooner.
- Farmers can produce plants on a **large scale** efficiently.
- Useful for plants that produce **few or sterile seeds** (e.g., banana, seedless grapes).

Krishi Vigyan Kendras (KVKs):

- Various KVKs under **ICAR (Indian Council of Agricultural Research)** teach farmers modern grafting and propagation techniques.
- Helps farmers grow high-yield fruits and boost their income.

4.3 Budding in Yeast and Hydra

- **Definition:** A form of asexual reproduction where a new organism grows as an **outgrowth (bud)** from the parent body and eventually separates to live independently.

Budding in Yeast:

- Yeast is a **unicellular** organism.
- A small, round outgrowth called a **bud** forms on the parent cell.
- The bud receives genetic material, grows in size, and eventually **separates** to become an independent organism.

- Yeast is active in **warm conditions (25–35°C)** — which is why bread rises in a warm kitchen.

Budding in Hydra:

- Hydra is a **simple multicellular** animal.
- **Repeated cell division** at a specific site on the parent body produces a bud.
- The bud grows and develops body structures similar to the parent, then **detaches** to live independently.
- **Multiple buds** can grow on a single Hydra at the same time.

4.4 Spore Formation in Fungi

- Fungi reproduce asexually through **spore formation**.
- **Spores** are tiny, lightweight structures, usually **single-celled**, produced in very large numbers.
- They are dispersed through **air currents** — that's how they settle on bread, walls, etc.

Types of Mould Spores:

- **Rhizopus** (black mould on bread): Spores form inside a **round sac-like structure (sporangium)** at the tip of hyphae.
- **Aspergillus** (found on damp walls, rotting food): Spores form on a **swollen vesicle** at the tip of a long fungal strand.

Germination Conditions:

- Spores need **warmth (25–35°C)** and **moisture** to germinate into new individuals.
- Low temperatures in a **refrigerator** slow or stop spore reproduction — this is why refrigerated food lasts much longer.
- Before refrigerators (about 100 years ago), fresh food lasted only 1–2 days!

Fungi — Not Just Spoilers:

- Fungi play important roles in nature by **decomposing organic waste** and dead matter, recycling nutrients in ecosystems.
- They are a source of important **antibiotics** such as **penicillin and amoxicillin**, which have saved millions of lives.
- They are also being explored for **environmental uses**, including degradation of heavy metals from industrial effluents and breakdown of plastic waste.

5. Sexual Reproduction

5.1 What is Sexual Reproduction?

- **Two parents** contribute genetic material; offspring are formed by the **fusion of gametes**, resulting in **variation**.
- **Gametes** are reproductive cells (sex cells) formed by **meiosis**. Male gamete = **sperm**; female gamete = **egg**.

- In flowering plants, **pollen grains** carry the male gamete, and the **ovule** contains the female gamete.

5.2 Chromosomes and Meiosis

- **Chromosomes** are thread-like structures in the nucleus that carry genetic information.
- Each species has a **fixed number** of chromosomes. Human body cells contain **46 chromosomes** arranged in **23 pairs**.
- If each generation received a complete set from both parents, the chromosome number would **double** every generation. **Meiosis** prevents this by **halving** the chromosome number in gametes.
- **Meiosis**: A special type of cell division that reduces the chromosome number from **diploid (46)** to **haploid (23)** in humans.
- This ensures that when two gametes fuse during fertilisation, the resulting cell has the correct chromosome number of **46**.
- During meiosis, chromosomes from each pair are distributed **randomly** into the gametes, producing an enormous number of possible genetic combinations → **variation**.

5.3 Sexual Reproduction in Flowering Plants

- Flowering plants (**angiosperms**) are the most diverse group of plants on Earth. **Flowers** are their organs of sexual reproduction.

Parts of a Flower:

Whorl	Part	Function
1. Sepals	Outermost, usually green	Enclose and protect the flower bud
2. Petals	Brightly coloured, often fragrant	Attract pollinators
3. Stamen (male)	Anther + Filament	Anther produces pollen (male gametes); filament supports the anther
4. Pistil/Carpel (female)	Stigma + Style + Ovary	Stigma receives pollen; style connects stigma to ovary; ovary contains ovules (female gametes)

Pollination:

- **Definition**: The transfer of pollen grains from the **anther** to the **stigma** of a flower.
- Pollination is essential for fertilisation and fruit formation.

Types of Pollination:

Type	Description	Variation
Self-pollination	Pollen from anther to stigma of the same flower or another flower on the same plant	No genetic variation
Cross-pollination	Pollen from anther of one plant to stigma of a flower on a different plant of the same species	Promotes genetic variation

Pollination Agents (Pollinators):

Agent	Examples	Adaptations
Wind	Wheat, maize, rice	Pollen small, light, produced in large quantities; stigmas long and feathery
Water	Vallisneria, Hydrilla	Pollen released into water, carried by currents
Insects	Sunflower, Hibiscus, marigold	Flowers brightly coloured, produce nectar and fragrance; pollen large and sticky
Birds	Coral tree, Hibiscus	Attract birds like sunbirds and Indian white-eye, which transfer pollen while feeding on nectar

Fertilisation and Seed Formation:

- After pollen lands on a compatible stigma, it **germinates** and produces a **pollen tube**.
- The pollen tube grows down through the style and into the ovary, carrying the **male gamete** towards the ovule.
- The male gamete **fuses with the egg cell** inside the ovule — this fusion is called **fertilisation**.
- The fertilised egg is called the **zygote**, which divides repeatedly and develops into an **embryo**.
- The **ovule** matures into a **seed** with a protective seed coat, and the **ovary** enlarges into a **fruit**.
- Seeds are dispersed by wind, water, or animals.
- Under suitable conditions of **moisture, air, and temperature**, the seed **germinates** and grows into a new plant.

Plant Breeding and Applications:

- Sexual reproduction in plants is important for **plant breeding** — selecting plants with desirable traits over generations.
- **Artificial hybridisation:** Stamens are removed before maturity, the flower is bagged to prevent unwanted pollination, and selected pollen is manually transferred to the stigma.
- **Genetic engineering:** Inserting specific genes into plant DNA to develop high-yielding, pest-resistant, and drought-tolerant crops.
- **P. Maheshwari**, known as the "**Father of Indian Embryology**", pioneered in-vitro fertilisation in flowering plants.

5.4 Sexual Reproduction in Animals

External Fertilisation:

- Female releases eggs into water; male releases sperm over them.
- **Fertilisation occurs outside the body** — seen in most **fish and amphibians** (e.g., frogs).
- Many eggs are lost to water currents and predators, so a **large number of eggs** are produced to ensure survival.

Internal Fertilisation:

- Male introduces sperm into the female's body; **fertilisation occurs inside the body**.
- Seen in **reptiles, birds, and mammals**.
- Provides **greater protection** to gametes and increases chances of successful fertilisation.
- **Fewer eggs** are produced as chances of survival are much higher.

Variations in Reproductive Strategies among Animals:

Animal	Habitat	Fertilisation	Eggs Produced	Survival of Young
Fish	Water	External	100s to 1000s at a time	Low
Frog	Water/Land	External	5,000 to 50,000 at a time	Low
Lizard	Land	Internal	2 to 20 at a time	Moderate
Bird	Water/Land	Internal	1 to 15 at a time	Moderate to High

- Fish, amphibians, and many insects produce **large numbers of eggs** with **little yolk** — larvae hatch early and feed themselves.
- Reptiles and birds produce **fewer eggs** with **plenty of yolk** — embryo is nourished until hatching.
- In mammals, the embryo develops **inside the mother's body** and is nourished through the **placenta**; after birth, young are fed with **milk**.

5.5 Reproduction in Human Beings

Human reproduction begins at **puberty**, when reproductive organs mature and start producing gametes — testes producing sperm in males, ovaries releasing eggs in females.

Male Reproductive System:

Part	Function
Testes (pair)	Produce sperm and male hormones; located in the scrotum (maintains slightly lower temperature needed for sperm production)
Vas deferens	Tubes that carry sperm from testes to the urethra
Seminal vesicles & prostate gland	Secrete fluids that mix with sperm to provide nourishment and aid movement
Urethra	Common passage for urine and semen (not at the same time)
Penis	Used for ejecting sperm and also passing urine

Sperm Structure: Head containing genetic material + long tail that helps it swim towards the egg.

Female Reproductive System:

Part	Function
Ovaries (pair)	Produce egg cells (ova) and secrete female sex hormones
Fallopian tubes (oviducts)	Connect each ovary to the uterus; usual site of fertilisation
Uterus	Thick-walled muscular organ where the embryo implants and develops
Cervix	Narrow lower part of uterus connecting it to the vagina
Vagina	Muscular canal that receives sperm during intercourse; birth canal during childbirth

Gametogenesis:

- The process of formation of gametes through **meiosis** in the testes and ovaries.
- Human sperm and eggs each contain **23 chromosomes**.
- When a sperm fertilises an egg, the resulting zygote has **46 chromosomes**.

- In males, gametogenesis produces many **small, motile** sperm; in females, it produces a **single large** egg.

Comparison of Male and Female Gametes:

Feature	Sperm	Egg
Size	Very small	Large
Number produced	Millions	Few
Stored nutrients	Absent	Present
Motility	Actively motile	Non-motile

Fertilisation and Implantation:

- From puberty onwards, a mature egg is released from an ovary approximately **once a month** — this is called **ovulation**.
- The egg travels through the **Fallopian tube** towards the uterus.
- During sexual intercourse, **millions of sperm** are deposited in the vagina and travel through the cervix and uterus to reach the Fallopian tube.
- If a sperm fuses with the egg, **fertilisation** occurs, forming a **zygote**.
- The zygote undergoes repeated **mitotic divisions** as it moves towards the uterus, forming an **embryo**.
- The embryo then **embeds in the thickened lining of the uterus** — this is called **implantation**, which marks the beginning of **pregnancy**.
- **In 1978, Subhash Mukhopadhyay** performed India's first IVF procedure, leading to the birth of **Kanupriya Agarwal (Durga)**.
- **IVF (In Vitro Fertilisation)**: Fertilisation occurs outside the body in a laboratory; the resulting embryo is transferred into the uterus.

5.6 Menstrual Cycle

- If the egg released during ovulation is **not fertilised**, the thickened uterine lining is no longer needed.
- The lining **breaks down and is shed**, along with a small amount of blood, through the vagina over **3 to 7 days** — this is called **menstruation** (period).

- Menstruation is a **normal and healthy** function of the female reproductive system.
- The entire cycle repeats approximately every **28 days** (21 to 35 days is also normal).
- It begins at **puberty** (usually ages 10–14) and continues until **menopause** at around age 50.

Phases of the Menstrual Cycle (Typical 28-Day Period):

Phase	Days	Events
Menstruation	Days 1–5	Uterine lining sheds. Blood and tissue leave through the vagina.
Follicular phase	Days 6–13	Uterine lining rebuilds. An egg matures in the ovary.
Ovulation	Day 14	A mature egg is released from the ovary into the Fallopian tube.
Luteal phase	Days 15–28	Uterine lining thickens further. If no fertilisation occurs, the cycle repeats.

Sex Determination:

- Every human cell contains two sex chromosomes: females have **XX**, males have **XY**.
- During meiosis, all eggs carry one **X** chromosome, while sperm carry either **X** or **Y**.
- If an **X-bearing sperm** fertilises the egg → child is **female (XX)**.
- If a **Y-bearing sperm** fertilises the egg → child is **male (XY)**.
- **The father determines the biological sex of the child.**

Menstrual Hygiene:

- Menstruation is a biological process and a sign of a healthy reproductive system. There is no basis for any social stigma associated with it.
- Sanitary pads (preferably biodegradable), tampons, and menstrual cups are safe to use. Pads should be changed every **4 to 6 hours**.
- The genital area should be washed with clean water regularly. Hands must be washed before and after changing products.

5.7 Pregnancy and Childbirth

- After implantation, special tissues develop between the uterine wall and the foetus called the **placenta**, through which the **nutritional, excretory, and respiratory needs** of the foetus are met.
- The development of the foetus inside the uterus till birth takes about **9 months** (divided into three trimesters).
- The birth of a fully developed foetus occurs as a result of **rhythmic contraction** of the muscles in the uterus.

- **Breastfeeding** is essential as it provides complete nutrition and protects the baby from diseases. Both mother and baby need proper care, including good nutrition, rest, and timely health support.

6. Reproductive Health

6.1 What is Reproductive Health?

It includes aspects like:

- Responsible, safe, and satisfying reproductive life.
- Awareness regarding fertility regulation methods, the right, freedom, and choice to control birth.
- Ability to prevent and control sexually transmitted diseases.

6.2 Sexual Maturity vs. Emotional Maturity

- **Sexual maturity:** The stage during adolescence when the body becomes capable of reproduction. In boys, sperm production begins; in girls, menstrual cycles start.
- **Emotional maturity** develops later and involves handling emotions and making responsible decisions.
- Readiness for sexual activity requires **responsible decision-making** to avoid unplanned pregnancies and sexually transmitted infections (STIs).

6.3 Sexually Transmitted Infections (STIs)

- Infectious diseases caused by bacteria, viruses, protozoans, and fungi that spread through **sexual contact**.
- Examples: **gonorrhoea, herpes, genital warts, syphilis, and HIV** (which eventually leads to AIDS).
- **Use of condoms** helps prevent STIs and also reduces the chances of pregnancy.

6.4 Methods to Prevent Unwanted Pregnancy (Contraception)

Method	How It Works	Examples
Barrier Method	Physical devices prevent entry of sperm into the genital tract; also prevent STIs	Condoms, vaginal covers
Chemical Method	Oral pills (hormonal preparations) inhibit production of gametes by changing hormonal balances	Oral contraceptive pills

Method	How It Works	Examples
Intra-Uterine Devices (IUDs)	Copper-T placed safely in the uterus; prevents implantation	Copper-T
Surgical Methods	A small portion of the vas deferens (males) or fallopian tube (females) is surgically removed or ligated (tied)	Vasectomy (males), Tubectomy (females)

6.5 Abortion

- **Abortion:** The surgical removal of an unwanted pregnancy, generally carried out within the **first trimester**, when the embryo is small.
- **Prenatal sex determination and sex-selective abortion are illegal in India** as they disturb the natural sex ratio in society.

7. Quick Revision — Key Terms

Term	Definition
Reproduction	Biological process by which living organisms produce new individuals of the same species
Asexual Reproduction	Reproduction involving one parent; produces genetically identical offspring (clones)
Sexual Reproduction	Reproduction involving two parents; gametes fuse to form offspring with variation
Clone	An organism produced by asexual reproduction that is genetically identical to its parent
Gametes	Reproductive cells (sperm and egg) formed by meiosis
Meiosis	Cell division that reduces chromosome number from diploid to haploid; forms gametes
Fertilisation	Fusion of male and female gametes to form a zygote
Zygote	The fertilised egg; develops into an embryo

Term	Definition
Embryo	Early stage of development formed by repeated mitotic divisions of the zygote
Implantation	Attachment of the developing embryo to the inner lining of the uterus
Placenta	Special tissue between uterine wall and foetus; provides nutrition, excretion, and respiration
Ovulation	Release of one mature egg from an ovary, usually once a month
Menstruation	Shedding of the thickened uterine lining with blood when egg is not fertilised