Lecture 6. Nutrition and control of food intake.
Part 1. Control of hunger, satiety and appetite
First - some definitions.
Hunger is the craving for food - any food.
Appetite is the desire for a specific food.
Satiety is the opposite of hunger - i.e. that feeling that you couldn't eat another thing no matter what.
The overhead of the neuroanatomy of the centres in the brain thought to control these different
feelings/behaviours can be found in "Principles of Neural Science" by Kandell, Schwartz & Jessell,
Fig 47-3C.

The Feeding Centre
The evidence that the lateral nucleus of the hypothalamus controls feeding is as follows:
In experimental animals, electrical stimulation of this area of the brain by implanted electrodes causes uncontrolled eating (hyperphagia). Animals will continue to eat and won't stop. Destruction of this centre by surgery or injection of a chemical neurotoxin will result in aphagia or no eating at all despite starvation.
This area of the brain is sensitive to low plasma glucose and amino acid concentrations either of which will stimulate the neurons and cause feeding behaviour. Input from olfactory visual and gustatory neurons will also affect neuronal activity in this region. Feeding can also be modulated by higher centres such as those areas of the brain involved in emotions (how many of you eat during the build-up to exams?)

The satiety centre
Similar evidence exists as that described above for the ventromedial nucleus of the hypothalamus being the satiety centre. Stimulation of this area will cause refusal to eat, and destruction results in uncontrolled eating and subsequent obesity. The ventromedial nucleus also responds to circulating levels of glucose and amino acids, but in the opposite way to the lateral nucleus. The nucleus is also stimulated by inputs from the stomach signalling distension (i.e. "I'm full") and by circulating hormones. The most important of these are CCK released by fats in the gut, and insulin released from the pancreas. Both these hormones will stimulate the ventromedial nucleus to inhibit feeding.
Some drugs take advantage of this system - amphetamines which were originally developed as appetite suppressants hijack the neurotransmitter systems in the VMN, stimulate the neurons and suppress feeding.

Regulation of food intake
The lateral nucleus and ventromedial nucleus are regulated by similar parameters, and the regulation of these two centres is integrated so that food intake is balanced to meet requirements. The VMN has inputs to the lateral nucleus so that if the VMN is activated, the LN is inhibited.
In animals food intake is regulated by dietary need, although some domesticated animals have such easy access to food that they may become obese through overeating. Appetite for food is also

generally controlled by need in animals - salt deficiency will stimulate animals to find a "salt lick" where they can replenish NaCl levels. This is controlled by an area of the brain called the amygdala in the limbic system, which if lesioned (damaged) results in lack of food choice i.e. appetite. The major control of appetite in humans in developed countries, however, is probably taste preference and cultural pressures rather than dietary requirement. The amygdala may play a role in the emotional modulation of food intake in humans.
Problems with food intake, either too much or too little cause major problems with health and impact dramatically upon health care professionals.
Britain is predicted to have over 50% of the population being clinically obese within the next 10 years.

Obesity is a contributing factor in many diseases but particularly cardiovascular disease which accounts for over 50% of deaths in the developed world. Obesity can be caused by many factors, in addition to poor diet, and can result in patients suffering from hyperinsulinaemia and insulin resistance, hypercortisolaemia, hypertension and increased risk of thrombosis.
Eating disorders should not be ignored as they are real disorders that can result in dramatic health problems.

Anorexia nervosa has many consequences which can lead to increased morbidity and mortality, such as osteoporosis, hypotension with consequent risk of cerebrovascular accident, anaemia and cardiac arrythmias.

Part 2 Nutrition
From an examination of the control of feeding we can see that we obviously need to take in food. We know from early observations (and those we see in the present day of starving populations) that we require certain constituents to our diet in order to stay healthy.
Normal adult calorific intake in the developed countries is 3000-6000kcal per day, depending on occupation. We need to take in proteins, fats, vitamins and minerals. Carbohydrates are mostly not essential to our diets, but are the preferred source of energy for the body. Non-starch polysaccharide intake (fibre) is fairly important in gut health. We generally have about 50% of our intake as carbohydrate, which is far too high, and 15% as fat, (also too high), and we don't eat anywhere near enough fibre.

Proteins
We need protein as we turnover cells in our bodies all the time and we need to replace them. We also lose a lot of protein by loss of gut cells and breakdown of dietary protein into urea. Of whole body protein, 50% of it is made up of only four proteins, collagen (25%), myosin, (12%), actin (8%) and haemoglobin (5%).

Its fairly obvious that the areas of the body in which the protein is turned over fastest will be those that are most affected if protein is deficient. These are the liver (very metabolically active), the gut (loses epithelium every day) and the white blood cells. These three areas account for about 70% of total protein turnover per day, with muscle accounting for about 25%. In starvation therefore people

suffer liver failure, gut absorption problems due to loss of enterocytes (which of course exacerbates the malnutrition), immunological deficiencies and associated infections, and muscle wasting.
There are essential amino acids which we must have in our diets, as we cannot manufacture them from other dietary components. These are:
Isoleucine, leucine, lysine, methionine, phenylalanine, threonine & valine. Meat has all these amino-acids, but vegetarians may become deficient in some as milk & peas lack Met and grains lack Lys.

Fats
Essential fatty acids, particularly linolenic acid and linoleic acid cannot be manufactured in the body and must be derived from the diet. Lack of these fatty acids results in disruption of the skin and gut barriers due to lack of waterproofing layers and lubricants. Of particular importance is the need for fat in infants, for adequate CNS myelination. Low fat intake in the under fives can result in poor CNS myelination and subsequent problems with CNS function. The derivatives of these fatty acids are also extremely important in immune function and inflammation.

Carbohydrates
Although we can manage perfectly well without carbohydrate in our diet, this food is the body's preferred source of energy. The only necessary carbohydrates in the diet are non-starch polysaccharides (fibre) which should constitute the majority of carbohydrate in the diet. In reality this is not the case, we all eat too much refined carbohydrate and not enough fibre (in the developed world).

Vitamins
There are two classes of vitamins - water, and fat soluble. This distinction is important as deficiencies in the fat soluble vitamins do not manifest as quickly as those of the water soluble vitamins as body fat acts as a reservoir for a certain period of time. You should be aware of the principal vitamin deficiencies, in particular those which are of importance to dentistry.

Minerals and trace elements
Deficiency of some minerals (iron, calcium) can be relatively common, especially in certain groups. Trace element deficiencies are rare as provided diet is OK intake is usually sufficient.

The controversies regarding the inclusion of fluoride in drinking water as a public health measure will be dealt with later in the course, but you should be aware of the effect of addition of 1ppm fluoride on caries incidence.