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# AN ILLUSTRATED GUIDE TO THE IMMUNE SYSTEM

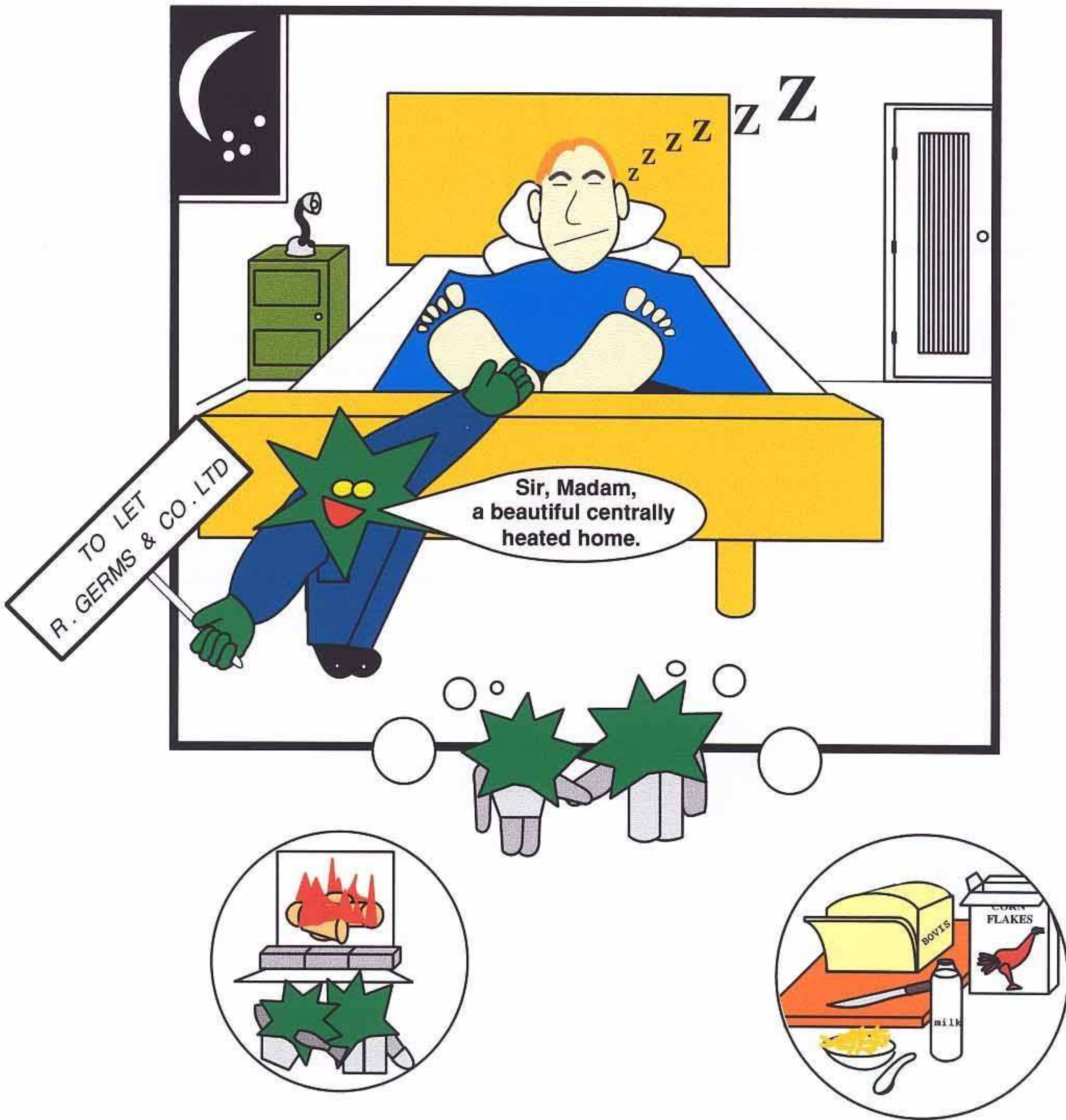


BY  
JOSEPH LOCKYER

# **CHAPTER ONE**

## **MEETING OUR FRIENDS AND ENEMIES**

MICROBES

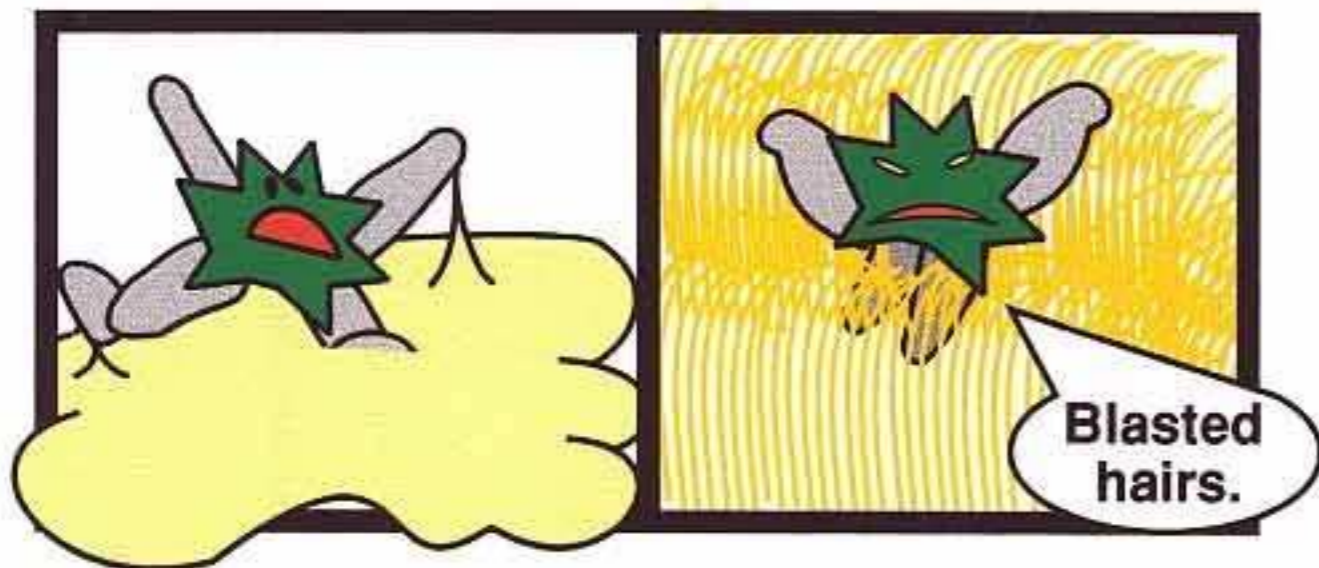


Unfortunately, this estate agent just happened to forget to mention that it is very difficult to get in!

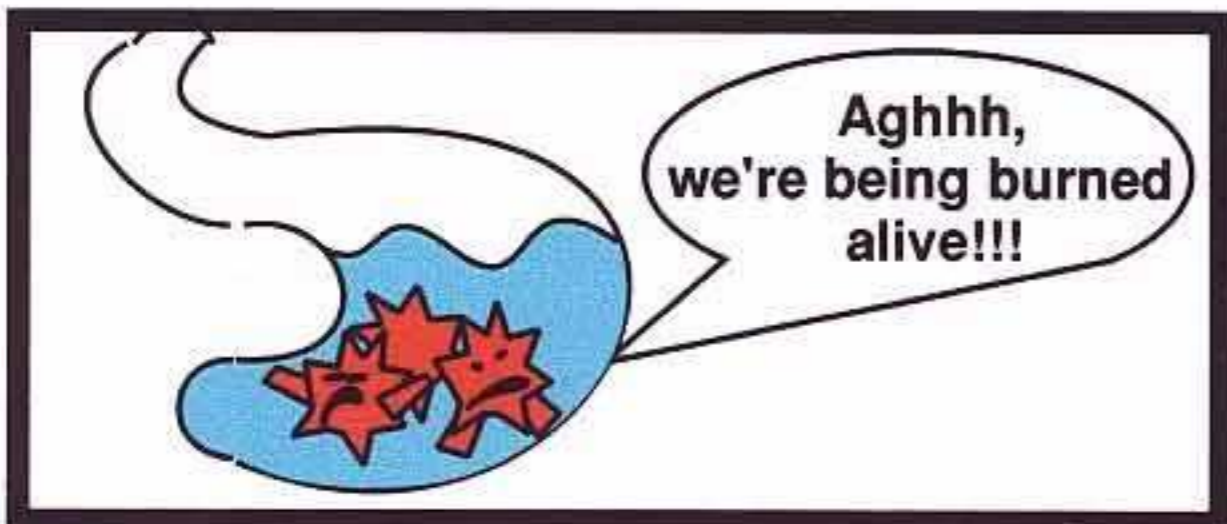
**WHAT STOPS MOST MICROBES GETTING IN?**



**Intact skin acts as a barrier.**



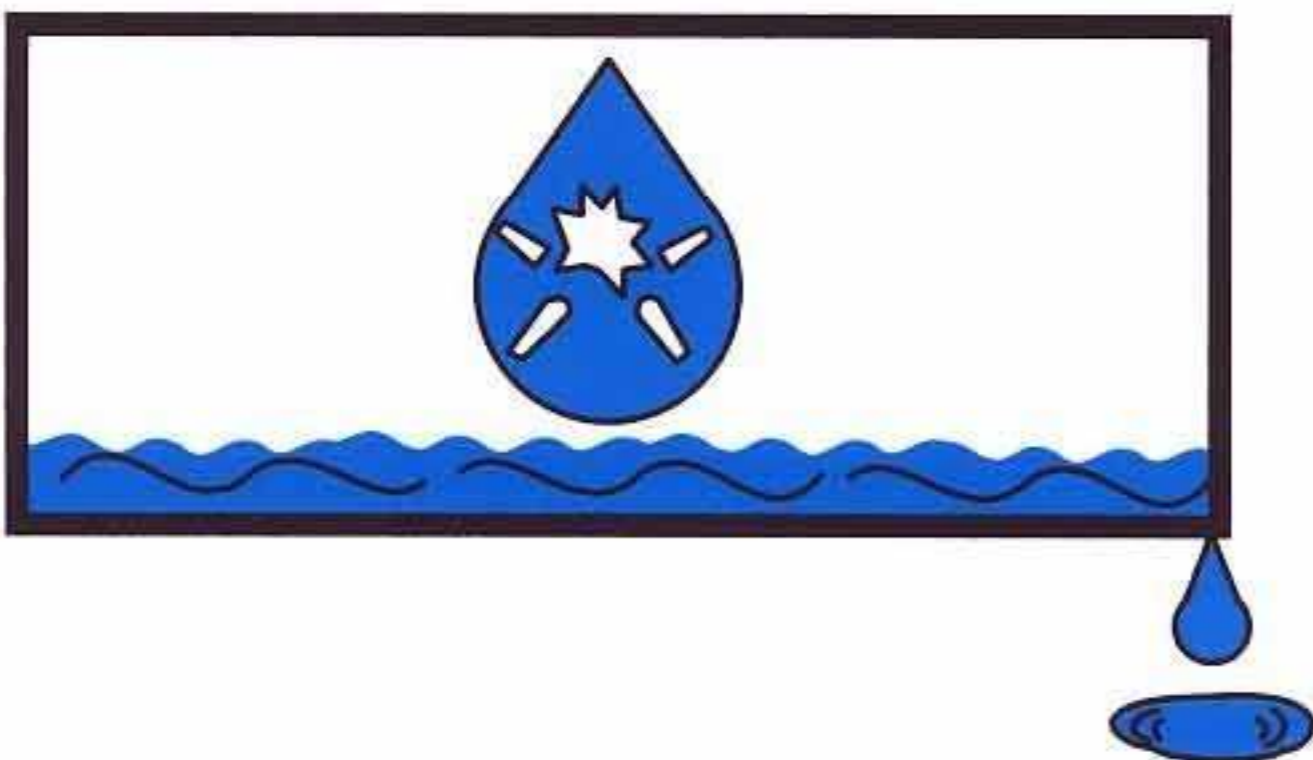
**Sticky mucus and tiny hairs called "cilia" protect the airways.**



**Stomach acid sterilises our food.**

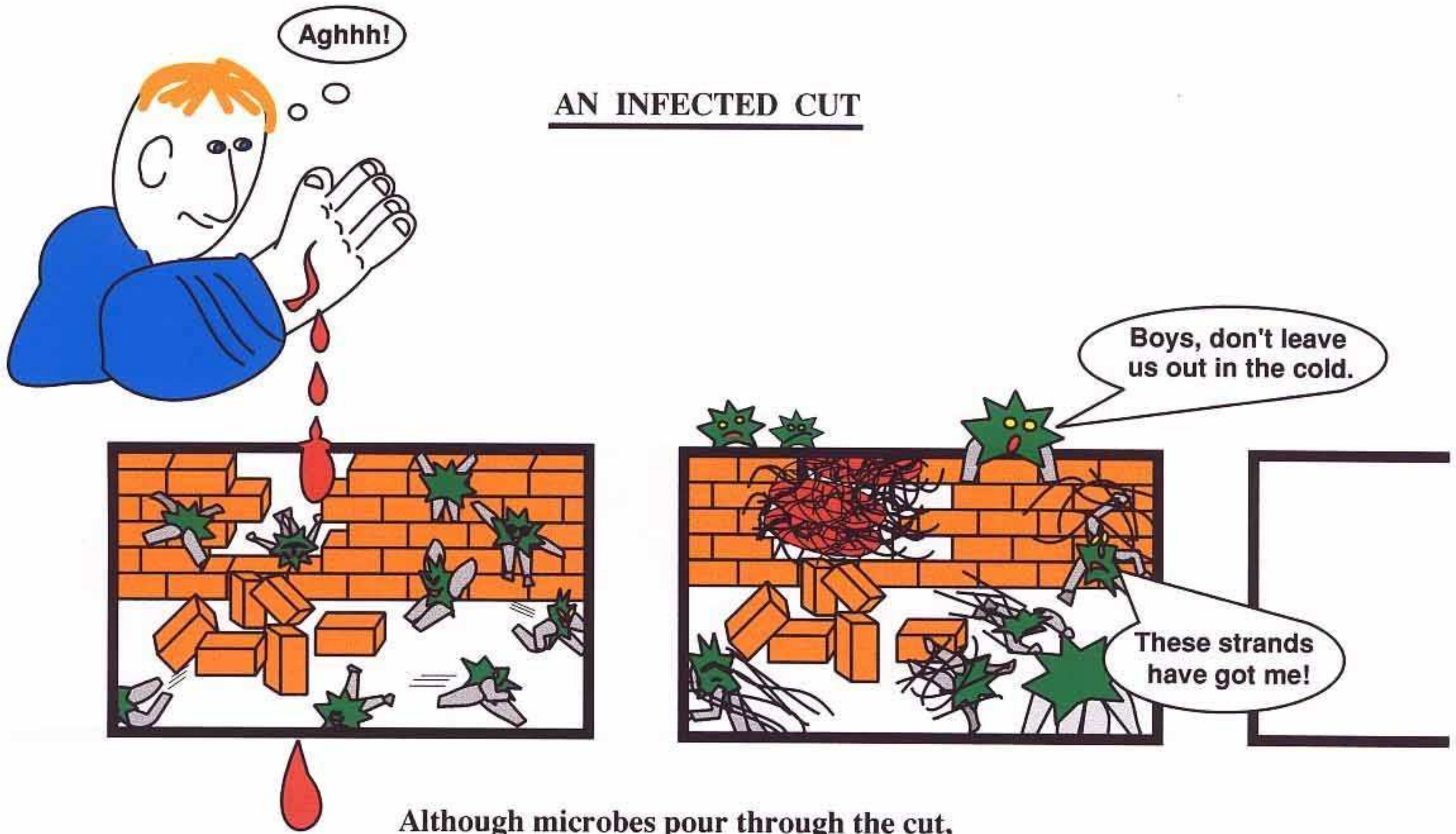


**Because friendly commensal bacteria live inside our bodies, pathogenic bacteria (which could cause illnesses), are kept out.**



**Enzymes in tears will kill some bacteria.**

## AN INFECTED CUT



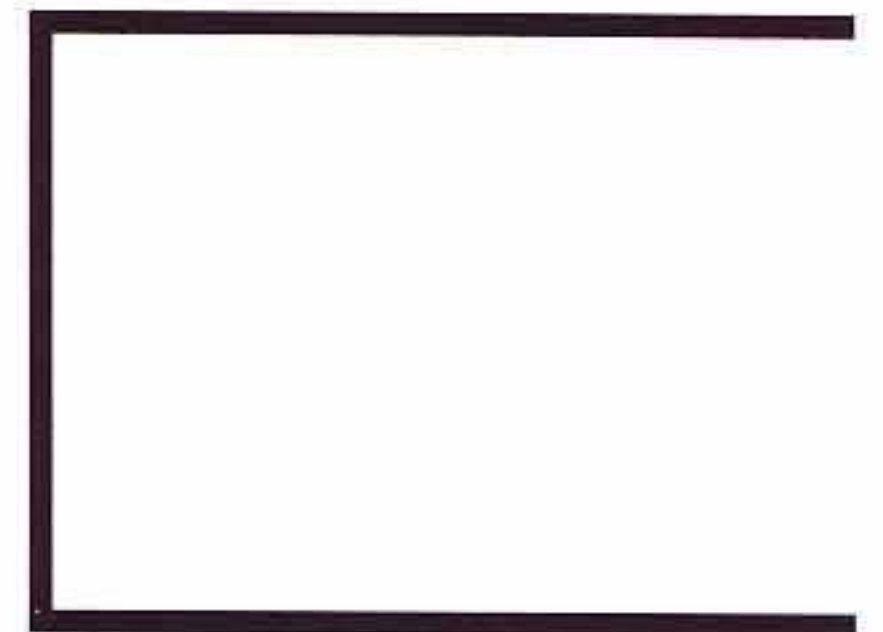
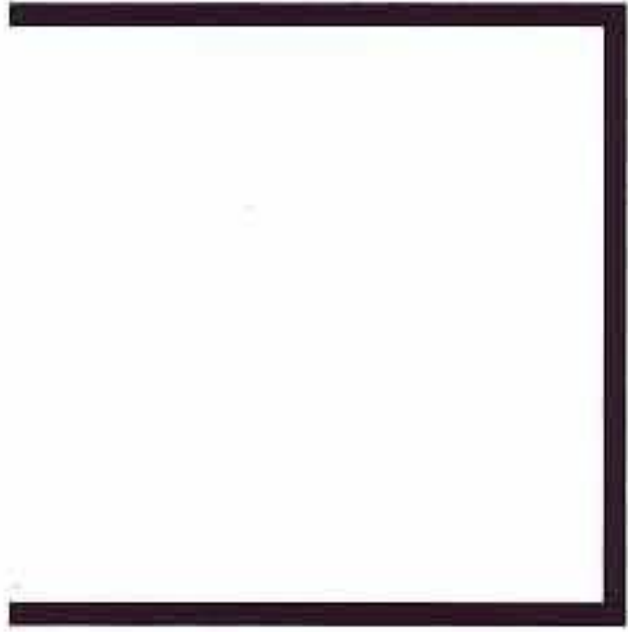
Easy reading



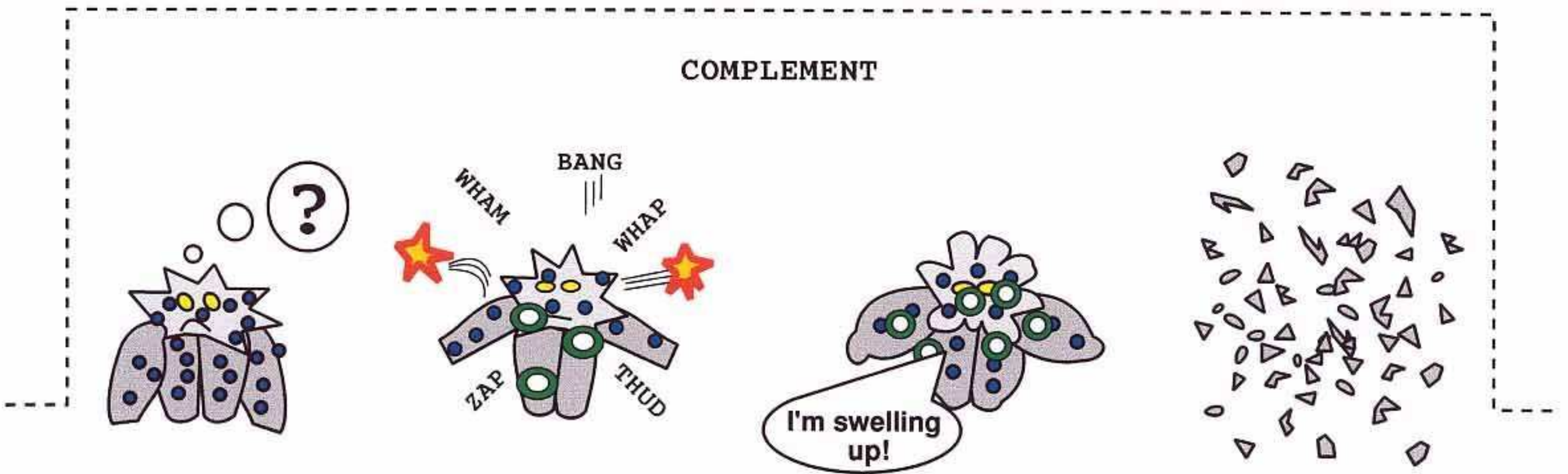
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Technical information

The fibrin strands shown above, form in blood to help it clot and to ensnare foreign material.

THINGS GET WORSE

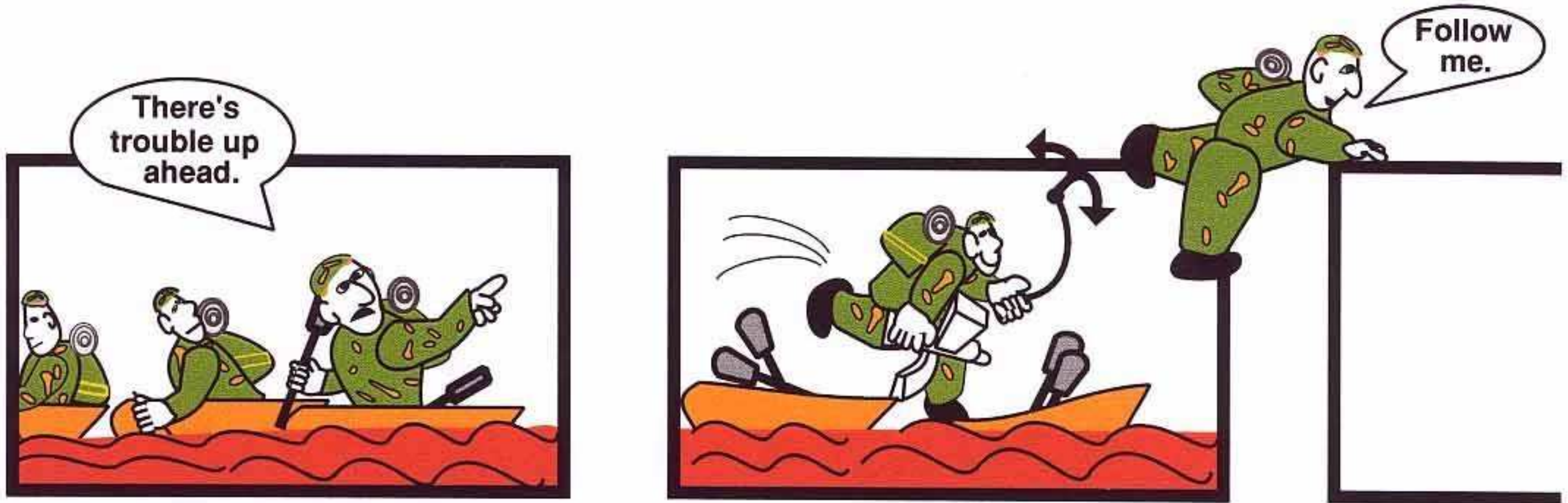


Despite the fibrin and inflammation released by activated complement, the microbes start to multiply and infect the locality.



Complement (a group of immune chemicals), is rapidly activated when it comes into contact with a microbe.

## NEUTROPHILS



Meanwhile (in a nearby blood vessel), these neutrophils detect activated complement and realise they must leave the blood vessel, to see if they are needed.

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Neutrophils circulate around the body in the blood, ready to respond quickly, when the need arises.



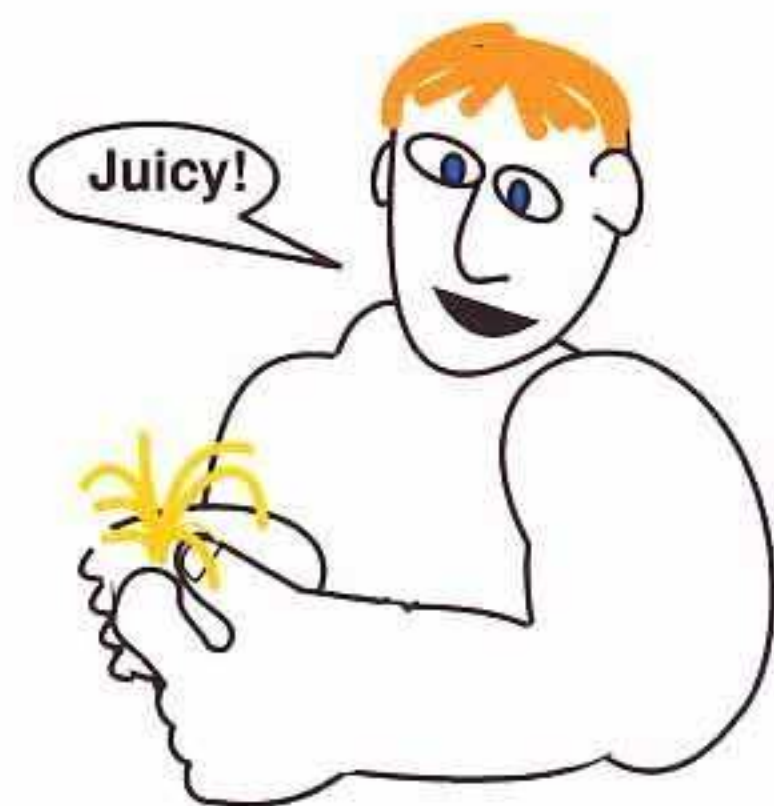
LIFE IS JUST ONE BIG BATTLE FOR SURVIVAL



Emerging from the blood vessel, the neutrophils blow the microbes away!!

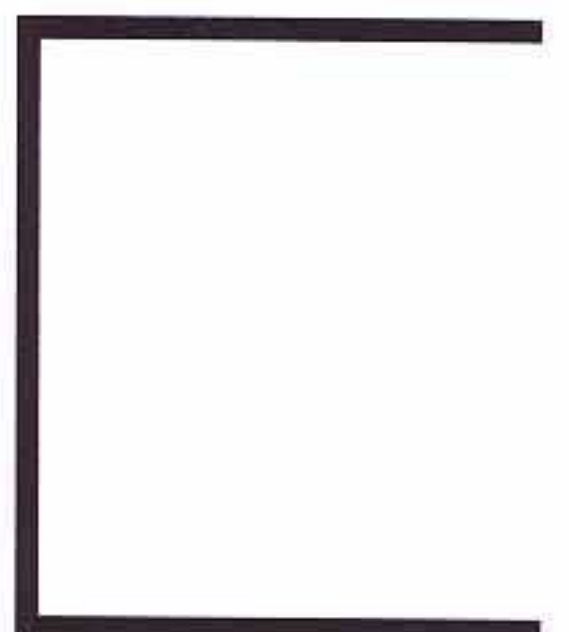
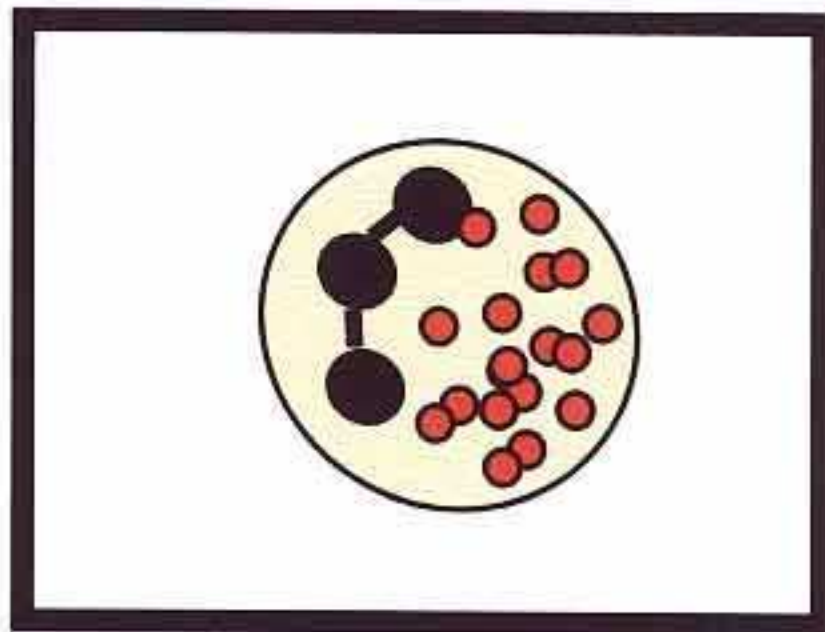


Soon it is all over, but many dead neutrophils now litter the war zone.



Suprisingly, pus that spurts from a spot, is mostly made up of dead neutrophils.

A PERSONAL PROFILE OF A NEUTROPHIL (PART 1)



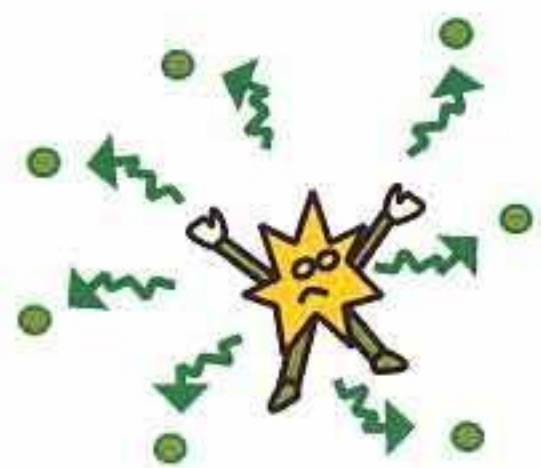
Although the neutrophil is the commonest white blood cell, it only lives for about 2 days.

It has a multi-lobed nucleus and can contain up to 200 granules.

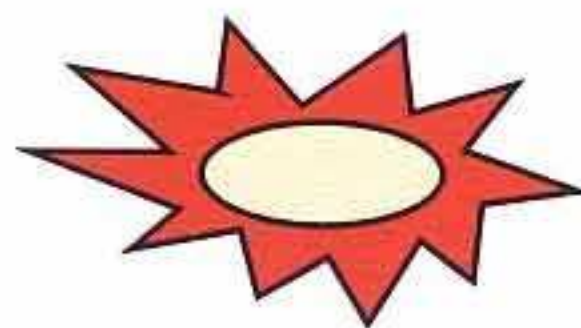
WHAT ATTRACTS A NEUTROPHIL?



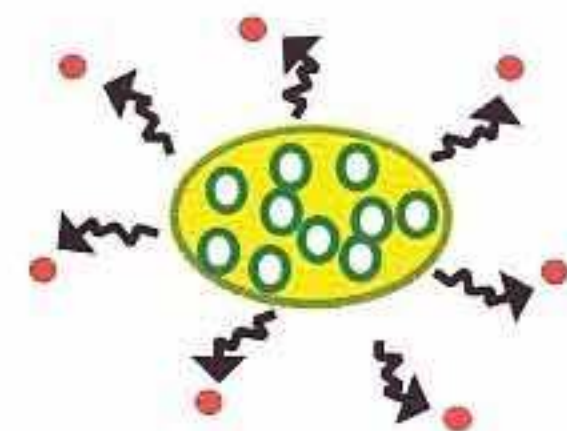
Other immune cells



Traces of bacteria

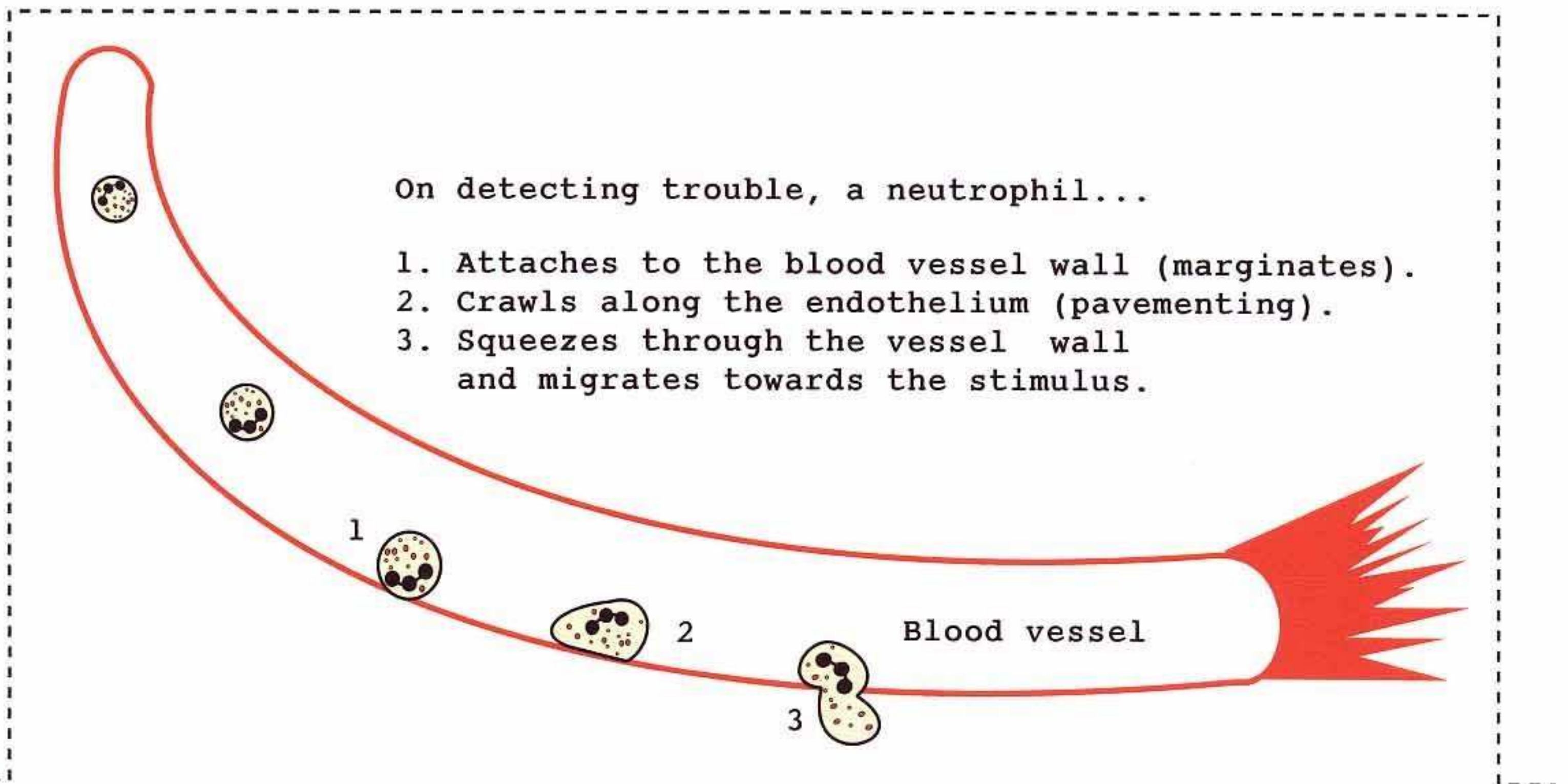
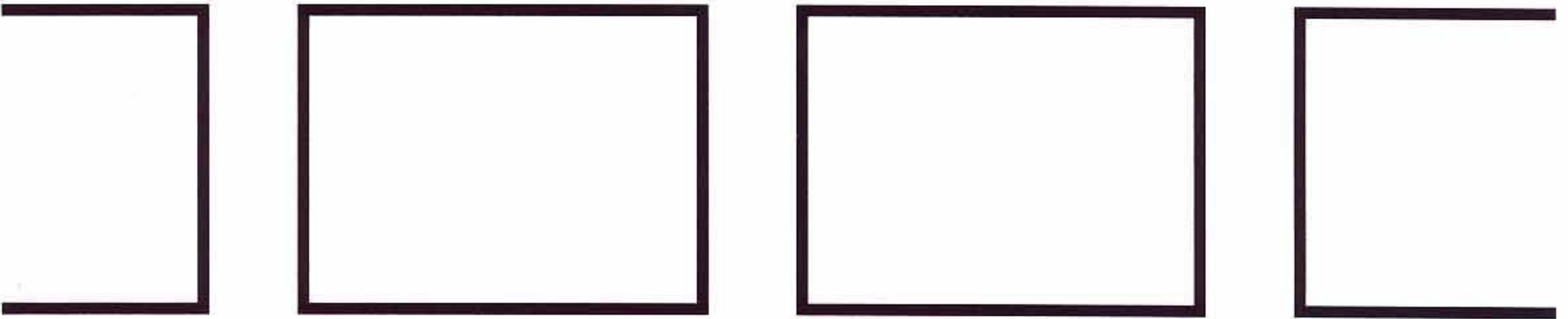


Heat damaged cells



Complement activation

A PERSONAL PROFILE OF A NEUTROPHIL (PART 2)



Neutrophils can function in places where there is little oxygen, through carrying energy reserves (glycogen).

## HOW NEUTROPHILS KILL INVADING BACTERIA

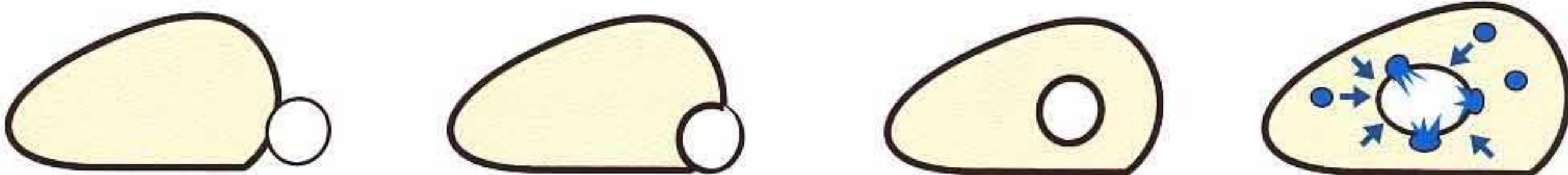


Neutrophils kill microbes by 'eating' and 'digesting' them.



To complete the job, inflammatory mediators are also released.

### HOW A NEUTROPHIL 'EATS' AND 'DIGESTS' A MICROBE



Attaching onto its prey, the neutrophil's membrane folds around the microbe, as it is drawn inside. The package now has a battery of toxic chemicals emptied into it, to kill and digest the intruder.

## THE MONOCYTE



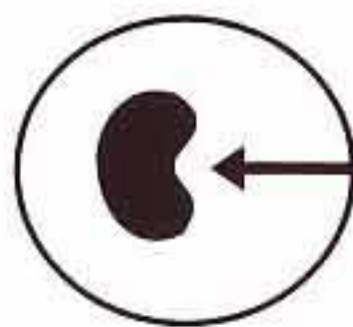
This young monocyte has just left the bone marrow.



After only a short time, he is welcomed into his new home.



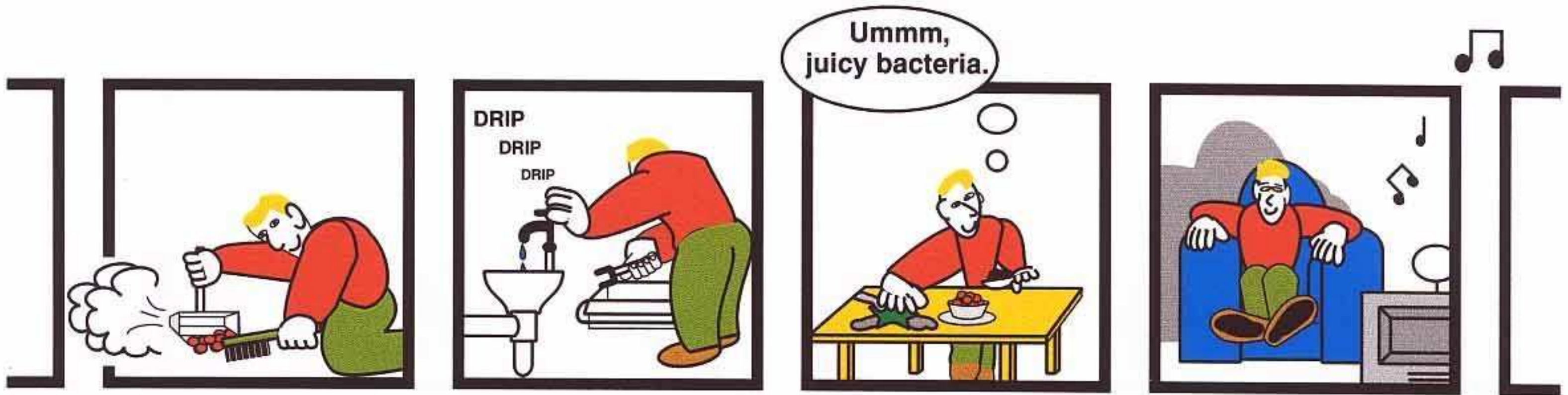
Here, he will become an adult macrophage.



Monocytes have a bean-shaped nucleus.

A monocyte starts life in the bone marrow. It then enters the blood and circulates around the body. After about 30 hours, the monocyte will migrate into the tissues and develop into a macrophage.

## MACROPHAGES



Unlike the adventurous neutrophils, macrophages are happy just staying put and keeping their home tidy.

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Macrophages are found all over the body. Their job is to remove waste and to facilitate new growth and development.

THESE MACROPHAGES SUDDENLY FIND THERE IS PLENTY TO DO

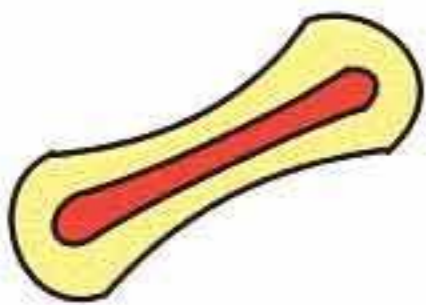


"Typical" said a macrophage, "those neutrophils are always leaving the place in a complete mess"!

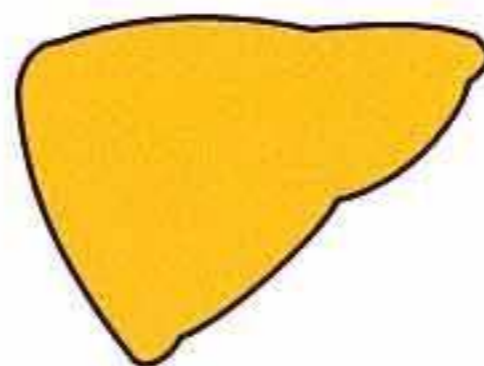


However, it was not long before they had cleared away the dead and got things back to normal.

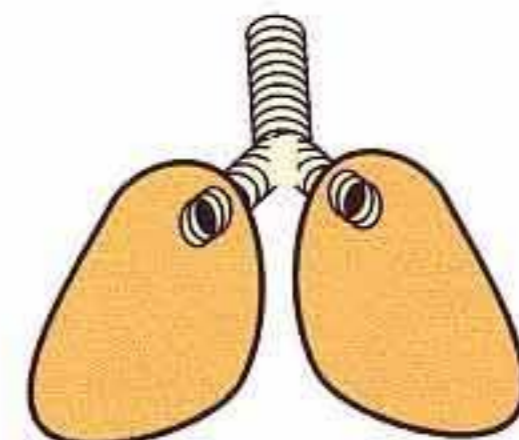
3 EXAMPLES OF WHERE MACROPHAGES ARE FOUND



Macrophages in bone, are called "osteoblasts".



Macrophages in the liver, are called "kupffer cells".



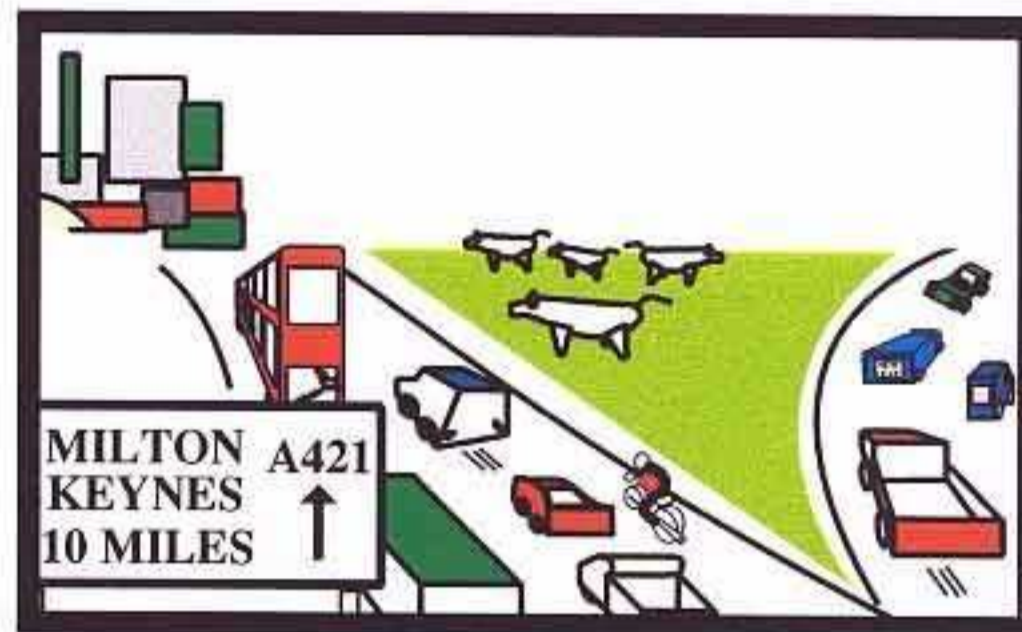
While in the lungs, these cells are called "alveolar macrophages".

**IF OUR BLOOD IS RED, WHY ARE WE BLACK OR WHITE AND NOT RED?**

**Roads give us a clue.**



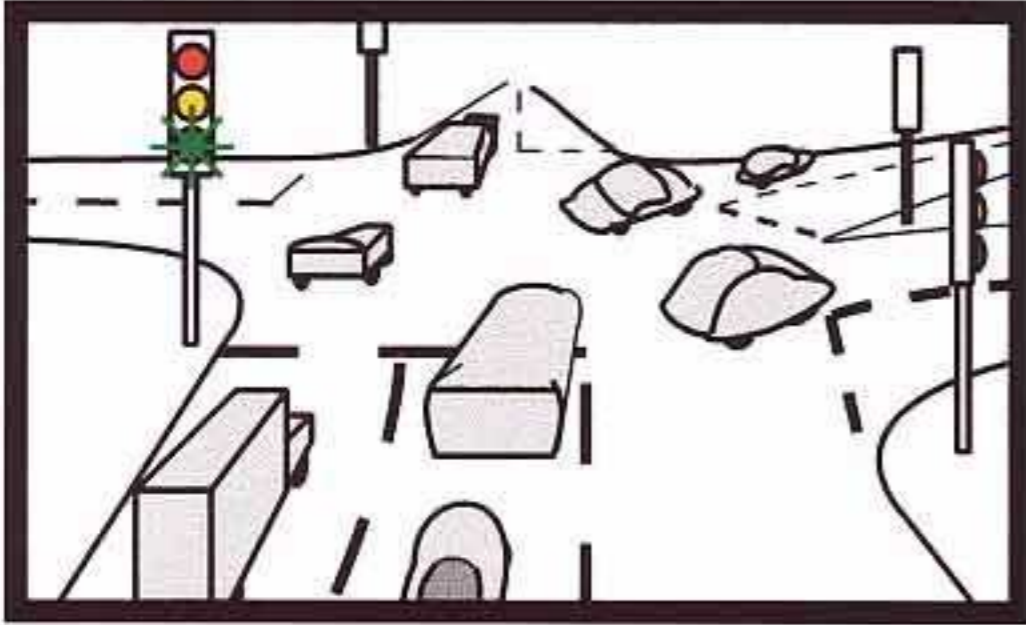
**Just like most days, a large volume of traffic is pouring out of London.**



**Travelling along the busy motorway, vehicles filter off onto smaller roads as they approach their destination.**



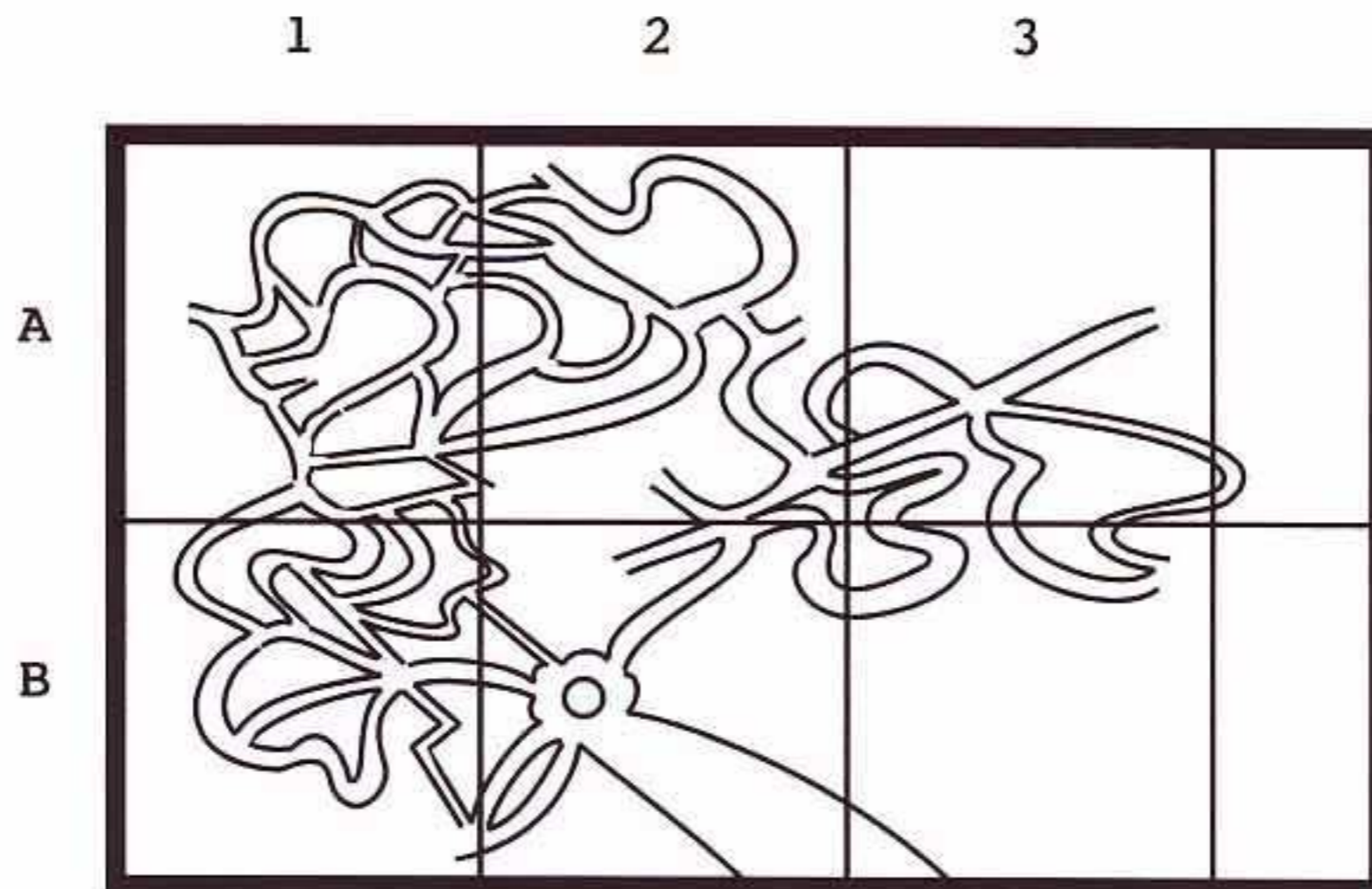




"Welcome to Milton Keynes".



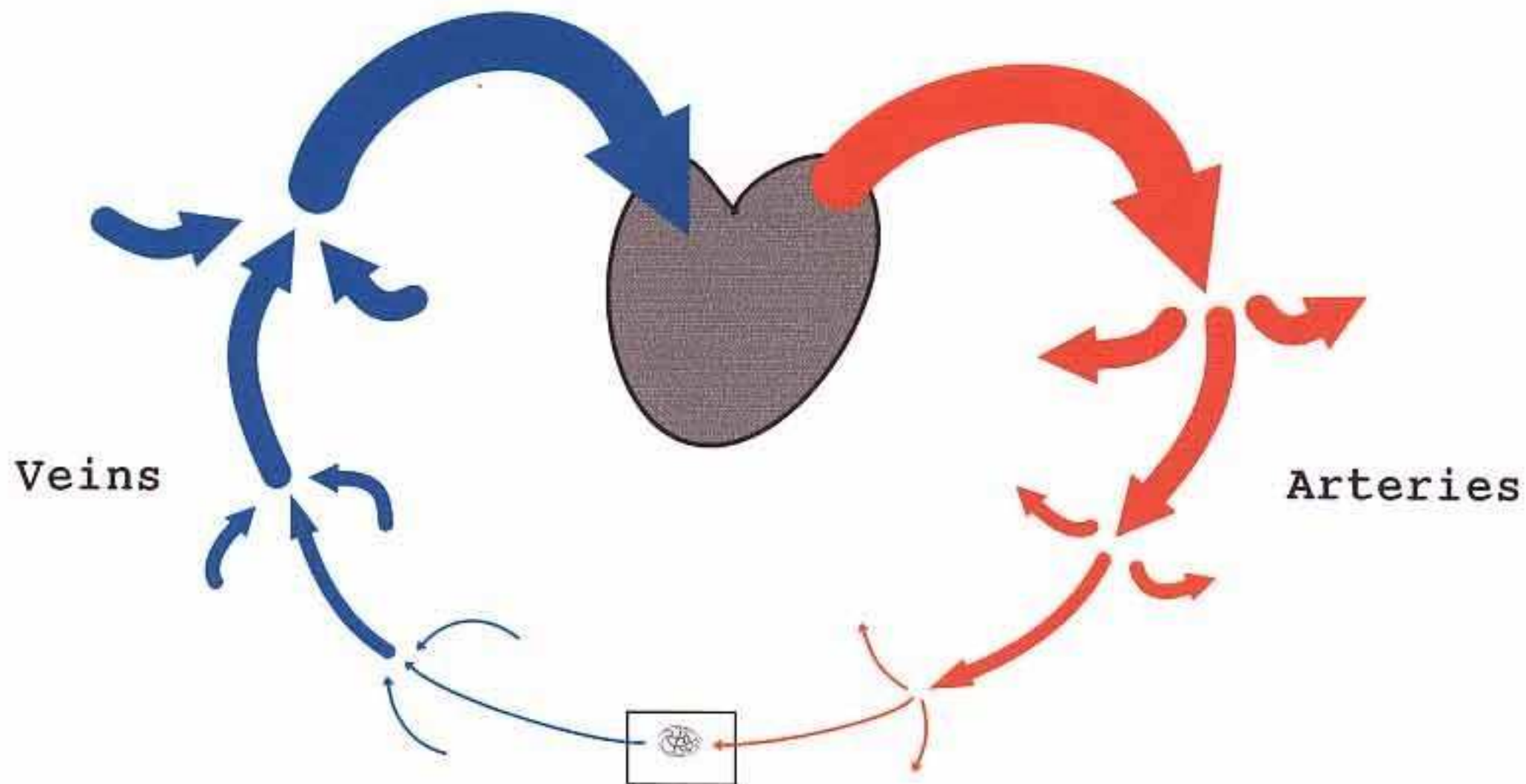
In the town, traffic moves much more slowly. Lorries deliver goods and people leave their cars to shop in the narrow side streets.



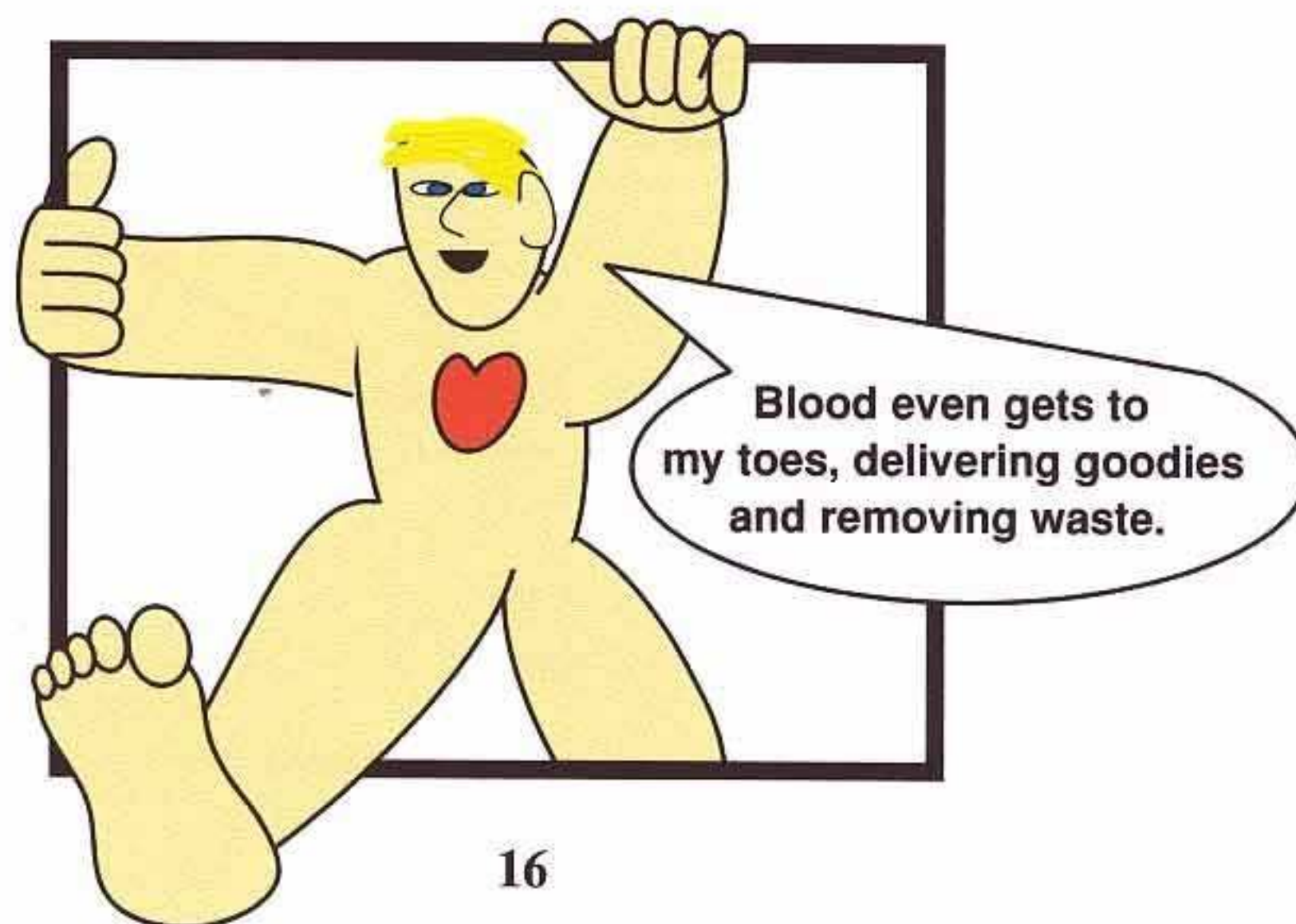
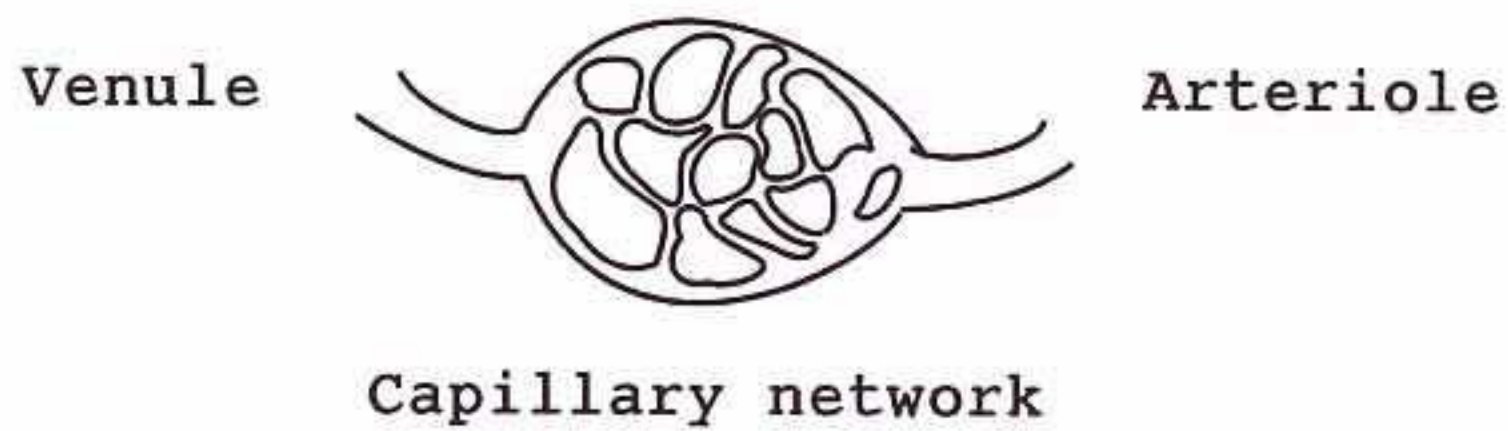
This local street map, shows how a trunk road, can quickly branch into hundreds of tiny town streets.

## THE CIRCULATION

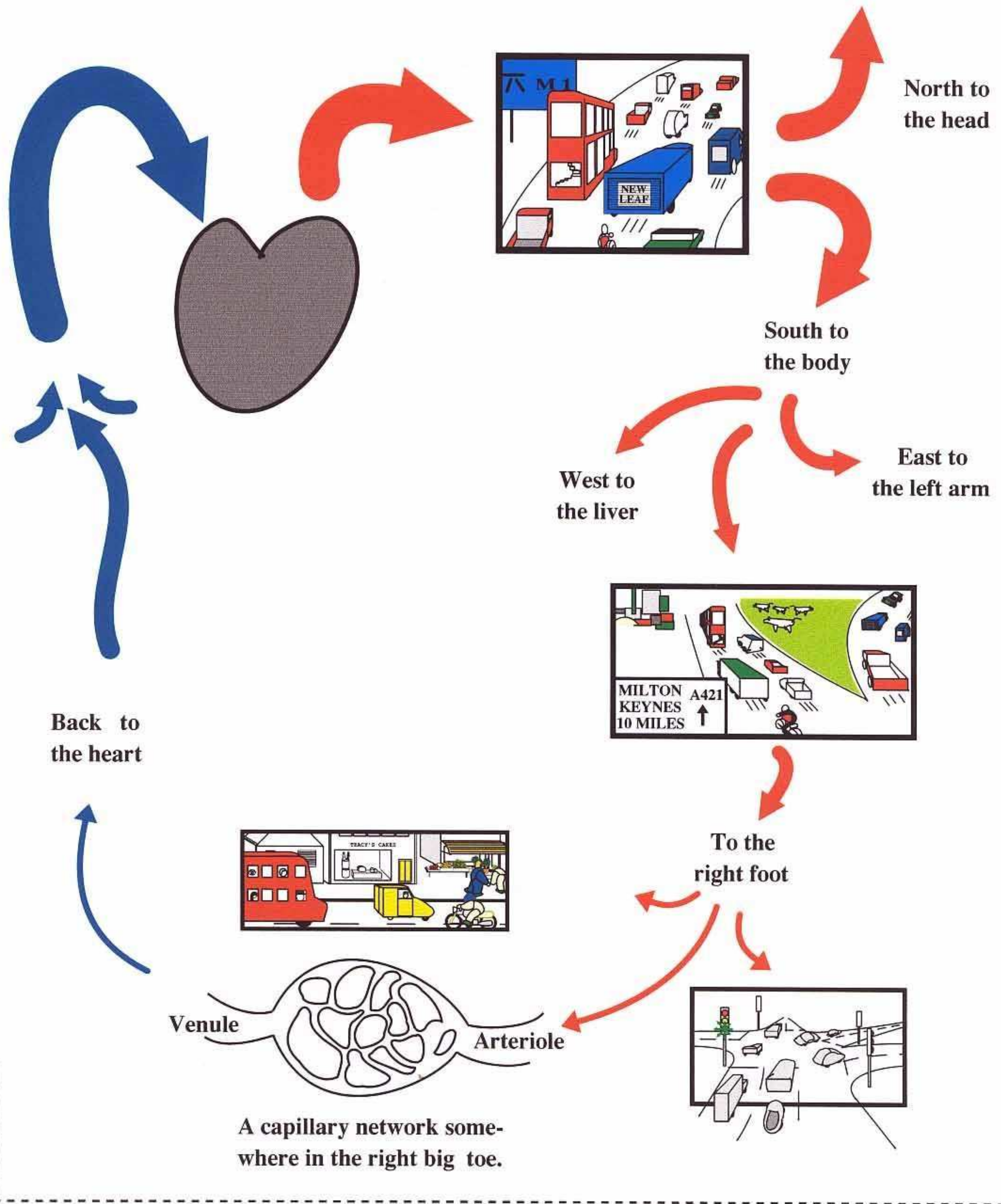
Blood is pumped around the body in arteries and then returns to the heart via the veins. Note how both the arteries and the veins divide into narrower and narrower vessels.

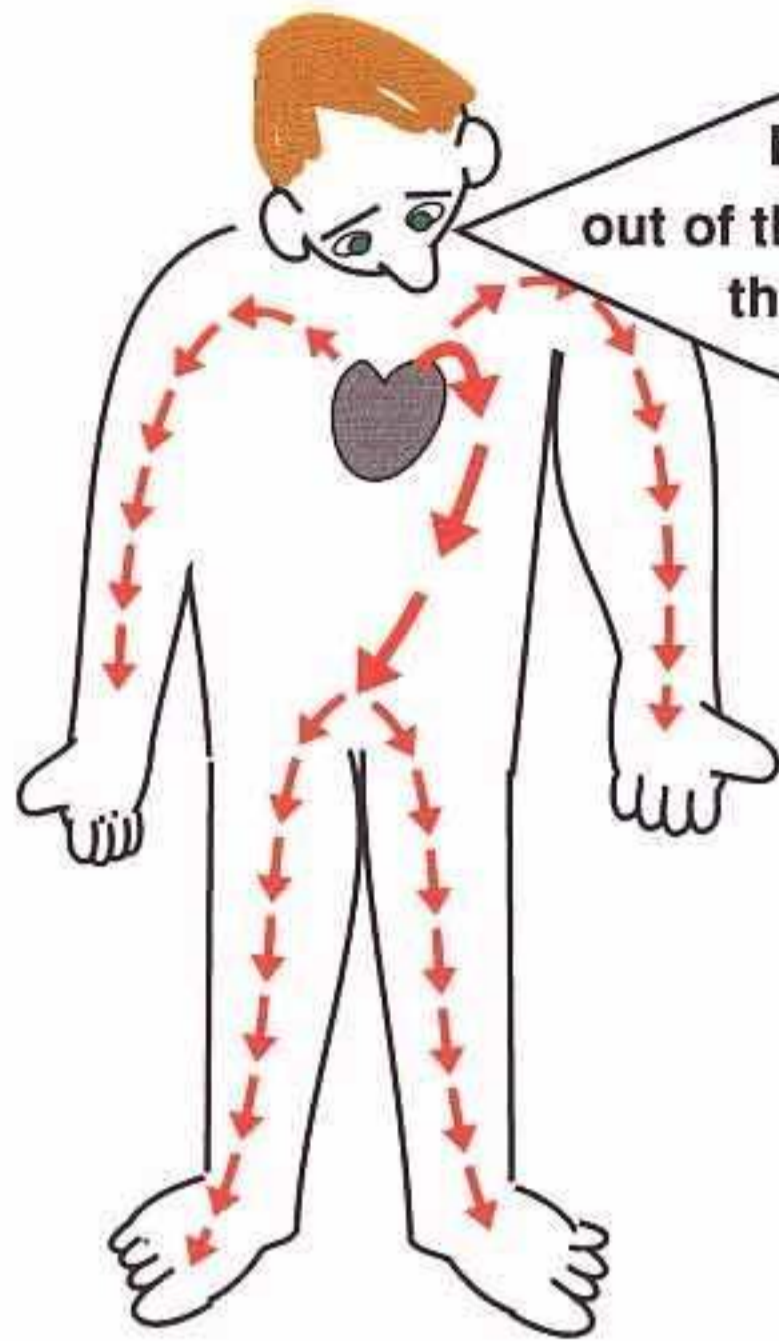


The narrowest artery, called an "arteriole", is linked to the narrowest vein, called a "venule", via a capillary network.

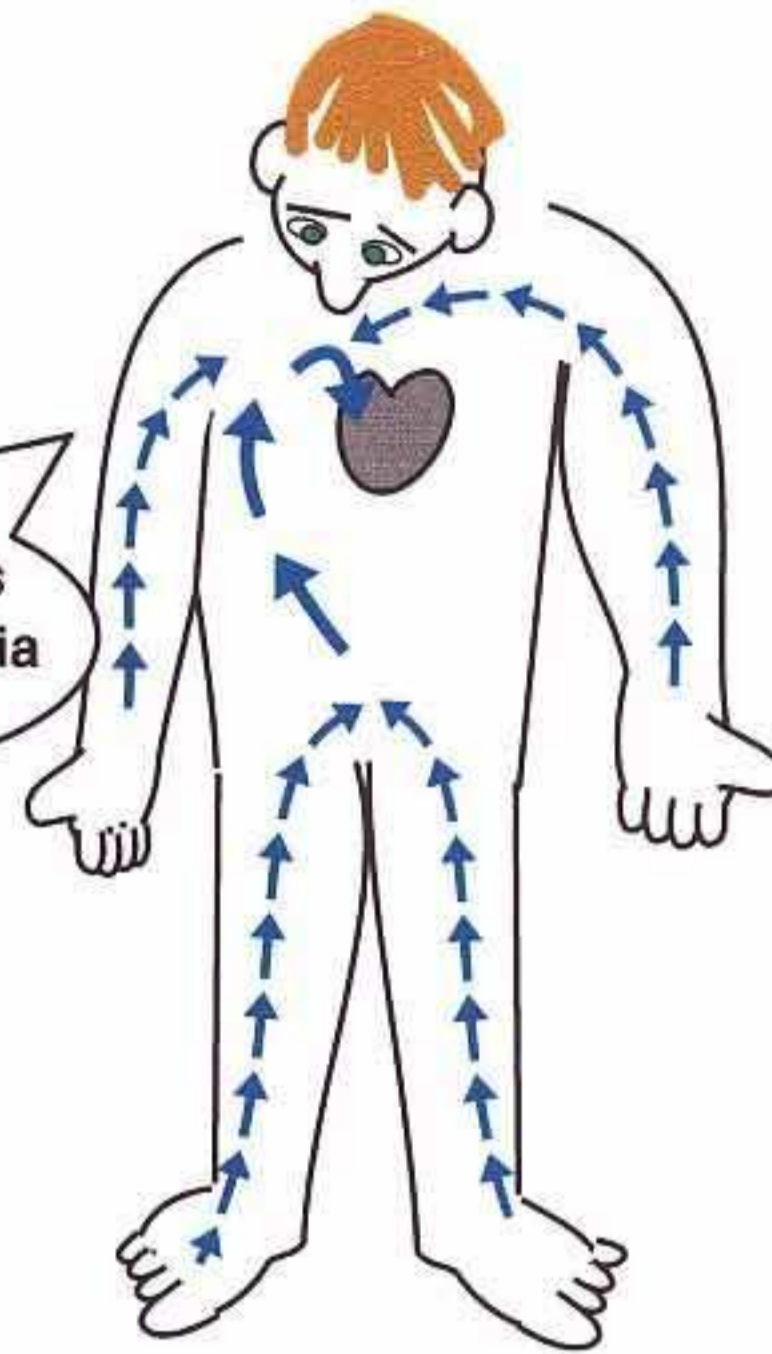


A ROAD MAP OF THE ROUTE BLOOD TAKES TO GET TO A TOE





Blood is pumped out of the heart and around the body in arteries.



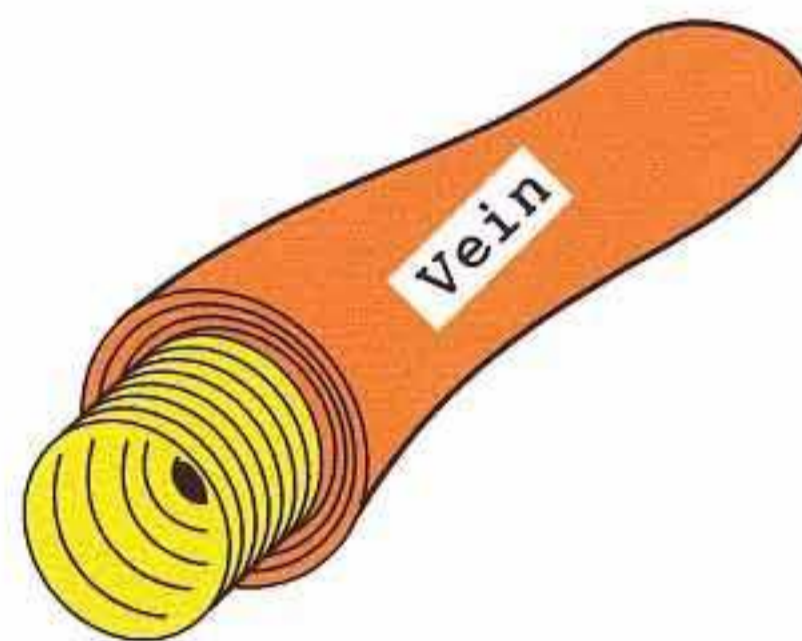
It then returns to the heart via the veins.

**HIGH PRESSURE SYSTEM**

**LOW PRESSURE SYSTEM**

Arteries have thick walls, a narrow bore and are lined with endothelial cells.

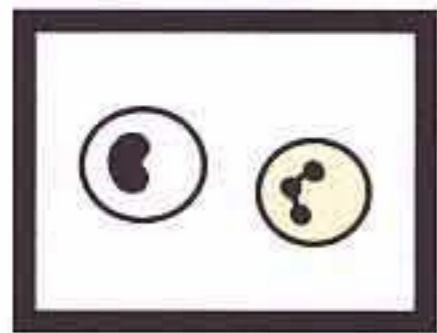
Veins have thin walls, a wider bore and they too are lined by endothelial cells.



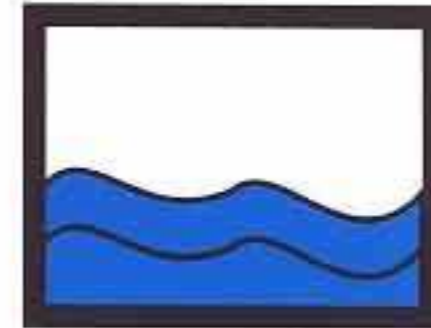
Capillaries are very narrow vessels, with 'wafer thin' walls, made up solely of endothelial cells.

## BLOOD

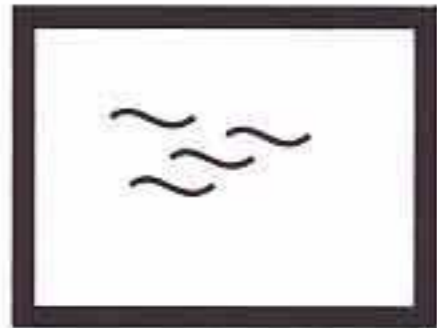
Our blood is red in colour because it contains large numbers of red blood cells. However, it also contains many other vital things such as:-



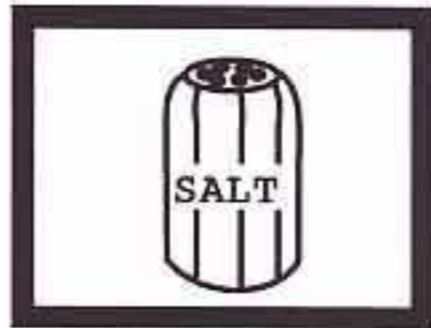
White blood cells



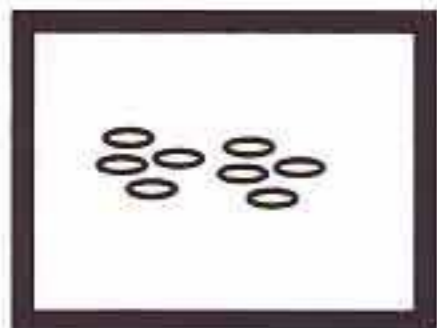
Water



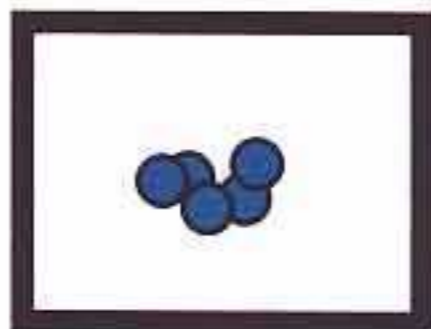
Fibrinogen



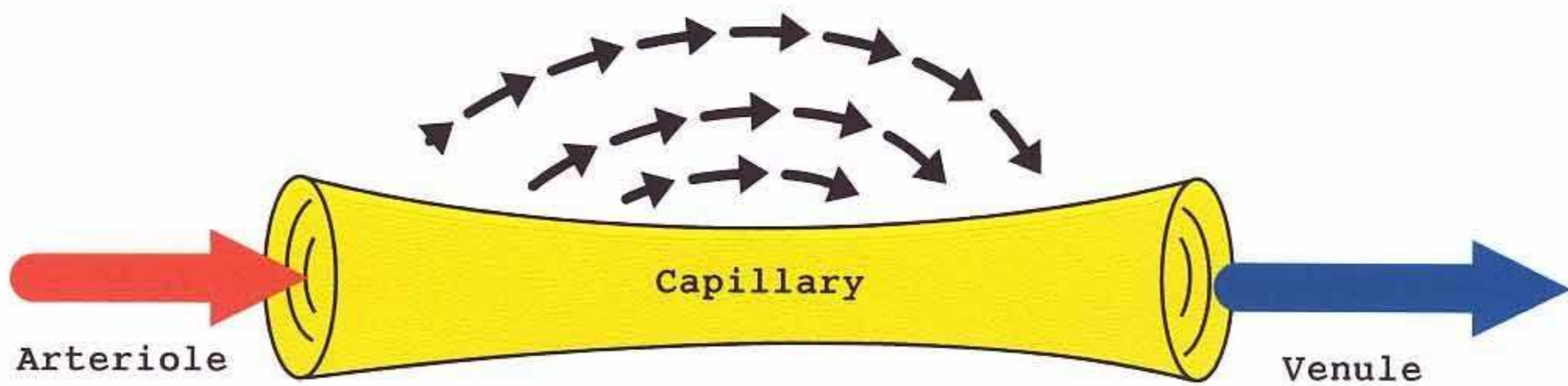
Minerals



Platelets



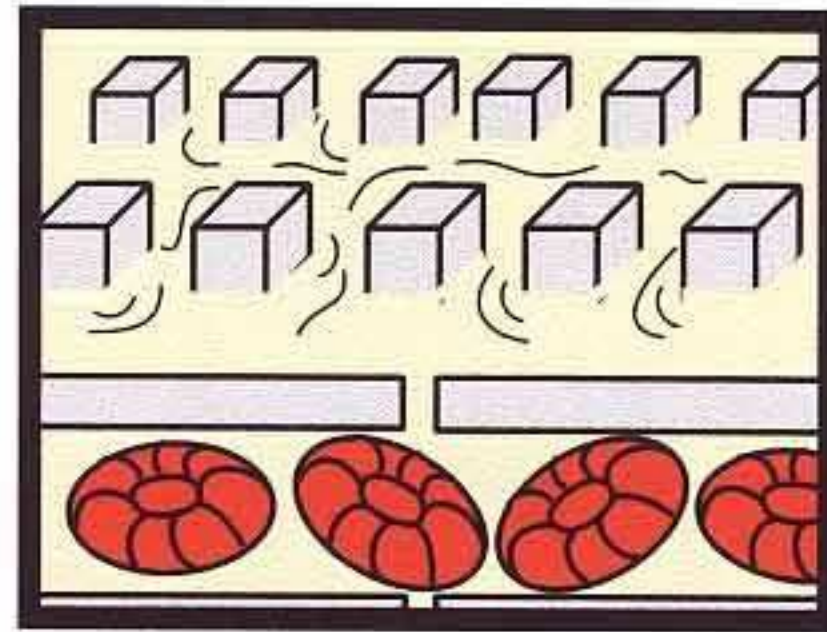
Albumin and globulin



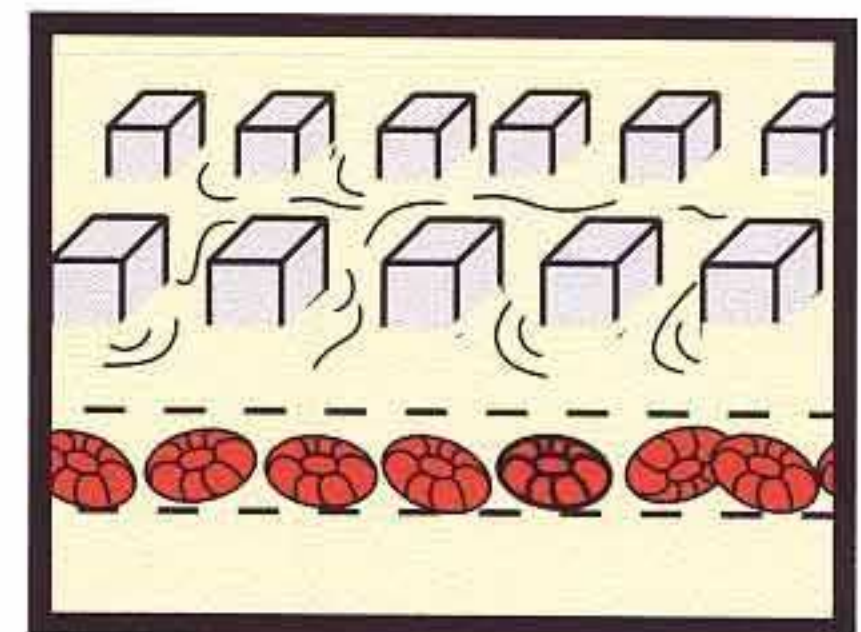
As the capillary is narrower than the arteriole, there is a pressure build up. This forces fluid out of the vessel and into the tissues. Tissue fluid is then drawn back into the venule.



After doing the shopping, the car is left in the street as it is too big to bring indoors!



Likewise, red blood cells and other large particles, are too big to pass through the gaps in the capillary walls.

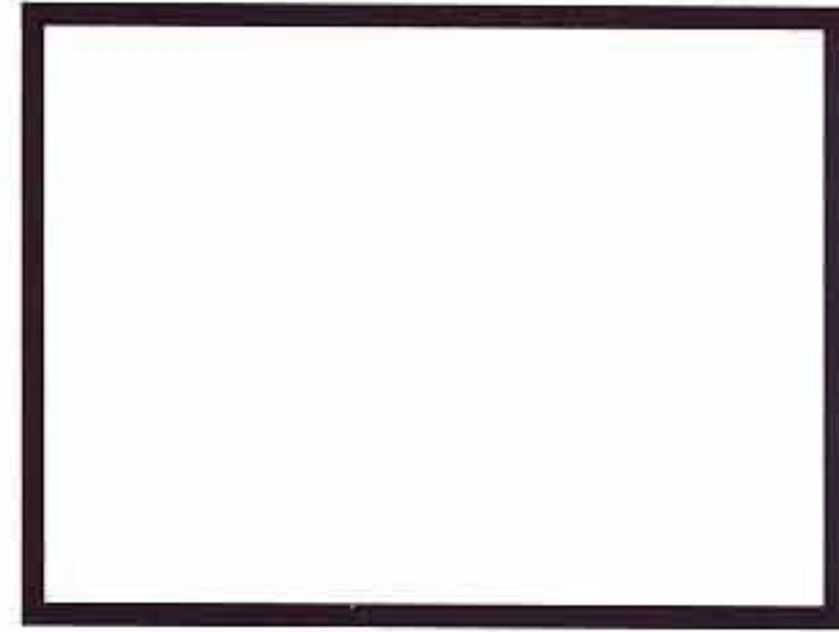


However, water carries small particles through these gaps and into the tissues to bathe the cells.

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So if our blood is red, why are we black or white and not red? The answer is simple. The red blood cells which give blood its red colour, are confined to the blood vessels.

## INFLAMMATION



The classic signs of an inflammatory response are:- redness, heat, swelling, pain and a loss of function.

### SOME OF THE MAIN CAUSES OF INFLAMMATION



Trauma



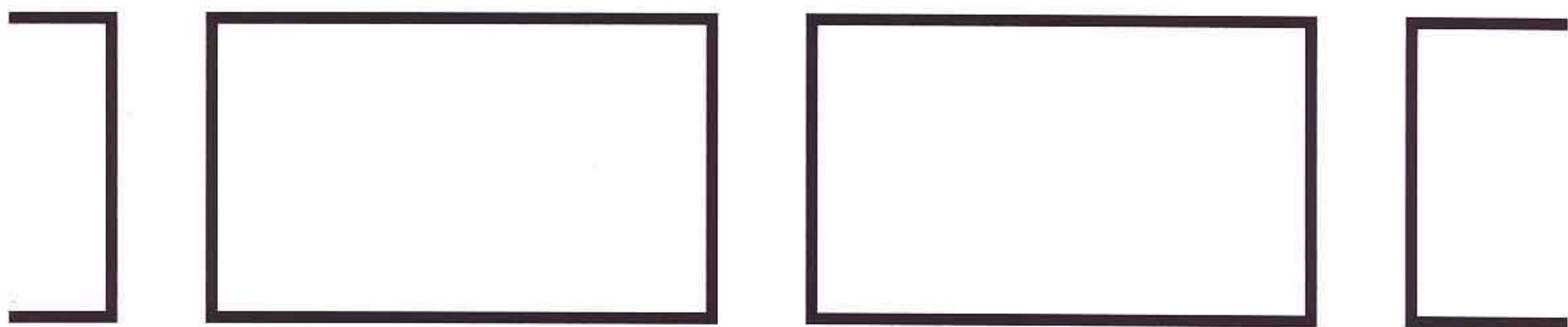
Infection



Burns



Fractures



AN INFLAMMATORY RESPONSE



PAIN

Nearby nerves are irritated.



HOT AND RED

Local arterioles dilate to increase the amount of blood entering the affected area.

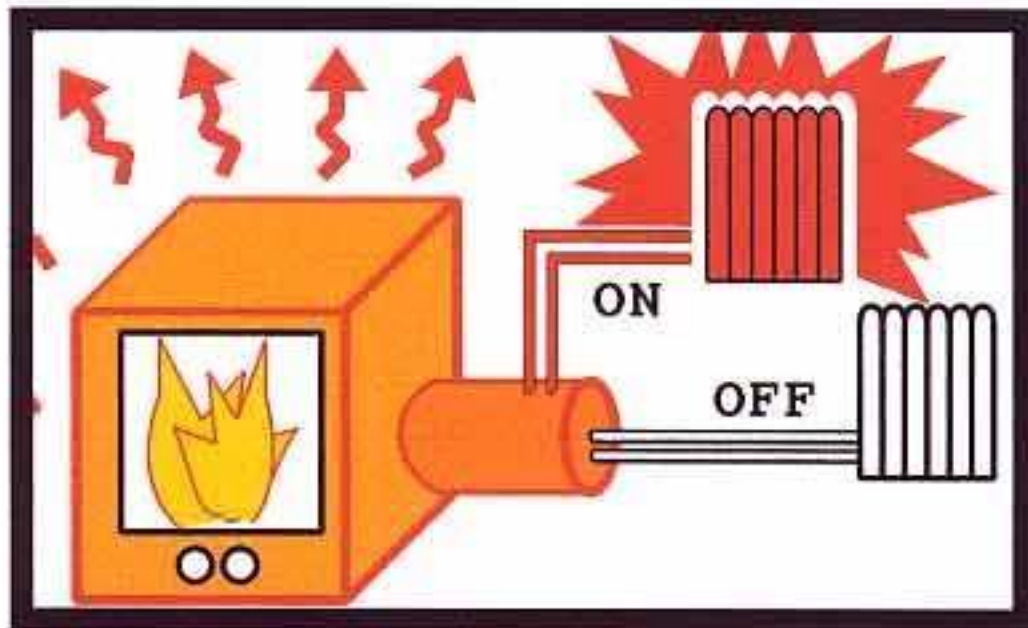


SWELLING

Gaps in the blood vessel walls widen to allow increased fluid and larger particles to escape into the tissues.



DOES A RADIATOR GENERATE HEAT IF IT FEELS WARM?



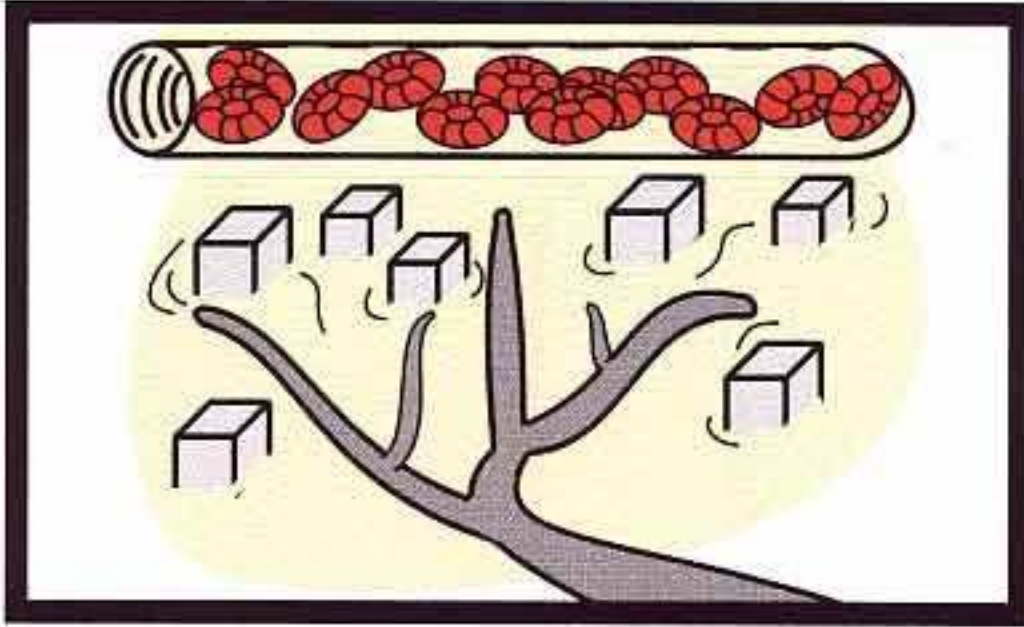
Although a radiator may feel hot, the heat is generated in a boiler.

This inflamed finger feels hot, but is the heat generated here?

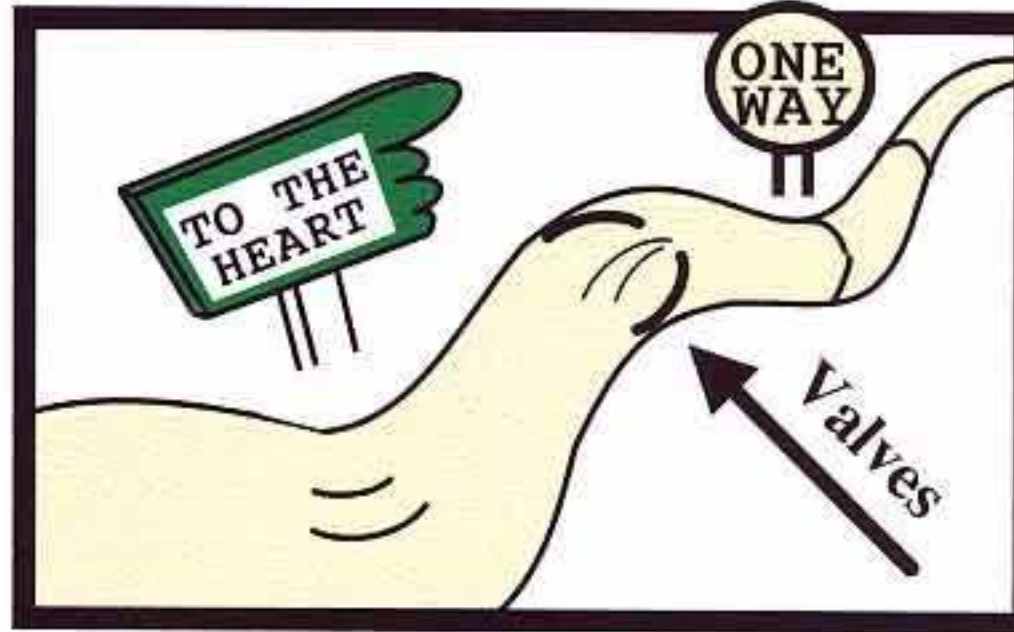


Again the answer is "no", as the liver acts like a boiler. Local arterioles in the affected part dilate and this then allows more warm blood to enter the affected area.

## LYMPH AND THE LYMPHATIC SYSTEM



Some of the tissue fluid bathing the cells (see page 20), drains into lymph vessels.



Inside the lymph vessels, valves ensure that the collected fluid (now called "lymph"), only flows one way.

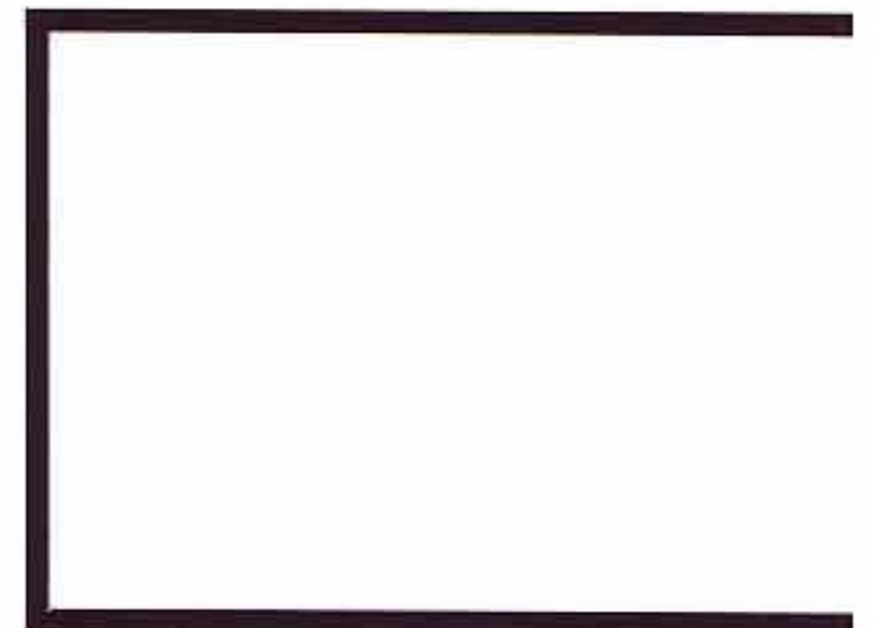
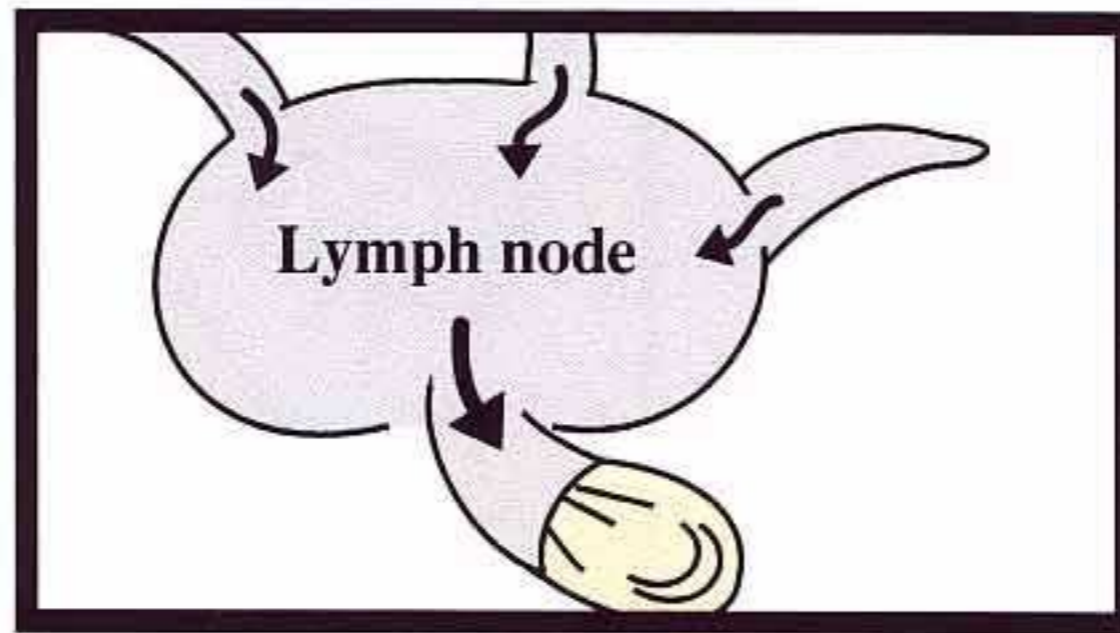


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Lymph vessels are found all over the body. They track back to the heart and empty the collected lymph there.

## LYMPH NODES

These are found where a number of lymph vessels join together.



Lymph flowing back towards the heart, is filtered as it passes through the lymph nodes.



In Africa, a parasite can block the lymph nodes draining the leg, causing tissue fluid to build up. This condition is known as elephantiasis.

## INSIDE A LYMPH NODE



While these macrophages are busy removing debris from the lymph, some B cells appear to be sleeping on the job.

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As the lymph passes through the node, any waste material in it is removed.

## MEET THE B LYMPHOCYTE

He was born and raised in the bone marrow.



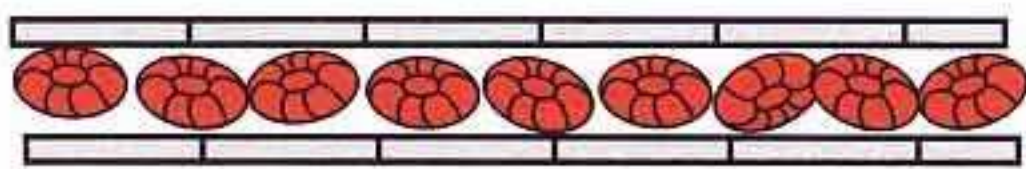
On reaching maturity, the B cell must leave to find a new home.



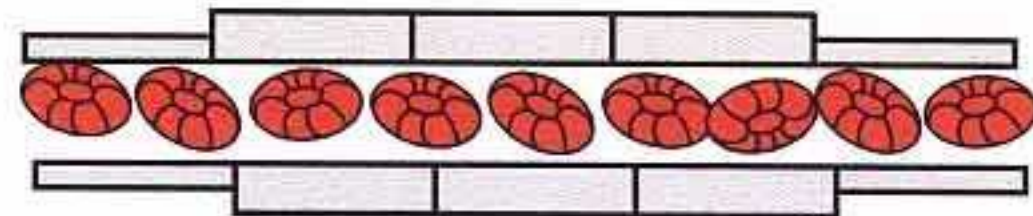
Carried in the blood, he reaches his new home, a lymph node.



Soon the B cell is eagerly leaving the blood vessel to find out what lies inside.

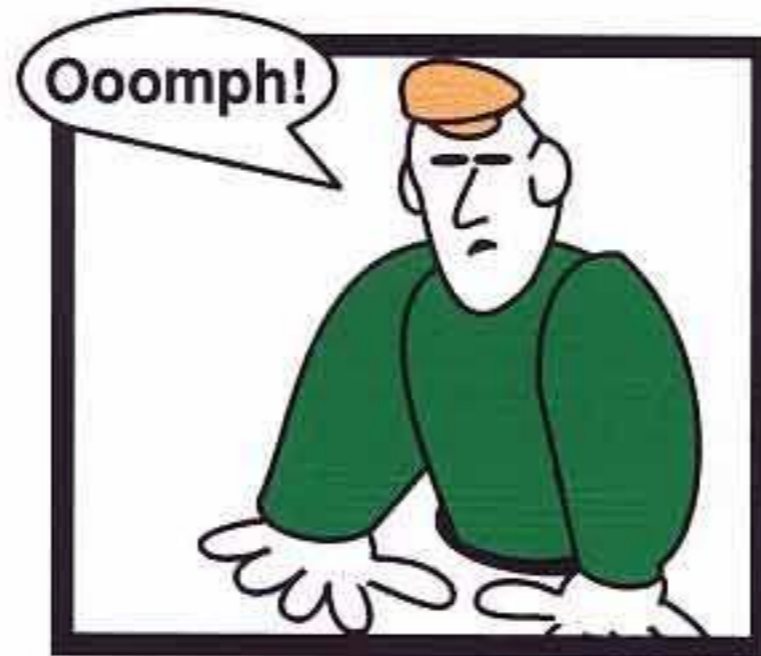
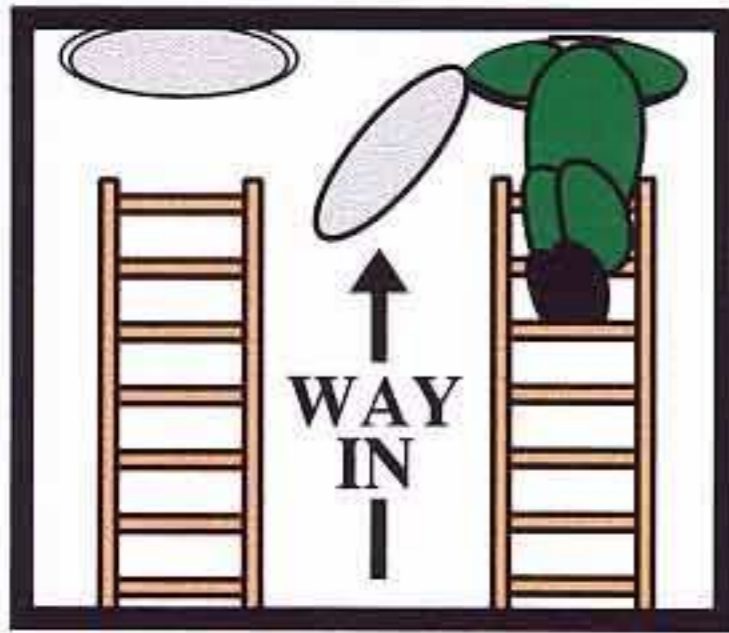


Most blood vessels are lined by thin endothelial cells.

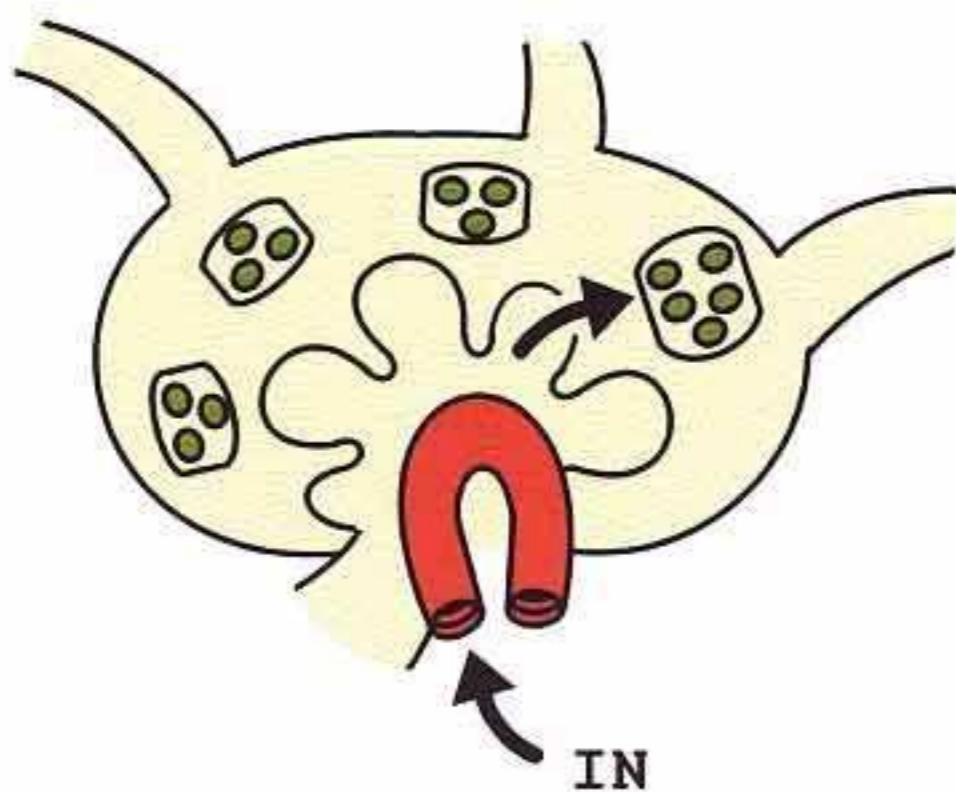


But some veins inside the lymph node are lined with high endothelial venules.

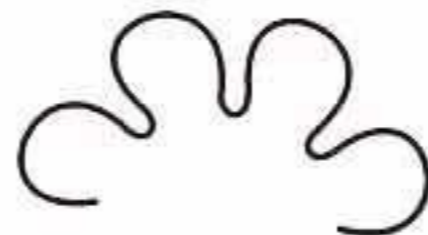
THE YOUNG B LYMPHOCTE'S NEW HOME



Although it is a tight squeeze getting out of the blood vessel, he is soon joining his brothers in one of the primary follicles.



Primary follicle (containing resting B cells).

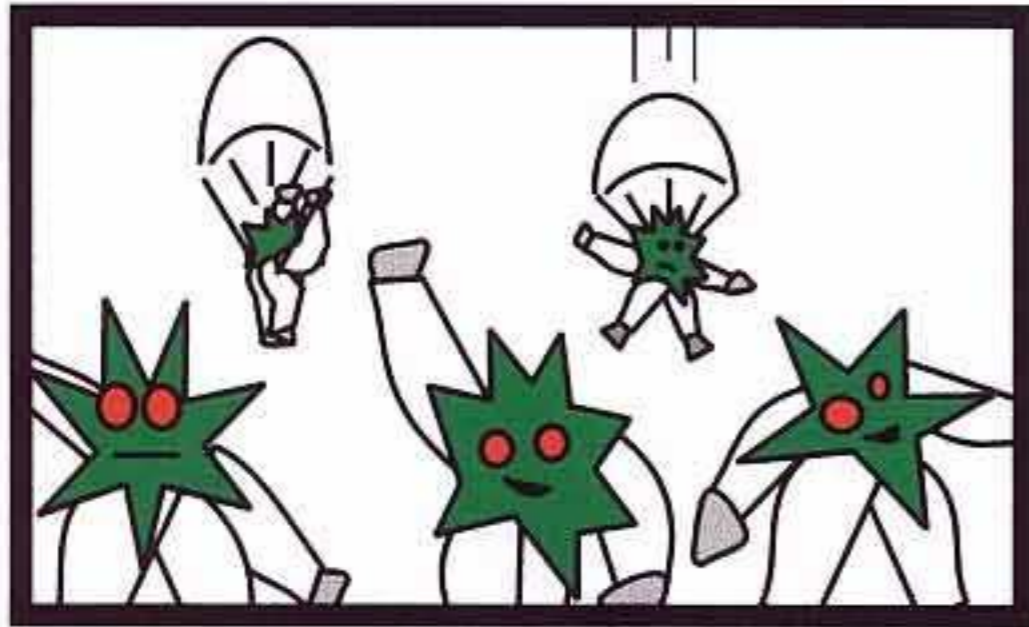


Medullary cords

B cells use the high endothelial venules to enter a lymph node and then make their way to one of the primary follicles.



## POOR PIERCE MYSKIN GETS THE POINT



These microbes see the opening and enter the cut to infect his foot.

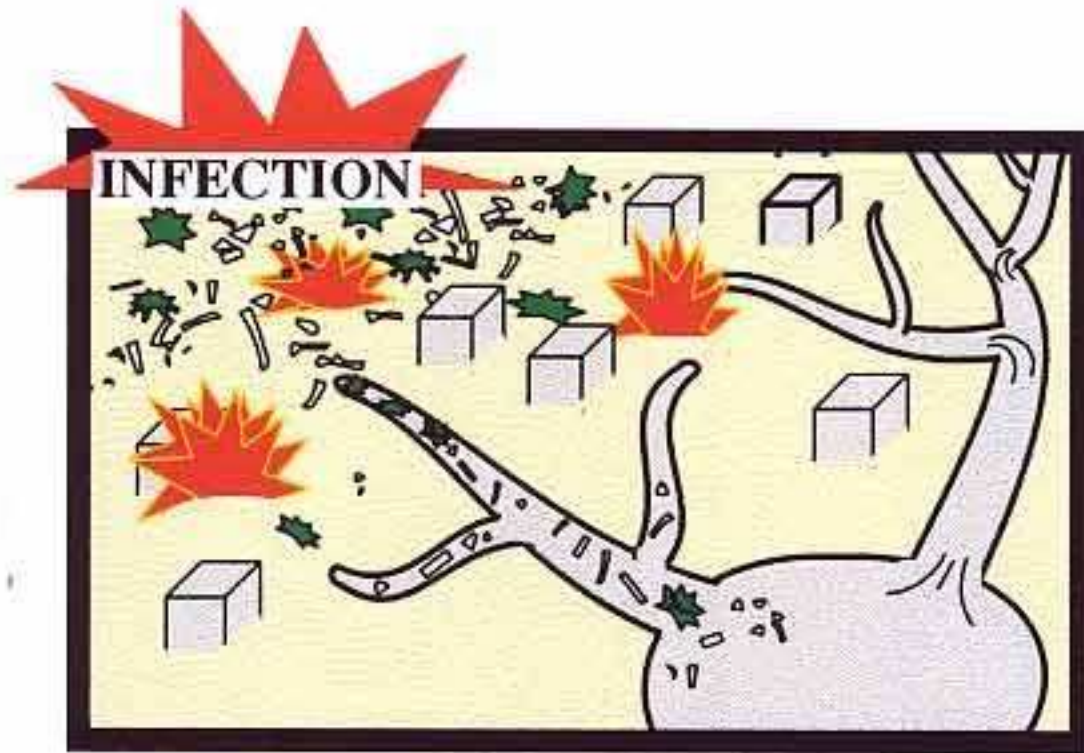


Alerted to the danger, neutrophils are quick to appear on the scene.

---

Neutrophils will leave a blood vessel and enter the tissues, if they detect things like traces of bacteria, activated complement or inflammation.

**INFECTED DEBRIS GETS WASHED INTO A LYMPH NODE**



Lymph from the infection is soon draining into this lymph node.



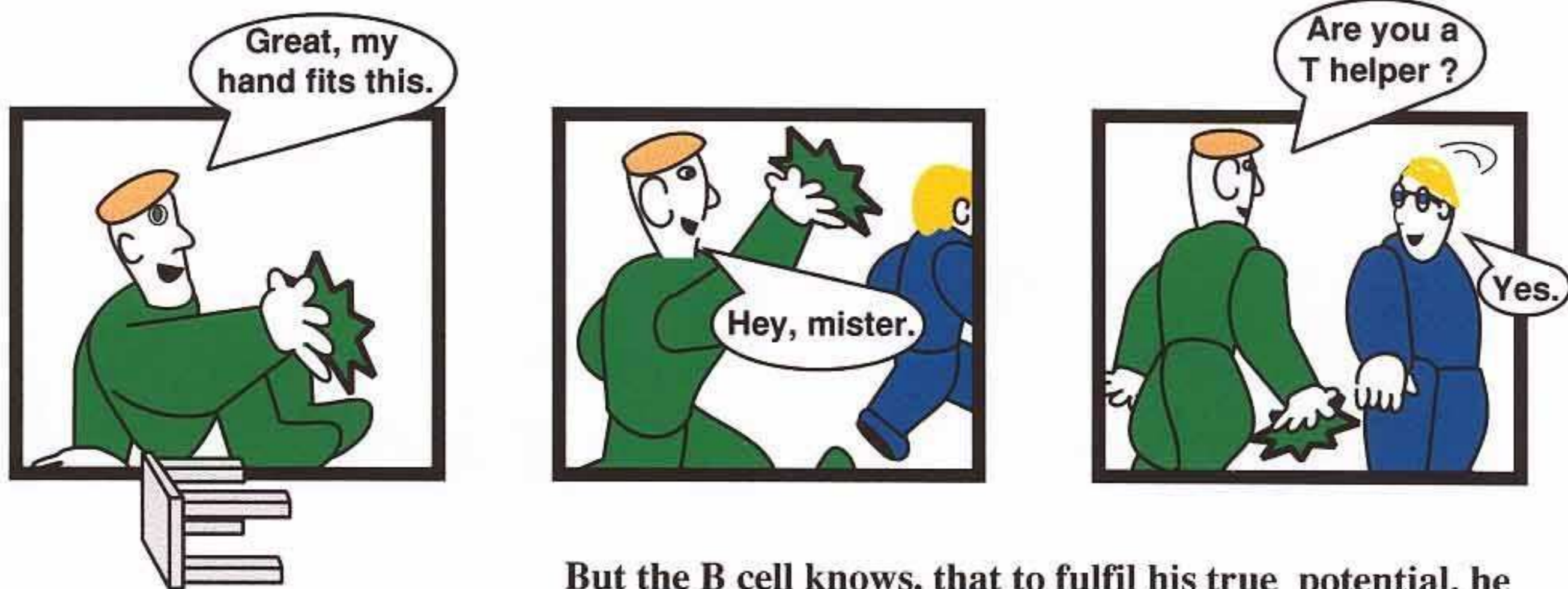
One of the B cell's suddenly 'grabs' a passing microbe.

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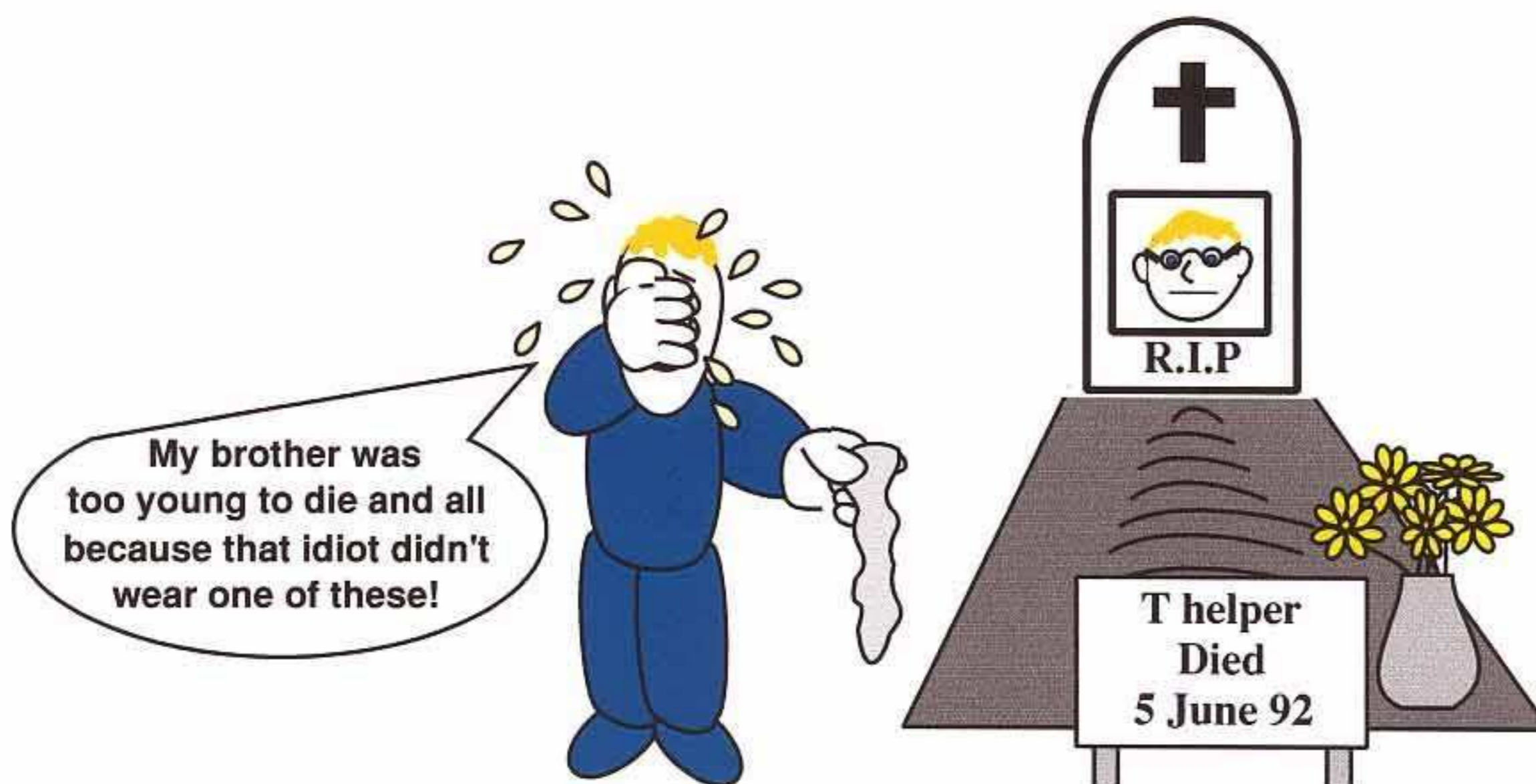
Unlike the macrophages, each B cell has a unique fixed 'hand' shape, which greatly limits what it can attach onto.



## THE B CELL MEETS T HELPER LYMPHOCYTE



But the B cell knows, that to fulfil his true potential, he now needs that special something from a T helper cell.



This is the immune cell which the AIDS virus infects and destroys.

## THE B CELL IS LET DOWN



---

Like the B cell, each T helper has a unique fixed 'hand' shape. This greatly limits what he too, is able to attach onto.

ANOTHER T HELPER ENTERS THE LYMPH NODE

Excuse me, but does your hand fit this shape?



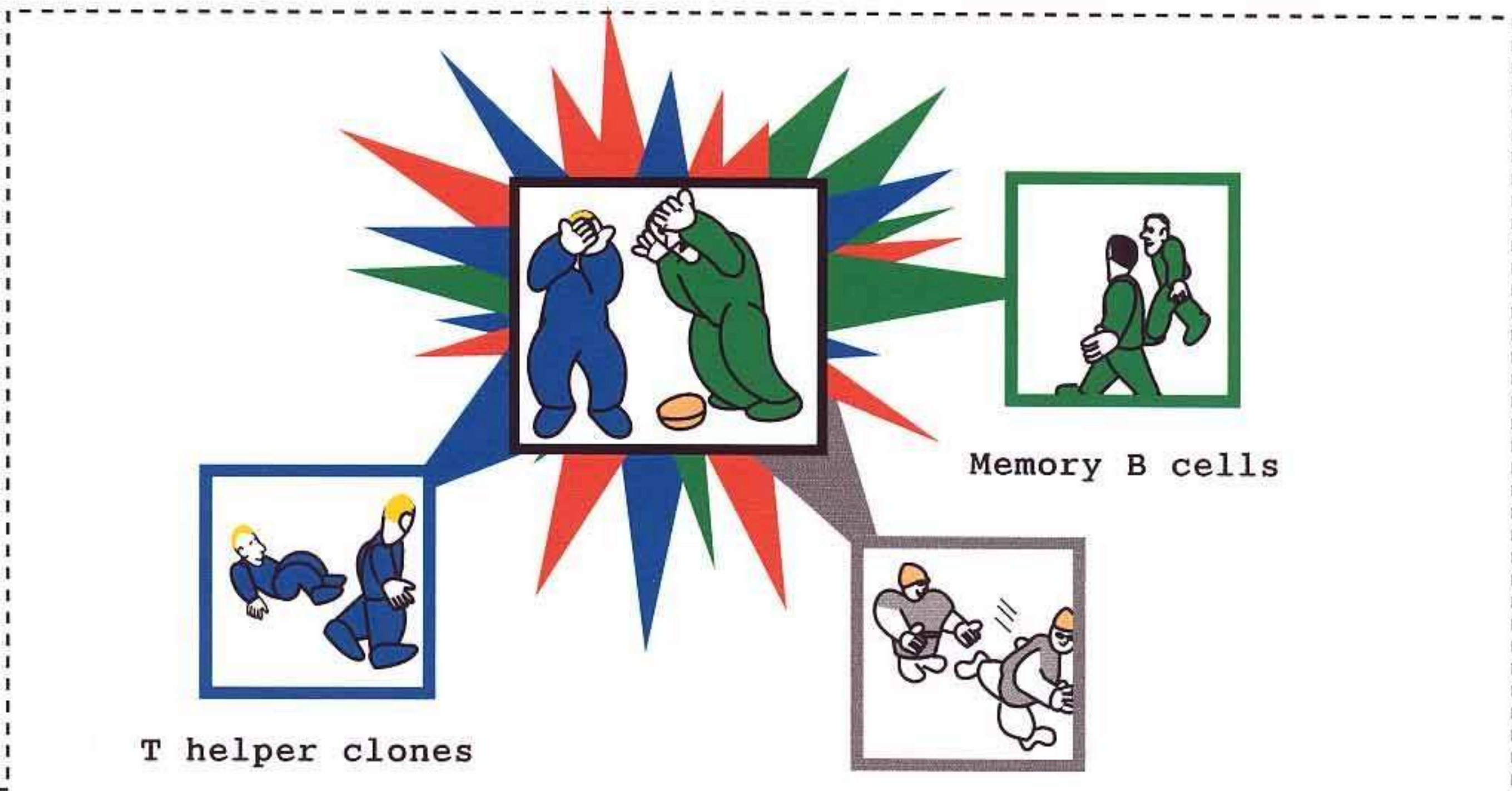
The B cell now meets another T helper cell.



To his great delight, this T helper's 'hand' fits!!

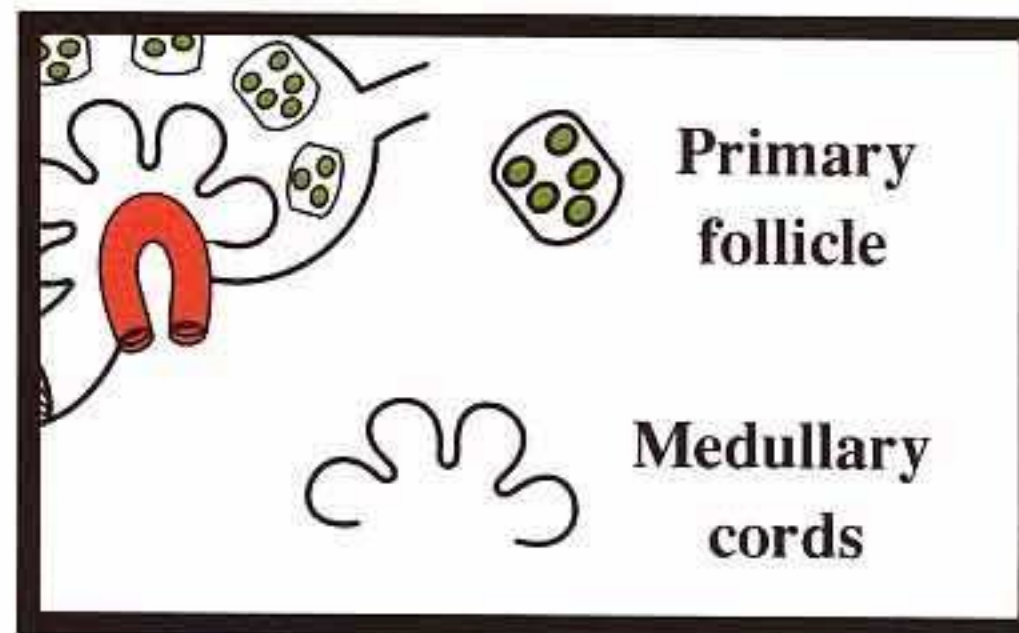
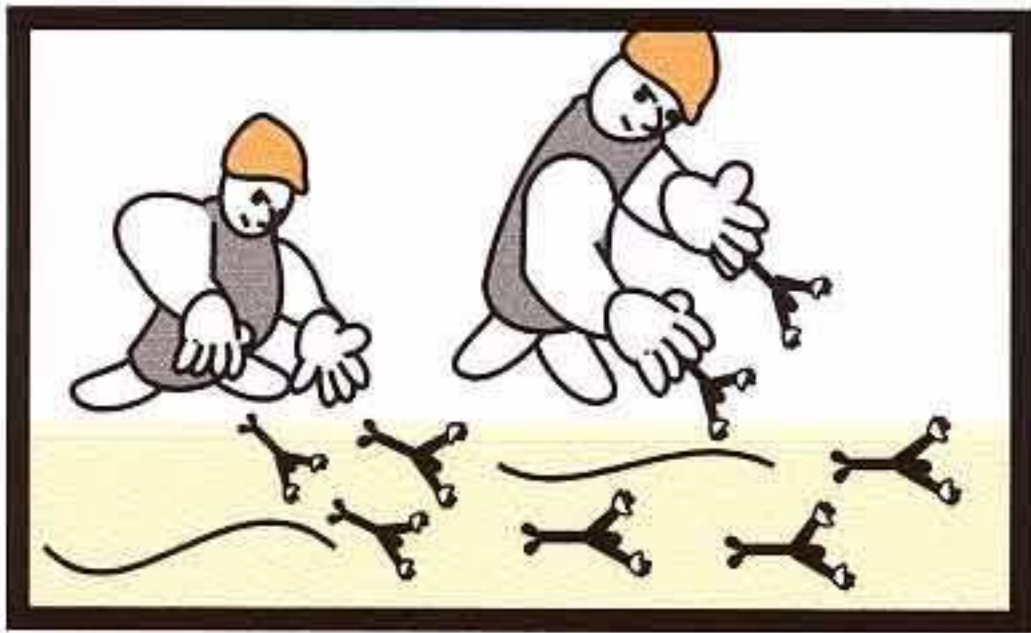


He then gives the B cell something interesting.

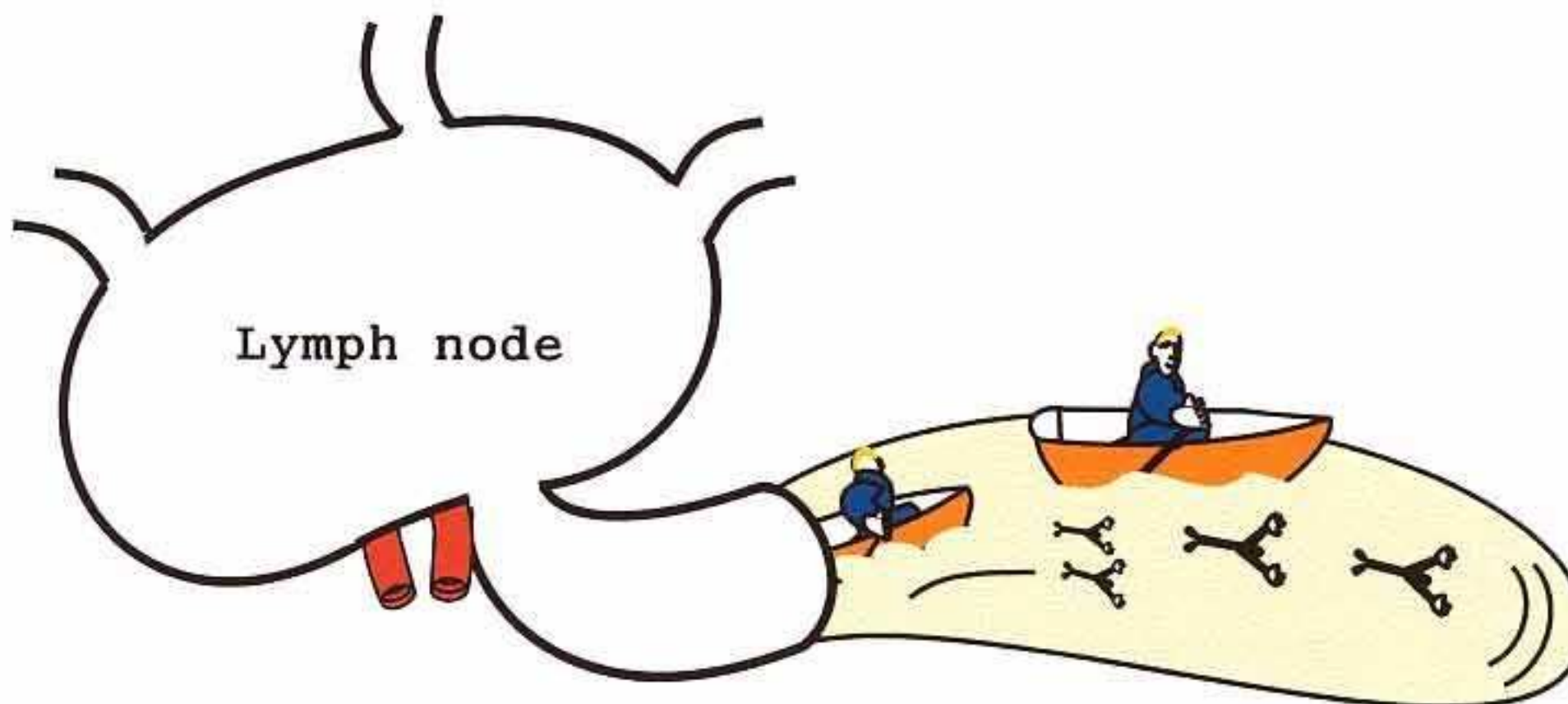


If the T helper's 'hand' fits, it releases factors which affect both cells. The T helper clones itself and the B cell changes into plasma cells and memory B cells.

AS THE DUST SETTLES

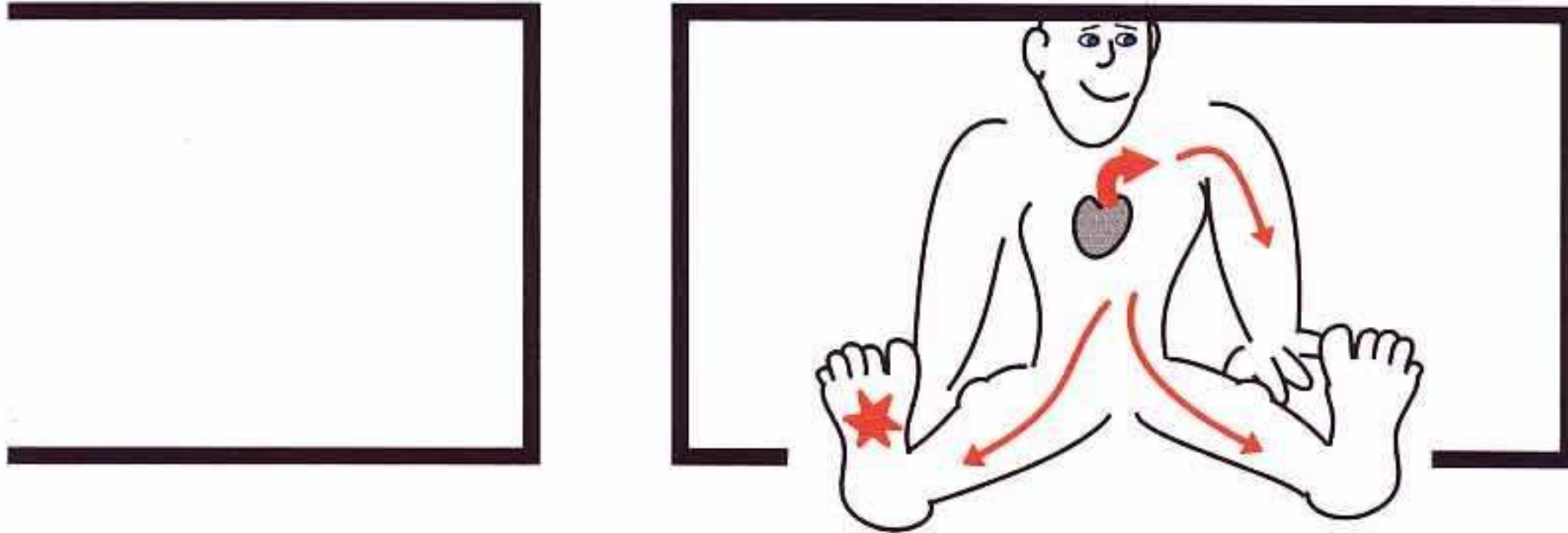


Leaving their primary follicle, the plasma cells will go to the medullary cords. Here, they will each start to release large quantities of antibodies.

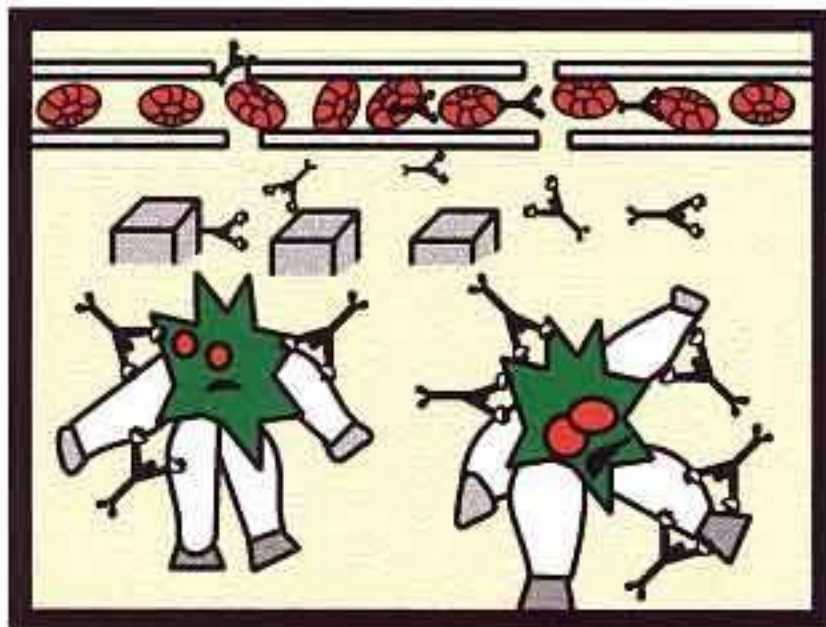


Lymph flowing out of the node on its journey back to the heart, now contains antibodies and T helper cells.

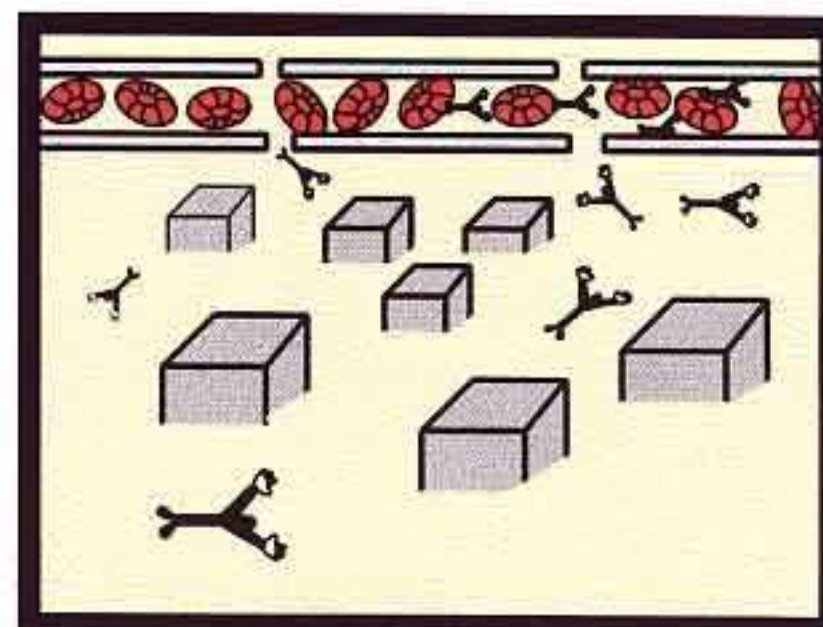
## PIERCE MYSKIN'S ANTIBODIES DO THE TRICK



From the heart, the antibodies are carried around his body in the blood.



Entering the infected part of the foot, the antibodies apprehend the microbes.



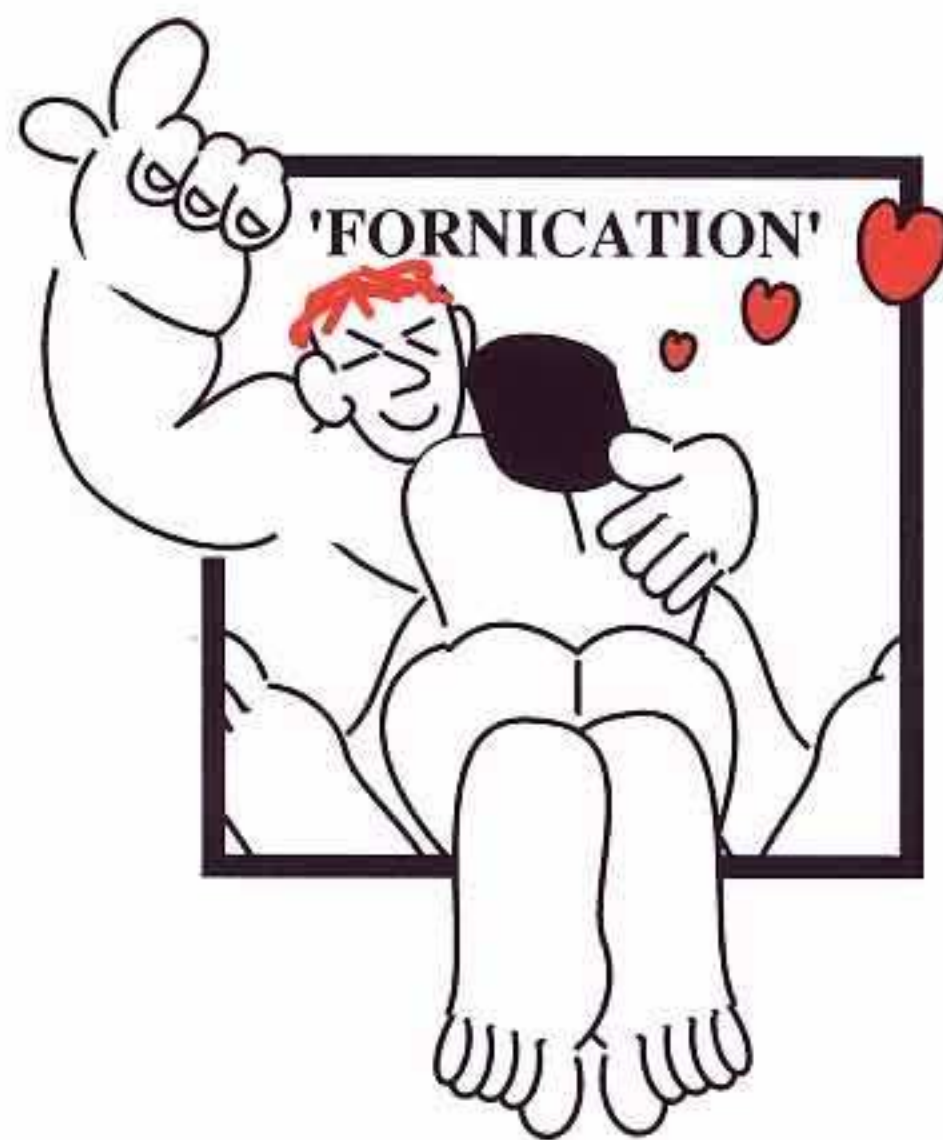
They also enter the uninfected foot, but here there's nothing to attach onto.

Antibodies, unlike red blood cells, are small enough to pass out through the small gaps in the capillary walls and into the tissues.

**INFECTION AND THE 5 DEADLY F's**



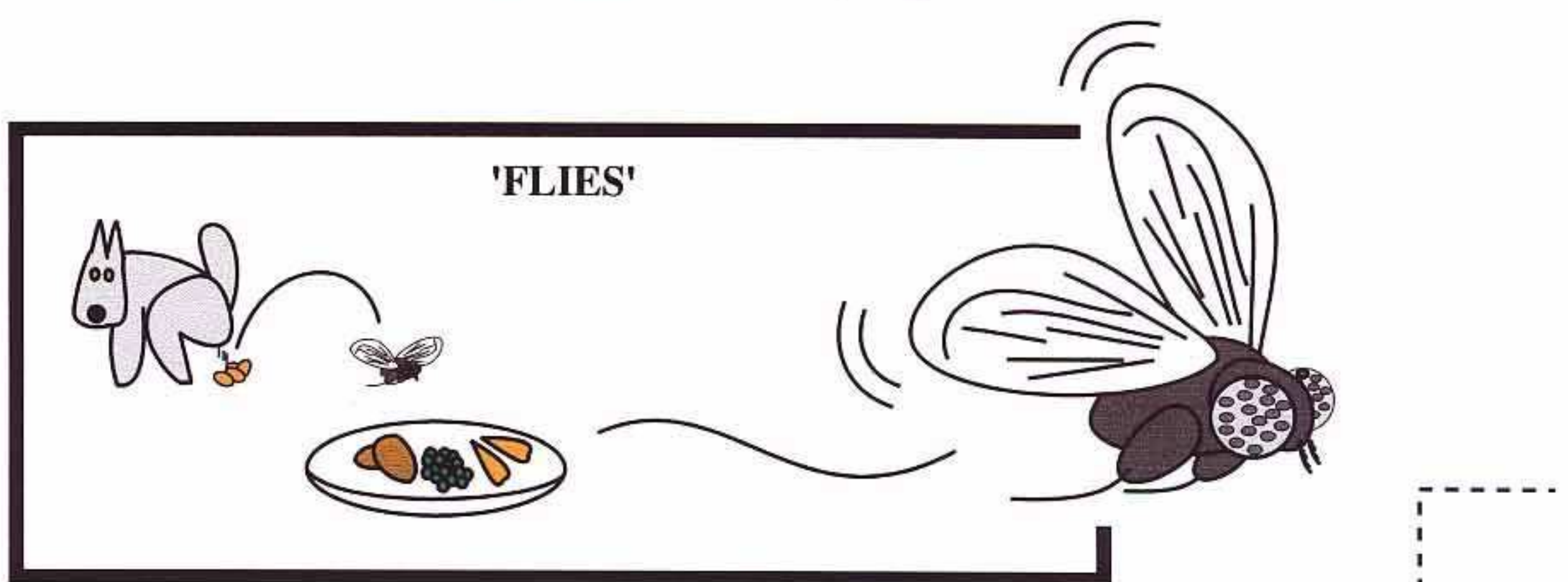
**Eating or inhaling any contaminated material.**



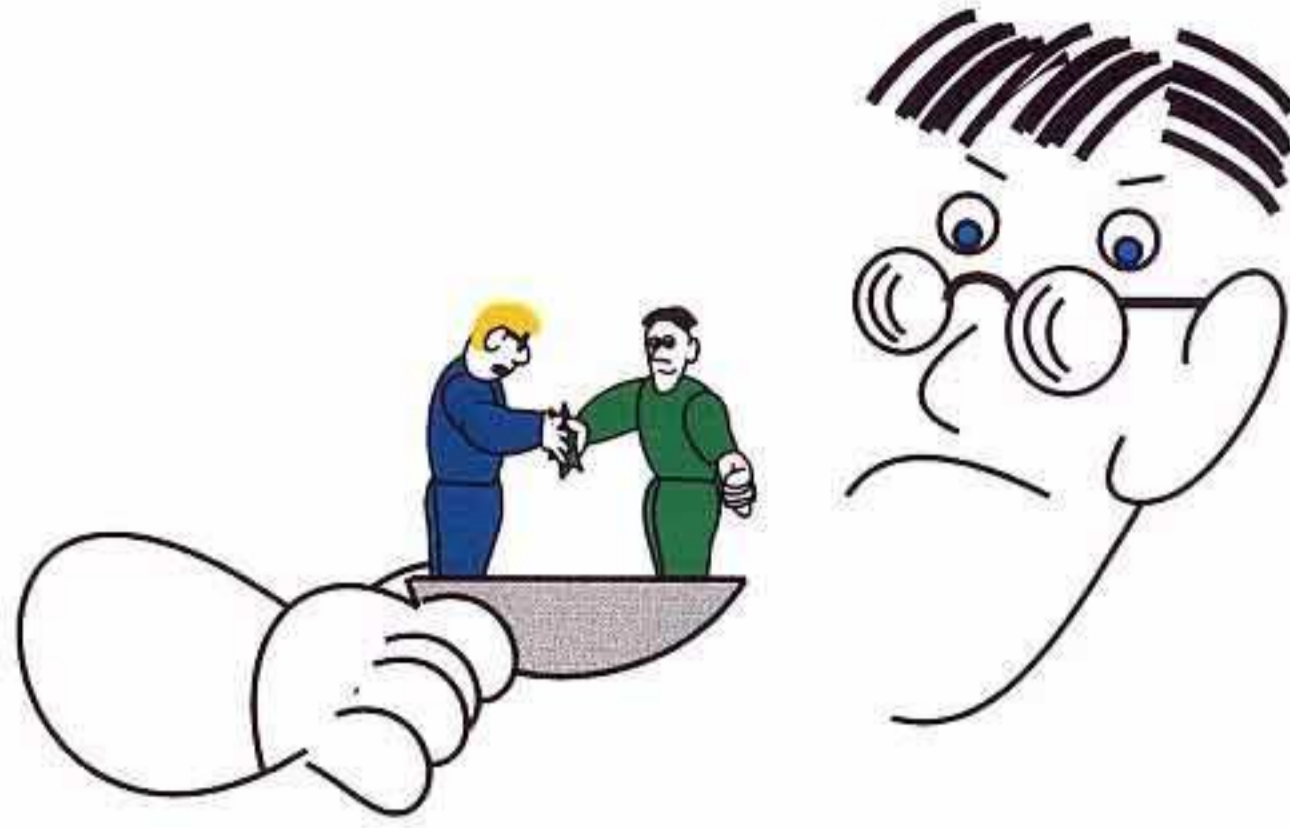
**Touching an infected inanimate object (ie a tap).**



**Just think where your fingers might have been and where they may now be going!!**



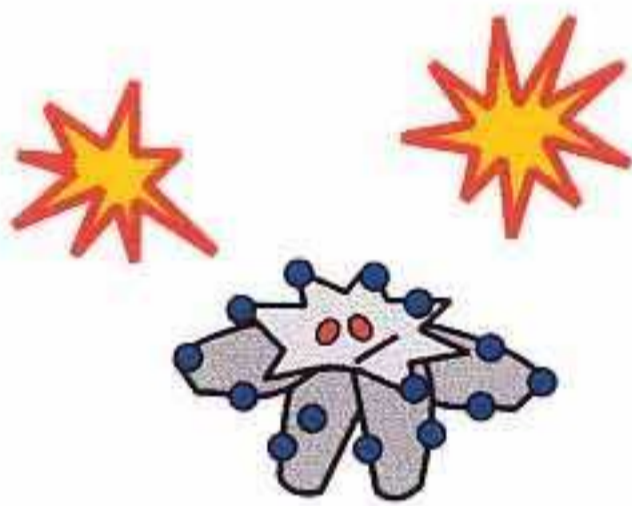
**This method of transferring germs, involves living things (ie flies, dogs etc), physically carrying microbes from A to B.**



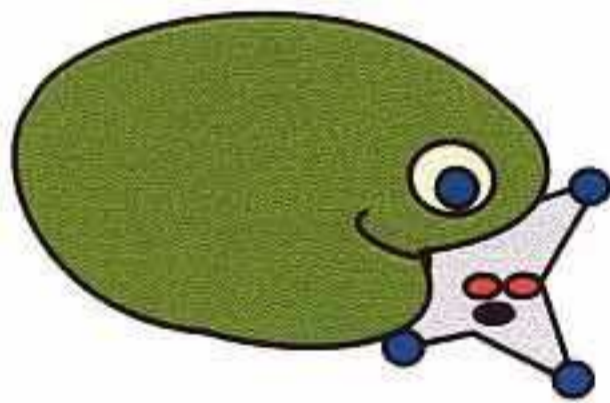
In the laboratory, scientists find it very difficult to get T helper cells to stimulate B cells into releasing antibodies. To see what is missing, turn to page 289.

MORE FACTS ABOUT COMPLEMENT

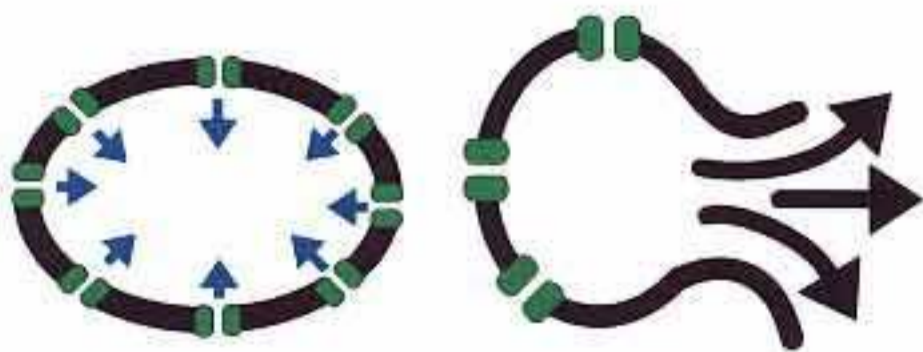
(see page 5)



When complement comes into contact with a microbe, it 'sticks' to its surface and causes inflammation.



The pieces of complement 'sticking' to the microbe, make it much easier for an immune cell, to now 'eat' the blighter (see page 268).



Complement also forms pores in the surface of the microbe. These allow water to flow into it, so that the microbe swells and then bursts.