Public Health England

oxford vaccine group

How do vaccines work?

2017

Public Health England

oxford vaccine group

Learning objectives

- Describe key features of innate, active and passive immunity
- Explain the basic immune response to a vaccine
- Name the different vaccine types used and contrast their benefits/limitations

Public Health England

How vaccines work glossary

oxford vaccine group

In pairs match these words to the definitions in your pack

immunogenicity

adaptive immune system

acquired immunity

B-cells

antibodies

antigen

T-cells

secondary immune response

innate immune system

primary immune response

Immune defence – innate and adaptive

INNATE

1 **surface barriers**

- skin / mucous membranes
- antimicrobial proteins

2 **internal defence**

- phagocytes, NK cells
- fever, inflammation

ADAPTIVE

3 **adaptive defence**

- B-lymphocytes & antibodies
- T-lymphocytes

Immune defence – innate and adaptive

INNATE (inborn)

immediate, ready-made
no memory
less specific, general

ADAPTIVE (acquired)

response lag > 96 hrs
efficient memory
antigen specific

Acquired immunity – components

ACTIVE
(own Ab or effector cells)

- infection
- vaccination

PASSIVE
(ready-made Ab)

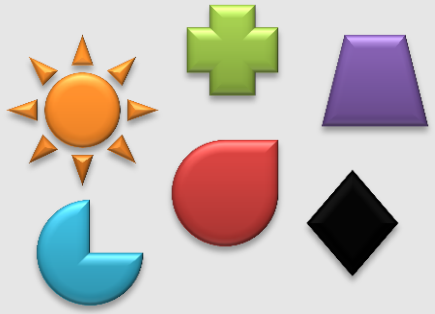
- maternal Ab
- IVIG/SCIG

Basic immune response to infection/vaccine

Basic immune response to infection/vaccine

Antigens

- proteins
- polysaccharides
- others

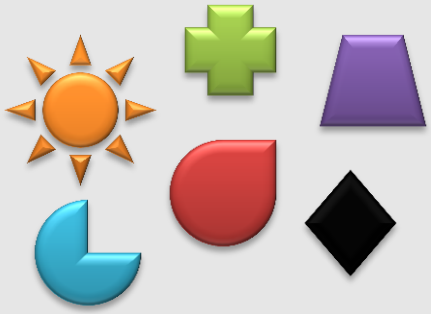


1. Distinctively shaped substance
2. Different human infections have own distinct antigens
3. Recognisable by the immune system

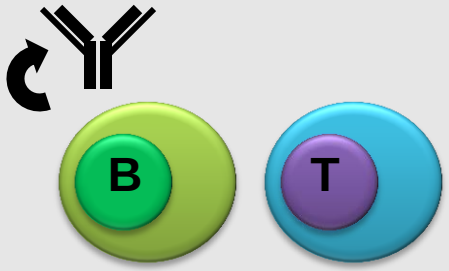
Basic immune response to infection/vaccine

Antigens

- proteins
- polysaccharides
- others



lymphocytes



Basic immune response to infection/vaccine

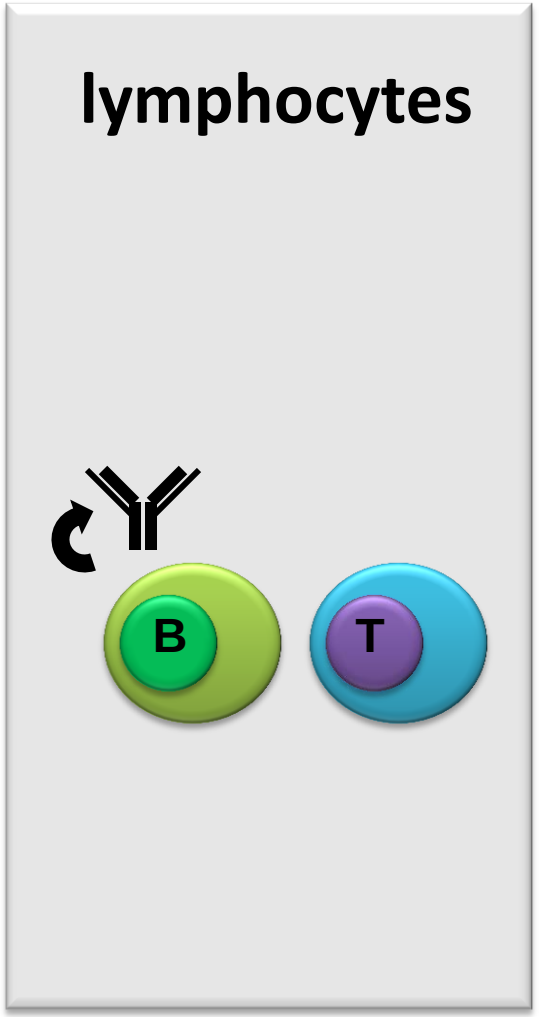
Reside in strategic lymphoid organs/system and circulate in the blood

B cells (humoral response):

- Can respond to free antigen
- Manufactures antibodies

T cells (cell-mediated response):

- Don’t produce antibodies
- Stimulate B cells
- Kill pathogens



Antibodies

- A Y shaped protein that recognises a specific antigen
- Reacts to an antigen of the right shape
- More than 100,000,000 specific antibodies / B cells
- Potential to develop responses

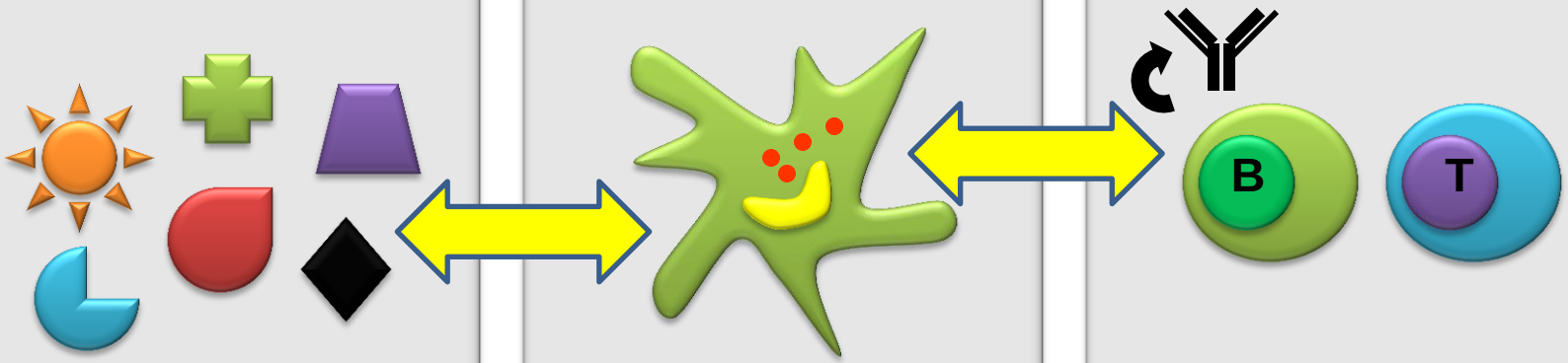
Basic immune response to infection/vaccine

Antigens

- proteins
- polysaccharides
- others

Antigen Presenting Cells

lymphocytes



Basic immune response to infection/vaccine

How does it work?

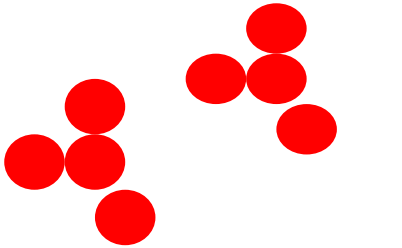
Basic immune response to infection/vaccine

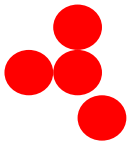
On your tables:

There are 5 cards outlining the adaptive immune response to a primary infection/vaccination.

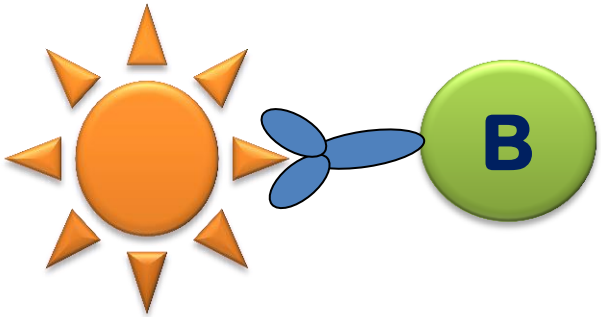
Please sort these into the correct order

Pathogen is introduced

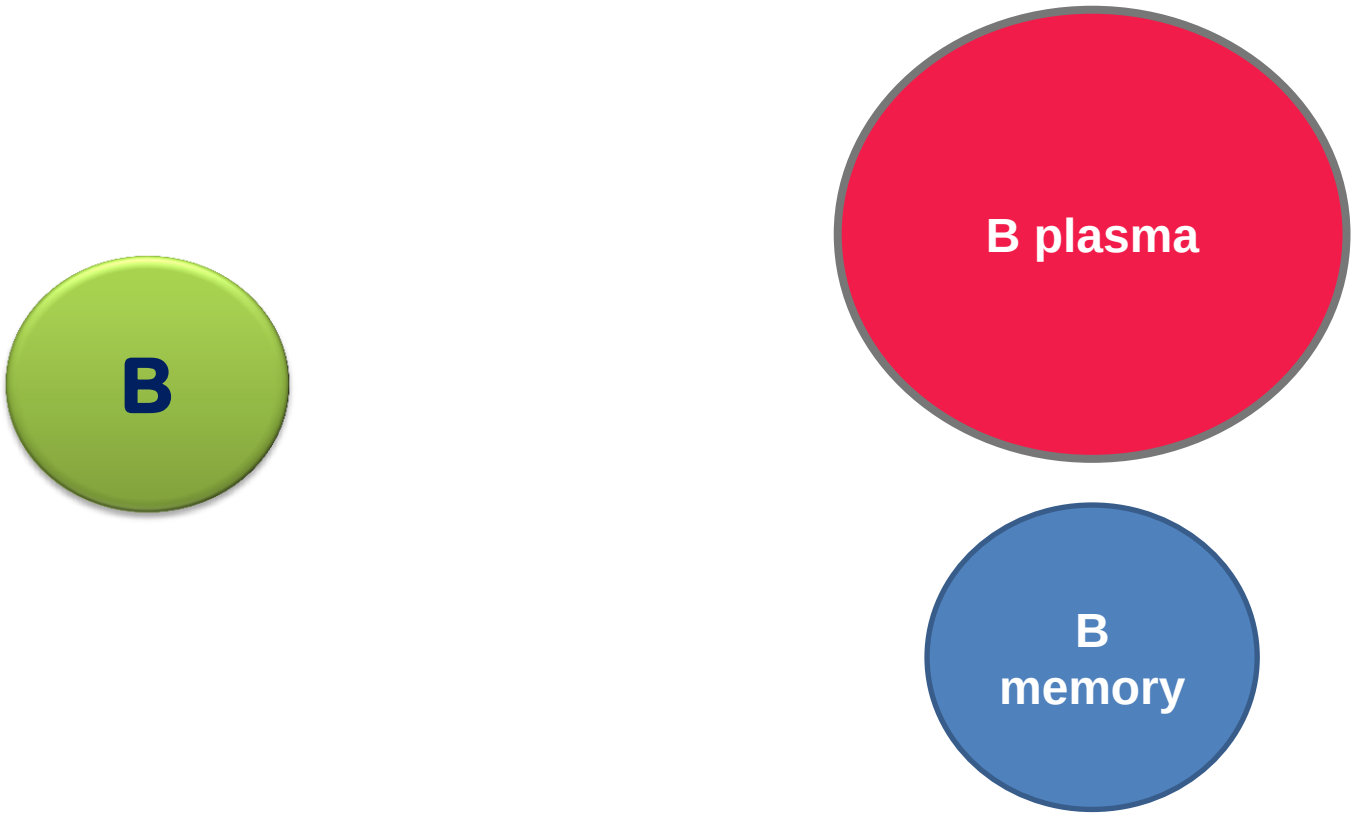




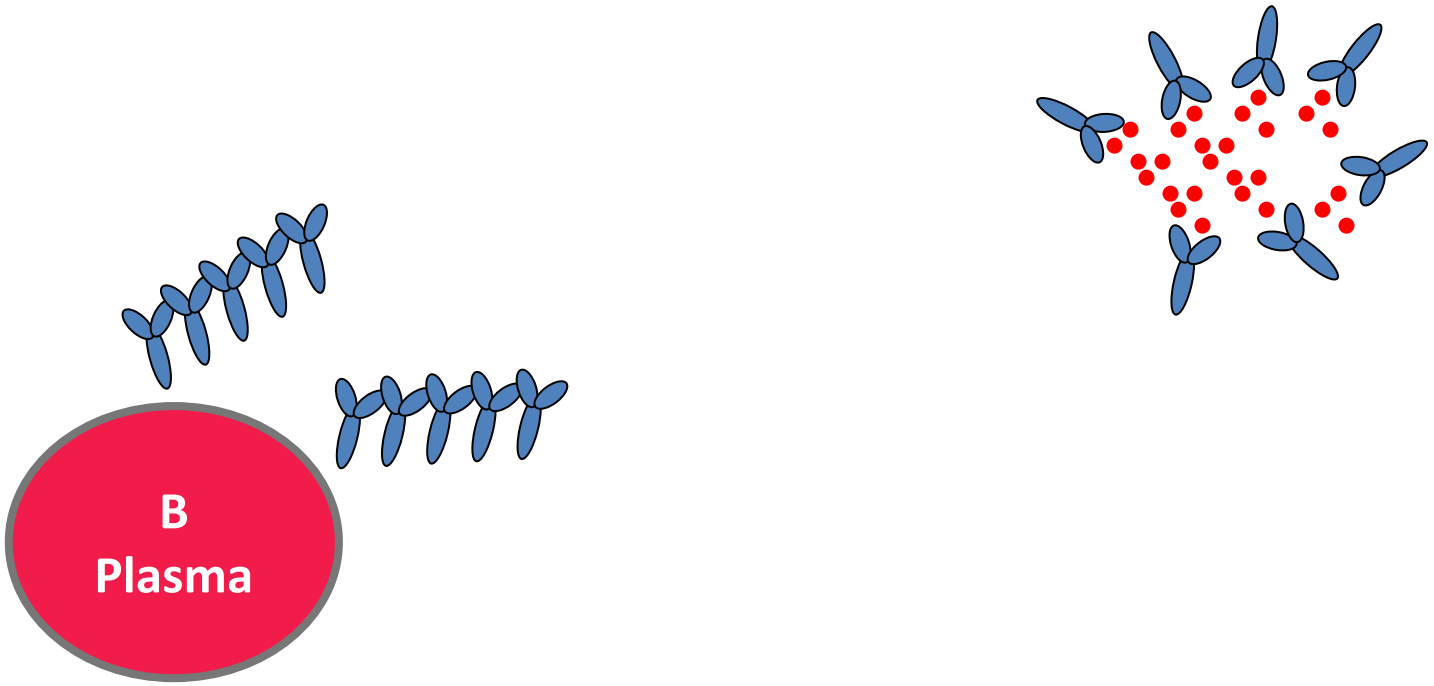
Naïve B cell is stimulated by antigen on the pathogen (or by APC/ T cell)



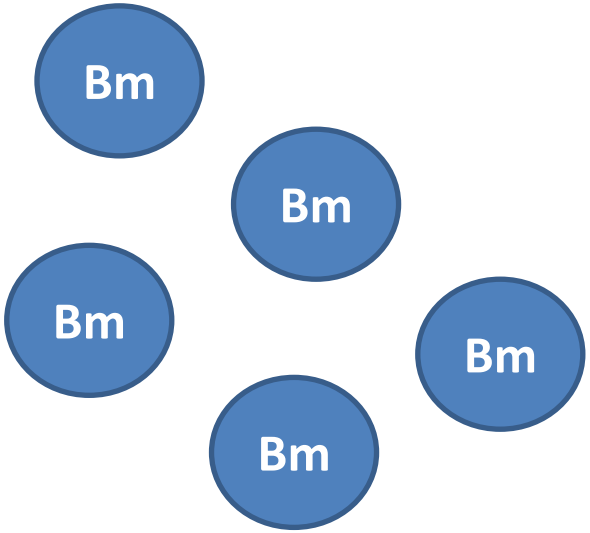
Naïve B cells rapidly multiply (proliferate) and differentiate into 1 of 2 cell types: plasma cells and memory cells



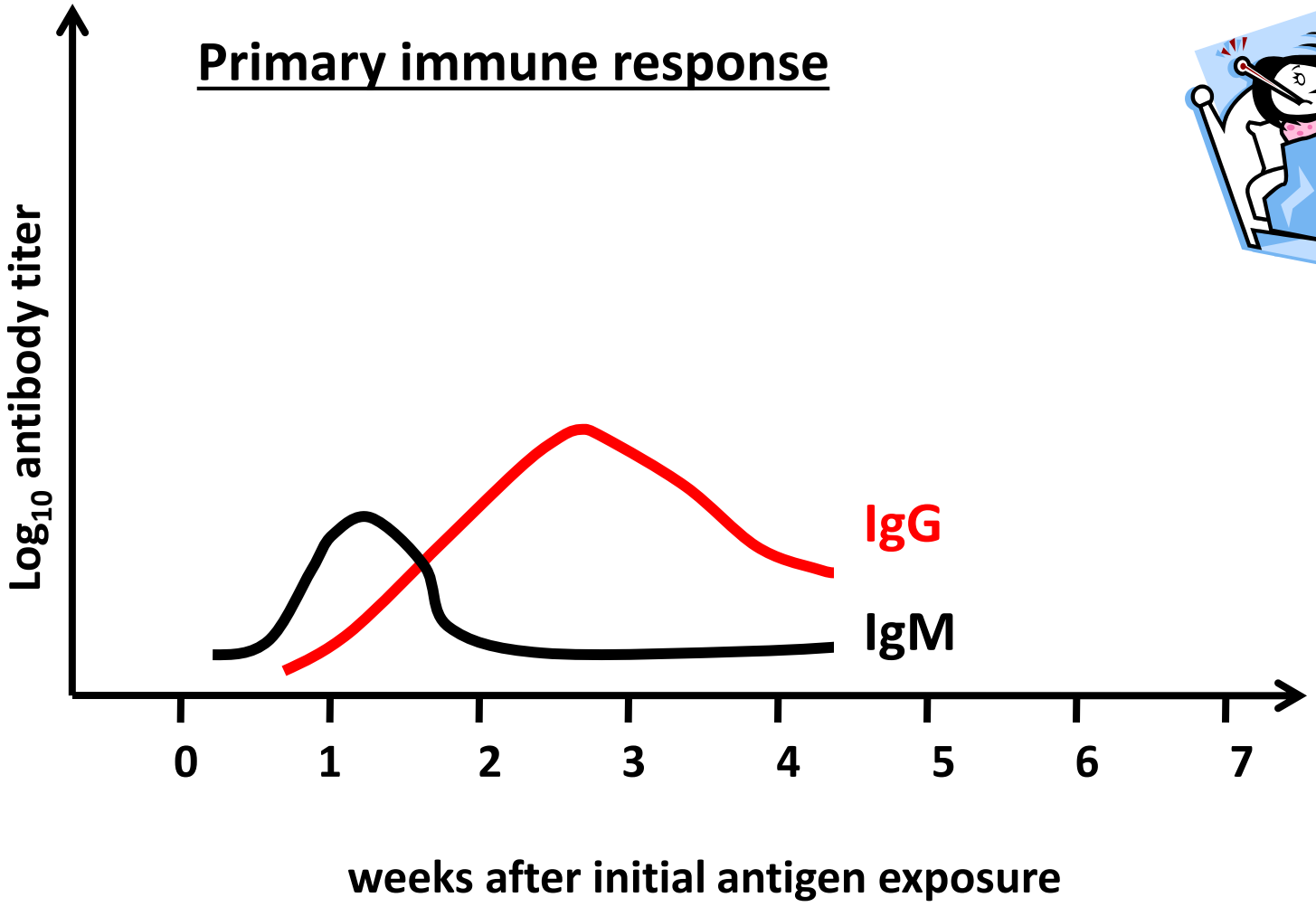
B plasma cells secrete antibodies specific to the antigen.
Pathogen is killed/neutralised.



B memory cells remain in lymph/circulation with antigen specific antibody; ready for the next time…



Basic immune response to infection/vaccine



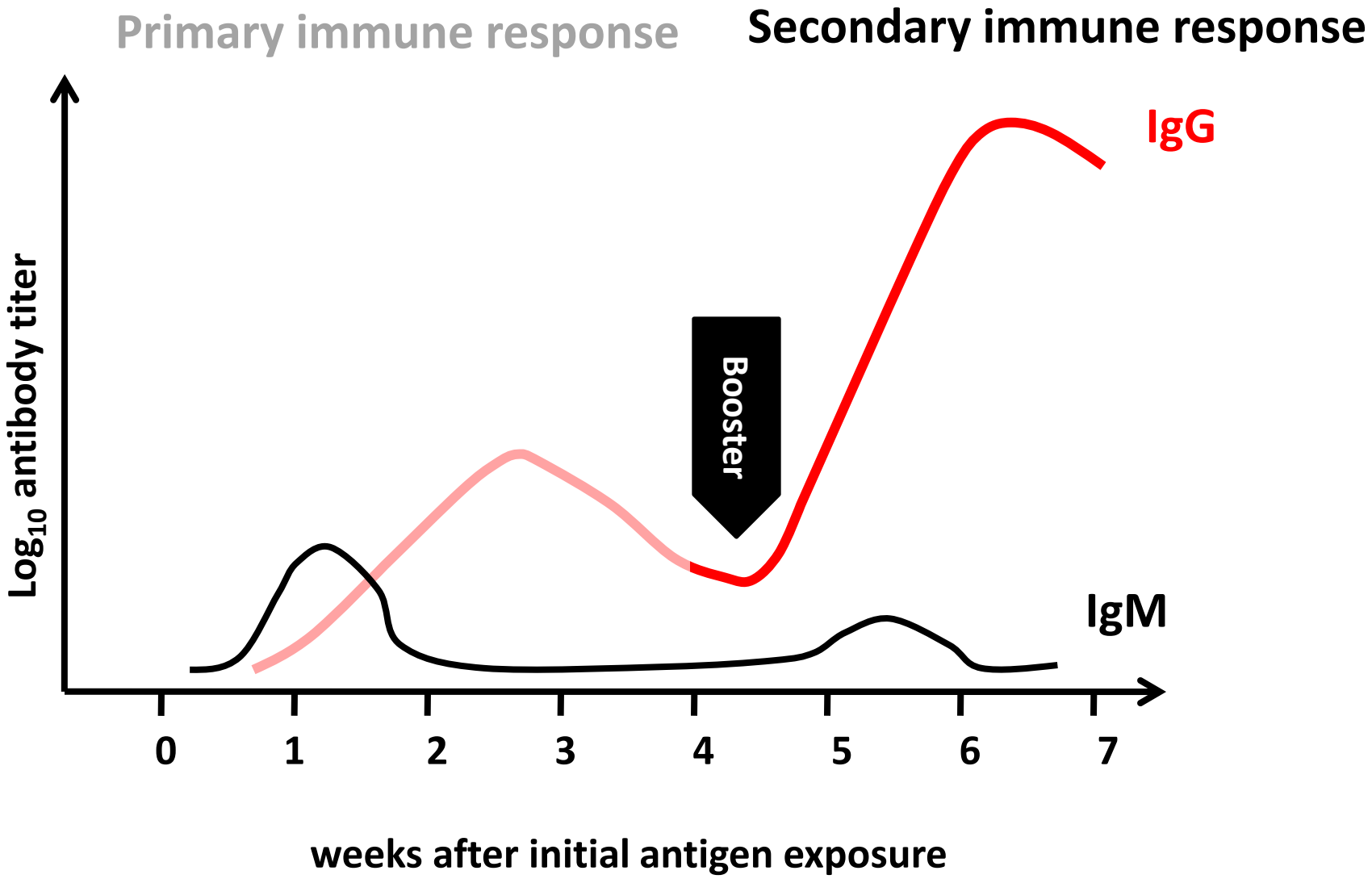
Basic immune response to infection/vaccine

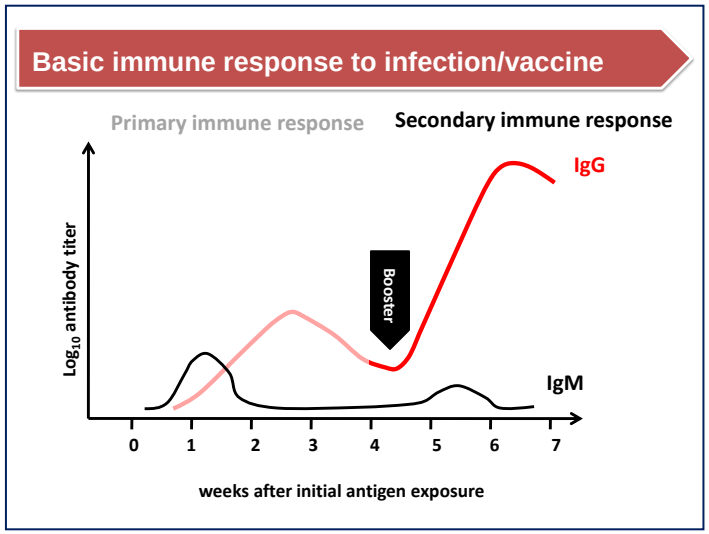
On your tables, look at the cards now. What would be different when the immune system meets the infection for a second or subsequent time?

Memory response

- Antibodies of the right specificity produced more rapidly
- Memory is boosted
- Main antibody is IgG which persists for longer

Basic immune response to infection/vaccine





Why are intervals left between doses of vaccines?

- To allow **each immune response to develop**
- To **avoid immune interference**

Vaccination

Aims to stimulates immunity without the morbidity/mortality associated with natural infection

Does everyone develop immunity following vaccination?

Primary Vaccine Failure: Failure to seroconvert (produce antibodies)

Secondary Vaccine Failure: waning immunity after seroconversion

Can vaccines overload the immune system?

NO

- The bacteria in our bodies outnumber our own cells
  - the human body is composed of 10 trillion cells and contains 100 trillion bacteria
- On average there are:
  - 1000 bacteria on each cm2 cm of your skin
  - 1,000,000 bacteria on each cm2 of your scalp
  - 100,000,000 bacteria per gram of saliva
  - 10,000,000 bacteria per gram of nasal mucus*
- There are a lot less antigens in vaccines

(Data courtesy of HPA core curriculum slide set core topic 2)

Acquired immunity – components

ACTIVE
(own Ab or effector cells)

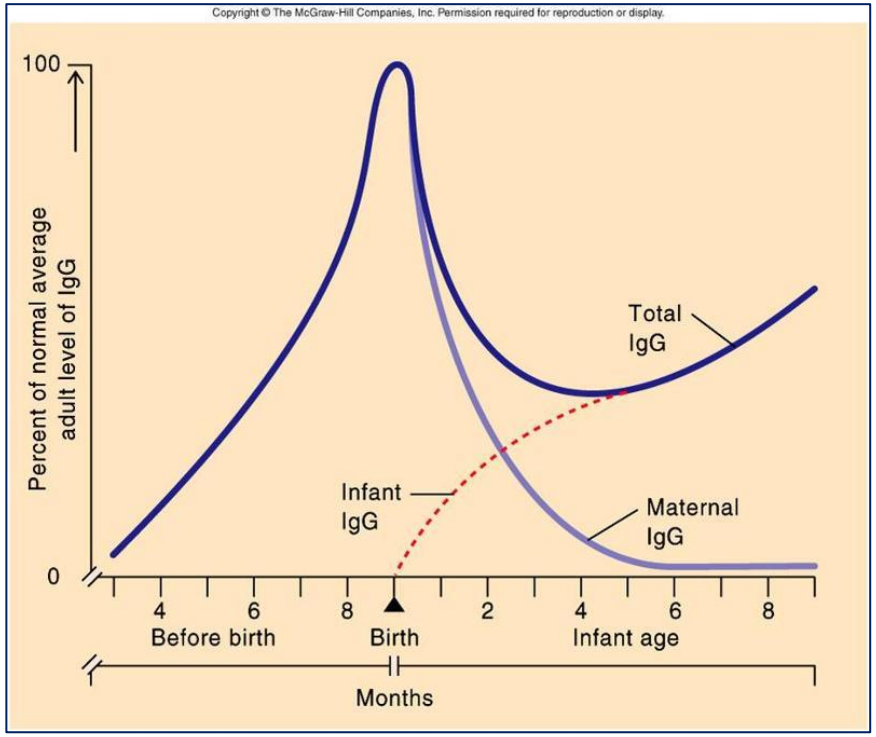
- infection
- vaccination

PASSIVE
(ready-made Ab)

- maternal Ab
- IVIG/SCIG

PASSIVE IMMUNIZATION

Maternal Antibodies



- Transplacental transfer of antibodies occurs from 16 weeks
- Vaccines given during pregnancy my confer immunity to the infant
- Maternal antibodies provide infants with protection but may interfere with vaccines given (e.g. MMR)

PASSIVE IMMUNIZATION

- administration of pre-formed immunoglobulins:

  (1) Human Normal Immunoglobulin (pooled human antibody)
  - Hepatitis A

  (2) Specific immunoglobulin e.g. from convalescent patients
  - Hepatitis B
  - Rabies
  - Varicella

Advantages	Disadvantages
(1) **rapid** protection within hours (e.g. post-exposure prophylaxis)	(1) effect lasts only 3-(6) months (2) involves using a blood derived product (3) may limit own immune response, especially to live vaccine

Vaccine types

LIVE (attenuated)

- BCG
- MMR
- Varicella
- Yellow fever
- Rotavirus
- Shingles

- Fluenz (nasal flu)

- Oral polio
- Oral typhoid

DEAD (inactivated)

intact (whole microorganism)

- Polio, Rabies
- Influenza
- Hepatitis A
- Old pertussis / typhoid

fragments

- Influenza
- Hepatitis B
- HPV

toxoids

- Diphtheria
- Pertusssis
- Tetanus

polysaccharide

- Pneumoccal (PPV)
- Typhoid

conjugate

- MenC
- Men ACWY
- PCV
- Hib

proteins

- Men B

Vaccine types – LIVE (attenuated)

- partly like natural infection
- mimic the immune but not the virulence aspects of the disease

Advantages

(1) Potent, close to the naturally acquired immune response
(2) often lifelong immunity, no need for repeated boosters*

* measles component of MMR has 90% response, 2nd dose is for the 10% who didn't respond

Disadvantages

(1) may reproduce features of the disease as sub-clinical or mild form of the infection
(2) may revert to virulent form (e.g. OPV)
(3) cannot be given to immunosuppressed or pregnant patients

Vaccine types – INACTIVATED

Advantages

(1) usually safe for immuno-suppressed individuals or pregnant women

(2) more stable and easier to store and transport

Disadvantages

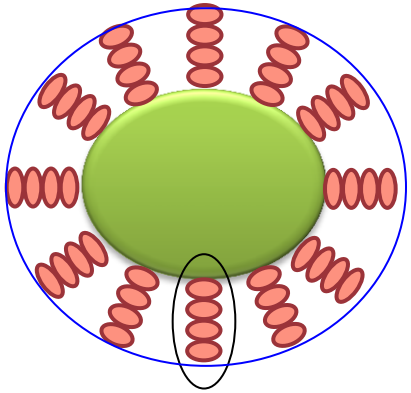
(1) less immunogenic requiring additional measures to enhance the immune response:

a) higher antigen dose
b) repeated priming doses
c) booster doses
d) adjuvants
e) conjugation

(2) weaker cell-mediated responses

(3) higher price

INACTIVATED vaccine - conjugation



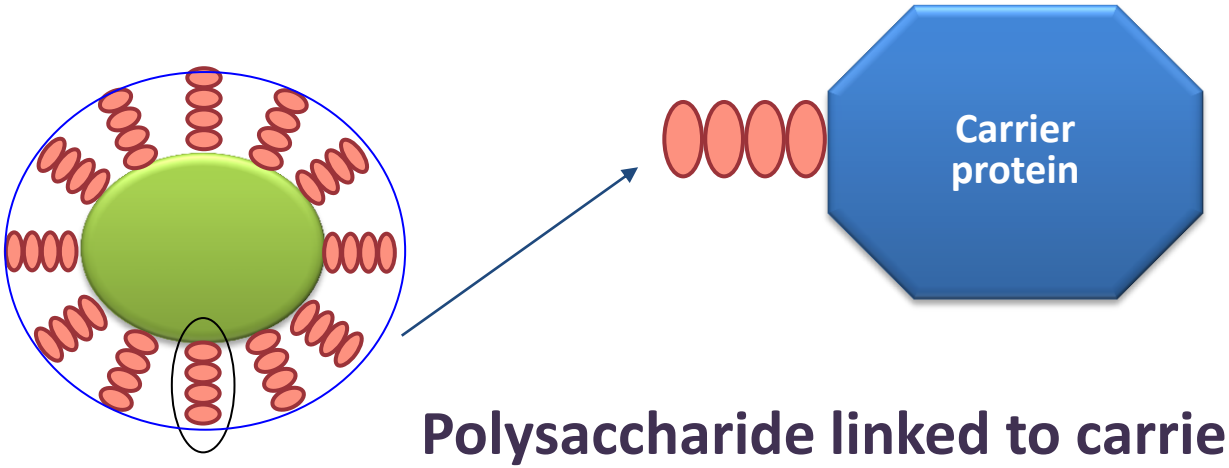
Encapsulated bacterium:
e.g. N. meningitidis, S. pneumoniae, H. influenzae

The immune response to polysaccharide antigens is not fully developed before the of age of 2 years

INACTIVATED vaccine - conjugation

Conjugation:

a process of **attaching (linking) the polysaccharide antigen to a protein carrier** (e.g. diphtheria or tetanus) that the infant's immune system already recognises, to provoke an immune response



Polysaccharide linked to carrier protein

Conditions affecting immune response to vaccination

- Immunosuppression
- Prematurity

  (some evidence premature babies may have sub-optimal response to Hib and Hep B vaccines but should be scheduled on basis of their actual date of birth)

- Malnutrition and chronic disease
- Nephrotic syndrome
- Sickle cell disease and other causes of hyposplenism
- Simultaneous administration of immunoglobulin

THE FINISHER.....

1. Why are 5 doses of tetanus vaccine given across a lifetime but only 2 doses of MMR?

2. What is the difference between passive and active immunity?

3. Why would you recommend a patient receives a vaccine rather than develops immunity from natural infection?

http://immunologyanimation.phe.org.uk