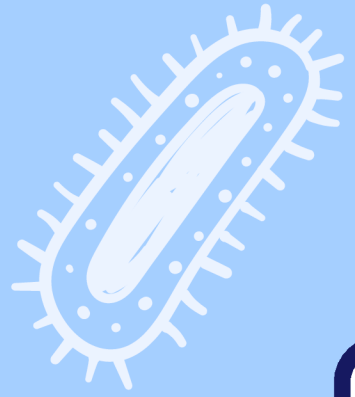
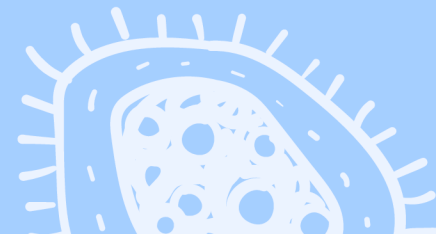




Lecture 3

Bacterial Growth & physiology



Bacterial Growth

Definitions

B. Reproduction

culture media

A) Definition

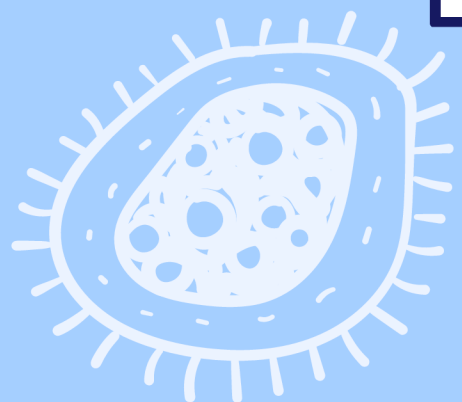
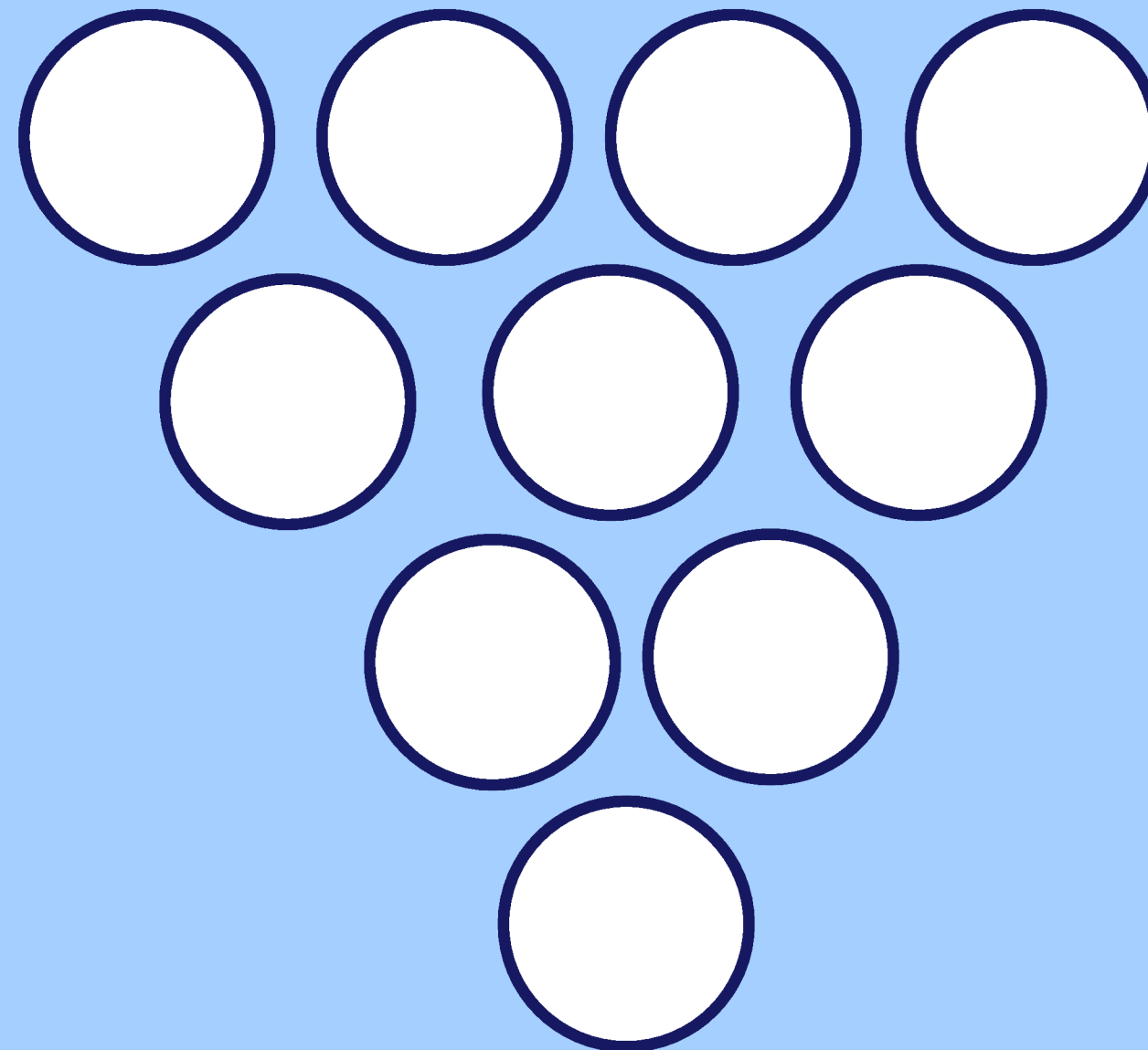
B) Classification

C) Types

Bacterial growth curve

Bacterial Growth: Definition

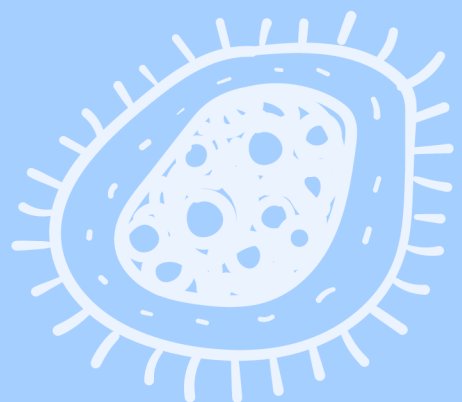
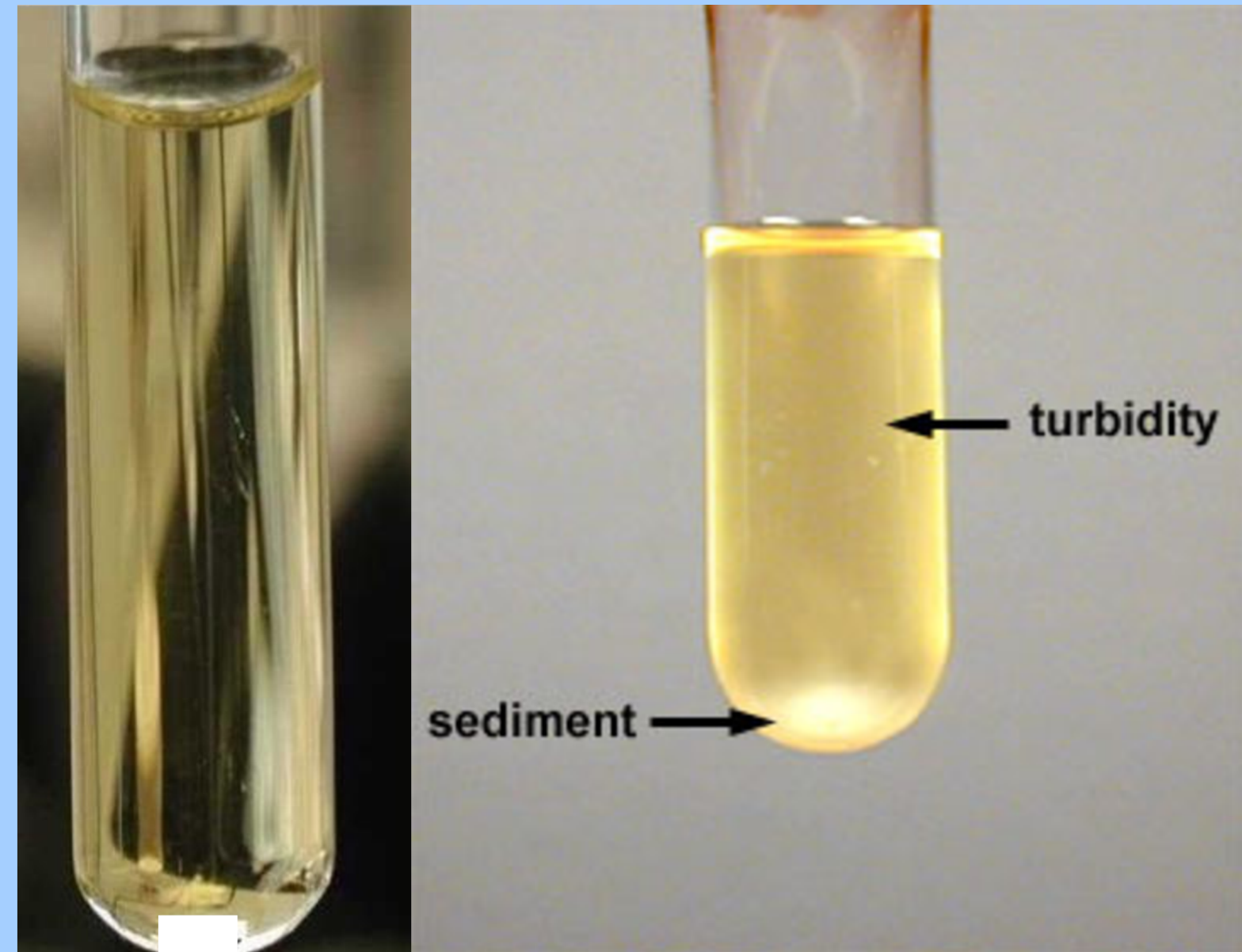
Size
& Number of
organism



I) Bacterial Growth

Indicated by

a) Turbidity of
the fluid media

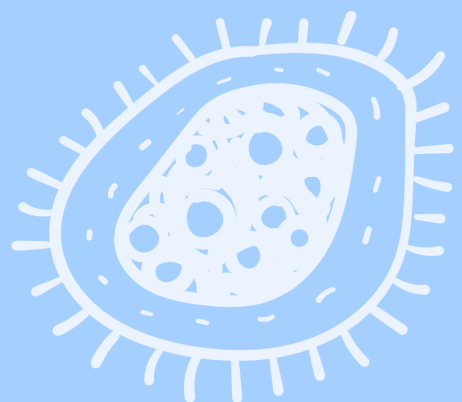
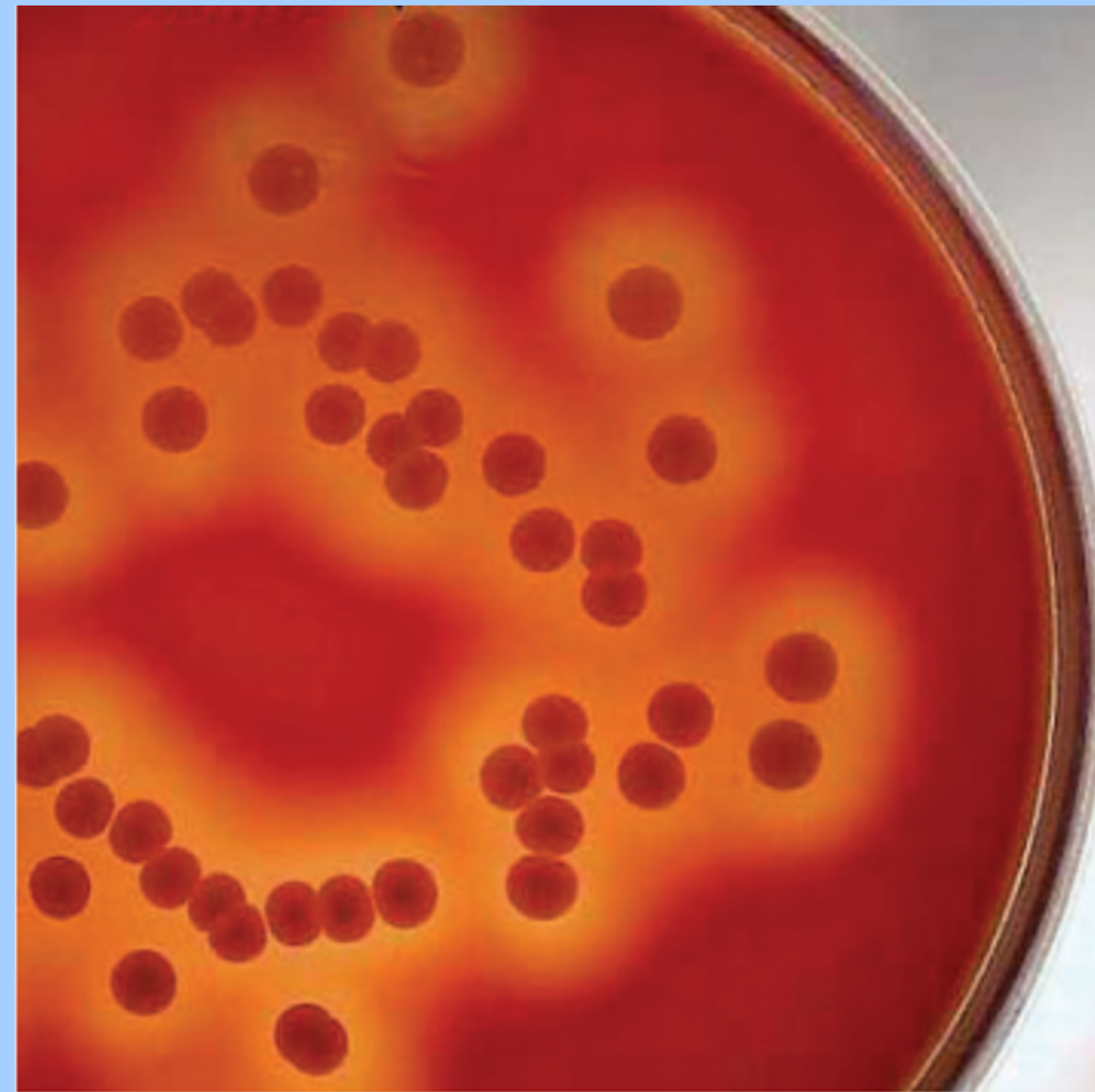


I) Bacterial Growth

Indicated by

b) Colonies *on solid media*

(Macroscopic product)



2) Colony (Macroscopic product)

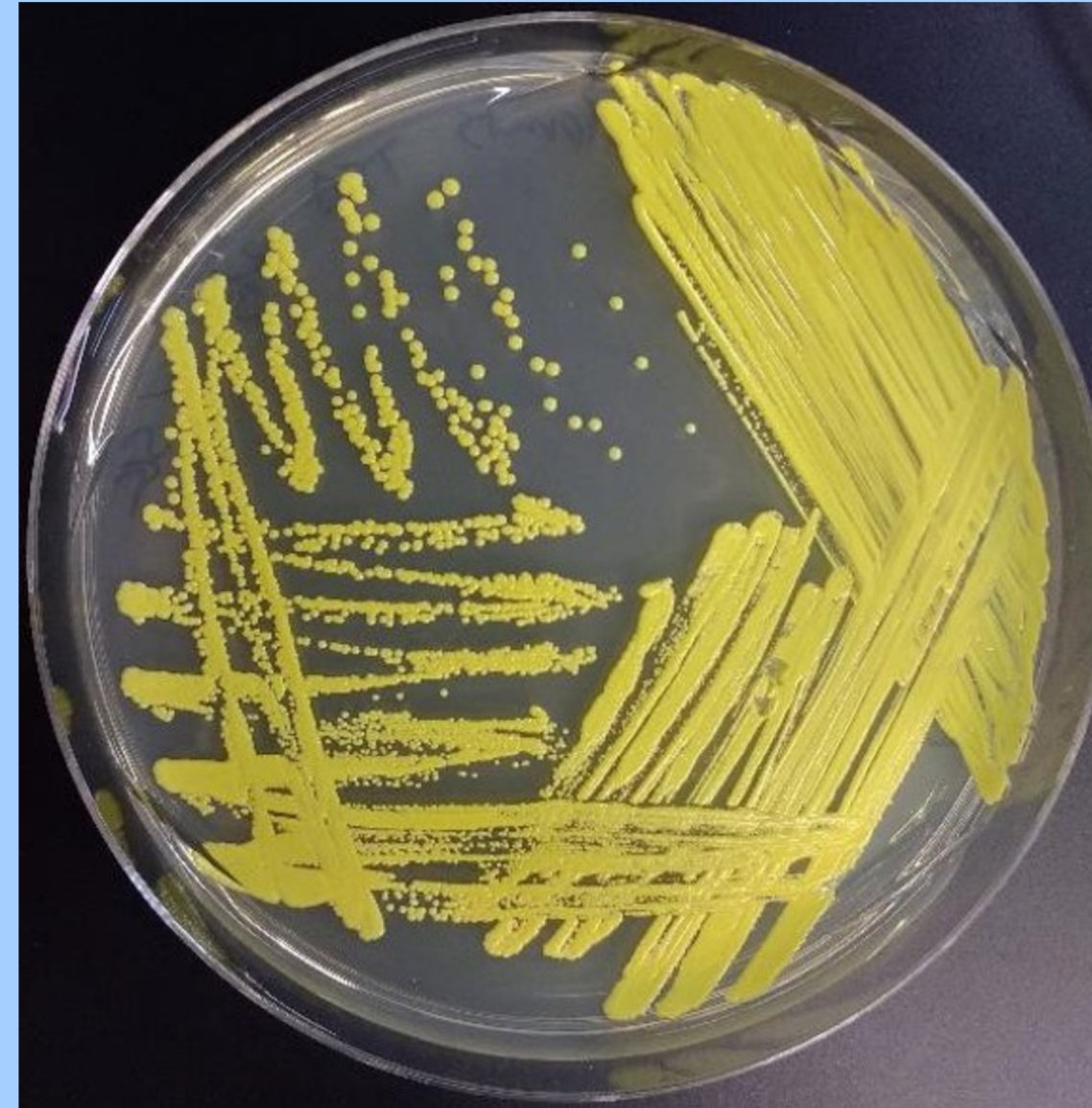
Single bacterium

On solid media

After 20–30 division

Binary fission

Colony



So the appearance of colony will be after 20–30 division of single bacterium

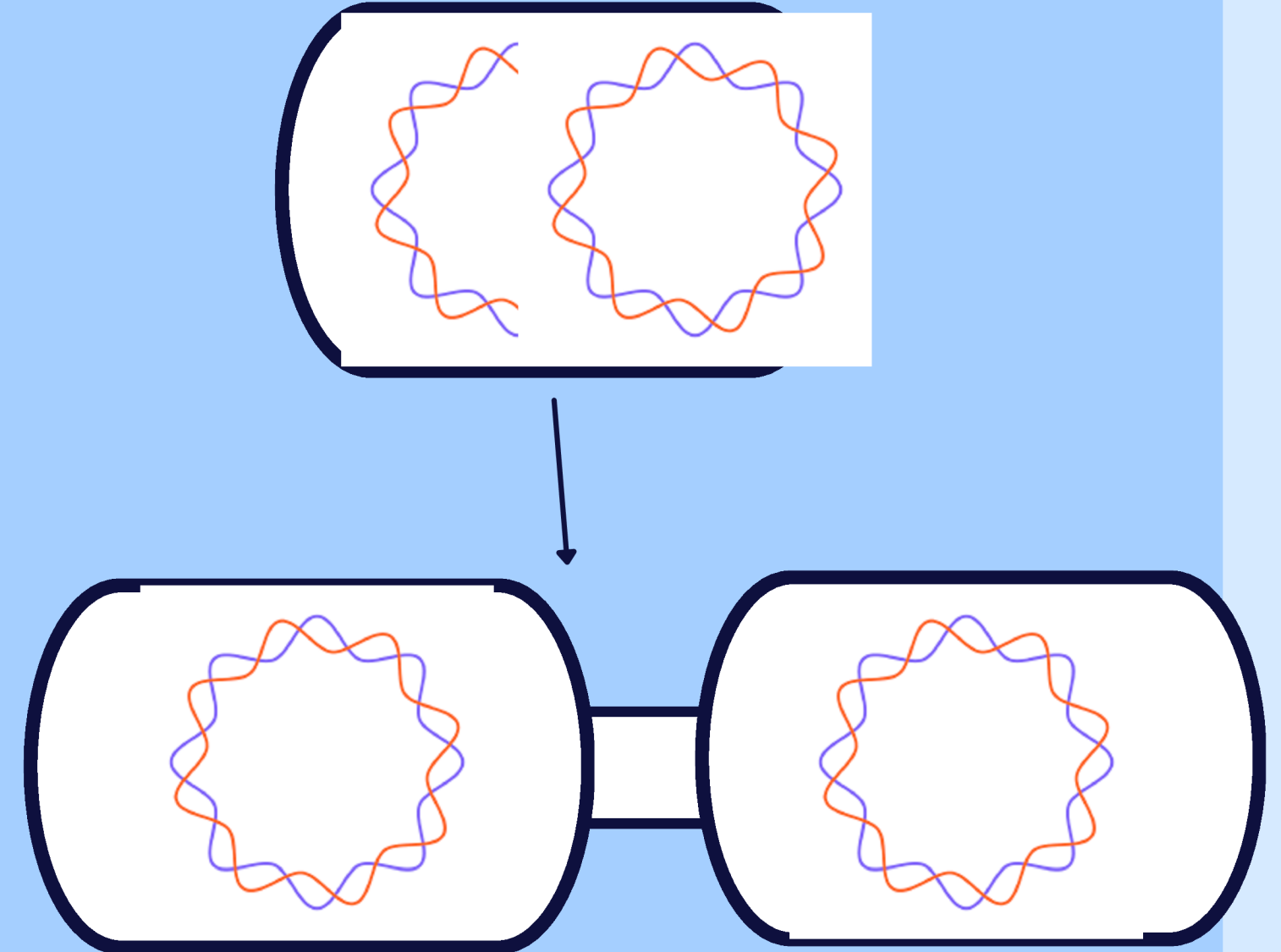
2) Colony

After 20–30 division

Binary fission

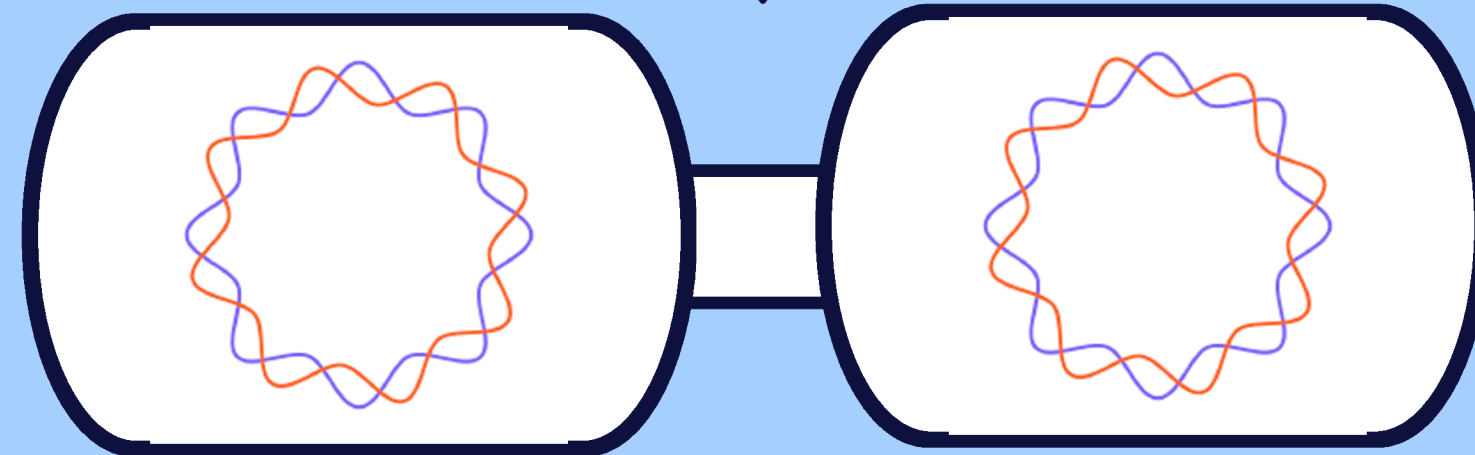
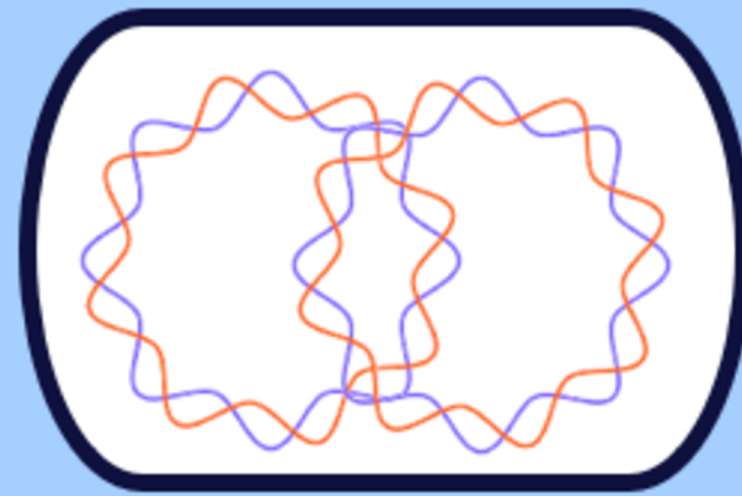
1 Million

(2^{20})



3) Generation time (doubling time)

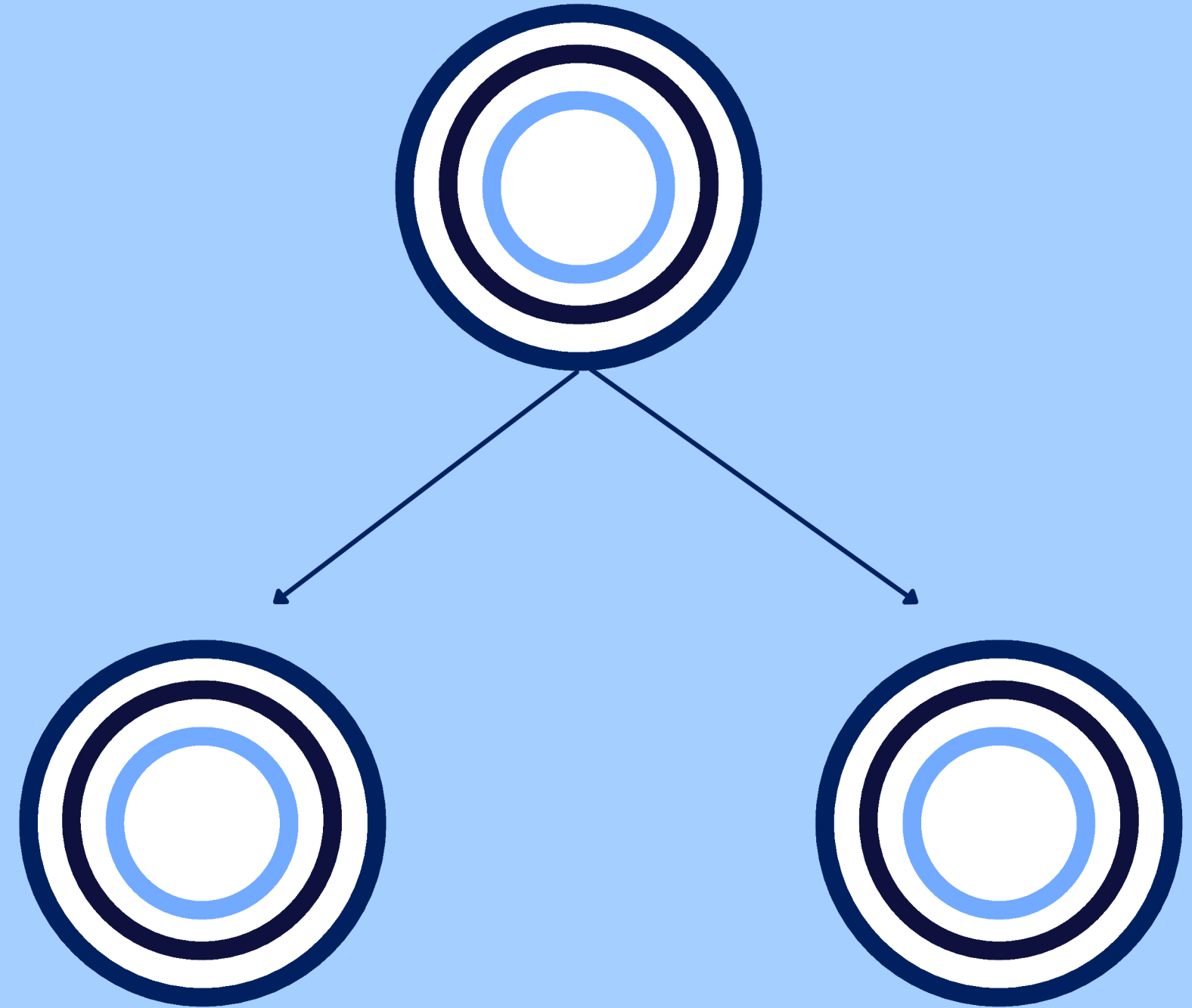
13min (*V.cholerae*)



24 hrs (*M.tuberculosis*)

Bacterial Reproduction

Binary fission



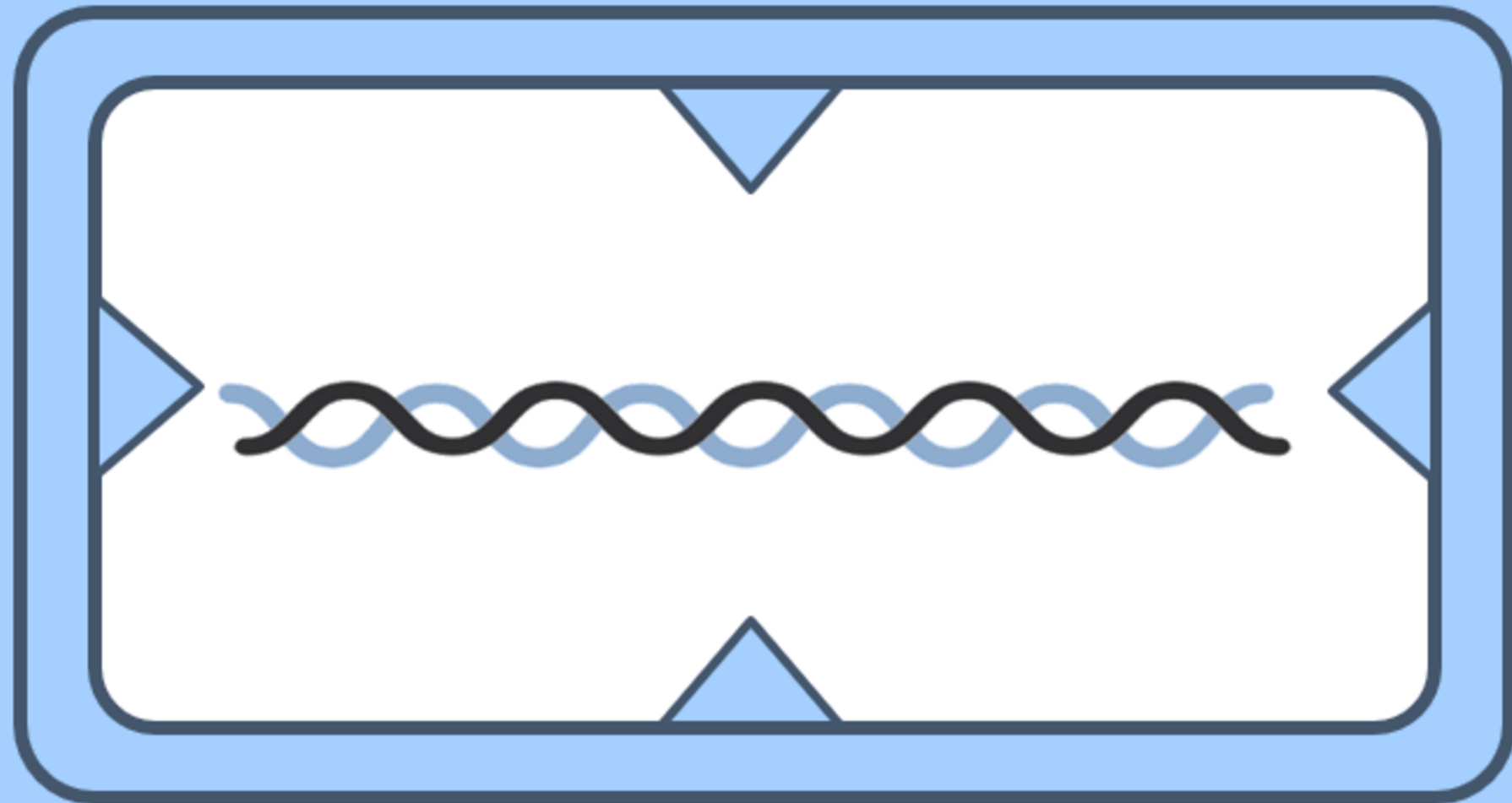
Bacterial Reproduction

I Elongation



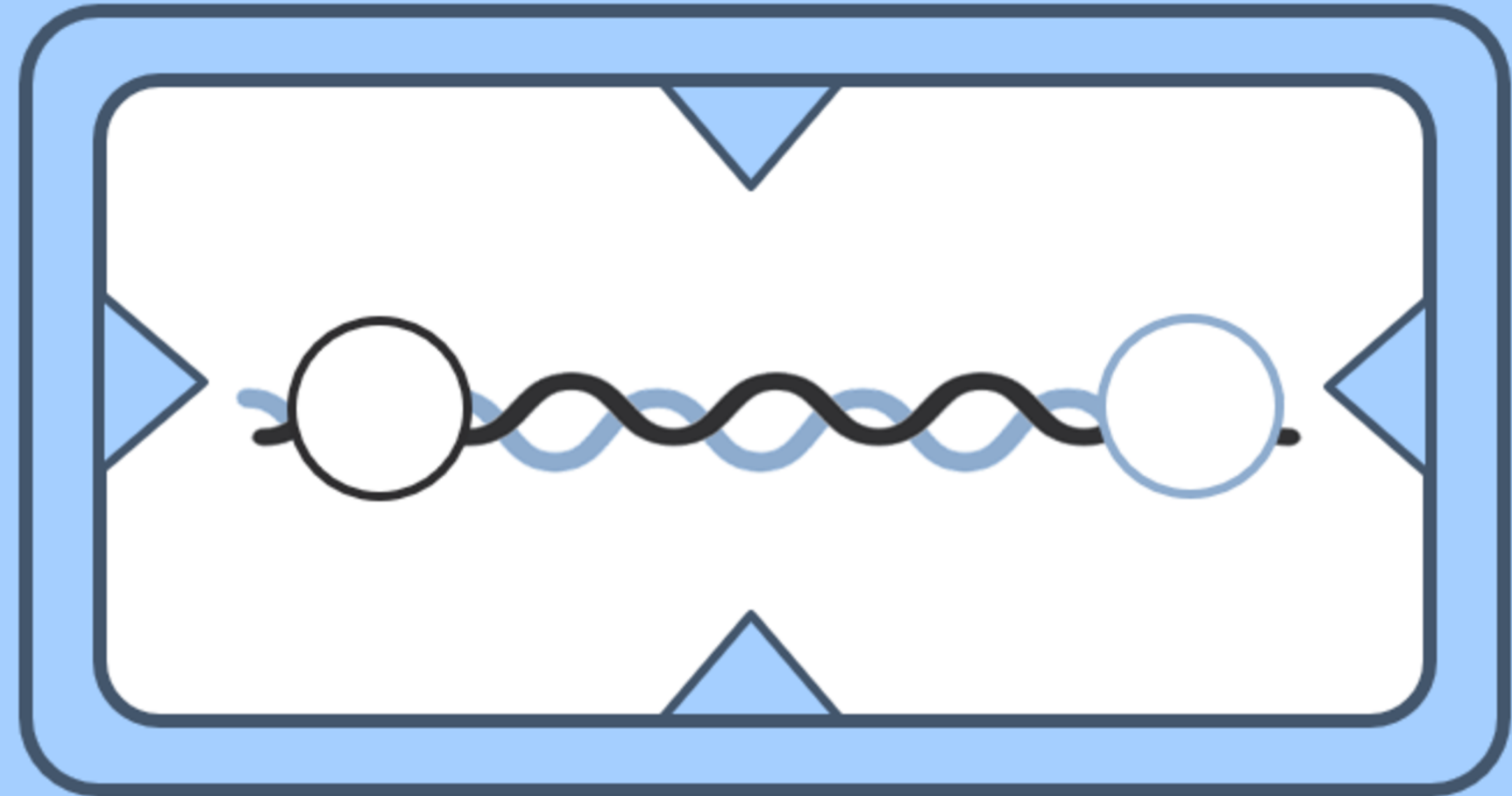
Bacterial Reproduction

2 Separation of
2 strands
(ssDNA attached to
mesosome)



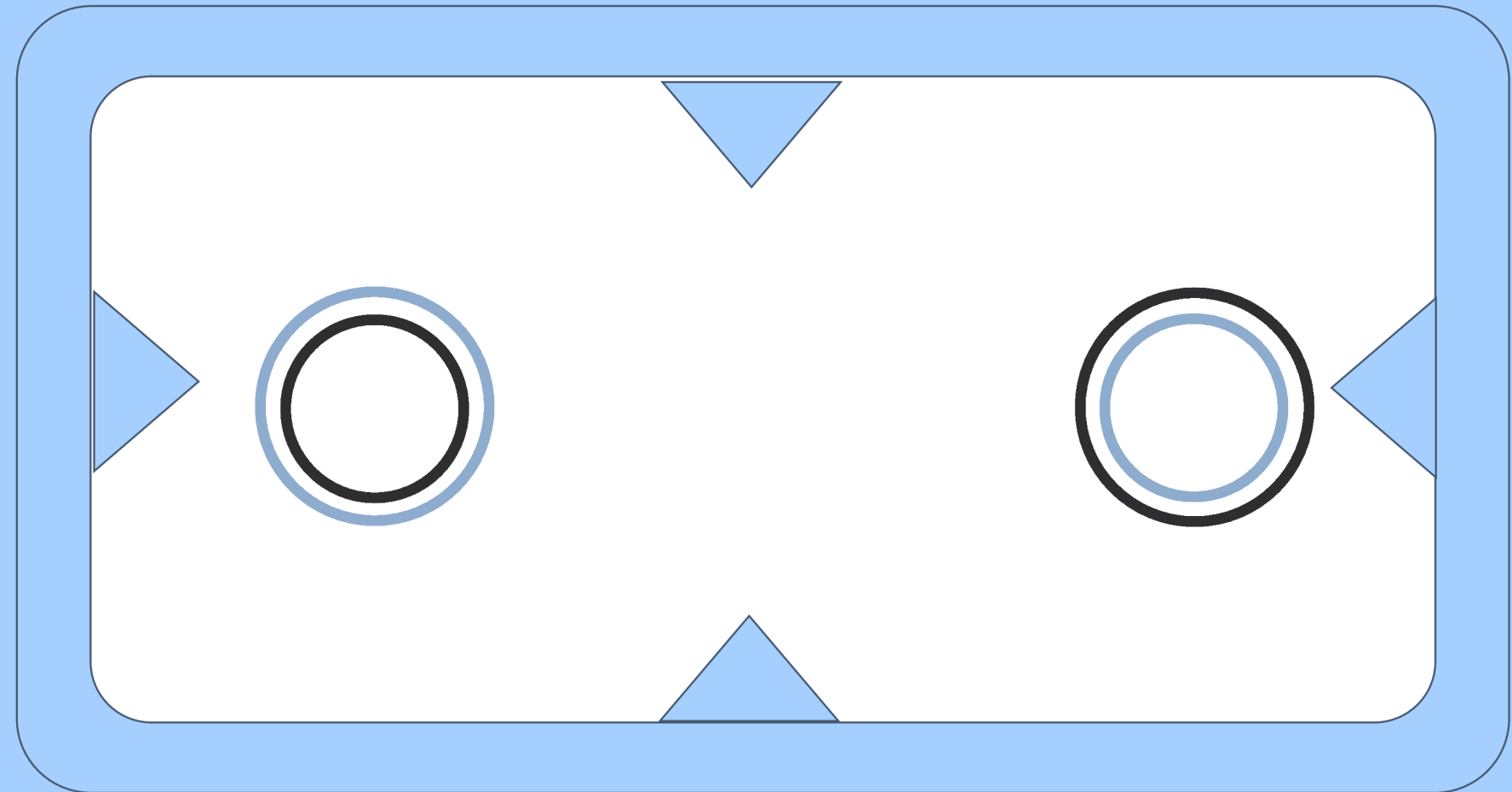
Bacterial Reproduction

2 Separation of
2 strands



Bacterial Reproduction

3 Separate ssDNA &
become dsDNA



Bacterial Reproduction

4

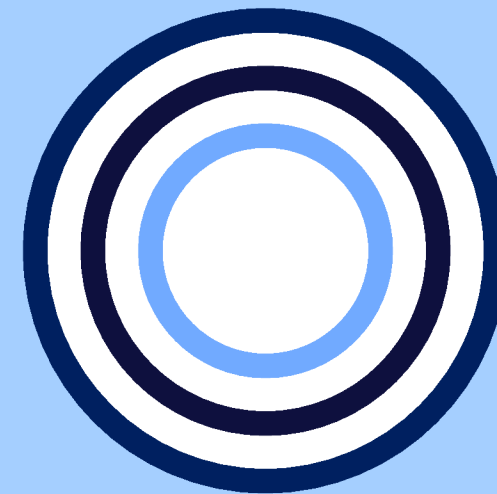
Formation of
division septum



Bacterial Reproduction

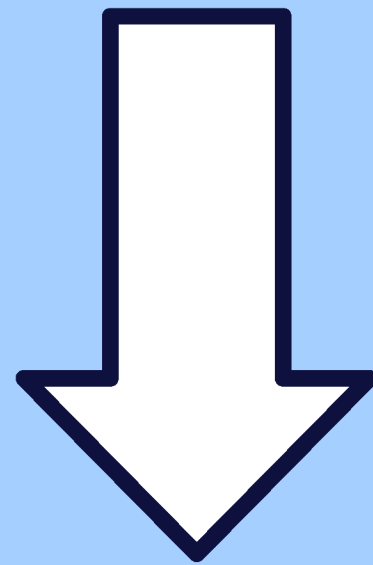
5

Cell separation



Bacterial culture media

Bacteria grow
(*In vitro*)



Need nutrients for
growth



Artificial

Purpose



Study Properties



Purpose

2

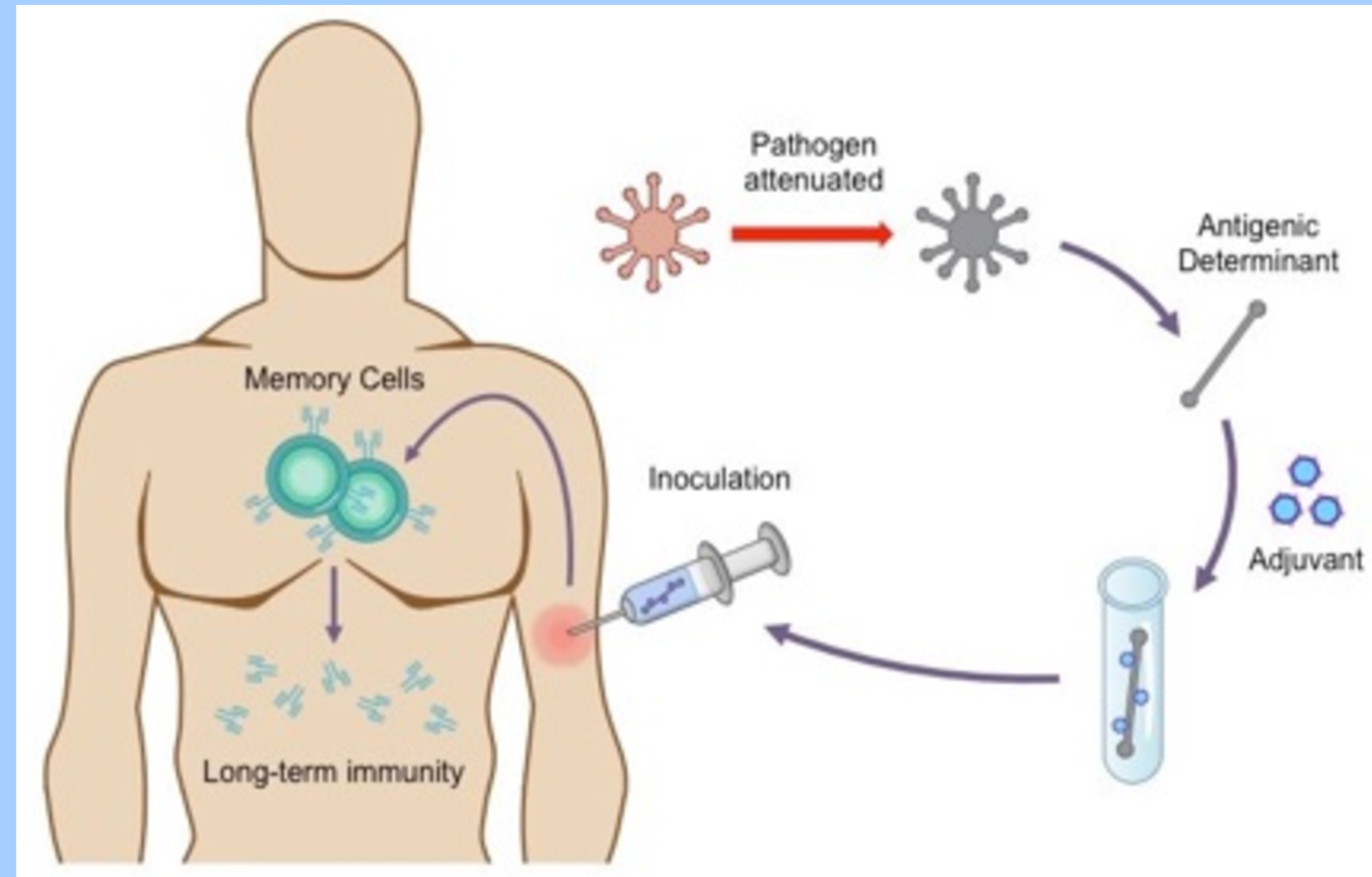
**Isolation &
diagnosis
(Causative agent)**



Purpose

3

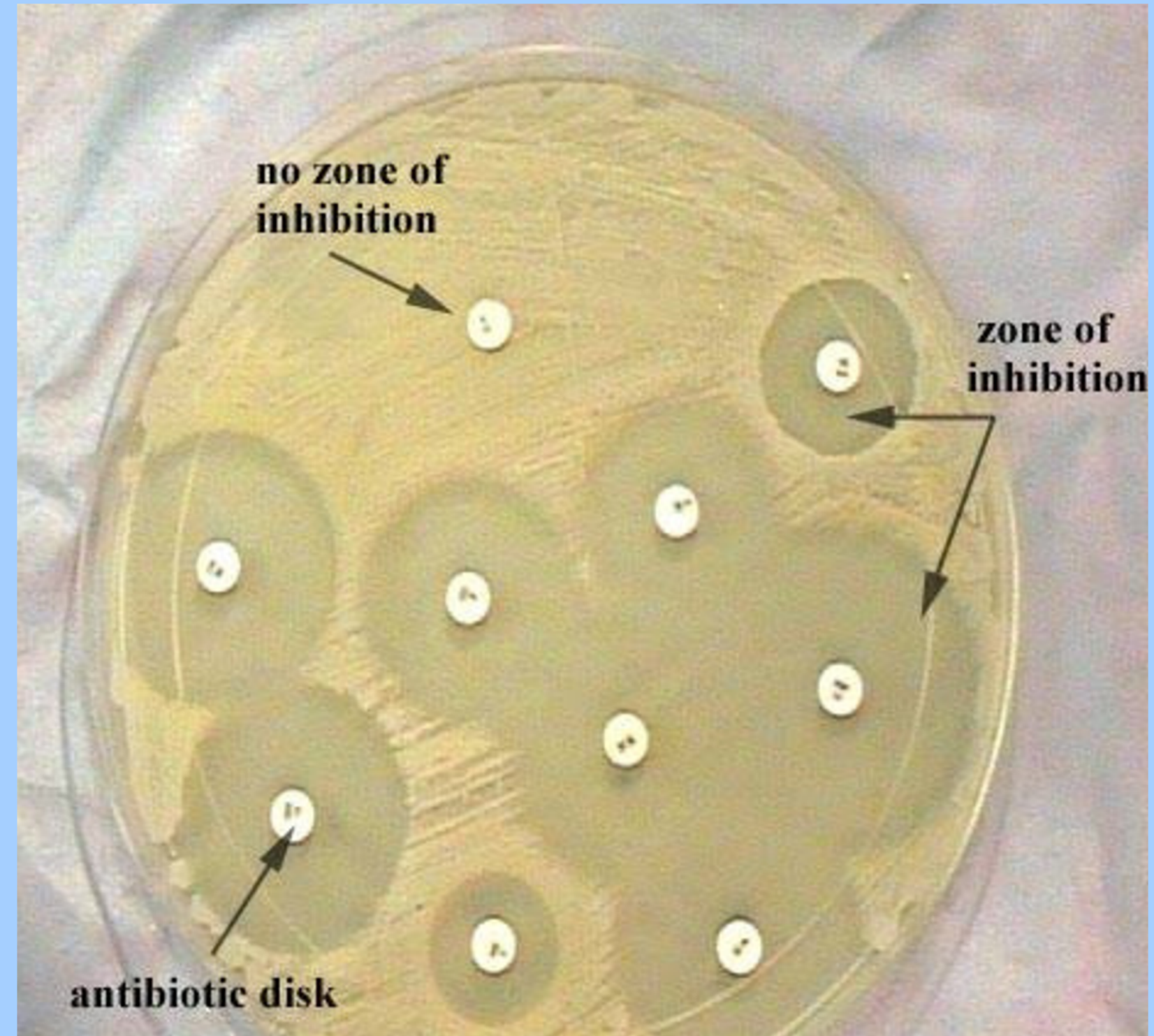
Prepare vaccine &
Other product



Purpose

4

**For Selection
proper antibiotics**



Classification of media

Liquid



Solid



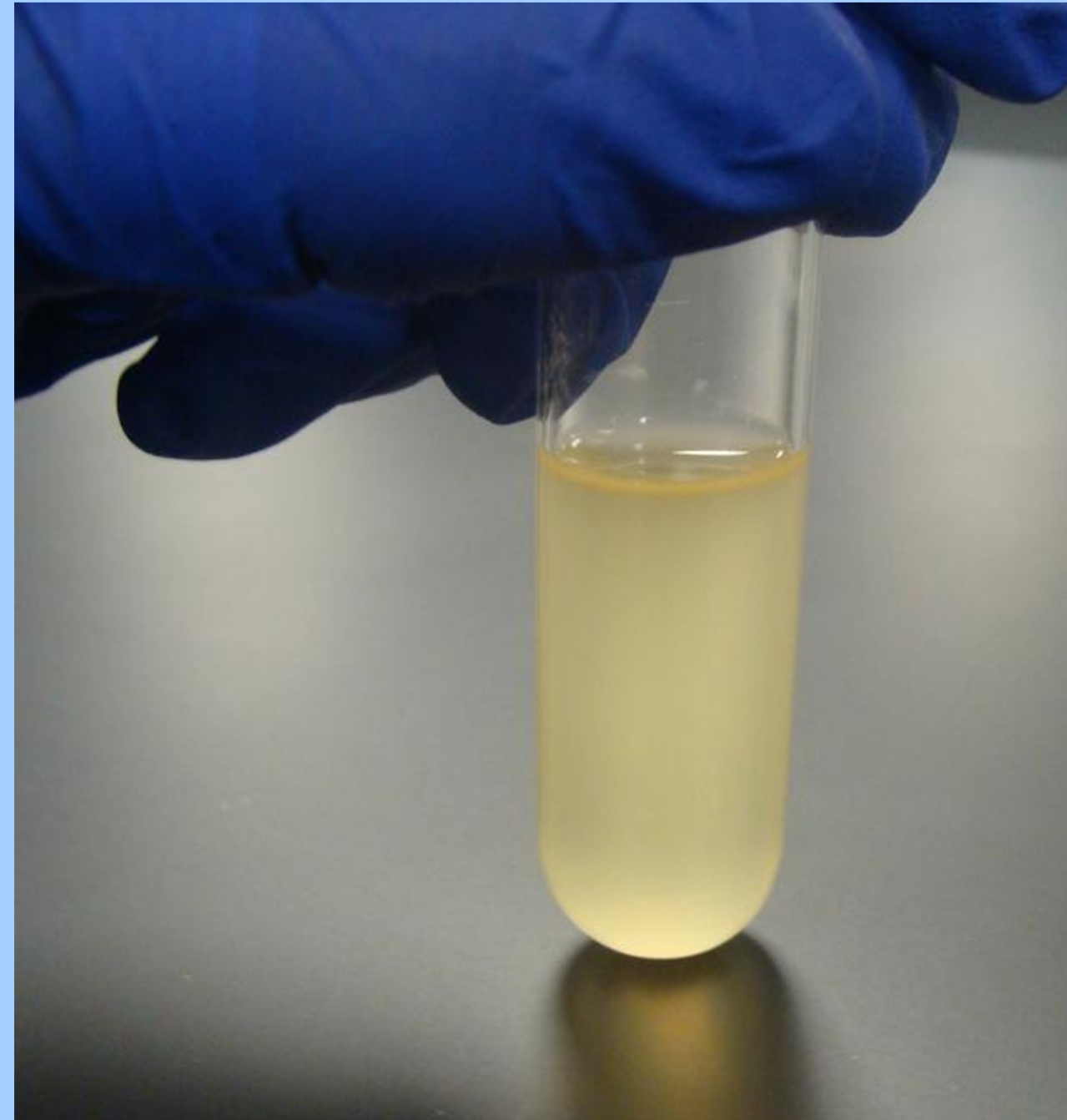
Types of media

- 1) Simple media
- 2) Enriched media
- 3) Selective media
- 4) Differential media



Simple media

Basic requirement for
growth of most
bacteria



Simple media

A) Peptone water

Peptone + 0.5% NaCl

Enhancement

Sugar media



Simple media

B) Nutrient broth

Meat extract

Enhancement



Simple media

C) Nutrient agar plate

Nutrient broth + 2%

agar agar

(Seaweed)



Staph. aureus

Enriched media

Fastidious bacteria
Need blood, serum for
growth



Enriched media

A) Blood agar

Nutrient agar heated at
 45°C
(semisolid)
+ sheep blood

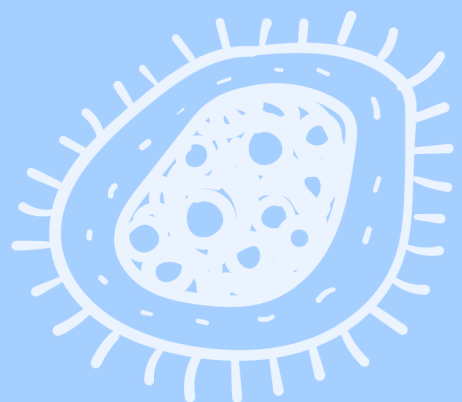
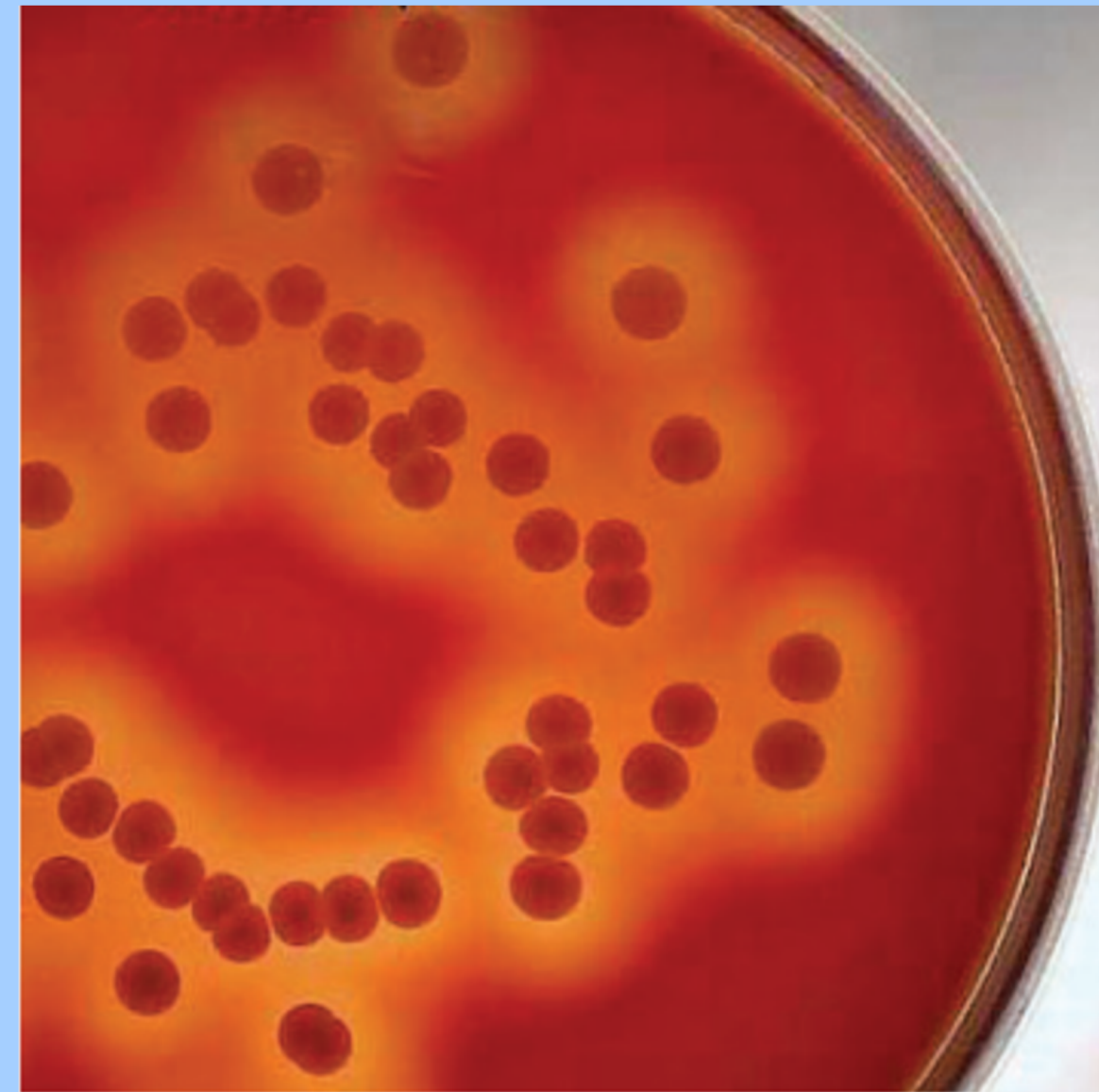


Enriched media

A) Blood agar

Streptococci

Strept. pyogenes



Hemolysis on blood agar:

A. Complete (beta) hemolysis:

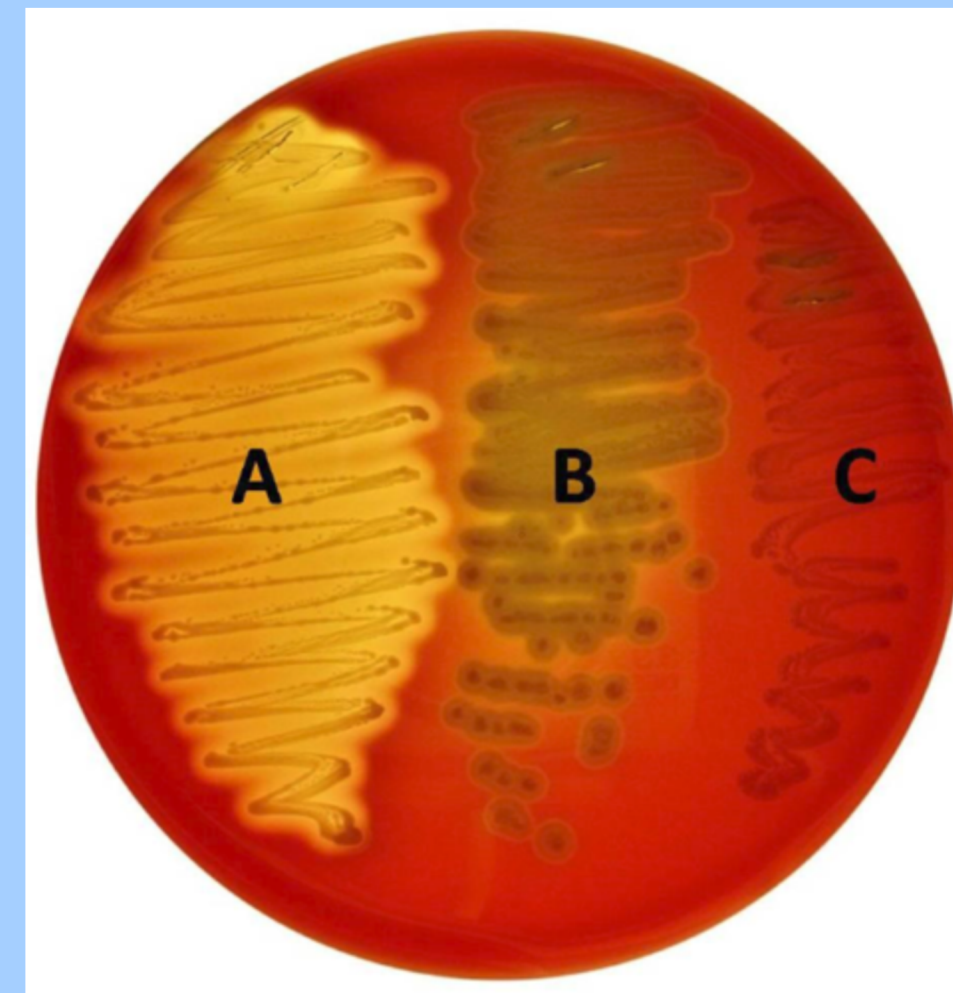
- *Staphylococcus aureus*
- *Streptococcus pyogenes*

C. No (gamma) hemolysis:

- *Enterococci*.

B. Partial (alpha) hemolysis:

- *Streptococcus viridans*
- *pneumococci*.

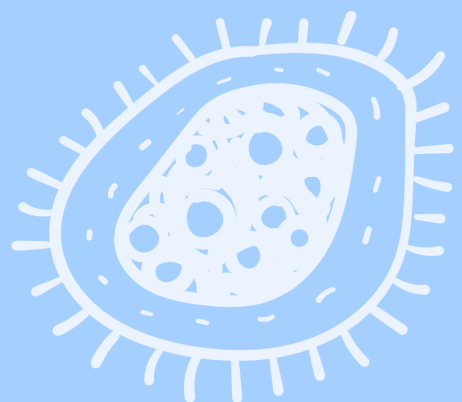
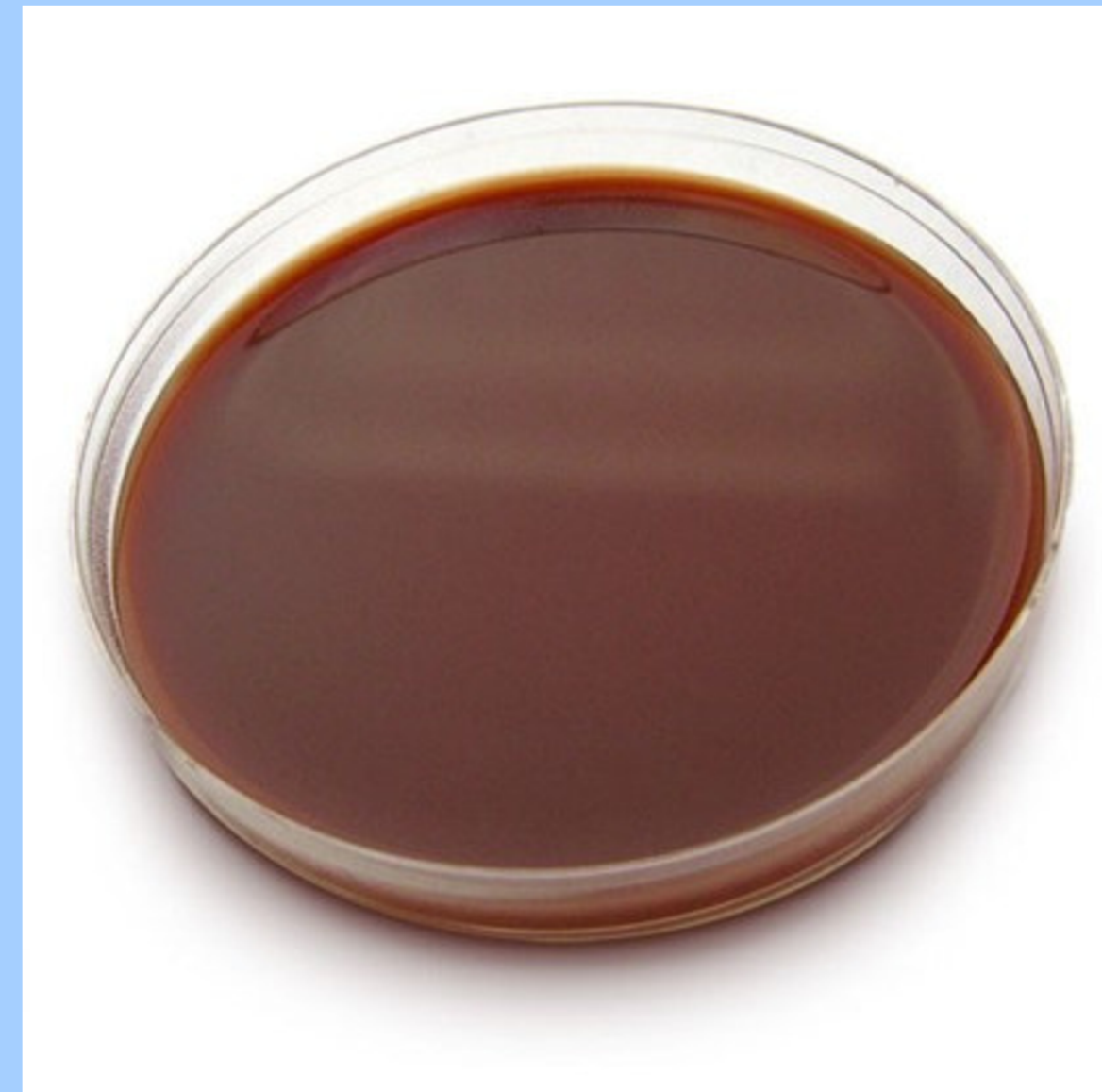


Enriched media

B) Chocolate agar

Nutrient agar heated
at 100°C, add blood

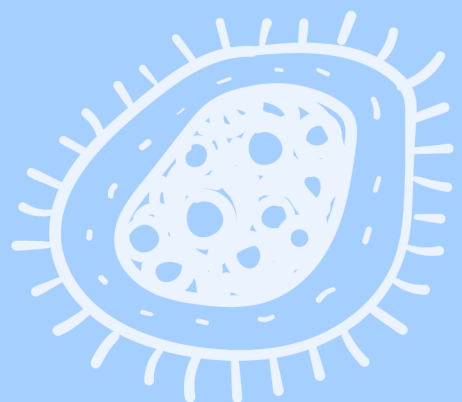
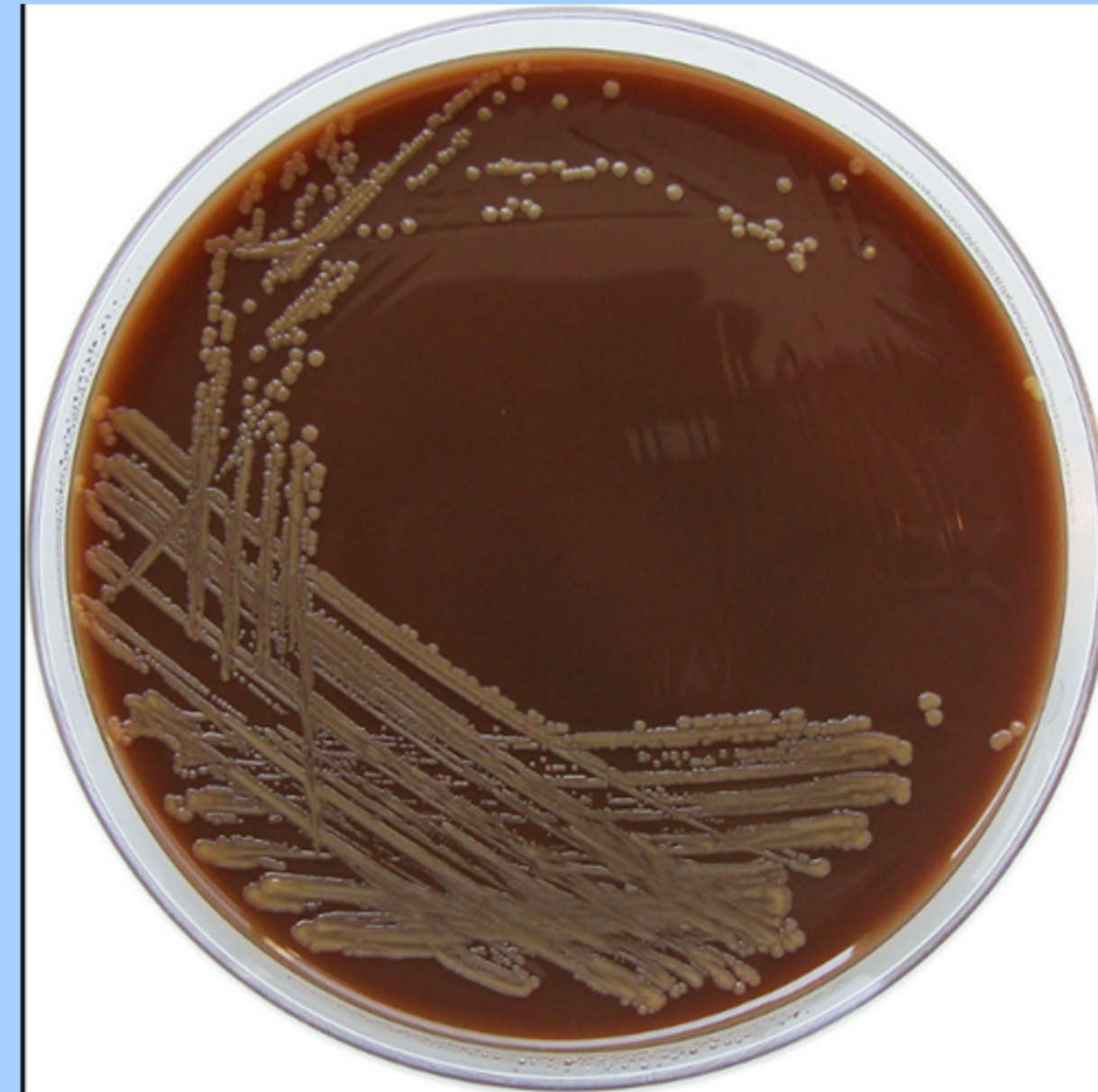
Hb  Haematin
(Chocolate)



Enriched media

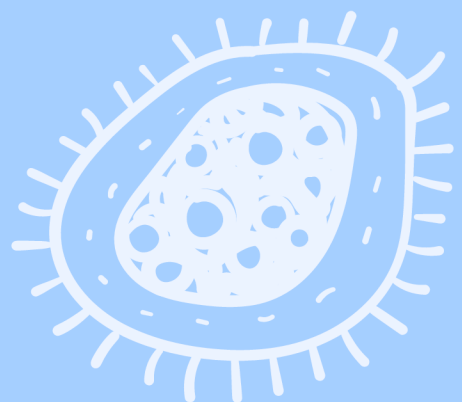
B) Chocolate agar

Haemophilus
Neisseria



Selective media

**Allow a certain *organism* to grow
(Selective) &
inhibits the growth *of others***

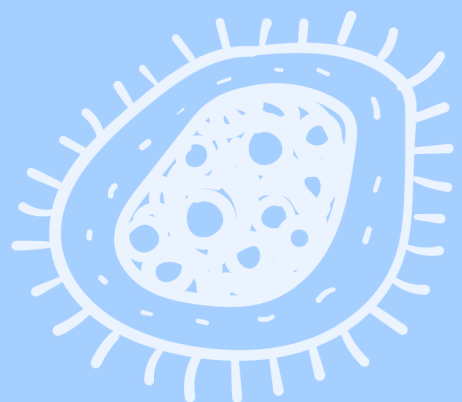


Selective media

Lowenstein Jensen medium

Malachite green

Mycobacterium tuberculosis

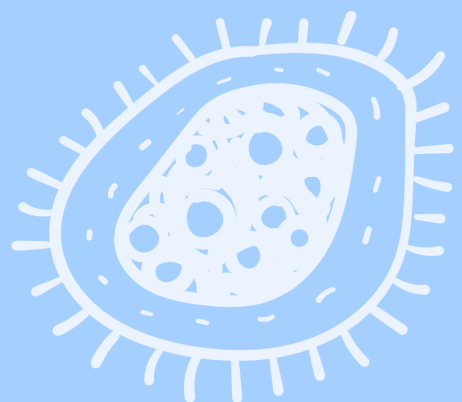
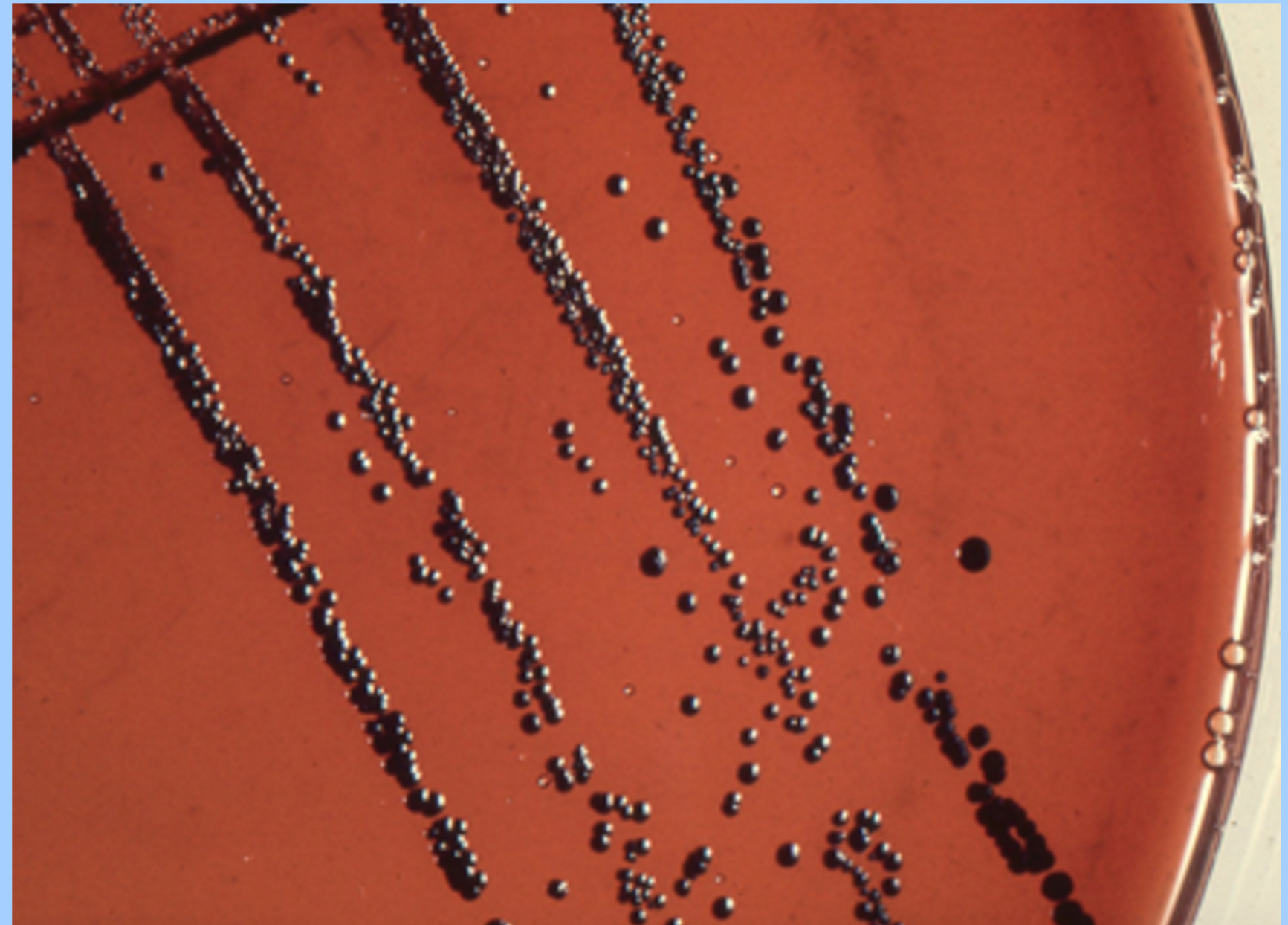


Selective media

Blood tellurite agar

Potassium tellurite

C. diphtheriae



Differential media

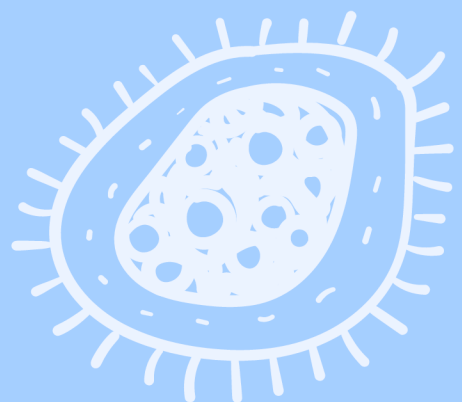
Selective

+

Indicator

Allow a certain *organism*
to grow

Indicator *to differentiate*
(change in visibly)



Purpose

MacConkey's agar

Bile (Enterobacteria)

Lactose= test sugar

Peptone

Neutral red =pH indicator



Pink

Pale

Differential media

Mannitol salt agar

(high salt 7.5% NaCl)

Phenol red = pH indicator



Staph.spp

Staphylococcus
aureus

Staphylococcus
epidermidis

Differential media

Thiosulfate–Citrate–Bile–Sucrose Agar. (TCBS)

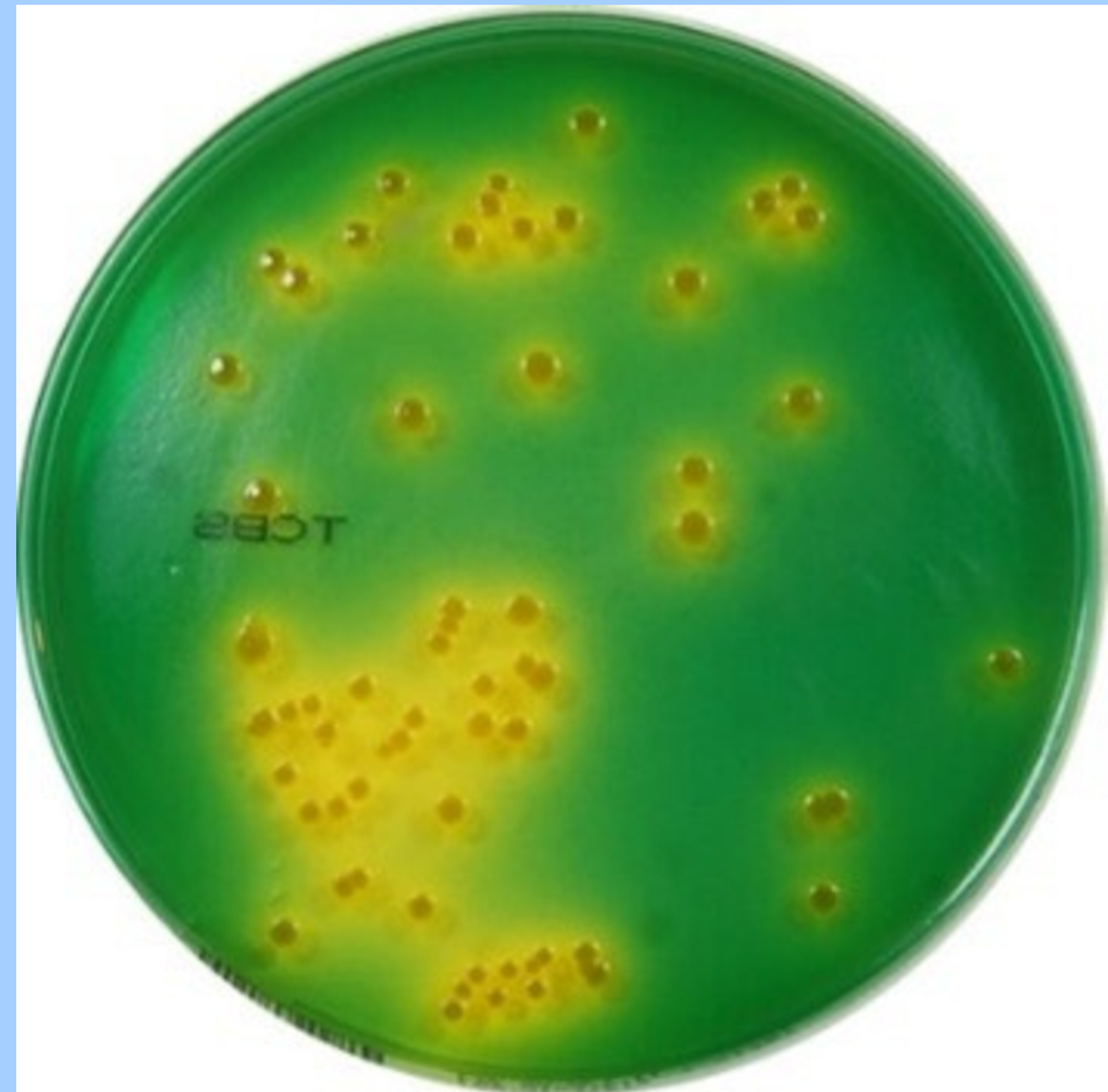
Thiosulphate

Bile

Citrate

Sucrose as test sugar

Bromothymol blue

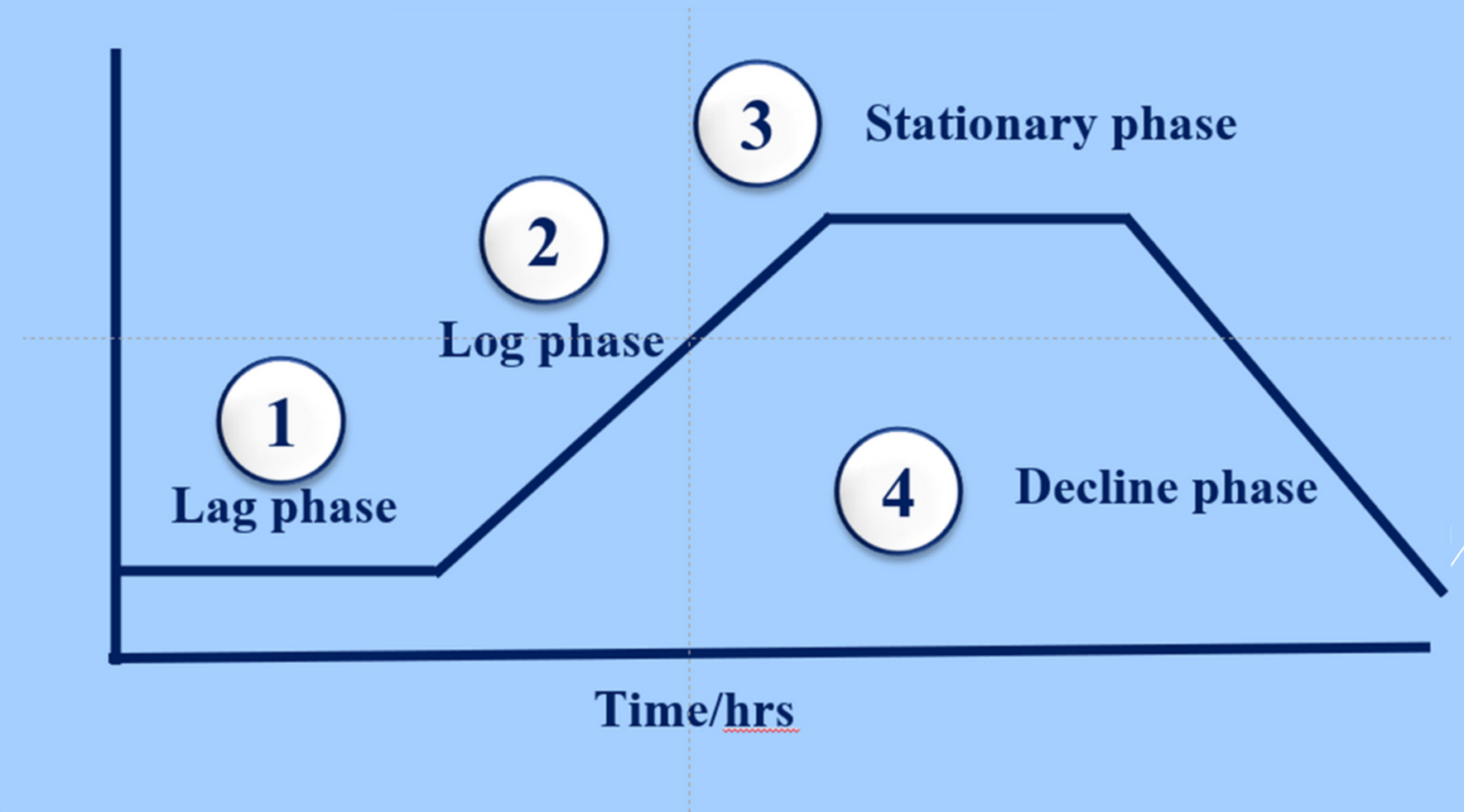


Bacterial growth curve

- 1) Lag phase
- 2) Log phase
- 3) Stationary phase
- 4) Decline phase

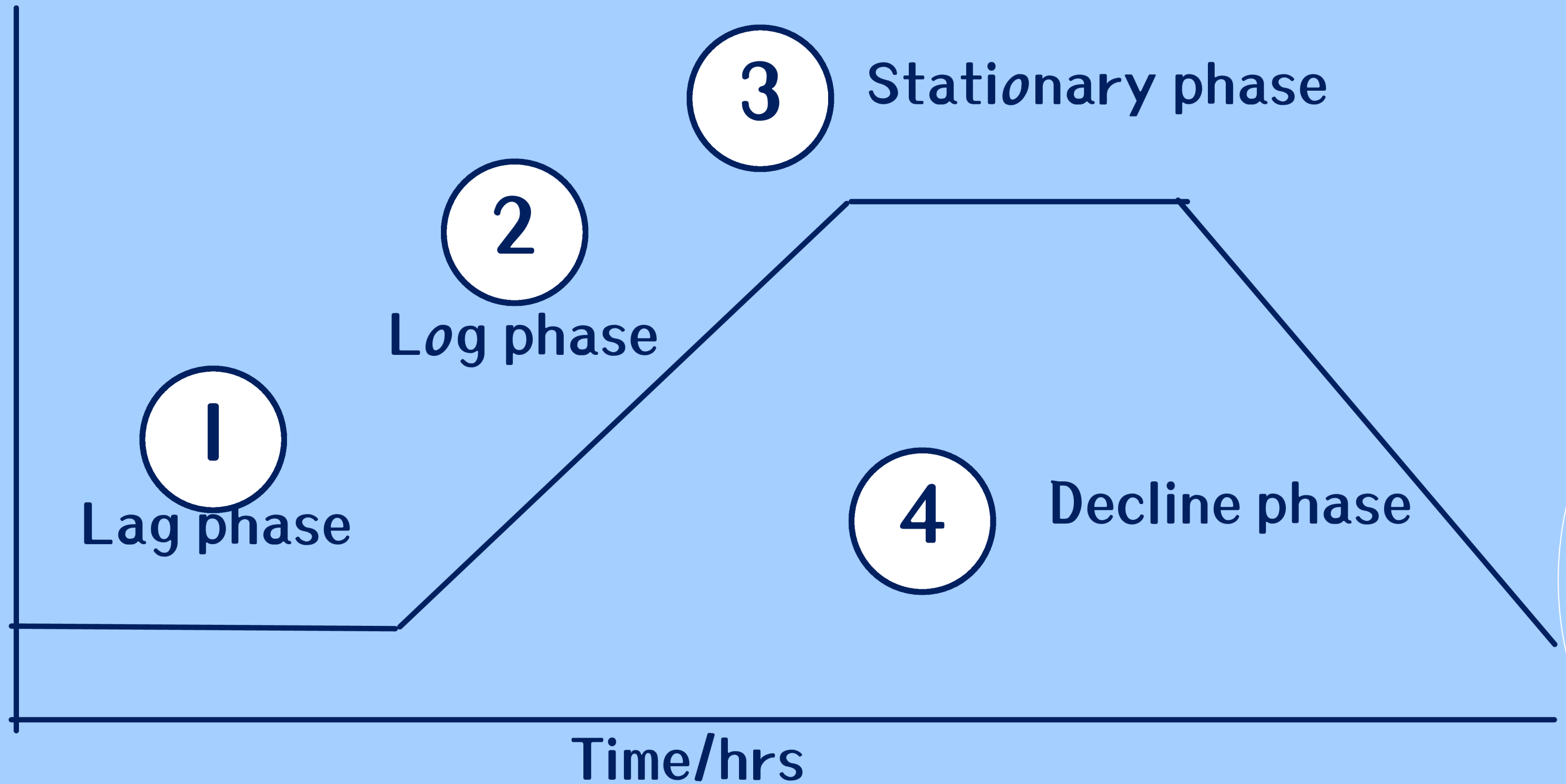
Bacterial growth curve

If a small number
of bacteria are inoculated
into a liquid nutrient
medium

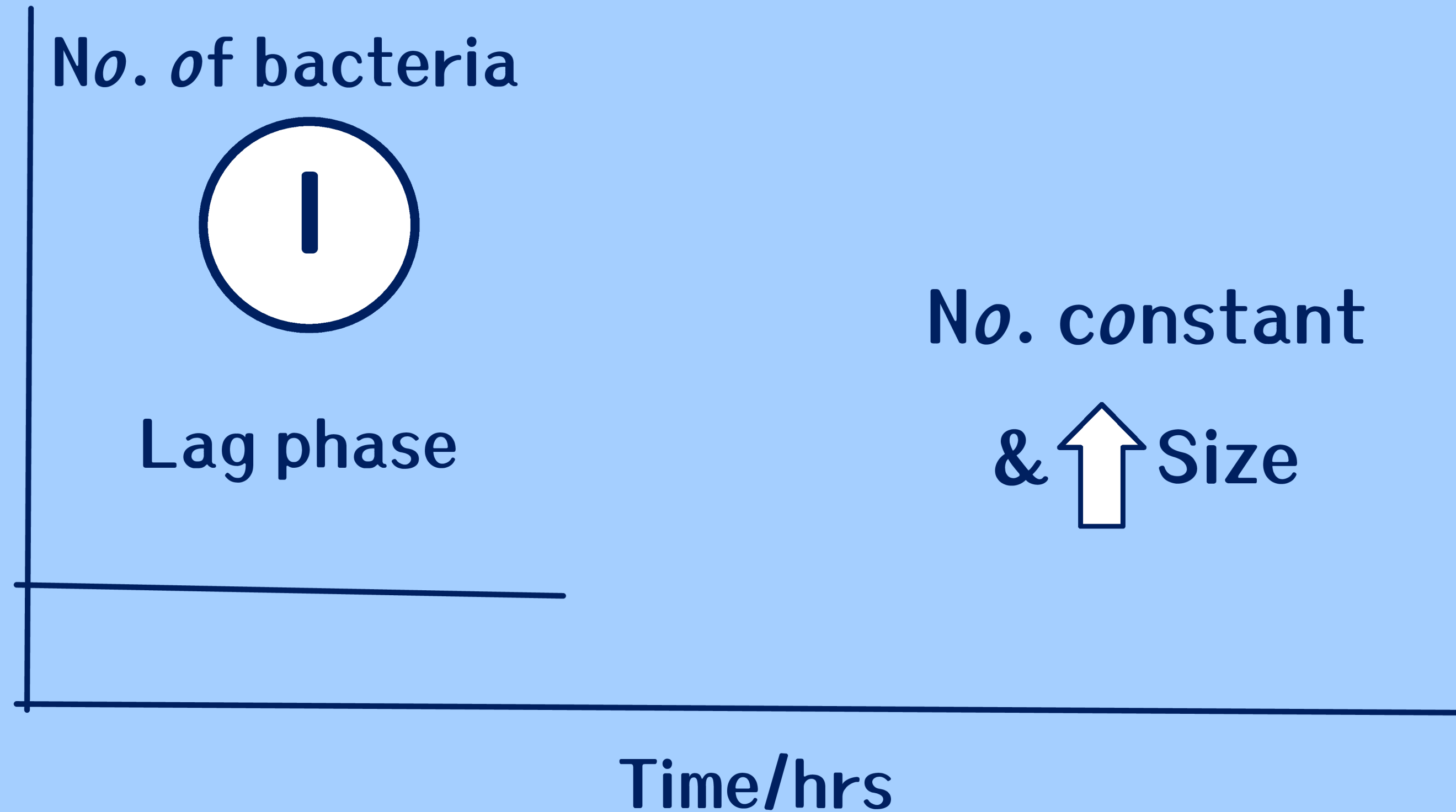


72h

Bacterial growth curve



Lag phase



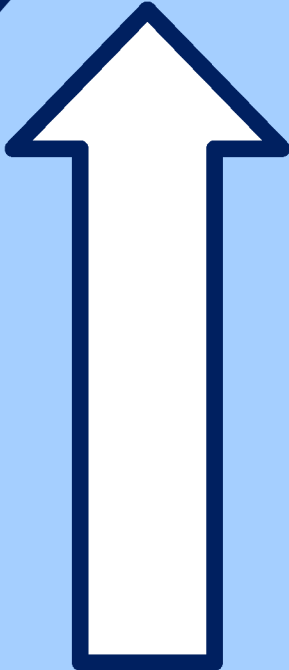
Log phase

No. of bacteria

Start division

2

Log phase

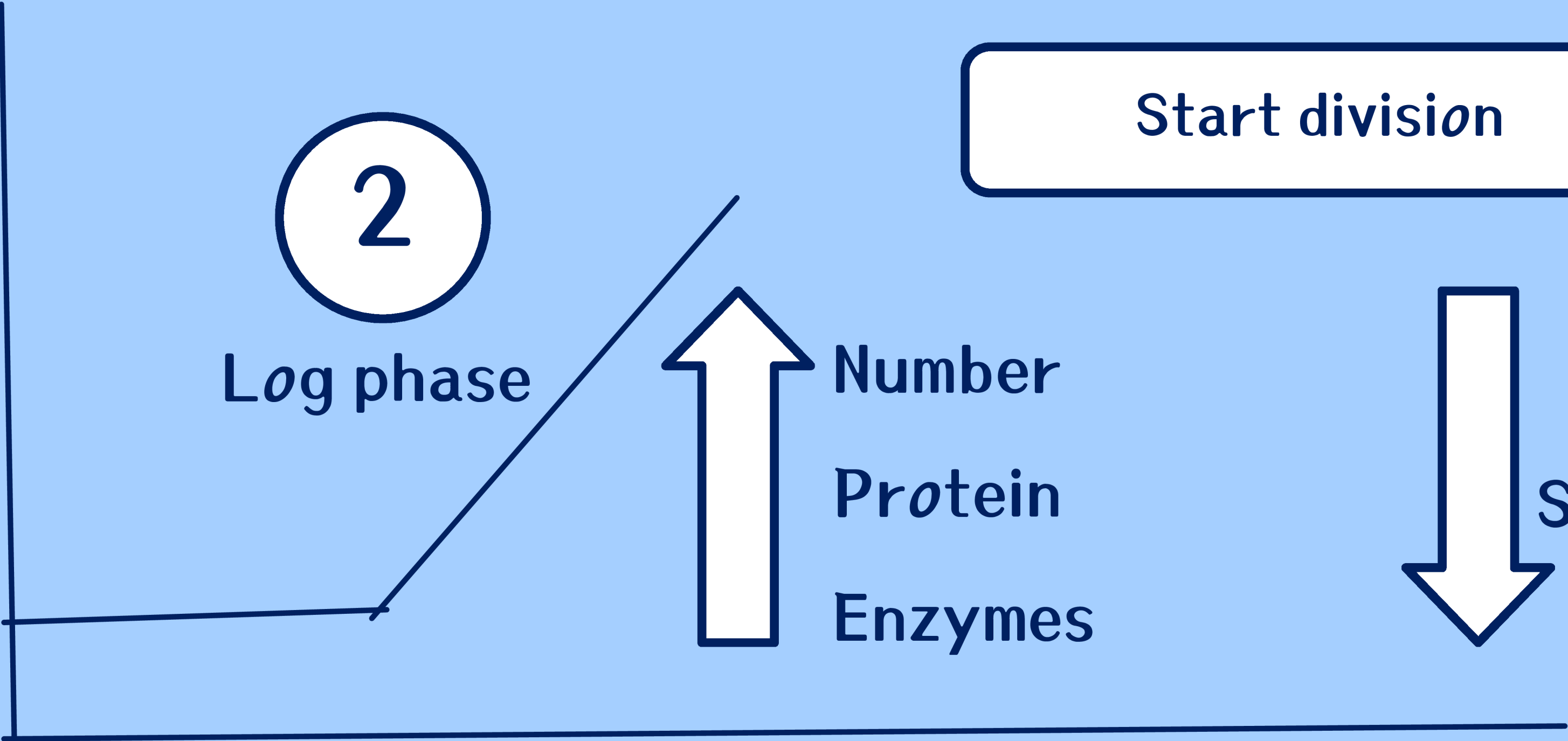


Number
Protein
Enzymes



Size

Time/hrs



Stationary phase

No. of bacteria

3

Stationary phase

Constant number

No. of division = No. of
death

(Waste product)

Time/hrs

Decline phase

Nutrient broth

4

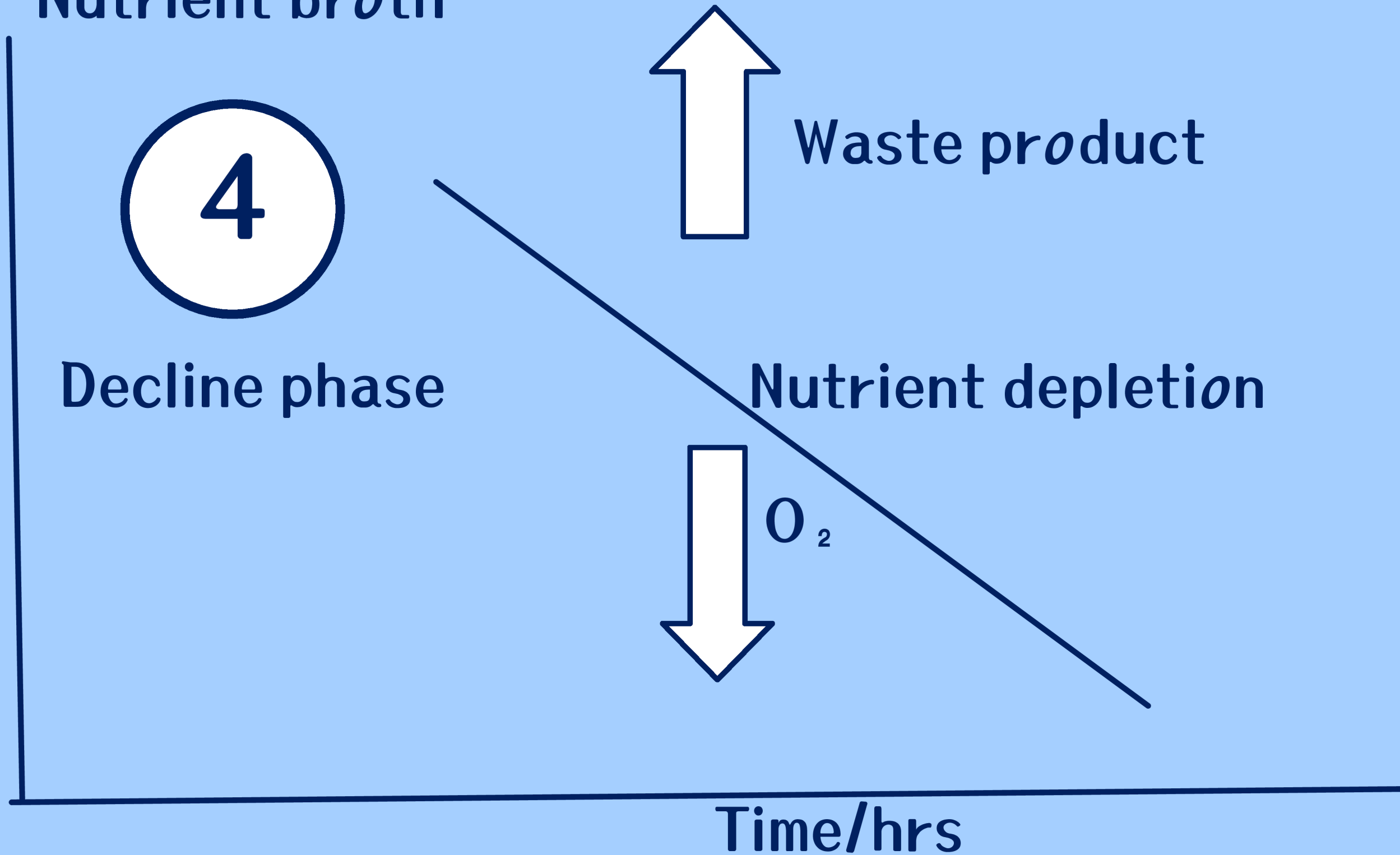
Waste product

Decline phase

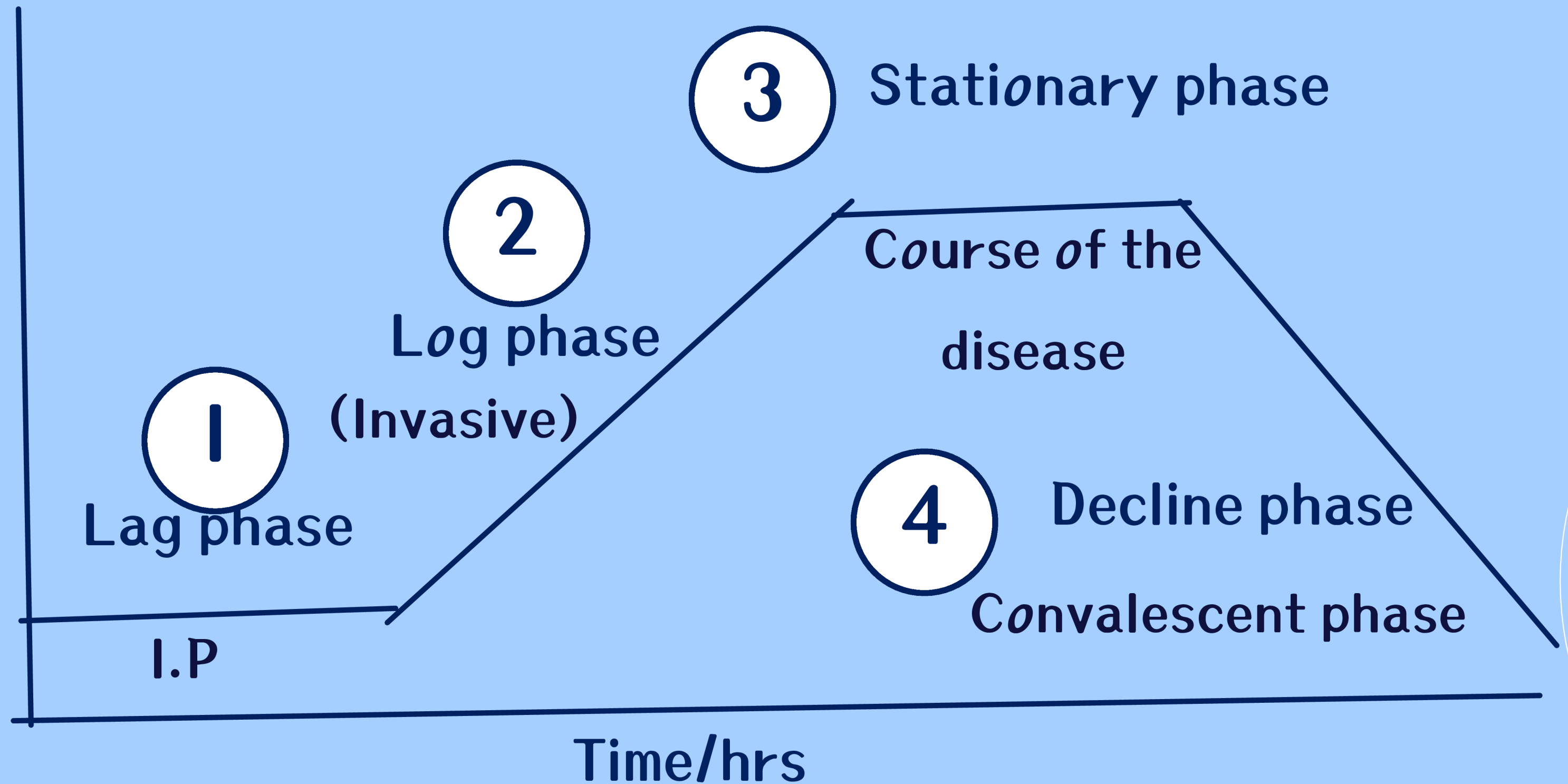
Nutrient depletion

O_2

Time/hrs



Bacterial growth curve



Bacterial growth requirements

Growth Requirements

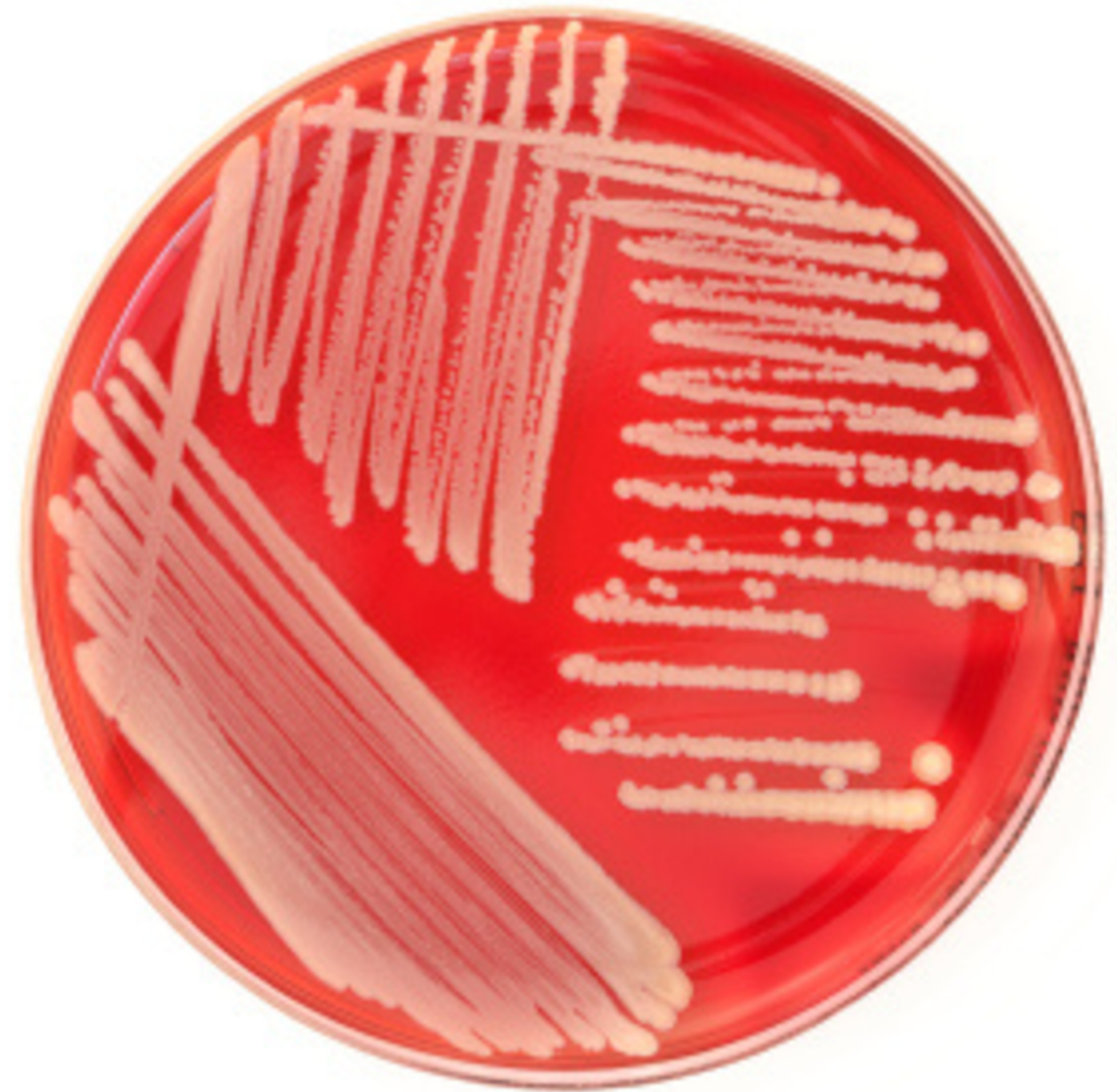
A) Nutrition

B) Gaseous

C) Temp. & pH

A) Nutrition

Maintenance of bacterial growth



A) Nutrition

1- Autotrophic

auto = self

Trophic=nutrition

2- Heterotrophic

hetero = different

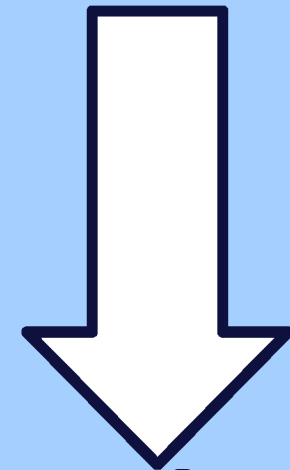
Trophic = nutrition

Autotrophic

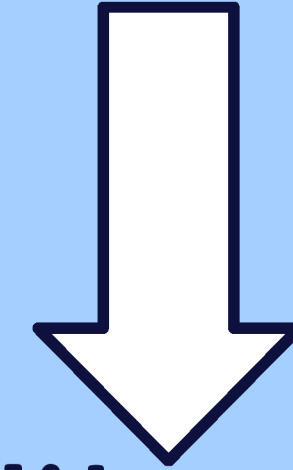
CO_2

Ammonium

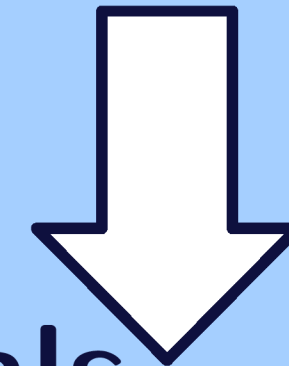
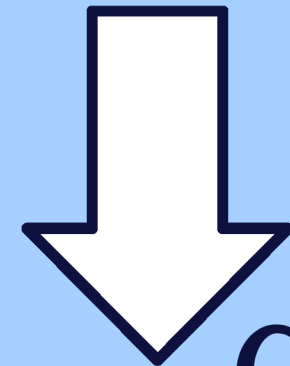
Utilize simple
inorganic
substance



Carbon



Nitrogen

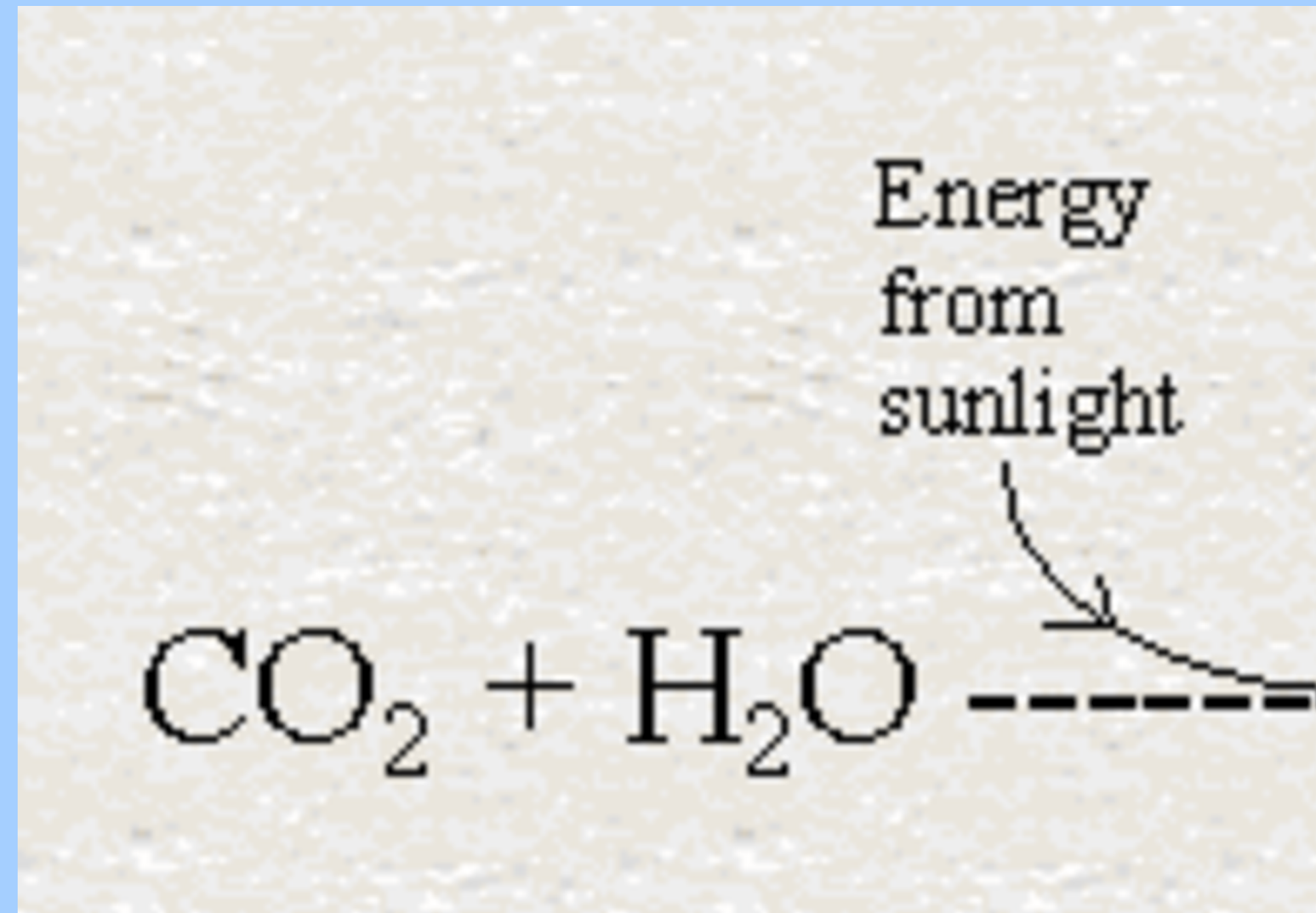


Complex organic materials

(Saprophytic)

Autotrophic

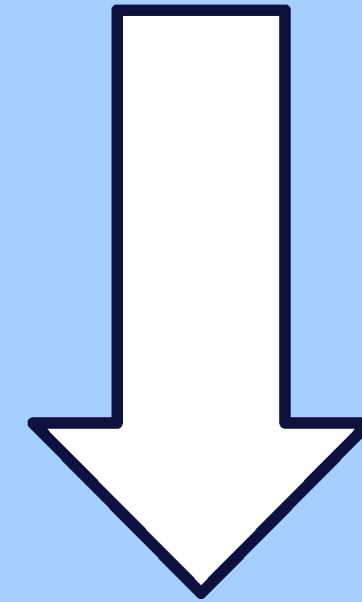
**No medical
importance**



Heterotrophic

Parasitic

**These bacteria require complex
preformed *organic* substances
e.g. sugars, proteins etc.**



Living host

Medical important

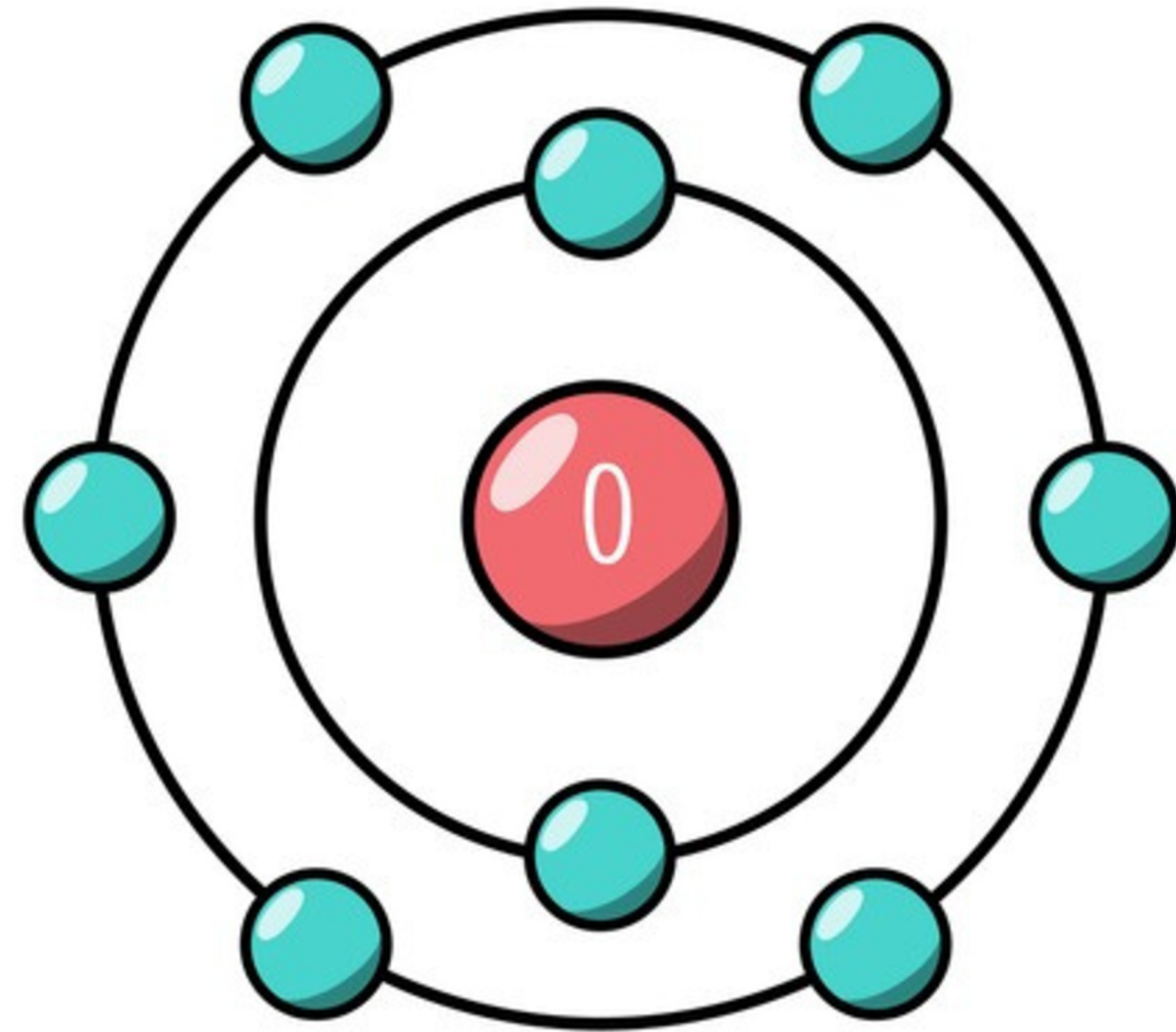
Growth Requirements

Gaseous requirements

O_2 requirement, bacteria are classified into 5 groups

O₂ requirement

- 1) Obligate aerobes
- 2) Obligate anaerobes
- 3) Facultative anaerobes
- 4) Micro-aerophilic
- 5) Aero-tolerant



OXYGEN

Respiration

Glucose catabolism

Energy production

Aerobic respiration

(O_2)

Anaerobic respiration

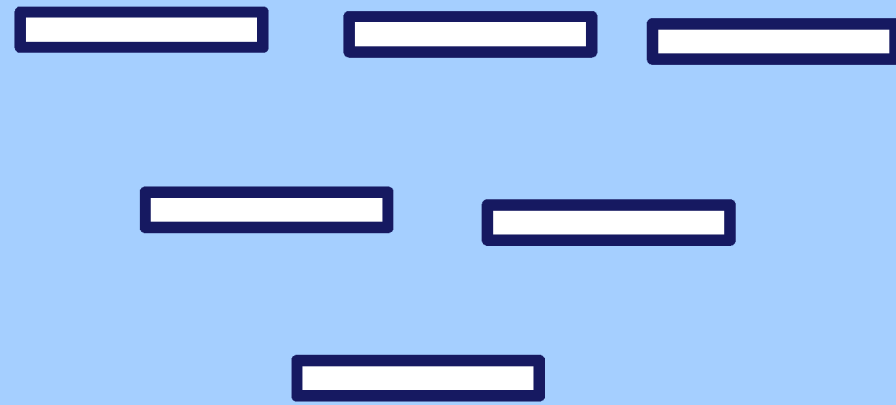
(No O_2)



energy

I– Obligate aerobes (Aerobic respiration)

Presence of O_2



Growth

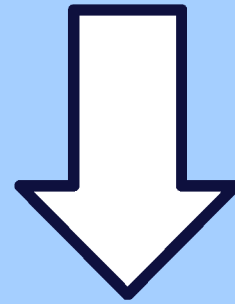
Absence of O_2

No growth

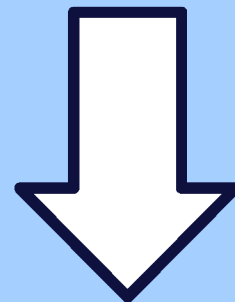
e.g. *Pseudomonas aeruginosa*

I– Obligate aerobes (Aerobic respiration)

Aerobic respiration



For production Energy (ATP)



Glucose catabolism (glycolysis)

I – Obligate aerobes (Aerobic respiration)



Oxidative phosphorylation

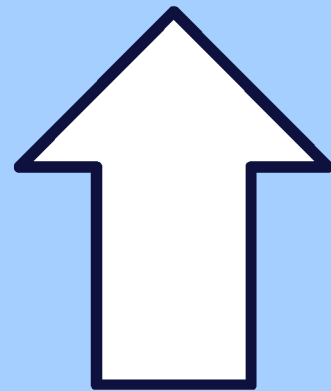


38 ATP

I – Obligate aerobes

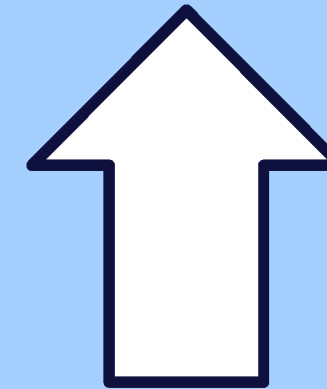
Highly *toxic* molecules

Superoxide (O_2^-)



Superoxide dismutase

(H_2O_2)



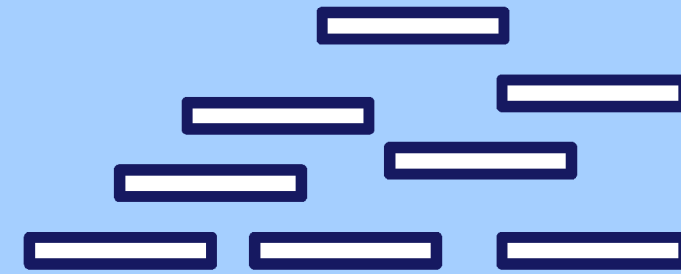
Catalase

2- Obligate anaerobes

Presence of O₂

No growth

Absence of O₂



Growth

Bacteroides fragilis

2 Obligate anaerobes (Anaerobic respiration)



O_2



Other pathway

4 ATP

Lack Superoxide dismutase & Catalase

2 Obligate anaerobes (Anaerobic respiration)

The organism used inorganic molecules

Nitrate

Sulfate

Co₂



Carry H⁺

13 ATP + 4 ATP

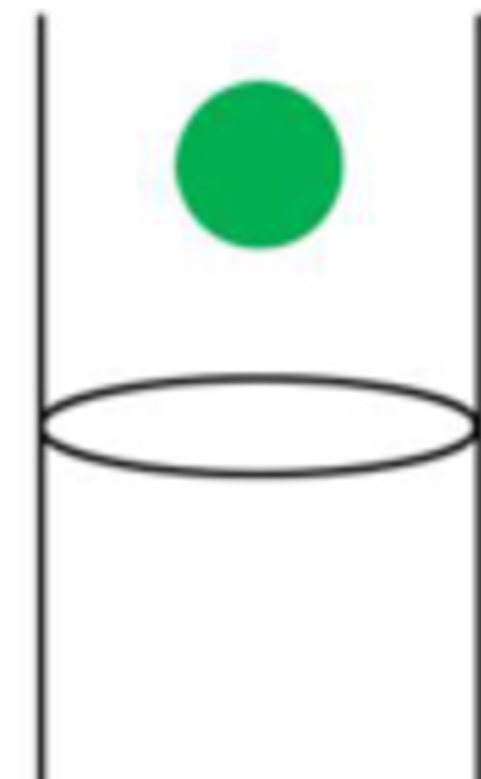
17 ATP

Lack

Superoxide dismutase

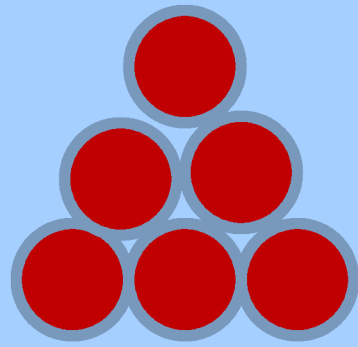
Catalase

**Obligate
Anaerobe**



3- Facultative anaerobes

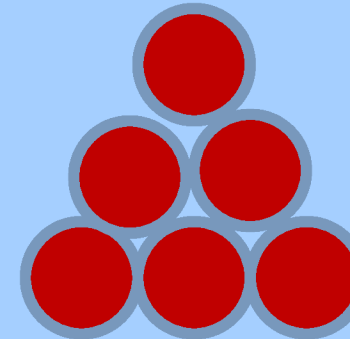
Presence of O_2



Growth

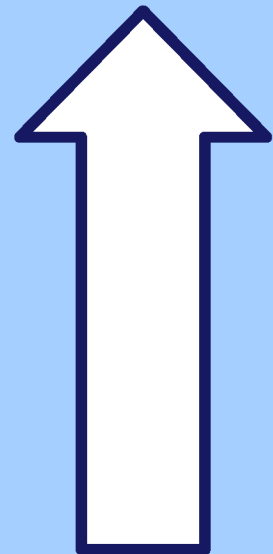
Rate of growth

Absence of O_2



Growth

Most bacteria



3- Facultative anaerobes

Anaerobes

Fermentation

Glucose

glycolysis

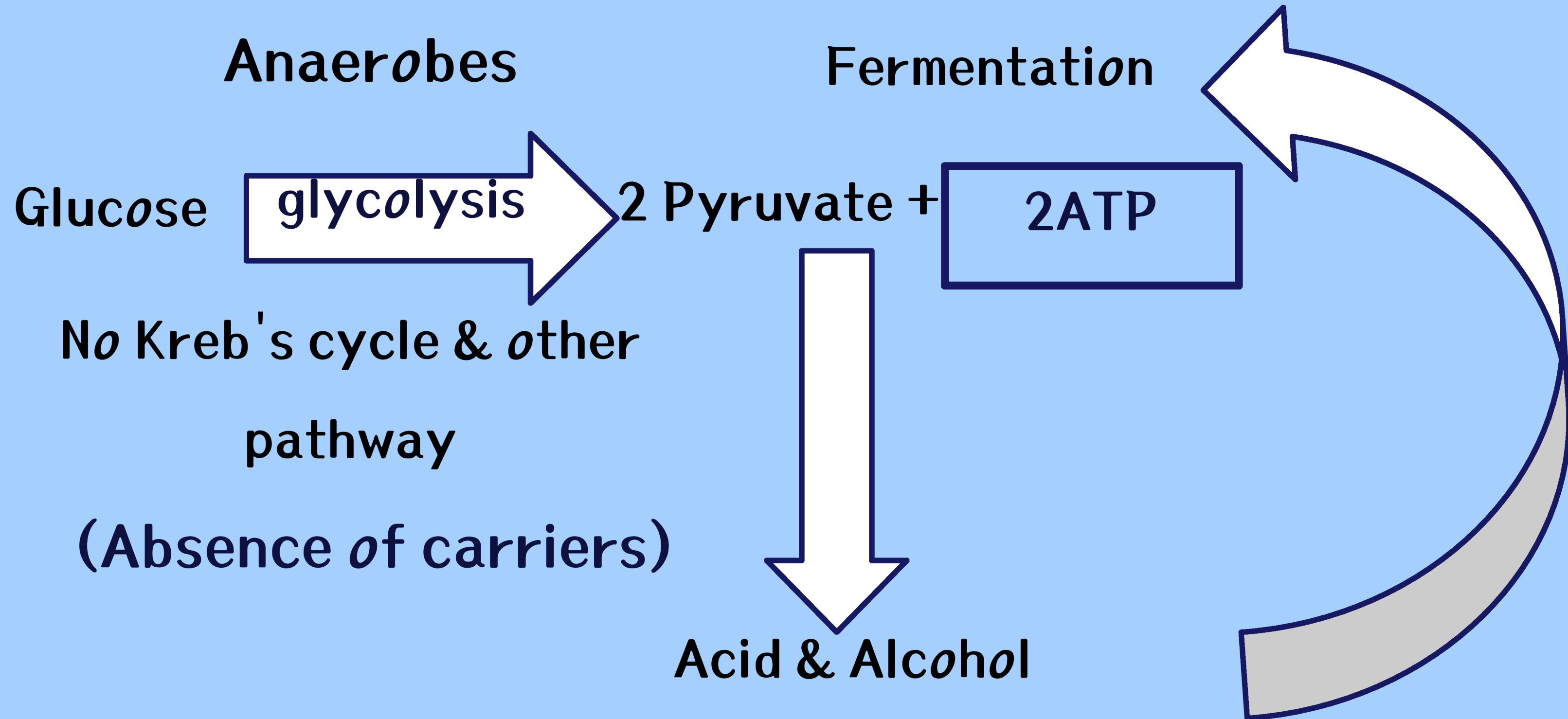
2 Pyruvate +

2ATP

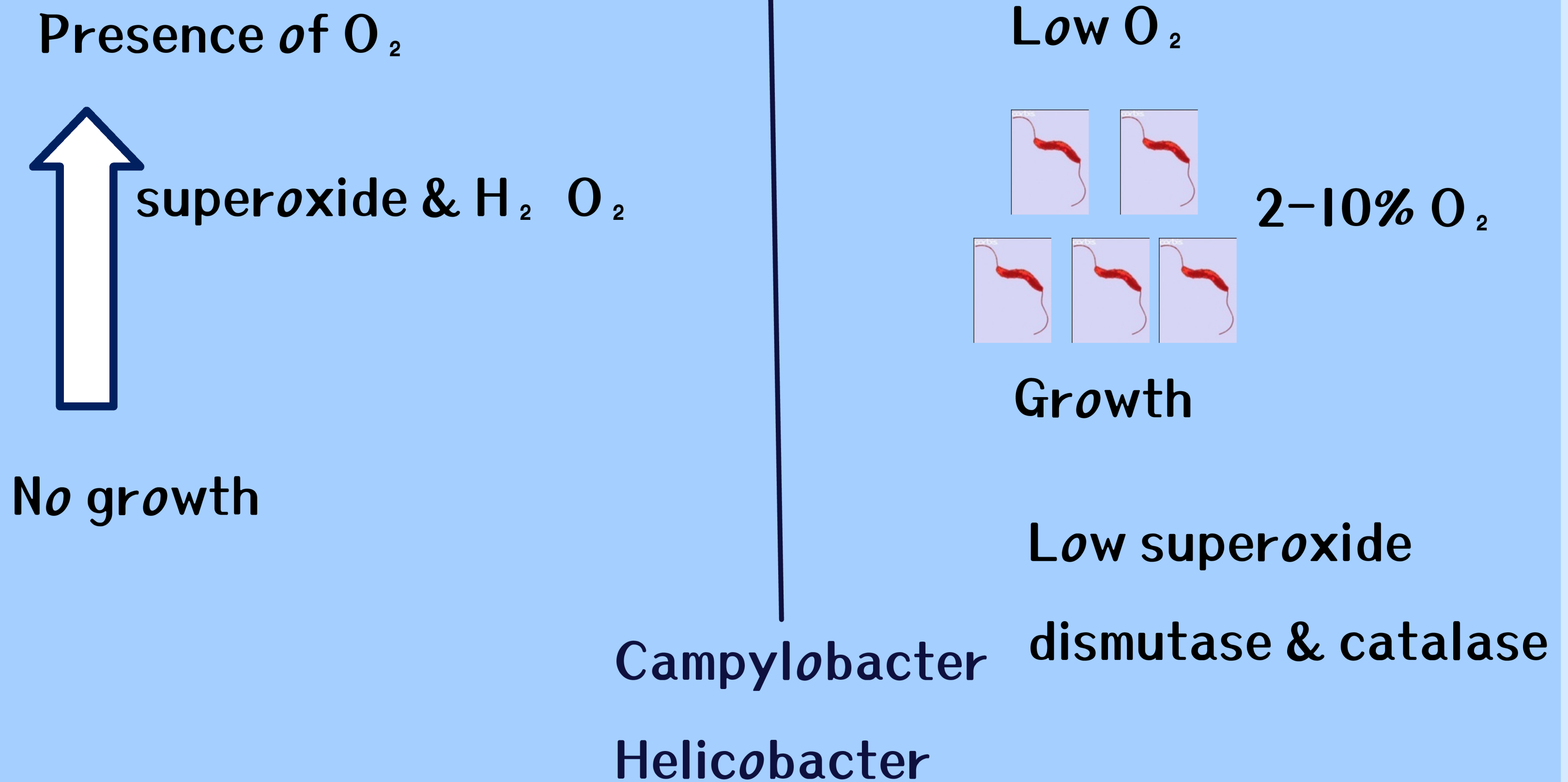
No Kreb's cycle & other
pathway

(Absence of carriers)

Acid & Alcohol

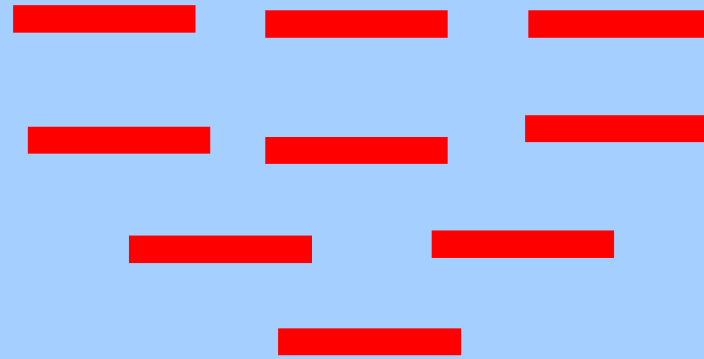


4- *Micro*-aerophilic

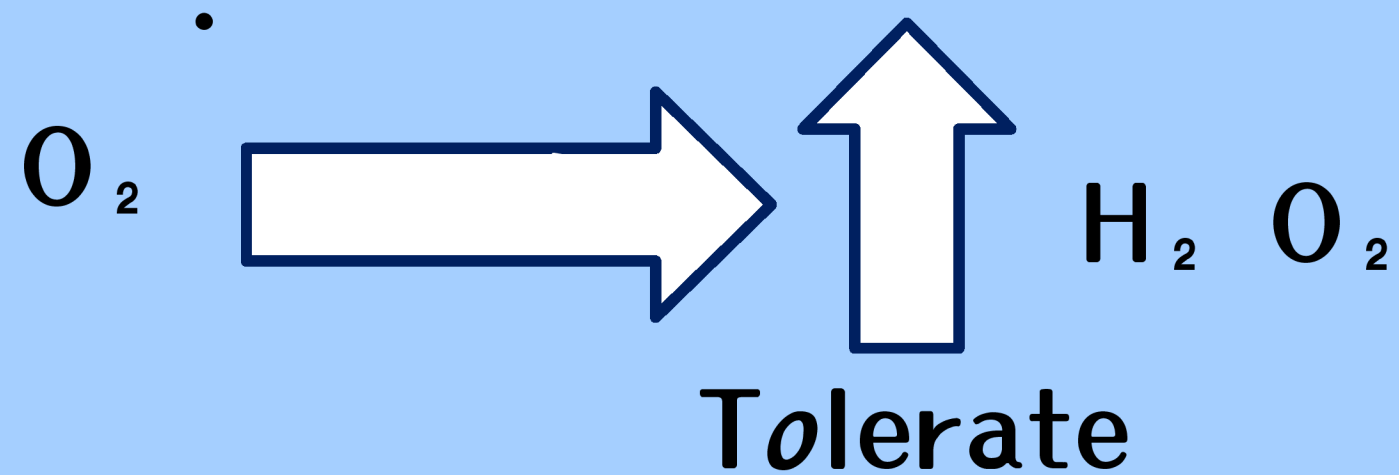


5- *Aero-tolerant anaerobes*

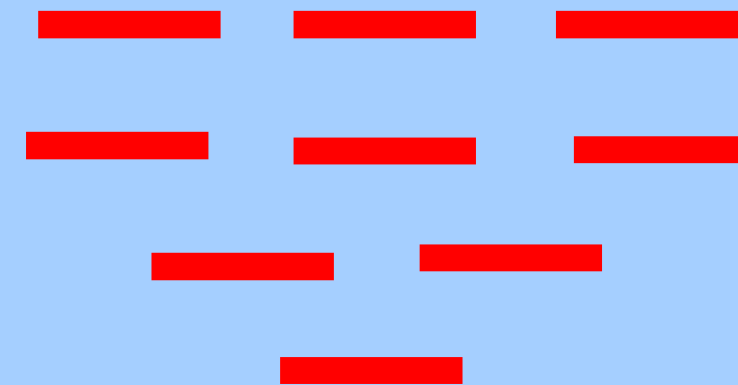
Low O₂



Superoxide dismutase



Absence of O₂



Growth

Cl. perfringens

Growth Requirement: CO₂ requirements

```
graph TD; A[Growth Requirement: CO2 requirements] --- B[CO2 (0.03%)]; A --- C[CO2 (5-10%) (Capnophilic)]; B --- D[Present in air is sufficient]; C --- E[Neisseria]; C --- F[Brucella];
```

CO₂ (0.03%)

Present in air
is sufficient

CO₂ (5–10%)

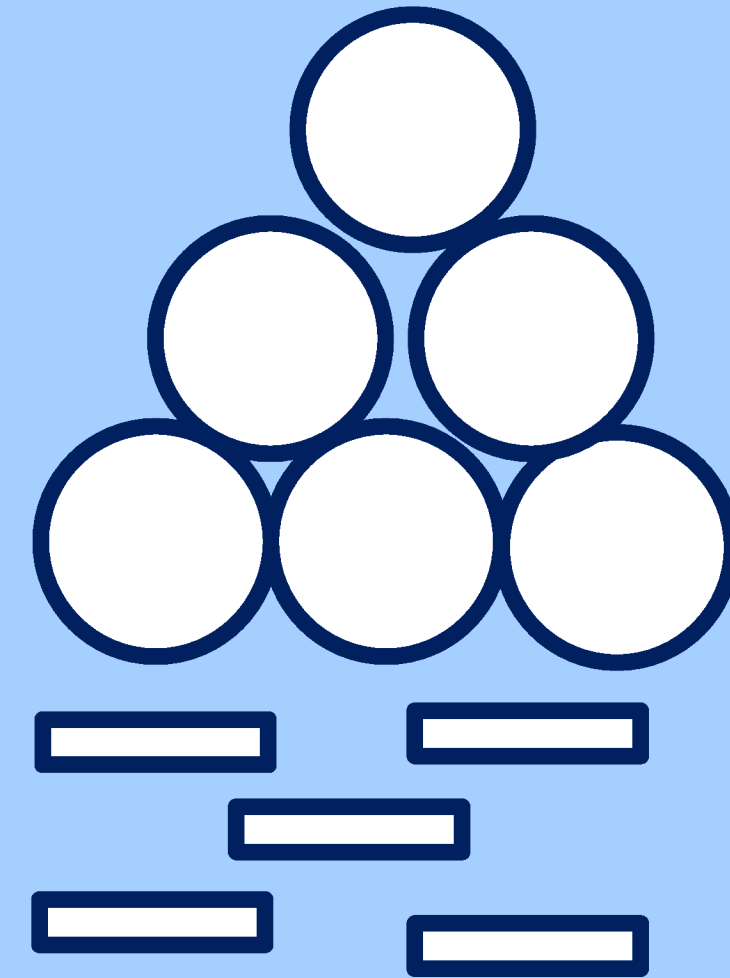
(Capnophilic)

Neisseria

Brucella

Growth Requirement: Hydrogen ion (pH)

pH (7.2 – 7.4)
(Most bacteria)



Hydrogen ion (pH)

Alkaline (pH 9)



Vibrio cholerae

Acidic (pH 4)



Lactobacilli

Growth Requirement: Temperature

Mesophilic
(20–45)
(Most bacteria)

Psychrophilic
(0–15)

Thermophilic
(55–65)