Unit 11 · Monera

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
- **MCQ (1 mark)**
  - name a form (round cells in chains → streptococci)
  - nucleoid vs plasmid
  - mode of nutrition from clues (oxidizes ammonia → chemoautotrophic)
  - growth phase where division = death (stationary)
  - site of N_2 fixation in *Nostoc* (heterocysts)
- **Short (in parts)**
  - define plasmid; naked DNA
  - symbiotic bacteria with examples
  - autotrophic vs heterotrophic bacteria
  - bacterial cell with labeled diagram
  - why blue-green algae are in Monera
  - growth curve; decomposers; roles of Monera

Key terms

Microbiology: study of living things too small to see; **bacteriology**: of bacteria.

Monera: kingdom of **prokaryotes** (*pro* before + *karyon* nucleus): bacteria + cyanobacteria.

Naked DNA: not wrapped round **histones**.

Nucleoid (incipient nucleus): circular naked DNA, no membrane.

Plasmid: small extra ring of DNA (**extrachromosomal**); copies itself; e.g. antibiotic resistance; passes between bacteria.

Pleomorphism: changing shape with conditions (*Corynebacterium*, *Legionella*).

Anoxygenic photosynthesis: no water used, no oxygen given off.

Chemosynthesis: food from CO_2 with energy from oxidizing inorganic compounds.

Generation time: time for one doubling.

Heterocyst: thick-walled pale cell where cyanobacteria fix nitrogen.

Trichome: row of cells; **filament** = trichome + sheath.

Hormogonia: pieces of a filament broken at heterocysts.

General

- **Leeuwenhoek** (1632–1723), Delft cloth merchant: tiny lenses (~270×); saw bacteria 1676 ("animalcules"); Fellow of the Royal Society 1680; father of microbiology
- most **ancient**, **smallest**, **simplest** life; mats ~3.5 billion years old
- everywhere: hot springs, salt water, inside organisms, deep crust, ocean floor
- **features**
  - microscopic, **unicellular** (chains, filaments, colonies)
  - **prokaryotic**: no organized nucleus, **no membrane-bound organelles**
  - **rigid cell wall**
  - **circular naked DNA** = nucleoid
  - autotrophic or heterotrophic; **major decomposers**
  - **no sexual reproduction** (no gamete fusion)
- two groups: **bacteria** and **cyanobacteria**
- Woese (1977): prokaryotes are **Bacteria** and **Archaea**; three **domains** (Bacteria, Archaea, Eukarya)

Bacteria

- size **0.5–1.5 µm** across; smallest of cellular organisms
- *Mycoplasma* 0.2–0.3 µm, **no wall**; largest *Thiomargarita magnifica* (to 2 cm)

Forms

Shape	Arrangement	Example
cocci (round; mostly no flagella)	**mono-**: single · **diplo-**: pairs · **tetra-**: fours (two planes) · **strepto-**: chains (one plane) · **staphylo-**: grape clusters (random planes) · **sarcina**: cubes of 8 (three planes)	*Streptococcus pneumoniae* (pneumonia); *S. thermophilus* (curd); *S. pyogenes* (sore throat); *Staphylococcus aureus* (boils)
bacilli (rods; some flagella)	single · **diplo-**: pairs · **strepto-**: chains · **palisade**: side by side	*E. coli*; *Bacillus anthracis* (anthrax); *Corynebacterium diphtheriae*
helical	**vibrio**: comma · **spirillum**: rigid spiral (flexible: **spirochetes**)	*Vibrio cholerae*; *Spirillum volutans*; *Treponema* (syphilis)
filamentous	branched threads	*Streptomyces*: smell of rain-wet earth; **streptomycin**

Structure of a bacterial cell (outside in)

1. **slime layer** (thin, loose) or **capsule** (thick, firm): **polysaccharide** (protein in anthrax); against drying, chemicals, white blood cells; sticking (tooth plaque)
2. **cell wall**: rigid **peptidoglycan** (murein, mucopeptide); shape, stops bursting; **penicillin** blocks it
3. **plasma membrane**: selectively permeable; **respiratory enzymes** on it: **site of respiration**
4. **cytoplasm**
   - **70S ribosomes** (eukaryotes 80S)
   - food granules: glycogen, lipid, protein
   - **gas vacuoles** (floating)
   - **chromatophores** (thylakoids) with pigments in photosynthetic ones
5. **nucleoid**: one circular, double-stranded, naked DNA
6. **plasmids**
7. **flagella**: protein whips, turn like propellers; can grow through a capsule (*E. coli*, *Salmonella*)
8. **pili** (fimbriae): short, many; **attach**; **sex pilus** for conjugation

- **mesosomes**: **artifacts** of chemical treatment
- gene swapping: **transformation** (Griffith 1928), **conjugation** (sex pilus, plasmid), **transduction** (virus); spreads antibiotic resistance

Curd (Activity 3.2)

- pinhead of curd + water; optional methylene blue or crystal violet (air-dry, heat-fix, 1 min, rinse)
- cover slip from one edge; low to high power; oil immersion at 1000×
- **rods** (*Lactobacillus*) + **round cells in chains** (*Streptococcus thermophilus*)
- lactose → **lactic acid**: sour, proteins clump; juju dhau

Nutrition

Autotrophic	Heterotrophic
own food from CO_2	take ready-made food
light or chemical energy	energy from food taken in
few bacteria	**most** bacteria
photoautotrophs: bacteriochlorophyll	no photosynthetic pigments
producers	decomposers, parasites, symbionts
Chlorobium, *Chromatium*, *Nitrosomonas*, *Nitrobacter*	*Pseudomonas*, *Salmonella* Typhi, *Rhizobium*

Photoautotrophs

- **anoxygenic**: H donor is $\mathbf{H_2S}$, thiosulphate, H_2 or organic; **no $\mathbf{O_2}$**
- **green sulphur** (*Chlorobium*), **purple sulphur** (*Chromatium*): sulphur springs, pond mud
- $6\,CO_2 + 12\,H_2S \rightarrow C_6H_{12}O_6 + 6\,H_2O + 12\,S$ (light, bacteriochlorophyll)
- cyanobacteria the exception: split water, give O_2

Chemoautotrophs (no light)

Group	Oxidizes	Example
nitrifying	ammonia → nitrite; nitrite → nitrate	*Nitrosomonas*, *Nitrobacter*
sulphur	H_2S, sulphur	*Beggiatoa*, *Thiobacillus*
iron	ferrous → ferric	*Gallionella*, *Ferrobacillus*
hydrogen	H_2	*Hydrogenomonas*

- methane oxidizers (*Methylococcus*): often listed; strictly not autotrophs (carbon from methane)
- hydrothermal vents (*Alvin*, 1977): tube worms live on chemosynthetic bacteria

Heterotrophs

- **saprophytic**: dead matter; secrete enzymes, absorb; **decomposers**, recycle nutrients; *Pseudomonas*, *Acetobacter* (vinegar), *Clostridium*, *Bacillus*
- **parasitic**: living host; **pathogenic**: *Mycobacterium tuberculosis* (TB), *Clostridium tetani* (tetanus), *Salmonella* Typhi (typhoid), *Vibrio cholerae* (cholera)
- **symbiotic** (both gain)
  - *Rhizobium*: **root nodules** of legumes; fixes N_2 → ammonia; gets sugars, home
  - *E. coli* in large intestine: makes **vitamin K**
  - rumen bacteria digest cellulose
- dead bodies vanish: decomposers break them down; ice, drying, salt, smoke stop them (Ötzi; sukuti, gundruk)

Useful and harmful

- useful: *Lactobacillus* (curd, gundruk), *Bacillus subtilis* (kinema), *Acetobacter*, *Rhizobium*, compost, biogas, *Streptomyces*, insulin-making *E. coli*, sewage
- harmful: TB, typhoid, cholera, tetanus, *Clostridium botulinum*, *Xanthomonas* (citrus canker, rice blight), spoiled food, tooth decay

Growth

- growth = increase in **number**, by **binary fission** (copy DNA, lengthen, split into two equal cells)
- exponential: after n generations, 2^n cells
- generation time: *E. coli* ~**20 min**; TB bacterium 15–20 h
- conditions: oxygen, pH (near neutral), temperature (37 °C for pathogens; some > 80 °C), light, osmotic pressure (pickles), pressure, moisture, nutrients

Growth curve (living cells, log scale, against time; broth **inoculated**, **incubated**)

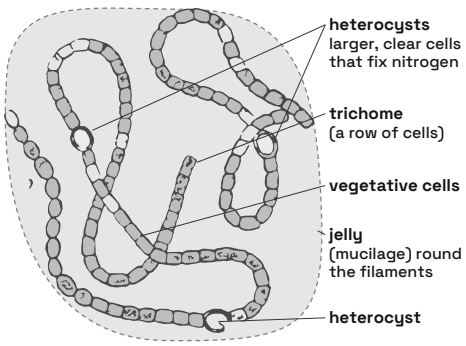
1. **lag**: active, **not dividing**; making enzymes; number steady
2. **log** (exponential): fastest steady division; **straight line** on log scale; cells uniform; penicillin works best
3. **stationary**: food short, **toxic waste**; **dividing = dying**; flat
4. **decline** (death): **dying > new**; falls

Cyanobacteria

- *kyanos*, dark blue; once **blue-green algae**; **photosynthetic bacteria**
- water, soil, walls, bark, rocks, hot springs, glaciers
- **stromatolites** > 3 billion years
- **chlorophyll** *a*: autotrophic; **split water, give O_2**
- symbiosis: lichens; *Anabaena* in *Azolla*

Features

1. unicellular (*Chroococcus*, *Synechococcus*), **filamentous** (*Nostoc*, *Anabaena*, *Oscillatoria*), colonial (*Microcystis*)
2. **peptidoglycan** wall + **mucilaginous sheath**; plasma membrane
3. **no membrane-bound organelles**
4. pigments: chlorophyll *a*, carotenes, xanthophylls, **phycobilins** (blue **phycocyanin**, red **phycoerythrin**) on **thylakoids** in the **chromoplasm**; **no chloroplasts**
5. **nucleoid** (**centroplasm**): circular DNA, no histones
6. **no flagella** (*Oscillatoria* glides)
7. **trichome**; *Nostoc*: filaments in a jelly ball
8. **heterocysts** (*Nostoc*, *Anabaena*, *Scytonema*): **nitrogen fixation**; keep out O_2 (it destroys **nitrogenase**)
9. **binary fission** (no mitosis); vegetative: fission, **hormogonia**; asexual: **akinetes**; **no sexual reproduction**



Nostoc: trichomes of bead-like cells in jelly, with heterocysts.

	Blue-green algae	Bacteria	Plants
cell	prokaryotic	prokaryotic	eukaryotic
nucleus	nucleoid	nucleoid	true, with membrane
DNA	circular, no histones	circular, no histones	linear, histones
organelles	none	none	mitochondria, chloroplasts…
pigments	chl *a*, phycobilins on thylakoids	bacteriochlorophyll	chl *a*, *b* in chloroplasts
ribosomes	70S	70S	80S
wall	peptidoglycan	peptidoglycan	cellulose
sex	none	none	sexual and asexual

- so they are in **Monera**: the kingdom goes by the cell

Importance

- **Great Oxidation Event** (~2.4 billion years ago): first O_2, ozone layer
- chloroplast = swallowed cyanobacterium (**endosymbiont theory**)
- rice fields: *Anabaena*, *Nostoc* fix N_2; *Azolla* green manure
- *Spirulina*: protein supplement
- *Microcystis* blooms: toxins; *Trichodesmium* (Red Sea)

COMMON MISTAKES

✗ Bacteria respire in mesosomes
✓ mesosomes are **artifacts**; respiration is on the **plasma membrane**.

✗ Bacterial DNA has histones
✓ it is **naked**.

✗ Bacterial ribosomes are 80S
✓ **70S**.

✗ Photosynthetic bacteria give off oxygen
✓ most are **anoxygenic** (H_2S, sulphur given off); only cyanobacteria give O_2.

✗ Bacterial growth means cells get bigger
✓ it means more **cells**.

✗ In the stationary phase bacteria stop dividing
✓ division **equals** death.

✗ Blue-green algae are algae
✓ **cyanobacteria**, in Monera.

✗ Most bacteria are autotrophic
✓ **most are heterotrophic**.