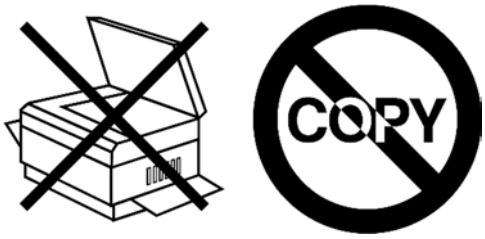
VCE Exam Revision Lectures

Unit 3 Biology

Copyright Notice



Samples in Other Subjects

For sample notes relating to the below subjects, please contact TSFX on 03 9663 3311 or admin@tsfx.edu.au.

- Accounting
- Economics
- Further Mathematics
- English Language
- Health & Human Development
- Literature
- Physical Education
- Physics
- Specialist Mathematics

THE SECOND LINE OF DEFENCE: INNATE (NON-SPECIFIC)

If the first line of defence has failed, the ***second line of defence*** is employed. It involves innate responses to the presence of foreign particles in the internal environment of the organism.

This line of defence cannot distinguish one type of micro-organism from another.

No memory to pathogen is formed at the conclusion of the battle, i.e. This response is the same no matter how often a person is infected with the same pathogen.

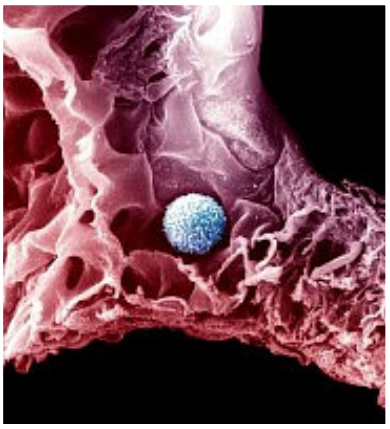
PHAGOCYTES

Phagocytes are white blood cells that move to the point of pathogen entry. As with all blood cells, phagocytes are formed in the bone marrow. They freely move through the lymphatic and circulatory systems, and will leave these vessels (via amoeboid movement) in order to track down and destroy pathogens.

- Phagocytes engulf pathogens via ***endocytosis (phagocytosis)***. After phagocytosis, a lysosome fuses with the phagocytic vesicle and the pathogen is digested.

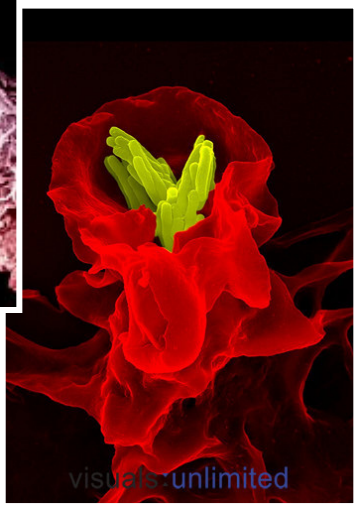
- Not only phagocytic in nature, ***neutrophils***, the most common white blood cell, also release chemicals designed to kill bacteria. With an inability for form new lysosomes, each neutrophil perishes after killing only a small quota of bacteria, forming pus.

- An important phagocyte in the human body is the ***macrophage*** ("big eater"). Macrophages detect and destroy microbes by following the chemical trail of the microbe.

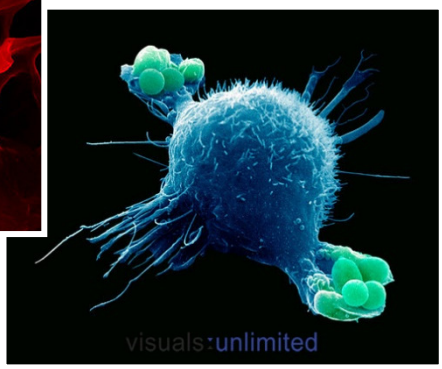


A phagocyte engulfs an inhaled air particle in an alveolus.

visualsunlimited.com



A macrophage engulfs tuberculosis bacteria.



A macrophage engulfs cocci bacteria.

- Some pathogens are too large to be engulfed by one phagocyte (e.g. blood flukes). In such cases, many phagocytes attach to the pathogen in an attempt to destroy it.

- The presence or absence of an antigen on the surface of a foreign particle or organism (e.g. Pollen grain, bacteria, roundworm etc.) will determine whether or not a phagocyte will attack it.

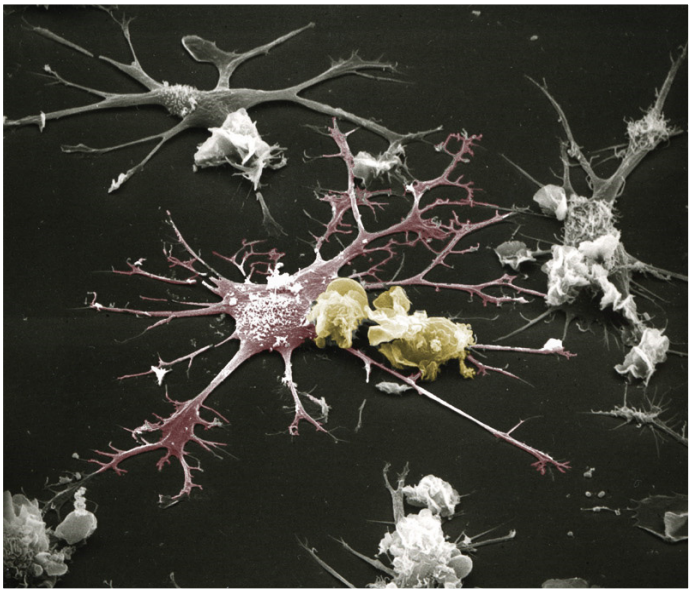
- After ingesting a pathogen, a macrophage will proceed to display the pathogen's antigens on its own cell membrane in order to arouse recognition and further action on the part of the immune system.

- ***Eosinophils*** and ***basophils*** play a small role in phagocytosis. As with basophils, eosinophils are involved in allergic responses.

  In addition to containing histamine, basophils contain the anti-clotting agent heparin. Eosinophils have a role in antigen presentation and can release cytokines and cytotoxic chemicals.

- It is only in recent years that the significant defensive role played by ***dendritic cells*** has become more apparent. They play a key role in processing antigen material and presenting it on their surface to other cells of the immune system, e.g. lymphocytes of the third line.

  Dendritic cells are present in small quantities in **tissues that are in contact with the external environment,** mainly the *skin* and the inner lining of the *nose, lungs, stomach* and *intestines.*

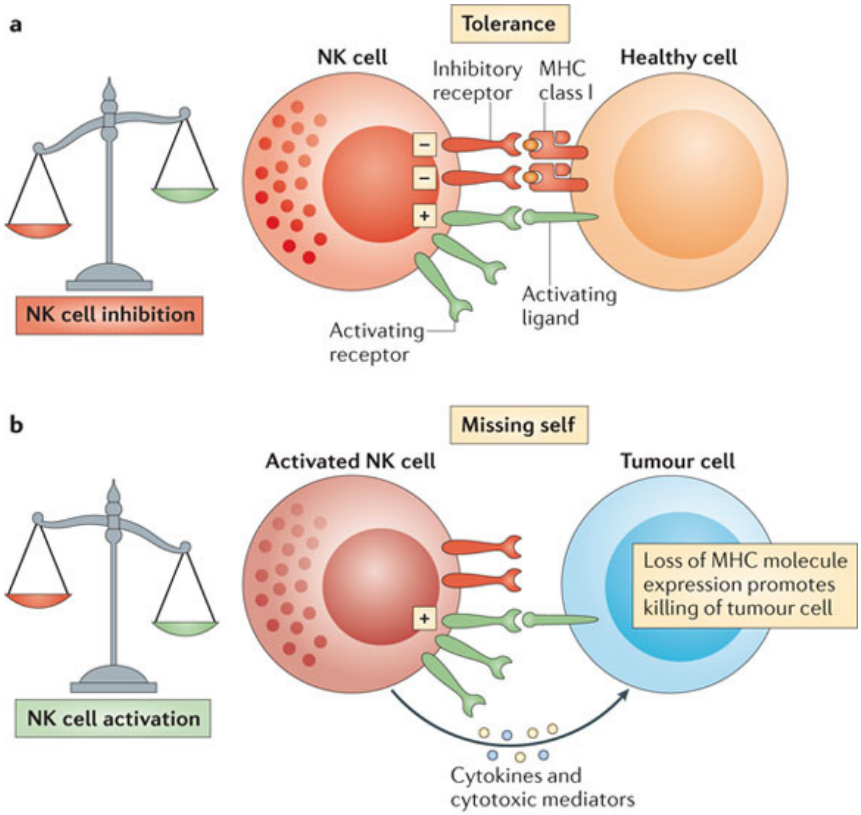


Dendritic cells clearly revealing their dendrite-like extensions

Once activated, dendritic cells migrate to the lymphoid tissues where they interact with T cells and B cells of the third line of defence to initiate the appropriate immune response.

NATURAL KILLER CELLS

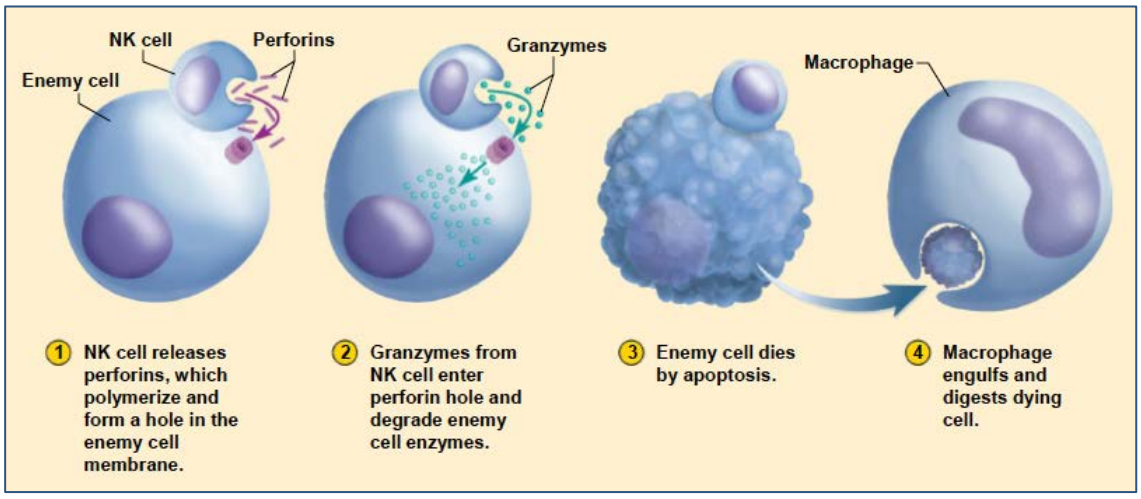
- ***Natural killer (NK) cells*** operate in a different manner to white blood cells that ingest foreign particles. Instead, they attack and kill viral-infected cells of the body and directly kill cancer cells. NK cells are **non-specific lymphocytes**.



Nature

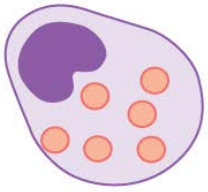
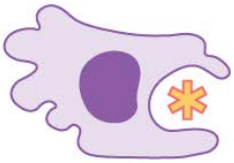
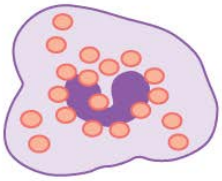
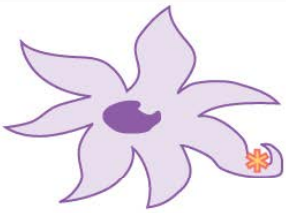
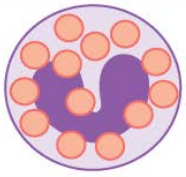
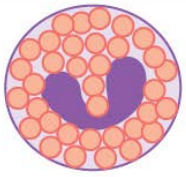
- Natural killer cells act by attacking any cells of the body which do not display Class I MHC markers. When they attach to cancer or viral-infected cells they release perforins which form pores in the membrane of the cell.

- Secreted granzymes then enter the perforin pores and degrade enzymes of the cell and it dies via apoptosis.



StudyBlue

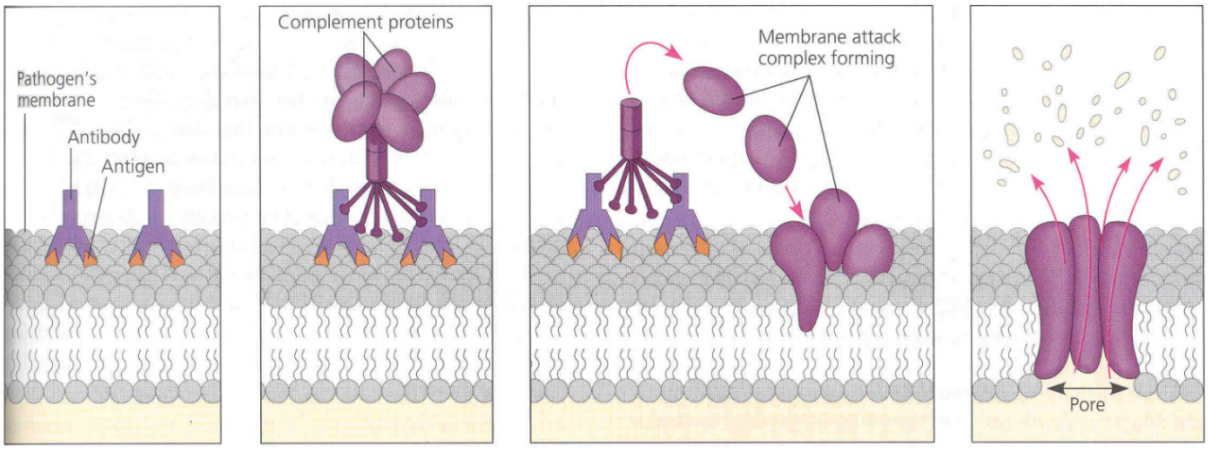
SUMMARY OF INNATE IMMUNE CELLS AND MODES OF ACTION

Cell type	Characteristics	Location	Image
Mast cell	Dilates blood vessels and induces inflammation through release of histamines and heparin. Recruits macrophages and neutrophils. Involved in wound healing and defense against pathogens but can also be responsible for allergic reactions.	Connective tissues, mucous membranes	
Macrophage	Phagocytic cell that consumes foreign pathogens and cancer cells. Stimulates response of other immune cells.	Migrates from blood vessels into tissues.	
Natural killer cell	Kills tumor cells and virus-infected cells.	Circulates in blood and migrates into tissues.	
Dendritic cell	Presents antigens on its surface, thereby triggering adaptive immunity.	Present in epithelial tissue, including skin, lung and tissues of the digestive tract. Migrates to lymph nodes upon activation.	
Monocyte	Differentiates into macrophages and dendritic cells in response to inflammation.	Stored in spleen, moves through blood vessels to infected tissues.	
Neutrophil	First responders at the site of infection or trauma, this abundant phagocytic cell represents 50-60 percent of all leukocytes. Releases toxins that kill or inhibit bacteria and fungi and recruits other immune cells to the site of infection.	Migrates from blood vessels into tissues.	
Basophil	Responsible for defense against parasites. Releases histamines that cause inflammation and may be responsible for allergic reactions.	Circulates in blood and migrates to tissues.	
Eosinophil	Releases toxins that kill bacteria and parasites but also causes tissue damage.	Circulates in blood and migrates to tissues.	

PROTEINS THAT KILL OR IMPEDE INVADING MICROBES

COMPLEMENT

Complement proteins are a group of proteins that assist phagocytes in recognising the presence of pathogens. They continually circulate in blood plasma.



(Campbell NA & JB Reece, 2002)

- A particular group of proteins, called ***antibodies*** *(discussed later in the booklet),* circulate in the bloodstream, and they will attach to specific invading microorganisms. Complement proteins then **innately** attach to the tails of the antibodies on the invading microorganisms (mainly bacteria) and act as flags, making the pathogen more readily identifiable to the immune system, and thus attracting phagocytes to the site of infection.

- Complement proteins lyse the cell membranes of bacteria and fungi, and the leaking cell contents further stimulate phagocytic action.

CYTOKINES

Cytokines are a variety of signalling molecules which include interferons, interleukins, and growth factors. They are secreted by certain cells of the immune system and have an effect on other cells. All are protein, peptide or glycoprotein in nature.

They are produced by a broad range of cells, including immune cells like macrophages, B lymphocytes, T lymphocytes and mast cells, as well as endothelial cells.

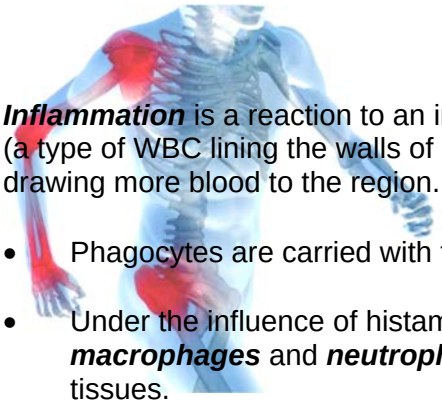
Interferon is a cytokine that is secreted by viral infected cells.

- The release of interferon makes adjacent uninfected cells more resistant to the virus, thus reducing their chances of infection. It triggers these cells to make particular enzymes which prevent the virus from synthesising more copies of itself inside the cell.

- Interferon can reduce the success rates of viruses that do not have far to travel to a host cell, e.g. Common cold and influenza viruses.

Chemokines are cytokines which are secreted by cells at a site of infection or inflammation (see next page), thereby attracting white blood cells to the region.

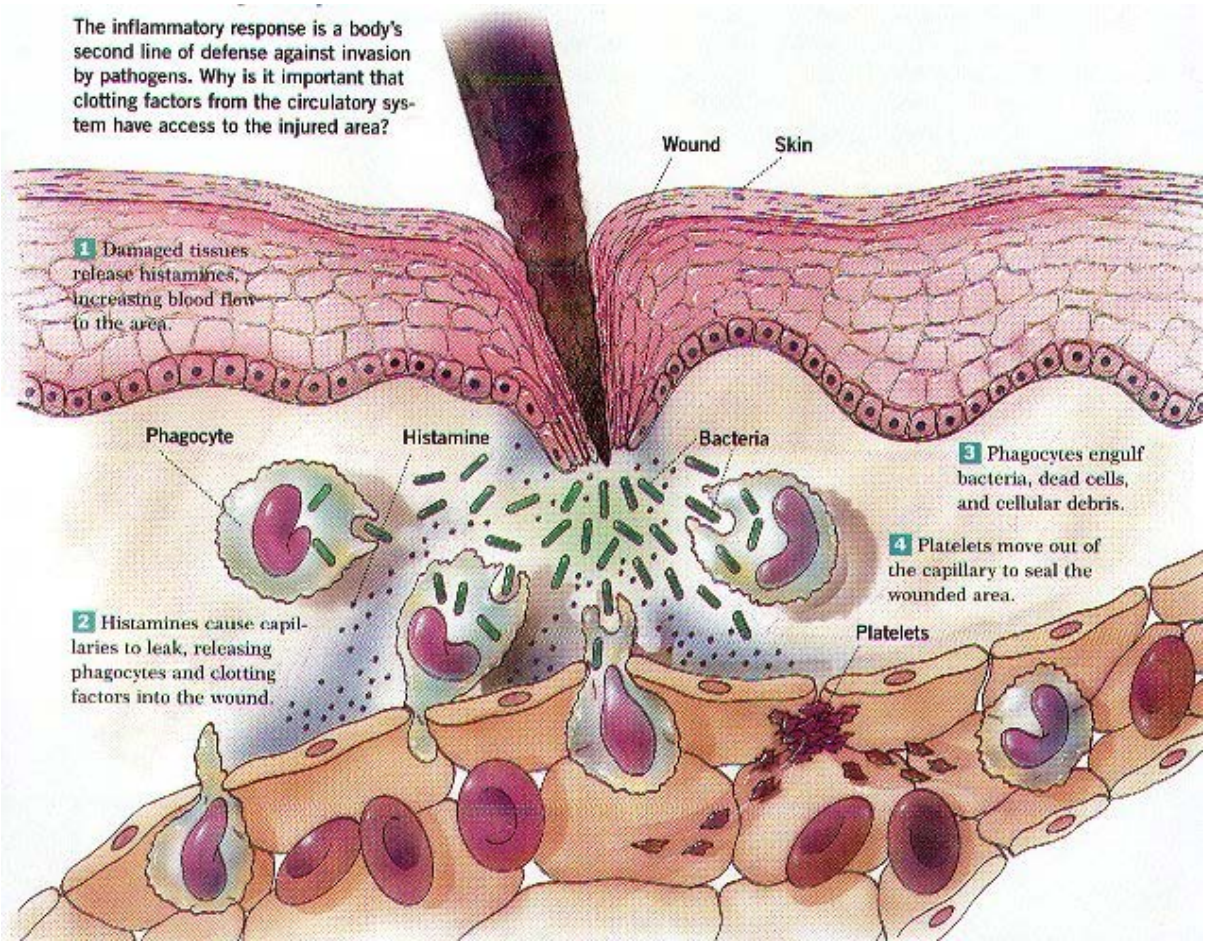
INFLAMMATION



Inflammation is a reaction to an infection whereby ***histamines***, released from ***mast cells*** (a type of WBC lining the walls of blood vessels), cause local arterioles to expand, thus drawing more blood to the region.

- Phagocytes are carried with the blood to the area of infection.
- Under the influence of histamine, capillaries become highly permeable, so ***macrophages*** and ***neutrophils*** pass easily from the bloodstream to the infected tissues.

breakingmuscle.com



inflammation.jpg

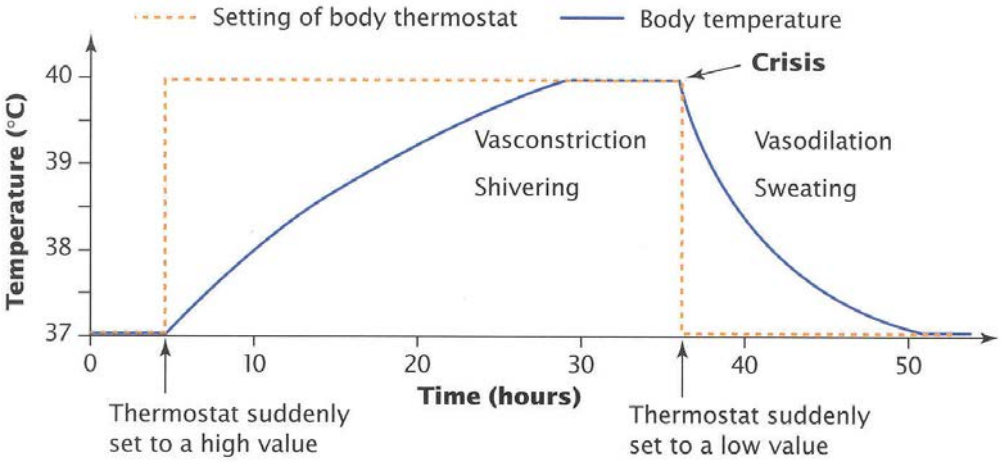
- Preliminary phagocytes that move to the area release histamine to attract more phagocytes.
- Neutrophils (a type of phagocyte) also release chemicals which kill bacteria, and macrophages clean up the mess.

TEMPERATURE RESPONSE

If an invader has been detected in the body in considerable numbers, ***macrophages*** release a ***cytokine**** called ***interleukin-1***.

Interleukin-1 travels to the brain, where it resets the ***hypothalamus***, resulting in a ***fever***.

The invading microbes do not reproduce as well at the higher body temperature, giving the white blood cells, which perform well at the higher body temperature, an improved chance of overcoming them.



makehealtheasy.com

THE LYMPHATIC SYSTEM

The lymphatic system plays a vital role in defending the human body against the myriad of pathogens it can be exposed to during a lifetime. It is a system of vessels and lymph nodes which, although separate from the circulatory system, does return fluid and protein to the blood.

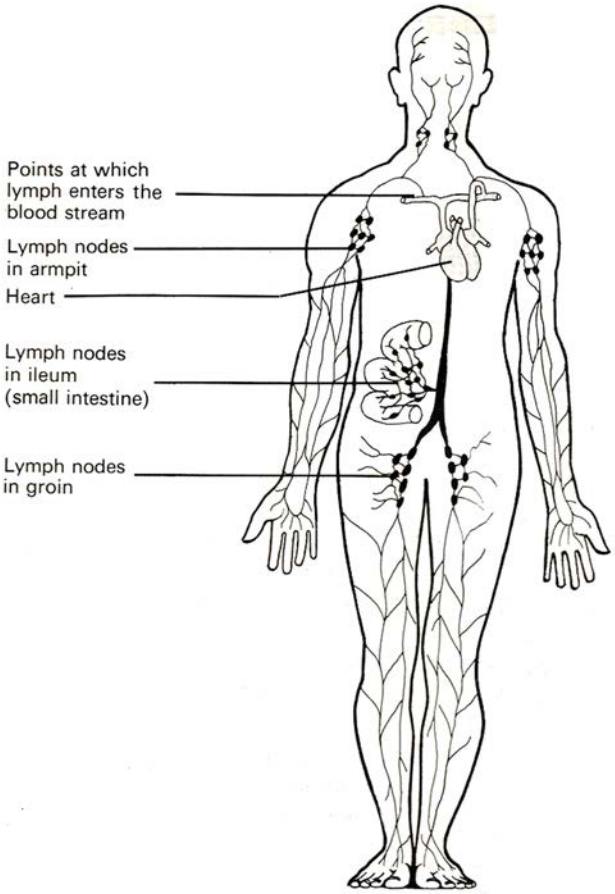
- Fluid and plasma proteins enter the lymphatic system via tiny blind-ending lymph capillaries. This fluid, once within the lymphatic system, is referred to as ***lymph***. It is similar in composition to interstitial fluid.

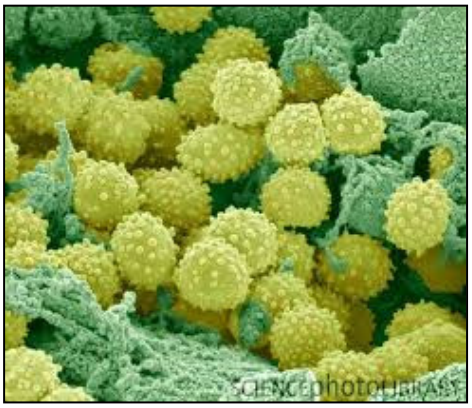
- Lymph capillaries merge to form increasingly larger vessels which ultimately drain lymph back into the bloodstream at the vena cavae (the large veins returning blood to the heart from the body).

- As with veins, lymph vessels contain **valves that prevent the backflow of fluid.** This ensures a **one-way flow of lymph** within the body.

  Hence, the squeezing of fluid within the lymphatic system towards the heart is largely dependent on movement of surrounding skeletal muscles of the body.

- Along the length of lymph vessels are sections known as ***lymph nodes***. Inside each node are sections filled with white blood cells which filter the lymph passing through.





sciencephoto.com *(Beckett, BS, 1979)*

Lymph nodes swell during an infection, as the particular type of white blood cell responsible for fighting the infection multiplies rapidly in order to overcome and destroy the invader, typically a virus or bacterium. You may have noticed swollen nodes in your neck or tonsils during the course of an infection.

- As well as lymph nodes located in various parts of the body, the spleen, tonsils and appendix are part of the lymphatic system.

PRIMARY LYMPHOID TISSUE

Primary lymphoid organs generate lymphocytes from immature progenitor cells. The thymus (a gland in the chest) and the bone marrow comprise the primary lymphoid organs involved in the production and development of the cells of the immune system.

- Bone marrow is responsible for both the creation of T cells and the production and maturation of B cells. From the bone marrow, B cells immediately join the circulatory system and travel to secondary lymphoid organs in search of pathogens.

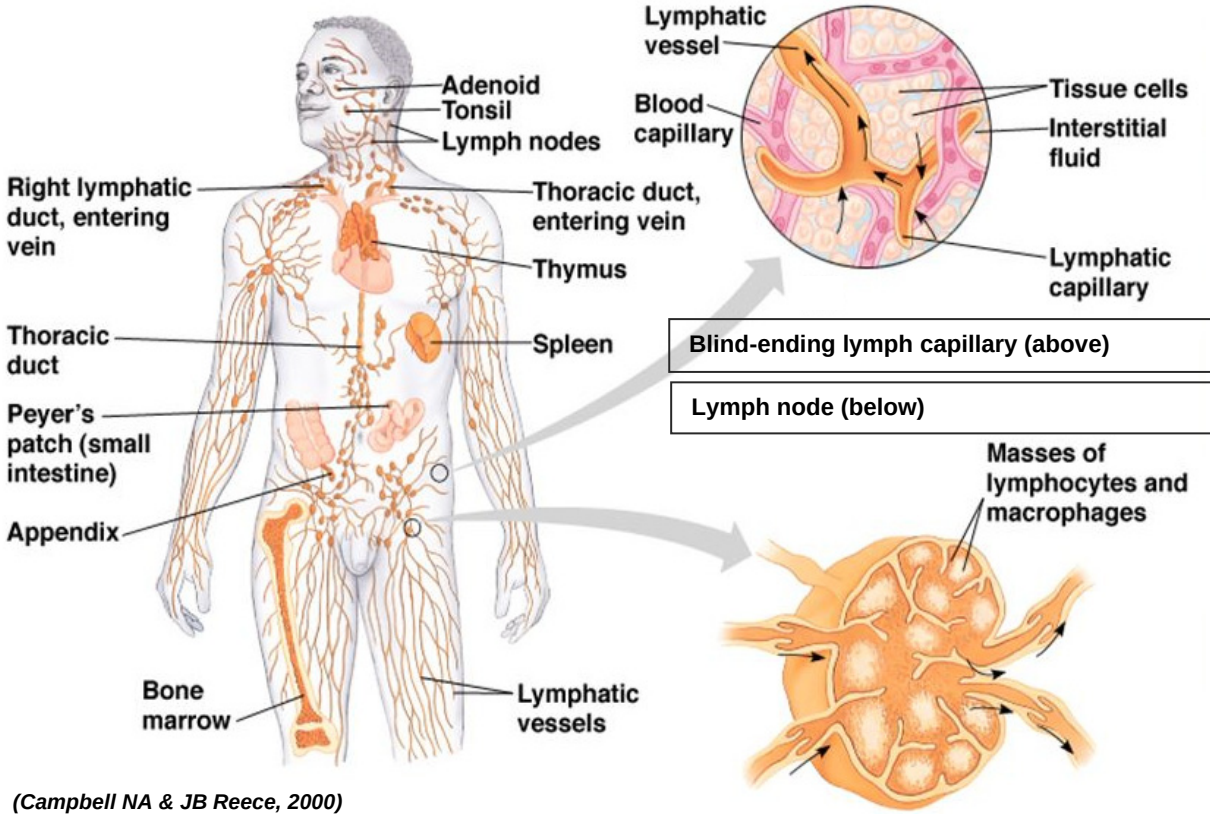
- T cells, instead, travel from the bone marrow to the thymus where they develop further. Mature T cells then join B cells in the bone marrow. The majority of T cells that entered the thymus begin a process of apoptosis as they were designed to kill self cells.

SECONDARY LYMPHOID TISSUE

Secondary lymphoid organs, which include lymph nodes and the spleen, maintain mature naive lymphocytes and initiate an adaptive immune response. The secondary lymphoid organs are the sites of lymphocyte activation by antigens.

Secondary lymphoid tissue provides the environment for the foreign molecules (antigens) to be recognised by the lymphocytes. It is exemplified by the ***lymph nodes,*** and the lymphoid follicles in tonsils. Lymph nodes are the key sites of lymph filtration, where antigens are screened. There are approximately 500 – 700 lymph nodes within a human body, and each node contains thousands of white blood cells. they are predominantly located in the neck, and chest, underarms, groin and intestines.

Activation leads to rapid mitosis (clonal expansion) of B and T cells. Mature lymphocytes recirculate between the blood and the secondary lymphoid organs until they encounter their specific antigen.



(Campbell NA & JB Reece, 2000)

THE THIRD LINE OF DEFENCE – ADAPTIVE (SPECIFIC)

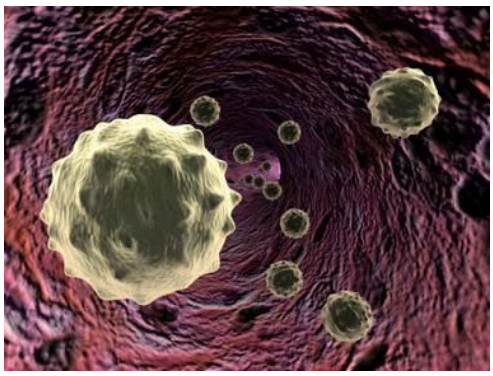
If the first and second lines of defence have not prevented an infection, specific immunity, involving the action of ***B cells*** (including their production of ***antibodies***) and ***T cells***, will come into play.

The third line of defence involves:

- An ***adaptive (specific) response*** for each type of infection.
- A ***memory*** of the pathogen resulting from the infection.

  B cells mature in the ***bone marrow***.

  T cells mature in the ***thymus gland***.



www.buzzle.com

Other non-specific white blood cells (WBCs) assist the B cells and T cells in their operation. WBCs are continually circulating in the blood and lymphatic system acting as mobile defence forces for our body.

Swollen lymph glands and the presence of white pus near sores are both clear signs of WBC activity.

B Lymphocytes (B cells) and T lymphocytes (T cells) are highly specific in action:

- Different varieties of T lymphocytes have the roles of mobilising the entire specific response to disease, destroying viral infected cells, foreign eukaryotic cells and cancer cells, and controlling the length of the immune response.
- Each type of B lymphocyte secretes one specific type of antibody, which will specifically bind to one type of antigen.
- Approximately 80% of all lymphocytes are T cells and 20% are B cells.

Antigens & Antibodies

As previously noted, antigens are compounds, often proteins, which trigger an immune response, including the production of ***antibodies***.

Antibodies are proteins produced by *B cells* which *specifically* react with the antigens that caused their formation. We will discuss them shortly.

Naïve T and B Cells

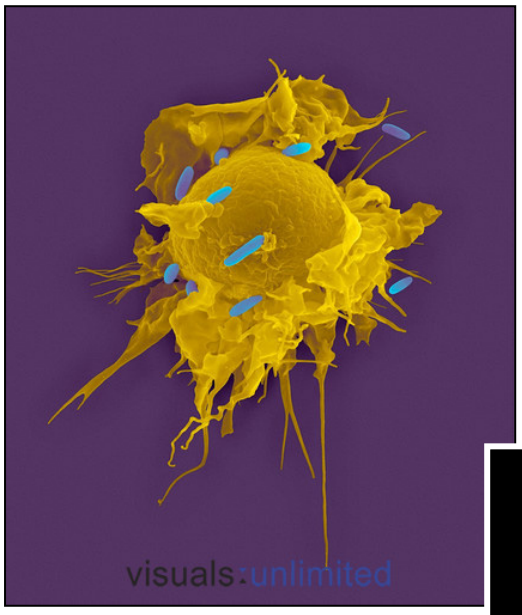
A ***naïve T cell*** is a T cell that has differentiated in bone marrow and has successfully undergone maturation (the mechanism by which T cells that are reactive to self or not reactive enough to non-self are destroyed) in the thymus. But naïve T cells are those T cells that have never been exposed to the antigen that they are programmed to respond to. Among these are the naive forms of helper T cells and cytotoxic T cells. A naive T cell is considered mature, yet unlike activated T cells or memory T cells, it has yet to encounter its relevant antigen. The same can be said for naïve B cells.

PRIMARY RESPONSE

The primary response of the third line of defence occurs after first contact with a pathogen. It is slow to develop and the individual usually suffers some of the symptoms of the disease.

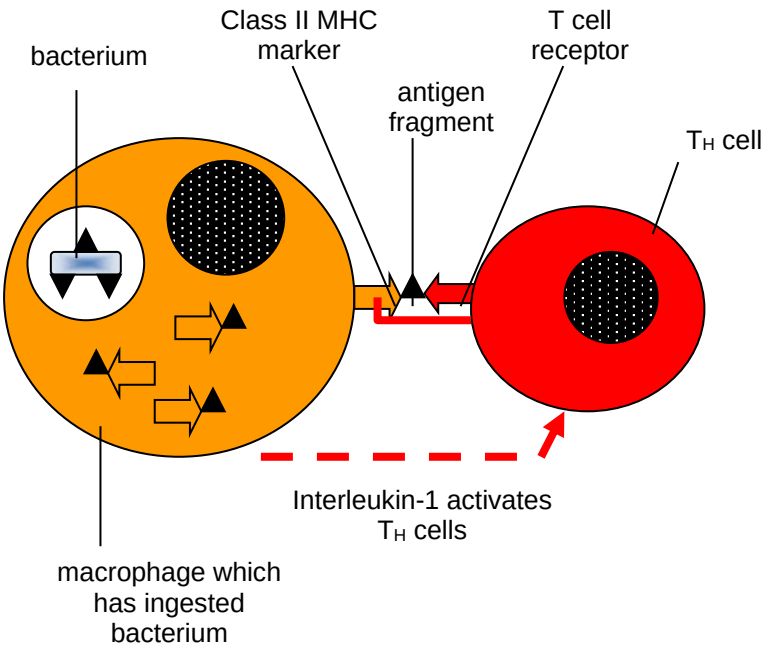
A ***macrophage*** captures the pathogen and advertises some of its antigens on its own cell membrane. The antigen fragment is displayed on a ***class II MHC marker*** of the macrophage. The macrophage also releases a cytokine, ***interleukin-1*** in order to attract ***helper T cells***.

The helper T cells release the cytokine ***interleukin-2*** in order to activate ***B cells***, ***cytotoxic T cells*** and ***more helper T cells***.



An alveolar macrophage engulfing *E. coli* bacteria. Antigen fragments from the bacteria will then be presented on the surface of the cell to attract helper T cells.

A human macrophage on the move in search of foreign particles.



The first phase of the primary response: A phagocyte (e.g. a macrophage, dendritic cell etc.) presents an antigen fragment to a helper T cell.

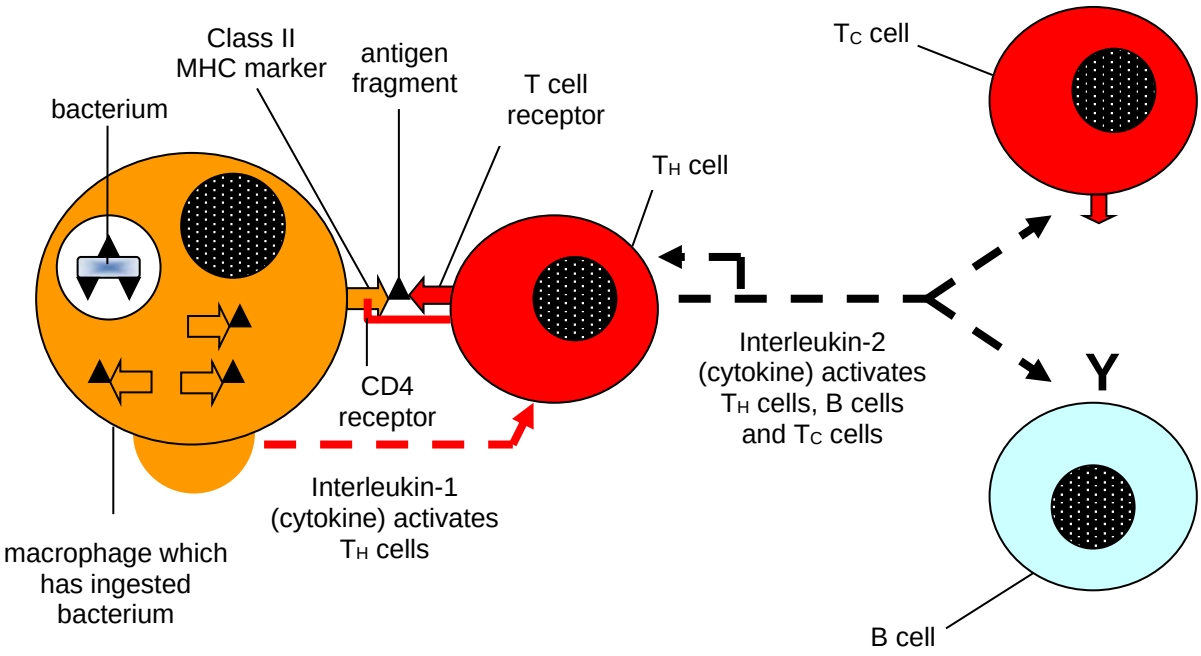
CELL MEDIATED (CELLULAR) IMMUNITY

Cell mediated (cellular) immunity involves the resistance to disease resulting from the action of cells. It involves attacks on pathogens which are inside cells.

Three types of T cells involved in cellular immunity include: ***helper*** (T_H) cells, ***cytotoxic*** (T_C) cells and ***memory*** T cells.

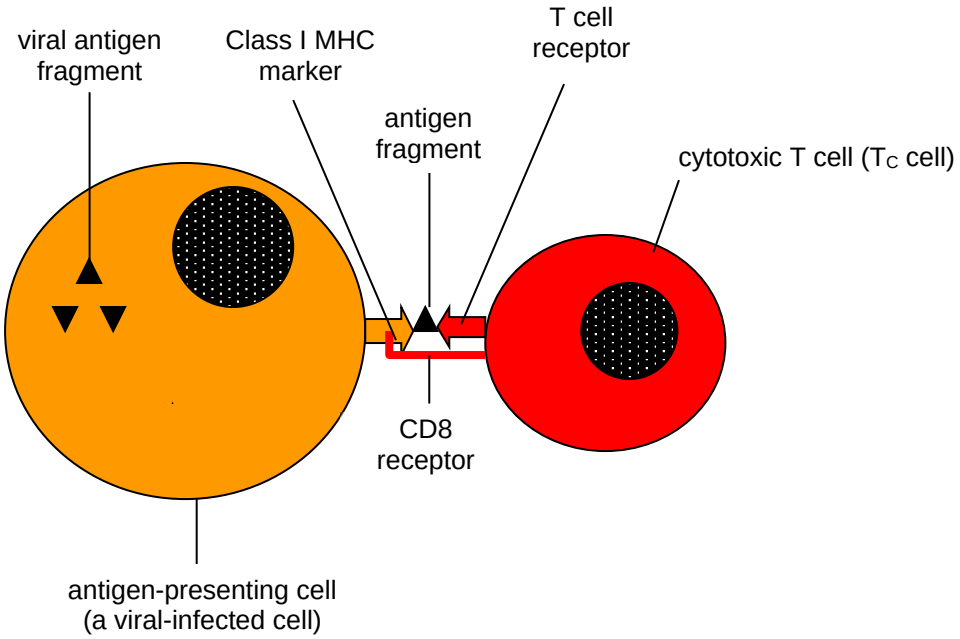
- After engulfing an invader, a macrophage (or dendritic cell) displays the invader's antigens on its own cell membrane. The activated macrophage is carried to the lymph node where the T cells are accumulated. This improves the chances of finding a matching T cell rapidly.

- The macrophage also releases a cytokine to attract the appropriate helper T cells. Using their complementary ***T cell receptors***, helper T cells also recognise the non-self antigens displayed by the ***class II markers*** of the macrophage and bind to the antigen. The ***receptors*** of the helper T cell directly bind to the class II MHC marker of the macrophage, and amplify the signal generated by the T cell receptor. The macrophage cytokine also generates a ***fever*** in the body, which aids in disease resistance.

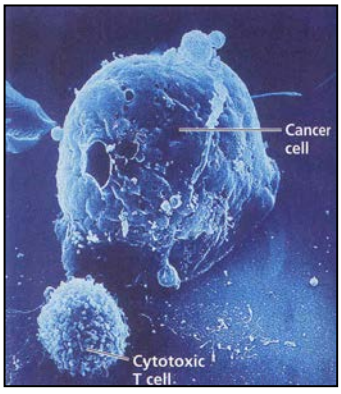


- Once recognition has occurred, helper T cells stimulate other helper T cells, cytotoxic T cells and B cells specific to that particular disease to become activated (clonal selection). They do this by releasing their own cytokine. Without notification from helper T cells, cytotoxic T cells and **most** B cells will remain inactive against the particular pathogen or parasite they are programmed to attack.

Cytotoxic T cells kill body cells that have been infected with a pathogen (e.g. viruses). They use their T cell receptors to recognise the ***class I MHC marker-antigen complex*** on the infected cell surface. Their complementary receptors bind to the class I MHC marker of the infected cell. The cytotoxic T cell then secretes ***perforin*** proteins that lyse the membrane of the infected cell, along with **granzymes** which digest proteins, including viral proteins, within the cell. This kills the infected cell and prevents the further spread of the disease from that cell.



Cellular immunity is specific because a T cell surface receptor on a T cell will only attach to one type of antigen. An antigen has to bind to a T cell's surface receptor in order for the T cell to be stimulated.

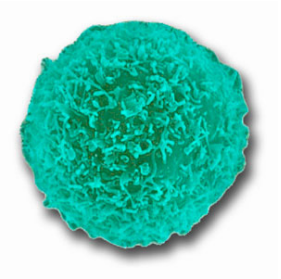


library.thinkquest.org

SUMMARY OF THE ROLES OF THE FOUR CLASSES OF T CELLS

Helper T cells: The most important of all white blood cells, for without their presence, no specific immune response, from either T cells or B cells, could take place effectively. Once activated by interleukin-1, helper T cells release interleukin-2 which mobilises other T cells and B cells specific to the particular infection. They also release interferon.

Cytotoxic T cells: Recognise and destroy viral infected cells, cancer cells and foreign eukaryotic cells (**e.g.** *Protists and fungi*). Cytotoxic T cells lyse infected cells with ***perforin*** and release toxins to destroy the cell and its contents. The release of cytokines further stimulates phagocytosis by macrophages. Cytotoxic T cells can also release interferon.



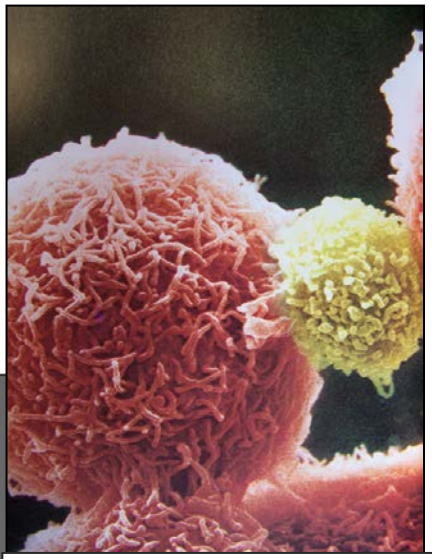
Memory T cells: Retain the ability to quickly recognise foreign antigens so that a rapid response occurs with subsequent invasions.

T cells only seem to respond to antigens if they are presented by MHC markers on a eukaryotic cell. They are blind to isolated or free antigens.

e.g. Cytotoxic T cells will not attack free viruses – the viral antigen must be displayed with a class I MHC molecule (self molecule) to activate a cytotoxic T cell attack.

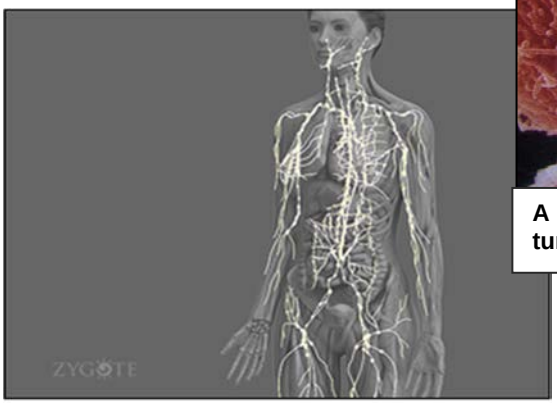
Natural killer cells (NK cells) are another group of cytotoxic lymphocytes. They exhibit innate immune activity and are neither T nor B cells.

The natural killer cells are not activated by specific MHC-antigen interactions, and so are not specific to one type of pathogen-infected cell. Their mode of operation, however, is otherwise similar to that of cytotoxic T cells. They destroy a variety of viral-infected cells and cancer cells by secreting powerful cytotoxins.



A natural killer cell binds to two tumour cells

conkwest.com



CELL MEDIATED IMMUNITY IN ACTION

Invasion of body by a pathogen (**e.g.** a virus or bacterium) which acts as an antigen.

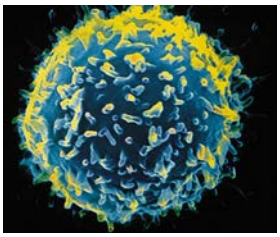
↓

Macrophages engulf the pathogen and display and carry the ***antigen*** to lymph nodes. Interleukin-1 released.

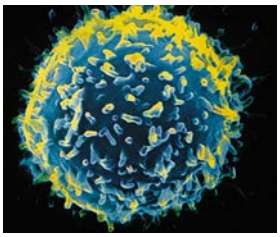
↓

Interleukin-1 and antigens "activate" ***helper T lymphocytes***.

↓



Helper T cells release interleukin-2. Helper T lymphocytes enlarge and divide repeatedly to form a clone of identical cells.



Most of these T lymphocytes differentiate to form ***cytotoxic T lymphocytes*** ***helper T lymphocytes*** (CD4 cells) and ***suppressor T lymphocytes***.

↓

Cytotoxic T cells leave lymph nodes and migrate to sites of infection.

↓

Cytotoxic T cells release ***cytokines (interleukins)***.

Destroy pathogens.

Cause more T cells to become "activated" and so attract more macrophages.

Increase inflammation.

Stimulate macrophages to ingest pathogens.

Some form ***T memory cells***.

↓

T memory cells remain in lymph nodes.

↓

More cytotoxic T lymphocytes are **rapidly** produced on re-exposure to the pathogen.

(secondary immune response).

HUMORAL IMMUNITY

Humoral immunity involves the resistance to disease by the production of ***antibodies (immunoglobulins)*** that bind to specific antigens.

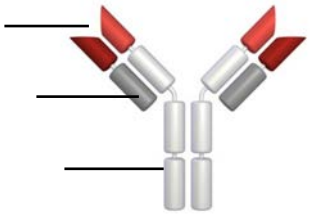
Antigens can be defined as a group of compounds, typically proteins, that:

_____

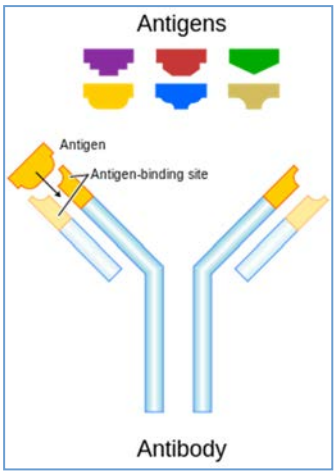
_____

An ***antibody*** is a protein molecule designed to attach to only ***one specific type of antigen.*** B cells produce antibodies (immunoglobulins), and each time a different type of pathogen enters a host, a different B cell must produce the specific antibody that is required for defence against the disease.

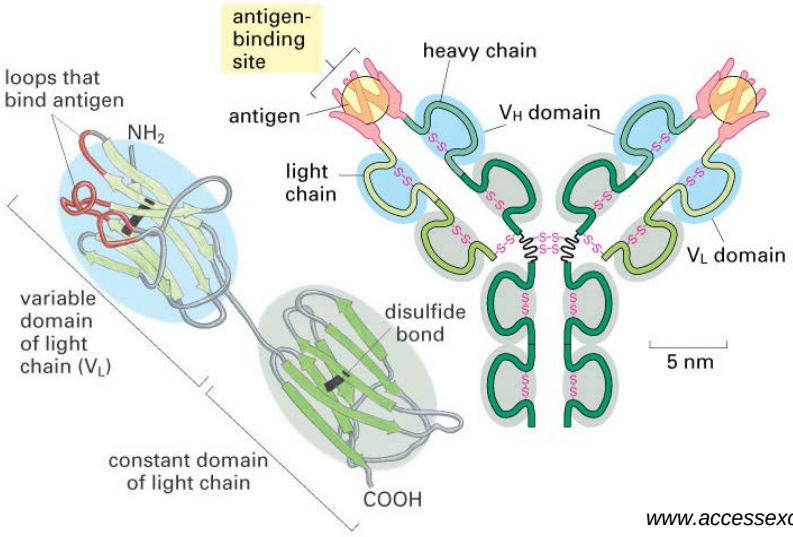
- An antibody has four chains; two heavy chains and two light (shorter) chains. Two antigen-binding sites are present on each antibody. Consequently, each antibody can attach to two antigens of the one specific type.



Fvasconcellos

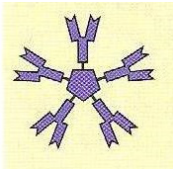


- B cells typically carry antibodies on their cell membranes. Millions of types of B cells are produced by the body, each with a different type of antibody on its surface. Hence, many different antibodies exist in the body, e.g. Immunoglobulin G (IgG) etc.



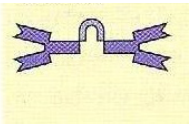
www.accessexcellence.org

TYPES OF ANTIBODIES (IMMUNOGLOBULINS)



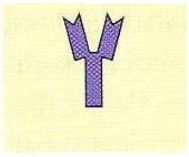
IgMs (pentamers) are the first circulating antibodies to appear in response to an initial exposure to an antigen. Their concentration in the blood then declines rapidly. Their presence indicates a current infection. Very effective in agglutination and in reactions involving complement. Too large to cross the placenta.

IgG is the most abundant of the circulating antibodies. It readily crosses walls of blood vessels and enters tissue fluids. It also ***crosses the placenta*** and confers passive immunity to the foetus. IgG protects against bacteria, viruses, toxins in the blood and lymph, and triggers the action of complement.



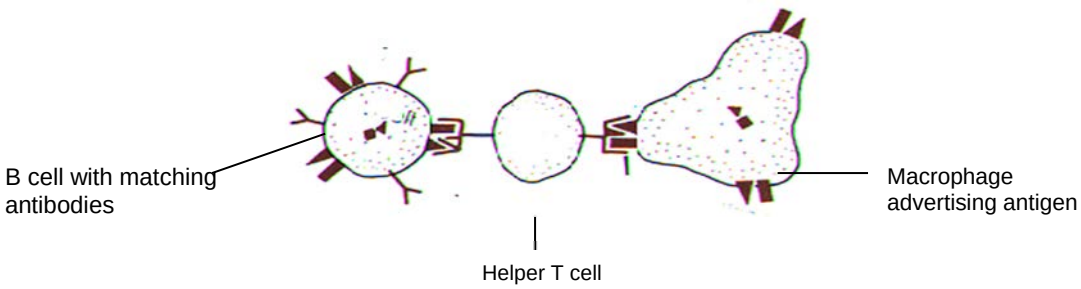
IgA (a dimer) is produced by cells in mucous membranes, with the primary role of preventing the attachment of viruses and bacteria to epithelial linings. IgA is also found in many body secretions such as saliva, tears and perspiration. Its presence in ***milk*** helps to prevent gastrointestinal infections in babies.

IgD antibodies are mostly found on the surfaces of B cells, probably functioning as antigen receptors that help to initiate the differentiation of B cells into plasma cells and memory cells. They do not activate complement nor cross the placenta.



IgE antibodies are slightly larger than IgG and represent only a small fraction of blood antibodies. The tails attach to mast cells and basophils, and when triggered by an antigen, cause these cells to release ***histamine*** which causes an allergic reaction.

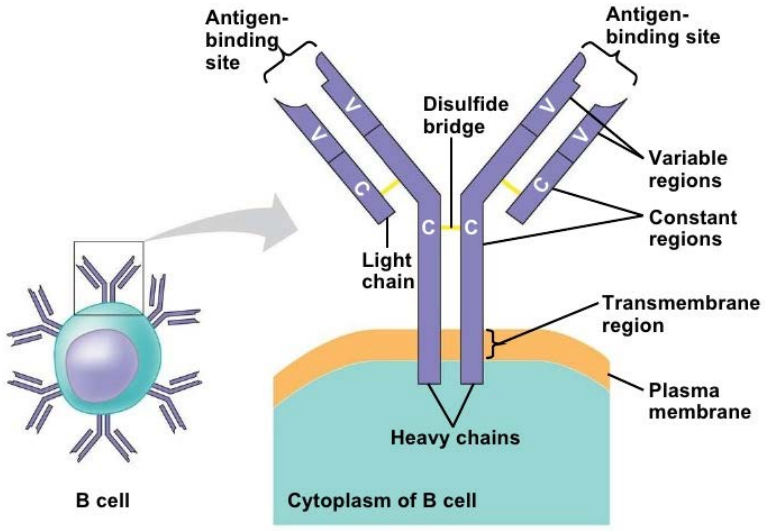
- All forms of an antibody have a constant region, e.g. All IgG antibodies have the same constant region; however, the variable region differs according to the target antigen.
- When an antigen enters the body, it **may** be engulfed by a macrophage or dendritic cell and delivered to the lymph nodes with the aid of a helper T cell. It will pass many B cells before it meets the B cell with the matching antibody.



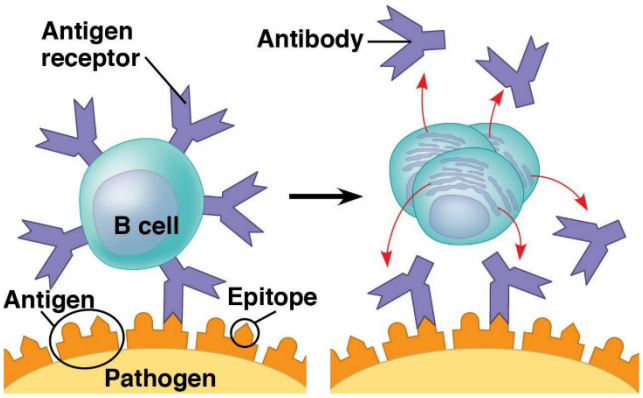
- Upon presentation of the particular antigen, the B cell is stimulated to divide rapidly by mitosis, resulting in the production of many clones. These clones become specialised, forming many ***plasma cells*** and some ***memory cells (clonal selection*** and ***expansion)***.

B CELL ANTIGEN RECEPTORS

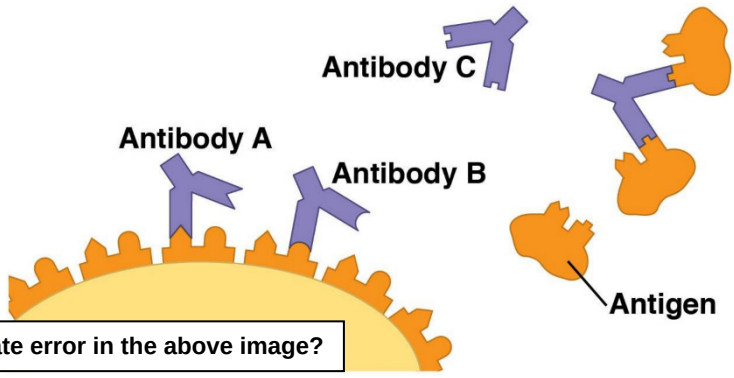
When presented with a specific non-self antigen, a specific B cell antigen receptor (an antibody located on the surface of a specific B cell) will bind to it.



Following binding, the B cell gives rise to plasma cells that secrete a soluble form of the receptor, i.e. Antibodies.



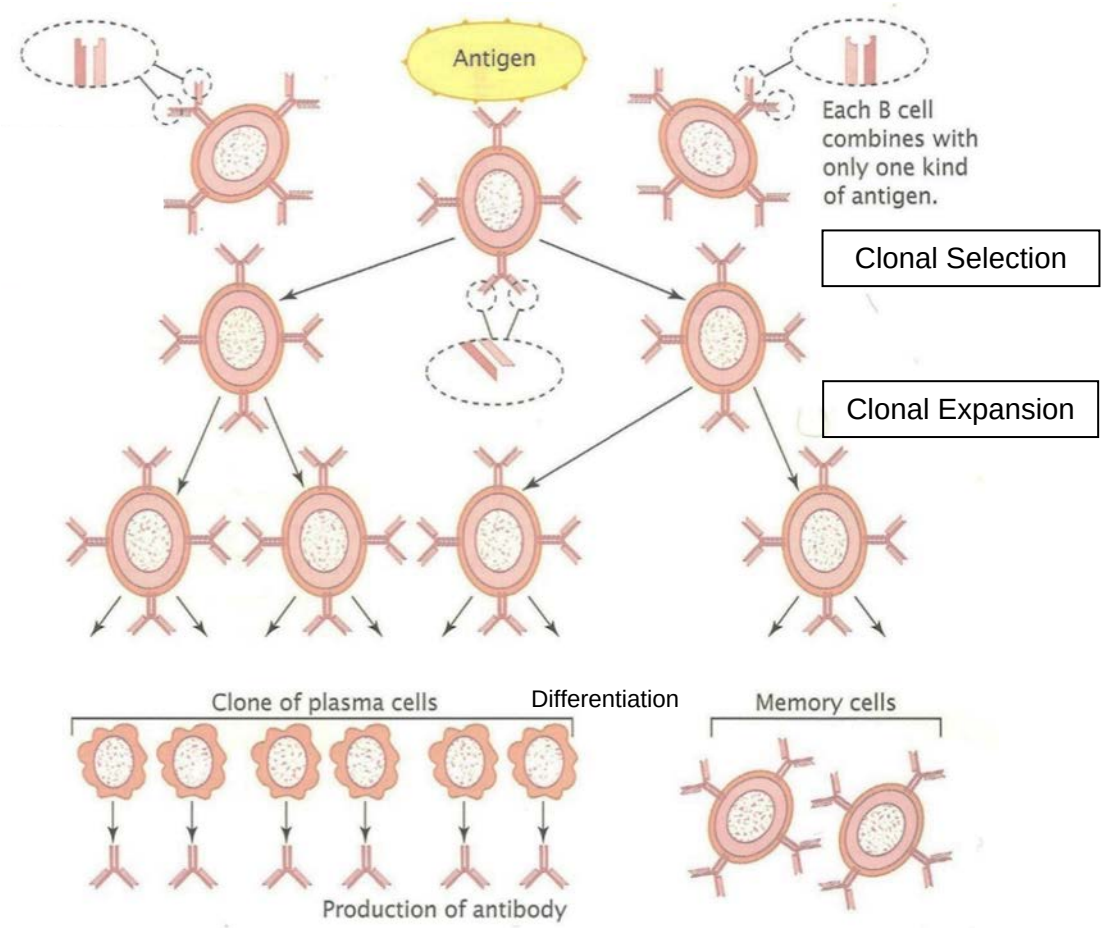
Different antibodies can recognise distinct non-self antigens on the same pathogen. Antibodies can recognise free antigens as well as antigens on a pathogen's surface.



Can you pick the deliberate error in the above image?

(Campbell, NA et al, 2016)

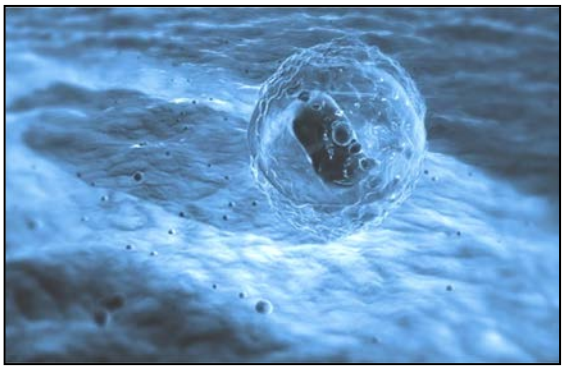
THE HUMORAL RESPONSE



(Kinnear J & M Martin, 2006)

- A few antibodies are insufficient to counter a massive infection by a pathogen. To overcome this problem, each plasma cell produces free antibodies at a rate of thousands per second, releasing them directly into the bloodstream.

- The specific type of antibody used to fight an infection remains in the organism for many years (often a lifetime) attached to memory cells. Memory cells allow for a more rapid and emphatic response by the immune system if the pathogen ever returns. Plasma cells, by contrast, die within days of their formation via apoptosis.



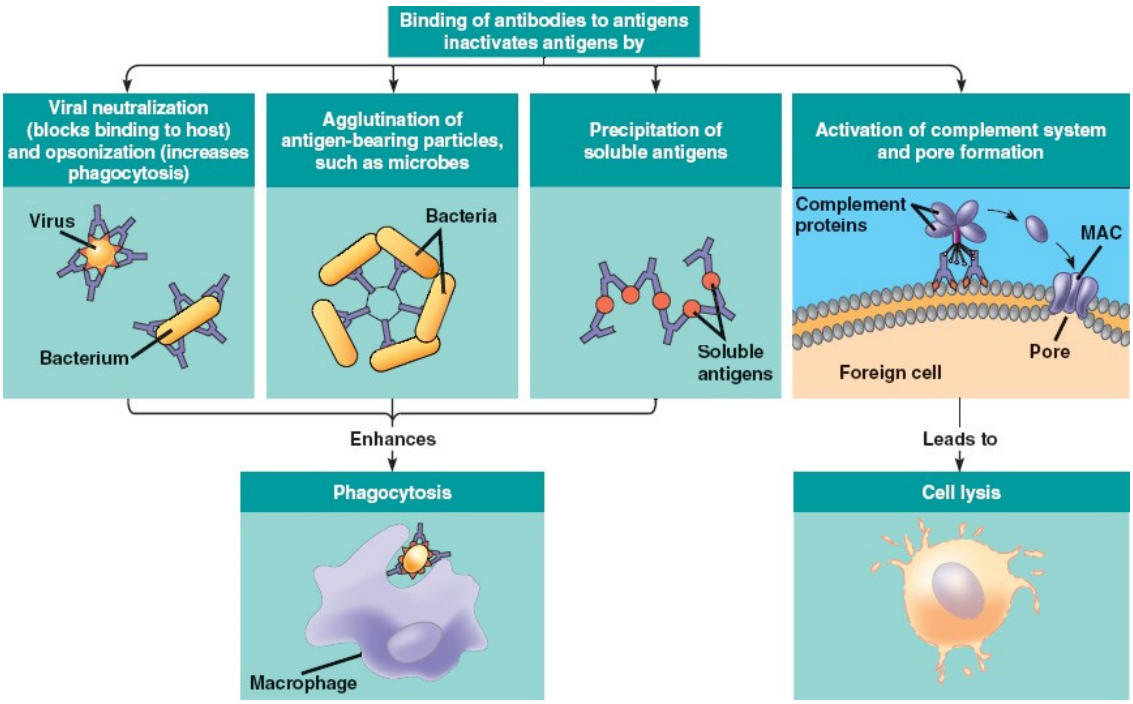
B cell in motion *trialx.com*

- B memory cells have the same antibody-antigen specificity as the parent cell.

ANTIBODY ACTION

Antibodies can act in a number of ways:

1. **Neutralisation:** By coating pathogens, antibodies ***neutralise*** viral particles and cellular pathogens preventing them from attaching to host cells.

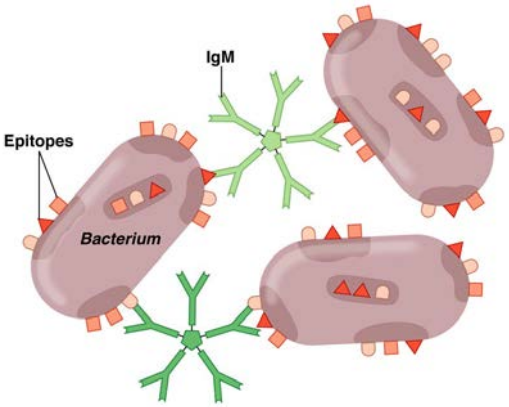


http://www.bio1151b.nicerweb.net/Locked/media/ch43/antigen_disposal..html

2. ***Agglutination*** of antigen-bearing particles exposes the pathogens to being engulfed by phagocytes.

3. ***Precipitation*** of soluble antigens (e.g. Snake venom) by antibodies also stimulates an attack by phagocytes such as macrophages. The toxins are rendered useless in a precipitated form.

4. Antibodies activate ***complement proteins*** which puncture cell membranes of pathogens.

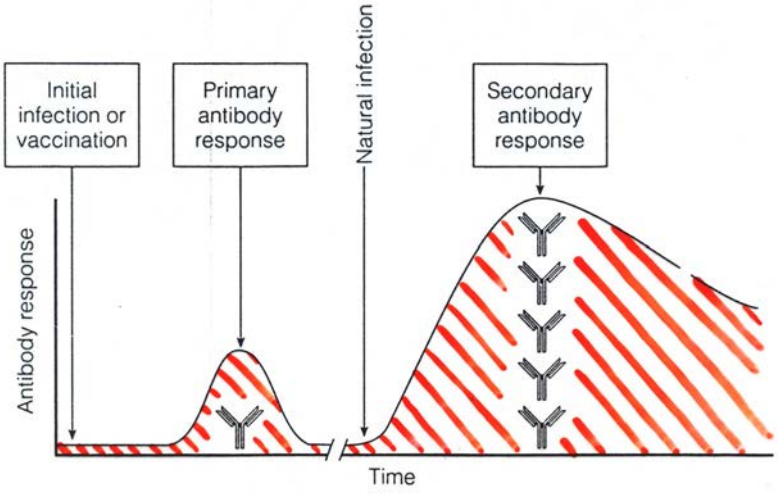


OPSONISATION

Opsonisation is the immune process where antigens such as bacteria and viruses are prepared for destruction by a phagocyte. In this process a molecule (e.g. an antibody or complement protein) attaches to the antigen which enhances destruction of the antigen by marking it for phagocytosis**.**

SECONDARY IMMUNE RESPONSE

A ***secondary immune response*** occurs after a ***second exposure to same pathogen***.
B cells react more quickly and vigorously than they did in the initial response. Antibodies are produced much more rapidly, and in much greater quantity, due to the presence of ***memory cells***.



(Kinnear J & M Martin, 2000)

Typically, an individual does not suffer any symptoms of the disease.

Characteristics of Antibodies

	IgG	IgA	IgM	IgD	IgE
Approx. concentration in serum (mg/mL)	12	2	1	0.04	0.00002
Ability to cross placenta	Yes	No	No	No	No
Present in saliva and tears	No	Yes	No	No	No
Present in milk	Yes	Yes	No	No	No
Active against viruses	Yes	Yes	Some	No	No
Active against certain bacteria	Yes	Yes	Yes	No	No
Involved in allergy reactions	No	No	No	No	Yes

(Kinnear J & M Martin, 1993)

HUMORAL IMMUNITY

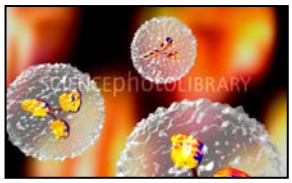
Invasion of body by a pathogen (**e.g.** virus or bacterium),
which acts as an ***antigen***.

↓

Macrophages carry the antigen
to lymph nodes.

↓

Antigen "activates"
B lymphocytes.



sciencephoto.com

↓

B lymphocytes enlarge and divide repeatedly
to form a clone (***clonal expansion,*** clonal proliferation) of identical cells
(by mitosis).

Most of these B lymphocytes
form ***plasma cells***.

↓

Plasma cells secrete ***antibodies***
(up to 2,000 per sec).
Plasma cells do not live very long.

Some B lymphocytes become differentiate to
B memory cells.

↓

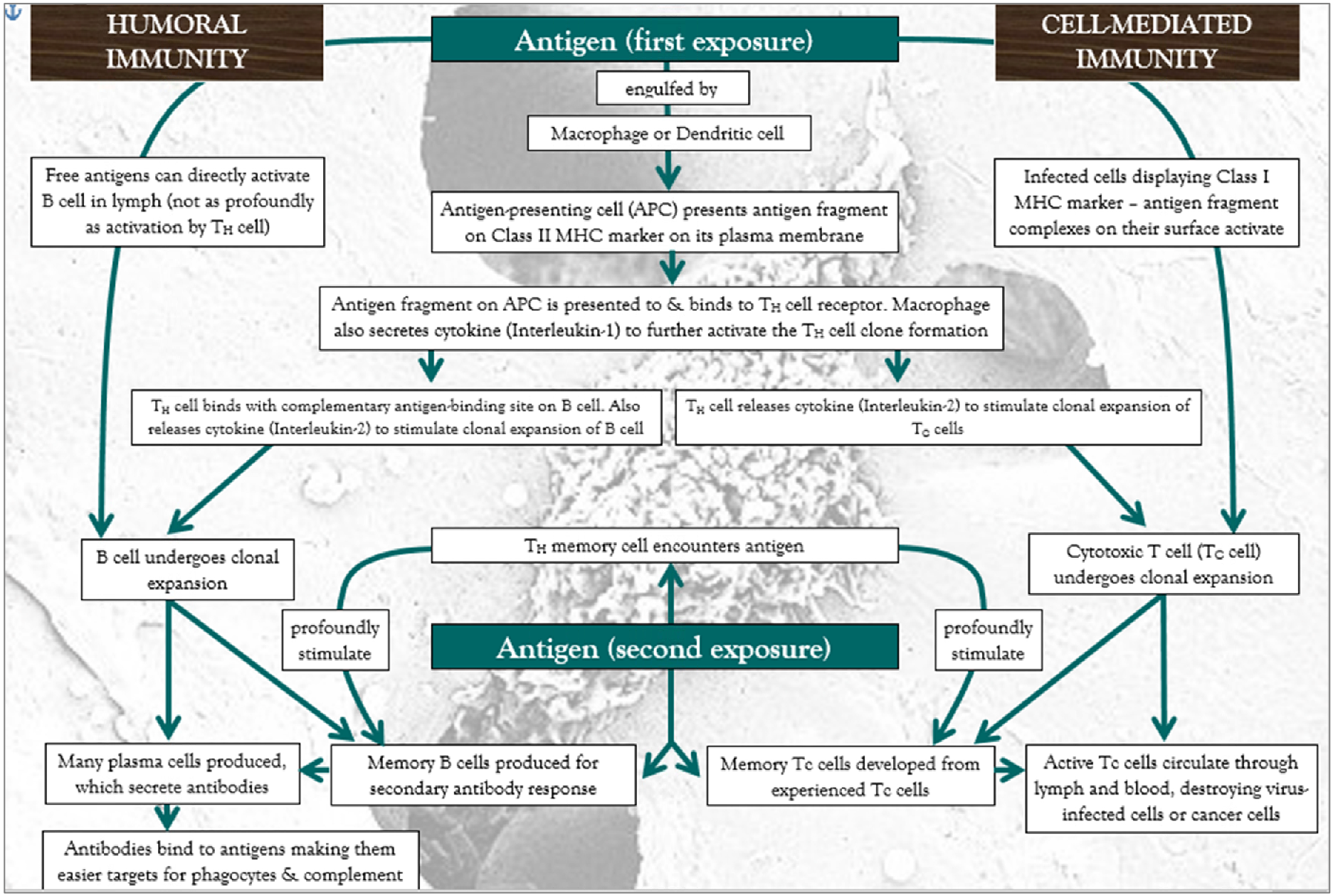
Long-term immunity.

B memory cells will rapidly divide to produce appropriate plasma cells which make more antibodies on re-exposure to the pathogen ***(secondary immune response)***. This will enable a much more rapid and emphatic response to a second attack by the ***antigen***.

Pathogen or its toxin
is inactivated.

Stimulation of phagocytosis of
the pathogen by neutrophils
and macrophages.

Activation of the
Complement system.



(Adapted from *Campbell, NA et al, 2002*)

In summary:

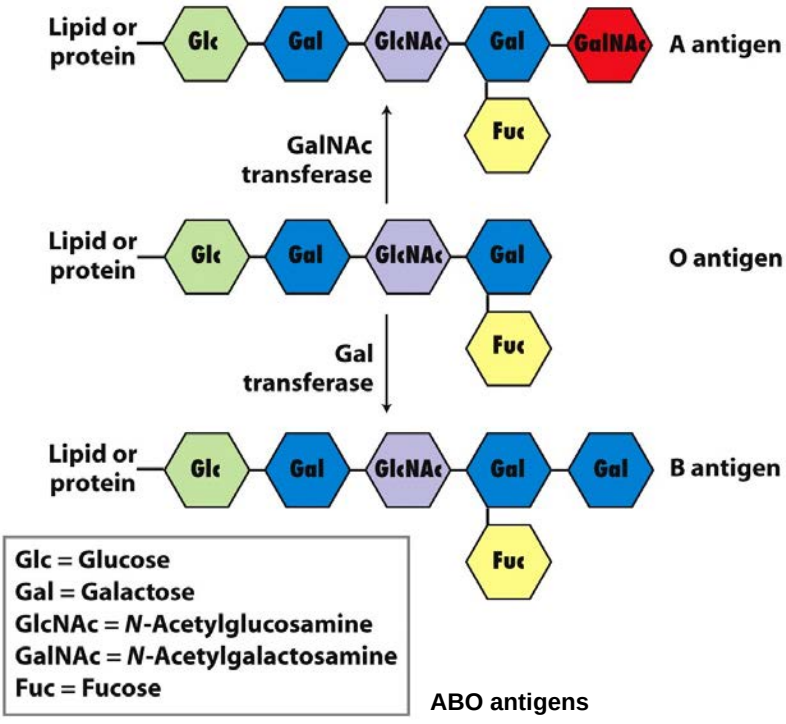
- Innate immunity (first and second lines of defence) involves the same response to any type of pathogen irrespective of how many times the patient has been exposed to the agent. No flexibility exists with this response.

- Adaptive immunity (T and B cells) involves the production of specialised cells and substances that act against one particular infection. Adaptive immunity has a **memory** so that when the patient is faced with the same pathogen again, a more rapid and profound response occurs, reducing the chance of a recurrence of disease.

ABO ANTIGENS

Antigens present on red blood cells include those of the ABO system (glycolipids) and the Rhesus factor (a protein). Ambulance officers ensure that the correct blood type is used when giving a transfusion to an accident victim.

The Rhesus monkey from which the Rhesus factor was investigated



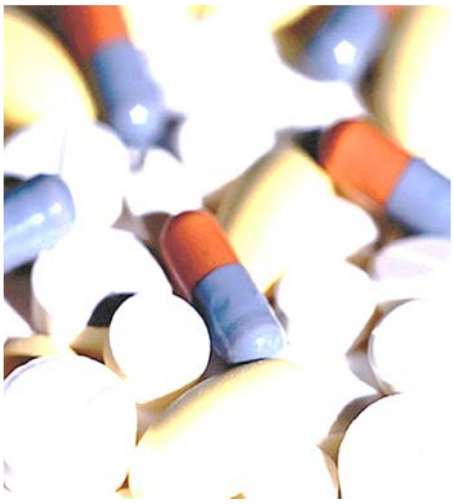
ABO antigens

Bearing in mind that donor blood cannot contain any antigens not originally present in a recipient's blood, state which of the following transfusions would result in an undesirable clotting event:

- ABO antigens (A or B)
- Rhesus antigens (+)

e.g.	***Donor***		***Recipient***	***Result***
	O-	+	B+	⟶
	O+	+	A-	⟶
	B-	+	O-	⟶
	B+	+	AB+	⟶

TRANSPLANT REJECTION



Donor organs contain foreign antigens. Therefore, a patient's body produces antibodies in the process of rejecting the donor tissue.

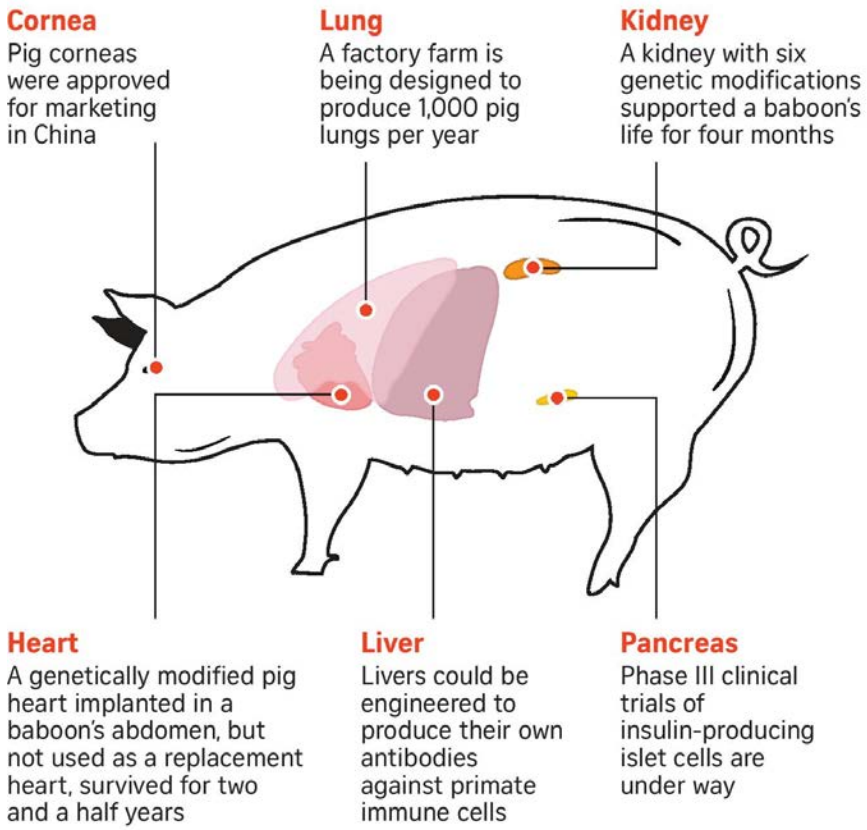
Drugs such as ***cyclosporine*** have been developed which reduce the intensity of a patient's immune system response (it reduces levels of a chemical that stimulates certain cytotoxic T cells) so that it does not reject the donated antigens.

Without the use of immunosuppressive drugs, a transplanted tissue (organ) would be recognised as foreign by cytotoxic T cells. Along with phagocytes and natural killer cells, the cytotoxic T cells would eventually destroy all of the transplanted tissue.

Choice Cuts – Eliminating Rejection with Gene Editing

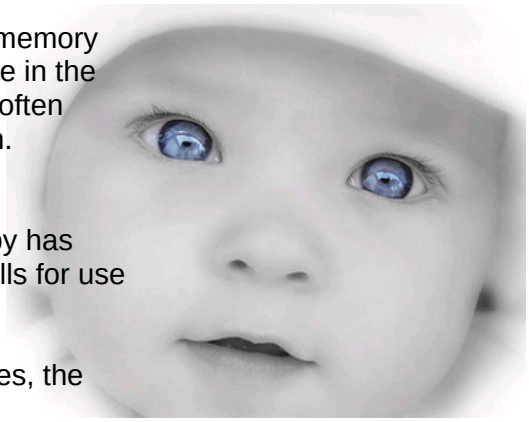
In the hope of producing organs that will not be rejected by human recipients, specific pig genes, that code for non-self antigens, are 'being knocked out' by researchers.

Researchers are looking to source an increasing variety of living tissue, including solid organs, from pigs. Many are attempting to genetically engineer the animals to reduce the risk of infection in humans.



- In a process called gene editing, some genes, while still present in the cell, are prevented from being turned on.
- If enough gene editing occurs within the cell (so no 'foreign' pig antigens are produced), it may eliminate the need for immunosuppressive drugs entirely.
- Gene edited pig islet cells from the pancreas were almost ready for trials in Type 1 diabetics in 2015**.**

RHESUS DISEASE



After the birth of a first Rh+ baby, an Rh– mother has memory cells for Rhesus antigen. This is due to the fact that late in the term of the pregnancy, foetal red blood cell fragments often cross the placenta and enter the mother's bloodstream.

By the time the Rh+ antigens have been detected and responded to by the mother's immune system, the baby has been born. The mother, however, now has memory cells for use in future pregnancies.

Hence, in subsequent pregnancies involving Rh+ babies, the baby is at risk from the immune response of mother.

QUESTION 1 (VCAA 2017)
Which of the following matches a cell correctly with its role in an immune response?

	Cell	Role
A	Macrophage	Stimulates inflammation by secreting interferon
B	Dendritic cell	Presents fragments of antigens to T helper cells
C	Mast cell	Engulfs bacteria and debris
D	Neutrophil	Secretes antibodies

QUESTION 2 (VCAA 2009)
HLA antigens trigger against organ transplants. These antigens must be matched as closely as possible if a transplant is to succeed.

A young man required a kidney transplant. There were four people prepared to act as a donor. The HLA antigens of the young man and potential donors are given below.

young man requiring transplant
A1 B7 C3 DP11
A4 B6 C7 DP22

potential donor	mother	father	older brother	next-door neighbour
HLA antigens	A4 B6 C7 DP22 A3 B23 C6 DP12	A1 B7 C3 DP11 A7 B19 C12 DP20	A7 B19 C12 DP20 A3 B23 C6 DP12	A1 B7 C3 DP11 A4 B6 C1 DP22

The individual most likely to be used as a donor is the young man's:

A Father
B Mother
C Older brother
D Next-door neighbour

QUESTION 3
Antibodies form a very important component of the third line of defence. Antibodies are made by:

A Smooth endoplasmic reticulum.
B Free ribosomes.
C Rough endoplasmic reticulum.
D Nucleoli.

QUESTION 4
Complement forms part of the:

A Third line of defence.
B Second line of defence.
C First line of defence.
D Specific response by the body.

QUESTION 5 (VCAA 2017)
The lymphatic system includes the lymph nodes, spleen and tonsils.

In these particular organs

A clotting factors are inactivated to help seal a wound.
B clonal selection and proliferation of B cells occurs.
C non-self antigens are identified by red blood cells.
D the initial response to an allergen is triggered.

QUESTION 6
What is the number of antigen-binding sites on an antibody?

A One
B Two
C Three
D Six

QUESTION 7 (VCAA 2006)
Long-term immunity results from:

A Administration of chicken pox vaccine.
B The inflammatory response to a bee sting.
C An injection of immunoglobulin if exposed to mumps.
D The passage of maternal antibodies to the developing fetus.

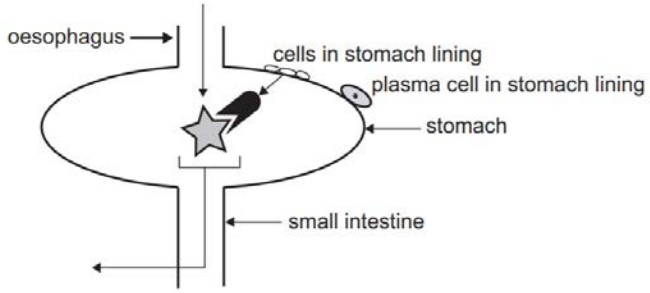
QUESTION 8 (VCAA 2005)
In humans, failure to absorb vitamin B_{12} results in pernicious anaemia.

Normally, vitamin B_{12} enters the stomach and becomes attached to a 'factor' that is produced by cells in the stomach wall. The vitamin with the attached factor then moves into the small intestine and is transported across the small intestine wall into the bloodstream.

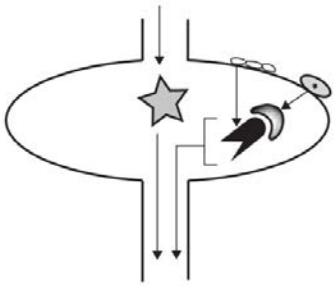
In pernicious anaemia, antibodies against the factor are produced by plasma cells in the stomach wall. The antibodies combine with the factor so that it is no longer available to combine with the vitamin. Therefore, the vitamin cannot be absorbed.

The pathway involved when a person has pernicious anaemia is:

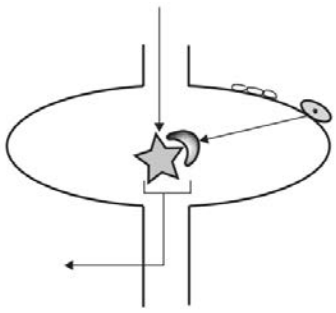
A.



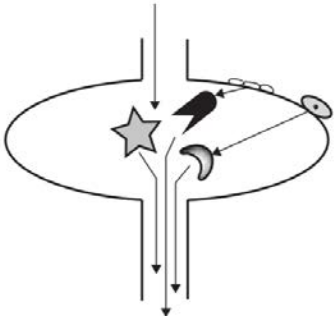
B.



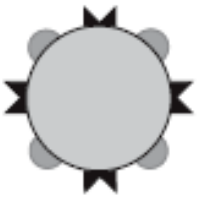
C.



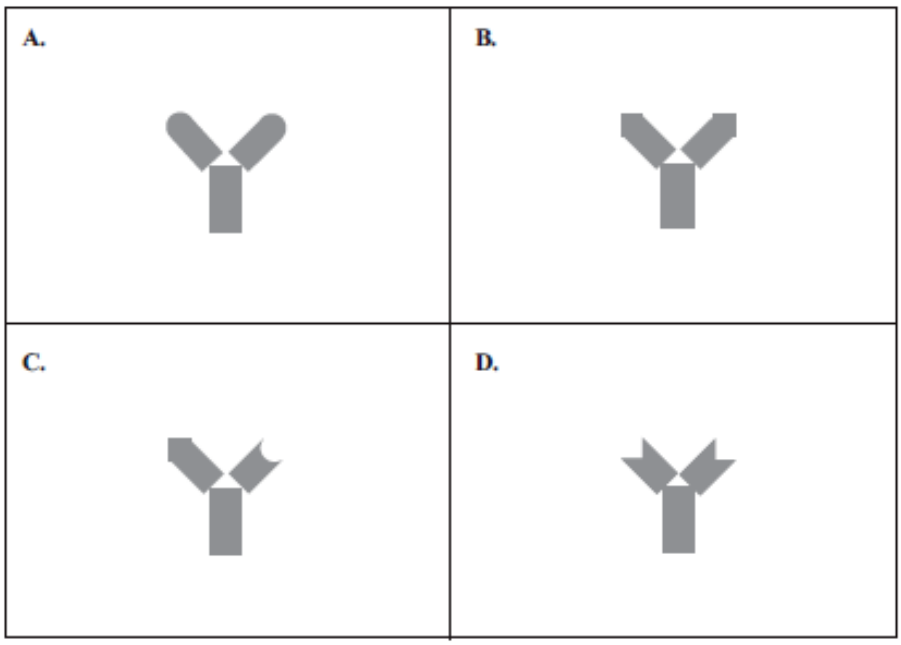
D.



QUESTION 9 (VCAA 2006)
A disease-causing bacterium has the following structure:



The kind of antibodies most effective against this type of bacterium would be:



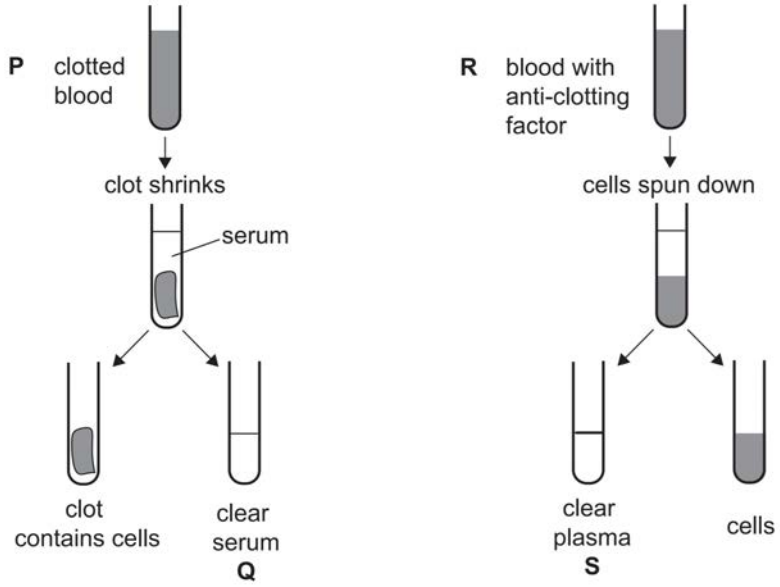
QUESTION 10 (VCAA 2002)
Illness in animals is often accompanied by fever, which is a rise in body temperature. Fever is caused by the resetting of the temperature control centre. This control centre is located in the:

A Skin
B Hypothalamus
C Pituitary gland
D Thyroid gland

QUESTION 11
Natural killer cells differ in their mode of action from cytotoxic T cells in that they:

A Are specific.
B Are non-specific.
C Engulf pathogens.
D Are produced in the thyroid gland.

QUESTION 12 (VCAA 2011)
A late step in the clotting of blood is the conversion of soluble fibrinogen to insoluble fibrin. Examine the following diagram:



It is reasonable to conclude that fibrin is present in:

A P
B Q
C R
D S

QUESTION 13
Cell mediated immunity involves the:

A T lymphocytes.
B B lymphocytes.
C Plasma cells.
D Basophils.

QUESTION 14
Suppressor T cells play an important role in:

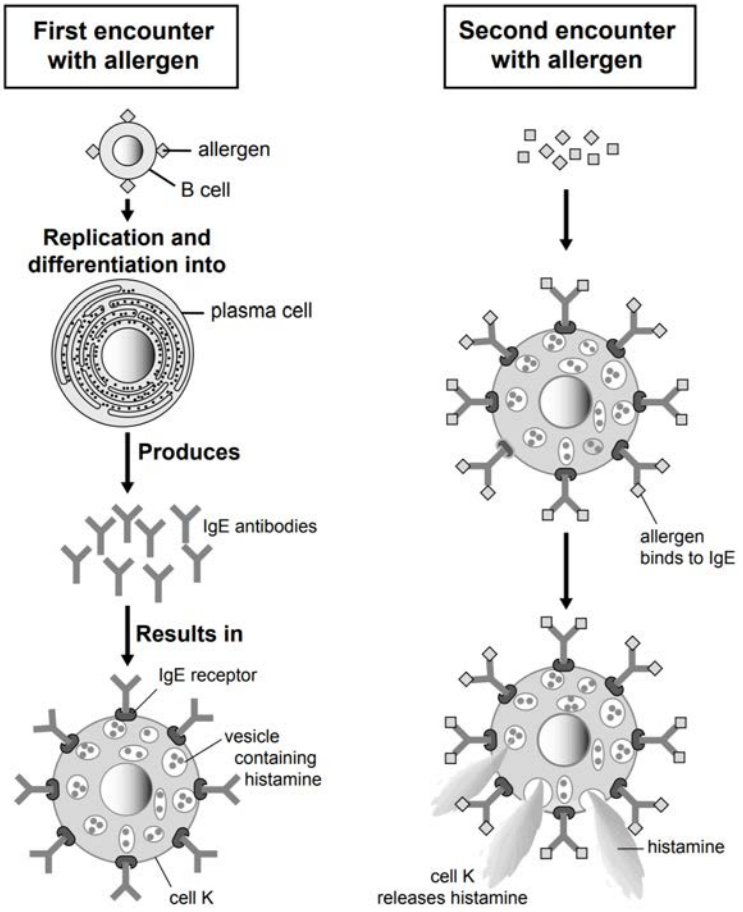
A Stimulating plasma cells to secrete antibodies.

B Turning off the immune response.

C Preventing the activation of helper T cells until B cells have completed their immune response.

D Suppressing viral infections.

QUESTION 15 (VCAA 2007)
The diagrams below outline the sequence of events involved in an allergic response.



(a) Name one well-recognised allergen. (1 mark) _____

Examine the plasma cell shown in the above diagram.

(b) (i) Identify the organelle that is abundant in the cytosol of the plasma cell. (1 mark)

_____

(ii) Explain the specific role of this organelle in the plasma cell. (1 mark)

_____

_____

(c) (i) Name the type of cell represented by cell K. (1 mark) _____

Cells of type K can produce localised allergic responses in particular regions of the body.

(ii) Name one such region of the body. (1 mark) _____

(iii) Describe one effect of the release of histamine by cell K into the surrounding extracellular fluid or bloodstream. (1 mark)

_____

_____

(iv) Name the process by which histamine is released by cell K. (1 mark)