The Immune System

Human Body vs. Microbes

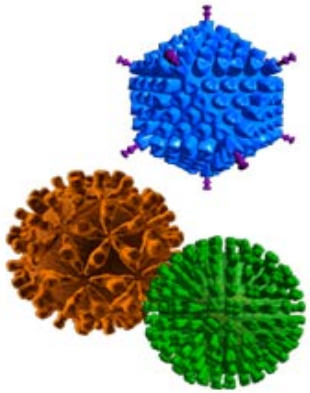
Our 1st Line of Defense...

- The Integumentary System…
  - Skin
  - Mucous membranes
  - Mucous
- provides a physical barrier preventing microbial access

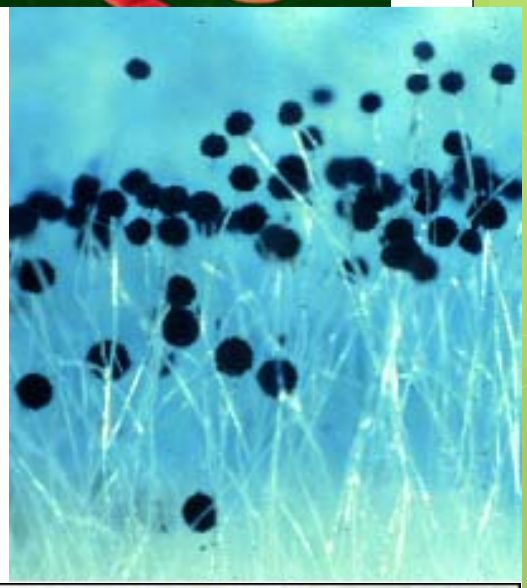
The Invaders . . .

- Bacteria

- Viruses



- Parasites
  - Fungi, protists, & worms



Other mechanisms of Defense…

- Physiological variables
  - pH of our environment
  - temperature of our environment
- Chemical defenses
  - nitric oxide, enzymes, proteins, complement
- AND the IMMUNE SYSTEM…

Immune System : 2 branches

- The Innate Immune system =
  - A general response to anything other than recognized “self cells”
- The Adaptive Immune System =
  - A specific counter-assault against a “known foreign” invader [previously recognized]

Major Concepts -

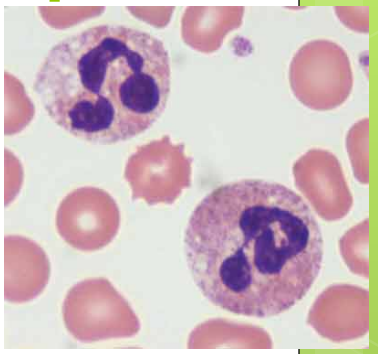
- What Happens during an infection ?
- How can immune cells distinguish foreign invaders from our own cells ?
- How can we make 100,000,000 different antibodies with only 30,000 genes ?

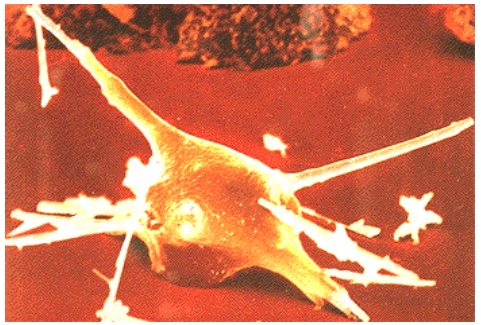
What Happens during an infection?

- Innate Immunity - the troops are called to battle…
  - Injury & infection
  - Macrophages slip between cells to arrive
  - Cytokine chemicals attract other “troops”
  - Histamine chemicals dilate blood vessels for easier access to injury
  - Innate Immunity - http://www.youtube.com/watch?v=d0fgMaQfAQw&feature=player_embedded#!

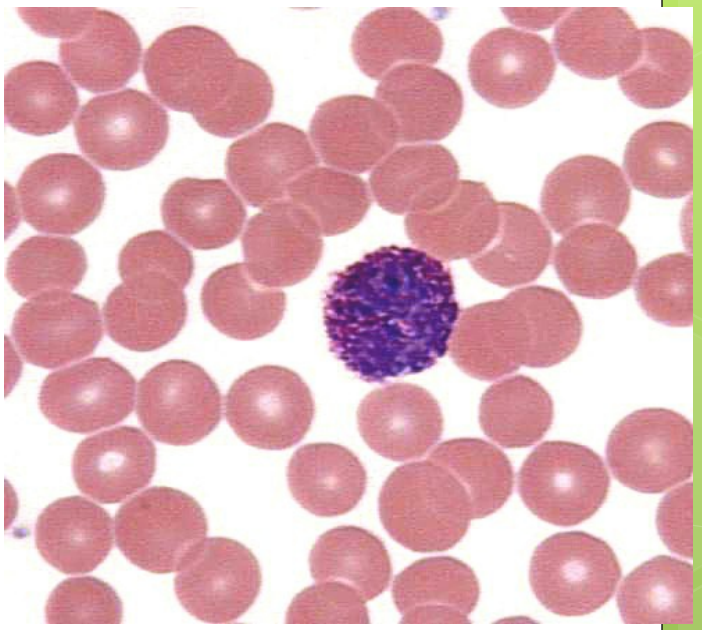
What are Macrophages?

- Phagocytic cells - able to ingest small foreign invaders
  - Neutrophils
  - Monocytes
- They release cytokines that enhance the immune response





- Mast cells /basophils
  - Release histamine that dilates blood vessels
  - Causes redness, swelling, and heat/fever



Your Challenge . . .

- You are a macrophage in the following game…
- Your mission is to phagocytize the mumps viruses
- Use your mouse on the arrows ⇐ or ⇑ or ⇒
- HINT: *antigens are specialized proteins on cell surfaces that provide I.D. recognition*
- http://www.pbs.org/wgbh/nova/aids/immunewave.html

Summary:

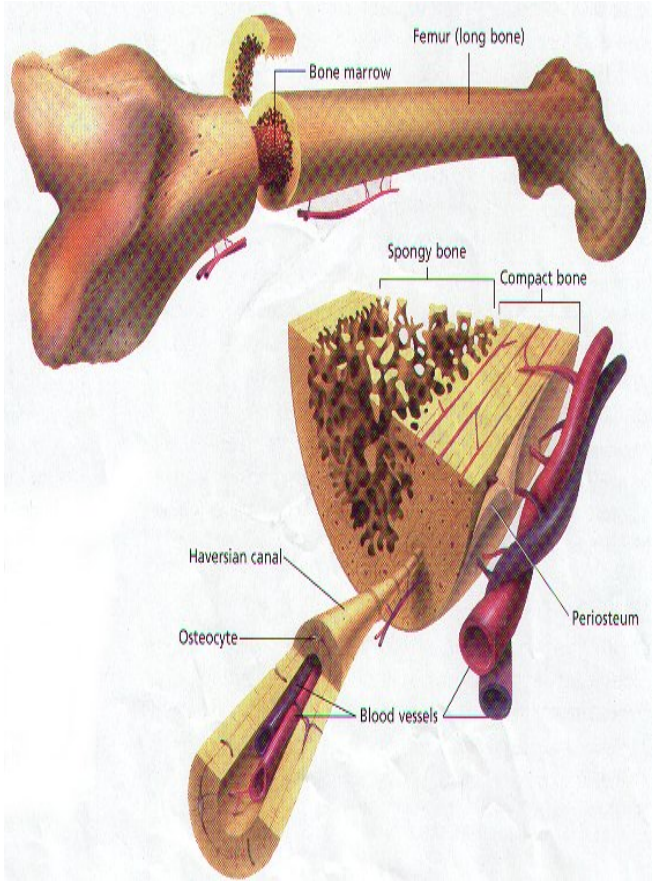
- Macrophages are able to launch the first strike…
- More help is needed to overcome rapidly reproducing invaders…
- Help from the ADAPTIVE IMMUNE System, which results in a coordinated successful defense !
- Major players . . . the B lymphocytes

How can antibodies distinguish our self from foreign invaders?

- Adaptive Immune System
- There are 2 types of lymphocytes:
  - T lymphocytes (Helper T Cells) - help signal immune cells into action
  - B lymphocytes (B Cells) - make special proteins called antibodies

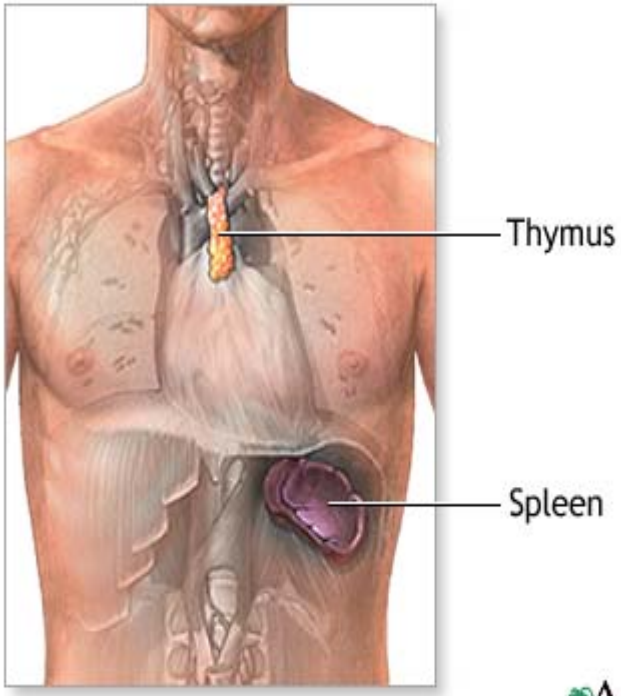
How can antibodies distinguish "self" cells from foreign invaders?

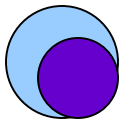
- Adaptive Immune System
- As you recall, there are 2 types of lymphocytes:
  - 1st Type - (Helper T)
    - Begins in bone marrow



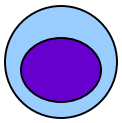
Helper T Cells then migrate to the thymus gland …

- They are sorted into 2 types:
  - Identification tag is a protein called Major Histocompatability Complex (MHC)





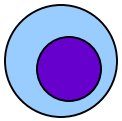
Foreign



Self- ID

& in the thymus gland . . .

- All diversely varying MHC lymphocytes will wait for a call to action . . .
- All "self" MHC cells are destroyed - to remove the chance of "friendly fire" casualties



Foreign

Saved to be educated… in body defense

Dropped out!

- These Lymphocytes will mature into T-Helper cells
- They function to stimulate B cells to activate their attack against the invaders

Adaptive Immune System

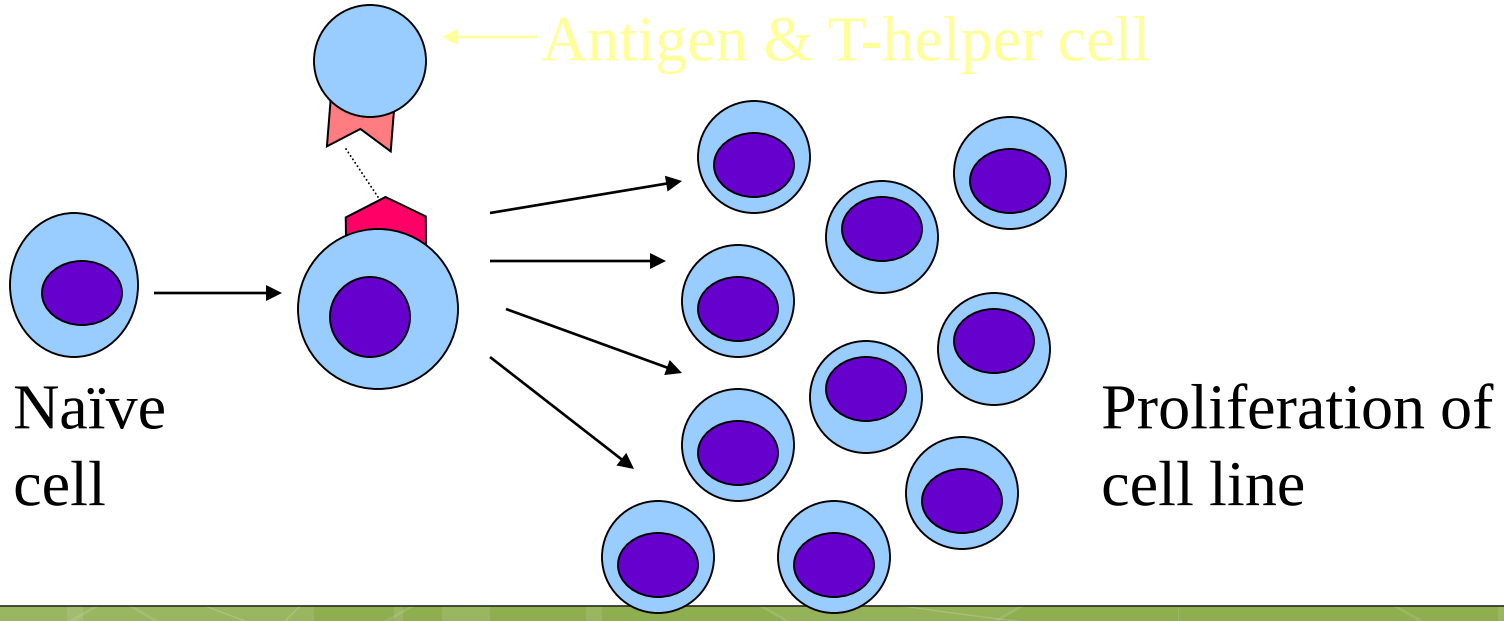
- The 2nd type of lymphocyte is:
  - B lymphocytes (B Cells) - start in the bone marrow and circulate through the body
  - They are called into action when stimulated by a foreign antigen. . .
    - Usually a protein from the invader

When an invader attacks. . .

- An antigen is phagocytized (‘eaten’) by the B cell
- Invader is then broken into non-infective pieces
- Pieces attached to the cell’s MHC when processed through the cell machinery
- MHC-antigen complex is placed on the cell membrane surface
  - Where it is recognized by the T Helper cell
- Animation: Antigen Expression Process - http://www.nature.com/nrm/journal/v2/n3/animation/nrm0301_179a_swf_MEDIA1.html

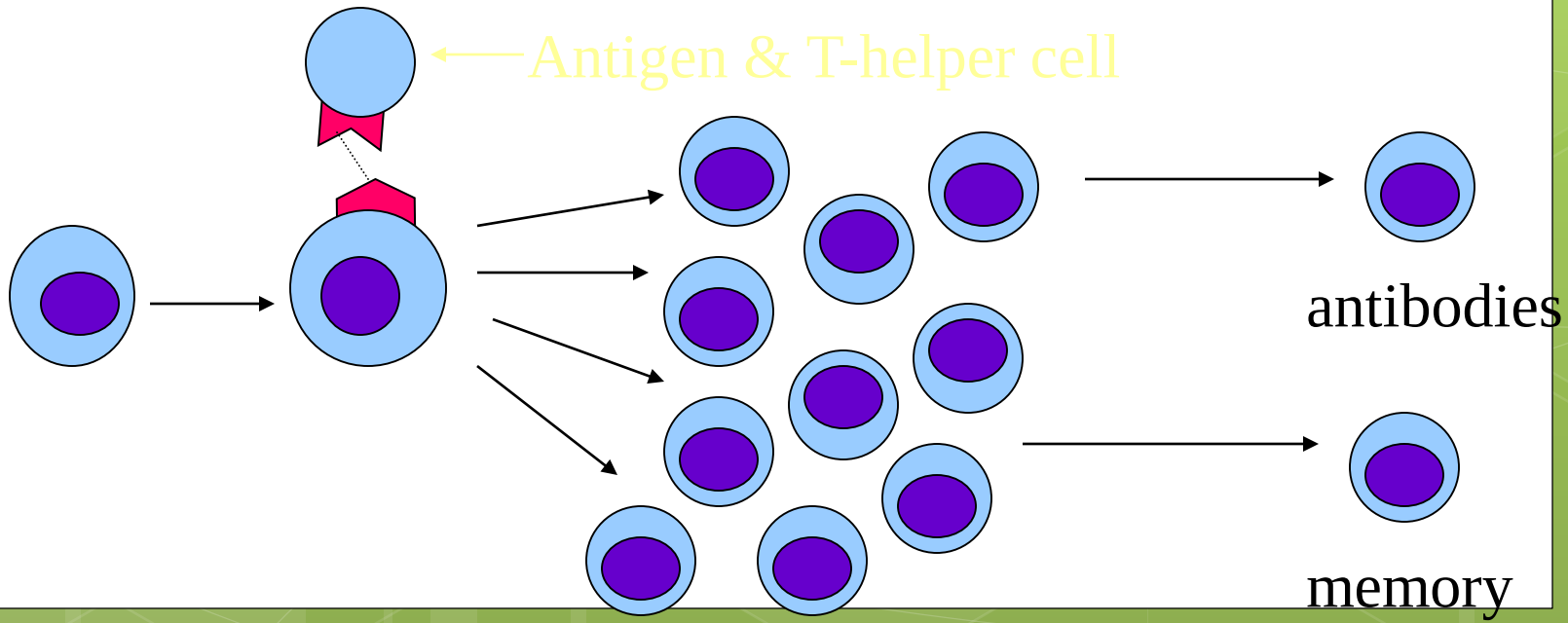
When help arrives . . .

- The T-helper cell receptor "docks" with the B cell's MHComplex
- B cells proliferate . . .



B cells differentiate into . . .

- Antibody producing cells (attack mode)
- Memory cells (future protection from same invader)



The RESULT . . .

- The Antibody producing B cells mounts a successful attack against the invader
- Memory B cells save the “recognition ID” for many years in preparation for future invasion

How can we make 100,000,000 different antibodies with only 30,000 genes?

- Problem:
  - Microorganisms easily out-number the total number of genes on the human genome
    - If only one gene was responsible for coding for one antibody, there still wouldn't be enough information to use
- Question:
  - How can such a small amount of information be used for successful antibody diversity ?

Consider the following . . .

What is true about the different cells of the body?

- Which Statement is most correct ?
  a. All cells in the body are the same and function the same way
  b. All cells are the same, but function differently because they are located in different places
  c. All cells have the same genetic material, but different cells use different active genes to make them function differently
- Does this same principle apply to antibodies ?

The correct answer is . . .

- c All cells have the same genetic material, but different cells use different active genes to make them function differently

Summary

- What Happens during an infection ?
  - The immune system activates a multitude of characters to defend the body in a variety of ways
  - Several players work together, feedback systems enhance or suppress functions as changes occur

Summary

- How can immune cells distinguish foreign invaders from our own cells ?
  - By using the invader's own antigen, immune cells can be produced for specific organisms & used to enhance the defense effort

Summary

- How can we make 100,000,000 different antibodies with only 30,000 genes ?
  - Mixing & matching pieces of genetic material produce huge numbers of antibodies
    - As well as very specific antibodies
- The immune system is well equipped to defend the human body against the daily onslaught of microorganisms . . . If everything goes as planned . . .

For further information . . .

- **Immunology Project Resources –**
- Understanding Autoimmune Disease
- http://www.niaid.nih.gov/publications/autoimmune/work.htm
- Antibody descriptions [IgG, IgM, IgA]
- http://sprojects.mmi.mcgill.ca/immunology/Ig_text.htm
- Immunology Hyperlinked History & Molecular Movies
- http://www.bio.davidson.edu/courses/Immunology/Bio307.html
- Nature Magazine & Immunology
- http://www.nature.com/nature/view/030102.html
- NCBI Genome Database
- http://www.ncbi.nlm.nih.gov/
- NCBI Genome Base
- http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=1589796
- Immune System Animation Links through Anatomy & Physiology Groups
- http://science.nhmccd.edu/biol/ap2int.htm
- Pier,G. ,_Lyczak,J., Wetzler,L; Immunology, Infection, and Immunity; American Society for Microbiology Press,2004,p.12.