2.3 Viruses

BACKGROUND INFORMATION

Viral history is relatively short. It begins with the isolation of the human influenza virus in the 1930s and crystallization of the tobacco mosaic virus in 1933, and moves through the identification of HIV as the cause of AIDS in 1983 and the mapping of the structure of the common cold virus in 1985. It continues today with the discovery of the coronavirus as the causative agent in severe acute respiratory syndrome (SARS) in 2003. None of the emerging and re-emerging infectious diseases of the past 25 years, from HIV/AIDS and hepatitis C to Sin Nombre (Hantavirus) and West Nile, is close to eradication or control. Experts predict that the diseases will spread and grow more virulent.

Viruses constantly mutate and change, and for this reason, infectious disease experts worry about a new flu pandemic. The worst pandemic in history, the Spanish Flu of 1918–1919, killed at least 20 million people, including about 30 000 Canadians. The Asian Flu of 1957, and the milder Hong Kong Flu in 1968, killed hundreds of thousands worldwide. Pandemic influenza viruses are more infectious than the regular variety because people have no immunity to them. These viruses seem to arise where people handle domestic ducks, chickens, and pigs. These interconnections provide an ideal environment for viruses to mix, mutate, and spread. When an animal flu virus infects a person who already has the flu, genetic material from the two viruses may mix or rearrange to create a new virus. This mixing is exactly what scientists think happened with the normally benign coronavirus. The source of the common cold in humans, this virus causes major illness in cats, dogs, chickens, pigs, and cattle. Experts say the new human coronavirus arose when it incorporated similar but foreign RNA into its genetic code. SARS may be caused by a combination of a new strain of coronavirus and a meta-pneumovirus, which infects the lungs and triggers an immune reaction that can be so overwhelming that victims suffocate or die of organ failure. At the time of this publication (September 2003) researchers at the B.C. Cancer Agency had drafted the first sequence of the coronavirus genome for development of a diagnostic test, but many questions about the causative agent have yet to be answered.

Misconceptions

Viruses represent an example of the "which came first?" riddle. Viruses seem to be a stage between abiotic and biotic organisms, yet they must have appeared after cells, as viruses cannot reproduce on their own. Because viruses are not living organisms, they cannot be classified according to the taxonomy presented in Section 2.1. A universal system for classifying viruses and a unified taxonomy were established by the International Committee on Taxonomy of Viruses (ICTV) in 1966. The system uses a series of ranked taxa: order (-virales) is the highest currently recognized, then family (-viridae), subfamily (-virinae), genus (-virus), and species (e.g., tobacco mosaic virus). For example, the Ebola virus from Kikwit is classified as Order Mononegavirales; Family Filoviridae; Genus Filovirus; Species Ebola virus Zaire. Because viral names for the family, genus, and species can be very similar, and because the vernacular name usually does not indicate the family or genus to which the virus belongs, a decimal numbering system is also used for viral classification. In formal taxonomic usage, the first letters of virus family, subfamily, and genus names are capitalized and the terms are printed in italics. Species designations are not capitalized (unless they are derived from a place name or a host family or genus name), nor are they italicized. It was decided years ago that viral nomenclature would not use Latinized binomial terms.

Related Background Resources

- Viruses: http://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?name=Viruses
- Introduction to Viruses: http://www.ucmp.berkeley.edu/alllife/virus.html
- Viruses From Structure to Biology: http://medicine.wustl.edu/%7Evirology/timeline.htm
- Canadian Communicable Diseases Report (CCDC): http://www.hc-sc.gc.ca/pphb-dgspsp/publicat/ccdr-rmtc/96vol22/index.html
- Facts about Influenza: http://www.nfid.org/library/influenza/what/index.html
- Infectious Diseases: http://hopkins-heic.org/infectious_diseases/
- World Health Organization: Disease Outbreaks: http://www.who.int/disease-outbreak-news/disease/bydisease.htm
- Virology on the World Wide Web: http://www.virology.net/garryfavweb.html
- Big Picture Book of Viruses: http://www.virology.net/Big_Virology/BVHomePage.html
- Virus Pictures: http://www.rkm.com.au/VIRUS/index.html
- Viruses: http://tolweb.org/tree?group=Viruses&contgroup=Life
- Fact Sheets on Infectious Diseases: http://www.astdhpphe.org/infect/
- National Geographic video: *Virus*, 1994, 25 min, no. WE51618

ASSESSMENT PLANNING

Overall Skills Expectations
SIS.04
SIS.05
SIS.06
SIS.09
Overall Expectations
M.01
M.03
Specific Expectations
M1.01 compare the structure and properties of the genetic material of viruses and bacteria with those of eukaryotic cells
M1.02 illustrate the differences between representative bacteria (including Eubacteria and Archaebacteria), protists, viruses, and fungi by comparing their shape, motility, ecological role, and connection to human diseases
M1.03 analyse and explain the different methods of reproduction in various types of viruses, monera, and fungi
M1.04 describe the anatomy and physiology of representative organisms from monera, protists, fungi, and viruses
M3.01 evaluate the impact of viral, bacterial, and fungal infection on the health of host organisms, and on humans in particular

Achievement Chart Categories	Assessment/Evaluation Opportunities (Evidence)	Assessment Tools
Knowledge/Understanding	Understanding Concepts, q. 1–5 M1.01–M1.04	Rubric 1: Knowledge/Understanding
Inquiry	Applying Inquiry Skills, q. 6, 7 M3.01	Rubric 2: Inquiry
Making Connections	Making Connections, q. 8–10 M3.01	Rubric 4: Making Connections Rubric 6: Research Skills Self-Assessment Checklist 2: Research Skills

Assessment Opportunities

Knowledge/Understanding Collect student answers to Understanding Concepts questions 1 to 5, and compare to answers provided in the Solutions Manual. To determine their level of achievement, use *Assessment Rubric 1: Knowledge/Understanding* assessment criteria:
- Understanding of concepts, principles, laws, and theories (identifying assumptions, communicating misconceptions, providing explanations)
- Knowledge of facts and terms
- Transfer of concepts to new contexts
- Understanding of relationships among concepts

Inquiry Collect student answers to Applying Inquiry Skills questions 6 and 7 to assess their inquiry skills. To determine their level of achievement, use *Assessment Rubric 2: Inquiry* assessment criterion:
- Analyzing and interpreting

Making Connections Collect student work for Making Connections, questions 8 to 10. To determine the level of achievement, use *Assessment Rubric 4: Making Connections* assessment criteria:
- Understanding (making) connections among science, technology, society, and the environment
- Analysis of social and economic issues involving science and technology
- Proposing courses of practical action in relation to science- and technology-based problems

Assessment Rubric 6: Research Skills (all criteria) and *Self-Assessment Checklist 2: Research Skills* may also be used to assess question 10.

INSTRUCTIONAL PLANNING

Suggested Time
Narrative/Section Questions—70 min

TEACHING SUGGESTIONS

- Ask students to name viruses that are in the news today. They may answer SARS, West Nile, Norwalk, or influenza, depending on current outbreaks. Write responses on the board and eliminate any bacterial or fungal diseases. If there is an Internet connection in the classroom, try the World Health Organization (WHO) Communicable Disease Surveillance and Response, Disease Outbreak News, updated daily on their Web site: http://www.who.int/disease-outbreak-news/disease/bydisease.htm. The WHO tracks evolving infectious disease situations, sounds the alarm when needed, shares expertise, and mounts the necessary response. Look up the current status of some of the viruses named by students.

- Four classes of microorganisms are surveyed in this unit; viruses are the first. To ensure that major expectations are met, summary tables appear in the workbook for each category of microorganism. **Workbook 2.3 Additional Practice: All about Viruses** can be assigned now and used for summary notes as you proceed through the narrative in this section. Students will use these summary tables as review and study aids.
- To accompany the summary tables, assign **LSM 2.3-1: Additional Practice: Structure of Representative Organisms**. Students can label the bacteriophage diagram now and complete the others during the appropriate sections.
- Teachers may want to review the types of nucleic acids shown in the head of the virus in Figure 2 (see Student Text, Unit 1, Section 1.5, pp. 33–34). The functions of DNA and RNA may also be reviewed. Point out to students that viruses are classified according to their genetic molecule (DNA or RNA). Whether the nucleic acid is single-stranded or double-stranded also determines viral classification. See the listings in Table 1 (p. 106 of the Student Text).
- Direct students to an interactive Web site to perform a classic experiment that demonstrates the principles of virus replication: http://www-micro.msb.le.ac.uk/LabWork/grow/grow1.htm. An excellent slide sequence of the lysogenic cycle is available at http://www.cat.cc.md.us/courses/bio141/lecguide/unit2/viruses/u2fig18a.html.
- Some resources classify viral reproduction into three categories, as summarized in the table:

Lytic Cycle	Lysogenic Cycle	Retroviruses
- virus injects its genetic material into the host cell - genetic material enters the nucleus and is inserted into host's DNA, reprogramming its nucleus - cell immediately uses its machinery to produce the parts of future viroids - parts are assembled and the cell explodes (lysis), releasing more harmful viroids "Virulent" viruses undergo a lytic cycle.	- viral genes do not go into action immediately; viral genetic material simply makes a circle and sits quietly - each time the cell divides, its daughter contains the dormant viral material "Temperate" viruses undergo a lysogenic cycle. At some point, the lytic cycle is triggered.	- virus contains RNA as its genetic material virus contains an enzyme called reverse transcriptase, which it uses to make DNA from an RNA template (this never occurs in cellular organisms) - cell then follows the directions found in the new DNA code and the lytic cycle is triggered Retroviruses include rhinovirus and HIV.

- Write "West Nile Virus" on the board and ask students to respond with what comes immediately to mind. Make a list of word associations. These could include dead crows, mosquitoes, deaths (18 in Canada as of the end of April 2003), warm weather, migration north and west, and so on. Read aloud the information in **Workbook 2.3 Case Study: West Nile Virus**. Assign the questions, and have students exchange their answers with a partner for correction. Reassure students that Health Canada, in preparing for future West Nile Virus seasons, is focusing its efforts in six main areas of activity: (1) conducting Canada-wide surveillance for West Nile virus, (2) keeping Canada's blood system safe from West Nile virus, (3) testing for West Nile virus, (4) using safe and effective pesticides and insect repellents, (5) keeping Canadians informed about new findings on West Nile virus, and (6) working in collaboration with First Nations communities on reserves for surveillance and testing, education and awareness, and prevention and response about West Nile Virus.

- Provide students with background information on influenza. Reportable diseases in Ontario since 1923, types A and B influenza continue to be a major cause of preventable illness and death in Ontario. On average, 70 000 to 75 000 hospitalizations and 500 to 1500 deaths in Canada yearly are influenza-related. Annual infection rates in Canada range from 10% to 20% and can be considerably higher in epidemics. Current control measures in Canada include vaccination and treatment with anti-viral medication. New influenza vaccines are developed yearly to reflect the antigenic characteristics of the circulating strains.
- Students may wonder why killer influenza strains are identified by year, not a five-year span or a decade (e.g., Spanish Flu of 1918–1919, Asian Flu of 1957, Hong Kong Flu of 1968). Explain that humans have no immunity to a new virus, so the spread and severity of the disease are often greatest during that first entry into a population. If this agent goes through a population and then re-enters it the next year, it will encounter people who were previously infected and are now immune. That immunity often reduces the activity and severity of the disease. The human immune system response will be covered in Section 2.9.
- After discussing the representative virus—influenza—direct students to **Workbook 2.3: Common Cold and Flu Viruses**. Explain that, aside from the personal effects of these common viruses, they have significant economic effects. The alternative exercise compares the common cold and influenza using the following characteristics: general description, symptoms, transmission, incubation, communicability, treatment, and prevention. Students respond to questions based on information in the comparison chart. As a follow-up question, you could ask why there is no vaccine for the common cold. (There are more than 100 recognized forms of rhinovirus and these constantly mutate.) A possible debate statement could be, "Given the economic cost to society, influenza vaccination should be mandatory for all."
- Emphasize to students that the common cold is a virally related syndrome and has been associated with more than 100 different viruses, including human coronavirus and rhinovirus. These viruses differ in structure and symptoms. This table compares the two viruses.

	Rhinovirus	**Coronavirus**
Nature of disease	- upper respiratory tract - inflammation, edema, copious nasal discharge - immunity declines within a month	- epithelium of upper respiratory tract - poor immune response (no cross-immunity) - importance of immunity is unknown
Characteristics	- non-enveloped, icosahedral, RNA	- enveloped, helical, RNA
Transmission	- sneeze (aerosol), hands, fomites (substances capable of absorbing or retaining the virus)	- same as rhinovirus
Incubation period	- 1 to 3 days	- 2 to 5 days

	Rhinovirus	Coronavirus
Duration	- 3 days to 2 weeks, virus shed nasally for 2 to 3 days	- virus shed for about 1 week
Severity	- nasal discharge, congestion, sneezing, headache, mildly sore throat and/or cough, little or no fever	- nasal discharge, malaise, cough, sore throat not as prominent as in rhinovirus, little or no fever, lower respiratory tract not involved
At risk groups	- asthmatic children, adults with chronic bronchitis, and smokers - preschool children	- asthmatic children and adults with chronic bronchitis
Seasonality	- common in autumn and spring	- more common in winter

- Students will be aware that antibiotics are ineffective against viruses. Ask them to hypothesize why this is the case. In Section 2.11, they will learn that antibiotics work by preventing bacteria from constructing a cell wall or from manufacturing cell proteins. A virus has neither a cell wall nor cell proteins. In preparation for Section 2.12 on antibiotics resistance, ask students to hypothesize what might happen if antibiotics were used to treat viral infections.
- Although antibiotics are ineffective for viral infections, other medications are prescribed. These antiviral drugs work by interrupting binding, replication, or assembly within the host cell. Because viruses hijack normal processes within the host cell, most antiviral drugs inhibit the natural and necessary processes of healthy cells. Therefore, as in cancer chemotherapy, the main principle of antiviral research is to develop drugs that specifically affect viral mechanisms without having toxic effects on normal, uninfected cells. A common broad-spectrum antiviral drug is Ribavirin, which targets RNA viruses such as hepatitis C (HCV), herpes simplex virus (HSV), measles, mumps, and Lassa fever.
- Tattooing is an increasingly popular form of body adornment. Several students in the class may have tattoos. Ask students what health risks this process poses. Students may mention infection, but ask them to be more specific. Any microorganism transferred by contact can be implanted into the body by the needle. The most common contaminant is the virus that causes hepatitis B. Assign one student the task of researching and presenting facts about hepatitis B. In Canada, tattoo artists do not have to be licensed, but Health Canada prescribes certain safe working guidelines for tattoo artists. These include always using sterile, disposable needles; wearing gloves and not touching their eyes, mouth, ears, or nose; opening the ink bottle with a clean tissue and preventing the open mouth of the bottle from touching anything; bandaging clients with packaged sterile bandages; washing their hands after every procedure; never tattooing someone if they have uncovered cuts, sores, or hangnails; and disposing of used needles properly. After listing these guidelines for students, ask what responsibilities consumers have to ensure their own safety.
- Ask students to investigate and report on ways in which viruses resemble living organisms and ways in which they differ from living organisms. These traits would include the following:
  - Viruses have no metabolic apparatus and do not digest, respire, and so on.
  - They are not made of cells. They have no cell membrane, nucleus, or cytoplasm.
  - They are crystalline. Solutions of viruses leave behind crystals when evaporated.
  - They can reproduce but only inside a host.
  - They contain genes made of either DNA or RNA.
  - They can take over the cell activity of hosts they invade, not just kill them.
  - They can cause transmittable (contagious) diseases.

- **Workbook 2.1–2.3 Self Quiz** can be given now, as this is a natural break point before the next topic. Answers to the quiz are available in the Workbook for students to self-check. Encourage students to use this quiz to assess their learning. Do they understand the concepts in Sections 2.1 to 2.3? What review do they need before new topics begin?