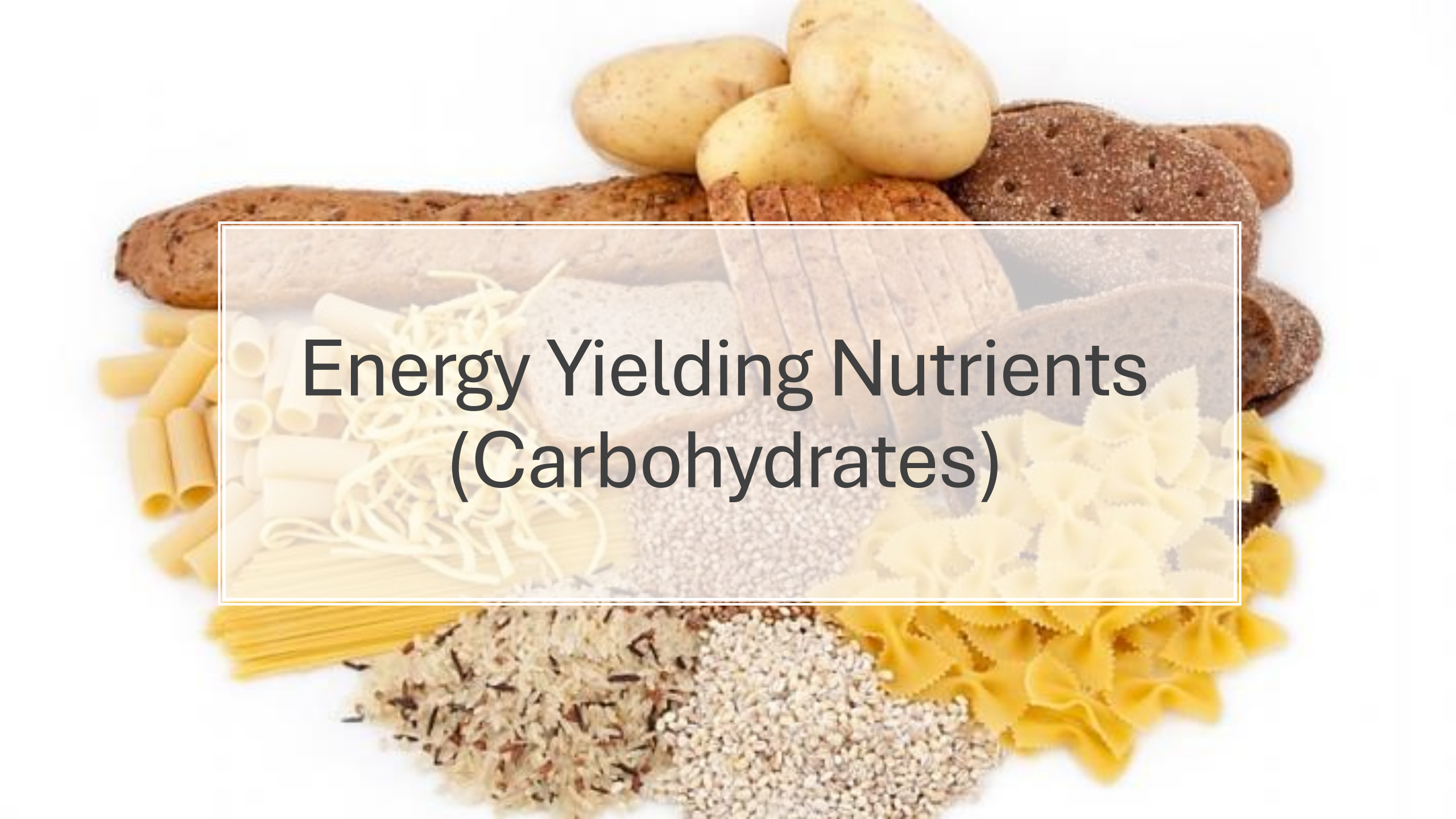


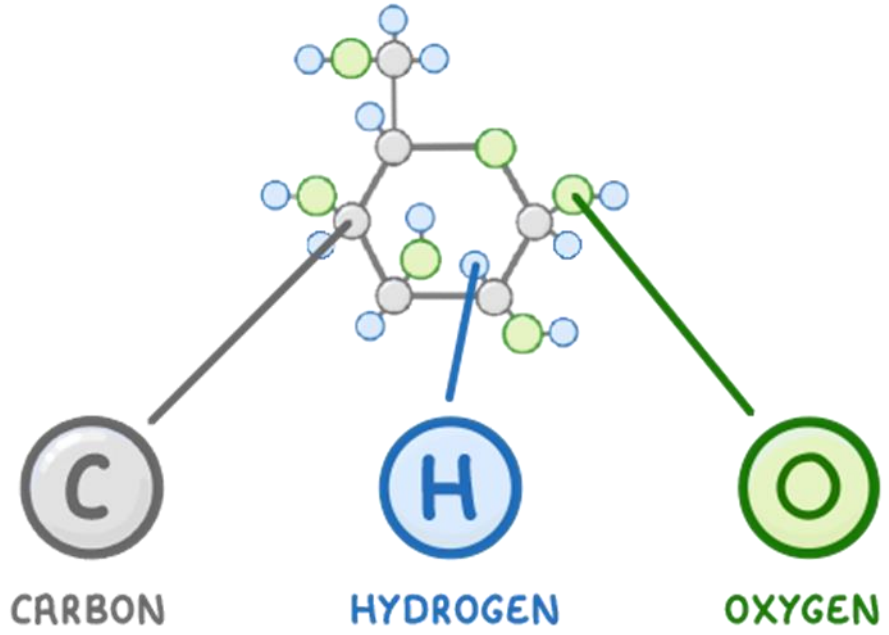
Energy Yielding Nutrients (Carbohydrates)

Learning Objectives

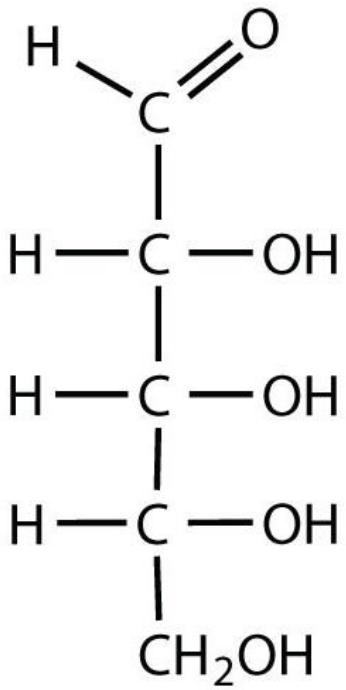
At the end of the class, students should be able to:

- ❑ State the functions of carbohydrates.
- ❑List the dietary sources of carbohydrates.
- ❑State the Recommended Daily Intake (RDI).
- ❑Describe the classification of carbohydrates
- ❑ Explain the mechanism of digestion, absorption, and storage of carbohydrates.
- ❑Identify the deficiency and symptoms of deficiency.
- ❑State the symptoms of excess carbohydrate intake.

Introduction

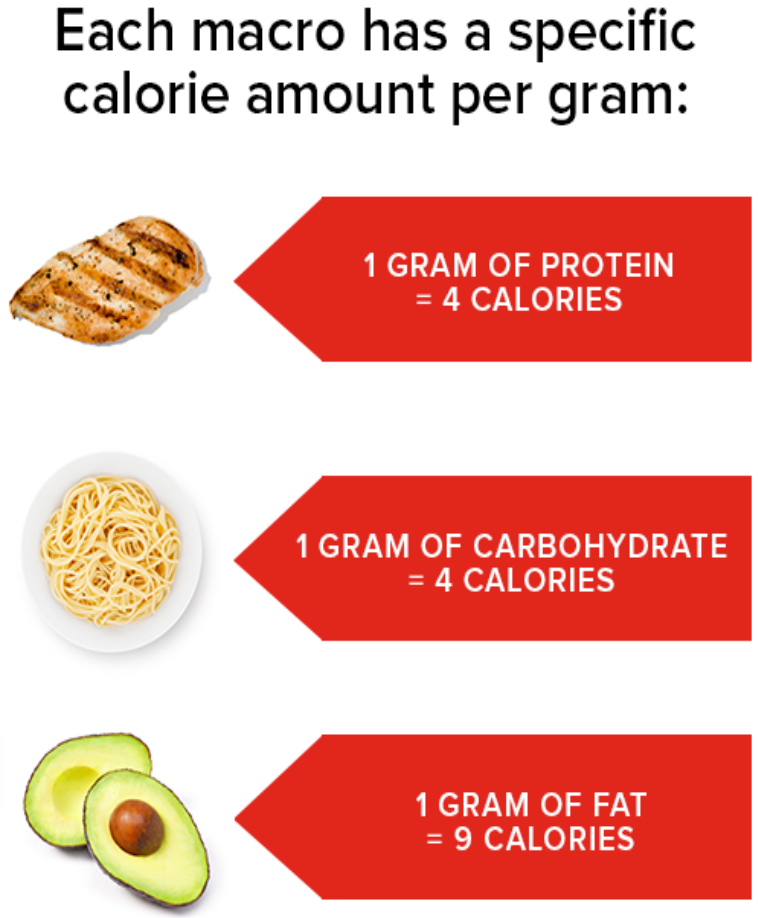


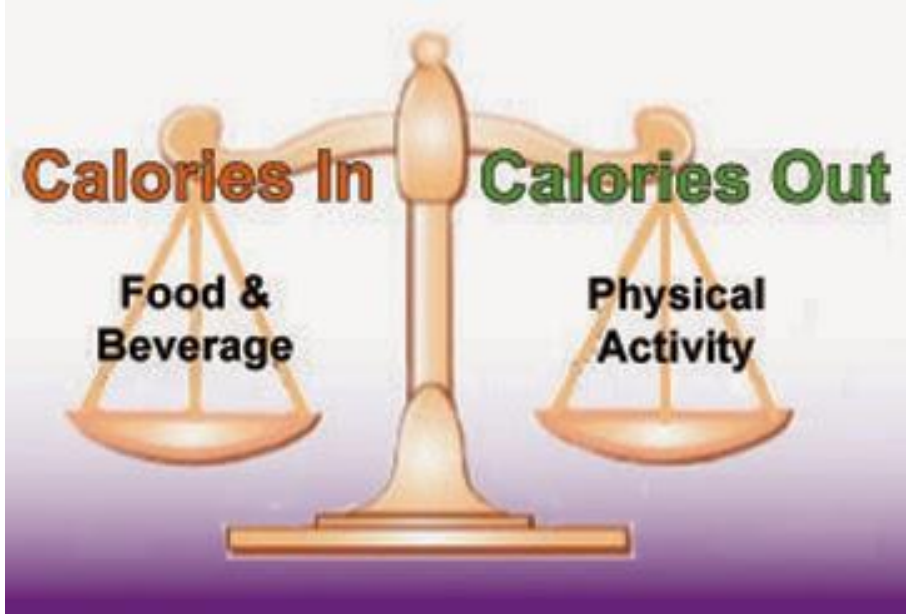
- Organic compounds made up of made of carbon, hydrogen and oxygen.
- The main source of energy.
- All carbohydrates are converted to glucose when digested → energy
- According to the **Recommended Nutrient Intakes (RNI) for Malaysia 2017 and the Malaysian Dietary Guidelines (MDG)**, carbohydrates should contribute **45-65%** of total daily energy intake for an average Malaysian adult.



Introduction

- For example, with a daily energy requirement of 2,000 kcal, the recommended carbohydrate intake would be:
- **50% of total energy**:
  - Energy from carbohydrates: 2,000 kcal × 0.45 =900 kcal
  - Grams of carbohydrates: 900 kcal ÷ 4 kcal/g = 225 grams
- **65% of total energy**:
  - Energy from carbohydrates: 2,000 kcal × 0.65 = 1,300 kcal
  - Grams of carbohydrates: 1,300 kcal ÷ 4 kcal/g = 325 grams
- Therefore, for a 2,000 kcal daily intake, the recommended carbohydrate consumption ranges from **225 to 325 grams** per day.





What are Calories?

The amount of energy released when nutrients are broken down is measured in units called **calories**.

The more calories a food has, the more energy it contains.

MYTH

The fewer carbs the better. It's all the fault of bread and pasta. Carbohydrates inevitably get fat. Simple carbohydrates may not be good for you.
With a carbohydrate-free diet, the body gets enough vitamins and minerals.

TRUTH

Carbohydrates are actually the main energy for our bodies. During digestion, the main carbohydrates, starches, and sugars are broken down into glucose. Glucose is the necessary energy for our brain and central nervous system.

Reference Daily Intake (RDI)

Table 1.1: Recommended number of servings for each food group based on 1500 kcal, 1800 kcal and 2000 kcal per day

Food group	Recommended number of servings		
	1500 kcal*	1800 kcal*	2000 kcal*
Vegetable[1]	≥ 3	≥ 3	≥ 3
Fruit[2]	2	2	2
Rice, other cereals, wholegrain cereal-based products and tubers[3]	3	4	5
Poultry/ Meat/ Egg[4]	1	1	2
Fish[5]	1	1	1
Legumes (combine bean, lentil and soy)[6]	1	1	1
Milk & milk products[7]	2	2	2
Fats /oils (including 1 serving from nuts and seeds)[8]	6	8	9
Sugar[9]	1	1	2

Notes:
Tips to remember, the more physically active you are, the more calories are required per day. However, if you are very sedentary, less calories are needed per day.
[1] Calorie free
[2] Based on 15 g carbohydrate and 60 kcal per serving;
[3] Based on 30 g carbohydrate, 4 g protein, 1 g fat and 150 kcal per serving;
[4] Based on 14 g protein, 8 g fat and 130 kcal per serving;
[5] Based on 14 g protein, 2 g fat and 70 kcal per serving;
[6] Based on 40 g carbohydrate, 14 g protein, 0.5 g fat and 220 kcal per serving.
[7] Based on 15 g carbohydrate, 8 g protein, 1 g fat and 90 kcal per serving;
[8] Based on 5 g fat and 45 kcal (including 1 serving of nuts & seeds = 5 g of fat and 65 kcal);
[9] Based on 15 g CHO and 60 kcal. 1 serving of sugar = 3 teaspoons; 1 teaspoon = 5 g of carbohydrate and 20 kcal.
Sources: Suzana *et al.* (2015); *RNI (2017)

RDI = Provides a **general guideline** for the amount of carbohydrates to be consumed daily based on a **2,000-calorie diet**
General reference value used for food labeling and does not necessarily take into account individual factors such as age, gender, or activity level.

Recommended Dietary Allowance (RDA)

Table E3.1.A4. Nutritional goals for each age/sex group used in assessing adequacy of USDA Food Patterns at various calorie levels

	Source of goal*	child 1 - 3	female 4 - 8	male 4 - 8	female 9--13	male 9--13	female 14-18	male 14-18	female 19-30	male 19-30	female 31-50	male 31-50	female 51+	male 51+
Calorie level(s) assessed		1000	1200	1400, 1600	1600	1800	1800	2200, 2800, 3200	2000	2400, 2600, 3000	1800	2200	1600	2000
Macronutrients														
Protein, g	RDA	13	19	19	34	34	46	52	46	56	46	56	46	56
Protein, % kcal	AMDR	5--20	10--30	10--30	10--30	10--30	10--30	10--30	10--35	10--35	10--35	10--35	10--35	10--35
Carbohydrate, g	RDA	130	130	130	130	130	130	130	130	130	130	130	130	130
Carbohydrate, %kcal	AMDR	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65	45--65
Dietary Fiber, g	14g/1000kcal	14	16.8	19.6	22.4	25.2	25.2	30.8	28	33.6	25.2	30.8	22.4	28
Total fat, %kcal	AMDR	30-40	25-35	25-35	25-35	25-35	25-35	25-35	20-35	20-35	20-35	20-35	20-35	20-35
Saturated fat, %kcal	DG	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Linoleic acid, g	AI	7	10	10	10	12	11	16	12	17	12	17	11	14
Linolenic acid, g	AI	0.7	0.9	0.9	1	1.2	1.1	1.6	1.1	1.6	1.1	1.6	1.1	1.6

* RDA- Recommended Dietary Allowance, AI= Adequate Intake, UL = Tolerable Upper Intake Level, AMDR = Acceptable Macronutrient Distribution Range,
DG = 2010 and 2015 Dietary Guidelines recommended limit; 14g fiber per 1000 kcal = basis for AI for fiber.

RDA = Provide **minimum daily amount** of a nutrient that **most people need** to meet their basic health needs.

- RDA is set at **130 grams per day**.
- Based on the minimum amount of carbohydrates required to meet the needs of the brain (to function properly).
- Individual adjustments are made for factors such as activity level, health conditions, and total energy needs.

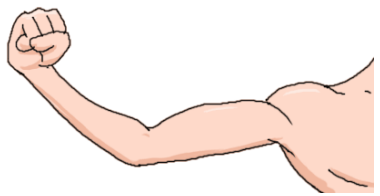
Functions of Carbohydrates

Primary Energy Source
Carbs broken down into glucose, which is used by cells for energy.

Fuel for Brain
The only carbohydrate-dependent organ in the body

Promotes Digestive Health
Dietary fiber supports bowel movements, prevents constipation, and lowers cholesterol.

Protein-Sparing Effect
Prevents the use of proteins for energy production.



Improve muscle mass
Glycogen stored in muscles

Regulator of mood
Increases serotonin production in the brain, contributing to feelings of happiness and relaxation

Structural Support
Cellulose, form structural components in plants cell wall

Dietary Sources

STARCHY VEG

- Butternut Squash
- Potatoes
- Pumpkin
- Sweet Potatoes

LEGUMES

- Beans
- Chickpeas
- Lentils
- Peas and Pulses

WHOLE GRAIN

- Amaranth
- Barley
- Buckwheat
- Oats
- Quinoa
- Rice
- Sorghum
- Spelt
- Sprouted Grains

(You can bump up your protein intake with legumes and whole grains.)

FRUIT

(Fresh, not dried)

- Apples
- Apricots
- Bananas
- Beries and Cherries
- Figs
- Grapefruit
- Grapes
- Guavas
- Kiwifruit
- Lemons and Limes

FRUIT (continued)

- Mangoes
- Melons
- Nectarines
- Oranges
- Peaches
- Pears
- Persimmons
- Pineapple
- Plums
- Pomegranates
- Watermelon



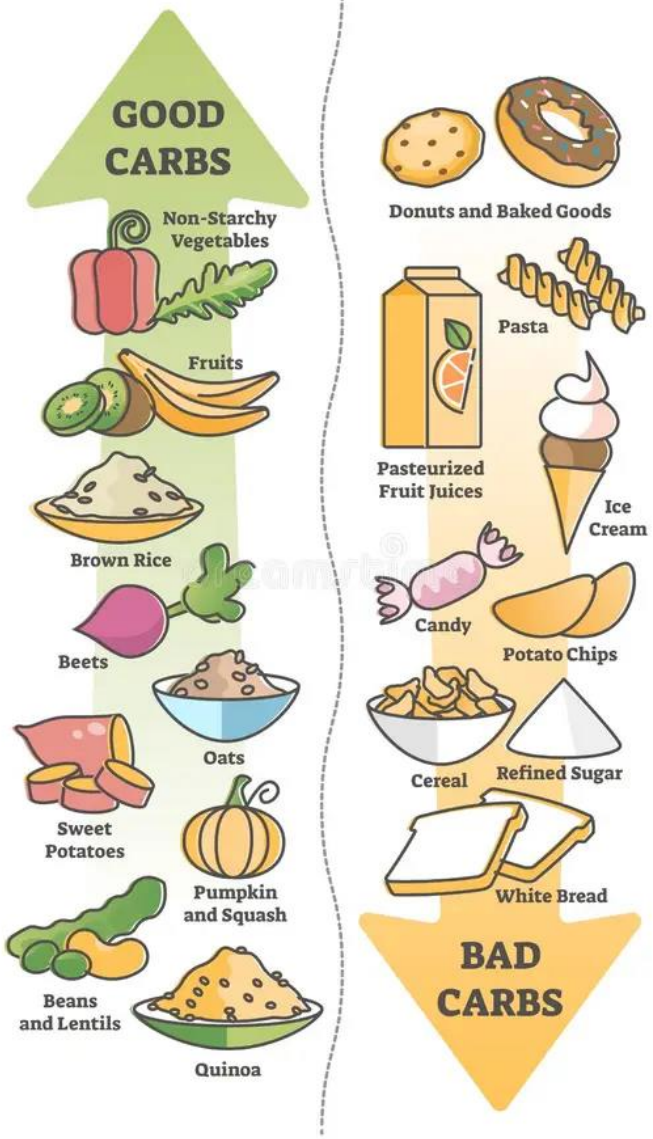









Dietary Sources



Myth

Eating carbs is unhealthy for your weight.

Fact

Only simple carbs are bad.
Complex carbs are healthy.

Classification of Carbohydrates

Based on digestibility

Simple Carbohydrates

- Single or double sugar molecules (monosaccharides/disaccharides)Simple carbohydrates
- Quick digestion and absorption
- Low in fiber, vitamins, and minerals (especially in processed forms)
- Causes rapid spikes in blood sugar levels, weight gain

Complex Carbohydrates

- Long chains of sugar molecules (polysaccharides)
- Slower digestion and absorption
- Higher in fiber, vitamins, and minerals (especially in whole foods)
- Causes more stable blood sugar levels, helps with digestion

SIMPLE CARBS


White bread


White pasta


White rice

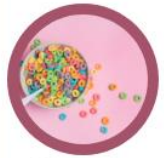

Cakes


Cookies


Candy


Ice cream


Non-diet sodas


Sugary cereals


Sweetened drinks

COMPLEX CARBS


Whole wheat bread


Brown rice


Starchy vegetables


Fruit


Beans


Lentils

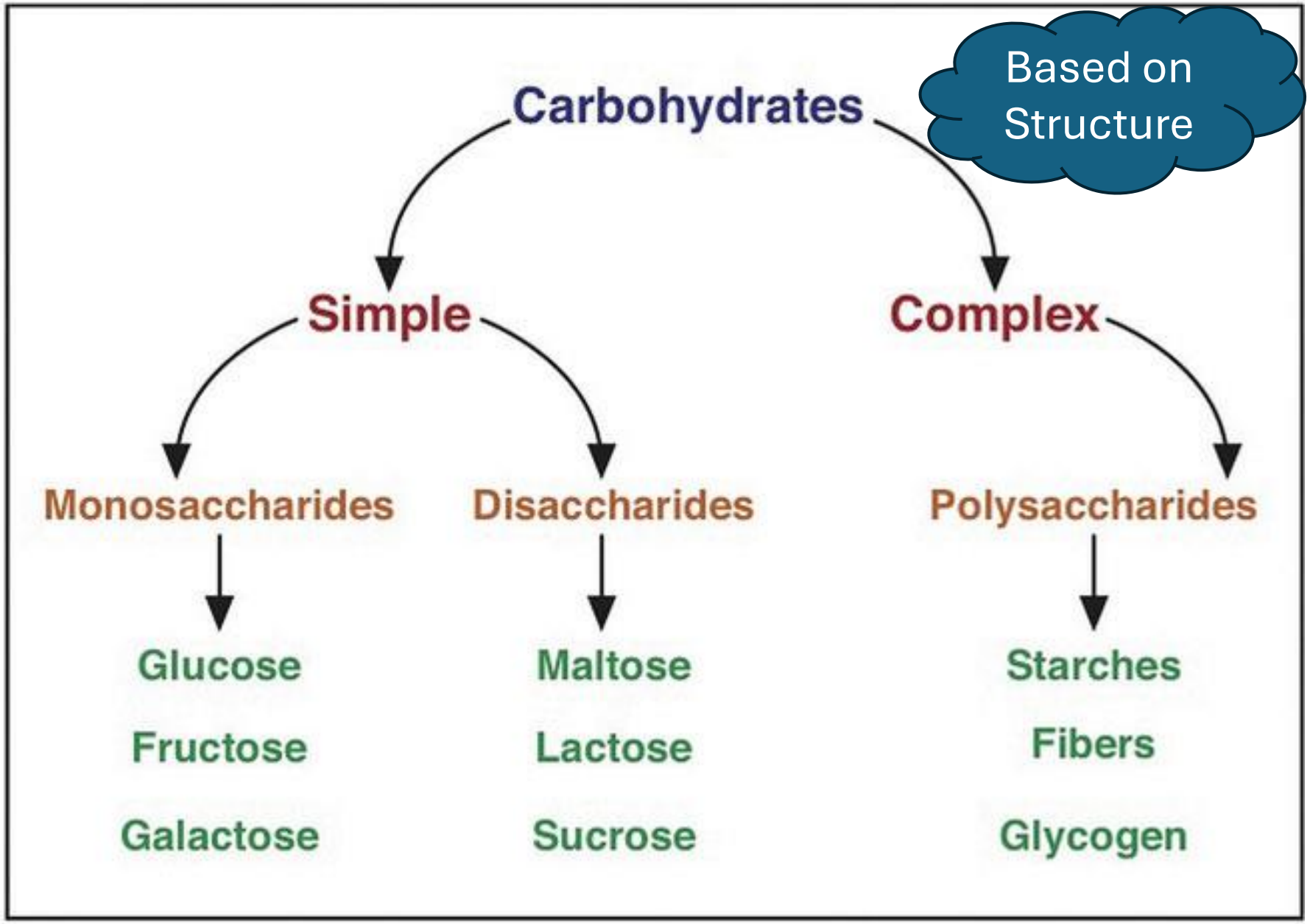

Quinoa


Oats


Sweet potatoes


Chia seeds

Classification of Carbohydrates



Monosaccharides

- The **simplest form** of carbohydrates- consisting of just **one sugar unit.**
- Examples:
  - ❑Glucose (main energy source for the body)
  - ❑Fructose (found in fruits)
  - ❑Galactose (found in milk
- They are quickly absorbed into the bloodstream and provide immediate energy.
- They do not need to be broken down further before absorption.

Disaccharides

- These carbohydrates consist of **two monosaccharides linked together.**
- Examples:
  - ❑Sucrose (table sugar) – made of glucose and fructose
  - ❑Lactose (milk sugar) – made of glucose and galactose
  - ❑Maltose (malt sugar) – made of two glucose unit
- Disaccharides must be broken down into monosaccharides before they can be absorbed by the body.

Sucrose – Table sugar

- Made from sugar cane or sugar beets
- Occur naturally in honey, maple syrup, carrots and sweet fruits

TABLE 5.1 *Nutritional Comparison of Selected Sweeteners*

Sugar/Syrup 1 Tablespoon	Water %	Kcal	Protein g	Carb g	Vit. C mg	Calcium mg	Folate mcg	Potassium mg	Iron mg	Zinc mg
Honey	17	64	0	17	0.1	1	0	11	0.09	0.05
Raw sugar	2	46	0	12	0	10	0.125	42	0.23	0.03
Brown sugar	<1	36	0	9	0	8	0	33	0.18	0.02
White granulated sugar	0	48	0	13	0	0	0	0	0	0

DIFFERENT NAMES FOR SUGAR

Agave Nectar	Granulated Sugar
Barley Malt	Grape Sugar
Beet Sugar	High Fructose Corn Syrup
Blackstrap Molasses	Honey
Brown Sugar	Invert Sugar
Cane Juice	Lactose
Cane Syrup	Malt
Caramel	Maltodextrin
Corn Syrup	Mannitol
Confectioner's Sugar	Maple Syrup
Carob Syrup	Molasses
Date Sugar	Organic Raw Sugar
Dextran	Powdered Sugar
Dextrose	Refiner's Syrup
Ethyl Maltol	Rice Syrup
Fructose	Sorbitol
Fruit Juice	Sorghum Syrup
Glucose	Sucrose
Golden Sugar	Turbinado Sugar

Polysaccharides

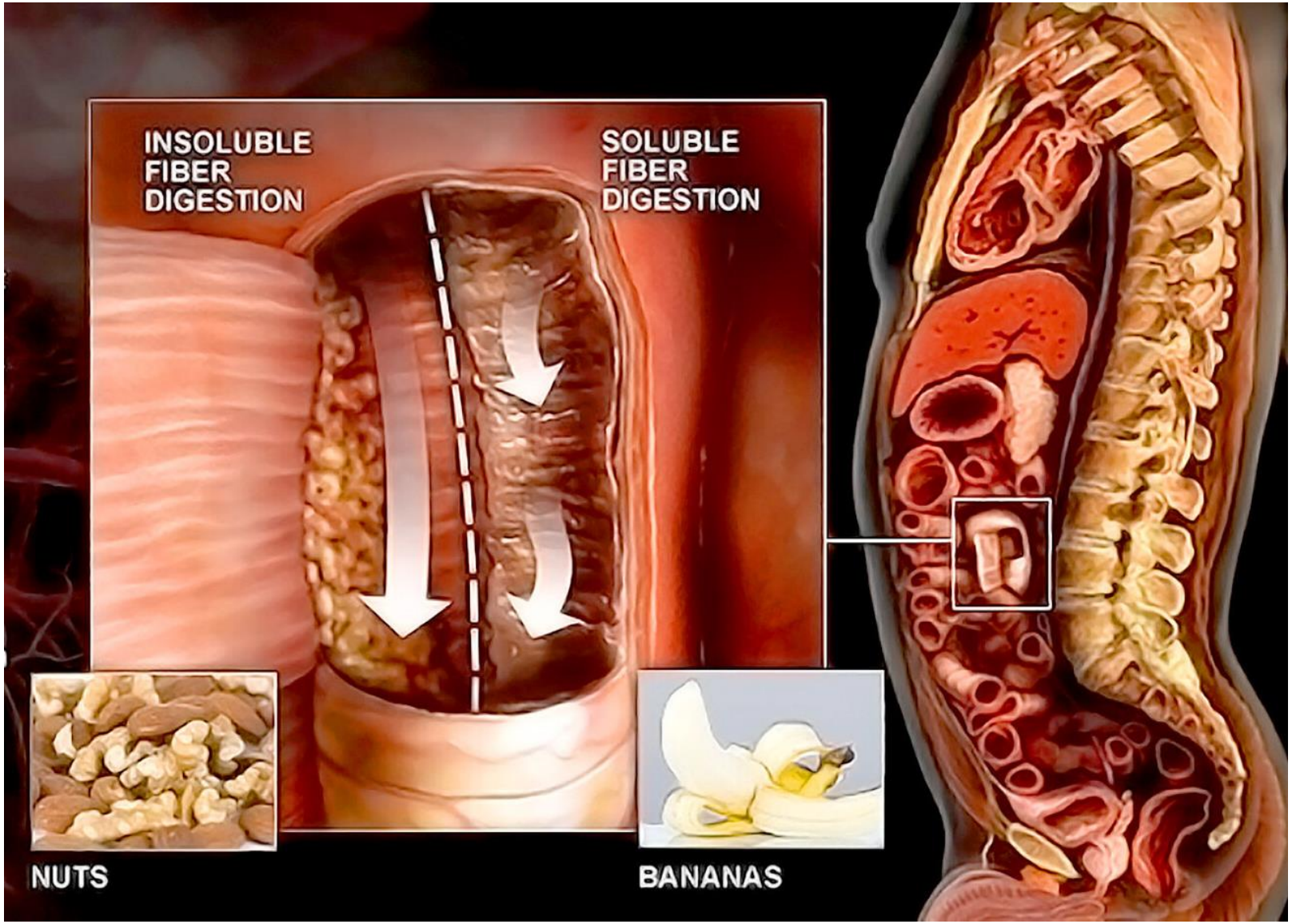
- These are made up of three or more sugar units linked together in long chains.
- Examples:
  - ❑Starch (found in plants like potatoes, rice, and wheat)
  - ❑Glycogen (Storage form of glucose, stored in muscles and liver, serves as a quick energy reserve)
  - ❑Cellulose (fiber in plant cell walls, important for digestion but not digestible by humans)
- They are slowly digested and provide a steady release of energy.

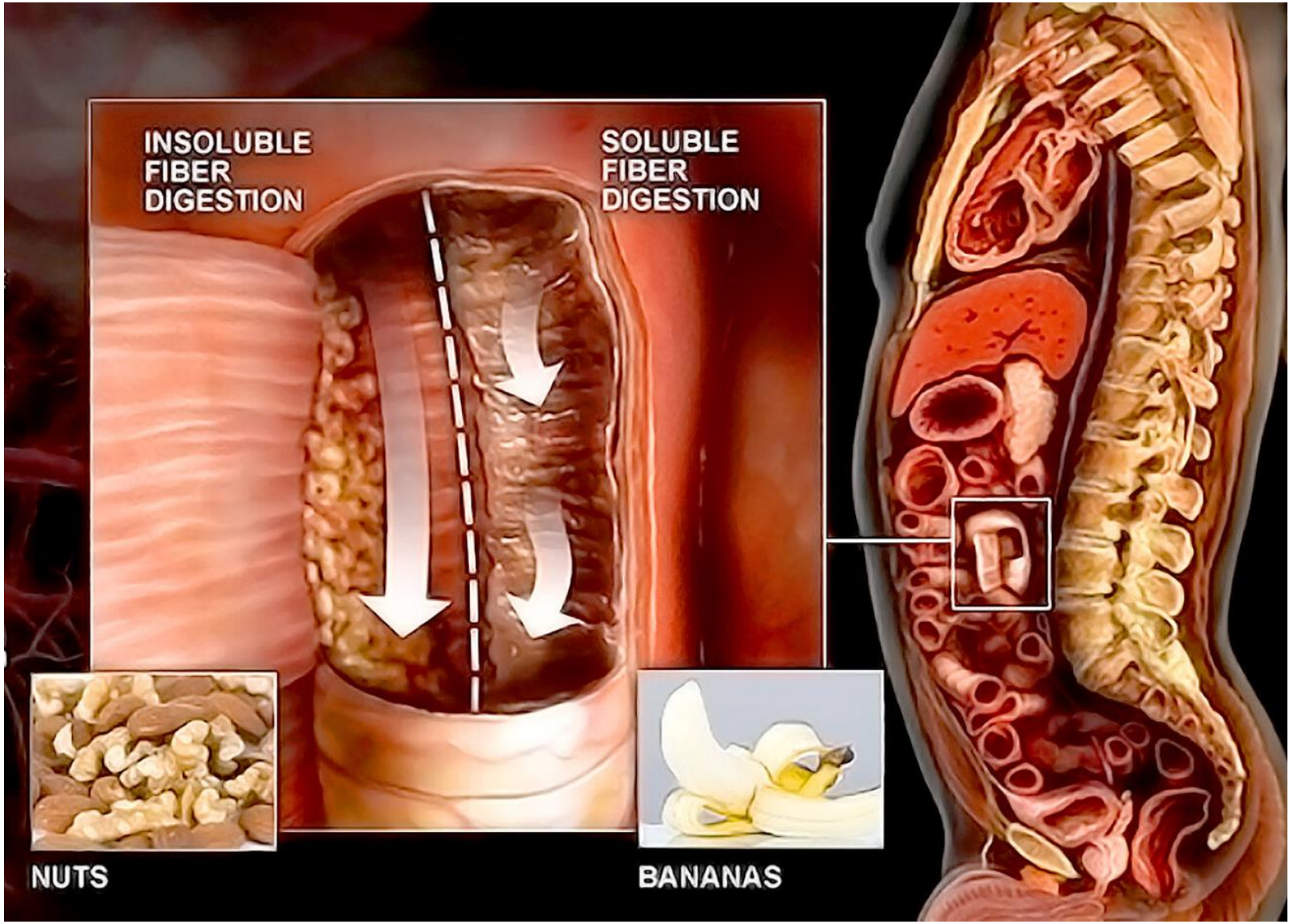
Fibers

- A type of carbohydrate that cannot be broken down into sugar molecules.
- Human digestive enzyme lack the capability to hydrolyze certain bonds present in fiber molecules.
  - ➢ lack enzyme cellulase
  - ➢ without cellulase, cannot convert fibers into monosaccharides
- Primarily found in plants (Vegetable & Fruits)
- Passes through the body essentially undigested.

Insoluble Fibers

- Does not dissolve in water
- Pass through the digestive tract mostly intact
- Prevent constipation
- Aiding in stool bulk





Soluble Fibers

- Dissolve in water, form a gel-like substance
- Can be fermented by gut bacteria
- Slows down digestion (lead to feeling fullness)
- Support gut bacteria
- Help in weight loss
- Helps with constipation and diarrhea
- Provide colon protection

Soluble Fiber

Dissolves in water to form a gel-like substance. Helps with constipation and diarrhea.

Food Sources:

- Oats and oatmeal
- Barley
- Legumes (beans, lentils, peas, chickpeas, soybeans)
- Chia seeds
- Apples and applesauce
- Pears
- Oranges
- Grapefruit
- Bananas
- Berries
- Broccoli
- Carrots
- Brussels sprouts
- Avocado
- Sweet potato
- Psyllium husk
- Fiber supplements

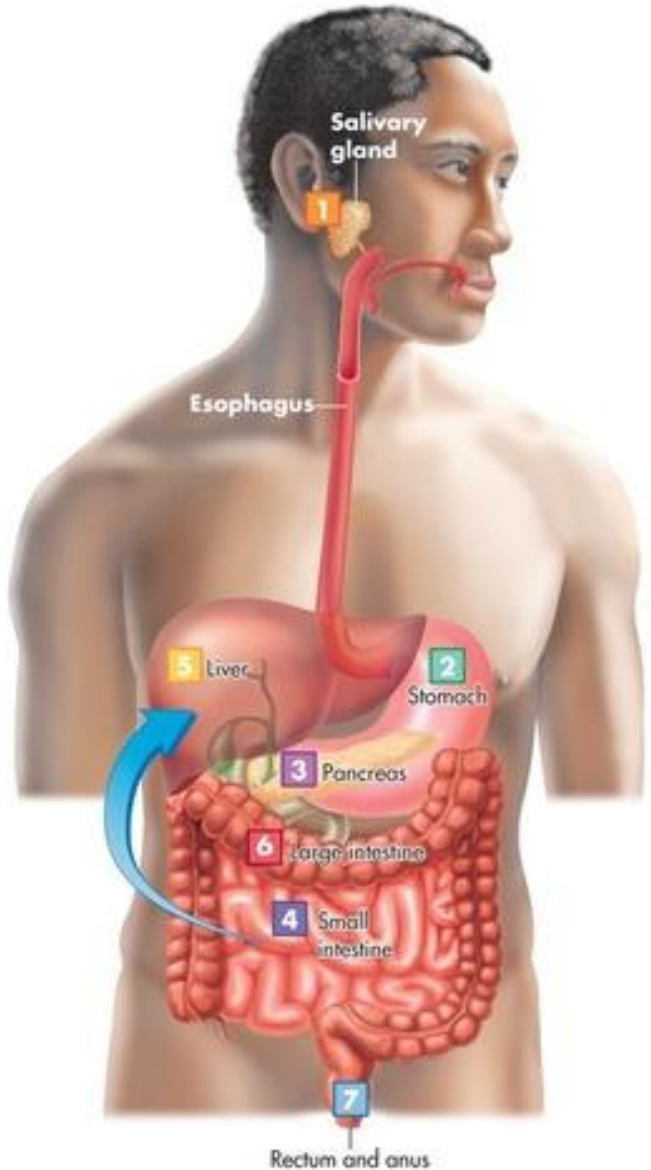
Insoluble Fiber

Traps and holds onto water pulled from intestines. Helps with constipation.

Food Sources:

- Ground flax seeds (flaxmeal)
- Wheat bran
- Nuts
- Seeds
- Cauliflower
- Green beans
- Leafy greens (spinach, kale, collard)
- Potatoes with skin
- Fruits and vegetables with skin
- Whole grains (eg. whole wheat or whole grain pasta, bread, and crackers)
- Brown rice

Digestion, Absorption & Storage



Carbohydrates

1 **Mouth:** Some starch is broken down to polysaccharide and disaccharide units by salivary amylase.

2 **Stomach:** Salivary amylase is inactivated by the acidity in the stomach. No further digestion occurs in the stomach.

3 **Pancreas:** Pancreatic amylase and dextrinase are secreted into the small intestine to break polysaccharides from starch into disaccharides.

4 **Small intestine:** Enzymes in the wall of the small intestine break down the disaccharides into monosaccharides.

5 **Liver:** The absorbed monosaccharides are transported to the liver by the portal vein.

6 **Large intestine:** Some soluble fiber is metabolized into acids and gases by bacteria in the large intestine.

7 **Rectum and anus:** Insoluble fiber escapes digestion and is excreted in feces.

Digestion

1. **Mouth :** Digestion of carbohydrates begins in the mouth. The enzyme **salivary amylase** starts breaking down starches into maltose (a disaccharide).

2. **Stomach**: In the stomach, the acidic environment decrease the action of salivary amylase, so no further digestion occurs here.

3. **Small Intestine**: Once the partially digested food enters the small intestine, the pancreatic amylase continues breaking down starches into disaccharides (maltose, sucrose, lactose). Other enzymes that break disaccharides into monosaccharides.

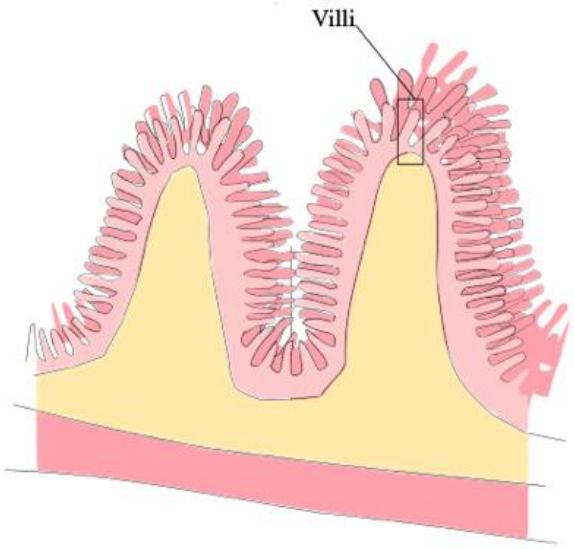
   Maltose → Glucose + Glucose

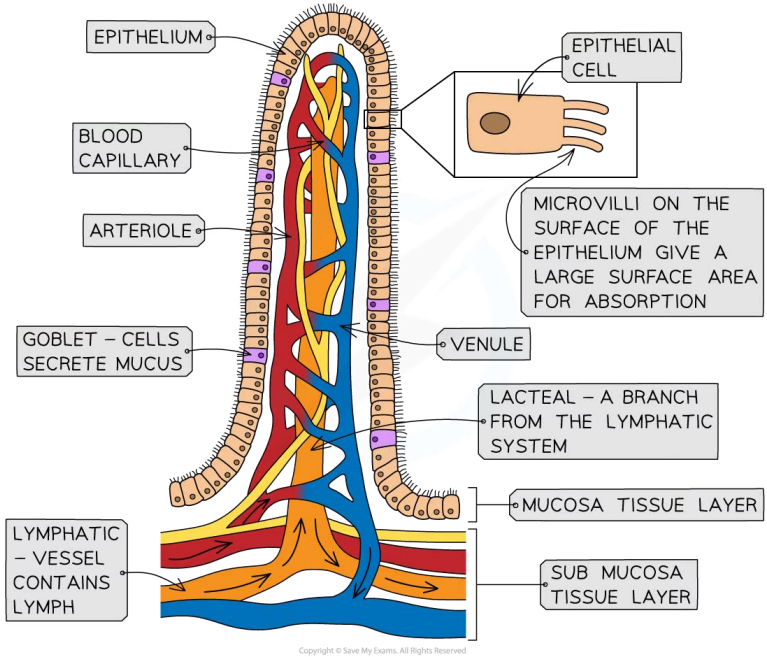
   Lactose → Glucose + Galactose

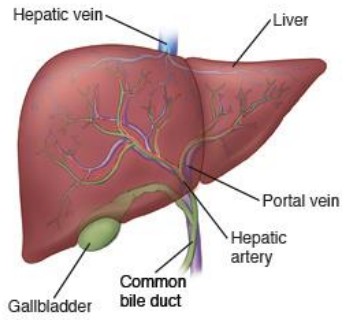
   Sucrose → Glucose + Fructose

Absorption

- The monosaccharides are absorbed by the villi ((finger-like projections) in the small intestine.
- Food molecules are transferred from the central space in small intestine into the villi.
- Once absorbed, the monosaccharides are transported via the bloodstream to the liver for further processing.





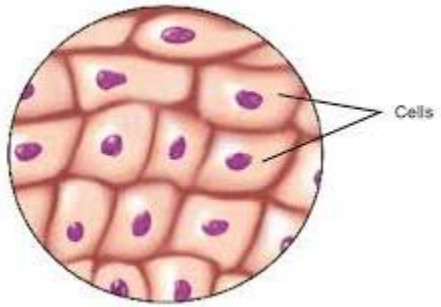


Transport to the liver

- Glucose metabolism
- Convert glucose into glycogen (store in liver and muscle)

Conversion into Fat

- Excessive glucose converted into fafty acids (store in adipose tissue)

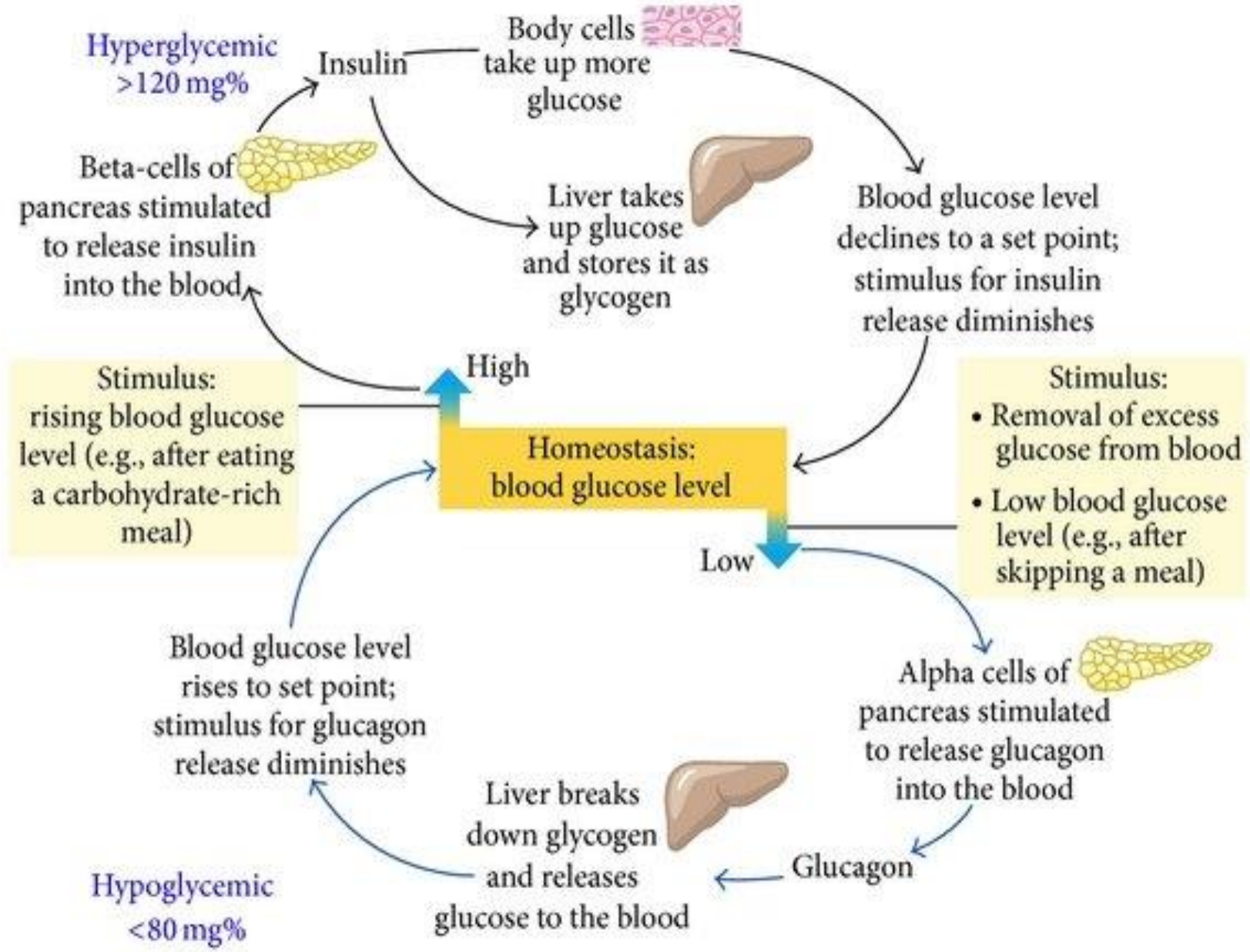


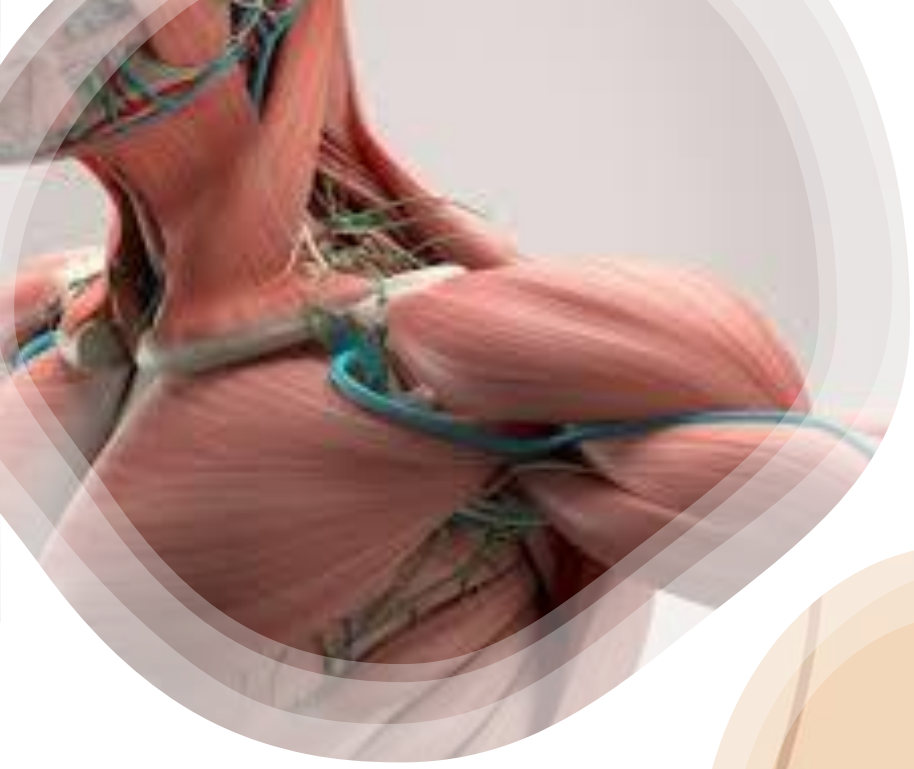
Uptake by cells

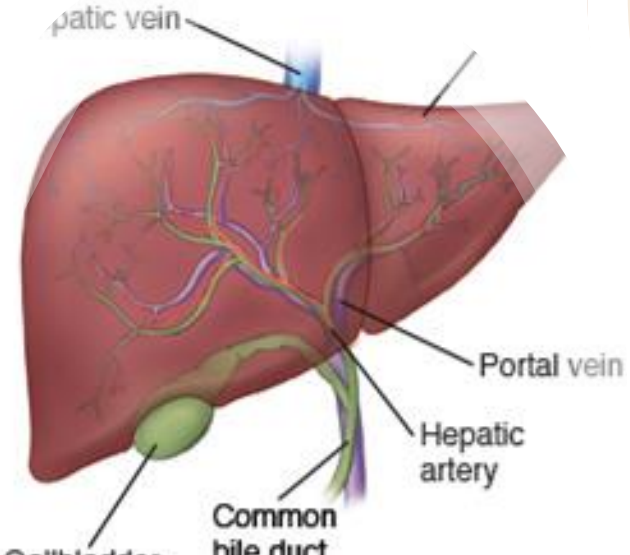
- Convert glucose into energy

If there's still too much glucose in the blood, the body releases **insulin** to help move the glucose into cells and keep blood sugar levels balanced.

Homesostasis Blood sugar level





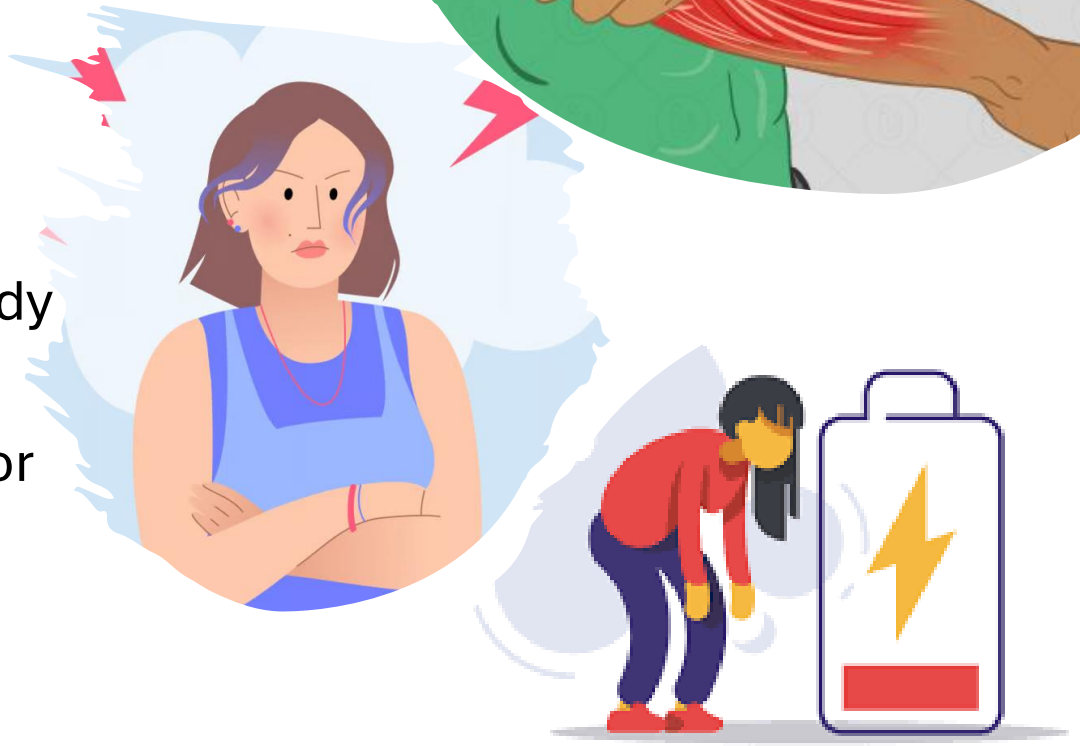


Storage

- **Liver**: Glucose is either stored as **glycogen** or released into the bloodstream, depending on the body's needs.
- **Muscles**: Glycogen is also stored in muscles for energy during physical activity.
- **Excess Glucose**: When the liver and muscles reach their glycogen storage capacity, excess glucose is converted into **fat** and stored in adipose tissue.

Deficiency of Carbohydrates

- Carbohydrate deficiency occurs when the body does not receive enough carbohydrates to meet its energy needs (Hypoglycemia)
- Symptoms:
  - **Fatigue:** Due to the lack of glucose, the body has less energy for daily activities.
  - **Muscle Weakness:** Low glucose availability can lead to muscle weakness and lack of endurance.
  - **Ketosis:** In severe carbohydrate deficiency, the body starts breaking down fats for energy, producing ketones, which can lead to **ketoacidosis**.
  - **Poor Concentration:** The brain relies on glucose for energy, and low carbohydrate intake can impair cognitive function.
  - **Irritability and Mood Swings**: The brain's glucose needs are not met, leading to irritability or mood changes.



Excessive Carbohydrates

- Consuming an excessive amount of carbohydrates can lead to an imbalance in energy storage and metabolism.
- Symptoms of Excess:
  - ✓**Weight Gain**: Excess carbohydrates that are not used for energy are converted into fat and stored in the body.
  - ✓**Increased Blood Sugar Levels**: Overconsumption of carbohydrates can lead to insulin resistance, increasing the risk of **type 2 diabetes**.
  - ✓**Fatty Liver Disease**: Excessive carbohydrate intake, especially from sugary foods, can lead to fat accumulation in the liver
  - ✓**Tooth Decay:** High carbohydrate intake, especially from sugary foods, can increase the risk of **dental cavities** due to the fermentation of sugars by bacteria in the mouth.
  - ✓**Digestive Problems**: Excess carbohydrates, particularly those from fiber-rich foods, can cause **bloating**, **gas**, or **diarrhea** in some individuals.

Category	Fasting Glucose (Venous plasma)	Random Glucose (Venous plasma)	HbA1c
Normal	<6.1 mmol/L	<7.8 mmol/L	≤ 5.6%
Pre-diabetic	6.1-6.9 mmol/L	7.8-11 mmol/L	5.7%-6.2%
Type 2 Diabetes Mellitus	≥7.0 mmol/L	≥11.1 mmol/L	≥ 6.3%

Glycemic Index

Low GI (<55), Medium GI (56-69) and High GI (70>)

Grains / Starchs		Vegetables		Fruits		Dairy		Proteins	
Rice Bran	27	Asparagus	15	Grapefruit	25	Low-Fat Yogurt	14	Peanuts	21
Bran Cereal	42	Broccoli	15	Apple	38	Plain Yogurt	14	Beans, Dried	40
Spaghetti	42	Celery	15	Peach	42	Whole Milk	27	Lentils	41
Corn, sweet	54	Cucumber	15	Orange	44	Soy Milk	30	Kidney Beans	41
Wild Rice	57	Lettuce	15	Grape	46	Fat-Free Milk	32	Split Peas	45
Sweet Potatoes	61	Peppers	15	Banana	54	Skim Milk	32	Lima Beans	46
White Rice	64	Spinach	15	Mango	56	Chocolate Milk	35	Chickpeas	47
Cous Cous	65	Tomatoes	15	Pineapple	66	Fruit Yogurt	36	Pinto Beans	55
Whole Wheat Bread	71	Chickpeas	33	Watermelon	72	Ice Cream	61	Black-Eyed Beans	59
		Cooked Carrots	39						
Muesli	80								
Baked Potatoes	85								
Oatmeal	87								
Taco Shells	97								
White Bread	100								
Bagel, White	103								


THANK
YOU