Biotechnology

Industrial, medical, environmental and commercial applications of biological materials

Involves use of micro-organisms, enzymes

Can be beneficial/destructive

Enzyme Biotechnology

Enzymes as industrial catalysts

Highly specific, efficient in small amounts

Work at normal temperatures and pressure (less energy input to maintain)

E.G.:

Biological washing powder:

Protease, amylase and lipase

Remove blood (proteins-protease), starch (carbohydrates-amylase), and grease (fats-lipase)

Other e.g.

Breakdown of starch to glucose for yeast fermentation: amylase from germinating barley

Pre-digestion of baby food: trypsin

Common Enzymes:

Lactase: break down lactose (milk sugars)

Sucrase: digest sucrose

Amylase: Breakdown starch into simpler sugars

Pepsin: Proteins

Digestive system: breakdown of large food particles into smaller ones for absorption into bloodstream

Respiratory system: break down glucose to produce energy in respiration

Reproduction: formation of sperms and eggs and development of foetus

Seed Germination: Break down stored food like starch and fats in seeds into soluble molecules for embryo to grow into plant

Growth: enzymes make new cell membranes and protoplasm for increase in body mass

Enzymes are from:

Whole cells /

Extracellular enzymes

Advantages of using microorganisms to produce extracellular enzymes:

High growth rate, produce more enzyme per body mass than whole cells

Can be cultured economically using low cost substrates for nutrition
Can be genetically engineered to contain genes from plants/animals, which encode for a particular protein
Can survive at extreme temperature and pH, useful in certain industrial conditions

CREATION PROCESS

Inoculum where selected strain of enzyme-yielding bacteria is selected
Stored in fermenter vessel containing nutrient solution, optimal pH and temperature: optimum environment
Downstream process:
Microorganism are filtered off
Concentration of enzyme solution by removing water
Addition of antibacterial agents to prevent contamination
Cold storage

Immobilized enzymes:

Attached to or contained in insoluble support material

Enzyme can be reused

Product is enzyme-free (not contaminated)

Important if enzyme is important, or if products can be destroyed by the process used to remove enzymes

Enzyme is more resistant to different pH or temperature (heat is conducted to immobilised enzymes slower)

Enzymes are physically ADSORPED onto a surface
Entrapped enzymes in lattice
Enzyme contained in beads
Enzyme covalently bonded together

Immobilized whole-cell VS Immobilized cell-free

Whole cell:

Good: less cost if enzymes are difficult or expensive to extract from cells

Bad: substantial portion of substrate product is converted into bacterial biomass (used by bacterial cells for growth)

Optimum condition to produce product is not optimum condition for bacteria growth

Cell-free:

Good: easy to obtain in bulk

No wasted side reactions

Bad: some enzymes are difficult or expensive to extract

Immobilized enzymes VS isolated free enzymes

Isolated free enzymes have much higher enzymatic activity

Lactose-free milk:

Some people are lactose-intolerant

Their bodies lack lactase to break down lactose (glucose+galactose)

Milk is passed through column of immobilized lactase: milk needs to be passed through multiple times so that most of the lactose is broken down

Chemicals of life

Biological Molecules:

Large, complex molecules produced by living organisms

Carbohydrates
Lipids
Proteins
Nucleic acids

Carbohydrates:

$C_x(H_2O)_y$

Monosaccharides (simplest sugar)
Disaccharides (2 monosaccharide molecules joined)
Polysaccharides (many monosaccharide molecules)

Monosaccharides:

$C_6H_{12}O_6$

Glucose

Galactose

Fructose

*They are all structural isomers: same chemical formula but different structures

Dehydration synthesis/Condensation reaction

Formation of a Complex molecule from the bonding of 2 simpler molecules with the removal of a water molecule.

Hydrolysis

To break down a complex molecule (opposite of dehydration synthesis) using a acid or enzyme

Disaccharides

Sucrose -> glucose+fructose

Lactose-> glucose+galactose

Maltose-> glucose+glucose

$C_{12}H_{22}O_{11}$

Polysaccharides/Glycans

Polymers of hundreds or thousands of monosaccharides

Formed by linking monomers in enzyme-mediated dehydration synthesis

Functions:

Energy storage
Starch
Glycogen
Structural support
Cellulose
Chitin

Differ in

Nature of recurring monosaccharides
Length of chains
Degree or presence of branching

Starch: long chain, straight/slight branching

Glycogen: Long chain, presence of branching

Cellulose: no branching

Storage Polysaccharides:

Compact and inert
Mobilized quickly when food materials are unavailable in environment
Starch in plants, glycogen in animals

Starch and glucose:

Large size, insoluble to water, so exert no osmotic or chemical influence on cell
Fold into compact shapes
Easily converted to sugars by hydrolysis when needed

Carbohydrates: Bread, potato, sugar, flour

1g of carbohydrates give 16kJ of energy

Functions:

Source of energy
Form supporting structures (e.g. cellulose cell walls)
Form nucleic acids
Test for reducing sugars:

Reducing sugars can reduce Cu^{2+} ions in Benedict's solution to Cu^{+} ions, forming brick red precipitate of copper oxide

Benedict's test:

Add an equal volume of Benedict's solution to sample. Shake and heat in boiling water bath

Positive: coloured precipitate is seen:

Increasing amt of sugar: green - yellow - orange - red- brick red

Negative: solution remains blue

Sucrose is non-reducing sugar. How to test?

Add an acid (e.g. hydrochloric acid) to sucrose. When acid is added, sucrose is hydrolysed into glucose and fructose, which can be tested by Benedict's test.

Test for Starch:

Add a few drops of iodine SOLUTION to unknown sample

Positive: Blue-black mixture is seen

Negative: mixture remains yellowish-brown

Negative impact:

Overconsumption of carbohydrates leads to obesity! Excess carbohydrates are converted into fats and stored in tissues beneath skin and internal organs

Lipids

Made up of C, H and O

No fixed molecular formula
No fixed H:O ratio (more H than O)
1 g of fat = 38kJ energy

Types of lipids:

Animal and vegetable fats: triglycerides
Phospholipids: phosphate head + 2 fatty acids
Steroids (e.g. cholesterol): complex hydrocarbons

Triglycerides:

Formed by dehydration synthesis

Broken down by hydrolysis

Lipids:

Saturated fats: no double bonds
Animal fat e.g. pork fat, beef fat
Monounsaturated fats: 1 double bond
Olive oil, peanut oil, salmon, mackerel
Polyunsaturated fat: 2 double bonds
Vegetable oil, corn, nuts and seeds like almonds, walnuts

Functions:

Source and store of energy
Insulating material to prevent excessive heat loss
Solvent for fat-soluble vitamins and hormones
Layer of oil on skin surface restrict water loss from skin surface
Produce sex hormones

Overconsumption:

-Increase in blood level of Cholesterol

-Excessive cholesterol deposit on inner walls of arteries: hardening and narrowing of arteries: health risks

-High blood pressure

-Blood cot formation, blot cot swept into arteries supplying oxygenated blood to heart, blocking these arteries. Result in heart attack

Test for fat:

Ethanol-emulsion test:

Oil is insoluble and less dense, and will float in water.

When oil is dissolved into alcohol (ethanol) with which water is miscible,

The alcohol with oil mixes with water. The oil does not mix but is left as oil droplets throughout the water. Light passing through is scattered and gives suspension milky white appearance

Add ethanol to a drop of oil. Shake mixture thoroughly to dissolve oil. Add water to mixture and shake. If white emulsion is formed and heat is produced, fat is present.

Proteins

C, H, O, N

Basic unit: amino acid

By dehydration synthesis, amino can be joined to form dipeptides, oligopeptides or polypeptide

Proteins/peptides can be broken down into amino acids by hydrolysis

1g of protein = 17kJ of energy

During starvation, body uses stored fats for energy. Protein is last energy source used as muscles and tissues consist largely of proteins.

Sources: meat, eggs, milk, seafood, peas, beans, nuts

Function:

Synthesis of protoplasm, growth and repair of body cells
Synthesis of enzymes and hormones
Form antibodies to combat diseases
Energy source

Globular proteins:

Transport proteins: haemoglobin (oxygen from lungs to body), membrane pumps (transport molecules across cell membrane
Enzymes: speed up chemical reactions in body
Antibodies: immunity of body

Structural protein:

Collagen (bone, teeth, skin), Keratin (hair & nails)

Biuret Test:

Add sodium hydroxide solution to protein solution

Shake thoroughly

Add 1% copper sulphate solution to mixture, drop by drop

Positive: violet/purple coloration

Negative: remains blue

Water: Importance

70-80% of cell content in body is water

Universal solvent, media of many chemical reactions

Transport agent for digested food substances, hormones

Raw material for photosynthesis

Temperature regulation: excess heat removed by evaporation of sweat from skin surface

Plant Nutrition

Leaf:

Leaf blade (lamina)
Lead Stalk (petiole)
Leaf Base

Leaf Blade:

Large flat surface to maximise exposure to sunlight by increasing surface area to volume ratio
Thin to allow CO_2 to reach the inner cells quickly
Thin to allow sunlight to reach all the cells

Leaf Stalk

Hold lamina away from stem to get more sunlight

Leaf Veins:

Carry water/mineral salts to cells in leaf blade
Carry food from leaf blade to other parts of plant

Cuticle:

Waxy, uppermost layer of leaf
Reduce water loss by reducing diffusion of water vapour from the leaf
Prevent bacteria from being collected on the leaf and infecting the leaf

Epidermis:

Single layer of closely packed cells
Both upper and lower layer of leaf
Keeps the leaf's shape
Reduce evaporation from leaf
Prevent bacteria and fungi from entering leaf
Focus light on mesophyll layers

Palisade Mesophyll Tissue:

Contain many chloroplasts, which absorb sunlight for photosynthesis

Spongy Mesophyll Tissue:

Irregularly shaped
Loosely arraigned with intercellular air spaces among tissue
Layer of moisture on tissue to allow diffusion of gases (Co2)
Contains chloroplasts

Chloroplasts:

Thylakoid: captures light energy for light-dependent part of photosynthesis

Granum: stack of ~50 thylakoids

Stroma: contain enzymes of light-independent stage of photosynthesis

Starch grain: stores excess glucose

Stomata:

Present in the epidermis
More abundant in lower epidermis
Pair of guard cells surrounding a stomatal pore

*Floating plants have more stoma on upper surface

Guard cells contain chloroplasts, unlike epidermal cells

*ALL EPIDERMAL CELLS XCEPT FOR GUARD CELLS CANNOT PHOTOSYNTHESISE

Daytime:

Presence of sunlight, photosynthesis takes place in guard cells.

Sugar produced causes water potential in guard cells to drop, and water enters guard cells through osmosis

Guard cells swell and become turgid, opening stomata pore

Nighttime:

Lack of sunlight, respiration. Sugar is used up

Water potential increases, and water leaves guard cells through osmosis.

Guard cells become flaccid and stomatal pore closes

*Guard cells have thicker cellulose wall on the side of stomata pore.

Therefore, the is part of cell wall cannot stretch as easily

Entry of CO2

When CO2 is used in photosynthesis, CO2 concentration in the leaf is lower than in atmospheric air. Diffusion gradient exists and CO2 diffuses in through stomata and dissolves through film of moisture in mesophyll cells.

PHOTOSYNTHESIS

Converts light energy from fun to chemical energy stored in carbohydrates.

Uses:

Direct source of food for plants and indirectly for animals
Provide energy in coal, petroleum and natural gas
Removes carbon dioxide and release oxygen into air, "purify"

Autotrophs: organisms that make organic matter from inorganic matter. Photoautrophs use light.

Heterotrophs live on compounds produced by other organisms

Conditions:

Temperature (for enzyme activity)

Light

Water

Chlorophyll

Carbon dioxide

Photosynthesis:

Light dependent stage
Energy from sun absorbed by chlorophyll and converted into chemical energy
Light energy splits water molecules t oxygen and hydrogen
Light energy------> chemical energy
$12H_2O$------------> $6O_2 + 24H$
Photolysis
Light independent stage
Hydrogen reduce carbon dioxide to carbohydrates (glucose)
Energy required comes from light stage
$6CO_2 + 24H$ -------> $C_6H_{12}O_6 + 6H_2O$

Absorption and action spectrum

Absorption spectrum: graph of absorbance of different wavelengths of light by a photosynthetic pigment

Action spectrum: graph of photosynthetic rates at different wavelength of light

*Magnesium ions are required to form chlorophyll pigment

Limiting Factor:

A factor that directly affects a process if quantity is changed

Limiting of photosynthesis: concentration of carbon dioxide, temperature, light intensity

Leaf adaptations:

Vein has xylem and phloem for transportation of sugars and water and mineral salts
Petiole holds leaf in position to absorb maximum sunlight
Large flat surface to absorb maximum sunlight
Think lamina to allow CO_2 to reach inner cells quickly.
Chloroplasts have chlorophyll for photosynthesis
More chloroplasts on upper palisade tissue where more sunlight
Stomata in epidermal layers to allow CO_2 diffusion in and out of leaf

Fates of Glucose:

Used in tissue respiration to provide energy for cellular activities

Makes cellulose cell walls

Excess is converted to sucrose, transported to storage organs, and stored as starch.

No3 turns glucose to amino acids

In darkness, starch is reverted to simple sugars by enzymes

Starch ---> maltose by diastase/amylase

Maltose ---> glucose by maltase

Proteins ---> Peptones by pepsin

Peptones ---> amino acids by erepsin

Fats ---> fatty acids by lipase

Cellular Respiration:

Aerobic respiration
Anaerobic respiration
Yeast
Muscles

Respiration: The oxidation of food substances with the release of energy

Occurs in all living cells

Energy released is stored as ATP (adenosine triphosphate)

Use of energy:

Synthesis:
Form new substances for growth, development and repair
Transport:
Transport materials through active transport
Movement of materials across cell membranes
Movement:
Contraction of muscles
Heat production
Maintain constant body temperature in warm-blooded animals

Aerobic Respiration:

Break down food substances in presence of oxygen

Release lots of energy (stored in ATP)

One glucose molecule can produce 32-34 ATP

Respiration takes place in mitochondria

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + lots of energy

In ATP, energy is stored in bonds between phosphate groups and adenosine

ATP is reservoir of chemical energy

ATP combines with H_2O molecules and is hydrolysed to form ADP and inorganic phosphate, exergonic reaction (release energy)

ADP and inorganic phosphate goes through phosphorylation to form ATP (endergonic)

ATP is formed through respiration and photosynthesis

Anaerobic Respiration: breakdown of food substances in absence of oxygen. Release small amounts of energy (2 ATP per glucose molecule)

Anaerobic respiration in Yeast:

Yeast can respire aerobically/anaerobically

Fermentation (anaerobic respiration): used in wine and bread making

$C_6H_{12}O_6$ ---> $2CO_2$ + $2C_2H_5OH$(ethanol) + small amount of energy

Muscle Respiration: during muscular activity, if insufficient oxygen is transported to muscles, muscles go through anaerobic respiration: incomplete respiration, lactic acid builds up

*Aerobic respiration goes on during anaerobic respiration

$C_6H_{12}O_6$ ---> $2CH_3CHOCOOH$ + small amount of energy

During anaerobic respiration, only 1st stage of respiration occurs (glycolysis)

Muscle fatigue due to lactic acid buildup

After exercise, oxygen debt occurs. Lactic acid is transported to liver, and some is oxidised to produce energy, which is used to convert remaining lactic acid to glucose, which is transported to muscles for use or storage.

Small amt of ATP produced during anaerobic

Waste product in lactic acid and ethanol contain much energy

Lactic acid and ethanol are harmful to organisms if they accumulate

Yeast cannot metabolize ethanol

Respiration VS Photosynthesis

Energy liberated VS energy stored in carbohydrate molecules

Oxygen used, CO_2 and H_2O released VS carbon dioxide and water used, O_2 released

Catabolic process, breakdown glucose VS anabolic process, form glucose

Occurs al the time VS occurs in chlorophyll and sunlight

Loss of dry mass VS gain of dry mass

External Respiration

Inspiration: air taken into body

Expiration: air given out of body

*Breathing is controlled body, NOT you!

Lungs: organ for exchange of gas between man and environment. 2 lungs. Located in chest/thoracic cavity

Air passage:

Nostril -> Nasal cavity -> Pharynx (where nasal cavity meets oral cavity) -> larynx (voice box) ->Trachea -> bronchi -> bronchioles -> alveoli

Air enters through nose or mouth

Nose breathing:

Dust and foreign particles trapped by hair in nostrils and mucus on mucous membrane

Air is warmed and moistened before entering lungs

Harmful chemicals detected by sensory cells in mucous membrane

Trachea:

Supported by C shaped cartilage:

C shaped to:
Allow space for trachea contract/expand during talking/coughing so that trachea does not break
Is always open/hollow to give unobstructed way for airflow

Divides into right bronchus and left bronchus

Right divides into 3 bronchial tubes, left into 2 bronchial tubes

*C shaped cartilage also in bronchus and bronchial tubes

Epithelium lining on bronchi and trachea have hair that moves mucus (secreted by gland cells in epithelium that trap bacteria and dust particles) from bronchioles to larynx and pharynx

Bronchial tubes in linings divide into many bronchioles. Every bronchiole has a cluster of air sacs/alveoli.

Alveolar walls are only 1 cell thin, moist and well supplied with blood capillaries (also 1 cell thick)

Gaseous exchange takes place through alveoli walls

Large surface area for gaseous exchange

Ribs:

Chest wall supported by ribs, in front attached to sternum (chest bones)

Behind Attached to vertebral column (backbone)

Intercostal muscles:

External Vs. internal intercostal muscles

Between ribs

When one set contract, other relax, (ribs move up and down), change thoracic cavity volume

Diaphragm:

This sheet of tissue separating thorax from abdomen

Inhalation: Diaphragm contract, flattens downwards, chest expand due to intercostal muscles, increase thoracic activity

Exhalation: Diaphragm relax, diaphragm arches upward, chest contracts due to intercostal muscles, reduce thoracic activity

INSPIRATION

Thoracic cavity expand

Lung expands to fill up thoracic cavity.

Air pressure in lungs lower than atmospheric pressure, air rushes into lungs:

External intercostal muscles contract, inter intercostal muscles relax

Ribs swing upward/outwards

Sternum moves up and further away from backbone

Diaphragm contracts and flattens

Volume of thorax increase -> air pressure in thorax decrease -> air rush into lungs

EXPIRATION

Internal intercostal muscles contract, external intercostal muscles relax

Ribs are lowered, sternum returns to original position, nearer to backbone

Diaphragm relaxes and arches upwards, decreased thoracic cavity volume.

Decreased air pressure -> air rushes out of lungs

Gaseous exchange:

Air entering lungs contain more oxygen, less carbon dioxide

Blood entering lungs contain less oxygen, more carbon dioxide

Diffusion gradient for O2 and CO2:

Maintained by:

Continuous flow of blood through blood capillaries to maintain high CO2 concentration in blood
Continuous flow of air through alveoli through ventilation (inspiration and expiration) to maintain high O2 level in air

Membrane separating blood capillaries from alveolar air is permeable to both gases

During pause between inspiration and expiration:

Oxygen dissolves in moisture lining of alveolar walls
Dissolved oxygen diffused into blood, combines with haemoglobin to form oxyhaemoglobin
Carbon dioxide diffuse into alveolar air

Each haemoglobin contain 4 heme groups to contain 4 oxygen molecules which are unloaded onto haemoglobin

Oxygen air->blood: $4O_2+Hb->HbO_8$

Carbon dioxide blood->air: H +HCO3 (bicarbonate ion) -> H_2CO_3 ->(using carbonic anhydrase) H_2O + CO_2

Carbon dioxide diffuse out of blood through alveolar cavities

Water evaporates from alveolar walls, and heat also escapes from blood into alveolar air

* * Myth busted: Main reason for breathing is not take in oxygen but to remove carbon dioxide!

Dissolved CO_2 is acidic. If not removed from body, can affect enzymatic activity in body and cause us to malfunction/die

Smoking:

Carbon monoxide poisoning:

Colourless, odourless gas that binds irreversibly to Hb to form carbaminohaemoglobin.

Oxygen transport reduced

Cause fetal deformity or underdevelopment if pregnant

Toxins in tobacco smoke cause inflammation of epithelium of airways, causing hyper production of mucus, which blocks airways, breathing difficulties.

Emphysema: toxins in smoke and coughing can cause walls between air sacs to disintegrate: less surface area to volume ratio for exchange of axes, irreparable

Lung cancer

Cold-blooded reptiles have right systemic aorta to pump more blood around body to increase blood flow and temperature.

Fish:

Lamella, gill arch,

Countercurrent exchange system: Blood flow in the opposite direction of the H_2O flow so that there is maintained diffusion gradient for oxygen to constantly diffuse from water to blood.

<u>Transport in Plants</u>

Monocot:

Petal is multiple of 3
Parallel veins
Fibres spreading, adventitious roots
Vascular bundles scattered all around cross-section of stem
One cotyledon in seed

Dicot:

Petal multiple is 4/5
Network veins
Taproots
Vascular bundles found on stem boundaries
Two cotyledons

Flowering plants: Angiosperms

Xylem vessel:

Transport water and mineral salts from soil to other parts of the plants
Provide mechanical support for plant

Is a dead structure: lost all protoplasms, is hollow to allow transportation for water and mineral salt to all parts of plant.

Xylem VS trachea:

Both are hollow;

Xylem is completely rigid, but trachea has c-shape cartilage to allow flexibility

In xylem, lignin is present as secondary coating for support and additional strength. There are different forms/patterns of lignification.

Phloem Vessel

Transport food substances from leaves to other parts of plant in form of sucrose

Sieve plates: perforated with sieve pores to allow food substances to pass through

Companion cell: Dense cytoplasm with many organelles, provide sieve tube with energy for active transport

Degenerate protoplasm: lost most of its cytoplasm or organelles: allows food substances to pass through more easily

Phloem is kept alive by energy from companion cells

Vascular bundle: xylem + phloem + cambium (separates xylem/phloem)

Cortex: Food storage

Pith: Central region of stem, food storage

Endodermis: innermost layer of cortex

*Xylem is always inner. In leaves xylem is closer to cuticle, phloem closer to vein

*No stomata on veins!

Absorption of water:

Water potential of cell sap in root hair is lower than soil water
Water enters root hair cells by osmosis through partially permeable membrane.
Mineral salts enter by diffusion or active transport.

Adaptations:

Root hair cells have protrusion, increase surface area for max. Absorption
Root hair cells are abundant in mitochondria, more energy through respiration to carry out activity

Water movement:

Apoplast pathway: cell wall to cell wall

Symplast pathway: cytoplasm to cytoplasm
Vacuolar pathway: vacuole to vacuole

In cortex of roots, absorbed water and mineral salts are forced to go into symplast pathway from apoplast pathway by Casparian strip, and only apoplast pathway is allow to travel up vascular bundle, control transport

Transpiration:

Water exits xylem and enter mesophyll cells, travel from cell to cell by osmosis
Water evaporates from water layer on surface of mesophyll cells
Diffuse through intercellular air spaces, out of stomata

How does stomata open?

Glucose production: Daytime, guard cells photosynthesise, produce glucose. This reduces water potential, and water enters by osmosis. Guard cells become turgid, and Stomata closes.
Nighttime, Guard cells do not photosynthesise, glucose used up by respiration, water potential increases, water released by transpiration
K+ ions:
Glucose produced in daytime powers K+ ion pumps that pump potassium into guard cell, lowering water potential, allowing water to enter via osmosis. Guard cell becomes turgid

Factors affecting transpiration:

Transpiration increase with (measured with photometer)

Decrease in humidity
Low humidity increase concentration gradient of water vapour between inside of outside of leaf, increase transpiration
Increase in temperature
Water evaporates faster. Also, high temp = water can hold more water vapour. Humidity takes longer time to be saturated, concentration grad. Is maintained longer, transpiration rate rise
Increase in water supply
Increase in light intensity
Stomata open up for photosynthesis, rate of transpiration increase
Increase in wind speed
Wind can move the layer of water vapour near leaf surface, remove humidity of surroundings.
Thin cuticle thickness
Thinner layer makes it easier for water to pass through waterproof cuticle
Open stomata
Water vapour can leave plant more easily

Water moves up stem by:

Root pressure: entry of water into root creates force that pushes water up
Capillarity
MAIN: transpiration pull

Transpiration pull:

Water leaves mesophyll cells through transpiration.
As water vapour leaves, more water in thin film evaporates. Mesophyll cells will absorb more water from neighbouring cells. These cells obtain water from source (xylem).
This removal of water by osmosis from xylem results in suction force that pulls column of water up xylem vessels. (Water moves as a column due to cohesive and adhesive forces)
This pull creates tension that can pull water up high heights. (>100m)

Mass flow: transport of food through phloem

Active loading of sugars into phloem at source (leaf) cause water potential to drop.
Water from neighbouring xylem enters by osmosis. This uptake of water creates high pressure at source.
At the sink cell (storage root), sugar is taken up for storage, water potential increased. Water leaves phloem by osmosis and enters xylem
Therefore, low pressure at sink cells, high pressure at source(leaf), sugars move from source to sink, along pressure gradient

Adaptations:

Xerophytes (dry conditions):

Thick cuticle, reduce transpiration
Absence of true leaf, limit transpiration
Reduce surface area to volume ratio of leaves
Sunken stomata, moist air trapped in area around stomata increase humidity
Succulent leaves/stem to store water
Extensive root system to absorb more water

Hydrophytes (wet conditions):

Stomata located on upper side, as underside is submerged
Thin cuticle, as it is unnecessary, does not need to limit water loss, allow diffusion of water into cell
Xylem is reduced or absent: Allows for stems to flow with water current (if xylem are rigid with lignin, might snap due to water pressure), unnecessary, water can diffuse into plant