Blood & Immunity
Blood Composition

- The blood is a tissue (made of cells) and fluid called plasma.

- Plasma is mainly water, with dissolved solutes (e.g. glucose, amino acids).

- 91% water
- 7% proteins
- 2% nutrients

5 million RBC per mm$^3$
Red Blood Cells

- Carry oxygen using hemoglobin
- “bi-concave” shape
- In healthy people, most common type
• RBC develop in the bone marrow and circulate for about 100–120 days in the body before their components are recycled by white blood cells

• Do not have a nucleus
White Blood Cells

- Part of the immune system (fight disease)
- Have a nucleus
- produced from special cells in bone marrow
Platelets

• Small (1/5 size of RBC), irregular shape

• The sticky surface lets them form clots to stop bleeding.
Usually, every time you have a cut or bruise, your blood clots to stop the bleeding.
HEMOGLOBIN (Hb)

• Each red blood cell contains 280 million Hb molecules

• Hb contains iron (about 2 grams in entire body)

• Increases O$_2$ carrying capacity 70 times

• Each Hb molecule can temporarily bind 4 O$_2$ molecules
Carbon Monoxide

• CO tends to bind very tightly to Hb which prevents $O_2$ from being transported

• colourless, odorless, tasteless

• Hb and CO is approximately 230 times stronger than between hemoglobin and $O_2$ so hemoglobin binds to CO in preference to oxygen
Symptoms of poisoning

• lightheadedness, confusion, headache, and flu-like effects
Four people were transported to hospital in critical condition following exposure to carbon monoxide in a southeast Edmonton home.

Edmonton Fire Rescue spokeswoman Chrystal Coleman said fire crews were called to assist Alberta Health Services at a residence near 37A Avenue and 23rd Street at 4:11 p.m. on Sunday.

“The call was five patients affected by carbon monoxide that was coming from a car idling in a garage,” Coleman said.

The car had idled in the garage for approximately 40 minutes, with the garage door half open. The car was turned off but the person who called emergency services symptoms said the patients were still experiencing symptoms.

Coleman said Atco Gas was also at the scene investigating. Carbon monoxide is colourless, odourless and tasteless.

Alberta Health Services confirmed Sunday evening that of the five people transported to hospital, four remained in critical condition and one was in non-life threatening condition.

pparsons@edmontonjournal.com
Buffers

• an aqueous solution that resists changes in pH when an acid or a base is added

• Buffers resist changes in pH

• All the carbon dioxide being added to the blood as a waste product of cellular metabolism tends to change into **carbonic acid**, $\text{H}_2\text{CO}_3\ (\text{aq})$

• $\text{CO}_2\ (\text{aq}) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{CO}_3(aq)$
• This tends to decrease the pH of the blood

• If left unchecked, it would lead to *acidosis*

• an enzyme changes the carbonic acid to *bicarbonate*, \( \text{HCO}_3^- \) (aq)

• \( \text{H}_2\text{CO}_3 \) (aq) \( \rightarrow \) \( \text{HCO}_3^- \) (aq) + \( \text{H}^+ \) (aq)
Bicarbonate cont’ed

• The bicarbonate is carried in the plasma to the lungs where it is changed back into carbon dioxide and water

• The carbon dioxide diffuses into the lungs and is exhaled
(a) CO₂ carried in RBC

(b) HCO₃⁻ dissolved in plasma as carbonic acid

(c) CO₂ dissolved in plasma

CO₂ + H₂O → H₂CO₃ → HCO₃⁻ + H⁺
### The pH Scale

<table>
<thead>
<tr>
<th>Acid</th>
<th>Neutral</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0-6</td>
<td>13-14</td>
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<tr>
<td>1</td>
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<td>6</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>4</td>
<td>4</td>
<td>11.0</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>11.0</td>
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<tr>
<td>6</td>
<td>2-2.9</td>
<td>11.0</td>
</tr>
<tr>
<td>7</td>
<td>3-3.9</td>
<td>11.0</td>
</tr>
<tr>
<td>8</td>
<td>4-4.9</td>
<td>11.0</td>
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<tr>
<td>9</td>
<td>5-5.9</td>
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<tr>
<td>10</td>
<td>6-6.9</td>
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<td>11.0</td>
</tr>
<tr>
<td>14</td>
<td>10-10.9</td>
<td>11.0</td>
</tr>
</tbody>
</table>

- **Acid**
  - Lemon juice (2.0)
  - Stomach acid (2.0)
  - Peat moss (3.0)
  - Orange juice (4.0)

- **Neutral**
  - Blood (7.3)
  - Seawater (8.2)
  - Baking soda (8.5)

- **Alkaline**
  - Ammonia (11.0)
  - Garden lime (13.0)
  - Strong lye (14.0)

Graph (c) Marion Owen
Blood pH Levels

- **Death**: pH 6
- **Acidosis**: pH 7
- **Normal pH**: pH 7.35
- **Alkalosis**: pH 7.45
- **Death**: pH 7.8

The pH levels are indicated with different colors and emotional icons for visual representation.
Immune System
• Your immune system fights **foreign invaders** *(PATHOGENS)*
• Bacteria
• Viruses
• Fungi
• Toxins
• Particulate matter (dust, pollen, etc)
• Organ transplants
The first lines of defense against foreign invaders:

- **Skin**
  - Acts as a barrier

- **Hairs and Cillia**
  - Filter out and sweep away dust particles

- **Stomach Acid**

- **Mucous and Wax**
  - Trap then flush particles

**Inner ear cilia**

**E-Z Ear Wax Remover**
- LED-light lets you see into the ear to remove wax safely.
• Once pathogens infiltrate the body, the immune response involves several different types of white blood cells:

  • Macrophages
  • Helper T-cells
  • B-lymphocytes
  • Killer T-cells
  • Suppressor T-cells
  • Memory cells
Step 1: Macrophages:

- When an area is infected, a hormone is released which attracts macrophages. (Greek for “big eater”)
"Walking macrophage": A major player in the body's immune system, this white blood cell is probing an air sac in a human lung with pneumonia. It was looking for debris, bacteria or other foreign matter that it would have ingested like a tiny vacuum cleaner. x7000
• An antigen is a substance/molecule that, when introduced into the body, triggers the production of an antibody by the immune system
• Macrophages engulf the germ and display its surface shape (antigen) for other immune cells to see
Step 2: Helper-T cells

- Identifies the foreign antigen on the macrophage and begins to multiply

- Alerts B cells and direct the body's defence
Step 3: B-cells

- Make antibodies that lock onto foreign antigens making it easier for other immune cells to destroy them.
• They also release a hormone, which causes the B-cells to divide rapidly, producing large amounts of the antibody.

• **Antibodies** are large Y-shaped proteins which function to identify and help remove foreign antigens or targets such as viruses and bacteria.
• Antibodies are effective only against 1 antigen

• Antibodies attach to the antigens to deactivate them
Step 3b: Cytotoxic “Killer” T cells

- The surface of infected cells changes, and this change is recognized by T cells.

- killer T cells kill infected cells, preventing these cells from producing more pathogen
1. Cytotoxic T cell binds to infected cell
2. Perforin makes holes in infected cell's membrane
3. Infected cell lyses

Infected cell with foreign antigen
Perforin molecule
Cytotoxic T cell
Hole forming
Step 4: Suppressor T-cells

• Regulates the immune response

• Responsible for turning off the immune response after an infection has been cleared
Step 5: Memory B cells

• Some B-cells retain memory of the foreign invader and rest until another infection of the same pathogen occurs.

• If the same pathogen infects the person, the memory cells produce the antibodies.

• See pages 64, 65 in text.
Antibiotics

• In 1929, Alexander Fleming discovered penicillin.

• Many other antibiotics have been developed since then.
Hansen’s disease
At the age of 7, this girl had thickened facial skin due to Hansen’s disease. After 2 years of treatment with antibiotics, her appearance had improved dramatically.
• Antibiotics are not effective against viral infections

• Some pathogens are becoming immune or resistant to antibiotics.
I THINK I NEED ANTIBACTERIALS FOR MY COL...

Colds are VIRAL!
## Antibiotic resistant infections

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Pathogen</th>
<th>Resistances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td><em>Streptococcus pneumoniae</em></td>
<td>Penicillin</td>
</tr>
<tr>
<td>Dysentery</td>
<td><em>S dysenteriae</em></td>
<td>Multiple resistances</td>
</tr>
<tr>
<td>Typhoid</td>
<td><em>Salmonella typhi</em></td>
<td>Multiple resistances</td>
</tr>
<tr>
<td>Gonorrhea</td>
<td><em>N gonorrhoeae</em></td>
<td>Penicillin and tetracycline</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td><em>M tuberculosis</em></td>
<td>Rifampicine and INH</td>
</tr>
<tr>
<td>Nosocomial infections</td>
<td><em>S aureus</em></td>
<td>Methicillin, vancomycin</td>
</tr>
<tr>
<td></td>
<td><em>E species</em></td>
<td>Vancomycin</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella pneumoniae</em></td>
<td>Multiple resistances</td>
</tr>
</tbody>
</table>
Biologists Discover New Method for Discovering Antibiotics

Biologists at the University of California, San Diego have developed a revolutionary new method for identifying and characterizing antibiotics, an advance that could lead to the discovery of new antibiotics to treat antibiotic resistant bacteria.

The researchers, who published their findings in this week’s early online edition of the journal *Proceedings of the National Academy of Sciences*, made their discovery by developing a way to perform the equivalent of an autopsy on bacterial cells.

“This will provide a powerful new tool for identifying compounds that kill bacteria and determining how they work,” said Joseph Pogliano, a professor of biology at UC San Diego who headed the research team. “Some bacteria have evolved resistance to every known class of antibiotic and,
“This will provide a powerful new tool for identifying compounds that kill bacteria and determining how they work,” said Joseph Pogliano, a professor of biology at UC San Diego who headed the research team. “Some bacteria have evolved resistance to every known class of antibiotic and, when these multi-drug resistant bacteria cause an infection, they are nearly impossible to treat. There is an urgent need for new antibiotics capable of treating infections caused by antibiotic resistant bacteria.”

The Centers for Disease Control and Prevention issued an alarming report in March that antibiotic-resistant strains of Carbapenem-Resistant Enterobacteriaceae, or CRE, had been found to cause infections in patients in nearly 200 hospitals in the United States alone. Because no antibiotics on the market are effective at treating these infections, about one-half of patients die from CRE infections. These outbreaks are difficult to contain, and in a 2011 outbreak of Klebsiella pneumonia at the U.S. National Institutes of Health Clinical Center, the bacteria spread despite strict infection control procedures and was detected in drains and medical devices that had been subject to standard decontamination protocols.

“We are finally running out of the miracle drugs,” said Pogliano, who detailed the history: The antibiotic penicillin was first discovered in the late 1920s, and received widespread clinical use in the 1940s. However, bacteria quickly evolved resistance to penicillin, so new and better versions were developed. Since that time, a continuous race has been fought to identify new antibiotics in order to stay one step ahead of the evolving resistance. In the 2011 outbreak of Klebsiella, the bacteria evolved resistance even to colistin, a drug of last resort because of its severe side effects.
Highly drug-resistant gonorrhoea is spreading in the north of England with an outbreak centred in Leeds, sexual health doctors have told the BBC.

One of the main treatments has become useless against the new strain of the sexually transmitted infection.

Twelve cases have been confirmed in Leeds and a further four have been reported in Macclesfield, Oldham and Scunthorpe.
• The outbreak in Leeds adds to growing concern that gonorrhoea is becoming untreatable.

• In 2011, Japan reported a case of complete resistance to cephalosporin-class antibiotics, which included the main treatment ceftriaxone.
Vaccinations

- Involves the injection of dead or weakened pathogens into the body

- Immune system then produces antibodies
Diseases and their decline in the U.S. since vaccinations were introduced.
Federal health officials are warning that measles — a highly-contagious respiratory infection that the U.S. virtually eradicated back in 2000 — is making a serious comeback. This year is on track to have the highest number of measles cases in the past 17 years, and Centers for Disease Control (CDC) researchers say that’s likely because of pervasive anti-vaccine beliefs that have allowed the disease to spread.

The CDC investigated a decades’ worth of measles cases, including new data from as recently as last month, and concluded that the number of infections have been steadily creeping up in recent years. There used to be about 60 annual cases of measles in the U.S. But so far this year, 159 cases of measles have been reported.

Most of this year’s infections stemmed from three different outbreaks: 58 cases in New York City, 23 cases in North Carolina, and 21 cases in Texas. CDC
Polio victims
Polio strain spreads to China from Pakistan

Polio has been found in China for the first time since 1999 after spreading from Pakistan, the World Health Organization (WHO) has confirmed.

It said a strain of polio (WPV1) found in China was genetically linked with the type now circulating in Pakistan.

At least seven cases have now been confirmed in China's western Xinjiang province, which borders Pakistan.

The WHO warned there was a high risk of the crippling virus spreading further during Muslim pilgrimages to Mecca.

Polio (also called poliomyelitis) is highly infectious and affects the nervous system, sometimes resulting in paralysis.

It is transmitted through contaminated food, drinking water and faeces.

'Right things done'

On Tuesday, the WHO said the polio cases in Xinjiang had been detected in the past two months.

The Chinese authorities are now investigating the cases, and a mass vaccination campaign has been launched in the region.

"So far all the right things are being done," WHO spokesman Oliver Rosenbauer told Reuters news agency.

Polio was last brought into China from India in 1999. China's last cases were reported in 1994.
• Smallpox was one of the world's most feared diseases until it was eradicated by a global vaccination programme led by the World Health Organization.

• The last known natural case was in Somalia in 1977
References to measles can be found as far back as the 7th century A.D. Measles was described by the philosopher Rhazes in the 10th century A.D. as "more dreaded than smallpox."

In 1529, a measles outbreak in Cuba killed two-thirds of the natives who had previously survived smallpox. Two years later, measles was responsible for the deaths of half the population of Honduras.

Measles killed nearly 12,000 people in the United States in 1916, 75% of them younger than five years old.

In roughly the last 150 years, measles has been estimated to have killed about 200 million people worldwide.

Before the vaccine became available in 1963, measles caused approximately 450 deaths annually in the USA.

We have an extremely effective vaccine, but measles is making a comeback. Unvaccinated children are extremely likely to catch it if exposed.

Remember - Vaccinations Save Lives
Figure A1.18: This graph shows how the concentration of antibodies is influenced by vaccination and a second exposure.
Measles Complications

- Pneumonia, acute encephalitis, corneal ulceration
PRE-VACCINE ERA
ESTIMATED ANNUAL
MORBIDITY IN THE U.S.

% DECREASE

MOST RECENT
REPORTS OF
CASES IN THE U.S.

- DIPHTHERIA 100%
  - 21,053
  - 0

- H. INFLUENZA 99%
  - 20,000
  - 243

- HEPATITIS A 91%
  - 117,333
  - 11,049

- HEPATITIS B 83%
  - 66,232
  - 11,269

- MEASLES 99%
  - 530,217
  - 61

- MUMPS 99%
  - 162,344
  - 982

- PERTUSSIS 93%
  - 200,752
  - 13,506

- PNEUMOCOCCAL DISEASE 74%
  - 16,069
  - 4,167

- POLIO 100%
  - 16,316
  - 0

- RUBELLA 99%
  - 47,745
  - 4

- CONGENITAL RUBELLA 99%
  - 152
  - 1

- SMALLPOX 100%
  - 29,005
  - 0

- TETANUS 98%
  - 580
  - 14

- VARICELLA 89%
  - 4,085,120
  - 449,343
Weakened pathogen is injected into the body

White blood cells respond to presence of pathogens (identify the antigen which is a protein)
White blood cells make an antibody

Antibodies are mass-produced which will bind to the antigen on the pathogen
If you lived in the USA in 1900, you had a 53% chance of dying from an infectious disease by the time you were 47. That means over half of these people would not live to 50. Average life expectancy was 47.

In 2010 only 3% of people died of an infectious disease before their 79th birthday, so the chances are you will live long enough to die of something else. Average life expectancy was 79.

Ref: http://tinyurl.com/kwmowpn
Immune Disorders

- Often occur due to an overactive or “confused” immune system.

- Allergies occur when the immune system mistakes harmless substances for invaders.
**ALLERGENS**

**ALLERGENS** may be classified by their route of primary exposure: **INHALED, INGESTED, CONTACTED AND INJECTED**

<table>
<thead>
<tr>
<th>INHALED ALLERGENS:</th>
<th>&gt;Pollens</th>
<th>&gt;Molds/fungi</th>
<th>&gt;House dust mites</th>
<th>&gt;Animal danders</th>
<th>&gt;Cockroaches</th>
<th>&gt;Latex particles</th>
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</thead>
<tbody>
<tr>
<td>INGESTED ALLERGENS:</td>
<td>&gt;Foods</td>
<td>&gt;Drugs</td>
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<tr>
<td>CONTACT ALLERGENS:</td>
<td>&gt;Plants</td>
<td>&gt;Drugs</td>
<td>&gt;Cosmetics</td>
<td>&gt;Jewelry</td>
<td>&gt;Latex products</td>
<td>&gt;Occupational chemicals/dyes</td>
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<tr>
<td>INJECTED ALLERGENS:</td>
<td>&gt;Drugs</td>
<td>&gt;Allergy products</td>
<td>&gt;Blood products</td>
<td>&gt;Stinging insects</td>
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</tr>
</tbody>
</table>

**COMMON ALLERGENS:**

> Dust mites  > Pollens from weeds, grasses and trees  > Animal dander and molds
Autoimmune Disorders

• The immune system attacks the body’s own cells

• Failure of suppressor T cells to control mutated killer T cells, and B cells

• Rheumatoid Arthritis, Multiple Sclerosis, Type 1 Diabetes, Inflammatory Bowel Diseases, Psoriasis
Arthritis

• inflammation causes tissue damage that the body tries to deal with by creating more inflammation.

• The inflammation causes swelling, pain, redness and a loss of motion in the joint; it can change the bones and connective tissues, reducing their ability to function.
• Drugs and infections can weaken suppressor T cells

• The # of suppressor T cells decreases with age
Immune System Suppression: (underactive immunity)

- Immunosuppression disorders can occur from birth or be acquired (AIDS)
Immunosuppressant drugs are often used to prevent the immune system from attacking transplanted tissue.
H.I.V. and A.I.D.S

• HIV: Human Immunodeficiency Virus

• HIV infects and destroys helper-T cells

• This reduces the ability of the whole immune system to fight pathogens
• The result is AIDS: Acquired Immunodeficiency Syndrome
• *HIV* antigens change shape often making vaccines ineffective.

• *HIV* particles may remain dormant for years inside of helper T-cells.
Histamine

• histamine causes capillaries to become more permeable to white blood cells and other proteins to attack foreign bodies in the affected tissue.

• This causes inflammation, which lets other chemicals from your immune system step in to do repair work.

• Also triggers the release of mucous
• https://www.youtube.com/watch?v=pJa6KVLwl9U&t=137s