The Search for Better Health

Defining “Health” is not easy because it has many components, some which are very subjective. (physical, mental and social well-being)

“Disease” is similarly difficult to define, because it is a very broad topic and can cover mild occurrences (e.g. the common cold) to increasingly severe diseases.

The Links Between Gene Expression and Maintenance and Repair of Body Tissue

Every cell in your body contains in its chromosomes, ALL the genes needed to specify all your body parts, functions and traits. In each cell though, only some of the genes are “Switched-on”. During the embryo stage, the body underwent a process called cell differentiation.

- If a muscle cell suddenly switched on the genes appropriate for a blood cell, it would no longer be functioning properly.
- Gene expression occurs throughout the life of an organism, and it is essential that it functions correctly to maintain good health. If a gene is faulty and the polypeptides and proteins it creates are also faulty, then cell process or structures may be abnormal and disease can result

Genes, Mitosis, Cell Differentiation / Specialisation and the Maintenance of Health

Genes:
• Genes control the production of proteins in the body (needed for proper functioning) and so healthy genes ensure the correct proteins are made.
• Through the production of proteins (especially enzymes), genes ensure the correct cell processes occur, maintaining metabolism and homeostasis.

Mitosis:
• The processes that enables genetic material to be copied exactly. Mitosis is the process that organisms use to grow, and maintain and repair body cells.

Cell Differentiation and Specialisation
• [covered in the above section]
Infectious Disease:
- Caused by a **pathogen**
- The disease can be transferred from one organism to another
- Pathogens can be microscopic or macroscopic
- E.g. viruses (influenza), bacteria (tonsillitis), protozoans (malaria), prions (CJD), fungi (tinea).

Non-infectious Disease:
- Are NOT Caused by a pathogen
- **Inherited** (genetic) disease: Down’s Syndrome, hemophilia
- **Nutritional disease**: scurvy, beriberi, kwashiorkor
- **Environmental disease**: skin cancer, asbestosis

Cleanliness in Food, Water and Personal Hygiene

The intake of food and water provide an easy way for micro-organisms to enter our bodies.

**Food**
- Heating - Killing microbes with high temperatures (pasteurize: subject to a process of partial sterilization, esp. one involving heat treatment or irradiation)
- Cooling - Refrigeration slows down the growth of microbes.
- National Food Safety Standards in place.

**Water**
- Nasty Microbes can originate from dead animal carcasses or feces in water supplies. Also growth’s such as algal blooms which release toxins into water.
- Government Regulation is also in place.

**Drinking Water Treatment - Case Study:**

1. The water sits for quite a while in a large reservoir. This allows time for much of the suspended matter to settle on the bottom.
2. The water is filtered, to remove any remaining suspended solids. This is achieved by passing the water through sand beds or charcoal.
3. The water is then chlorinated to remove any remaining microbes. Other chemicals such as fluoride may also be added here.

**Personal Hygiene**
- Washing hands regularly, cleaning wounds, washing dishes and clothes etc.

*Any organism that causes disease is called a Pathogen*

**To cause a disease pathogen must:**
- Be present in sufficient numbers to cause disease
- Survive in, or on the body without being destroyed by the body’s natural defenses
- Escape from one host to another
Pasteur & Koch

Micro-organisms and pathogens were only discovered around the mid 19th century. Before this, people thought living things came to being due to "spontaneous generation" - that is, they came into existence from non-living matter.

**Louis Pasteur**

- Discovered that infectious diseases are caused by micro-organisms. This is known as his 'Germ Theory of Disease'
- His famous experiment did 2 things:
  - Disproved the generally held idea of the 'Spontaneous Generation' of life, and helped establish the "Cell Theory" - There was strange particles in the air!
  - Proved that decay in food was caused by air-borne microbes

**Pasteur’s Work with Anthrax**

- Demonstrated that Anthrax is caused by a rod-shaped bacterium.
- He developed a weakened strain of this bacterium
- He took 50 cheep, and inoculated 25 of them with the weakened strain. After they recovered, he inject all 50 sheep with the normal Anthrax.
- The 25 of them that were inoculated survived, while the others did not.
- We now call this process **Vaccination**

**Pasteur’s Work with Fermentation**

- Examined samples of fermenting wine with microscope, and identified and described the micro-organisms present.
- While working in the wine industry, Pasteur showed that **heating the wine to 55°C for a few minutes kills the microbes that spoil them, this process is called Pasteurisation**. - Now used for both wine and beer.

**Robert Koch**

- Koch also studied the Anthrax disease.
- Noticed a certain bacteria always present in the blood of diseased individuals.
- Removed a sample of blood and injected it into a healthy animal, and found it caused the disease.
- To make sure it wasn’t any other component of the blood he even removed the specific bacterium, and it alone was injected. This also resulted in disease.

**Koch’s Postulates** : A criteria that must be met to make sure a particular microorganism causes a particular disease.

- The microorganism must be present in every organism with the disease
- The microorganism must be isolated from the host and cultured.
- A potential host, when inoculated with the cultured microorganism, must develop the same symptoms as the original host.
- The micro-organism must be able to be isolated from the second host and be identified as the same species as the original culture.
Pathogens

Prions
- Still mysterious - discovered about 20 years ago
- Not living things, and are not cellular
- Cause disease especially of nerve tissue such as the brain.
- They seem to be proteins twisted in wrong shape, and are able to cause other proteins to change into the wrong shape also
- e.g. Creutzfeld Jacobs Disease

Viruses
- They invade a living cell and ‘hijack’ its genetic machinery
- The cell is taken over and forced to make more virus particles - like a chain reaction
- Viruses are not cellular - Each small capsule of protein, containing either DNA or RNA. - They are also very small
- e.g. Influenza (FLU)

Bacteria
- Enormously varied group of single-celled, prokaryotic organisms.
- Only some are pathogenic (cause disease), many are very useful.
- e.g. of disease: Anthrax

Protozoans
- Single-celled organism, eukaryotic but lacking cell wall.
- e.g. of disease: Malaria

Fungi
- Include various mold and yeast. Most are very useful e.g. Yeast (bread & beer) and mushrooms.
- Only very few cause disease.
- e.g. of disease: Tinea (Athlete’s Foot)

Macro Parasites
- Ectoparasites ; Outside of the body, e.g. ticks, fleas, leeches, mites, lice. Generally, ectoparasites only become major threats to health if they are vectors for microscopic pathogens
- Endoparasites ; Those that live inside body e.g. Tapeworm.
Antibiotics

- The first and most famous discovery of an antibiotic was penicillin in 1928.
- Antibiotics are selectively toxic to living cells. They kill or inhibit the cells of microbes such as bacteria, but do not harm human cells.
- During 20th century - brought under control a range of diseases (mostly bacterial) that had been problems for centuries! Before the discovery of antibiotics, many people died of what we now would think of as simple infections.

Antibiotic Resistance

- Unfortunately Natural Selection has meant that among the billions of pathogenic cells, there may be some that have a natural resistance to an antibiotic. New antibiotics need to be developed or discovered, in order to keep winning the war against the germs!
- When we use antibiotics it kills all the other bacteria and leaves the resistant cells to survive and reproduce and evolution takes place allowing them to multiply.

Malaria

- 4 BC: Greeks thought that the symptoms of malaria were caused by either breathing in marsh vapours or bites of insects that live in marshes
- 1880: Charles Laveran observed micro-organisms in blood from malarial patients but could not understand the method of transmission.
- 1894: Patrick Manson proposed that malaria is transmitted by mosquitoes
- 1898: Grassi discovered that malaria was transmitted by the Anopheles mosquito.
- 1897-1899: Ronald Ross established that the protozoan Plasmodium was the cause of malaria, winning the Nobel Prize.
- Early 20th: Treatments of malaria were developed, including anti-malarial drugs such as quinine. Efforts to stop the spread of malaria include using DDT to kill the disease vector – the mosquito.
- Today: Resistance to quinine and other drugs by the Plasmodium, as well as DDT resistance by the mosquitoes has become a problem. Development of a malarial vaccine is the main direction research is going.

<table>
<thead>
<tr>
<th>Cause</th>
<th>The parasitic protozoan, Plasmodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>The Anopheles mosquitos are the hosts that transmit the disease. Pathogen enters blood, travels to liver cells, where it hides from immune system. There it multiplies rapidly producing dozens of cells called merozoites. The merozoites travel back into the blood where they infect Red Blood Cells, again multiplying by mitosis. The merozoites burst out of the RBC’s every 48 - 72 hours, as they do, they release toxins. This causes symptoms.</td>
</tr>
<tr>
<td>Symptoms</td>
<td>The toxins cause reoccurring attacks of shivering, fever, headaches, nausea, sweating and lethargy. The destruction of many RBC’s Causes Anemia.</td>
</tr>
</tbody>
</table>
**Host Response**
The host produces anti-bodies to fight the pathogens, but the parasite continually produces a different set of antigens, so the immune response is not effective.

**Treatment**
Natural resistance can develop, but only very slowly. Also anti-malarial drugs such as Quinine.

**Prevention**
Protective clothing, insect repellent, mosquito nets.

**Control**
Draining swamps, spraying with insecticide.

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**The First Line of Defence**

**Skin**
- The outside surface of skin is layers of dead dry skin, virtually impenetrable by microbes.
- Skin has population of harmless bacteria that help stop invading bacteria from multiplying (competition)
- Sebaceous glands (oil glands) secrete sebum (oil). The lipids in the sebum are broken down by the skin's bacteria into acids which inhibit bacterial and fungal growth.
- If the skin is broken, blood clotting mechanisms quickly form a seal.

**Mucous Membranes**
- Mucous Membranes secrete mucous, which traps pathogens.
- The digestive, respiratory, reproductive and urinary tracts are lined with mucous.

**Cilia**
- Minute hairs that line the nose and some respiratory tubes.
- The hairs 'beat' in a rhythmic way to move mucous (and trapped pathogens) along for disposal - to nose or throat (coughed or swallowed)

**Chemical Barriers**
- Create conditions which make the surfaces inhospitable for the potential pathogens.
- e.g. - the acidic environment in the stomach / the alkaline conditions in the small intestine

**Other Defences**
- Tears contain lysosomes that destroy bacteria
- Microflora - harmless micro-organisms that live on the inside or the outside of the body and create acidic conditions that pathogens can't tolerate or keep the populations of pathogens in check by acting as competitors.
- Microflora Imbalance: Female reproductive tract normally protected by microflora. Taking medications such as antibiotics can upset the normal balance of microflora. The yeast Candida albicans (which is always present in small numbers) can take advantage and multiply rapidly resulting in “Thrush”.

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**Antigens & Immune Response**
- There are 2 more lines of defence, but first to body has to recognise that foreign invaders are present.
- Each of body cells has outside of its cell, special proteins that act as identification markers, which say to the immune system “Self”
- Anti-Gens are chemicals (such as proteins on foreign cells) that are recognised as “Not-Self” and trigger an immune response. They trigger to production of Anti-Bodies
Organ Transplants

- An transplanted organ contains proteins (anti-gens) that are recognised as foreign “not-self”. This leads the immune system to attack the implanted organ.
- Today, new drugs (that suppress the immune response) and techniques (e.g. closely matching donors “tissue type”) prevent the body from creating antibodies, or cytotoxic t-cells (covered later) which would destroy the organ. The danger, is the patients inability to fight of infection while the immune system is suppressed.

**BLOOD CELLS**

ERYTHROCYTES
Red Blood Cells
Carry oxygen

LEUCOCYTES
White Blood Cells
Immune System

BASOPHILS
involved in inflammation

EOSINOPHILS

NEUTROPHILS

MACROPHAGES
These 3 types carry out "Phagocytosis"

LYMPHOCYTES
form the 3rd Line of Defence

B-CELLS
(2 types)
produce Antibodies

T-CELLS
(4 types)
Kill infected body cells

When pathogens get past 1st line barrier, their antigens set off 2nd line of defence. This stage is also Non-specific. The immune response will be the same regardless of the anti-gen.

**Inflammation**

- When the cells are damaged they release chemicals that trigger a distress signal. Basophils release the chemical Histamine.
- **Dilation of blood capillaries** around injury site allows more blood to flow to area - bringing clotting factors and phagocyte cells to destroy pathogens.
- **This also creates heat**, heat can inhibit some pathogens and speed up all chemical reactions.
- **Blood capillaries also become more permeable.** This allows blood to flow directly into the tissues - the added pressure draining the fluid into the lymph system. Which washes the debris toward to lymph nodes for disposal.

**Phagocytosis**

- **Phagocytosis means literally “to eat cells”**. A phagocyte cell engulfs a foreign body and is destroyed by digestive enzymes within the phagocyte cell.
- When large numbers of phagocytes gather at a site of infection, they form pus.
Cell Death - Apoptosis
- Sometimes, tissues may become so infected that the best defence is to seal off the area and sacrifice the body cells within.
- The cell is either given orders to commit suicide, it creates antigens on its cellular membrane (which attract phagocytes) or it forms an extensive layer of many cells that “wall off” the infected site forming a capsule or cyst. The debris within will be destroyed by phagocytes.

The Lymphatic System
- As the blood circulates, some of the blood plasma always seeps out and bathes the cells in “tissue fluid”. The lymphatic system transports this tissue fluid away from the cells toward a point near the heart where it rejoins the blood stream. At various points along vessels - special chambers called “lymph nodes” or lymph glands - they contain many phagocytes to eat foreign cells. They also contain lymphocytes that form the third line of defence.

The Third Line of Defence

The 3rd line of defence is said to be “specific” because the Lymphocyte cells are able to identify particular pathogens by their antigens and set up defences that will accurately target each one. The pathogen will be destroyed not only in the current infection, but in future infections also.
- The second time around it can act faster and more efficiently - even before symptoms. ‘immunity’
Helper T cells are the major driving force and the main regulators of immune defense. Their primary task is to activate B cells and killer T cells. However, the helper T cells themselves must be activated. The phagocyte which has eaten an invader, travels to the nearest lymph node to give information about the captured pathogen. The phagocyte displays an antigen fragment from the invader on its own surface, a process called antigen presentation. The receptor of a helper T cell recognizes the antigen and the helper T cell is activated. Once activated, helper T cells start to divide and to produce proteins that activate B and T cells as well as other immune cells.

**Side note:** Antibodies are also known as immunoglobulin

**Side note:** Each B cell and T cell is specific for a particular antigen. What this means is that each is able to bind to a particular molecular structure. Much like the enzyme lock-and-key model.

**Side note:** Cytokines are a group of Signaling Compounds that are used for communication between cells. They coordinate the functions of cells so that they can act together as a whole, such as in the immune response.
Vaccinations

- Vaccine is the process of putting antigens into a person body so they become immune, without having to actually suffer the disease to become immune.
- **Vaccines cause memory B-cell and memory T-cells to be produced.**

► Small Pox
A viral (infectious) disease, with a high death rate that was totally eliminated by 1977 after a world-wide effort to eradicate it.

► Polio
A horrible viral disease that results in paralysis of limbs, has a vaccination that has been used worldwide since 1950, almost eradicking the disease except for a few african regions. Minor outbreaks in other countries are rare.

► Diphtheria
A disease cause by a very contagious bacterium, leaving serious nerve and heart problems even when the infection had been cured. Thus, prevention was definitely better than cure. It was successfully eradicated by the 1970’s.

Epidemiology

- An epidemic is an outbreak of a disease that affects a large number of people in a particular place at the same time. Epidemi-(c)-ology is the study of epidemics, especially by looking for certain patterns and correlations that could indicate the cause or how the disease is spread. It is based on careful collection and analysis of statistical information.
- Data may be collected from hospitals and health care workers, from government census’ etc.

- The epidemiology study of lung cancer is a good example: The correlation between lung cancer and smoking was suggested by epidemiology as early as the 1950’s. Big tobacco companies refuted the claim, yet multiple experiments where conducted, based on the results, eventually becoming overwhelming.
- Public Awareness Advertisements showed a decrease in the amount of smokers in the population, and with it a decrease in the incidences of lung cancer.

Lung Cancer & Smoking

- The difficulty that arises with epidemiology studies, is that it is difficult to establish a **Cause & Effect** relationship. For example, it is one thing to say that everyone with a certain disease also watches television, but to make the next step, and say that television caused the disease, requires experimentation.
- **Cause**: It is only now that we know that tobacco smoke contains many carcinogens such as benzene.
- **Effect**: The result is an uncontrolled growth of tumors in the lungs, causing them to eventually collapse. (both the lungs and the people)
Inherited: Hemophilia

- Inherited diseases are caused by gene and chromosome abnormalities and are transmitted by reproduction.

Hemophilia is a disease in which a person's blood lacks certain blood clotting "factors". **Cause:** It is caused by a recessive sex-linked gene. It is carried on the X chromosome and so it is inherited more commonly in males than females.

**Occurrence:** Occurs in males only, at a rate of 1 in every 5,000 births.

**Symptoms:**
- Body is unable to stop bleeding from even minor injuries
- Even with gentle activity there is internal bleeding, extreme pain at joints and disability.
- Untreated, Hemophilia is usually fatal in childhood.

**Treatment / Management:** Treatment involves 2-3 injections per week of blood clotting factors extracted from donated blood. - Allows sufferers to live relatively normal life.

Nutritional: Scurvy

- Nutritional diseases are caused by incorrect or insufficient diets. It can be over-eating (obesity) or under nourishment (anorexia)

Scurvy is a disease in which a main protein “collagen” of the skin, bone and hair cannot be produced, so hair begins to fall out, skin discolors and teeth fall out. **Cause:** Lack of vitamin C in the diet. Vitamin C is found in fruits such as oranges, and in some vegetables such as tomatoes. - used to be common on ships - no fresh food.

Environmental: Melanoma

- Many factors in the environment can cause disease, e.g. pollution or radiation.

Melanoma is a cancer that causes dark, irregular shaped moles to occur on the skin. The cells from these tumors can then spread to other vital organs in the body. **Cause:** UV radiation damages skin cells, causing mutations in the DNA that greatly increase the risk of a Melanoma developing.
Quarantine in Australia

- Australia’s agricultural industry is not only important for supplying us with food, but also a major part of the economy. Disease / pests could have a devastating impact.
- In Australia, quarantine is a major strategy used to prevent the entry and spread of a variety of plant / animal diseases and pests.
- Certain plant seeds, certain foods, soil/ plant matter are all prohibited from entering.
- People who wish to bring live animals, must have them quarantined - put through a long process of isolation where vets make sure they are free from disease.
- People entering from certain “risky” parts of the world must show proof of vaccination.

The Success of Quarantine

- Because of Australia’s strict quarantine rules, Australian plants and animals do not have some of the serious diseases found in other countries. - Effective /o/ woo
- E.g. foot-and-mouth disease / mad cow disease: Which would devastate sheep and cattle
- Malaria & Rabies: Serious human diseases.
- Fruit flies: (preventing spread across regions of Aus) Cause severe damage to fruit crops (this is why fruit is not able to be brought across borders)

Pesticides

Using pesticides on the vectors of the malaria disease was one strategy to help control / prevent disease.
DDT, is the pesticide that was used to kill populations of the Anopheles mosquito, the vector of malaria. It was very effective in the beginning, ridding many areas of the world from malaria, but then pesticide-resistance reduced its efficiency. Many areas have DDT-resistant mosquitos. Other pesticides have since become popular.

Pathogens and Insect Damage on Plants

Blight
Causes death of plant tissue

Gall
A growth or swelling caused by an invasion of pathogens

Eucalyptus Rust
Caused by a fungus

Caterpillars
Cause damage to the leaf e.g. Ochrogaster lunifer

Prevention instead of Cure

In the field of human disease control, the emphasis has shifted from treatment and cure, towards prevention. While antibiotics still have their value as treatment drugs, the great success story of human health has been mass vaccination to prevent millions of people ever getting certain diseases. The same trend is occurring with plant and animal diseases, and pest control -- Quarantine (stop before happens)