Topic 1: Principles of nutrition, physiology, and health

1.1 Energy in Foods

Science understanding

The importance of the macronutrients (protein, carbohydrates and lipids) and water and their respective energy values

- Nutrient energy values per kJ per gram
- Composition of macronutrients in food
  - Recommended proportions of individual macronutrients as a % of the total macronutrients
- Nutrient reference values
  - Estimated Average Requirement (EAR)
  - Recommended Daily Intake (RDI)
  - Adequate Intake (AI)
  - Tolerable Upper Intake Level (UL)
  - EARs for energy through life cycle (Estimated Energy Requirement (EER))

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Energy yielding nutrients

In the human body, three nutrients can be used to provide energy: carbohydrates, proteins and lipids. The other nutrients: vitamins, minerals and water do not provide energy to the body, and therefore are not **energy-yielding**. The energy released from carbohydrates, proteins and lipids is measured in **kilojoules** (kJ). However, in countries such as the United States, the term calories is still used as the preferred unit of food energy.

Fast fact

1 Calorie is equal to 4.2 kilojoules.

Most foods contain all three energy-yielding nutrients, as well as water, vitamins and minerals. The energy stored within a food item is only released when its bonds are completely broken down in the body during metabolism. This energy is then used to fuel everyday activities, such as sending electrical impulses through the brain and nerves, moving muscles and synthesising body compounds.

The amount of energy provided depends on the quantity of carbohydrates, proteins and lipids a food item contains. Each macronutrient yields a different number of kilojoules per gram. Carbohydrates yield approximately **16.7 kJ** per gram, protein yields **16.7 kJ** per gram and triglycerides yield the greatest amount of **37.7 kJ** per gram (as shown in Table 1.1.1). Therefore, a food item with a greater amount of lipids will provide a greater amount of energy; this food item would be **energy dense**.

Table 1.1.1: Energy provided by energy-yielding macronutrients.

Macronutrient	Energy (kJ/g)	Energy (cal/g)
Carbohydrate	16.7	4
Protein	16.7	4
Lipid	37.7	9

National Health and Medical Research Council, 2006. Nutrient reference values for Australia and New Zealand: Dietary energy, viewed 18 July 2018, <https://www.nrv.gov.au/dietary-energy>.

Alcohol contributes 29.3 kilojoules per gram (7 calories per gram). However, it is not considered a nutrient, as, due to its diuretic nature, it depletes the body of its nutrients and interferes with the growth, maintenance and repair of the body. Water provides no kilojoules, contributing 0 kilojoules per gram and serves other benefits in the body (explained further in Topic 1.5: Water and Other Fluids).

Questions

1. Identify how calories can be converted to kilojoules.

.....(1 mark) (KA4)

2. Complete the following table by rounding the energy values (kJ/g) for Carbohydrates and Protein to the nearest whole number. (Please note: the energy value of lipids used in calculations will be 37kJ/g as used in practice by dietitians, and therefore does not get rounded up as the other macronutrients do).

Reminder

Rounding to the nearest whole number: if the number after the decimal is lower than 5, round down. If the number after the decimal is 5 or greater, round up.

Macronutrient	Energy (kJ/g) as a decimal	Energy (kJ/g) as a whole number
Carbohydrate	16.7	
Protein	16.7	

(2 marks) (KA4)

Calculating the composition of macronutrients in food

To calculate the energy composition from a food product, the quantity (grams) of carbohydrate, protein and lipid is multiplied by the energy provided by one gram of each of these macronutrients. These amounts are then added together. This total is a legal requirement and must be displayed on all nutritional information panels (Figure 1.1.1).

NUTRITION INFORMATION

Servings per package: 3
Serving size: 150g

	Quantity per serving	Quantity per 100 g
Energy	608 kJ	405 kJ
Protein	4.2 g	2.8 g
Fat, total	7.4 g	4.9 g
— saturated	4.5 g	3.0 g
Carbohydrate, total	18.6 g	12.4 g
— sugars	18.6 g	12.4 g
Sodium	90 mg	60 mg

Ingredients: Whole milk, concentrated skim milk, sugar, banana (8%), strawberry (6%), grape (4%), peach (2%), pineapple (2%), gelatine, culture, thickener (1442)

All quantities above are averages

Figure 1.1.1: The energy content per serving and per 100 g (or mL) is a legal requirement of all nutritional information panels on food products.

Example

Calculate the total energy provided by a cup of fried rice containing 5 g protein, 30 g carbohydrate and 11 g lipid. Show all your calculations and round your final answer to the nearest whole number.

30 g carbohydrate × 17 kJ/g = 510 kJ

5 g protein × 17 kJ/g = 85 kJ

11 g lipid × 37kJ/g = 407 kJ

Total = 1002 kJ

The **energy distribution (%)** of each energy-yielding nutrient can be calculated using the following formula:

$$\text{Energy distribution} = \frac{\text{amount of energy provided per macronutrient}}{\text{total energy provided}} \times 100$$

Example

Calculate the energy distribution of each macronutrient in the fried rice example above. Show all calculations and round your answers to the nearest whole number.

Carbohydrate energy distribution $= \frac{510}{1002} \times 100 = 50.9\% \approx 51\%$

Protein energy distribution $= \frac{85}{1002} \times 100 = 8.4\% \approx 8\%$

Lipid energy distribution $= \frac{407}{1002} \times 100 = 40.6\% \approx 41\%$

Reminder

To confirm your calculations are correct, add up all your percentages. The total should equal 100.

These percentages can then be compared to the acceptable macronutrient distribution ranges (AMDR) (Figure 1.1.2). These are recommendations for optimising the balance of macronutrient intake to reduce the risk of developing diet-related disorders, while also allowing for an adequate intake of nutrients. These ranges are set for healthy individuals who are maintaining their body weight and are not appropriate for weight loss or management of a specific health concern.

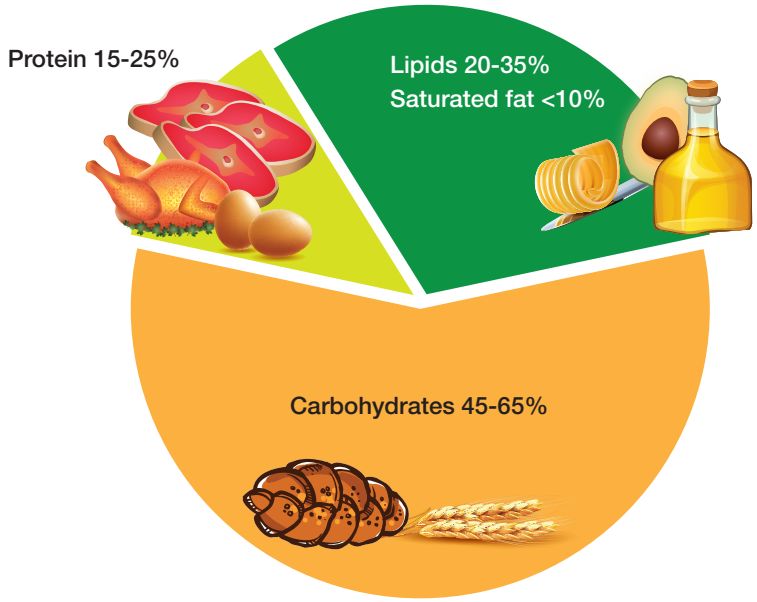

Figure 1.1.2: The acceptable macronutrient distribution ranges of each of the energy-yielding nutrients for individuals.

Example

Compare the energy distribution of each of the macronutrients in the fried rice example with those from the acceptable macronutrient distribution ranges, and make suitable recommendations when necessary to ensure they meet these ranges.

Knowing that the fried rice provides 51% of its kilojoules as carbohydrates tells an individual that this is a suitable carbohydrate selection as it is within the recommended range of 45–65%. On the other hand, only 8% of the kilojoules are provided by protein, which tells an individual they need to make higher protein selections at other times of the day to meet the recommended range of 15–25%. The fried rice provides 41% of its kilojoules as lipids, which suggests that an individual should make lower lipid selections at other times of the day to keep with the recommended range of 20–35%.

Questions

3. (a) An adolescent male has the following energy intake:

170g carbohydrate (120g simple carbohydrates, 50g complex carbohydrates)

75g protein

110g lipid (70g saturated, 20g polyunsaturated, 20g monounsaturated)

Calculate the total energy provided to this male adolescent after consuming the quantities of each macronutrient listed above. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA2, KA4)

(b) Calculate the energy distribution of each macronutrient from the male adolescent's diet from part (a). Show all your calculations and round your answers to the nearest whole number.

(3 marks) (KA2, KA4)

(c) Compare the energy distribution of each macronutrient calculated in part (b) with those from the acceptable macronutrient distribution ranges, and make suitable recommendations.

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.....*(3 marks) (IAE3)*

4. Australian researchers found that children and adolescents consume more energy from energy dense foods than any other age group, with the average child receiving three packaged snack foods in their lunchbox each day. Parents should aim to provide only one snack food in their child's lunch box each day, and ideally be less than 600kJ.

On the next page, calculate the total energy provided by one serving of each of the following lunch box snacks and make a recommendation to which snack parents should choose to include in their child's lunch box. Show all your calculations and round your final answer to the nearest whole number.

	SNACK A **Small packet (20g) of Original Popcorn**	**SNACK B** **Fruit & Nut Muesli Bar (45g)**	**SNACK C** **Mini Blueberry Muffin (40g)**
Protein	1.8g	4.1g	1.7g
Fat, total	5.1g	6.7g	6.2g
Fat, saturated	1.0g	1.1g	1.0g
Carbohydrate, total	8.4g	25.1	17.0g
Carbohydrate, sugars	0.7g	7.8g	9.4g

1

Questions

(4 marks) (KA4, IAE3)

Nutrient Reference Values

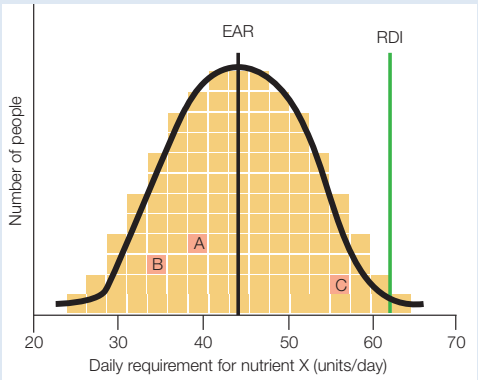
Nutrient reference values (NRVs) are a set of recommendations for nutritional intake based on current available scientific knowledge that best support the health of individuals in Australia and New Zealand. These recommendations apply to healthy people and may not be appropriate for people with diseases that require an increase or decrease in nutrient needs. Each person's body is unique and has its own set of requirements. Men differ from women and needs change as people grow from infancy to old age. This is why nutrient recommendations are based on age, gender and specific life stages. These values provide recommended intakes for energy (kilojoules), protein, carbohydrate, fibre, fats, water, vitamins and minerals. The NRVs are made up of 5 different values (as discussed in Table 1.1.2):

Table 1.1.2: Description of NRVs used in Australia and New Zealand

NRV	Description
Estimated Average Requirement (EAR)	The average amount of a nutrient estimated to meet the nutrient requirements of half of a group of healthy individuals in a specific life stage and gender group.
Recommended Daily Intake (RDI)	The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (approximately 98%) healthy individuals in a specific life stage and gender group. The RDI is set high enough above the EAR to meet the needs of most healthy people. When people's nutrient intakes are consistently below their daily requirements, they can become deficient, causing their nutrient stores to deplete and leading to poor health and deficiency symptoms. This is why the RDI is set so much higher than the EAR, to ensure this value meets the nutrient needs of as many people as possible.
Adequate Intake (AI)	The AI reflects the average amount of a nutrient that a group of healthy individuals consumes. This NRV is used when an RDI or EAR cannot be determined due to insufficient scientific evidence. Therefore, AI relies heavily on scientific judgement.
Tolerable Upper Intake Level (UL)	The UL is the point in which an individual exceeds the recommended intake and where a nutrient is likely to become toxic. It is recommended that an individual not exceed these recommendations often or by much. The RDI should not be thought of as a minimum amount, and a more accurate view is to see an individual's requirements as a range, with a marginal and danger zone both below and above this this range.
Estimated Energy Requirement (EER)	The EER represents the average dietary energy intake (kilojoules consumed per day) that will maintain an energy balance in a person who has a healthy body weight and level of physical activity. These values are determined to sustain a healthy and active life, as too much energy can lead to weight gain and its associated health consequences.

Questions

5. The EAR and RDI of a specific nutrient is shown in the graph on the right. Each square in the graph below represents an individual with unique nutritional requirements, however three different individuals are shown: A, B and C.



(a) With reference to the graph, state the daily requirement for nutrient X for the following individuals:

A: ..... *(1 mark) (IAE3)*

C: ..... *(1 mark) (IAE3)*

(b) Suggest one reason why individual C has a higher daily requirement of nutrient X than individual A.

.....

..... *(1 mark) (KA2)*

(c) True or False: An RDI for a nutrient is the amount that everyone needs to consume each day. Provide reasoning to explain your answer.

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..... *(2 marks) (KA2)*

(d) Explain why the RDI value is much higher than the EAR value on the graph.

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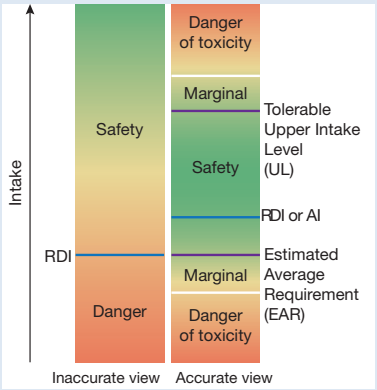
..... *(2 marks) (KA2)*

6. The image below demonstrates an inaccurate view vs accurate view of the nutrient intakes of individuals.



(a) With reference to the image above (accurate view), identify when an individual's intake of a nutrient would be inadequate.

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..... *(1 mark) (IAE3)*

(b) Explain why the view for nutrient intakes on the right in the image above is regarded as the accurate representation.

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..... *(2 marks) (KA2)*

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Key terms

Acceptable macronutrient distribution ranges (AMDR)	Estimated Average Requirement (EAR)
Adequate Intake (AI)	Estimated Energy Requirement (EER)
Carbohydrates yield 16.7 kJ/g ≈ 17kJ/g	Kilojoule (kJ)
Energy dense nutrient	Lipids yield 37 kJ/g
Energy composition	Nutrient Reference Value (NRV)
Energy distribution	Proteins yield 16.7 kJ/g ≈ 17kJ/g
Energy-yielding nutrient	Recommended Dietary Intake (RDI)
	Tolerable Upper Intake Level (UL)

Review questions: 1.1 Energy in foods

1. An advertisement for a new 'super protein supplement' claims to contain 20 g protein and provide 50 kJ per serving. Explain if this claim is possible and provide evidence to justify your answer.

(2 marks) (KA4, IAE3)

2. Refer to the ingredients list and nutritional information panel for one serving (100 g) of pasta carbonara.

	100 grams	Ingredients
Energy (kJ)		250 g cooked pasta
Protein (g)	14	20 g butter
Carbohydrates – total (g)	29	1 cup thickened cream
Carbohydrates – sugar (g)	4	250 g bacon
Fat – total (g)	14	2 eggs
Fat – polyunsaturated (g)	2	2 egg yolks
Fat – monounsaturated (g)	3	1 cup grated parmesan cheese
Fat – saturated (g)	9	1 tablespoon rosemary
Dietary fibre (g)	1.5	Pinch of salt
Sodium (mg)	200	Pinch of pepper

(a) Calculate the total energy of one serving (100 grams) of pasta carbonara. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA4, IAE3)

(b) Calculate the energy distribution of each energy-yielding nutrient and make recommendations in comparison to the acceptable macronutrient distribution ranges for Australians. Show all calculations and round your answers to the nearest whole number.

(6 marks) (KA4, IAE3)

(c) Suggest three specific modifications to the ingredients for the pasta carbonara recipe that would reduce the meal's energy density and increase its nutrient density.

(3 marks) (KA2)

3. Refer to the following nutritional information panel for a meal made by an elderly female aged 70 years old.

	Per serving
Energy (kJ)	
Protein (g)	15
Carbohydrates – total (g)	58
Carbohydrates – sugar (g)	36
Fat – total (g)	31
Fat – saturated (g)	18
Dietary fibre (g)	3
Sodium (mg)	320

(a) Calculate the total energy content provided by one serving of this meal. Show all calculations and round to the nearest whole number.

(4 marks) (KA2, KA4)

(b) The estimated energy requirement (EER) for an elderly female is 7600 kJ. What percentage of that recommended daily energy requirement is provided by this meal? Show all calculations and round your answer to the nearest whole number.

(2 marks) (KA2, KA4)

(c) Using the NRV calculator on the following website: https://www.nrv.gov.au/nutrients-energy-calc, determine the NRVs of the following nutrients for this elderly woman.

	AI	EAR	RDI	UL
Calcium				
Iron				
Vitamin C				
Dietary Fibre				
Water				

(5 marks) (IAE3)

4. Refer to the nutritional information panel of one serving of a mango fruit smoothie.

	Per serving
Energy (kJ)	
Protein (g)	8.4
Carbohydrates – total (g)	89.6
Carbohydrates – sugar (g)	79.5
Fat – total (g)	6
Fat – saturated (g)	2.3
Dietary fibre (g)	3.5
Sodium (mg)	154

(a) Calculate the quantity of carbohydrates that are not sugars (complex) in this mango fruit smoothie. Show all your calculations.

(1 mark) (KA4)

(b) Calculate the total energy content provided by one serving of a mango fruit smoothie. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA4, IAE3)

5. Calculate the amount of energy provided by alcohol in a glass of wine containing 520 kJ, 2.6 g carbohydrate and 1 g protein. Show all your calculations and round your final answer to the nearest whole number.

(3 marks) (KA2, KA4)

6. Refer to the following nutrition information panel from a packet of breakfast cereal.

	Per serving	Per 100 g
Protein (g)	2.2	8.8
Fat – total (g)	0.6	2.5
Fat – saturated (g)	0.2	0.8
Carbohydrate – total (g)	21.1	84.5
Carbohydrate – sugars (g)	6.3	25

(a) Calculate the total energy provided from one 100 g serving of the breakfast cereal. Show all your calculations and round your final answer to the nearest whole number.

(4 marks) (KA2, KA4)

(b) Using the NRV calculator on the following website: https://www.nrv.gov.au/nutrients-energy-calc, determine your estimated energy requirement (EER). Then calculate the proportion (%) of energy that this breakfast cereal would account for, in comparison to your EER. Show all calculation and round your final answer to the nearest whole number.

To calculate your EER, determine your physical activity level (PAL) and then multiply that value by 1000 to get it into kJ.

Your EER:..... *(2 marks) (KA2, IAE3)*

(c) Using the NRV calculator on the following website: https://www.nrv.gov.au/nutrients-energy-calc, determine your NRVs of the following five nutrients.

	AI	EAR	RDI	UL
Calcium				
Iron				
Vitamin C				
Dietary Fibre				
Water				

(5 marks) (IAE3)

Total: ____ / 45 marks

Macronutrients

The macronutrients can be defined as the nutrients humans consume, and need, in the largest quantities. Macro, meaning 'large', alludes to this. Their requirements are prescribed in grams per day, whilst other nutrients have only milli or microgram needs. Not only are macronutrients defined by being needed in large quantities each day, but they also give humans energy. Each macronutrient provides a differing amount of energy. While water does make up a large proportion of what we consume each day, and need, it does not provide any energy and is therefore not considered a true macronutrient. The true macronutrients that are needed in large amounts each day, and provide energy, are carbohydrates, lipids and protein.

1.2 Carbohydrates

Science understanding

Recognition that macro nutrients have a specific function and structure

- The structure and classification of carbohydrates as a nutrient
- Sources of carbohydrates in the diet
- The function and nutritional significance of the following carbohydrates:
    - Polysaccharides
    - Disaccharide
    - Monosaccharide
    - Glucose molecule
    - The effects of different carbohydrates on blood sugar levels
    - The role of soluble and insoluble fibre in the body

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Structure and Classification of Carbohydrates

Carbohydrates are made from combinations of the elements carbon (C), hydrogen (H) and oxygen (O). You may see carbohydrates referred to as CHO. Atoms of these elements arrange into a variety of structures called saccharides. The carbohydrate saccharides we consume include:

- **monosaccharides** (single unit)
- **disaccharides** (double unit of two joined monosaccharides)
- **oligosaccharides** (small number of joined monosaccharides, typically three to ten)
- **polysaccharides** (long linear or highly branched chains of many joined monosaccharides).

Simple Carbohydrates

The monosaccharides and disaccharides can be collectively termed the **simple carbohydrates (sugars)**. They can be considered 'smaller' based on being only one or two saccharide units in size. Within each saccharide classification of the simple sugars, there are several different types of simple carbohydrates (as shown in table 1.2.1), possessing different structural features. Each monosaccharide contains 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms, which can be written in shorthand as $C_6H_{12}O_6$.

The monosaccharides include:

- glucose
- fructose
- galactose

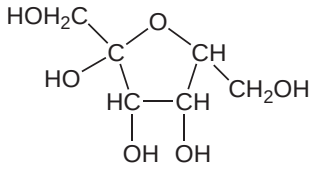
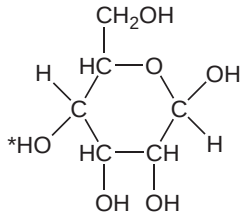
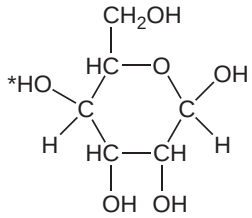
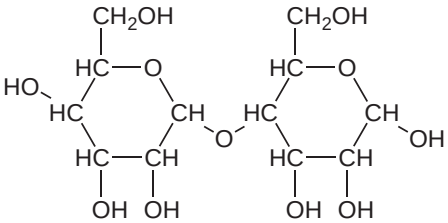
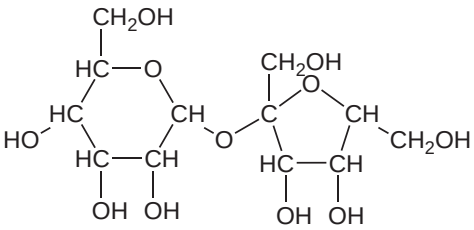
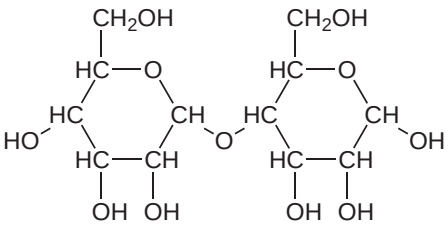
The disaccharides include:

- maltose (glucose + glucose)
- sucrose (glucose + fructose)
- lactose (glucose + galactose)

Fast fact

To make a disaccharide, a chemical reaction known as condensation links two monosaccharides together. A hydroxyl (OH) group from one monosaccharide and a hydrogen (H) atom from the other combine to create a molecule of water (H_2O). The two originally separate monosaccharides link together with single oxygen (O).

Table 1.2.1: Classification and structure of simple carbohydrates (Monosaccharides and Disaccharides)

Carbohydrate classification	Examples	Structure
Monosaccharide	Fructose	
	Glucose	
	Galactose	
		*The orientation of the hydroxyl group (OH) around the fourth carbon is the only structural difference between glucose and galactose.
Disaccharides	Lactose	
		(Galactose + Glucose)
	Sucrose	
		(Glucose + Fructose)
	Maltose	
		(Glucose + Glucose)

Extension activity

The World Health Organisation recommends our free (added) sugar consumption should only make up 10% of our total daily energy intake, which equates to approximately 50g or 12 teaspoons a day.

The Australian Health Survey found that in 2011-2012, Australians were consuming an average of 105 grams of total sugars per day, with just over half of this being free sugars (60g each day, or the equivalent of 14 teaspoons of white sugar), with the balance (45 grams) being the naturally occurring sugars.

Research and explain the difference between the following terms: free sugar, naturally occurring sugar and total sugar.

Look up and state the name of common free sugars that are added to foods in Australia.

The amount of sugar on the Nutritional Information Panel (NIP) of food products includes the naturally occurring sugar, as well as the free sugars. Avoiding sugar completely is not necessary, but to try and avoid large amounts of added sugar look to see if there is more than 15g of sugar per 100g, and then check the ingredients list for added sugar or alternate names that are listed high.

Look up the sugar content per 100g of commonly consumed carbohydrates or perceived "healthy" carbohydrates.

Food	Sugar per 100g	Food	Sugar per 100g

Complex Carbohydrates

The remaining saccharide classifications, namely the oligosaccharides and polysaccharides, can be collectively known as the **complex carbohydrates (sugars)**. They can be considered to be 'larger' in size, especially the polysaccharides, which may be composed of several hundred thousand joined glucose molecules! Like the monosaccharides and disaccharides, the saccharides of the complex sugar grouping can further be divided into examples of different sugars, each with a unique structure. The structure of each molecule belonging to the complex sugars, or the oligo- and poly-saccharide classification, is shown in detail in Table 1.2.2.

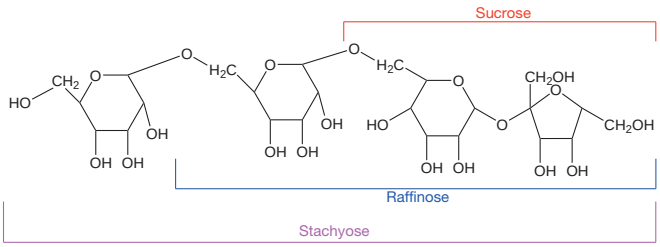
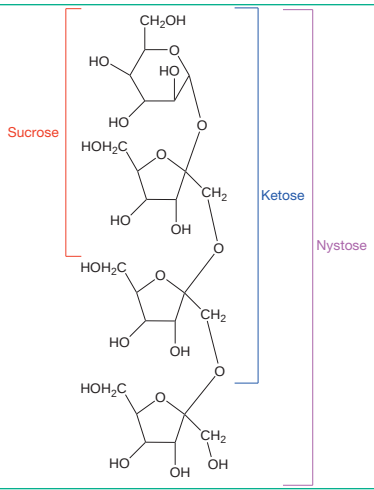
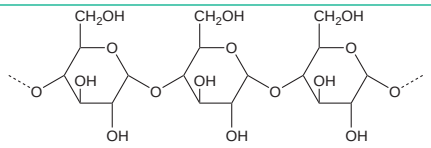
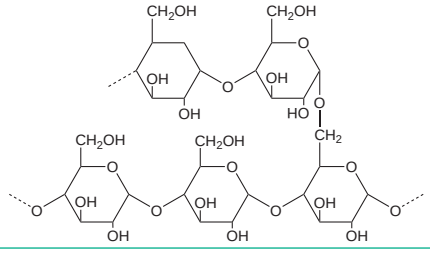
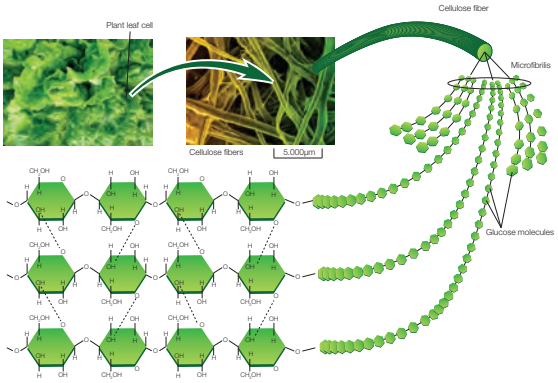
The oligosaccharides include:

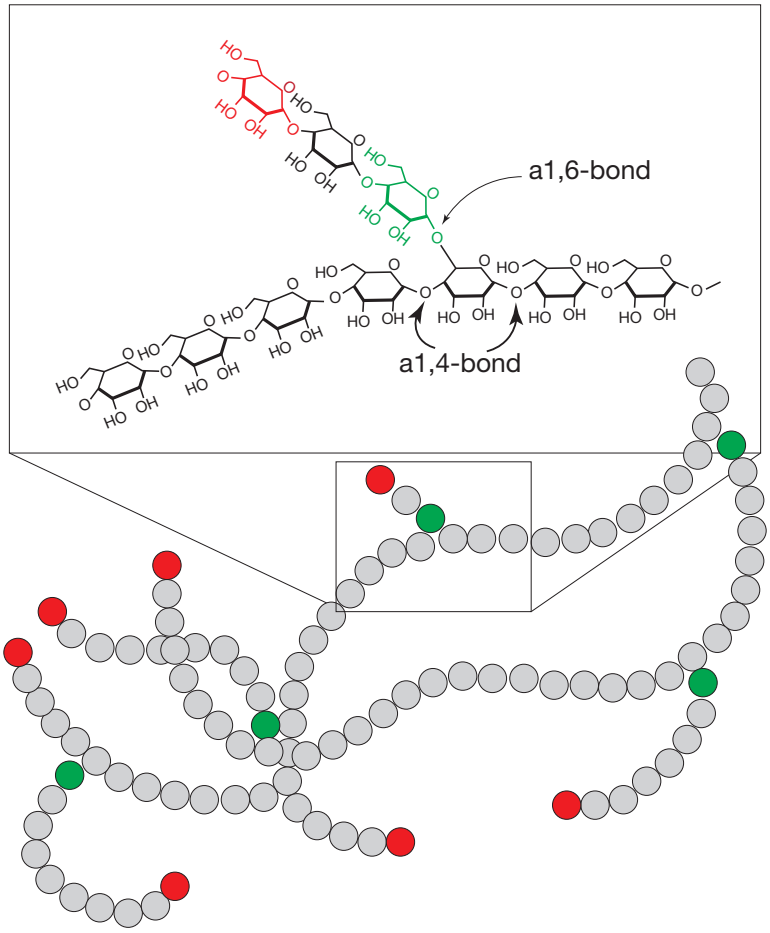
- Galacto-oligosaccharides: Raffinose and Stachyose
- Fructo-oligosaccharides: ketose and nystose

The Polysaccharides include:

- Starch
- Resistant Starch
- Glycogen
- Soluble and Insoluble Fibre

Table 1.2.2: Classification and structure of complex carbohydrates (Oligosaccharides and Polysaccharides)

Carbohydrate classification	Examples	Structure
Oligosaccharides	Galacto-oligosaccharides (such as raffinose and stachyose)	
		(Galactose + Galactose + Glucose + Fructose)
	Fructo-oligosaccharides (such as ketose and nystose)	
		(Glucose + Fructose + Fructose + Fructose)
Polysaccharides	Starch and resistant starch	 **OR** 
		(Glucose + Glucose + Glucose + etc.)
	Soluble and insoluble fibre	
		(Glucose + Glucose + Glucose + etc.)

Carbohydrate classification	Examples	Structure
Glycogen	Glucose + Glucose + Glucose + etc.)	

Questions

1. Using the information presented in Tables 1.2.1 and 1.2.2, rank the following in order of size (number of molecules).

Fructose Starch Lactose Raffinose

Smallest: .....

.....

..... Largest

(2 marks) (KA2)

Extension activity

Explain the role of Glycogen when excessive simple carbohydrates and starch are consumed.:

.....

.....

.....

.....

1

Sources of Carbohydrates in the Diet

Food and/or beverages that are good sources of each of the examples of saccharides are displayed on the following continuum. The continuum lists the saccharide examples from the most to least sweet, with the sweeter sugars coinciding with those we crave most.

Very sweet

Fructose
Found naturally in honey and sweet fruits, e.g. grapes.

Can be added as high-fructose corn syrup in foods and beverages, such as confectionery and soft drink.

Sucrose
Found naturally in sweet fruits.

Added as granulated sugar (table sugar, e.g. raw sugar) from sugar-cane processing (called refined sugar) in many foods, such as cakes and dried fruit.

Glucose
Found naturally in honey and fruit.

Added in foods such as sauces and cereals.

Definition

Sugar added to food is termed refined sugar.

Galactose
Not found naturally in high amounts in its monosaccharide form. When galactose is found in foods, it is usually present in its disaccharide form, i.e. joined to glucose to form lactose.

Maltose
Not found naturally in high amounts in any foods. However, when foods high in starch undergo processing (such as cooking), the starch can end up being broken down into maltose. This may be the case in breads, cereals, sweet potatoes, etc.

Can be added in foods with a malt flavour, e.g. malt milkshake, malt biscuits, confectionery.

Oligosaccharides
Found naturally in the onion group (onions, garlic, etc.) and legumes.

Can be added to foods such as cereals and yoghurts as inulin; its creamy texture is used to replace oils, and its sweet taste is used to replace sucrose.

Lactose
Found naturally in the dairy group (milk, cheese, etc.), making it the only carbohydrate that doesn't come from plants.

Can be added to bread and bread products.

Starch
Found naturally in foods such as oats, rice, legumes, corn and root vegetables. It is used as a primary ingredient in cereals, breads, pasta, etc.

Corn starch/potato starch (called refined starch) can be added as a thickener to many processed foods, such as custard.

Soluble fibre
Found naturally in the pith (flesh) of fruits and the flesh of vegetables, plus in foods such as oats, legumes, and soy products.

Can be added to many fibre-enriched/fortified foods, such as bread.

Insoluble fibre
Found naturally in foods such as bran, nuts, seeds, the skins of fruit and vegetables; also used as an ingredient in wholemeal/whole wheat products, such as wholemeal bread.

Can be added to many fibre-enriched/fortified foods, such as bread.

Least sweet

Questions

2. Using information from the continuum of sweetness, which sugar would be the most addictive?

.....*(1 mark) (IAE3)*

Extension activity

According to Nutrition Australia, it is recommended that between 25-30g of fibre is an adequate daily intake for Australians. Research foods you typically eat and compile a list of foods and their fibre quantities to determine if you meet this recommendation.

Food	Fibre per serve (g)	Food	Fibre per serve (g)

Functions and Nutritional Significance of Carbohydrates

Carbohydrates have a vast range of functions due to this macronutrient having a number of different types of simple and complex carbohydrates.

Source of Energy

The primary function of simple carbohydrates and starch is to provide energy (17 kJ/g).

Simple carbohydrates and starch are broken down and converted into glucose after consumption (see digestion of carbohydrates and metabolism of carbohydrates for further details). Once glucose is absorbed into the bloodstream, it is transported to cells (especially muscle cells) and broken down further to create energy in the form of adenosine triphosphate (ATP) through a process of cellular respiration.

Definitions

Cellular respiration is a metabolic pathway that breaks down glucose into carbon dioxide and water and produces ATP also during this reaction.

Fast fact

The brain can only use glucose to produce ATP to provide energy; therefore glucose is the body's preferred source of energy.

Simple Carbohydrates

Monosaccharides are already small enough to enter the bloodstream, while disaccharides need only one bond broken between the two joined monosaccharides before they can be absorbed into the bloodstream. Both monosaccharides and disaccharides can therefore enter the bloodstream quickly and are associated with a rapid rise in blood glucose levels and consequential rapid energy release (as shown in Figure 1.2.1). Foods or beverages consumed that produce this blood glucose response are known to have a high **glycaemic index** (high GI).

Definition

Glycaemic Index (GI) is a measure of how a food or beverage will affect blood glucose levels after consumption.

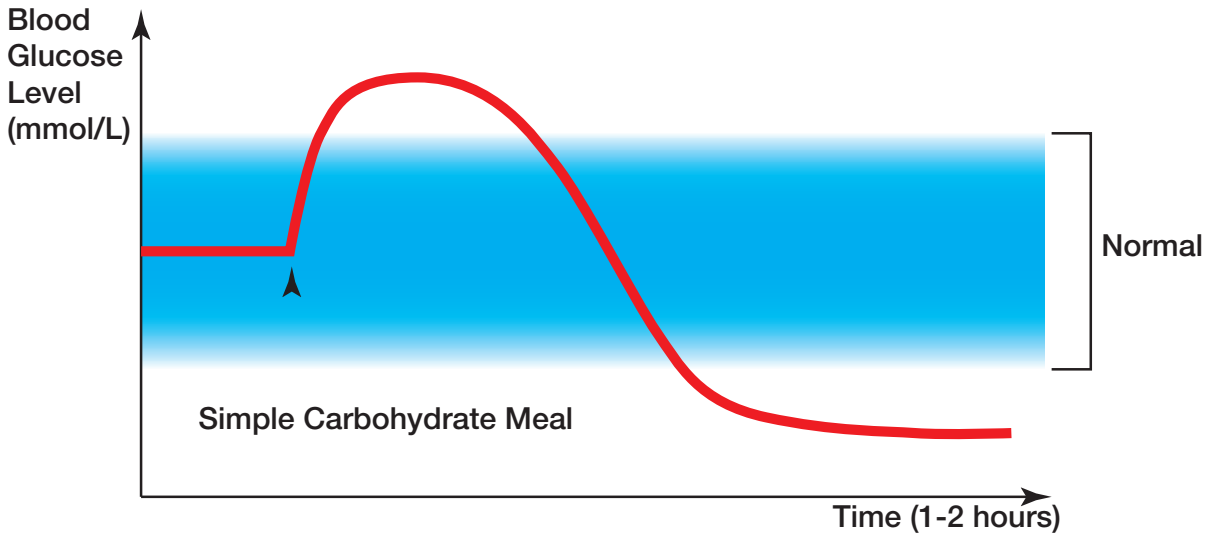


Figure 1.2.1: Effect of simple sugars on blood glucose levels (high GI).

Complex Carbohydrates

Starch, on the other hand, is a much larger molecule, made of hundreds of glucose units bonded together (as shown in Table 1.2.2). Therefore, it breaks down into glucose slowly and takes longer to be absorbed into the bloodstream. This results in a lower and more gradual elevation in blood glucose levels and, consequentially, sustained energy (as shown in Figure 1.2.2). Foods or beverages that produce this blood glucose response are known to have a low glycaemic index (low GI).

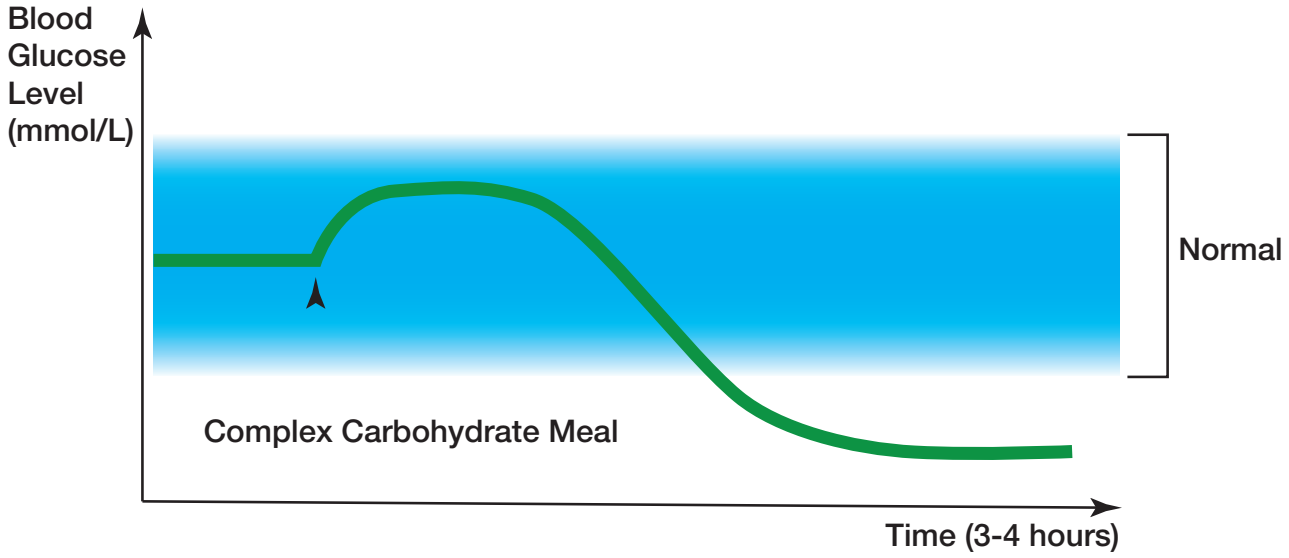


Figure 1.2.2: Effect of starch on blood glucose levels (low GI).

Questions

3. Classify the following carbohydrates as either simple or complex:

Glucose: .....

Oligosaccharides: .....

Fructose: .....

Maltose: .....

Starch: ..... *(5 marks) (KA1)*

4. Many foods high in starch, such as white bread, baked potatoes and white rice are processed (e.g. cooked) having had their starch partly broken down into smaller chains including maltose. Explain the effect these foods would have on blood glucose levels, and why.

.....

.....

.....

.....

..... *(3 marks) (KA2)*

5. Explain the effect of the following carbohydrates on blood glucose levels after consumption.

Glucose: .....

.....

.....

.....

Starch: .....

.....

.....

..... *(4 marks) (KA2)*

A component of the Cell Membrane

Blood glucose can also be used for a structural role, as part of the cell membrane. Glucose molecules will bond together and form short-chain oligosaccharides on the exterior of the cell membranes (Figure 1.2.3). The role of these oligosaccharides is in cell recognition: how our body recognises our own cells in contrast to those that are foreign, such as bacteria or viruses.

Reminder

Oligosaccharides are 3 to 10 glucose molecules joined together.

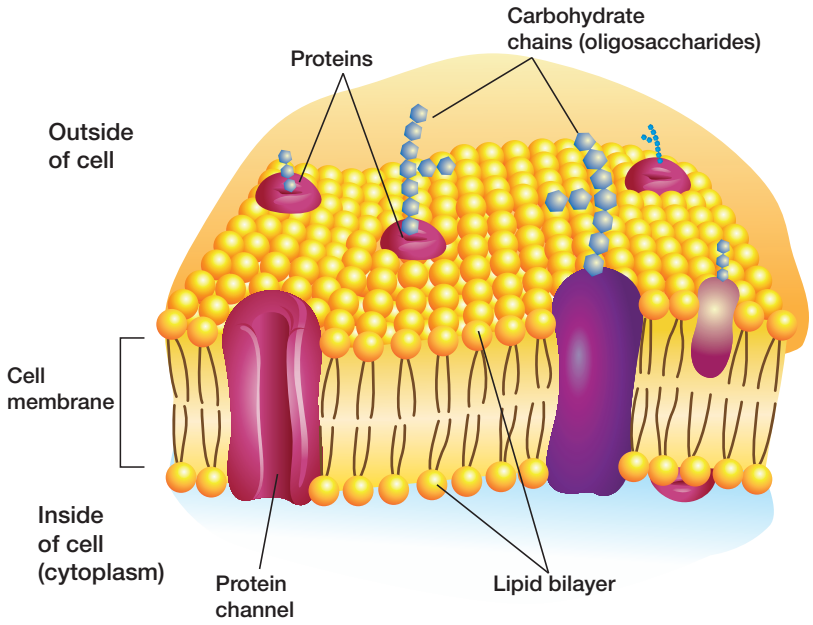


Figure 1.2.3: Oligosaccharides in the cell membrane.

Achieving efficient nutrient absorption and satiety

Oligosaccharides, resistant starch and soluble fibre cannot be broken down into glucose and absorbed into the bloodstream. Instead, most of these carbohydrates bind water and partly dissolve to become 'gel-like' in the stomach. The addition of water to the carbohydrate food consumed can also cause expansion of the stomach. The gel-like consistency of the carbohydrate food, plus the increase in volume from the addition of water, causes food to empty from the stomach into the small intestine at a slower rate. The slower rate of stomach emptying has two roles:

1. It slows initial digestion and therefore maximises the absorption of nutrients (including monosaccharides) from the duodenum (the first part of the small intestine).
2. It keeps the body feeling fuller for longer (this feeling is called **satiety**), via two means:
   i. expansion of the stomach triggers the feeling of satiety
   ii. slow absorption of monosaccharides gives a gradual blood glucose rise, providing sustained or longer-lasting energy. This can also help to regulate blood glucose levels.

Definitions

Many foods high in starch, particularly when eaten raw, without any processing (for example bananas with some green to them, and beans), will not be completely digested into glucose. The starch that isn't digested is called resistant starch.