Lecture 2 – Major questions in food chemistry & biochemistry
(answers through examples)

Question 1: What are the absolute and/or relative abundances of specific molecular components or groups of molecules in foods?
All foods have a specific nutritional value. → energy, carbohydrates (sugars, dietary fibre), fat, protein, vitamins (vit A, Thiamine, Riboflavin, Niacin, vit B) minerals (calcium, iron, magnesium, manganese, phosphorus)

Question 2: Why do we want to measure the abundance of specific molecular components or groups of these components in foods?
Need to know levels of components in large range of food to help identify and manage dietary deficiencies in Australia.
Calcium – healthy bones & teeth, maintain blood pH
Iodine – synthesis of thyroid hormones, help control metabolism, growth and development
Iron – synthesize haem, energy transduction, synthesize neurotransmitters
Zinc – make insulin
Vit D – calcium absorption, healthy bones & muscles
Omega-3 fatty acids – required for brain function

Question 3: How can we measure the abundance of specific molecular components or groups of these components in foods?
Phenolic compounds represent one of the three major categories of plant secondary products. We can measure (specific) using the Folin-Ciocalteu method, which is based on a chemical reduction. Presence of phenolic compounds have a blue colour, which can be measured using a spectrophotometer (at 760 nm).

Question 4: How do molecular components of foods change with food processing, storage, cooking and digestion?
Eggs - contain proteins, behave differently under different conditions. E.g. cooked 60˚C = custard like, 80˚C = bouncy & firm. Ovalbumin, ovomucin, ovotransferrin give capacity to set and be whipped.
55 to 60℃ → proteins start to lose their structure
60℃ → ovotransferrin begins to bond with itself, creating a semi-solid matrix (turns the egg white milk)
68℃ → ovotransferrin forms opaque solid, though the egg white is still quite soft and moist.
82℃ → ovalbumin cross-links and solidifies giving a firm egg white.

Question 5: In what ways are the various molecular components in foods important for human health?
Polyunsaturated fatty acids contain more than one double bond in their backbone. Lipids containing polyunsaturated fatty acids are typically liquid at room temperature. Consumption of polyunsaturated lipids in moderation can assist in reducing levels of low density lipoprotein (LDL) cholesterol. This 'bad cholesterol' forms plaque, which can cause atheroslerosis (clogged arteries), leading to heart attacks and strokes.

Question 6: How does the health importance of the various molecular components in foods vary between people (age, gender, sensitivities, allergies, physical activity,…)?
Amino acids are essential in the diet for an adult human. Histidine is a non-essential aa, but growing children are not able to synthesize histidine fast enough to meet their needs.

Question 7: Do specific foods contain harmful molecular components at dangerous levels?
3-MCPD is carcinogenic & highly suspected to be genotoxic and cause male fertility effects.

Question 8: What are the influences of water in the chemistry and biochemistry of foods?
The behaviour of proteins in solution is markedly affected by the presence of low-molecular-weight ions whose concentration depends on the water content of the food.

Question 9: How do we determine whether health claims for a food or food component are valid?
Gluten – nitrogenous part of flour.
About 1% of the Australian population suffers from coeliac disease, the management of which requires a gluten-free diet. People with gluten sensitivity (prevalence unknown) and possibly those with certain types of chronic autoimmune diseases may also benefit from a gluten-free diet.

Major question 10: What are the mechanisms by which bioactive compounds in foods come to have their effects on the human body?
Consumption of fruits and vegetables, which contain substantial amounts of antioxidants, has substantial positive health effects, including longevity. Much harder to understand how the bioactive compounds affect the body and internal mechanisms.

Question 11: *What are the links between gut microbiota and human health*
Some microbes in the gut ferment dietary fibre into short-chain fatty acids, which are then absorbed into the body (as nutrients)

Question 12: What are the implications of recent biotechnological advances in plant and animal breeding for foods
CRISPR = Clustered Regularly Interspaced Short Palindromic Repeats (of DNA).
Cas9 = CRISPR-associated protein-9 nuclease.
CRISPR-Cas9 has now been employed for genome editing in a range of bacterial, plant and animal (including human) cells. Great potential to improve production & quality of food

Lecture 3: Context – the agri-food industries

Growing world population
- 9.7 billion by 2050
- need to increase productivity of crop and livestock farming systems and raise output per unit of input
- need to develop efficient supply chains, produce in an environmentally sustainable way (higher atmospheric CO_2, average temps, and change in rainfall patterns)
- 1960 supported 2.4 people per ha of land, in 2025 needs to support 6 people

Agri-food value chian
Agriculture is now massive part in agri-food chain. Need to understand farm & resource management, post farm gate handling & processing, transport, regulation, quality assurance, RnD

Some factors influence agri-food chain (dynamic & complex)
- globalisation
- expansion of supermarkets
- increased demand for processed foods with extended shelf-life
Changing preferences for food: convenience, expected health outcomes, animal welfare issues, desire to know provenance, appreciation for cuisines

Australian agriculture
- Can be divided by value in 6 sectors: grains & oilseeds (29.8%), meat (24%), sugarcane, cotton and wine (13.5%), wool (7%), dairy (6.6%), horticulture (4.5%)
- receives low gov subsidies comparatively to Europe, Japan, US, South Korea
- Aus farmers deal with volatile climates
- Australian agricultural production = 1% global
- Australia has 135,000 farmers → feed 80 million
- Australia's ag product export = $41 billion worth
- Australian farmers supply 93% of food eaten in Aus

Employment in the Australian agri-food value chain
In Australia, agriculture contributes 2.3% of GDP, and only 307,000 people were employed. Indirect employment = 1.6 million people

Skill and costs
- shortage of skilled labour
- post-farm services are high

Producing foods to address global problems
- feed 1 billion chronically hungry people
- treat 2 billion people with micronutrient deficiencies
- reduce 1.6 billion people who consume too much food
- Healthier diets – prevention better than treatment
- promote healthier food with high consumer acceptance.

Lecture 4 – What's in a label

Food labelling in Australia
- Labelling standards set by FSANZ in Food Standards Code
- Distinct labelling for all consumable foods

Country of origin labelling
- Packaged food must carry a statement identifying either: (1) the country where the food is made, produced or grown, (2) where the food was manufactured or packaged (3) made from local or imported ingredients

Food standards code for cereals
- Code requires that wheat flour is sold as suitable for making bread must contain: no less than 2 mg/kg, no more than 3 mg/kg of folic acid; no less than 6.4mg/kg thiamine
- Iodised salt must be used for making bread

Food standards code for milk
- The code requires that cow's milk must contain: less than 32g of milkfat, no less than 30k/kg of protein
- Skim milk must contain: no more than 1.5g/kg of milkfat, no less than 30g/kg of protein

Lecture 5 – from grains to marsupials

Cultured meat
- made through animal cell culture rather than rearing & slaughtering animals
-muscle cells, fat cells and connective tissue grown in controlled, sterile environment

Potential benefit:
- use less water, land and energy, produce less greenhouse gas emissions
- does not distort global grain market
- can be grown without antibiotics
- outbreaks of zoonotic diseases are prevented
- shelf-life longer

Critical technologies required to produce cultured meat
- cell line development
- cell culture media
- scaffolding and product structuring
- bioreactor design

Algae as food
- algae consist of microalgae and macroalgae
- only need water, warmth and sunlight
- algae proteins and carbs are being fed to cattle and farmed fish

Algae contain high levels of omega-3 and omega-7 fatty acids
- Omega-3 and omega-7 fatty acids in fish come from the algae they eat

Seaweeds are edible algae – nori, kombu

Nutritional value of seaweeds
- contains iron, calcium, magnesium, potassium, zinc, vitamin K, vitamin E, thiamine, riboflavin, niacin, folate
- Brown algae (rich iodine content)
- Dulse

Aboriginal foods
- primarily hunter-gatherers
- fruits, seeds and greens highly seasonal
- food sources were linked to cycle of fire and rain
- southern zone = roots important for diet, northern = plants along rivers
- animals highly desirable

Kangaroo
- low in fat
- contain L-carnitine – metabolised by gut microbes into TMAO (leads to build up of plaque in arteries). Abundant in red meat.

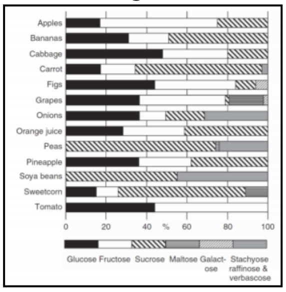
Finger lime
- grow in northern NSW and SE Queensland. used in jams, marmalades & chutneys.
- peel contains volatile compounds

Warrigal Greens
- can be grown hydroponically and are used as a leafy green vegetable. Contain oxalate, nitrate and saponin (affect palatability & can be toxic). Can be removed by blanching.

Quandong
- tart flesh. High content of oil and protein.
- contain a rare amino acid, santalbic acid, which in rates was absorbed and widely distributed in body tissue

Lecture 6: Food carbohydrates

Mono and oligosaccharides of total sugar in foods



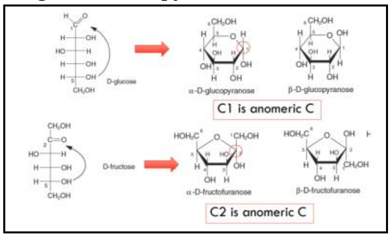
Monosaccharides
Free monosaccharides are rare:
- fruits (apples and pears)
- cereal grain
Building blocks and precursors:
- oligo- and polysaccharides
- biochemical metabolites
Active functional group: carbonyl
- aldoses
- ketoses

Biologically important monosaccharides
Aldoses: D-glyceraldehyde, D-ribose, D-glucose, D-mannose, D-galactose
Ketoses: dihydroxyacetone, D-ribulose, D-fructose

Monosaccharides
- Simplest: trioses (3C - glyceraldehyde, Dihydroxyacetone), tretoses (4C), Pentoses (5C), Hexoses (6C), Heptoses (7C)
- Optical isomers; chiral centres, rotate plane of polarized light, clockwise rotation of light (dextrorotatory), anticlockwise rotation (levorotatory)
- Enantiomers (mirror images)
→ Monosaccharides as building blocks for cell wall polymers

Functional groups are reactive
Aldehydes, ketones → (hemi-)acetal, (hemi-)ketal
→ less active & reactions can take place within the molecule

Ring formation: pyranoses, furanoses



α- and β-configuration of D(+)-Glucose
Ring conformation
- glucose preferentially has chair conformation to minimise torsion
- Bulky -OH and CH2OH groups aere perpendicular or parallel to an imaginary axis through the ring

Reversible isomerisation
- Glc, Fru, and Man are interconvertible in dilute alkali
- Analogous reactions with phosphorylated forms of these hexoses are important in all living cells (catalysed by isomerases, epimerases)

Sugar derivatives
Sugar alcohols as low calories sweeteners
- Synthesised on industrial scale under mild reducing conditions (H2) from their analogue sugars.
- D-Sorbitol (D-Glc)
  - made from corn syrup
  - naturally present in apples (0.5-1%, 1-2% pears, peaches, plums, cherries, celery)
  - starting point for industrial manufacture of ascorbic acid

Glycosidic bonds
- Reaction between anomeric C and external hydroxyl
- Monosaccharide disaccharide polysaccharide
- Anomeric C no longer a reducing agent

Glycosidic bonds
Properties in Di-, Oligo-, Polysaccharides
- Stable under ordinary conditions, but readily hydrolysed under acidic conditions or by enzymes
- Fixes hemiacetal structure in either alpha or beta configuration and abolishes mutarotation
Glycosides
- Reserved for class of specific compounds: sugar linked to non-sugar (aglycone)
  – Flavonoids (sugar linked to phenolic hydroxyl