

Module 2

Macronutrients Part-I

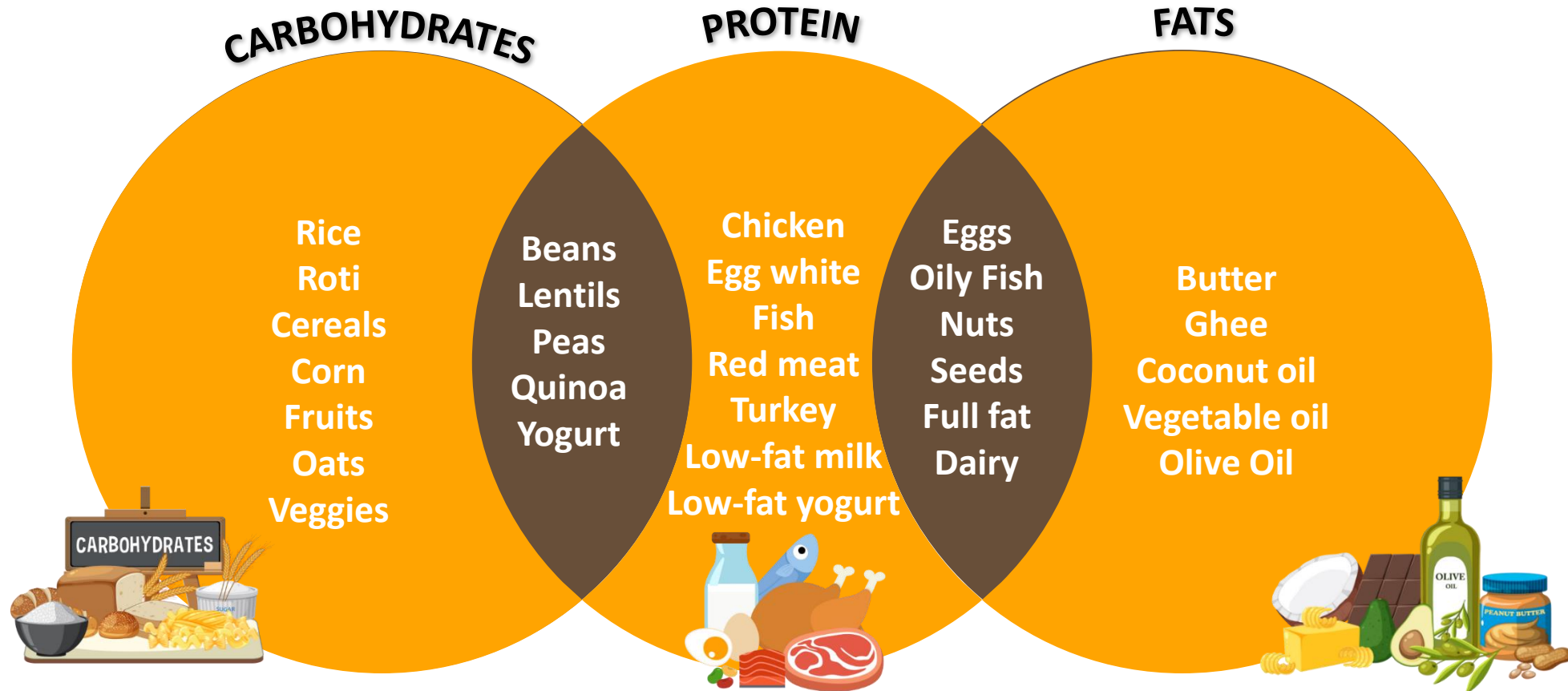
Module coverage



Topic	Sub-topics covered	Learning objectives
2) Macronutrients: Carbohydrate, protein, fat.	• Carbohydrate (including fiber): Types, function, sources, deficiency. • Protein: Types, function, sources, deficiency • Fat: Types, function, sources, deficiency.	✓ Clarity regarding the role of specific nutrients in the body. ✓ Their food sources and effect of deficiency.

Macronutrients

Macronutrients are required in large amounts for energy, growth and repair.^[13]

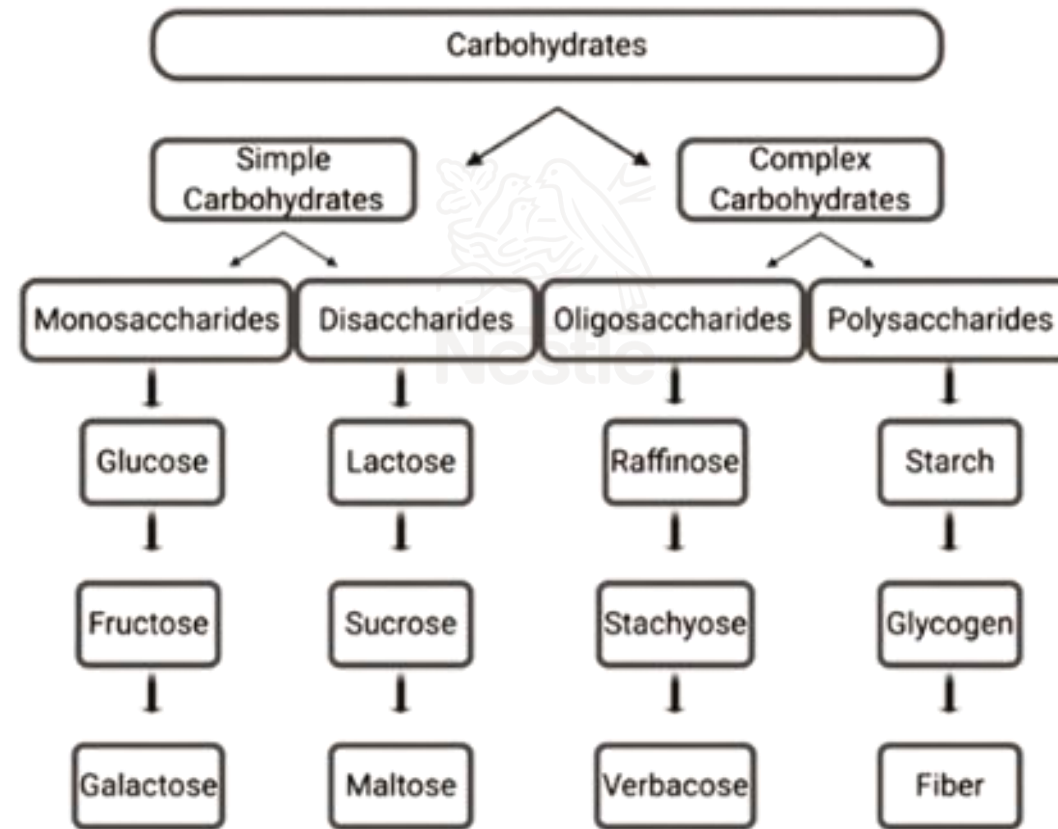


Carbohydrates

Carbohydrates

Carbohydrates are sugars and polymers such as starch, with variations in chain length and branching that provide unique characteristics.^[15]

Simple carbohydrates are sugars that are made up of one or two sugar molecules (mono or disaccharides). These are the most basic forms of carbohydrates. These are broken down quickly by the body to provide energy.



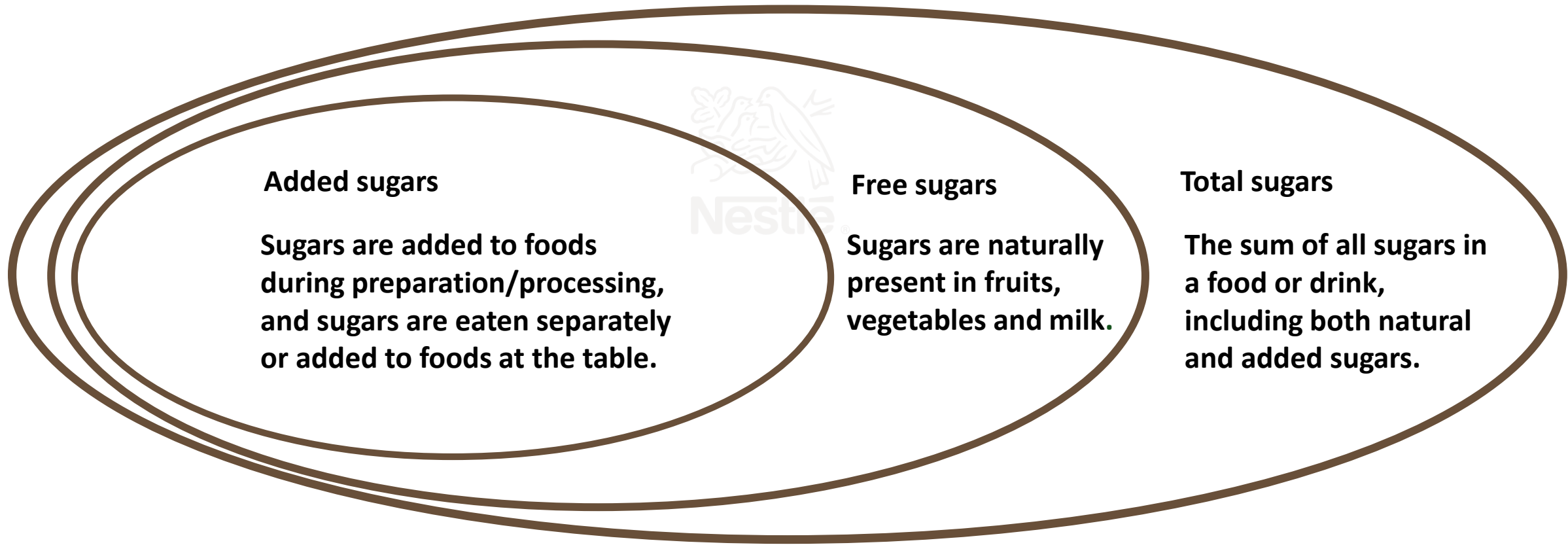
Complex carbohydrates are composed of three or more monosaccharide units (oligo or polysaccharides) strung together in long, complex chains.

They may have branching, as in the case of starch (amylose and amylopectin).

The complex structure leads to many characteristics such as non-Newtonian characteristics, gelatinization, non-fermentability, etc.

Types of dietary sugars

The source of the sugar is important since added sugars are restricted to 50 grams per day in a 2000 calories diet | 1 gram of carbohydrate = 4 calories.



Sources of carbohydrates



Natural sources have been substituted by isolated/synthesized ingredients as in the case of polyols and soluble fibers.



Mono



Di



Poly

Glucose	Fruits and Honey
Fructose	Fruits and Honey
Galactose	Milk
Xylose	Fruits, Vegetables, Cereals

Sucrose	Cane and sugar beet
Lactose	Milk
Trehalose	Mushrooms
Maltose	Barley, bread, cereals

Starch	Maize, Tapioca, Wheat, Rice
Resistant starch	Legumes, seeds, raw banana

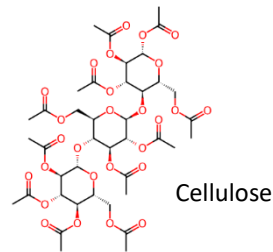
Dietary fibers are indigestible polysaccharides that modulate gut microbiome and/or add fecal bulk depending upon their nature.

Dietary fiber

“Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine.”^[16]

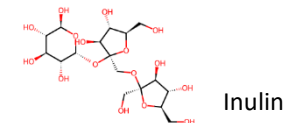
Insoluble Fiber

- Insoluble fibers do not dissolve in water.
- These fibers increase faecal bulk, improve digestion and may help prevent cancer and conditions of the colon.
- Sources of soluble fiber include - Whole wheat flour, Wheat bran, Legumes, Nuts, Many vegetables - especially those with a skin (zucchini, potatoes, corn, etc.).



Soluble Fiber

- Soluble fibers dissolve in water and are fermentable in the body.
- These may improve cholesterol and help support healthy blood sugar levels.
- Soluble fiber is found in: Apples, Oats, Beans (especially black beans, kidney beans, and navy beans), Barley, Citrus fruits, and chicory roots.



RDA: Dietary fiber

Summary of Recommended Dietary Allowances (RDA) of Nutrients For Indians, 2024

Category/ Age group	Body weight (kg)	Dietary fiber*(g/d)
Adult Men >18y (Sedentary physical activity)	65.0	30.0
Adult Men >18y (Moderate physical activity))	65.0	40.0
Adult Men >18y (Heavy physical activity)	65.0	50.0
Adult Women >18y (Sedentary physical activity)	55.0	25.0
Adult Women >18y (Moderate physical activity)	55.0	30.0
Adult Women >18y (Heavy physical activity)	55.0	40.0
Pregnant women (2 nd trimester)	55 + 10 GWG	0
Pregnant women (3 rd trimester)		0
Lactation 0-6m	55.0	0
Lactation 7-12m	55.0	0
Infants 0-6m	5.8	0.0
Infants 6-12m	8.5	0.0
Children 1-3y	12.9	15.0
Children 4-6y	18.3	20.0
Children 7-9y	25.3	26.0
Boys 10-12y	34.9	33.0
Girls 10-12y	36.4	30.0
Boys 13-15y	50.5	43.0
Girls 13-15y	49.6	36.0
Boys 16-18y	64.4	50.0
Girls 16-18y	55.7	38.0
Men ≥60y	0.0	30.0
Women ≥60y	0.0	25.0

Unrefined cereals and grains used in habitual Indian diets can provide the RDA of dietary fiber.^[17]

* Adequate Intake (AI) ; **GWG** – Gestation Weight Gain

Source: 17) SINGH, ARCHANA & Singh, Som. (2015). Dietary fiber content of Indian diets. Asian Journal of Pharmaceutical and Clinical Research. 8. 58-61.

<https://journals.innovareacademics.in/index.php/ajpcr/article/view/5831/2424>

Table source: https://www.nin.res.in/RDA_short_Report_2024.html

Functions of carbohydrates



The primary function of carbohydrates is energy.

Energy Production

The primary role of carbohydrates is to supply energy to all cells in the body. Many cells prefer glucose as a source of energy over other compounds like fatty acids. Some cells, such as red blood cells, can only produce cellular energy from glucose. For energy storage, carbohydrates are stored in the form of glycogen in the muscles and liver.^[18]

Regulation of metabolic process

Carbohydrates play a vital role in regulating blood glucose and insulin levels, managing cholesterol and triglycerides, and assisting with fermentation processes.^[19]

Building Macromolecules

Most absorbed glucose is used to make energy, and some glucose is converted to ribose and deoxyribose, which are essential building blocks of important macromolecules such as RNA, DNA, and ATP. ^[20]

Suggested read: 18) <https://pressbooks-dev.oer.hawaii.edu/humannutrition/chapter/the-functions-of-carbohydrates-in-the-body/>

19) <https://www.ncbi.nlm.nih.gov/books/NBK459280/>

20) <https://pressbooks.oer.hawaii.edu/humannutrition2/chapter/4-the-functions-of-carbohydrates-in-the-body/>

The most obvious way carbohydrates affect health is through their impact on blood sugar levels.^[21]

Hypoglycemia (Low Blood Sugar Level) - <80mg/dl

Associated symptoms: Brain Fog,
Headaches, Dizziness, Irritability,
Constipation, Muscle Cramps, Bad
Breath, weight loss.

Hyperglycemia (Higher Blood Sugar Level) - >200mg/dl

Main indicator of Diabetes
mellitus.

- Pre-prandial capillary plasma glucose: 80-130 mg/dl and post-prandial capillary plasma glucose: <180 mg/dl should be the metabolic targets to achieve the normal blood sugar level.^[22]
- Lifestyle-related diseases such as diabetes, CVD and obesity are on the rise.^[22]
- Glycemic index and Glycemic load measure the impact of foods on blood sugar levels.^[23]

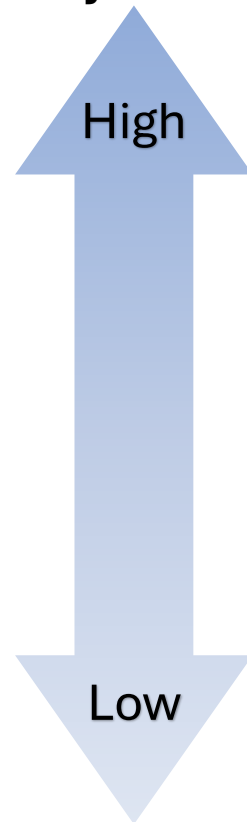
Introduction to glycemic index and control

Choosing foods with low GI and GL is important to maintain blood glucose levels within prescribed limits.^[24]

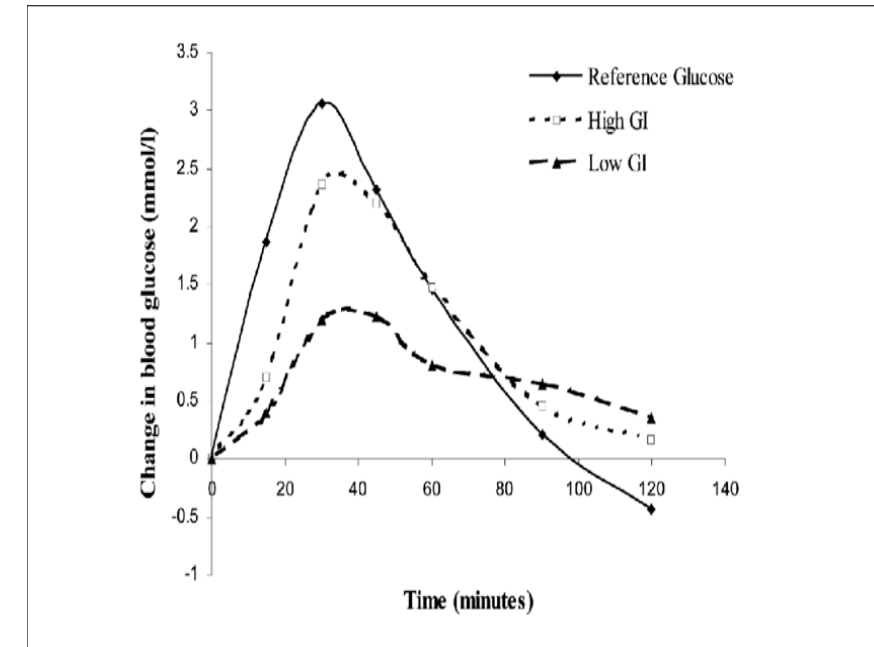
Glycemic Index (GI) of some common foods

Glycemic Index (GI) refers to the ranking of foods based on the postprandial blood glucose response compared with a reference food.

Glycemic Load is a measure of how much a specific serving of food will raise blood sugar levels, considering both the glycemic index (GI) of the food and the amount of carbohydrates in that serving.



Glucose	100
White bread	100
Baked potato	85
Honey	73
Sucrose	65
Boiled new potato	62
Idli	60
Brown rice	55
Chocolate	49
Boiled carrots	47
Orange	44
Apple	38
Skim milk	32
Lentils	29
Fructose	23



Carbohydrate along with fats contribute the maximum calories in the diet.

A well-designed diet will balance carbohydrate and fat, including their many types

'My plate of the day' (NIN, ICMR) prescribes 100g-130g of carbohydrates/day should be ensured for age group one year and above. This level is the minimum required for brain glucose utilization.

The quantity and quality of carbohydrates are important to maintain the good health and have been substantially to impact nutrition related chronic disorders/ NCDs. Source should have both simple and complex carbohydrates.

Hence the GI and GL of this diet is sufficiently within range to provide a well-balanced diet.

Suggested read: Present Knowledge in Nutrition (Eleventh Edition), by Bernadette P. Marriott, Diane F. Birt, Virginia A. Stallings, Allison A. Yates Volume 1: Basic Nutrition and Metabolism, Page 37-50



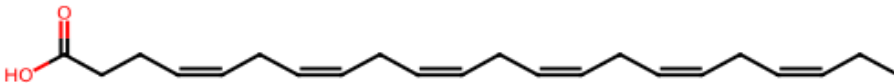
Fats – Classification and sources

Fats are hydrophobic (water-repelling) molecules, that serves as structural components (in cell membranes) and energy storage in living organisms.

Oleic acid



Docosahexaenoic acid (DHA)



There are four main types of fats:

1. **MUFA:** Monounsaturated fatty acids are defined as fatty acids that contain one double bond in their carbon chain, typically existing as cis-isomers in nature. Examples: Oleic acid^[25] Other dietary sources: Avocados, nuts (almonds, peanuts, and walnuts).
2. **PUFA: Polyunsaturated fatty acids** are a class of fatty acids that include n-6 and n-3 fatty acids. The n-3 fatty acid α -linolenic acid is a precursor for the long-chain products docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). These are widely known as essential fatty acids since they cannot be synthesized in the human body and must be obtained from the diet. Examples: Fish, sunflower oils^[26]. Other dietary sources: Fatty Fish: Salmon, mackerel, and sardines are excellent sources of omega-3 fatty acids, a type of polyunsaturated fat. Flaxseeds: A good source of omega-3 fatty acids. Nuts and Seeds: Chia seeds, walnuts, and flaxseeds. Eggs: Contain both monounsaturated and polyunsaturated fats. Dark chocolate.

To be continued...

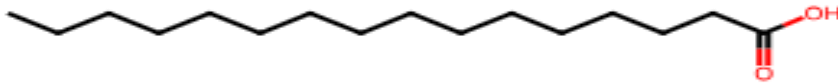
Source: 25) <https://www.sciencedirect.com/topics/chemistry/monounsaturated-fatty-acid>

26) <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/polyunsaturated-fatty-acid>

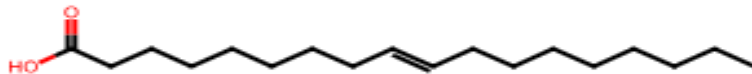
Fats - Classification and sources

Fats are hydrophobic (water-repelling) molecules, that serves as structural components (in cell membranes) and energy storage in living organisms.

Palmitic Acid



Elaidic Acid



4. Saturated: Saturated fatty acids (SFAs) are made up of a carbon chain with no double bonds. SFAs are not essential nutrients. They are mainly obtained through dietary intake of animal fats. They can raise LDL cholesterol levels, which can increase the risk of heart disease. Examples: Butter, and other animal fats^[27]. Animal Products: Meats, dairy products (cheese, butter, milk), and eggs are natural sources of saturated fats. Some plant-based oils: Coconut oil, palm oil, and palm kernel oil contain saturated fats.

1. Trans fats: Trans fat is the final product of a chemical process called hydrogenation, which is used to transform healthy monounsaturated and polyunsaturated vegetable oils into solid fats and prevent them from becoming rancid. These are also called Partially Hydrogenated Oils (PHO). Examples: Margarine.^[28] Partially hydrogenated oils like vanaspati.

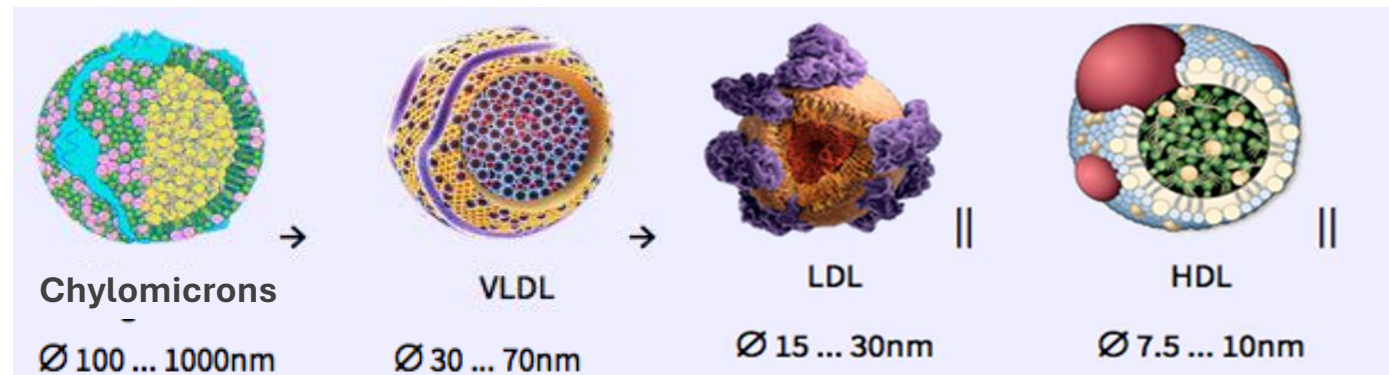
Cholesterol

Cholesterol is a waxy lipid that is transported through lipoproteins.

Cholesterol is a structural component of cell membranes and serves as a building block for synthesizing various steroid hormones, vitamin D, and bile acids. Besides their structural role in providing stability and fluidity. Cholesterol also plays a crucial role in regulating cell function. The body produces some cholesterol but also obtains it from animal products, such as meat, eggs, and dairy. High cholesterol levels can increase your risk of heart disease. ^[29]

It is carried in the blood as: low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol.

Lipoproteins are essential for transporting fats throughout the body. There are four classes of lipoproteins: Chylomicrons, Very Low-Density Lipoproteins (VLDL), Low-Density Lipoproteins (LDL) and High-Density Lipoproteins (HDL). ^[30]



Functions of fats

Fats are calorie dense, providing 9 calories per gram.

- **Storage:** Fats are the body's primary energy reserve. They are stored in adipose tissue (fat cells) as triglycerides.
- **Insulation:** Fats provide insulation, helping to maintain body temperature.
- **Protection:** Fat deposits cushion and protect vital organs.
- **Hormone Production:** Some hormones, such as estrogen and testosterone, are derived from cholesterol, a type of fat.
- **Absorption of Vitamins:** Fats are essential for the absorption of fat-soluble vitamins (A, D, E, and K).
- **Membrane component:** Fats are an integral part of the cellular membrane.

Improper fat consumption - Impact

Typically excess of fats is the problem, but in the case of PUFAs (Omega-3 and 6) deficiency can lead to cognitive disorders, CVD and impaired functioning of the body.

- **Obesity associated inflammation:** It is not the quantity but the quality of LDL that contributes to disease: “bad cholesterol” becomes worse due to obesity-associated inflammation.^[31]
- **Dry, scaly skin and hair loss:** Fats help maintain skin moisture and integrity. Deficiency can lead to dry, itchy, and flaky skin, like having eczema or psoriasis. **Hair Loss:** Fats contribute to healthy hair structure. Lack of fat can cause hair thinning, brittleness, or excessive shedding.
- **Impaired wound healing:** Fats are involved in tissue repair and regeneration. Wounds may take longer to heal or be more prone to infection with fat deficiency.^[32]
- **Hormonal imbalances:** Fats (especially cholesterol) are precursors to certain hormones. Deficiency can disrupt hormone production, leading to irregular periods, fatigue, or mood swings.

RDA: Fats



Summary of Recommended Dietary Allowances (RDA) of Nutrients For Indians, 2024

Category/ Age group	Minimum level of total fat	Minimum level* of fat (%E) from foods (excluding fats/oils used for cooking)	Added or visible fat	
			%E	g/p/d
Adult Men >18y (Sedentary physical activity)	20.0	15.0	15.0	25.0
Adult Men >18y (Moderate physical activity))	20.0	15.0	15.0	30.0
Adult Men >18y (Heavy physical activity)	20.0	15.0	15.0	40.0
Adult Women >18y (Sedentary physical activity)	20.0	15.0	15.0	20.0
Adult Women >18y (Moderate physical activity)	20.0	15.0	15.0	25.0
Adult Women >18y (Heavy physical activity)	20.0	15.0	15.0	30.0
Pregnant women (2 nd and 3 rd trimester)	20.0	15.0	15.0	30.0
Lactating women	20.0	15.0	15.0	30.0
Infants 0-6m	40.0-60.0	15.0	Mother's Milk	
Infants 6-24m	35.0	15.0	20	25
Children 3-6y	25.0	15.0	15.0	25.0
Children 7-9y	25.0	15.0	15.0	30.0
Boys 10-12y	25.0	15.0	15.0	35.0
Boys 13-15y	25.0	15.0	15.0	45.0
Boys 16-18y	25.0	15.0	15.0	50.0
Girls 10-12y	25.0	15.0	15.0	35.0
Girls 13-15y	25.0	15.0	15.0	40.0
Girls 16-18y	25.0	15.0	15.0	35.0

* If diet provides higher than 10%E from fat, visible fat requirement proportionally reduces.

Carbohydrate along with fats contribute the maximum calories in the diet.

Conclusion



- **Fat is a concentrated form of energy among other macronutrients.**
- **A small quantity of fat (1g) can provide 9 calories.**
- **Excess levels of saturated and trans fats and cholesterol can be detrimental to the human body**
- **Unsaturated fats are considered good fats. Consuming them in moderate levels helps to maintain good health and body functions.**
- **Nuts like almonds, walnuts, peanuts (groundnuts), seeds like sesame seeds, and flax seeds. Cooking Oils: mustard oil, groundnut oil and ghee in moderation, incorporating these into your daily meals, can contribute to a healthy intake of beneficial fats.**

Suggested read: Nutrition science, B.Srilakshmi, Sixth edition, 2018, Chapter: 5 Lipids, Page: 58-84