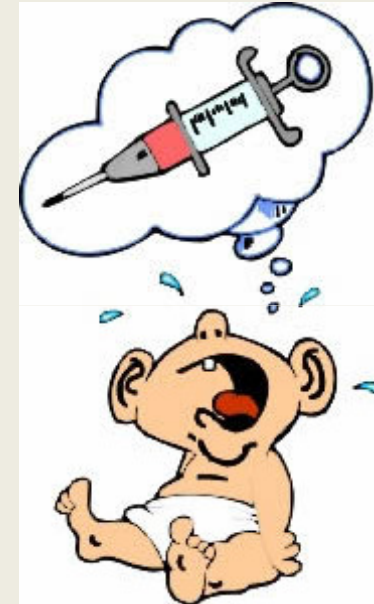
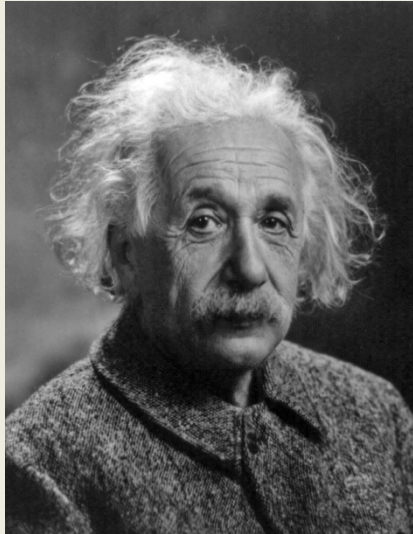


# The Immune System and Immunisation



Dr. Fiona McGuire  
SMO Public Health

# The Immune System



ALBERT EINSTEIN

*“Make things as simple as possible (but not simpler).”*

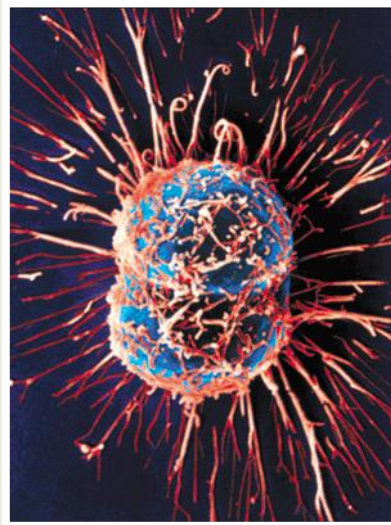
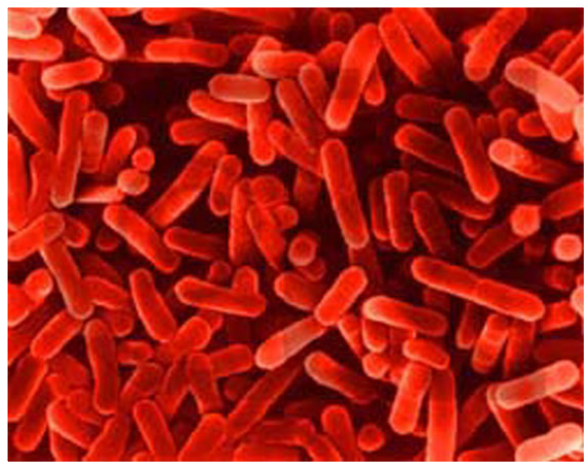
# Outline of Talk



- An overview of the immune system
- The journey of a pathogen and the obstacles it meets
- How vaccines work and how soon we are protected
- Types of vaccine – live vs inactivated
- Vaccine components
- Timing of vaccinations, timing of adverse reactions
- Herd immunity

# What is the immune system?

- The body's defense against disease causing organisms, malfunctioning cells, and foreign particles



# Pathogens

- Pathogens: disease causing agents- such as- bacteria, virus, and fungi
- Patho- sickness agent
- Gen- to create



# The Immune System – Defence Against Pathogens

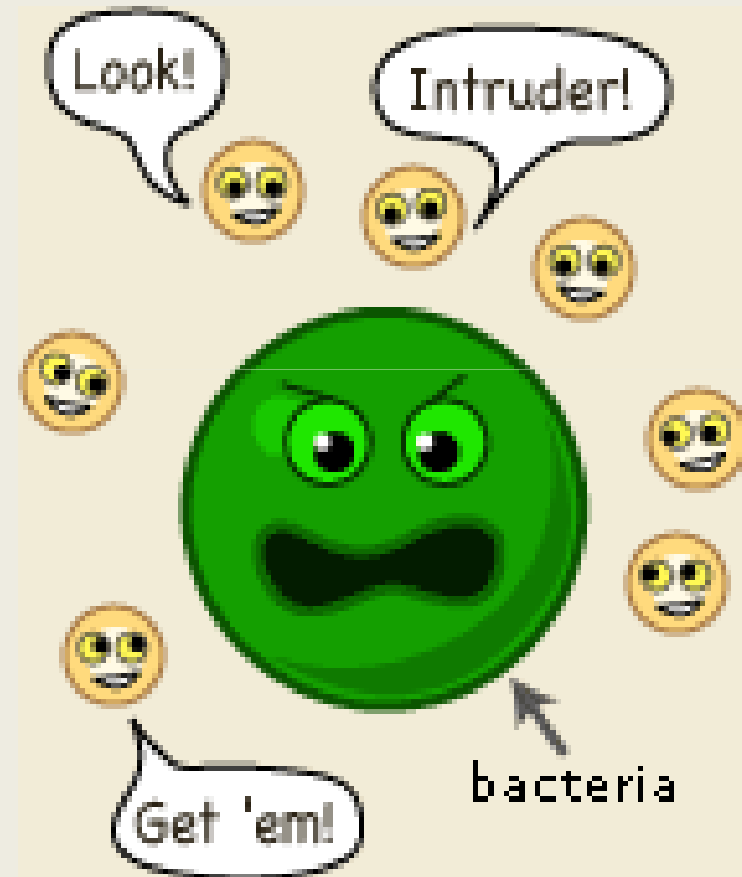
- In other words, how to stop David from killing Goliath...



# The Immune System

Array of organs, cells and chemicals that:

- Determine self from “non-self”
- Identify potential dangers to the body
- Eliminate them by mounting an immune response



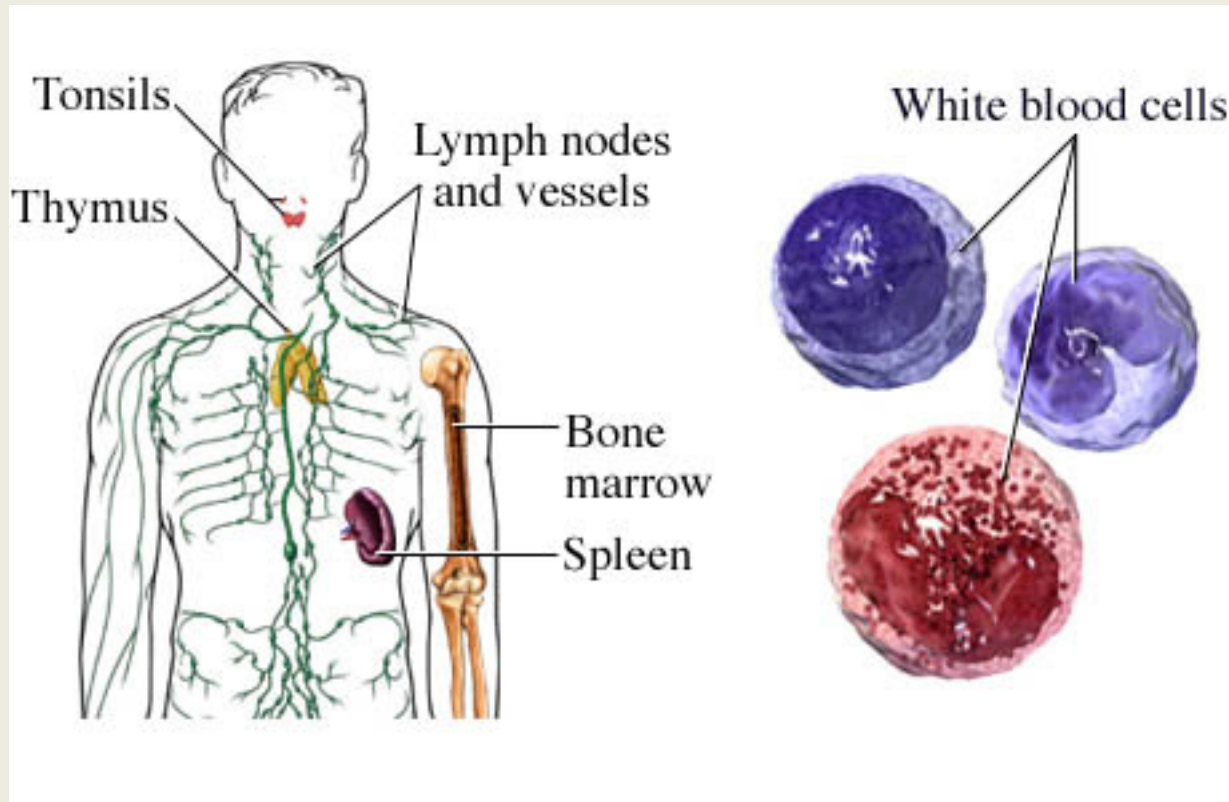
# The Infant's Immune system...

- Naive – needs exposure to foreign antigen in order to develop normally
- Maternally acquired immunity is temporary and does not protect against all infections.
- The infant immune system has the capacity to cope with a vast array of antigens at any one time.



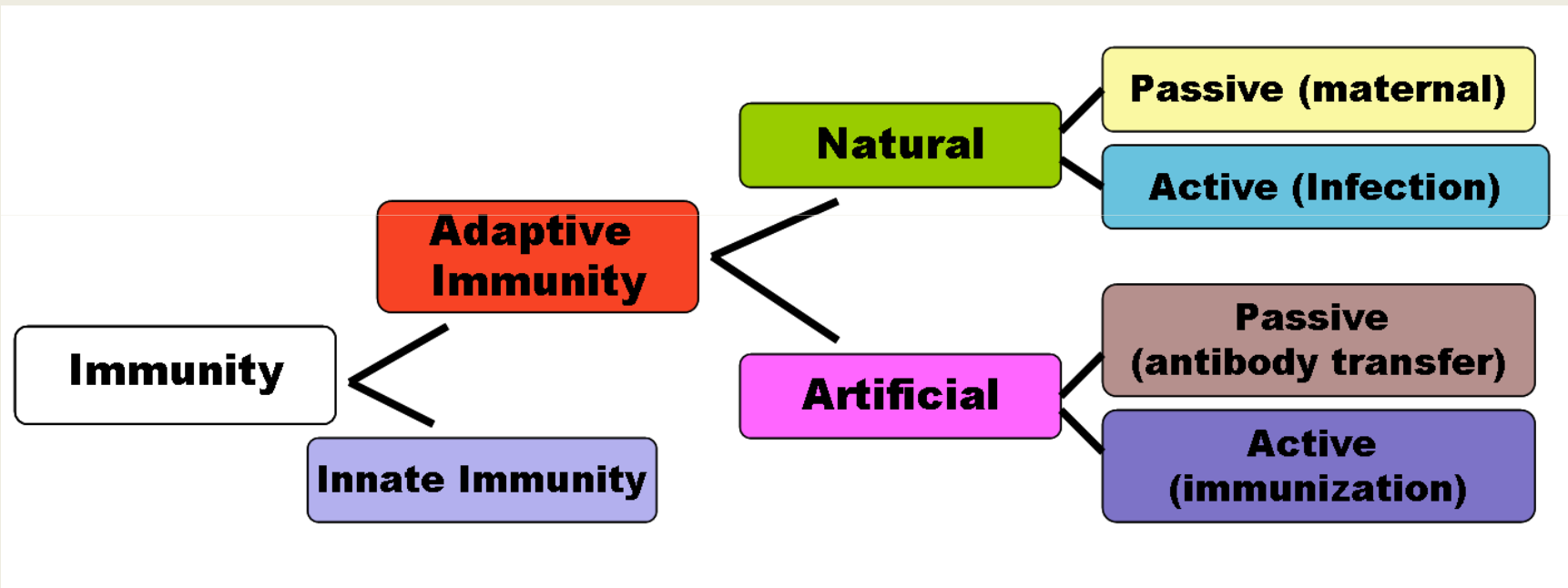


# Immune System Components



Source: <http://www.webmd.com/a-to-z-guides/components-of-the-immune-system>

# Organisation of the Immune System



# Immunity: Active and Passive

## Active immunity



Naturally acquired



Artificially acquired

## Passive immunity



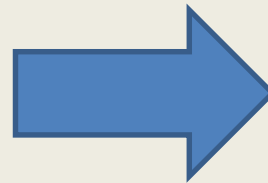
Naturally acquired



Artificially acquired

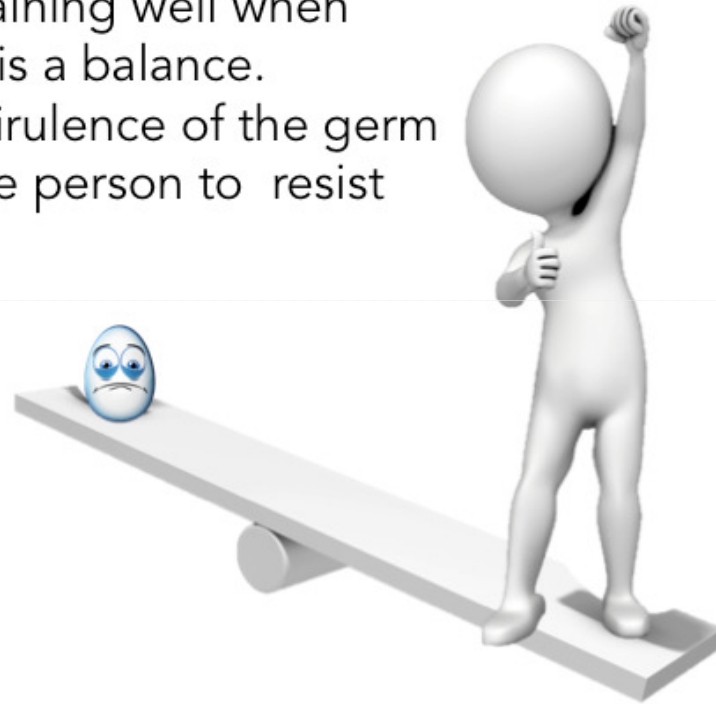
Artwork by Jeanne Kelly, ©2004

# The Pathogen's Journey



# Will Sickness Occur?

Getting sick or remaining well when exposed to a germ is a balance. It depends on the virulence of the germ and the ability of the person to resist the infection.



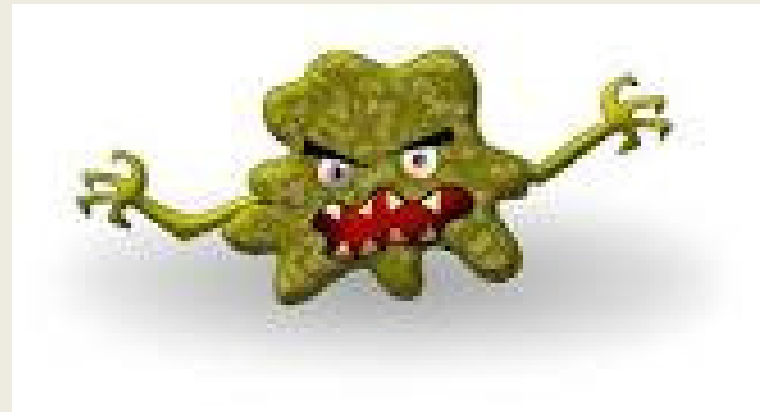
Both of these things are variable.

# The Consequences of Infection...

- Lifelong immunity (most of the time!)
- May be innocuous

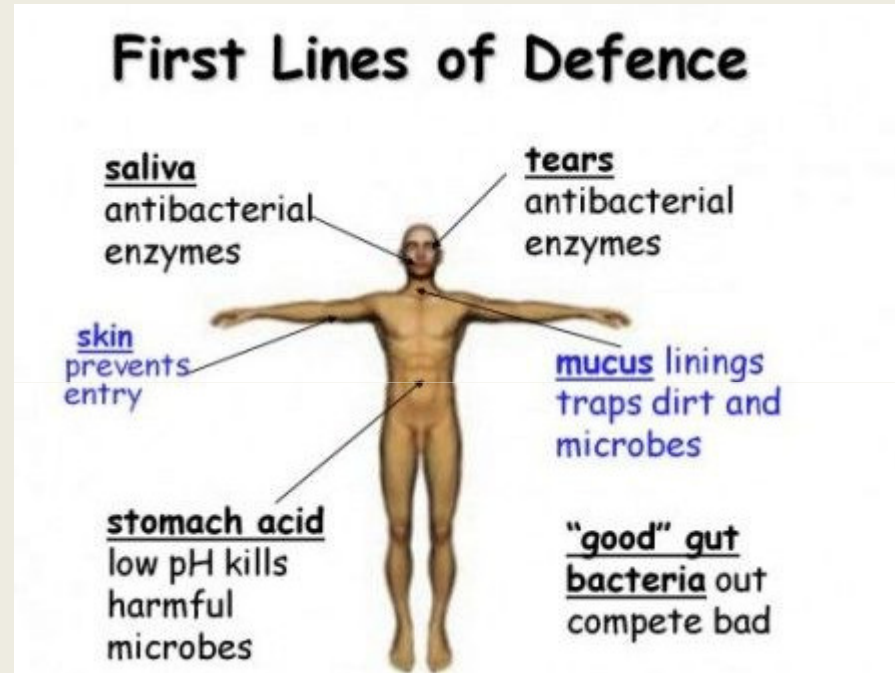
BUT....

- May cause serious disease
- May cause permanent damage to the host
- May cause death



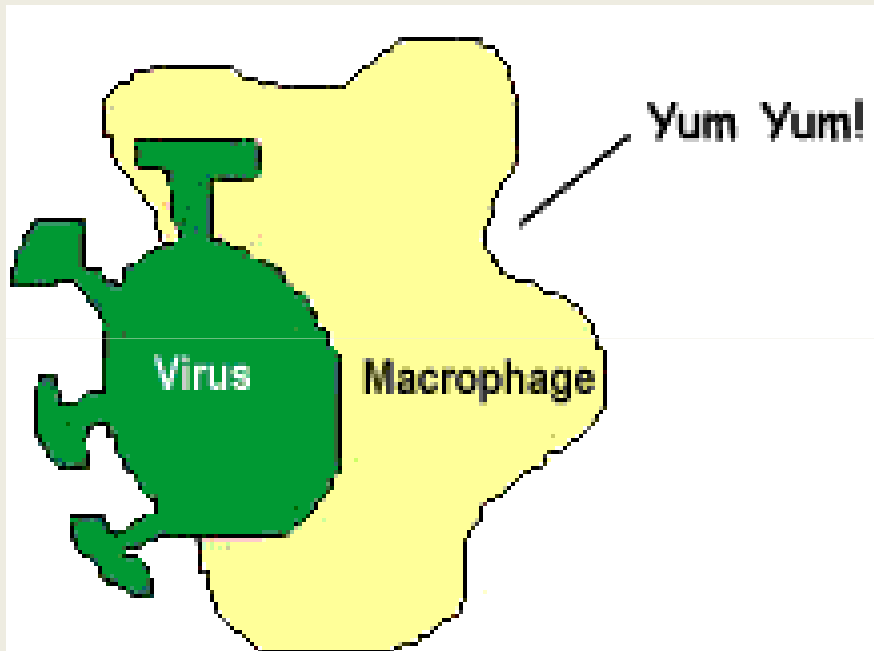
# The Pathogen soon encounters the first level of defence

- Physical barriers (intact skin, intact mucous membranes, cilia etc....)
- Physiological factors (eg pH, temp)
- Protein secretions (complement, interferons)
- Phagocytes – macrophages and PMNLs



Defining characteristic of innate immunity - **NO MEMORY PERSISTS.**

# Macrophages – part of the first level of defence



**Figure 2**  
Macrophage surrounds/"eats" the virus

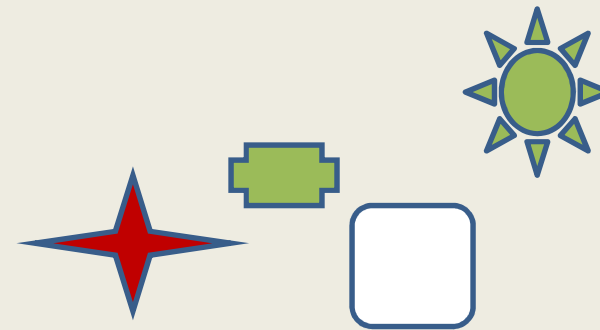
- Digest most of the micro-organism
- Regurgitate the antigens
- Display antigens on their surface so that another type of white blood cell (lymphocytes) can take over.



# What is an antigen?



**Microbe**



**Fragments of Microbe =  
antigen**

**“Anything that can be bound by an antibody”**

# The Pathogen Next Encounters the Second Level of Defence

- **Adaptive immunity**
- The foreign agent is recognised in a specific manner e.g.
  - B Cells
  - T Cells

**THE IMMUNE SYSTEM  
ACQUIRES MEMORY**



# Cell-Mediated Immune Response

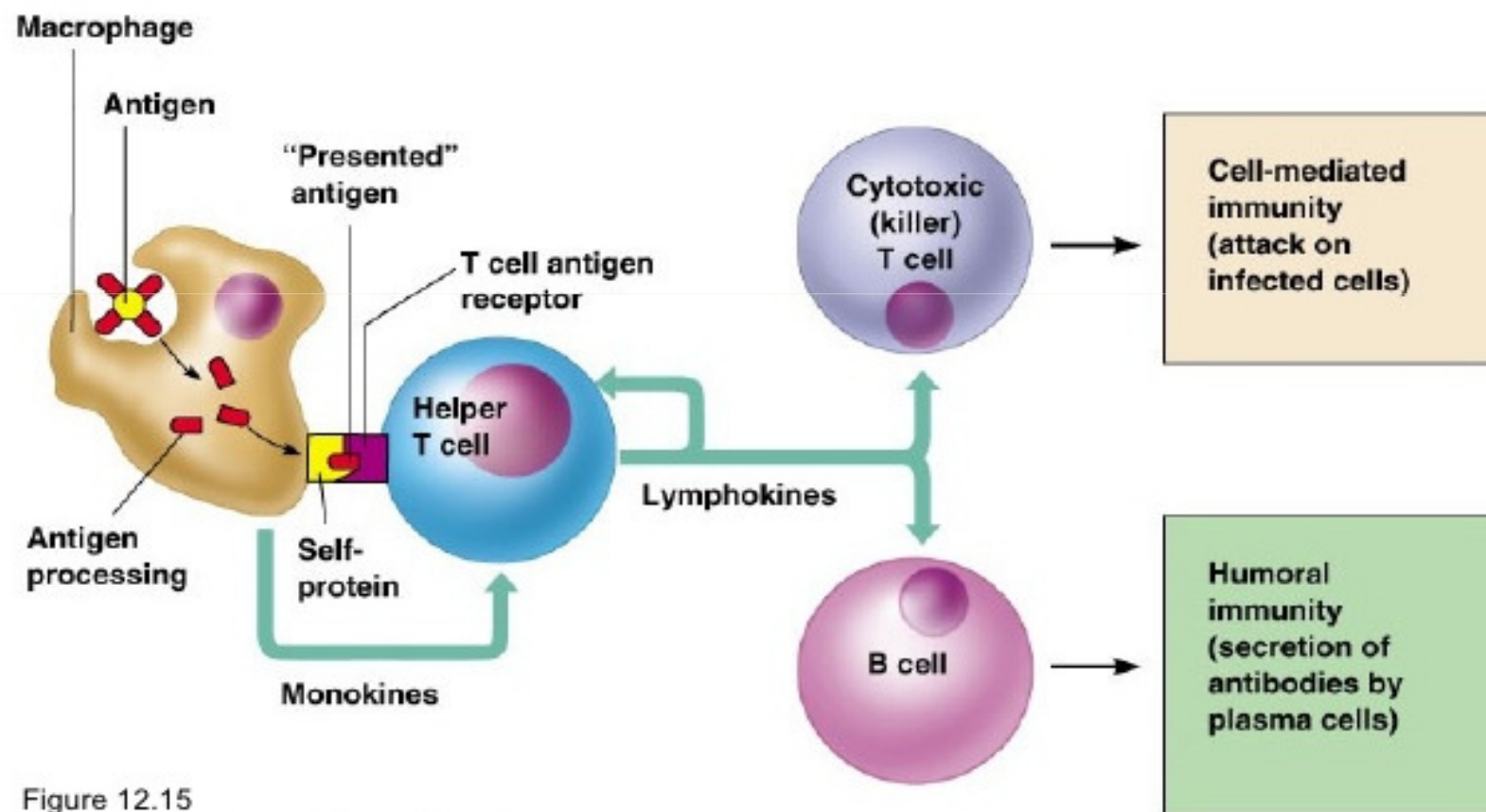
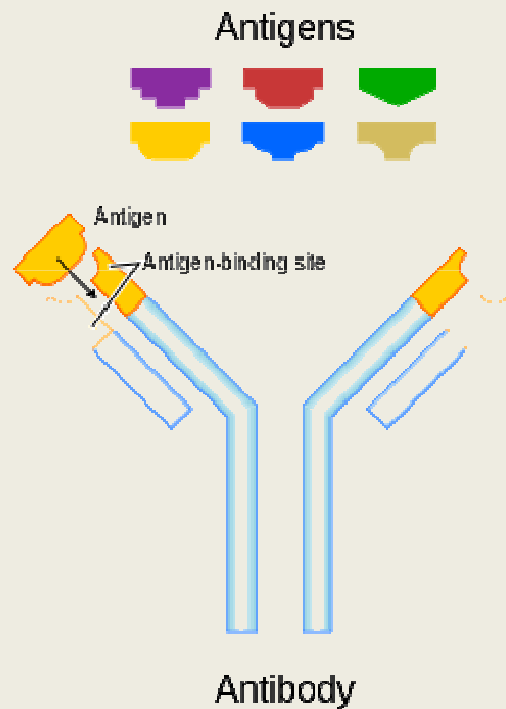


Figure 12.15

# What is an Antibody?



- Produced to one specific epitope (ie is antigen specific)
- Neutralises toxins
- Blocks adhesion/ cell entry
- Kills via complement
- Neutralises viral infectivity and prevents replication.

# Immune System Superheroes!

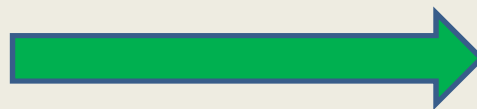
Macrophages  
And Helper T  
Cells



T Cells



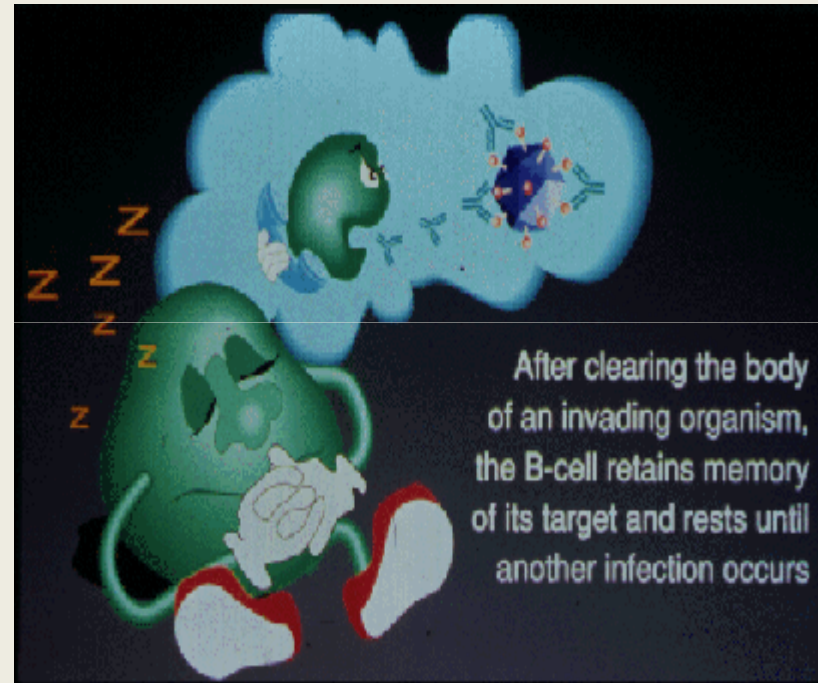
Antibodies  
(from B Cells)



Gone but not  
forgotten!

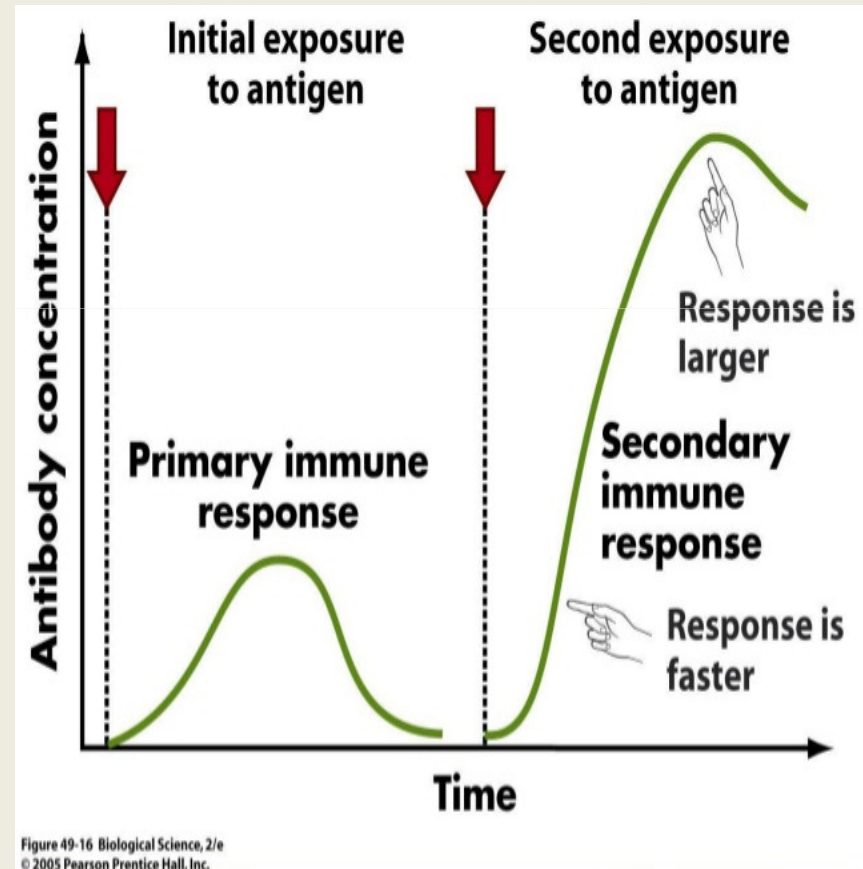
# Memory Cells

- Once infection has been eliminated, some B and T cells become memory cells
- These retain memory of the antigen
- On re-exposure, powerful immune response.
- This ability of the immune system to have a memory for previous antigens is the basis for vaccination.



# How Soon After Exposure to an Antigen are we Protected?

- Immune response is generated after 4-7/7
- >7/7 get Primary immune response (IgM), lasts 3 weeks, memory cells made.
- Secondary/subsequent immune response, IgG, faster
- It takes 2 weeks to get optimum immune response after vaccination.



# In Simple Terms....

**Vaccines work** by making us produce antibodies to fight disease without actually infecting us with the disease. If the **vaccinated** person then comes into contact with the disease itself, their immune system will recognise it and immediately produce the antibodies they need to fight it.





# The Ideal Vaccine

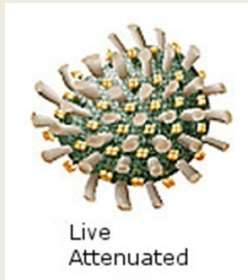
- Produces the same immune protection as an infection without causing disease
- Generates long-lasting immunity
- Interrupts spread of infection



# Vaccines can be broadly divided into two types

- Live attenuated
- Inactivated





# Basic Differences

## Live Attenuated – “Weak Pathogen”

- A version of the living microbe that has been weakened in the lab so it can't cause disease.
- Vaccines are longer lasting and require fewer boosters
- However the disease could mutate back to the pathogenic strain
- eg BCG/ MMR/ Rotavirus/ Varicella/ Yellow fever

## Inactive – “Dead Pathogen”

- Produced by killing the disease-causing microbe with chemicals, heat, or radiation.
- Cannot cause disease
- Cannot replicate
- Immune response mainly antibody based
- Antibody titre falls with time
- 3-5 doses required
- Classified as inactivated/conjugate/recombinant/subunit

# Inactivated Vaccines

## Whole

- viruses
- bacteria

## Fractional

- protein-based
  - toxoid
  - subunit
- polysaccharide-based
  - pure
  - conjugate

# Live Attenuated Vaccines

- Produced by weakening a live pathogen and removing its ability to cause disease

PROS	CONS
<ul style="list-style-type: none"><li>• Large immune response</li><li>• Good “teachers” of the immune system</li><li>• Generally only 1-2 doses needed</li></ul>	<ul style="list-style-type: none"><li>• Need strict refrigeration</li><li>• Could mutate back to disease-causing strain</li></ul>

# Inactivated Vaccines

- Produced by killing the pathogen

PROS	CONS
<ul style="list-style-type: none"><li>• They may not have to be stored as carefully.</li><li>• They will never come back to life and cause the disease.</li></ul>	<ul style="list-style-type: none"><li>• They usually require booster shots because they only weakly stimulate the immune system to make antibodies.</li></ul>

# Toxoid Vaccines

- Produced by inactivating the toxin produced by some pathogens eg tetanus and diphtheria

PROS	CONS
<ul style="list-style-type: none"><li>• Generally only need one or two shots</li><li>• They will never come back to life and cause the disease.</li></ul>	<ul style="list-style-type: none"><li>• Require refrigeration</li></ul>

# Subunit Vaccines

- Produced by extracting the antigenic part of a micro-organism. Eg hep B and strep pneumo

PROS	CONS
<ul style="list-style-type: none"><li>• They will never come back to life and cause the disease.</li></ul>	<ul style="list-style-type: none"><li>• They are more difficult to make and require new, expensive technology.</li></ul>



# How Vaccines Are Made



Microbes grown on  
suitable medium



Purified to remove compounds that  
could cause allergic reactions

(not always possible)

# Vaccine Components

- Suspension fluid (water, saline etc)
- Preservatives, stabilisers, antimicrobial agents
  - a) Trace amounts
  - b) May cause allergic reaction
- Adjuvants
  - a) Aluminium salts – to increase immunogenicity
  - b) Eg hep B , tet, diphth



# True or False?

Several childhood vaccines contain mercury, which is toxic to the nervous system.



# Thiomersal

- Mercury containing compound used as a preservative and an inactivating agent
- In 1999 EU and US manufacturers decided to decrease thiomersal levels in vaccines as a precaution and to retain trust in vaccine supply
- WHO state that there is no evidence of toxicity
- **All vaccines in the infant immunisation programme are thiomersal free**

# Timing of Vaccinations



# Why are Gaps Needed Between Doses?

- To allow each immune response to develop eg primary immunisation
- To avoid immune interference – if another live vaccine is given while the immune system is making a primary immune response, the activation of the innate immune system may neutralise the second vaccine. Hence we wait 4 weeks.

# Timing of Primary Immunisation Course

- Maternal IgG is transferred across the placenta
- Passively acquired IgG can suppress response to DTP, Polio, Men C and Hib for 2 months
- Maternal antibody to measles may interfere for 1 year.

# True or False?

Vaccinations can “overload” the immune system





# Can Vaccines Overload the Immune System?

- We are exposed to countless antigens every day, in the food we eat, in the air we breathe, in the water we drink.
- The human body contains 100 trillion bacteria.
- The immune system is capable of responding to 100,000,000,000 antigens at a given time
- The MMR contains only 24 antigens.

**NO EVIDENCE THAT VACCINES OVERLOAD THE IMMUNE SYSTEM**

**Arguing that vaccines will  
overwhelm a child's immune system**



**is like arguing that a tablespoon will  
make an Olympic swimming pool  
overflow**

[thelogicofscience.com](http://thelogicofscience.com)

# Vaccine Failures and Reactions



When it's a joke for everyone,  
except the guy next in line.

# Vaccine failures

- Primary failure – when an individual fails to respond to the initial vaccine (eg 10% MMR)
- Secondary failure – responds initially but response wanes over time (most inactivated vaccines)



# Timing of Vaccine Reactions

- Inactivated – generally within 48h
- Live vaccine – according to time taken for virus to replicate

Eg MMR vaccine

- a) Reactions to measles (malaise, fever, rash) occur in 1<sup>st</sup> week
- b) Rubella (pain, joint swelling) in 2<sup>nd</sup> week
- c) Mumps (parotid swelling) in 3<sup>rd</sup> week

# Adverse events

- Live vaccine – frequency of adverse events falls with number of doses
- Inactivated vaccines – frequency of adverse events increases with number of doses...

if antibody levels are good, this binds to antigen in subseq dose, producing an Immune response which, if big enough, is inflammatory



# HERD IMMUNITY

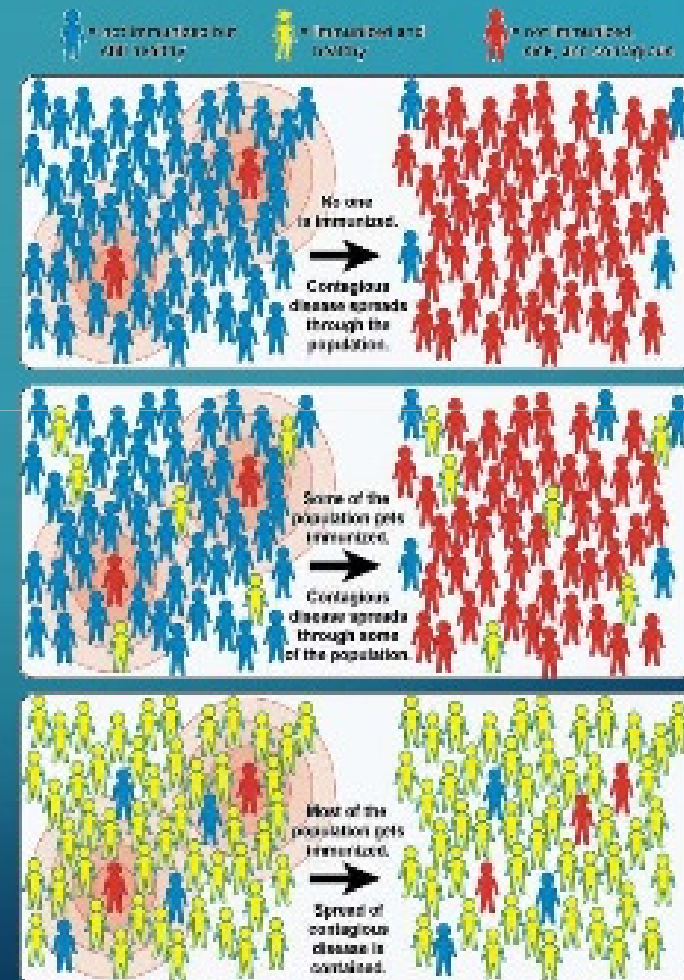
- When most people in community are immune to a particular infection that is spread from *person to person*, the natural transmission of the infection is effectively inhibited
- Vaccine uptake rates >90% (measles 95%)
- Not tetanus!



# Herd Immunity

## HERD IMMUNITY

- If enough of the population is immunized, even those that aren't are protected
- Who relies on herd immunity?
  - Infants
  - Elderly
  - Those with weakened immune systems
  - Those who are allergic to the vaccine



<http://www.vaccines.gov/basics/protection/>



# Thanks!

