1. Pendahuluan

- Menentukan nutrisi yang dibutuhkan oleh mikroorganisme pada dasarnya identik dengan mengetahui komposisi sel. Hal ini disebabkan nutrisi dibutuhkan oleh sel mikroorganisme untuk tumbuh dan berkembang.
- Unsur yang paling banyak dibutuhkan oleh mikroorganisme secara umum disebut dengan makroelemen yang mencakup karbon, oksigen, hydrogen, nitrogen, sulfur, fosfor, kalium, kalsium, magnesium dan besi.
- Selain makronutrien dikenal pula mikronutrien yaitu nutrien yang dibutuhkan dalam jumlah kecil/sedikit. Contoh mikronutrien adalah mangan, seng, kobalt, molybdenum, nikel dan tembaga.

![Periodic Table]

- Essential elements as a percent of cell dry weight
- Micronutrient composition of a cell

![Graph]

- Diagram showing the composition and percentage of essential elements in cell dry weight.

2. Medium Pertumbuhan

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Agrindustrial Technology – Brawijaya University
Tipe mikroorganisme

<table>
<thead>
<tr>
<th>Table 5.1</th>
<th>Sources of Carbon, Energy, and Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Sources</td>
<td></td>
</tr>
<tr>
<td>Autotrophs</td>
<td>$\text{CO}_2$ and principal biosynthetic carbon source (section 10.3)</td>
</tr>
<tr>
<td>Heterotrophs</td>
<td>Reduced, performed, organic molecules from other organisms (chapters 9 and 10)</td>
</tr>
<tr>
<td>Energy Sources</td>
<td></td>
</tr>
<tr>
<td>Phototrophs</td>
<td>Light (section 9.12)</td>
</tr>
<tr>
<td>Chemoautotrophs</td>
<td>Oxidation of organic or inorganic compounds (chapter 9)</td>
</tr>
<tr>
<td>Electron Sources</td>
<td></td>
</tr>
<tr>
<td>Lithotrophs</td>
<td>Reduced inorganic molecules (section 9.11)</td>
</tr>
<tr>
<td>Organotrophs</td>
<td>Organic molecules (chapter 9)</td>
</tr>
</tbody>
</table>

Tipe mikroorganisme berdasar nutrisi utama

<table>
<thead>
<tr>
<th>Table 12</th>
<th>Major Nutritional Types of Microorganisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional Type</td>
<td>Carbon Source</td>
</tr>
<tr>
<td>Photosynthetic</td>
<td>$\text{CO}_2$</td>
</tr>
<tr>
<td>Phototrophic</td>
<td></td>
</tr>
<tr>
<td>Chemoautotrophic</td>
<td></td>
</tr>
<tr>
<td>Chemoorganotrophic</td>
<td></td>
</tr>
</tbody>
</table>

Carbon and Nitrogen

- All cells require carbon, and most prokaryotes require organic (carbon-containing) compounds as their source of carbon.
- Heterotrophic bacteria assimilate organic compounds and use them to make new cell material.
- Amino acids, fatty acids, organic acids, sugars, nitrogen bases, aromatic compounds, and countless other organic compounds can be transported and catabolized by one or another bacterium.
- Autotrophic microorganisms build their cellular structures from carbon dioxide ($\text{CO}_2$) with energy obtained from light or inorganic chemicals.
Carbon and Nitrogen

- A bacterial cell is about 13% nitrogen, which is present in proteins, nucleic acids, and several other cell constituents.
- The bulk of nitrogen available in nature is in inorganic form as ammonia ($NH_3$), nitrate ($NO_3^-$), or nitrogen gas ($N_2$).
- Nitrogen in organic compounds, for example, in amino acids, may also be available to microorganisms; if organic N is available and is taken up, the compound can immediately enter the monomer pool for biosynthesis or be catabolized as an energy source.

Other Macronutrients: P, S, K, Mg, Ca, Na

- Phosphorus is a key element in nucleic acids and phospholipids and is typically supplied to a cell as phosphate ($PO_4^{3-}$).
- Sulfur is present in the amino acids cysteine and methionine and also in several vitamins, including thiamine, biotin, and lipic acid. Sulfur can be supplied to cells in several forms, including sulfide ($H_2S^-$) and sulfate ($SO_4^{2-}$).
- Potassium (K) is required for the activity of several enzymes, whereas magnesium (Mg) functions to stabilize ribosomes, membranes, and nucleic acids and is also required for the activity of many enzymes.
- Calcium (Ca) is not required by all cells but can play a role in helping to stabilize microbial cell walls, and it plays a key role in the heat stability of endospores.
- Sodium (Na) is required by some, but not all, microorganisms, and its requirement is typically a reflection of the habitat. For example, seawater contains relatively high levels of $Na^+$, and marine microorganisms typically require $Na^+$ for growth.

Micronutrients: Iron and Other Trace Metals

- Iron (Fe), which plays a major role in cellular respiration. Iron is a key component of cytochromes and of iron-sulfur proteins involved in electron transport reactions.
- Under anoxic conditions, iron is generally in the ferrous ($Fe^{2+}$) form and soluble. However, under anaerobic conditions, iron is typically in the ferric ($Fe^{3+}$) form as part of insoluble minerals.
- To obtain $Fe^{3+}$ from such minerals, cells produce iron-binding molecules called siderophores that function to bind $Fe^{3+}$ and transport it into the cell.
- A major group of siderophores is the hydroxamic acids, organic molecules that chelate $Fe^{3+}$ strongly.
Micronutrients: Iron and Other Trace Metals

However, as important as iron is for most cells, some organisms can grow in the absence of iron.
For example, many lactic acid bacteria such as species of Lactobacillus do not contain detectable iron and grow normally in its absence. In these organisms, manganese (Mn) often plays a role similar to that just described for iron.
Many other metals are required or otherwise metabolized by microorganisms (Figure 4.1a).
Like iron, these micronutrients are called trace elements or trace metals.
Micronutrients typically play a role as cofactors for enzymes.
Table 4.1 lists the major micronutrients and examples of enzymes in which each plays a role in the cell.

<table>
<thead>
<tr>
<th>Element</th>
<th>Cellular function or metabolite of which a part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (Fe)</td>
<td>Activator for various enzymes; also forms its own proteins in bacteria</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>Key to cyanide metabolism and complex cobalamin derivatives</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Essential for hemoglobin, cytochrome oxidase, etc.</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Essential for the structure of chlorophyll</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>Essential for nitrate reductase and sulfate oxidase</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Essential for many enzymes</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Essential for many enzymes and compounds</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Essential for many enzymes</td>
</tr>
</tbody>
</table>

Micronutrients: Growth Factors

Growth factors are organic compounds that, like trace metals, are required in only very small amounts.
Growth factors are vitamins, amino acids, purines, pyrimidines, or various other organic molecules.
Although most microorganisms are able to biosynthesize the growth factors they need, some must obtain one or more of them from the environment and thus must be supplied with these compounds when cultured in the laboratory.
Vitamins are the most commonly required growth factors.
Most vitamins function as coenzymes, which are non-protein components of enzymes.
Vitamin requirements vary among microorganisms, ranging from none to several. Lactic acid bacteria, which include the genera Streptococcus, Lactobacillus, and Leuconostoc, are renowned for their many vitamin requirements, which are even more extensive than those of humans (see Table 4.2).
Kebutuhan vitamin

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Function</th>
<th>Example of Microorganisms Requiring Vitamin*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kubes</td>
<td>Carbonates (Ca, Mg, Sr, Ba)</td>
<td>Lactobacillus (bacteria)</td>
</tr>
<tr>
<td>Mangan</td>
<td>Oxidized metal ions</td>
<td>Chromatium methanolicum (P)</td>
</tr>
<tr>
<td>Copper</td>
<td>Manganese and cobalt</td>
<td>Acinetobacter calcoaceticus (P)</td>
</tr>
<tr>
<td>Iron</td>
<td>Nitrogenase</td>
<td>Clostridium pasteurianum (P)</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Molybdenum-cofactor</td>
<td>Clostridium beijerinckii (P)</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Sulfur</td>
<td>Desulfovibrio desulfuricans (P)</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Cobalt</td>
<td>Escherichia coli (B)</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Cobalt</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Boron</td>
<td>Boron</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Magnesium</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Phosphorus</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Iodine</td>
<td>Iodine</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Selenium</td>
<td>Selenium</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Fluoride</td>
<td>Bacillus cereus (P)</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Vanadium</td>
<td>Bacillus cereus (P)</td>
</tr>
</tbody>
</table>

*Note: *denotes microorganisms from the following groups: Actinobacteria, Bacteroidetes, and Firmicutes.

3 Culture Media

- Culture media are the nutrient solutions used to grow microorganisms in the laboratory.
- Classes of Culture Media: Defined Media and Complex Media
  - Defined media are prepared by adding precise amounts of highly purified inorganic or organic chemicals to distilled water.
  - Complex media employ digests of microbial, animal or plant products, such as casein (milk protein), beef (beef extract), soy-beans (tryptic soy broth), yeast cells (yeast extract), or any of a number of other highly nutritious yet impure substances.

<table>
<thead>
<tr>
<th>Table 3.1: Example of culture media for microorganisms with simple and demanding nutritional requirements*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defined culture medium for</strong></td>
</tr>
<tr>
<td><strong>Bacillus subtilis</strong></td>
</tr>
<tr>
<td><strong>E. coli</strong></td>
</tr>
<tr>
<td><strong>L. mesenteroides</strong></td>
</tr>
<tr>
<td><strong>Thiobacillus thiooxidans</strong></td>
</tr>
</tbody>
</table>

*Note: *denotes culture medium for the following groups: Lactic acid bacteria, E. coli, and L. mesenteroides.
• An enriched medium, often used for the culture of otherwise difficult-to-grow nutritionally demanding (fastidious) microorganisms, starts with a complex base and is embellished with additional nutrients such as serum, blood, or other highly nutritious substances.

• A selective medium contains compounds that inhibit the growth of some microorganisms but not others.

• Differential media are quite useful for distinguishing different species of bacteria and are therefore widely used in clinical diagnostics and systematic microbiology.

Nutritional Requirements and Biosynthetic Capacity

• The complex medium is easiest to prepare and supports growth of both of the chemoorganotrophs, Escherichia coli and Leuconostoc mesenteroides, the examples used in the table.

• However, the simple defined medium supports growth of E. Coli but not of L. mesenteroides.

• Growth of the latter organism, a fastidious (nutritionally demanding) bacterium, in a defined medium requires the addition of several nutrients not needed by E. coli.

• By contrast, E. Coli can synthesize everything it needs from a single carbon compound, in this case, glucose.

• The nutritional needs of L. mesenteroides can be satisfied by preparing either a highly supplemented defined medium, a rather laborious under-taking because of all the individual nutrients that need to be added (Table 4.2), or by preparing a complex medium, a much less demanding operation.

Media Kultur

Table 4.2 Examples of Defined Media

<table>
<thead>
<tr>
<th>Media Kultur</th>
<th>Examples of Defined Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>DG-11 Medium for Cytoplasts</td>
<td>Amount (g/tone)</td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
</tr>
<tr>
<td>K2HPO4</td>
<td>1.0</td>
</tr>
<tr>
<td>MgSO4.7H2O</td>
<td>0.75</td>
</tr>
<tr>
<td>CaCl2.2H2O</td>
<td>0.008</td>
</tr>
<tr>
<td>Corn starch</td>
<td>0.008</td>
</tr>
<tr>
<td>Yeast extract</td>
<td>0.008</td>
</tr>
<tr>
<td>NaN3</td>
<td>0.01</td>
</tr>
<tr>
<td>NaNH4</td>
<td>0.02</td>
</tr>
<tr>
<td>Final pH</td>
<td>7.0</td>
</tr>
<tr>
<td>Medium for Escherichia coli</td>
<td>Amount (g/tone)</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.0</td>
</tr>
<tr>
<td>NaN3</td>
<td>0.01</td>
</tr>
<tr>
<td>NaNH4</td>
<td>1.5</td>
</tr>
<tr>
<td>NaNH4</td>
<td>0.2</td>
</tr>
<tr>
<td>MgCl2.6H2O</td>
<td>0.008</td>
</tr>
<tr>
<td>CaCl2.2H2O</td>
<td>0.008</td>
</tr>
<tr>
<td>Final pH</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Contoh medium komplek

<table>
<thead>
<tr>
<th>Tabel 3.4</th>
<th>Some Common Complex Media</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kandungan</strong></td>
<td><strong>Konsentrasi (g/L)</strong></td>
</tr>
<tr>
<td>Protein (gelatine hidrolisate)</td>
<td>5</td>
</tr>
<tr>
<td>Beef extract</td>
<td>3</td>
</tr>
<tr>
<td>Trypsin Soy Broth</td>
<td></td>
</tr>
<tr>
<td>Trypsin (pancreatic digest of casein)</td>
<td>17</td>
</tr>
<tr>
<td>Peptone (soybean-digested)</td>
<td>3</td>
</tr>
<tr>
<td>Glucose</td>
<td>2.5</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>5</td>
</tr>
<tr>
<td>Diphosphates</td>
<td>2.5</td>
</tr>
<tr>
<td>MacConkey Agar</td>
<td></td>
</tr>
<tr>
<td>Pancreatic digest of gelatine</td>
<td>17.0</td>
</tr>
<tr>
<td>Peptone digest of casein</td>
<td>1.5</td>
</tr>
<tr>
<td>Peptic digest of animal tissue</td>
<td>1.5</td>
</tr>
<tr>
<td>Lactose</td>
<td>10.0</td>
</tr>
<tr>
<td>Bile salts</td>
<td>1.5</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>5.0</td>
</tr>
<tr>
<td>Neutral red</td>
<td>0.01</td>
</tr>
<tr>
<td>Crystal violet</td>
<td>0.001</td>
</tr>
<tr>
<td>Agar</td>
<td>13.0</td>
</tr>
</tbody>
</table>

Tugas individu

Tulis media pertumbuhan
1. Sintetik
2. Kompleks
3. Cair
4. Padat
(dari jurnal berbahasa Inggris – lampirkan jurnalnya).

Sebut mikroorganisme yang ditumbuhkan pada media tersebut
Thank You!