GENERAL BIOLOGY · STUDY GUIDE

Exam 5 Study Guide

This guide covers chapters 9 and 10. First you see how one species becomes two, how to read the trees that record those splits, and how four billion years of history unfolded. Then you meet the microbes that run the planet: bacteria and archaea, viruses, protists and fungi. Work one chapter at a time. Read the "what to know" paragraphs, copy the tables out by hand, then try each worked case with the steps covered. Finish each chapter with its ten self-test items. The cram sheet at the end holds every date, barrier and group.

WHAT THIS GUIDE COVERS

- Chapter 9 · the four species concepts, prezygotic and postzygotic barriers, allopatric and sympatric speciation, polyploidy, hybrid zones, the tempo of speciation, tree reading, clades and shared derived characters, parsimony, molecular clocks, the origin of life, radiometric dating and the major events and mass extinctions of life's history.
- Chapter 10 · prokaryotic structure and the Gram stain, binary fission and gene transfer, nutritional modes, Bacteria versus Archaea, virus structure and replication cycles, retroviruses, viroids and prions, endosymbiosis and protist supergroups, fungal structure, life cycles and groups, the nitrogen cycle, symbioses, Koch's postulates, toxins and antibiotic resistance.

CHAPTER 9

Speciation, Phylogeny and the History of Life

Read it in full: **Chapter 9 in the textbook**. See it in motion: **Speciation Lab** and **Phylogeny Lab**.

What to know

Speciation links microevolution to macroevolution, and it needs gene flow to stop. The **biological species concept** (Mayr) defines a species as populations that interbreed in nature and produce viable, fertile offspring. It cannot be used for fossils or asexual organisms, and some clear species

still hybridize. The **morphological** concept uses form, the **ecological** concept uses niche, and the **phylogenetic** concept uses the smallest group with a unique shared ancestry.

Prezygotic barriers act before fertilization: habitat, temporal (spotted skunks breed in different seasons), behavioral (meadowlark songs), mechanical (snails with opposite coiling) and gametic (sea urchin bindin). **Postzygotic barriers** act on the hybrid: reduced hybrid viability, reduced hybrid fertility (the mule: horse 64, donkey 62, mule 63 chromosomes) and hybrid breakdown. A mule shows that "any offspring" is not enough; the offspring must be fertile.

In **allopatric speciation**, a geographic barrier splits a population, by vicariance (a river shifts, the Isthmus of Panama rises) or dispersal (colonists reach an island). The parts then diverge by selection, drift and mutation, and barriers arise as a side effect. Snapping shrimp give 15 sister pairs across Panama. Allopatric speciation is thought to be the most common mode.

In **sympatric speciation**, gene flow stops within one area. **Polyploidy** can make a new species in one generation: an autopolyploid (4n) is isolated because 4n × 2n gives sterile 3n offspring; an **allopolyploid** forms when a sterile hybrid doubles its chromosomes so every chromosome has a partner. Perhaps 25 to 40 percent or more of flowering plants arose this way, and bread wheat is hexaploid. Habitat differentiation (apple maggot flies on apples versus hawthorn) and sexual selection (Lake Victoria cichlids choosing by color) also work.

In a **hybrid zone**, three outcomes are possible. **Reinforcement** strengthens prezygotic barriers when hybrids are less fit (pied and collared flycatchers look most different where they overlap). **Fusion** merges the gene pools (cichlids in murky water). **Stability** keeps hybrids forming. Speciation can follow **punctuated equilibrium** (long stasis, short bursts) or **gradualism**; on average, full isolation often takes a few million years.

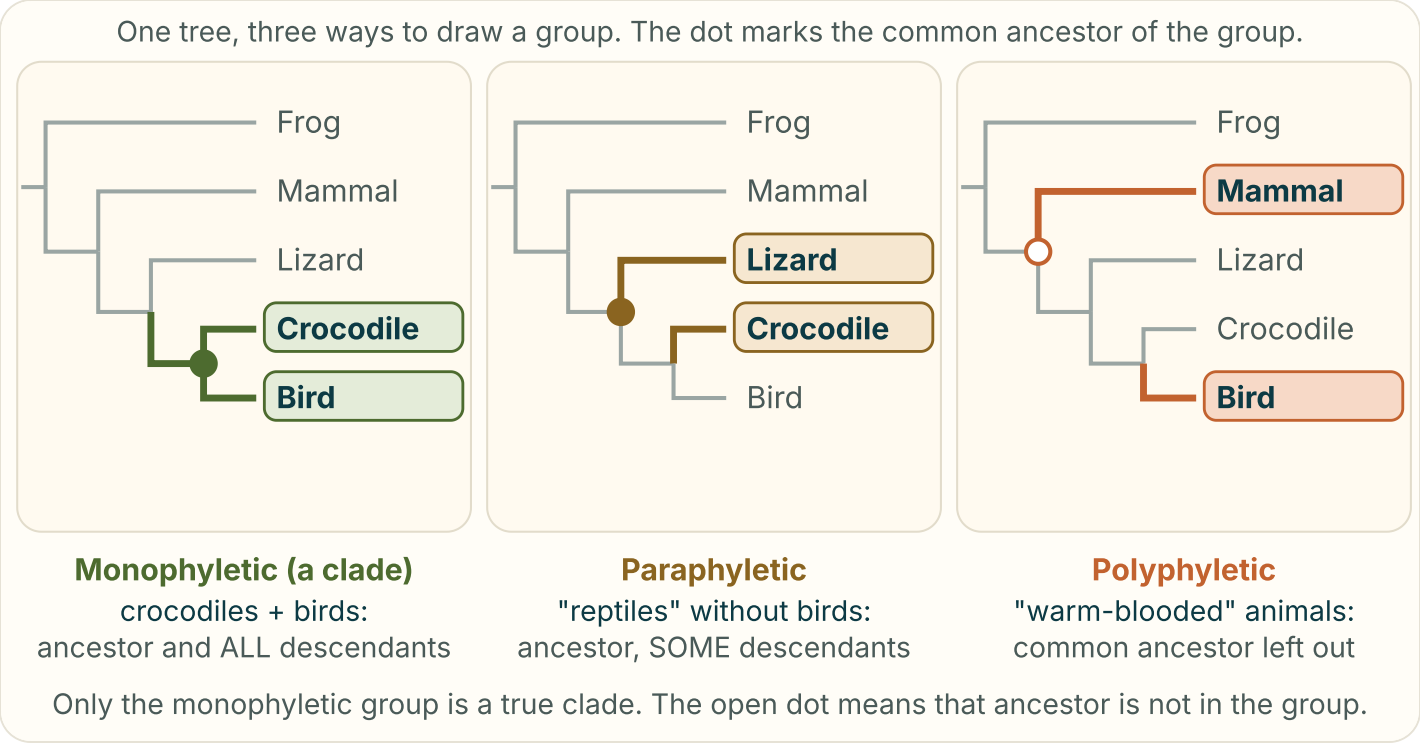
A **phylogenetic tree** is a hypothesis. Nodes are common ancestors; **sister taxa** share the most recent ancestor; a polytomy is an unresolved node. Trees show descent, not overall similarity. Branch length means nothing unless scaled, tip order means nothing because branches rotate, and no living taxon is the ancestor of another. Humans and chimpanzees share an ancestor from about 6 to 7 million years ago. Linnaean names run domain, kingdom, phylum, class, order, family, genus, species.

A **clade** (monophyletic group) is an ancestor and all its descendants. A **paraphyletic** group leaves out some descendants ("reptiles" without birds). A **polyphyletic** group lacks the common ancestor ("warm-blooded animals"). **Shared derived characters** define clades; shared ancestral characters do not sort within a group. An **outgroup** tells ancestral from derived. Analogous traits cause **homoplasy**. **Maximum parsimony** picks the tree with the fewest changes. A **molecular clock**, calibrated by fossils, dates splits from sequence differences. Horizontal gene transfer makes the base of the three domain tree a web.

Earth formed about 4.6 billion years ago; stromatolites date to about 3.5 billion. The origin of life is modeled in four stages: **abiotic synthesis** of monomers (Miller and Urey, 1953; vents; meteorites), joining into **polymers** on hot clay, **protocells** (self-assembling vesicles) and **self-replicating molecules**. The **RNA world** idea rests on ribozymes, and the RNA core of the ribosome is a molecular fossil of it.

Fossils form mostly in sedimentary rock and are biased toward hard-bodied, abundant, aquatic organisms that lasted a long time. **Relative dating** orders layers. **Radiometric dating** uses half-lives: carbon-14 (5,730 years; up to about 50,000 to 75,000 years), potassium-40 (about 1.3 billion years), uranium-235 (about 704 million) and uranium-238 (about 4.5 billion). Older fossils are dated by volcanic layers above and below.

Key events: the **Great Oxidation Event** about 2.4 billion years ago (cyanobacteria), eukaryotes about 1.8 billion, multicellular algae about 1.2 billion, Ediacaran animals 635 to 541 million, the **Cambrian explosion** about 535 to 525 million, and life on land by about 500 to 470 million. **Pangaea** formed about 250 million years ago and began to break up about 200 million years ago. There have been five **mass extinctions**: end-Ordovician (444), Late Devonian (372), end-Permian (252, about 96% of marine species), end-Triassic (201) and end-Cretaceous (66, an asteroid at Chicxulub). Recovery takes 5 to 10 million years or more, with **adaptive radiation** into empty niches.



Good groups and bad groups. A clade keeps an ancestor and every one of its descendants. Leave one out and the group is paraphyletic; skip the ancestor and it is polyphyletic.

LOCK THESE IN

- Biological species = interbreed in nature AND fertile offspring.
- Prezygotic: habitat, temporal, behavioral, mechanical, gametic. Postzygotic: viability, fertility, breakdown.
- Allopatric = geographic barrier. Sympatric = polyploidy, habitat or sexual selection.
- Allopolyploid: sterile hybrid plus chromosome doubling = fertile new species.
- Reinforcement, fusion or stability in hybrid zones.
- Clade = ancestor plus ALL descendants; defined by shared derived characters.
- Each half-life halves what remains. Carbon-14: 5,730 years.
- Big five: Ordovician, Devonian, Permian (252, worst), Triassic, Cretaceous (66).

Key terms and comparisons: barriers and speciation

Item	Type or mode	Example
Habitat isolation	Prezygotic	Water and land garter snakes
Temporal isolation	Prezygotic	Skunks breeding in different seasons
Behavioral isolation	Prezygotic	Meadowlark songs; firefly flashes
Mechanical isolation	Prezygotic	Snails with opposite coiling
Gametic isolation	Prezygotic	Sea urchin bindin
Reduced hybrid viability	Postzygotic	Salamander hybrids
Reduced hybrid fertility	Postzygotic	Mule
Hybrid breakdown	Postzygotic	Some rice strains
Vicariance	Allopatric	Isthmus of Panama and snapping shrimp
Allopolyploidy	Sympatric	Bread wheat; triticale
Habitat differentiation	Sympatric	Apple maggot fly
Sexual selection	Sympatric	Lake Victoria cichlids

Dating and timeline

Item	Value
Carbon-14	Half-life 5,730 years; to N-14
Potassium-40	About 1.3 billion years; to Ar-40
Uranium-238	About 4.5 billion years; to Pb-206
Age from half-lives	Age = number of half-lives × half-life
Earth	About 4.6 billion years
Oldest fossils	Stromatolites about 3.5 billion years
Great Oxidation Event	About 2.4 billion years ago
First eukaryotes	About 1.8 billion years ago
Cambrian explosion	About 535 to 525 million years ago
End-Permian extinction	252 million years; about 96% of marine species
End-Cretaceous extinction	66 million years; nonavian dinosaurs

Worked cases

WORKED CASE 1 · AN ALLOPOLYPLOID COUNT

A plant with 2n = 10 crosses with a related plant with 2n = 16. The hybrid is sterile. Later its chromosome number doubles. How many chromosomes does the new plant have, and why is it fertile?

STEP 1 · GAMETES

Each parent gives n: 5 and 8.

STEP 2 · HYBRID

5 + 8 = 13 chromosomes, none with a partner, so meiosis fails: **sterile**.

STEP 3 · DOUBLE

13 × 2 = **26**. Every chromosome now has an identical partner.

STEP 4 · RESULT

Meiosis works, so the plant is fertile with its own kind but isolated from both parents: a new species in one step.

WORKED CASE 2 · HOW OLD IS IT?

A charcoal sample keeps 1/16 of the carbon-14 ratio of living wood. A volcanic ash has 25 percent of its original potassium-40 left. Date both.

STEP 1 · COUNT CARBON HALF-LIVES

$1/16 = (1/2)^4$, so 4 half-lives.

STEP 2 · CARBON AGE

$4 \times 5{,}730$ = **22,920 years**, inside the range of the method.

STEP 3 · COUNT POTASSIUM HALF-LIVES

$25\% = (1/2)^2$, so 2 half-lives.

STEP 4 · POTASSIUM AGE

2×1.3 billion = **about 2.6 billion years**.

WHY TWO CLOCKS

Carbon-14 is gone after about 50,000 to 75,000 years, so older fossils need long half-life isotopes in volcanic layers.

WORKED CASE 3 · A MOLECULAR CLOCK

Two species that split 20 million years ago (dated by fossils) differ at 40 sites in a gene. Two other species differ at 14 sites in the same gene. When did they split?

STEP 1 · FIND THE RATE

$40 \div 20 = 2$ differences per million years.

STEP 2 · APPLY IT

$14 \div 2$ = **7 million years ago**.

THE CAUTION

Rates can differ among genes and lineages, so clocks need careful calibration.

WORKED CASE 4 · CLADE OR NOT?

On a tree of vertebrates, decide whether each group is monophyletic: (a) birds plus all dinosaurs; (b) "reptiles" leaving out birds; (c) "warm-blooded animals," birds plus mammals.

STEP 1 · (A)

It holds the ancestor and every descendant: **monophyletic**, a clade.

STEP 2 · (B)

It holds the ancestor but leaves out birds, which descend from it: **paraphyletic**.

STEP 3 · (C)

It gathers two lineages without their common ancestor, because endothermy evolved twice: **polyphyletic**.

ONE SNIP TEST

If one cut on the tree drops off exactly your group, it is a clade.

TRAPS PEOPLE FALL INTO

- **Thinking any hybrid means one species.** The offspring must be fertile and the mating must happen in nature.
- **Calling species that now share a range "sympatric speciation."** The mode depends on where populations were when barriers arose.
- **Reading tip order or branch length.** Branches rotate; length means nothing unless scaled.
- **Saying humans came from chimpanzees.** Sister taxa share a common ancestor; neither is the other's ancestor.
- **Using shared ancestral characters to group within a clade.** Only shared derived characters define clades.
- **Treating decay as a fixed amount.** Each half-life removes half of what is left.
- **Reading a fossil gap as proof of absence.** The record is biased toward hard parts and watery settings.
- **Calling the Cambrian explosion the first animals.** Many lineages began earlier; hard parts made them visible.

Chapter 9 self-test · ten items

1. Two frog populations in one pond breed three weeks apart. Which barrier is this?

A. Habitat isolation, prezygotic

B. Gametic isolation, postzygotic

C. Temporal isolation, prezygotic

D. Hybrid breakdown, postzygotic

C. Temporal isolation, prezygotic Their breeding seasons do not overlap, so mating never happens. That is a prezygotic, temporal barrier.

2. Why can the biological species concept not classify a fossil trilobite?

A. Trilobites had no DNA at all
B. Trilobites were all asexual
C. Fossils show no body features
D. Interbreeding cannot be tested

D. Interbreeding cannot be tested The concept rests on interbreeding in nature, which cannot be observed for extinct organisms.

3. A tetraploid plant arises in a diploid population. Why is it isolated at once?

A. Its diploid crosses give sterile 3n
B. It flowers only at night thereafter
C. It cannot make any working gametes
D. It moves at once to a new habitat

A. Its diploid crosses give sterile 3n Triploid offspring have unpaired chromosomes in meiosis, so gene flow with the parents stops.

4. In a hybrid zone, hybrids are much less fit. What should happen over time?

A. The two gene pools fuse into one
B. Prezygotic barriers grow stronger
C. Postzygotic barriers disappear
D. Hybrids become steadily fitter

B. Prezygotic barriers grow stronger Reinforcement: selection favors individuals that avoid mating with the other species.

5. What does a node on a phylogenetic tree represent?

A. The ages of all of the living groups
B. A living species shown at a tip
C. The degree of overall similarity
D. An ancestor where two lineages split

D. An ancestor where two lineages split Each branch point is the divergence of lineages from a shared ancestor.

6. Hair is found in all mammals and in no other animals. What kind of character is it for mammals?

A. A shared derived character
B. A homoplasy
C. A shared ancestral character
D. An outgroup character

A. A shared derived character It is a novelty unique to the mammal clade, so it defines that clade.

7. Which statement about the Miller and Urey experiment is accurate?

A. It showed oxygen was abundant early
B. It produced the first living cells
C. Sparks through gases made amino acids
D. It proved that RNA came first

C. Sparks through gases made amino acids Organic monomers formed from simple gases with electric sparks in about a week.

8. A bone has 1/8 of the original carbon-14 ratio. About how old is it?

A. 11,460 years
B. 17,190 years
C. 5,730 years
D. 45,840 years

B. 17,190 years One eighth is three half-lives: 3 × 5,730 = 17,190 years.

9. Which mass extinction was the largest?

A. End-Ordovician, about 444 million years ago
B. End-Cretaceous, about 66 million years ago
C. End-Permian, about 252 million years ago
D. Late Devonian, about 372 million years ago

C. End-Permian, about 252 million years ago The end-Permian event killed about 96 percent of marine species.

10. Why did mammals diversify after the Cretaceous extinction?

A. Mammals first appeared at that time
B. Many niches were suddenly empty
C. The asteroid caused new mutations
D. Mammals outcompeted living dinosaurs

B. Many niches were suddenly empty Removing nonavian dinosaurs left roles open, and mammals underwent adaptive radiation.

CHAPTER 10

Bacteria, Archaea, Viruses, Protists and Fungi

Read it in full: **Chapter 10 in the textbook**. See it in motion: **Prokaryotes Lab** and **Protists Lab** and **Fungi Lab**.

What to know

Prokaryotes (Bacteria and Archaea) have no nucleus or membrane-bounded organelles. Most are 0.5 to 5 micrometers. Shapes are cocci, bacilli and spirals. The chromosome is usually one circle in the **nucleoid**, often with **plasmids**, and ribosomes are 70S. Capsules and slime layers help cells stick and form biofilms; fimbriae attach; pili pull cells together; bacterial flagella rotate like propellers. Some bacteria make **endospores** that survive boiling, which is why canned food is pressure cooked.

The **Gram stain** sorts walls. **Gram positive** bacteria have thick peptidoglycan and stay purple. **Gram negative** bacteria have thin peptidoglycan under an outer membrane with lipopolysaccharide and stain pink; the outer membrane blocks many drugs. Penicillin blocks peptidoglycan cross-linking, which human cells do not have. Archaea lack peptidoglycan.

Prokaryotes reproduce by **binary fission**, some every 20 minutes. They gain variation by mutation and by horizontal gene transfer: **transformation** (naked DNA from outside), **transduction** (DNA carried by a phage) and **conjugation** (direct transfer through a pilus, as with the F factor). R plasmids carry resistance genes between species.

Nutritional modes: photoautotrophs (light, CO_2), chemoautotrophs (inorganic chemicals, CO_2; prokaryotes only), photoheterotrophs (light, organic carbon; prokaryotes only) and chemoheterotrophs (organic for both). Oxygen needs: obligate aerobes, obligate anaerobes and facultative anaerobes such as E. coli. Only prokaryotes fix nitrogen; Anabaena does it in heterocysts. Bacterial groups include proteobacteria (E. coli, Rhizobium, the mitochondrial ancestors), cyanobacteria, gram positive bacteria, spirochetes and chlamydias. Archaea include extreme halophiles, extreme thermophiles (one grows at 121 °C) and methanogens.

A **virus** is nucleic acid in a protein **capsid**, sometimes inside an envelope made from host membrane. It has no ribosomes or metabolism and replicates only inside a host. Most are 20 to 300 nm. The genome can be DNA or RNA, single or double stranded. **Host range** depends on the fit between viral surface proteins and host receptors; HIV binds CD4 on helper T cells.

Phages follow two cycles. In the **lytic cycle** the phage makes copies and bursts the cell, releasing about 100 to 200 phages. In the **lysogenic cycle** a temperate phage such as lambda inserts as a

prophage and is copied with the chromosome until a stress signal switches it to lytic. Prophage genes give diphtheria, botulism and scarlet fever bacteria their toxins. Bacteria defend with restriction enzymes and CRISPR-Cas.

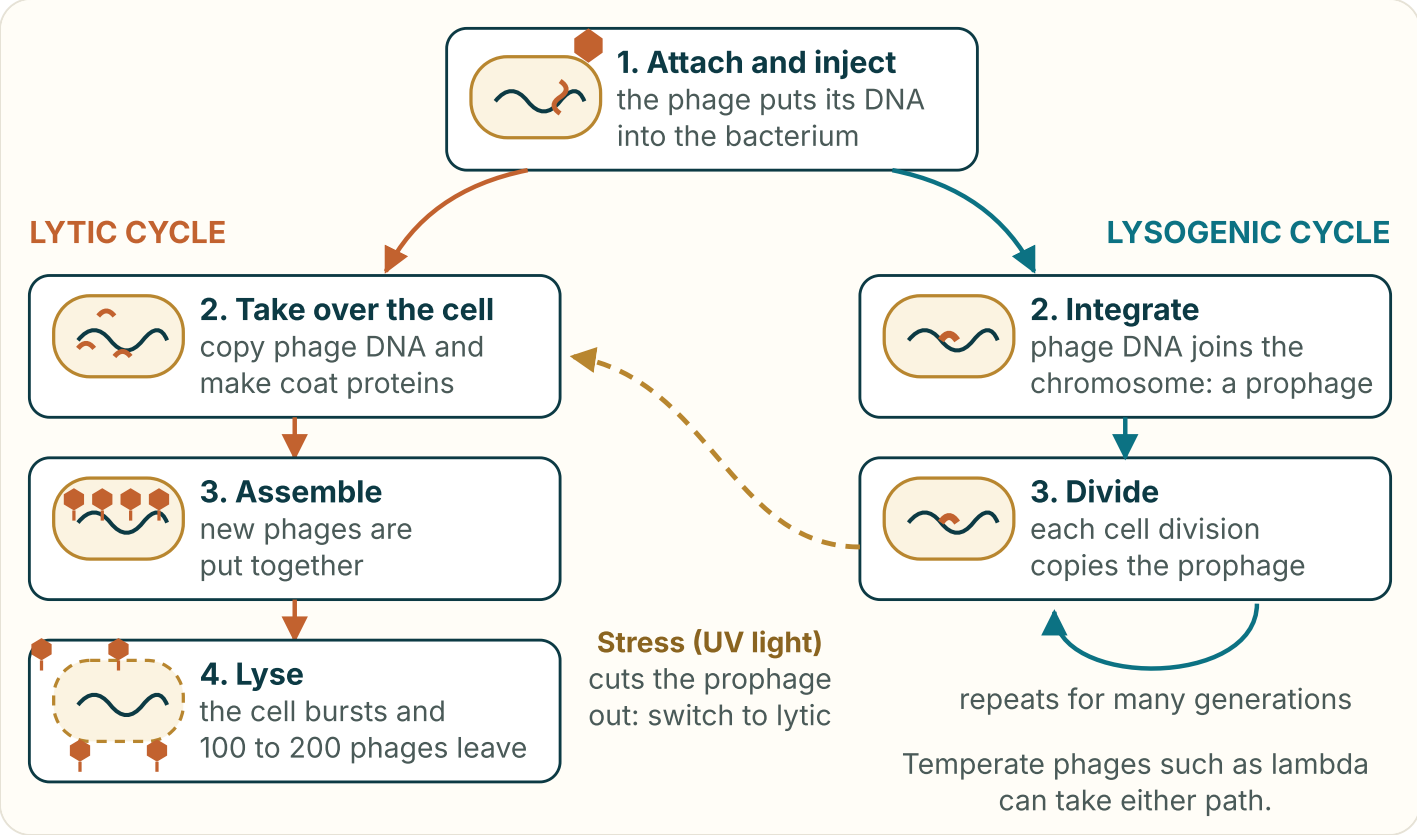
Enveloped animal viruses enter by fusion or endocytosis and leave by budding. RNA viruses use an RNA-dependent RNA polymerase with no proofreading, so they mutate fast. Positive-sense genomes act as mRNA; negative-sense genomes must be copied first. **Retroviruses** such as HIV use reverse transcriptase to make DNA, which integrase inserts as a permanent **provirus**; drugs hold HIV down but cannot remove proviruses. About 8 percent of the human genome is old retroviral DNA. Emerging viruses usually spill over from animals. **Viroids** are naked RNA that infect plants; **prions** are misfolded proteins that resist normal sterilization.

Protists are eukaryotes that are not plants, animals or fungi; they are paraphyletic. Mitochondria and plastids came from **endosymbiosis**: two membranes, circular DNA, 70S ribosomes, fission-like division and bacterial gene sequences. **Primary endosymbiosis** of a cyanobacterium gave red algae, green algae and plants (two plastid membranes). **Secondary endosymbiosis** of an alga gave plastids with three or four membranes, sometimes with a leftover nucleomorph.

The supergroups: **Excavata** (Giardia, Trichomonas, Trypanosoma, Euglena), **SAR** (diatoms, brown algae and kelps, oomycetes, dinoflagellates, Plasmodium, Paramecium, forams), **Archaeplastida** (red algae, green algae, land plants) and **Unikonta** (amoebozoans and slime molds; opisthokonts, which include animals, fungi and choanoflagellates). Plasmodium alternates between mosquitoes and humans, multiplying in liver and red blood cells.

Fungi are absorptive heterotrophs related to animals. They secrete enzymes and absorb the products. Most grow as **hyphae** with chitin walls, forming a **mycelium**. Hyphae are septate or coenocytic. Mycorrhizae trade minerals for plant sugars. Sexual reproduction runs **plasmogamy** (cytoplasm fuses), a heterokaryon or dikaryon (n + n), then **karyogamy** (nuclei fuse), and the short-lived diploid zygote undergoes meiosis. Groups: chytrids (flagellated zoospores; amphibian disease), zygomycetes (bread mold), glomeromycetes (arbuscular mycorrhizae), ascomycetes (asci; yeast, Penicillium) and basidiomycetes (basidia; mushrooms).

Microbes are the main **decomposers**, and prokaryotes run every step of the **nitrogen cycle**: fixation (N_2 to NH_3/NH_4^+), ammonification, nitrification (NH_4^+ to NO_2^- to NO_3^-) and denitrification (NO_3^- to N_2). Symbioses include mutualism, commensalism and parasitism; examples are root nodules, mycorrhizae, lichens, rumen microbes and the human gut microbiome. **Koch's postulates** link a microbe to a disease. **Exotoxins** are secreted proteins (botulinum, cholera toxin); **endotoxins** are lipopolysaccharide from gram negative outer membranes, released when cells die. Antibiotic resistance spreads by selection and R plasmids.



Two ways for a phage to live. The lytic cycle kills the host now. The lysogenic cycle rides along in the chromosome until stress flips it to lytic.

LOCK THESE IN

- Gram positive: thick peptidoglycan, purple. Gram negative: thin layer plus outer membrane, pink.
- Transformation = naked DNA; transduction = phage; conjugation = pilus.
- Chemoautotrophs and photoheterotrophs are prokaryotes only.
- Lytic bursts the cell; lysogenic hides as a prophage.
- Retroviruses: reverse transcriptase, integrase, permanent provirus.
- Two plastid membranes = primary endosymbiosis; three or four = secondary.
- Fungi: chitin, absorption, plasmogamy before karyogamy.
- Nitrogen cycle: fixation, ammonification, nitrification, denitrification.

Key terms and comparisons: microbes

Item	Feature	Example
Photoautotroph	Light; CO_2	Cyanobacteria, plants
Chemoautotroph	Inorganic chemicals; CO_2	Nitrifying bacteria, vent archaea
Photoheterotroph	Light; organic carbon	Purple nonsulfur bacteria
Chemoheterotroph	Organic for both	Most bacteria, fungi, animals
Positive-sense RNA virus	Genome acts as mRNA	Polio, coronaviruses
Negative-sense RNA virus	Polymerase copies genome first	Influenza, measles, rabies
Retrovirus	RNA to DNA; provirus	HIV
Prophage	Phage DNA in a bacterial chromosome; can leave	Lambda
Provirus	Retroviral DNA in a eukaryotic chromosome; stays	HIV
Exotoxin	Secreted protein	Botulinum, cholera toxin
Endotoxin	LPS of gram negative outer membrane	Salmonella

Key terms and comparisons: Bacteria, Archaea and Eukarya

Feature	Bacteria	Archaea	Eukarya
Nuclear envelope	Absent	Absent	Present
Peptidoglycan	Present	Absent	Absent
RNA polymerase	One kind	Several	Several
Histones	Absent	Some	Present
Streptomycin	Inhibited	Not inhibited	Not inhibited

Key terms and comparisons: fungal groups

Group	Hyphae	Sexual structure	Example
Chytrids	Coenocytic or single cells	Flagellated zoospores	Amphibian chytrid
Zygomycetes	Coenocytic	Zygosporangium	Black bread mold
Glomeromycetes	Coenocytic	None known	Arbuscular mycorrhizae
Ascomycetes	Septate	Ascus	Yeast, Penicillium, morels
Basidiomycetes	Septate, dikaryotic	Basidium	Mushrooms, rusts

Worked cases

WORKED CASE 1 · WHICH TRANSFER MECHANISM?

Sensitive bacteria become resistant after mixing with a filtered extract of resistant cells (no living cells, no viruses). Adding DNase blocks the change. In a second test, resistance passes only when living donor cells touch recipients. Name each mechanism.

STEP 1 · TEST 1

Free DNA did the work, and DNase destroys free DNA: **transformation**.

STEP 2 · RULE OUT THE OTHERS

Transduction protects DNA inside a phage, so DNase would not stop it; the filter removed phages anyway.

STEP 3 · TEST 2

Living cells in contact means a pilus: **conjugation**, often moving an R plasmid.

WORKED CASE 2 · GROWTH BY BINARY FISSION

One bacterium divides every 20 minutes with no limits. How many cells after 3 hours? After 6 hours?

STEP 1 · COUNT GENERATIONS

180 ÷ 20 = 9 generations; 360 ÷ 20 = 18.

STEP 2 · DOUBLE EACH TIME

2^9 = **512 cells**; 2^{18} = **262,144 cells**.

WHY IT MATTERS

Even a rare mutation appears often in a fast-growing population, which is why resistance evolves within days.

WORKED CASE 3 · READING A PLASTID'S HISTORY

Alga X has a plastid with two membranes. Alga Y has four membranes and a tiny nucleus between them. Explain each.

STEP 1 · COUNT THE MEMBRANES

Two membranes match an engulfed cyanobacterium: **primary endosymbiosis** (red or green algae).

STEP 2 · EXTRA MEMBRANES

Three or four mean a eukaryote engulfed a whole alga: **secondary endosymbiosis**.

STEP 3 · THE EXTRA NUCLEUS

The nucleomorph is the leftover nucleus of the engulfed alga, a clear trace of the event.

WORKED CASE 4 · FOLLOWING NITROGEN THROUGH A FIELD

Clover grows in a nitrogen-poor field and is plowed under. Trace the nitrogen to the next crop.

STEP 1 · FIXATION

Rhizobium in clover nodules turns N_2 into ammonia, which becomes ammonium.

STEP 2 · AMMONIFICATION

After the clover dies, decomposers release ammonium from its proteins.

STEP 3 · NITRIFICATION

Chemoautotrophic bacteria oxidize ammonium to nitrite and then nitrate, which the crop absorbs.

THE LEAK

In waterlogged, low-oxygen soil, denitrifying bacteria can return nitrate to N_2.

TRAPS PEOPLE FALL INTO

- **Saying prokaryotes cannot exchange genes.** They do so constantly by transformation, transduction and conjugation.
- **Treating antibiotics as antivirals.** Antibiotics hit bacterial structures that viruses lack.
- **Calling viruses cells.** They have no ribosomes or metabolism and need a host to replicate.
- **Mixing prophage and provirus.** A prophage can leave a bacterial chromosome; a provirus stays in a eukaryotic one.
- **Calling protists a clade.** They are paraphyletic; some are closer to plants, animals or fungi.
- **Calling fungi plants.** Fungi have chitin, store glycogen, absorb food and sit with animals in the opisthokonts.
- **Thinking the mushroom is the whole fungus.** It is a short-lived reproductive body; the mycelium is the organism.
- **Swapping exotoxin and endotoxin.** Exo is exported protein; endo is embedded LPS released at death.

Chapter 10 self-test · ten items

1. A bacterium stains pink after a Gram stain. What does its envelope have?

A. A wall built of chitin, as in a fungus

B. Thick peptidoglycan with no outer membrane

C. No cell wall of any kind at all

D. Thin peptidoglycan under an outer membrane

D. Thin peptidoglycan under an outer membrane Gram negative cells lose the crystal violet through a thin wall and take up the pink counterstain.

2. Which nutritional mode is found only in prokaryotes?

A. Chemoautotrophy
B. Absorptive heterotrophy
C. Photoautotrophy
D. Chemoheterotrophy

A. Chemoautotrophy Getting energy from inorganic chemicals while fixing CO_2 is a prokaryote specialty.

3. Which is true of archaea but not bacteria?

A. They contain no ribosomes at all
B. They have a membrane-bound nucleus
C. Their walls lack peptidoglycan
D. They are inhibited by streptomycin

C. Their walls lack peptidoglycan Archaeal walls are made of other polysaccharides and proteins, and archaea resist streptomycin.

4. Why are diphtheria bacteria harmful only when they carry a certain prophage?

A. The prophage blocks all toxin genes
B. The toxin gene is on the prophage
C. The prophage makes the wall thicker
D. The prophage kills the host bacterium

B. The toxin gene is on the prophage Some prophage genes are expressed during lysogeny, and the diphtheria toxin gene is one of them.

5. Why can HIV drugs control infection but not cure it?

A. Proviruses remain in host chromosomes
B. The drugs destroy reverse transcriptase
C. HIV cannot copy itself without drugs
D. HIV has a DNA genome that hides

A. Proviruses remain in host chromosomes Integrated proviruses in long-lived cells persist and can restart infection if treatment stops.

6. Which agent has no nucleic acid at all?

A. A bacteriophage
B. A retrovirus
C. A prion particle
D. A viroid particle

C. A prion particle Prions are misfolded proteins. Viroids are naked RNA, and viruses carry DNA or RNA.

7. A plastid with two membranes suggests which history?

A. Engulfment of an alphaproteobacterium
B. Primary endosymbiosis of a cyanobacterium
C. Budding from the nuclear envelope
D. Secondary endosymbiosis of a red alga

B. Primary endosymbiosis of a cyanobacterium Two membranes match the engulfed cyanobacterium plus the host vesicle, as in red and green algae and plants.

8. Plasmodium, the cause of malaria, belongs to which group?

A. Diplomonads, in the Excavata
B. Red algae, in Archaeplastida
C. Amoebozoans, in the Unikonta
D. Apicomplexans, in the SAR clade

D. Apicomplexans, in the SAR clade Apicomplexans are alveolates with an apical complex for entering host cells.

9. In a fungal life cycle, what happens between plasmogamy and karyogamy?

A. Meiosis makes the first diploid spores
B. Paired haploid nuclei share each cell
C. The zygote divides by mitosis many times
D. The mycelium becomes fully diploid

B. Paired haploid nuclei share each cell After cytoplasm fuses, the nuclei stay separate as a heterokaryon or dikaryon (n + n).

10. Which step of the nitrogen cycle turns ammonium into nitrate?

A. Nitrogen fixation
B. Denitrification
C. Nitrification
D. Ammonification

C. Nitrification Chemoautotrophic bacteria oxidize ammonium to nitrite and then nitrate.

Cram sheet

Everything from chapters 9 and 10 in one place. Cover the right column and see if you can rebuild each row.

Numbers to know

Item	Value	Note
Mule	64 + 62 parents; mule 63	Sterile hybrid
Polyploid plants	25 to 40% or more	Bread wheat is 6n
Human and chimp split	About 6 to 7 million years ago	Sister taxa
Carbon-14	5,730 years	To about 50,000 to 75,000 years
K-40; U-238	1.3 billion; 4.5 billion years	Volcanic layers
Earth; first fossils	4.6 billion; 3.5 billion years	Stromatolites
Oxygen; eukaryotes	2.4 billion; 1.8 billion years ago	Cyanobacteria; endosymbiosis
Cambrian explosion	About 535 to 525 million years ago	Hard parts
Big five	444, 372, 252, 201, 66 million years ago	Permian worst
Prokaryote size	0.5 to 5 µm	Viruses 20 to 300 nm
Fastest division	About every 20 minutes	Doubling
Phage burst	About 100 to 200 per cell	Lytic cycle
Retroviral DNA in our genome	About 8%	Ancient infections
Air nitrogen	About 78% N_2	Fixed only by prokaryotes

Key terms and comparisons

Pair	How to tell them apart
Prezygotic vs postzygotic	Before fertilization; on the hybrid.
Allopatric vs sympatric	Geographic barrier; same area.
Autopolyploid vs allopolyploid	Extra sets from one species; doubled hybrid of two species.
Monophyletic, paraphyletic, polyphyletic	All descendants; some descendants; no common ancestor.
Shared derived vs ancestral	Defines a clade; shared by the whole group.
Relative vs radiometric dating	Order of layers; age in years.
Gram positive vs negative	Thick wall, purple; thin wall plus outer membrane, pink.
Lytic vs lysogenic	Burst the cell; hide as a prophage.
Plasmogamy vs karyogamy	Cytoplasm fuses; nuclei fuse.
Exotoxin vs endotoxin	Secreted protein; outer membrane LPS.

Rules that win points

Topic	The rule
Species test	Interbreed in nature AND fertile offspring.
Tree reading	Follow nodes, not tips; branches rotate.
Dating	Count half-lives, then multiply.
Origin of life	Build, link, wrap, copy.
Gene transfer	DNase stops only transformation.
Plastids	Count the membranes.

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