AP Biology Summer Reading - *The Hot Zone* by Richard Preston

You will be reading a book that is"...bloodcurdling, and based on truth." The book Is about the Ebola virus. Before you read the book read the attached information about viruses. If you have questions about the assignment, the virus handouts or about the questions below, email me: catherine.raziano@zacharyschools.org

As you read the book, ***The Hot Zone***, summarize the chapters as notes for yourself in what you are going to use as your AP notebook. Read and highlight the attached handouts on viruses and put them in the notebook as well. As you read, list and define new scientific terms in your notebook. This is for you to use to study for your first test which will include information from the book and the handouts.

Read the questions below before you read the book *The Hot Zone*. Answer the questions listed below on a separate piece of paper, typed or hand-written. Your responses to the questions are due on the first day of class. We will discuss the book and viruses on the first day of class so bring the book ***The Hot Zone*** to school for the first day of class.

The new AP curriculum is all about finding supporting evidence from what you have read, about doing labs or reading about experiments and being able to use data to support hypotheses. I have adjusted the questions about this book to that type of question so some of the questions have changed since last year.

Have a great summer- hope you enjoy the book as much as I did!! See you soon!

Questions

1. Describe Monet's symptoms. Did they appear all at the same time or little by little?

2. State and then explain what would you have done if you had been a passenger on the plane with Monet to protect yourself from the disease?

3. What could you have done to help Monet on the plane?

3. Evaluate the section of the book when Monet is being treated in the emergency room. What did Dr. Musoke do that could have contributed to the spread of the disease? Explain

4. Around p. 39 (it probably depends on the type of book you used), the author lists four possible intermediate hosts. What is an intermediate host? Pick any two of the four he lists and give evidence to support the idea that those are intermediate hosts.

5. Who was Peter Cardinal? Describe the steps of the experimental protocol that Gene Johnson used to culture the sample of Peter Cardinal's blood serum to isolate the cause of his death..

6. Describe the experiment and the evidence from the experiment that confirmed that Ebola could travel through the air. What happened in the monkey house in Reston that also supported that idea? Explain.

7. Why do scientists keep diaries of their lab notes? Is this a useful practice? Explain.

8. How did the scientists in the book culture (make more viruses) the Ebola virus? What does culture mean in the previous sentence?

9. There were at least four different samples of Ebola-like virus cultured, what were the samples?

10. Write a list of the steps in the procedure used by Geisbert to prepare samples for the EM.

11. Peter thinks Marburg is not easy to catch. Make a list of evidence to support his hypothesis.

12. Dan thinks that Marburg is an airborne infection. Make a list of evidence to support his hypothesis.

13. What could Jarhrling do to test to see if the monkey virus reacted in humans? What did it mean if the cells were glowing?

14. Summarize Col. Nancy Jaax's arguments answering General Russell's questions as to whether there was any evidence that the virus was airborne. What could you add to her argument?

15. Tom resolves to keep working even if he tests positive for the virus. How would you have reacted under these same circumstances? What other plans would you make about your life if you had been in Tom's shoes?

16. Ebola and other similar viruses are said to "hide". How and where does a virus strain "hide" ? What evidence supports your answer?

18. Given what you know about this case and what happened to the people involved, if you were President of the US at the time, who would you have promoted and who would you have gotten fired? Explain why you would make those decisions?

19. What factors make Kitum Cave "a nice place for a virus to jump species?" Give evidence to support each of your factors?

20. Based on this true story of Ebola, what is your opinion about viruses -are they living or non living - use facts to support your answer.

22. Based on the information in the book and in the handout, what type of viral life cycle do Ebola have? What facts from the book support your statement?

Difficulties With the Five-Kingdom System

We have seen that all classification schemes pose problems, and the five-kingdom system is no exception. There is clearly a distinction between prokaryotes and eukaryotes. However, the four eukaryotic kingdoms are unsatisfactory for two main reasons. First, modern taxonomy should aim to classify organisms so that the members of a group are related more closely to each other than to members of other groups. The kingdom Protista violates this rule by containing organisms that are related more closely to some plants than to any other protists. Second, many different protist lines gave rise to multicellular groups, and so none of the three higher kingdoms contains the single ancestor (if any) of all its members. For instance, different groups of fungi clearly arose from different protist groups rather than from a common fungal ancestor. In fact, multicellular lines originated from protists at least 17 different times, and it seems likely that the eukaryotic condition itself originated independently more than once. Breaking up the world of life into truly monophyletic groups would give us more kingdoms than we wish to bother with for most purposes. Despite its inadequacies, the five-kingdom system is widely used today, not because it is natural but because it is convenient.

19-E The Problem of Viruses

Viruses are tiny particles composed largely of nucleic acid and protein, but lacking many of the features of living cells. They occupy a strange limbo somewhere between the living and nonliving worlds. Viruses are like living organisms in possessing genetic material, composed of nucleic acids and capable of mutation and recombination. Viruses can therefore evolve and adapt to their changing environments. On the other hand, viruses are not made up of cells, and they have no ribosomes, nor the metabolic machinery for protein synthesis and energy generation.

Lacking these components, viruses are invariably parasites. They can reproduce only inside living cells, and even here their reproduction is unique. Cells reproduce by growing and eventually dividing into two new cells. By contrast, viruses are disassembled into their separate components: nucleic acid genomes and protein coats. The virus takes over the host cell and causes its metabolic machinery to produce a few dozen to hundreds of new viral genomes, and thousands of protein subunits to make new viral coats. Then these components are assembled into new virus particles. These particles are the same size as the original: unlike cells, viruses do not grow (Table 19–2).

TABLE 19–2 Differences Between Viruses and Cells

CHARACTER	VIRUSES	CELLS
Structure	Virus particle: nucleic acid core inside protein capsid	Cell containing nucleic acids, lipid-protein membrane, ribosomes, cytoplasm, etc.
Nucleic acids	DNA or RNA, but not both	Both DNA and RNA
Enzymes	One or a few; e.g., lysozyme (digests bacterial cell wall), polymerase (replicates viral genome)	Many enzymes; diverse functions
Metabolism	None; relies on host cell metabolism for monomers, protein synthesis machinery, and some enzymes of nucleic acid synthesis	Makes own ribosomes and enzymes needed for synthesis of proteins, nucleic acids, etc.
Reproduction	Nucleic acid genome and capsid proteins produced separately, then assembled into virus particle	Division into two similar cells following growth

Another bizarre feature of viruses is that many of them can be crystallized, a common enough property of minerals and even of fairly complex organic molecules, but certainly not of living cells. Furthermore, crystallized viruses, when wetted and exposed to living host cells, soon establish infections and get back to the business of causing the cell to make more virus particles.

Because of all these odd characteristics, viruses are not considered real living organisms and do not belong in the five kingdoms. Nevertheless, since viruses are active only inside living cells, and indeed may have devastating effects on their hosts, the study of viruses is clearly the province of biology.

Viruses are tiny parasitic particles that can be produced only inside living cells. Viruses do not eat, grow, metabolize, make proteins, or reproduce by themselves, but they do evolve.

19-F Virus Structure

Viruses are extremely small, ranging from about 15 to a few hundred nanometres in diameter. Only the largest surpass the smallest bacteria in size. The "basic" virus particle consists of a nucleic acid molecule and a surrounding protein coat, the **capsid.** In addition, some viruses have a membranous outer envelope of glycoprotein and lipid covering the capsid. Most of these enveloped viruses infect animals. Virus particles may also contain one or a few enzymes—those needed for them to invade a cell and for the replication of the viral nucleic acid.

The capsid protects the genetic material in its passage from one host cell to another. Viral capsid or envelope proteins also bind specifically to receptor molecules on the host cell's outer surface, the first step in invading a cell. The capsid is made up of a number of protein subunits, and their organization determines the virus particle's shape: most are either helical or polyhedral, or a combination of the two. A more complex structure occurs in some **bacteriophages**—viruses that infect bacteria, often called just **phages** (Figure 19–11).

The viral genome consists of a molecule of DNA or RNA, but not both, which may be either single- or double-stranded. Some RNA viral genomes

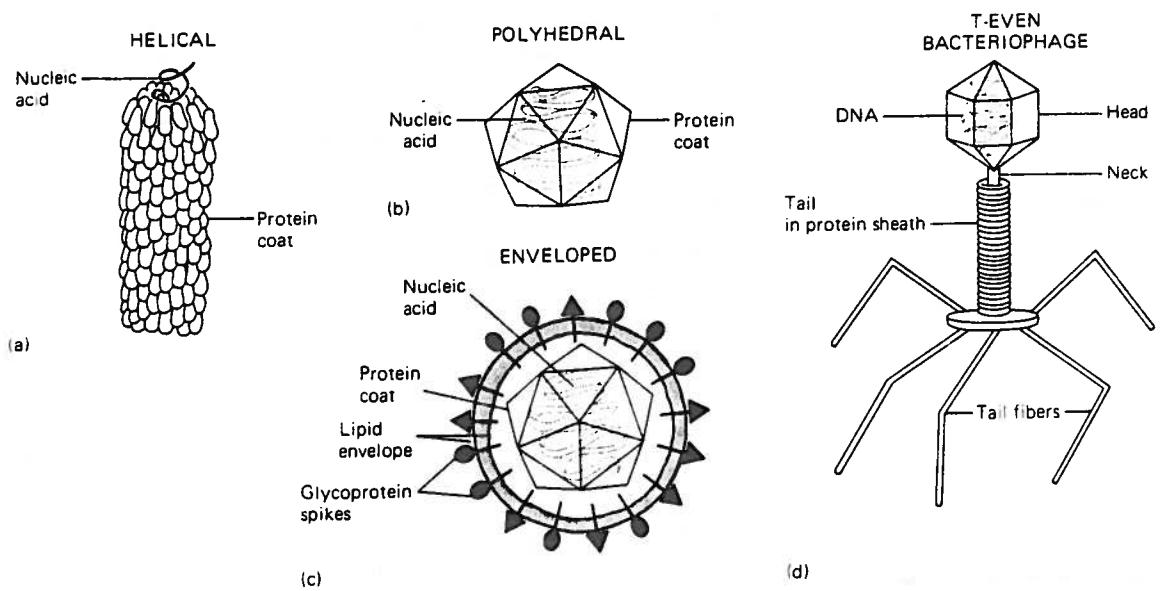
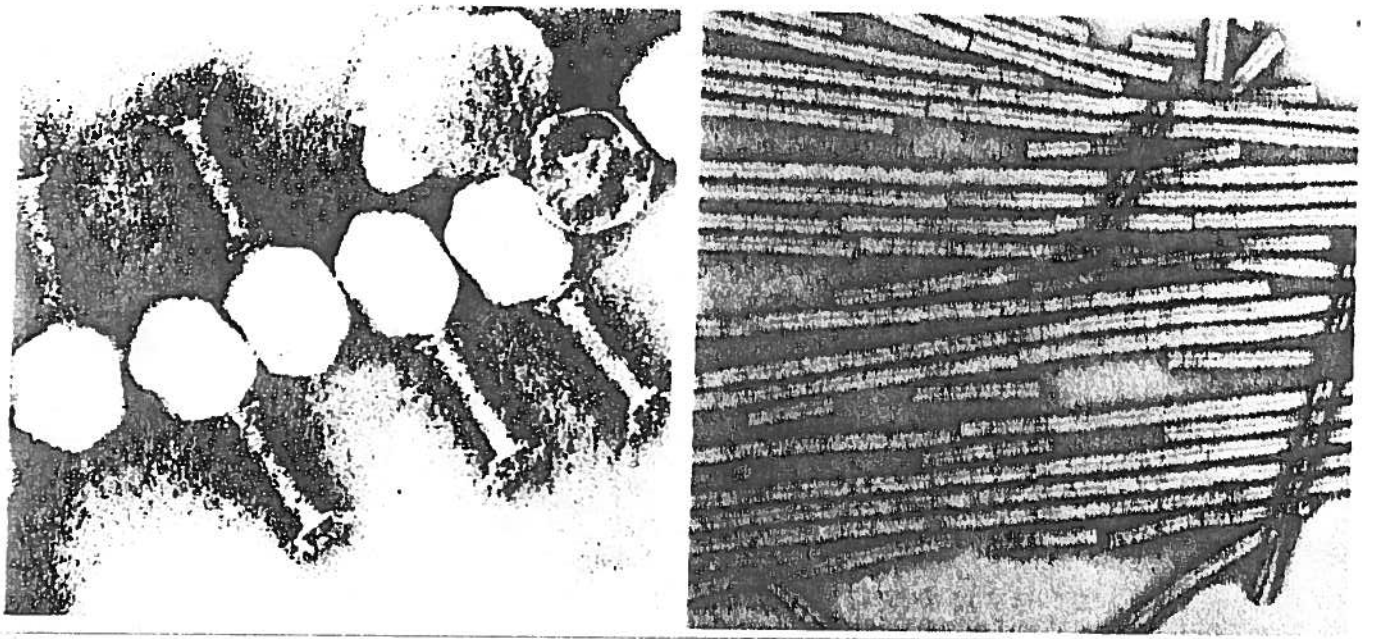


FIGURE 19–11 Virus structure. (a) The nucleic acid of a helical virus is wound inside a coat of repeating protein subunits arranged in a helical pattern. (b) A polyhedral virus has a protein coat in the shape of an icosahedron, a geometric solid having 20 faces. (c) Enveloped viruses have a membranous outer envelope around a helical or (as here) polyhedral protein coat. (d) T-even bacteriophages, which attack Escherichia coli, *have more complex protein coats. The head encloses the DNA genome. The tail fibers attach to the bacterial cell wall and contract to inject the DNA into the host cell.*



(a) (b)

FIGURE 19–12 Electron micrographs of virus particles. (a) Bacteriophage T4, which infects Escherichia coli. *(b) Tobacco mosaic virus, the first virus shown to have RNA as its genetic material. (a, Carolina Biological Supply Company; b, Biophoto Associates)*

consist of more than one molecule. The largest viral genomes contain hundreds of genes, whereas the smallest have only a handful. In something as small as a virus, space is extremely limited. There is room only for genes that code for basic necessities, such as viral coat proteins, virus-specific nucleic acid polymerase enzymes, enzymes needed to take over the host cell, and regulatory genes for rapid production of new viral components. In enveloped vi-

TABLE 19–3 Major Groups of Viruses That Infect Animals

GROUP	EXAMPLES—SOME MEMBERS CAUSE
VIRUSES WITH DNA GENOMES	
Poxviruses	Smallpox, cowpox, myxomatosis in rabbits, diseases in fowl
Herpesviruses	Human oral and genital infections, Epstein-Barr infections, tumors
Adenoviruses	Human respiratory and intestinal infections, conjunctivitis, sore throat, tumors
Papovaviruses	Human warts; cancers in other animals
VIRUSES WITH RNA GENOMES	
Paramyxoviruses	Human rubeola, mumps; canine distemper; Newcastle disease of chickens
Myxoviruses	Influenza of humans, other animals
Retroviruses	Rous sarcoma of chickens; mouse mammary tumor; feline leukemia; AIDS
Rhabdoviruses	Rabies, various infections
Reoviruses	Vomiting and diarrhea in children, Colorado tick fever
Togaviruses	Human rubella, yellow fever, dengue, equine encephalitis, etc.
Picornaviruses	Intestinal infections (enteroviruses), poliomyelitis, common cold (rhinoviruses)

ruses, the envelope proteins are encoded by the viral genome, whereas the lipids are appropriated from the host cell's plasma membrane.

A virus consists of a DNA or RNA molecule inside a protein capsid, which is sometimes enclosed in a membranous envelope.

Viruses are classified according to whether they have DNA or RNA genomes, by capsid shape and size, and by presence or absence of an envelope. Table 19–3 lists major groups of viruses that infect animals.

19-G Viral Reproductive Cycles

Three main types of reproductive cycles have been found among viruses.

A **lytic cycle** occurs when a virus invades a cell, destroys the cell's DNA, takes over its metabolic machinery, and causes the cell to make as many as several thousand new virus particles. Viral enzymes then cause the cell to break, or **lyse**. The released virus particles disperse to infect new host cells (see Figure 9–4). A cell invaded by a lytic virus is almost invariably killed by it within a very short time.

Some phages, called temperate phages, may either go through a lytic cycle and destroy the host cell, or may instead enter a dormant phase in which their DNA is joined to the host's (Figure 19–13). Here the viral DNA is replicated with the host's in each cell generation. A host cell containing a temperate phage is called a **lysogenic** cell. Certain external stimuli can cause a lysogenic

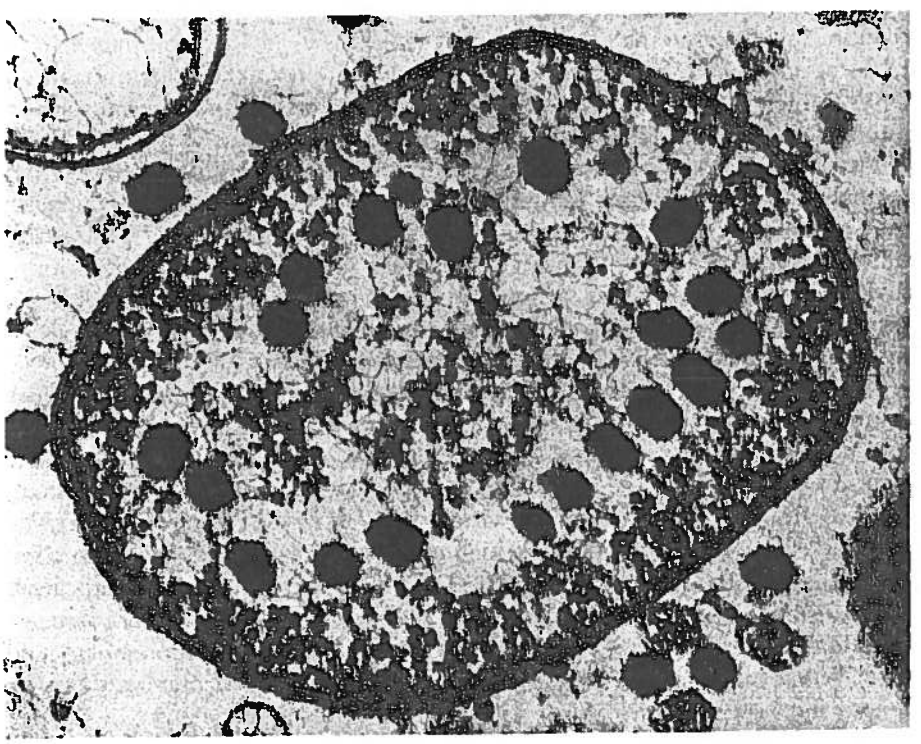
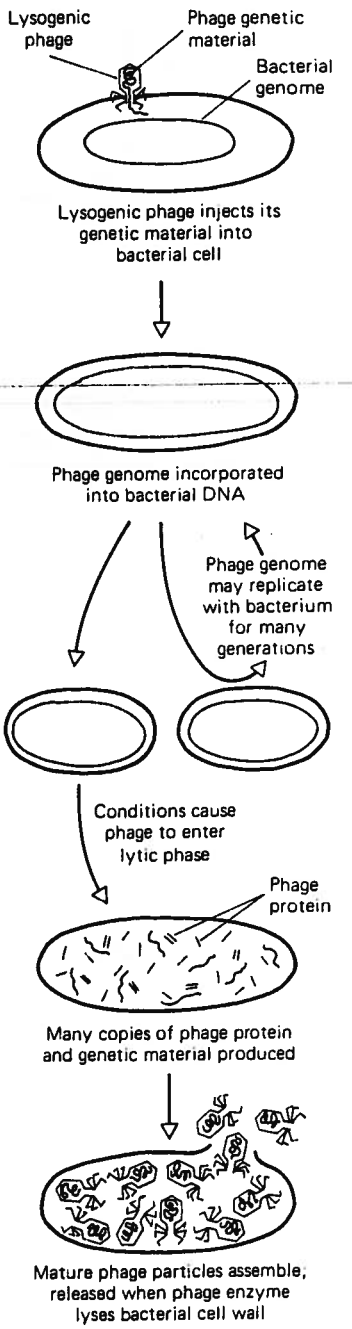


FIGURE 19–14 Electron micrograph of a cell of the bacterium Escherichia coli *infected with a bacteriophage. The black hexagons inside the cell are new phages produced after the phage genetic material was injected into the bacterium. Note the empty phage coats attached to the cell wall. The thin fibrous material in the cell is DNA. (L. D. Simon,* Virology *38:287, 1969)*

FIGURE 19–13 Reproductive cycle of a lysogenic, or temperate, phage. The host may survive for many generations with the phage genetic material incorporated into the host genome, until some condition triggers the phage to become lytic. In a strictly lytic cycle, the second and third steps shown here do not occur.



cell's phage DNA to enter the lytic cycle, releasing intact phages. Herpes viruses in animals show comparable cycles.

Some lysogenic bacterial cells are of importance to human health. The bacteria that cause diphtheria, botulism, and scarlet fever produce the toxins responsible for these diseases only when they contain particular phages, which carry the genes encoding the toxins.

Phages that are released when a lysogenic cell finally lyses may carry along part of the bacterial DNA, which is later inserted into the DNA of a new host bacterium. This process, called **transduction** ("carrying across"), produces genetic recombination in the new host. Viruses that can carry DNA from one cell to another are used in recombinant DNA experiments (Section 11-D) and in studies of bacterial genetics.

In the lytic and lysogenic cycles, virus particles are assembled inside the host cell and released when the cell lyses. A few phages, and many animal viruses, are produced and released continuously by budding from intact host cells. New copies of the viral genome and capsid combine in the cytoplasm and then move to the host's plasma membrane. Here they attach to viral envelope proteins that the host has made and inserted into its own membrane. The host's plasma membrane then bulges out around the forming virus particle, until at last the virus, surrounded by its new membranous envelope, buds off from the host cell (Figure 19–15). Enveloped animal viruses that bud from their host cells in this way include influenza, measles, mumps, and rabies viruses.

Viruses with genomes of RNA instead of DNA have novel mechanisms of replication. If the RNA is single-stranded, it usually serves as the template for a complementary RNA strand. This second strand then acts as a template for new copies of the viral genome identical to the original RNA strand.

Other viruses with single-stranded RNA genomes code for an unusual enzyme called **reverse transcriptase.** Contrary to the usual flow of genetic information, this enzyme uses the RNA as a template to make a complementary DNA strand! Next, the DNA acts as the template to make double-stranded DNA, which is then inserted into the host cell genome. Here it is transcribed into many new viral RNA molecules.

Viruses that produce reverse transcriptase are called **retroviruses.** Since their genomes spend some time joined to the host DNA, new retrovirus particles may also incorporate host genes and carry them to new host cells. At least 20 different vertebrate genes that can cause cancer (oncogenes) have been identified in various retroviruses. When these genes are controlled by the virus's promoter signals, the cell may contain too much of the encoded protein, which in turn causes changes that make the cell cancerous.

An example of a retrovirus with a lytic cycle is the one that causes acquired immune deficiency syndrome (AIDS). The AIDS virus enters the bloodstream and its capsid binds specifically to receptors on a T helper cell (part of the immune system; Chapter 26). Inside the cell, the virus loses its protein coat, leaving the RNA genome and the virus's one enzyme in the cytoplasm. The enzyme is reverse transcriptase, which rapidly makes a DNA molecule complementary to the RNA genome. The DNA enters the nucleus, inserts itself into a cell chromosome, and directs the cell to produce more AIDS viruses. Eventually the cell releases a flood of new viruses into the bloodstream and dies. When many of its T helper cells have been destroyed, the body can no longer fight off diseases.

Some viruses destroy their host cells within a short time of attacking them. Others "go underground" in the host's DNA for long periods before they are reproduced and destroy the host. Still others cause living host cells to produce new virus particles continuously.

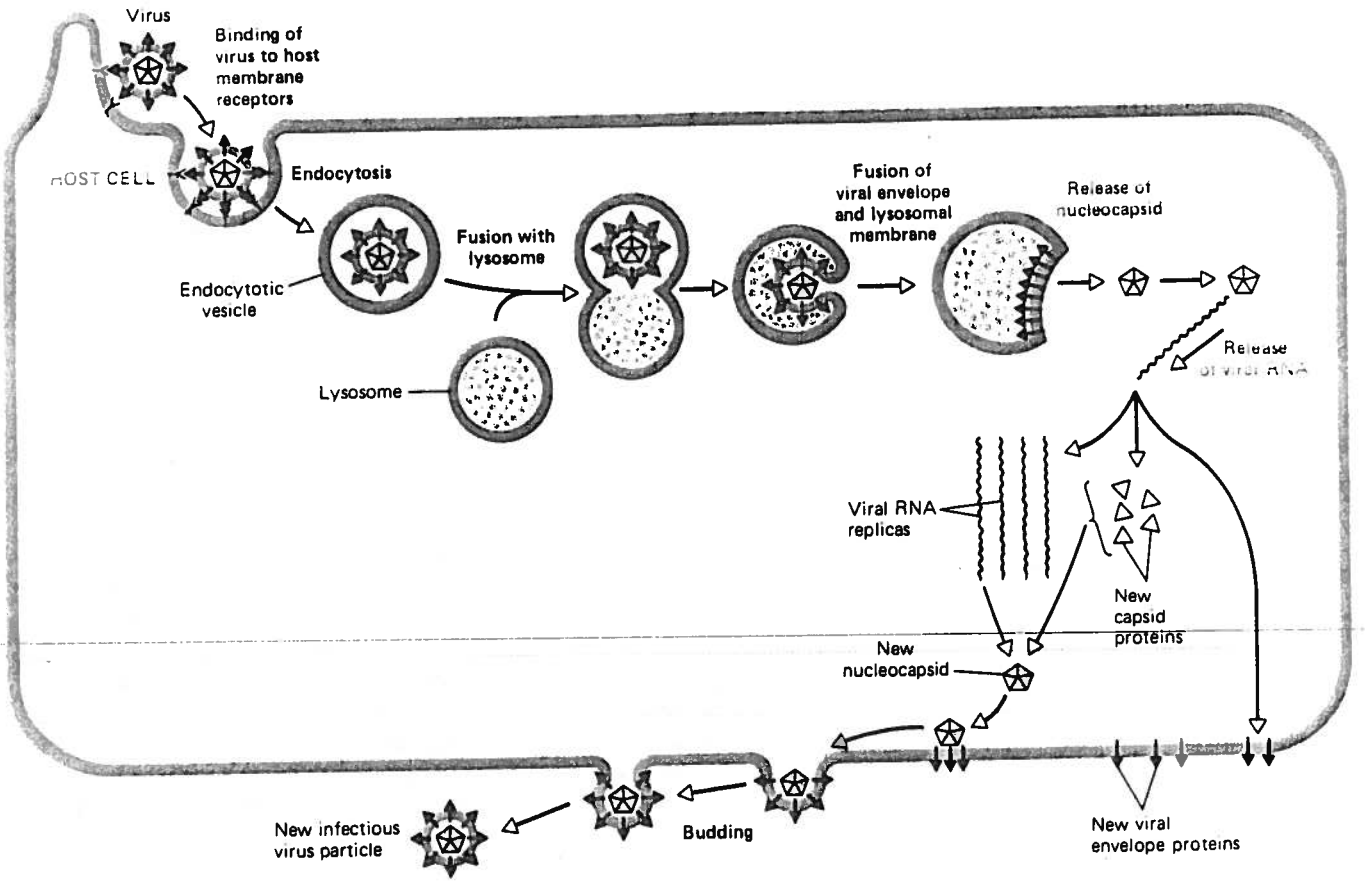


FIGURE 19–15 An animal cell becomes infected by a virus (top left) and produces many new viral genomes and protein coats, which combine in the cytoplasm to form nucleocapsids. These move to the plasma membrane, where they associate with new viral envelope proteins, also produced by the host under the direction of viral RNA. The finished virus particle buds off from the plasma membrane (bottom).

19-H Viral Diseases of Plants and Animals

Before a virus can invade a cell, its outer proteins must bind to protein receptors on the host cell surface. Because of this specificity, each kind of virus can attack only particular kinds of host cells. Polio viruses can infect only humans and a few other primates (monkeys, apes, etc.); the common cold virus attacks the cells lining the human respiratory tract.

Virus diseases of plants include tobacco mosaic and necrosis, alfalfa mosaic, and wound tumor. Plant viruses may be spread by wind or insects. It is usually impossible to cure diseased plants. Instead, farmers try to prevent the spread of viruses, and breeders try to develop virus-resistant strains of important crop plants.

Viral diseases of animals include rabies, chickenpox, polio, colds, influenza, warts, AIDS, and some forms of cancer. Various herpes viruses that cause eukaryotic cells to become lysogenic may cause some human cancers. Different herpes viruses cause cold sores, venereal infections, and mononucleosis. Even after the symptoms of the infection have disappeared, the virus apparently remains in a lysogenic form, and can enter the lytic cycle when the person is ill or stressed, causing a fresh outbreak of cold sores or genital sores.

Most viruses cause disease by disturbing the cell's metabolism and eventually destroying it. The virus is reproduced in the dying cell, and the new

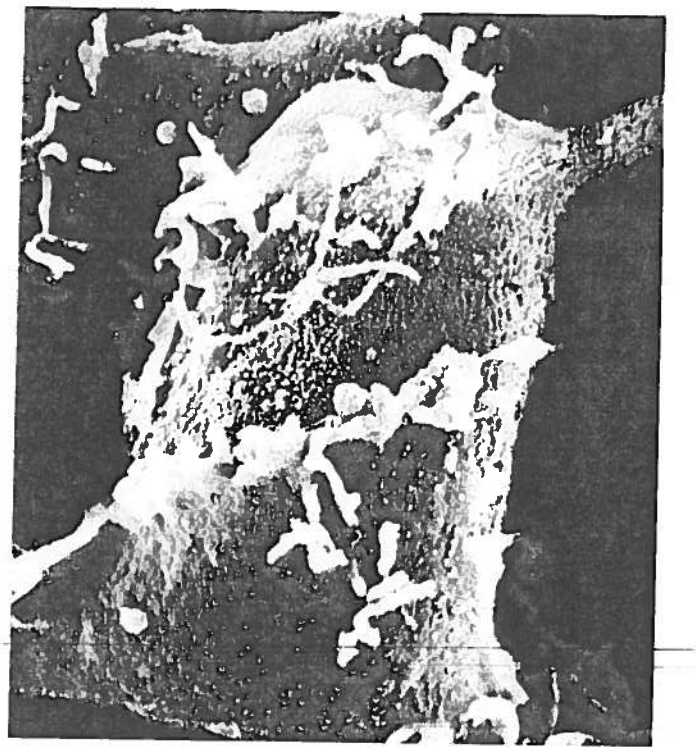


FIGURE 19–16 A human cell rupturing as it releases newly formed viruses (blue) into the surrounding fluid. (Photo by Lennart Nilsson, copyright Boehringer Ingelheim International, GmbH).

viruses then invade neighboring cells (Figure 19–16). The symptoms of viral infections, such as fever and swollen lymph nodes, are caused not by the viruses but by the activity of the body's immune system, which destroys most viruses before they can cause serious damage (Chapter 26).

Because viruses rely so heavily on host cell machinery for their reproduction, it is extremely difficult to find drugs that will destroy viruses without damaging the host equally. The antiviral drug acyclovir, used externally to treat herpes simplex infections and warts, works by interfering more with the virus's DNA polymerase than with the host's. Because it is so difficult to treat them, our best defense against viral diseases is still prevention: good hygiene, vaccination, and quarantine of infectious cases. Thanks to such practices, the age-old scourge of smallpox became extinct in the late 1970s, and new vaccines have put the viruses causing polio, measles, and rubella (German measles) on the endangered list in the United States.

Viral diseases are best fought by preventive methods such as cleanliness and vaccination.

19-I Viroids

In recent years, infectious, disease-causing particles even smaller than viruses have been isolated from plants. A **viroid** consists of a short, single strand of RNA, which folds into a hairpin shape maintained by base-pairing (Figure 19–17). Viroids have no capsids—not surprisingly, since they contain too few nucleotides to code for the proteins to make such a coat. Indeed, infected host cells do not appear to contain any proteins coded by the viroid genome. How, then, does a viroid cause disease? We don't yet know, but there are two main

hypotheses: that it somehow interferes with the regulation (turning on and off) of host cell genes, or that it interferes with intron splicing (Section 10-E).

Viroids have killed more than ten million coconut trees in the Philippines, and decimated the United States chrysanthemum trade in the 1950s. Viroids also cause spindle tuber of potatoes, exocortis of citrus trees, and several other diseases of important crop plants.

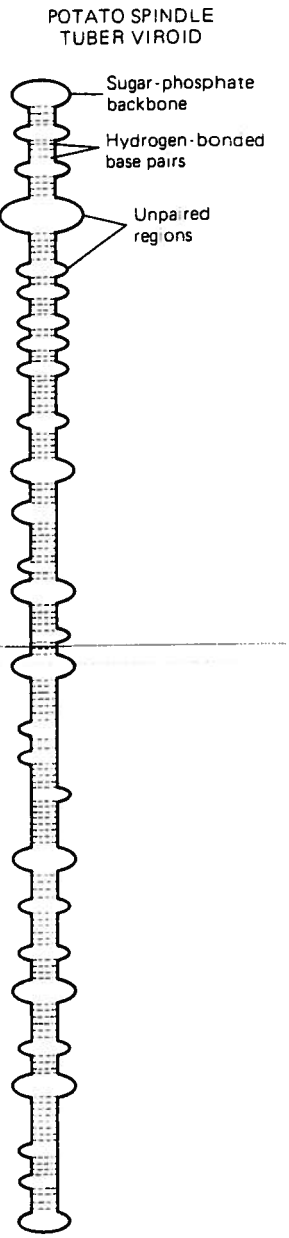


FIGURE 19–17 The RNA of the viroid that causes spindle tuber of potatoes is 359 nucleotides long, and is thought to fold up into the structure shown here.

19-J Viruses and Evolution

The peculiarities of viruses raise the question: what is their evolutionary origin? Several answers have been proposed. The first was that viruses are evolutionary relics, descended from ancestors that never evolved into true cells. When biologists realized that viruses depend totally on the very complex protein-synthesis and energy-generating machinery of living cells, most discarded this idea. Second, viruses may be reduced cells, which became parasites inside other cells and eventually jettisoned most of their own cell components and genes. These things were, after all, readily available in their host cells. Some fairly large viruses, containing dozens of genes and surrounded by a lipoprotein membrane, might be viewed as stripped-down cells. A third view is that viruses are neither retarded pre-cells nor regressed cells, but renegade genes that must return "home" to be replicated. This view is supported by the fact that the genetic similarity seems to be much closer between virus and host than between one virus and another.

Whatever the case, viruses clearly play an important role in the evolution of cellular organisms. First, they exert selective pressure. Second, many viral genomes are inserted into the host DNA and later released from it, often carrying part of the host's genome along into new host cells of the same or different species. Third, studies show that viral genes have become permanent parts of most species' genomes.

Viruses themselves often evolve very rapidly. Those that cause colds or influenza mutate often, producing offspring with novel genes. Hence some of the virus particles can always find some hosts that have not yet built up immunity to the proteins produced by their particular genes.

Summary

Taxonomy is the branch of biology concerned with relationships among organisms and with their classification. The basic unit of classification is the species; each species is given a unique Latin binomial, denoting its genus and species.

Species are grouped into progressively more inclusive taxa. The main levels in the taxonomic hierarchy, from most to least inclusive, are: kingdom, phylum, class, order, family, genus, and species. A taxon in each higher level contains one or more taxa of the next lower level. Taxa are not units intrinsic in nature, waiting to be discovered by humans, but instead are artificial inventions to help us think about living organisms in an orderly manner. Biologists often disagree about how the rules of taxonomy should be applied and where the lines should be drawn to define taxa.

In theory, living things are classified by phylogenetic relationships, but these are often difficult to disentangle, and the sheer number of existing species precludes drawing up a phylogenetic tree that encompasses all known organisms. In practice, therefore, living things are usually classified by morphology. Other features, such as physiology, biochemistry, behavior, and geographic distribution, are also used.

This book uses the taxonomic system that divides organisms into five kingdoms: Monera, the prokaryotes; Protista, the unicellular eukaryotes; Plantae, the plants; Fungi, the fungi; and Animalia, the animals. This classification is based largely on the mode of nutrition and cellular organization of organisms. Several evolutionary lines of organisms are almost certainly grouped in each kingdom.

Viruses do not share all the features of cellular organisms and do not belong in the five kingdoms of living organisms. Viruses resemble cells in that they contain nucleic acid and protein molecules, and some are surrounded by membranous envelopes of lipid and protein. Unlike cells, viruses lack the metabolic machinery to synthesize proteins and to generate energy, and many viruses can be crystallized. Cells reproduce by dividing in two, but hundreds of viruses may be produced in a host cell after infection by a single virus particle.

A virus particle's capsid or envelope proteins bind to the surface of a host cell by means of specific protein-receptor interactions. The viral genome, consisting of either DNA or RNA, but not both, enters the cell interior. In a lytic cycle, the virus immediately takes over the host cell's metabolic machinery, causing it to produce new virus particles, which are then freed by lysis of the host cell. In a lysogenic cycle, the viral genome becomes incorporated into the host's DNA and is replicated and passed along to the cell's progeny. Eventually the viral genome is released from that of the host, possibly taking along some of the host's genetic material, and the production and release of virus particles takes place as in the lytic cycle. Another kind of cycle involves the gradual production and release of viral particles, leaving the host cell intact, at least for a while.

Viral disruption of host cells is responsible for many diseases, including some tumors, in plants and animals. Some plant diseases are caused by viroids, which are short, naked strands of RNA that do not code for protein. The mechanism by which viroids cause disease is still unknown.

Self-Quiz

1. Modern classification is based on:
   a. taxonomy
   b. phylogeny
   c. morphology
   d. fossils
   e. autotrophy
2. All of the following make it difficult to construct acceptable classification schemes except:
   a. deciding where to impose artificial cutoffs in the midst of a naturally continuous series of organisms
   b. convergent evolution
   c. differences in rates of evolution for different characters
   d. persistence of conservative characters
   e. the large numbers of species that must be accommodated
3. The Latin binomial for the common dog is properly written:
   a. canis familiaris
   b. Canis Familiaris
   c. Canis familiaris
   d. *Canis familiaris*
   e. *canis familiaris*
4. In which of the following lists are the levels of the taxonomic hierarchy *not* arranged in correct descending order?
   a. phylum, order, family
   b. class, family, genus
   c. class, order, family
   d. family, class, order
   e. order, family, genus
5. Characters of two different organisms that have evolved from the same structure in an ancestral form but now have very different appearance and function can properly be termed (give all correct answers):
   a. derived
   b. homologous
   c. polyphyletic
   d. conservative
   e. convergent
6. You are given a microscope slide on which is mounted some biological material. On examining it, you observe that there are numerous individual cells containing chloroplasts and swimming around rapidly. This material belongs in the kingdom _____.