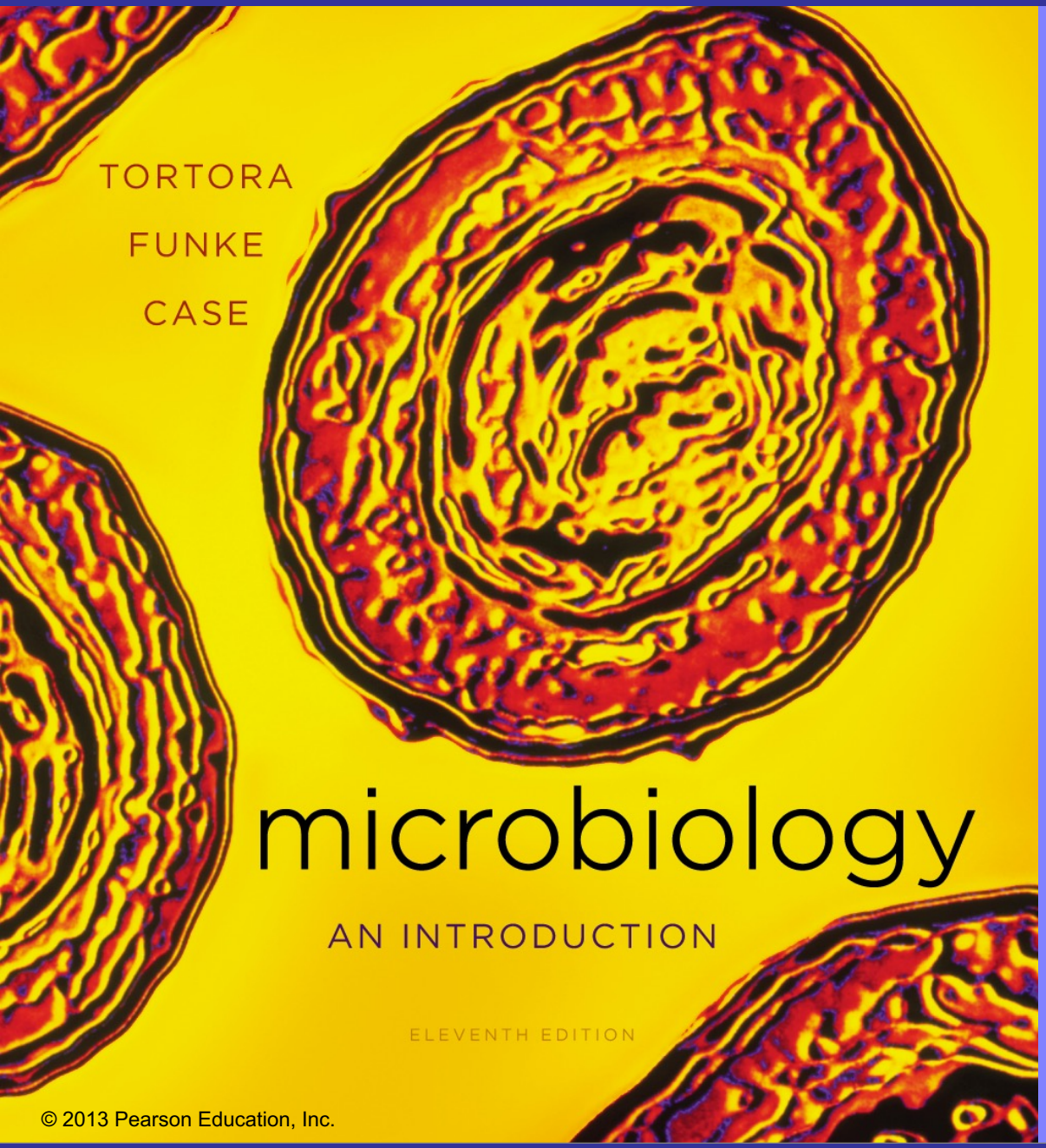


Chapter 28

Applied and Industrial Microbiology

Lectures prepared by Christine L. Case

Lecture 34
1st May 2023

Historically…

- Drying
- Osmotic pressure (salt or sugar)
- Fermentation

Foods and Disease

- **Hazard Analysis and Critical Control Point (HACCP)**

Management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

  - FDA (Food and Drug Administration)
  - USDA (United States Department of Agriculture and Food and Drug Administration)

Figure 28.1 The commercial sterilization process in industrial canning.

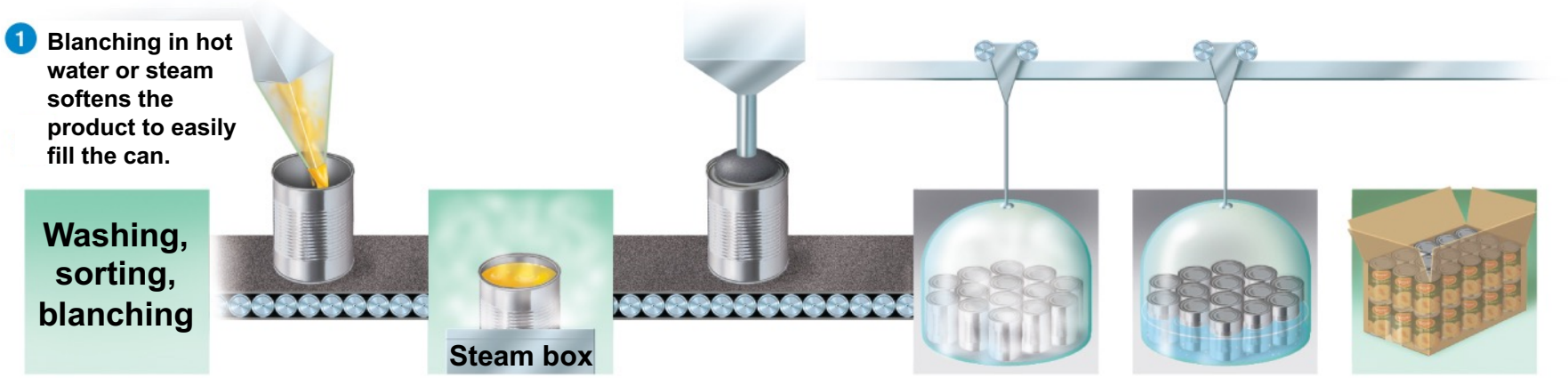
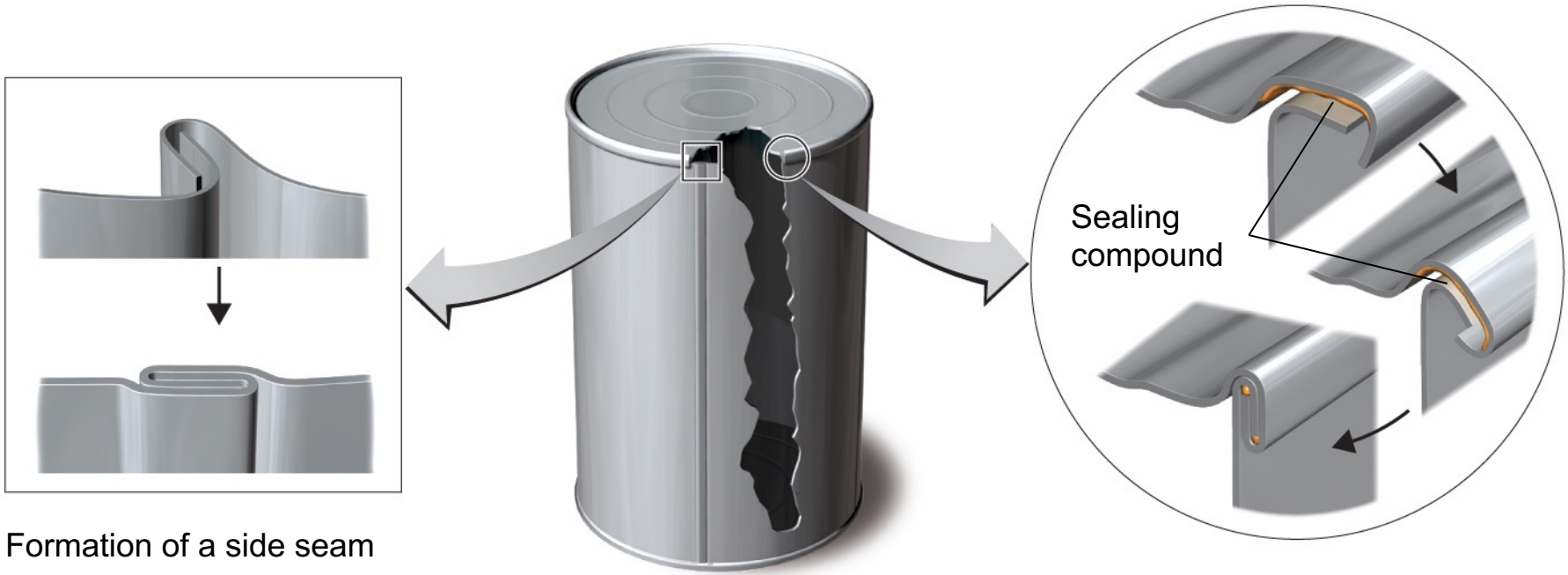


Figure 28.2 Commercial canning retorts.

Figure 28.3 The construction of a metal can.



Commercial Sterilization

- Destroys *C. botulinum* endospores
- **12D treatment** kills 10^{12} endospores
- **Thermophilic anaerobic spoilage**: surviving endospores multiply, causing the can to swell from gas
- Or **flat sour spoilage**

Low-acid canned food spoilage

Flat sour	*Geobacillus stearothermophilus*	Can is not swollen
Thermophilic anaerobic	*Thermoanaerobacterium thermosaccharolyticum*	Swollen can
Putrefactive anaerobic	*Clostridium sporogenes, C. botulinum*	Swollen can

Food Preservation

- **Aseptic packaging**: presterilized materials assembled into packages and aseptically filled

Figure 28.5 Irradiation logo. (International radura symbol)

TABLE 28.2 Approximate Doses of Radiation Needed to Kill Various Organisms (Prions Are Not Affected)

Organisms	Dose (kGy)*
Higher animals (whole body)	0.005–0.1
Insects	0.01–1
Non–endospore-forming bacteria	0.5–10
Bacterial endospores	10–50
Viruses	10–200

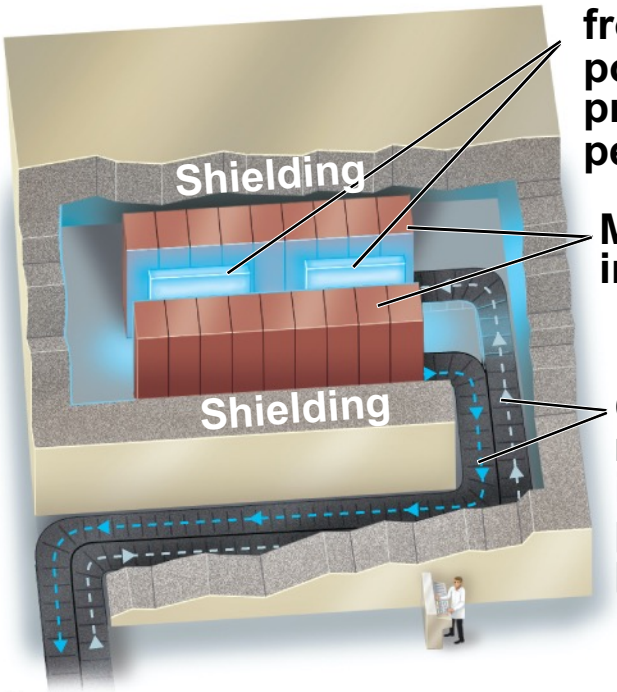
*Gray is a measure of ionizing irradiation; kGy is 1000 Grays.

Source: J. Farkas, "Physical Methods of Food Preservation," in *Food Microbiology: Fundamentals and Frontiers*, 2d ed., M.P. Doyle et al. (eds) (Washington, DC: ASM Press, 2001).

Ionizing Radiation

Low dose	1 kGy	Killing insects
Pasteurizing dose	1-10 kGy	Meats and poultry
High dose	>10 kGy	Sterilizing spices

Figure 28.6 A gamma-ray irradiation facility.

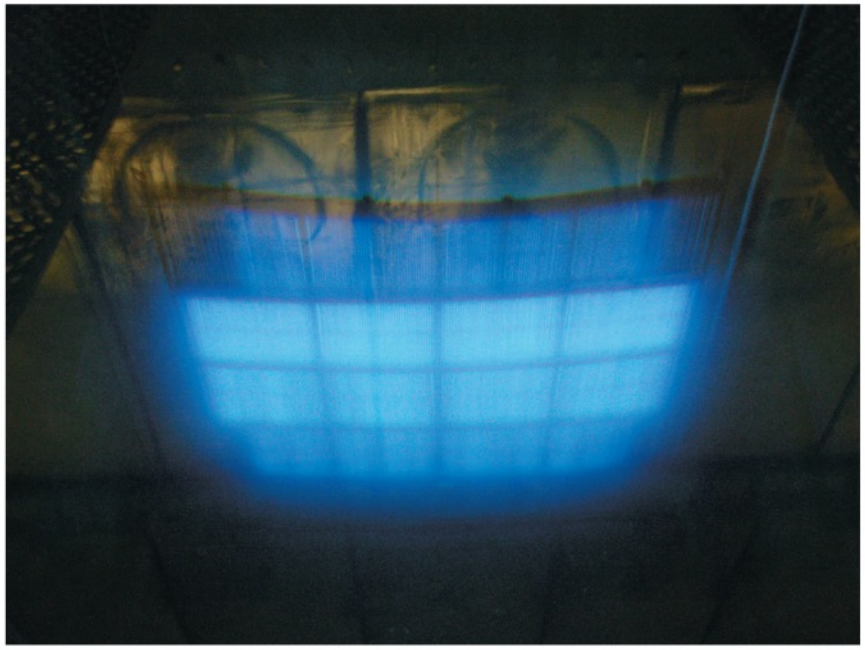


Irradiation sources lifted from storage pool for processing period

Material to be irradiated

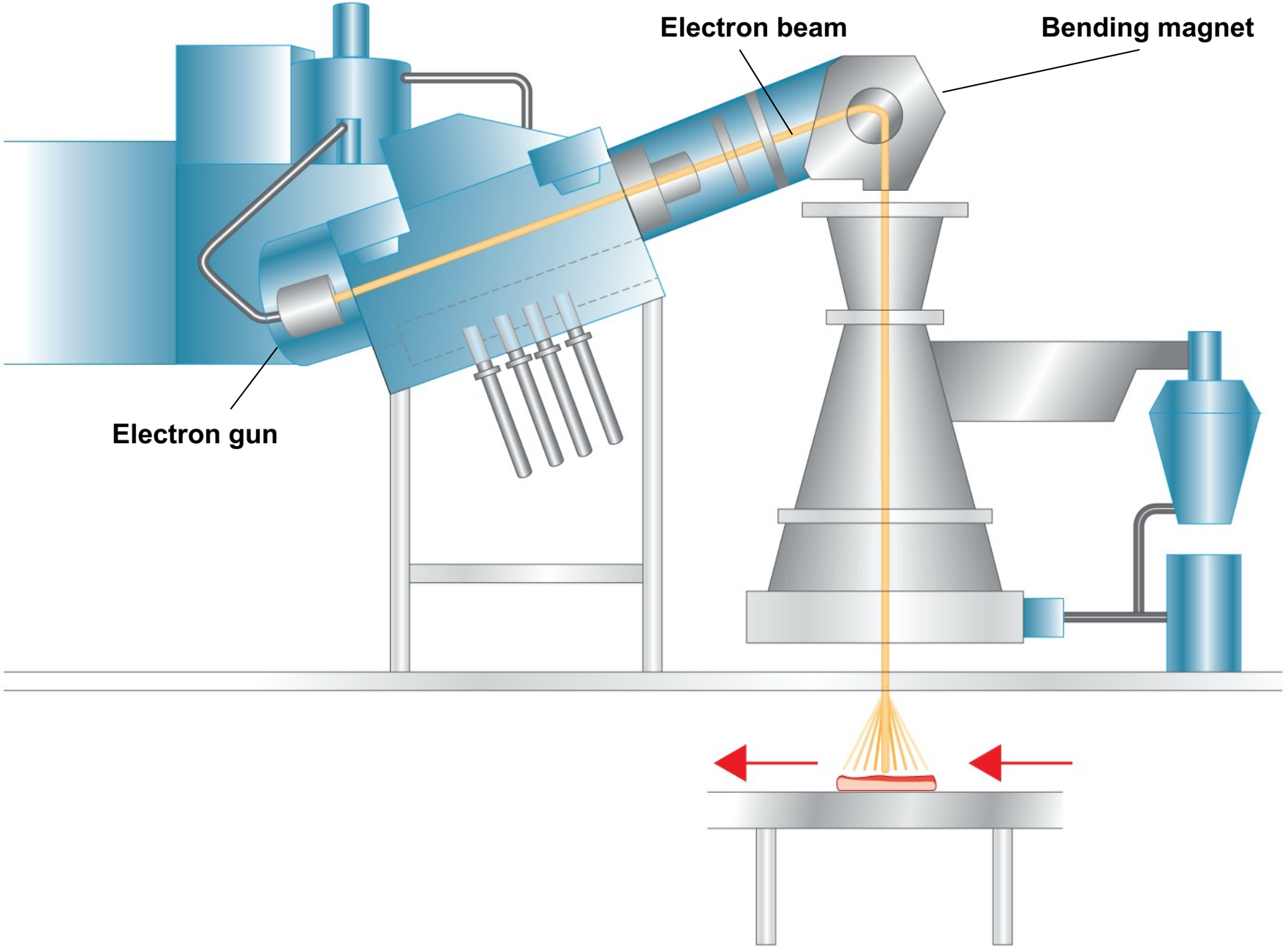
Conveyors to move material in and out of processing position

(a) An irradiation facility, showing the path of the material to be irradiated



(b) The irradiation source is submerged in the storage pool. The blue glow is Cerenkov radiation caused by charged particles exceeding the speed of light in water.

Figure 28.7 Electron-beam accelerator.



High Pressure

- Prewrapped, precooked foods
- 87,000 psi
- Kills *Salmonella*, *Listeria*, *E. coli*
- Preserves color and flavor well

Role of Micororganisms in Food production

Cheese

- **Curd**: solid **casein** from lactic acid bacteria and **rennin**
- **Whey**: liquid separated from curd
- Hard cheeses are produced by lactic acid bacteria
- Semisoft cheeses are ripened by *Penicillium* on surface

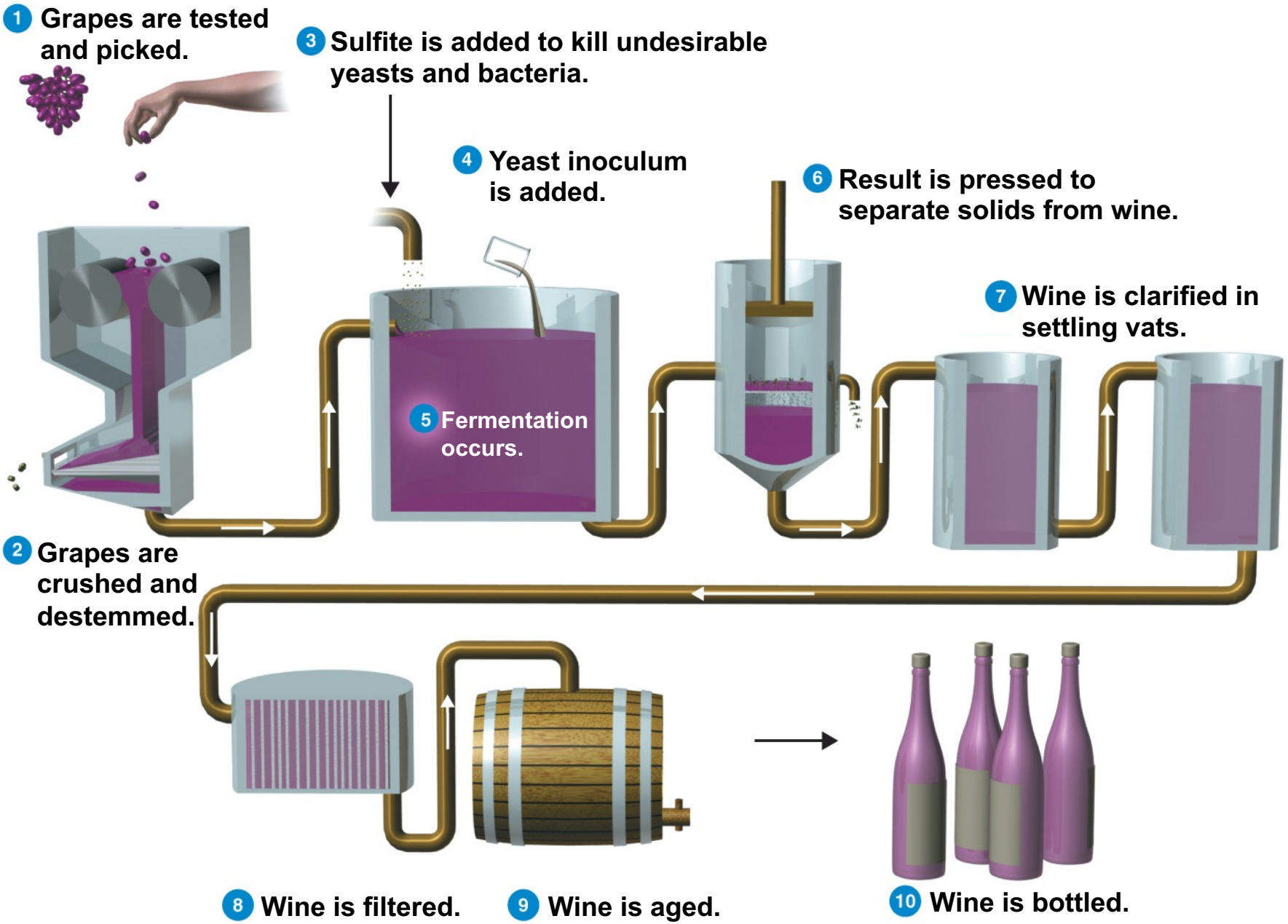
Figure 28.8 Making cheddar cheese.

(a) The milk has been coagulated by the action of rennin (forming curd) and is inoculated with ripening bacteria for flavor and acidity. Here the workers are cutting the curd into slabs.

(b) The curd is chopped into small cubes to facilitate efficient draining of whey.

(c) The curd is milled to allow even more drainage of whey and is compressed into blocks for extended ripening. The longer the ripening, the more acidic (sharper) the cheese.

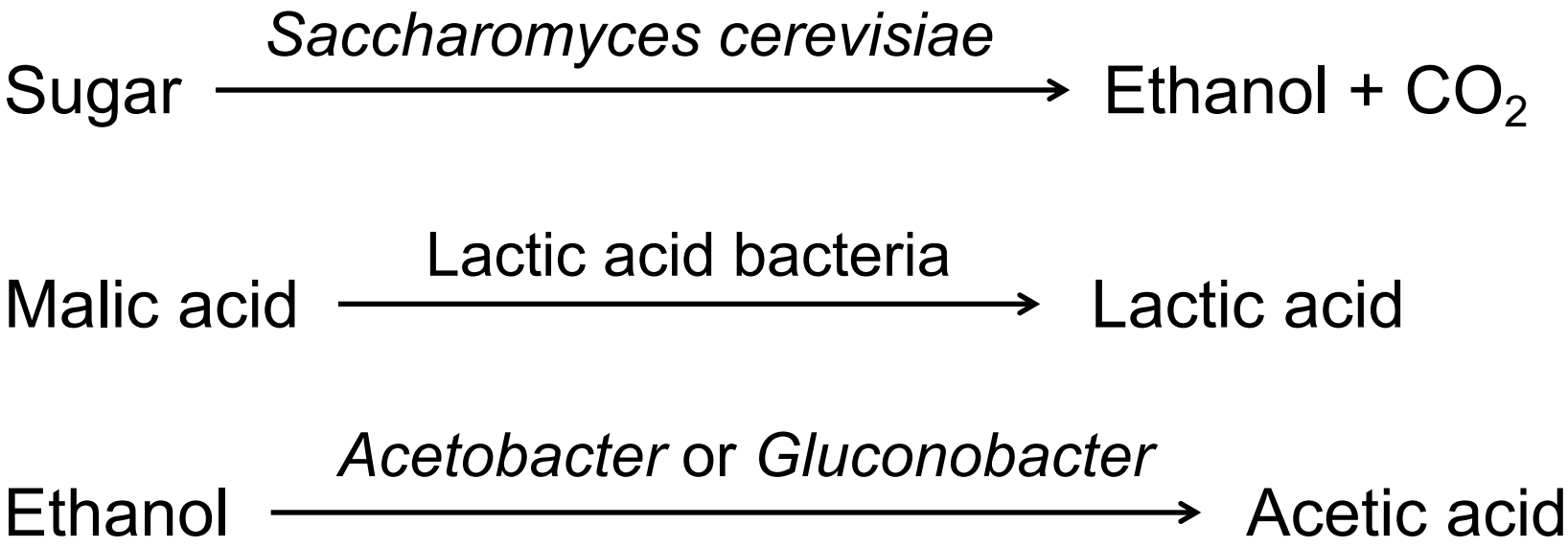
Figure 28.9 The basic steps in making red wine.



Alcoholic Beverages and Vinegar

- **Beer** and **ale** are fermented starch
  - **Malting**: germinating barley converts starch to maltose and glucose
- For **sake**, rice starch is converted to sugar by *Aspergillus*
- Wine is fermented plant sugars
- Yeast ferment sugars to ethanol and CO_2
  - Grape wine requires bacterial **malolactic fermentation**
- *Acetobacter* and *Gluconobacter* convert ethanol to acetic acid

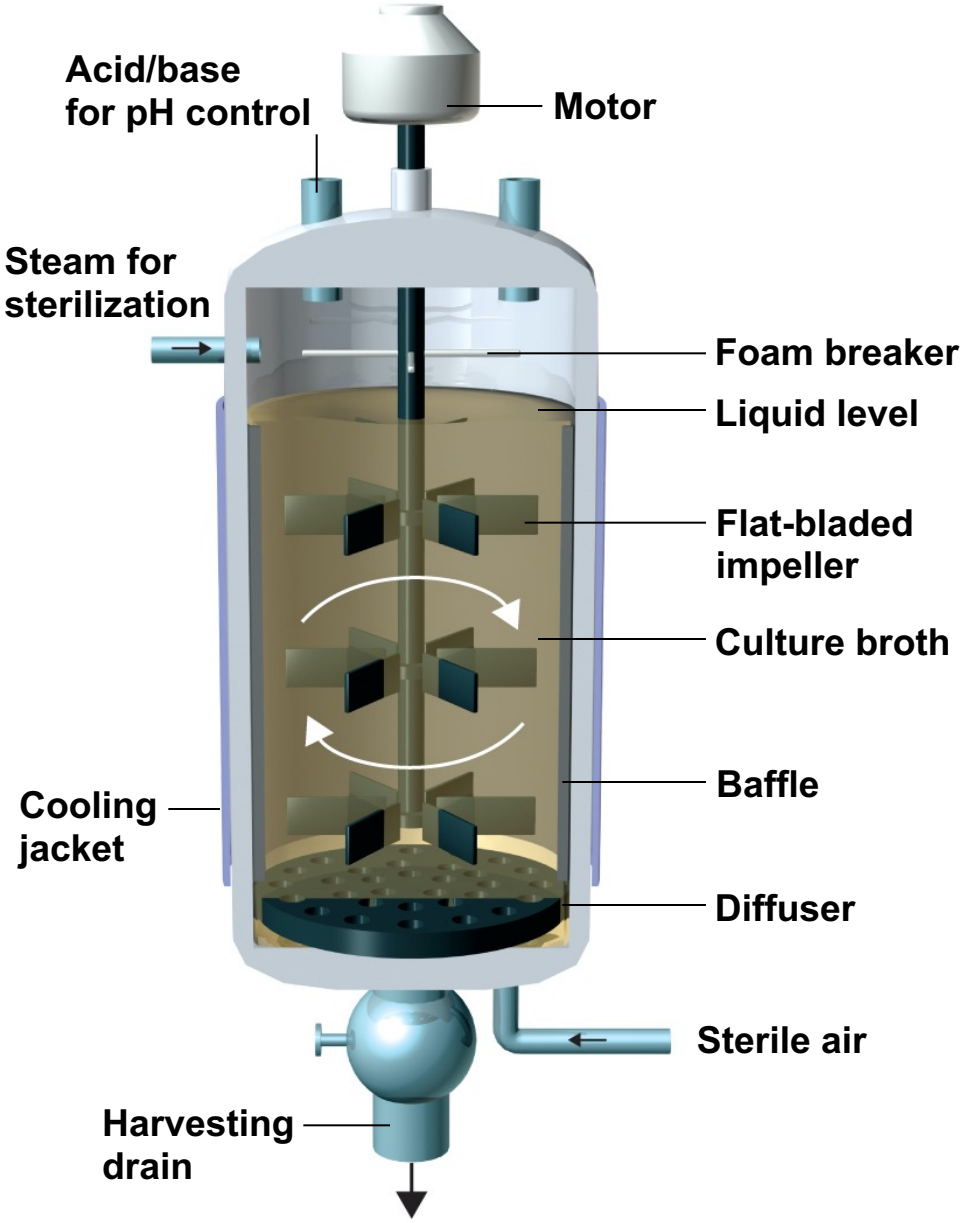
Microbial Metabolism



Biotechnology

- Use of microorganisms, cells, or cell components to make a product
  - Classical: fermentation
  - Recombinant DNA

Figure 28.10a Bioreactors for industrial fermentations.

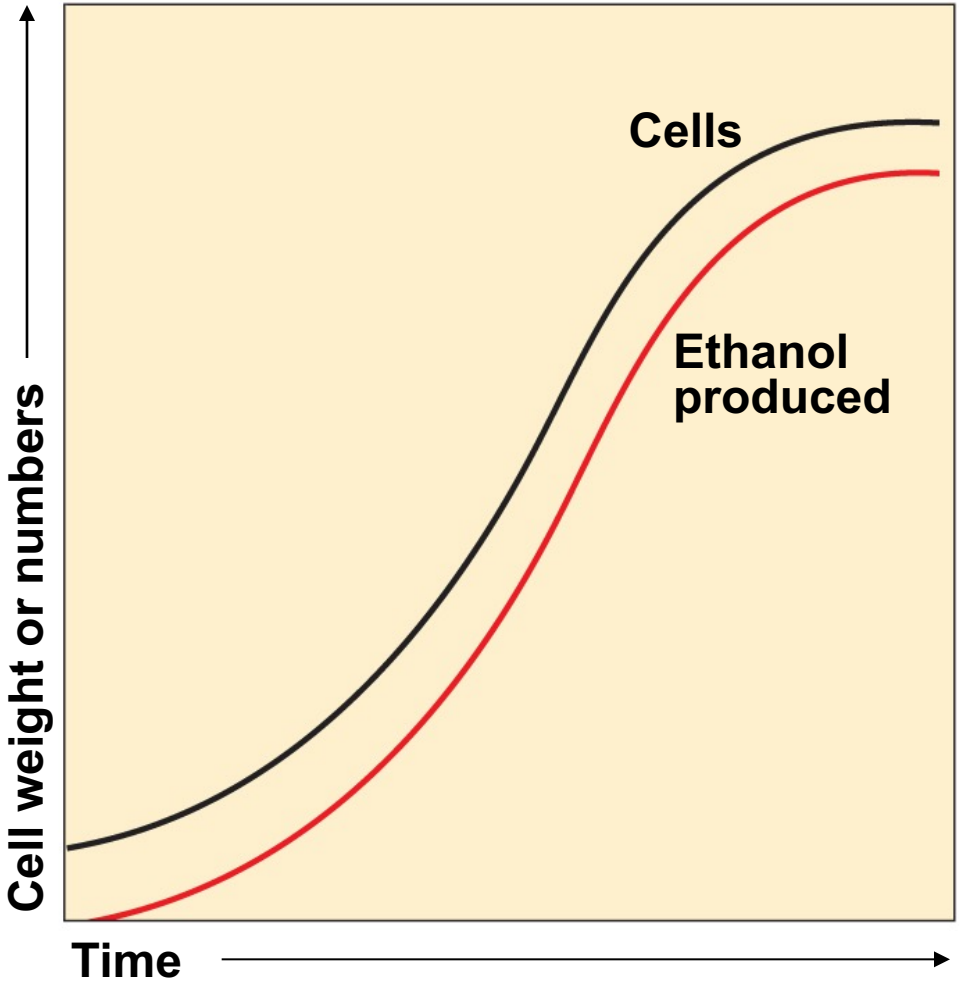


(a) Section of a continuously stirred bioreactor

Figure 28.10b Bioreactors for industrial fermentations.

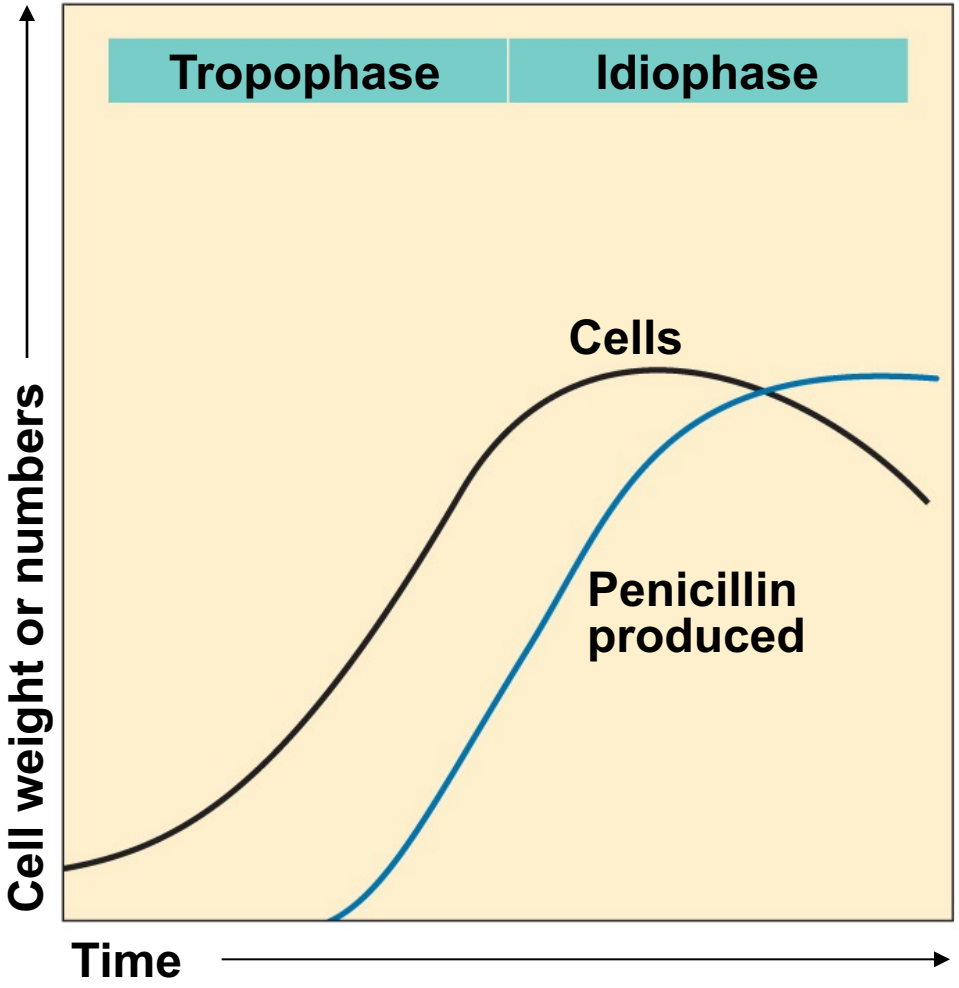
(b) Bioreactor tank, at left

Figure 28.11a Primary and secondary fermentation.



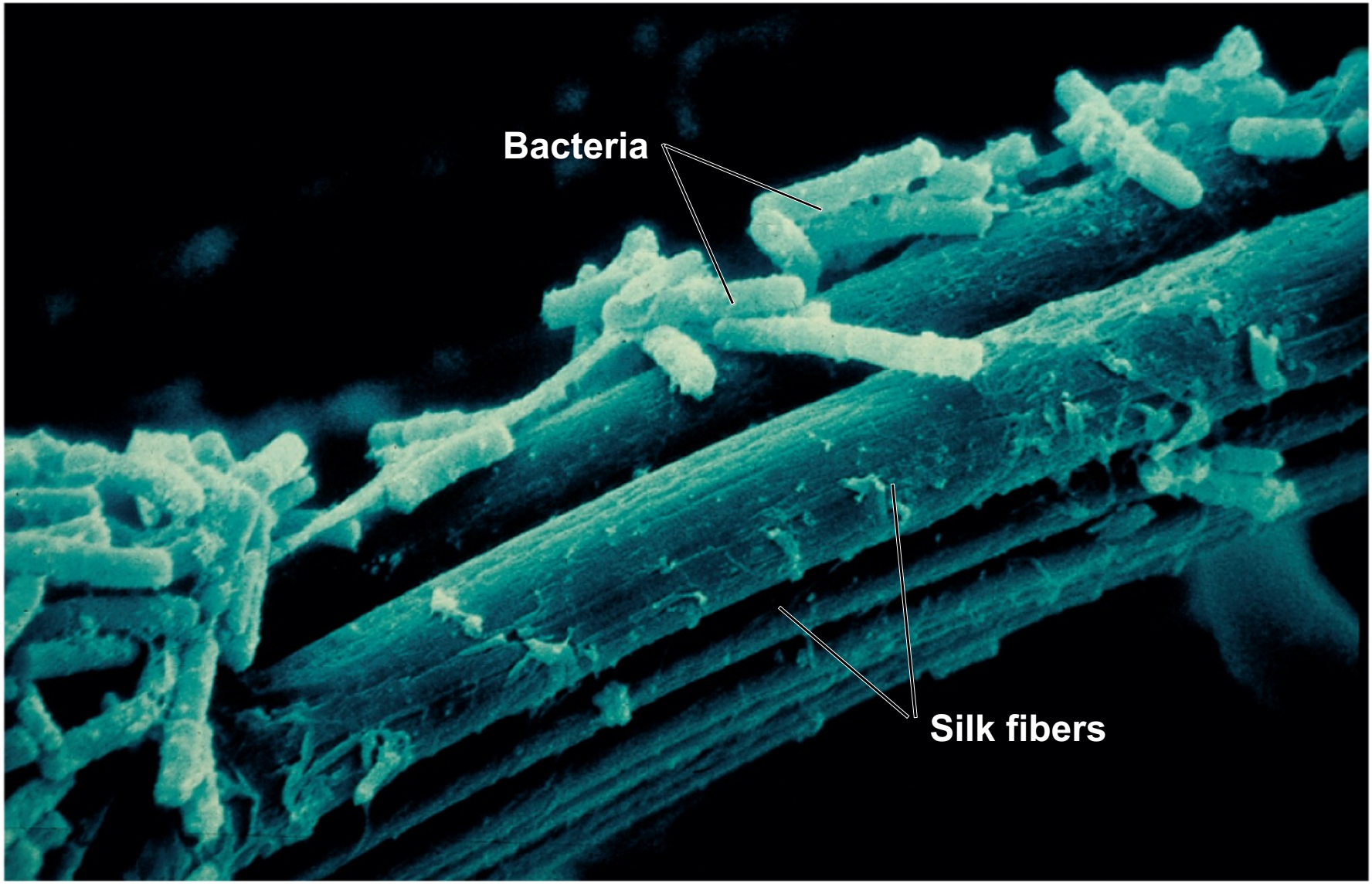
(a) A primary metabolite, such as ethanol from yeast, has a production curve that lags only slightly behind the line showing cell growth.

Figure 28.11b Primary and secondary fermentation.



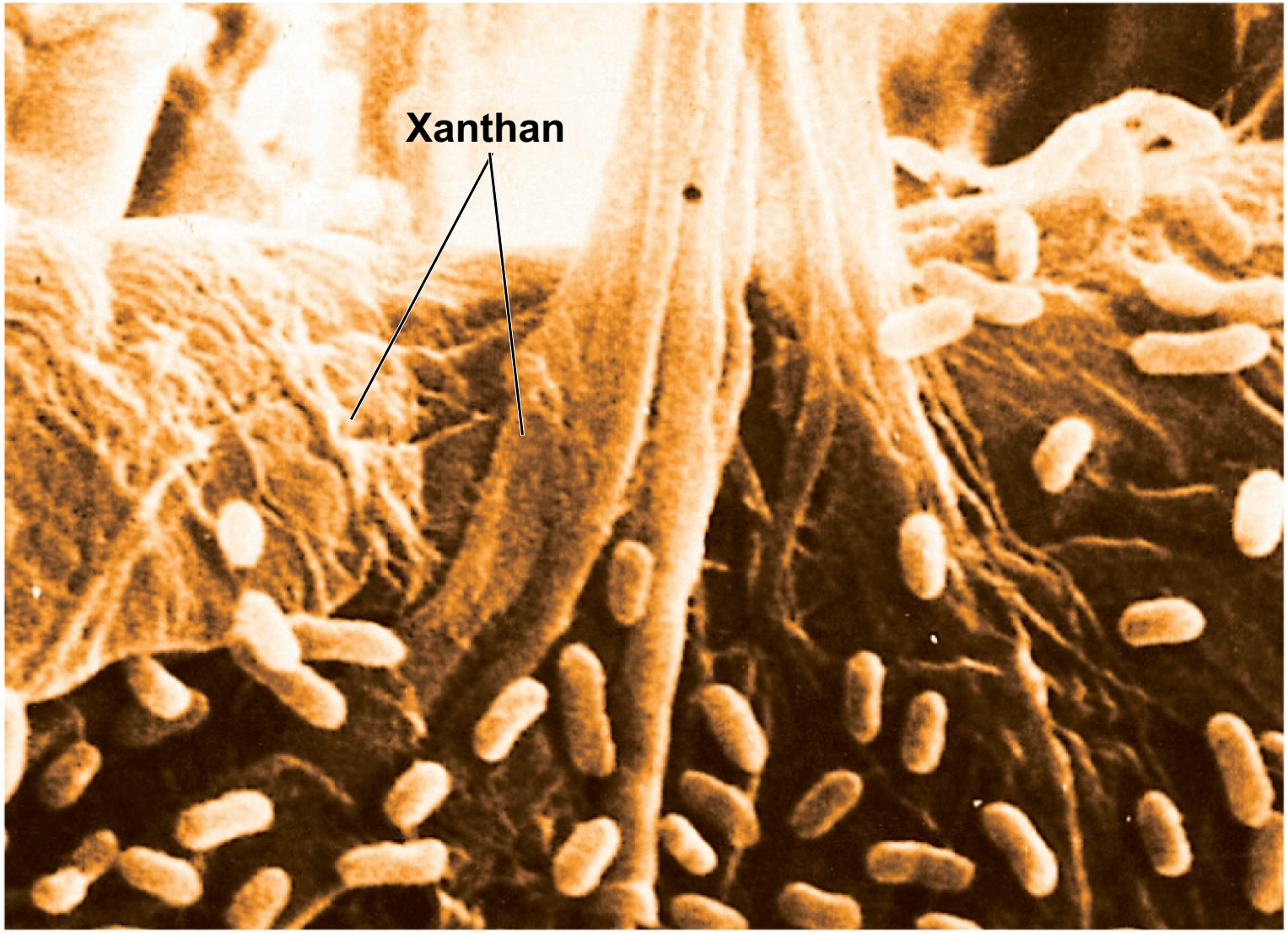
(b) A secondary metabolite, such as penicillin from mold, begins to be produced only after the logarithmic growth phase of the cell (tropophase) is completed. The main production of the secondary metabolite occurs during the stationary phase of cell growth (idiophase).

Figure 28.12 Immobilized cells.



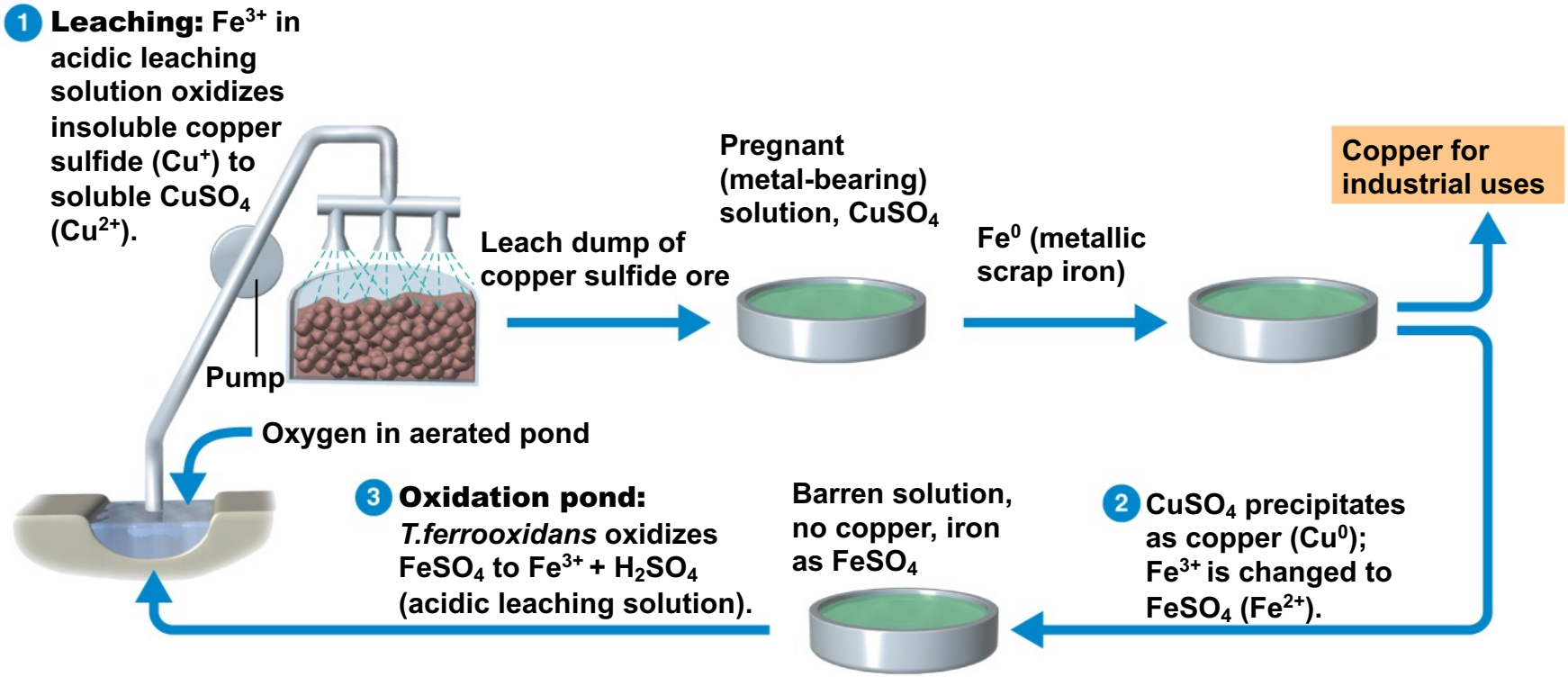
Industrial Products

- Xanthan
- Amino acids
- Citric acid
- Enzymes
- Vitamins
- Antibiotics
- Steroids



Xanthomonas campestris **producing gooey xanthan.**

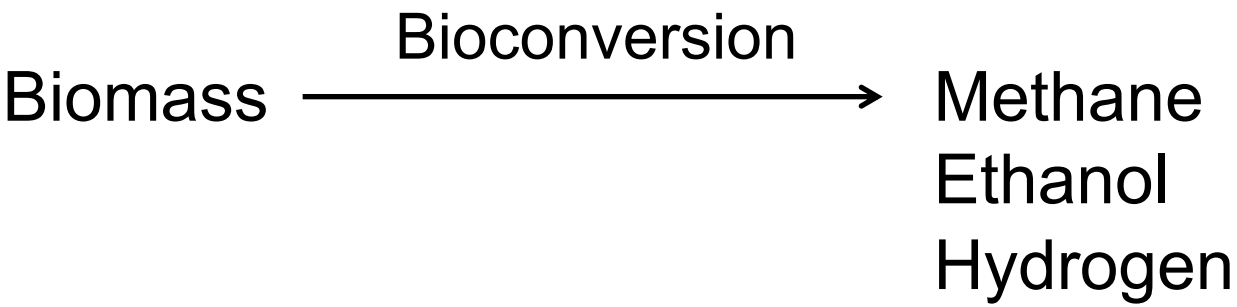
Figure 28.14 Biological (*Thiobacillus ferroxidans*) leaching of copper ores.



Thiobacillus get their energy from the oxidation of a reduced form of the iron (Fe2+) to an oxidized form (Fe3+). Sulphuric acid is also a product of the reaction. The acidic solution of Fe3+ is applied and allowed to percolate downslope through the ore body. Fe3+ converts Insoluble Cu+ to soluble Cu2+. This react with iron and precipitate out as Cu0

Alternative Energy Sources Using Microbes

- Cellulose digested by cellulase
- Sugars fermented to ethanol or higher alcohols or hydrogen



- Algal oils

Figure 28.15 Methane production from solid wastes in landfills.

Industrial Microbiology and the Future

- Food processing
- Pharmaceuticals from rDNA technology
- Ethanol and hydrogen
- And more