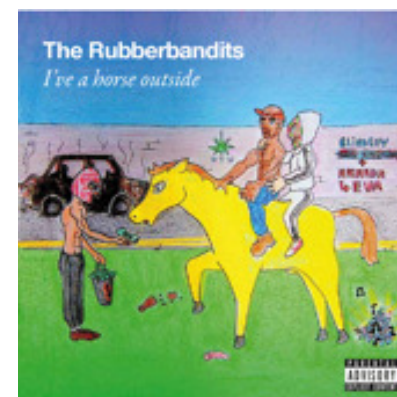


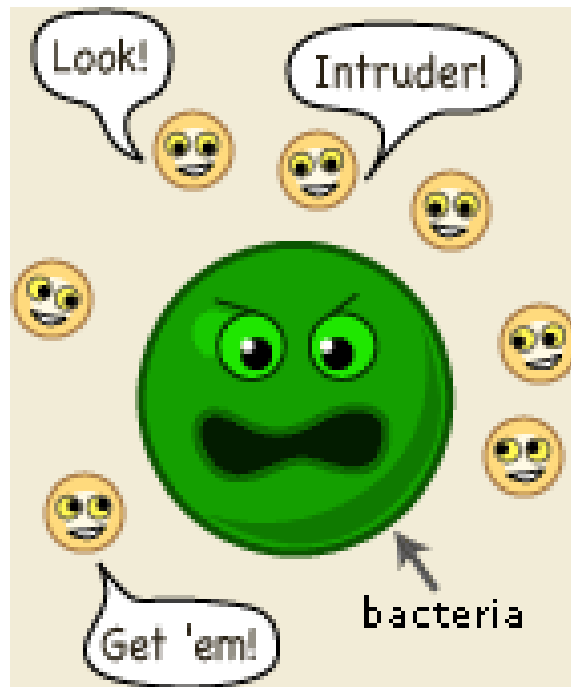
# Immunity and How Vaccines Work

Dr. Ann Hogan  
Principal Medical Officer  
CHO3

# Welcome!



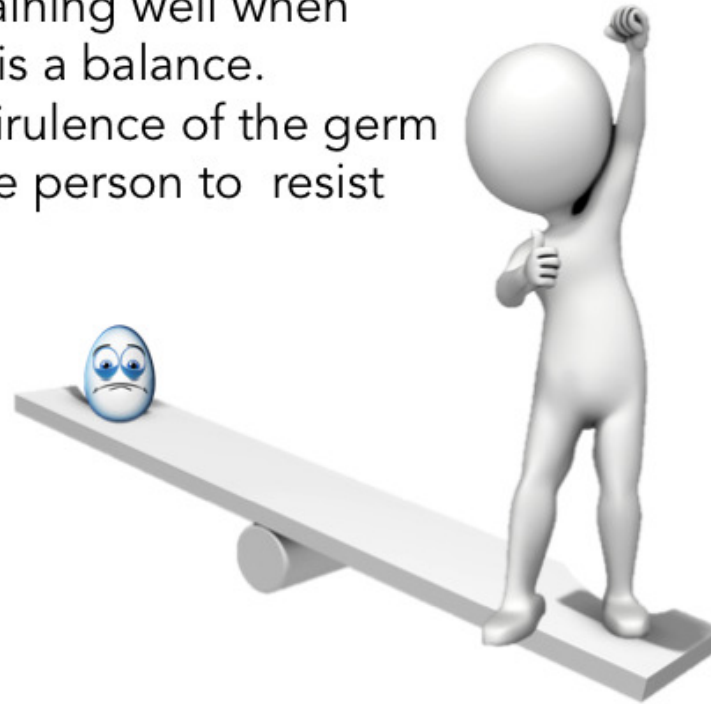
# The Immune System



The body's ability  
to protect itself  
from Infectious  
Disease.

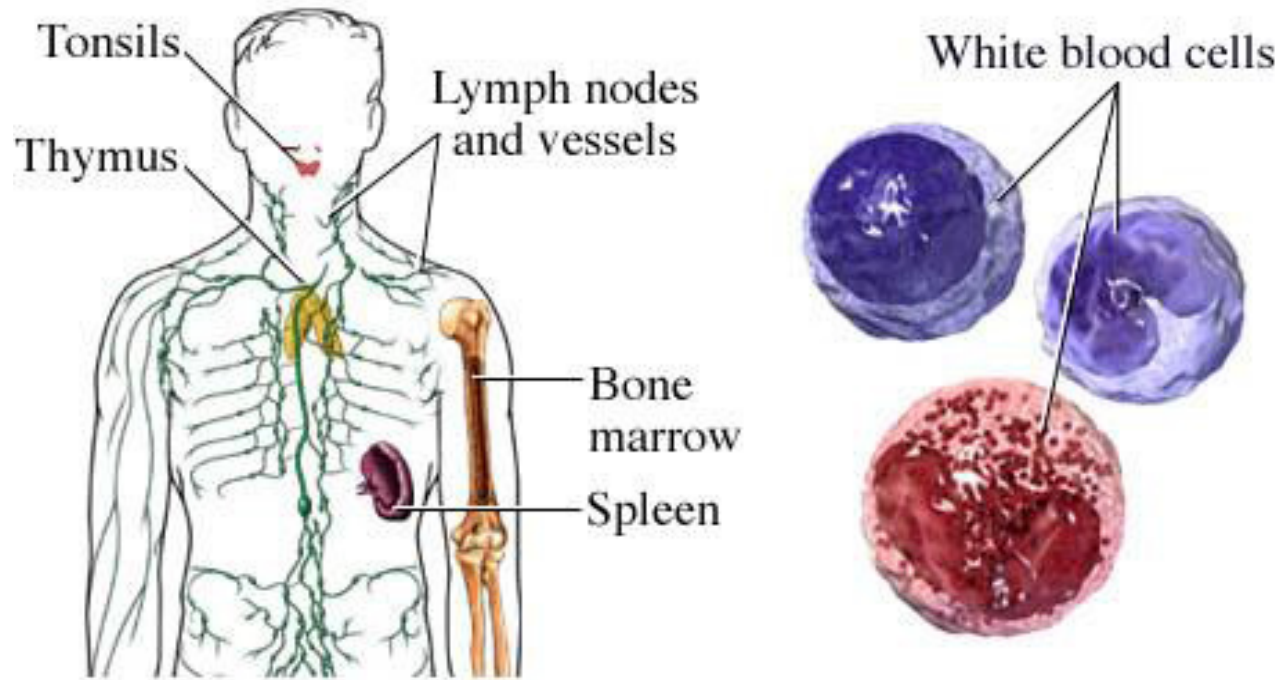
# Will Sickness Occur?

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.

# Immune System Components

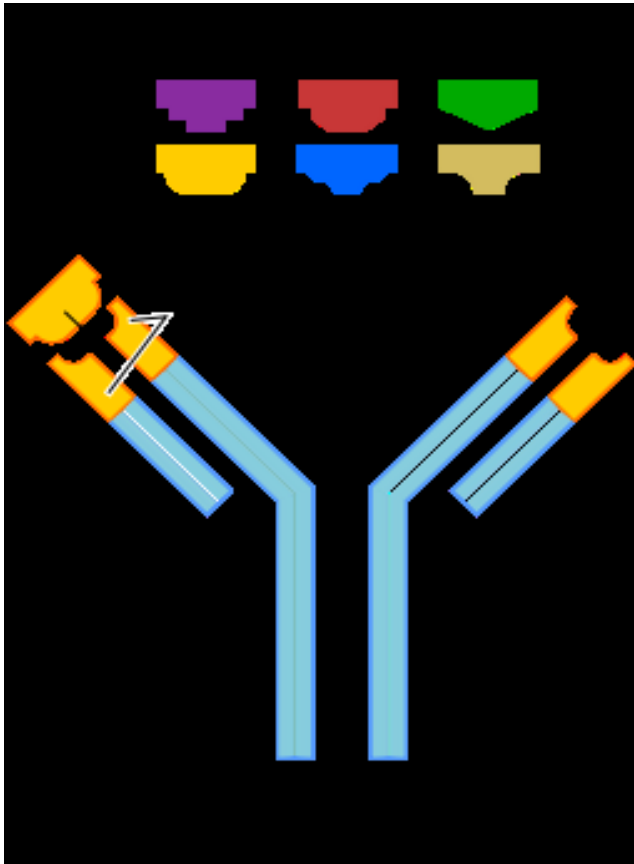


Source: <http://www.webmd.com/a-to-z-guides/components-of-the-immune-system>

# What is an antigen?

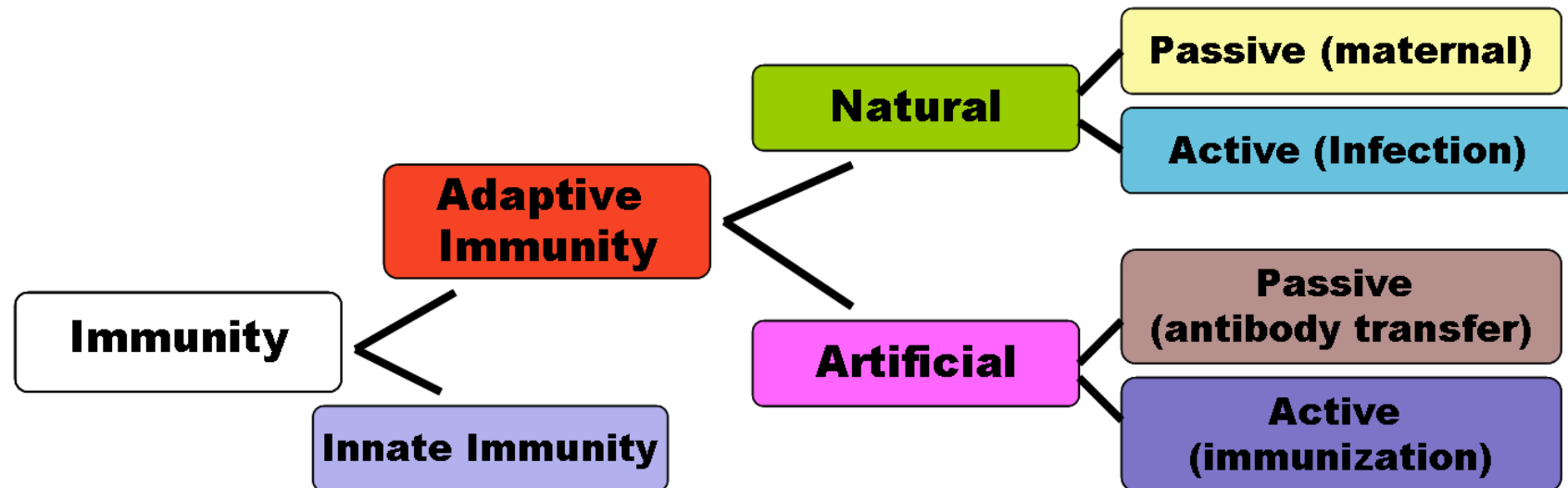
- Anything that can be bound by an antibody
- Fragments of microbes can be antigens
- The foreign agent/antigen is recognised in a specific manner e.g
  - B Cells
  - T Cells

# 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.

# Organisation of the Immune System





# Immunity without memory

- Physical barriers
- Chemical barriers
- Immunological barriers
- No memory of protection

# Immunity with memory :

## Passive Immunity

Transfer of antibodies from people who have immunity to those who do not:

- Mother to baby across placenta
- Blood transfusion
- Blood products including immunoglobulin.

Temporary protection

# Immunity with memory :

## Active Immunity

- Contact with disease
- Vaccination

Body develops its own antibodies to the disease.

Vaccines provide immunity without complications of the disease

# Consequences of Infection

- May be innocuous
- May cause serious Illness
- May cause death
- May have lifelong consequences

and

- Lifelong Immunity (most of the time)

# Macrophages

- 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.

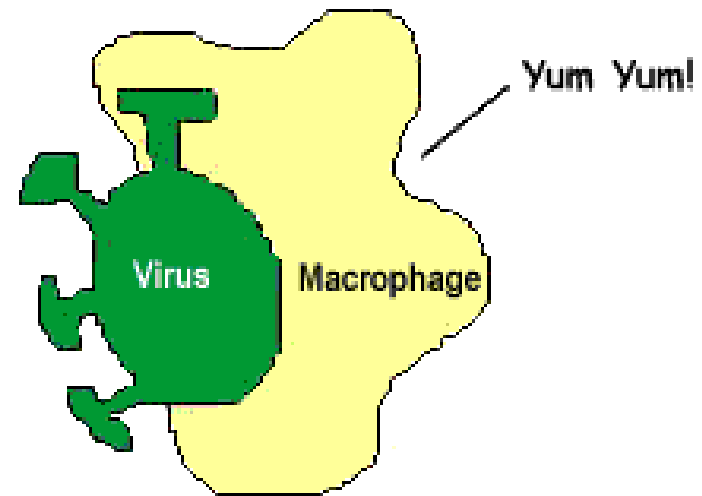


Figure 2  
Macrophage surrounds/"eats" the virus

# Cell-Mediated Immune Response

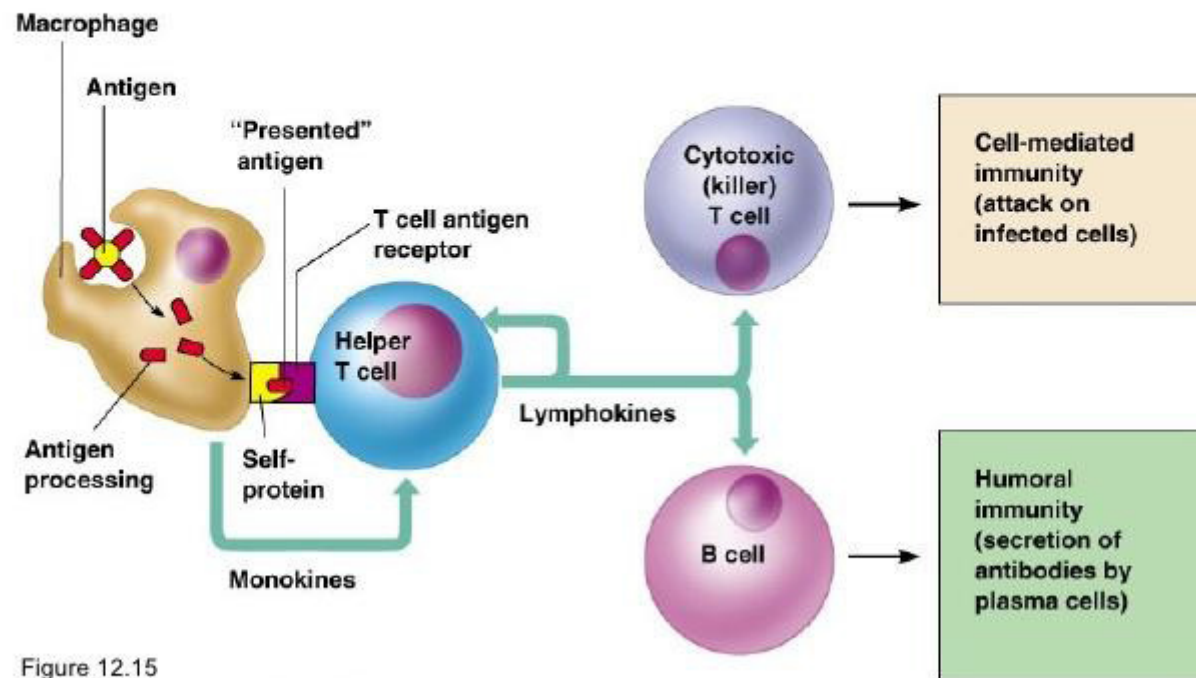


Figure 12.15

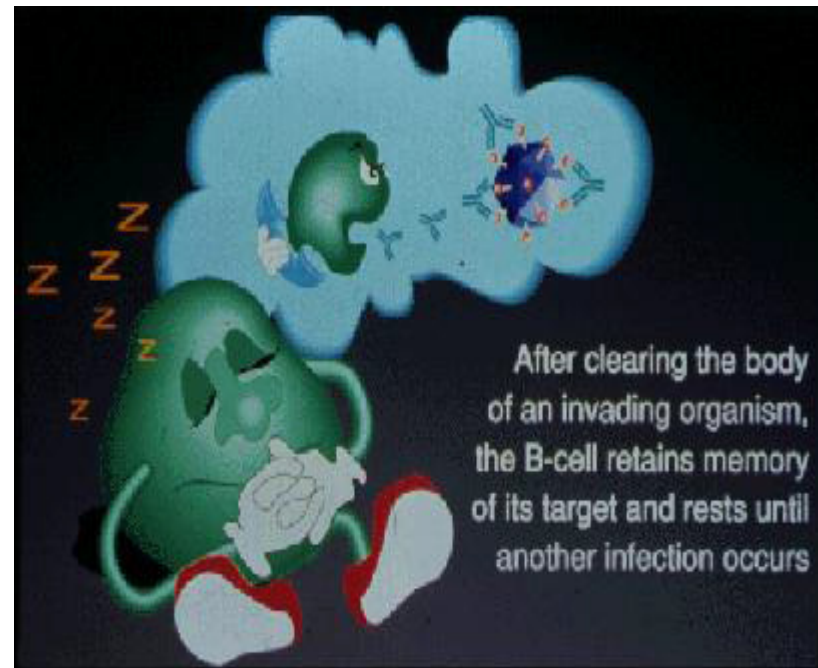
# How Immunity works

- Macrophages and helper T cells
- T Cells
- B Cells
- Invader repelled
- Not forgotten.



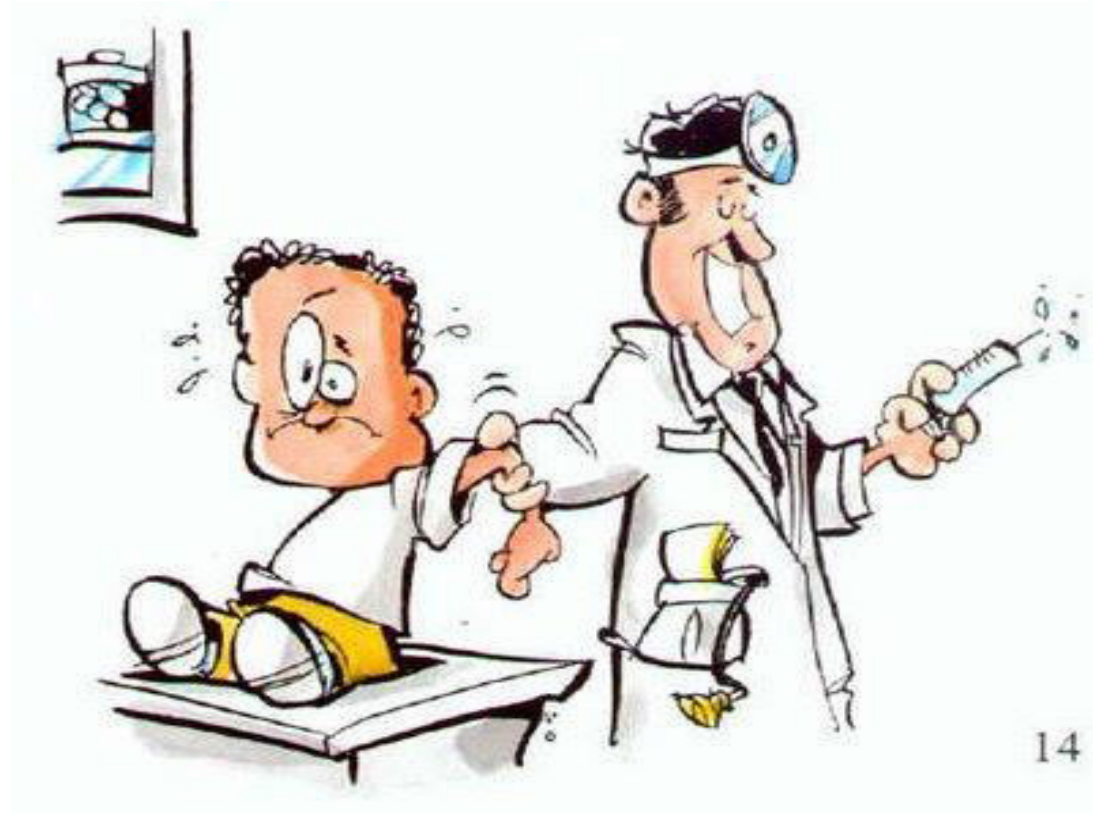
# Memory Cells

- 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.





# Vaccines and How They Work



# History

- Evidence that Chinese used smallpox inoculation (variolation) as early as 1000AD
- Also practised in Africa & Turkey
- 1796: Edward Jenner used cowpox material to create immunity to smallpox.
- 1885: Louis Pasteur & Rabies Vaccine

# The Ideal Vaccine

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



# How Soon After Immunisation are we Protected?

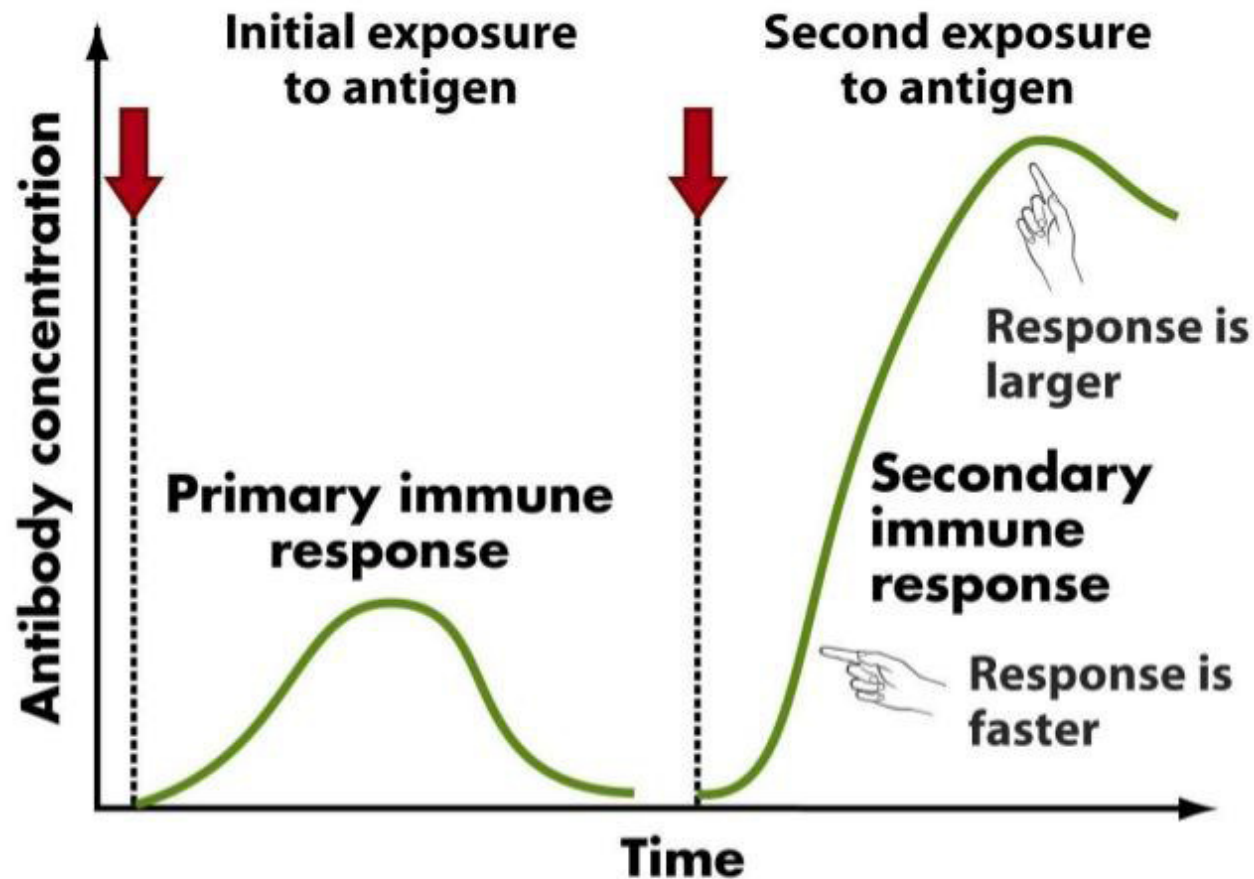


Figure 49-16 Biological Science, 2/e  
© 2005 Pearson Prentice Hall, Inc.

# 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.**



# 2 types of vaccines

- Live attenuated
  - Whole vaccines
- Inactivated
  - Whole vaccines
    - Viruses
    - Bacteria
  - Fractional
    - Protein-based
    - Polysaccharide-based

# Live Attenuated Vaccines

- Vaccines are longer lasting and require fewer boosters
- However the disease could mutate back to the pathogenic strain
- Harder to make for bacteria
- Examples: BCG/ MMR/ Rotavirus/ Varicella/ Yellow fever



Live  
Attenuated

# Non Live Vaccine

- Cannot cause disease
- Cannot replicate
- Immune response mainly antibody based
- Antibody titre falls with time
- 3-5 doses required
- Classified as whole  
inactivated/conjugate/recombinant/subunit



# Whole Inactivated Vaccine

- Organisms are killed or inactivated by heat or chemicals but remain antigenic.
- They are usually safe but less effective than live attenuated vaccines.
- Larger doses and more boosters are required.
- e.g. polio virus (IPV)



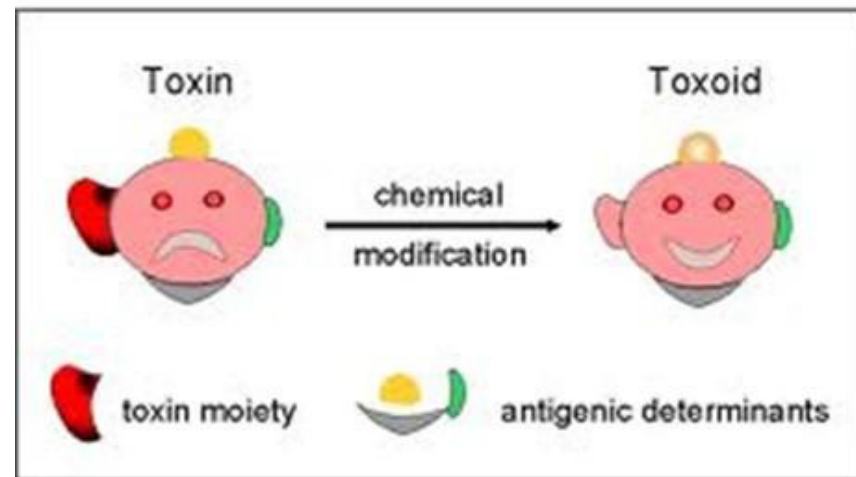
Whole  
Inactivated



# Toxoid Vaccine

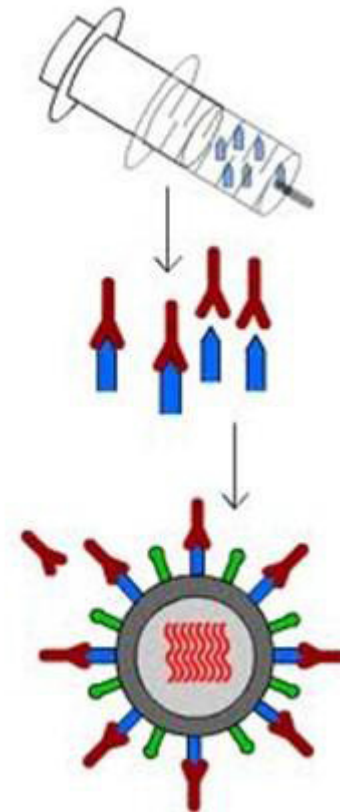
- A purified toxin produced by the antigen is used to elicit a response
- e.g. tetanus, diphtheria

## Modification of Toxin to Toxoid



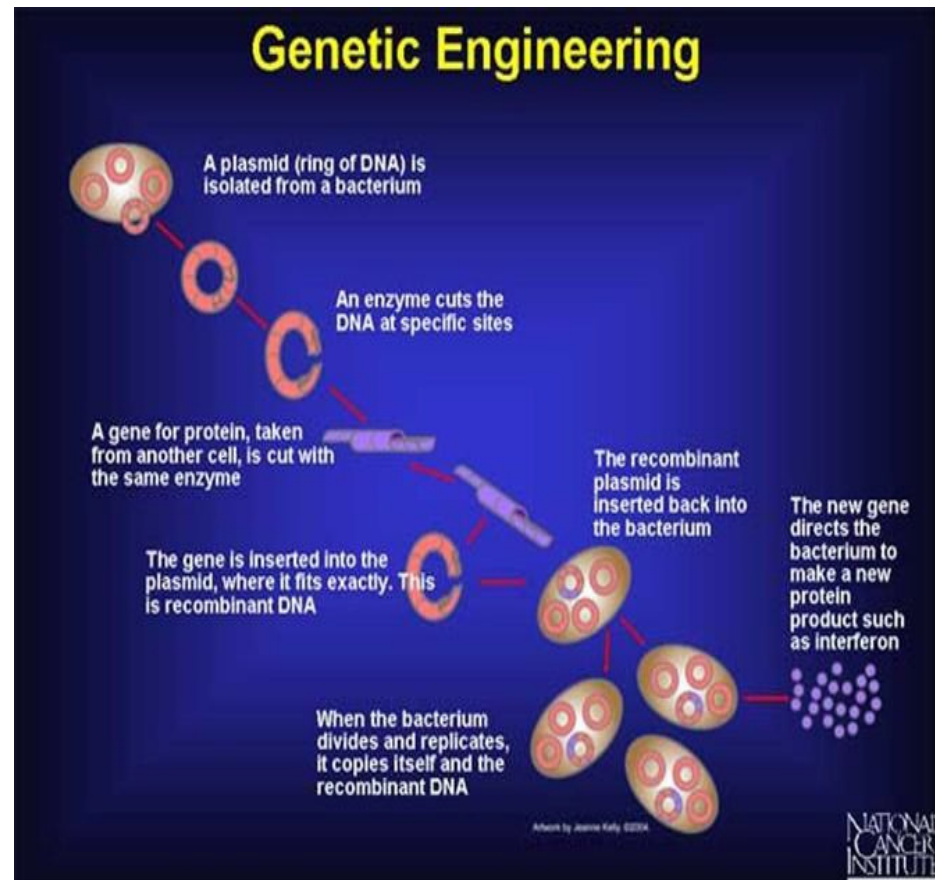
# Sub unit Vaccine

- Contains only specific antigenic proteins of an infectious agent.
- Antigens have been separated from the rest of the vaccine
- e.g. acellular pertussis and some influenza.



# Recombinant Vaccine (a type of Subunit)

- Recombinant DNA technology
- e.g. HPV and Hep B



# Conjugate Vaccine

- Some bacteria are encapsulated making it difficult for the immune system to respond
- Carrier proteins are used which combine with antigens to improve immunogenicity
- Their efficacy and safety appear to be high.
- e.g. Men C , PCV, Hib.

“Other Ingredients” needed to  
make a Vaccine



# COMMON COMPONENTS OF VACCINES

As well as the active components, vaccines contain a number of other substances. This graphic examines these and the reasons for their inclusion.

## ACTIVE COMPONENTS



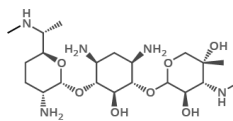
A form of the virus, bacteria or toxin that causes the disease is used as the antigen. This antigen is modified from the original form so it no longer causes disease, but still elicits an immune response from the body. To modify the disease-causing agent, it can be treated with specific chemicals, so it cannot replicate. It can also be treated so it does not cause serious disease, or only parts of the disease-causing agent that do not cause serious symptoms can be used.

## ADJUVANTS

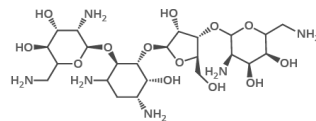


Added to enhance the body's immune response to the vaccine. How they work isn't entirely understood, but it's thought they help keep antigens near the site of injection. This means they can be easily accessed by the immune system cells. There is no evidence of any serious adverse effects from adjuvants, though they can cause some minor reaction near the injection site.

## ANTIBIOTICS

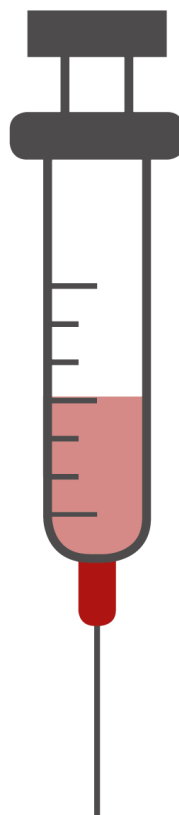


GENTAMICIN

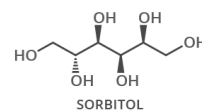


NEOMYCIN

Antibiotics are used in the manufacturing process of the vaccine to prevent bacterial contamination. They are later removed, and only residual quantities remain in the vaccine after the production process.



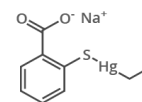
## STABILISERS



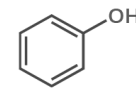
$\text{MgSO}_4$   
MAGNESIUM SULFATE

Vaccines need to be storable, so stabilisers are added to ensure the various components remain stable and effective. A variety of different stabilisers are used; either inorganic magnesium salts such as magnesium sulfate or magnesium chloride, or mixtures of lactose, sorbitol and gelatin. Monosodium glutamate and glycine are also used in some cases.

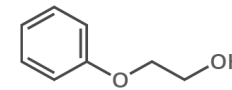
## PRESERVATIVES



THIOMERSAL



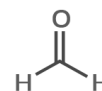
PHENOL



PHENOXYETHANOL

Preservatives help prevent contamination of vaccines. They are used particularly in multi-dose vaccines. Thiomersal is a common preservative, though its use declined in the late 1990s when vaccines were falsely linked to child autism. This link was later shown to be an elaborate medical hoax, and there is no link between thiomersal and autism.

## TRACE COMPONENTS



FORMALDEHYDE

These are left-over from the vaccine production process. Though they are purposefully removed, residual amounts remain. Formaldehyde is one such agent, used to deactivate viruses and detoxify bacteria, but amount remaining is several hundred times lower than the smallest amount known to cause harm in humans.



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# 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) e.g. hep B , tet, diph





# 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 Vaccines and their Side Effects



# Infant 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.



# 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.



# Why are Gaps Needed Between Doses?

- To allow each immune response to develop  
e.g. 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.

# 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

- 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
- e.g. MMR vaccine
  - a) Reactions to measles (malaise, fever, rash) occur in 1st week
  - b) Rubella (pain, joint swelling) in 2nd week
  - c) Mumps (parotid swelling) in 3rd 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 subsequent dose, producing an immune response which, if big enough, is inflammatory

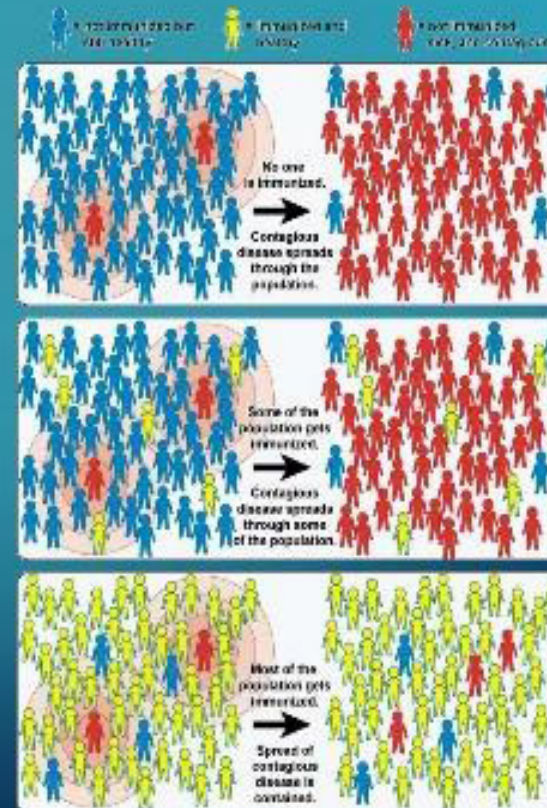
# Susceptible populations

- Not everyone produces an immune response
- Not everyone can get certain vaccinations
- Other factors e.g. immunosuppression can cause susceptibility

# 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/>

# Thank you!

