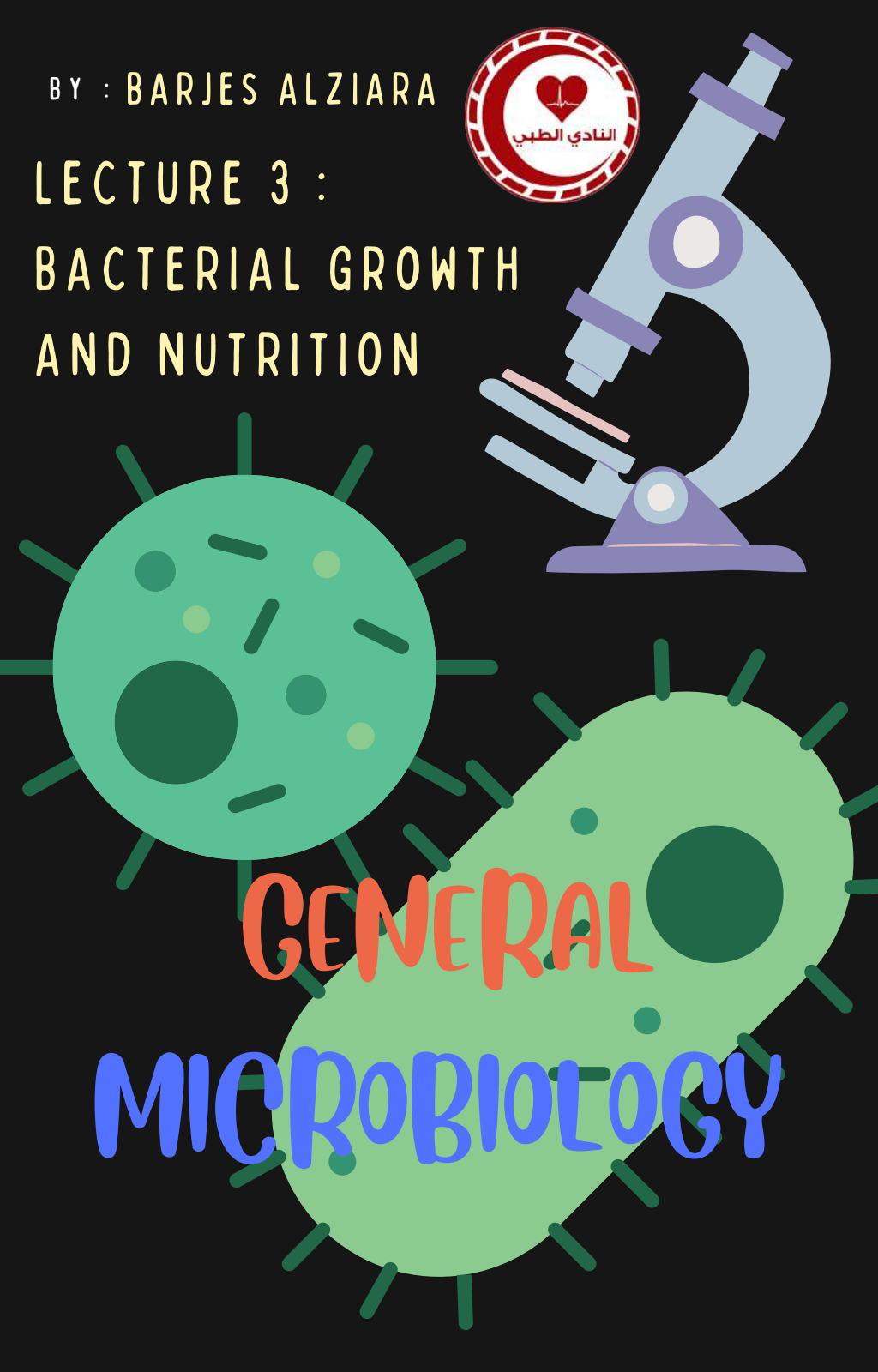
BY : BARJES ALZIARA

LECTURE 3 : BACTERIAL GROWTH AND NUTRITION



GENERAL MICROBIOLOGY

Introduction

- **Microbial growth refers to both the increase in cell size and number of cells in a population.**

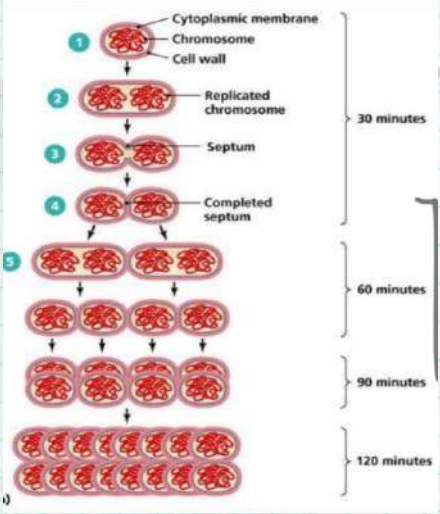
- **Importance of understanding bacterial growth:**
  - Bacterial survival and transmission
  - In vitro diagnostic (laboratory culture)
  - Cessation of bacterial growth for treatment

مشان نعالج صح لازم نعرف نوع البكتيريا اللي بتسبب المرض
نعرف عن طرق بقائها ع قيد الحياة (العمليات الحيوية) و انتقالها
من كائن لاخر

Microbial growth/Binary Fission

بتعمل دبل لكل العضيات و بتكبر بعدها بتنقسم لثنتين متماثلتين في كل
اشي

Bacteria growth by cell division;
binary or transverse division.



During binary fission the parent cell enlarges, duplicates its chromosomes and forms a central transverse septum that divides the cell into two daughter cells.

طبعا مش كل البكتيريا الها نفس قدرة الانقسام بنفس المدة
في بكتيريا اسرع من بكتيريا ثانية

و الانقسام بدل ع اشي جدا مهم هو انه البكتيريا حية و بتعمل عمليات حيوية مشان هيك بتقدر تتكاثر

Generation time under optimal conditions

- **Generation time is the time it takes for a single cell to grow and divide**

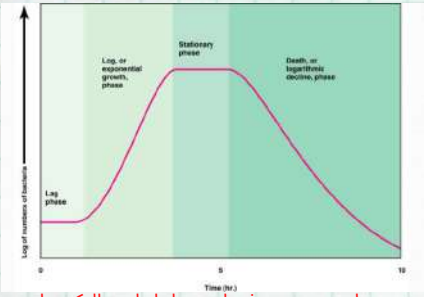
هذول ٤ انواع بكتيريا و مدة انقسام كل نوع فيهم
من الحكي بنقدر نعرف انه E coli بدها 12.5 دقيقة مشان تنقسم
اما مثلا ال Treponema pallidum بدها 30 ساعة

Organism	Generation Time
Escherichia coli	12.5 min
Staphylococcus aureus	27-30 min
Mycobacterium tuberculosis (agent of Tuberculosis)	18 – 24 hrs
Treponema pallidum (agent of Syphilis)	30 hrs

هسه clinically الموضوع هذا بفيدنا نكتشف اذا صاحب العينة مصاب ولا لا يعني لازم نزرع عينة و نشوف اذا تواجد عنا بكتيريا على حسب ال generation time

The Growth Curve

طبعا هذا الحكي كله ما بيصير بجسم الانسان كله بالمختبر



During lag phase, cells are recovering from a period of no growth and are making macromolecules in preparation for growth

During log phase cultures are growing maximally bacteria multiple at the fastest rate possible under the conditions provided.

Bacteria here are(1) susceptible to cell wall active antibiotics.(2) form metabolic end product.

حلو هسه هون في أربع مراحل لنمو البكتيريا
الاولى اسمها lag هاي المرحلة بيصير فيها بتجهز البكتيريا حالها للانقسام بانها تصنع انزيمات و جزيئات و بتعمل replication للعضيات اللي فيها
الثانية log هاي هي مرحلة الانقسام و بهاي المرحلة بكثر عدد البكتيريا بشكل كبير
بتستمر لحد ما يبلش الغذاء ينقص
الثالثة الstationary هون بثبت النمو لانه بسبب قله الغذاء بعض البكتيريا بتصير تموت فتوصل مرحلة ثبات بين الانقسام و موت البكتيريا
اخر مرحلة death مرحلة من اسمها بموت فيها كل البكتيريا سواء من غذاء نقض او من حرارة او ظروف ثانية

- **Stationary phase occurs when nutrients are depleted and wastes accumulate (Growth rate = death rate)**

- **During death phase death rate is greater than growth rate**

Factors Affecting Bacterial Growth

- **Temperature**
- **pH**
- **Osmotic pressure**
- **Oxygen**
- **Nutrition**

الحرارة متى ما زادت عن الحد المحتمل راح يحدث denaturation

Temperature

- **Hydrogen bonds will break at high temperatures leads to protein denaturation**
- **Lipids will be more liquid**
- **Outside membrane cannot preserve the integrity of the cell and it will disintegrate**
- **Minimum Temperature: Temperature below which growth ceases, or lowest temperature at which microbes will grow**

الحرارة المثالية للبكتيريا مشان تعيش

- **Optimum Temperature: Temperature at which its growth rate is the fastest**
- **Maximum Temperature: Temperature above which growth ceases, or highest temperature at which microbes will grow**

Temperature Classes of Organisms

Psychrophiles (**0-20°C**) بتحب الحرارة الواطية و بتكون في المحيطات و المناطق الباردة
انواع نادرة منها بتصيب الانسان

Cold temperature optima

Most of these microbes are found in the oceans, where the temperature is often 5oC or colder. They can also be found in the Arctic and the Antarctic, living in ice wherever they can find pockets of liquid water.

Listeria monocytogenes هاي اهم مثال عليها
مشكلتها ممكن تعمل تسمم غذائي للشخص يعني اذا حطيت صحن اكل فيه هاي البكتيريا بالثلاجة راح تتكاثر و ممكن تسببلك تسمم

Mesophiles (**20 – 45°C**) النوع الثاني امثر واحد بسبب امراض لانه ال optimal temp اله نفس درجة الانسان
الباقي ممكن يعمل بس مش قد هاي فهي تعتبر اكثر قروب مهم

Midrange temperature optima

normal human microbiota and pathogens (e.g., E. coli, Salmonella spp., and Lactobacillus spp.) are mesophiles.

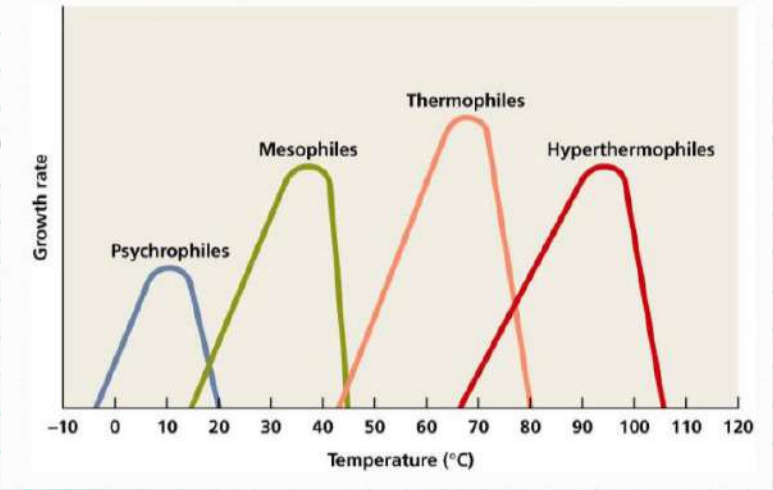
Thermophiles(**50-80°C**)

Growth temperature optima between 50°C and 80°C

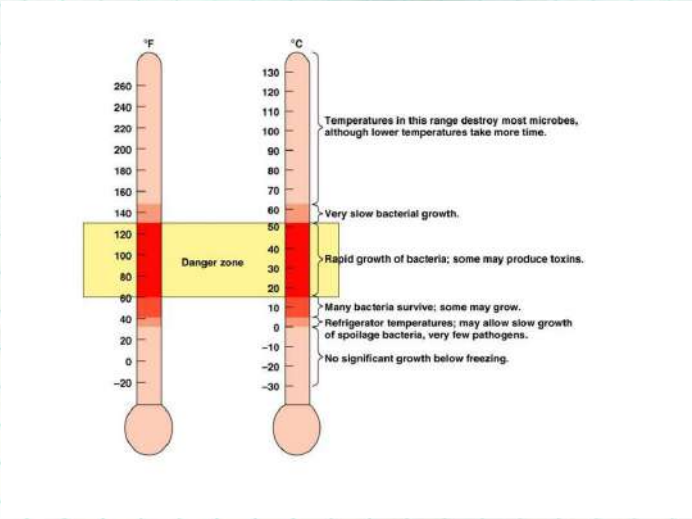
Hyperthermophiles

Optima greater than 80°C
These organisms inhabit hot environments including boiling hot springs

Classification of Microorganisms by Temperature



Mesophiles



بالنسبة لل mesophiles فاذا رفعنا الحرارة راح تموت بينما اذا خفضناها راح يصيرinhibtion لل growth

pH and Microbial Growth

Each organism has a pH range and a pH optimum

- Acidophiles: Grow optimally between ~pH 0 and 5.5 (Helicobacter pylori)
- Neutrophiles: Growoptimally between pH 5.5 and 8
- Alkalophiles: Grow optimally between pH 8 – 11.5 (Vibrio cholera)

نفس الحكي تبع الحرارة ينطبق هون في بكتيريا بتحب الوسط الحمضي في بكتيريا بتفضل القاعدي و في بكتيريا بتفضل المتعادل

Most bacteria grow between pH 6.5 and 7.5

Molds and yeasts grow between pH 5 and 6

Human blood and tissues has pH 7.2+0.2

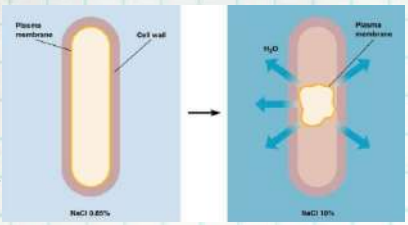
Lactobacillus bacteria can tolerate acidic environments at pH values 3.5–6.8

Vibrio cholerae, the pathogenic agent of cholera, grows best at the slightly basic pH of 8.0; it can survive pH values of 11.0 but is inactivated by the acid of the stomach.

Osmotic Effects on Microbial Growth

الصورة اليمين البيئة hypertonic اما الشمال hypotonic

- **Osmotic pressure depends on the surrounding solute concentration and water availability**
- **Hypertonic environments, increase salt or sugar, cause plasmolysis**



حكينا المحاضرة اللي قبل انه البكتيريا hyperosmolar بالنسبة لاجسامنا
يعني لو فاتت على جسمنا ممكن يصيرلها swelling
طبعا حكينا اللي بحميها من هذا الاشي ال cell wall
بس اذا زادت عن الحد ال osmolarity ما راح يقدر يحميها

Classification :

الدكتور حكا احفظوا هذول التعاريف
اعرفوا فرقوا بينهم لانه تعاريفهم متشابهة

هاي احسن بيئة الها اللي فيها كمية مذاب عالية او بتعبير ثاني ضغط اسموزي عالي

- **Osmophiles: organisms which thrive in high solute**
- **Osmotolerant: organisms which tolerate high solute**

هاي بتقدر تتحمل البيئة اللي ضغطها الاسموزي عالي بس مش احسن بيئة الها

- **Halophiles: organisms which thrive in high salt**

هاي نفس الosmophiles بس متخصصة بال salt

- **Halotolerant: organisms which tolerate high salt**
- **Barophiles: organisms which thrive in high pressure**
- **Barotolerant: organisms which tolerate high pressure**

Classification of Organisms Based on O2 Utilization

very important الدكتور حكا عنهم

Aerobes

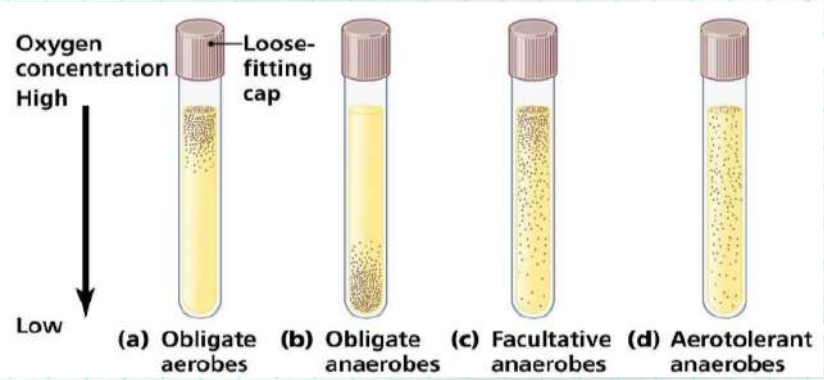
- Grow in ambient air, which contains 21% oxygen and a small amount of (0.03%) carbon dioxide.
- Aerobes obtain some of their energy from glycolysis but they get most of the energy through aerobic respiration (via the Krebs cycle and oxidative phosphorylation).
- Aerobes require molecular oxygen as a terminal electron acceptor, so they cannot grow in its absence.

بتعيش بالوسط اللي فيه O2 و بتعمل atp عن طريق oxidative phosphorylation

Anaerobes

- Anaerobes can not grow in the presence of oxygen
- oxygen is toxic to them.
- Anaerobes do not use free O2 as their final electron acceptor.
- Instead, they use inorganic oxygen-containing molecules such as nitrate (NO_3^-), nitrite (NO_2^-), and sulfate (SO_4^{2-}), in a process called anaerobic respiration.
- Their metabolism frequently is a fermentative type

بتعيش بالوسط اللي ما فيه O2 و يعتبر toxic الها بتنتج atp عن طريق fermentation



They have an absolute requirement of free oxygen to grow

هاي اجباري يكون في O2والا ما راح تعيش

Killed by free oxygen

هاي اذا كان في O2 بتموت

Capable of growth under aerobic and anaerobic conditions

هاي بتعيش سواء في O2 او مافي
بس يفضل انه يكون في
لو ما في بتعمل fermentation مشان
تنتج طاقة

Aerotolerant anaerobes can survive in the presence of oxygen but not use it in their metabolism

هاي بتعيش سواء في O2 او مافي
بس لو في ما بتستخدمه لانه toxic
بس مش مميت الها

اقرأوا الحكي اللي بأخر الصفحة اللي بعدها بعدين ارجعوا للجداول

هذول امثلة

OBLIGATE AEROBES

THEY HAVE AN ABSOLUTE REQUIREMENT OF FREE OXYGEN TO GROW

- **BACILLUS**
- **PSEUDOMONAS**
- **MYCOBACTERIUM**

اخر بكتيريا بتسبب ال tuberculosis هاي ثاني مرة بحكيها الدكتور اعرفوها احتياط

OBLIGATE ANAEROBES

- **KILLED BY FREE OXYGEN**
- **KILLED NOT BY GASEOUS OXYGEN BUT BY A HIGHLY REACTIVE AND TOXIC FORM OF OXYGEN CALLED SUPEROXIDE AND HYDROGEN PEROXIDE.**
- **LACK SUPEROXIDE DISMUTASE AND CATALASE ENZYMES TO NEUTRALIZE OXYGEN FREE RADICALS THUS, THEY SUCCUMB TO THE TOXIC EFFECTS OF SUPEROXIDE AND HYDROGEN PEROXIDE**

- **ACTINOMYCES**
- **BACTEROIDES**
- **CLOSTRIDIUM**

ABCS

هذول البكيتريا ممكن يعمللونا infection في المناطق اللي ما بوصلها O2

FACULTATIVE ANAEROBES

- **CAPABLE OF GROWTH UNDER AEROBIC AND ANAEROBIC CONDITIONS.**
- **THEY USE OXYGEN IF IT IS AVAILABLE BUT CAN FUNCTION WITHOUT IT.**
- **WHEN OXYGEN IS PRESENT, THEY PREFERENTIALLY USE OXYGEN AS A TERMINAL ELECTRON ACCEPTOR AND CARRY ON AEROBIC METABOLISM**
- **BUT THEY SHIFT TO ANAEROBIC METABOLISM WHEN OXYGEN IS ABSENT**

ENTEROBACTERIACEAE

STAPHYLOCOCCUS AUREUS

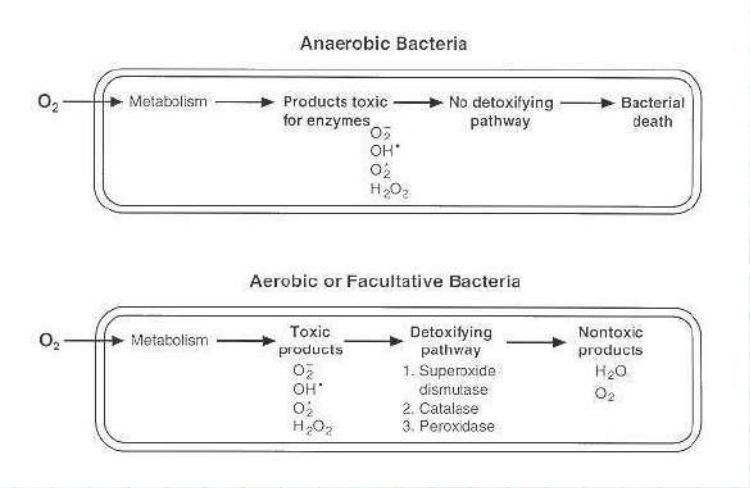
AEROTOLERANT ANAEROBES

- **THEY ARE ANAEROBIC BACTERIA THAT ARE NOT KILLED BY EXPOSURE TO OXYGEN.**
- **AEROTOLERANT ANAEROBES CAN SURVIVE IN THE PRESENCE OF OXYGEN BUT NOT USE IT IN THEIR METABOLISM.**
- **CAPTURES ENERGY BY FERMENTATION, REGARDLESS OF WHETHER THE ENVIRONMENT CONTAINS OXYGEN.**

LACTOBACILLUS

تدخل هاي البكتيريا في صناعة الاجبان زي ما قلنا انها بتعمل عملية fermentation

ليش ال O2 يعتبر toxic لبعض البكتيريا و بعضها لا ؟؟
لانه الاوكسجين بس يفوت بيصيرله عمليات ال metabolism هاي العمليات تنتج مادتين superoxide(O2-) و peroxide (H2O2)
هذول المواد toxic فاذا ما في نظام يتخلص منهم راح يتراكموا و يسببوا موت الخلية
هسه الخلايا من نوع Obligate aerobes او Facultative anaerobes
فيهم نظام اسمه detoxifying system هذا النظام بعمل على تحويل الH2O2 و O2- ل O2 و H2O عن طريق انزيمين همه ال superoxide dismutase و ال catalase
و برضو بيصير هذا الحكي بخلايا الانسان
اما ال Obligate anaerobes و Aerotolerant anaerobes ما عندهم هذا النظام فبتراكم عندهم المواد السامة و بعمللها تسمم



- **Utilization of O2 during metabolism yields toxic by-products including O2-, singlet oxygen (1O2) and/or H2O2**
- **Toxic O2 products can be converted to harmless substances if the organism has catalase (or peroxidase) and superoxide dismutase (SOD)**
- **SOD converts O2- into H2O2 and O2**
- **Catalase breaks down H2O2 into H2O and O2**
- **Any organism that can live in or requires O2 has SOD and catalase (peroxidase)**

Oxygen and Microbial Growth

Using oxygen (O2) in metabolism creates toxic waste

Microbes that are able to use aerobic respiration produce enzymes to

detoxify oxygen:

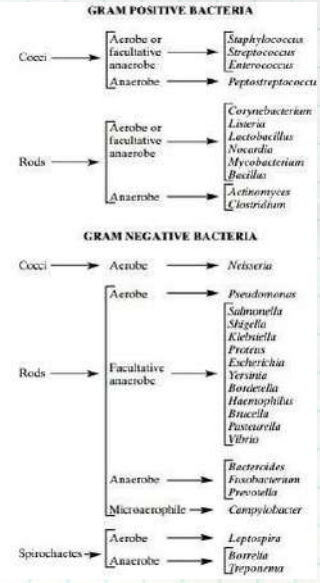
Catalase: H2O2 ---> H20 and 02

Superoxide dismutase (SOD): oxygen radical ---> H202 and O2

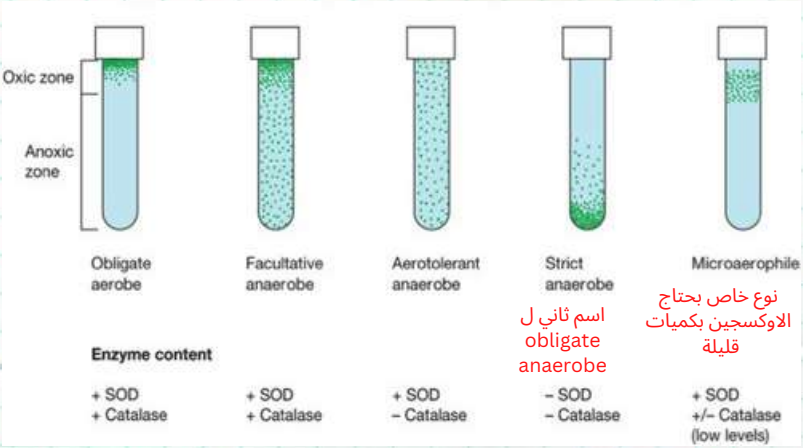
Microbes that don't make these enzymes cannot exist in the presence of oxygen.

The enzyme superoxide dismutase reduces the superoxide to oxygen gas and hydrogen peroxide (H2O2).

Subsequently, the toxic hydrogen peroxide generated in this reaction is converted to water and oxygen by the enzyme catalase,



هذ الجدول مطلوب
😊😊
بس مش هسه بعد
ما نخلص ال
bacteriology
لقدام الدكتور حكا
راح يصير اسهل



- **Obligate aerobes and most facultative anaerobes have both superoxide dismutase and catalase.**

- **Some facultative and aerotolerant anaerobes have superoxide dismutase but lack catalase.**

- **Most obligate anaerobes lack both enzymes.**

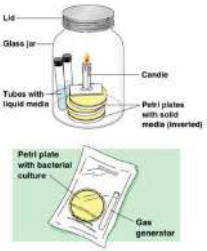
CAPNOPHILES

CAPNOPHILIC (OR CARBON DIOXIDE–LOVING) BACTERIA REQUIRE INCREASED CONCENTRATION OF CARBON DIOXIDE (5% – 10%) AND APPROXIMATELY 15% OXYGEN.

THIS CONDITION CAN BE ACHIEVED BY A CANDLE JAR (3% CARBON DIOXIDE) OR CARBON DIOXIDE INCUBATOR, JAR, OR BAG.

HAEMOPHILUS INFLUENZAE, NEISSERIA GONORRHEA

هاي البكتيريا بتفضل تكون ببيئة فيها co2



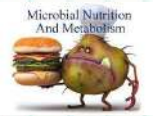
Neisseria gonorrhea

تسبب احد الامراض المنقولة جنسيا لدى الرجال

Haemophilus influenzae

بتسبب عدوى في الاذن الوسطى و التهاب في الجيوب

Microbial Nutrition

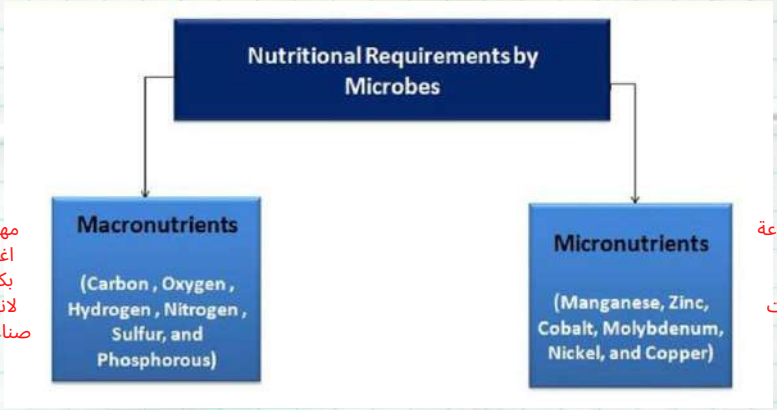


- **Organisms use a variety of nutrients for:**

1- their energy needs

2- to build organic molecules & cellular structures

- **Nutrients are those substances that are energy sources to drive the metabolic or biosynthetic processes by the microbial cells**



مهمة و تحتاجها اغلب البكتيريا بكميات عالية لانها بتدخل في صناعة مواد الخلية

بتحتاجها في صناعة الانزيمات و الهرمونات بتحتاجها بكميات قليلة

- **Carbon**

Structural organic molecules as energy source

- **Nitrogen**

In amino acids, proteins

- **Sulfur**

In amino acids, thiamine, biotin

- **Phosphorus**

In DNA, RNA, ATP, and membranes

Metals and organic compounds needed in very small amounts, usually as enzyme and cofactors

Special requirements

- **Amino acids**
- **Nucleotide bases**

Enzymatic cofactors or "vitamins"

هذا الجدول مراجعة
لحالات البكتيريا مع
الاكسجين
و كل نوع راح نوخذ
عنه لقدام

Classification	Characteristics	Examples
Aerobes	• grow in ambient air, which contains 21% oxygen and a small amount of (0.03%) carbon dioxide. • Aerobes obtain some of their energy from glycolysis but they get most of the energy through aerobic respiration (via the Krebs cycle and oxidative phosphorylation). • Aerobes require molecular oxygen as a terminal electron acceptor, so they cannot grow in its absence.	Bacillus
Obligate aerobes	They have an absolute requirement of free oxygen to grow	Bacillus, Pseudomonas, Mycobacterium
Anaerobes	• Anaerobes can not grow in the presence of oxygen • oxygen is toxic to them. • Anaerobes do not use free O2 as their final electron acceptor. • Instead, they use inorganic oxygen-containing molecules such as nitrate (NO3-), nitrite (NO2−), and sulfate (SO_4^{2-}), in a process called anaerobic respiration. • their metabolism frequently is a fermentative type	
Obligate anaerobes	• killed by free oxygen • Obligate anaerobes are killed not by gaseous oxygen but by a highly reactive and toxic form of oxygen called **superoxide and hydrogen peroxide**. • obligate anaerobes lack **superoxide dismutase and catalase enzymes** to neutralize oxygen free radicals thus, they succumb to the toxic effects of superoxide and hydrogen peroxide	*Actinomyces** *Bacteroides* *Clostridium* **ABCs**
Facultative anaerobes	• Facultative anaerobes are versatile organisms capable of growth under aerobic and anaerobic conditions. • They use oxygen if it is available but can function without it. • When oxygen is present, they preferentially use oxygen as a terminal electron acceptor and carry on aerobic metabolism, but they shift to anaerobic metabolism when oxygen is absent	e.g., Enterobacteriaceae family, Staphylococcus aureus, etc
Aerotolerant anaerobes	• They are anaerobic bacteria that are not killed by exposure to oxygen. • Aerotolerant anaerobes can survive in the presence of oxygen but not use it in their metabolism.	Lactobacillus, for example, always captures energy by fermentation, regardless of whether the environment contains oxygen.
Capnophiles	• Capnophilic (or carbon dioxide–loving) bacteria require increased concentration of carbon dioxide (5% – 10%) and approximately 15% oxygen. • This condition can be achieved by a candle jar (3% carbon dioxide) or carbon dioxide incubator, jar, or bag.	Haemophilus influenzae, Neisseria gonorrhea
Microaerophiles	• Requires low but not full oxygen tension • Higher oxygen tensions may be inhibitory to them.	Campylobacter jejuni, Helicobacter pylori