**B cell response**

Macrophage and helper T cell involvement with initiating a B cell response:

Antigen fits with this B cell

Different B cell clones

Making antibodies

When specific B cells are activated, they multiply

Some cells become memory cells, stored in case of a subsequent infection

Vaccines and the quest to eliminate infectious disease

Vaccines introduce antigen (dead or weakened) to induce production of memory B & T cells, antibodies

Memory cells are activated on real exposure to bacteria, virus. Antibodies already present to label

Lung cancer vaccination
What about T cells?

T cells recognize virus-infected or cancerous body cells (cell-mediated)

- When triggered, T cells w/specific ‘self-antigen’ multiply. Killer T cells contact and release chemicals to kill the cells with the self-antigen marker.

What triggers T cells?

Macrophages “wear what they eat” (in this case, self marker plus antigen from pathogen, or self markers on cancerous cells)

- Helper T cells are triggered and activate killer T cells and memory T cells.

Self marker + antigen

Antigens and MHC Proteins

- MHC protein
- Antigen
- Foreign microbe
- Processed antigen

Helper T-cell activation and the B and T cells formed as a result

- Humoral immunity: formation of antibodies by plasma cells
- Cell-mediated immunity: attack on infected cells
How Killer T-cells kill body cells

Virus invades host cell

Protein coat has antigen

Host cell

How Killer T-cells kill body cells

Viral antigen is displayed on surface of host cell with self-antigen

Host cell

How Killer T-cells kill body cells

Killer T cell recognizes and binds with a specific foreign antigen complex

Host cell with virus

Killer T cell

How Killer T-cells kill body cells

Killer T cell releases chemicals that destroy cell

Foreign viral antigen

Self-antigen
Helper T cells

Helper T cells do not kill cells, but amplify effects of other WBCs:
- Enhance production of T and B cells, make chemotaxins for phagocytes
- “Master switch” for immune response

So…what are these self markers?

The MHC is a set of genes that code for glycoproteins on cell membranes and mark cells as “self”

So…what are these self markers?

Matching MHC markers is important when transplanting organs

Bacterial infection:
- At first: phagocytes, histamine release, inflammatory response
- Inflammation brings phagocytes, plasma proteins (complement system, clotting proteins)
- Bacteria antigen stimulates helper T cells, B cells get activated: antibodies
- Bacteria get labeled w/antibodies, killed by complement, macrophages, killer cells.

This slide is just another way to organize things for immune response to help study. I won’t use in lecture
Viral infection:

- Virus inside body cells **do not** trigger macrophages, B-cells, or complement.
- Virus-infected or cancerous cells release interferon, signaling neighboring cells and attracting natural killer cells, macrophages, complement. Virus ‘out in the open’ can be attacked.
- Self-antigen combination triggers T-helpers, which help stimulate killer T cells (takes days) and attract macrophages to the area.

This slide is just another way to organize things for immune response to help study. I won’t use in lecture.

Blood groups

ABO blood types are named by antigens on the surface of RBCs: A, B, AB, or O (neither antigen).

- People acquire antibodies for the blood antigens they do not have on their RBCs.
- Blood type O: universal donor (no antigens).
- Blood type AB: universal recipient (no antibodies)

Allergies: adaptive immunity gone wrong

Reactivity to a harmless substance in environment

Common triggers: pollen, molds, bee stings, dust, fur, mites, penicillin

- **Hives** - allergens on skin
- **Hay fever** - allergens in nasal passages
- **Asthma** - allergens in airway
Allergies involve a particular type of antibody – IgE antibodies

IgE antibodies trigger mast cells and basophils to produce histamine and other chemicals at the site of the allergens

How does the immune system react differently for different allergies?

Skin: Besides IgE response, can be a T-cell response to substance (ex: urushiol oil)

Airway: besides histamine, leukotrienes are released – airway constricted

Gut: traditional food allergies are IgE (egg, milk, wheat, nuts, shellfish, etc.) Histamine dilation, leukotriene constriction.
Some are T-cell allergies w/delayed effects (gluten, milk).

Anaphylactic shock

Systemic anaphylaxis- when large amounts of histamine and inflammatory signals are released all at once to blood.

- Widespread dilation - hypotension. Airway constriction. Victim can die within minutes. Often due to penicillin, bee venom.

- How does the immune system react differently for different allergies?

  - They generally reduce the histamine signal
  - They can be bronchodilators, reduce leukotrienes, decongestants (constrict capillaries), injectable epinephrine, anti IgE
  - Corticosteroids inhibit expression of cytokines and other signals of inflammation

What do allergy medications do?
Development of ‘tolerance’
Tolerance of substances develops early via clonal deletion of specific lymphocytes

- **Central tolerance**: B and T cells that respond to self-antigen are destroyed
- **Error** often results in autoimmune disease
- **Peripheral tolerance**: regulatory cells inhibit response to environmental antigens
- **Error** often results in allergies
  
  Allergies can have late onset, even in adulthood

Hygiene hypothesis
Keeping a child’s environment ‘too clean’ may prevent proper development of immune system

- **Recent study**: Exposing ‘high-risk’ infants to peanuts reduced later allergies by 80%

What are autoimmune diseases?
Immune system wrongly attacks body cells, often caused by production of autoantibodies

- **Rheumatoid arthritis** – autoantibodies attach to joints and induce inflammation & attack by complement, and WBCs

A few immune related disorders:

- Diabetes Type I
- Crohn’s Disease
- Multiple Sclerosis
- Pernicious anemia
- Addison’s disease
- Lupus
Triggering of autoimmune disease

AI diseases often have an environmental trigger, those with certain genotypes can be more susceptible to it.

A trigger can be an infection with antigen that is molecularly similar to markers on body cells.

Possible environmental agents: silica, mercury, nitrates in drinking water, groundwater pollutants, drugs, many other chemicals...

Respiratory system

Airway: from nasal passages down to trachea, bronchioles and alveoli. The trachea and bronchi are reinforced with cartilage.

Larynx (voicebox) has vocal cords.

Bronchioles can dilate and constrict.
Increasing cavity volume, air enters

If lung pressure is less than atmospheric pressure, air enters the lungs.

Inspiration and expiration: how we change chest volume

Transmural pressure gradient lungs will always expand to fill pleural cavity
What determines airflow?

\[ F = \Delta P / R \]

same equation as blood flow!

Major determinant of resistance is radius of bronchioles

Disease can increase resistance (asthma, bronchitis)

Surface tension at alveoli

Surface tension – whenever water layer meets air – water molecules are attracted to each other.

Surface tension along the lining of alveoli resists expansion of alveoli.

Surfactant reduces surface tension.

Gas exchange and partial pressure gradients

Air is a mixture of gases
Nitrogen is 79% of air. Its partial pressure: 0.79 x 760 = 600.4

<table>
<thead>
<tr>
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<th>Alveoli</th>
<th>Capillaries</th>
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<tbody>
<tr>
<td>(P_{O_2})</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>(P_{CO_2})</td>
<td>40</td>
<td>46</td>
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Hemoglobin saturation

Most \(O_2\) is carried by Hb - some is dissolved in plasma and determines partial pressure

Hb saturation is high where \(P_{O_2}\) is high (lungs).

Saturation remains high even \(P_{O_2}\) is 60

Small decrease in \(P_{O_2}\) makes Hb unload much more \(O_2\)

Oxygen saturation curve
Shifting the curve

Increase in CO\textsubscript{2} from tissue shifts the saturation curve to the right

Increased acidity (H\textsuperscript{+}, carbonic acid) and temperature has the same effect - Bohr effect

Most O\textsubscript{2} carried on hemoglobin

A teensy bit of O\textsubscript{2} is dissolved in plasma

Chemoreceptors sense O\textsubscript{2} dissolved in blood

Carotid and aortic bodies send info to the medulla

P\textsubscript{O2} and P\textsubscript{CO2} and H\textsuperscript{+} can be detected

O\textsubscript{2} saturation is not detected

Spirometry

Measures airflow and volume of inspiration and expiration