

BEER

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Some history

- In Babylonia 6000 B. C – first recorded document about beer
- By 4000 B. C there was 16 different types of beer made from barley and honey
- Imperial Egypt, 4000 B. C had 4 types of beer
- 2300 B. C China had beer called Kiv
- Inca Indians made beer from corn
- Aztec Indians in Mexico made beer from cactus and called it pulque

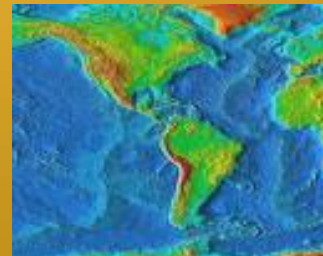
History -Europe

- Egypt-Greece-Rome-Spain-Germany
- The old Germanic tribes quickly learned to make beer from germinated barley and called it PEOR or BIOR
- In Europe, until the 13th century oats was the most widely used grain for beer making



History - America

- 1502- Columbus was given corn beer by the Indians
- 1548-First colonization attempt in Virginia put small brewery and made beer from corn
- Thomas Jefferson, Samuel Adams, George Washington were all brewers



Raw materials

- MALT (Malted cereal, usually barley)
- WATER
- HOPS
- “ADJUNCT” – Additional carbohydrate (corn, rice.....)
- YEAST
- CO₂ – can be added in addition to naturally formed one
- Sugars (glucose, fructose)
- Enzymes

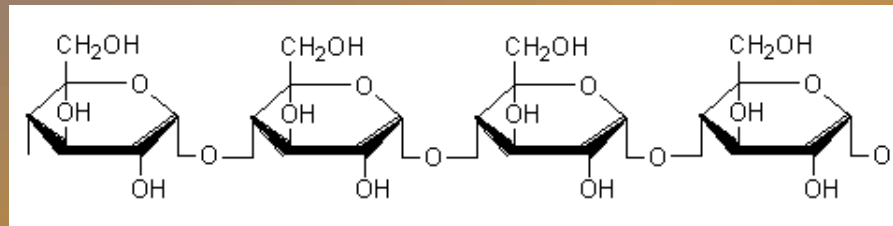
Chemistry

Two distinctive processes are present

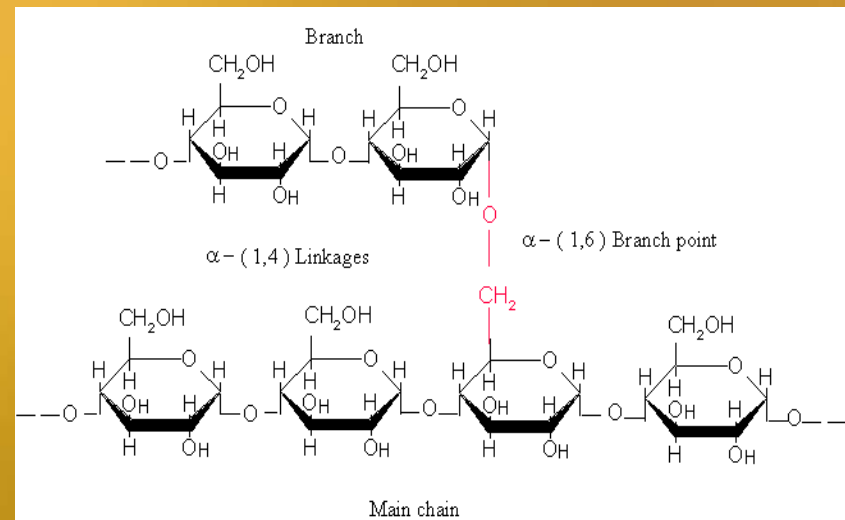
1. Saccharification and liquefaction – break down of starch into simple sugars (glucose), maltose, maltodextrins and oligosaccharides
2. Fermentation- break down of sugars under anaerobic conditions to ethanol and CO₂

STARCH

- **AMYLOSE (20-30%)** – linear polymer of glucose molecules connected with α 1-4 glycosidic linkage

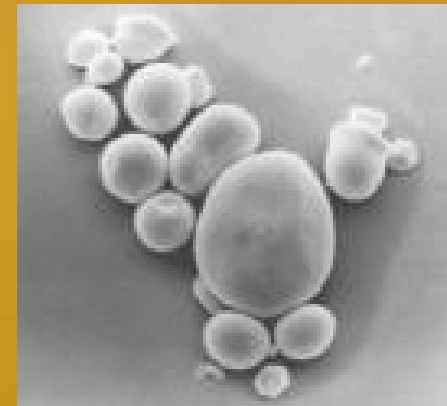
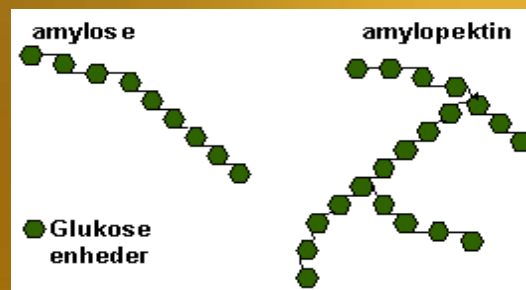
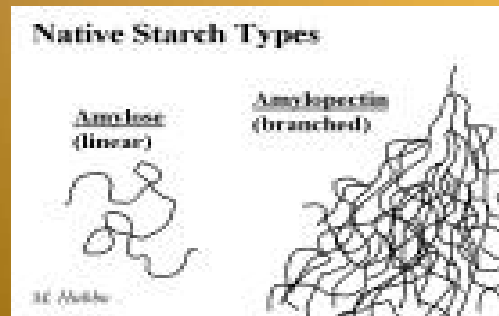


- **AMYLOPECTIN (70-80%)** – branched polymer of glucose molecules with α 1-4 glycosidic linkage and 1-6 glycosidic linkage at the branching points



Starch

- Starch is the major carbohydrate reserve in plant tubers and seed endosperm where it is found as granules
- Each granule typically contains several million amylopectin molecules accompanied by a much larger number of smaller amylose molecules

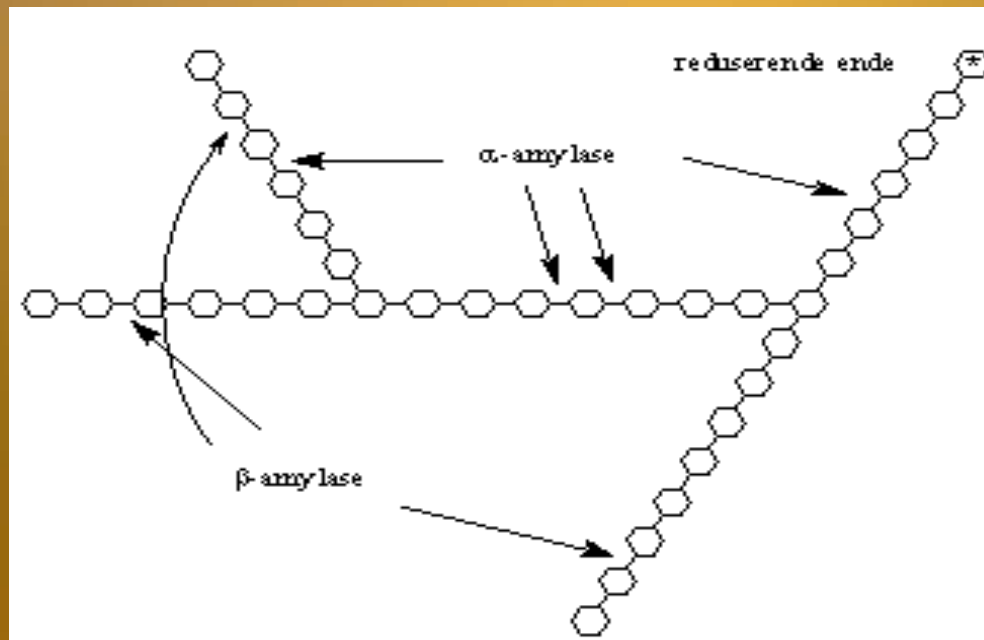


Starch breakdown

- Acid hydrolysis (not suitable in food industry) to glucose
- Enzymatic hydrolysis
 - α – Amylase
 - β - Amylase
 - Glucoamylase
- Enzymes are provided by malted barley
- Use of commercially available enzymes, usually isolated from microorganism is very expensive

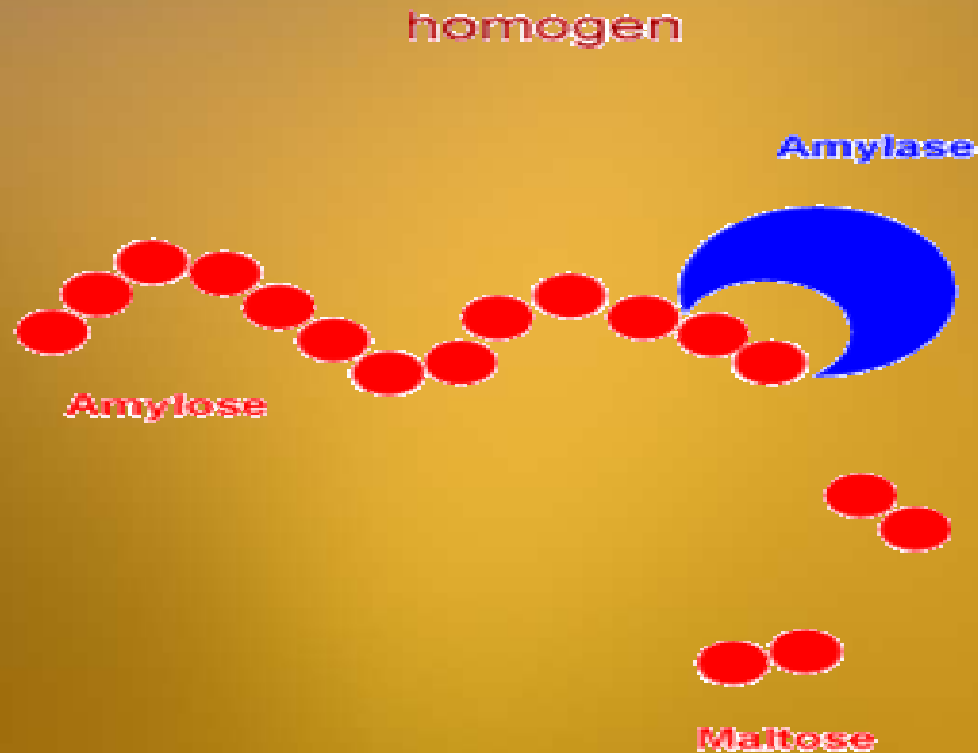
α Amylase

- It is Endoenzyme
- Hydrolyses α 1-4 linkage inside of starch molecule
- Main product are maltodextrins (few molecules of glucose linked together)



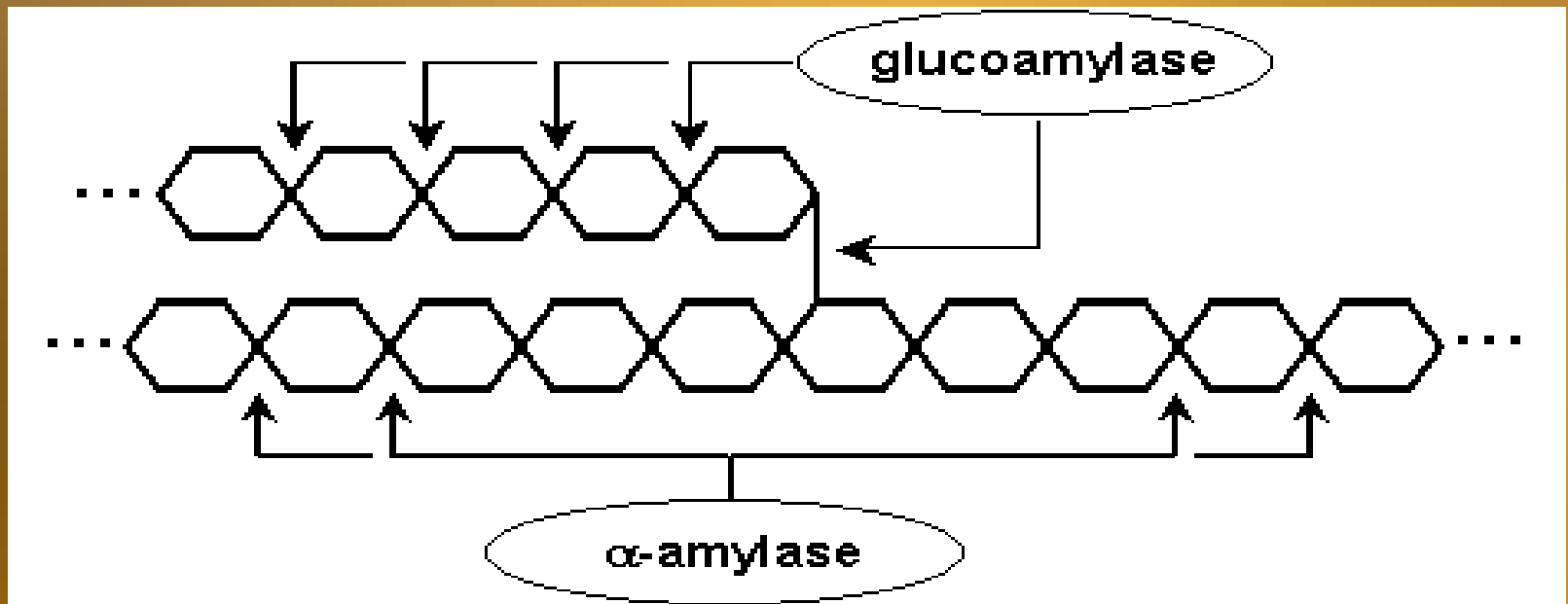
β -Amylase

- Exoenzyme- hydrolyses starch molecule from the end
- Main product is maltose (92 glucose molecules linked together with α 1-4 linkage)

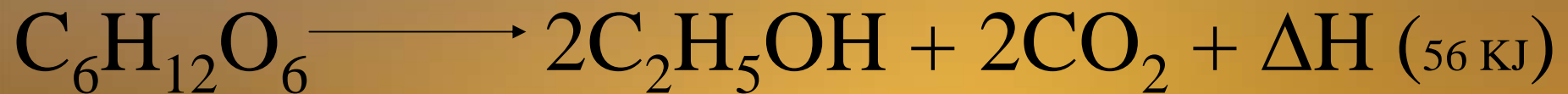


Glucoamylase

- Can hydrolyze α 1-6 glucosidic linkage (branch points)
- Responsible for starch debranching
- Can also hydrolyze α 1-4 glucosidic linkage from the end



Fermentation- Big Picture



Theoretical yield ~ 51.7%

Actual yield ~ 40-48%

But it isn't so simple

- Glycolysis central pathway

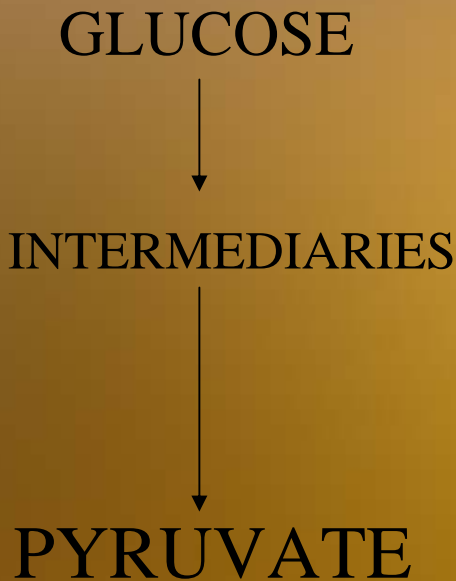
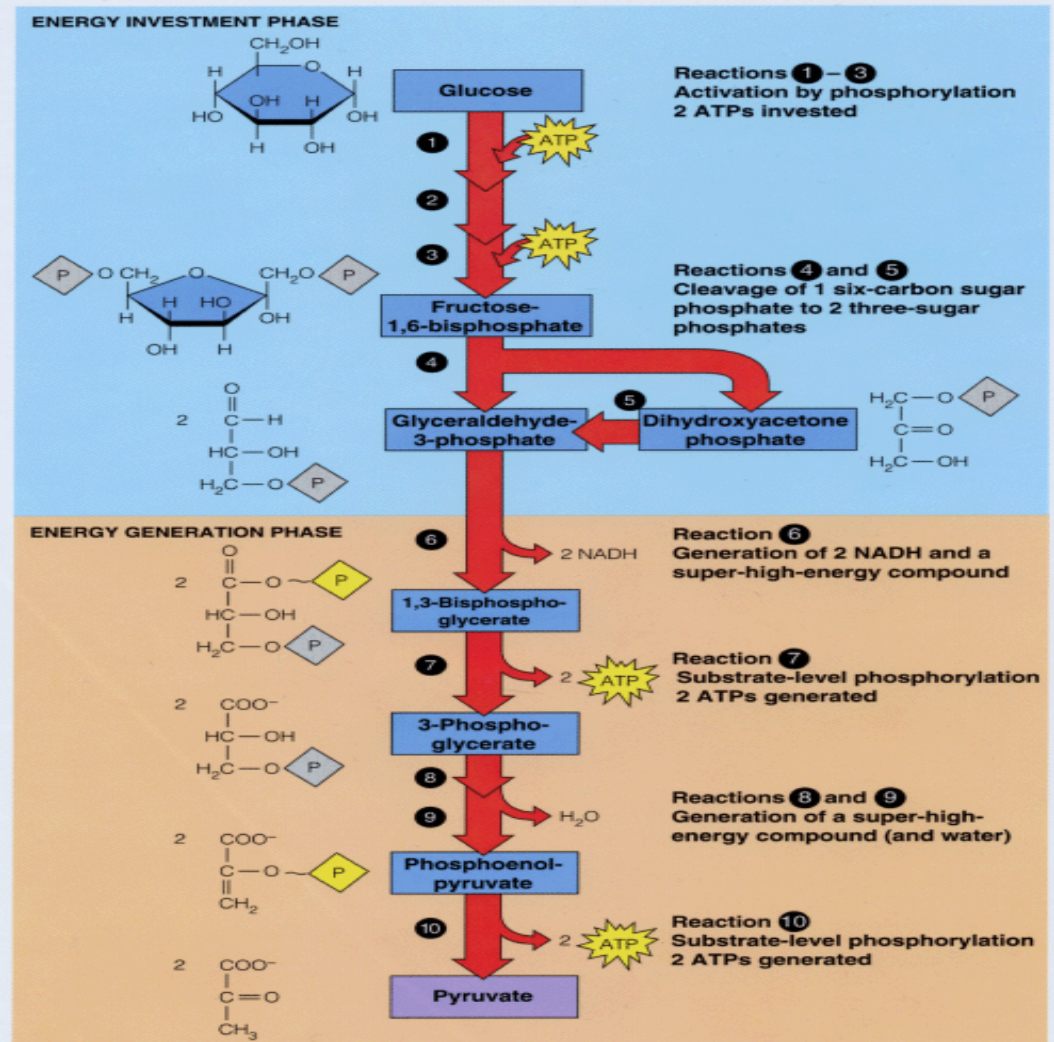
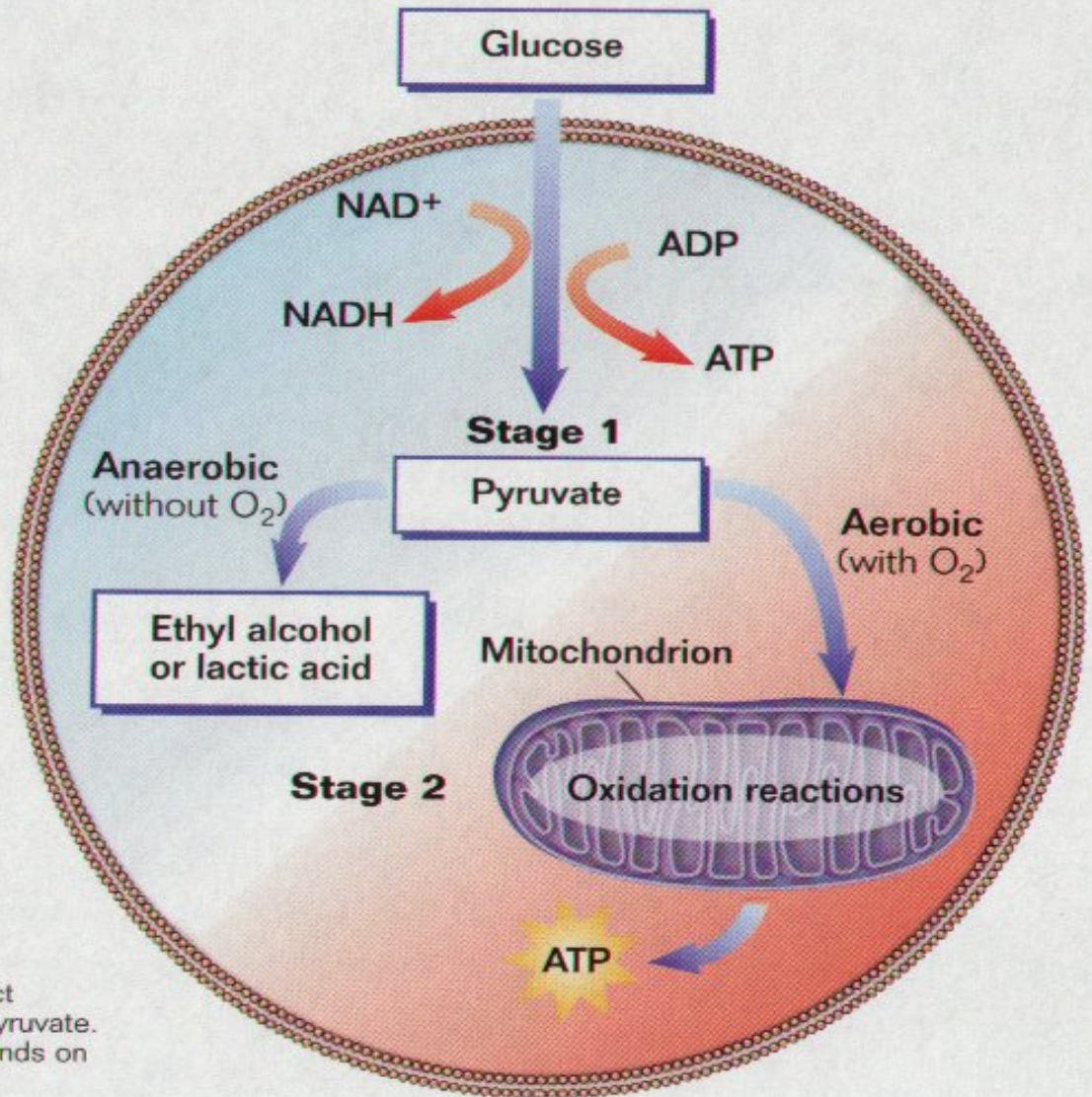


Figure 13.3 An overview of glycolysis





Cellular respiration occurs in two distinct stages. First, glucose is converted to pyruvate. The outcome of the second stage depends on the presence of oxygen.

Malt

- Most important ingredient in beer making, from the standpoint of quality and functionality
- Barley malt is to beer as grapes are to wine
- Malted barley has a high amounts of enzymes for converting its starch supply into simple sugars
- Contains protein, which is needed for yeast
- Flavor

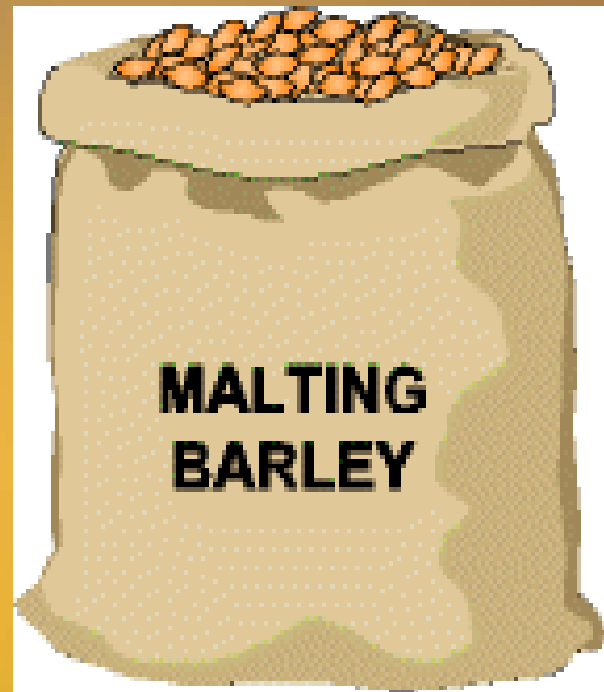
Malting

Malting serves the purpose of:

1. converting insoluble starch to soluble starch (gelatinization)
2. reducing complex proteins
3. generating nutrients for yeast development
4. and the development of ENZYMES

Malting steps

1. Steeping
2. Germination
3. Kilning



Steeping

- Mixing the barley kernels with water to raise the moisture level and activate the metabolic processes of the dormant kernel.
- The water is drained, and the moist grains are turned several times during steeping to increase oxygen uptake
- Generally, the barley spends about 40 hours in tanks of fresh, clean water, with three intervals during which the water is allowed to drain.
- Draining is done to remove dissolved carbon dioxide and to reintroduce oxygen-rich water.
- Steeping is complete when the white tips of the rootlets emerge, which is known as chitting. At this point the grains will have swollen one and one-third times their original size.

Steeping



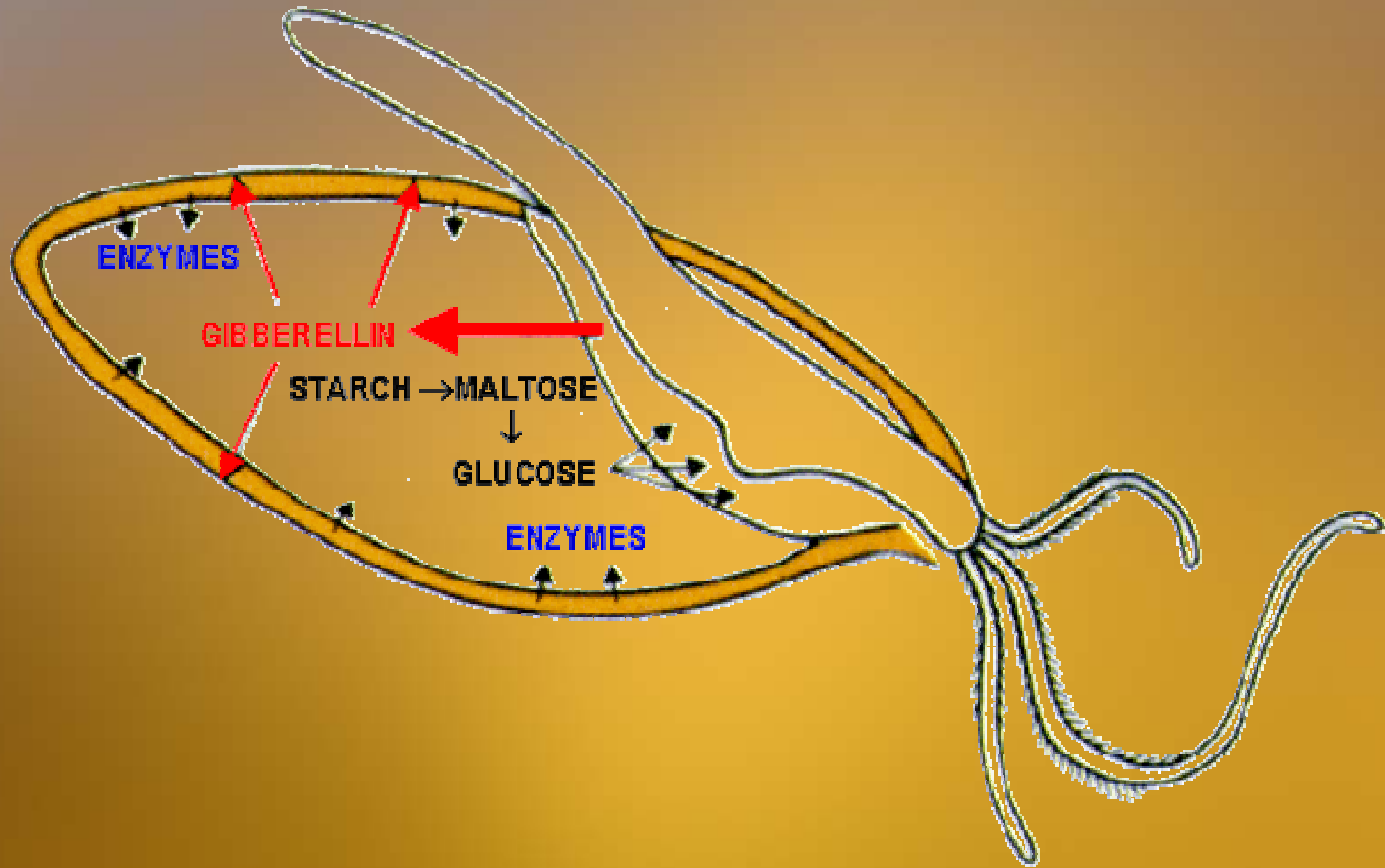
Germination

- Wet barley is germinated by maintaining it at a suitable temperature and humidity level until adequate modification has been achieved.
- Floor malting is an old process in which the chitted malt is spread on the floor to a height of 10 to 20 cm.



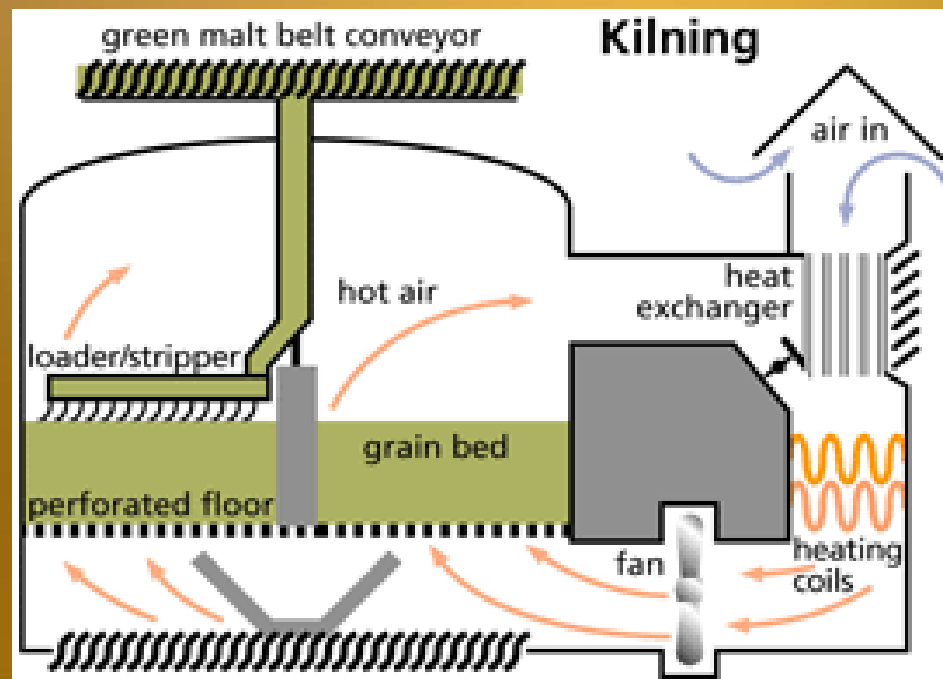
GREEN MALT

Germinated barley



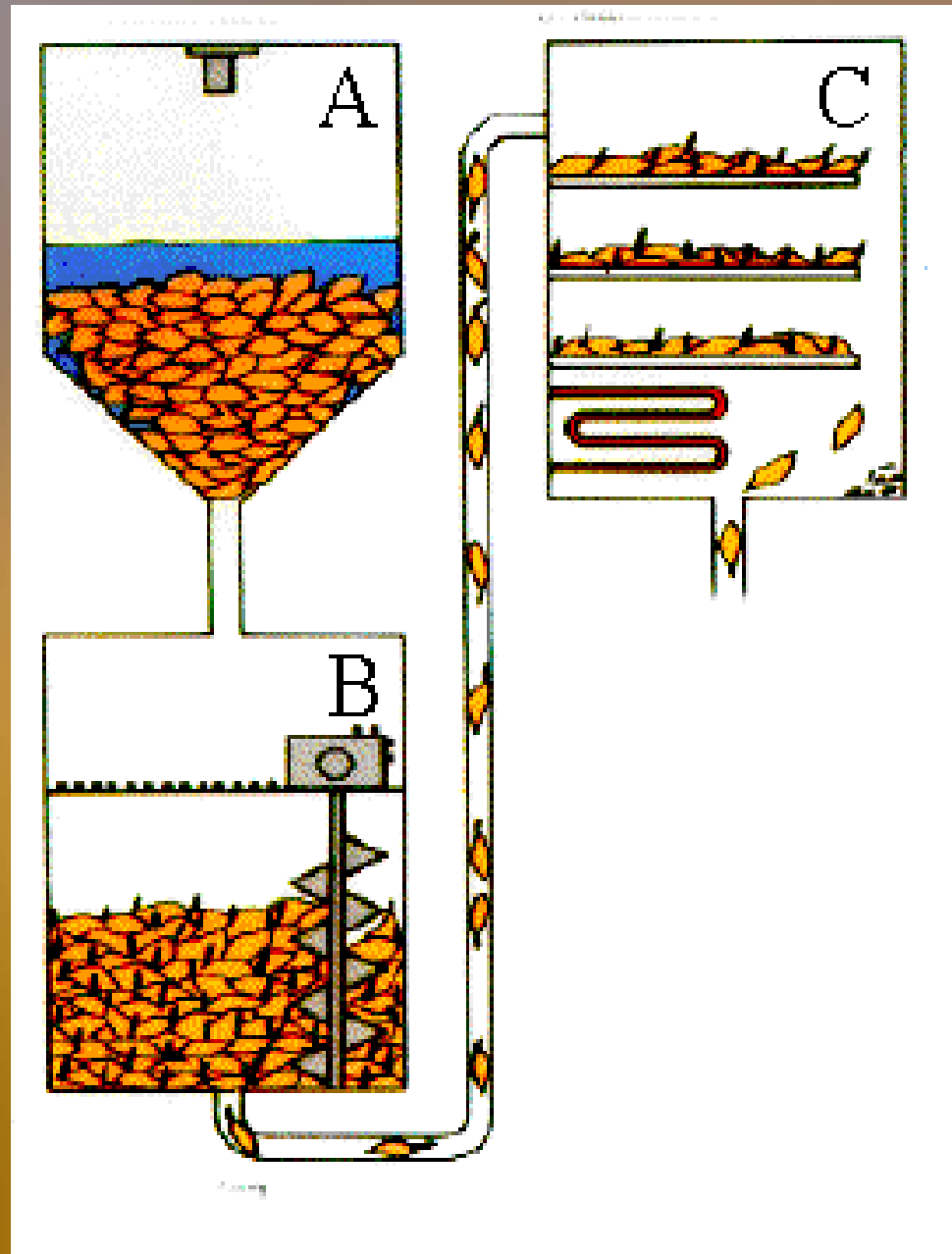
Kilning-drying

- Drying the green malt in the kiln
- Malts are kilned at different temperatures
- The temperature regime in the kiln determines the color of the malt and the amount of enzymes which survive for use in the mashing process.



Steeping vessel
(42-48%
moisture)

Germination
(5 days)



Dryer

Overview of malting

Storage	Moisture Temperature	12-14% 12C
Steeping	Moisture	45%
Germination	Time Temperature	5 days 12-16C
Kiln drying	Temperature Moisture	up to 85C 4%
Removal of rootlets		

Water

- The mineral content of brewing water has long been recognized as making an important contribution to the flavor of beer.
- The Ca, Mg, Na, K, Sulfites are most important constituents of water effecting brewing process and beer
- pH, Alkalinity and Hardness
- Breweries were located on sites with established, consistent water supplies having characteristic mineral compositions. This led to the emergence of regional beer characteristics in locations such as Dortmund, Pilsen, and Vienna.

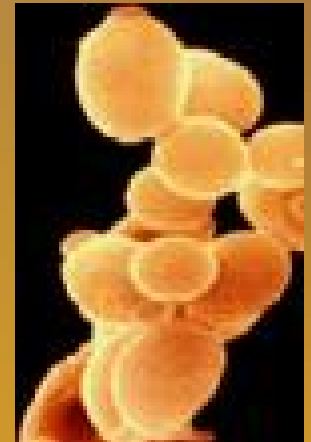


Adjuncts

- Unmalted grains such as corn, rice, rye, oats, barley, and wheat
- they provide extract at a lower cost (a cheaper form of carbohydrate)
- beers with enhanced physical stability, superior chill-proof qualities, and greater brilliancy.
- contribute very little protein material which is advantageous in terms of colloidal stability.
- Flavor contribution
 - rice - neutral aroma and taste
 - corn - fuller flavor
 - wheat - imparts a dryness to beer.

Yeast

- Responsible for converting fermentable sugars into alcohol and other byproducts.
- *Saccharomyces cerevisie*
- *Saccharomyces uvarum*



There are two types of beer yeast

1. Ale yeast (the "top-fermenting" type)
2. Lager yeast (the "bottom-fermenting" type)

ALE

- Best used at temperatures ranging from 10 to 25°C,
- yeasts rise to the surface during fermentation, creating a very thick, rich yeast head. That is why the term "top-fermenting" is associated with ale yeasts.
- Produces a beer high in esters, which many regard as a distinctive character of ale beers.
- *Saccharomyces cerevisiae*
- Europe & Australia

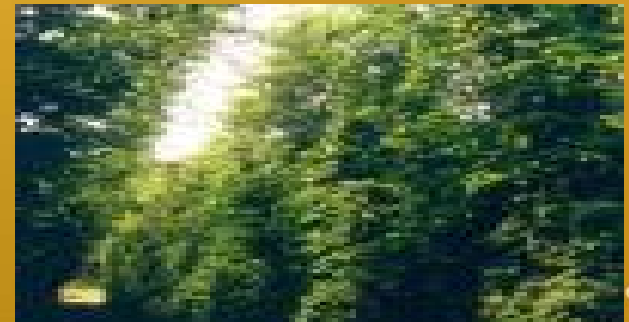
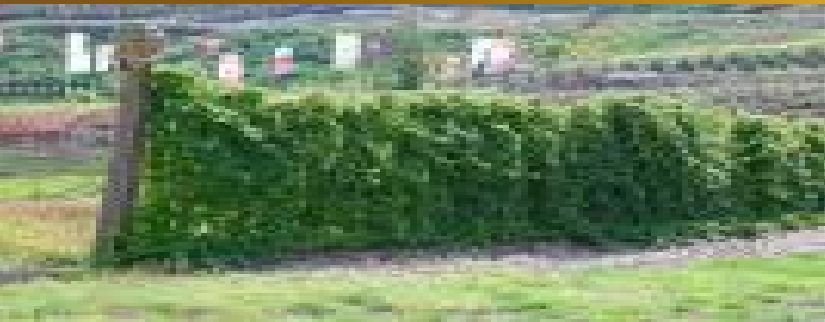
Lager

- Yeast strains are best used at temperatures ranging from 7 to 15°C.
- grow less rapidly than ale yeasts
- settle out to the bottom of the fermenter as fermentation nears completion
- This is why they are often referred to as "bottom" yeasts.
- *Saccharomyces uvarum*
- North America

Hops



- Impart color – rich in tannins
- Flavor and aroma
- Provide proteins to yeast
- Aid in foam formation and stabilization
- Provides coagulation of proteins (to get rid of them)
- Inhibits most Gram + bacteria (Lactic acid)



General steps in beer making

- MASHING
- BREWING
- FERMENTATION
- STORAGE
- FINISHING AND PACKAGING

Malt milling

- Malted barley is crushed in the roller mill
- Resultant material is called the grist



Mashing

Grounded malt + Water + adjuncts cereal

MASH

- Mashing begins at ~ 38°C
- Temperature is gradually raised to 77°C
- Heating is done in steps with rest periods of ~30 min (Allows enzymes to work before they are heat inactivated)

Changes during mashing

- Extraction of readily soluble materials
- Gelatinization of starch (Only gelatinized starch is susceptible to enzymatic hydrolysis)
- Enzymatic break down of gelatinized starch to oligosaccharides, dextrans, maltose, glucose
- Proteins are also extracted and broken down to amino acids by proteolytic enzymes



MASHING
VESSEL

“TUN”



WORT (liquid part)

Mashing vessel is designed that way that after mashing, the liquid fraction high in yeast fermentable sugars (WORT) can be separated from the grains

Brewing

Wort

Hops



Brew kettle or
Wort Tun

Boiling for 2.5 h

Drawing out the wort through a layer of settled hops

Cooling

Purpose of brewing

- Concentration of wort (more solids)
- Nearly sterilizes it
- Inactivates enzymes
- Precipitates remaining proteins (if not precipitated it would form beer turbidity)
- Caramelizes sugars slightly
- Extract flavor, preservative and tanninlike substances from hops

Fermentation

- Fermentable carbohydrates in the wort are converted by the yeast into alcohol, carbon dioxide, and numerous byproducts.
- The byproducts have a considerable effect on the taste, aroma, and other characteristic properties of the beer.
- Fermentation is dependent on the composition of the wort, the yeast, and fermentation conditions.

Ale vs. Lager fermentation

ALE

- Ale yeast (top-fermenting)
- Ferments the wort in four to six days
- 15 to 20 degrees Celsius (59 to 68 deg. F).

LAGER

- Fermentation with lager yeast (bottom-fermenting)
- temperatures between 4 and 9 degrees C. (39.2 and 48.2 deg. F).
- It takes about eight days, Then the yeast settles to the very bottom.

Purpose of the fermentation

- Formation of ETOH (alcohol)
- Lowers the pH
- Produces dissolved CO₂ (0.3% by weight)
- Development of flavor components



Beer conditioning

- After fermentation beer is quickly cooled to 0°C
- Passed through a filter system to remove yeast and other suspended material
- Pumped into pressure storage tanks



GREEN BEER

LAGERING

- Storage of beer at 0°C
- Further settling of finely suspended proteins, yeast and other remaining materials
- Development of esters and other flavor compounds (give beer improved body and mellow flavor)



Lagering-Chill haze

- Chill haze is phenomenon in which remaining proteins and tannins form a colloidal haze when beer is cooled to low temperature
- At higher temperatures this complex is soluble and it does not form haze
- This is allowed to happen during lagering to prevent it from occurring in finished product
- To remove this chill haze
 1. Addition of earth of clay is applied during lagering to absorb these colloids
 2. Proteolytic enzymes are added to break down the proteins

Lagering – Adding CO₂

- Carbon dioxide contributes to perceived "fullness" or "body"
- Enhances foaming potential
- Acts as a flavor enhancer
- Extends the shelf life of the product (purging out the oxygen).
- The closer the carbonating temperature is to 0°C and the higher the pressure, the greater the carbon dioxide absorption.
- Brewer must know the maximum working pressure of the tanks, and when tanks are subject to overpressure.

Final finishing-filtering

- Filtration –to remove traces of suspended material and give beer “clear look”



Plate and Frame filter

Bottling

- The bottling of beer is one of the most complex aspects of brewery operations and the most labor intensive of the entire production process.
- The bottling of beer can be divided into the following steps:
 - 1) flash pasteurization (71.5 to 74°C and held at this temperature 15 to 30 seconds) (Not in USA)
 - 2) bottle feeding
 - 3) bottle rinsing,
 - 4) bottle filling,
 - 5) tunnel pasteurization (60°C, several minutes)
 - 6) bottle labeling,
 - 7) case packing.

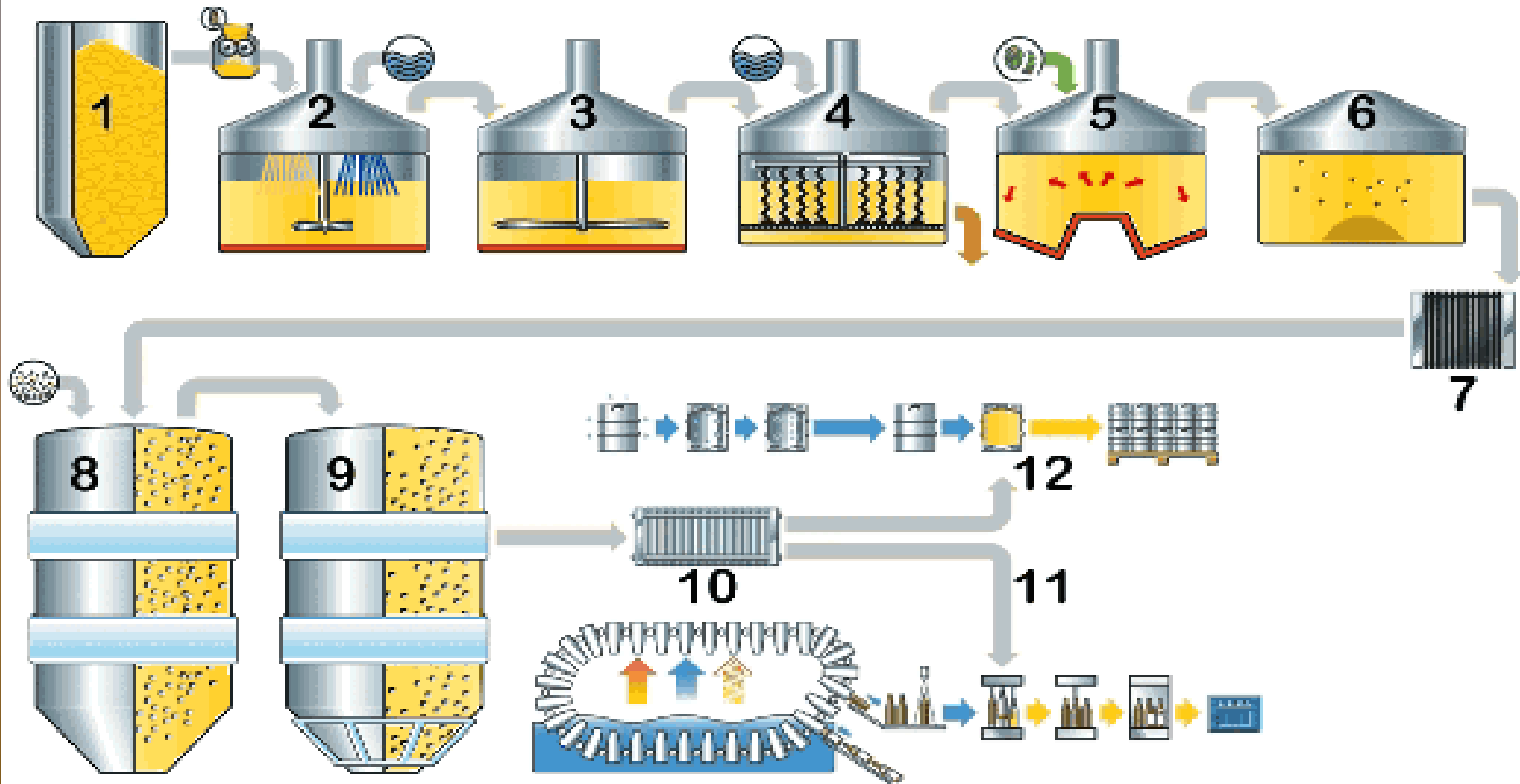
Beer bottling



Keg (Draft beer)

- Pasteurized or not
- Held under refrigeration temperature
- Filling carbonated pasteurized beer into sterile aluminum or stainless steel kegs of various sizes.
- Better taste ?





1. malt-silo
 2. mash vat
 3. mash pan
 4. clarification vat

5. wort pan
 6. whirlpool
 7. wort cooler
 8. fermentation tank

9. lagering cellar
 10. beer filtration
 11. filling in bottles
 12. filling in kegs

Beer spoilage microorganisms

1. Gram-positive

Lactic acid bacteria

Lactobacillus spp.

Pediococcus spp.

2. Gram-negative:

acetic acid bacteria

Acetobacter spp

Acetomonas spp.

Zymomonas spp.

Enterobacteriaceae.spp

Pectinatus spp.

3. Molds

Mucor,

Penicillium,

Aspergillus,

Cladosporium,

Geotrichum,

and *Rhizopus*.

4. Wild yeasts

Types of beer

- **Lager beer** (North America, yeast on the bottom)
 - Pilsner (light with medium flavor (North America))
 - Dortmunder (light lager with ~10% rice)
 - Vienna (medium dark lager, mild hop taste)
 - Munich (lager, very dark in color, small amount of grapes used in brew to give slight sweet taste)
 - Bock (Lager, dark brown, strong hop taste)
- **Ale Beer** (yeast remaining on the top)
 - Guinness (dark color, mild hop taste, added grapes)
 - Porter (dark brown and slightly reddish color, mild hop flavor)

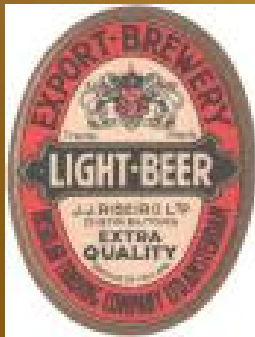
Beer composition (4% alcohol)

- 90 % water
- 4.4g carbohydrate
- 6g protein
- 4mg of calcium
- 26mg of phosphorus
- 0.03mg of riboflavin (Vitamin B2)
- 0.2mg of niacin
- Trace of thiamin (vitamin B2)
- 0.2g of ash



Light beer

- Contains one half to one third less calories
- Less alcohol
- Prepared with mash lower in solids



Alcohol side effects

- dilation of blood vessels (which causes flushed skin)
- increased gastric secretion in the stomach
- mood swings
- unrestrained behavior
- inability to control motor functions as basic as walking
- blackouts
- sleep problems
- hangovers
- liver failure





Most famous beer drinker



QUESTIONS ??????????



HAVE A SAFE AND FUN SPRING BREAK