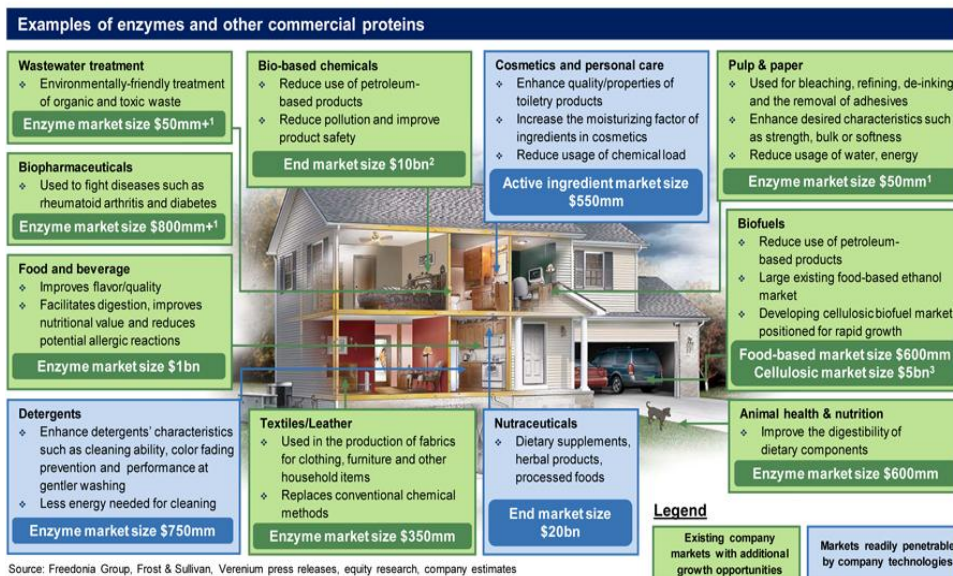


Enzymes and other proteins are part of everyday life



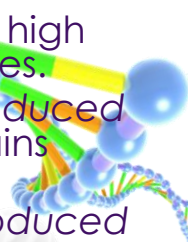
•Enzymes

- The term “ enzyme ” was first coined by Kuhne in 1877 meaning “ in yeast
- Buchner referred to the glycolytic enzyme complex as “ zymase, ” meaning “ the enzyme of yeast itself. ”
- Enzymes became valuable in manufacturing because of their rapid and efficient action at low concentrations under mild pH values and temperatures, their high degree of substrate specificity (which reduced side - product formation), their low toxicity, and the ease of terminating their action by mild treatments

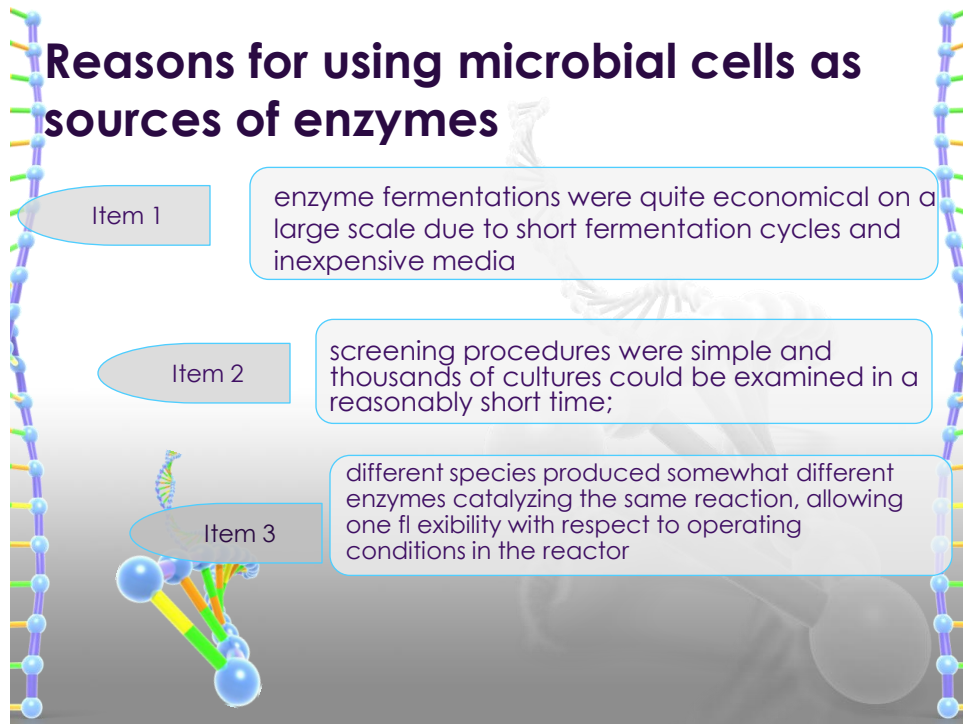


Enzymes

- Some microbial strains produced very high concentrations of extracellular enzymes.
- Wild strains of *Bacillus licheniformis* produced 5 g/l of protease and commercial strains made 20 g/l.
- High - yielding strains of *Aspergillus* produced 20 g/l of glucoamylase.



Reasons for using microbial cells as sources of enzymes



Item 1 enzyme fermentations were quite economical on a large scale due to short fermentation cycles and inexpensive media

Item 2 screening procedures were simple and thousands of cultures could be examined in a reasonably short time;

Item 3 different species produced somewhat different enzymes catalyzing the same reaction, allowing one flexibility with respect to operating conditions in the reactor

Enzymes

- In the 1980s and 1990s, microbial enzymes were increasingly used for applications which traditionally employed plant and animal enzymes
- These shifts included the partial replacement of:
 - amylases of malted barley and wheat in the beer, baking, and textile industries by amylases from *Bacillus* and *Aspergillus* ;
 - plant and animal proteases by *Aspergillus* protease for chilling beer and tenderizing meat;
 - pancreatic proteases by *Aspergillus* and *Bacillus* protease for leather bating and in detergent preparations; and
 - calf stomach rennet (chymosin) by *Mucor rennins* for cheese manufacture.

Enzymes

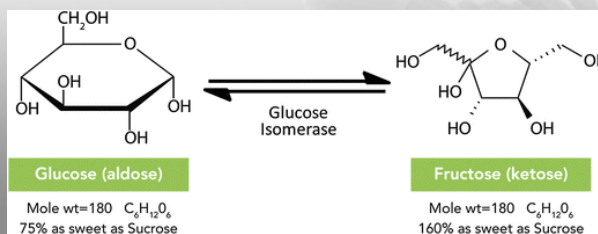
Important industrial enzymes included the following:



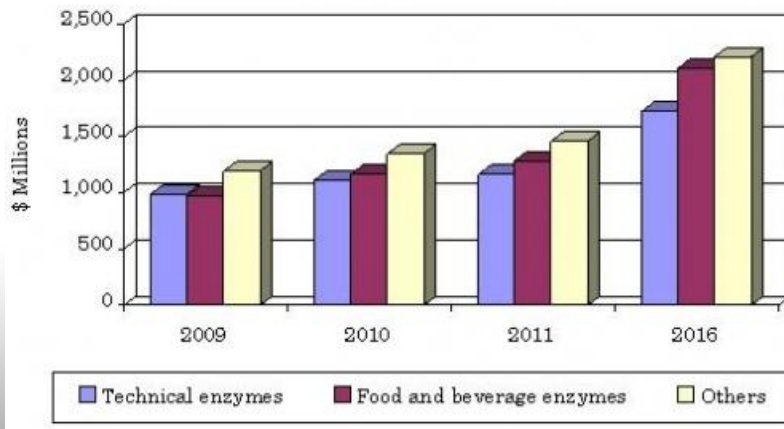
- glucose isomerase for production of high - fructose corn sirup;
- penicillin acylase for production of semi - synthetic penicillins;
- peroxidase for manufacture of phenolic resins (which could replace synthetic phenol - formaldehydes); and
- Nitrile hydrolase for hydration of acrylonitrile to acrylamide

Glucose isomerase

- Glucose isomerase was used in conjunction with α -amylase and glucoamylase to convert starch to mixtures of glucose and fructose known as " high fructose corn syrup.
- " The development of glucose isomerase permitted the corn wet milling industry to capture 30% of the sweetener business from the sugar industry in the 1970s.
- In the United States alone, high fructose corn syrup is produced at 30 billion pounds per year



industrial enzyme market



Recombinant

- Over 50% of the market is provided by recombinant processes
- Sixty per cent of the calf rennin (chymosin) used for cheese making in the United States is supplied by recombinant *E. coli* and the two lipases used industrially (i.e., *Humicola* lipase produced in *Aspergillus* and *Pseudomonas* lipase) are both recombinant
- Plant phytase (produced in recombinant *A. niger*) is used as a feed for 50% of all pigs in Holland. A 1000 - fold increase in phytase production was achieved in *A. niger* by use of recombinant technology.

Recombinant

- Scientists at Novo Nordisk have isolated a very desirable lipase for use in detergents from a species of *Humicola* .
- For production purposes, the gene was cloned into *A. oryzae* where it produced 1000 - fold more enzyme
- Over 60% of the enzymes used in the detergent, food, and starch processing industries are recombinant products

