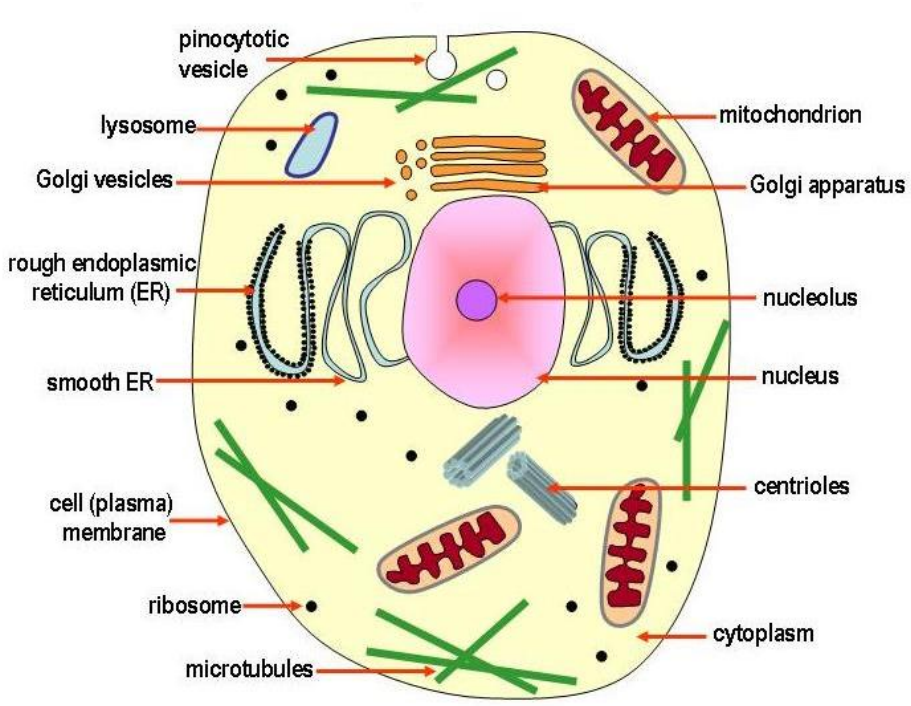
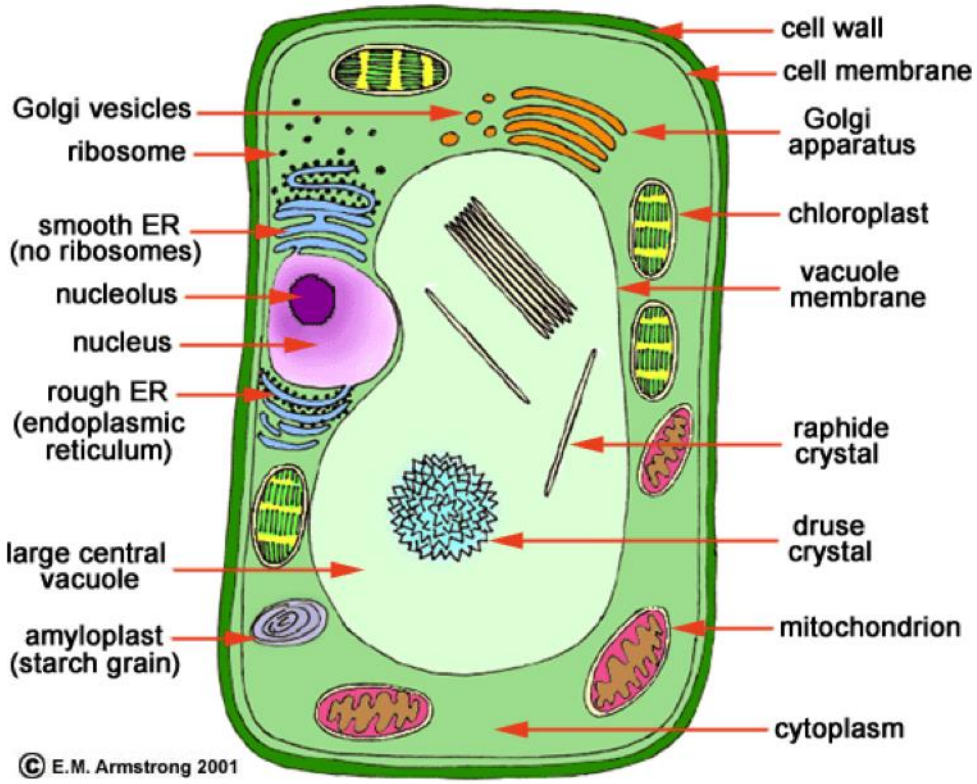
SENIOR FIVE TERM 1

TOPIC 1/1: Agricultural Biology in Crops and Animals

Fine structure of animal cell



Fine structure of plant cell



Differences between plant cell and animal cell

	Plant Cell	**Animal cells**
1	Has chloroplast	Lack chloroplast
2	Has cell wall	Lack cell walls
3	Has large central vacuole	Lack a vacuole or has small vacuoles
4	Has starch granule	Lack starch granule
5	Nucleus at the side	Nucleus centrally placed
6	Tonoplast present around vacuole	Tonoplast absent
7	Centrioles absent	Centrioles present
8	Cilia and flagella absent in higher plants	Cilia and flagella present
9	Few cells are capable of division	Almost all cells are capable of division

Parts of the cell

1. **Cytoplasm**

All cells have a cytoplasmic matrix. It is an aqueous solution or colloidal suspension of mainly vital cellular materials. It is the site for protein synthesis and metabolic activities

Functions of the cytoplasm
1. Contain or keep organelles
2. Contains nutrients for organelles
3. Stores materials
4. Maintain conductive atmosphere for cellular reaction

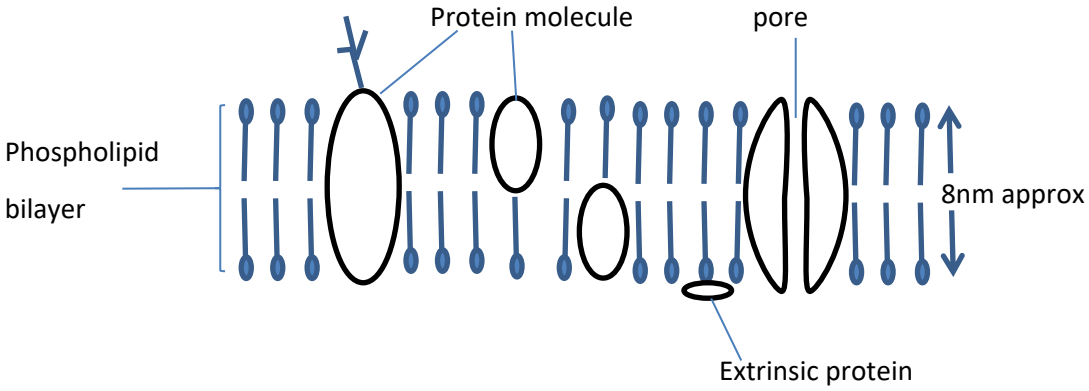
2. Cell membrane

It serves as a boundary between the cell and its environment. It may permanently exclude some items from the cell while permanently retaining others.

Functions of the cell membranes
1. It separates the contents of the cell from the external environment.
2. Controls exchange of materials between the cells and external environment
3. It separates compartment with specialized functions inside the cell
4. Acts as receptor site for recognizing external stimulus such as hormones.
5. Allows uptake of materials by phagocytosis and pinocytosis.
6. Support enzymes of complex metabolic pathways in place for close proximity.

The fluid mosaic model of the cell

- The cell membrane is about 7nm thick
- It consists of a continuous phospholipid bilayer in which proteins are scattered in a mosaic manner.
- Proteins penetrate through the bilayer at a varying degree to form intrinsic and extrinsic proteins
- Intrinsic protein are those that penetrate through the bilayer while extrinsic proteins are those that float on top as islands in a sea.



Components of cell membrane and their function

1. Phospholipids: affect the fluidity and permeability of the membrane
2. Cholesterol: make the membrane less fluid at higher temperature.

3. Glucolipids: act as recognition sites e.g. human blood group system is as result of different glycolipids on the cell membrane of red blood cell.
4. Proteins:
   (i) provide structural support for the membrane,
   (ii) assist in active transport across the membrane
   (iii) act as recognition sites
   (iv) act as enzyme, energy transducers and electron carriers
5. Glycoproteins are recognition sites, e.g., for neurotransmitters and hormones.

The nucleus

This is the largest cell organelle enclosed by a double membrane perforated by nuclear pores. It contains chromatin which is the form of chromosomes during interphase. The nucleus also contains nucleolus that produces ribosomes

Functions of nucleus

1. Contains DNA for inheritance controlling cell division and protein synthesis.
2. The nucleolus manufactures ribosome
3. Controls all activities of the cell

28. Growth in size of a single cell is limited by the

A. cytoplasm.

B. nucleus.

C. cell vacuole.

D. cell membrane.

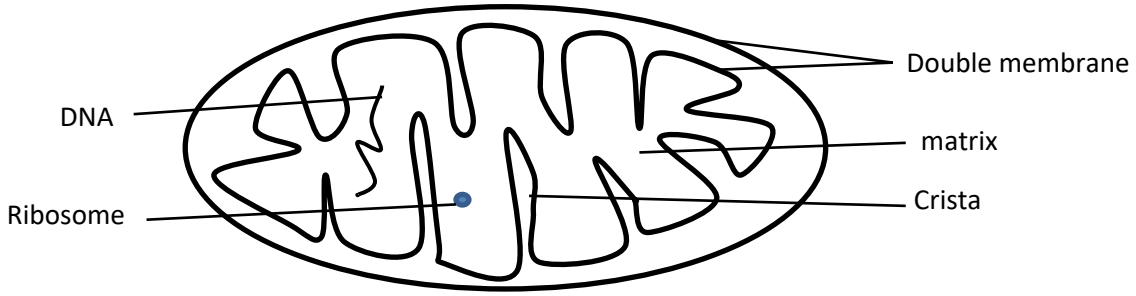
Nuscloli

Functions of nucleoli

The nucleolus is the site of synthesis of ribosomal RNA which is combined with proteins in the cytoplasm to make ribosomes.

Mitochondria

It a cell organelle surrounded by two membranes, the inner being folded to form **cristae**. The mitochondrion contains a matrix with a few ribosomes a circular DNA molecule and phosphate granules. Its main function is producing energy by aerobic respiration.



Adaptations of mitochondria to its function

1. The inner membrane is folded to form cristae that increase surface area for enzymatic activities.
2. Contains circular DNA to produce the necessary enzymes.
3. Has a large surface area for diffusion of gases.
4. Matrix contain necessary enzymes for Krebs cycle

Endoplasmic reticulum

This is a system of flattened membranes bound sacs called cisternae, forming tubes and sheet. Is continuous with the outer membrane of the nuclear envelope. Some of its parts is covered by ribosome and this is called **rough endoplasmic reticulum**. The part without ribosomes is called **smooth endoplasmic reticulum**.

Functions of endoplasmic reticulum

1. Ribosomes are site of protein synthesis
2. Smooth endoplasmic reticulum is a site of lipids and steroid synthesis.
3. The tubes are for intracellular transport

Golgi apparatus

Consists of stack flattened membrane-bound sacs, called cisternae, continuously being formed at one end of the stack and budded off as vesicles at the other.

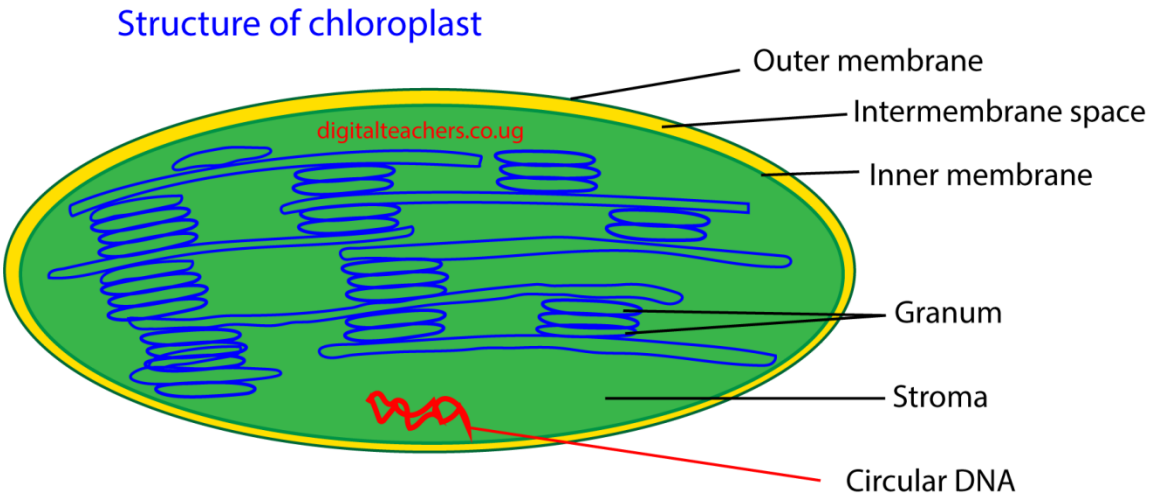
Functions of Golgi apparatus

1. Producing glycoproteins by adding carbohydrates to proteins
2. Producing secretory enzymes, e.g. digestive enzymes
3. Replenishing the cell wall
4. Produces materials for synthesis of plant cell wall.
5. Produces lysosomes concerned with breakdown of worn out structures in the cell.

Lysosome

Single small organelle that contain enzymes to destroy worn out parts of the cell and autolysis (digestion of the cell)

Chloroplasts



It is restricted to plant cell and used for photosynthesis. It is surrounded by an envelope of two membranes and contains a gel-like stroma through which runs a system of membranes that are stacked in places to form **grana**. The stroma contains ribosomes, circular DNS and lipid droplets.

Similarities between mitochondria and chloroplasts

1. Both have double membrane, circular DNA
2. Inner membrane is folded to increase the surface area
3. Contain ATPase enzyme for ATP synthesis
4. Both occur in plant
5. Both contain carrier proteins
6. Both contain circular DNA
7. Both contain ribosome,

Differences between mitochondria and chloroplasts

Chloroplast	Mitochondria
Structural difference	
1. Contain chlorophyll	Does not contain chlorophyll
2. Inner membrane form grana	Inner membrane folded to form cristae
3. May contain starch granules	Does not contain starch granules
Functional difference	
4. Use water	Produce water
5. Produce O_2	Produce CO_2
6. Use sunlight and store its energy in food made	Set energy free from food for work
7. Occur only in green plants	Occur in both plants and animals

The role of plant cells and animal cells in agriculture production

Role of Plant Cells in Agriculture

(i) **Photosynthesis**: Chloroplasts in plant cells convert sunlight into energy, producing food (carbohydrates) that sustains crops.
(ii) **Cell walls**: Provide structure and strength, allowing plants to grow upright and maximize sunlight capture.
(iii) **Storage vacuoles**: Store water, nutrients, and waste, helping plants survive droughts and nutrient shortages.
(iv) **Reproduction**: Plant cells enable seed formation, fruit development, and vegetative propagation (cuttings, grafting).
(v) **Nutrient cycling**: Root cells absorb minerals and water, supporting soil fertility and crop yields.
(vi) **Genetic improvement**: Plant cell biology underpins biotechnology (e.g., tissue culture, genetic modification) to create disease-resistant and high-yield varieties.

Role of Animal Cells in Agriculture

(i) **Growth and development**: Animal cells (muscle, bone, fat) determine livestock productivity (meat, milk, eggs).
(ii) **Reproduction**: Gametes (sperm and egg cells) ensure breeding and genetic diversity in livestock.

(iii) **Immune cells**: Protect animals from diseases, reducing losses in farming.
(iv) **Digestive cells**: Specialized cells in the gut absorb nutrients, influencing feed efficiency.
(v) **Biotechnology applications**: Animal cell culture is used in vaccine production, artificial insemination, and cloning to improve livestock health and productivity.
(vi) **By-products**: Animal cells contribute to leather, wool, and manure production, supporting multiple agricultural industries.

Chemical components of plant and animal cells and their uses

Chemical Components of Plant Cells

(i) **Cellulose (in cell walls)**
- Provides rigidity and structural support.
- Used industrially in paper, textiles, and biofuels.

(ii) **Chlorophyll (in chloroplasts)**
- Captures sunlight for photosynthesis.
- Basis of food production in agriculture.

(iii) **Starch (storage carbohydrate)**
- Stores energy in plant cells.
- Used as food, animal feed, and in industries (e.g., adhesives, bioplastics).

(iv) **Proteins**
- Enzymes regulate metabolic processes.
- Used in food (soy protein), pharmaceuticals, and biotechnology.

(v) **Lipids (oils and fats)**
- Energy storage and membrane structure.
- Used in cooking oils, cosmetics, and biofuel production.

(vi) **Nucleic acids (DNA & RNA)**
- Carry genetic information for plant growth and reproduction.
- Basis for crop improvement through biotechnology.

Chemical Components of Animal Cells

(i) **Proteins**

- Structural (collagen, keratin) and functional (enzymes, hormones).
- Used in food (meat, milk, eggs), pharmaceuticals, and leather production.

(ii) **Lipids (fats and cholesterol)**

- Energy storage and cell membrane integrity.
- Used in dairy products, meat, and industrial applications (soap, cosmetics).

(iii) **Carbohydrates (glycogen)**

- Stored energy in animal cells.

- Important for metabolism and livestock productivity.

(iv) **Nucleic acids (DNA & RNA)**

- Control heredity and protein synthesis.
- Used in genetic improvement of livestock and disease research.

(v) **Minerals and ions (Ca^{2+}, Na^{+}, K^{+}, Mg^{2+})**

- Regulate nerve impulses, muscle contraction, and enzyme activity.
- Essential in animal nutrition and veterinary medicine.

(vi) **Water**

- Medium for biochemical reactions.
- Maintains cell shape and regulates temperature.

Cell physiology

Cell physiology in agriculture refers to the study of how plant and animal cells function to support crop growth, livestock productivity, and overall agricultural systems. By understanding cellular processes such as photosynthesis, respiration, nutrient absorption, and reproduction, farmers and scientists can improve yields, enhance sustainability, and adapt to environmental challenges.

Role of Plant Cell Physiology in Agriculture

- **Photosynthesis:** Chloroplasts convert sunlight into chemical energy, forming the basis of crop productivity.
- **Respiration:** Mitochondria release energy (ATP) for growth, reproduction, and stress resistance.
- **Water relations:** Processes like osmosis, diffusion, and transpiration regulate water balance, crucial for drought tolerance.
- **Nutrient uptake:** Root cells absorb minerals (nitrogen, phosphorus, potassium), directly affecting yield.
- **Growth and division:** Mitosis drives tissue growth, while meiosis ensures genetic diversity in seeds.
- **Stress physiology:** Cells respond to heat, salinity, and pests, influencing crop resilience.

Role of Animal Cell Physiology in Agriculture

- **Growth and metabolism:** Muscle and fat cells determine meat and dairy production.

- **Reproductive cells:** Gametes ensure livestock breeding and genetic improvement.
- **Immune cells:** Protect animals from diseases, reducing losses in farming.
- **Digestive cells:** Specialized gut cells absorb nutrients, improving feed efficiency.
- **Biotechnology:** Animal cell culture supports vaccine production, artificial insemination, and cloning.

Osmosis

Osmosis is a fundamental biological process where water molecules move across a **semi-permeable membrane** from a region of **low solute concentration (high water potential)** to a region of **high solute concentration (low water potential)**

Features of Osmosis

- **Passive process**: Does not require energy (ATP).
- **Selective movement**: Only water molecules move, not solutes.
- **Semi-permeable membrane**: Allows water to pass but restricts larger molecules or ions.
- **Direction of flow**: Always from dilute solution → concentrated solution until equilibrium is reached.

Importance of osmosis in Plant Cells

- **Turgor pressure**: Osmosis fills vacuoles with water, pressing the cell membrane against the cell wall, keeping plants firm.
- **Nutrient uptake**: Helps roots absorb water from the soil.
- **Growth**: Drives cell expansion during plant development.
- **Wilting**: Occurs when water leaves cells due to osmosis in dry conditions.

Importance of osmosis in Animal Cells

- **Cell volume regulation**: Prevents cells from shrinking (crenation) or bursting (lysis).
- **Transport of fluids**: Maintains balance of water between blood plasma and tissues.
- **Kidney function**: Osmosis regulates water reabsorption, maintaining hydration.
- **Digestion**: Helps in absorption of water in intestines.

Key Takeaway

Osmosis is the **movement of water across membranes** that sustains life in both plants and animals. It underpins processes like **plant rigidity, nutrient absorption, and fluid balance in animals**, making it vital for agriculture, medicine, and everyday life.

Factors affecting the rate of osmosis

Factor	Effect on Osmosis Rate
Concentration gradient	Larger difference → faster osmosis
Temperature	Higher temperature → faster (up to a limit)
Surface area	Larger area → faster
Membrane thickness	Thinner → faster
Membrane permeability	More permeable → faster
Pressure	High opposing pressure → slower
Solute type	Strong gradients → faster

Axperiment to demonstrate osmosis

Materials: Potatoes, knife, ruler, cups, water, sugar or salt, scale (optional).

Setup:

- **Label** three cups: pure water, dilute solution (e.g., 5% sugar/salt), concentrated solution (e.g., 10–15%).
- **Cut** equal potato cylinders or slices (same size and thickness).
- **Measure** initial mass or length (optional).
- **Immerse** one potato piece in each cup for 45–60 minutes.

Observations:

- **Pure water (hypotonic):** Potato becomes firm and swells; mass/length increases.
- **Dilute solution (near isotonic):** Slight or no change.
- **Concentrated solution (hypertonic):** Potato becomes soft and shrinks; mass/length decreases.

Explanation:

Water moves into cells in pure water (increasing turgor) and out of cells in concentrated solution (loss of turgor), demonstrating osmosis.

Diffusion

Diffusion is the passive movement of particles (atoms, molecules, or ions) from a region of **high concentration** to a region of **low concentration**, until equilibrium is reached. It is a fundamental process in biology, chemistry, and everyday life.

Key Features of Diffusion

- **Passive process**: Does not require energy (ATP).

- **Concentration gradient**: Movement occurs down the gradient (from high → low).
- **Random motion**: Driven by the natural kinetic energy of particles.
- **Equilibrium**: Stops when concentrations are equal across the space.

Importance of diffusion in Plant Cells

(i) **Gas exchange**: Oxygen and carbon dioxide diffuse in and out of leaves during photosynthesis and respiration.
(ii) **Nutrient transport**: Minerals and water vapor diffuse through root hairs and stomata.
(iii) **Fragrance release**: Flowers release scents by diffusion into the air to attract pollinators.

Importance in Animal Cells

(i) **Respiration**: Oxygen diffuses from alveoli into blood; carbon dioxide diffuses outduring gaseous exchange.
(ii) **Digestion**: Nutrients (like glucose) diffuse into blood vessels in the small intestine during absorption.
(iii) **Waste removal**: Carbon dioxide and urea diffuse out of cells into blood for excretion.
(iv) **Nerve function**: Diffusion of ions (Na^+, K^+, Cl^-) across membranes helps transmit impulses.

Everyday Examples

Example	Explanation
Perfume spreading in a room	Molecules move from high concentration near the bottle to low concentration in the air
Sugar dissolving in tea	Sugar molecules spread evenly throughout the liquid
Breathing	Oxygen diffuses into blood, carbon dioxide diffuses out
Cooking	Aroma of food diffuses through the kitchen

Key Takeaway

Diffusion is the **natural spreading of particles** that underpins vital processes like breathing, photosynthesis, and nutrient absorption. It is essential for life and explains how substances move without energy input.

Factors affecting the rate of diffusion

Factor	Effect on Rate of Diffusion	Example
Concentration gradient	Larger difference → faster diffusion	Oxygen into blood from alveoli
Temperature	Higher temperature → faster diffusion	Faster scent spread in warm air
Surface area	Larger area → faster diffusion	Root hairs absorbing minerals
Distance/thickness	Thinner barrier → faster diffusion	Alveoli walls in lungs
Molecule size/nature	Smaller/non-polar → faster diffusion	CO_2 vs glucose
Medium	Gas > liquid > solid	Perfume vs sugar in water

Experiment to demonstrate diffusion

(1) Iodine diffusion into potato tissue (starch staining)

Purpose: Show iodine molecules diffusing into living plant tissue and binding to starch.

Materials: Fresh potato slice (1 cm thick), knife, iodine solution, two clear cups, water, timer.

Steps:

- **Prepare:** Rinse two potato slices; place one in water (control) and one in iodine solution.
- **Wait:** 10–20 minutes.
- **Observe:** Remove slices, rinse lightly.

Observations:

- **Iodine beaker:** Potato turns blue-black from the surface inward.
- **Water beaker (control):** No color change.

Explanation:

- **Diffusion:** Iodine molecules move from high concentration in the solution into the potato's cells down their concentration gradient.
- **Result:** Iodine binds starch in amyloplasts, revealing how small molecules penetrate living tissue via diffusion.

(2) Leaf stomata water vapor diffusion (cobalt chloride paper)

Purpose: Show diffusion of water vapor from a living leaf through stomata.

Materials: Fresh broadleaf, cobalt chloride paper (blue), petroleum jelly or tape, tweezer, timer.

Steps:

- **Prepare:** Place a strip of cobalt chloride paper on the leaf's underside (more stomata). Seal edges lightly to hold.
- **Wait:** 1–5 minutes.

Observations:

- Paper turns from blue to pink under the leaf, indicating moisture arrival.

Explanation:

- **Diffusion:** Water vapor produced in leaf air spaces diffuses out through stomata down its concentration gradient to the paper, changing its color.

Controls:

- Cover stomata with petroleum jelly on part of the leaf before placing cobalt paper; color change is slower or absent there.

Active transport

Active transport is the movement of molecules or ions across a cell membrane **against their concentration gradient** (from low concentration → high concentration). Unlike diffusion or osmosis, it requires **energy in the form of ATP** and often involves **specialized carrier proteins or pumps**.

Key Features of active transport

(i) **Energy-dependent**: Uses ATP to move substances.
(ii) **Against gradient**: Moves molecules from low → high concentration.
(iii) **Carrier proteins/pumps**: Specialized proteins in the membrane facilitate transport.
(iv) **Selective process**: Only specific molecules or ions are transported.

Importance in Plant Cells

(i) **Mineral uptake**: Root hair cells actively transport ions like nitrate, phosphate, and potassium from soil into the plant.
(ii) **Sugar loading**: Active transport moves sucrose into phloem for distribution during translocation.

(iii) **Maintaining turgor**: Helps regulate ion balance, which influences water movement and cell rigidity.

Importance in Animal Cells

(i) **Nerve impulses**: Sodium-potassium pump maintains ion gradients essential for transmitting signals.
(ii) **Nutrient absorption**: Intestinal cells actively transport glucose and amino acids into the bloodstream.
(iii) **Kidney function**: Active transport reabsorbs essential ions and nutrients from urine back into blood.
(iv) **Cell homeostasis**: Maintains proper pH and ion balance inside cells.

Factors affecting the rate of active transport

Factor	Effect on Rate of Active Transport
ATP availability	More ATP → faster transport
Concentration of molecules	Higher concentration → faster until saturation
Carrier protein number	More proteins → higher rate
Oxygen supply	More oxygen → more ATP → faster transport
Temperature	Moderate increase → faster; extreme → slower
pH	Optimal pH → efficient transport
Inhibitors/toxins	Reduce or stop transport

Transmission Genetics and Genetic Engineering

The causes, similarities and differences among organisms with a focus on genetics

Genetics provides the blueprint for life, explaining **why organisms share traits** and **why they differ**. By studying DNA, genes, and chromosomes, we uncover the causes of variation and the unity of living things.

Causes of Genetic Variation

(i) **Mutations**
- Random changes in DNA sequence.
- Can create new traits (e.g., disease resistance in crops).

(ii) **Sexual reproduction**
- Meiosis produces gametes with half the genetic material.
- Crossing over and independent assortment shuffle genes, creating unique offspring.

(iii) **Gene flow**
- Movement of genes between populations through migration or cross-breeding.
- In agriculture, cross-pollination introduces new traits into plant varieties.

(iv) **Genetic drift**

- Random changes in gene frequencies, especially in small populations.
- Can lead to loss of genetic diversity.

(v) **Natural selection**

- Traits that improve survival and reproduction become more common.
- Example: drought-tolerant maize varieties thrive in dry regions.

Similarities among Organisms (Genetic Basis)

- **Universal genetic code:** All organisms use DNA (or RNA in some viruses) with the same four bases (A, T, G, C).
- **Shared cellular machinery**: Ribosomes, enzymes, and proteins function similarly across species.
- **Homologous genes**: Many genes are conserved across species (e.g., genes for cell division, respiration).
- **Basic life processes**: Growth, reproduction, and energy use are genetically controlled in all organisms.

Differences among Organisms (Genetic Basis)

- **Genome size and complexity**: Bacteria have small genomes; humans and plants have much larger ones.
- **Chromosome number**: Varies widely: humans have 46, fruit flies 8, maize 20.
- **Gene expression**: Same genes can be expressed differently, leading to diverse traits.
- **Specialized adaptations**: Genetic differences explain unique features (e.g., chlorophyll in plants vs hemoglobin in animals).

Summary Table

Aspect	Similarities	Differences
Genetic material	DNA is universal	Genome size and chromosome number vary
Cell processes	Protein synthesis, respiration	Expression patterns differ
Genes	Many conserved across species	Mutations create unique traits
Adaptations	All adapt via genetics	Specific traits differ (e.g., photosynthesis vs oxygen transport)

Key Takeaway

Genetics explains both the **unity of life** (shared DNA, universal code, common processes) and the **diversity of life** (mutations, adaptations, gene expression differences). Organisms are similar because they share a common genetic foundation, yet they differ because of **variation and evolution** driven by genetic changes.

Application of the knowledge of genetics and genes to address challenges in crop and animal production

Applications in Crop Production

(i) **Disease resistance**: Breeding or genetic engineering introduces genes that protect crops against pests and pathogens. Example: Bt maize contains a gene from *Bacillus thuringiensis* that resists stem borers.
(ii) **Drought and climate tolerance**: Identifying and transferring genes for water-use efficiency or heat tolerance helps crops survive harsh conditions. Example: Drought-tolerant rice and maize varieties.
(iii) **Nutritional improvement (biofortification)**: Genetic modification enhances vitamins and minerals in staple crops. Example: Golden rice enriched with vitamin A.
(iv) **Yield improvement**: Selective breeding and marker-assisted selection identify high-yield genes. Example: Hybrid maize varieties with superior productivity.
(v) **Reduced chemical use**: Pest-resistant crops reduce reliance on pesticides, lowering costs and environmental damage.

Applications in Animal Production

(i) **Disease resistance**: Genetic selection for animals with stronger immune systems reduces losses. Example: Breeding cattle resistant to tick-borne diseases.
(ii) **Improved productivity**: Genes controlling milk yield, egg production, or growth rate are selected to enhance output. Example: Dairy cows bred for higher milk protein content.
(iii) **Reproductive technologies**: Artificial insemination and embryo transfer spread desirable genes quickly. Example: Fast multiplication of superior bulls in cattle herds.
(iv) **Nutritional quality**: Genetic selection improves meat tenderness, fat composition, and egg nutrient content.
(v) **Adaptation to environment**: Indigenous breeds with genes for heat tolerance or disease resistance are conserved and crossbred with exotic breeds.

Thank You

Dr. Bbosa Science