# Protection and Control

# Bubble Boy

# The Body's Natural Defenses

Your immune system works around the clock in thousands of different ways. However, it does its work largely unnoticed. We only notice it when something fails or reacts to our immune system.

Here are some examples:

- When you get a **cut**, all sorts of bacteria and viruses enter your body through the break in the skin. When you get a splinter you also have the sliver of wood as a foreign object inside your body. Your immune system responds and **eliminates the invaders** while the skin heals itself and seals the puncture. In rare cases the immune system misses something and the cut gets **infected**. It gets inflamed and will often fill with pus. Inflammation and pus are both side-effects of the immune system doing its job.

- When a mosquito **bites** you, you get a red, itchy bump. That too is a visible sign of your immune system at work.

- Each day you **inhale** thousands of microorganisms (bacteria and viruses) that are floating in the air. Your immune system deals with all of them without a problem. Occasionally a germ gets past the immune system and you catch a cold, get the flu or worse. A cold or flu is a visible sign that your immune system failed to stop the microorganism. The fact that you get over the cold or flu is a visible sign that your immune system was able to eliminate the invader after learning about it. If your immune system did nothing, you would never get over a cold or anything else.

- Each day you also **eat** hundreds of germs, and again most of these die in the saliva or the acid of the stomach. Occasionally, however, one gets through and causes **food poisoning**. There is normally a very visible effect of this breach of the immune system: vomiting and diarrhea are two of the most common symptoms.

- There are also all kinds of human ailments that are caused by the immune system working in unexpected or incorrect ways that cause problems. For example, some people have allergies. **Allergies** are really just the immune system **overreacting** to certain stimuli that other people don't react to at all. Some people have diabetes, which is caused by the immune system inappropriately attacking cells in the pancreas and destroying them. Some people have rheumatoid arthritis, which is caused by the immune system acting inappropriately in the joints. In many different diseases, the cause is actually an immune system error!

- Finally, we sometimes see the immune system because it prevents us from doing things that would be otherwise beneficial. For example, **organ transplants** are much harder than they should be because the immune system often rejects the transplanted organ.

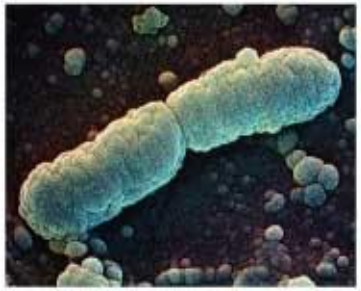
# Lines of Defense

- The body has three lines of defense against microbial attack:

i) **external barriers** to invasion keep microbes out of the body;

ii) **nonspecific internal defenses** combat invading microbes

iii) **specific immune response** -- the immune system directs its assault against specific microbes



**BARRIERS**

| Skin | Mucous membranes |
|---|---|

if barriers are penetrated, the body responds with

**NONSPECIFIC INTERNAL DEFENSES**

| Phagocytosis | Natural killer cells | Inflammation | Fever |
|---|---|---|---|

if nonspecific defenses are insufficient, the body responds with

**SPECIFIC IMMUNE RESPONSE**

| Cell-mediated immunity | Humoral immunity |
|---|---|

# Function of Fever

When a child or parent becomes feverish with shivers, chills, and sweats, our first thought is to get the temperature down. Pharmacies sell billions of fever-reducing pills like aspirin and acetaminophen every year, and schools often insist that students stay home until their fever is gone.

But is this "fever phobia" backed up by science?

Increasingly, medical researchers are discovering that fever has endured in mammals and other creatures for good reasons, though the reasons why are not clear. Often, a fever in response to an infection is actually a reflection of the body's defenses going into high gear. Some parts of the immune system work better at a higher temperature, which strengthens resistance to infection and increases the odds of survival.

The new thinking is that mild fever can be a positive adaptation and shouldn't necessarily be treated. At other times, though, fever may spur the microbes' growth rate by raising the temperature of the host body. In this case, the attackers have evolved a way to chemically manipulate the host's immune system for their own advantage. And a high fever is a danger sign, especially in young children.

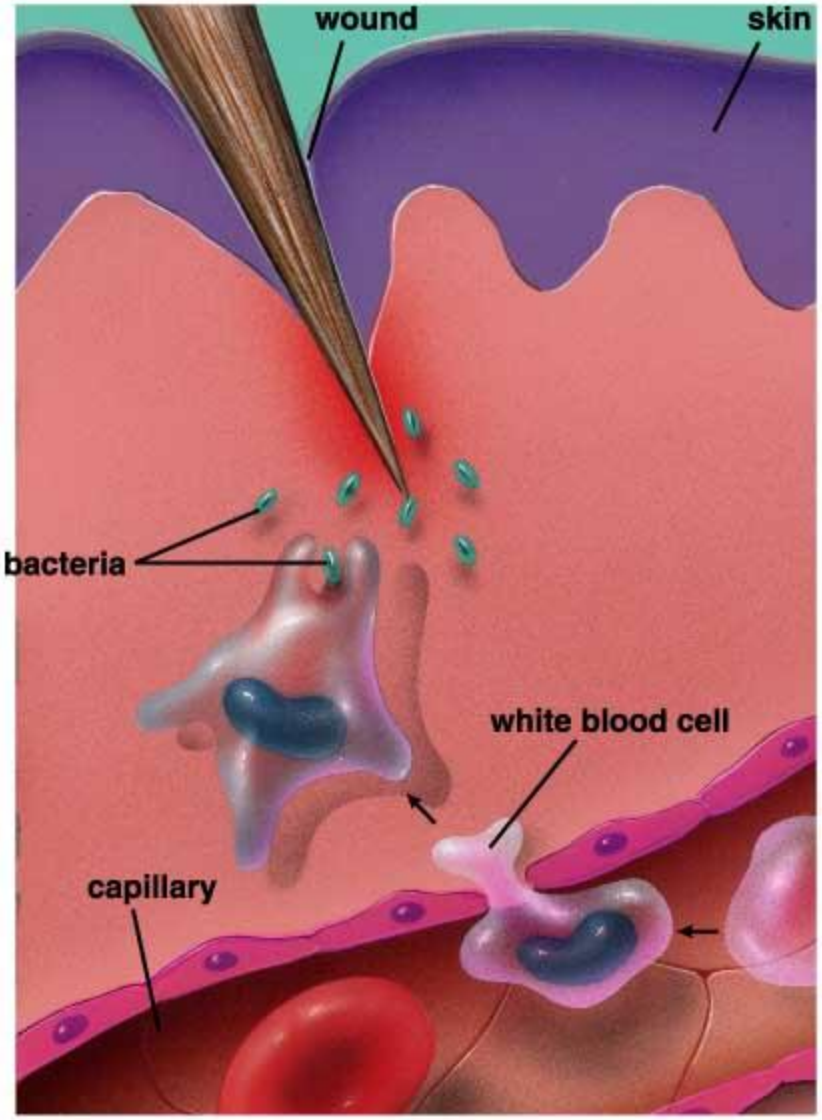
What is this mysterious phenomenon, fever? It's not simply a rise in body temperature. It is an upward shift in the body's "set point," or core temperature, which is regulated by the hypothalamus in the brain. In response to an infection, the body releases chemicals that cause a sensation of being cold. The hypothalamus then raises the set point by making the body burn fat, reduce blood flow to the skin, and shiver.

Most of the time, fever isn't dangerous in itself, but a patient will feel more comfortable at a lower temperature. In a dramatic demonstration of fever's benefits, researcher Matthew Kluger infected desert iguanas with bacteria.

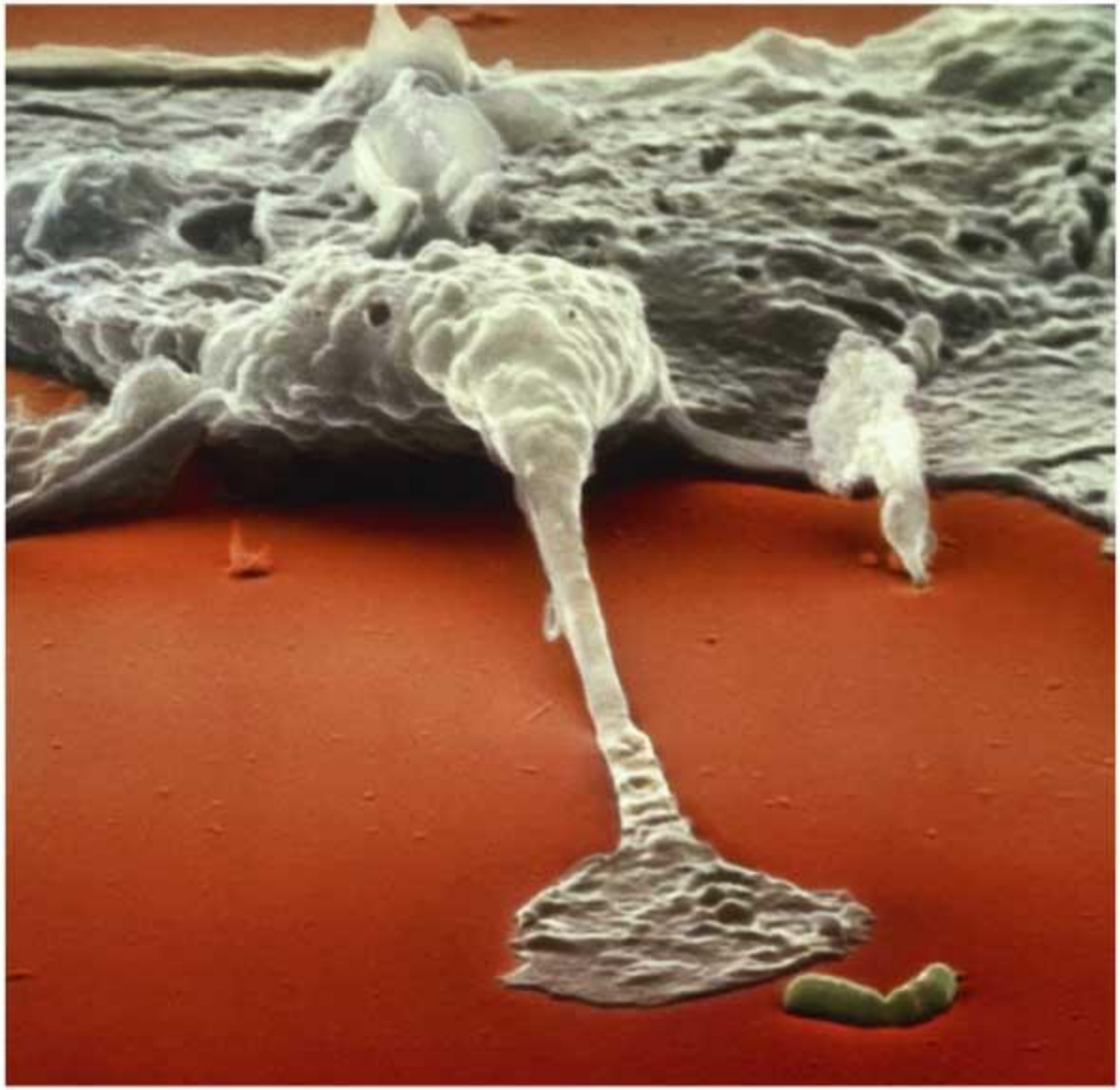
Because these lizards are cold-blooded, they could only warm their bodies by seeking outside heat -- in this case, sunlamps. All except one of 13 iguanas sought the warmth to raise their temperatures, and those 12 survived; the other one died.

After that, Kluger injected 12 other iguanas with live bacteria, and also gave them a fever-fighting drug. Five of them failed to develop a fever, and died as a result. The other seven, which somehow became feverish despite the drug, survived.

Despite experiments like this, scientists haven't yet answered all their questions about this common and ancient body symptom.


wound
skin
bacteria
white blood cell
capillary


5 micrometers



# Specific Defenses

- The immune system also generates specific responses to specific invaders. A specific defense mechanism builds up resistance against a specific pathogen or antigen.

  This system is more effective than the nonspecific methods as it has a memory component that improves response time when an invader of the same type (or species) is again encountered. Specific defenses are tailored to an individual threat. Two types of specific defenses are antibody-mediated and cell-mediated responses.

i) **Antibody-Mediated (Humoral) Immunity** results from the production of antibodies specific to a given antigen (antibody-generators, located on the surface of an invader). **Antibodies** bind to the antigens on invaders and kill or inactivate them in several ways. Most antibodies are themselves proteins or are a mix of protein and polysaccharides. **Antigens** can be any molecule that causes antibody production.

Antibody-mediated immunity is provided by the B cells. Within a few days after an infection, an antigen causes the production of large amounts of the antibody capable of interacting with it.

http://www.youtube.com/watch?v=lrYlZJiuf18

**ii) Cell-mediated Immunity** requires direct physical contact with antigens. It is provided by T cells and does not involve the secretion of antibodies. T cells are involved in the attacking of certain bacteria, viruses, fungi and immunity to cancer cells.

# Four kinds of T cells:

1) **Cytotoxic (Killer) T cell**- defends the body by destroying foreign, infected, and cancerous cells. A cell infected with a virus will display viral antigens on its plasma membrane. Killer T cells recognize the viral antigens and attach to that cell's plasma membrane. The T cells secrete proteins that punch holes in the infected cell's plasma membrane. The infected cell's cytoplasm leaks out, the cell dies, and is removed by phagocytes. Killer T cells may also bind to cells of **transplanted organs**.

# Four kinds of T cells

**2) Helper T cells** - regulate immune responses, enabling the other T cells and B cells to perform their functions by secreting messenger proteins or by direct contact with other cells. It is this cell that is destroyed by the HIV virus in patients with **Acquired Immune Deficiency Syndrome (AIDS)** . Destruction of helper T cells results in a depressed immune response allowing infection by a variety of microorganisms and the growth of certain kinds of tumors.

# Four kinds of T cells

3) **Suppressor T cells** - reduce the immune response of B cells and T cells to keep them in check.

4) **Memory T cells** - remain in the body awaiting the reintroduction of the antigen

- Under normal circumstances, the immune system responds to foreign organisms by the production of antibodies (B Cells) and the stimulation of specialized cells (T Cells) which destroy the organisms or neutralize their toxic products. In a normal healthy individual there is a balance of all the different cell types of the immune system providing an effective defense against all foreign invaders. When the immune response is not working properly (**immunodeficient**), the individual will become more susceptible to repeated infections.

- When the immune system is out of balance, this function may be misdirected resulting in an immune response against the body's own cells producing a condition known as an **autoimmune disease**.

- Examples of autoimmune disease are **multiple sclerosis, rheumatoid arthritis, type 1 diabetes and lupus.**

- The function of the immune system most recently discovered is the system's ability to recognize and eliminate the abnormal (mutant) cells that frequently arise within the body. These mutant, or **cancer cells** may occur spontaneously, or they may be induced by certain viruses (oncogenic viruses) or chemicals (mutagens). An immune system that is functioning properly can recognize and dispose of such cancer cells by means of a process called immune surveillance. The malfunction of this process may result in cancer.

- **Complement System**
- The complement system, like antibodies, is a series of proteins. There are millions of different antibodies in your blood stream, each sensitive to a specific antigen. There are only a handful of proteins in the complement system, and they are floating freely in your blood. Complements are manufactured in the liver. The complement proteins are activated by and work with (**complement**) the antibodies, hence the name. They cause lysing (bursting) of cells and signal to phagocytes that a cell needs to be removed.

- Read notes on antibodies, vaccines, and allergies

# Winnipeg National Microbiology Laboratory

- The NML is located at the Canadian Science Centre for Human and Animal Health, the only facility to have high containment laboratories for human and animal health in one facility. It is recognized as a leading facility in an elite group of 15 centres around the world, equipped with laboratories ranging from biosafety level 2 to level 4 designed to accommodate the most basic to the most deadly infectious organisms.

- Contains a Level 4 Laboratory:
  - http://www.nml-lnm.gc.ca/video/index-eng.htm
  - They even fax themselves their notes!

# Buffet Busters

- You can play this online game to identify food-borne pathogens (put out by Health Canada)
- http://www.buffetbusters.ca/

# Immune cells in Action

- Antibodies and Viruses

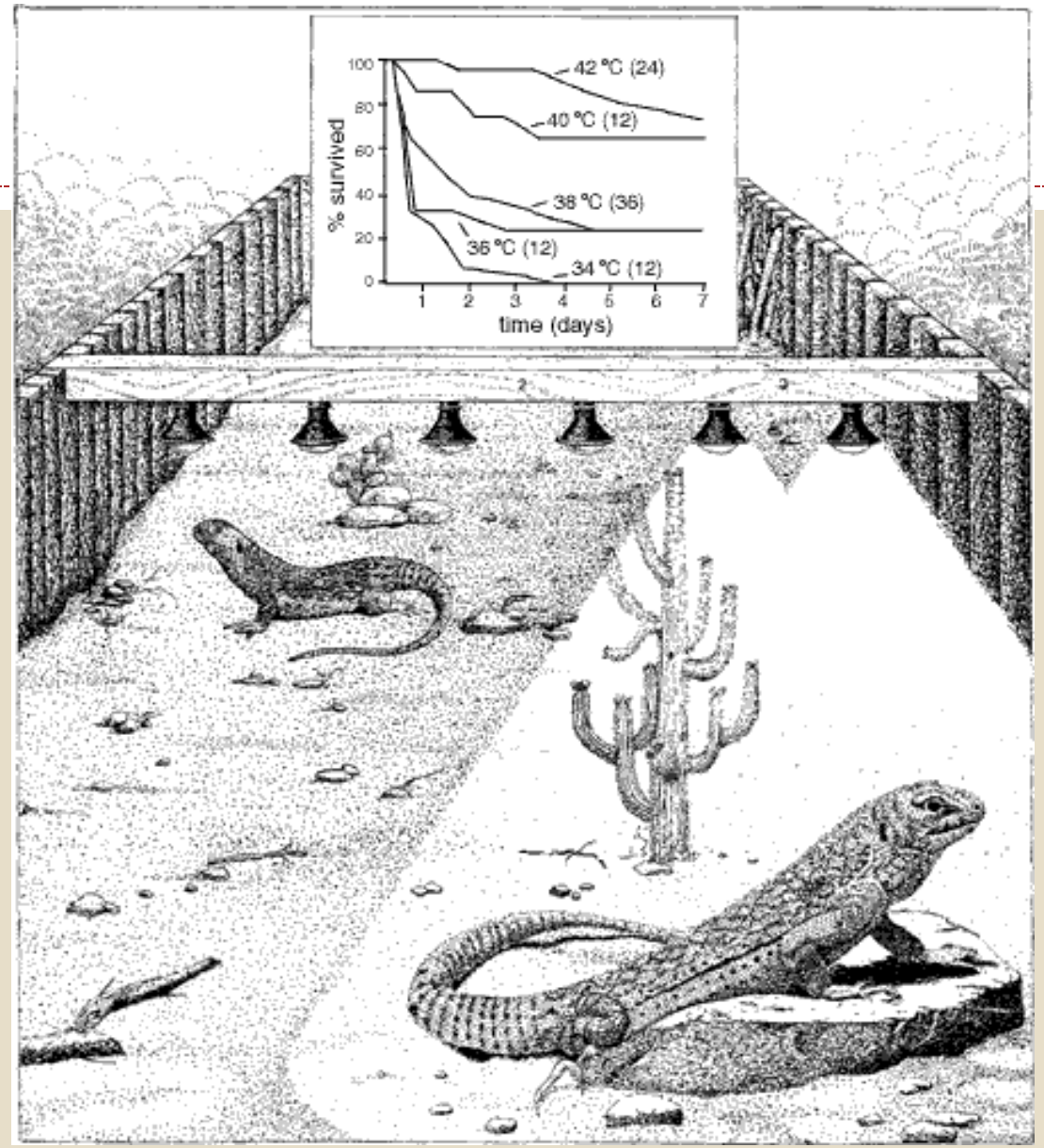
- http://www.teachersdomain.org/search/?mode=refined&query=immune

# AIDS Immunity

- http://www.teachersdomain.org/resource/tdc02.sci.life.gen.hivimmunity/

# Fever and the Brain

- http://www.teachersdomain.org/resource/tdc02.sci.life.reg.fevervid/


% survived
time (days)
42 °C (24)
40 °C (12)
38 °C (36)
36 °C (12)
34 °C (12)

# Flu Virus

- http://www.pbs.org/wnet/secrets/previous_seasons/lessons/index.html - under Interactive Lessons – *Caught the flu?*

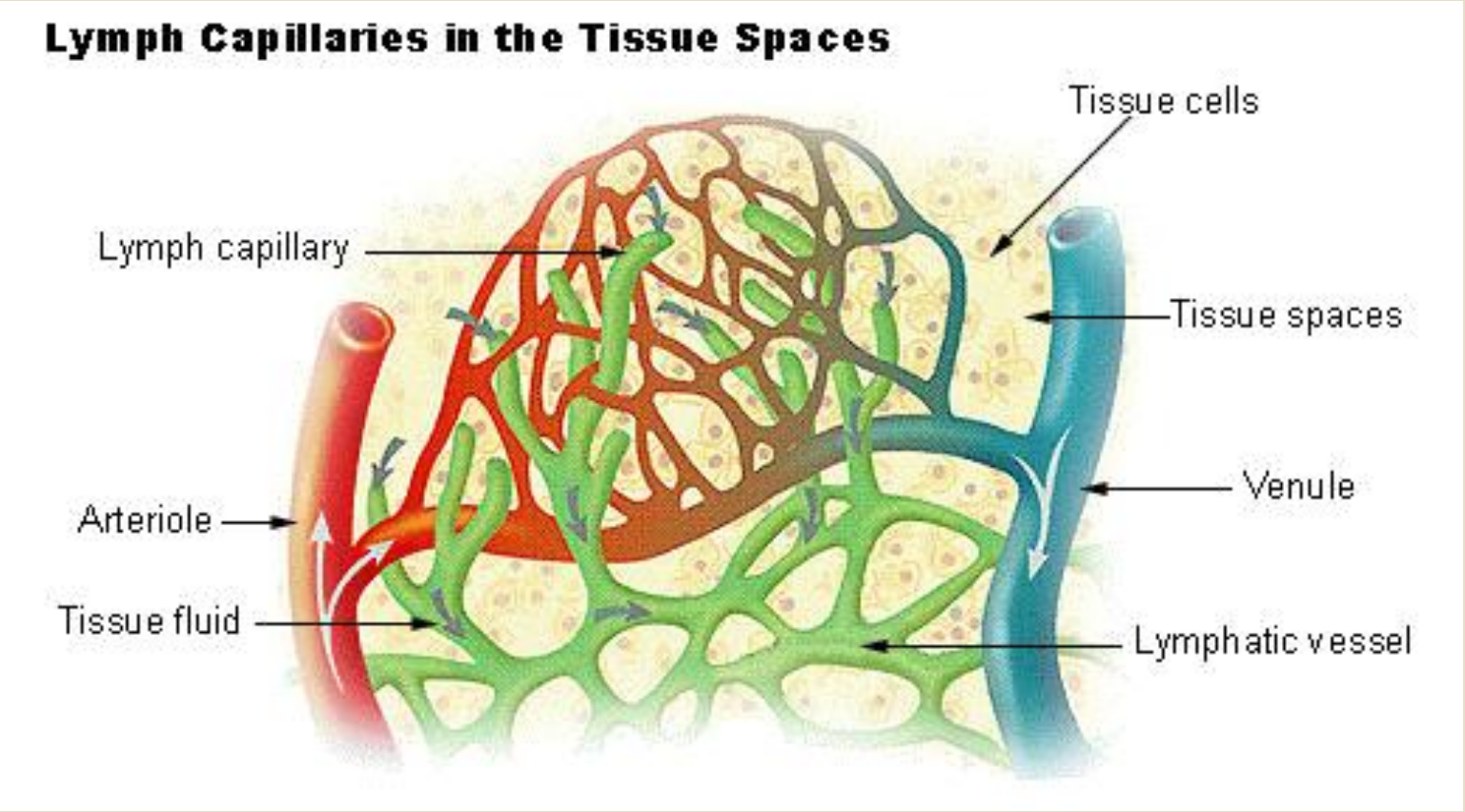
# Lymphatic System

- The lymphatic system can be thought of as a **secondary circulatory system**. The lymph vessels contain a clear, colorless fluid called **lymph**, which is derived from a network of capillaries which collect this clear fluid as it filters through the capillaries of the blood. The lymphatic system provides our immune defenses, filters foreign substances and cell debris from the blood and destroys them; and produces a type of white blood cells known as **lymphocytes**, which circulate in the blood and lymph vessels.

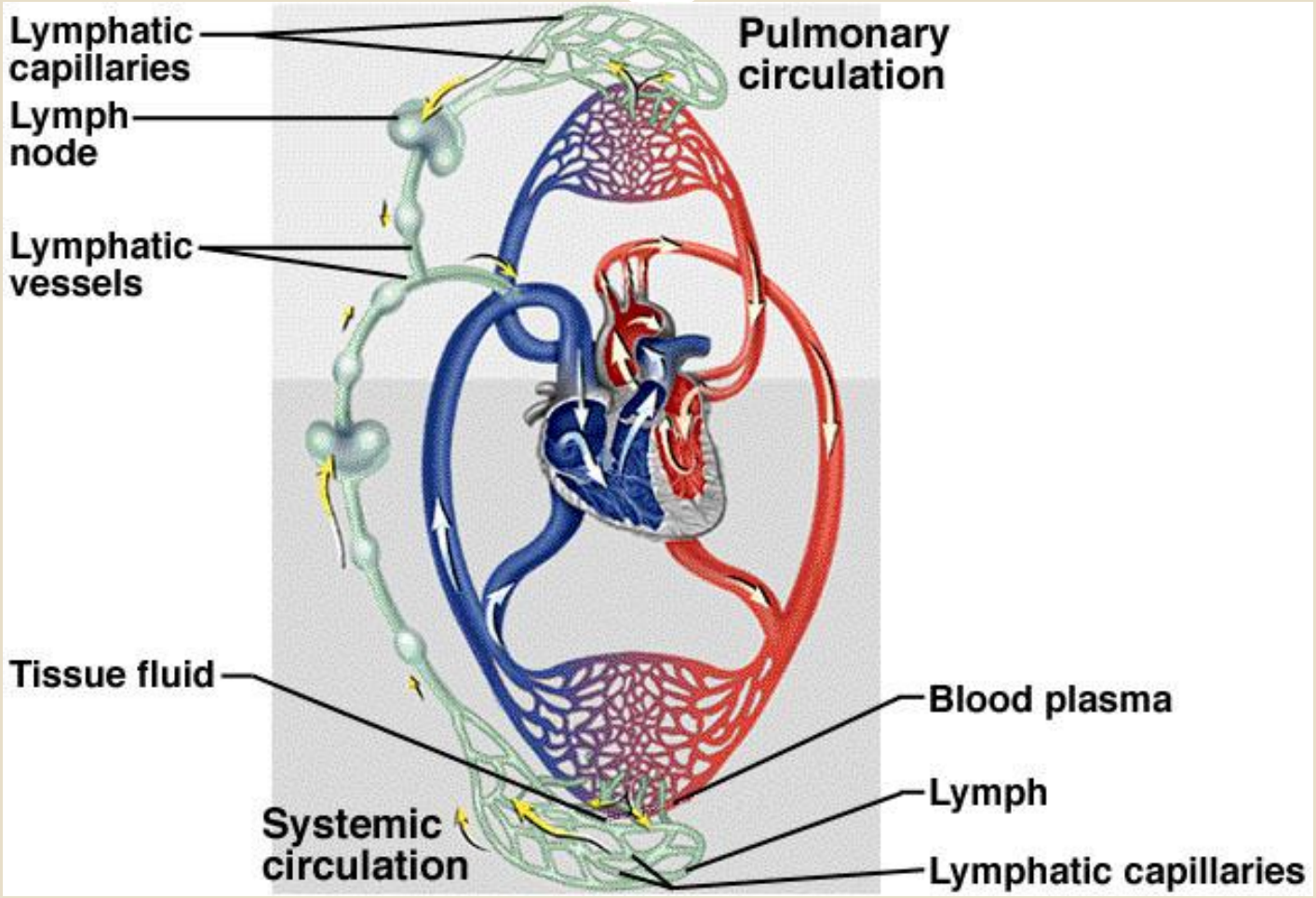
- List the 3 functions of the lymphatic system

i. it returns excess interstitial fluid to the blood.
ii. it provides defense against invading microorganisms and disease.
iii. absorption of fats and fat-soluble vitamins from the digestive system

# Lymphatic System



# Lympatic System

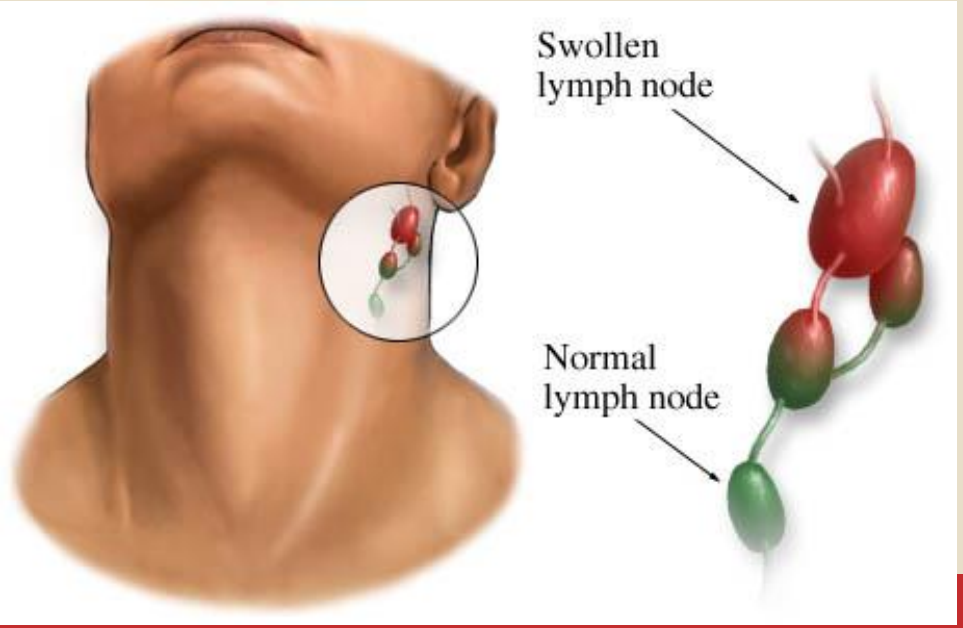


# Lymphatic System

- Lymph passes from tiny capillaries to lymph vessels and flows through lymph nodes that are located along the course of these vessels. Cells of the lymph nodes **phagocytize**, or ingest bacteria, old red blood cells, and toxic and cellular waste. Finally, the lymph flows into either the thoracic duct, a large vessel that runs parallel to the spinal column, or into the right lymphatic duct, both of which transport the lymph back into veins of the shoulder areas where is reenters the general circulation. All lymph vessels contain **one-way valves**, like the veins, to prevent backflow.

# Lymphatic System

In an infection, the lymph nodes occasionally become enlarged with lymph and white blood cells and become palpable (can be felt by an examiner). These can be felt most easily at the neck, in infections of the neck and head; in the armpit, in infections of the breast or arm; and in the groin, in infections of the pelvis or lower extremities.



# Buboes – Swollen Lymph Nodes

- The plague:

could it happen again?

- http://www.geotimes.org/may07/article.html?id=feature_plague.html

Buboes, or swollen lymph nodes, are classic signs of bubonic plague. Buboes appear in the lymph nodes closest to where a flea bit a person. Photograph is courtesy of CDC.

# Lymphatic System

The lymphatic system consists of:

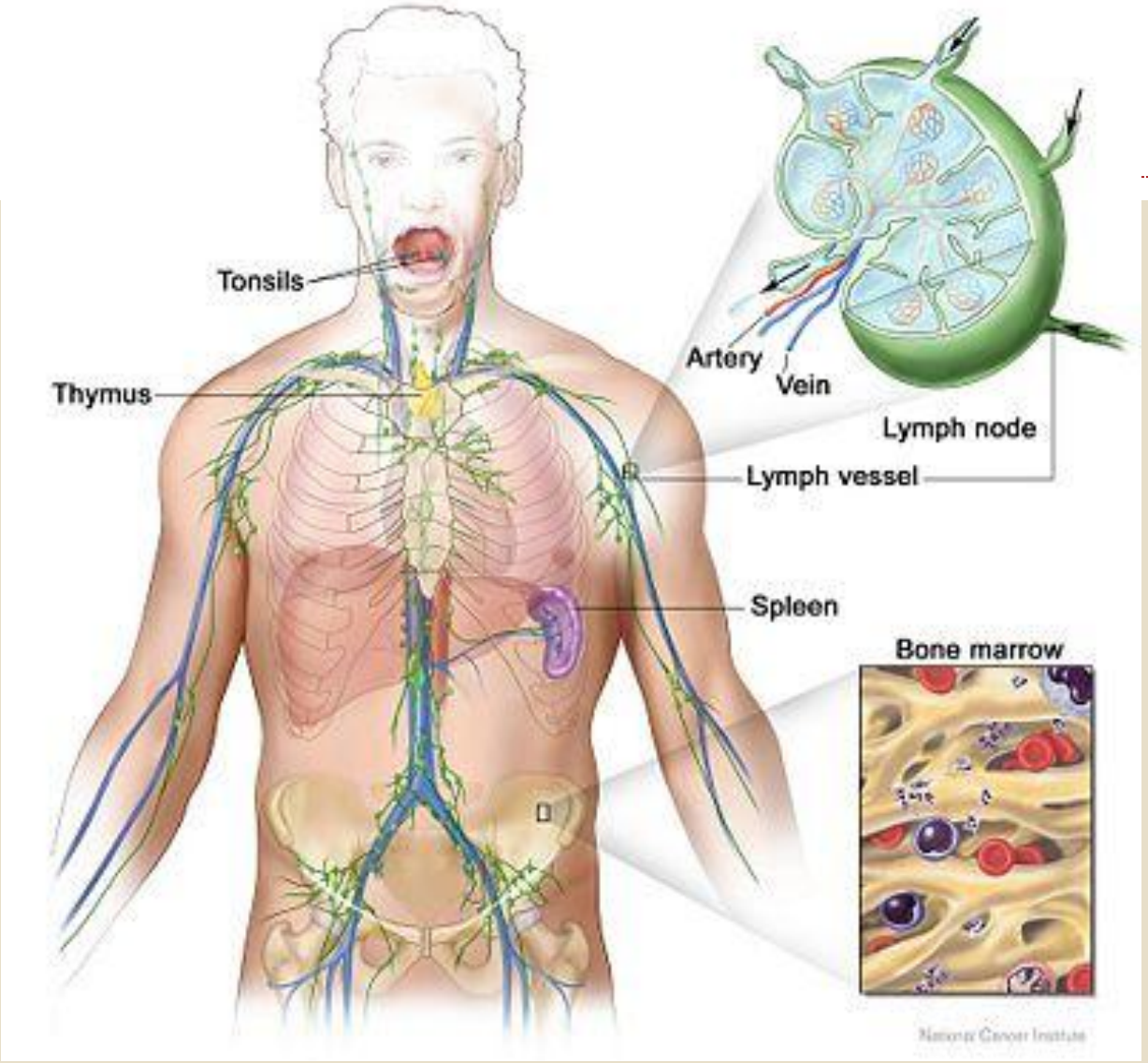
i) a network of **lymph capillaries** and larger vessels that empty into the circulatory system

ii) numerous small **lymph nodes**

iii) patches of lymphocyte-rich connective tissue (including the **tonsils**)

iv) **thymus**

v) **spleen**


Tonsils
Thymus
Spleen
Bone marrow
Artery
Vein
Lymph node
Lymph vessel

The spleen, thymus, and bone marrow manufacture lymphocytes, which are the major cell type of the system. Lymphocytes arise from by mitosis of **stem cells** in the bone marrow. Stem cells differentiate into the major players in the immune system (granulocytes, monocytes, and lymphocytes). Stem cells also differentiate into cells in the blood that are not involved in immune function, such as erythrocytes (red blood cells) and megakaryocytes (platelets). Stem cells continue to be produced and differentiate throughout your lifetime.

The **thymus** is considered the central organ that controls lymphocyte production and antibody formation. The thymus is particularly active in infants and young children but decreases in size and importance in early adulthood.

The **spleen** is also involved in the destruction of old cells and other substances by phagocytosis and plays a role in immune responses. Just as the lymph nodes filter lymph, the spleen filters blood, exposing it to macrophages and lymphocytes that destroy foreign particles and aged red blood cells.

Lymphocytes can be classified as **T cells** (thymus-derived) or **B cells** (bone-marrow-derived).

**Disorder – Elephantiases: results from blocked lymphatic vessels**

When scarring of lymph vessels from infection by a parasitic worm prevents lymph from returning to the bloodstream, the affected area can become massively swollen. This is often a problem in the breasts of women and the scrotum of men.