Book 1, chapter 3: Nutrition

This chapter is a bit of a mixture of the science and healthcare aspects of the course.

The components of a balanced diet: carbohydrates, lipids (fats), proteins, vitamins, minerals and water.

The estimated average requirement varies by age and gender.

Body Mass Index (BMI) = weight (in kg) / (height in metres)^2

BMI of 25 and above is classed as obese

Carbohydrates come in polysaccharides (non-sweet) and monosaccharides and disaccharides (free/simple sugars both sweet).

The simple sugars (eg glucose, galactose and fructose) come in intrinsic (forming part of the structure of the food and usually called dietary fibre) and extrinsic (not forming part of the structure eg in fruit extracts and added sugars). Although lactose (in milk) may be extrinsic it doesn't have the same effects on humans as sucrose and therefore in terms of dietary recommendations the term non-milk extrinsic sugar is used.

Our main polysaccharides are starch (plants, mostly digestible), glycogen (from animals, digestible) and cellulose (plants, not digestible: this is the fibre/roughage). Starch comes in rapidly digestible, slowly digestible and resistant varieties (of which the last is digested by bacteria in the large intestine).

Lipids (fats) are insoluble in water and come in two varieties: fats (solid) and oils (liquid). They used in a number of contexts within the body: a concentrated store of energy (as triacylglycerols in adipose tissue), to prolong emptying time of the stomach, to transport and store fat-soluble vitamins, as a source of precursors for cellular structures, in mylination of neurons. Fatty acids with double bonds are unsaturated, those without double bonds are saturated. Those with one double bond are monounsaturated fatty acids and those with many double bonds are known as polyunsaturated fatty acids. The presence of the double bonds makes the fats less dense thus less energy density. Humans can't manufacture fats with double bonds thus must obtain them from the diet.

[BIT MORE HERE: p118 Linoleic, cholesterol lipoproteins (especially LDL, HDL)]

Proteins are used in the growth, repair and maintenance of tissues eg as enzymes, antibodies, collagen in bone, etc. They are built from amino acids. [MORE REQUIRED?]

Minerals are required in very small but essential quantities in the diet. The perform the following functions: as structural components (eg calcium, phosphorus and magnesium compounds in bones and teeth), as ions in cells and extracellular fluids, for communication between cells, as essential components of many important molecules (eg iodine for the thyroid).

Vitamins are generally not manufactured in the body although the bacteria in the large intestine does produce a number of them. Fat soluble ones (A,D, E, K) can be stored in the body as can the water soluble B and C but other water soluble vitamins are eliminated in the urine.

Vitamin A is stored in the liver and adult stores are usually sufficient for 2 years. It's essential in the light-sensitive pigment in the retina and acts as an anti-oxidant. Excess quantities of it can cause abnormal development and there's so much in the liver of polar bears that it's lethal.

Vitamin B helps enzyme activity. B1 (Thiamin) is important in carbohydrate, alcohol and some amino acid metabolism; around 30 days supply are stored. B2 (Riboflavin) aids carbohydrate and protein metabolism, mainly in the eyes and skin. Niacin is similar but can be manufactured; it inhibits cholesterol production and helps the breakdown of fats. B6 (pyridoxine) is associated with fat, glycogen and amino acid metabolism, and the synthesis of non-essential amino acids. B12 (cobalamin) exists as a number of cobalamin compounds which need to be bound to intrinsic factor to be absorbed. The only source is animal products and it's essential for mylination.

Folate (folic acid) is required for DNA synthesis.

Pantothenic acid and biotin is important in the synthesis of lipids and glucose and the catabolism of some amino acids.

Vitamin C is associated with the formation of a protein called collagen.

Vitamin D is mainly supplied by sunlight and is essential for absorption of calcium and thus bone formation.

Vitamin E acts as an antioxidant.

Vitamin K is synthesized in the large intestine by bacteria in the normal intestinal flora and is absorbed directly. It's required for the synthesis of various blood clotting factors.

Water is obtained directly, via various foods and as a side-effect of metabolic processes.

Book 1, chapter 4: Digestion and absorption of nutrients

This chapter follows food from one end to the other in some detail.

Mouth

Upper and lower jaw with 28 to 32 teeth in adults. The visible tooth is called the *crown*, the part within the gum is called the *root*. The crown is covered in enamel which is resistant to corrosion by acids and enzymes and consists of a protein similar to keratin in which crystals of calcium salts and other minerals are embedded. Inside the crown is the dentine which is similar to bone within which is the *pulp* which is supplied with blood vessels, nerves and lymph vessels. All this is held in place by ligaments and a substance called *cement*. While the teeth are chewing the food, the salivary glands are starting the digestion of the carbohydrate using the enzyme *salivary amylase* producing maltose, short polysaccharide chains and mucus (a glycoprotein) that acts as a lubricant. Saliva also contains *lysozyme* (antibacterial) and antibodies and is also slightly acidic thus playing a part not only in digestion but in attacking the bacteria in the mouth. The resulting mixture is called *bolus*.

Oesophagus

This is the long pipe leading from the mouth into the stomach. Food is moved down it by *peristalis* ie a wave of contractions by the smooth muscle in the gut wall. A weak sphincter stops the stomach contents washing up again.

Stomach

The mucosal epithelium contains lots of glands formed by invagination. The products of these include:

Hydrochloric acid and *intrinsic factor* (required to produce B12 in the small intestine) both produced by the parietal cells

Pepsinogen produced by the *chief cells* is converted to the enzyme pepsin by the HCl from the parietal cells.

Mucus from the *goblet cells* acts as a lubricant and helps protect the stomach lining from the HCl.

Food arriving in the stomach is still quite bulky and it is contractions by the smooth muscle of the stomach wall that helps mix this with the HCl and dissolve the lumps to produce a soup like mixture called *chyme*.

Small intestine

This is basically a long tube with a massive surface area (around 300 square metres) thanks to the finger-like projections called *villi* and the *brush border* on these. Food is passed to this in bursts via the *pyloric sphincter*. The role of the small intestine is to complete the enzymatic digestion of macromolecules and absorb the smaller molecular products. The sections are the *duodenum*, the *jejunum* and the *ileum*.

Proteins are broken down into peptide fragments by the pancreatic enzymes *trypsin* and *chromotrypsin*. These are further broken down to free amino acids by *carboxypeptidase* (from the pancreas) and *aminopeptidase* (in the brush border). These free amino acids are charged hydrophilic molecules

which cross the epithelial cell membrane by active transport (ie using ATP for power).

Carbohydrates are broken up by the pancreatic enzyme *amalyse*. *Lactase* breaks up lactose, the only sugar in milk. The resulting monosaccharides are passed across the cell membranes by diffusion.

Lipids and fatty acids must first be emulsified by the bile salts [MORE NEEDED HERE: p168]

Minerals and vitamins are absorbed generally by active transport but some minerals require specific vitamins to aid this. For example, vitamin D for calcium absorption, intrinsic factor for B12 absorption.

Water is absorbed by osmosis.

Pancreas

This is a dual-function organ which produces both digestive enzymes and controls the level of blood sugar. The digestive enzymes are exocrine secretions (ie fluids secreted from the surface of epithelial tissue like sweat) consisting of *bicarbonate ions* (to neutralise the acidic chyme) and include the following digestive enzymes or rather the precursors to these as the active enzymes are formed in the gut lumen:

pancreatic amylase which breaks down polysaccharides

lipase which breaks down lipids

nucleases which break down nucleic acids

Separately from these there are the *islets of Langerhans* which produce the hormones *insulin* (from the Beta cells) and *glucagon* (from the Alpha cells) that are released in response to high and low blood glucose levels respectively.

Liver

This is the largest organ in the body and has a host of functions.

For digestion, it produces the exocrine secretion *bile*. This consists of biocarbonate ions (to neutralise the chyme), phospholipids, cholesterol and cholesterol derived molecules known as *bile salts* plus waste products from the liver. The bile salts aid digestion by emulsifying the fats. Between meals, this lot is stored in the *gall bladder*.

In response to the pancreatic insulin excretions the liver converts glucose to glycogen. High levels of glucagon cause it to do the reverse.

It acts as a store for the fat soluble vitamins A, D, E, K as well as iron and copper along with some water soluble vitamins.

It converts nitrogenous waste to urea which leaves as urine.

It's involved in the synthesis of blood plasma.

And a whole host of other things. Hence, it produces a lot of heat.

Large intestine

Most of the digestion takes place in the small intestine and the large intestine is mainly concerned with absorbing water and salts and the production of a number of vitamins by the bacteria that it contains. These vitamins include B12 (also in food), K (for blood clotting and usually not in sufficient quantities in food), B1 and B2.

Bacteria here break down fibre (non-digestible carbohydrates), hence the wind from beans.

As with the small intestine, peristalis moves the bolus along but much more slowly.

Disorders of the gut

Diarrhoea results from disturbances to the processes of absorption and secretion and causes losses of water and mineral salts.

Coeliac disease is an inflammation of the upper small intestine by ingestion of gluten by those allergic to it.

Inflammatory bowel disease: *Crohn's disease* and *ulcerative colitis*.

Colon cancer

Book 2, chapter 1: The nervous system

Imaging the nervous system Computerised Tomography (CT) produces the cross-sectional images using x-rays. Positron Emission Tomography (PET) provides information on brain activity via radioactively tagged material. Magnetic Resonance Imaging (MRI) gives more detail by using a magnetic field; not suitable for those with pacemakers. Functional MRI (fMRI) detects blood flows and provides a detailed anatomical image.

The nervous system is divided into the Central Nervous System (CNS) [the brain and spinal cord] and the Peripheral Nervous System (PNS) [everything else obviously]. Neurons sending information to the CNS are called sensory/afferent; those carrying information outwards are called motor/efferent. Nerves are bundles of axons and usually has of both types of axon. In addition there are interneurons deep in the brain or spinal cord.

CNS environment: meninges and cerebrospinal fluid. The brain is covered by three protective sheets (the meninges: dura, arachnoid and pia mater) that extend down the spinal cord. Bacterial or viral infection of this region is called meningitis. Within the brain are regions called ventricles filled with cerebrospinal fluid (CSF). Hydrocephalus is the condition where excessive amounts of CSF replace space that would normally be replaced by the brain; up to 90% of the volume can be CSF before noticeable mental disabilities are detected.

The brain is divided into two hemispheres although there is considerable interconnections between them. The primary interconnection is a bundle of myelinated axons called the corpus callosum. The outer layer (the cerebral

cortex) is heavily wrinkled. It is divided into four lobes (p14): frontal, temporal, parietal and occipital. Phineas Gage's accident damaging his frontal lobes showed how important they were in executive function.

Deeper structures include the amygdala, hippocampus, hypothalamus which are part of the lymbic system. The basal ganglia are concerned with learning motor skills and in the control of movement. Disorders in the basal ganglia manifest themselves as problems in movement eg excessive involuntary movement (Huntington's disease) or inadequacy of voluntary movements (Parkinson's disease).

The thalamus sorts and interprets sensory information received from the peripheral nervous system and relays these to the appropriate region of the cerebral cortex. It also links the cerebral cortex with other parts of the brain; for example, it has links with the basal ganglia and thus it too has a role in the control of movement. The hypothalamus controls activities such as heart rate, respiration and fat metabolism along with homeostatic functions such as regulating body temperature, appetite and water balance. It acts as a bridge between the nervous and endocrine systems.

The brainstem (midbrain, pons and medulla) deals with the essential activities of life eg regulating breathing and blood circulation, vomiting and swallowing (medula), sleep (pons).

The cerebellum is involved with the control of movement, specifically posture, balance and locomotion. It's involvement is essentially in the maintenance of movement (ie the autopilot) rather than initiation of movement. Damage to this area results in ataxia that has the effect of requiring conscious control of all movement with over/undershooting the target and jerky movements are the result.

The cranial nerves deal with such things as the sense of smell, control of eye muscles, sensory input from the tongue, etc.

The left brain usually controls the right side of the body (but remember plasticity). Brain functions are usually localised in one hemisphere (eg language on the left but not for all individuals). In some cases of epilepsy cutting the corpus callosum can cure the symtoms. **Laughter?**

Organisation of the nerves: The spinal cord is divided into white and grey matter. The peripheral nervous system (PNS) is divided into the somatic (voluntary) and autonomic (involuntary) branches. The ANS is subdivided into enteric, sympathetic (down the spinal cord and then out to the organ) and parasympathetic (direct to the organ) nervous systems. For example, sympathetic activity increases heart rate (releasing noradrenalin) whilst parasympathetic decreases it (releasing acetylcholine). [MORE DETAIL: P28]

Cells of the nervous system: p30-37. Lot of detail re how the chemical interactions make the system work. Dendrites are extensions from the cell.

Overview of sensory and motor systems. The corticospinal pathway is the path of myelinated neurons (mostly large) that start in the motor cortex and run to a specific location in the spinal cord; mainly involved in fine

movements. The non-corticospinal pathway starts in the brainstem and terminates at interneurons associated with the motor neurons in the spinal cord; it's mainly responsible for the control of whole limbs, rather than, say, the fingers.

When things go wrong... Epilepsy: the drugs used act to prevent the neurons from firing continuously. Traumatic head injury; loss of consciousness for more than six hours is pretty serious to put it mildly!

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