Unit 2 · Life and Life Process

STUDY NOTES

Key terms

Microbiology: study of microorganisms and viruses (*mikros*, *bios*, *logos*).
Host cell: living cell a virus takes over to make new viruses.
Bacteriophage (phage): virus that infects bacteria.
Lysis: bursting open of the cell.
Virulent / temperate phage: only kills / can also join the host's DNA (lysogenic cycle).
Generation time: time between divisions; number doubles in it.
Pseudomycelium: chain of yeast cells that stayed attached.
Mycelium: network of hyphae.
Coenocytic: no cross walls, many nuclei, shared cytoplasm.
Saprophyte: digests dead food outside itself, absorbs it.
Heterothallic: mates only with the other strain, + or −.
Isogamous: fusing gametangia look alike.

Formulas

$N = N_0 \times 2^n$	N_0 start; N later; n generations **Use:** bacteria, yeast while doubling
$n = \frac{\text{time passed}}{\text{generation time}}$	same time unit **Use:** number of doublings
$N = N_0 \times b^n$	b burst size; n lytic cycles **Use:** phages

- one phage, 100 a burst, 3 cycles (90 min at 30 min): $100^3 = 10^6$
- culture 300 → 4,800 in 2 h: $16 = 2^4$, so $120 \div 4 = 30$ min
- one cell, 20 min: $2^{20} = 1{,}048{,}576$ in 6 h 40 min
- 1 h → 2 h at 20 min: $8N_0 \to 64N_0 = 8\times$, not $2\times$
- real culture: **lag** → **log phase** (formula works) → **stationary** (food out, wastes) → dies off

2.1 Microbiology

Microbe	Size	Seen with
phage T4	about 200 nm long	electron microscope
E. coli	about 2 µm long	good light microscope
yeast	5–10 µm	light microscope
Amoeba proteus	about 500 µm	hand lens, just
Mucor threads	10–20 µm wide	fur: naked eye

By microbe:

- bacteriology
- virology
- mycology (fungi)
- protozoology
- phycology (algae)

By use:

- medical
- immunology
- agricultural
- food
- industrial
- environmental

Importance

- **medicine**
  - causes of TB, cholera, typhoid, COVID-19
  - antibiotics (penicillin from *Penicillium*)
  - vaccines
  - insulin from *E. coli* since 1982
- **agriculture**
  - *Rhizobium* fixes nitrogen in legume nodules
  - compost
  - crop diseases (late blight, rust)
- **food**
  - lactic acid bacteria (dahi, gundruk)
  - *Bacillus* (kinema)
  - yeasts and molds in marcha (jaand, chhyang)
  - yeast (bread, sel roti)
  - why food spoils
- **industry**
  - alcohol
  - vinegar
  - citric acid
  - vitamins
  - enzymes
  - medicines
- **environment**
  - decomposers
  - sewage
  - biogas
- **research**: *E. coli*, baker's yeast

History:

- Hooke drew a *Mucor* (*Micrographia*, 1665)
- Leeuwenhoek saw "animalcules" (1676), tooth bacteria (1683)
- Pasteur and Koch: microbes cause fermentation, disease

2.2 Reproduction

Virus:

- no cell
- no food store
- no machinery
- is copied by its host (**obligate parasite**)

Phage T4 on *E. coli*:

- head (capsid) with DNA
- collar
- hollow tail with sheath
- baseplate
- six tail fibers

Lytic cycle (about 25–30 min at 37 °C; 100–150 phages a burst):

1. **Attachment**: fibers grip receptors, key in a lock; only the host that fits
2. **Penetration**: sheath contracts, tube through wall, lysozyme makes a hole; **DNA only** enters; "ghost" stays out
3. **Biosynthesis**: phage enzyme chops host DNA; host's ribosomes make phage DNA and proteins
4. **Maturation**: parts assemble; complete at about 20 min
5. **Release**: holes in membrane, lysozyme digests wall; cell bursts

- other books: 4 or 6 steps; the same process
- only DNA enters: Hershey and Chase, 1952 → genes are DNA
- phages found by Twort (1915), d'Hérelle (1917); phage therapy

Binary fission (*E. coli*): one circular chromosome, about 4.6 million base pairs, in the nucleoid

1. DNA copied from one point: two loops
2. cell grows; loops move apart
3. FtsZ protein ring; membrane and wall grow in: **septum**
4. septum closes: two equal, identical cells

no spindle; about **20 min** at 37 °C

Budding (yeast, *Saccharomyces cerevisiae*, a eukaryote)

1. **bud** pushes out; cytoplasm flows in
2. nucleus divides by mitosis in the **neck**; envelope stays whole
3. bud takes cytoplasm, mitochondria, part of vacuole
4. wall across neck; bud breaks away; **bud scar** on mother (about 20–30 daughters)

	Fission (E. coli)	Budding (yeast)
parent	prokaryote	eukaryote
DNA	copied, pulled apart; no spindle	mitosis
two cells	equal	big mother, small bud
parent	gone	lives on, scars
doubling	about 20 min	about 1½–2 h (30 °C)

2.3 Mucor (pin mold)

- saprophyte on
  - damp bread
  - dung
  - fruit
  - soil
- **mycelium** of **hyphae**
  - chitin wall
  - no cross walls
  - every nucleus **haploid (n)**
- **no rhizoids or stolons**: those are *Rhizopus*

Vegetative: fragmentation.

Asexual (usual, when well fed):

1. hypha grows up: **sporangiophore**
2. tip swells: **sporangium**
3. dome-shaped wall cuts off sterile **columella**; outside: **sporangiospores** (n, by mitosis)
4. ripe: white or yellow → gray-black; wall breaks; **collar** left; wind carries spores
5. spore on damp food → **germ tube** → mycelium

Others: **chlamydospores** (thick walls, for bad times); yeast-like budding in sugary liquid with little air.

Sexual (food short, or strains meet); *M. mucedo* heterothallic:

1. hormones → **zygophores** meet
2. tips swell: **progametangia** (many nuclei)
3. cross wall: **gametangium** (tip) + **suspensor** (stalk)
4. wall dissolves; + and − nuclei fuse: **diploid (2n)**; **conjugation**
5. **zygospore**: thick, black, warty; rests for months
6. **meiosis** on germination → **germ sporangiophore** → **germ sporangium** of n spores → + or − mycelia

Cycle:

- mycelium (n) → sporangium → spores (n) → mycelium
- the + and − mycelia (n) → gametangia → zygospore (2n) → meiosis → spores (n) → mycelia
- zygospore: the only 2n stage

Sporangiospore	Zygospore
asexual, in a sporangium	sexual, two gametangia fuse
n	2n
small, thin wall, thousands	large, single, thick wall
spreads by wind	survives bad times
offspring: copies	offspring: new combinations

Blakeslee (1904):

- pure cultures from single spores
- zygospores only where two strains met
- named + and −

2.4 Advantages and disadvantages

Advantages	Disadvantages
decomposer: recycles nutrients	spoils bread, fruit, vegetables, jam, grain; hyphae run deep
starters (marcha); *sufu*	*M. piriformis*: soft rot of stored apples, pears
microbial rennet; enzymes	**mucormycosis** in weak immunity (diabetes, steroids): often sinus → eyes, brain; about half die in sinus form; not person to person
alcohol from plant waste (*M. indicus*)	spores: allergies, asthma
breaks down pollutants; hyphae soak up metals	infects cattle, pigs, poultry

- mold needs water: fast in monsoon, slow at 4 °C (doesn't die)

COMMON MISTAKES

✗ virus reproduces by fission
✓ no cell to split; copied by its host.

✗ whole phage enters the cell
✓ only its DNA.

✗ 2 h of doubling = 2 × 1 h
✓ every 20 min doubles: 64 ÷ 8 = 8 ×.

✗ 6 generations = 6 ×
✓ $2^6 = 64$ ×.

✗ *Mucor* has rhizoids
✓ that is *Rhizopus*.

✗ sporangiospores diploid
✓ n, by mitosis; only the zygospore is 2n.

✗ + and − are male and female
✓ look alike; "able to mate with the other".

✗ moldy roti safe once scraped
✓ hyphae run deep; throw it away.