Worksheet 17.1

Chapter 17: Food chemistry – glossary

**Aldehydes (Alkanals)**  A homologous series of compounds with the general formula RCHO, where the –CHO group (the aldehyde group) consists of a carbonyl group attached to a hydrogen atom. R is an alkyl or aryl group.

**Alkyl group**  A group, with the general formula C\textsubscript{n}H\textsubscript{2n+1}, obtained by removing a hydrogen atom from an alkane. It is usually represented by R.

**Aryl group**  A group of atoms derived from benzene by removing one hydrogen atom that is bonded to the benzene ring.

**Amylopectin**  The water-soluble component of starch. It is a condensation polymer with a highly branched chain of glucose molecules.

**Amylose**  The water-insoluble component of starch. It is a condensation polymer with a linear chain of many glucose monomers.

**Anthocyanins**  The anthocyanins are the most widely distributed pigment in plants and are present, for example, in strawberries, plums, cranberries, blueberries and raspberries. They are a sub-class of flavonoids responsible for a range of colours in fruits and vegetables including yellow, red and blue. They all have very similar three-ring C\textsubscript{6}C\textsubscript{3}C\textsubscript{6} structures with conjugated double bonds, but vary in the number and position of the hydroxy groups and alkoxy side chains.

**Antioxidant**  A substance that delays the onset or slows the rate of oxidation. It is used to extend the shelf life of food.

**Asymmetric (chiral) carbon atom**  A carbon atom that is attached to four different atoms or groups of atoms.

**Auto-oxidation**  The direct combination of a substance with molecular oxygen at ordinary temperature. The auto-oxidation of unsaturated fats occurs in air in the absence of enzymes.

**Cahn–Ingold–Prelog (CIP) priority rules**  A set of rules used to assign the R/S configuration to a chiral carbon atom. The atoms bonded to the chiral carbon are ranked in order of increasing atomic number. If two or more atoms have the same atomic number, the next atoms are used to rank the substituents. Double bonds count as double. The molecule is then viewed with the lowest ranking substituent pointing away from the observer. If the priority of the remaining three substituents decreases in a clockwise direction, it is assigned the R-form; if priority decreases in an anticlockwise direction, it is the S-form.

**Caramelization**  A non-enzymatic browning reaction used extensively in cooking which gives sugars a nutty flavour and brown colour. Caramelization is a complex, poorly understood process that produces hundreds of chemicals. The reactions occurring include: inversion, condensation, dehydration and fragmentation. It occurs with foods of high carbohydrate content and low nitrogen content.
**Carbohydrate**  Carbohydrates are organic compounds that contain the elements carbon, hydrogen and oxygen. The ratio of hydrogen to oxygen atoms is usually 2:1 and their formulas are of the form $C_nH_{2n}O_n$.

**Carotenoids**  They are a class of naturally occurring richly coloured pigments synthesized by plants, algae and photosynthetic bacteria. They are the sources of the yellow, orange and red colours of many plants, fruits and vegetables and provide most of the carotenoids in the human diet.

**Chelating agents**  A chelating agent is a molecule which can act as a multi-dentate ligand and form several dative covalent bonds to a single metal ion. EDTA is an example. They are used in food manufacture to remove traces of metal ions which might otherwise cause foods to deteriorate. They are also called sequestrants.

**Chiral (asymmetric) centre**  An atom, usually a carbon atom, in a molecule that is attached to four different groups.

**Chiral molecule**  A molecule that is non-superimposable on its mirror image.

**Chlorophyll**  This pigment gives plants and algae their green colour. It absorbs the light needed for photosynthesis. The basic structure consists of a porphyrin ring with a central magnesium ion. The long hydrocarbon tail attached to the porphyrin ring makes chlorophyll fat-soluble and insoluble in water. Two different types of chlorophyll ($\text{chlorophyll } a$ and chlorophyll $b$) are found in plants. The small difference in side chains allows the two forms to absorb light at slightly different wavelengths.

**Cholesterol**  An important steroid with a distinctive fused four-ring structure. It is found in many animal food products and is a key component of cell membranes and a precursor for other steroids.

**Chromophore**  A group of atoms responsible for absorbing UV and visible radiation. They generally include a $\pi$ system of electrons present in unsaturated groups such as $C \equiv C$, $C = O$, $N = N$, $NO_2$ and the benzene ring.

**Cis-**  Geometric isomers with the same group (e.g. H atoms) on the same side of the double bond or ring.

**Cis-trans isomerism**  A form of stereo-isomerism present in molecules with bonds with restricted rotation: alkenes or cyclic structures.

**Colloid**  A dispersion of small particles of one material in another.

**Complementary colours**  Two colours which produce white light when added together.

**Complete protein**  A protein that provides all of the essential amino acids.

**Condensation polymers**  A type of polymerization which involves the elimination of small molecules, usually water. Proteins and polysaccharides are both examples.

**Configuration**  The spatial arrangement of atoms or functional groups within a molecule.

**Conjugated molecules**  These have double or triple bonds that are separated by one single bond. The electrons in the $\pi$ molecular orbitals are delocalized over an extended region of the double and single bonds.
**CORN rules**  A set of rules used to assign the D/L configuration of a chiral carbon atom in an amino acid. The system depends on the arrangement in space of the COOH, R, NH2 groups and H atom around the asymmetric carbon, with the hydrogen atom again pointing away from the viewer. If the CORN groups are arranged clockwise, then it is the D-enantiomer; if they are arranged anticlockwise, it is the L-enantiomer.

**Dative covalent bond**  A dative covalent bond is formed when one atom supplies both electrons of the shared bonding pair in a covalent bond.

**Delocalization (of electrons)**  This occurs when molecules or ions have parallel p orbitals which form an extended π molecular orbital over three or more atoms.

**Disaccharide**  A carbohydrate consisting of two monosaccharide units joined by a covalent bond during a condensation reaction.

**Emulsion**  A dispersed mixture of two liquid components which normally do not mix, in which one component is distributed as droplets in the other.

**Enantiomer**  A compound whose molecular structure is not superimposable on its mirror image.

**Essential amino acids**  Amino acids that cannot be synthesized by humans and must be obtained from the diet.

**Ester**  Organic compounds formed by the condensation reaction between alcohols and carboxylic acids. They have the general formula R¹COOR². Fats and oils are triesters.

**Fat**  Fats are solid triesters (triglycerides) formed from three long-chain fatty acid (carboxylic acid) molecules and one glycerol molecule.

**Fatty acid**  A long-chain carboxylic acid which chemically combines with glycerol (propane-1,2,3-triol) to form fats and oils.

**Foam**  A dispersed mixture of two components which normally do not mix in which the dispersed component is gaseous.

**Food**  Any substance, whether processed, semi-processed or raw that is intended for human consumption, and includes beverages, chewing gum and any substance that has been used in the manufacture, preparation or treatment of ‘food’, but does not include cosmetics, tobacco or substances used only as drugs (Codex definition 2005).

**Gene**  A segment of a DNA molecule that contains the genetic code for a protein molecule.

**Geometric isomerism**  Geometric isomerism occurs in alkenes when there is restricted rotation about a carbon–carbon double bond. It can also occur in a ring system where there is restricted rotation about a carbon–carbon single bond.

**Globular protein**  Soluble proteins with a globular or rounded shape.

**Glycosidic bond**  The –O– covalent bond formed between two reacting sugar molecules, or the bond between the sugar and base in a nucleotide.

**Heme**  An iron complex found in the protein haemoglobin.
Haemoglobin  A quaternary protein composed of four polypeptide chains combined with a heme group. It can bond and transport oxygen molecules from the lungs to body tissues.

Herbicide  A substance designed to kill plants.

Homolytic fission  The breaking of a covalent bond which results in one electron from the bond being left on each fragment, leading to the production of two free radicals.

Hydrogenation  The addition of hydrogen across a multiple bond. The reaction generally uses a transition metal catalyst.

Hydrolysis  A chemical reaction involving water. Covalent bonds are broken during the reaction and the elements of water are added to the chemical fragments.

Hydroperoxides (ROOH)  Key intermediates in the free-radical chain mechanism occurring during oxidative rancidity. They degrade to volatile aldehydes and ketones, which have strong off-flavours.

Hydrophilic  Molecules or functional groups that have high solubility in water.

Hydrophobic  Molecules or functional groups that have poor solubility in water.

Incomplete protein  A protein that does not provide all the essential amino acids.

Indicator (acid–base)  A substance which changes colour over a particular pH range. Their end point can be used to measure the equivalence point during titrations.

Initiation  The first elementary step in a free-radical reaction. It involves the homolytic fission of a bond, generally by ultraviolet radiation or high temperature. Free radicals are produced.

Ketones (alkanones)  A homologous series of compounds with the general formula $R^1COR^2$, with two alkyl groups bonded to a carbonyl group.

Kinetic stability  If two chemicals react relatively slowly because the activation energy is relatively high, then the system is kinetically stable.

Ligand  A molecule or negative ion that donates a pair of electrons to a central metal ion to form a dative or coordinate covalent bond. Ligands are Lewis acids.

Lipids  Biological compounds which are soluble in organic solvent, but have limited insolubility in water. Fats, oils and steroids are examples.

Maillard reactions  Maillard browning involves a complex series of reactions between amino acids and reducing sugars, usually at increased temperatures.

Miscible liquids  Liquids that mix in all proportions, for example, ethanol and water.

Molecular orbitals  Molecular orbitals are formed in molecules when atomic orbitals combine and merge when atoms bond together. $\sigma$ and $\pi$ bonds are made from molecular orbitals.

Monodentate ligand  A ligand that forms one dative covalent bond to a central metal ion.

Monosaccharide  They contain one carbonyl group (C = O) and at least two hydroxyl (–OH) groups, and have the empirical formula CH$_2$O. Monosaccharides are the building blocks of disaccharides and polysaccharides.

Nomenclature  A system of rules for naming.
**Nutrient**  Any substance obtained from food and used by the body to provide energy, regulate growth, maintenance and repair of the body’s tissues. Proteins, lipids, carbohydrates, vitamins, minerals and water are considered nutrients.

**Oil**  Oils are liquid triesters (triglycerides) formed from three long-chain fatty acid (carboxylic acid) molecules and one glycerol molecule.

**Optical isomerism**  Optical isomers rotate plane-polarized light in equal and opposite directions. It occurs when a molecule is not superimposable on its own mirror image. The molecule must possess a chiral centre.

**Optically active**  A compound that is able to rotate plane-polarized light.

**Oxidising agent (oxidant)**  A chemical or substance that accepts electrons from the reactant or one of the reactants and brings about oxidation. The oxidizing agent is reduced.

**Peptide**  An amide bond formed between the amino group of an amino acid and the carboxyl group of another (in the presence of enzymes), with the elimination of water.

**Peptide bond**  An amide bond resulting from the condensation reaction between the amine group of one amino acid and the carboxylic acid group from another amino acid.

**Phase**  A physically or chemically distinct part of a chemical system. A phase is homogenous throughout and is separated from other phases by a phase boundary.

**Phenol**  An organic compound in which a hydroxyl group is bonded directly to one of the carbon atoms of a benzene ring.

**Phenolphthalein**  A common acid–base indicator, used for strong acid/strong base and weak acid/strong base titrations. It is colourless in acid solution, pink in alkaline solution.

**Photochemical reaction**  A reaction initiated by light.

**Photolysis**  The splitting of molecules into fragments (often free radicals) by light, usually ultraviolet radiation.

**Pi (\(\pi\)) bond**  A bond formed by the sideways overlap of two p-orbitals. In a \(\pi\) bond the electron density is concentrated on either side of the internuclear axis. A \(\pi\) bond is weaker than a \(\sigma\) bond.

**Plane-polarized light**  Electromagnetic radiation in which both components of the wave oscillate in a single plane. It is used in the detection of optical activity.

**Polyamide**  A polymer in which the monomer molecules are linked by amide bonds.

**Polydentate ligand**  A ligand that forms more than one dative covalent bond to a central metal ion. EDTA is an example.

**Polymer**  A compound containing very large molecules composed of repeating units called monomers.
Polymerization  A chemical reaction in which small molecules called monomers are joined together covalently to form a polymer.

Polypeptide  A long linear chain of between 10 and 100 amino acids linked by a peptide bond.

Polysaccharides  Carbohydrates whose molecules contain chains of many monosaccharide molecules.

Porphyrin ring  This consists of four pyrrole rings linked by a single bridging carbon atom. It is present in heme and chlorophyll.

Precursor  A molecule which is an ingredient, reactant or intermediate in a synthetic pathway for a particular product.

Primary structure (of a protein)  The order or sequence of the amino acids in a polypeptide chain.

Propagation  An elementary reaction involving one free radical which causes the formation of another free radical.

Protein  A molecule composed of one or more polypeptide chains, each with a characteristic sequence of amino acids linked via peptide bonds.

Pyrrole  Pyrrole is a heterocyclic aromatic organic compound, with a five-membered ring of formula C₄H₄NH. Pyrroles are components of the porphyrins, heme and chlorophyll.

Quaternary structure  The overall three-dimensional structure of a protein composed of two or more polypeptide chains.

Racemic mixture  An equimolar mixture of two enantiomers of the same compound. The mixture is not optically active as the rotation of plane-polarized light of the two enantiomers are equal but opposite.

Rancidity  The production of flavours in lipids that our senses perceive as off, because they have a disagreeable smell, taste, texture or appearance.

Reducing agent (reductant)  A chemical or substance that donates electrons to the reactant or one of the reactants and so brings about reduction. The reducing agent itself is oxidized.

Resolution  The separation of a racemic mixture into its two enantiomers (optical isomers).

Restricted rotation  This occurs when bonded atoms cannot rotate relative to one another. It occurs when the atoms are either part of a ring structure or bonded by a double bond.

Saturated fat  A fatty acid containing only fully saturated hydrocarbon groups. There are no C = C bonds.

Shelf life  A food reaches its shelf life when it no longer maintains the expected quality desired by the consumer because of changes in flavour, smell, texture and appearance (colour, mass) or because of microbial spoilage.

Sigma (σ) bond  A bond formed by the end-to-end overlap of two atomic orbitals along the internuclear axis.
Stabilizers  Substances such as trisodium phosphate, \( \text{Na}_3\text{PO}_4 \), which are added to emulsions to prevent them from separating out into the separate phases.

Stereoisomerism  Isomers which arise from differences in the shapes of molecules. Geometric and optical isomers are examples.

Steroid  A lipid with a characteristic fused four-ring carbon structure. Examples include cholesterol and the sex hormones.

Sugar  A sweet, crystalline and water-soluble mono- or disaccharide.

Suspension  A dispersed mixture of a solid in a fluid.

Termination  An elementary step in a reaction involving the combination of two radicals to form a molecule.

Tertiary butyl group  A carbon atom bonded to three alkyl groups. It is a common structural unit found in the synthetic antioxidants BHA, BHT and TBHQ.

Trans-  Geometric isomers with the same group (e.g. H atoms) on opposite sides of either a double bond or a ring structure.

Triglycerides  These are triesters produced from glycerol by the esterification of three hydroxyl groups with fatty acids. They occur naturally in animal and vegetable tissues and are important energy sources.

Unsaturated  A term used to describe a molecule, such as an alkene or fat, containing one or more carbon–carbon double or triple bonds.

Unsaturated fatty acid  A fatty acid containing one or more carbon–carbon double bonds.

Vitamin  Various unrelated fat-soluble or water-soluble organic substances needed in small amounts for normal activity and growth of the body. They are obtained naturally from plant and animal foods.