Immunity &
How Vaccines work

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Learning Outcomes

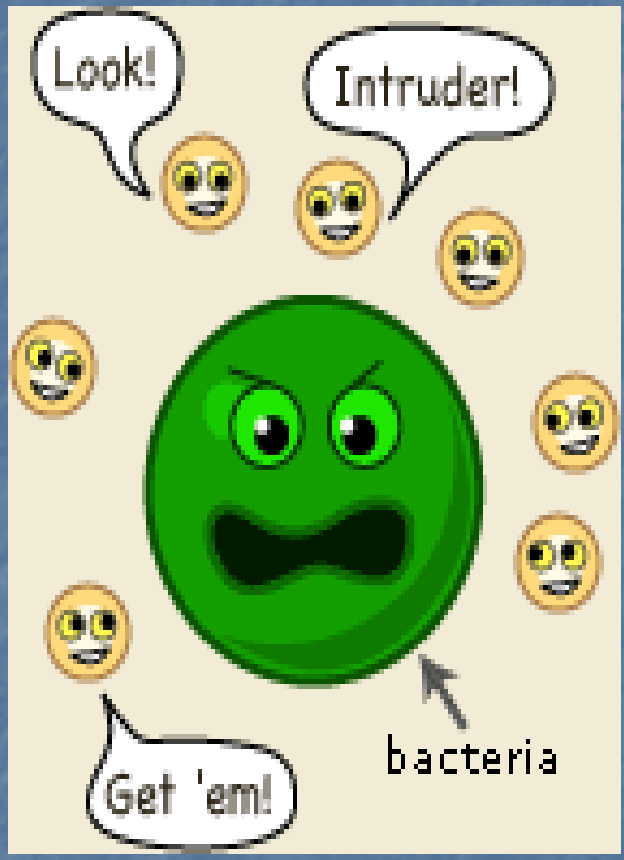
- Understand how our immune system works.
- Understand how vaccines work and the differences between various vaccines.
- Be confident in explaining to our patients concepts such as herd immunity, adverse effects, vaccine overload and vaccine failure.

What is the immune system?

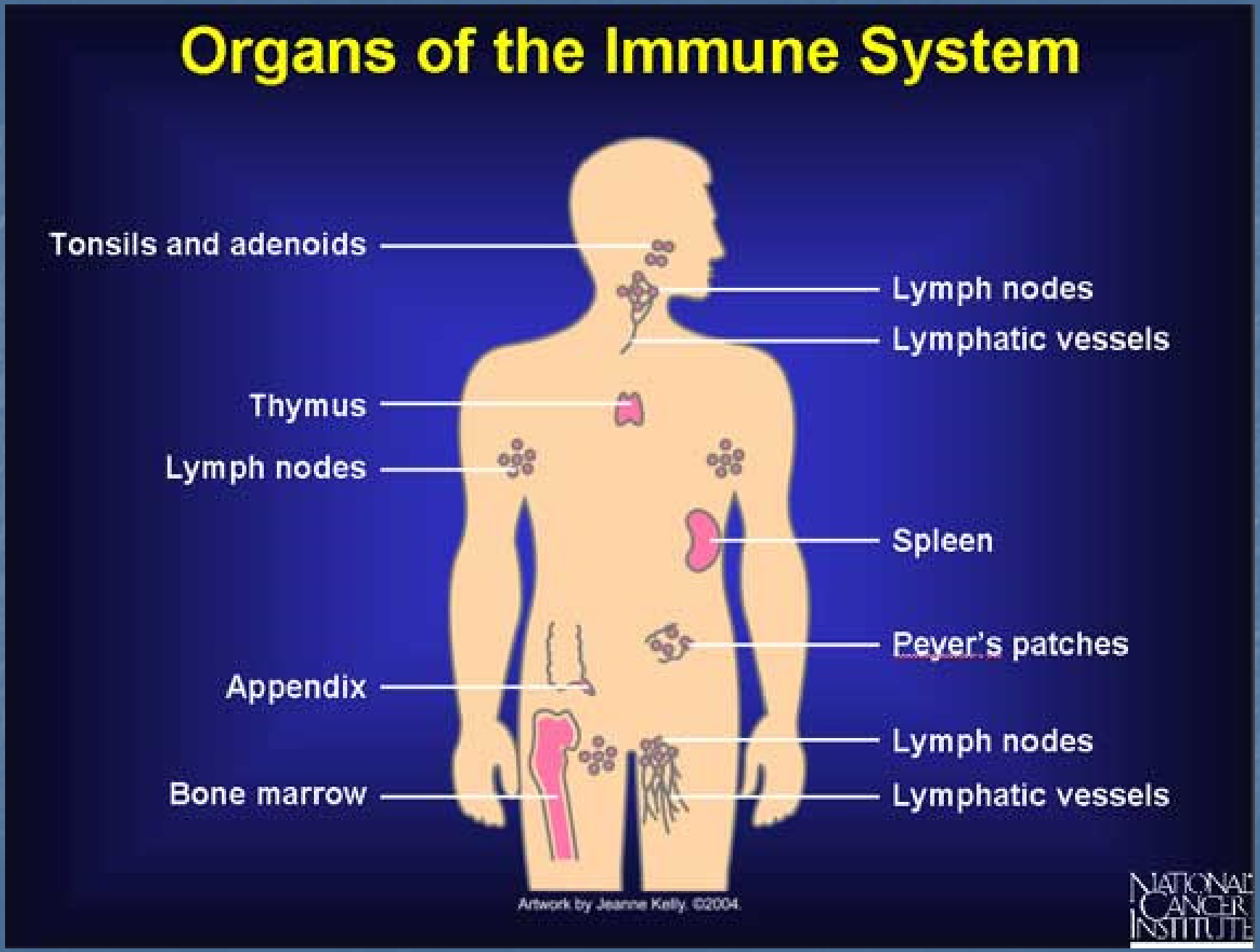
Our body's defence against disease causing organisms, malfunctioning cells and foreign particles.

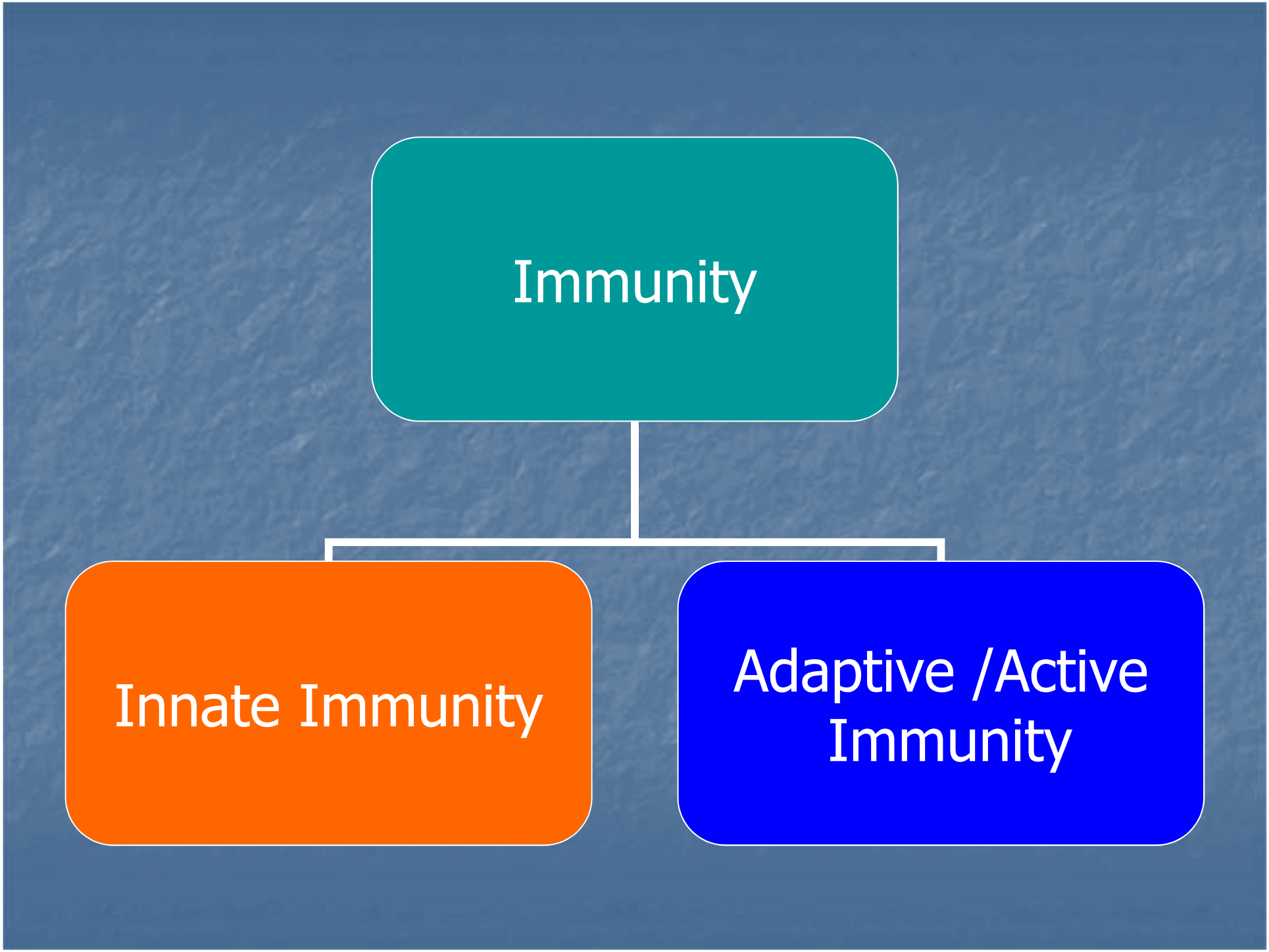
Array of organs, cells and chemicals that:

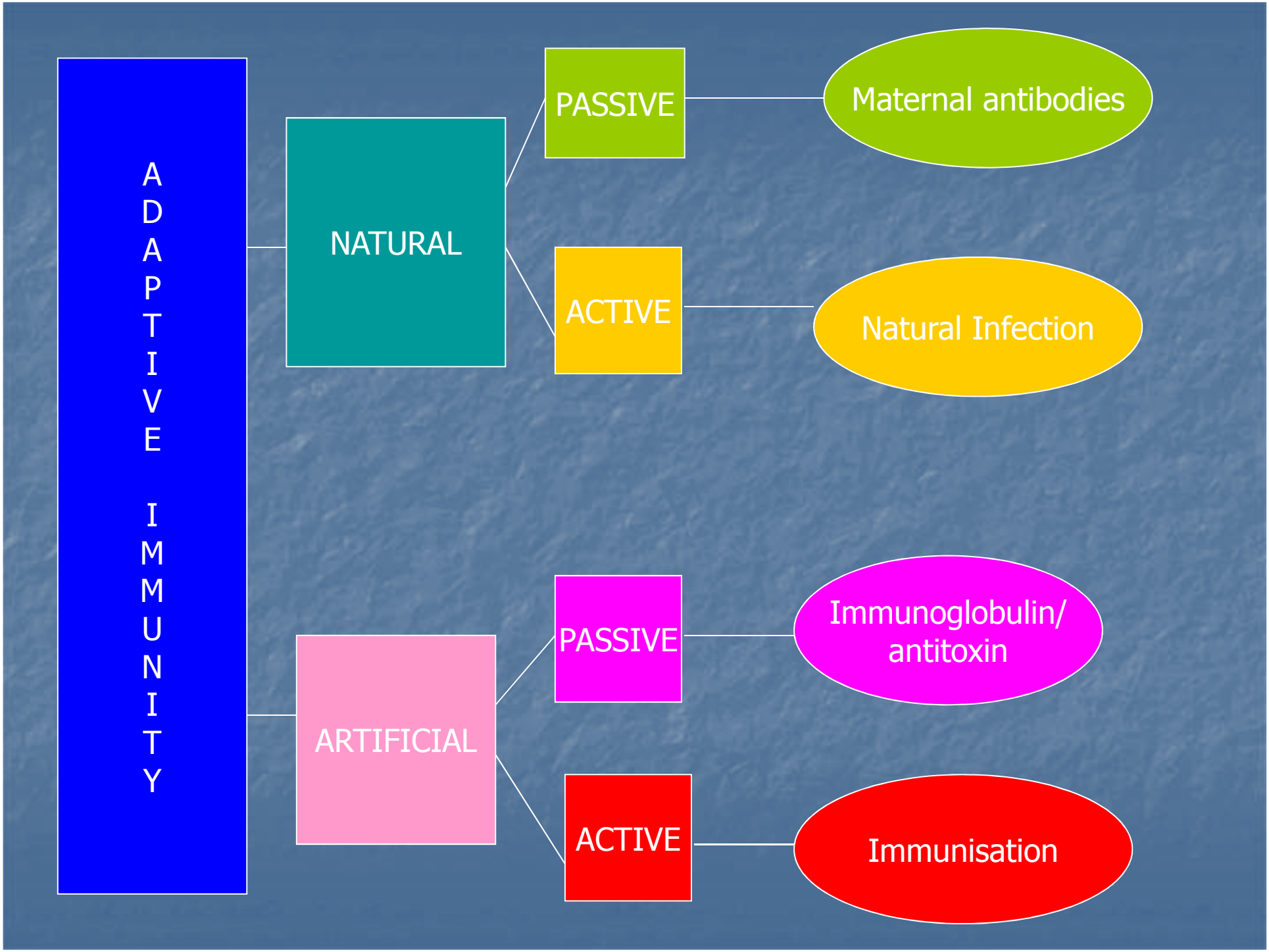
1. Determine self from "non-self".
2. Identify potential dangers to the body.
3. Eliminate them by mounting a response.



Organs of the Immune System



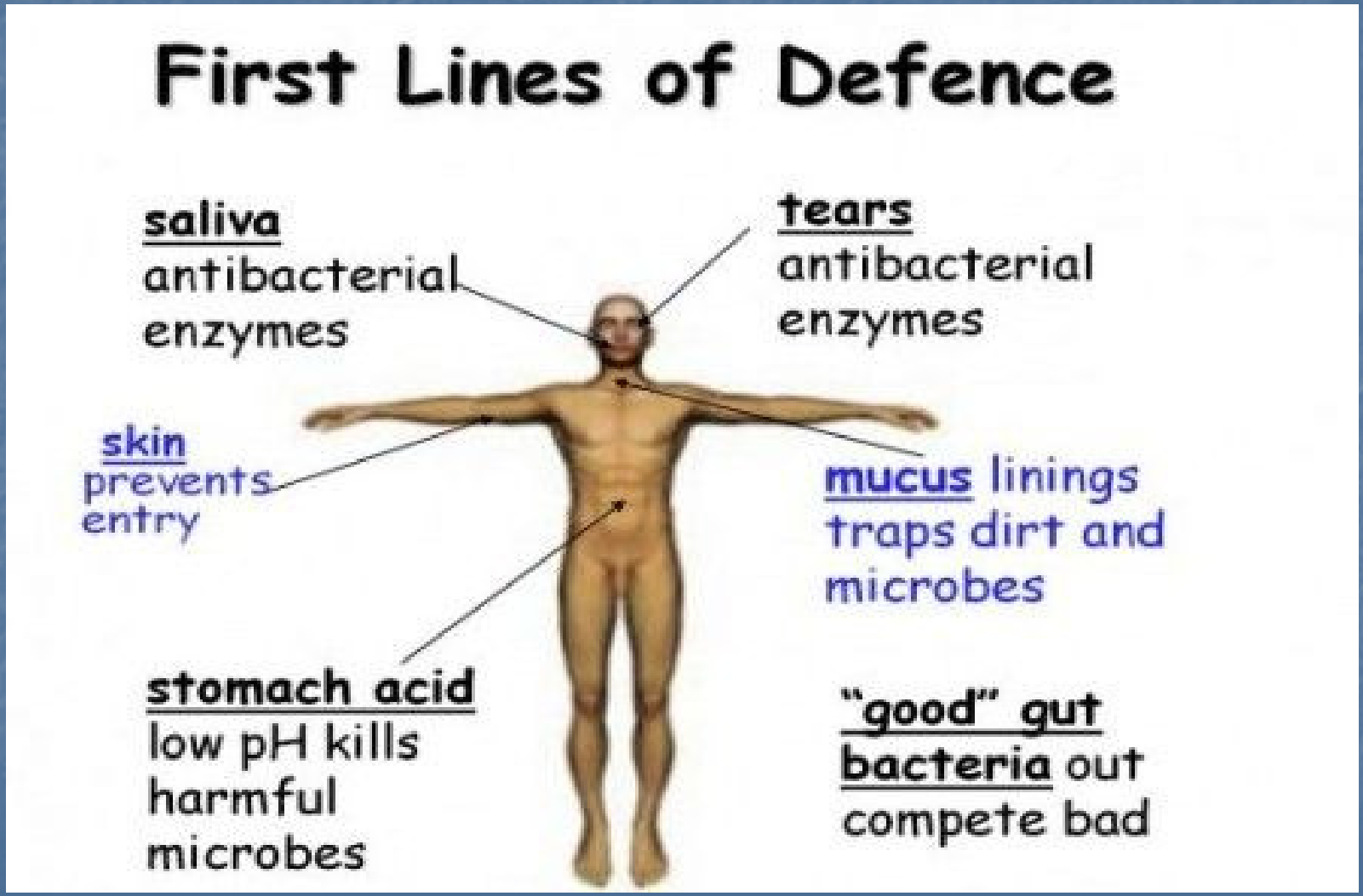

Immunity
Innate Immunity
Adaptive /Active Immunity


ADAPTIVE IMMUNITY
NATURAL
PASSIVE
Maternal antibodies
ACTIVE
Natural Infection
ARTIFICIAL
PASSIVE
Immunoglobulin/ antitoxin
ACTIVE
Immunisation

The Pathogen's Journey

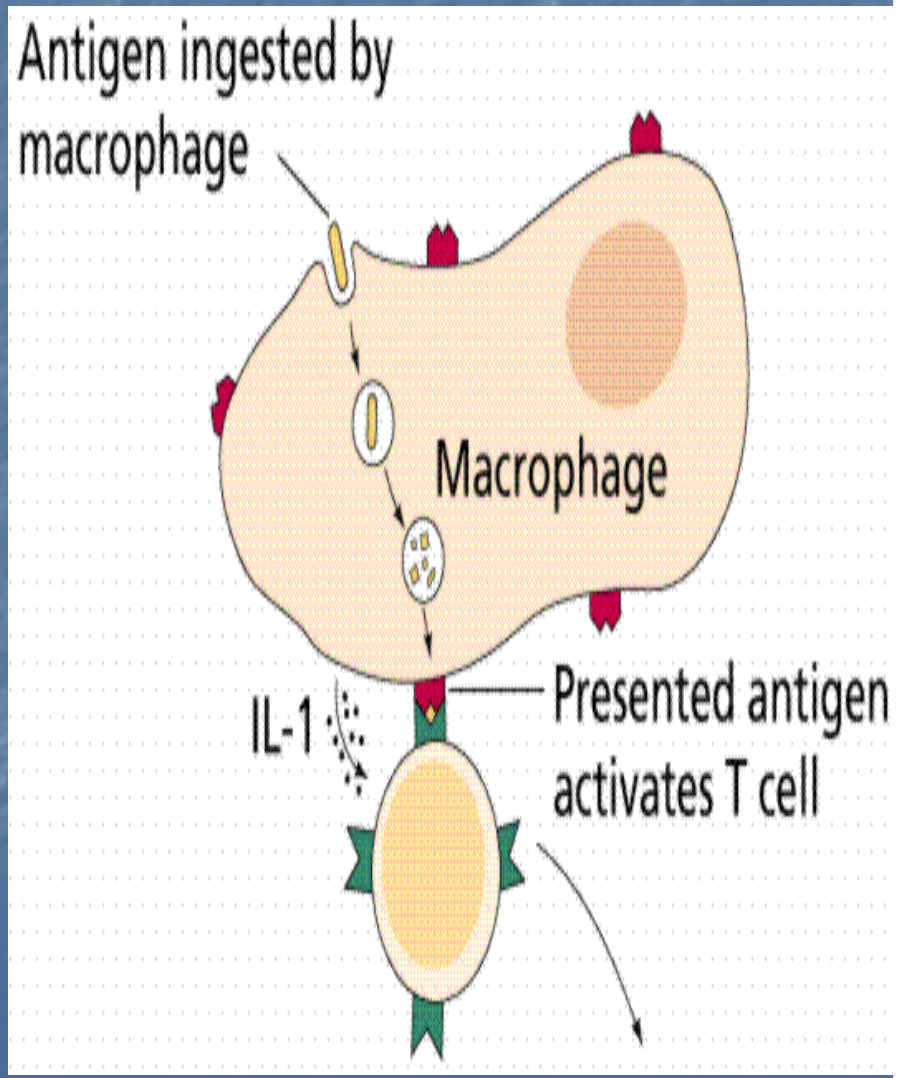
- In order to understand how vaccines work we first need to look at how our immune system works.

Innate Immunity



Macrophages – part of the first level of defence

1. **Digest** most of the micro – organism,
2. **Regurgitate** the antigens,
3. **Display** the antigens on surface so that lymphocytes can take over.
4. They **carry** the antigen to the lymph nodes where they stimulate the Adaptive/Active immune system (B cells & T cell lymphocytes) to join the fight.



Adaptive Immunity

2nd Line of Defence:

- The foreign antigen is recognised in a specific manner e.g. B Cells ,T Cells.
- Increases in strength and effectiveness with each encounter.
- Memory develops which provides lifelong immunity to reinfection with the same pathogen.

Adaptive Immunity

- **Humoral Immunity**

  B Cells

  - Antibody Mediated

- **Cell Mediated**

  T Cells

  1. Killer/Cytotoxic: destroy infected cells & microbes

  2. Helper – messenger cells which stimulate and direct activity of other cells – B cells & T Killer.

Cell-Mediated Immune Response

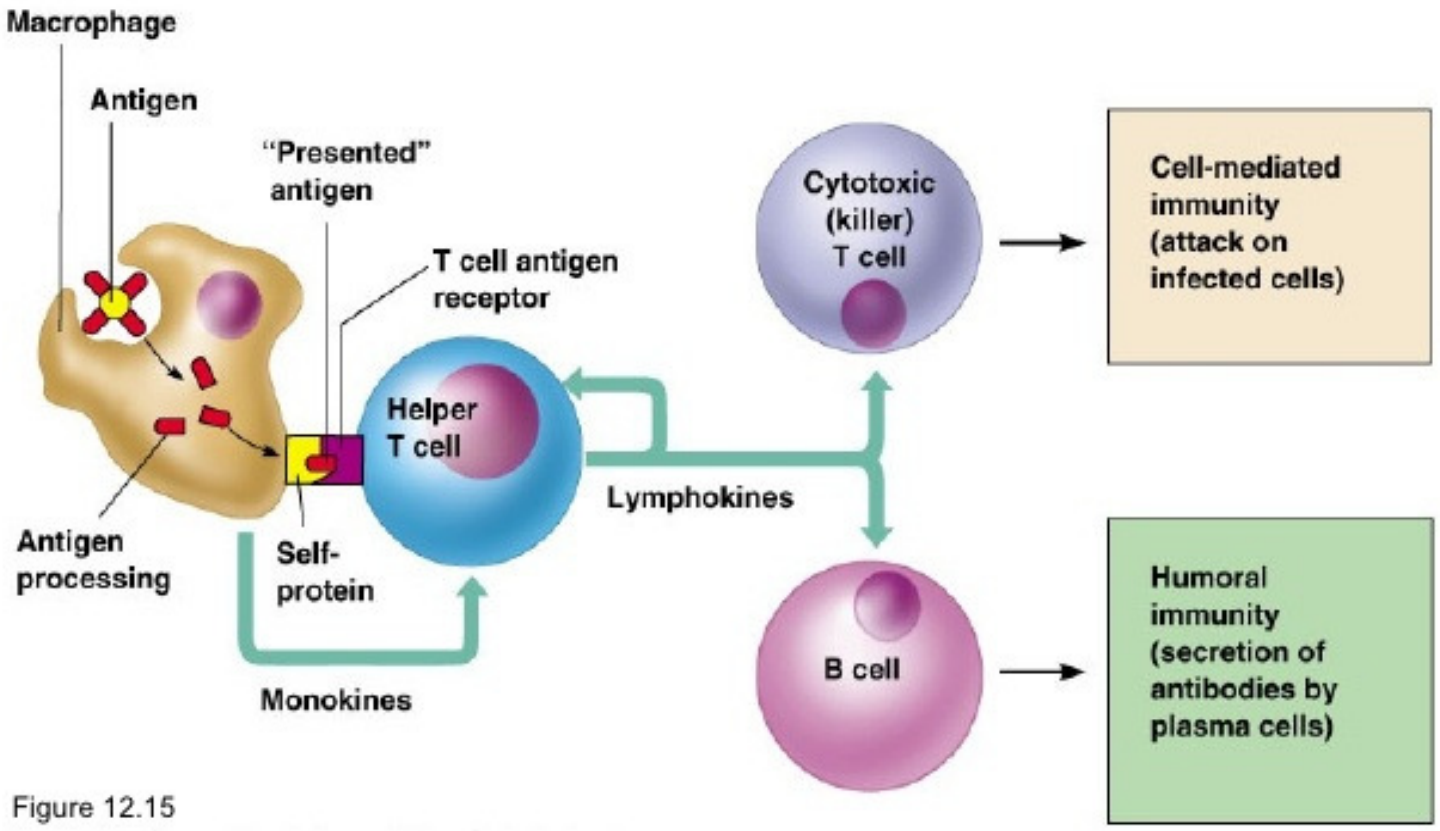


Figure 12.15

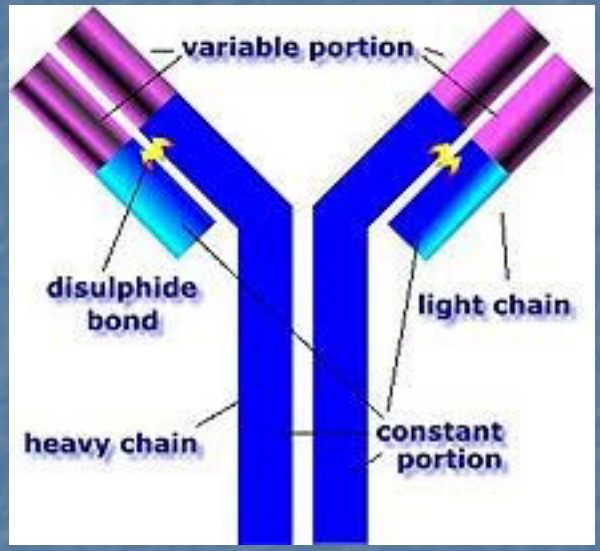
What is an antibody?

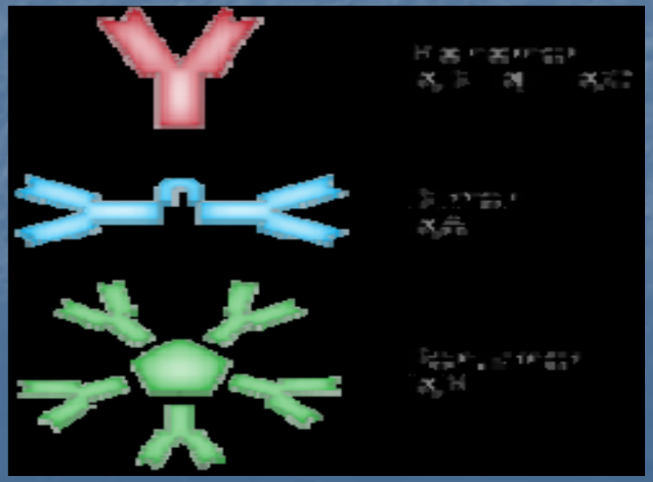
- Each antibody is specific for its antigen.
  - no cross protection.

- We have millions of different antibodies.

- Antibody Isotypes:
  IgM, IgG, IgA, IgD, IgE.

- When B cells come into contact with their matching antigen, they are stimulated to divide into larger cells called plasma cells, which secrete huge amounts of antibodies.





Antibodies - functions

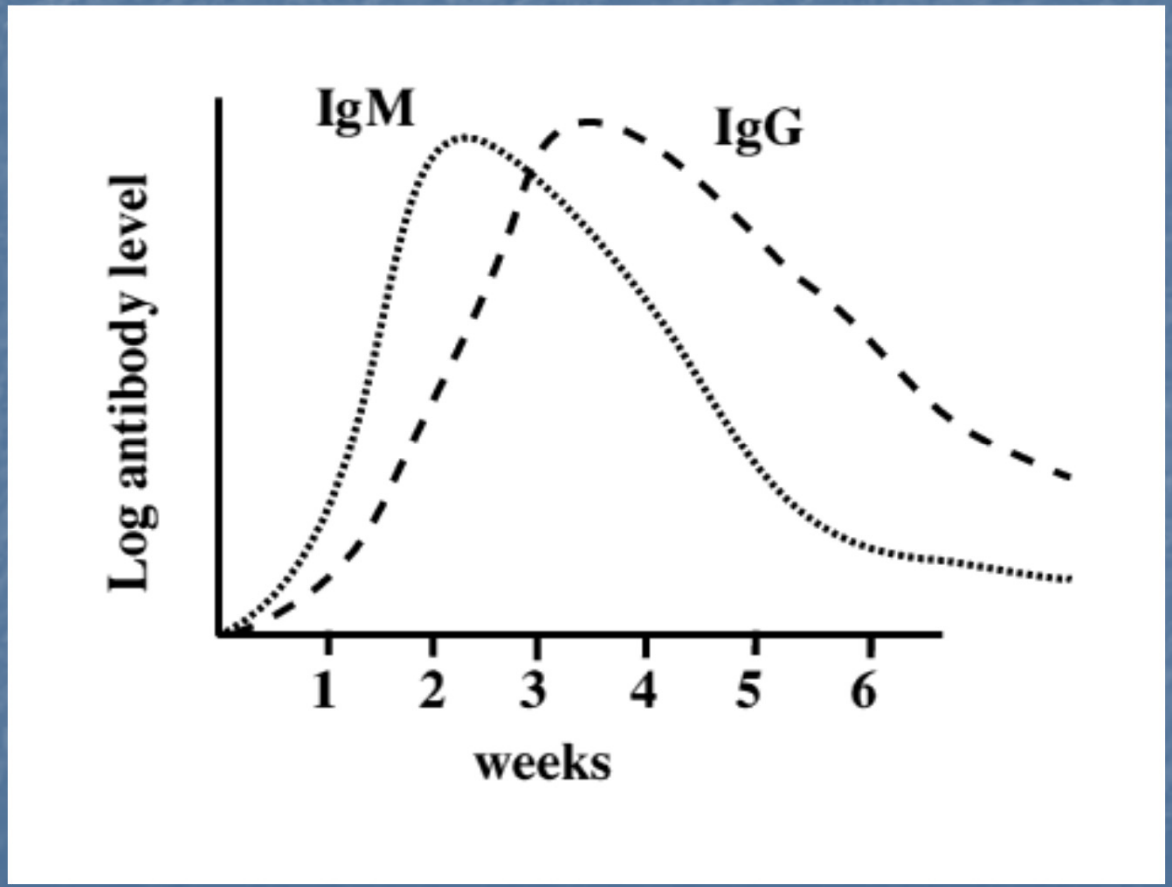
1. These antibodies circulate and attack the microorganisms that have not yet infected cells.

2. Antibodies gather on the micro-organism's surface. This blocks adhesion / cell entry of the antigen, Neutralises and prevents organism's replication, Signals (cytokines) macrophages and other wbcs to come.

3. Kills organism via complement proteins – lysis.

4. Neutralises toxin.

How soon after exposure to an antigen are we protected?



Immune response generated after 4-7 days.

Primary immune response

- Rapid, >7/7
- Mainly IgM
- last 3/52, memory cells made

Secondary immune response

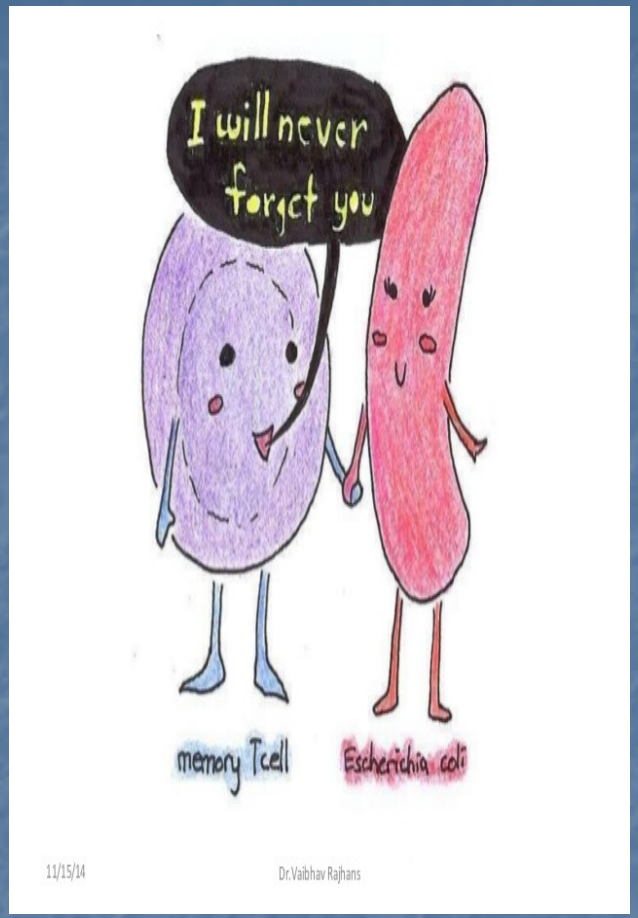
- More powerful and faster
- Mainly IgG

Takes 2 weeks to get optimum immune response after vaccination.

Specific memory is the hallmark of the adaptive immune response

Memory Cells

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

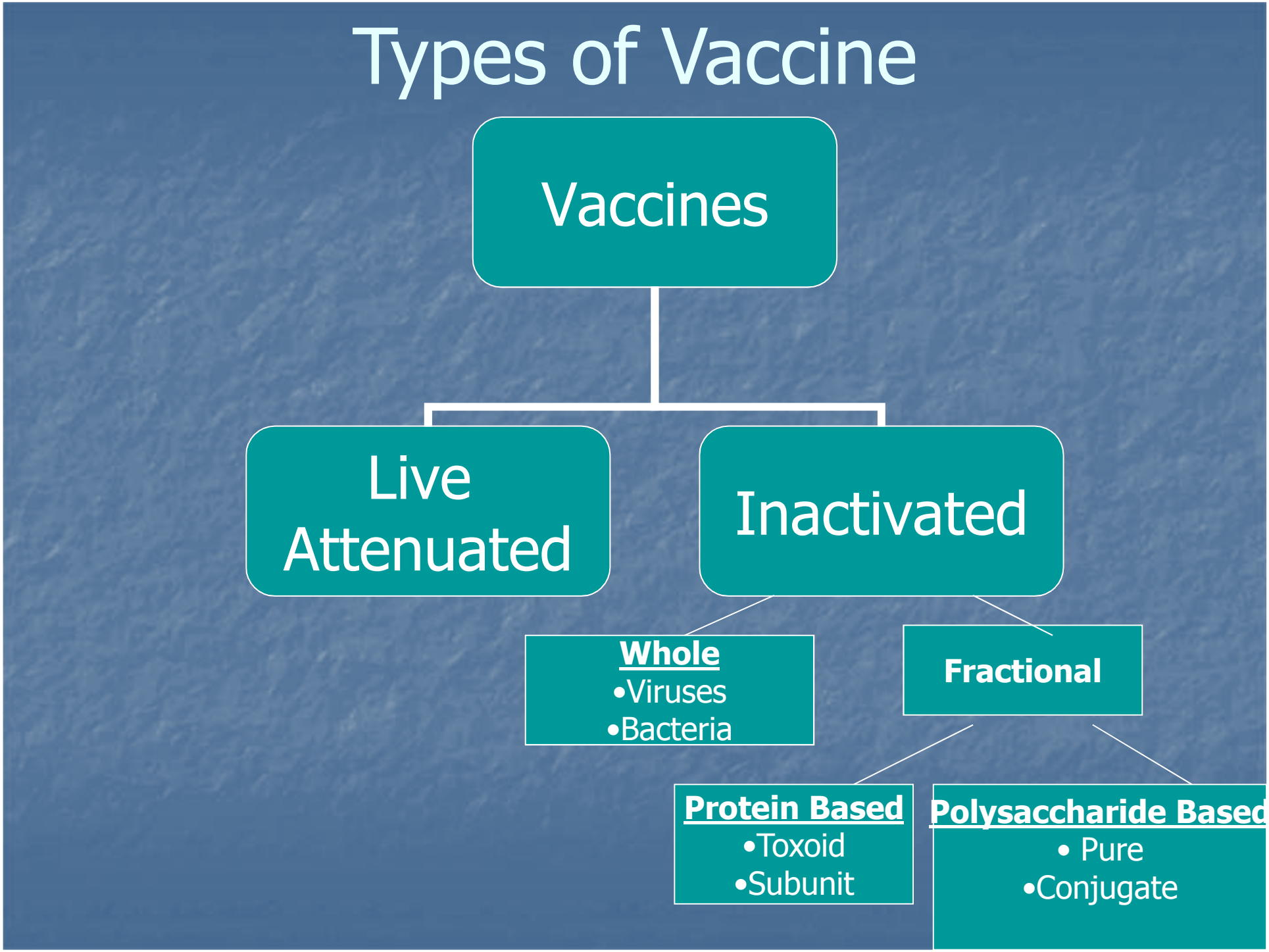
Same Immune Protection As Infection Without Causing Disease

The Ideal Vaccine

Interrupts Spread of Infection

Long Lasting Immunity

Types of Vaccine



Live Attenuated Vaccines

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

Advantage

- Potent, response close to the optimal naturally acquired immune response.
- Produces long lasting immunity after 1-2 doses.

Disadvantage

- May reproduce features of the disease as subclinical or mild form of the infection.
- May revert to virulent form (e.g. OPV).
- Cannot be given to immunosuppressed or pregnant patients.
- Need strict refrigeration.

Inactivated Vaccines

Produced by killing the pathogen

Advantages

- Cannot cause infection.
- Can be given to immunosuppressed and pregnant individuals.
- May not have to be stored as carefully.

Disadvantages

- Less immunogenic and require addition of adjuvants and booster doses.

Types of Inactivated Vaccine

Whole
organisms are killed/inactivated by heat or chemicals but remain antigenic.

Toxoid
Toxin produced by antigen that has been inactivated/weakened through chemical modification.

Subunit
Produced by extracting the antigenic part of a Microorganism.
Recombinant vaccines – subunit vaccine

Conjugate
Some bacteria are encapsulated (Polysaccharides)– difficult for immune System to Respond.
Carrier Proteins (Infants immune system recognises this) used to combine with Polysaccharide antigen and this provokes immune response.

“Other Ingredients” needed to make a Vaccine

Vaccine Components

- **Suspension fluid** (water, saline etc)

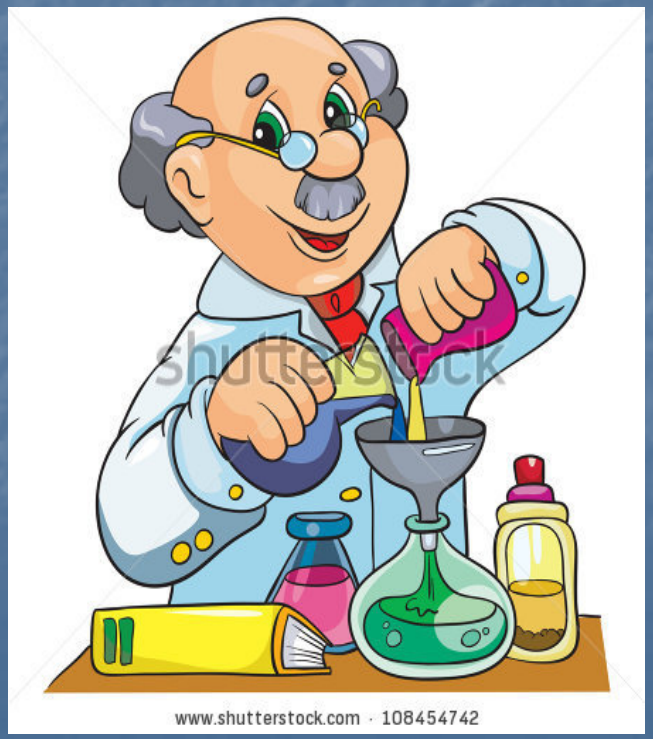
- **Preservatives, stabilisers,antimicrobial agents** (formaldehyde, antibiotics).

  (a) Trace amounts.

  (b) May cause allergic reaction.

- **Adjuvants**

(a) Aluminium salts.



Adjuvant

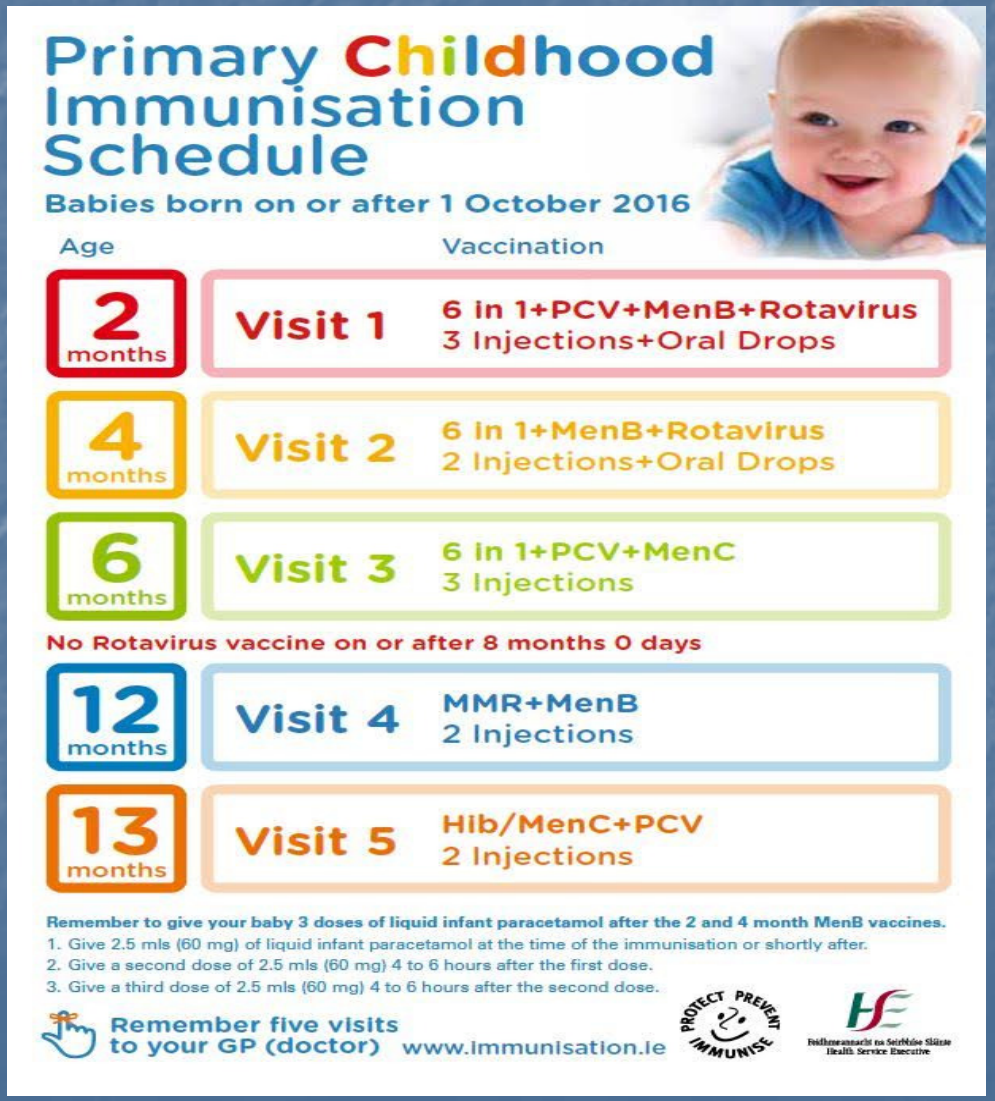
- Increase immunogenicity of vaccines containing inactivated micro-organisms or their products.
- Enhances the immune response to the vaccine's antigen by:
  - Slowing down the release of antigen at injection site.
  - Improved delivery of antigen to lymph node.
  - Assist macrophage in presentation of antigens to lymphocytes.

E.g. Hep B, tetanus toxoid, diphtheria toxoid

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.

What vaccines in our Primary Childhood Immunisations contain thiomersal?



Adverse Events

- Event that is unintended following administration of vaccines.

Adverse events

- Most common side effects are mild whereas the diseases they are designed to prevent can be serious or deadly.
- Serious side effects are reported infrequently 1 per 100,000 doses on average.
- **Live vaccine** – frequency of adverse events falls with number of doses.
- **Inactivated vaccines** – frequency of adverse events increases with number of doses.

Adverse Events

- 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 1st week.
b) Rubella (pain, joint swelling) in 2nd week.
c) Mumps (parotid swelling) in 3rd week.

Do 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

Vaccine Failure

Primary failure

- an individual fails to make an adequate immune response to the initial vaccination (e.g. in about 10% of measles and mumps vaccine recipients)

- Infection possible any time post vaccination

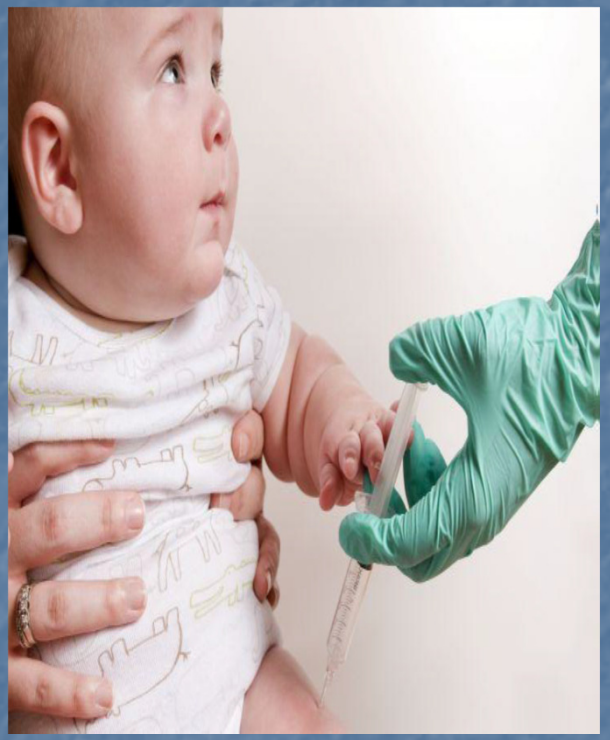
Secondary Failure

- an individual makes an adequate immune response initially but then immunity wanes over time.

- a feature of most inactivated vaccines, hence the need for boosters.

Timing of Vaccines

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.

Time Intervals between vaccine doses

Antigen Combinations	Recommended minimum interval between doses
Non Live Vaccines	May be given simultaneously or at any interval between doses.
Non Live and Live Vaccines	May be given simultaneously or at any interval between doses.
MMR and Yellow fever	Not on same day. At least 4 weeks apart.
MMR, Varicella & Zoster vaccines	Can be given on same day but if not at least 4 weeks apart.
Other Live Vaccines – BCG, Rotavirus, MMR, Varicella, Zoster, Oral Typhoid, LA Influenza, Yellow Fever	Apart from combinations above can be given on the same day or at any time before or after each other.

Herd Immunity

- A certain level of immunity in the population which protects the whole population because the disease stops spreading.

- To achieve herd immunity the % of people who need to be vaccinated depends on the disease and the vaccines used.

Why is Herd Immunity important?

- No vaccine is 100% effective.
- Some people unable to be vaccinated.
- Most effective way of indirectly protecting people who do not respond to vaccines or those who cannot be given vaccines for medical reasons.

Summary

- Innate/Adaptive Immunity.
- Ability of Immune system to develop memory!
- Primary Immune V Secondary Immune Response.
- Types of Vaccines and constituents.
- Timing.
- Vaccine Failure, Adverse Events, Herd Immunity.

Thanks!