New Jersey Center for Teaching and Learning

Progressive Science Initiative

This material is made freely available at www.njctl.org and is intended for the non-commercial use of students and teachers. These materials may not be used for any commercial purpose without the written permission of the owners. NJCTL maintains its website for the convenience of teachers who wish to make their work available to other teachers, participate in a virtual professional learning community, and/or provide access to course materials to parents, students and others.

Click to go to website:
www.njctl.org

AP BIOLOGY

Big Idea 2
Part C

December 2012

www.njctl.org

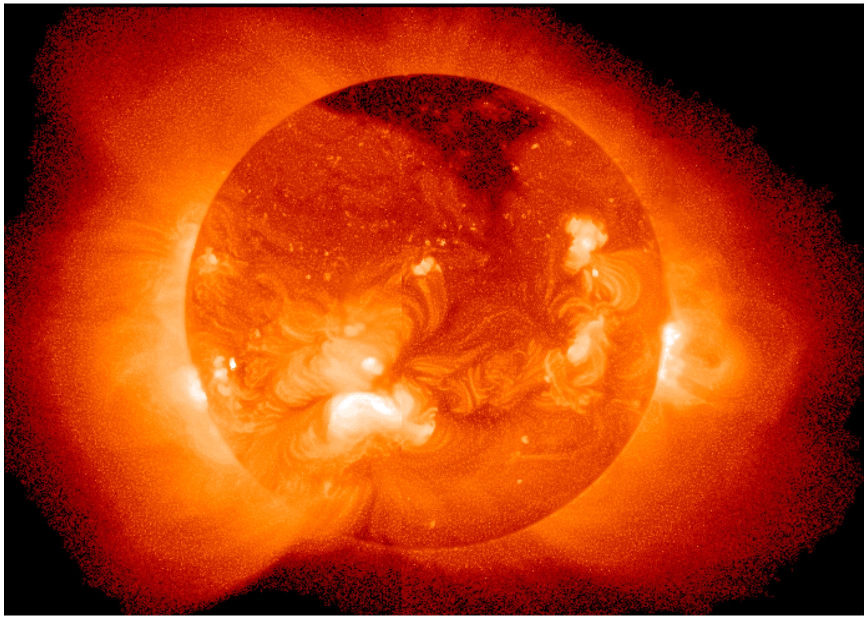
Big Idea 2: Part C

Click on the topic to go to that section

Evolution of Signaling

Return to
Table of
Contents

The Sun Supplies the Energy of Life

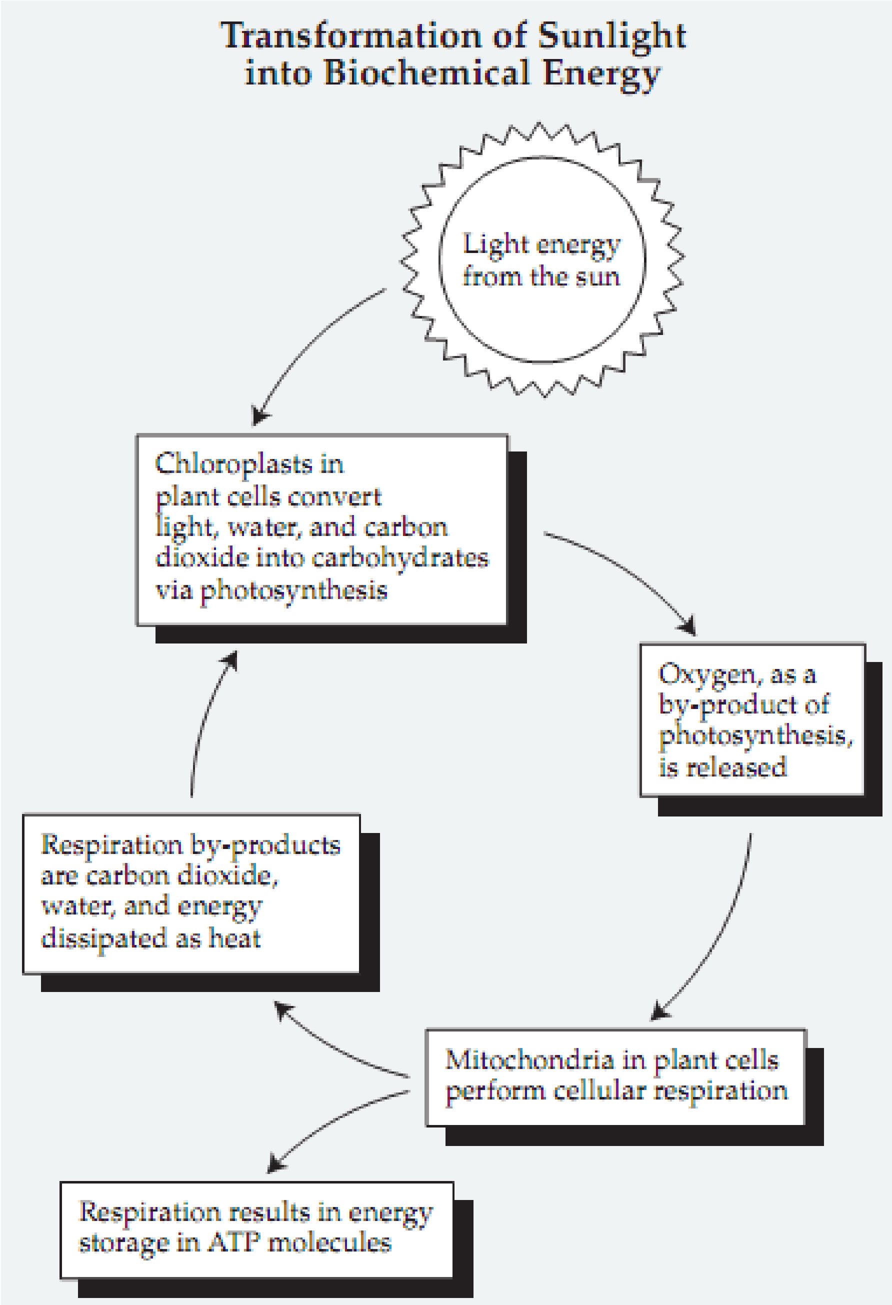


As we have seen, the energy of life begins as sunlight. But how does that energy flow through life on our planet?

Now that we know the specifics at a molecular level, lets look at the way specific organisms actually collect and use their energy.

Overview

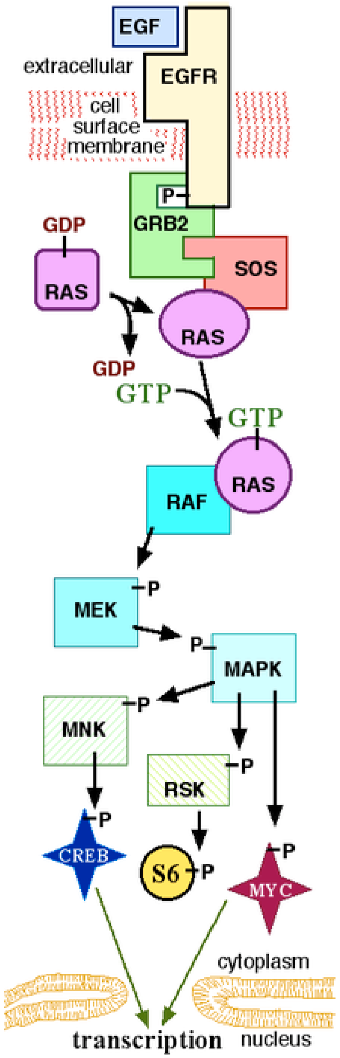
As a recap, look over this flow chart to review the important molecules that transfer from system to system.



Cellular Signaling

Cellular signaling is a part of a complex system of communication that governs basic cellular activities and coordinates cell actions.

The ability of cells to perceive and correctly respond to their microenvironment is the basis of development, tissue repair, and immunity.



Evolution of Signaling

Single-celled organisms communicate with one another as well as the cells of multi-celled organisms.

Correct and appropriate signaling pathways are generally under strong selective pressure and show shared evolution among organisms with shared pathways.

1 Which of the following organisms would likely not show similar communication pathways to the others?

- A peacock
- B turtle
- C butterfly
- D shark
- E alligator

answer

Surface Communication

Cell surfaces protect, support, and join cells.

Cells interact with their environments and each other via their surfaces. Cells need to pass water, nutrients, hormones, and many, many more substances to one another.

Signal transduction pathways link signal reception on a cell's surface with an appropriate cellular response.

Single-celled Signaling

In single-celled organisms, signal transduction pathways influence how the cell responds to its environment.

Certain bacteria use chemical messengers to communicate to other nearby cells and regulate specific reproductive pathways in response to population density. This is known as **quorum sensing.**

Quorum Sensing

Quorum sensing is a system of stimulus and response related to the population density of bacteria. Many bacterial species use it to coordinate gene expression regarding specific behaviors which are dependent on the size of a local population.

Bacteria will produce and release signaling molecules. The same bacteria also have receptors for that molecule on their surface.

When the signal binds to a receptor on another organism, it activates a system which typically causes another specific behavior in the group.

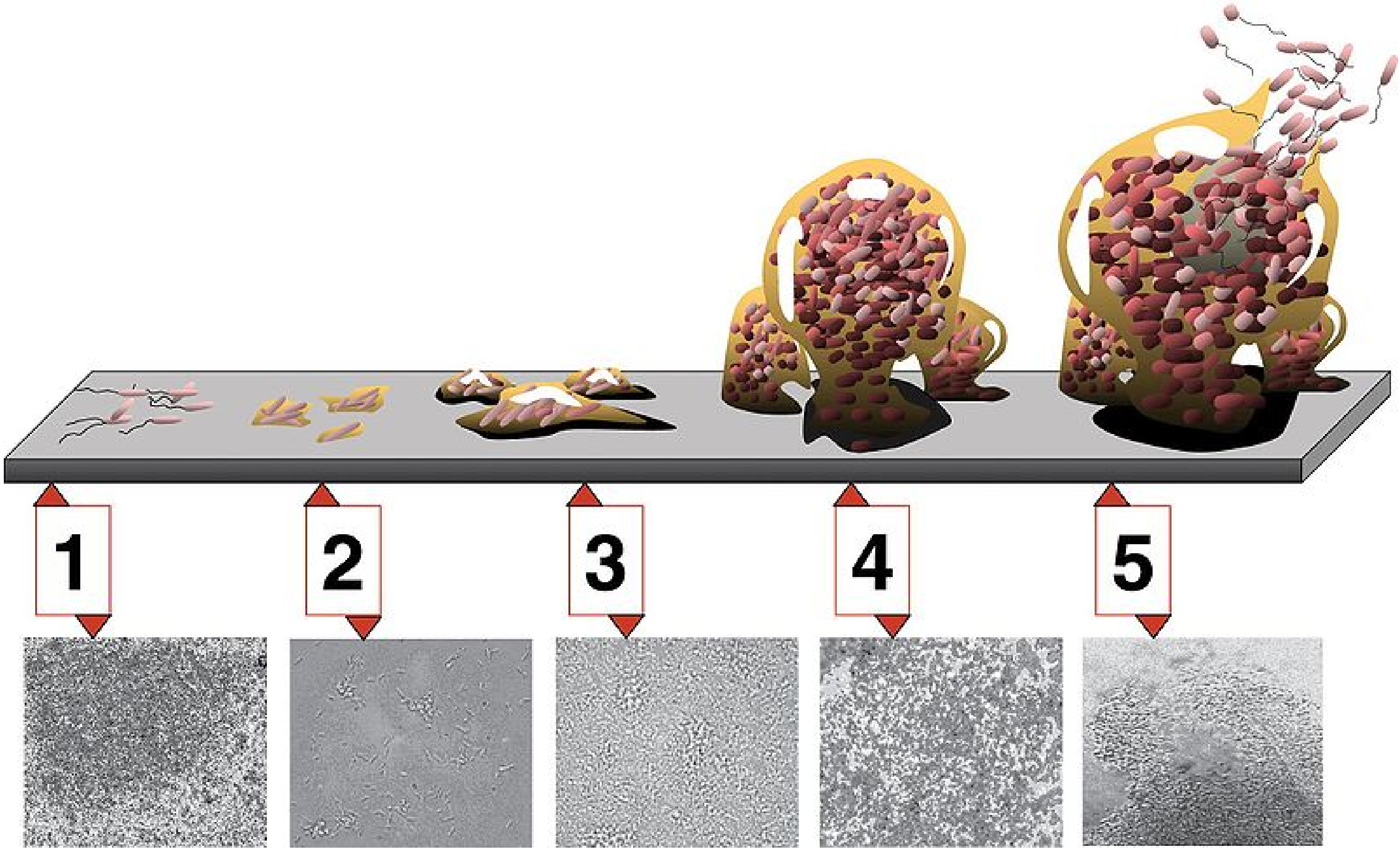
Example of Quorum Sensing: *Pseudomonas aeruginosa*

Pseudomonas aeruginosa use quorum sensing to coordinate cell aggregation. They grow within a host without harming it until they reach a certain concentration.

Once that concentration is reached, they release a signal to aggressively replicate in order to overcome the host's immune system. The bacteria create a **biofilm** wherein they form a layer which completely covers the host's tissue and then reproduce at a exponential rate.

Research has shown that garlic inhibits the formation of these *Pseudomonas* biofilms by blocking the quorum sensing pathway. This is called **quorum inhibition**.

Biofilm development in *Pseudomonas aeruginosa*



Quorum Sensing

Quorum Sensing Introduction

Quorum Sensing Explanation

Below is a longer video that ties in quorum sensing and antibiotic resistance. Teacher may want to pause and discuss for student understanding.

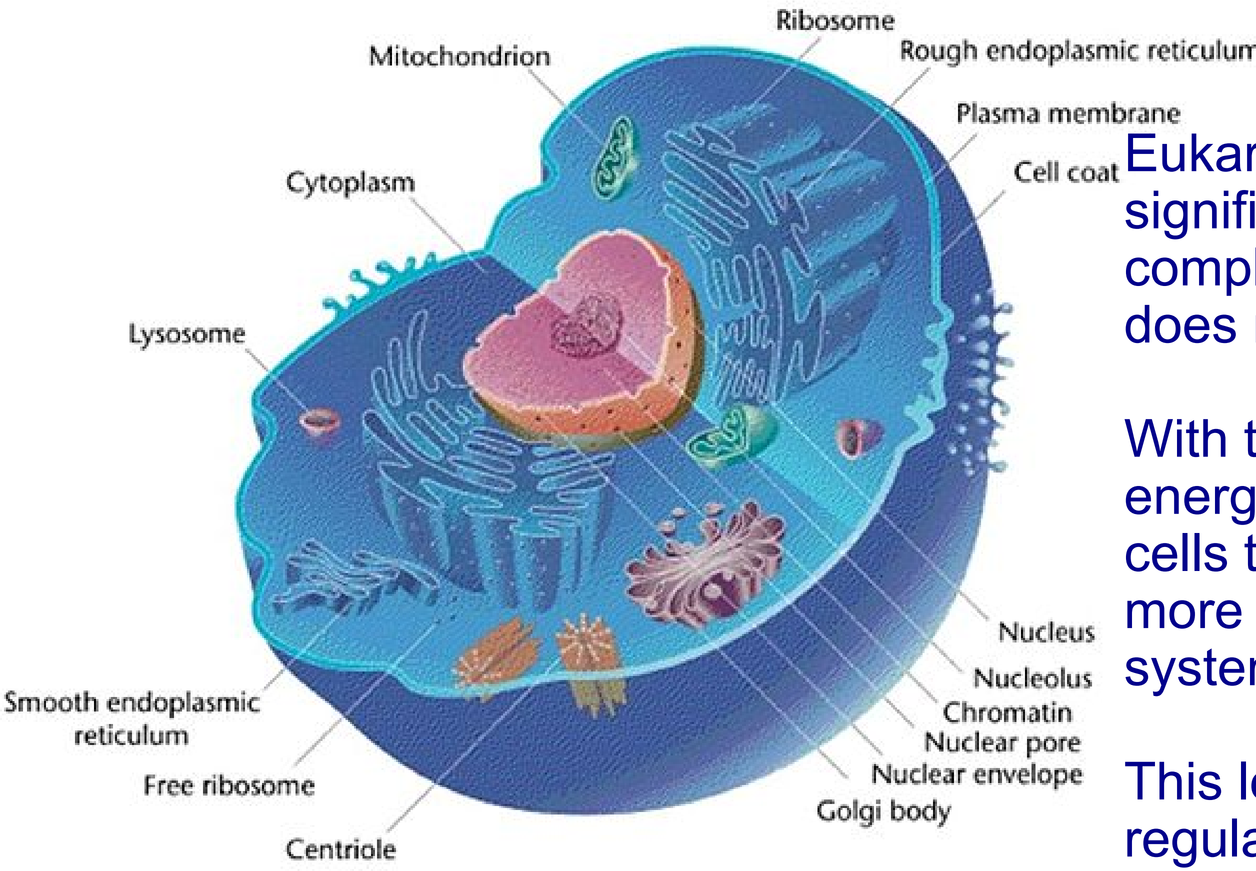
Click here for a TED talk on Quorum Sensing

2 Quorum sensing would most likely occur when:

- A an antibiotic attacks a bacterial infection
- B bacteria reach a certain concentration
- C bacteria sense the presence of an antibiotic
- D a biofilm is broken down

answer

Complexity Continues to Increase



Eukaryotic cells mark a significant increase in the complexity of life... but it does not stop there.

With the new found energy efficiency of these cells they soon develop more complex metabolic systems.

This leads to new regulation and new ability.

Surface Area to Volume Ratio

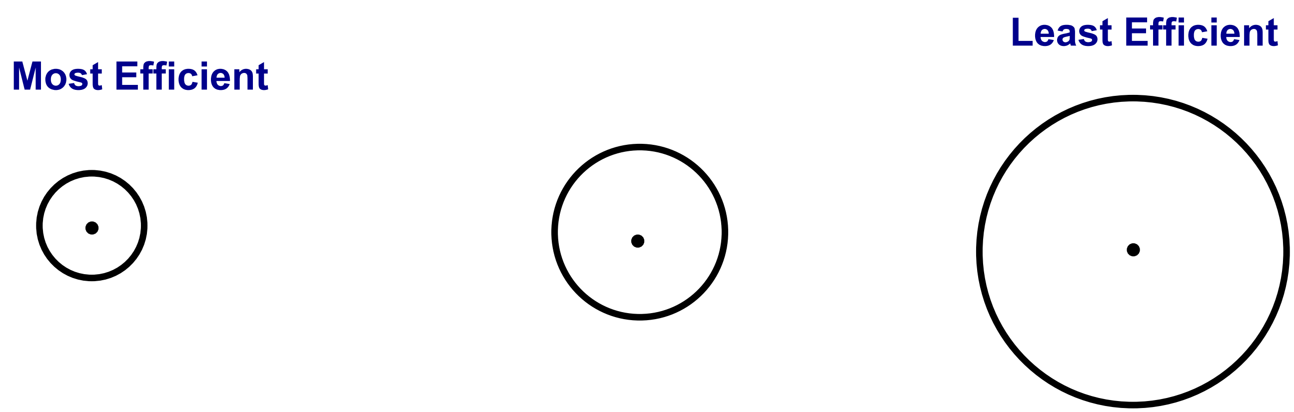
At the time when prokaryotic cells were evolving, there were most likely different sizes of cells. A cell's efficiency and ability to survive depended on its **surface area to volume ratio**.

The volume of the cell determines the amount of chemical activity it can carry out per unit time. The surface area of the cell determines the amount of substances the cell can take in from the environment and the amount of waste it can release.

As a cell grows in size, it's surface area to volume ratio decreases. It performs chemical reactions faster, but it has a harder time getting nutrients in and waste out.

Limits of Cell Size

We know that cells need to be small enough so that they have an increased surface area to volume ratio, but be large enough to perform the chemical reactions of metabolism.



The smaller the cell, the larger its surface area and the smaller its volume.

The bigger the cell, the smaller the surface area is compared to its large volume inside.

Cell Size

Eukaryotic cells are, on average, much larger than prokaryotic cells. The average diameter of most prokaryotic cells is between 1 and 10μm. By contrast, most eukaryotic cells are between 5 to 100μm in diameter.

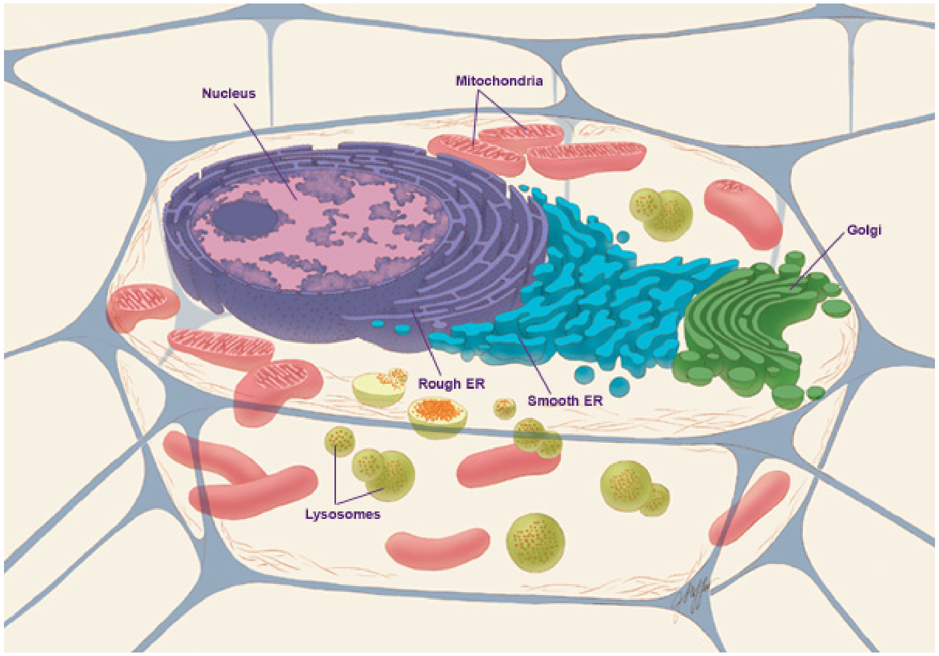
Animal Cell (Eukaryote)

Bacterium (Prokaryote)

Organelles

To increase efficiency in the larger cell, eukaryotes evolved many bacterium-sized parts known as **organelles**.

Organelles subdivide the cell into specialized compartments.



They play many important roles in the cell. Some transport waste to the cell membrane. Others keep the molecules required for specific chemical reactions located within a certain compartment so theydo not need to diffuse long distances to be useful. Each organelle has a specific job to do and is essential to the functioning of the cell.

3 How did eukaryotes solve the problem of diffusion?

- A By remaining the same size as prokaryotes.
- B By using a nucleus.
- C Compartmentalization.
- D They haven't solved the problem.

answer

4 Which is NOT an advantage of compartmentalization?

- A It allows incomaptible chemical reactions to be separated.
- B It increases the efficiency of chemical reactions.
- C It decreases the speed of reactions since reactants have to travel farther.
- D Substrates required for particular reactions can be localized and maintained at high concentrations within organelles.

answer

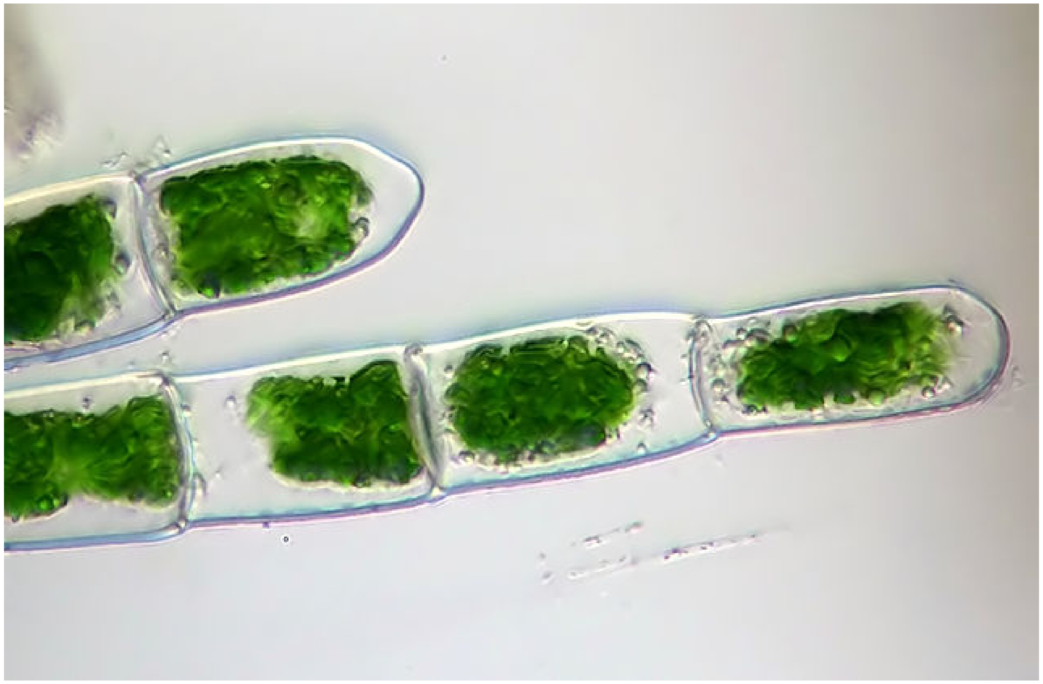
Signal Transduction

Return to
Table of
Contents

Symbiosis Continues

In the same way that prokaryotes used symbiosis to increase their survivability, the first single celled eukaryotes began to **specialize** and coordinate into small colonies.

These colonies could do more, be more efficient, and out-survive the eukaryotes that were on their own.



Muticellularity Leads to Macroscopic Life Forms

Early **multi-celled eukaryotes** were small but they began to lay the foundation for larger and larger organisms.

These organisms develop different survival mechanisms and metabolic processes based on the ability of the eukaryotic cell.

Muti-cellularity Leads to Macroscopic Life Forms

Animals, multi-cell euk. that rely on plants to produce sugar

Algae, simple multi-cell euk. that are similar to the first multi-cell euk.

Plants, multi- cell euk. that use photosynthesis to capture sun energy

Fungus, multi-cell euk. that live on decomposing matter

Mammals, animals with highly complex homeostasis

Paramecium, single celled eukaryote

Complexity = Survivability?

Macroscopic organisms contain far more complex metabolic systems. These more complex systems require that an organism take in more energy and nutrients.

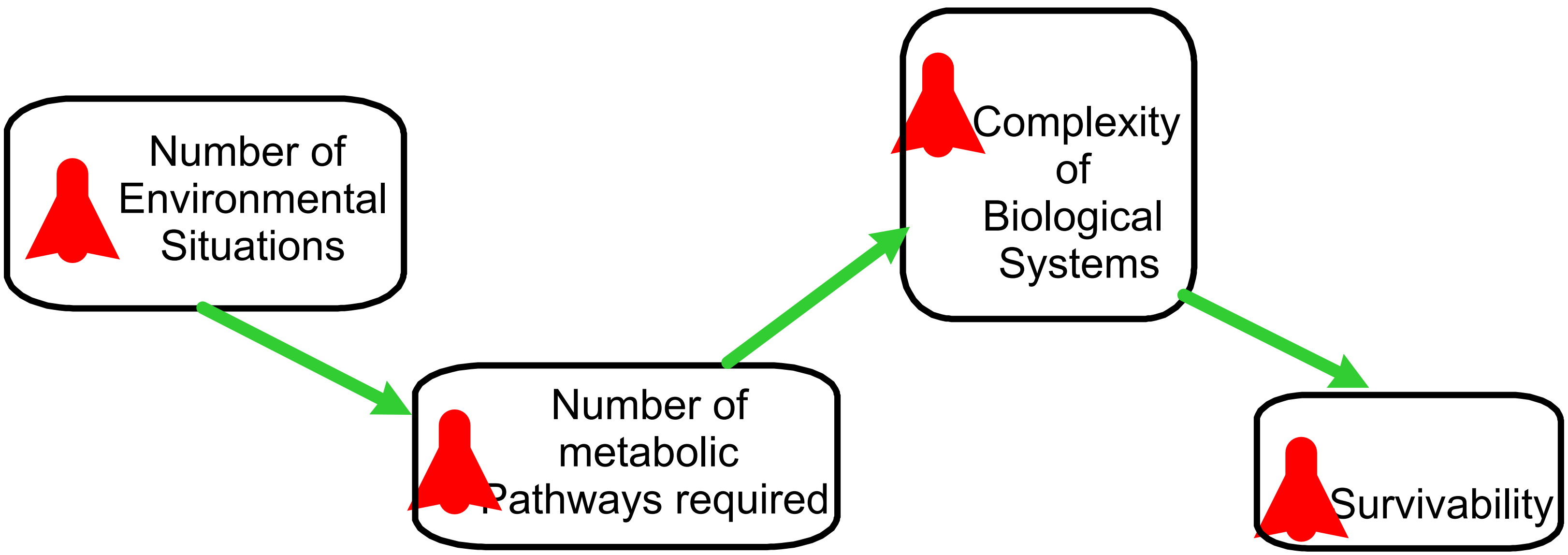
If we have established that evolution favors survivability, then why is it that more complex organisms have evolved?

What is it about complexity that increases survivability?

Complexity = Survivability?

Simply stated, the adaptability of an organism or group of organisms directly relates to their ability to survive.

Higher adaptability requires systems that can adjust to an increasing number of environmental situations. As biological systems "learn" to deal with changes in the environment they naturally become more complex.



5

- A Formation of macroscopic organisms
- B Decreased metabolic activity
- C Increase of symbiosis
- D Compartmentalization of cellular proesses

answer

Transcription Factors

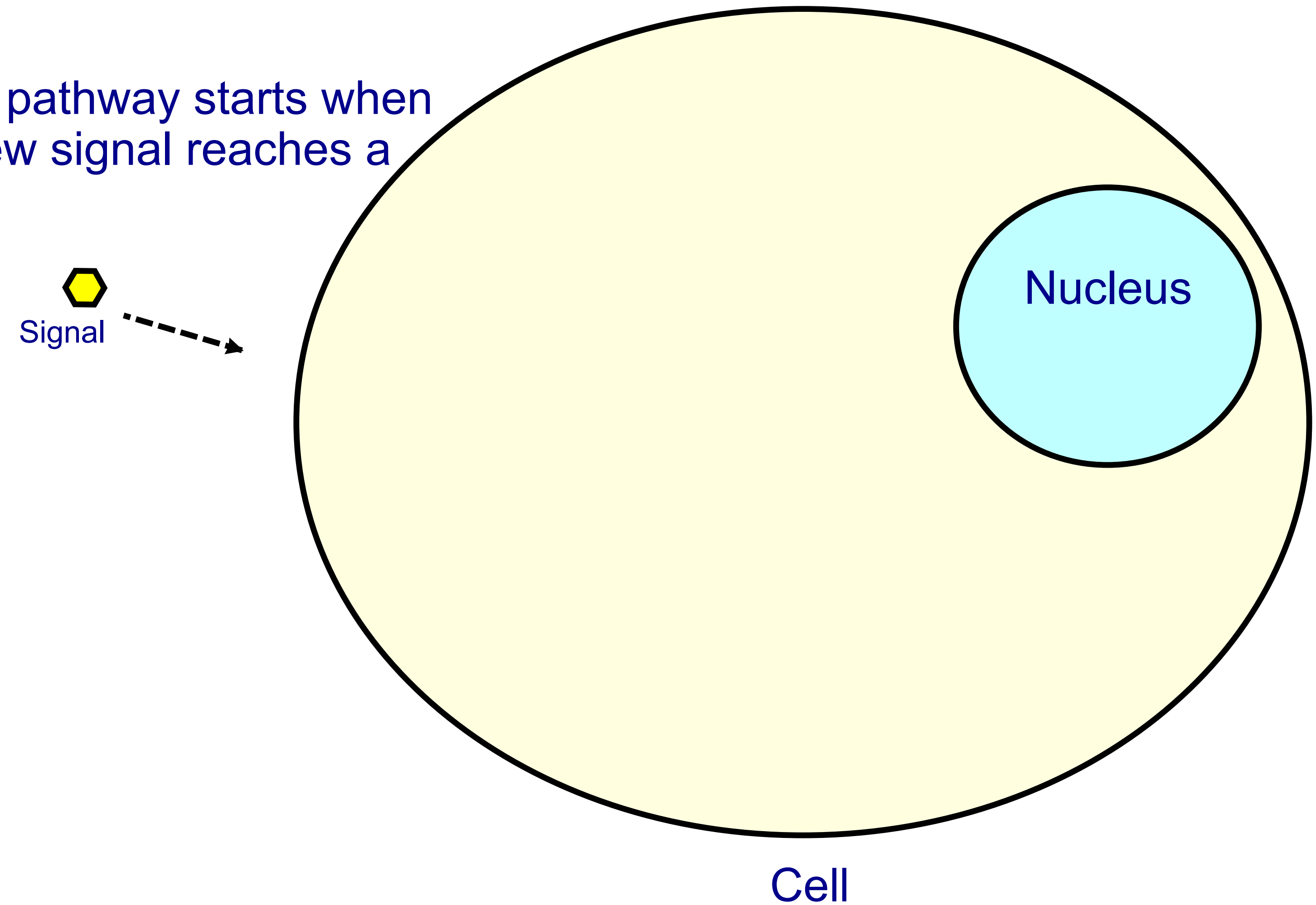
Transcription factors are key forregulation of a multi-celled organism and increased complexity.

Transcription factors are molecules that cause a cell to **respond to a signal in the environment in a very specific way**. This signal is anything that the cell has the ability to respond to. It could be light, a chemical, a hormone, heat, etc.

A **signal transduction pathway** is how a cell reads cues in its environment and knows to take the appropriate action.

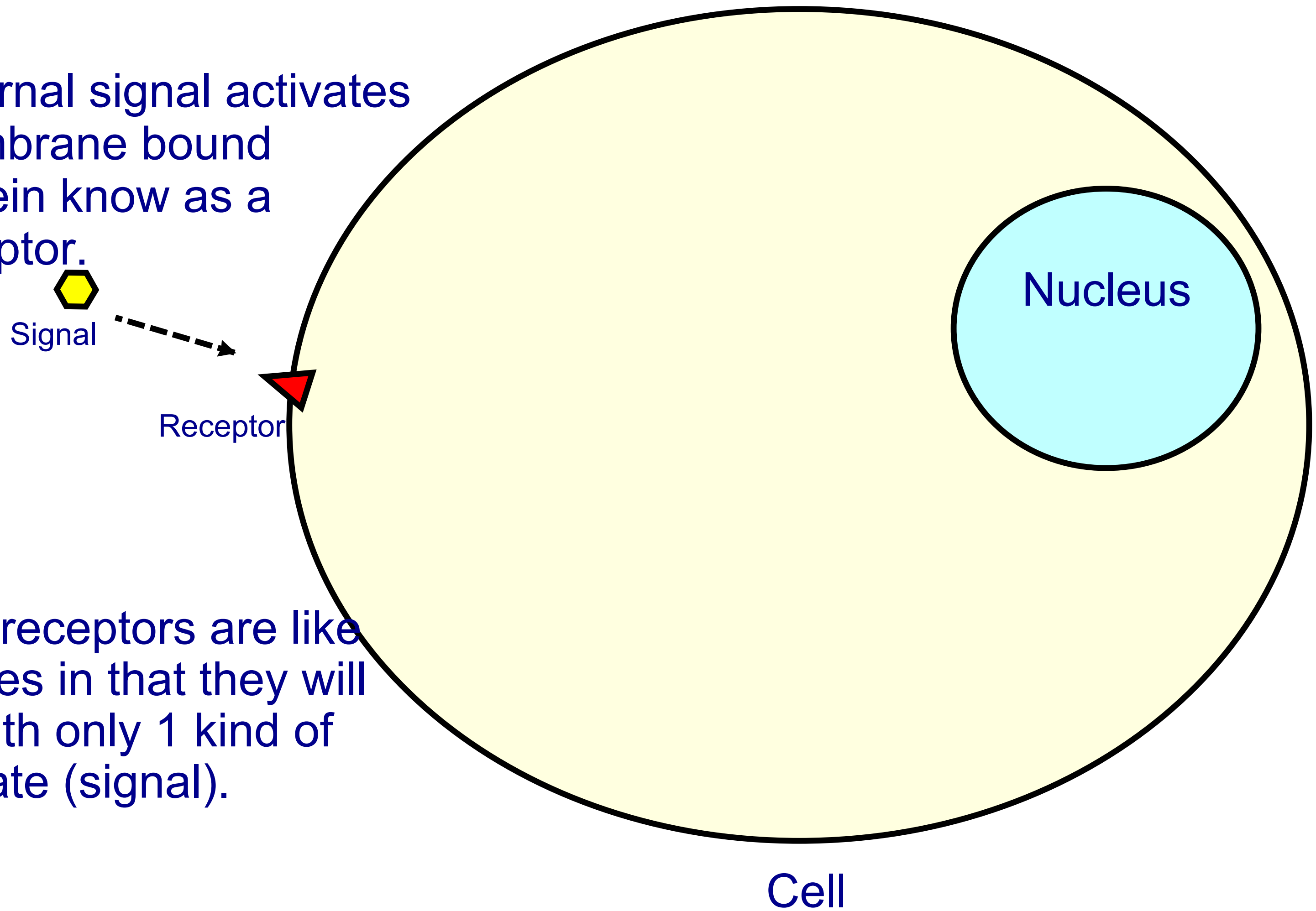
Signal Transduction Pathway
Reception

The pathway starts when a new signal reaches a cell.



Signal Transduction Pathway
Reception

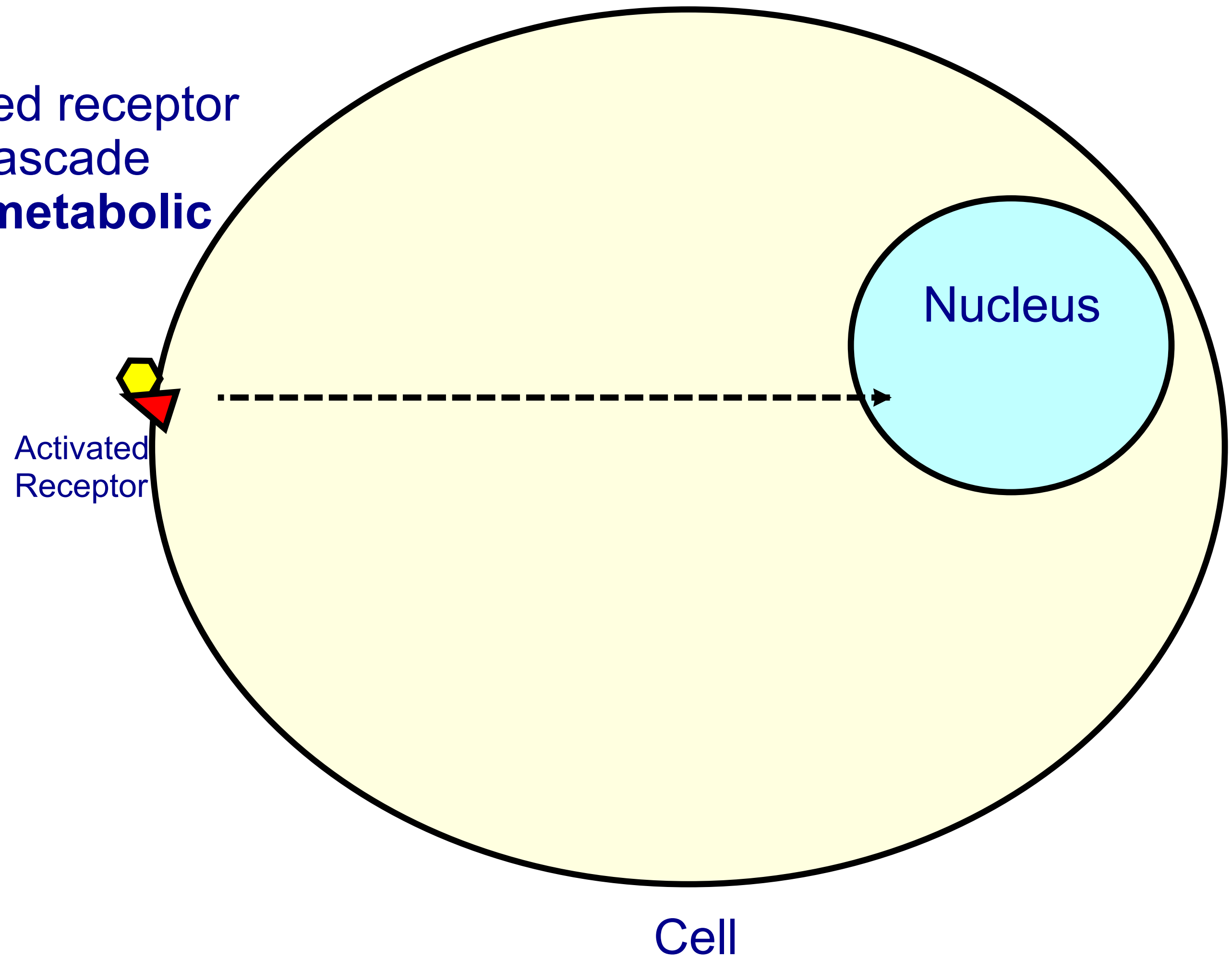
External signal activates membrane bound protein know as a receptor.



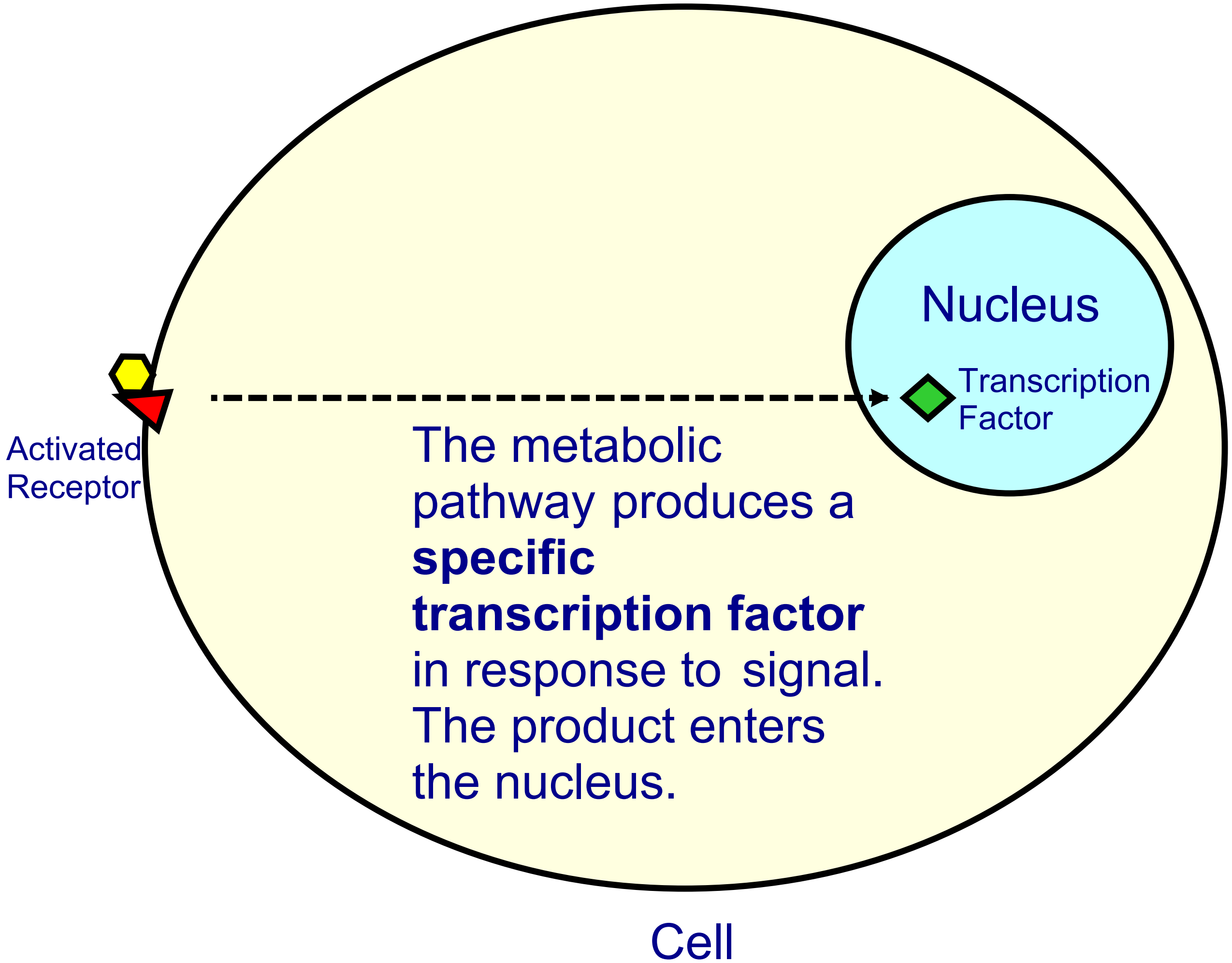
These receptors are like enzymes in that they will bind with only 1 kind of substrate (signal).

Signal Transduction Pathway
Transduction

The activated receptor triggers a cascade reaction, a **metabolic pathway**.



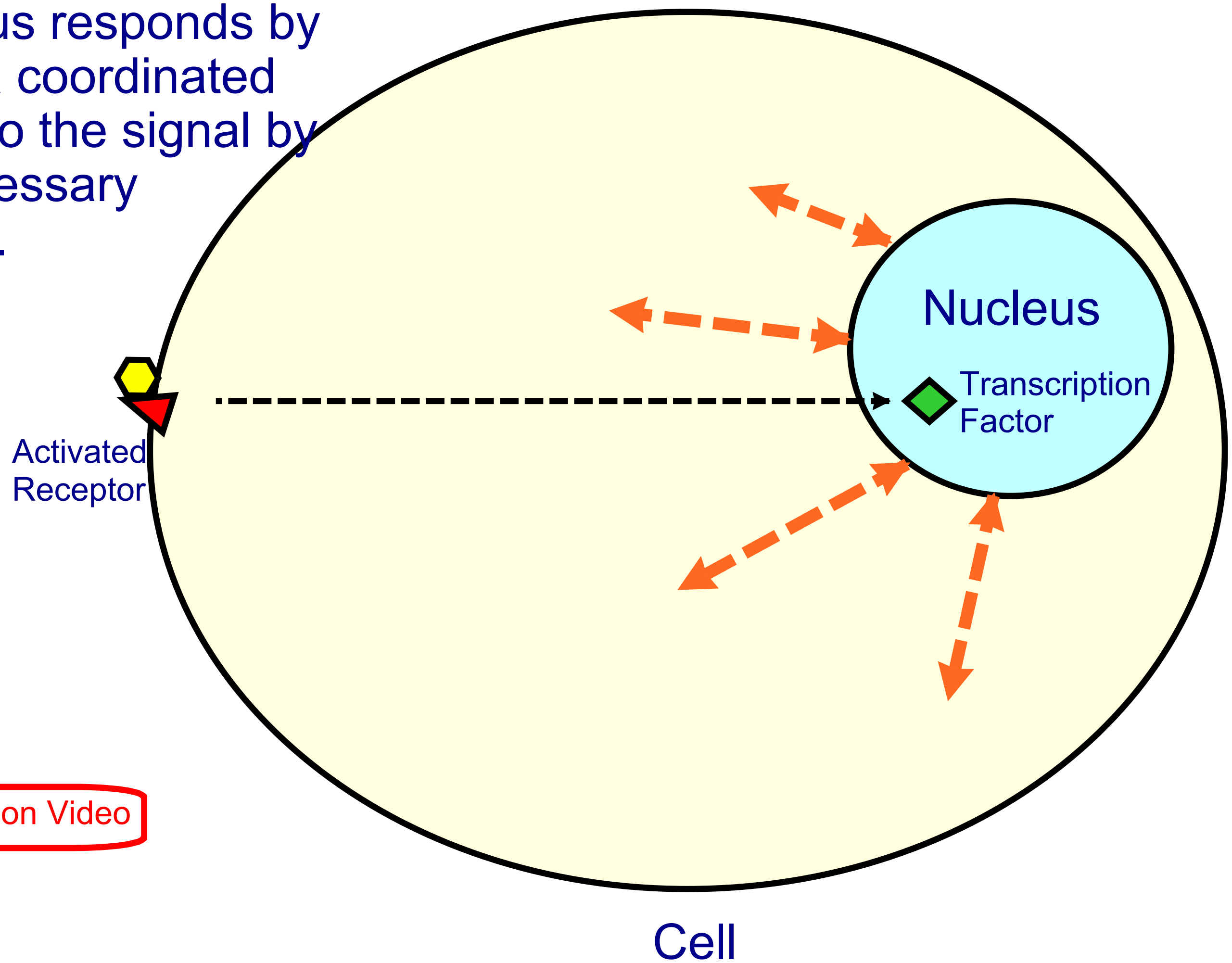
Signal Transduction Pathway
Transduction



The metabolic pathway produces a **specific transcription factor** in response to signal. The product enters the nucleus.

Signal Transduction Pathway
Response

The nucleus responds by signaling a coordinated response to the signal by all the necessary organelles.



Signal Transduction Video

Multicellular Signaling

In multicellular organisms, signal transduction pathways coordinate activities within cells that support the function of the organism as a whole.

One interesting example of this is the temperature-dependent sex determination in some vertebrates.

Temperature Dependent Sex Determination

In some vertebrates, certain hormones are influenced and released when ambient conditions reach a pivotal temperature.

In turtles, typically males are produced when ambient temperatures are lower than a set temperature (species dependent). When temperatures are higher, females are produced.

6

- A heat
- B light
- C hormone
- D all of the above

answer

7

- A A transcription factor
- B Cell movement
- C A signal
- D Receptors on the cell membrane

answer

Local Cell Communication

Return to Table of Contents

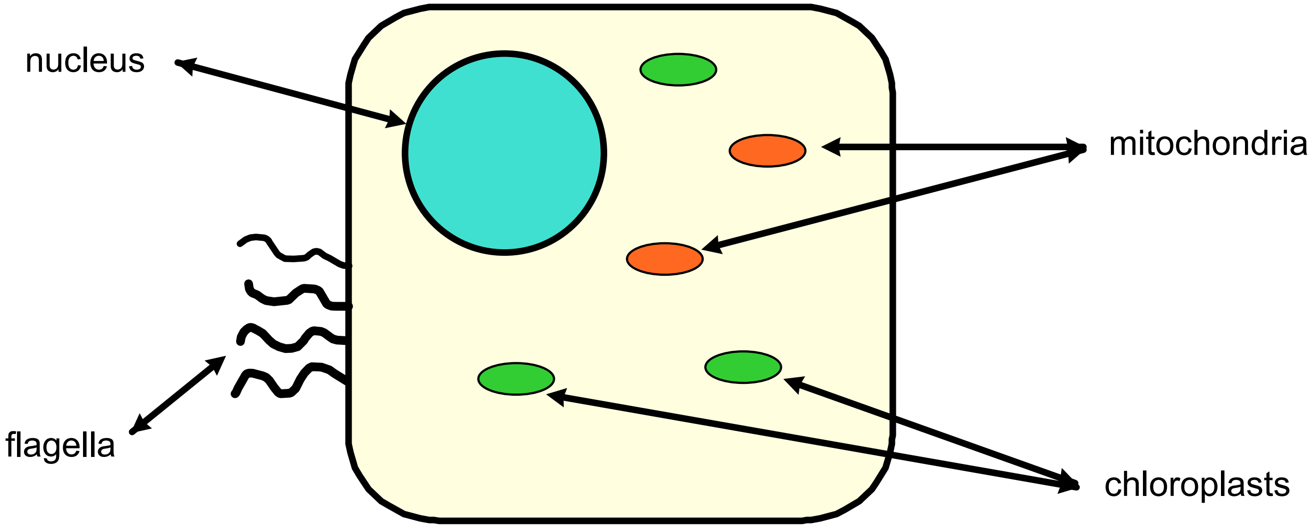
Multi-cell Organisms Require Cellular Communication

So single cells respond to the environment by adjusting their internal conditions. What about a multicellular organism? The many cells in the organism must make adjustments simultaneously.

In order for an organism to take advantage of being multicellular it must have the ability to communicate from cell to cell.

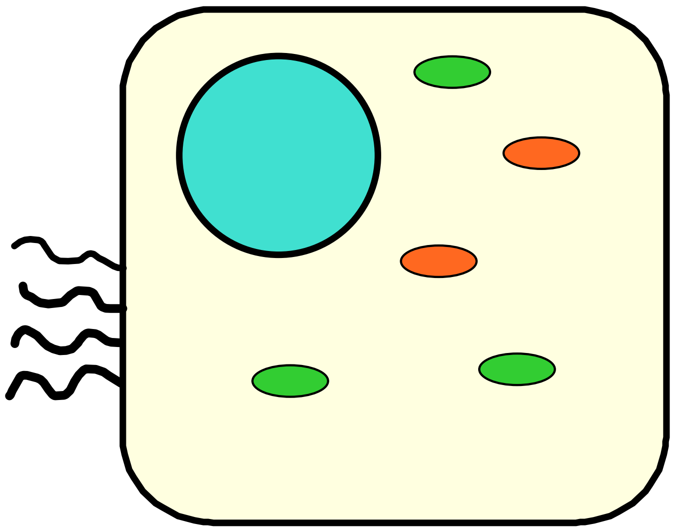
Multi-cell Organisms Require Cellular Communication

Let us look at a few examples of different types of organisms adjusting to their surroundings.We will start with a single celled, photosynthetic, **motile** (ability to move toward or away from something), eukaryotic organism.



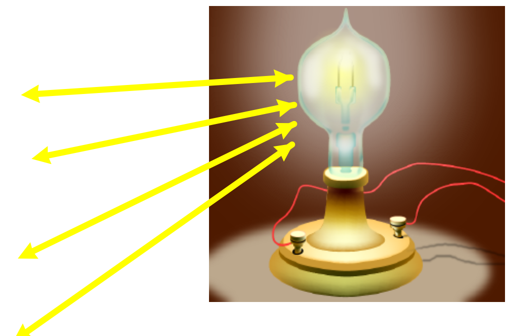
Multi-cell Organisms Require Cellular Communication

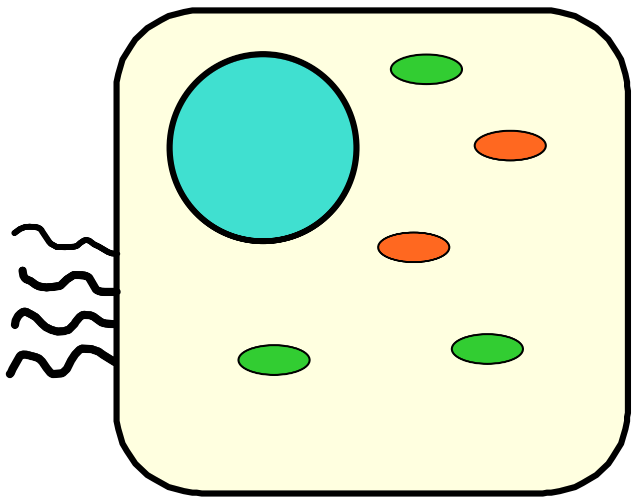
This cell has the ability to move toward light by directing its flagellum to oscillate in a particular direction, this is known as **phototaxis**. Moving closer to the cell allows the cell to produce more sugar by photosynthesis.



Multi-cell Organisms Require Cellular Communication

Write down a step by step explanation of how this cell will start moving toward the light in terms of a signal transduction pathway.

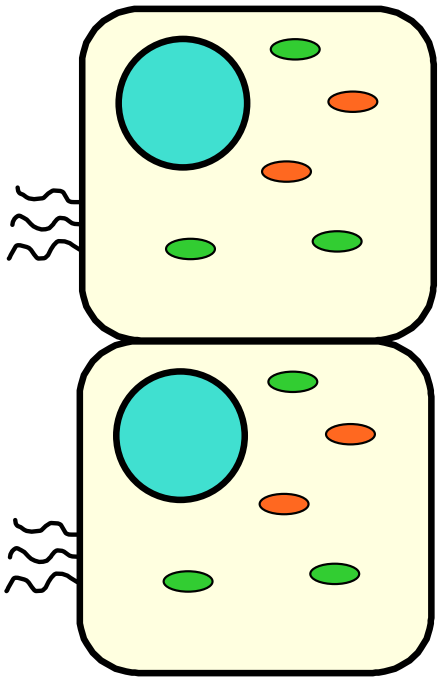


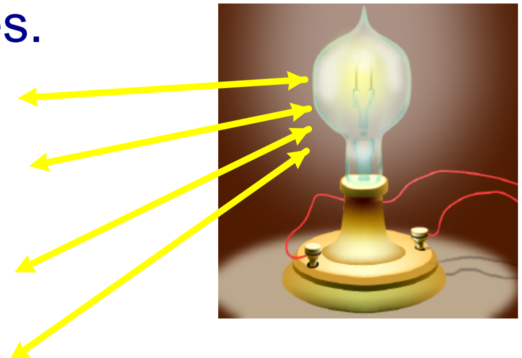


answer

Multi-cell Organisms Require Cellular Communication

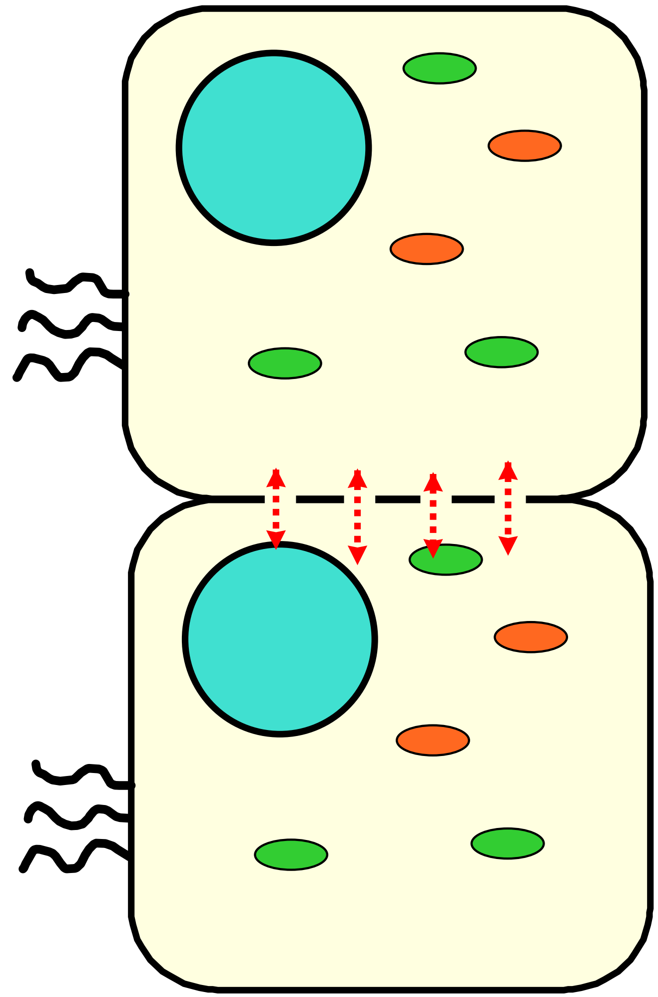
Lets look at a 2 celled organism. Both cells must propel themselves together. If only one does, or one is slower than the other this organism will spin in circles.





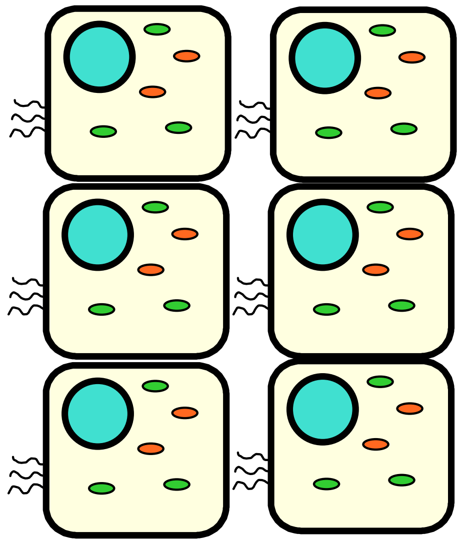
Multi-cell Organisms Require Cellular Communication

Looking more closely, these 2 cells share **gap junctions,** small channels in their membranes that allow molecules to pass. These ensure that the amount of transcription factor and nuclear signaling is consistent in both cells.



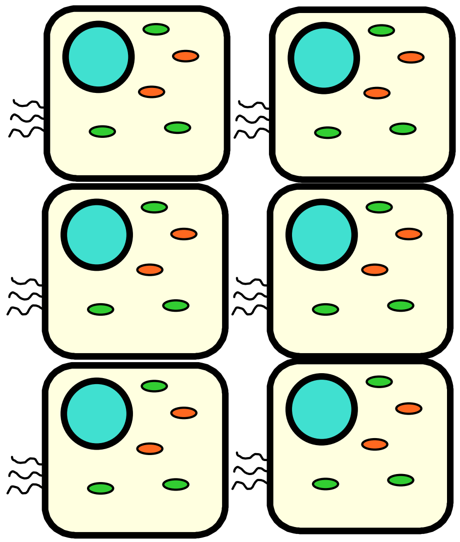
Multi-cell Organisms Require Cellular Communication

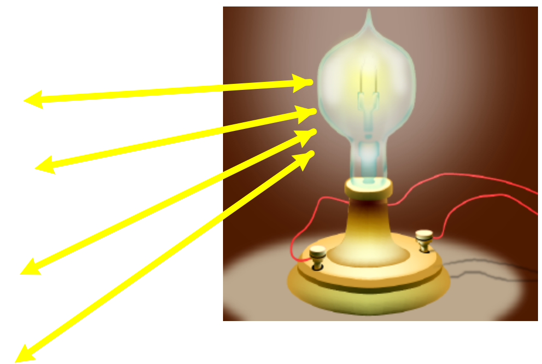
Now lets look at a multi-celled version of the same fictitious organism.



Multi-cell Organisms Require Cellular Communication

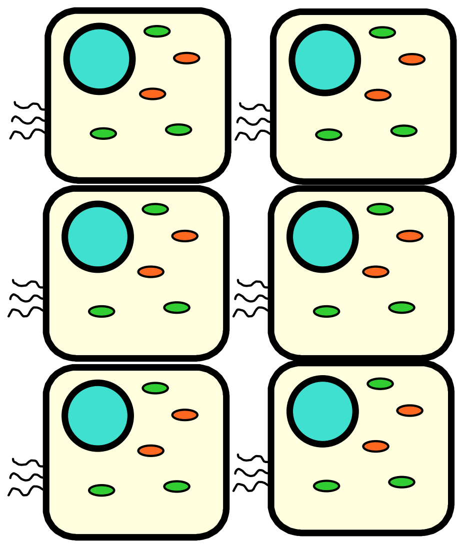
If we add a light source, what problems does this organism face? How could the organism overcome these problems. Discuss in a small group then suggest problems and solutions to the class.

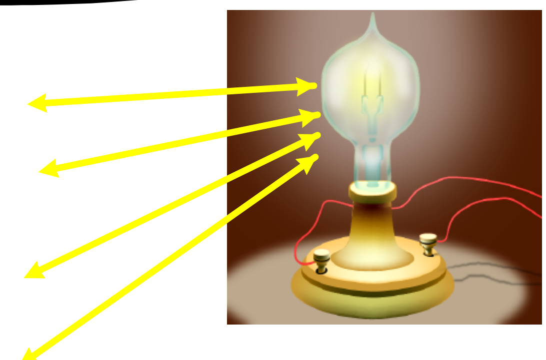




Multi-cell Organisms Require Cellular Communication

Problem:

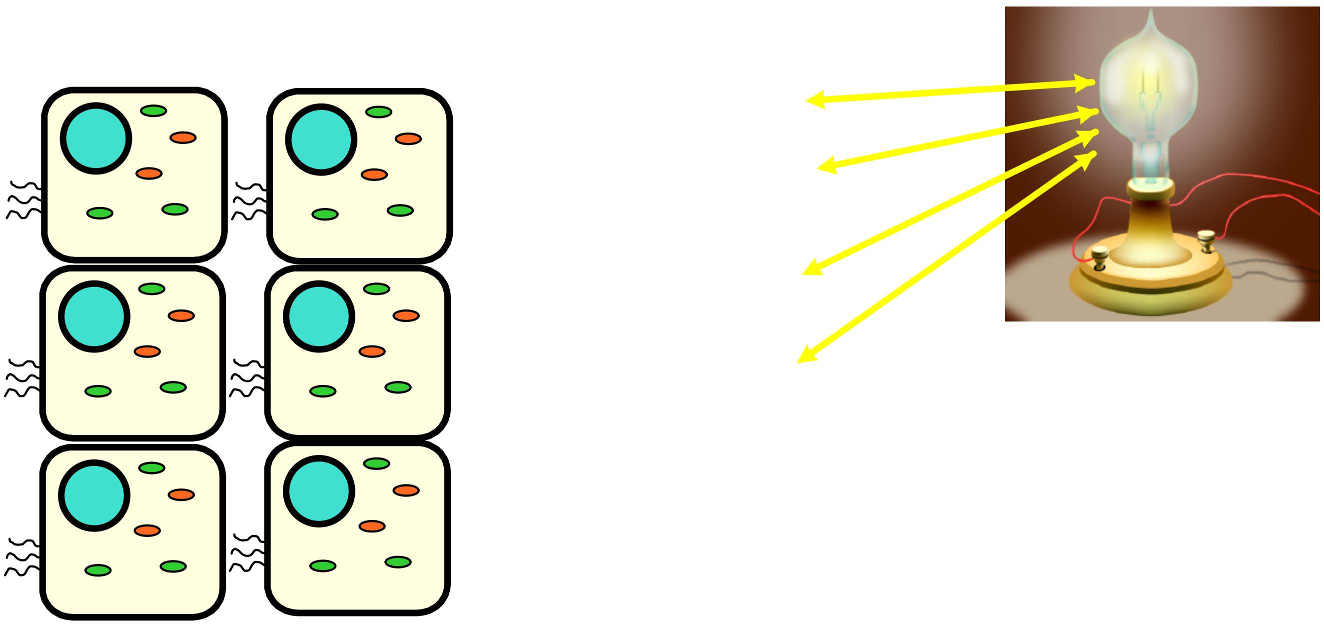




Solution:

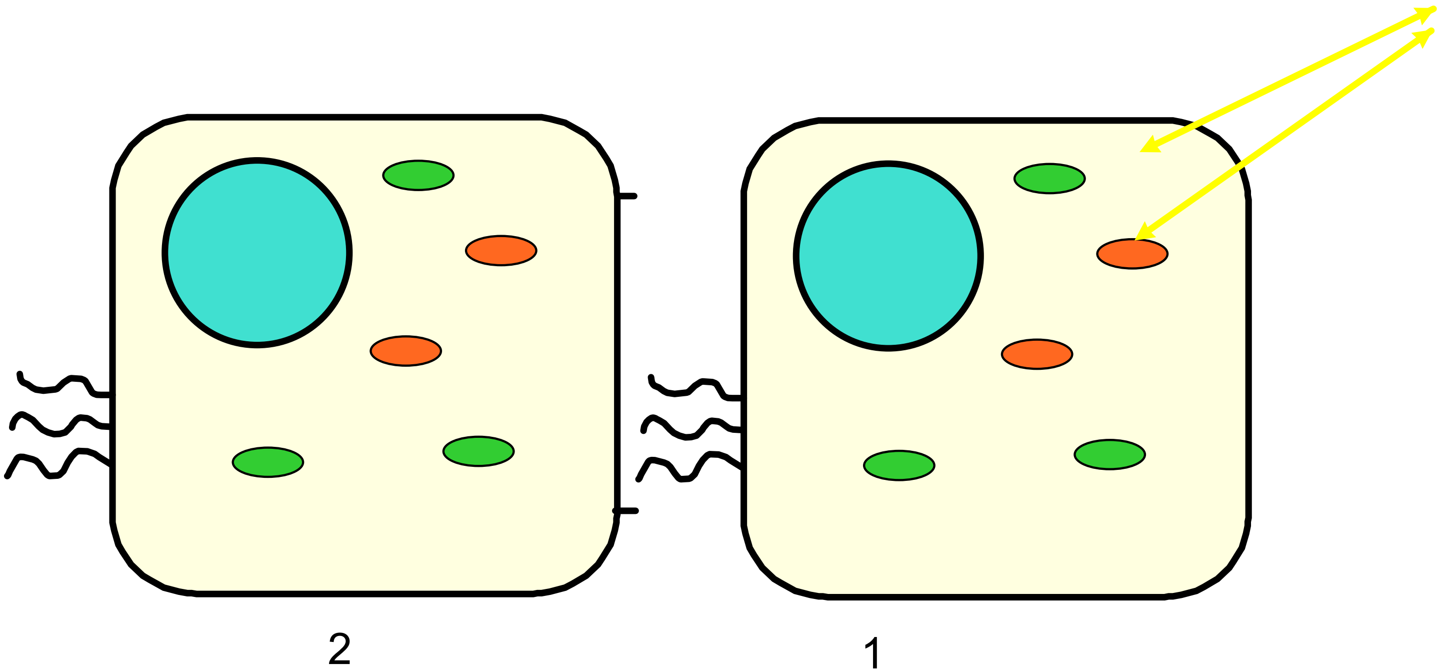
Local Cell to Cell Communication

There are several ways a cell can communicate with another cell. In this situation, receptor communication would be best. Lets look closely at 2 of these cells.



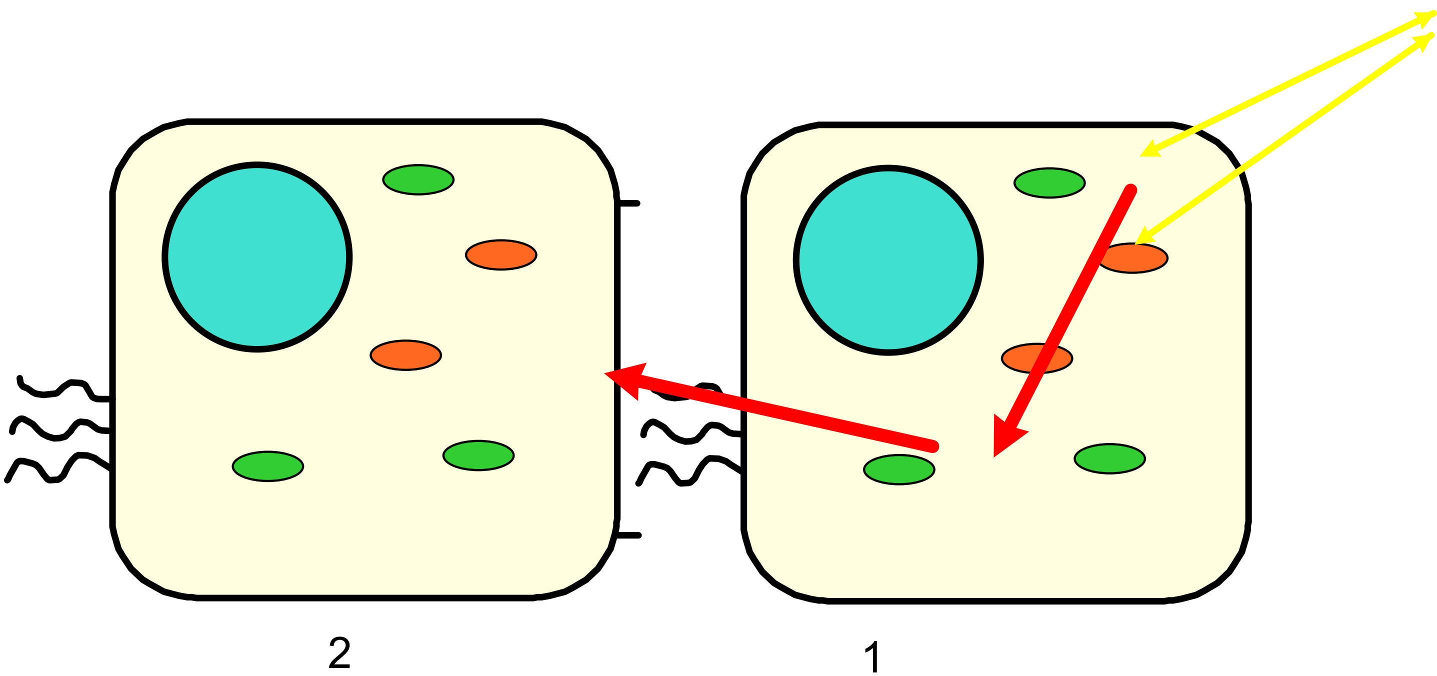
Local Cell to Cell Communication

Unlike the single celled organism, cell 1 does not want to activate its flagella when contacted by light. That would cause it to move away. It would need to signal its partner, cell 2.



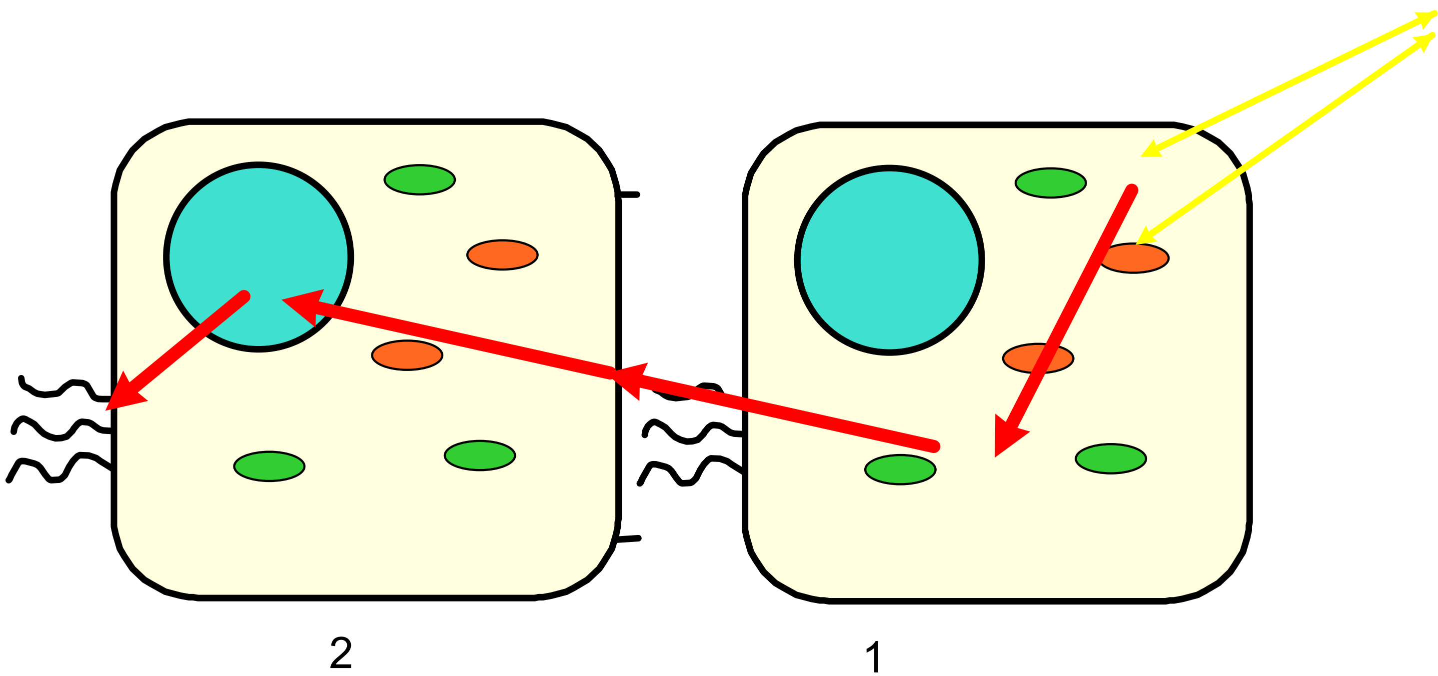
Local Cell to Cell Communication

A signal transduction pathway would still occur in cell 1, but the nucleus in 1 would produce proteins that become signals for cell 2.



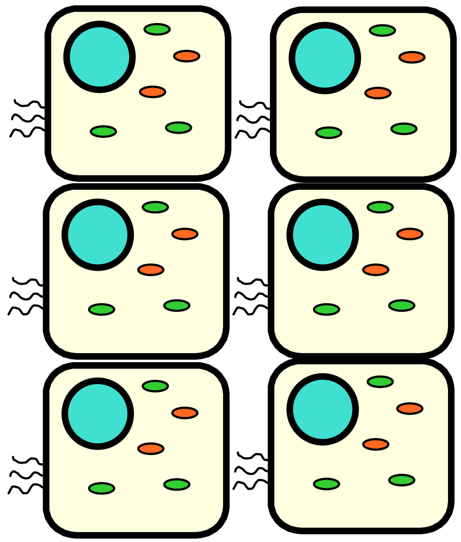
Local Cell to Cell Communication

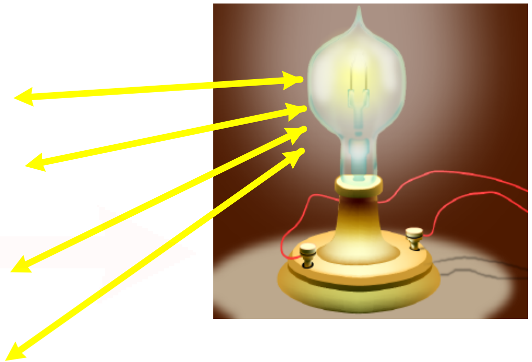
The signal produced by the nucleus of 1 would set off a second transduction pathway that would make cell 2 engage its flagella.



Local Cell to Cell Communication

The organism would move to the light. This system works well for less complex, smaller multi-celled organisms, and can be used for some systems in larger organisms.



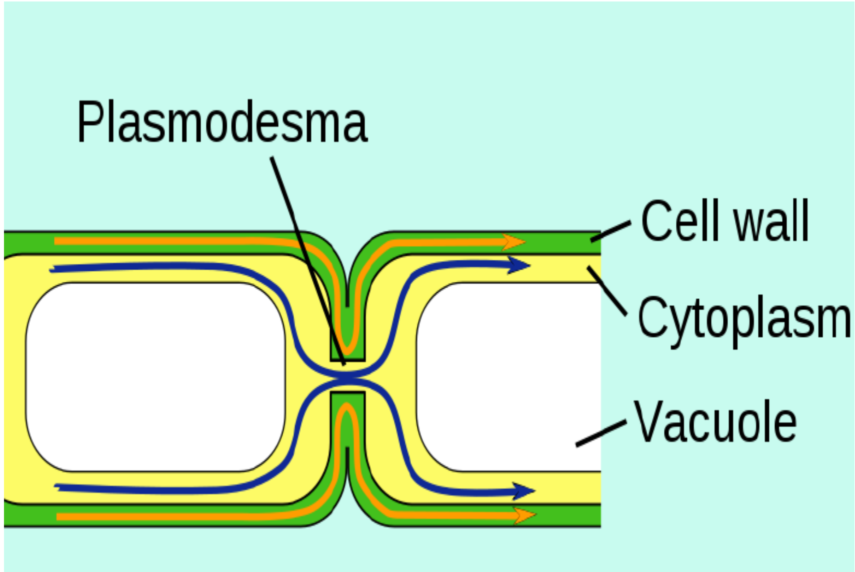


Eukaryotic Communication Junctions

The physical pathway that adjacent cells in multicellular organisms have which aid in communication and transfer of substances to one another are called **cell junctions.**

Animal and plant cells have different types of cell junctions. This is mainly because plants have cell walls and animal cells do not.

Junctions specific to plant cells



Plant cells connect using **plasmodesmata** which are channels that allow them to share water, food, and communicate via chemical messages.

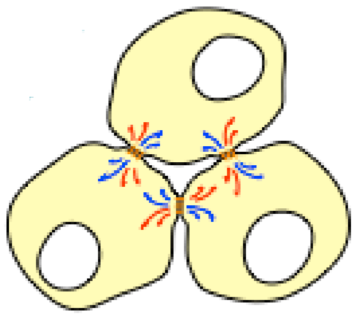
Animal Cell Junctions

Animal cells have 3 types of junctions:

Tight junctions: can bind cells together into leakproof sheets

Adhering junctions: fasten cells together into strong sheets. They are somewhat leakproof.

Communicating (Gap) junctions: allow substances to flow from cell to cell. They are totally leaky. They are the equivalent of plasmodesmata in plants.



Examples of Animal Cell Junctions

8

- A Tight junctions
- B Gap junctions
- C Adhering junctions
- D Plasmodesmata

answer

9

- A Tight junctions
- B Adhering junctions
- C Gap juctions
- D Plasmodesmata

answer

Regulation

When a receptor receives an external signal from another cell, the response can either be to increase or decrease the concentration of a specific molecule within the cell.

Increasing the concentration is called **upregulation** and decreasing production of that molecule is called **downregulation**.

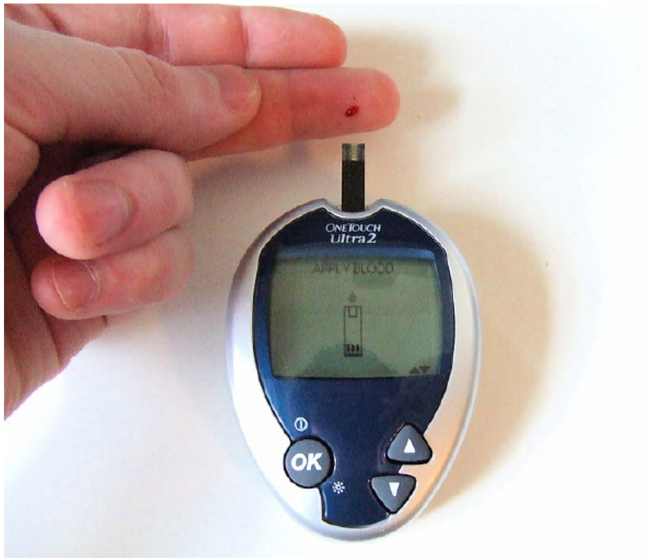
Upregulation

Specifically during **upregulation**, the number of receptors on the surface of target cells increase, making the cells more sensitive to a hormone or another agent.

For example, there is an increase in uterine oxytocin receptors in the third trimester of pregnancy, promoting the contraction of the smooth muscle of the uterus.

Downregulation

Alternatively, **downregulation** is a decrease in the number of receptors on the surface of target cells, making the cells less sensitive to a hormone or another agent. Some receptors can be rapidly downregulated.



An example of downregulation occurs in Type II diabetes. This form of the disease is characterized by elevated levels of insulin in the bloodstream but a loss of insulin receptors. This downregulation can sometimes be reversed through exercise, and occasionally, a change in diet can also resolve the issue.

10

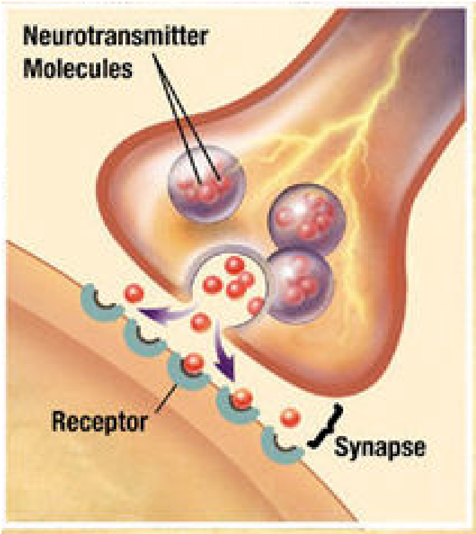
- ○ A upregulation
- ○ B downregulation

answer

Short Distance Cell Communication

Eukaryotic cells can communicate over short distances by releasing regulator chemicals. These regulators attach to receptors embedded in the plasma membrane of nearby cells.

Neurotransmitters work this way, being released to travel from a neuron to a target cell across a very small synapse.



Long Distance Cell Communication

Cells can also communicate over long distances.

For example, signaling molecules such as the hormone testosterone, are produced by endocrine cells. These hormones can travel long distances through the blood to reach different target cells in many regions of the body.

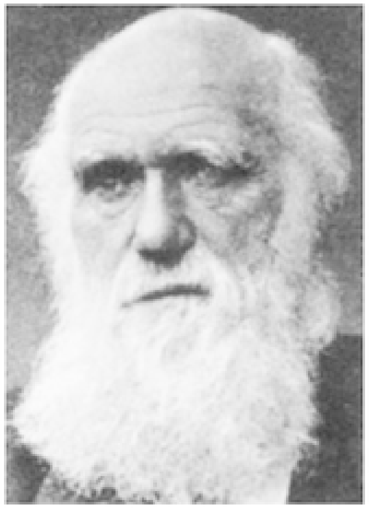
Cell Communication Across Systems

Return to Table of Contents

Cell to Cell Communication

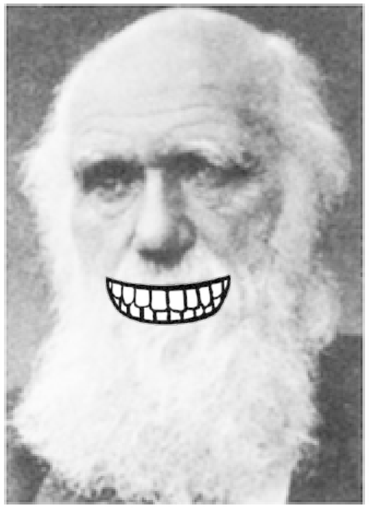
What about much larger organisms with lots of specialized cells and complex responses? When many systems have to respond simultaneously?

Let us use Darwin as our example of a complex, multi-celled organism.



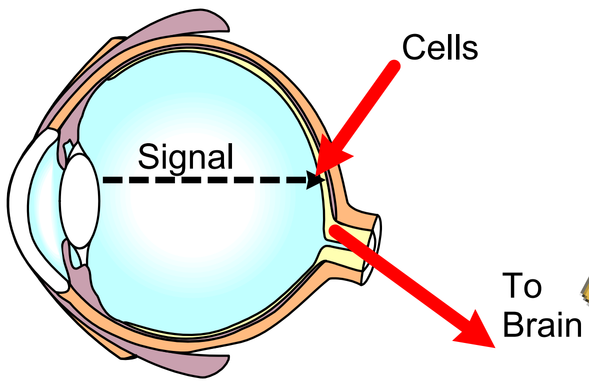
Cell to Cell Communication

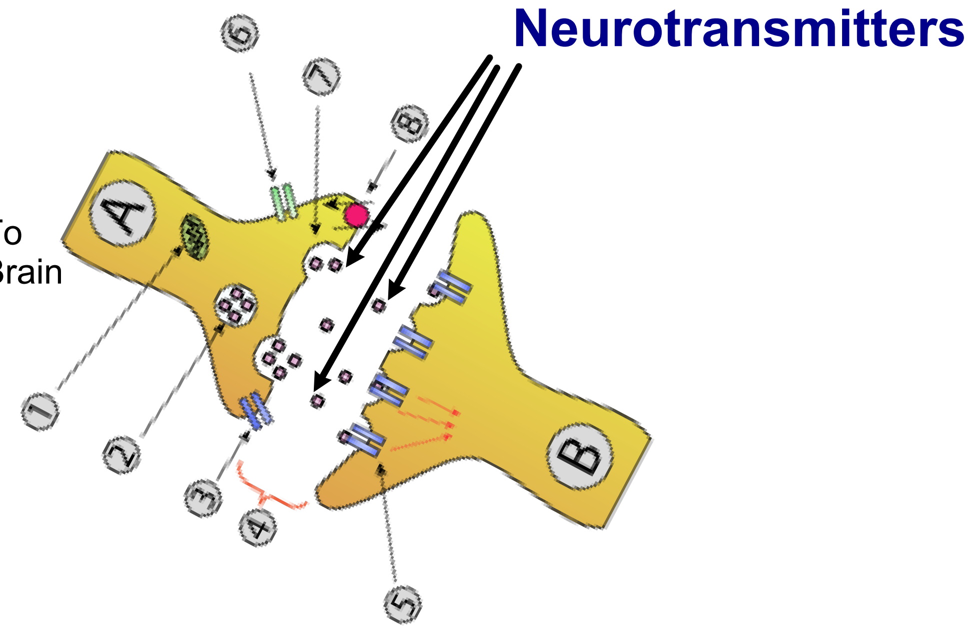
When Darwin sees a cheeseburger he smiles.
Why?
What is happening at a cellular level?
What is the signal?
What cells respond?



Cell to Cell Communication

What is the signal?



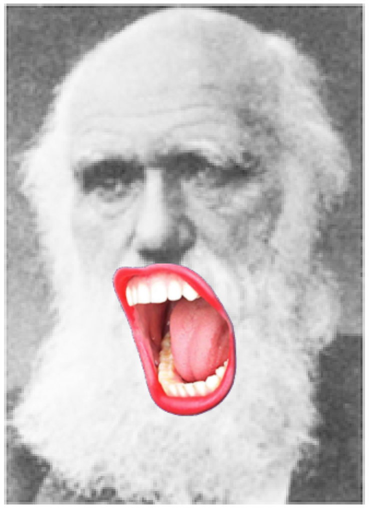


Nerves are specialized cells as well. **Neurotransmitters**, protein signals, are released by nerve A in a certain pattern, based on the image of the bear. Nerve B receives them as a signal for a specific transduction pathway. Nerve A is the signaling optic nerve, nerve B acts as the receptor for the brain.

Hormone Response

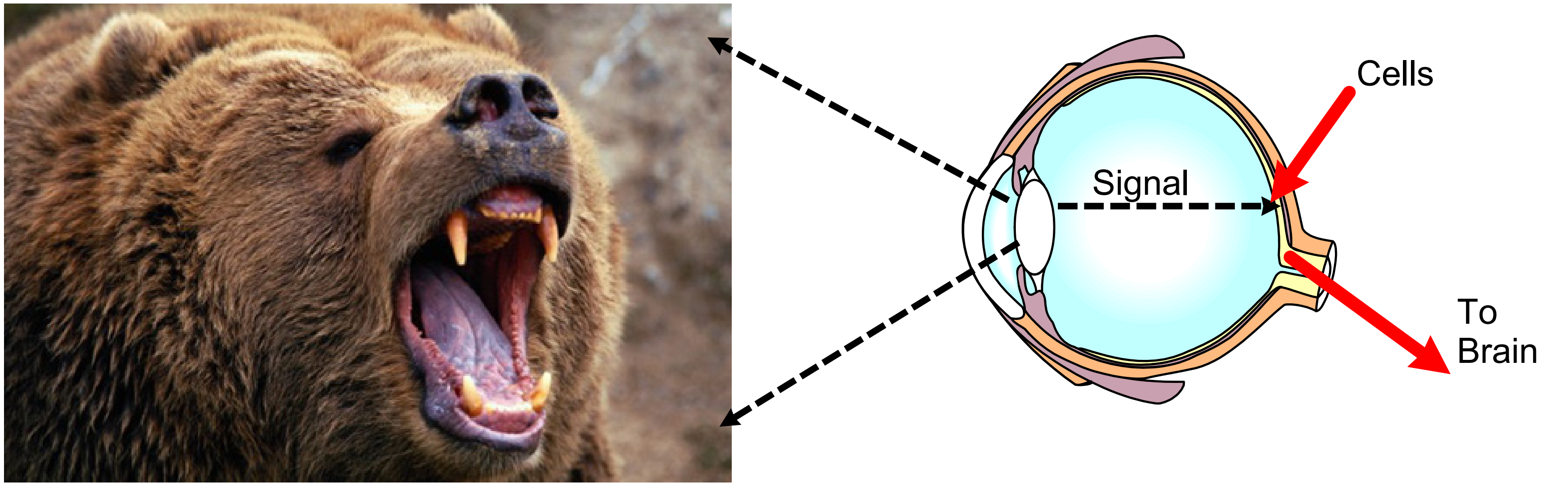
When Darwin sees an angry bear...

Let us take a look at the **hormone** response that is responsible for most of what Darwin is feeling right now.



Cell to Cell Communication

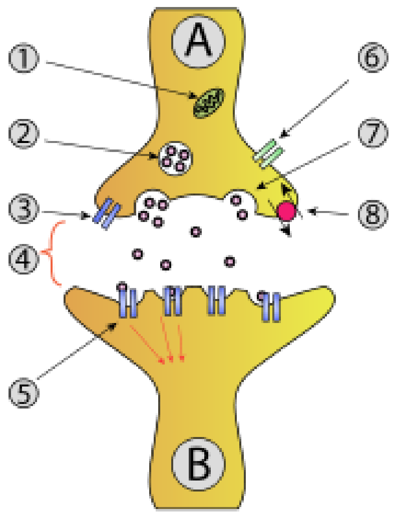
What is the signal?



The image of the bear (pattern of light waves) on the retinal cells in Darwin's eye use **synaptic signaling** to relay the image to the brain through the optic nerve.

Cell to Cell Communication

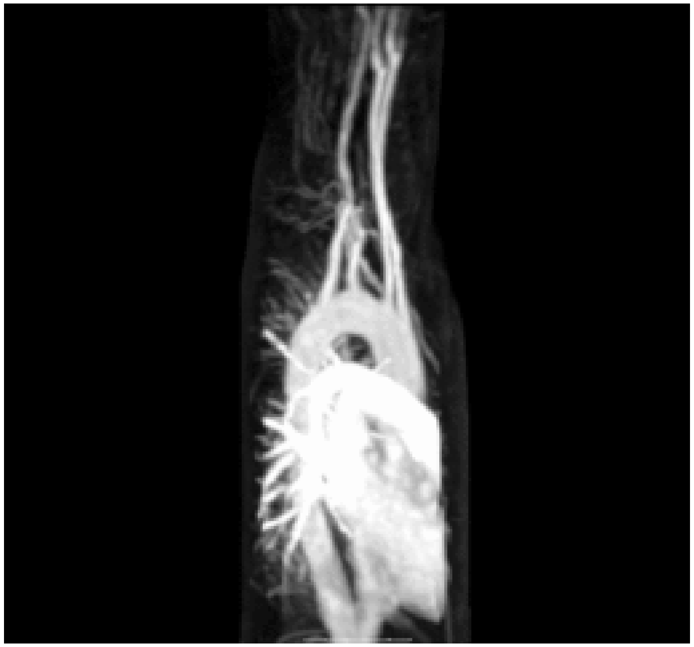
What is the signal?



The brain begins a massive cascade of synaptic signals through millions of nerve cells. It calculates the proper response and releases **hormones** into the blood stream. In this case, the "fight or flight" molecule will be released: **epinephrine** (adrenalin)

Cell to Cell Communication

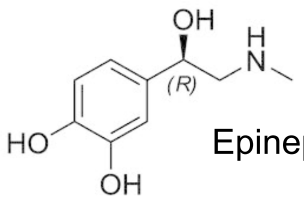
What is the signal?



Epinephrine is released into the blood stream, where it is sent throughout the body. Each cell it contacts will have a different response to the molecule.

Cell to Cell Communication

Since epinephrine is only a signal molecule it can have different effects on different cells. It all depends on what a particular cell is programed to do in the presence of epinephrine



Epinephrine

- Hair follicle muscle cell - contract, hair stands up
- Sweat gland muscle cell - contract, sweat is released
- Lung cells - relax, take in more air
- Heart cells - speed up, more oxygen to cells for respiration
- Liver cells - release glucose, to supply more energy to cells

...among other responses

Cell to Cell Communication

Click here for an animation of fight or flight signalling

Feedback Loops

A feedback loop is the path that leads from the initial generation of a signal to the modification of an event. They are the cause-and-effect sequence in biology.

Feedback loops can either be positive or negative.

Negative Feedback Loops

A negative feedback loop happens when the outcome of an action acts to reverse cause of the original signal. The thermostat in your house acts on a negative feedback circuit.

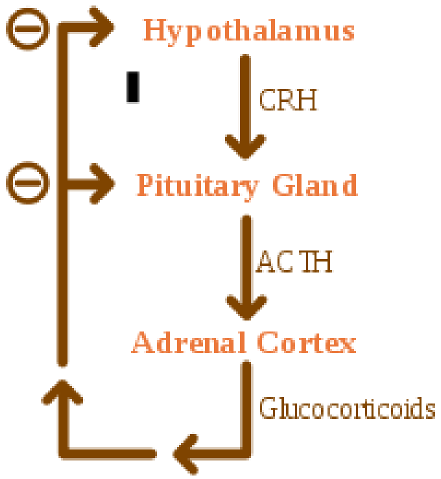
When the thermostat senses it is too hot, it turns on the air conditioner to cool it off. If the house is too cool, it will send a signal to warm the house up.

Negative Feedback Examples

Most control systems in the body involve negative feedback systems. Cells send signals to other cells to fix problems they are sensing. This could involve the release of another signal to counteract a problem or more simply, the shut down of the original signal.

Examples include:

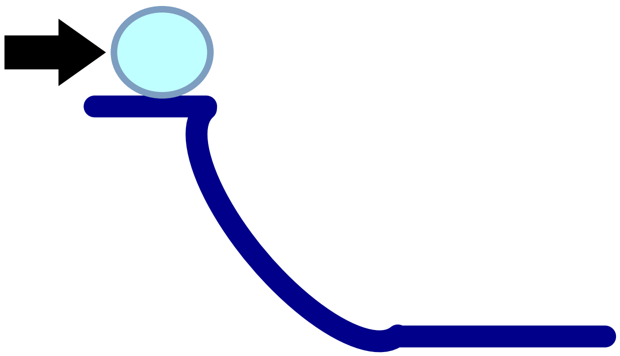
body temperature control
the regulation of pituitary hormones
control of blood glucose levels



Positive Feedback Loops

A positive feedback loop is one which involves cells continually amplifying a signal until an outcome is reached. The key to positive feedback loops is that any small change will be amplified.

A snowball rolling down an increasingly steep hill will continue to pick up speed until it gets to the bottom of the hill.



Positive Feedback Examples

Activities associated with childbirth offer two examples of positive feedback loops.

As contractions happen during labor, the hormone oxytocin is released into the bloodstream. As oxytocin levels increase, more contractions occur, until the baby is born which stops the feedback loop.

Another example involves lactation. The more a newborn baby suckles, the more milk is produced. This is due to a positive feedback loop involving the hormone prolactin.

Feedback Loop Explanation

click here for a video
explanation of
feed back loops

11 The "fight-or-flight" adrenalin response to an emergency situation would be considered a:

- A Negative Feedback Loop
- B Positive Feedback Loop

answer

12 Calcitonin is a hormone released from cells in the thyroid gland which controls circulating blood levels of calcium in conjunction with the parathyroid hormone. This would be an example of a:

- A Negative Feedback Loop
- B Positive Feedback Loop

answer

Immune System Response

Return to Table of Contents

Animal Immunity

The immune system of animals is one of the most complex homeostatic systems found in nature. It has to be complex because it has to be able to adjust to uncountable random events that could undermine the entire metabolic system of a multicellular eukaryote.

The 2 major dangers that the immune system protects against:

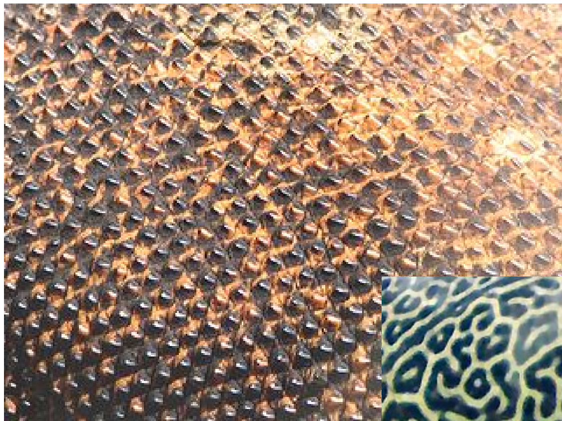
1. Foreign invading cells
2. Damaged or diseased cells that are part of the animal

Animal Immunity

Innate immunity refer to the non-specific systems for immediate response to potentially lethal **pathogens**. Any foreign cell or virus that has the ability to harm the animal is a pathogenic microbe.

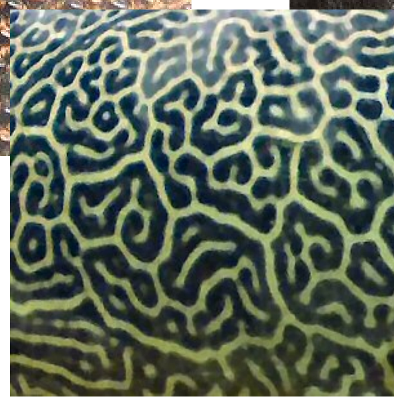
Innate Immunity

First line of defense is skin. There are many varieties but all serve the same functions for immunity.



Komodo Dragon

Rhino

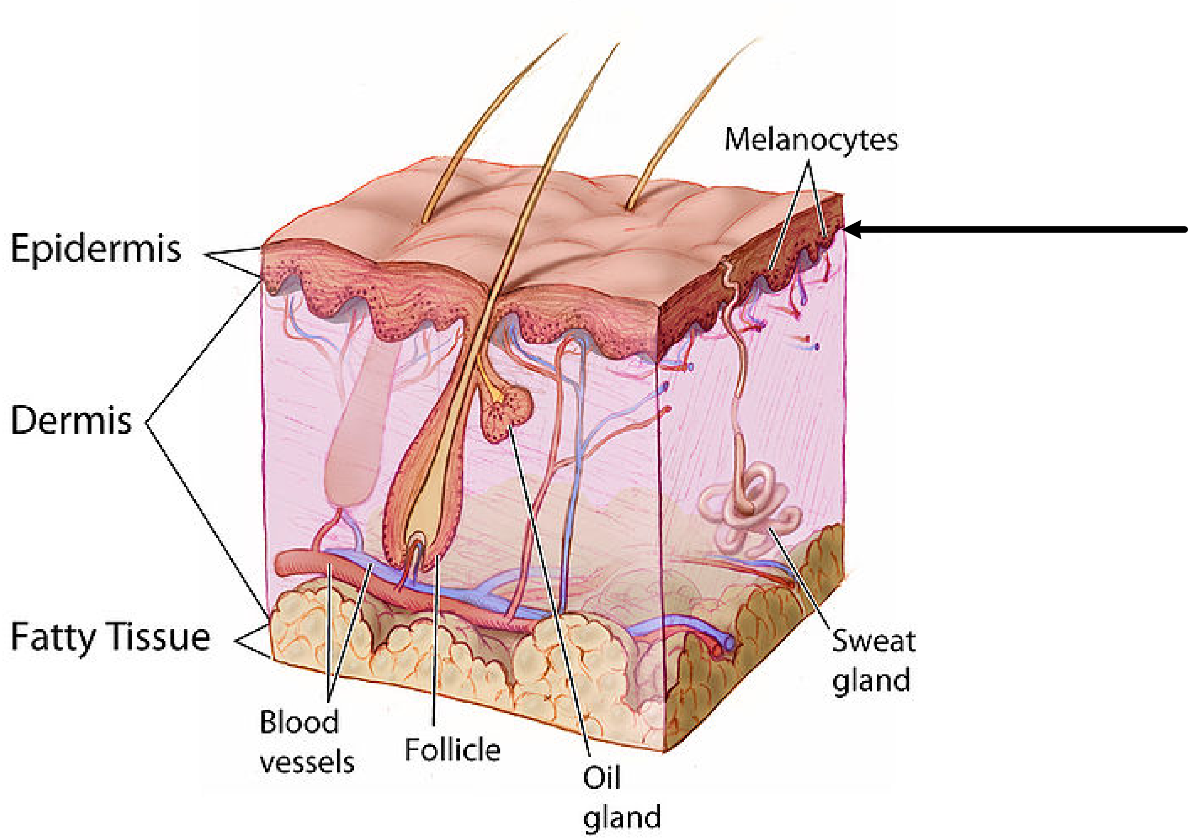


Puffer Fish

Human

Innate Immunity

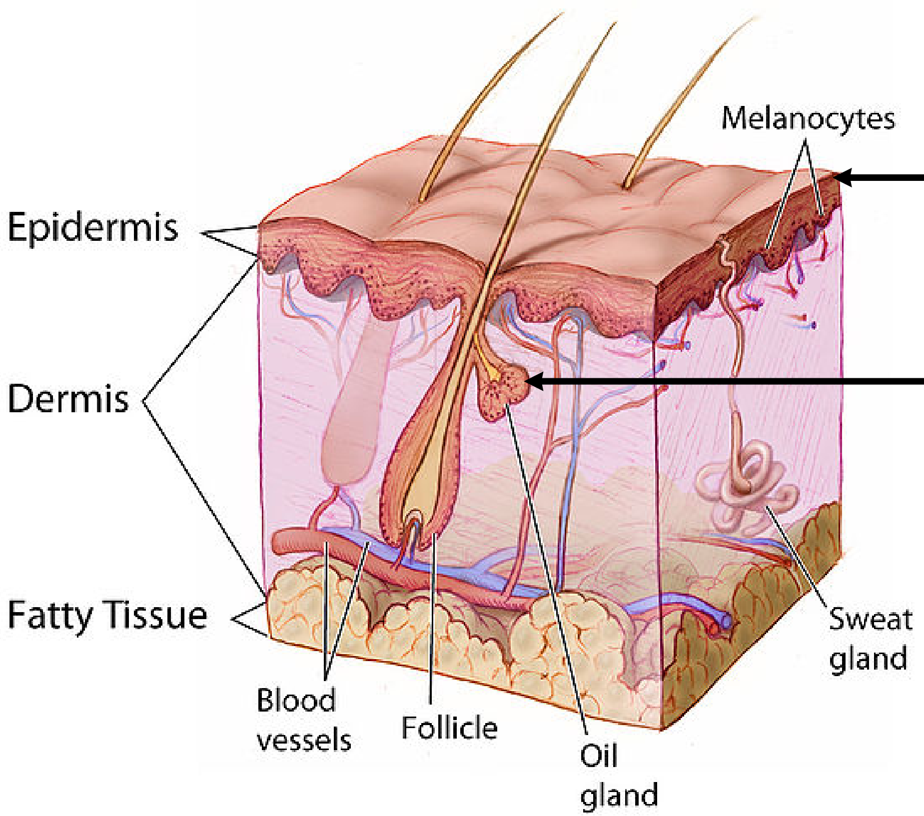
Some features that aid skin in its defense of the body.



Thick layer of dead cells in the epidermis creates a physical barrier.

Innate Immunity

Some features that aid skin in its defense of the body.

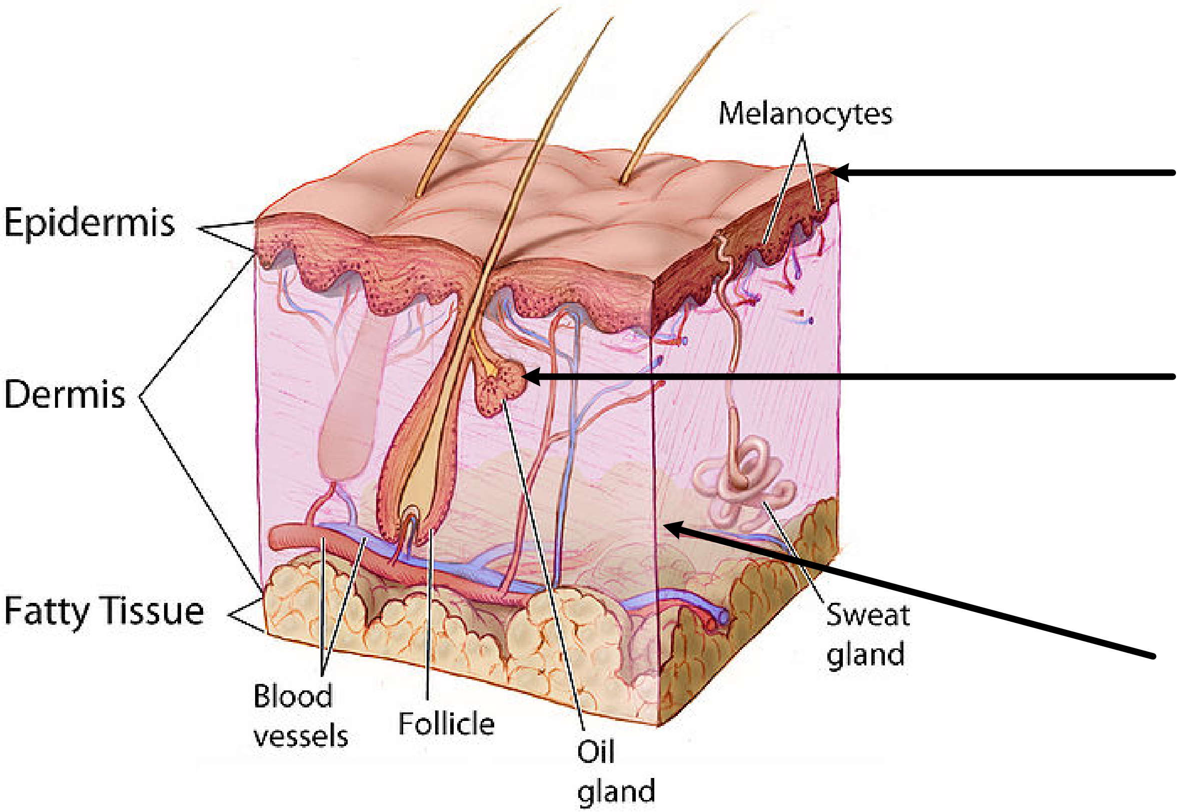


Thick layer of dead cells in the epidermis creates a physical barrier.

Sweat glands secrete waxy substances that pathogenic microbes have a hard time adhering to. It also has a pH of less than 6 which hurts pathogenic microbes.

Innate Immunity

Some features that aid skin in its defense of the body.



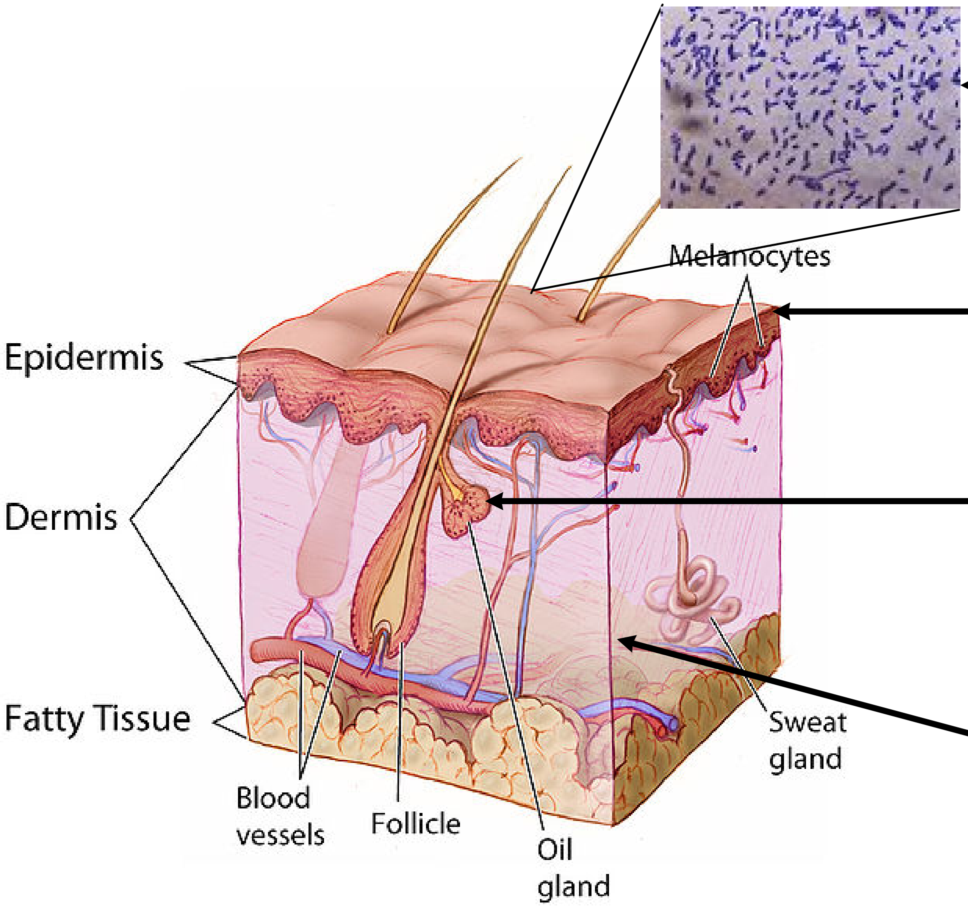
Thick layer of dead cells in the epidermis creates a physical barrier.

Sweat glands secrete waxy substances that pathogenic microbes have a hard time adhering to. It also has a pH of less than 6 which hurts pathogenic microbes.

The dermis provides distance and insulation between major vessels of the blood stream and the external environment. Extracellular fluid and fats fill this area.

Innate Immunity

Some features that aid skin in its defense of the body.



Symbiotic bacteria crowds the surface of the skin making it hard for unwelcome bacteria to find room.

Thick layer of dead cells in the epidermis creates a physical barrier.

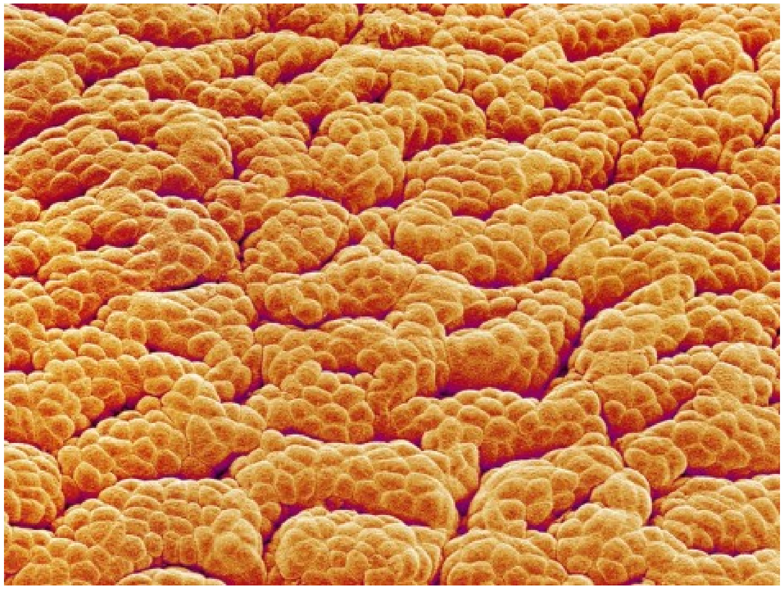
Sweat glands secrete waxy substances that pathogenic microbes have a hard time adhering to. It also has a pH of less than 6 which hurts pathogenic microbes.

The dermis provides distance and insulation between major vessels of the blood stream and the external environment. Extracellular fluid and fats fill this area.

Innate Immunity

Where contact with the environment is necessary for the animal, skin cannot be used to block foreign contaminants. In these cases, **mucus membranes** are used to stop pathogenic microbes from entering systems.

Mucus cells secrete products that are rich in **glycoproteins** and water. It is a viscous fluid containing antiseptic enzymes that will breakdown bacterial and viral components.



Innate Immunity

In mammals, this mucus serves to protect: respiratory cells, gastrointestinal (digestive) cells, urogenital (vaginal) cells, visual cells, and auditory systems.

A major function of this mucus is to protect against infectious agents such as fungi, bacteria, and viruses. The cells in an average human body produces about a quart of mucus per day.

1 quart

13

- A Sweat glands
- B Symbiotic bacteria
- C Mucus
- D Dead skin cells

answer

Innate Immunity

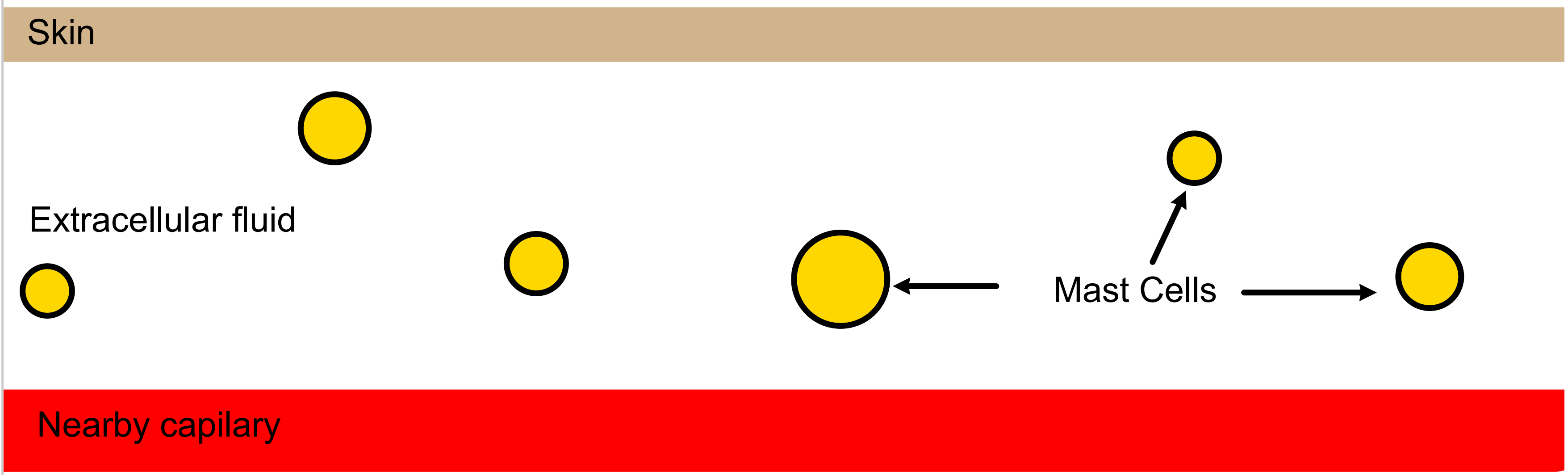
If a foreign invader makes it past the skin and mucous membrane, the body has specialized cells that can detect and respond.

Innate Immunity

Consider a laceration (cut) on a part of your body. Immediately foreign cells are entering the break in your bodies barrier. Take a moment and describe to another person what happens in the few minutes after a cut. Make a list of your bodies responses. Can you relate these symptoms to fighting infection?

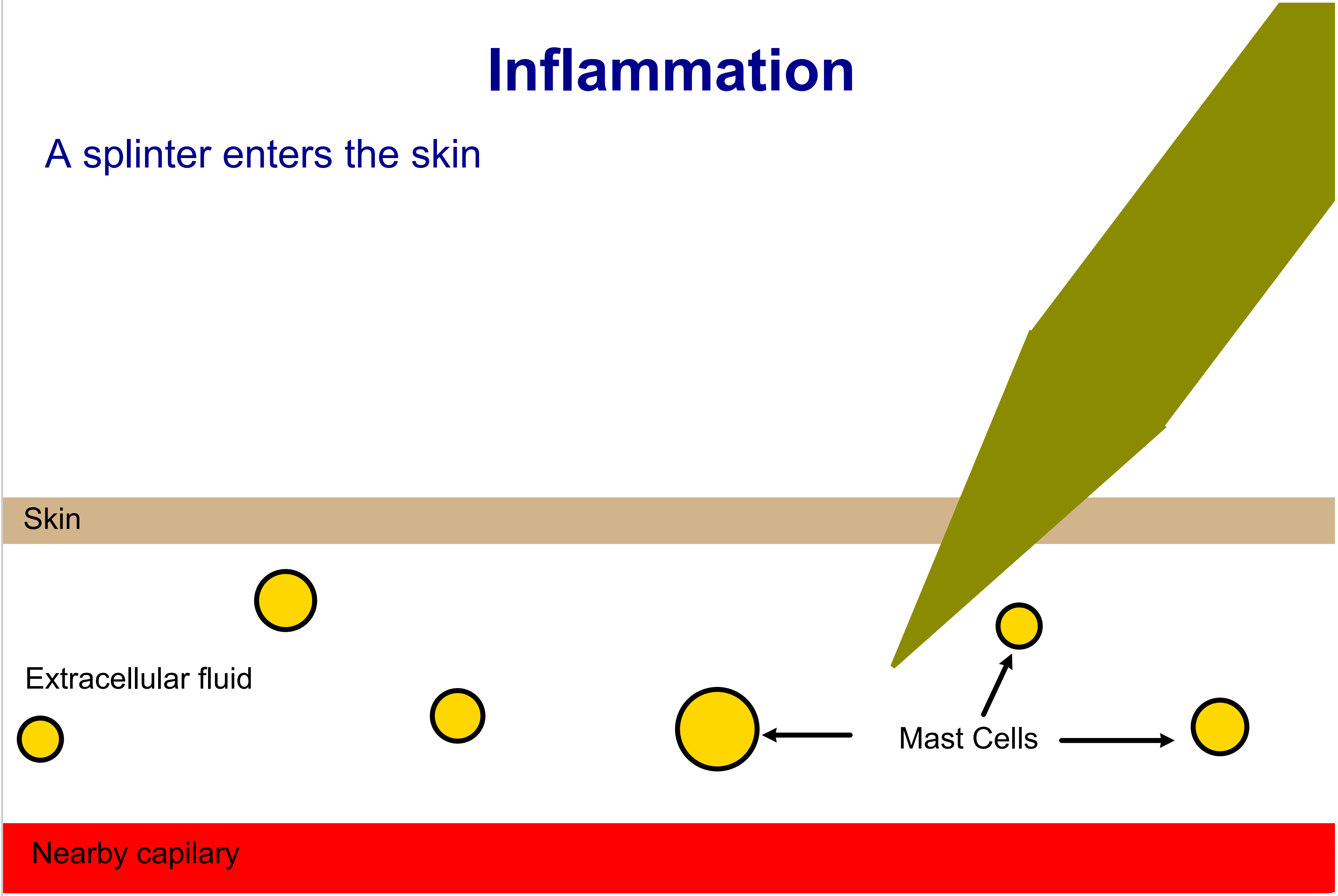
Inflammation

Inflammation is a response triggered by bacteria that enters the skin. A metabolic pathway is initiated by the presence of bacteria under the skin.



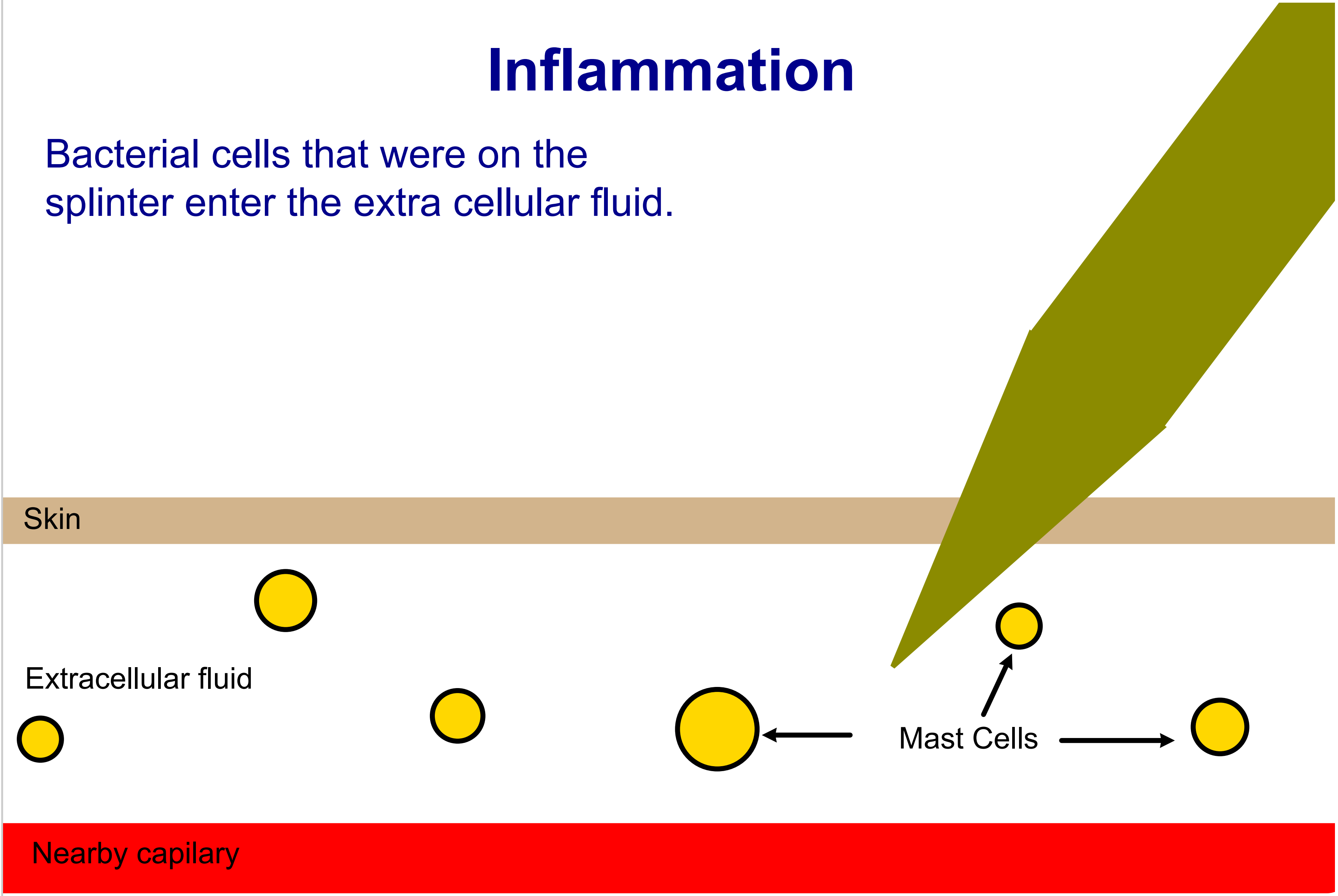
Inflammation

A splinter enters the skin



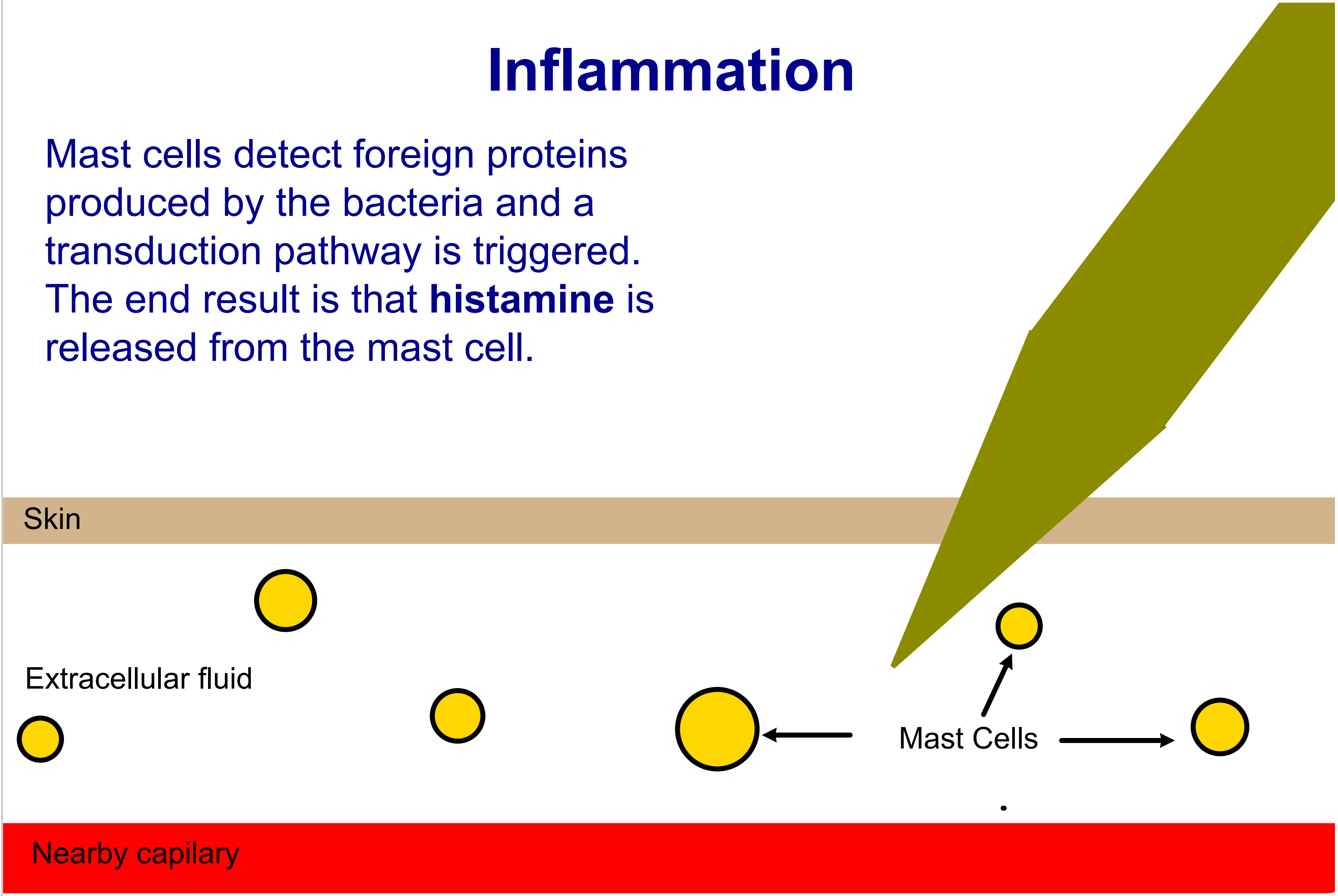
Inflammation

Bacterial cells that were on the splinter enter the extra cellular fluid.



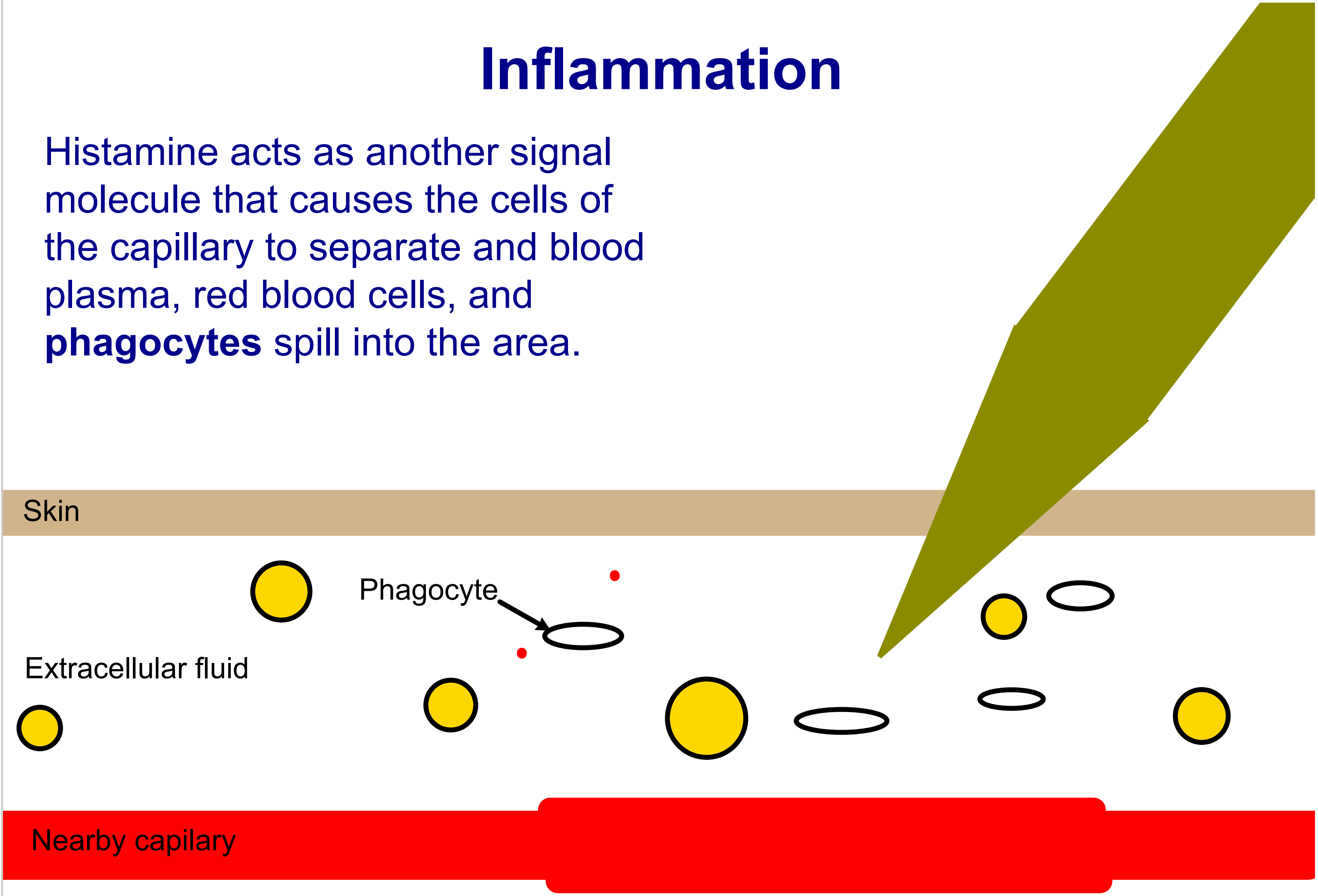
Inflammation

Mast cells detect foreign proteins produced by the bacteria and a transduction pathway is triggered. The end result is that **histamine** is released from the mast cell.



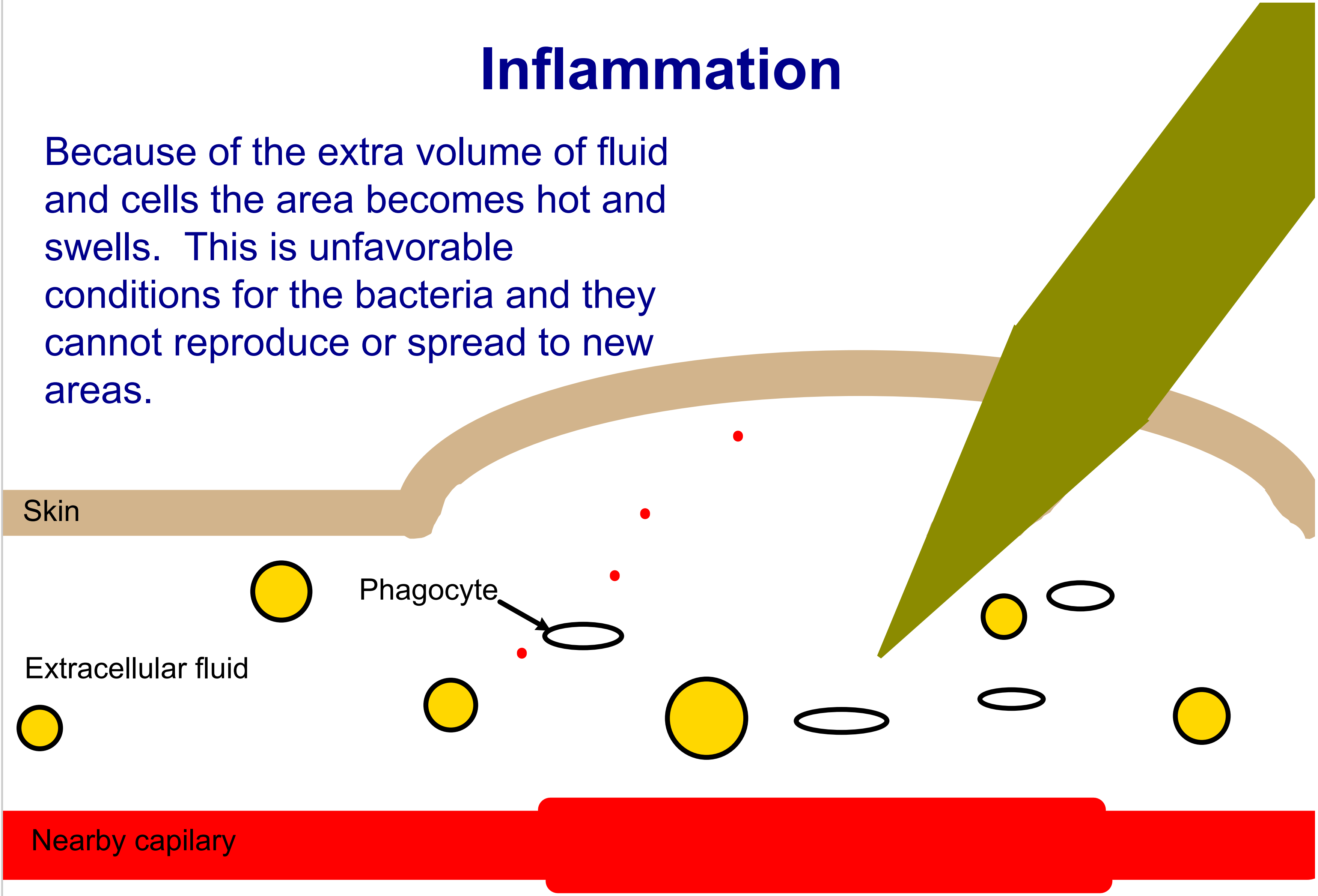
Inflammation

Histamine acts as another signal molecule that causes the cells of the capillary to separate and blood plasma, red blood cells, and **phagocytes** spill into the area.



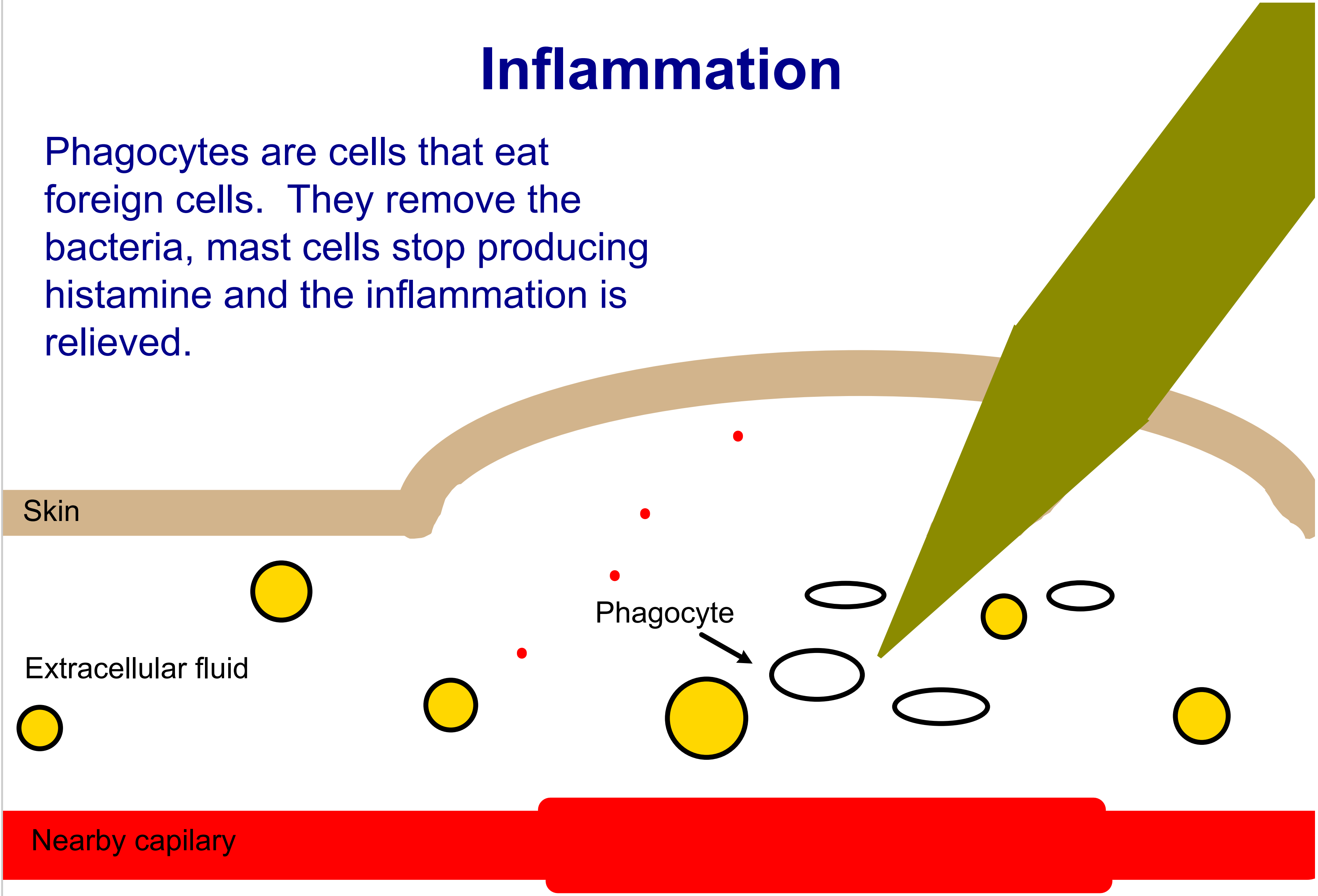
Inflammation

Because of the extra volume of fluid and cells the area becomes hot and swells. This is unfavorable conditions for the bacteria and they cannot reproduce or spread to new areas.



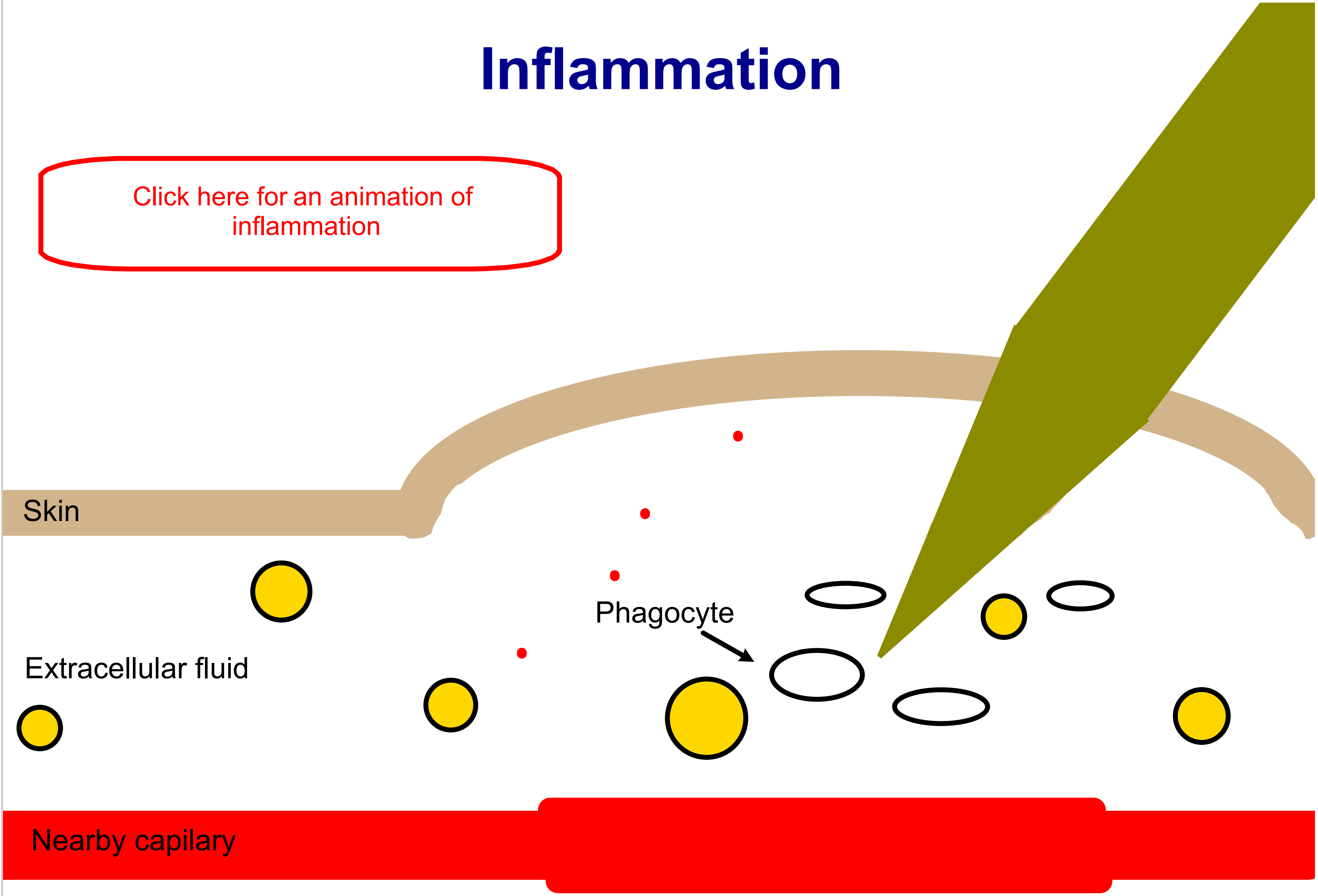
Inflammation

Phagocytes are cells that eat foreign cells. They remove the bacteria, mast cells stop producing histamine and the inflammation is relieved.



Inflammation

Click here for an animation of inflammation



14

- A Mast cells produce histamine, swelling occurs, red blood cells and phagocytes enter the area, phagocytes eat the foreign cells
- B Mast cells produce histamine, red blood cells and phagocytes enter the area, swelling occurs, phagocytes eat the foreign bacteria
- C Histamine produces mast cells, phagocytes eat the mast cells, swelling occurs, new red blood cells enter the area
- D Swelling occurs, mast cells produce histamine, red blood cells and phagocytes enter, phagocytes eat the foreign bacteria

answer

Specific Immunity

Most organisms (simple eukaryotes, plants, fungi, etc) have some amount of innate immunity. But not all have **specific immunity.**

Mammals are examples of organisms that have the ability to defend against specific pathogens.

Specific Immunity

The specific immunity of mammals includes two types of response

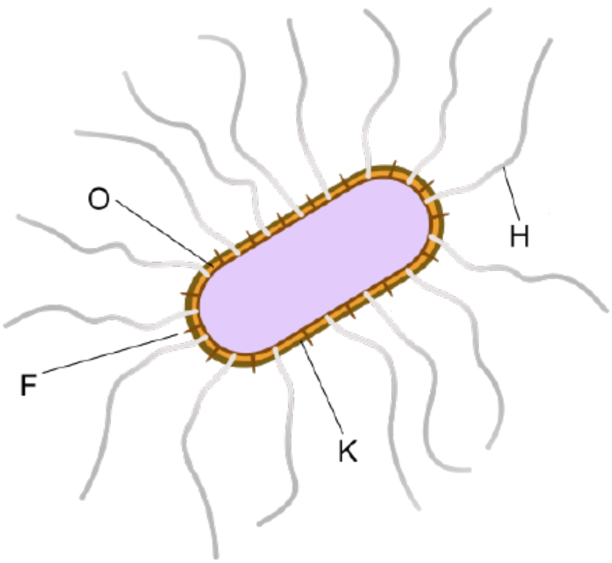
Humoral: Attacking pathogens in the extracellular matrix, prior to entering a body cell

Cell mediated: Destroying body cells that have been infected by pathogens or have become cancerous.

Both responses are derived from white blood cells known as **lymphocytes.**

The Humoral Response

All pathogenic invaders have **antigens**, proteins that induce the release of **antibodies** because they are recognized as foreign to the organism being invaded. Antibodies are molecular flags that stick to he antigen and mark them for destruction by the immune system.



This bacterial cell has many surface proteins that the mammalian immune system will recognize as non-self proteins. Any of them could act as an antigen.

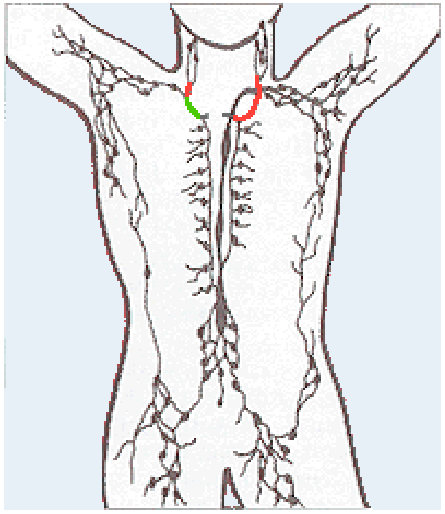
15

- A introduced by pathogens
- B produced by mammals
- C serve as flags for the immune system to destroy
- D another word for antibodies

answer

The Humoral Response

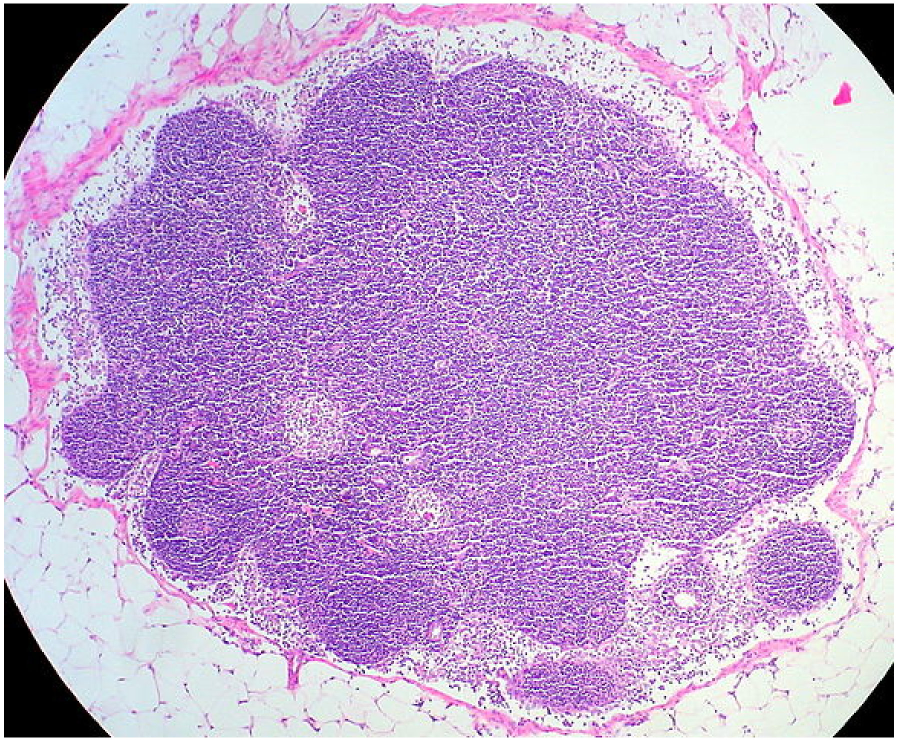
The humoral refers to the liquid that fills the spaces between the cells in a multicellular eukaryote. This fluid is transported and maintained by the **lymph system**, a series of vessels that filter and transport humoral through the organism.



If an invading microbe makes it past the innate immunity defenses, it will then be in the humoral and enter the lymph system.

The Humoral Response

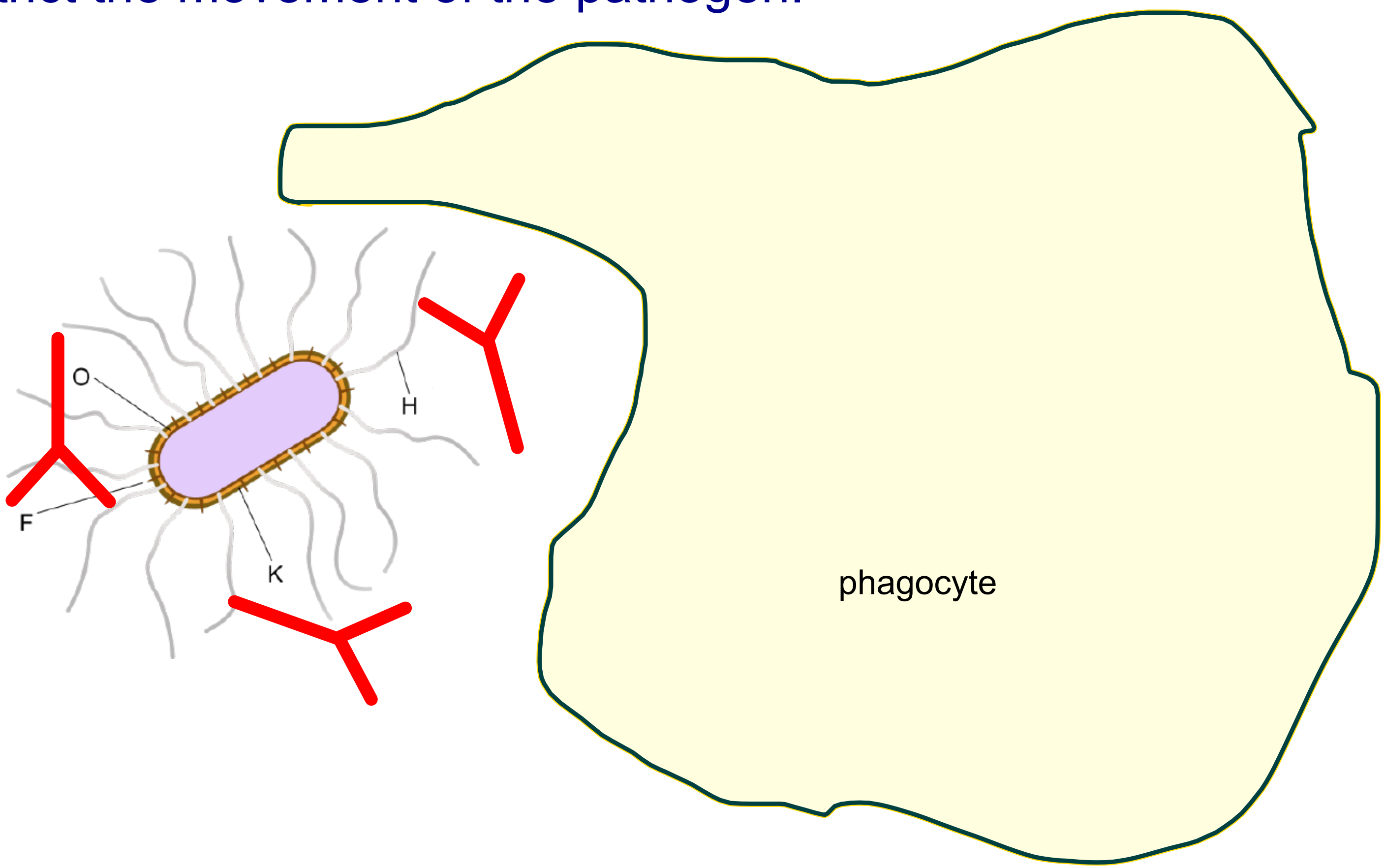
Inside the lymph nodes of the lymph system many leukocytes (white blood cells) known as **B cells** lay dormant until they are activated by a specific antigen.



A cross section of a lymph node magnified 100x. The small dots are millions of B cells. Each is slightly different than the others and will only be activated in the presence of a specific antigen.

The Humoral Response

Antibodies, also know as **immunoglobulins**, bind with the antigen to make the pathogen highly "visible" to phagocytes and restrict the movement of the pathogen.



The Humoral Response

Clonal selection is the process by which the humoral response to a specific pathogen is activated.

Watch the below video and see if you can identify the antigen.

Click here for an animation of clonal selection

The Humoral Response

Once a specific B cell is activated is remains active for the life of the organism. If the same invader ever enters the organism again it will be immediately tagged and destroyed.

This is know as immune memory. The second exposure will be quickly handled by the immune system because many B cells and antibodies are already circulating through the body.

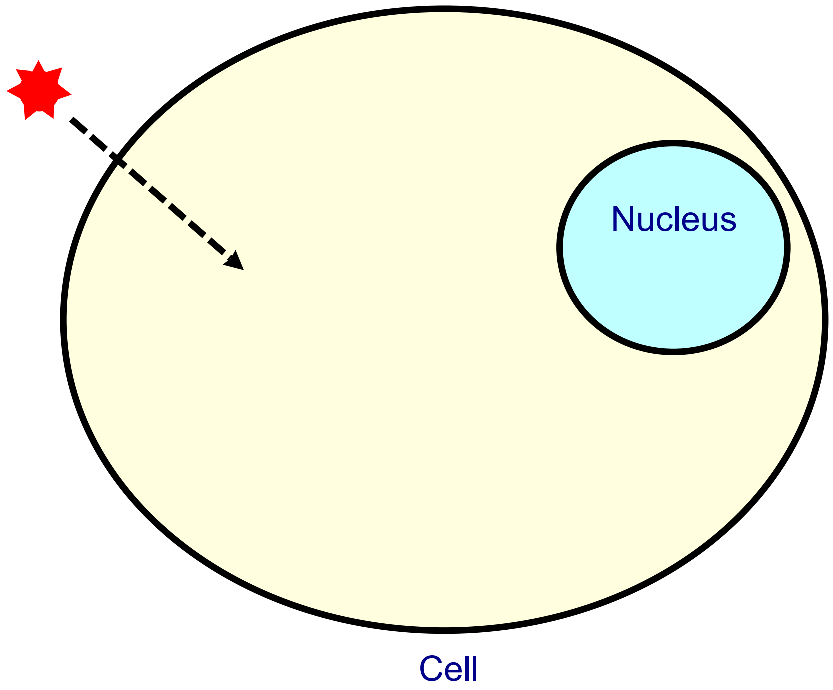
Cell-mediated Response

The last line of defense in the immune system.

Once the invading pathogen has infiltrated the cells of the mammal, the only way to get rid of the invader is to destroy the host cell.

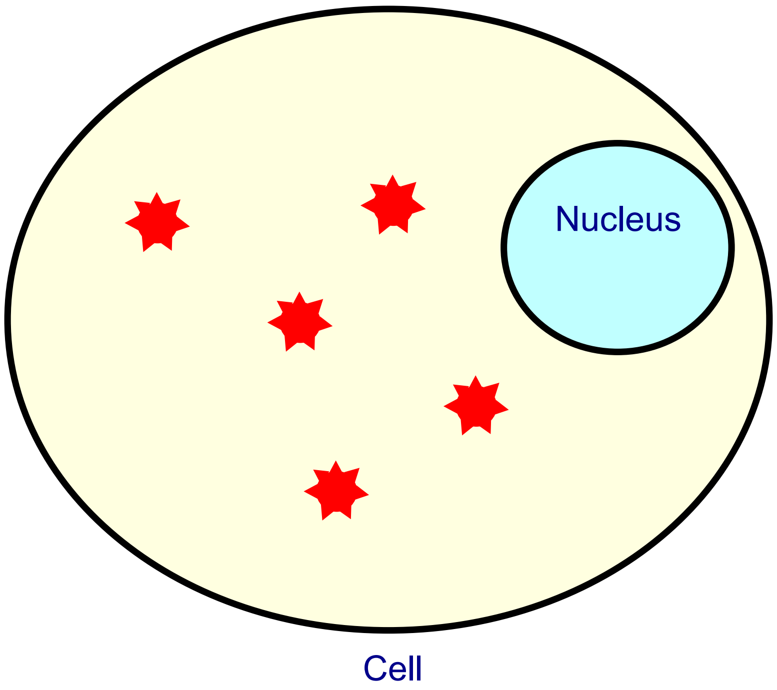
Cell-mediated Response

The pathogen gains access to the cell by penetrating its membrane.



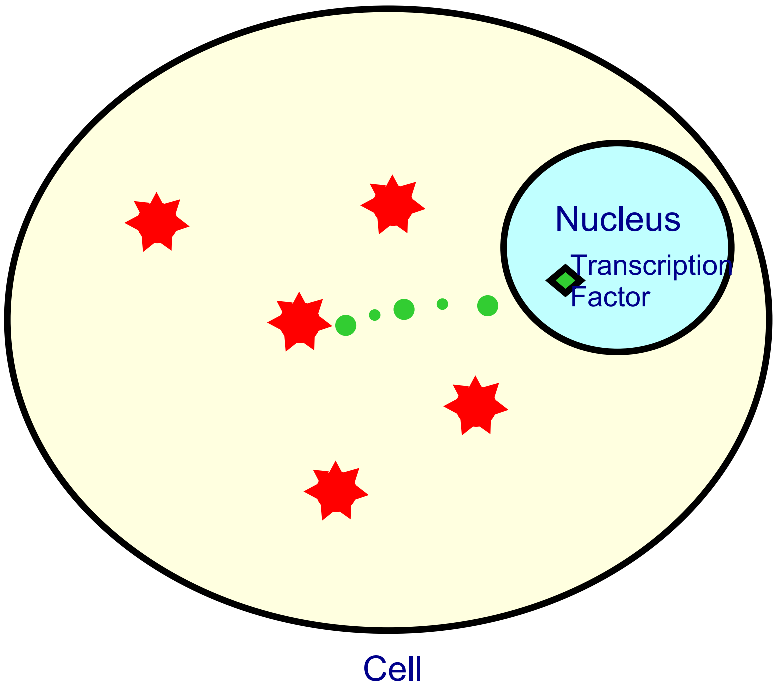
Cell-mediated Response

Once inside the cell the invader begins to replicate and disrupt the cells normal function.



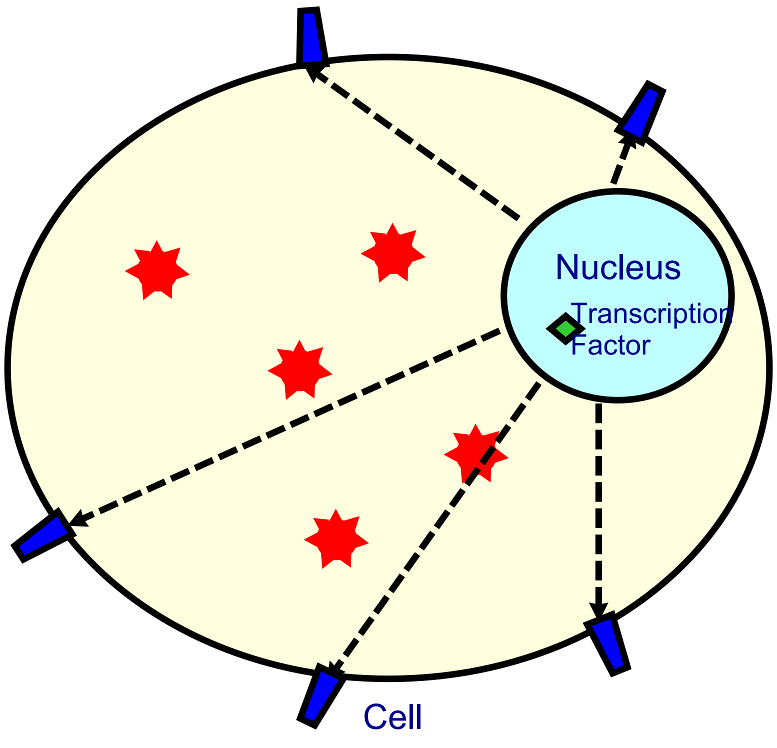
Cell-mediated Response

The disruption activates special molecules designed to alert the nucleus to a problem. They start a transcription pathway and a transcription factor is produced.



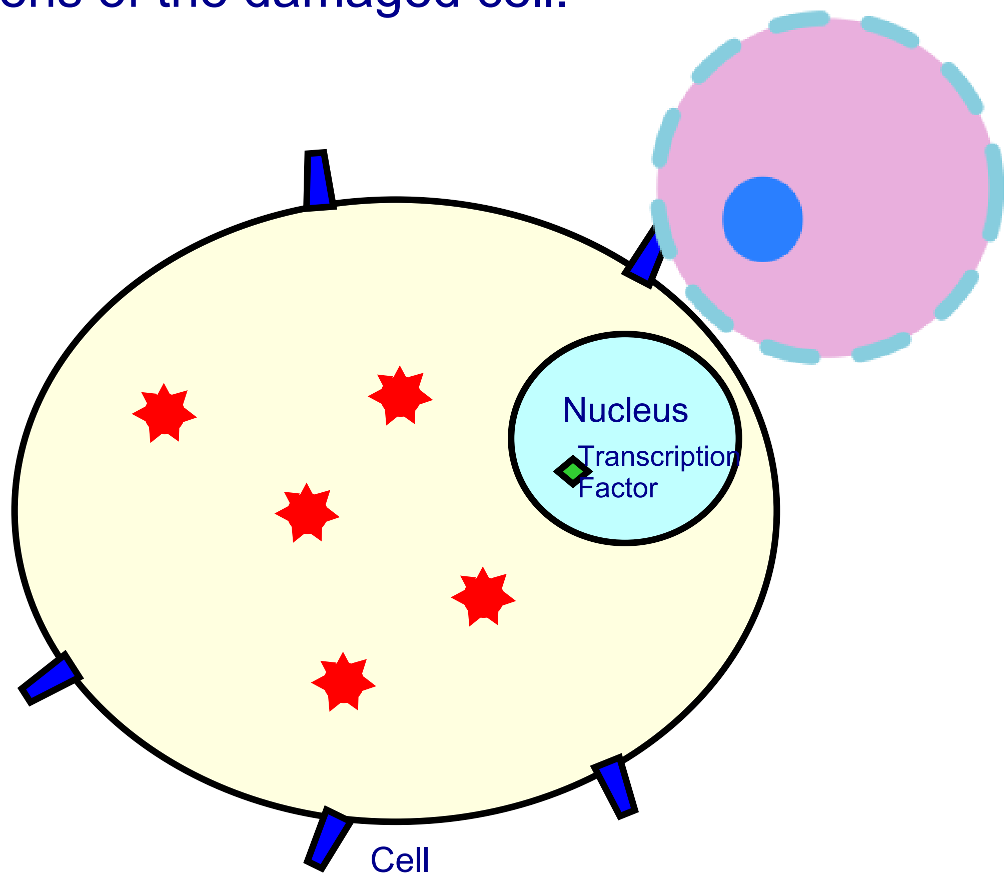
Cell-mediated Response

The transcription factor activates a gene that produces a membrane protein that will act as a flag to alert immune system cells that it is infected



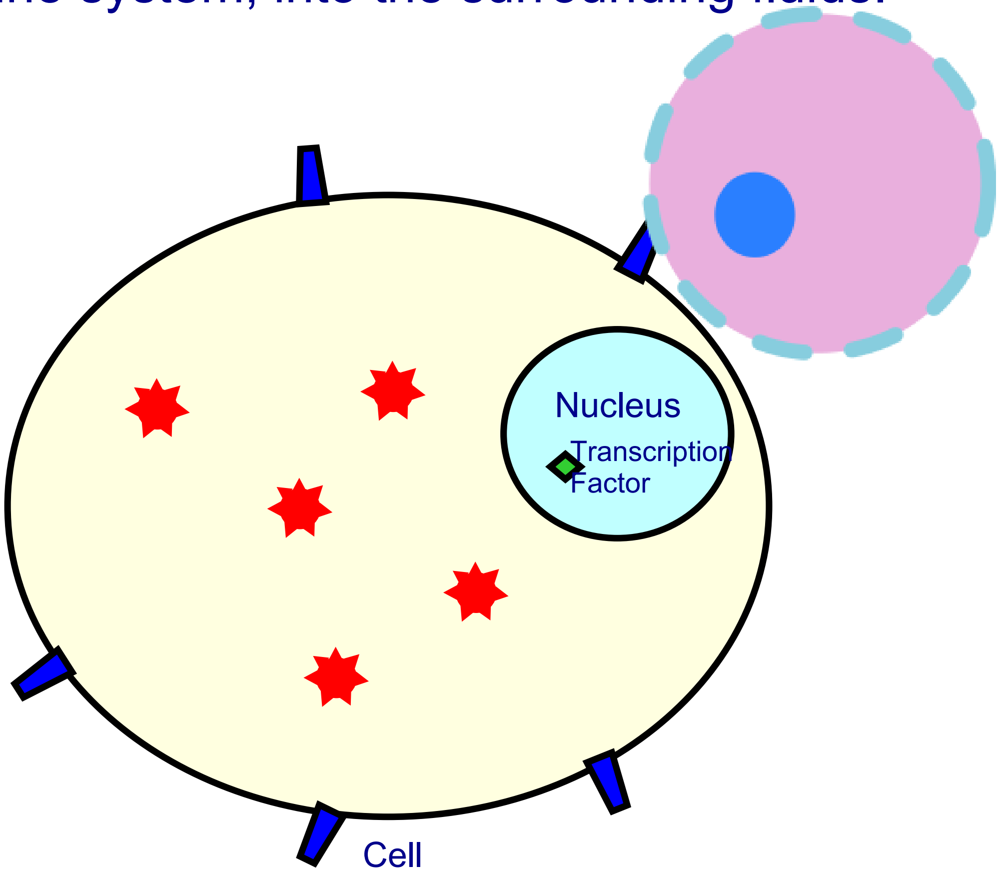
Cell-mediated Response

This cell is now a **dendritic cell** or antigen presenting cell. A special leukocyte known as a **helper T cell** attaches to the antigens of the damaged cell.



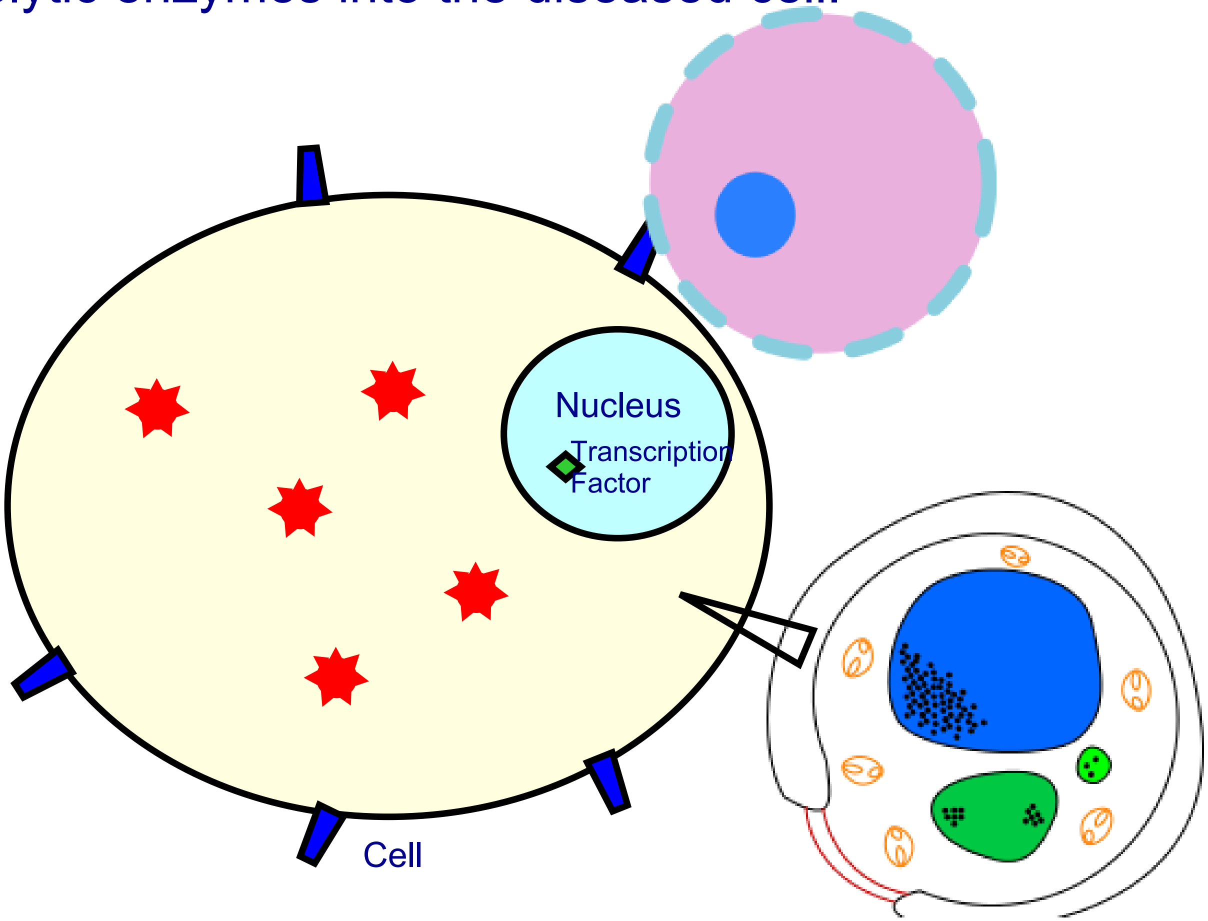
Cell-mediated Response

The helper T cell activates and releases **cytokines**, free floating proteins that communicate with other cells of the immune system, into the surrounding fluids.



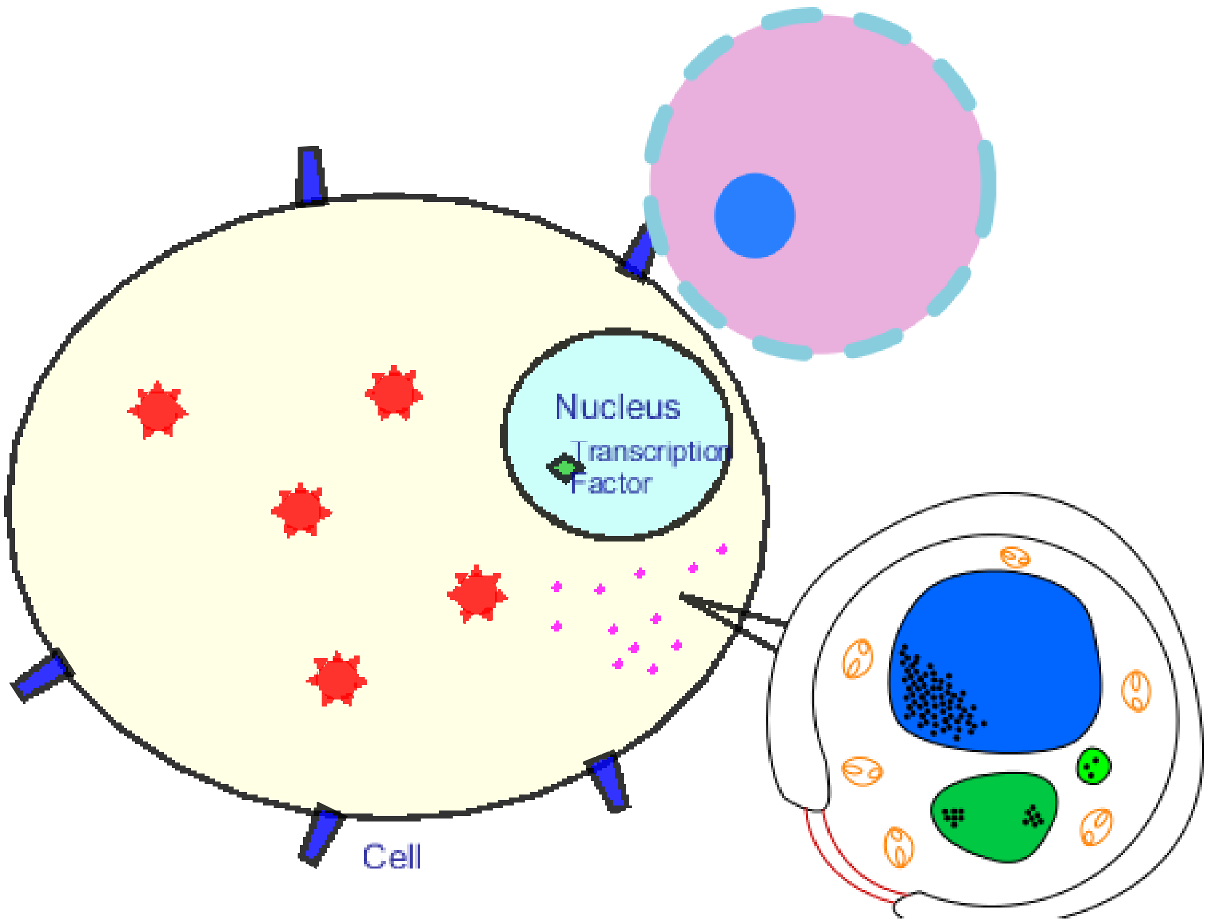
Cell-mediated Response

The cytokines do 2 things: They alert B cells to activate humoral defenses; and they bring **cytotoxic T cells** that inject hydrolytic enzymes into the diseased cell.



Cell-mediated Response

The diseased cell and its invaders are eliminated.



16

- A the T cells are destroyed
- B the pathogen is destroyed
- C diseased cell is destroyed
- D diseased cell and the pathogen is destroyed

17

- A Humoral response
- B Cell-mediated response

Immune System Practice

Imagine you are a virus trying to infect a cell. Put the below words in order of what you would have to overcome to successfully destroy a cell (some may be used more than once)

helper T cells

inflammation

phagocytes

cytotoxic T cells

cell membrane

phagocytes

mucus

skin

B cells

histamine

lymph system

antibodies