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## A-level Food and Nutrition

SENIOR Five term 2

### TOPIC 3/3: Absorption and Metabolism of Nutrients

**Competency:** The learner develops an understanding of nutrient absorption and metabolism and applies this knowledge to promote health, manage diet, and enhance overall well-being.

### Application of the knowledge of nutrient absorption and metabolism in management of meals.

Managing meals effectively requires understanding **how nutrients are absorbed and metabolized** in the body. This knowledge helps design diets that maximize energy, maintain health, and prevent nutrient deficiencies.

#### Principles of Nutrient Absorption

(i) **Carbohydrates:**

- Broken down into glucose in the small intestine.
- Absorbed into the bloodstream and used for immediate energy or stored as glycogen in the liver and muscles.

**Meal management:** Include complex carbs (whole grains, legumes) for sustained energy release.

(ii) **Proteins:**

- Digested into amino acids.
- Absorbed in the small intestine and used for tissue repair, enzyme production, and hormones.

**Meal management:** Distribute protein intake across meals (beans, fish, eggs) to support muscle repair and satiety.

(iii) **Fats:**

- Broken down into fatty acids and glycerol.
- Absorbed via lymphatic system and used for energy, cell membranes, and fat-soluble vitamins (A, D, E, K).

**Meal management:** Include healthy fats (avocado, groundnuts, sesame oil) to aid vitamin absorption.

(iv) **Vitamins & Minerals:**

- Water-soluble vitamins (C, B-complex) absorbed directly into blood; excess excreted in urine.
- Fat-soluble vitamins (A, D, E, K) absorbed with dietary fat.
- Minerals (iron, calcium, zinc) absorbed depending on enhancers (e.g., vitamin C improves iron absorption).

**Meal management:** Pair foods wisely (e.g., citrus with beans to boost iron absorption).

(v) **Water:**

- Absorbed in the small and large intestine.
- Essential for transport, temperature regulation, and metabolism.

**Meal management:** Ensure adequate hydration throughout the day.

## Principles of Metabolism

**Catabolism:** Breaking down nutrients to release energy (ATP).

**Anabolism:** Building up molecules for growth and repair.

**Meal management:**

- Balance energy intake with expenditure to maintain healthy weight.
- Include nutrient-dense foods to support anabolic processes (growth, healing).
- Avoid excess refined sugars and fats that overload catabolic pathways, leading to fat storage.

## Applications of Principles of nutrient absorption and metabolism in Meal Management

(i) **Balanced meals:** Combine carbs, proteins, fats, vitamins, and minerals for complete nutrition.

(ii) **Meal timing:**

- Breakfast rich in complex carbs and protein for energy.
- Lunch balanced for sustained productivity.

- Dinner lighter, focusing on easy-to-digest foods.

**(iii) Food combinations:**

- Beans + posho (protein + carb).
- Matoke + groundnut sauce (carb + healthy fat + protein).
- Millet porridge + milk (carb + protein + calcium).

**(iv) Special considerations:**

- **Athletes:** Higher protein and carb intake for muscle repair and glycogen replenishment.
- **Children:** Nutrient-dense meals for growth.
- **Elderly:** Easy-to-digest foods, with emphasis on calcium and vitamin D.

**Summary Table**

Nutrient	Absorption	Metabolism Role	Meal Management
<b>Carbohydrates</b>	Glucose in small intestine	Energy (ATP), glycogen storage	Whole grains, legumes
<b>Proteins</b>	Amino acids in small intestine	Tissue repair, enzymes	Beans, fish, eggs
<b>Fats</b>	Fatty acids via lymph	Energy, vitamin absorption	Avocado, groundnuts
<b>Vitamins</b>	Water-soluble in blood, fat-soluble with fats	Coenzymes, antioxidants	Citrus + beans, milk
<b>Minerals</b>	Absorption varies	Bone health, oxygen transport	Iron-rich foods with vitamin C
<b>Water</b>	Intestines	Transport, regulation	Hydration throughout day

**Conclusion**

By applying knowledge of **nutrient absorption and metabolism**, meals can be managed to:

- Maximize nutrient uptake,
- Support energy balance,
- Prevent deficiencies, and
- Promote overall health.

This is the foundation of **nutrition planning**—ensuring meals are not just filling, but also functional for the body’s needs.

## Factors that affect nutrient absorption in the body

Nutrient absorption is influenced by **biological processes** in the digestive system and by **dietary and lifestyle factors** that either enhance or hinder uptake. Let’s break this down nutrient by nutrient:

### Carbohydrates

**Process:** Digested into glucose, absorbed in the small intestine.

#### Enhancing Factors:

- Adequate enzyme activity (amylase, maltase).
- Fiber in moderate amounts slows absorption, preventing spikes in blood sugar.

#### Hindering Factors:

- Enzyme deficiencies (e.g., lactase deficiency → lactose intolerance).
- Excess fiber may reduce absorption efficiency.

### Proteins

**Process:** Broken down into amino acids, absorbed in the small intestine.

#### Enhancing Factors:

- Adequate stomach acid (HCl) and pepsin activity.
- Balanced intake of essential amino acids.

#### Hindering Factors:

- Low stomach acid (hypochlorhydria).
- Certain plant compounds (trypsin inhibitors in legumes if not cooked properly).

### Fats

**Process:** Broken down into fatty acids and glycerol, absorbed via the lymphatic system.

#### Enhancing Factors:

- Presence of bile salts (emulsification).

- Adequate pancreatic lipase.
- Consuming fat-soluble vitamins (A, D, E, K) with dietary fat.

#### **Hindering Factors:**

- Gallbladder or liver disease (reduced bile production).
- Very low-fat diets impair absorption of fat-soluble vitamins.

### **Vitamins**

#### **Water-Soluble (C, B-complex)**

**Enhancing Factors:** Vitamin C enhances iron absorption; adequate hydration supports transport.

**Hindering Factors:** Heat destroys Vitamin C; alcohol reduces B-vitamin absorption.

#### **Fat-Soluble (A, D, E, K)**

- **Enhancing Factors:** Presence of dietary fat.
- **Hindering Factors:** Fat malabsorption disorders (celiac disease, pancreatitis).

### **Minerals**

#### **Iron**

- **Enhancing Factors:** Vitamin C, animal protein (heme iron).
- **Hindering Factors:** Phytates (in grains), tannins (tea/coffee), calcium (competes with iron).

#### **Calcium**

- **Enhancing Factors:** Vitamin D, lactose.
- **Hindering Factors:** Phytates, oxalates (spinach), excess caffeine.

#### **Zinc**

- **Enhancing Factors:** Animal protein.
- **Hindering Factors:** Phytates in whole grains.

#### **Magnesium**

- **Enhancing Factors:** Adequate protein intake.
- **Hindering Factors:** Excess alcohol, high-fat diets.

## Water

- **Process:** Absorbed in small and large intestine.
- **Enhancing Factors:** Adequate hydration, electrolytes (sodium, potassium).
- **Hindering Factors:** Diarrhea, dehydration, excess alcohol.

## Summary Table

Nutrient	Enhancing Factors	Hindering Factors
<b>Carbohydrates</b>	Enzymes, moderate fiber	Enzyme deficiency, excess fiber
<b>Proteins</b>	Stomach acid, complete amino acids	Low acid, trypsin inhibitors
<b>Fats</b>	Bile salts, dietary fat	Gallbladder/liver disease, very low-fat diet
<b>Vitamins (Water-soluble)</b>	Vitamin C, hydration	Heat, alcohol
<b>Vitamins (Fat-soluble)</b>	Dietary fat	Fat malabsorption
<b>Iron</b>	Vitamin C, heme iron	Phytates, tannins, calcium
<b>Calcium</b>	Vitamin D, lactose	Phytates, oxalates, caffeine
<b>Zinc</b>	Animal protein	Phytates
<b>Magnesium</b>	Protein intake	Alcohol, high-fat diet
<b>Water</b>	Hydration, electrolytes	Diarrhea, dehydration

## Conclusion

Nutrient absorption depends on **digestive processes** and **dietary interactions**. Enhancers like vitamin C, bile salts, and balanced diets improve absorption, while inhibitors like phytates, tannins, excess fiber, or disease conditions reduce it. Applying this knowledge helps in **meal planning** to maximize nutrient uptake and overall health.

## Metabolic process in food and nutrition

### Role of protein metabolism in food and nutrition

#### 1. Deamination

**Definition:** Deamination is the **metabolic process of removing an amino group (-NH<sub>2</sub>) from an amino acid**, producing ammonia and a keto acid.

**Location:** Primarily occurs in the **liver**, but also in the kidneys.

**Enzymes involved:** Deaminases catalyze the reaction.

### Steps in Deamination

- (i) **Removal of amino group** from the amino acid.
- (ii) **Formation of ammonia (NH<sub>3</sub>)**, which is toxic.
- (iii) **Conversion of ammonia to urea** in the urea cycle for safe excretion via urine.
- (iv) **Carbon skeleton (keto acid)** is recycled:
  - Oxidized for energy (ATP production).
  - Converted into glucose (gluconeogenesis).
  - Converted into fat for storage.

### Role in Food and Nutrition

- (i) **Protein metabolism:**
  - When dietary protein intake exceeds body needs, deamination prevents amino acid buildup.
  - Ensures amino acids are used efficiently for energy or storage.
- (ii) **Energy production:**
  - Carbon skeletons from deaminated amino acids can enter the Krebs cycle to generate ATP.
  - Important during fasting or low-carbohydrate diets when protein is used as an energy source.
- (iii) **Nitrogen balance:**
  - Deamination regulates nitrogen levels, preventing toxic ammonia accumulation.
  - Supports homeostasis in protein-rich diets.
- (iv) **Clinical relevance:**
  - Excessive deamination (from very high protein intake) stresses the liver and kidneys.
  - Balanced diets prevent overload of nitrogen waste.

## 2. Transamination

**Definition:** Transamination is the process of **transferring an amino group (-NH<sub>2</sub>) from one amino acid to a keto acid**, forming a new amino acid.

**Location:** Occurs mainly in the **liver** (and to some extent in muscles).

**Enzymes involved:** Transaminases (also called aminotransferases), such as ALT (alanine transaminase) and AST (aspartate transaminase).

## Role in Food and Nutrition

### (i) Amino Acid Balance

- Transamination allows the body to **synthesize non-essential amino acids** from essential ones.
- Example: Glutamate can donate its amino group to form alanine or aspartate.
- **Nutritional impact:** Even if the diet lacks some non-essential amino acids, the body can make them through transamination, ensuring protein balance.

### (ii) Efficient Protein Utilization

- Dietary proteins are broken down into amino acids.
- Transamination helps convert excess amino acids into forms the body needs.
- **Nutritional impact:** Prevents wastage of dietary protein and supports growth, repair, and enzyme production.

### (iii) Energy Production

- When protein intake exceeds needs, transamination helps redirect amino acids into energy pathways.
- The carbon skeletons of amino acids (after transamination) can enter the Krebs cycle for ATP production.
- **Nutritional impact:** Important during fasting, low-carb diets, or high-protein diets.

### (iv) Nitrogen Metabolism

- Transamination is the first step in nitrogen handling before deamination and urea formation.
- **Nutritional impact:** Maintains nitrogen balance, preventing toxic ammonia buildup.

### (v) Clinical & Food Processing Relevance

- In nutrition science, measuring transaminase activity (ALT, AST) helps assess liver health, which is central to protein metabolism.
- In food processing, understanding amino acid metabolism guides formulation of protein-rich diets and supplements.

## Role of lipid metabolism in food and nutrition

### 1. Carnitine Cycle

**Definition:** The carnitine cycle (also called the carnitine shuttle) is a metabolic pathway that transports long-chain fatty acids across the mitochondrial membrane.

**Key Steps:**

- (i) Fatty acids are activated to form acyl-CoA.
- (ii) Carnitine attaches to acyl-CoA, forming acyl-carnitine.
- (iii) Acyl-carnitine is shuttled into the mitochondria.
- (iv) Inside the mitochondria, carnitine is released, and fatty acids undergo  **$\beta$ -oxidation** to produce ATP.

**Location:** Occurs in the mitochondria of cells, especially in muscle, liver, and heart tissues.

### Role in Food and Nutrition

(i) **Fat Metabolism**

- The carnitine cycle is essential for breaking down dietary fats into energy.
- Foods rich in fat (meat, milk, groundnuts, avocado) rely on this cycle for energy conversion.
- **Nutritional impact:** Supports endurance and energy balance, especially during fasting or exercise.

(ii) **Energy Production**

- Long-chain fatty acids cannot enter mitochondria without carnitine.
- The cycle ensures fats are oxidized to generate ATP.
- **Nutritional impact:** Provides sustained energy from fat stores, sparing glucose and protein.

(iii) **Protein and Amino Acid Link**

- Carnitine itself is derived from amino acids lysine and methionine.
- Adequate protein intake supports carnitine synthesis.
- **Nutritional impact:** Diets deficient in these amino acids may impair fat metabolism.

(iv) **Nutrient Utilization**

- Fat-soluble vitamins (A, D, E, K) depend on proper fat metabolism for absorption.
- The carnitine cycle indirectly supports their nutritional role.

(v) **Clinical and Dietary Relevance**

- **Deficiency:** Rare, but can occur in vegetarians, malnutrition, or genetic disorders. Leads to fatigue, muscle weakness, and poor fat utilization.
- **Supplements:** L-carnitine is sometimes used to support fat metabolism, athletic performance, and recovery.
- **Food sources:** Carnitine is abundant in red meat, fish, poultry, and dairy.

## 2. Lipolysis

**Definition:** The breakdown of stored fat (triglycerides) into glycerol and free fatty acids.

**Where it occurs:** Mainly in adipose tissue, triggered by hormones like adrenaline, glucagon, and cortisol.

**Process:**

- (i) Triglycerides → glycerol + fatty acids.
- (ii) Fatty acids transported to mitochondria for **β-oxidation** → ATP production.

**Role in Food & Nutrition:**

- Provides energy during fasting, exercise, or low-carbohydrate intake.
- Helps maintain blood glucose by sparing protein and glycogen.
- Important in weight management and energy balance.

**Dietary Relevance:**

- High-fat foods (meat, milk, groundnuts, avocado) supply triglycerides that can later be mobilized through lipolysis.
- Lipolysis ensures these fats are not just stored but used for energy when needed.

## 3. Lipogenesis

**Definition:** The synthesis of fat (triglycerides) from non-fat sources, mainly carbohydrates and proteins.

**Where it occurs:** Primarily in the liver and adipose tissue.

**Process:**

- (i) Excess glucose → acetyl-CoA.
- (ii) Acetyl-CoA → fatty acids.
- (iii) Fatty acids + glycerol → triglycerides (stored in adipose tissue).

**Role in Food & Nutrition:**

- Stores excess energy from food for future use.
- Ensures survival during periods of food scarcity.
- Helps regulate energy balance by converting surplus nutrients into fat.

**Dietary Relevance:**

- High carbohydrate intake (e.g., posho, rice, bread, matoke) can lead to lipogenesis if energy needs are exceeded.
- Overactive lipogenesis contributes to obesity and metabolic disorders.

#### 4. Cholesterol Synthesis

**Definition:** Cholesterol synthesis is the biochemical pathway by which the body produces cholesterol from acetyl-CoA.

**Location:** Primarily in the **liver**, but also in the intestines and other tissues.

**Key Enzyme:** **HMG-CoA reductase**, which converts HMG-CoA to mevalonate, is the rate-limiting step.

**Pathway:** Acetyl-CoA → HMG-CoA → Mevalonate → Squalene → Lanosterol → Cholesterol.

**Role in Food and Nutrition**

(i) **Structural Role**

- Cholesterol is a major component of **cell membranes**, maintaining fluidity and integrity.
- Essential for growth and repair of tissues.

(ii) **Precursor Functions**

- Cholesterol is the precursor for:

- **Bile acids** (aid fat digestion and absorption).
- **Steroid hormones** (cortisol, estrogen, testosterone).
- **Vitamin D** (important for calcium absorption and bone health).

### (iii) Dietary Balance

- The body synthesizes cholesterol even if dietary intake is low, ensuring a stable pool.
- Foods like **meat, eggs, and dairy** provide cholesterol directly, while plant foods contain phytosterols that can reduce absorption.

### (iv) Health Implications

- Excess cholesterol synthesis or intake raises **LDL cholesterol**, linked to atherosclerosis and heart disease.
- Nutrients like **omega-3 fatty acids, fiber, and phytosterols** help lower LDL cholesterol, while moderate alcohol intake can raise HDL cholesterol.

## 5. Ketosis

**Definition:** A condition in which the liver converts fatty acids into **ketone bodies** (acetoacetate,  $\beta$ -hydroxybutyrate, acetone).

**Trigger:** Occurs when carbohydrate intake is very low, glycogen stores are depleted, and fat becomes the primary fuel.

**Location:** Ketone production happens in the **liver**, and ketones are used by muscles, brain, and other tissues for energy.

### Role in Food and Nutrition

#### (i) Energy Production

- Ketones provide an efficient energy source during fasting, prolonged exercise, or low-carb diets.
- The brain, which normally relies on glucose, can adapt to use ketones.

#### (ii) Weight Management

- Ketosis promotes fat breakdown (lipolysis), helping reduce body fat.
- Often used in **ketogenic diets** for weight loss.

#### (iii) Therapeutic Uses

- **Epilepsy management:** Ketogenic diets reduce seizures in some patients.
- **Diabetes:** Controlled ketosis can improve insulin sensitivity, though uncontrolled ketosis (ketoacidosis) is dangerous.
- **Neuroprotection:** Ketones may support brain health in conditions like Alzheimer's.

#### (iv) Food Sources & Diet

- **Foods that promote ketosis:**
  - High-fat foods (avocado, groundnuts, sesame seeds, dairy, meat, fish).
  - Low-carb vegetables (greens, cabbage, cauliflower).
  - Oils (coconut oil, olive oil).
- **Foods that hinder ketosis:**
  - High-carb staples (matoke, posho, rice, bread, cassava).
  - Sugary foods and drinks.

### Role of Carbohydrate metabolism in food and nutrition

#### 1. Glycolysis

**Definition:** Glycolysis is the metabolic pathway that breaks down **glucose** (from carbohydrates) into **pyruvate**, producing a small amount of energy.

**Location:** Occurs in the **cytoplasm** of cells.

**Process:**

- Glucose → 2 Pyruvate molecules.
- Produces **2 ATP** (energy) and **NADH** (electron carriers).

**Role in Food & Nutrition:**

- Provides **quick energy** from carbohydrate-rich foods (e.g., matoke, rice, bread, cassava).
- Supplies intermediates for biosynthesis (e.g., amino acids, fatty acids).
- Essential for tissues that rely heavily on glucose (brain, red blood cells).

#### 2. Krebs Cycle (Citric Acid Cycle)

**Definition:** A central metabolic pathway that oxidizes **acetyl-CoA** (from pyruvate, fats, or proteins) to produce energy-rich molecules.

**Location:** Occurs in the **mitochondria**.

**Process:**

- (i) Acetyl-CoA enters the cycle.
- (ii) Produces **NADH, FADH<sub>2</sub>, and GTP/ATP**.
- (iii) Releases **CO<sub>2</sub>** as a waste product.

**Role in Food & Nutrition:**

- (i) Provides the bulk of energy from foods (carbs, fats, proteins).
- (ii) Supplies reducing agents (NADH, FADH<sub>2</sub>) for the **electron transport chain**, which generates large amounts of ATP.
- (iii) Intermediates are used in biosynthesis (e.g., amino acids, heme for blood).
- (iv) Ensures efficient use of nutrients from diverse foods (beans, fish, milk, meat, groundnuts).

### 3. Electron Transport Chain

**Definition:** A series of protein complexes in the inner mitochondrial membrane that transfer electrons from NADH and FADH<sub>2</sub> to oxygen, producing water and ATP.

**Location:** Inner membrane of mitochondria.

**Inputs:** NADH and FADH<sub>2</sub> (from glycolysis, lipolysis, and the Krebs cycle).

**Outputs:** ATP (energy), water, and heat.

**Role in Food and Nutrition**

- (i) **Energy Conversion**
  - **Carbohydrates → glucose → glycolysis → NADH.**
  - **Fats → fatty acids → β-oxidation → NADH/FADH<sub>2</sub>.**
  - **Proteins → amino acids → Krebs cycle intermediates → NADH/FADH<sub>2</sub>.**
  - **All these feed into the ETC, producing ATP, which powers muscle contraction, digestion, and biosynthesis.**
- (ii) **Efficiency of Nutrient Use**

- **The ETC generates the majority of ATP (about 34 out of 38 ATP per glucose molecule).**
- **Ensures** that food energy is not wasted but fully harnessed.

(iii) **Oxygen Utilization**

- **The ETC is aerobic—it requires oxygen.**
- **Explains why oxygen intake (breathing) is vital for energy metabolism.**
- **In** nutrition, this links to aerobic exercise and oxygen delivery from hemoglobin.

(iv) **Heat Production**

- **Some energy is released as heat during electron transfer.**
- Important for maintaining body temperature, especially in cold environments.

(v) **Clinical and Dietary Relevance**

- **Deficiencies:** Lack of nutrients like iron, copper, or B-vitamins (cofactors for ETC enzymes) impairs ATP production.
- **Dietary balance:** Adequate intake of carbs, fats, proteins, and micronutrients ensures ETC efficiency.
- **Exercise nutrition:** Athletes rely on ETC efficiency for endurance, highlighting the importance of balanced diets.

#### 4. **Glycogenesis**

**Definition:** The synthesis of glycogen (a storage form of glucose) from glucose molecules.

**Location:** Mainly in the **liver** and **skeletal muscles**.

**Trigger:** Stimulated by **insulin** after carbohydrate-rich meals.

**Process:**

- (i) Glucose → Glucose-6-phosphate → Glucose-1-phosphate.
- (ii) Glucose-1-phosphate + UDP → Glycogen (branched polymer).

#### **Role in Food and Nutrition**

(i) **Energy Storage**

- After eating carbohydrate-rich foods (matoke, rice, posho, bread, cassava), excess glucose is stored as glycogen.

- Glycogen acts as a **short-term energy reserve**, easily mobilized when blood sugar drops.

(ii) **Blood Sugar Regulation**

- Glycogenesis prevents hyperglycemia (too much glucose in the blood) by storing excess glucose.
- Later, glycogen can be broken down (glycogenolysis) to maintain blood sugar during fasting.

(iii) **Muscle Function**

- Muscle glycogen provides energy during exercise and physical activity.
- Important for athletes and active individuals who rely on glycogen stores for endurance.

(iv) **Nutritional Balance**

- Ensures carbohydrates are not wasted but stored for future use.
- Explains why balanced carbohydrate intake is important—too little reduces glycogen stores, too much leads to fat storage after glycogen capacity is exceeded.

## 5. Gluconeogenesis

**Definition:** The synthesis of glucose from non-carbohydrate precursors such as amino acids, lactate, and glycerol.

**Location:** Primarily in the **liver**, and to a lesser extent in the kidneys.

**Trigger:** Activated when carbohydrate intake is low, glycogen stores are depleted, or energy demand is high.

**Precursors:**

- **Amino acids** (from protein breakdown).
- **Lactate** (from anaerobic glycolysis in muscles).
- **Glycerol** (from fat breakdown).

### Role in Food and Nutrition

(i) **Blood Sugar Regulation**

- Maintains **glucose supply** for tissues that depend on it (brain, red blood cells) when dietary carbs are scarce.
- Prevents hypoglycemia during fasting or prolonged exercise.

#### (ii) Protein Utilization

- Amino acids from dietary protein (beans, fish, eggs, milk) can be converted into glucose.
- Explains why adequate protein intake is important in low-carb diets.

#### (iii) Fat Utilization

- Glycerol from triglycerides contributes to glucose synthesis.
- Shows how fat-rich foods (groundnuts, avocado, sesame) indirectly support glucose production.

#### (iv) Exercise and Endurance

- Lactate produced during intense activity is recycled into glucose via the **Cori cycle**.
- Important for athletes relying on sustained energy.

#### (v) Clinical and Dietary Relevance

- **Fasting:** Gluconeogenesis is the main source of glucose after glycogen stores are depleted.
- **Low-carb diets:** Ensures glucose supply despite reduced carbohydrate intake.
- **Diabetes**

## 6. Glycogenolysis

**Definition:** The breakdown of glycogen into glucose-1-phosphate and eventually glucose-6-phosphate, which can enter glycolysis or be released into the bloodstream.

**Location:** Occurs mainly in the **liver** (to maintain blood glucose levels) and **muscles** (to provide energy for contraction).

**Trigger:** Stimulated by hormones such as **glucagon** (during fasting) and **adrenaline/epinephrine** (during exercise or stress).

## Role in Food and Nutrition

### (i) Blood Sugar Regulation

- Liver glycogenolysis maintains **blood glucose levels** when dietary carbohydrate intake is low (e.g., overnight fasting).
- Prevents hypoglycemia, ensuring a steady supply of glucose for the brain and red blood cells.

### (ii) Muscle Energy Supply

- Muscle glycogenolysis provides **quick energy** during exercise.
- **Important** for athletes and physically active individuals who rely on glycogen stores for endurance.

### (iii) Link to Diet

- Carbohydrate-rich foods (matoke, rice, posho, cassava, bread) replenish glycogen stores after meals.
- Glycogenolysis ensures these stored carbs are available when food is not immediately consumed.

### (iv) Nutritional Balance

- Explains why balanced carbohydrate intake is important:
  - Too little → glycogen stores deplete quickly, leading to fatigue.
  - Too much → excess carbs beyond glycogen capacity are converted into fat.

## The roles of different nutrients in energy production

### 1. Carbohydrates

**Role:** Primary and fastest source of energy.

**Process:**

- (i) Broken down into glucose.
- (ii) Glucose enters **glycolysis** → **Krebs cycle** → **electron transport chain**, producing ATP.

**Nutritional Impact:**

- (iii) Fuels the brain and red blood cells (which rely almost exclusively on glucose).
- (iv) Provides quick energy for physical activity.
- (v) Excess glucose stored as glycogen (short-term) or fat (long-term).

## 2. Proteins

**Role:** Secondary energy source when carbs and fats are insufficient.

**Process:**

- (i) Broken down into amino acids.
- (ii) Amino acids undergo **deamination/transamination**, then carbon skeletons enter the Krebs cycle.

**Nutritional Impact:**

- (i) Supports energy production during fasting or starvation.
- (ii) Normally prioritized for growth, repair, and enzymes rather than energy.
- (iii) Excess protein can be converted into glucose via **gluconeogenesis**.

## 3. Fats

**Role:** Major long-term energy reserve.

**Process:**

- (i) Broken down into glycerol and fatty acids.
- (ii) Fatty acids undergo  **$\beta$ -oxidation** → **acetyl-CoA** → **Krebs cycle** → **ETC**, yielding large amounts of ATP.

**Nutritional Impact:**

- (i) Provides sustained energy during rest and endurance exercise.
- (ii) Essential for absorption of fat-soluble vitamins (A, D, E, K).
- (iii) Excess fat stored in adipose tissue.

## 4. Vitamins & Minerals (Micronutrients)

**Role:** Cofactors and coenzymes in energy metabolism.

**Examples:**

- (i) **B-vitamins (B1, B2, B3, B5, B6):** Essential in glycolysis, Krebs cycle, and ETC.

- (ii) **Iron:** Critical for hemoglobin (oxygen transport) and cytochromes in ETC.
- (iii) **Magnesium:** Stabilizes ATP and supports enzyme activity.
- (iv) **Copper:** Helps in electron transport chain.

**Nutritional Impact:** Without these micronutrients, energy pathways slow down or fail.

## 5. Water

**Role:** Medium for biochemical reactions.

**Nutritional Impact:**

- (v) Facilitates transport of nutrients and removal of waste.
- (vi) Maintains temperature during energy metabolism.

## Energy and nutrient requirement

### (i) Infants (0–12 months)

**Energy:** ~100 kcal/kg/day (higher than adults due to rapid growth).

**Protein:** Essential for tissue growth; breast milk or formula provides adequate amounts.

**Fat:** High requirement for brain development (about 40–50% of calories).

**Micronutrients:** Iron (from 6 months), Vitamin D, calcium, zinc.

**Nutrition Focus:** Exclusive breastfeeding for 6 months, then gradual introduction of complementary foods.

### (ii) Children (1–9 years)

**Energy:** 1,000–1,600 kcal/day depending on age and activity.

**Protein:** 13–19 g/day for growth and repair.

**Carbohydrates:** 130 g/day minimum for brain function.

**Micronutrients:** Calcium and Vitamin D for bones; iron for cognitive development.

**Nutrition Focus:** Balanced meals with fruits, vegetables, whole grains, dairy, and lean proteins.

**(iii) Adolescents (10–18 years)**

**Energy:** 2,000–3,200 kcal/day depending on sex and activity.

**Protein:** 34–52 g/day to support muscle growth.

**Fat:** 25–35% of calories, emphasizing healthy fats.

**Micronutrients:** Iron (especially for girls due to menstruation), calcium, vitamin D, folate.

**Nutrition Focus:** Adequate calories for growth spurts, balanced diet to prevent deficiencies, limit junk food.

**(iv) Adults (19–64 years)**

**Energy:** 2,000–3,000 kcal/day depending on sex and activity.

**Protein:** 46 g/day (women), 56 g/day (men).

**Fat:** 20–35% of calories, with <10% from saturated fat.

**Micronutrients:** B-vitamins for metabolism, calcium and vitamin D for bone health, antioxidants (C, E).

**Nutrition Focus:** Maintenance of healthy weight, prevention of chronic diseases (diabetes, hypertension).

**(v) Older Adults (65+ years)**

**Energy:** Lower (~1,600–2,200 kcal/day) due to reduced activity and metabolism.

**Protein:** Higher proportion needed (1–1.2 g/kg/day) to prevent muscle loss.

**Micronutrients:** Vitamin B12 (absorption declines with age), calcium, vitamin D, fiber.

**Nutrition Focus:** Nutrient-dense foods, hydration, smaller frequent meals, prevention of osteoporosis and anemia.

## Summary Table

Age Group	Energy Needs	Key Nutrients	Nutrition Focus
Infants	~100 kcal/kg/day	Protein, fat, iron, vitamin D	Breastfeeding, complementary foods
Children	1,000–1,600 kcal/day	Protein, calcium, iron	Balanced meals, growth support
Adolescents	2,000–3,200 kcal/day	Protein, iron, calcium, folate	Growth spurts, limit junk food
Adults	2,000–3,000 kcal/day	Protein, B-vitamins, calcium	Weight maintenance, disease prevention
Older Adults	1,600–2,200 kcal/day	Protein, vitamin B12, calcium	Nutrient-dense foods, prevent muscle loss

## Using food tables to analyze nutrient composition and calculate requirements

- You need food tables
- These tables provide masses of nutrients and energy contents per 100g of common foods such as matooke, Irish potatoes, cassava etc.
- the tables also show the energy and nutrient requirements of different groups, such as infants, adolescents, elderly etc.

## Step-by-step workflow for using food tables to calculate total nutrient composition of a diet/meal

1. **Define the person/group:** Age, sex, physiological status, activity.
2. **List foods and portion sizes:** Weigh or estimate edible portions for each item in a meal/day.
3. **Extract nutrient values per 100 g from food tables.** i.e. For each food, note energy (kcal), macronutrients (g), and micronutrients (mg/μg).
4. **Calculate nutrients for the actual portion.**

### Formula

- Nutrient/energy per portion =  $\frac{\text{portion (g)}}{100} \times \text{Nutrient/energy per 100 g}$ .
5. Sum the energy or nutrient content from the components of a meal

6. **Compare intake vs requirements:** Check each nutrient total against the DRI target (RDA/AI, AMDR for macros).
7. Identify shortfalls or excesses; adjust foods/portions accordingly.
8. **Iterate and refine to reach required necessary food level.**

**Example calculation template (plug in values from your food table)**

- **Meal:** 150 g cooked beans; 200 g steamed matoke; 25 g groundnut sauce.
- **From table (examples to be replaced with real values):**
  - **Beans per 100 g:** Energy E1 kcal; Protein P 1 g; Iron Fe 1 mg; Folate Fo 1 µg.
  - **Matoke per 100 g:** Energy E2 kcal; Carb C2 g; Potassium K2 mg; Vitamin C V2 mg.
  - **Groundnuts per 100 g:** Energy E3 kcal; Fat F3 g; Protein P3 g; Vitamin E Ve3 mg.

- **Per-portion math:**

- Beans energy =  $\frac{150}{100} \cdot E1$ ; protein =  $\frac{150}{100} \cdot P1$ ; iron  $\frac{150}{100} \cdot Fe1$ .

- Matoke energy =  $\frac{200}{100} \cdot E2$ ; carb =  $\frac{200}{100} \cdot C2$ .

- Groundnuts energy =  $\frac{25}{100} \cdot E3$ ; fat =  $\frac{25}{100} \cdot F3$ .

- **Total energy:**  $E_{total} = \sum E_{foods} = \frac{150}{100} \cdot E1 + \frac{200}{100} \cdot E2 + \frac{25}{100} \cdot E3$

$$= 1.50 + 4 + 0.75$$

$$= 6.25 \text{ kCal}$$

- Compare the calculated energy with energy requirement of selected group
- If energy determined is higher, adjust the meal proportion by increasing the mass of food with low energy content while decreasing the mass of the food with low energy content until the required energy level is achieved.
- If energy determined is **lower**, adjust the meal proportion by increasing the mass of food with high energy content while decreasing the mass of the food with low energy content until the required energy level is achieved.
- Do the same for each nutrient.

### Practical tips for accuracy

- (i) **Portion precision:** Weigh foods or use validated household measure conversions from your table.
- (ii) **Cooking effects:** Account for cooked vs raw entries; use “edible portion” and “cooked weight” entries to avoid misestimates.
- (iii) **Bioavailability matters:** For iron, zinc, and calcium, consider enhancers/inhibitors (vitamin C, phytates) when interpreting adequacy; DRIs incorporate typical bioavailability assumptions.
- (iv) **Check limits:** Compare intakes not only to RDAs/AIs but also ULs for nutrients with toxicity risk (e.g., vitamin A, iron).
- (v) **Population context:** Use FAO/WHO data to align plans with local dietary patterns and identify realistic, culturally relevant substitutions.

Thank You

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