Branches On The Tree Of Life:

VIRUSES AND BACTERIA

Produced by BioMEDIA ASSOCIATES @ 2004 -- 30 minutes
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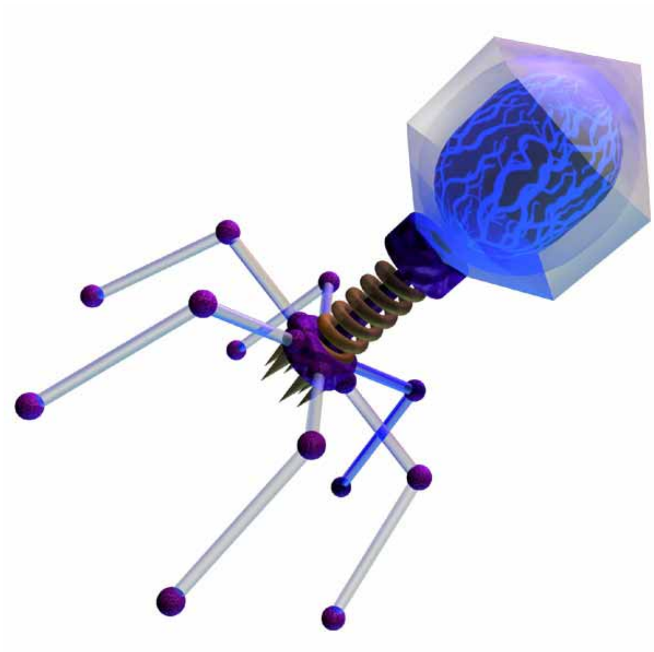
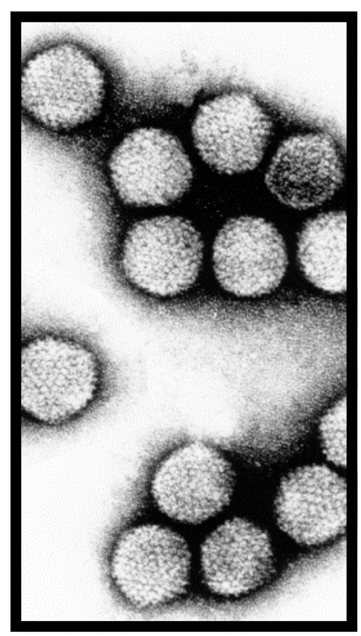


(Images in this guide are from the videeo program)

VIRUSES

Viruses are little more than packages of genetic information that subvert cells into producing more viruses. The discovery of viruses, and virus reproduction sections are from our 1980 film which has proven to be an excellent general introduction, and is presented with all new animation. A new six-minute section introduces “retroviruses” and describes the HIV infective cycle.

Discovery and Laboratory Study of Viruses



By the late 1800s bacterial-caused diseases were becoming well understood. Bacterial pathogens could be seen with a microscope and they could be cultured on agar plates. However, diseases in which no such organisms could be found confounded doctors and scientists. For diseases such as flues, measels, smallpox, and a number of other common ailments no causative organism could be found.

The break-through experiment showed that a certain disease of tobacco plants could be passed to healthy plants by inoculating them with the extracts from sick plants, after the extract had passed through filters that removed all bacteria-sized particles. The infective agent was rendered inactive by heat—a characteristic of a biological agent. It was also discovered that the mysterious agent could only increase within living cells. With the invention of the electron microscope in the 1940s virus particles were seen for the first time.

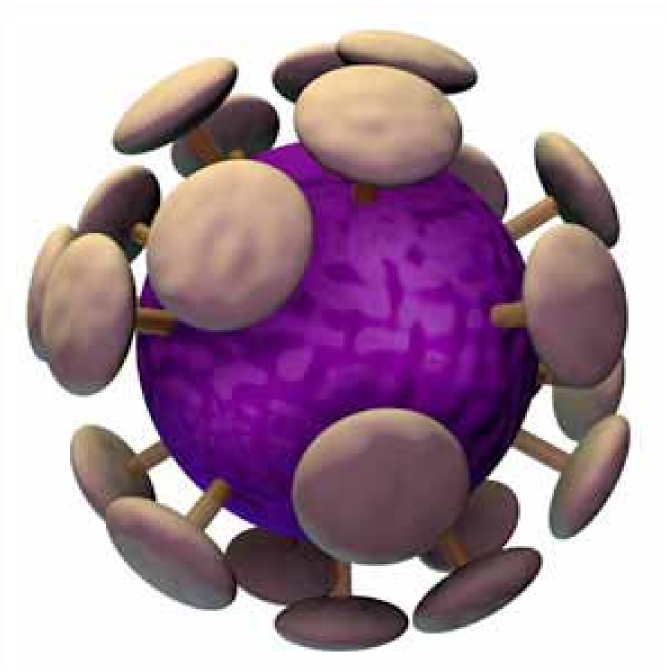
Viruses can only be cultured in living cells. The video shows a typical technique for using chick embryo cells to culture viruses.

Viruses are made up of a protein jacket, containing nucleic acids DNA or RNA, the genetic blueprints for making more viruses.

Virus Replication:

The virus outer jacket is covered by structures that aid the virus in recognizing and penetrating its host cell. These include receptor molecules that recognize a particular surface protein in the host cell's plasma membrane. Once viral genes are inside, they take over the host cell's protein manufacturing sites, feeding viral m-RNA into the host's ribosomes. In this way the host cell cranks out new viral proteins for the jackets, along with enzymes that will rupture the cell's outer surface, aiding the newly manufactured viruses in escaping from the cell.

Much of what is known about virus reproduction comes from studies of the viruses that attack bacteria. This is because bacteria are easily cultured, allowing the investigator plenty of material to work with. The T-4 bacteriophage and its many relatives have elaborate protein jackets that function as hypodermic needles, injecting the viral DNA through the bacterium's cell wall. Once inside, the viral DNA is translated into messenger RNA. mRNA feeds through the bacterium's protein-synthesizing equipment cranking out new viral proteins. The jackets are assembled first, then the viral DNA replicates many times. The DNA copies are inserted into the jackets. Eventually hundreds of new virus particles break out of the bacterium, ready to start a local epidemic in the bacterial population. In the lawn of bacteria on the experimenter's agar plates, these local "epidemics" each starting from a single virus, are seen as "plaques," clear regions of killed bacteria.



Retroviruses (HIV):

HIV is a retrovirus, a type of virus that uses RNA instead of DNA as its genetic instruction tape. HIV, which has a number of variations, is a parasite of primates, and the causative agent for AIDS in humans. The virus is delicate and does not remain viable outside of a body, so transfer is accomplished primarily by sexual activity or by contaminated needle use. Upon entering the blood stream, HIV binds to a particular type of white blood cell (a T-4 lymphocyte) using a particular cell surface protein as its signal. Engulfed by the cell, the viral RNA, helped by a particular viral enzyme (reversetranscriptase), is transcribed into strings of DNA. The DNA, again with the help of viral enzymes, snips into the host cell's DNA, becoming indistinguishable from the host's other genes. It may remain in this resting stage for long periods of time, or activate, transcribing new RNA blueprints for HIV. The RNA codes for its own jacket and these newly synthesized virus particles break out, killing their host cell and infecting nearby cells, causing failure of the host's immune system.

Bacteria

This program shows the vital roles bacteria play in the creation and management of ecological systems. It illustrates bacteria structure and shows how these tiny prokaryotes became integrated with nucleated cells, evolving into major cell organelles. It shows detailed observation of living bacteria, their structures, behaviors and interactions. It encourages students to set up “stinking brew” cultures in order to explore the diversity of naturally occurring bacteria through direct observation of the living organisms.

Bacteria & Atmospheric CO2

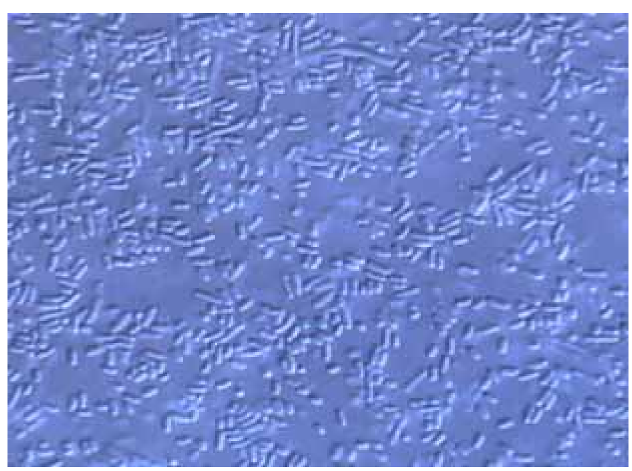
The “stinking brew” culture: To study bacteria in their natural environment, create a “stinking brew culture. As shown in the video program, place a handful of decomposing plant material into a jar and cover with aquarium or pond water. This is one of the best ways to culture vast numbers of very large bacteria, including many kinds that are easily observed with a student microscope. Textbooks often suggest that the only way to see bacteria is to kill and stain them on a slide. This approach is valid for disease-causing bacteria and can be useful for studying the shape of bacterial cells, but it misses the most interesting aspects of these amazing microbes — their behavior.

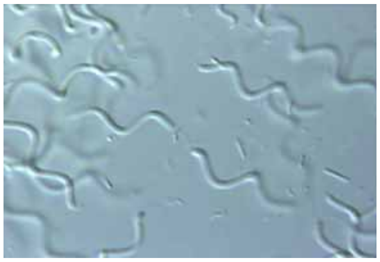
Decomposition-based Food Chains

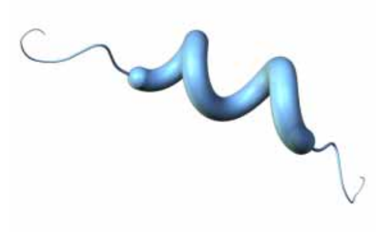
Analyze the footage of bacteria decomposing the Paramecium carcass. Based on your observations propose a theory that could account for their “homing” behavior. Make a list of the other adaptive traits shown in the DVD program.

Reproduction and Behavior

Begin with a bacillus 10 micrometers in length and give it an unlimited food source and optimum temperature so that it can divide every 30 minutes. Calculate how long it would take for a string of these rapidly multiplying rods to reach around the world.



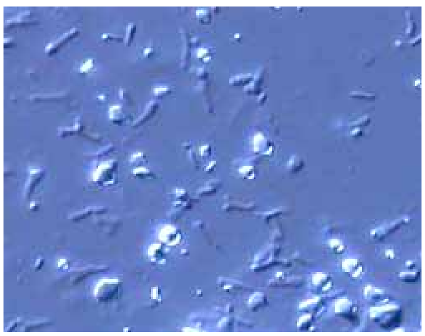




Spiral bacteria with flagella at each end. Light microscope view and graphic.

Nitrogen Fixation

How effective are nitrogen-fixing bacteria at encouraging plant growth? Compare growth rates between a set of bean plants grown in sterile soil and a set grown in soil to which the symbiotic bacterium *Rhizobacter* is added. When finished, compare the roots of plants in the test and control groups.

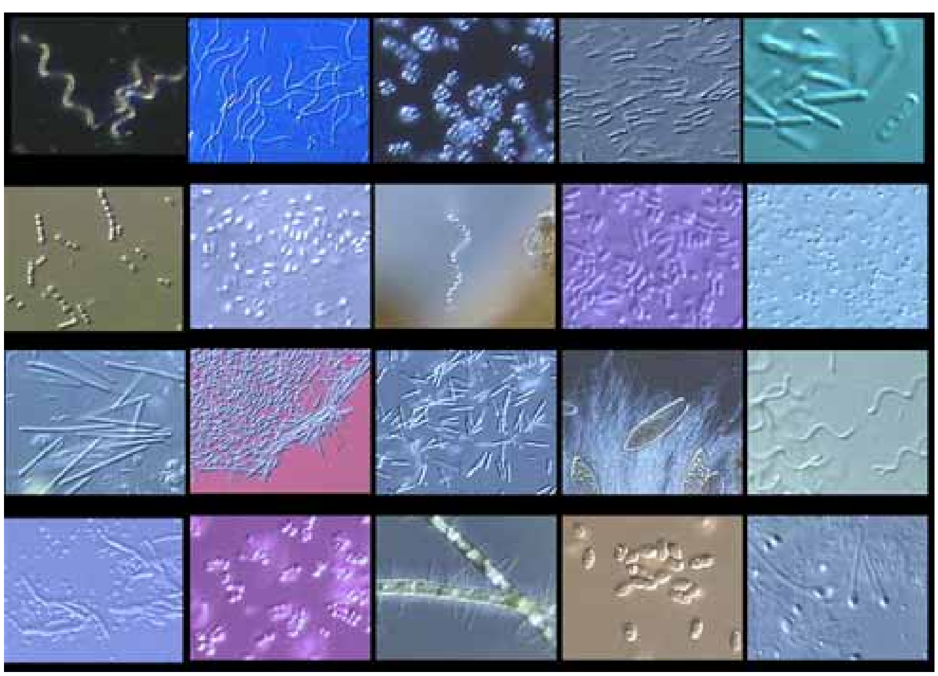


Rizobium (nitrogen-fixing bacterium)

Root nodules(full of N-fixing bacteria)

Bacteria Shapes & Structures

Most textbooks show the typical rods, spheres and spiral shapes found in disease–causing bacteria. Bacteria from the natural environment show a variety of additional shapes including long filaments, gliding strands, and chains. See how many different body forms you can find in your “stinking brew” culture.

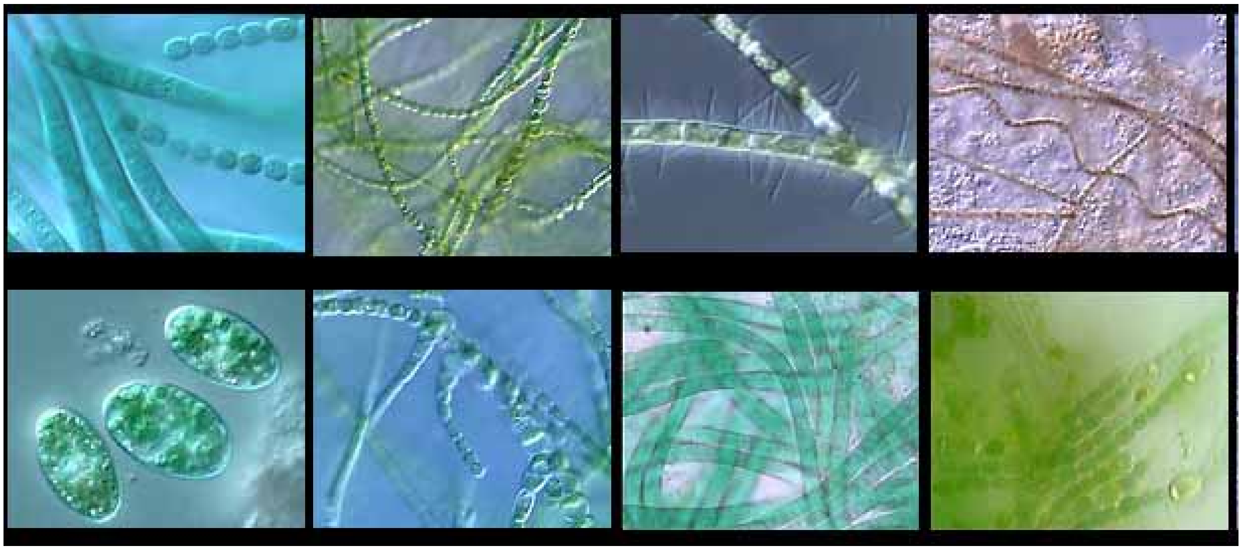


Bacteria Are Prokaryotic Cells

Make a list of the differences between prokaryotic cells (cells without membrane–bound organelles and without a nuclear envelope) and eukaryotic cells (cells that have these features).

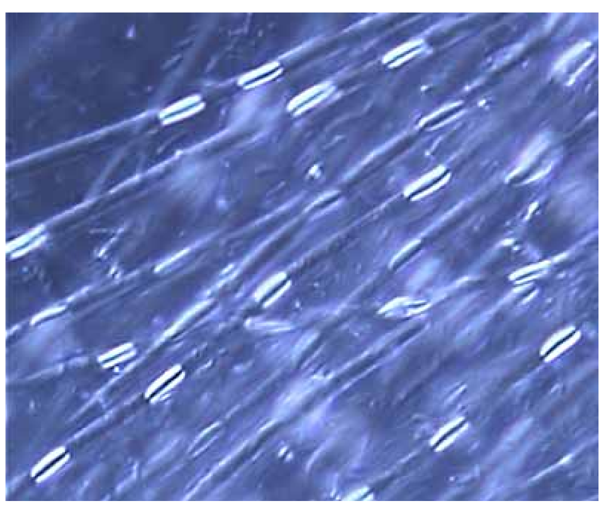
Cyanobacteria

Until recently, cyanobacteria were called blue-green algae. Today biologists separate photosynthetic prokaryotic cells from eukaryotic cells (green, brown, and red algae). How might planet earth look today had cyanobacteria not developed water-splitting photosynthesis?



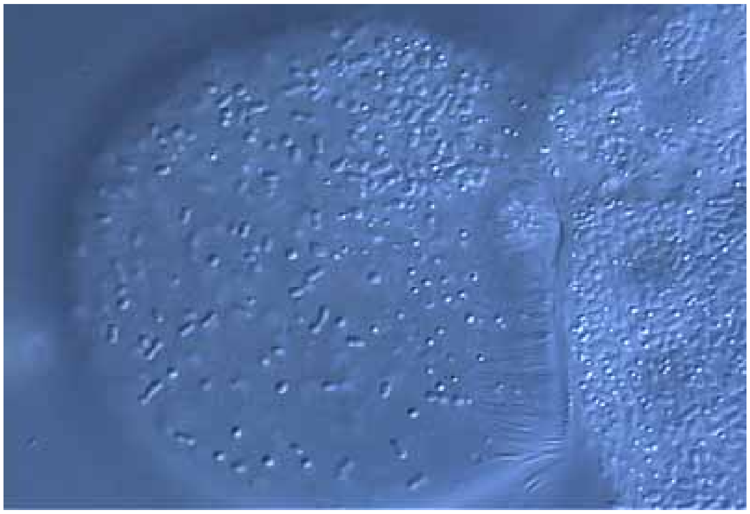
Bacteria as Symbionts

Opportunities for getting the nutrients and high energy compounds needed to support bacterial reproduction abound in the bodies of plants and animals. It's not surprising that certain bacteria have moved in and developed the adaptations for dispersal from human to human. Spores allow a time outside, awaiting the next host. Coughing and diarrhea are conditions induced by the parasite that encourage its dispersal. Some pathogens, such as the spirochetes that cause syphilis are transmitted sexually, never being required to leave a human body.



Tadpole intestine bacteria with spores

It may surprise that a number of the key organelles that make up our cells originated as symbiotic bacteria that formed long lasting partnerships with our cellular ancestors. The endosymbiotic theory of cellular evolution has become a foundation principle of modern biology.



Mitochondria in membrane bubble

Additional Bacteria Observations

We have added a 12 minute section showing living bacteria and cyanobacteria. This can be used as an introduction to the study of bacteria, where the observations are guaranteed to generate questions and interested discussion. Following up with the narrated modules then becomes an even more effective way to introduce the major concepts of bacteriology. The section contains many surprising observations—raw material for student research using frame by frame analysis of bacteria behavior. The observations can also be played during laboratory sessions to create a visual “bacteria ambiance” in the lab or classroom.