# BOT-HE-6016

## Industrial and Environmental Microbiology

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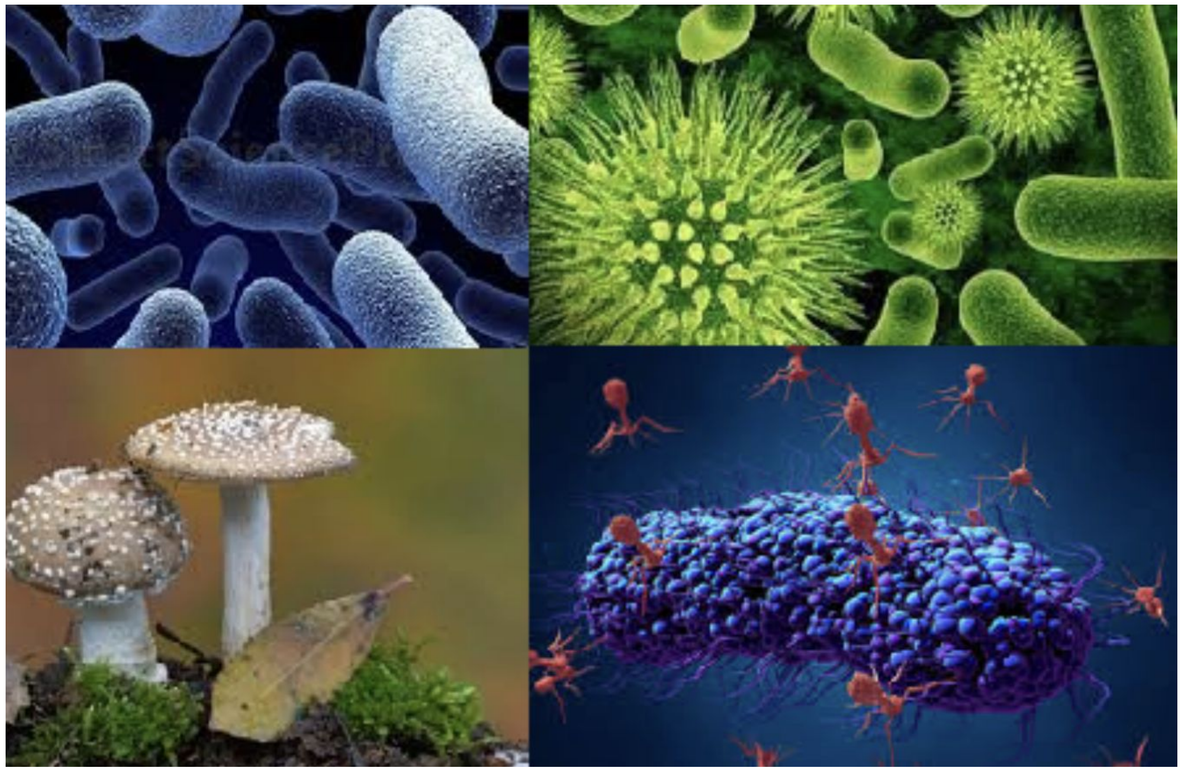
# Unit 1

## Scope of microbes in industry and environment

### What are microbes?

- Any organism that measures less than 0.1 mm in size.
- Cannot be seen by the naked eye.
- Unicellular.
- Include:
  - Bacteria
  - Fungi
  - Protists
  - Viruses
  - Archaea



# Why are microbes industrially important?

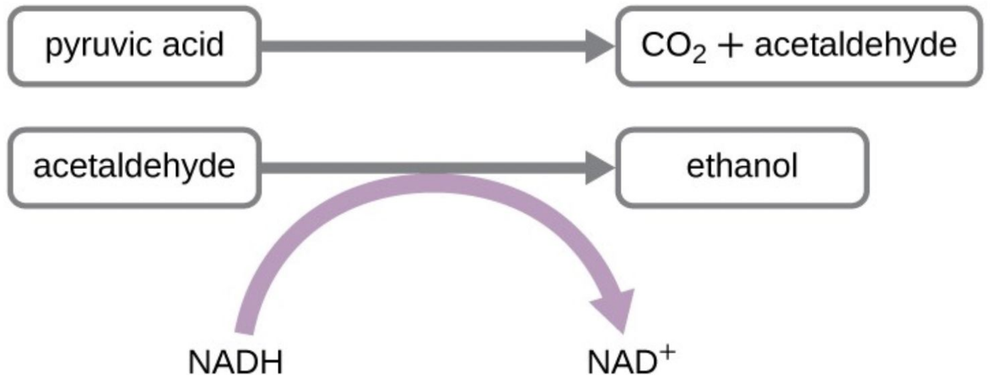
- Very high metabolic rate.
- Huge variety of enzymes to make different chemical conversions possible.
- Large surface area for quick absorption of nutrients and release of end products.
- Very high rate of multiplication; quick cell turnover.
- Efficient chemical factories, producing a variety of useful products.

# Stages in the evolution of microbial use in industries

Stage 1: The early 1900s: **The era of fermentation.**

**Fermentation:** Chemical breakdown of a **substrate** into simpler molecules **anaerobically** with the release of heat, by the action of microbes.

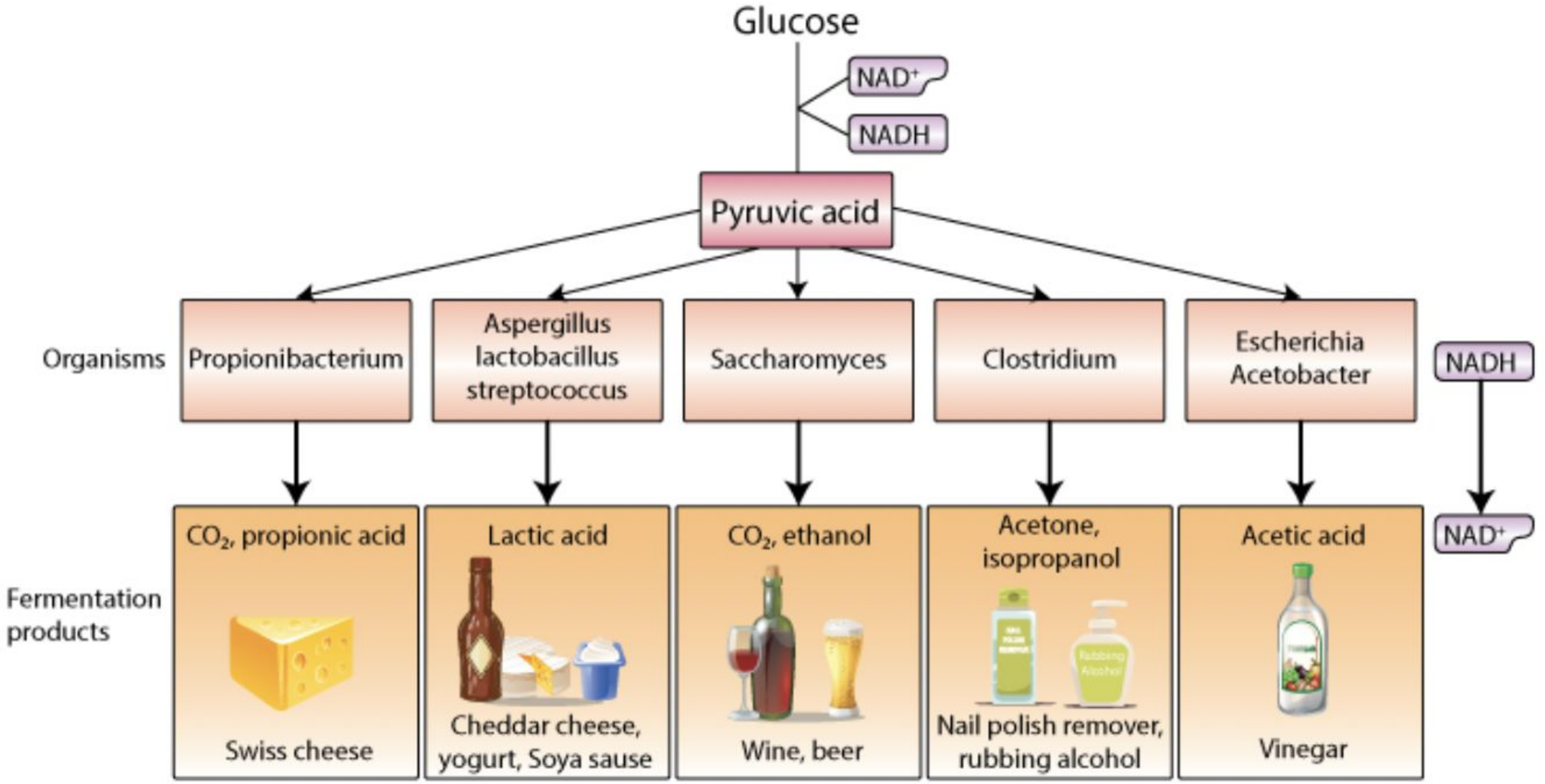
Metabolic process that produces chemical changes in organic substrates through the action of **cellular enzymes**.



# Applications of microbial fermentation

1. Alcoholic beverages.
2. Bread.
3. Soya sauce.
4. Dairy products.
5. Vinegar.
6. Vegetable products.
7. Meat products.

| Fermented Foods/Beverages | Substrates Used | Microorganisms Involved in Fermentation |
|---|---|---|
| Dairy products<br>Curd, Yogurt, Cheese, Yakult, Kefir | Milk and milk casein | *Lactobacillus bulgaricus, Lactococcus lactis, L. acidophilus, L. cremoris, L. casei, L. paracasei, L. thermophilus, L. kefiri, L. caucasicus, Penicillium camemberti, P. roqueforti, Acetobacter lovaniensis, Kluyveromyces lactis, Saccharomyces cerevisiae* |
| Vegetable products<br>Kimchi, Tempeh, Natto, Miso, Sauerkraut | Soybean, cabbage, ginger, cucumber, broccoli, radish | *Leuconostoc mesenteroides, Aspergillus* sp., *Rhizopus oligosporus, R. oryzae, L. sakei, L. plantarum, Thermotoga* sp., *L. hokkaidonensis, L. rhamnosus, Rhodotorula rubra, Leuconostoc carnosum, Bifidobacterium dentium, Enterococcus faecalis, Weissella confusa, Candida sake* |
| Cereals<br>Bahtura, Ambali, Chilra, Dosa, Kunu-Zaki, Marchu | Wheat, maize, sorghum, millet, rice | *L. pantheris, L. plantarum, Penicillium* sp., *S. cerevisiae, L. mesenteroides, E. faecalis, Trichosporon pullulans, Pediococcus acidilactici, P. cerevisiae, Delbrueckii hansenii, Deb. tamari* |
| Beverages<br>Wine, Beer, Kombucha, Sake | Grapes, rice, cereals | *Aspergillus oryzae, Zygosaccharomyces bailii, S. cerevisiae, Acetobacter pasteurianus, Gluconacetobacter, Acetobacter xylinus, Komagataeibacter xylinus* |
| Meat Products<br>Sucuk, Salami, Arjia, Jama, Nham | Meat | *L. sakei, L. curvatus, L. plantarum, Leuconostoc carnosum, Leuconostoc gelidium, B. licheniformis, E. faecalis, E. hirae, E. durans, Bacillus subtilis, L. divergens, L. carnis, E. cecorum, B. lentus* |


Glucose
NAD+
NADH
Pyruvic acid
Organisms
Propionibacterium
Aspergillus
lactobacillus
streptococcus
Saccharomyces
Clostridium
Escherichia
Acetobacter
NADH
NAD+
Fermentation
products
CO2, propionic acid
Swiss cheese
Lactic acid
Cheddar cheese,
yogurt, Soya sause
CO2, ethanol
Wine, beer
Acetone,
isopropanol
Nail polish remover,
rubbing alcohol
Acetic acid
Vinegar

# Stage 2: 1900-1940: **The era of antibiotics.**

First antibiotic to be discovered: “Wonder drug” **Penicillin** from ***Penicillium notatum.***

Sir Alexander Fleming + Howard Florey + Ernst Chain won the Nobel Prize in Medicine (1945) for their joint effort in mass production of penicillin.

| **Name of the antibiotic** | **Source** | **Diseases used for** |
|---|---|---|
| Bacitracin | *Bacillus subtilis* | Syphilis, Lymphonema or Reticulosis |
| Streptomycin | *Streptomyces griseus* | Meningitis, Pneumonia, Tuberculosis and Local Infection |
| Chloromycetin | *Streptomyces venezuelae* | Typhoid |
| Erythromycin | *Streptomyces erythreus* | Typhoid, Whooping cough and Diphtheria |
| Gentamicin | *Micromonospora purpurea* | Effective against Gram (+) bacteria |
| Tetracycline | *Streptomyces aureofaciens* | Acne, urinary and intestinal tract infections, conjunctivitis |

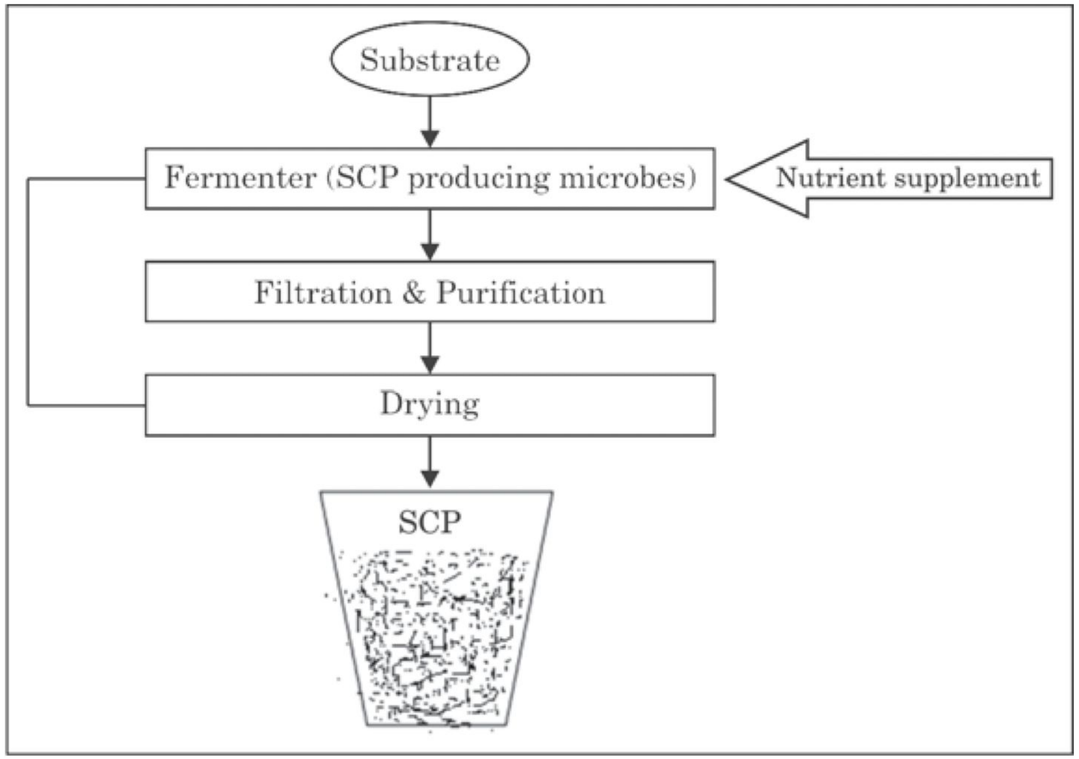
# Stage 3: 1940-1964: **The era of Single Cell Protein**

What are **SCPs**?

Crude or refined edible proteins.

Extracted from pure microbial cultures, dead or dried cell biomass.

Can prove to be a reliable, plausible alternative source of protein to mankind.




**Fungi**

- Aspergillus fumigatus
- Aspergillus niger
- Rhizopus cyclopean

**Yeast**

- Saccharomyces cerevisiae
- Candida tropicalis
- Candida utilis

**Algae**

- Spirulina (spa)
- Chlorella pyrenoidosa
- Chondrus crispus

**Bacteria**

- Pseudomonas fluorescens
- Lactobacillus
- Bacillus megaterium

# Stage 4: 1964-1979: **The era of secondary metabolites.**

**What are secondary metabolites?**

Compounds synthesized by microbial cell.

Low molecular mass products.

Not required directly for the survival of the microbe.

Can be used for human welfare.

| Product | Microorganism |
|---|---|
| Cephamycin C | *Streptomyces clavuligerus* |
| Coconut aroma | *Trichoderma* sp. |
| Ergot alkaloids | *Claviceps fusiformis* |
| Giberellic acid | *Giberella fujikuroi* |
| Iturin | *Bacillus subtillis* |
| Lycopene | *Fusarium solani pisi* |
| Ellagic acid | *Pediococcus pentosaceus* |
| Kaempferol and kaempferol-3-glucoside | *Aspergillus awamori* |
| Anthocyanin | *Aspergillus* sp. and *Rhizopus* sp. |
| Gallic acid | *Bacillus pumilus* |
| Vanillin | *Phanerochaete chrysosporium* |

Citric acid- *Aspergillus niger*

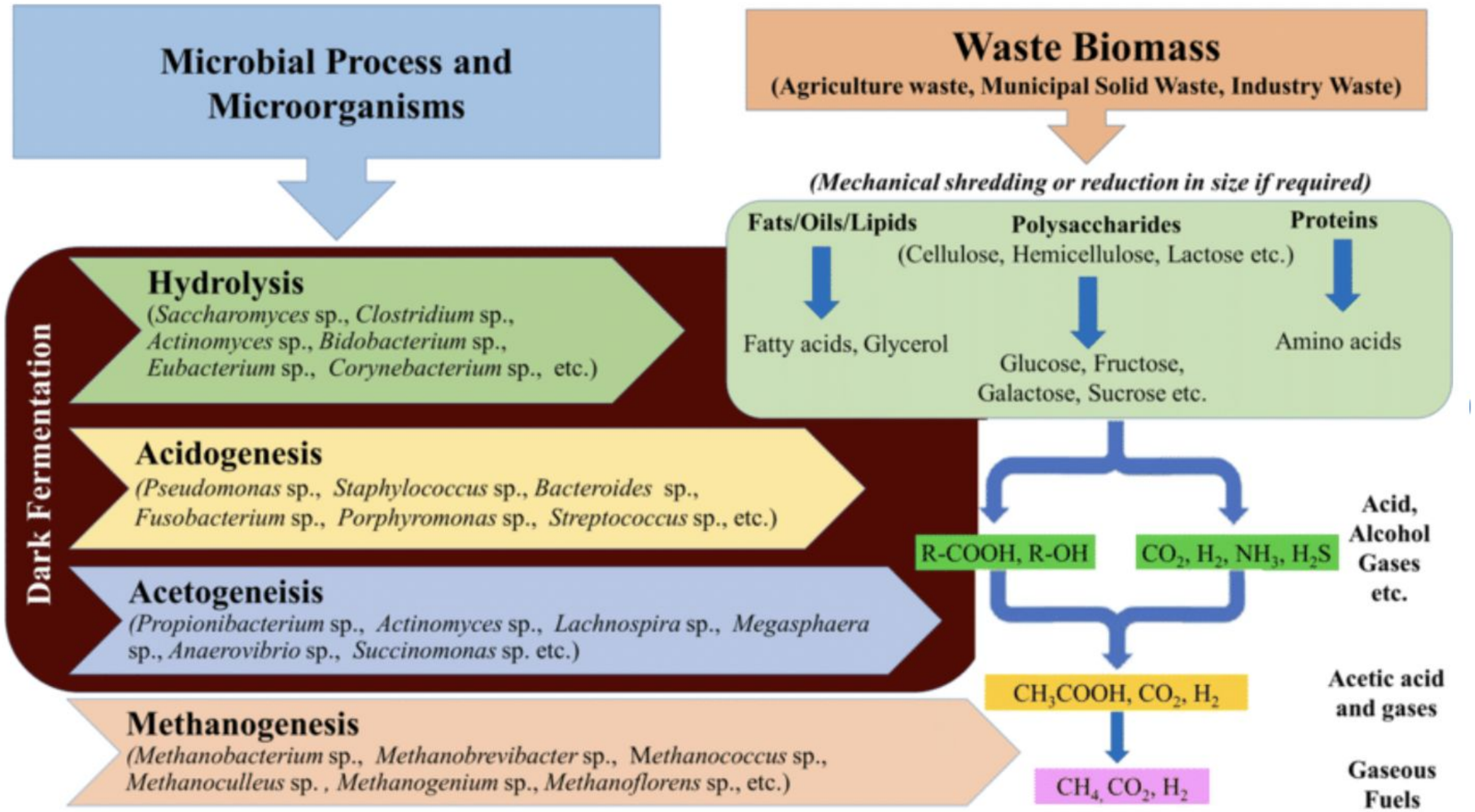
Acetic acid- *Acetobacter aceti*

Lactic acid- *Lactobacillus*

Butyric acid- *Clostridium butylicum*

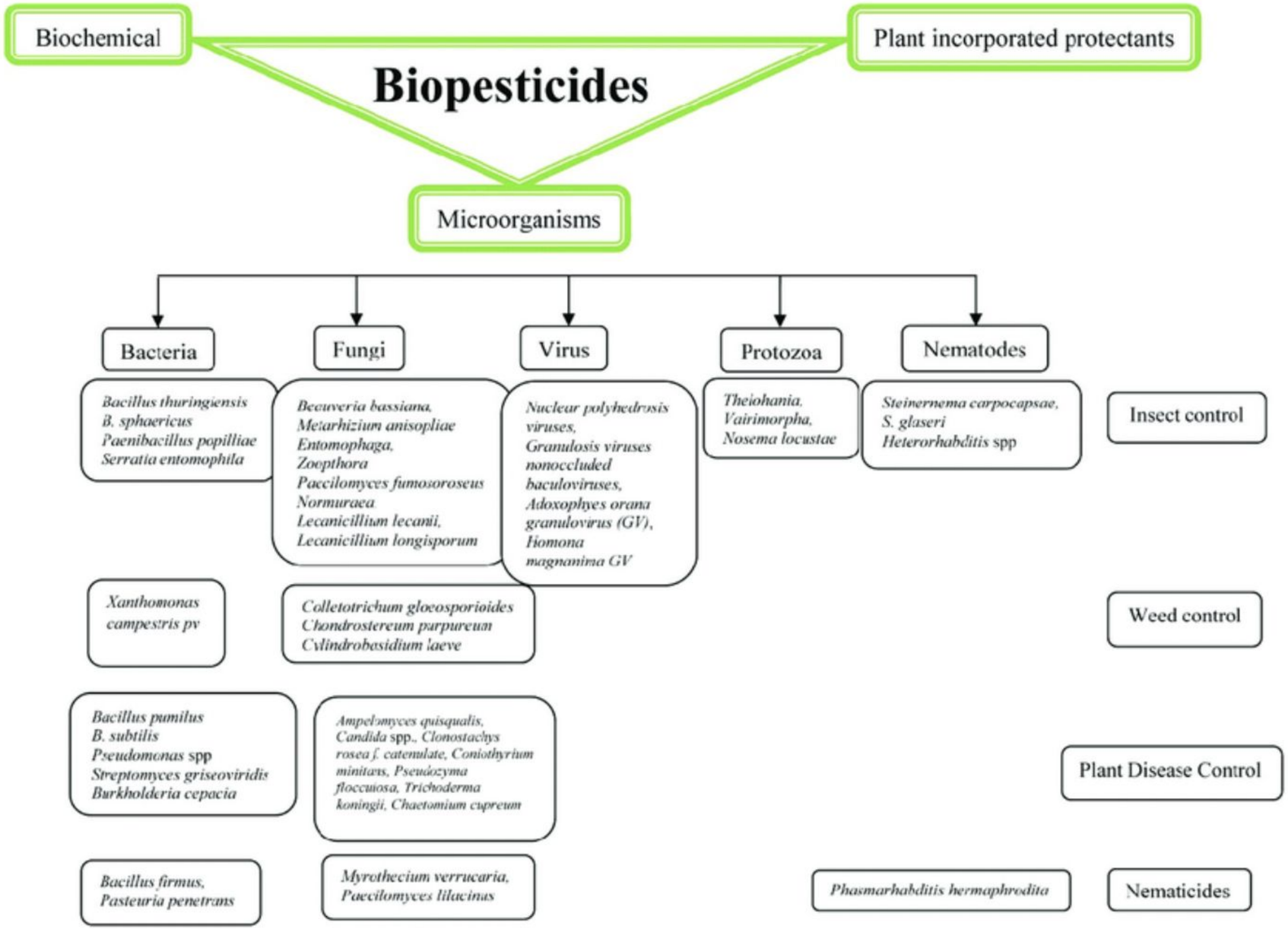
# Stage 5: 1979 onwards: **The era of**

- **Biogas**- Produced by methanogenic bacteria from sewage treatment.



- **Biocontrol of pests and diseases-**

Largest group of broad-spectrum pesticides.



- **Biofertilizers**- Symbiotic and non-symbiotic association between microbes and plants.
- Improve soil quality and provide optimum nutrient conditions for plant growth.

| Micro-organisms | Activity | Association | Uses in crops |
|---|---|---|---|
| *Rhizobium* | $N_2$-fixation | Symbiotic | Legumes(pulses, oilseeds, pasture and fodder crops |
| *Azotobacter* | $N_2$-fixation | Asymbiotic | |
| *Azospirillum* | $N_2$-fixation | Asymbiotic/ Symbiotic | Graminaceous crops (wheat, rice, jowar sugarcan,) |
| Blue green algae | $N_2$-fixation | Asymbiotic | Rice, wheat, maiz, vegetables, fruits |
| *Azolla-Anabaena* | Phosphorus solubilization | Symbiotic | Rice |
| Phosphorus solubilizer | Phosphorus solubilization | Asymbiotic | Many crops |
| *Mycorrhiza* | Phosphorus solubilization | Asymbiotic/ Symbiotic | Many crops including pulses |