Unit 12 · Viruses, and Biotechnology in Microbiology

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Introduction to Microbiology (Units 11–12 together): 3 of 75 marks, set as 1 short answer (5 marks, using the ±2 swing); with Biology, Cell Biology, Biota and Environment and Conservation a combined 21
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** short (5): "Explain five ways in which microorganisms are used in medicine."
- **MCQ (1 mark)**
  - why a virus can't grow in broth (obligate parasite, no ribosomes)
  - which disease is viral (rabies)
  - product not of microbial biotechnology; Bt crops; *Rhizobium* biofertilizer
- **Short (in parts)**
  - define virus; why neither prokaryote nor eukaryote; capsid
  - viruses between living and non-living
  - viruses vs bacteria
  - structure of a virus with diagram; lysozyme in infection
  - economic importance of viruses
  - microbial biotechnology in medicine, industry, farming, environment
  - biofertilizers vs chemical fertilizers; ethical issues

Key terms

Virus (Latin, venom; named by **Beijerinck**): ultramicroscopic, acellular, obligate intracellular parasite with **DNA or RNA**, replicating only in a living host cell.

Virology: study of viruses.

Virion: complete infectious virus particle outside a cell.

Capsid: protein coat of **capsomeres**; with the core = **nucleocapsid**.

Envelope: host-derived phospholipid bilayer with viral **spikes**.

Bacteriophage (phage): virus that infects bacteria.

Lytic cycle: phage multiplies, host bursts; **lysogenic**: phage DNA joins host DNA.

Biotechnology: controlled use of biological agents (microbes, enzymes, genes) for beneficial purposes.

Antibiotic: microbial substance that kills or stops other microbes, mainly bacteria.

Vaccine: microbe or its parts used to immunize.

GMO (transgenic): carries foreign genes.

Bioremediation: microbes clean up pollutants.

Viruses: introduction

- **Ivanovsky** (1892): tobacco mosaic juice infectious after a bacteria-proof filter
- **Beijerinck**: *contagium vivum fluidum*; named it "virus"
- **Stanley** (1935): crystallized **TMV**; Nobel 1946; TMV rods ~300 nm (electron microscope, 1939)
- **acellular**: no membrane, cytoplasm, ribosomes, organelles → **neither prokaryote nor eukaryote** (both are cells)
- outside host: **non-living**, crystallized, stored; inside: **replicates** → **borderline**
- no enzymes for energy, no ribosomes → **obligate parasites**
- **no place** in Whittaker's five kingdoms

Characteristics

1. **ultramicroscopic** (electron microscope)
2. **acellular**
3. **obligate parasites**: **no enzyme systems**
4. **no ATP** production
5. **one nucleic acid**: DNA **or** RNA
6. **capsid**
7. **host specific** (polio: humans, primates; rabies: nerve cells of mammals)
8. **crystallized**, inert outside
9. **mutation** (new flu vaccine yearly)
10. **infectious**
11. **incubation period**
12. **no metabolism**: respiration, nutrition, excretion
13. **high specific gravity** (ultracentrifuge)

- no ribosomes: the host's ribosomes make its capsid proteins
- grown in animal cell cultures, hens' eggs, host bacteria

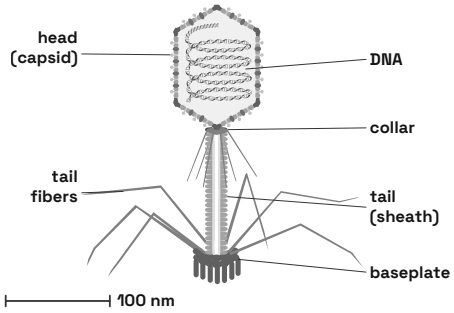
	Living	Non-living
virus shows	replication inside a host; genes passed on; **mutation**; infection; host specificity	crystallized, stored; no metabolism, respiration, nutrition; no growth outside; no cell

Virus	Bacterium
acellular	a living **cell**: membrane, cytoplasm
no ribosomes, no energy enzymes	**70S ribosomes**, own enzymes
DNA or RNA	**both** DNA and RNA
core in a **capsid**	nucleoid, plasmids
multiplies **only in a host**	grows and divides **on its own** (binary fission)
10–300 nm	~1,000 nm (0.5–1.5 μm)
not killed by antibiotics	antibiotics act on wall, 70S ribosome, enzymes

Structure

- **10–300 nm**; poliovirus ~30 nm; porcine circovirus < 20 nm; **mimivirus** ~750 nm (2003)
- light microscope limit ~200 nm
- shapes: **rod** (TMV), **filamentous** (Ebola), **spherical / polyhedral** (polio, adenovirus, influenza, HIV), **tadpole** (phage T4)
- nucleic acid + protein; TMV **5 % RNA, 95 % protein**

1. **core**: DNA or RNA; single- or double-stranded, linear or circular; **ssDNA** (parvoviruses), **dsRNA** (rotavirus): no cell uses these
2. **capsid**: **capsomeres**, identical, pattern fixed per virus (identification); protects core
3. **envelope** (some): phospholipid bilayer from host membrane + **spikes**
   - enveloped: influenza, HIV, coronavirus; **naked**: polio, TMV, adenovirus
   - soap destroys the envelope



Bacteriophage T4: head (capsid) with DNA, collar, sheath round the hollow tail, base plate, tail fibers.

Bacteriophage T4 (attacks *E. coli*)

- **head**: 20-sided capsid, ~85 × 120 nm, **dsDNA** inside
- **collar**
- hollow **tail** in a contractile **sheath**
- **base plate**, **tail pins**, six **tail fibers**

Infection (lytic cycle)

1. tail fibers grip receptors (by chance)
2. **lysozyme** at the tail tip digests the **peptidoglycan wall** → hole
3. sheath contracts; tail tube pushed in; **DNA injected**
4. phage genes take over; copies made
5. phage lysozyme breaks wall from inside → cell **lyses**; 100–200 phages released

- **lysogenic**: DNA joins host DNA, copied for generations; stress (UV) → lytic
- **animal viruses** need no lysozyme (no wall): spikes fit receptors, cell takes them in, or envelope fuses

Economic importance of viruses

Positive

1. **research tools**: recombinant DNA technology with phages
2. **gene therapy**: harmless virus as **vector** for a therapeutic gene (inherited blindness, immune disorders)
3. **cancer**: **virotherapy** (altered herpes virus, melanoma, 2015); **VDEPT** (enzyme gene turns a prodrug to poison in cancer cells)
4. **vaccines**: polio, measles, rabies, hepatitis B
5. **pest control**: **baculoviruses** (NPV of cotton bollworm *Helicoverpa*)
6. **beauty**: variegated tulips (tulip breaking virus; tulip mania 1637)
7. **killing bacteria**: phages clean water; **phage therapy**

Negative

1. **diseases**: people (cold to AIDS); crops (tomato leaf curl; mosaics of tobacco, papaya, cucumber); animals (foot-and-mouth, bird flu)
2. **industry**: phages destroy curd, cheese, antibiotic, enzyme bacteria
3. **biological weapons** (forbidden)

Disease	Virus
chickenpox	varicella-zoster
measles	measles virus (*Morbillivirus*)
AIDS	HIV
COVID-19	SARS-CoV-2
bird flu	influenza A, H5N1, H5N8
common cold	mostly rhinoviruses
dengue	dengue virus (*Aedes*)
hepatitis B, polio, rabies	their own viruses

- smallpox eradicated **1980**; Nepal polio-free **2014**; dengue > 50,000 cases in **2022**

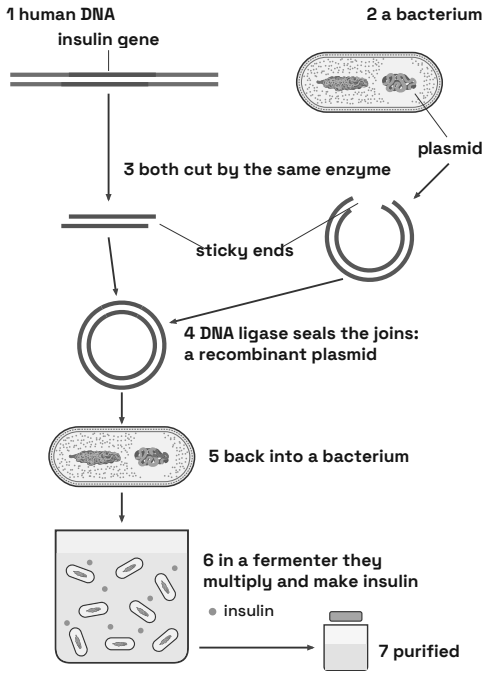
Microbial biotechnology

- **microbial biotechnology**: use of microbes (bacteria, fungi, viruses) or their parts
- old: bread, curd, wine, jaand; new: drugs, diagnosis, energy, waste, forensics

1. Medicine

- **antibiotics**: **penicillin** (*Penicillium*, Fleming 1928); **streptomycin** (*Streptomyces griseus*, Waksman 1943, first TB cure); tetracycline, erythromycin; made in **fermenters**
  - useless against viruses (act on wall, 70S ribosome, bacterial enzymes)

- **vaccines**: by fermentation and **recombinant DNA** (hepatitis B protein from yeast); smallpox 1980, polio 2014, maternal and newborn tetanus eliminated in Nepal 2005
- **gene therapy**: healthy gene added or replaces defective one; **viral vector**
- **molecular diagnosis**: recombinant DNA, **PCR**: AIDS, hepatitis, TB, COVID-19; cancer genes
- **insulin**: human gene in *E. coli* plasmid (Genentech 1978; sold 1982); before, from cow and pig pancreas



Human insulin gene into a plasmid, into a bacterium; bacteria multiply in a fermenter; insulin purified.

2. Industry

- **fermentation**: alcohol (yeast: sugar → alcohol + CO_2), bread (CO_2), curd, cheese, yogurt (lactic acid bacteria); gundruk, sinki, kinema (*Bacillus subtilis*), jaand, raksi (murcha)
- **tea and tobacco**: microbes cure tobacco; black tea's "fermentation" is the leaf's own enzymes (pu-erh truly microbial)
- **enzymes**: **proteases** (washing powder, meat), **pectinases** (clear juice), **amylases** (syrup), **rennet**
- **biofuels** (renewable): **ethanol** (yeast), **biogas** (methane from dung)

3. Agriculture

- **biofertilizers**: living microbes on **seeds** or in **soil**
  - *Penicillium bilaiae*: **dissolves phosphate**
  - *Rhizobium* (nodules), *Azotobacter* (free), *Anabaena*, *Nostoc*: **fix nitrogen**
- **bioherbicides**: fungi kill particular weeds; target only, no residue, persist
- **improved varieties**: **Bt cotton**, **Bt brinjal** (*Bacillus thuringiensis* gene, poisons caterpillars, less spraying); **golden rice** (beta-carotene)
- **GMOs**: bacterial enzymes cut and join DNA; plasmids carry it; *Agrobacterium* carries it into plants

Biofertilizers	Chemical fertilizers
living microbes	manufactured (urea, DAP, potash)
nutrients slowly, as needed	at once; much washed away
no runoff, no blooms	nitrate, phosphate runoff → blooms
improve soil life; lasting	acidify soil, harm soil life
cheap, renewable	costly, energy-heavy; Nepal imports all
slower; certain crops	fast, predictable

4. Environment

- **waste disposal**: sewage plants: aerobic tanks + anaerobic (biogas)
- **bioremediation**: *Exxon Valdez* (1989): fertilizer → native bacteria cleared oil 2–5× faster; Chakrabarty's *Pseudomonas* (1980): first patented GM organism
- **bioindicators**: heavy metals, hydrocarbons; bacteria that glow with **arsenic** (Tarai wells); *E. coli* = sewage in water

Ethical issues

1. **privileged information**: ownership of DNA data, a country's genes; patents on life
2. **ecological harm**: genes to wild relatives; non-target insects
3. **access**: expensive; poor left out
4. **interfering with nature**
5. **defects, side effects**
6. **safety**: clinical trials, informed consent; cost
7. **legal, religious**: stem cells, gene therapy, cloning, genome

- benefit: Bt cotton cut insecticide use (resistant pests where rules broken)

COMMON MISTAKES

✗ Viruses are prokaryotes
✓ **acellular**: neither prokaryote nor eukaryote.

✗ A virus has both DNA and RNA
✓ **one** only.

✗ Antibiotics cure viral diseases
✓ they act only on **bacteria**.

✗ Every virus uses lysozyme to enter
✓ only **phages** (bacterial walls); animal viruses use receptors or fusion.

✗ Viruses are in kingdom Monera
✓ **no kingdom** in the five-kingdom system.

✗ Black tea is fermented by microbes
✓ by the **leaf's own enzymes** and oxygen.