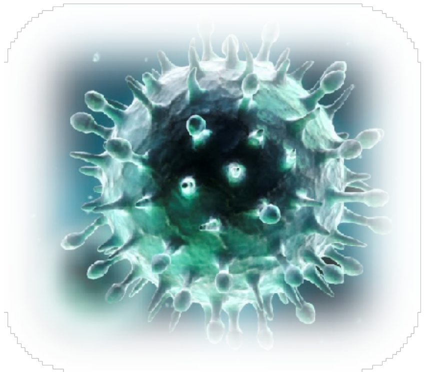
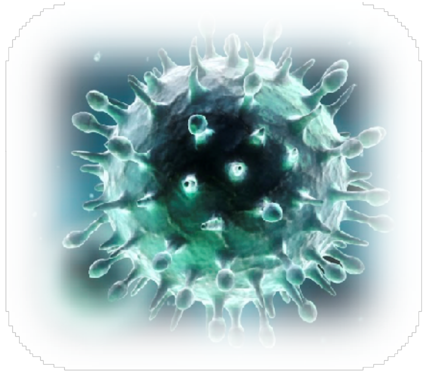
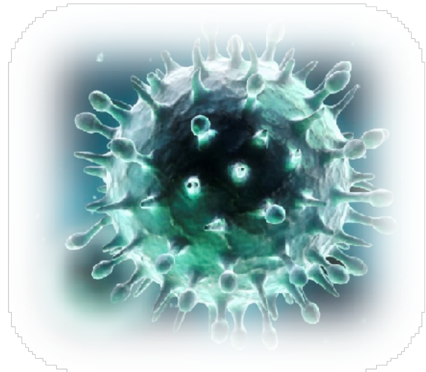
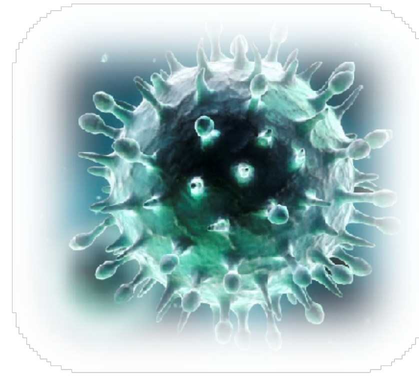





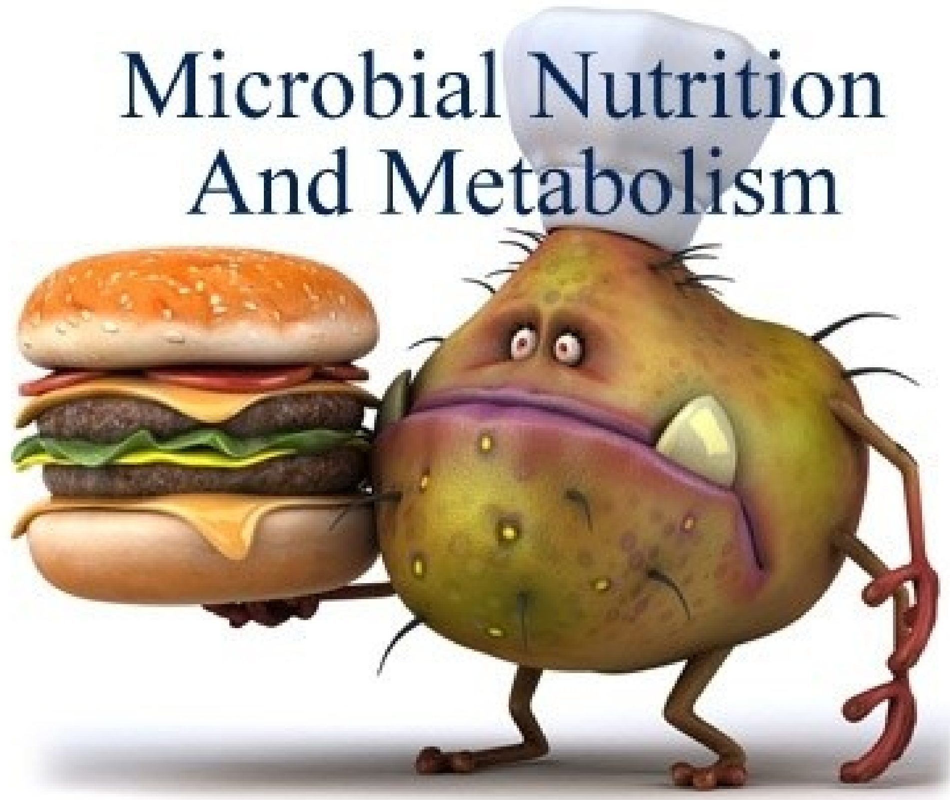
Nutritional types – Photolithoautotrophs, Photoorganoheterotrophs

Chemolithoautotrophs, Chemolithoheterotrophs and Chemoorganoheterotrophs

Princy

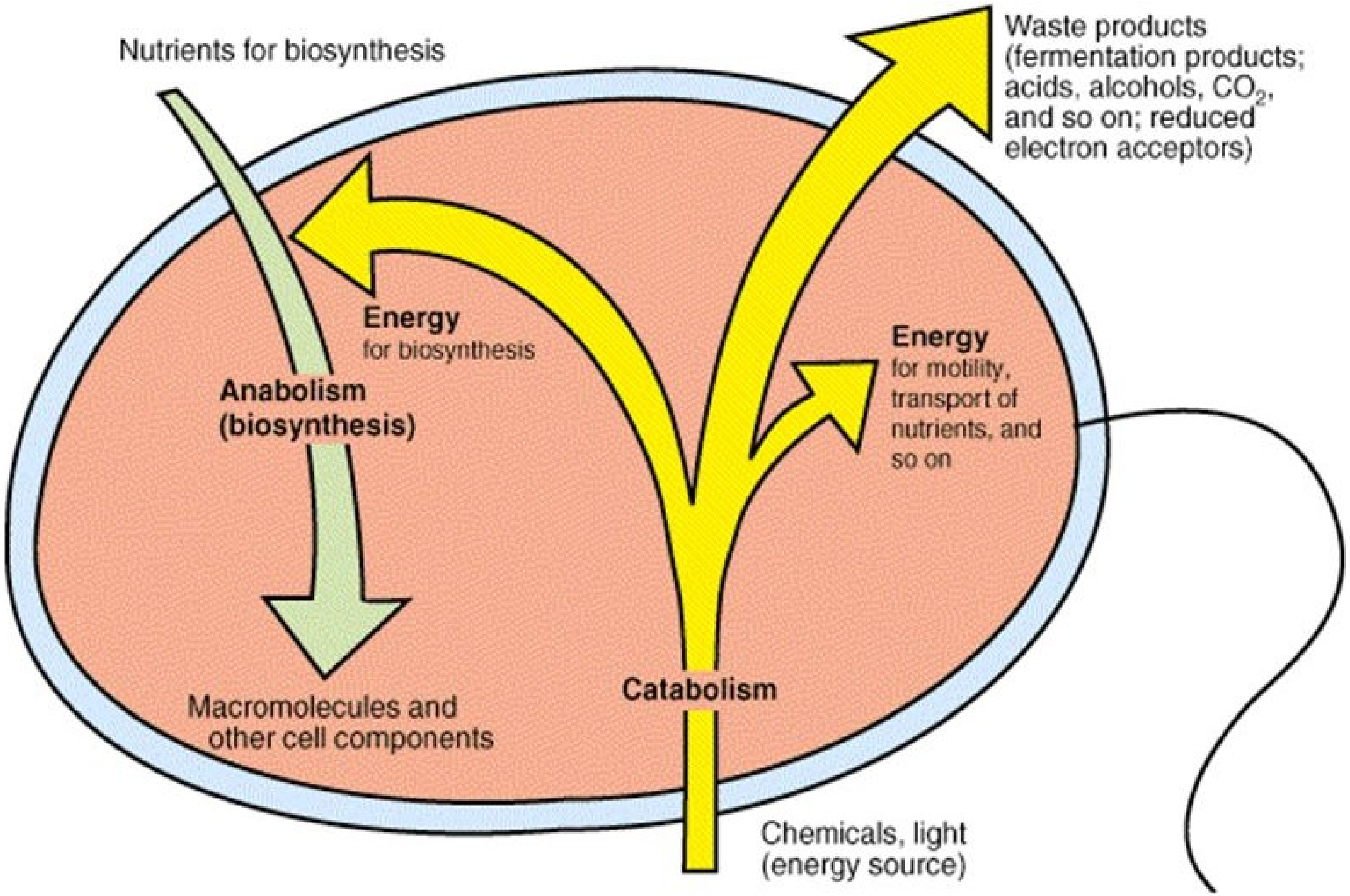
- Nutrition is the intake of food, considered in relation to the body's dietary needs (WHO).

- **Nutrients are substances used in biosynthesis** and energy release and therefore are required for microbial growth.



Microbial Nutrition

Cell metabolism



- All microorganisms can be placed in one of a few nutritional categories **on the basis of their requirements for carbon, energy, and electrons.**

- Analysis of microbial cell composition shows that over 95% of cell dry weight is made up of a few major elements:

- Carbon, **oxygen**, hydrogen, **nitrogen**, sulfur, **phosphorus**,
- Potassium, **calcium**, magnesium, and **iron.**

- These are called **macroelements** **or** **macronutrients** because they are required by microorganisms in **relatively large amounts.**

- The first six (C, O, H, N, S, and P) are components of carbohydrates, lipids, proteins, and nucleic acids.

- The remaining four macroelements (K, Ca, Mg, Fe) exist in the cell as cations and play a variety of roles.

- In addition to macroelements, all microorganisms require several nutrients in small amounts. These are called **micronutrients** or **trace elements**.

The micronutrients - are needed by most cells.

1. manganese
2. zinc
3. cobalt
4. molybdenum
5. nickel, and
6. copper

- However, cells require such small amounts that contaminants from water, glassware, and regular media components often are adequate for growth.

- In nature, micronutrients are ubiquitous and probably do not usually limit growth.

- **Micronutrients are normally a part of enzymes and cofactors**, and they aid in the catalysis of reactions and maintenance of protein structure.

- Finally, it must be emphasized that microorganisms require a balanced mixture of nutrients.

- If an essential nutrient is in short supply, microbial growth will be limited regardless of the concentrations of other nutrients.

Requirements for Carbon, Hydrogen, Oxygen and Electrons

- All organisms need carbon, hydrogen, oxygen, and a source of electrons.

- Carbon is needed for the skeletons or backbones of all the organic molecules from which organisms are built.

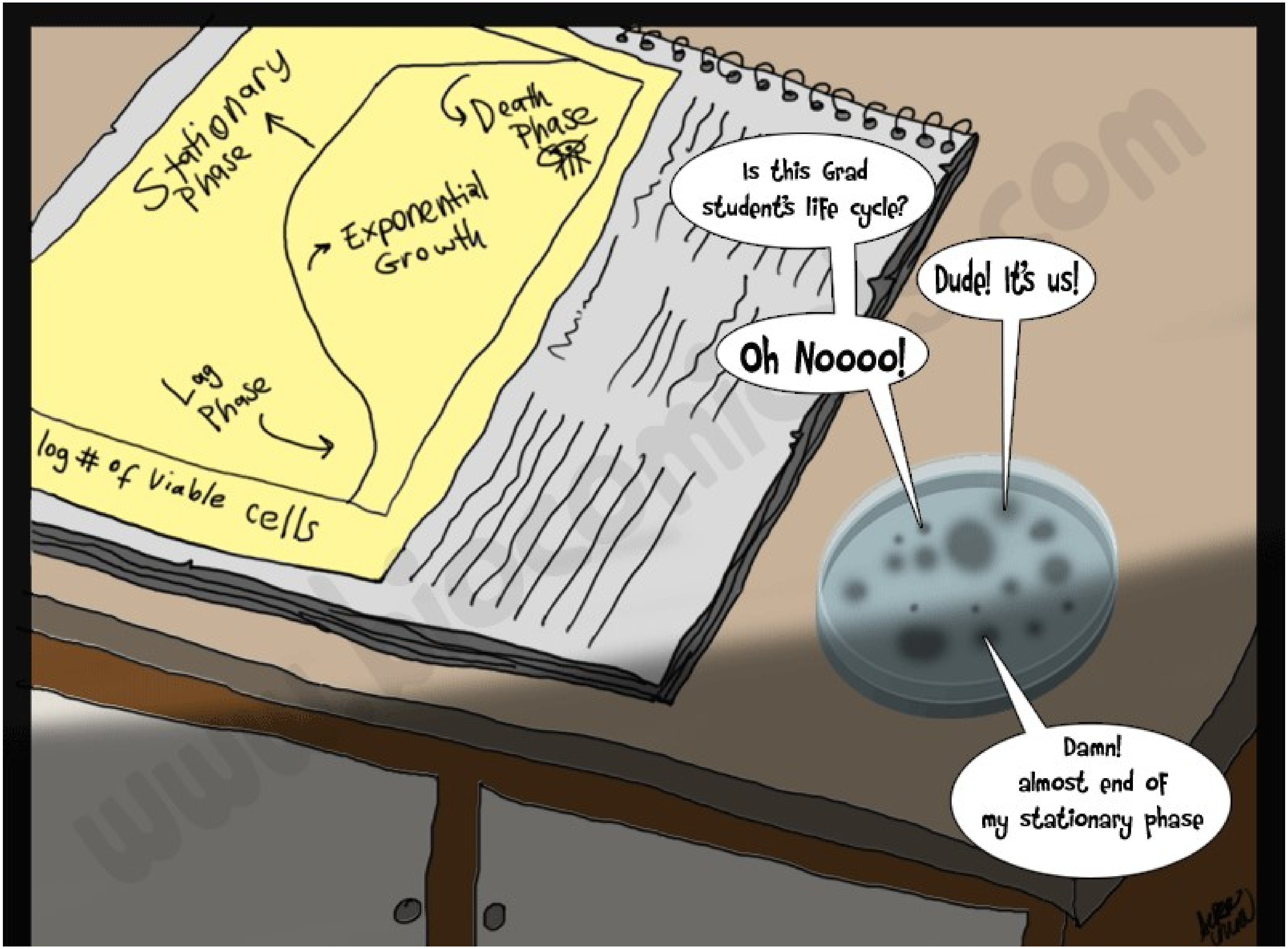
- Hydrogen and oxygen are also important elements found in organic molecules.

- The requirements for carbon, hydrogen, and oxygen often are satisfied together because molecules serving as carbon sources often contribute hydrogen and oxygen as well.

- Electrons are needed for two reasons.

1. The movement of electrons through **electron transport chains** and during other **oxidation-reduction reactions can provide energy** for use in cellular work.

2. Electrons also are needed to reduce molecules during biosynthesis (e.g., the reduction of CO_2 to form organic molecules).



Stationary phase
Death Phase
Exponential Growth
Lag Phase
log # of Viable cells
Is this Grad student's life cycle?
Dude! It's us!
Oh Noooo!
Damn! almost end of my stationary phase

- For instance, many heterotrophs—organisms that use reduced, preformed organic molecules as their carbon source—can also obtain hydrogen, oxygen, and electrons from the same molecules.

- Because the electrons provided by these organic carbon sources can be used in electron transport as well as in other oxidation-reduction reactions, many heterotrophs also use their carbon source as an energy source.

- **Indeed, the more reduced the organic carbon source (i.e., the more electrons it carries), the higher its energy content.**

- However, one carbon source, carbon dioxide (CO_2), supplies only carbon and oxygen so it cannot be used as a source of hydrogen, electrons, or energy.

- This is because CO_2 is the most oxidized form of carbon, lacks hydrogen, and is unable to donate electrons during oxidation-reduction reactions.

- Organisms that use CO_2 as their sole or principal source of carbon are called **autotrophs.**

- **Because CO_2 cannot supply** their energy needs, they must obtain energy from other sources, such as light or reduced inorganic molecules.

- A most remarkable nutritional characteristic of heterotrophic microorganisms is their extraordinary flexibility with respect to carbon sources.

- *Laboratory experiments indicate that there is no naturally occurring organic molecule that cannot be used by some microorganism.*

- Actinomycetes, common soil bacteria, will degrade amyl alcohol, paraffin, and even rubber.

- Some bacteria seem able to employ almost anything as a carbon source; for example, *Burkholderia cepacia* ***can use over 100 different carbon*** **compounds.**

- *Microbes can degrade even relatively indigestible human-made substances such as pesticides.*

- This is usually accomplished in complex microbial communities.

- These molecules sometimes are degraded in the presence of a growth-promoting nutrient that is metabolized at the same time—a process called **cometabolism.**

- Other microorganisms can use the products of this breakdown process as nutrients.

Sources of Carbon, Energy and Electrons	
Carbon Sources	
Autotrophs	CO_2 sole or principal biosynthetic carbon source.
Heterotrophs	Reduced, preformed, organic molecules from other organisms.
Energy Sources	
Phototrophs	Light
Chemotrophs	Oxidation of organic or inorganic compounds
Electron Sources	
Lithotrophs	Reduced inorganic molecules
Organotrophs	Organic molecules

There are only ***two sources of energy*** available to organisms:

- (1) Light energy, and
- (2) The energy derived from oxidizing organic or inorganic molecules.

- Despite the great metabolic diversity seen in microorganisms, most may be placed in one of five nutritional classes based on their primary sources of carbon, energy, and electrons**.**

  - The majority of microorganisms thus far studied are either **Photolithotrophic autotrophs** or **Chemoorganotrophic heterotrophs**.

Nutritional Types of Microorganisms

Energy Source	**Electron Source**	**Carbon Source**	**Nutritional Type**
Light *Photo-*	Organic -*organo*-	Organic -*heterotroph*	Photoorganoheterotroph
		Carbon dioxide -*autotroph*	(no known organisms)
	Inorganic -*litho*-	Organic -*heterotroph*	(no known organisms)
		Carbon dioxide -*autotroph*	Photolithoautotroph
Chemical compounds *Chemo*-	Organic -*organo*-	Organic -*heterotroph*	Chemoorganoheterotroph
		Carbon dioxide -*autotroph*	(no known organisms)
	Inorganic -*litho*-	Organic -*heterotroph*	Chemolithoheterotroph
		Carbon dioxide -*autotroph*	Chemolithoautotroph

Energy source

Carbon source

Photo lithotrophic autotrophs

Electron source

1. Photolithotrophic autotrophs

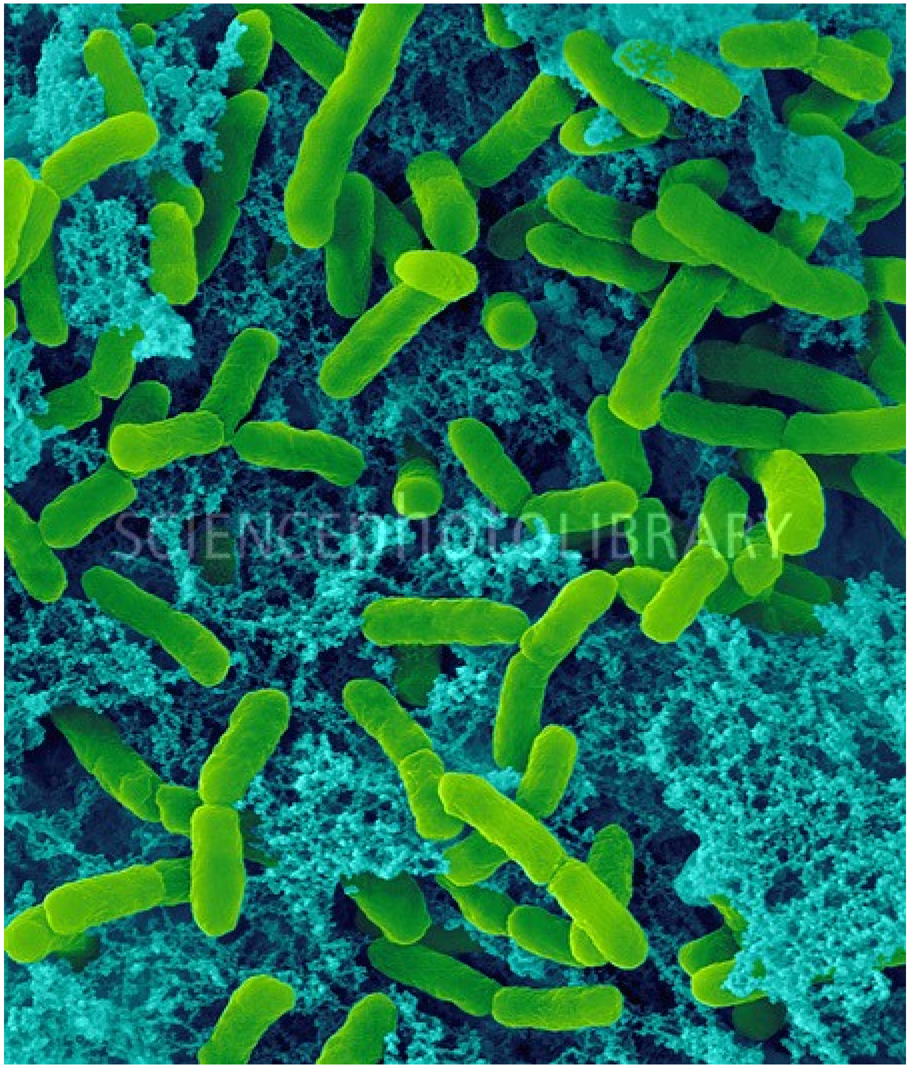
- Photolithotrophic autotrophs (often called **photoautotrophs** or photolithoautotrophs) use light energy and have CO_2 as their carbon source.

- *Photosynthetic protists* and *cyanobacteria* employ water as the electron donor and release oxygen.

- Other photolithoautotrophs, such as the *purple and green sulfur bacteria,* cannot oxidize water but extract electrons from inorganic donors like **hydrogen, hydrogen sulfide, and elemental sulfur.**

(a) Bloom of cyanobacteria (photolithoautotrophic bacteria)

Chlorobium - a genus of green sulfur bacteria

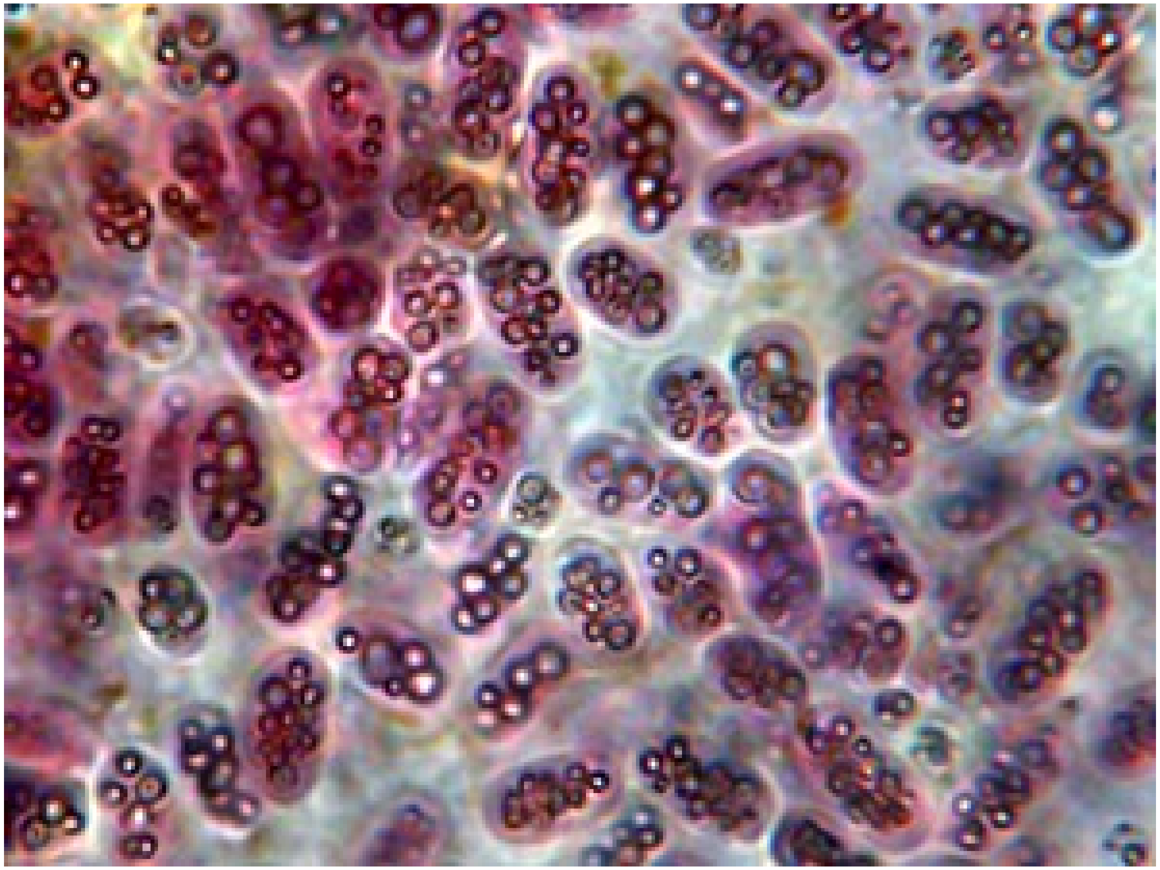


SEM image

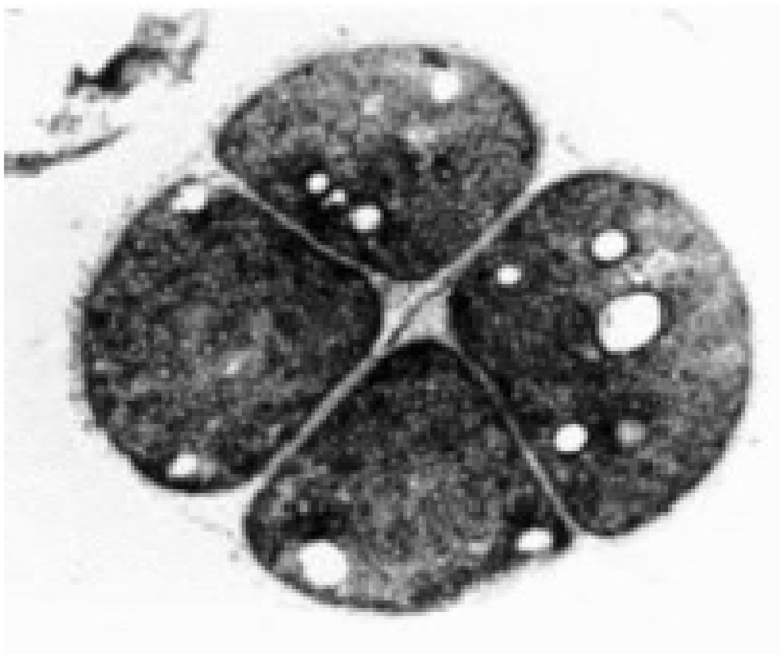
Thio –

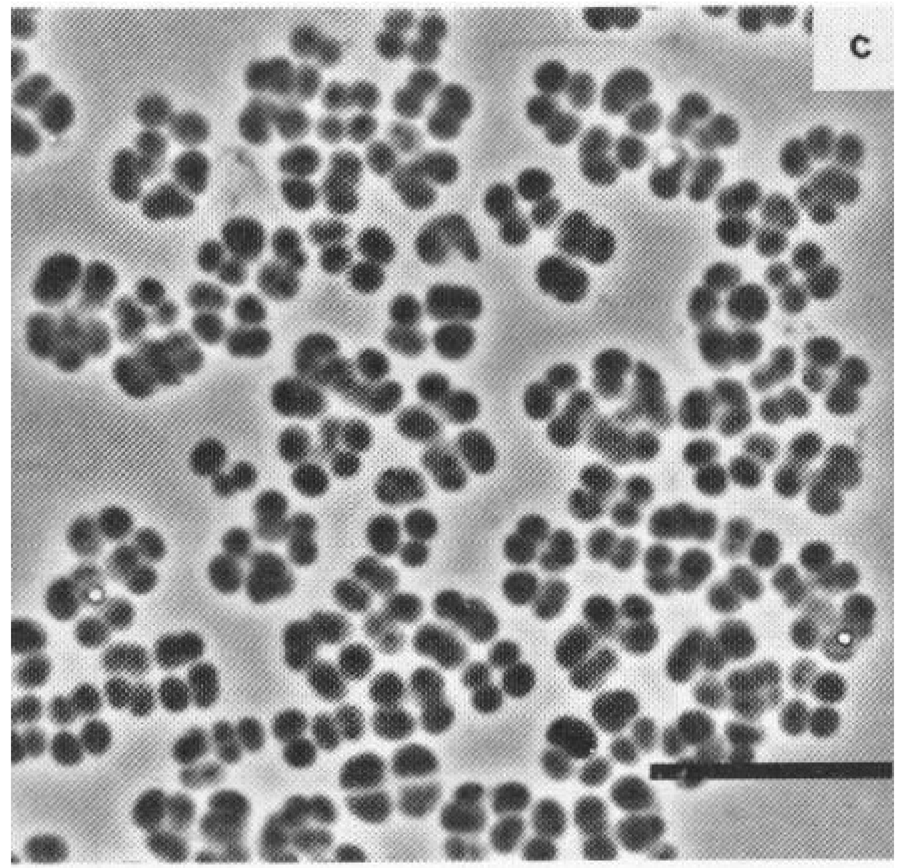
- denoting replacement of oxygen by sulphur in a compound

Chromatium - purple sulfur bacteria

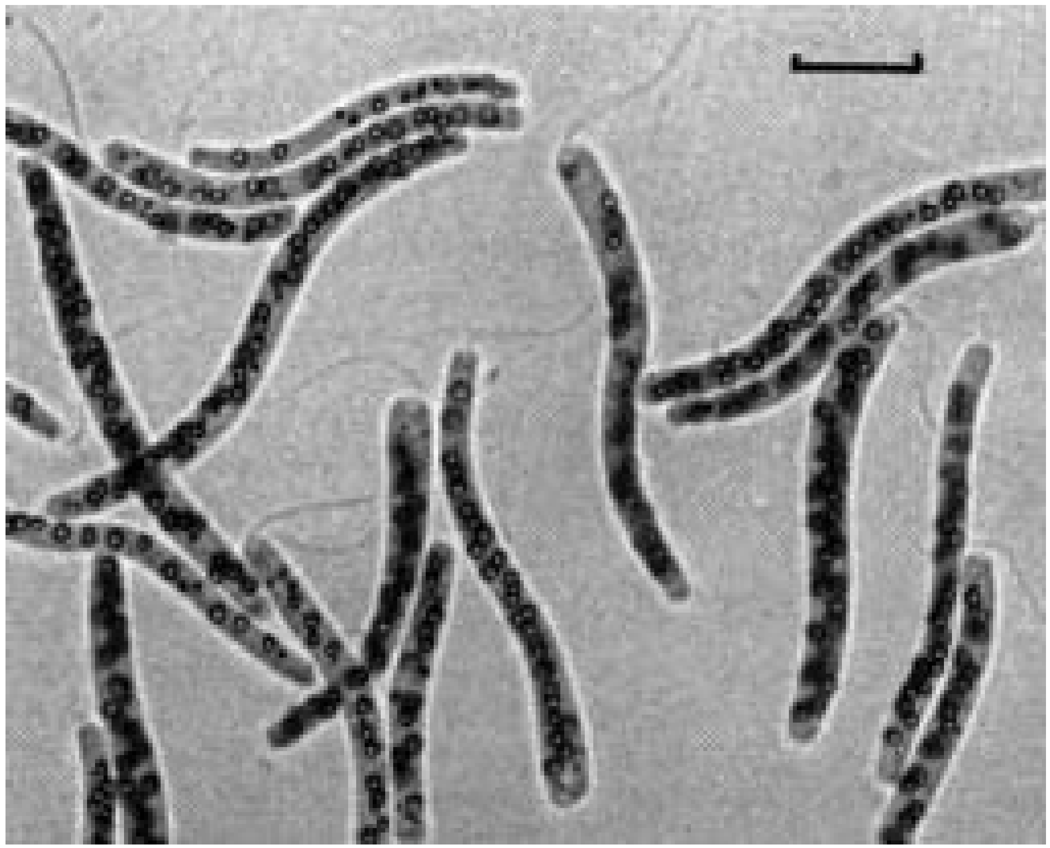


Thiocapsa- purple sulfur bacteria





Thiospirillum - spiral purple sulfur bacteria



Purple sulphur bacteria

(c) Purple sulfur bacteria

2. Chemoorganotrophic heterotrophs

- **Chemoorganotrophic heterotrophs (often** called **chemoheterotrophs, chemoorganoheterotrophs, or just** heterotrophs) use *organic compounds as sources of energy, hydrogen, electrons, and carbon*.

- Frequently the same organic nutrient will satisfy all these requirements.

- Essentially **all pathogenic microorganisms** are chemoheterotrophs.

Table 5.2 Major Nutritional Types of Microorganisms

Nutritional Type	Carbon Source	Energy Source	Electron Source	Representative Microorganisms
Photolithoautotrophy (photolithotrophic autotrophy)	CO_2	Light	Inorganic e^- donor	Purple and green sulfur bacteria, cyanobacteria
Photoorganoheterotrophy (photoorganotrophic heterotrophy)	Organic carbon, but CO_2 may also be used	Light	Organic e^- donor	Purple nonsulfur bacteria, green nonsulfur bacteria
Chemolithoautotrophy (chemolithotrophic autotrophy)	CO_2	Inorganic chemicals	Inorganic e^- donor	Sulfur-oxidizing bacteria, hydrogen-oxidizing bacteria, methanogens, nitrifying bacteria, iron-oxidizing bacteria
Chemolithoheterotrophy or mixotrophy (chemolithotrophic heterotrophy)	Organic carbon, but CO_2 may also be used	Inorganic chemicals	Inorganic e^- donor	Some sulfur-oxidizing bacteria (e.g., *Beggiatoa*)
Chemoorganoheterotrophy (chemoorganotrophic heterotrophy)	Organic carbon	Organic chemicals often same as C source	Organic e^- donor, often same as C source	Most nonphotosynthetic microbes, including most pathogens, fungi, many protists, and many archaea

The other nutritional classes have fewer known microorganisms but often are very important ecologically.

- Photo organotrophic heterotrophs
- Photo lithotrophic autotrophs

3. Photoorganotrophic heterotrophs

- Some photosynthetic bacteria (e.g. *purple and green non sulphur bacteria*) use organic matter as their electron donor and carbon source.

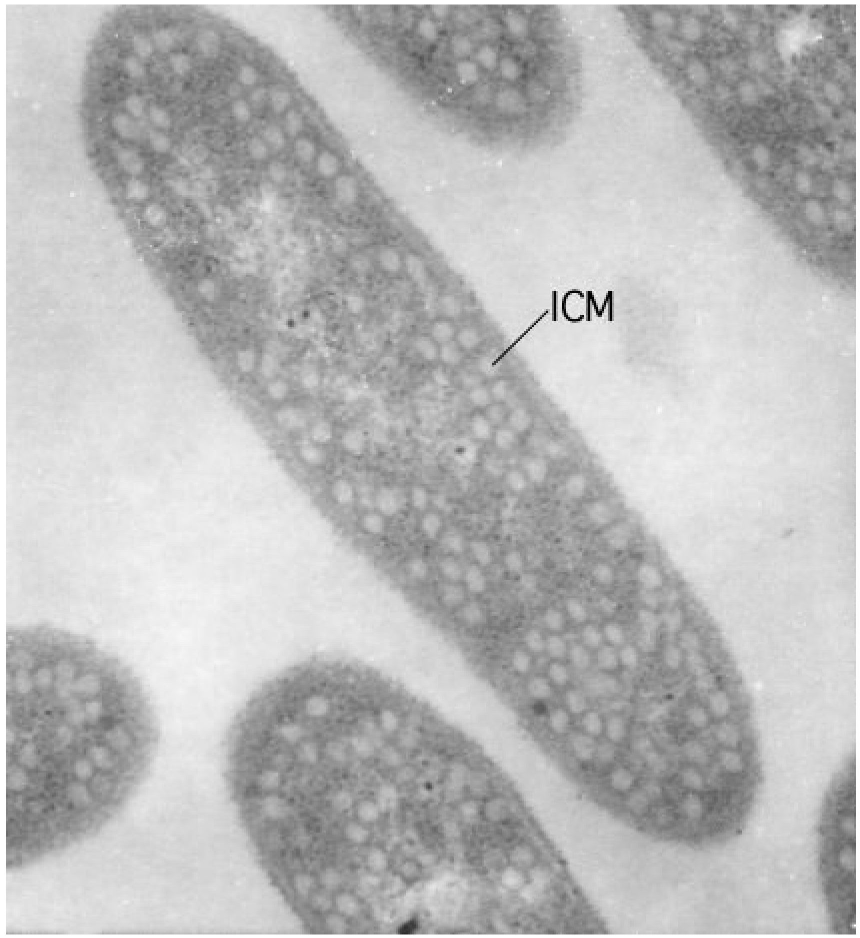
- These **photoorganotrophic heterotrophs (photoorganoheterotrophs) are common** inhabitants of polluted lakes and streams.

- Some of these bacteria also can grow as **photoautotrophs** with molecular hydrogen as an electron donor.

Rhodospirillum *rubrum* -is a purple nonsulfur bacterium

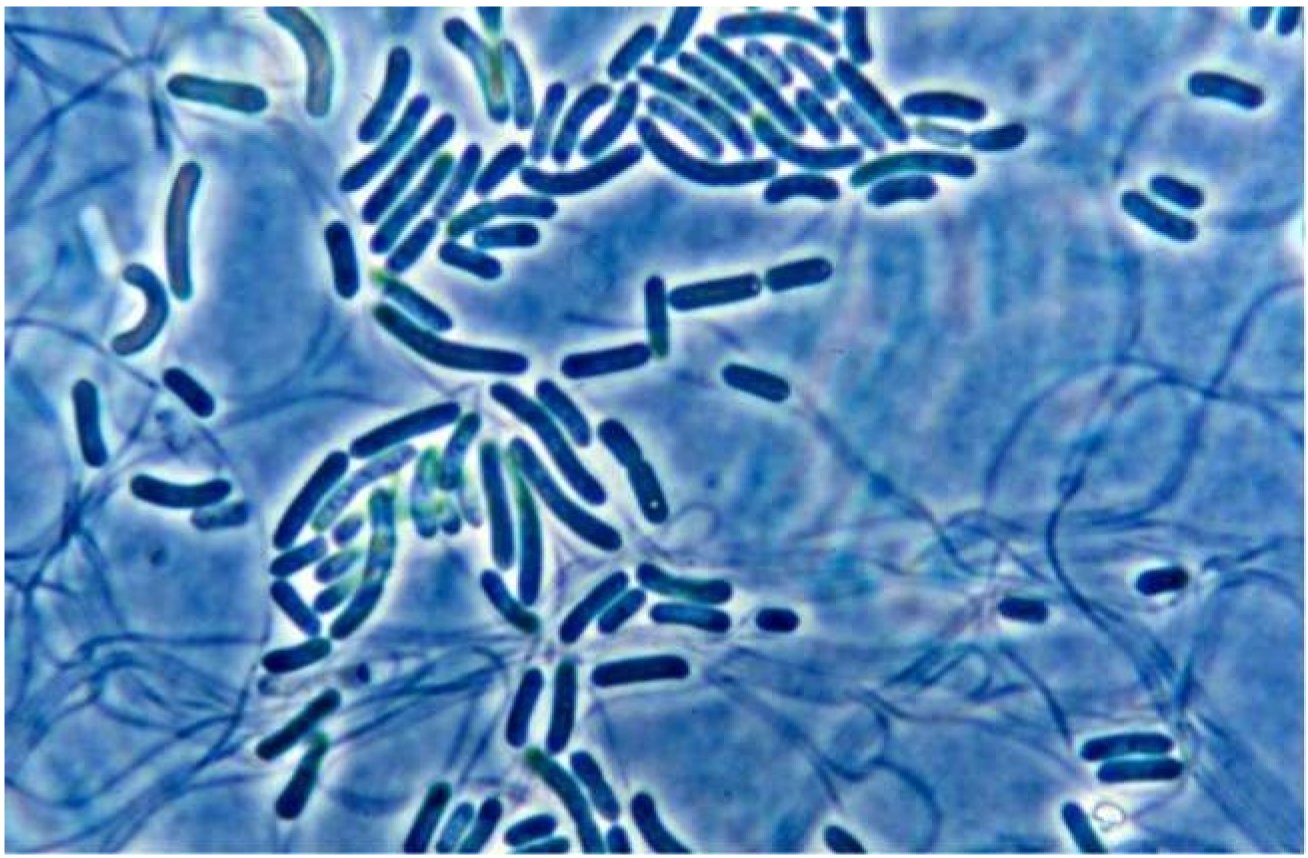
Rhodospirillum

Rhodobacter - purple nonsulfur bacterium

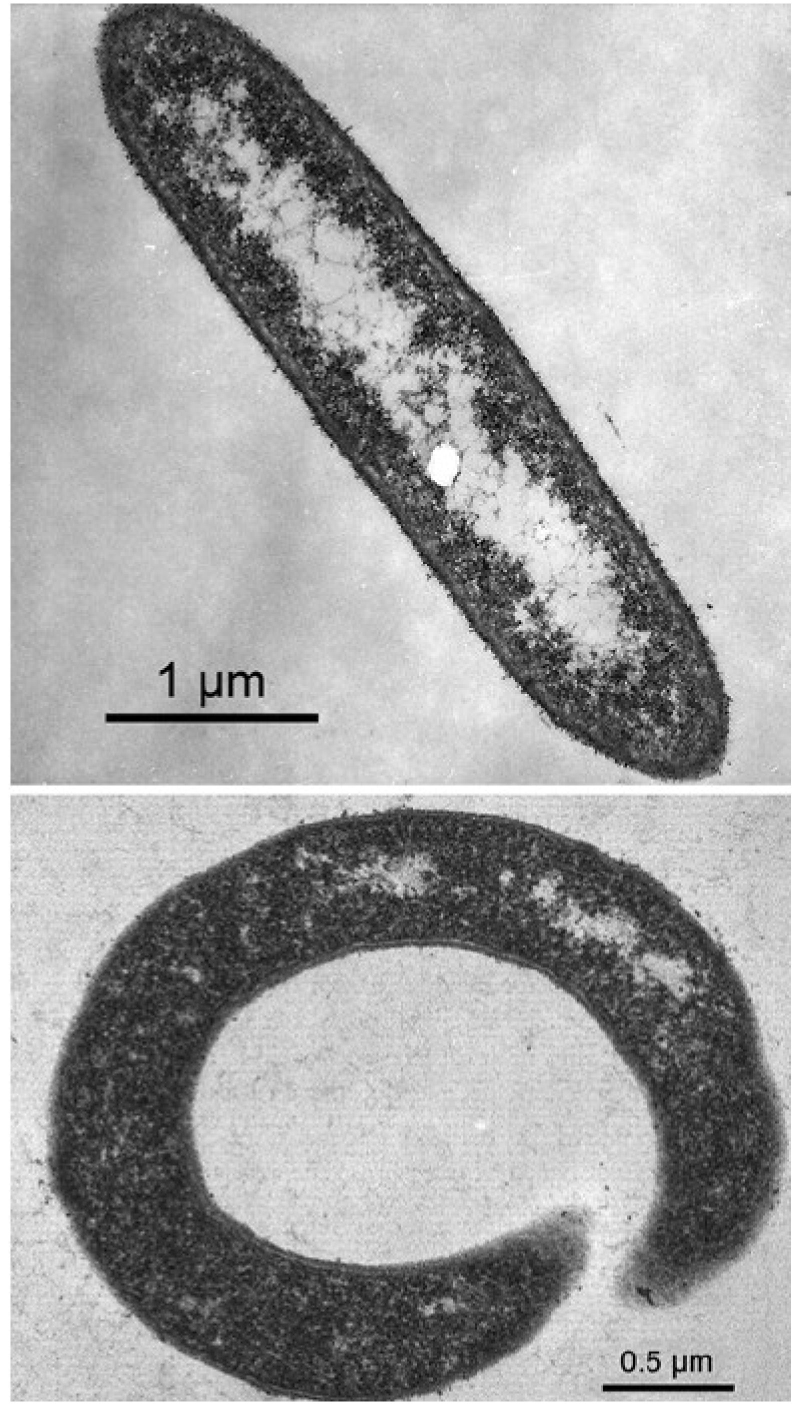


- Phylum Chloroflexi - green nonsulfur bacteria

e.g. *Chloroflexus aurantiacus*



Heliobacterium (anaerobic)



Chemoorganotrophic heterotrophs

autotrophs

- Chemolithotrophic

heterotrophs

4. Chemolithotrophic autotrophs

- ***Chemolithotrophic autotrophs*** **(chemolithoautotrophs),** oxidize reduced inorganic compounds such as iron, nitrogen, or sulfur molecules to derive both energy and electrons for biosynthesis**.**

- ***Carbon dioxide is the carbon*** source.

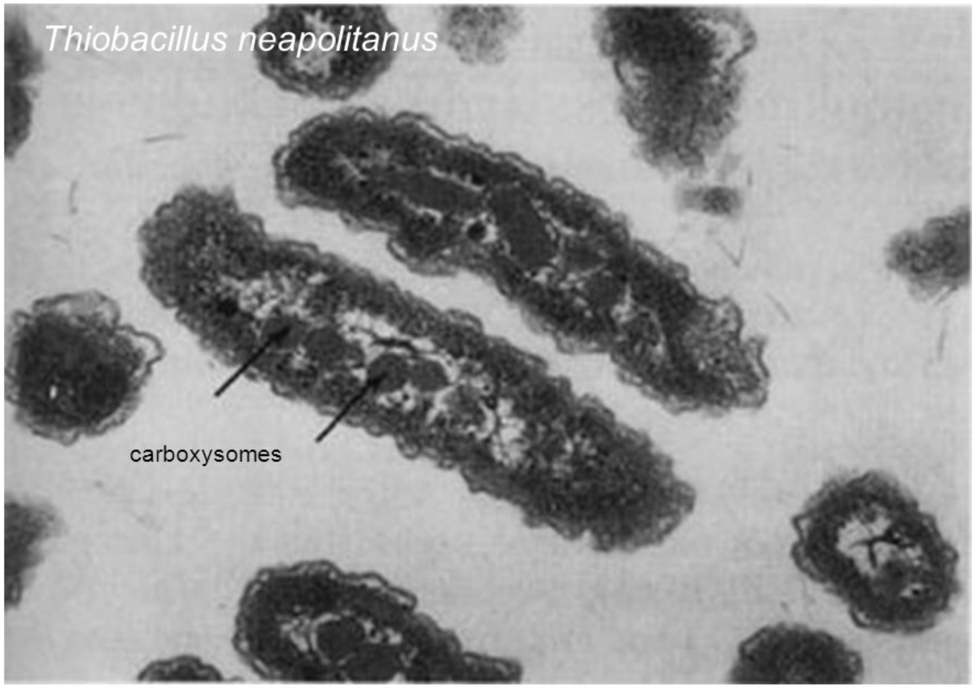
E.g. Sulfur oxidizing bacteria - Thiobacillus

- *Hydrogen oxidizing bacteria - Hydrogenobacter thermophilus, Helicobacter pylori*
- *Iron oxidizing bacteria – Ferrobacillus, Deferribacter autotrophicus*
- *Methanogens –*

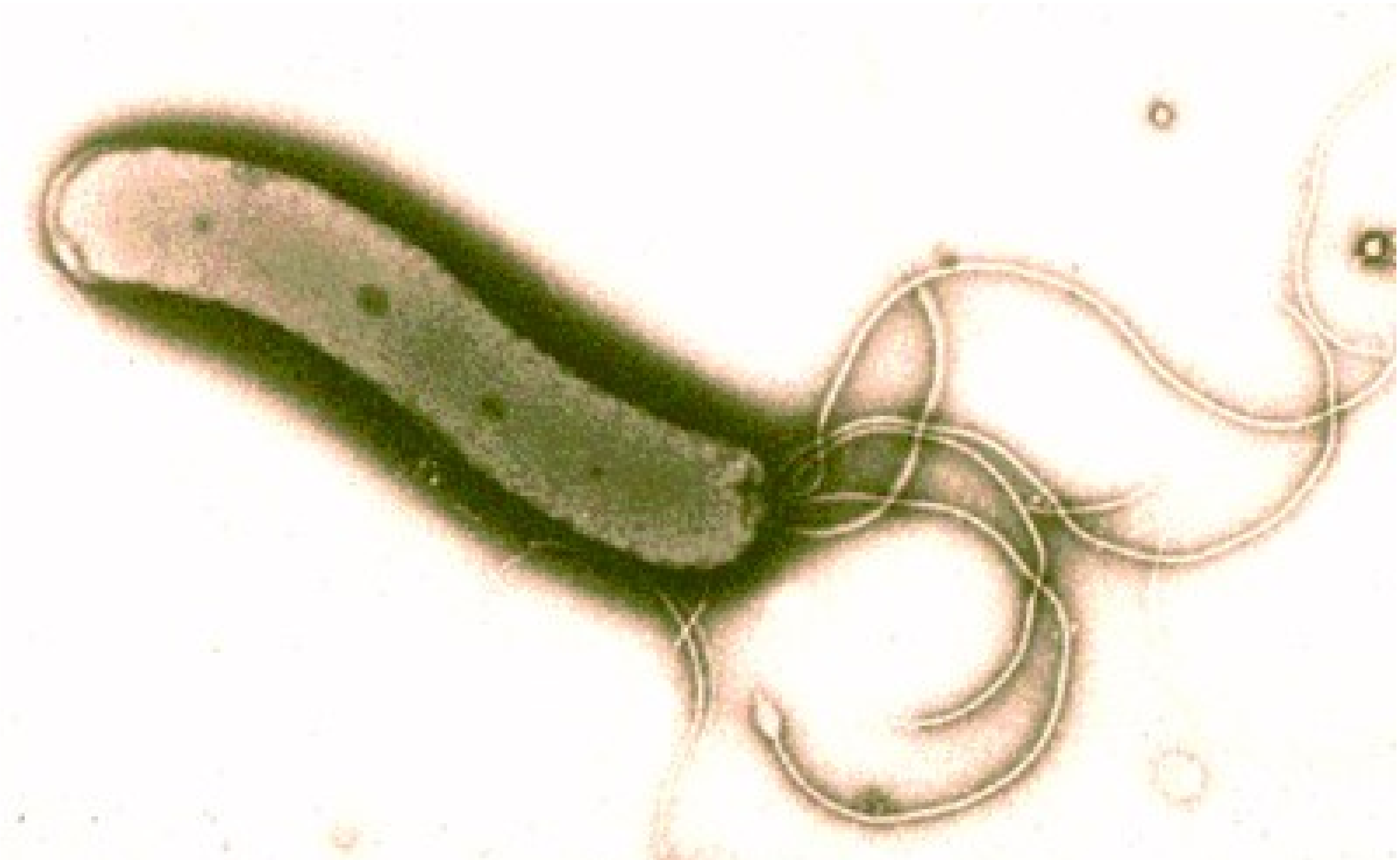
Methanothermobacter thermautotrophicus, Methanosarcina barkeri

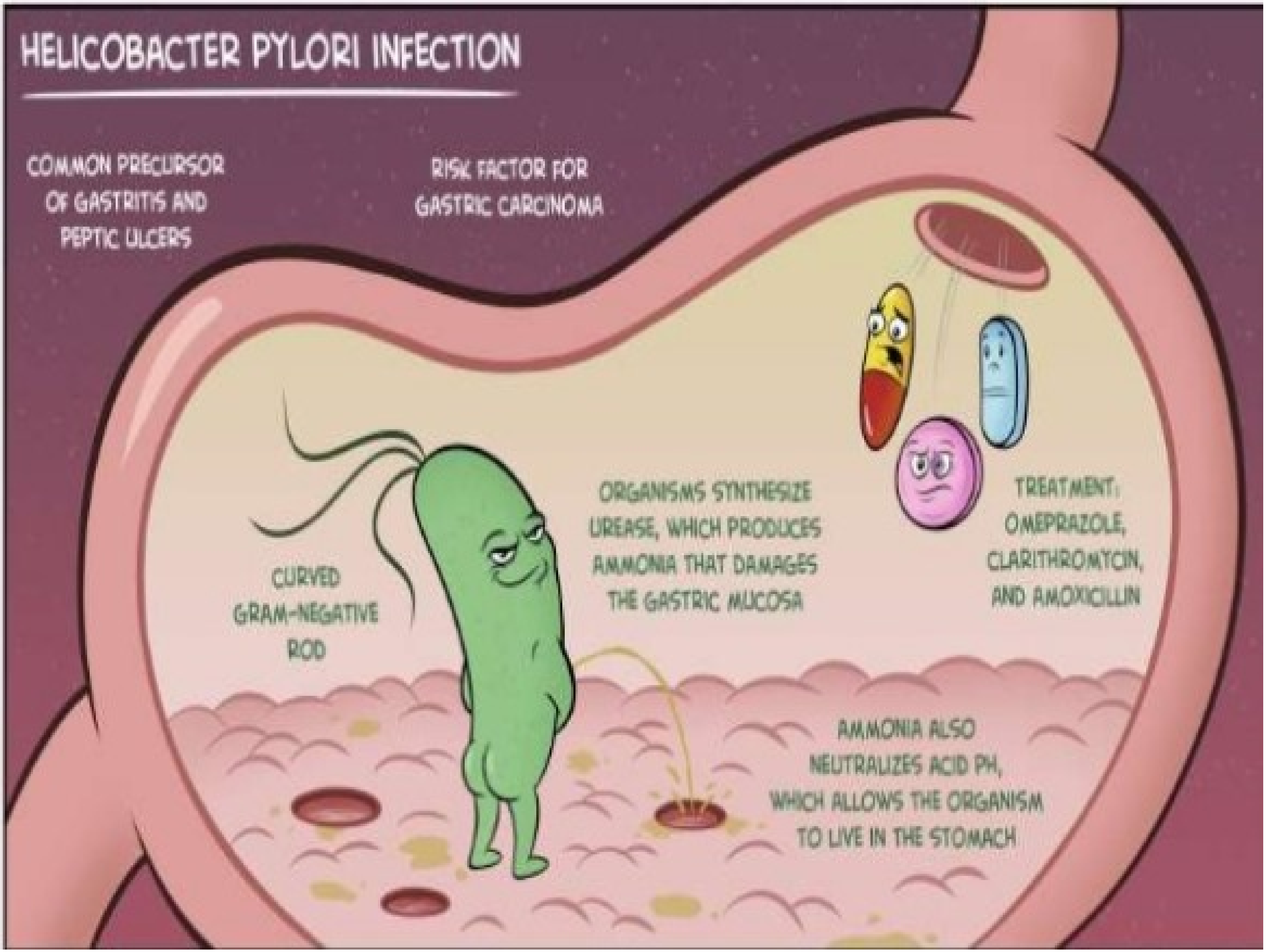
- *Nitrifying bacteria - Nitrobacter*

Thiobacillus

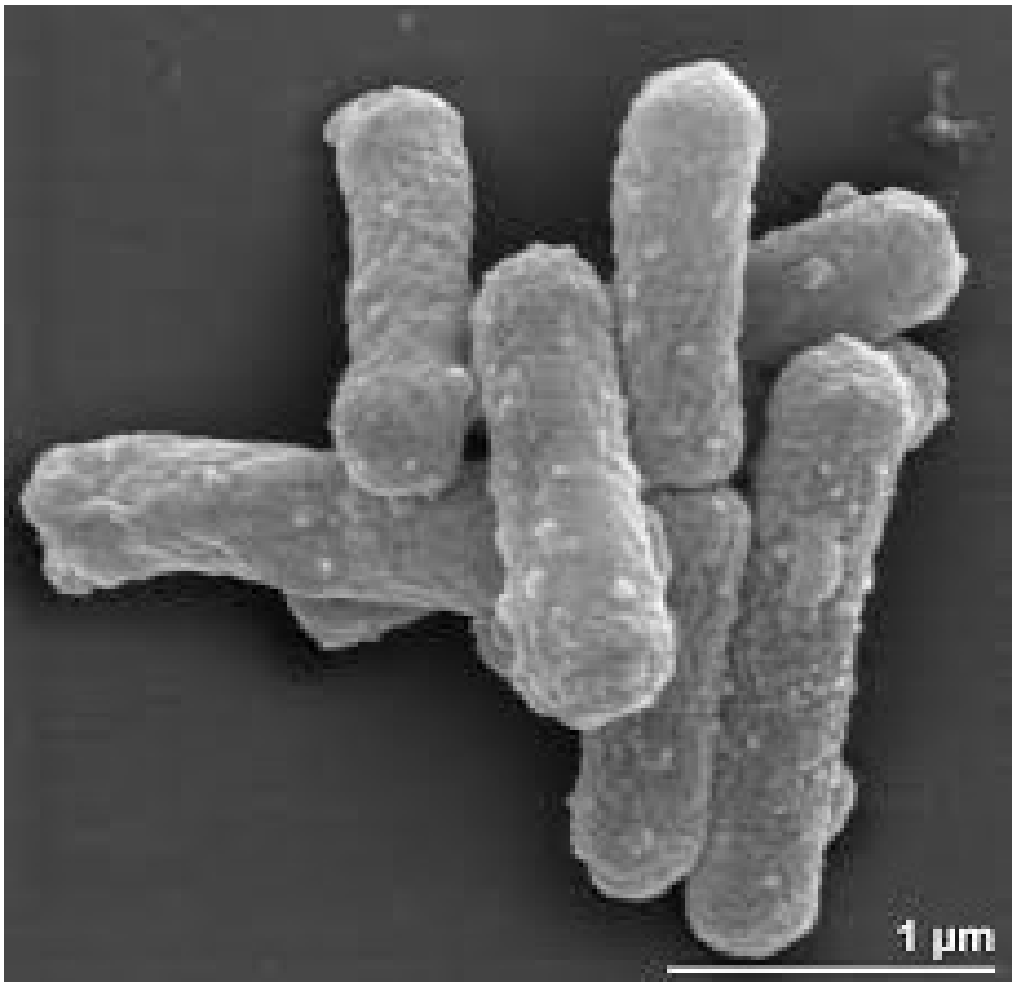


Helicobacter pylori

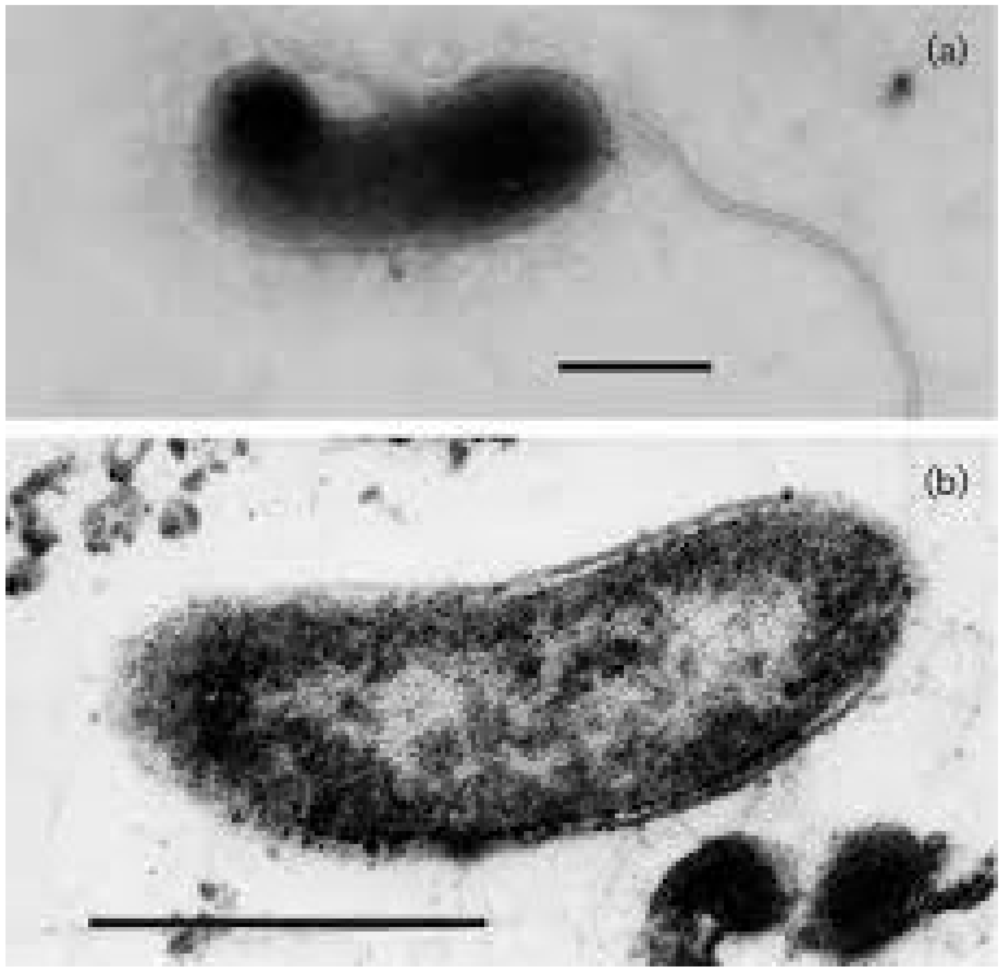



HELICOBACTER PYLORI INFECTION
COMMON PRECURSOR OF GASTRITIS AND PEPTIC ULCERS
RISK FACTOR FOR GASTRIC CARCINOMA
CURVED GRAM-NEGATIVE ROD
ORGANISMS SYNTHESIZE UREASE, WHICH PRODUCES AMMONIA THAT DAMAGES THE GASTRIC MUCOSA
TREATMENT: OMEPRAZOLE, CLARITHROMYCIN, AND AMOXICILLIN
AMMONIA ALSO NEUTRALIZES ACID PH, WHICH ALLOWS THE ORGANISM TO LIVE IN THE STOMACH

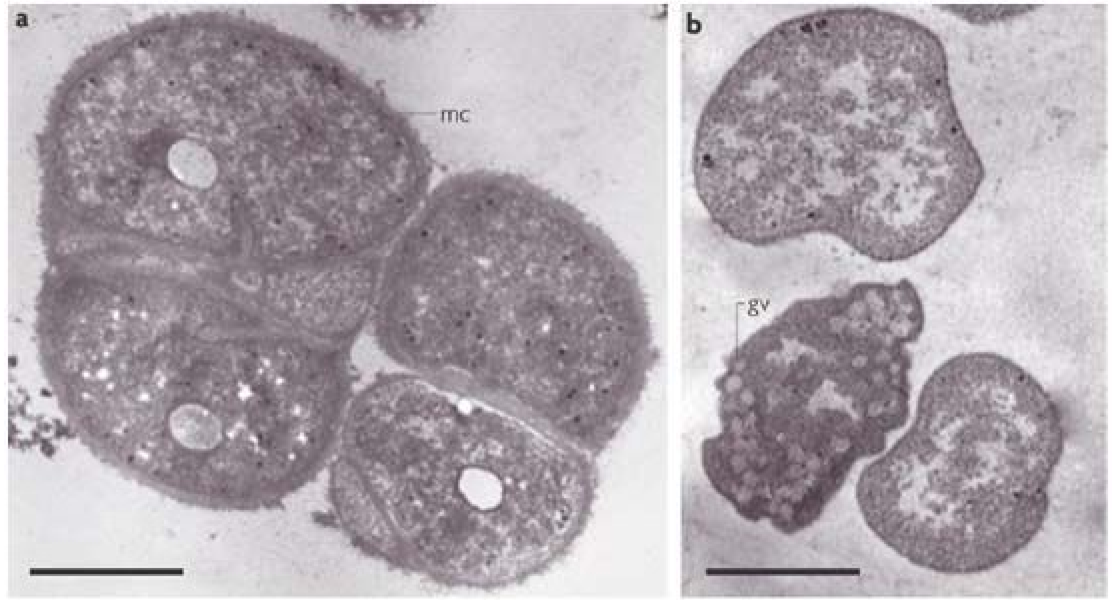
Hydrogenobacter thermophilus



Deferribacter



Methanosarcina barkeri



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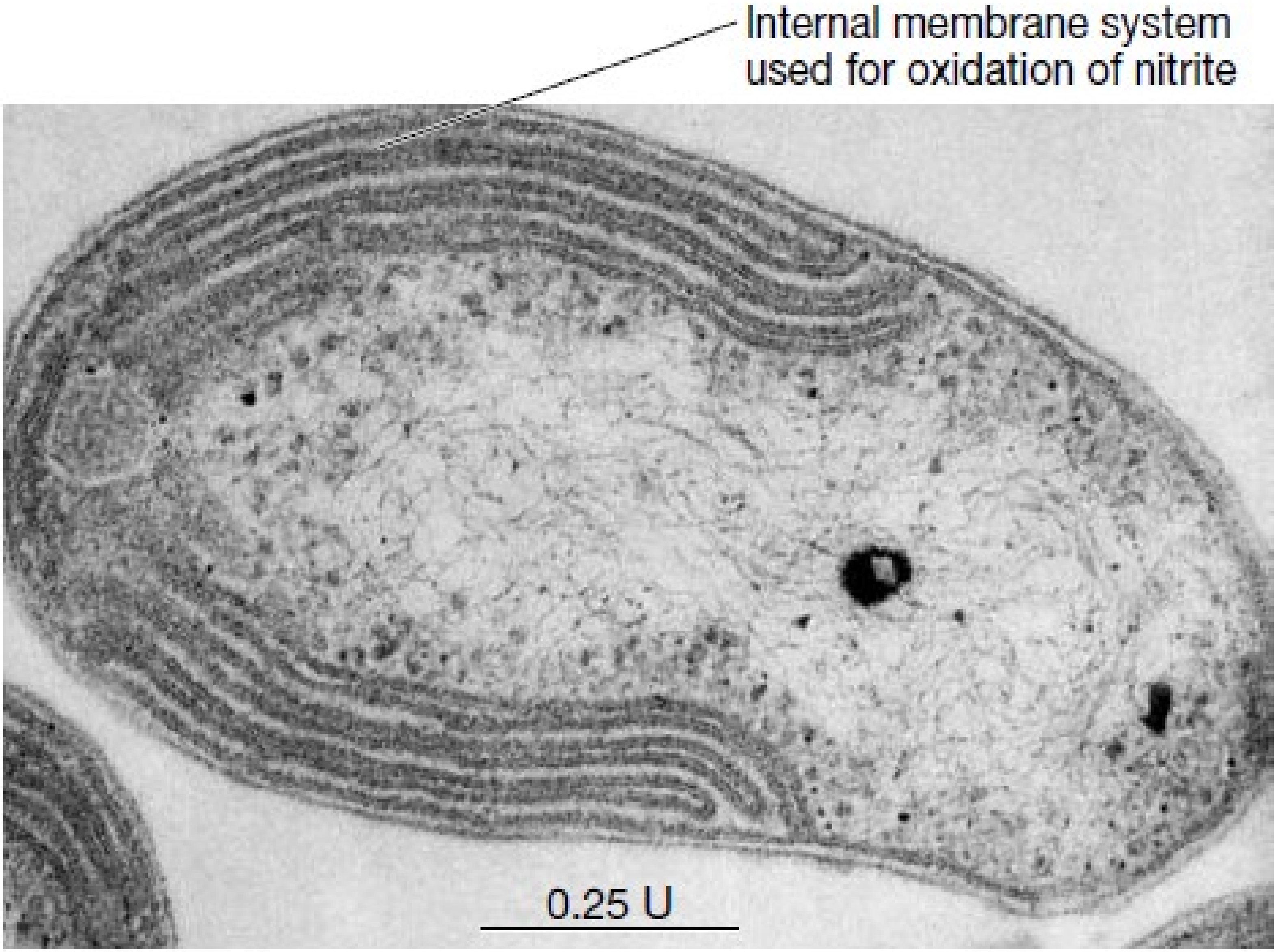


| *Nitrobacter winogradskyi*, a chemolithoautotroph

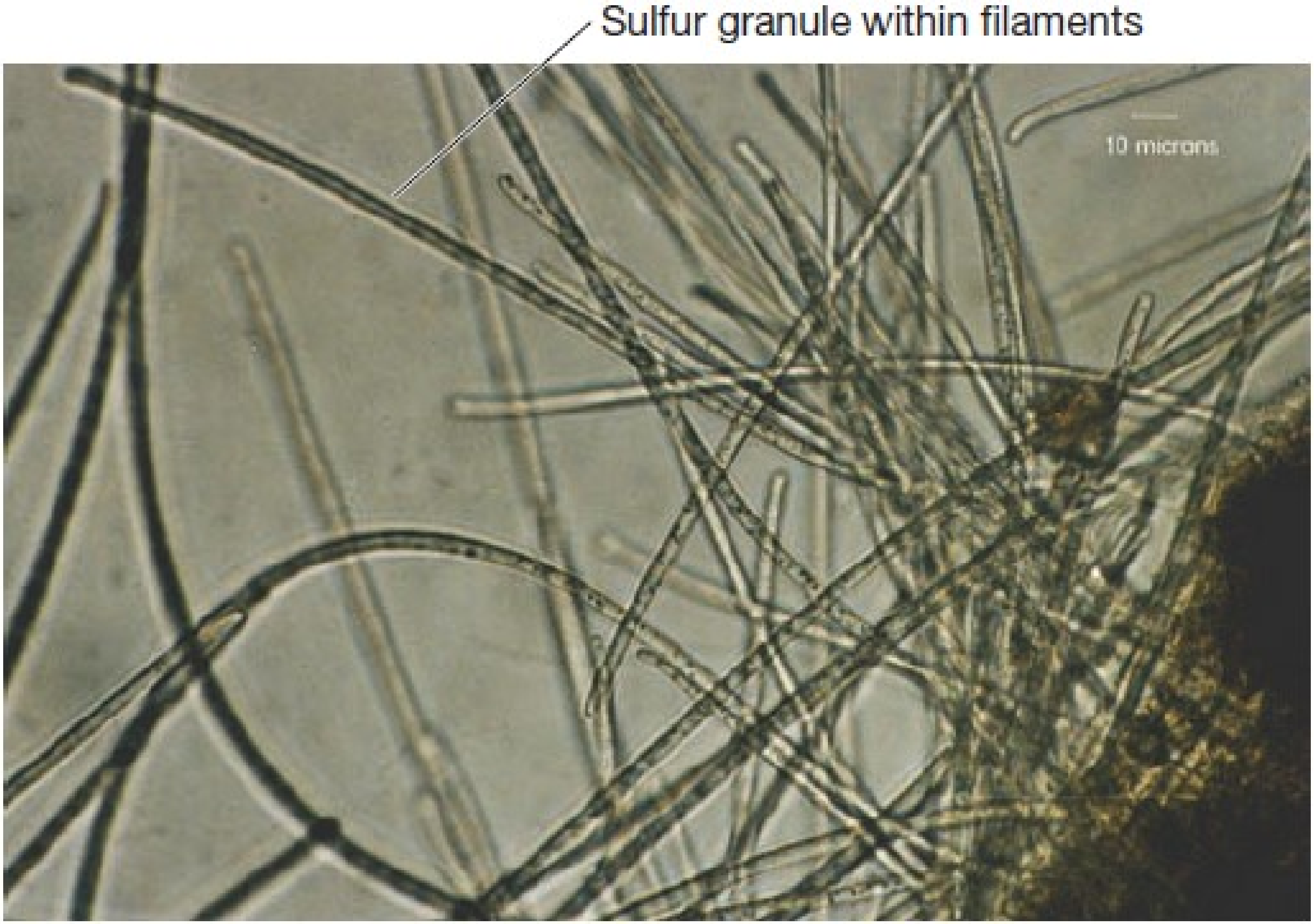
5. Chemolithoheterotrophs

- **Chemolithoheterotrophs, also known as mixotrophs**, *use **reduced inorganic molecules** as their energy* and electron source, but derive their carbon from **organic sources.**

- Chemolithotrophs contribute greatly to the chemical transformations of elements (e.g., the conversion of ammonia to nitrate or sulfur to sulfate) that continually occur in ecosystems.

- E.g. Some sulphur oxidizing bacteria - ***Beggiatoa***

Sulphur oxidizing bacteria



(b) *Beggiatoa alba*, a chemolithoheterotroph (mixotroph)

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Chemoorganoheterotrophy (chemoorganotrophic heterotrophy)	Organic carbon	Organic chemicals often same as C source	Organic e^- donor, often same as C source	Most nonphotosynthetic microbes, including most pathogens, fungi, many protists, and many archaea

- Although a particular species usually belongs in only one of the nutritional classes, some show great metabolic flexibility and alter their metabolic patterns in response to environmental changes.

- This sort of flexibility seems complex and confusing, yet it gives these microbes a definite advantage if environmental conditions frequently change.


Thank You