Energy Metabolism, Control of Food Intake and Food Safety

Naturopathic Nutrition 1
Learning Outcomes

On successful completion you will be able to:

• Explain the concept of energy expenditure and the factors which impact on this.

• Explain the factors affecting energy intake, energy expenditure and the bodily mechanisms which control food intake.

• Discuss sources of food toxins, possible food safety concerns including adverse reactions to food and discuss the ‘farm to fork’ regulations.

• Outline the correct procedures for food storage and the effects of a variety of cooking techniques on nutrient content.
Introduction:

- Long-term constancy of body weight is achieved through a highly complex network of regulatory systems.

[Diagram of energy metabolism with nodes for energy storage, long-term body weight regulation, and energy expenditure connected to energy intake.]
Failure of this regulation leads to:
- Obesity (and its complications).
- Protein-energy malnutrition and cachexia (wasting) in disease states like anorexia, cancer, infections.
Energy Balance:

- The average human consumes approximately one million calories per year.

- Despite this huge intake and short-term fluctuations, we keep a balance between how much energy is expended and consumed = Energy balance.

- The control of this mechanism is very precise - e.g. If energy intake chronically exceeds energy expenditure by only 25kcal/day, the person will become morbidly obese!

(Goran and Astrup 2002)
Energy Metabolism

Basic Concepts of Energy:

• Energy represents the capacity of a system to perform work.

• Different forms of energy - chemical, mechanical, electrical - all of which can be converted to heat.

• **First Law of Thermodynamics:** Energy cannot be created or destroyed, but it can be only transformed from one form into another.

• **Plants** depend on energy **captured from the sun** to synthesise proteins, carbohydrates, fats.

• **Animals** meet their energy needs **from chemical energy stored in plants** (and other animals).

(Dulloo and Schutz 2005)
Basic Concepts of Energy:

- The chemical energy obtained from foods is used to perform:
  - Chemical work (synthesis of new macromolecules).
  - Mechanical work (muscular contraction).
  - Electrical work (maintenance of ionic gradients across membranes).

(Dulloo and Schutz 2005)
Basic Concepts of Energy:

• Energy balance = Energy intake + Energy stores - Energy expenditure

• If the intake and expenditure are not equal:
  
  – **Negative energy balance** (then utilisation of body’s energy stores: glycogen, fat, protein).

  – **Positive energy balance** (then increase in body energy stores, primarily as fat).

(Dulloo and Schutz 2005)
Basic Concepts of Energy:

- **Second Law of Thermodynamics:** When food is utilised in the body (for chemical, mechanical or electrical work), this is always accompanied by the *loss of some energy in the form of heat*.

- This heat energy that is no longer available for work is called ‘entropy’.

- Up to 75% of the chemical energy in food is lost as heat!

(Dulloo and Schutz 2005)
Energy Metabolism

Units of Energy:

- Since all the energy used by the body will be eventually degraded as heat, the energy units are expressed as heat equivalent.

- **Calorie:** The amount of heat required to raise the temperature of 1g of water by 1°C this is the small calorie, written with a small ‘c’ and is more common in scientific literature etc.

- Nutritionally, **kilocalories** are used - 1kcal=1000cal, which can also be referred to as Calories, sometimes written with a large ‘C’. In a nutritional context the terms calorie and kilocalorie are used interchangeably.

- **Joule:** Is the energy used when a mass of 1kg is moved through 1 metre by a force of 1 Newton.

- Nutritionally **kilojoules** are used - 1kJ=1000J

(Dulloo and Schutz 2005)

1kcal=4.18kJ
Energy Metabolism

Energy Intake - Calculating Energy from Food:

- Human sources of energy - Macronutrients
  
  - 1g carbohydrate – 4.01kcal / 16.8kJ
  
  - 1g fat – 9.04kcal / 37.8kJ
  
  - 1g protein –4.01kcal / 16.8kJ
  
  - 1g alcohol- 7.03kcal / 29.4kJ

(Dulloo and Schutz 2005)
Energy Storage:

- Energy consumed in the form of food and drinks can be stored as:
  - Fat (major energy storage).
  - Glycogen (short-term energy/carbohydrate reserve).
  - Protein (rarely used by the body for energy except in severe cases of starvation and other wasting conditions).

(Goran and Astrup 2002)
Energy Metabolism

Energy Metabolism

Elements of Energy Expenditure:

Total daily energy expenditure or Metabolic rate depends on three factors: Basal Metabolic Rate (BMR), Physical activity, and Thermic effect of food.

- Basal Metabolic Rate (BMR) 60-75%
- Physical Activity 20%
- Thermic Effect of Food 10%

Goran and Astrup 2002
Energy Metabolism

Energy Expenditure - Basal Metabolic Rate:

• The body requires energy for a variety of functions.

• The largest use of energy is needed to fuel the basal metabolic rate (BMR):
  − The energy to maintain basic physiological functions (e.g. Heartbeat, respiration, etc.)
  − Minimum level of energy expended by the body to sustain life in the awake state.
  − Can be measured after a 12h fast while the subject is resting physically and mentally, and maintained in a thermoneutral, quiet environment.

(Goran and Astrup 2002)
Energy Metabolism

Energy Expenditure - Resting Metabolic Rate:

• There are difficulties to obtain BMR under most measurement conditions.

• This is why Resting Metabolic Rate (RMR) is usually used:
  – The same measurement conditions, although in this case less strictly controlled.
  – Difference: 3% higher energy expenditure in RMR than in BMR.
  – RMR is ca. 1kcal or 4.2kj / min.
  – RMR or BMR = 2/3 of the total energy expenditure.

(Goran and Astrup 2002)
Energy Metabolism

Energy Expenditure - Resting Metabolic Rate:

• RMR is variable among individuals (± 25%); but very consistent within individuals (<5%).

• RMR occurs mainly in the muscle and organ mass (or Fat Free Mass - FFM), so FFM determines up to 60-80% of RMR in individuals.

• FFM is heterogeneous:
  – Brain constitutes only 2% of FFM, and contributes 24% of the RMR.
  – Skeletal muscles - 43% of FFM, and contributes 22-36% of RMR.

(Goran and Astrup 2002)
Energy Metabolism

Energy Expenditure - Resting Metabolic Rate:

• FFM decreases with age, and so does RMR:
  - 79kcal or 331.8kJ/kg in 2.5 year old.
  - 36kcal or 151.2kJ/kg in 4-7 year old.
  - 21kcal or 88.2kJ/kg during adolescence.

• Fat tissue contributes ca. 10kcal or 42kJ/kg to RMR.

• Men have higher RMR by 50kcal or 210kJ/day (at all ages).

• Physically active people have higher RMR.

(Goran and Astrup 2002)
Energy Metabolism

Energy Expenditure - Resting Metabolic Rate:

• **Age, gender, physical activity** determine 80 - 90% of the variance in RMR.

• **The rest 10 - 20%**: Genetic factors; thyroid hormones, sympathetic nervous system activity.

(Goran and Astrup 2002)
Energy Expenditure - Thermic Effect of Foods:

• In addition to RMR there is an increase in energy expenditure in response to food intake:
  − Thermic effect of a meal or,
  − Diet-induced thermogenesis (DIT) (up to 5h after the meal ingestion).

• It is influenced by the quantity and macronutrient quality of the meal.

• DIT is usually 10% of the energy content of the meal.

• So after eating a banana (100kcal), 10kcal will be burnt off as heat!

(Goran and Astrup 2002)
Did you know? Carbohydrate Myths:

• DIT is highest for protein and carbohydrates and lowest for fats!

• This means that fat is the most easily stored macronutrient as body fat.
  – Conversion cost - 3% of calories.

• This process is performed so easily that the chemical structure of the dietary fat remains largely unchanged as it is stored.

(Goran and Astrup 2002; Astrup 2005; Stubbs et al 1997)
Energy Metabolism

Did you know? Carbohydrate Myths:

- Protein and sugars **require additional energy** for metabolic conversions into storage forms:
  - Glycogen and fat for glucose.
  - Fat for amino acids.

- Indirectly carbohydrates trigger even more DIT:
  - Carbohydrate-induced insulin secretion causes **increase in sympathetic activity and additional increase in energy expenditure**.
  - Falling blood glucose triggers the release of adrenaline with additional increase in sympathetic activity and more energy expenditure.

(Goran and Astrup 2002; Astrup 2005)
• The key is that **taking in excess calories** means that **body stores of fat will not be used as fuel in the presence of excessive carbohydrates**.

• Carbohydrates are not converted into body fat under normal circumstances in humans, as this process, de novo lipogenesis (DNL) is energetically not efficient (conversion cost - 30% of calories).

• Carbohydrates are not ‘easily’ turned into fat stores – but excess dietary fat is, and the body will use carbohydrates for fuel preferentially.


• Exception: Fructose **sugars in drinks** (soft drinks, sugary fruit juices) are easily turned into fat tissue and **feeding people very high amounts of sugar under experimental conditions has resulted in high levels of DNL**.

(Goran and Astrup 2002; Astrup 2005; Acheson et al 1984)
Did You Know? The Rationale Behind High Protein Diets:

- Why are carbohydrates blamed by the proponents of the high-protein diets?
- Carbohydrates in their refined forms do raise insulin levels (which promote fat storage).
- When refined carbohydrates are combined with fat e.g. Western diet, they promote obesity primarily by helping the dietary fat be stored as body fat.
- Contrary to popular opinion and numerous fad diet claims, excess carbohydrates are not usually turned to fat but oxidised as body heat.
- Suggested Reading: Comparison of Weight-Loss Diets with Different Compositions of Fat, Protein, and Carbohydrates. (Sacks et al. 2009)
  - [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2763382/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2763382/)

(Goran and Astrup 2002; Astrup 2005; Acheson et al 1984)
Energy Metabolism

Energy Expenditure - Physical Activity:

- The third source of energy expenditure in the body is the increase in metabolic rate caused by using skeletal muscles for any type of physical activity.

- It is the most variable part of energy expenditure - varies greatly among individuals.

- Through this component of energy expenditure - large changes in energy expenditure can be achieved.

(Goran and Astrup 2002)
<table>
<thead>
<tr>
<th>Activity</th>
<th>Calories Burnt</th>
<th>Activity</th>
<th>Calories Burnt</th>
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<tbody>
<tr>
<td>Aerobics: low impact</td>
<td>240</td>
<td>Aerobics: high impact</td>
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</tr>
<tr>
<td>Swimming: leisure</td>
<td>288</td>
<td>Dancing: slow, waltz, foxtrot, tango, foxtrot</td>
<td>144</td>
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<tr>
<td>Aerobics: water</td>
<td>192</td>
<td>Bicycling, stationary: moderate, 150 watts</td>
<td>336</td>
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<tr>
<td>Rowing, stationary: moderate</td>
<td>336</td>
<td>Golf: walking and pulling clubs</td>
<td>206</td>
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<tr>
<td>Soccer: leisure</td>
<td>336</td>
<td>Stair step machine: general</td>
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<tr>
<td>Running: 5mph (12 min/mile)</td>
<td>384</td>
<td>Weight lifting: vigorous</td>
<td>288</td>
</tr>
</tbody>
</table>
Energy Metabolism

Energy Expenditure – Other:

• **The energy cost of growth**: significant only in the first months of life.

• **Adaptive thermogenesis**: heat production during exposure to reduced temperatures (mostly in infants).

• **Drug-induced thermogenesis**:
  – **Nicotine**: Heavy smokers may have 10% higher energy expenditure than non-smokers of similar body size.
  – **Caffeine (coffee, tea, chocolate) capsaicin (hot chillies)**: Minor thermogenic effects.

• **Psychological thermogenesis**: anxiety, anticipation and stress stimulate adrenaline production leading to increased heat production.

(Goran and Astrup 2002; Dulloo and Schutz 2005)
Energy Requirements:

- Energy requirements of the body to maintain energy balance must be equal to total energy expenditure.

- Main factors accounting for energy expenditure:
  - Body weight
  - RMR
  - Free Fat Mass (FFM)
  - The energy expenditure is similar between lean and obese individuals after taking into account FFM differences - thus fatness has negligible effect on total energy expenditure.
Energy Requirements:

The lack of effect of increased body fat on total energy expenditure is due to opposing effects of:

- Additional energy cost of weight-bearing activities in overweight subjects and slightly greater RMR due to additional fat mass.
- The decreased likelihood of physical activity that is associated with carrying additional fat mass.

Read more:

(Goran and Astrup 2002)
Energy Metabolism

Energy Requirements:

• There is a decline in total energy expenditure in the elderly.

• Males have significantly higher total energy expenditure (independent of gender-related differences in RMR).

• Sedentary individuals and those with non-physical occupations have lower total energy expenditures than physical workers.

• The average level of physical activity performed by physical workers is still not sufficient to protect them from obesity
  - Additional exercise is required!

(Goran and Astrup 2002)
Estimated Energy Requirements - Adults in Kcal/Day

<table>
<thead>
<tr>
<th>Age</th>
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<th>Females</th>
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<tbody>
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<td>1940</td>
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<tr>
<td>51-59 years</td>
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<td>65-74 years</td>
<td>2330</td>
<td>1900</td>
</tr>
<tr>
<td>75 +</td>
<td>2100</td>
<td>1810</td>
</tr>
</tbody>
</table>

(Low to moderate physical activity level)

(Geissler and Powers 2005)
Did you know?

• There are different ways of expressing percentages of macronutrients in the diet:
  − As a % of energy intake - % of energy intake is clinically relevant, and most commonly found in nutrition textbooks and scientific studies.
  − As a % of macronutrient weight intake – which is now rarely used.
  − For our calculations remember there are approximately:
    • 9kcal/g fat
    • 4kcal/g of protein or carbohydrate
    • 7kcal/g alcohol

(Rolfes et al 2006; Mahan and Escott Stump 2008; Geissler and Powers 2005)
Example: 13 year old boy:

- Energy needs: 2220kcal/day
- Protein: 42g/day = 168kcal/day (42 x 4)
- Fat (approx. 33% of calories): 33% of 2220 = 733kcal = 81.5g/day (733 ÷ 9)
- Carbohydrate needs (must therefore be the deficit in energy consumed so 2220kcal - 901kcal = 1319kcal): 1319kcal ÷ 4 = 330g
- This totals 453g and 2220kcal per day.
Expressing Percentages of Macronutrients

As a % of energy intake:
• At 453g and 2220kcal per day
  – Protein: 42g/day
    \[(\frac{168}{2220}) \times 100 = 7.5\%\]
  – Fat: 81.5g/day
    \[(\frac{733}{2220}) \times 100 = 33\%\]
  – Carbohydrate: 330g/day
    \[(\frac{1319}{2220}) \times 100 = 59.5\%\]

As a % of macronutrient weight intake
• At 453g and 2220kcal per day
  – Protein: \((\frac{42g}{453g}) \times 100 = 9.2\%\)
  – Fat: \((\frac{81.5g}{453g}) \times 100 = 18\%\)
  – Carbohydrate: \((\frac{330g}{453g}) \times 100 = 72.8\%\)

• Much more clinically relevant
Energy Requirements - Disease and Trauma:

- Three factors to take into account:
  - Energy expenditure can be altered by disease or injury.
  - Physical activity in disease is impaired/reduced.
  - Underfeeding or overfeeding critically ill patients can result in metabolic complications.

(Goran and Astrup 2002; Geissler and Powers 2005)
Energy Metabolism

Energy Requirements - Disease and Trauma:

- Examples of altered metabolic rates:
  - Burn patients require 2 - 2.5 times their estimated RMR.
  - Anorexia nervosa patients - the same energy.
  - Cancer patients’ energy requirements may reach 145% of basal energy expenditure.

(Goran and Astrup 2002; Geissler and Powers 2005; Rolfes et al 2006)
Energy Metabolism

Energy Requirements - Physically Active Groups

• Regular participation in exercise elevates energy requirements:
  − Through the additional cost of the activity.
  − Through an increase in RMR.

• During exercise the energy expenditure increases mainly because skeletal muscle requires energy to contract.

• Regular physical activity increases muscle mass and thus RMR.

(Goran and Astrup 2002)
Energy Metabolism

- The average daily energy intake of UK adults is 9720kJ (2313 kcal) for men and 6870kJ (1632 kcal) for women. Irish values not available.

- These figures are below the EARs and have been falling steadily over time.

- Sedentary lifestyle and obesity levels are still on the increase. Assuming the intake estimates are correct, energy expenditure levels have fallen to a greater extent than our reduction in dietary energy intake.

- When energy intake falls there is a likelihood that micronutrient needs will no longer be met through diet.

Control of Food Intake

Control of Food Intake – Introduction:

• Human energy intake and body weight are thought to be regulated by homeostatic mechanisms and fluctuate only within narrow limits – this should occur without knowledge of EARs etc.

• A challenge to this theory is the current epidemic of obesity.

• Sheer availability of food may override any regulatory mechanisms we possess.

• Ready access to plentiful, palatable and affordable foods is a potential explanation for rising obesity rates.

(Drewnowski and Bellisle 2003)
Control of Food Intake – Introduction:

- Some researchers suggest that during millions of years of evolution, humans developed mechanisms that protect us from energy deficits.

- Due to the lack of periods of food abundance in human history, we have not developed mechanisms that protect us from excess food consumption!

(Drewnowski and Bellisle 2003)
Theories of Control - Glucostatic Theory:

- Developed by Jean Mayer in 1953.
- Food consumption is triggered by decreased glucose availability to the tissues.
- Increased hunger/decreased glucose levels; decreased hunger/increased glucose levels.
- The rate of tissue glucose utilisation is more important than blood glucose levels.

(Drewnowski and Bellisle 2003)
Theories of Control - Lipostatic Theory:

- Developed by GC Kennedy in 1953..

- Body fat is the key substance that regulates eating behaviour.

- After the meal, blood glucose levels gradually fall, and free fatty acid (FFA) levels in the blood are increased (from adipose tissue).

- Raised FFA can signal hypothalamus to stimulate hunger feelings.

- Numerous hormones secreted by the adipose tissue (e.g. leptin) can also play a role.

(Drewnowski and Bellisle 2003; Gawecki and Hryniewiecki 2008)
Theories of Control - Aminostatic Theory:

• Based on the premise that the brain can monitor amino acid levels in the blood.

• The fewer amino acids in the blood, the stronger the subjective hunger feelings.

• Amino acids are precursors of histamine or serotonin – neurotransmitters decreasing food intake.

• Not only the amount but also the right proportions of amino acids in foods are critical - synthetic powder proteins may not cause feelings of satiety.

(Drewnowski and Bellisle 2003; Gawecki and Hryniewiecki 2008)
Control of Food Intake

Theories of Control – Other:

• **The thermostatic theory** - heat generated during digestion leads to a rise in temperature which inhibits eating behaviours.

• **The hepatostatic theory** - metabolic activity of the liver during fasting states (as opposed to absorptive phases) regulates feeding behaviour.

(Drewnowski and Bellisle 2003)
Control of Food Intake

Theories of Control:

• There is evidence to support all of the theories.

• However those theories fail to explain why food intake varies among individuals with similar physical activity levels - no evidence for tight control!

• In Western societies nutrient composition of foods and beverages does not usually lead to adjustments of intake!

(Drewnowski and Bellisle 2003)
Energy Intake - Regulation of Food Intake:

- Quality and quantity of food intake is regulated by complex interactions among various hormones, neuroendocrine factors, central nervous system, organs, and environmental factors.

- **Appetite:** Psychological desire to eat, related to pleasant sensations that are often associated with specific foods.

- **Hunger:** Subjective feeling that determines when food consumption is initiated, signifying food deprivation to a degree that the next eating episode should take place.

- **Satiety:** State of inhibition over eating that leads to the termination of a meal.

(Goran and Astrup 2002)
Energy Intake - Regulation of Food Intake-Digestive Factors:

• Short-term internal factors regulating food intake:

  - The presence of food and drink in the stomach and intestine
  - Gastrointestinal distension (mechanoreceptors in the stomach)
  - Feeling of satiety

(Goran and Astrup 2002)
Energy Metabolism

Energy Intake - Regulation of Food Intake - Circulating Factors:

- Short-term internal factors regulating food intake:

- Carbohydrates
  - Glucose

- Fats
  - Fatty acids

- Proteins
  - Amino Acids

Liver signals the presence of these factors to the brain via vagus nerve.

Satiety

(Goran and Astrup 2002)
Energy Metabolism

Energy Intake - Regulation of Food Intake-Central Nervous System:

- Short-term internal factors regulating food intake:
  - Hypothalamus regulates feeding behaviour by responding to numerous neurotransmitters and sympathetic nervous system activity.
  - Food intake will decrease as sympathetic nervous system activity increases and vice versa.
  - So we are not likely to want to eat when we are running from a bear.

(Goran and Astrup 2002)
Energy Intake - Regulation of Food Intake-Digestive Factors:

- Short-term internal factors regulating food intake:

  In the presence of food and drink in the stomach
  
  Hormone cholecystokinin (CCK) is released by duodenum
  
  Feeling of satiety

(Goran and Astrup 2002)
Neuroscience of Food Intake

- **Serotonin**: Is thought to suppress appetite and carbohydrate cravings.
- **Dopamine**: Mediates food rewards, might be involved in food cravings.
- **Endorphins, endogenous opiate peptides**: Mediate pleasure response to sugar and fat (when treated with naloxone-endorphin blocker, chocoholics lose their addiction to chocolate!).
- **Neuropeptide Y (NPY)**: Potent stimulant of food intake.
- **Cholecystokinin (CCK)**: Hormone produced by the duodenum; **promotes satiety**, acts by delaying gastric emptying, thereby **increasing gastric distension**.
- **Insulin**: Potentiates the satiating effect of CCK; its action becomes less potent under conditions of a high-fat diet; it antagonizes NPY.

(Drewnowski and Bellisle 2003)
Neuroscience of Food Intake

• **Glucagon-like peptide1 (GLP-1):** Promotes satiety.

• **Bombesin:** A hormone found in the brain and gastrointestinal tract, shown to cause the secretion of various substances (such as gastrin and cholecystokinin) and to inhibit intestinal motility; acts in similar fashion to CCK, inhibits food intake.

• **Ghrelin:** A peptide related to the growth hormone; increases with food deprivation and may trigger a meal.

• **Leptin:** Originally though to promote satiety and stop feeding behaviour; however leptin levels are elevated in obese people – leptin is produced by fat cells. Leptin resistance may be the problem. One function of leptin is not to turn off the appetite, but together with neuropeptide Y-to turn it **on** when the food intake drops! Decrease in leptin is very efficient in stimulating appetite.

(Barnard 2001; Drewnowski and Bellisle 2003)
Energy Intake - Regulation of Food Intake:

**Appetite**: External learned response.

**Hunger and Satiety**: Controlled by internal bodily instincts.

- External factors influencing appetite and hunger:
  - Meal pattern, composition, smell, sight
  - Climate
  - Emotional factors (stress)
  - Disease states (anorexia, trauma, infections)

(Goran and Astrup 2002)
Energy Metabolism

- **External Factors Influencing Appetite:**
  - Specific learned likes and dislikes
  - Taste, palatability of foods
  - Cultural practices
  - Drugs, hormones

(Goran and Astrup 2002)
Control of Food Intake

Motivational States:

• Ideally people should begin to eat when they are hungry and stop when they are satiated.

• However people often eat when they are not hungry.

• Food choices and the amount of food are influenced by numerous environmental factors.

(Drewnowski and Bellisle 2003)
Control of Food Intake

Suggested Group Work:

• Suggest at least seven factors that can stimulate people to eat when they are not hungry.

• What are some positive ways we might divert this behaviour?
Control of Food Intake

Environmental Triggers of Eating Behaviour:

- Stress
- Insomnia
- Pleasure - Food texture and aroma
- Social eating
- Family traditions
- Religious traditions
- Job (business meetings, lunches, dinners)
- Loneliness
- Pushing down or avoiding ‘negative’ emotions
Control of Food Intake

Motivational States:

• **Sensory-specific satiety (flavour fatigue):** Foods that are similar in taste or appearance to those recently consumed are rated less pleasant than newly presented foods.

• So the perceived pleasantness of sweet taste is reduced following the ingestion of sweet glucose solutions.

• According to this theory, the availability of a wide variety of foods with different flavours and appearances, characteristic of the Western diet, can lead to overeating.

(Drewnowski and Bellisle 2003)
Control of Food Intake

The Role of Energy Density:

• One of the key factors controlling food intake is the energy density of the diet.

• Energy density = available energy per unit of weight

• Chocolate or potato chips - 5kcal/g

• Vegetables, fruit - 0.1-0.5kcal/g

(Drewnowski and Bellisle 2003)
Control of Food Intake

The Role of Energy Density:

**Highest Energy Density:**
- Meats
- Most dairy products
- Processed foods
- Oils

**Lowest Energy Density:**
- Vegetables
- Fruit
- Pulses
- Wholegrains

(Drewnowski and Bellisle 2003)
The Role of Energy Density:

- Energy-dense foods usually contain:
  - Lots of fat, sugar, starch
  - Little fibre, water

- Low energy-dense foods contain:
  - Lots of water, protein, fibre
  - Little fat, low sugar

(Drewnowski and Bellisle 2003)
The Role of Energy Density:

- People tend to consume a **constant weight or volume of food** as opposed to a **constant amount of energy**!

(Drewnowski and Bellisle 2003; Fuhrman 2003)
The Role of Energy Density:

- Energy-dense foods are:
  - Usually palatable and desirable (exception - lard).
  - **Not satiating**: In regards to mechanoreceptors, much more (calorie-wise) needs to be eaten to produce satiety.

- Foods with lower energy-density are:
  - **Very satiating**: High fibre and bulk in these foods stimulate mechanoreceptors without excessive calorie consumption.
  - Palatability depends on the foods (fruit is usually palatable to most people; spinach and kale are less so).

(Drewnowski and Bellisle 2003)
Control of Food Intake

The Role of Energy Density:

• Daily energy intakes would depend on food choices and on the energy density of the diet.

• Consumption of bulky, low energy-dense foods is thought to be an efficient way to lose weight.

• Switching from a high calorie density diet to a low energy density plant-based diet will cause you to consume 400 to 800 fewer calories a day without consciously restricting the amount of food that you eat.

(Drewnowski and Bellisle 2003; Lissner et al 1987)
Control of Food Intake

The Role of Energy Density:

Dr. Lissner performed an experiment where he hid fat in subjects’ food and then asked them to eat as much as they wanted. By cutting fat from 45% to 15% percent of the calories they unknowingly consumed 600 fewer calories.

(Lissner et al 1987)
Psychosocial factors:

- In **affluent societies** the primary influences on food choice are:
  - Taste
  - Convenience
  - Cost

- **Taste factors** predispose consumers to choose foods that are rich in:
  - Salt
  - Fat
  - Sugar

(Drewnowski and Bellisle 2003)
Psychosocial Factors:

- **Convenience factors** predispose consumers to choose packaged foods that are rich in:
  - Salt
  - Fat
  - Sugar

- **Cost factors** predispose consumers to choose foods that maximise dietary energy at lower cost and choose lower cost produce and products. These foods may be higher in:
  - Sugar
  - Fat
  - Poorer quality ingredients and pesticides

(Control of Food Intake (Drewnowski and Bellisle 2003))
Control of Food Intake

Psychosocial Factors:

- Nutritional concerns play a minor role in these choices.
- Psychosocial and environmental factors (including the impact of food industry advertising) have more impact on food choices today than our physiological needs!

(Drewnowski and Bellisle 2003)
Regulatory Issues: Main Goals in Food Policy

- Ensuring safe, wholesome and nutritious food supply for a population.

- Creation of a regulatory framework that ensures the quality and safety of the food supply.

- Outlining appropriate use of food-based approaches to promote health and prevent disease in a population.
Main Goals in Food Policy cont.:

• Ensuring the population has a food supply adequate enough to meet its needs.

• Address specific needs of vulnerable populations (elderly, pregnant and lactating mothers, children and those at risk of certain diseases).

• Enable countries to plan for crises, conflicts or natural disasters that affect availability of food for the population.
Regulatory Issues

Freedom From Hunger:
• Considered to be a basic human right.
• Adequate nutrition and quality/safety of food supply critical for basic human dignity.
• Also essential for productivity, health, and quality of life.

Disease:
• Food and waterborne diarrhoeal diseases are leading causes of illness and death in less developed countries, killing approximately 2.2 million people/annum, 1.9 million of whom are children.
Ensuring Safe and Nutritious Food Supply:

- F.A.O. (Food and Agricultural Organization of the United Nations) has close to 200 member nations which includes the EU. Their mandate is to ensure that people have regular access to high-enough quality food to lead active and healthy lives.

- F.A.O. is governed by a conference of Member Nations which meets every two years in order to approve the projects and budgets for the next biennium.
Ensuring Safe and Nutritious Food Supply:

- World Health Organization (WHO) has a branch called the Department of Food Safety, Zoonoses and Foodborne Diseases (FOS) which strives to reduce the serious negative impact of foodborne diseases worldwide.

- WHO works with the FAO to address food safety issues along the entire food chain - from production to consumption.
Ensuring Safe and Nutritious Food Supply:

- Codex Alimentarius is a set of agreed upon standards for food and agricultural products jointly sponsored by FAO and WHO.

- The EU Commission represents all EU countries at Codex meetings.

- In addition, the Foods Standards Agency (FSA) represents the UK.

- The Irish Department of Agriculture, Food and the Marine coordinate additional Irish representation at Codex.
Regulatory Issues

• Standards are voluntary and not necessarily adopted by all members.

• However Codex is recognised by World Trade Organization (WTO) agreements in the event of a dispute.

• International Food Safety Authorities Network (INFOSAN) was developed by WHO in combination with FAO to enhance collaboration amongst international experts on food safety at national and international levels.
Regulatory Issues

Food and Nutrition Monitoring:

• Data gathering is commissioned by the various agencies who oversee food safety – FAO, WHO, FSA, European Food Safety Authority (EFSA), Food Safety Authority of Ireland (FSAI) etc.

• Data collected can be used to track nutritional deficiency diseases, level of food security, risk of excessive intakes, issues related to food safety and problems specific to vulnerable groups (children, elderly).

• Linking of food monitoring data to public health monitoring is needed in order to determine the diet-food relationship to any of the major public health problems within a population.
## Food and Nutrition Monitoring:

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Regulatory Issues

Food Policy and Food Production:

• There is a huge range of legislation with laws and regulations that play an intricate part in ensuring that countries/individuals have continued access to adequate amounts of high quality and safe food.

• Agricultural legislation which assists food producers, subsidies and other forms of financial support is important in overall maintenance of an adequate food supply at local, national and global levels.
Regulatory Issues

Food Policy and Food Production:

- Price supports, government subsidies and export/import incentives do often cause a distortion in the distribution of overall food supplies.

- There is often excess production of certain grains, meat and dairy products, while other food groups which are also important to a balanced diet (fruit and vegetables) receive less attention/support.
Regulatory Issues

Food Policy and Food Production:

- Farming and fishing is tightly regulated for social, rural developmental, environmental, economic, health and many other reasons.
Regulatory Issues

Food Policy and Food Production:

• From the point of view of therapists the main interest must be how the totality of food production can be altered to improve the balance of nutrients available to the population.

• Many issues must be addressed.

• For example determine the differential in the supply of a certain food in order to reach a target of X number of servings per person per day.

• Examine trade implications – some countries may not have ready access to certain foods (e.g. northern countries and tropical fruits).
Regulatory Issues

Food Policy and Food Production:

• Look at availability of land to grow more of the foods in question.

• Consider what foods might be displaced by introducing the production of this target food.

• How to persuade the farmers/manufacturers to grow/produce these foods and to persuade consumers to buy them.
Supply and Demand:

• Things are always supply or demand driven.

• Supply-driven options try to manipulate the balance of foods produced to make the production of certain foods more attractive to the primary producer.

• Demand-driven options can alter population nutrient intake and involve public health nutrition promotion strategies such as:
  − Label information
  − Media campaigns
  − Work-based programmes
Supply and Demand:

• Another strategy is to leave the pattern of food selection alone, but to change the properties of foods consumed.

• In many parts of the world, dairy products are the main sources of saturated fatty acids, which can raise cholesterol levels believed to increase risk for CV disease.

• Processors can change this property of milk by making low or non-fat products available in the marketplace.

• This way, people can continue to consume the other nutrients in the milk while lowering their intake of saturated fatty acids.
‘Farm to Fork’

- The Food Standards Agency (FSA) has a very active role concerning the policies outlining Food Production from Farm to Fork and is responsible for food safety and hygiene, labelling and food law enforcement across the UK.

- In Ireland, the FSAI (Food Safety Authority of Ireland) is responsible for monitoring the quality of food offered to the Irish consumer, while the Department of Agriculture, Food and the Marine monitor the food production process.

- There are many policies outlining the safety and quality control that take place during the production of the food at the agricultural level right through to its various processing procedures, packaging and how it ends up on your dinner table.
‘Farm to Fork’

• These policies cover an array of issues including Genetically Modified Foods (GM), animal feed, the treatment of livestock, safety for farmers’ markets, pesticides, marine food monitoring and food labelling.

• For more information please see your Food Labelling lecture and the following links:
  - [https://www.food.gov.uk/enforcement/regulation](https://www.food.gov.uk/enforcement/regulation) - UK
  - [http://www.fsa.ie/](http://www.fsa.ie/) - Ireland
Fortification:

- Fortification involves the addition of nutrients to foods irrespective of whether or not the nutrients were originally present in the food.
- Fortification is a means of improving the nutritional status of a population (or potentially a sub-population).
- Fortified foods make an important contribution to diets.
- Some foods are fortified by UK law (e.g. margarine); others voluntarily (e.g. breakfast cereals).
- In Ireland, there are no mandatory fortification requirements.
Fortification


• Safety and technical considerations are taken into account when deciding which foods to fortify and to what level.

Fortification

• Nutrients or food components may be added for a variety of reasons:
  – **Restoration:** Nutrients lost during food processing may be replaced. This is particularly important if the food was a good source of a nutrient before processing. For example, by law in the UK, iron, thiamin and niacin must be added back to white and brown flour (but not wholemeal) as they are removed with the bran during the milling of wheat to make all flour - except wholemeal.
Fortification

• **Substitution:** To produce a substitute product with similar nutritive value. For example, margarine has vitamins A and D added, to levels comparable with butter. In the UK this is compulsory by law. Calcium is added voluntarily to some soya based drinks sold as substitutes for cow’s milk.
Fortification

- **Nutrients Added:** Adding nutrients to foods is not a new idea but the types of foods selected and the amounts of nutrients added will depend on the particular nutritional problems of the population and may change as understanding of nutritional needs increases.

- A range of different nutrients have been added to foods over time, including: vitamins (e.g. vitamins A, C, D and a range of B vitamins), minerals (e.g. iron, iodine, calcium and zinc), fibre, proteins and/or amino acids.
Fortification

Why Fortify Foods?

• Adding nutrients to foods, particularly staple foods, can increase intakes among the whole population.

• In countries where intakes of certain nutrients are very low, fortification can help to reduce nutrient deficiency diseases.

• One example is the addition of iodine to salt to decrease iodine deficiency disorders.
Fortification

Why Fortify Foods?

• Fortification of some foods may also be seen as providing a marketing advantage, especially where the purchasers have some awareness of the ‘benefits’ of the nutrient being added.

• The addition of a nutrient may also offer some technical benefit, e.g. vitamin C is an antioxidant and can reduce the rate of spoilage in some products.

• Vitamin E in Eskimo-3 Fish Oil is another example of preventing spoilage.
Fortification

Safety and Technical Considerations:

- Consumption of relatively large amounts of some nutrients can be harmful to health. Therefore it is important that decisions on the addition of nutrients to foods consider:
  - The intakes of the nutrients from unfortified foods.
  - The anticipated consumption of the food to be fortified.
  - The physiological availability (bioavailability) of the added nutrients.
  - The likely impact of fortification on overall intake of the nutrient(s).
  - The risk of excessive intakes of the added nutrients in ‘extreme’ consumers of a food.
Safety and Technical Considerations:

- The potential effects of fortification (and enhanced nutrient intake) on other nutrient and health indicators must also be considered, e.g. high intakes of folic acid from fortified foods (or supplements) may mask vitamin B12 deficiency.

- Also, high intakes of some micronutrients can interfere with the absorption of others, triggering new problems.

- Additionally, thought must be given to aspects such as the stability of the added nutrients and the effect on the sensory qualities of a food (taste, colour, texture).
Reasons for Concern Regarding Food Safety:

- Foodborne illness caused by microorganisms is a large public health problem.
- Most countries with systems for reporting cases of foodborne illness have documented significant increases over the past few decades in the incidence of diseases caused by microorganisms in food.
Food Safety

- Low-quality foods that are partially spoiled, adulterated, damaged by insects, rodents or birds, mis-labelled or otherwise unacceptable from a basic quality point of view can cheat consumers, cause unnecessary food losses and harm the reputation of food producers, food sector or even a country.
Chronic Effects of Foodborne Illness:

• Approximately 1.8 million children in developing countries (excluding China) died from diarrhoeal disease in 1998, caused by microbiological agents, mostly originating from food and water.

• One person in three in industrialised countries may be affected by foodborne illness each year.

• In the USA, some 76 million cases of foodborne illness, resulting in 325,000 hospitalisations and 5000 deaths, are estimated to occur each year.
Food Safety

Chronic Effects of Foodborne Illness:

• The medical costs and the value of the lives lost during just five foodborne outbreaks in England and Wales in 1996 were estimated at UK £300–700 million.

• In studies in the USA in 1995, it was estimated that the annual cost of the 3.3–12 million cases of foodborne illness caused by seven pathogens was US $6.5–35 billion.

• The cost of the estimated 11,500 daily cases of food poisoning in Australia was calculated at AU$ 2.6 billion annually.
Chronic Effects of Foodborne Illness:

- While most foodborne diseases are sporadic and often not reported, foodborne disease outbreaks may take on massive proportions.

- For example, in 1994, an outbreak of salmonellosis due to contaminated ice cream occurred in the USA, affecting an estimated 224,000 persons.

- In 1988, an outbreak of hepatitis A, resulting from the consumption of contaminated clams, affected some 300,000 individuals in China.
Food Safety

• The following make up vulnerable groups:
  − Elderly
  − Children
  − Pregnant or lactating/breastfeeding women
  − Immunocompromised individuals (HIV/AIDS, cancer, long-standing chronic illnesses)

• Why might this be?
  − You will cover this in more detail in your life stages lecture.
Types and Sources of Microbial Contamination

Bovine Spongiform Encephalopathy (BSE):

• ‘Mad Cow Disease’ saw a ban on British beef for 10 years, and killed approx. 200 people.

• Studies conducted in the UK suggest that the source of BSE was cattle feed prepared from bovine tissues, such as brain and spinal cord, that was contaminated by the BSE agent.

• The agent is highly stable, resisting freezing, drying and heating at normal cooking temperatures, even those used for pasteurization and sterilisation.
Bovine Spongiform Encephalopathy (BSE):

- Speculation as to the cause of the appearance of the agent causing the disease has ranged from spontaneous occurrence in cattle to entry into the cattle food chain from the carcasses of sheep with a similar disease, scrapie.

- The nature of the BSE agent is still a matter of debate.
Campylobacter Spp.

Campylobacter spp:

- Campylobacters are bacteria that are a major cause of diarrhoeal illness in humans.
- Generally regarded as the most common bacterial cause of gastroenteritis worldwide.
- Responsible for more cases of food poisoning than E.Coli, listeria and salmonella combined.
- Contaminated poultry is the major route of infection in the UK and Ireland.

(WHO 2009)
Campylobacter Spp.

**Campylobacter spp:**

- In developing countries, campylobacter infections in children under the age of two years are especially frequent, sometimes resulting in death.

- In almost all developed countries, the incidence of human campylobacter infections has been steadily increasing.

- In 2013, the FSA reported that two thirds of UK shop bought chicken is infected with campylobacter. Washing chicken is discouraged as it may splash the bacteria onto sink surrounds and infect utensils etc. spreading infection.

(FSA 2014)
Campylobacter Spp.

Campylobacter spp:

- Campylobacteriosis: In 2013, 400 000 people in the UK were infected, with 22 000 hospitalisations. Approx. 1700 people infected yearly in Ireland.

- The onset of disease symptoms usually occurs two to five days after infection, but can range from one to ten days.

- The most common clinical symptoms of campylobacter infections include diarrhoea (frequently with blood in the faeces), abdominal pain, fever, headache, nausea, and/or vomiting.

- The symptoms typically last three to six days. A fatal outcome is rare and is usually confined to very young or elderly patients or immunocompromised patients (approx. 110 people in the UK 2013).
Campylobacter Spp.

Campylobacter spp:

- Complications such as bacteraemia, hepatitis, pancreatitis (infections of the blood, liver and pancreas respectively), and abortion have all been reported with various degrees of frequency.

- Post-infection complications may include reactive arthritis (painful inflammation of the joints which can last for several months) and neurological disorders such as Guillain-Barré syndrome (1/1000 cases).

- The high incidence of campylobacter diarrhoea, as well as its duration and possible future consequences, make it highly important from a socio-economic perspective.

- In the UK infection is believed to cost the UK economy £900 million. Irish figures unavailable.

(FSA 2014)
Campylobacter Spp.

Campylobacter spp: Treatment

• Treatment is not generally indicated, except electrolyte replacement and rehydration.

• Antimicrobial treatment (erythromycin, tetracycline, quinolones) is indicated in invasive cases or to eliminate the carrier state.

• The prevention of infection requires control measures at all stages of the food chain, from agricultural production on the farm, to processing, manufacturing and preparation of foods in both commercial establishments and the domestic environment.
**Campylobacter spp: Precautions**

- Make sure your food is properly cooked and still hot when served, normal thorough cooking completely kills the bacteria.
- Campylobacter may infect raw milk and products made from raw milk.
- Avoid ice unless you are sure it is made from safe water.
- When the safety of drinking water is doubtful, boil it or if this is not possible, disinfect it with a reliable, slow-release disinfectant agent. These are usually available at pharmacies.
- Wash hands thoroughly and frequently using soap, in particular after contact with pets or farm animals, or after having been to the toilet.
- Wash fruit and vegetables carefully, particularly if they are eaten raw.
- You can’t see, taste or smell campylobacter.
Shigella Species:

- Shigella is a genus of bacteria that is a major cause of diarrhoea and dysentery.

- Dysentery is diarrhoea with blood and mucus in the stools.

- The bacteria are transmitted by ingestion of contaminated food or water, or through person-to-person contact.

- In the body, they can invade and destroy the cells lining the large intestine, causing mucosal ulceration.
Shigella

Shigella Species:

• Apart from diarrhoea, symptoms of Shigella infection include fever, abdominal cramps, and rectal pain.

• Most patients recover without complications within seven days.

• Shigellosis can be treated with antibiotics, although some strains have developed drug resistance.

(WHO 2009)
Shigella

Control and Prevention Strategies:

• Wash your hands thoroughly before and after handling food.

• Wash hands after going to the toilet.

• Wash and sanitise all surfaces used for preparing food products before and after use.

• Protect kitchen areas and food from insects, pests and other animals.

• Separate raw meat, poultry and seafood from other foods.
Control and Prevention Strategies:

- Cook foods thoroughly, especially meats, poultry, eggs and seafood.
- Bring stews and soups to boiling.
- For meat and poultry, make sure juices run clear and not pink.
- Reheat cooked food thoroughly.
- Use separate equipment and utensils (knives, cutting boards) for raw and cooked foods.
- Store raw and cooked foods separately as well.
Escherichia Coli (Enterohaemorrhagic E. Coli - EHEC):

- Escherichia coli (E. coli) is a bacterium that is commonly found in the gut of humans and warm-blooded animals.

- Most strains of E. coli are harmless. Some strains however, such as Enterohaemorrhagic E. coli (EHEC), can cause severe foodborne disease.

- It is transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products and raw milk.
Escherichia Coli (EHEC):

- Symptoms caused by EHEC include abdominal cramps and diarrhoea that may in some cases progress to bloody diarrhoea (haemorrhagic colitis).

- Fever and vomiting may also occur.

- The incubation period can range from three to eight days, with a median of three to four days.

- Most patients recover within ten days, but in a small proportion of patients (particularly young children and the elderly), the infection may lead to a life-threatening disease, such as Haemolytic Uraemic Syndrome (HUS).
Escherichia Coli

Escherichia Coli (EHEC):

- The incidence of EHEC infections varies by age group, with the highest incidence of reported cases occurring in children aged under 15 years.

- 63% to 85% of cases are a result of exposure to the pathogen through food.

- In the UK approx 3000 cases are reported each month.

( Public Health England 2014)
Escherichia Coli (EHEC):

- It is transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products and raw milk.

- Faecal contamination of water and other foods, as well as cross-contamination during food preparation (with beef and other meat products, contaminated surfaces and kitchen utensils), will also lead to infection.
Escherichia Coli (EHEC):

- Examples of foods implicated in outbreaks of E. coli strain O157:H7 include undercooked hamburgers, dried cured salami, unpasteurised fresh-pressed apple cider, yoghurt, cheese and milk.

- An increasing number of outbreaks are associated with the consumption of fruit and vegetables (sprouts, lettuce, coleslaw, salad) whereby contamination may be due to contact with faeces from domestic or wild animals at some stage during cultivation or handling.

(cdc.gov, Centre For Disease Control and Prevention, 2009)
Escherichia Coli (EHEC):

- Some kinds of E. coli cause disease by making a toxin called Shiga toxin.

- The bacteria that make these toxins are called “Shiga toxin-producing” E. coli, or STEC for short.

- You might hear them called verocytotoxie E. coli (VTEC) or enterohemorrhagic E. coli (EHEC); these all refer generally to the same group of bacteria.

- When you hear news reports about outbreaks of “E. coli” infections, they are usually talking about E. coli O157.

(cdc.gov/ecoli, Centre For Disease Control and Prevention, 2009)
Escherichia Coli (EHEC):

- EHEC has also been isolated from bodies of water (ponds, streams), wells and water troughs, and has been found to survive for months in manure and water trough sediments.

- Waterborne transmission has been reported, both from contaminated drinking water and from recreational waters.

- In Ireland 2013 there was approximately 704 reported cases of VTEC and 30% of private wells found to be contaminated with E. coli.

- Ireland has the highest rate of VTEC in Europe.

Escherichia Coli

Escherichia Coli (EHEC):

• The only effective method of eliminating EHEC from foods is to introduce a bactericidal treatment, such as heating (e.g. cooking or pasteurisation) or irradiation.

• Thorough cleaning of surfaces and cooking equipment is important.

• The FSA recommends that anti-bacterial gels not be used in place of soap and warm water.
Salmonella spp.:

- Millions of human cases are reported worldwide every year, resulting in thousands of deaths.

- Salmonellosis is caused by the bacteria Salmonella. Today, there are over 2,500 known types, or serotypes, of Salmonella.

- It constitutes a major public health burden and represents a significant cost in many countries.

- In the EU over 100 000 cases are reported yearly.

Salmonella spp.: 

• Since the beginning of the 1990s, strains of Salmonella which are resistant to a range of antimicrobials, including first-choice agents for the treatment of humans, have emerged and are threatening to become a serious public health problem.

• This resistance results from the misuse of antimicrobials both in humans and animal husbandry.

(WHO 2009)
Salmonella spp.:

- Salmonellosis in humans is generally contracted through the consumption of contaminated foods of animal origin (mainly meat, poultry, eggs and milk), although many other foods, including green vegetables contaminated from manure, have been implicated in its transmission.

- The causative organisms pass through the food chain from primary production to households or food service establishments and institutions.

(WHO 2009)
Salmonella

Salmonella spp.:

• Characterised by acute onset of fever, abdominal pain, diarrhoea, nausea and sometimes vomiting. In some cases, particularly in the very young and in the elderly, the associated dehydration can become severe and life-threatening.

• In such cases, as well as in cases where Salmonella causes bloodstream infection, effective antimicrobials are essential drugs for treatment.

• The antimicrobials most widely regarded as optimal for the treatment of salmonellosis in adults is the group of fluoroquinolones.

(WHO 2009)
Listeria:

- In most people listeria is a mild self limiting foodborne disease, with the common symptoms of fever, headache, diarrhoea and vomiting.
- In rare cases it can develop into more serious disease such as meningitis.
- Pregnant women are at increased risk – 20 times more likely to develop listeriosis which can cause miscarriage.
- Foods most at risk of being infected; pate, soft and ripened cheeses, smoked salmon, pre-packaged sandwiches and deli meats, avoid if pregnant.
- Reduce risks: avoid using food after use-by dates and follow storage and preparation instructions.
- Read more: [http://www.nhs.uk/Conditions/Food-poisoning/Pages/Causes.aspx](http://www.nhs.uk/Conditions/Food-poisoning/Pages/Causes.aspx)
**Types and Sources of Microbial Contamination**

**Norovirus:**
- Usually self limiting, most common cause of ‘stomach bug’ with up to 1 million people in the UK affected yearly.
- Symptoms: Vomiting and diarrhoea.
- Highly contagious, viral illness, does not respond to antibiotics.
- Infection occurs through transmission from infected persons and oysters/shellfish also carriers.
- FSA found 75% of raw oysters in UK oyster beds contained the virus although most at low levels.
- Hands, surfaces, towels and foods can be infected.
- Normal food preparation and hygiene required.

(FSA 2014)
Chemical Contamination

- The contamination of food by chemical hazards is a worldwide public health concern and is a leading cause of trade problems internationally.

- Contamination may occur through environmental pollution of the air, water and soil, such as the case with toxic metals, PCBs and dioxins, or through the intentional use of various chemicals, such as pesticides, animal drugs and other agrochemicals.

- Reading: *Which Pesticides are Banned in Europe?* [http://pan-europe.info/old/Resources/Links/Banned_in_the_EU.pdf](http://pan-europe.info/old/Resources/Links/Banned_in_the_EU.pdf)

- Reading: *'Suppressed' EU report could have banned pesticides worth billions* [http://www.theguardian.com/environment/2015/feb/02/suppressed-eu-report-could-have-banned-pesticides-worth-billions](http://www.theguardian.com/environment/2015/feb/02/suppressed-eu-report-could-have-banned-pesticides-worth-billions)
Persistent Organic Pollutants (POPs)

- Persistent Organic Pollutants (POPs) by definition, are organic compounds that are highly resistant to degradation by biological, photolytic or chemical means.

- POPs have very low water solubility and high lipid solubility leading to their ability to pass readily through the phospholipid structure of biological membranes and accumulate in fat.

(UNEP 2009)
Persistent Organic Pollutants (POPs)

• There are very specific properties of substances that would categorise them as POPs.

• They must be at the extreme of persistence, mobility and toxicity in order to rank them as POPs.

• Persistence must be measured in half lives (t1/2) which must be greater than six months (i.e. it takes the substance more than six months in order to be degraded to half its concentration).

(UNEP 2009)
Persistent Organic Pollutants (POPs)

- POPs must also possess a property that results in their movement into organisms, thus making them toxic to human beings (and all other living organisms on the planet).

- This property is lipophilicity or a tendency to preferentially dissolve in fats and lipids, rather than in water.

- Combined with environmental persistence and a resistance to biological degradation (long half-life), lipophilicity also results in biomagnification throughout the food chain.
Persistent Organic Pollutants (POPs)

- Another important property of POPs is that of semi-volatility.

- This property confers a degree of mobility through the atmosphere that is sufficient to allow relatively great amounts to enter the atmosphere and be transported over long distances.

- These substances may originate from hot regions but will condense and tend to remain in colder regions (e.g. POP levels measured in the Arctic).

- A list of The Dirty Dozen can be found at: http://www.epa.gov/international/toxics/pop.html#table These include: DDT, PCBs, dioxins and furans.

(UNEP 2009)
Persistent Organic Pollutants (POPs)

- If looked for in tissues or environmental samples, some POPs will almost always be found.

- It is most difficult to establish causality of illness/disease that is directly attributable to exposure to a specific POP.

- This difficulty is further emphasised by the fact that POPs rarely occur as single compounds.

(UNEP 2009)
Persistent Organic Pollutants (POPs)

- Investigators have demonstrated immune dysfunction as a plausible cause for increased mortality among marine mammals and have also demonstrated that the consumption of POP contaminated diets in seals may lead to vitamin and thyroid deficiencies and concomitant susceptibility to microbial infections and reproductive disorders.

- Exposure to POPs have been correlated with population declines in marine mammals, as studied in the St Lawrence River in Canada.
Persistent Organic Pollutants (POPs)

• Analysis of human milk, maternal blood and adipose tissue are all relevant matrices for assessment of body burdens for persistent organic pollutants.

• However, human milk is recognised as the preferred matrix because it has several important advantages.

• Biomonitoring of human milk data can provide information on the exposure of the mother as well as the infants.
Persistent Organic Pollutants (POPs)

- Since 1976, the World Health Organization through its GEMS/Food Programme has collected and evaluated information on levels of persistent organic pollutants in foods, including human milk.

- Over the period 1987-2003, it has coordinated three international studies of human milk to assess the levels and trends of polychlorinated dibenzodioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls.
POPs and Human Health

- As noted, it is most difficult to establish definitive cause and effect relationships for human exposure of POPs and incident disease.

- Humans encounter a broad range of environmental exposures and frequently to a mixture of chemicals at any one time.

- Some POPs have the potential to cause significant adverse effects to human health, both locally and globally, due to long-range transport.
POPs and Human Health

• Both short-term and long-term exposure have been shown to result in illness and death.

• The risk for long-term exposure is greatest in developing countries where the use of POPs in tropical agriculture has resulted in a large number of deaths and injuries.

• Short-term exposure to high concentrations of certain POPs in the Philippines showed that in 1990, endosulfan became the number one cause of pesticide-related acute poisoning among subsistence rice farmers and mango sprayers.
DDT – 1,1’(2,2,2,-Trichloroethylidene) bis (4-chlorobenzene)

- DDT is highly insoluble in water.
- It is soluble in most organic solvents.
- Its presence is ubiquitous in the environment and its residues have been found as far north as the Arctic.
- DDT was widely used during the Second World War to protect the troops and civilians from the spread of malaria, typhus and other vector-borne disease.
- After the war, DDT was widely used on a variety of agricultural crops and for the control of disease vectors as well.
- It is still being produced and used for vector control.
- Growing concern about the adverse environmental effects, especially on birds, led to severe restrictions on its use in the 1970s.
DDT – 1,1’(2,2,2,-Trichloroethyldene) bis (4-chlorobenzene)

• There is some evidence to suggest that DDT may be suppressive to the immune system, possibly by depressing humoral responses.

• DDT produces oestrogen-like alterations of reproductive development and there is also limited data that suggest a possible association between DDT and its metabolite DDE and a risk of breast cancer.
DDT – 1,1’(2,2,2,-Trichloroethylidene) bis (4-chlorobenzene)

- DDT affects fish behaviour.

- Atlantic salmon exposed to DDT as eggs experienced impaired balance and delayed appearance of normal behaviour patterns.

- DDT is best known for its adverse effects on reproduction in birds, especially due to the eggshell thinning in birds, thereby having significant adverse impact on reproductive success.

(UNEP 2009)
PCBs and Furans

- PCBs and furans are two groups of toxic compounds that have very similar chemical structures and properties.

- They are generally very insoluble in water, are lipophilic (fat-loving) and are very persistent.

- Neither dioxins nor furans are produced commercially and they have no known use.

- They are thus by-products resulting from the production of other chemicals.

(UNEP 2009)
PCBs and Furans

- Dioxins are released into the environment through the production of pesticides and other chlorinated substances.

- Furans are a major contaminant of PCBs.

- Health effects of exposure to dioxins and furans are peripheral neuropathies, fatigue, depression, personality changes, hepatitis, enlarged liver, abnormal enzyme levels and porphyria.
PCBs and Furans

• They are persistent environmental pollutants that enrich via the food chain.

• Dioxins and PCBs are associated with industrial discharges, including discharges into the sea, and ocean fish have varying levels of these substances often directly related to the proximity of their habitat to discharge areas.

• The level in farmed fish normally reflects the contamination level of the feed used, which has been also shown in above mentioned study by the detection of dioxins and PCBs in commercial fish feed.
PCBs and Furans

• The Joint FAO/WHO Expert Committee on Food Additives (JECFA) examined evidence on the toxicity of these chemicals and established a Provisional Tolerable Monthly Intake (PTMI).

• When evaluating standard diets in different parts of the world the results indicated that the estimated intakes of these chemicals approach or exceed this PTMI.

• Based on the mean contamination levels reported in above study, eating one or two portions per week of farmed salmon would result in a monthly intake below this level.

• However, an overall dietary risk assessment would require inclusion of other dietary sources of dioxins and dioxin-like PCBs.
PCBs and Furans

• FAO and WHO consider fish to be an important component of a nutritious diet, and that the risk of consuming contaminated fish must be weighted in view of the beneficial nutritive effects of fish.
Acrylamide:

• There is currently little information about, and poor understanding of, how acrylamide is formed in foods.

• It appears to be produced naturally in some foods that have been cooked or processed at high temperatures and the levels appear to increase with the duration of heating.

• The highest levels found so far were in starchy foods (potato and cereal products).
Acrylamide:

- Acrylamide is a chemical that is used to make polyacrylamide materials.

- Polyacrylamide is used in the treatment of drinking water and waste water where it is used to remove particles and other impurities.

- It is also used to make glues, paper and cosmetics.

- Polyacrylamide materials contain very small amounts of acrylamide.

- Acrylamide is known to cause cancer in animals. Also, certain doses of acrylamide are toxic to the nervous system of both animals and humans.
Acrylamide:

- In April 2002 the Swedish National Food Authority reported the presence of elevated levels of acrylamide in certain types of food processed at high temperatures.

- Since then, acrylamide has been found in a range of cooked and heat-processed foods in other countries, including the Netherlands, Norway, Switzerland, the United Kingdom and the United States.

- Previous concerns about acrylamide were focused on workers using acrylamide in their jobs, and cigarette smoking.

(WHO 2009)
Acrylamide

- Reading: *What is Acrylamide and how is it involved in food and health?*
  
The George Mateljan Foundation.

  
(cut and paste into your browser) .
Acrylamide:

- We don’t know exactly at what temperature acrylamide is formed in food.
- Food prepared at temperatures below 120 degrees Celsius have lower levels.
- Food should not be cooked excessively, i.e. for too long or at too high a temperature.
- However, all food, especially meat and meat products, should be cooked sufficiently to destroy food poisoning bacteria.
Alternatives to POPs?

- There are a variety of chemical and non-chemical alternatives for POPs.

- Not all developing countries use POPs and those who do still use them do not exclude the use of the alternatives.

- However, in a country such as Honduras, the use of some POPs is common due to a variety of reasons common amongst developing nations.
Cooking and Storage Methods

Freezing, Drying, Cooking, Reheating:

• Nearly every food preparation process reduces the amount of nutrients in food.

• In particular, processes that expose food to high levels of heat, light, and/or oxygen cause the greatest nutrient loss.

• Nutrients can also be ‘washed out’ of foods by fluids that are introduced during a cooking process.
Cooking and Storage Methods

Freezing, Drying, Cooking, Reheating:

- Boiling a potato can cause much of its B and C vitamins to migrate to the boiling water.

- You will still benefit from those nutrients if you consume the liquid (i.e. if the potato and water are being turned into potato soup), but not if you throw away the liquid.

- Similar losses also occur when you broil, roast, or fry in oil, and then drain off the drippings.
Cooking and Storage Methods

Freezing, Drying, Cooking, Reheating:

• The amount of nutrient loss caused by cooking has encouraged some health-conscious consumers to eat more raw foods.

• However, cooking is also beneficial, because it kills potentially harmful microorganisms that are present in the food supply.

• In particular, poultry and ground meats should be thoroughly cooked, and the surface of all fruit and vegetables should be carefully washed before eating.
Cooking and Storage Methods

Barbecue (BBQ):

- BBQ grilling is a popular cooking method, primarily because of the taste it imparts on meat.

- It can also be a healthier alternative to other cooking methods, because some of the meat's saturated fat content is reduced by the grilling process.

- Grilling also presents health risks.
Cooking and Storage Methods

• There are two types of carcinogenic compounds that are by-products of BBQing:

1. **Heterocyclic amines (HCAs):**
   - HCAs form when a meat is directly exposed to a flame or very high-temperature surface.
   - The creatine-rich meat juices react with the heat to form various HCAs, including amino-imidazo-quinolines, amino-imidazo-quinoxalines, amino-imidazo-pyridines, and aminocarbolines.
   - HCAs have been shown to cause DNA mutation, and may be a factor in the development of certain cancers.
2. **Polycyclic Aromatic Hydrocarbons (PAHs):**

- PAHs form in smoke that is produced when fat from the meat ignites or drips on the hot coals of the grill.
- Various PAHs present in the resulting smoke, including benzo[a]pyrene and dibenzo[a,h]anthracene, adhere to the outside surface of the grilled meat.
- PAH exposure is also believed to be linked to certain cancers.
Microwaving:

- Microwaves are a form of electromagnetic energy, like light waves or radio waves, and occupy a part of the electromagnetic spectrum of power, or energy.

- In our modern technological age, microwaves are used to relay long distance telephone signals, television programmes, and computer information across the earth or to a satellite in space.

- The microwave is most familiar to us as an energy source for cooking food.
Microwaving:

- Every microwave oven contains a magnetron, a tube in which electrons are affected by magnetic and electric fields in such a way as to produce micro wavelength radiation at about 2450 Mega Hertz (MHz) or 2.45 Giga Hertz (GHz).

- This microwave radiation interacts with the molecules in food.
Cooking and Storage Methods

Microwaving:

• In commercial models, the oven has a power input of about 1000 watts of alternating current.

• As these microwaves generated from the magnetron bombard the food, they cause the polar molecules to rotate at the same frequency millions of times a second.
Cooking and Storage Methods

Microwaving and its Potential Risks:

• Dr. Lita Lee of Hawaii reported in the December 9, 1989 Lancet:

"Microwaving baby formulas converted certain trans-amino acids into their synthetic cis-isomers. Synthetic isomers, whether cis-amino acids or trans-fatty acids, are not biologically active. Further, one of the amino acids, L-proline, was converted to its d-isomer, which is known to be neurotoxic (poisonous to the nervous system) and nephrotoxic (poisonous to the kidneys). It's bad enough that many babies are not nursed, but now they are given fake milk (baby formula) made even more toxic via microwaving."
Microwaving and its Potential Risks:

- It seems that this form of microwave radiation ‘heating’ potentially does something to the substances it heats.

- It is also quite possible that people who consume foods from a microwave oven are also ingesting these ‘unknowns’.
Microwaving and its Potential Risks:

- In Comparative Study of Food Prepared Conventionally and in the Microwave Oven, published by Raum & Zelt in 1992, it says:

  "A basic hypothesis of natural medicine states that the introduction into the human body of molecules and energies, to which it is not accustomed, is much more likely to cause harm than good. Microwaved food contains both molecules and energies not present in food cooked in the way humans have been cooking food since the discovery of fire."
Microwaving:

- There are warnings of certain foods exploding in the microwave due to the heating style (such as an egg inside its shell), or the dangers of using it to heat baby bottles because of the uneven heating. But nothing to do with the potential alteration of the organic constitution of the substance.

- As with all scientific arguments, one has to examine the research around the studies and the ways in which the studies were carried out.

THANK YOU