A-level Food and Nutrition

SENIOR Five term 2

TOPIC 1/3: Nutrients (continued)

Competency: The learner develops appropriate diet plans to prevent and manage nutritional imbalances for the health of an individual, family and the community.

Lipids

Chemistry of Lipids

1. **Basic Structure**

- Lipids are **hydrophobic molecules** due to long hydrocarbon chains.
- They may contain **polar head groups** (as in phospholipids) and **nonpolar tails**, giving amphipathic properties.
- Common types include **fatty acids, triglycerides, phospholipids, sterols, and waxes**.

2. **Chemical Properties**

- **Nonpolar nature**: Insoluble in water, soluble in organic solvents.
- **Ester linkages**: Triglycerides are formed by esterification of glycerol with three fatty acids.
- **Saturation**: Saturated fatty acids (no double bonds) vs unsaturated fatty acids (one or more double bonds).
- **Amphipathic behavior**: Phospholipids have hydrophilic heads and hydrophobic tails, enabling bilayer formation.
- **Sterol ring structure**: Cholesterol and steroid hormones have rigid ring systems that influence membrane fluidity and signaling.

Biological Functions of lipids

(i) **Energy storage**: Triglycerides store large amounts of energy, yielding more ATP per gram than carbohydrates.
(ii) **Structural role**: Phospholipids and cholesterol form cell membranes, maintaining fluidity and integrity.
(iii) **Insulation and protection**: Fat deposits cushion organs and insulate the body against cold.
(iv) **Hormone synthesis**: Cholesterol is the precursor for steroid hormones (e.g., estrogen, testosterone, cortisol).
(v) **Cell signaling**: Lipid-derived molecules (eicosanoids, prostaglandins) regulate inflammation, immunity, and other processes.
(vi) **Vitamin absorption**: Lipids enable absorption of fat-soluble vitamins (A, D, E, K).
(vii) **Protective coatings**: Waxes provide waterproofing in plants and protective layers in animals.

Culinary uses of lipids/ healthy uses of lipids in cookery

(i) **Cooking medium**: Oils and fats are used for frying, sautéing, and roasting because they conduct heat well. Use plant-based oils (olive, sunflower, canola, groundnut) for sautéing and light frying. They provide essential fatty acids and vitamin E.
(ii) **Flavor enhancement**: Lipids carry and intensify flavors, giving richness to dishes (e.g., butter in baking). **Natural fats like avocado, nuts, and seeds add richness and depth of flavor without excess saturated fat**.
(iii) **Texture improvement**: Fats add tenderness, moisture, and creaminess to foods like cakes, pastries, and sauces. Healthy oils and nut butters give smoothness and creaminess to soups, sauces, and baked goods.
(iv) **Emulsification**: Lipids help mix ingredients that normally don't blend, such as oil and water in mayonnaise.
(v) **Preservation**: Fats can act as barriers to moisture and oxygen, extending shelf life of foods.
(vi) **Nutrient absorption**: Lipids aid absorption of fat-soluble vitamins (A, D, E, K) from vegetables and fruits.
(vii) **Moderation in frying**: Opt for shallow frying or baking with small amounts of oil instead of deep frying.
(viii) **Substitution**: Replace butter and margarine with healthier oils (e.g., olive or avocado oil) in recipes.

Effects of Lipid Imbalances

(i) **High lipid levels (Hyperlipidemia)**
- Excess cholesterol and triglycerides in blood.

- Leads to **atherosclerosis, heart disease, stroke, and hypertension**.

(ii) **Low lipid levels (Hypolipidemia)**

- Impairs absorption of **fat-soluble vitamins (A, D, E, K)**.
- Causes fatigue, hormonal imbalances, and weakened immunity.

(iii) **Excess saturated and trans fats**

- Raise LDL ("bad" cholesterol).
- Promote obesity, insulin resistance, and cardiovascular disease.

(iv) **Deficiency of essential fatty acids (Omega-3, Omega-6)**

- Poor brain function, skin problems, impaired growth.
- Weak anti-inflammatory responses.

Management of Lipid Imbalances

(i) **Dietary modification**

- Reduce intake of saturated fats, trans fats, and refined foods.
- Increase consumption of fibre-rich foods, fruits, vegetables, legumes, and whole grains.
- Include healthy fats (olive oil, avocado, nuts, fish).

(ii) **Lifestyle changes**

- Regular physical activity to improve lipid metabolism.
- Maintain healthy body weight.
- Avoid smoking and excessive alcohol intake.

(iii) **Medical management**

- Lipid-lowering medications (e.g., statins) may be prescribed for hyperlipidemia.
- Supplements (omega-3 fatty acids) may help in deficiency states.
- Regular monitoring of blood lipid levels.

Examples of recipes that can manage lipid imbalances

Here are **two practical, heart-healthy recipes** formulated to help manage lipid imbalances (such as high LDL cholesterol, low HDL, or excess triglycerides). They emphasize **unsaturated fats, fibre, and plant-based ingredients**, while limiting saturated and trans fats:

1. Avocado & Bean Salad (Cholesterol-Friendly)

Ingredients

- 1 cup boiled **kidney beans** (soluble fibre lowers LDL cholesterol)
- 1 ripe **avocado** (monounsaturated fats raise HDL "good" cholesterol)

- 1 medium **tomato**, diced
- ½ cup **cucumber**, sliced
- 1 tbsp **olive oil**
- Juice of 1 **lemon**
- Pinch of black pepper

Preparation

1. Mix beans, avocado, tomato, and cucumber in a bowl.
2. Drizzle with olive oil and lemon juice.
3. Season with pepper and serve fresh.

Health Role: Fibre + healthy fats improve lipid profile, reduce cholesterol absorption, and support heart health.

2. Grilled Tilapia with Sukuma Wiki (Omega-3 Boost)

Ingredients

- 1 medium **tilapia fillet** (rich in omega-3 fatty acids)
- 2 cups **sukuma wiki (collard greens)**, chopped
- 1 onion, sliced
- 1 tbsp **canola or sunflower oil**
- Juice of 1 lime
- Pinch of garlic and ginger

Preparation

1. Marinate tilapia with lime juice, garlic, and ginger.
2. Grill until golden and cooked through.
3. Sauté onions and sukuma wiki lightly in oil.
4. Serve fish with greens on the side.

Health Role: Omega-3s reduce triglycerides and inflammation; leafy greens add fibre and antioxidants.

Summary of Benefits

- **Beans & avocado** → fibre + monounsaturated fats for cholesterol balance.
- **Tilapia & sukuma wiki** → omega-3s + antioxidants for triglyceride control and vascular health.

Basic nutritional status assessments

1. Body Mass Index (BMI)

- **Formula**: BMI = $\frac{Weight\ (kg)}{\text{Height (m)}^2}$

- **Interpretation** (WHO standards):
  - < 18.5 → Underweight
  - 18.5 – 24.9 → Normal weight
  - 25 – 29.9 → Overweight
  - ≥ 30 → Obese
- **Use**: Quick screening for undernutrition or overweight/obesity.

2. Mid-Upper Arm Circumference (MUAC)

- **How to measure**:
  - Use a non-stretch tape measure around the left upper arm, midway between shoulder and elbow.
- **Interpretation (Adults)**:
  - < 23 cm → Undernutrition
  - 23 – 32 cm → Normal
  - 32 cm → Overweight/obese
- **Interpretation (Children 6–59 months)**:
  - < 11.5 cm → Severe acute malnutrition
  - 11.5 – 12.5 cm → Moderate malnutrition
  - ≥ 12.5 cm → Normal
- **Use**: Simple, rapid tool for detecting malnutrition, especially in field/community settings.

3. Waist-to-Hip Ratio (WHR)

- **How to measure**:
  - Measure waist circumference (at the narrowest point or just above the navel).
  - Measure hip circumference (widest part of buttocks).
  - Calculate:

  Formula: WHR = $\frac{Waist\ circumference}{\text{Hip circumference}}$

- **Interpretation**:
  - Men: > 0.90 → Increased risk of cardiovascular disease
  - Women: > 0.85 → Increased risk of cardiovascular disease
- **Use**: Assesses fat distribution and risk of metabolic diseases.

Summary Table

Assessment	How it's done	Key Cut-offs	What it shows
BMI	Weight ÷ height^2		General nutritional status
MUAC	Tape around mid-arm		Quick malnutrition screening
WHR	Waist ÷ hip	>0.90 men, >0.85 women	Fat distribution & disease risk

Suitable Food Sources for Lipid Extraction

1. Avocado

- **Key Characteristics**:
  - Rich in **monounsaturated fatty acids (MUFA)**, especially oleic acid.
  - Contains phytosterols and antioxidants (vitamin E).
  - Oil is smooth, mild, and heat-stable, making it suitable for cooking and salads.
- **Health Role**: Supports heart health, lowers LDL cholesterol, raises HDL cholesterol.

2. Simsim (Sesame Seeds)

- **Key Characteristics**:
  - High in **polyunsaturated fatty acids (PUFA)**, mainly linoleic acid.
  - Contains lignans (sesamin, sesamol) with antioxidant properties.
  - Oil has a nutty flavor and is stable due to natural antioxidants.
- **Health Role**: Promotes cardiovascular health, reduces oxidative stress.

3. Peanut (Groundnut)

- **Key Characteristics**:
  - Rich in **monounsaturated fats** and moderate polyunsaturated fats.
  - Contains resveratrol and vitamin E.
  - Peanut oil is widely used for frying due to high smoke point.
- **Health Role**: Provides energy, supports lipid balance, and reduces risk of heart disease.

4. Sunflower Seeds

- **Key Characteristics**:
  - High in **polyunsaturated fats**, especially linoleic acid.
  - Rich in vitamin E (tocopherols), a natural antioxidant.
  - Oil is light, mild, and commonly used in cooking and margarine production.
- **Health Role**: Supports skin health, reduces inflammation, and lowers cholesterol.

5. Shea Nut

- **Key Characteristics**:
  - Contains **stearic and oleic acids** (saturated + monounsaturated fats).
  - Traditionally used for shea butter, both culinary and cosmetic.
  - Oil is semi-solid at room temperature, with moisturizing properties.
- **Health Role**: Provides energy, supports skin health, and has anti-inflammatory compounds.

Summary Table

Food Source	Main Lipid Type	Key Nutrients	Culinary/Health Role
Avocado	MUFA (oleic acid)	Vitamin E, phytosterols	Heart health, stable cooking oil
Simsim (Sesame)	PUFA (linoleic acid)	Lignans, antioxidants	Nutty oil, antioxidant-rich
Peanut	MUFA + PUFA	Vitamin E, resveratrol	Frying oil, cholesterol balance
Sunflower	PUFA (linoleic acid)	Vitamin E	Light oil, lowers cholesterol
Shea Nut	Saturated + MUFA	Stearic & oleic acids	Shea butter, energy + skin health

Procedure for extracting lipids from food sources

Below is a practical, modular guide you can adapt to different food sources (seeds like simsim/sesame, groundnuts/peanuts, sunflower; soft matrices like avocado; and harder matrices). Choose the method based on your equipment, safety constraints, and desired oil purity.

Overview of methods

- **Mechanical pressing:** Simple, food-safe; ideal for high-oil seeds and avocado.
- **Aqueous/enzymatic extraction:** Food-grade, minimizes solvents; good for seeds and nuts.
- **Solvent extraction (lab):** High yield; suitable for analysis and refining. Common variants include cold solvent maceration, Soxhlet, and biphasic systems.
- **Supercritical CO_2:** Premium purity, no solvent residue; requires specialized equipment.

1. Mechanical pressing (food-safe, minimal equipment)

Suitable sources

- Avocado pulp, groundnuts (peanuts), sesame (simsim), sunflower seeds, shea kernels.

Steps

1. **Pre-treatment:**
    - **Cleaning:** Remove stones, husks, spoiled material.
    - **Drying:** For seeds/nuts, dry to ~6–8% moisture to improve yield.
    - **Roasting (optional):** Light roast at low heat (e.g., 110–130°C, 10–20 min) to enhance flavor and release oil.
    - **Dehulling/grinding:** Crack or mill to a coarse meal to increase surface area.
2. **Pressing:**
    - **Cold-press:** Use a manual or screw press; maintain low temperature to preserve nutrients.
    - **Collect oil:** Filter through muslin or a fine sieve to remove solids.
3. **Clarification:**
    - **Settling:** Let the oil stand 12–24 hours to allow particulates to settle.
    - **Filtration:** Pass through filter paper or fine cloth; repeat if needed.
4. **Storage:**
    - **Protect from light/air:** Use dark, airtight bottles.
    - **Add antioxidants (optional):** A pinch of rosemary extract or vitamin E to delay rancidity.

2. Aqueous/enzymatic extraction (solvent-free)

Suitable sources

- Groundnuts, sesame, sunflower; works for avocado puree.

Steps

1. **Prepare slurry:**
    - **Grind:** Mill seeds/nuts to paste.
    - **Mix with warm water:** 1:3–1:5 paste-to-water ratio at 40–50°C, stir thoroughly.
2. **Enzyme-assisted (optional):**
    - Add food-grade **protease** and **cellulase/hemicellulase** to break matrices (follow manufacturer dose/time).
3. **Phase separation:**
    - **Stir and rest:** 30–60 minutes; oil rises to the top.
    - **Skim oil:** Remove floating oil layer carefully.
4. **Centrifugation (optional):**
    - Spin slurry to accelerate oil separation.
5. **Clarify and store:**
    - Filter, then bottle in dark, airtight containers.

3. Simple solvent maceration (lab-scale, high yield)

Note: Use only in a well-ventilated lab with appropriate PPE and solvent disposal. Not for home food production.

Suitable sources

- Dried, milled seeds and nuts; dehydrated avocado pulp.

Steps

1. **Sample prep:**
    - Dry material to low moisture; mill to fine meal.
2. **Defatting/extraction:**
    - **Choose solvent:** Food chemistry often uses hexane (non-polar) for neutral lipids; ethanol or isopropanol for safer handling but may co-extract polar compounds.
    - **Macerate:** Add solvent at ~1:5–1:10 solid-to-solvent ratio; stir/shake 1–4 hours.
3. **Filtration:**
    - Filter to separate solvent–oil extract from solids; repeat extraction for higher yield.
4. **Solvent removal:**
    - Evaporate under reduced pressure (rotary evaporator) or gentle warm air with fume hood to obtain crude oil.
5. **Cleanup:**
    - Optional **winterization:** Chill and filter to remove waxes.
    - **Drying:** Pass through anhydrous sodium sulfate; refilter.
6. **Storage:**
    - Dark, airtight bottles at cool temperature.

4. Soxhlet extraction (analytical/lab)

Steps

1. **Load sample:**
    - Place 2–20 g milled, dried material in a thimble.
2. **Extract:**
    - Use hexane or petroleum ether; reflux 4–8 hours until siphon cycles are clear.
3. **Recover oil:**
    - Evaporate solvent; dry residue to constant weight.
4. **Record yield:**
    - Calculate (% oil = extracted lipid mass / initial sample mass × 100).

5. Supercritical CO_2 extraction (advanced)

Steps (conceptual)

1. **Pre-treat:** Dry and mill material.
2. **Extraction:** Use CO_2 at ~31–60°C and 100–300 bar; adjust pressure for selectivity.
3. **Separation:** Depressurize to collect oil; no solvent removal needed.
4. **Advantages:** High purity, low oxidation, tunable selectivity with co-solvents (e.g., ethanol).

Source-specific notes

- **Avocado:** High moisture; dehydrate lightly or use mechanical pressing. Enzymatic or aqueous works for puree.
- **Sesame (simsim):** Small seeds; light roasting improves flavor; cold-press or hexane extraction yields well. Natural antioxidants aid stability.
- **Peanut (groundnut):** Dehull and roast gently to reduce beany notes; cold-press or solvent extraction common.
- **Sunflower:** Dehull; beware of waxes—winterization improves clarity.
- **Shea nut:** Requires drying, cracking, and boiling/hand-churning or pressing; semi-solid fat benefits from gentle heat for clarification.

Quality and safety considerations

(i) **Oxidation control:** Work quickly, keep temperatures low, minimize air exposure; consider antioxidants (vitamin E).
(ii) **Filtration and degumming:** For edible oils, hydrate phospholipids (warm water), settle, and remove gums.
(iii) **Neutralization (refining):** If needed, treat with mild alkali to reduce free fatty acids; wash and dry.
(iv) **Sensory checks:** Monitor color, aroma, and taste; avoid burnt notes from over-roasting.
(v) **Food safety:** For edible use, prefer mechanical/aqueous methods; avoid toxic solvent residues.

Quick decision guide

(i) **Edible, small-scale:** Mechanical pressing or aqueous extraction.
(ii) **Analytical yield/quantification:** Soxhlet or solvent maceration.
(iii) **Premium purity, commercial:** Supercritical CO_2 (if available).

Vitamins

Categories of Vitamins

1. Fat-Soluble Vitamins

- **Characteristics**:
  - Dissolve in fats and oils.
  - Stored in liver and fatty tissues.
  - Excess intake can lead to toxicity.
- **Examples & Sources**:
  - **Vitamin A** → Sources: liver, carrots, sweet potatoes, dark leafy greens.
  - **Vitamin D** → Sources: sunlight exposure, fish liver oils, fortified milk, eggs.
  - **Vitamin E** → Sources: vegetable oils (sunflower, olive), nuts, seeds, spinach.
  - **Vitamin K** → Sources: green leafy vegetables (kale, spinach), broccoli, cabbage.

2. Water-Soluble Vitamins

- **Characteristics**:
  - Dissolve in water.
  - Not stored in large amounts; excess excreted in urine.
  - Need regular intake from diet.
- **Examples & Sources**:
  - **Vitamin C (ascorbic acid)** → Sources: citrus fruits, guava, tomatoes, peppers.
  - **Vitamin B-complex group**:
    - **B1 (Thiamine)** → Sources: whole grains, legumes, pork.
    - **B2 (Riboflavin)** → Sources: milk, eggs, green vegetables.
    - **B3 (Niacin)** → Sources: meat, fish, peanuts.
    - **B5 (Pantothenic acid)** → Sources: eggs, mushrooms, whole grains.
    - **B6 (Pyridoxine)** → Sources: bananas, potatoes, poultry.
    - **B7 (Biotin)** → Sources: nuts, seeds, eggs.
    - **B9 (Folate)** → Sources: leafy greens, beans, fortified cereals.
    - **B12 (Cobalamin)** → Sources: meat, fish, dairy products.

Summary Table

Category	Vitamins	Sources
Fat-Soluble	A, D, E, K	Carrots, liver, fish oils, nuts, seeds, leafy greens
Water-Soluble	C, B-complex (B1–B12)	Citrus fruits, legumes, whole grains, meat, dairy, leafy greens

Conclusion:

- **Fat-soluble vitamins (A, D, E, K)** are stored in the body and linked to vision, bone health, antioxidant protection, and blood clotting.
- **Water-soluble vitamins (C and B-complex)** must be consumed regularly for energy metabolism, immunity, and nervous system function.

Properties of Vitamins

Vitamin	Solubility	Sensitivity	Functions
A	Fat-soluble	Light, oxygen	Vision, immunity
D	Fat-soluble	Light, oxidation	Bone health, Ca metabolism
E	Fat-soluble	Oxygen, light	Antioxidant, cell protection
K	Fat-soluble	Light	Blood clotting, bone health
C	Water-soluble	Heat, light, alkaline pH	Collagen, antioxidant, iron absorption
B1	Water-soluble	Heat, alkaline	Carbohydrate metabolism
B2	Water-soluble	Light	Energy metabolism
B3	Water-soluble	Stable	Nervous system, energy
B5	Water-soluble	Heat, acid	Fatty acid metabolism
B6	Water-soluble	Heat, light	Amino acid metabolism
B7	Water-soluble	Stable	Fatty acid/glucose metabolism
B9	Water-soluble	Heat, light, oxygen	DNA synthesis, cell division
B12	Water-soluble	Light, extreme pH	RBC formation, nerve function

Factors affecting the stability of vitamins

Factor	Vitamins Affected	Example
Light	A, K, B2	Riboflavin destroyed in milk under sunlight
Heat	C, B1, B9	Vitamin C lost in boiling vegetables
pH	C, B1	Thiamine destroyed in alkaline cooking water
Oxygen	C, E, A	Vitamin C oxidizes in cut fruits
Storage	D, Folate, C	Folate loss in flour during storage

Factors Affecting Vitamin Bioavailability

1. Food Matrix and Preparation

- The structure of food influences how vitamins are released and absorbed.
- **Examples**:
    - **Vitamin C** in raw fruits is more bioavailable than in overcooked vegetables.
    - **Folate** in leafy greens is partly bound and less available compared to synthetic folic acid in supplements.

2. Solubility and Fat Content

- Fat-soluble vitamins (A, D, E, K) require dietary fat for absorption.
- **Examples**:
    - **Vitamin D** absorption improves when consumed with fatty foods like fish or avocado.
    - Low-fat diets may reduce absorption of **Vitamin E**.

3. Interactions with Other Nutrients

- Some vitamins enhance or inhibit each other's absorption.
- **Examples**:
    - **Vitamin C** enhances iron absorption from plant foods.
    - Excessive **zinc** can interfere with absorption of **folate**.
    - High alcohol intake reduces absorption of **B-complex vitamins**.

4. Digestive Health and Enzymes

- Proper digestion and enzyme activity are essential for vitamin release.
- **Examples**:
    - **Vitamin B12** requires intrinsic factor from the stomach for absorption.
    - Malabsorption disorders (e.g., celiac disease) reduce uptake of fat-soluble vitamins.

5. pH and Stability in the Gut

- Vitamins can be destroyed or altered by stomach acidity or alkaline conditions.
- **Examples**:
    - **Thiamine (B1)** is unstable in alkaline environments.
    - **Vitamin C** is degraded in alkaline cooking water or prolonged storage.

6. Processing and Storage

- Food processing and storage reduce vitamin content, lowering bioavailability.
- **Examples**:
    - **Riboflavin (B2)** is destroyed by light in milk stored in clear bottles.
    - **Vitamin C** in fruit juices decreases over time if not refrigerated.

Summary Table

Factor	Effect	Example
Food matrix	Bound vitamins less available	Folate in leafy greens vs supplements
Fat content	Needed for fat-soluble vitamins	Vitamin D absorbed better with fatty foods
Nutrient interactions	Enhance or inhibit absorption	Vitamin C boosts iron uptake
Digestive health	Enzymes & intrinsic factor required	B12 needs intrinsic factor
pH conditions	Stability varies	Thiamine destroyed in alkaline pH
Processing/storage	Loss during cooking/light exposure	Riboflavin destroyed in sunlight

Vitamin Deficiencies

Fat-Soluble Vitamins

(i) **Vitamin A deficiency** → Night blindness, dry eyes (xerophthalmia), impaired immunity.
(ii) **Vitamin D deficiency** → Rickets in children, osteomalacia in adults, bone pain.
(iii) **Vitamin E deficiency** → Neurological problems, muscle weakness, hemolytic anemia.
(iv) **Vitamin K deficiency** → Impaired blood clotting, easy bruising, bleeding disorders.

Water-Soluble Vitamins

(i) **Vitamin C deficiency** → Scurvy (bleeding gums, poor wound healing, fatigue).
(ii) **Vitamin B1 (Thiamine) deficiency** → Beriberi (nerve and heart problems), Wernicke-Korsakoff syndrome.
(iii) **Vitamin B2 (Riboflavin) deficiency** → Cracks at mouth corners, sore throat, skin disorders.
(iv) **Vitamin B3 (Niacin) deficiency** → Pellagra (dermatitis, diarrhea, dementia).
(v) **Vitamin B6 (Pyridoxine) deficiency** → Anemia, depression, confusion.
(vi) **Vitamin B9 (Folate) deficiency** → Megaloblastic anemia, birth defects (neural tube defects).
(vii) **Vitamin B12 deficiency** → Pernicious anemia, neurological damage.

Vitamin Toxicities (Hypervitaminosis)

Fat-Soluble Vitamins

(i) **Vitamin A toxicity** → Headache, liver damage, bone pain, birth defects in pregnancy.
(ii) **Vitamin D toxicity** → Hypercalcemia (nausea, kidney damage, calcification of tissues).
(iii) **Vitamin E toxicity** → Increased bleeding risk, gastrointestinal upset.
(iv) **Vitamin K toxicity** → Rare, but can cause jaundice and hemolytic anemia in infants.

Water-Soluble Vitamins

(i) **Vitamin C toxicity** → Diarrhea, kidney stones, stomach cramps.
(ii) **Vitamin B3 (Niacin) toxicity** → Skin flushing, liver damage at high doses.
(iii) **Vitamin B6 toxicity** → Nerve damage, numbness, difficulty walking.
(iv) **Vitamin B9 (Folate) toxicity** → Masks vitamin B12 deficiency, leading to neurological damage.

Summary Table

Vitamin	Deficiency Effects	Toxicity Effects
A	Night blindness, dry eyes	Liver damage, birth defects
D	Rickets, weak bones	Hypercalcemia, kidney damage
E	Muscle weakness, anemia	Bleeding risk
K	Bleeding disorders	Rare, jaundice in infants
C	Scurvy	Diarrhea, kidney stones
B1	Beriberi, nerve damage	Rare
B2	Cracks at mouth corners	Rare
B3	Pellagra	Skin flushing, liver damage
B6	Anemia, confusion	Nerve damage
B9	Megaloblastic anemia	Masks B12 deficiency
B12	Pernicious anemia	Rare

Examples of recipes to correct vitamin imbalances

Here are **three practical recipes** designed to help manage common vitamin imbalances. Each dish emphasizes natural food sources rich in specific vitamins to correct deficiencies while avoiding excess intake.

1. Carrot & Pumpkin Stew (Vitamin A Boost)

For Vitamin A deficiency (night blindness, weak immunity)

Ingredients

- 2 medium carrots (rich in beta-carotene)
- 1 cup pumpkin cubes
- 1 onion, chopped
- 2 tomatoes, diced
- 1 tbsp sunflower oil
- Pinch of salt and garlic

Preparation

1. Sauté onion and garlic in sunflower oil.
2. Add carrots and pumpkin, cook until soft.
3. Add tomatoes, simmer for 10 minutes.
4. Serve with millet bread or rice.

Benefit: Carrots and pumpkin provide **beta-carotene**, converted to Vitamin A for eye and immune health.

2. Grilled Tilapia with Sukuma Wiki (Vitamin D & K Support)

For Vitamin D deficiency (weak bones) and Vitamin K deficiency (poor clotting)

Ingredients

- 1 tilapia fillet (Vitamin D, omega-3s)
- 2 cups sukuma wiki (collard greens, Vitamin K)
- 1 onion, sliced
- 1 tbsp canola oil
- Juice of 1 lemon

Preparation

1. Marinate tilapia with lemon juice and grill until golden.
2. Sauté onions and sukuma wiki lightly in oil.
3. Serve fish with greens on the side.

Benefit: Tilapia provides **Vitamin D** for bone health, while sukuma wiki supplies **Vitamin K** for blood clotting.

3. Citrus & Bean Salad (Vitamin C + Folate)

For Vitamin C deficiency (scurvy) and Folate deficiency (anemia, pregnancy needs)

Ingredients

- 1 cup boiled beans (folate, iron)
- 1 orange, peeled and sliced
- ½ cup guava chunks (Vitamin C powerhouse)
- 1 cucumber, diced
- 1 tbsp olive oil
- Pinch of black pepper

Preparation

1. Mix beans, orange slices, guava, and cucumber in a bowl.
2. Drizzle with olive oil and sprinkle pepper.
3. Serve fresh as a salad.

Benefit: Citrus and guava provide **Vitamin C** for collagen and iron absorption, while beans add **folate** for red blood cell formation.

Summary of Recipes & Vitamin Targets

Dish	Target Vitamins	Key Benefits
Carrot & Pumpkin Stew	Vitamin A	Eye health, immunity
Grilled Tilapia + Sukuma Wiki	Vitamin D & K	Bone strength, blood clotting
Citrus & Bean Salad	Vitamin C & Folate	Collagen, anemia prevention

Conclusion: These dishes use **local, affordable foods** (carrots, pumpkin, tilapia, sukuma wiki, beans, citrus fruits) to naturally correct vitamin imbalances. They are nutrient-dense, easy to prepare, and culturally adaptable.

Mineral salts

Categories of minerals

1. **Macro-Minerals**

(Required in larger amounts, usually >100 mg/day)

(i) Calcium

Sources: Milk, cheese, yogurt, sardines, green leafy vegetables (sukuma wiki, spinach).

Functions: Bone and teeth health, muscle contraction, blood clotting.

(ii) Potassium

Sources: Bananas, sweet potatoes, beans, avocados, tomatoes.

Functions: Fluid balance, nerve transmission, muscle function.

(iii) Magnesium

Sources: Nuts (groundnuts, simsim), whole grains, green leafy vegetables.

Functions: Enzyme activation, muscle relaxation, bone health.

(iv) Phosphorus

Sources: Meat, fish, eggs, legumes, dairy products.

Functions: Bone and teeth formation, energy metabolism (ATP).

(v) Sodium

Sources: Table salt, processed foods, seafood.

Functions: Fluid balance, nerve impulses, muscle contraction.

2. **Trace Elements**

(Required in smaller amounts, usually <100 mg/day)

(i) Iron

Sources: Red meat, liver, beans, spinach, fortified cereals.

Functions: Hemoglobin formation, oxygen transport, energy metabolism.

(ii) Zinc

Sources: Meat, fish, legumes, nuts, whole grains.

Functions: Immune function, wound healing, growth, reproduction.

(iii) Iodine

Sources: Iodized salt, seafood, seaweed.

Functions: Thyroid hormone synthesis, metabolism regulation.

(iv) Copper

Sources: Shellfish, nuts, seeds, whole grains.

Functions: Iron metabolism, connective tissue formation.

(v) Selenium

Sources: Fish, eggs, sunflower seeds, cereals.

Functions: Antioxidant defense, thyroid hormone metabolism.

(vi) Fluoride

Sources: Fluoridated water, tea, fish.

Functions: Strengthens teeth and bones, prevents dental caries.

Summary Table

Category	Mineral	Sources	Functions
Macro	Calcium	Dairy, leafy greens	Bones, clotting
Macro	Potassium	Bananas, beans	Fluid balance, nerves
Macro	Magnesium	Nuts, grains, greens	Enzymes, muscles
Macro	Phosphorus	Meat, fish, eggs	Energy, bones
Macro	Sodium	Salt, seafood	Fluid balance, nerves
Trace	Iron	Meat, beans, spinach	Hemoglobin, oxygen
Trace	Zinc	Meat, legumes, nuts	Immunity, growth
Trace	Iodine	Iodized salt, seafood	Thyroid hormones
Trace	Copper	Shellfish, seeds	Iron metabolism
Trace	Selenium	Fish, eggs, cereals	Antioxidant, thyroid
Trace	Fluoride	Water, tea, fish	Teeth, bones

Conclusion: Minerals are divided into **macro-minerals** (needed in larger amounts for structural and metabolic functions) and **trace elements** (needed in smaller amounts but equally vital for enzymes, hormones, and immunity). A **balanced diet with diverse foods** ensures adequate intake of both categories.

Interactions of Mineral Salts with Nutrients

1. Calcium

- **With Vitamin D** → Vitamin D enhances calcium absorption in the intestine.
- **With Phosphorus** → Works together for bone and teeth formation.
- **With Iron & Zinc** → Excess calcium can inhibit absorption of iron and zinc.

2. Iron

- **With Vitamin C** → Vitamin C enhances absorption of non-heme iron from plant foods.
- **With Calcium** → High calcium intake can reduce iron absorption.
- **With Phytates (from grains/legumes)** → Phytates bind iron, reducing its bioavailability.

3. Zinc

- **With Protein** → Animal protein improves zinc absorption.
- **With Iron & Calcium** → Excess iron or calcium supplements can interfere with zinc uptake.
- **With Phytates** → Phytates in cereals and legumes reduce zinc absorption.

4. Magnesium

- **With Calcium** → Competes for absorption; balance is important.
- **With Vitamin D** → Vitamin D helps regulate magnesium metabolism.
- **With Protein** → Adequate protein intake supports magnesium utilization.

5. Iodine

- **With Protein (Tyrosine)** → Combines with tyrosine to form thyroid hormones.
- **With Goitrogens (cassava, cabbage, millet)** → Goitrogens interfere with iodine uptake, leading to goiter if intake is low.

6. Sodium & Potassium

- **Balance with Water** → Work together to regulate fluid balance and blood pressure.
- **With Protein & Carbohydrates** → Sodium aids nutrient transport across cell membranes.
- **Excess Sodium** → Can increase calcium excretion, affecting bone health.

7. Selenium

- **With Vitamin E** → Acts synergistically as antioxidants, protecting cells from oxidative damage.
- **With Iodine** → Supports thyroid hormone metabolism.

Summary Table

Mineral	Positive Interaction	Negative Interaction
Calcium	Vitamin D (absorption), Phosphorus (bones)	Inhibits iron & zinc absorption
Iron	Vitamin C (enhances absorption)	Inhibited by calcium, phytates
Zinc	Protein (improves absorption)	Inhibited by excess iron, calcium, phytates
Magnesium	Vitamin D (regulation)	Competes with calcium
Iodine	Tyrosine (thyroid hormones)	Blocked by goitrogens (cassava, cabbage)
Sodium & Potassium	Balance fluid & BP	Excess sodium increases calcium loss
Selenium	Vitamin E (antioxidant synergy)	Deficiency worsens thyroid issues

Examples of recipes to manage mineral salt imbalances

Here are **three practical recipes** designed to help manage common **mineral element imbalances** in the body. Each dish emphasizes natural food sources rich in specific minerals to correct deficiencies while avoiding excess intake.

1. Millet Porridge with Milk (Calcium & Magnesium Boost)

For calcium deficiency (weak bones, poor clotting) and magnesium deficiency (muscle cramps, fatigue).

Ingredients

- 1 cup millet flour
- 2 cups milk (cow's milk or fortified plant milk)
- 1 tbsp ground simsim (sesame seeds)
- 1 tsp honey (optional)

Preparation

1. Mix millet flour with water to form a smooth paste.
2. Boil milk, then add millet paste slowly while stirring.
3. Cook until thickened, add simsim, and sweeten with honey.

Benefit: Milk provides **calcium**, millet and simsim add **magnesium**, supporting bone and muscle health.

2. Bean & Spinach Stew (Iron & Folate Support)

For iron deficiency (anemia) and folate deficiency (poor red blood cell formation).

Ingredients

- 2 cups boiled beans
- 2 cups spinach (or sukuma wiki), chopped
- 2 tomatoes, diced
- 1 onion, chopped
- 1 tbsp sunflower oil
- Juice of 1 lemon

Preparation

1. Sauté onion and tomatoes in oil.
2. Add beans and simmer for 10 minutes.
3. Stir in spinach and cook lightly.
4. Squeeze lemon juice before serving.

Benefit: Beans and spinach provide **iron and folate**, while lemon juice adds **Vitamin C** to enhance iron absorption.

3. Grilled Tilapia with Avocado Salad (Zinc, Selenium & Potassium Balance)

For zinc deficiency (poor immunity), selenium deficiency (weak antioxidant defense), and potassium deficiency (muscle weakness, high blood pressure).

Ingredients

- 1 tilapia fillet (zinc, selenium)
- 1 avocado (potassium, healthy fats)
- 1 tomato, diced
- ½ cucumber, sliced
- 1 tbsp olive oil
- Pinch of black pepper

Preparation

1. Marinate tilapia with pepper and grill until golden.

2. Dice avocado, tomato, and cucumber; mix with olive oil.
3. Serve fish with fresh avocado salad.

Benefit: Tilapia provides **zinc and selenium**, avocado supplies **potassium**, supporting immunity, antioxidant defense, and blood pressure regulation.

Summary of Recipes & Mineral Targets

Dish	Target Minerals	Key Benefits
Millet Porridge with Milk	Calcium, Magnesium	Bone strength, muscle function
Bean & Spinach Stew	Iron, Folate	Red blood cell formation, anemia prevention
Grilled Tilapia + Avocado Salad	Zinc, Selenium, Potassium	Immunity, antioxidant defense, blood pressure control

Conclusion: These dishes use **local, affordable foods** (millet, beans, spinach, tilapia, avocado, simsim, milk) to naturally correct mineral imbalances. They are nutrient-dense, easy to prepare, and culturally adaptable.

Water

Sources of Water in the body

- **Direct intake**: Drinking water, beverages (tea, milk, juice).
- **Food sources**: Fruits (watermelon, oranges), vegetables (cucumber, tomatoes), soups.
- **Metabolic water**: Produced inside the body during oxidation of macronutrients (e.g., glucose metabolism yields water).

Proportion of Water in the Body

- **Adults**: ~50–60% of body weight is water.
- **Infants**: ~70–80% (higher proportion).
- **Elderly**: ~45–50% (lower proportion due to reduced muscle mass).
- **Gender differences**: Men generally have more water than women because of higher muscle mass (muscle contains more water than fat).

Distribution of Water in Body Compartments

- **Intracellular fluid (ICF)**: ~2/3 of total body water.
    - Found inside cells.
    - Maintains cell shape, metabolic reactions, enzyme activity.

- **Extracellular fluid (ECF)**: ~1/3 of total body water.
    - **Interstitial fluid**: Surrounds cells, provides nutrient exchange.
    - **Plasma**: Fluid part of blood, transports nutrients, hormones, waste.
    - **Transcellular fluids**: Specialized fluids (cerebrospinal fluid, synovial fluid, digestive juices).

Role of Water in Overall Health

1. Hydration

- Maintains fluid balance and prevents dehydration.
- Regulates body temperature through sweating and evaporation.

2. Organ Functioning

- **Kidneys**: Water aids in excretion of waste products (urea, toxins).
- **Digestive system**: Essential for saliva, gastric juices, and nutrient absorption.
- **Circulatory system**: Plasma (mostly water) transports oxygen, nutrients, and hormones.
- **Brain & nerves**: Maintains electrolyte balance for nerve impulse transmission.

3. Metabolic Processes

- Acts as a solvent for biochemical reactions.
- Facilitates transport of glucose, amino acids, and minerals.
- Provides medium for enzymatic activity.

4. Structural Role

- Maintains cell turgor and elasticity of tissues.
- Lubricates joints (synovial fluid) and cushions organs.

Aspect	Details	Example
Sources	Drinking water, food, metabolic water	Fruits, soups, oxidation of glucose
Proportion	50–60% in adults, 70–80% infants	Men > women due to muscle mass
Distribution	2/3 intracellular, 1/3 extracellular	Plasma, interstitial, cerebrospinal fluid
Health Effects	Hydration, organ function, metabolism, structure	Kidney excretion, brain signaling, joint lubrication

Functions of Water in Food Nutrition

1. Hydration and Nutrient Transport

- Water is the medium through which nutrients (carbohydrates, proteins, fats, vitamins, minerals) are dissolved and transported in the body.
- It facilitates digestion by forming saliva and gastric juices, helping enzymes break down food.
- Example: Vitamin C and B-complex vitamins dissolve in water, making them easier to absorb.

2. Food Structure and Texture

- Water contributes to the texture of foods (e.g., crispness in vegetables, juiciness in fruits).
- It affects tenderness in baked goods and meat.
- Bound water in foods influences mouthfeel and palatability.

3. Water Activity and Food Preservation

- **Water activity (aw)** measures the availability of water for microbial growth.
- Foods with high water activity (fresh fruits, milk) spoil quickly, while low water activity foods (dried grains, powdered milk) are more stable.
- Controlling water activity through drying, salting, or sugar addition helps preserve food.

4. Metabolic and Physiological Roles

- Water is essential for biochemical reactions such as hydrolysis (breaking down starches and proteins).
- It regulates body temperature through sweating and evaporation.
- It aids in detoxification by flushing out waste products via urine.

5. Cooking and Food Processing

- Water acts as a solvent in cooking (soups, stews, boiling).
- It transfers heat during steaming and boiling, affecting nutrient retention.
- Excessive boiling can lead to loss of water-soluble vitamins (e.g., Vitamin C, B1).

Summary Table

Role of Water	Example in Food Nutrition	Impact
Hydration & transport	Dissolves vitamins, aids digestion	Nutrient absorption
Structure & texture	Crisp vegetables, tender bread	Palatability
Water activity	Dried grains vs fresh milk	Shelf life, microbial safety
Metabolic functions	Hydrolysis, detoxification	Energy metabolism, waste removal
Cooking & processing	Boiling, steaming	Nutrient retention or loss

Relationship between property of water and functions in the body

1. Universal Solvent

- **Property**: Water dissolves a wide range of substances (salts, sugars, amino acids).
- **Function in Body**:
  - Enables transport of nutrients, oxygen, and hormones in blood plasma (which is ~90% water).
  - Facilitates waste removal via urine.

2. High Heat Capacity

- **Property**: Water absorbs and retains heat without rapid temperature changes.
- **Function in Body**:
  - Maintains stable internal body temperature despite external fluctuations.
  - Supports thermoregulation through sweating and evaporation.

3. High Heat of Vaporization

- **Property**: Large amounts of energy are required to convert water into vapor.
- **Function in Body**:
  - Sweating removes excess heat efficiently, preventing overheating.
  - Critical for athletes and individuals in hot climates like Uganda.

4. Cohesion and Adhesion

- **Property**: Water molecules stick to each other (cohesion) and to other surfaces (adhesion).
- **Function in Body**:
    - Supports capillary action, allowing water and nutrients to move through tiny blood vessels.
    - Essential for circulation and nutrient delivery.

5. Polarity

- **Property**: Water molecules have positive and negative ends.
- **Function in Body**:
    - Facilitates biochemical reactions (hydrolysis, enzyme activity).
    - Helps maintain electrolyte balance for nerve and muscle function.

6. Distribution in Body Compartments

- **Property**: Water is distributed as intracellular fluid (~2/3) and extracellular fluid (~1/3).
- **Function in Body**:
    - Intracellular water maintains cell shape and metabolism.
    - Extracellular water (plasma, interstitial fluid) supports nutrient exchange and circulation.

Summary Table

Property	Function in Body
Universal solvent	Nutrient transport, waste removal
High heat capacity	Stable body temperature
High heat of vaporization	Cooling via sweating
Cohesion & adhesion	Capillary action, circulation
Polarity	Biochemical reactions, electrolyte balance
Compartmental distribution	Cell metabolism, nutrient exchange

Effects of dehydration on body functions

Dehydration reduces the body's ability to regulate temperature, transport nutrients, and remove waste. Even mild fluid loss can impair brain function, cause fatigue, and strain the kidneys, while severe dehydration can be life-threatening.

Definition of Dehydration

Dehydration occurs when the body loses more fluids than it takes in, leading to insufficient water for normal physiological processes. Causes include **excessive sweating, diarrhea, vomiting, fever, or inadequate fluid intake**.

Effects of Dehydration on Body Functions

1. Brain and Nervous System

- Reduced water impairs electrolyte balance, slowing nerve transmission.
- Symptoms: **confusion, dizziness, headaches, poor concentration, and brain fog**.
- Severe dehydration may cause seizures due to electrolyte imbalance.

2. Circulatory System

- Plasma volume decreases, making blood thicker.
- Results: **low blood pressure, rapid heartbeat, poor circulation**.
- In extreme cases, shock can occur.

3. Kidneys and Excretion

- Kidneys conserve water by reducing urine output.
- Leads to **dark, concentrated urine** and increased risk of kidney stones.
- Prolonged dehydration can cause **acute kidney injury**.

4. Digestive System

- Reduced saliva and gastric secretions impair digestion.
- Symptoms: **dry mouth, difficulty swallowing, constipation**.
- Severe dehydration may cause nausea and vomiting, worsening fluid loss.

5. Muscles and Physical Performance

- Loss of electrolytes (sodium, potassium, magnesium) causes **muscle cramps, weakness, and fatigue**.
- Athletic performance declines due to impaired thermoregulation and energy metabolism.

6. Skin and Temperature Regulation

- Less water reduces sweating, impairing cooling mechanisms.
- Symptoms: **dry skin, overheating, heat exhaustion, or heat stroke**.

- Particularly dangerous in hot climates like Uganda.

7. Immune and Cellular Function

- Water is essential for nutrient transport and waste removal.
- Dehydration slows cellular metabolism, reducing immune efficiency.

Severity Levels of Dehydration

Level	Fluid Loss	Symptoms	Risks
Mild	1–2% body weight	Thirst, dry mouth, reduced urine	Early fatigue, reduced focus
Moderate	3–5% body weight	Headache, dizziness, rapid pulse	Impaired organ function
Severe	>6% body weight	Confusion, fainting, very low BP	Kidney failure, shock, death

Conclusion

Dehydration affects **every major system**—from the brain and heart to kidneys and muscles. Mild dehydration reduces concentration and energy, while severe dehydration can cause organ failure and death. Regular hydration, especially in hot climates or during physical activity, is essential for maintaining **overall health and body function**.

Water Balance Mechanisms in the body

- **Intake vs. Output Regulation**:
  - Intake comes from drinking water, food, and metabolic water.
  - Output occurs via urine, sweat, feces, and respiration.
- **Hormonal Control**:
  - **Antidiuretic hormone (ADH)**: Increases water reabsorption in kidneys when dehydration occurs.
  - **Aldosterone**: Promotes sodium (and water) retention, maintaining blood pressure.
  - **Atrial natriuretic peptide (ANP)**: Promotes sodium and water excretion when blood volume is high.

Electrolyte Balance Mechanisms in the body

Electrolytes (sodium, potassium, chloride, calcium, phosphate) regulate fluid distribution, nerve impulses, and muscle contraction.

- **Sodium (Na^+)**: Major extracellular ion; controls water movement and blood pressure.
- **Potassium (K^+)**: Major intracellular ion; essential for nerve and muscle function.
- **Chloride (Cl^-)**: Maintains osmotic pressure and acid–base balance.

- **Calcium (Ca^{2+})**: Needed for muscle contraction, blood clotting, and bone health.
- **Phosphate (HPO_4^{2-})**: Important in energy metabolism and buffering.

Kidneys regulate electrolyte excretion and reabsorption, while hormones (aldosterone, parathyroid hormone) fine-tune balance.

Acid–Base Buffer Systems in the body

The body must maintain blood pH between **7.35–7.45**. Buffer systems, respiration, and renal function achieve this balance.

(i) Chemical Buffer Systems

- **Bicarbonate buffer system** (most important in blood):

  $H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

  Neutralizes excess acids or bases.

- **Phosphate buffer system**: Active in intracellular fluid and kidneys.
- **Protein buffer system**: Hemoglobin and plasma proteins bind or release hydrogen ions.

(ii) Respiratory Regulation

- Lungs control carbon dioxide (CO_2), which influences carbonic acid levels.
- **Increased CO_2** → lowers pH (respiratory acidosis).
- **Decreased CO_2** → raises pH (respiratory alkalosis).

(iii) Renal Regulation

- Kidneys excrete hydrogen ions (H^+) and reabsorb bicarbonate (HCO_3^-).
- Provides long-term pH balance.
- Example: In metabolic acidosis, kidneys increase H^+ excretion and HCO_3^- reabsorption.

Summary Table

Mechanism	Role	Example
ADH	Water reabsorption	Prevents dehydration
Aldosterone	Sodium retention	Maintains blood pressure
ANP	Sodium/water excretion	Prevents fluid overload
Bicarbonate buffer	Maintains blood pH	Neutralizes excess acid
Respiratory control	Adjusts CO_2	Rapid pH regulation
Renal control	Excretes H^+, reabsorbs HCO_3^-	Long-term pH balance

Conclusion

Water and electrolyte balance is maintained by **hormonal regulation, kidney function, and buffer systems**. The **acid–base buffer system (bicarbonate, phosphate, protein)**, together with respiratory and renal mechanisms, ensures stable blood pH and proper cellular function. Without these systems, dehydration, electrolyte imbalance, or acidosis/alkalosis could severely impair organ health.

Thank You

Dr. Bbosa Science