Make Your Beer Stand Out: The Key to Yeast Fermentation

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ESTD 1995
WHITE LABS
PURE YEAST & FERMENTATION

A Little Bit About White Labs

Why I'm Standing Here in Front of You

White Labs Motto – *"To be the best yeast company in the world"*

A Brief Outline

- **Introduction:**
  - **Yeast in the brewing process**
  - What is yeast?
  - *Saccharomyces cerevisiae*
  - Species of brewer's yeast
  - Unique properties of brewer's yeast & how this effects brewers
- **Flavor and a little bit of metabolism:**
  - Alcohol production in beer
  - Basic flavor components in beer
  - Basic Metabolism
  - Important fermentation flavors and some critical control points

An Introduction to Brewing and Yeast

“The basics”

For Those Who Don't Know…

Malting

Barley
↓
Steeping & Germination
↓
Drying & Kilning
↓
Malt

Mashing

Malt
↓
Water → Milling ← *Adjuncts*
↓
Heating
↓
Wort

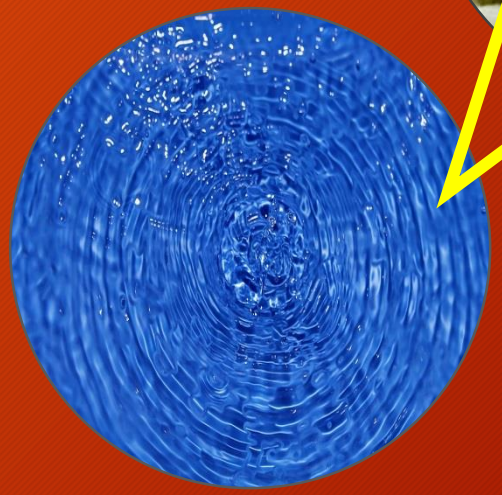
Fermentation

Wort
↓
Fermentation
↓
Conditioning & Maturation
↓
Beer

Post-Fermentation

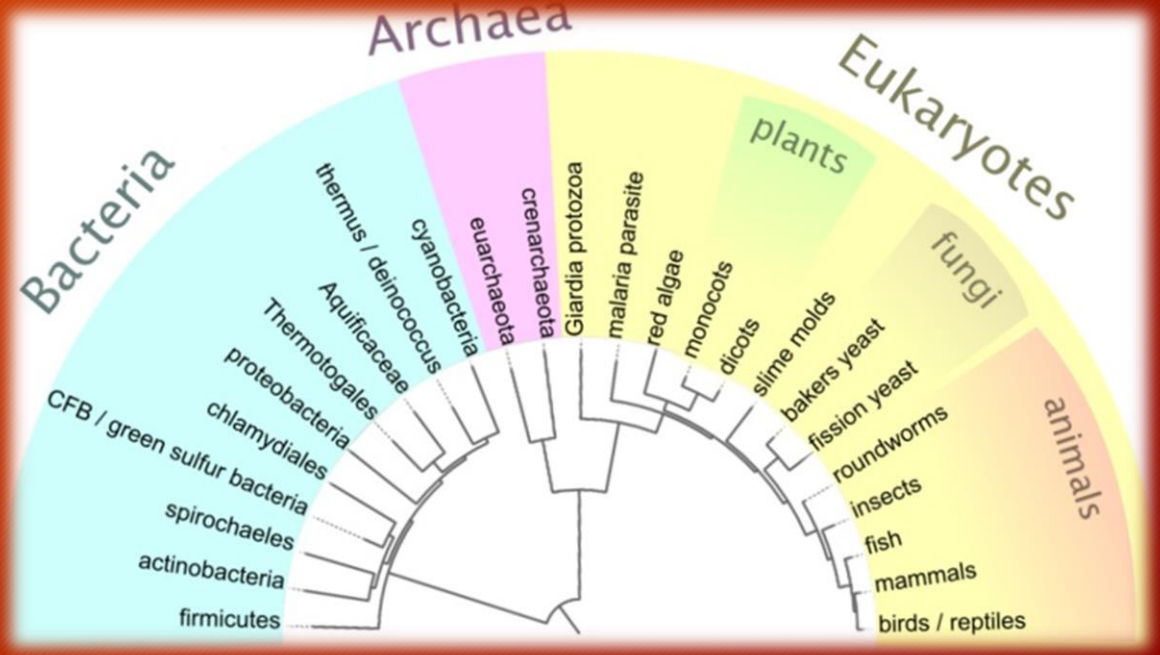
Beer
↓
Clarification & Filtration
↓
Packaging & *Pasteurization*
↓
Beer

Brewing Raw Materials



Yeast

- Morphological term meaning “single celled organism”
- In everyday language, yeast is synonymous with *Saccharomyces cerevisiae*
  - There are over 1500 species of yeast
- Ubiquitous in nature
  - Yeast are found in every biome and continent
  - Especially on fruits and vegetables



Saccharomyces cerevisiae

- One of the oldest domesticated organisms
  - Used for brewing beer in Sumeria and Babylonia around 6000 BC
- *Saccharomyces* = sugar fungus; *cerevisiae* = Roman Goddess of crops – Ceres
- Used as a eukaryotic model organism
  - Unicellular, doesn't need a lot of room to grow, eukaryotic → can be applicable to humans
  - 1st genome to ever be sequenced in 1996

Types of Brewer's Yeast

Saccharomyces cerevisiae

- Ale yeast
  "Top fermenting"

Saccharomyces pastorianus

- Lager yeast
  "Bottom fermenting"

Saccharomyces carlsbergensis
Saccharomyces uvarum
Saccharomyces bayanus
Saccharomyces eubayanus
S. cerevisiae + S. eubayanus

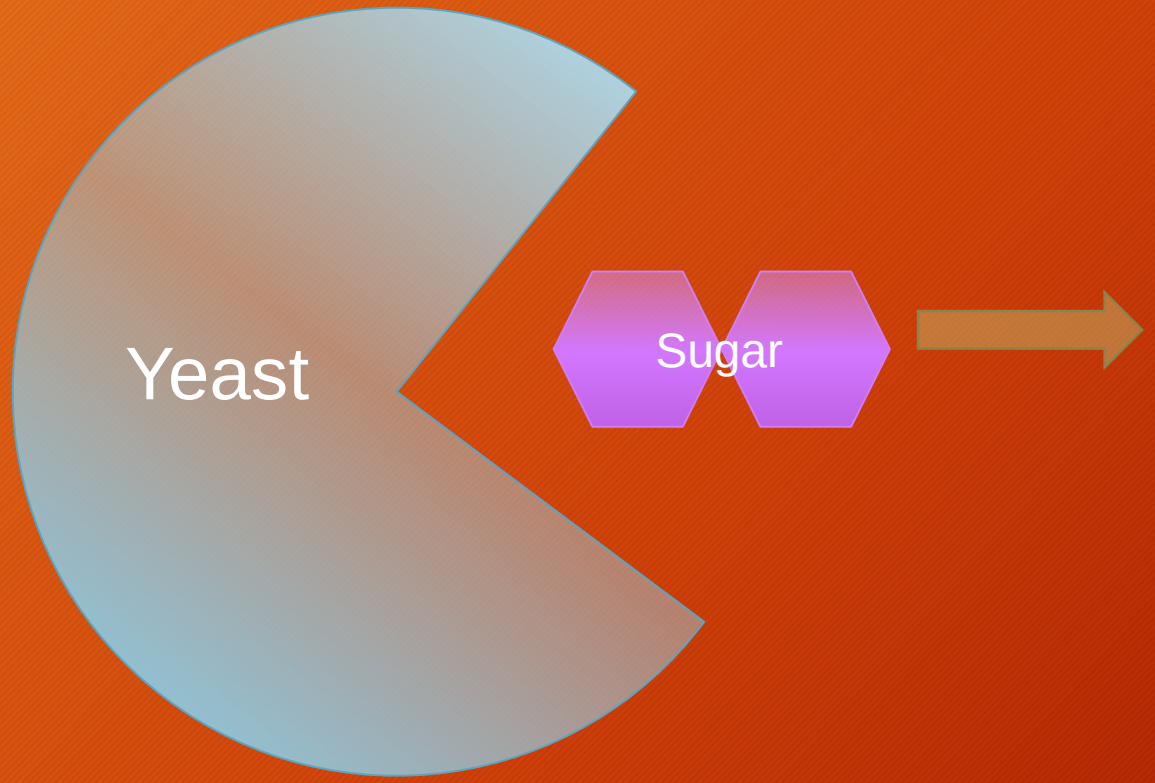
Other Hybrids?

All yeast used in brewing worldwide are non-GMO

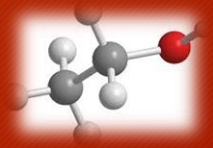
Unique Properties of Brewer's Yeast

Lab Strains	Brewing Strains
Haploid or diploid	Polyploid and aneuploidy
Sporulating	Sporulate poorly
Spores viable	Spores mostly non-viable
Able to mate (a & α mating types)	Mating Rare

Alcohol Production in Beer

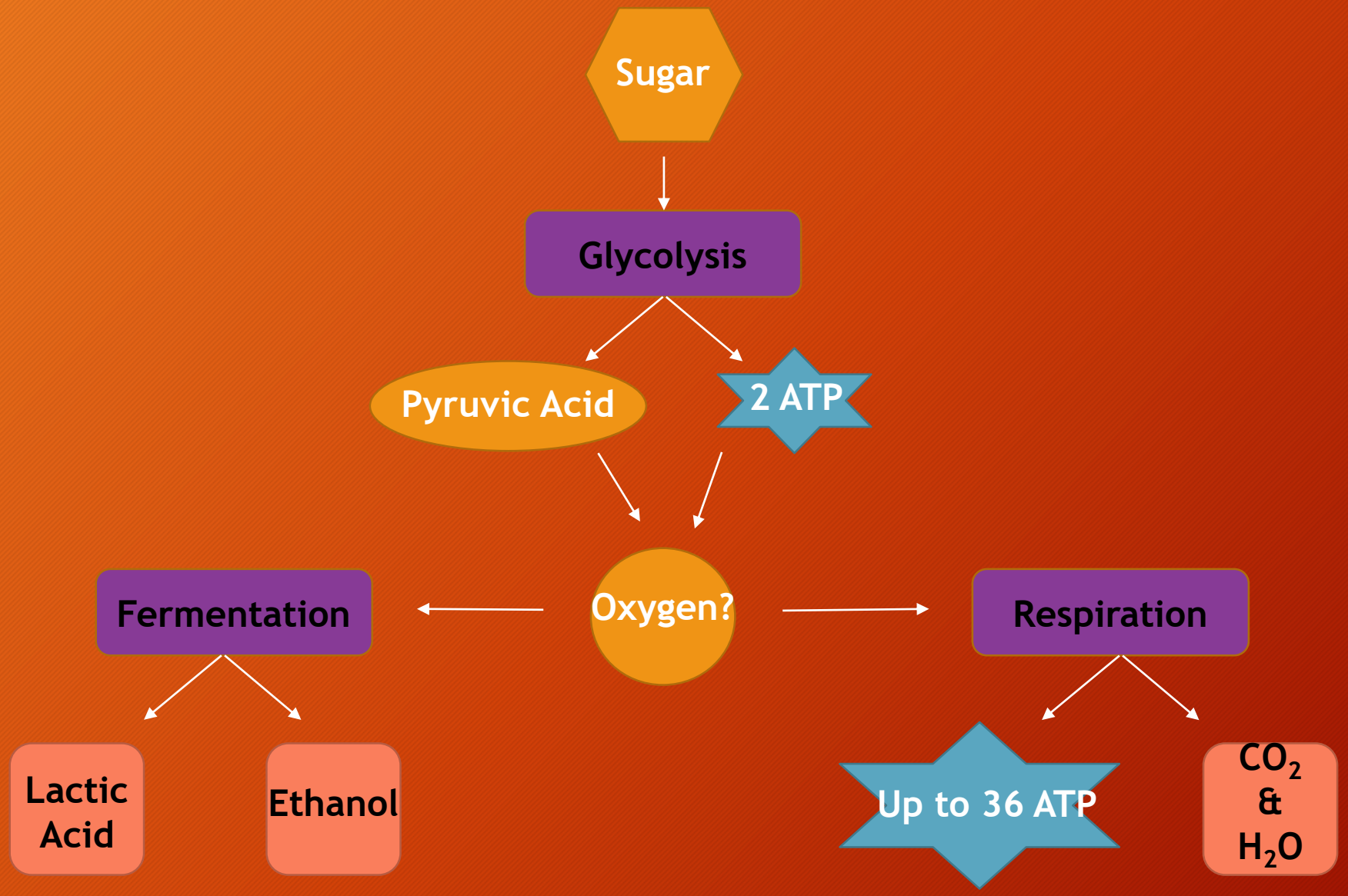


Ethanol



Flavor & (a little!) Metabolism

Why yeasts are so important to you as a brewer!


Sugar
Glycolysis
Pyruvic Acid
2 ATP
Oxygen?
Fermentation
Respiration
Lactic Acid
Ethanol
Up to 36 ATP
CO_2 & H_2O

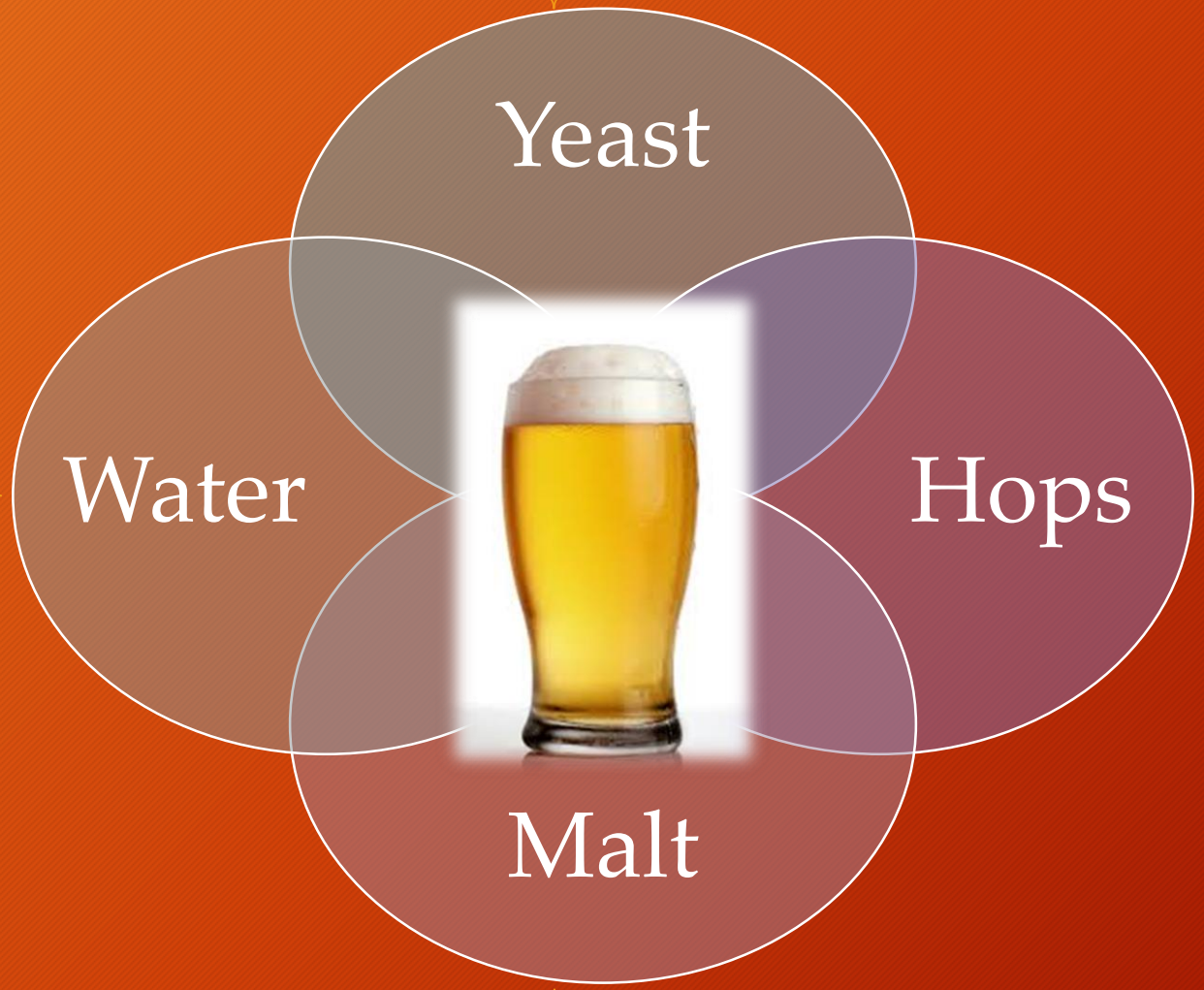
Alcoholic
Solventy

Estery
Fruity

Grassy
Butterscotch

Sulfury
Yeasty

Autolysis



Metallic
Salty

Floral
Citrus
Bitter

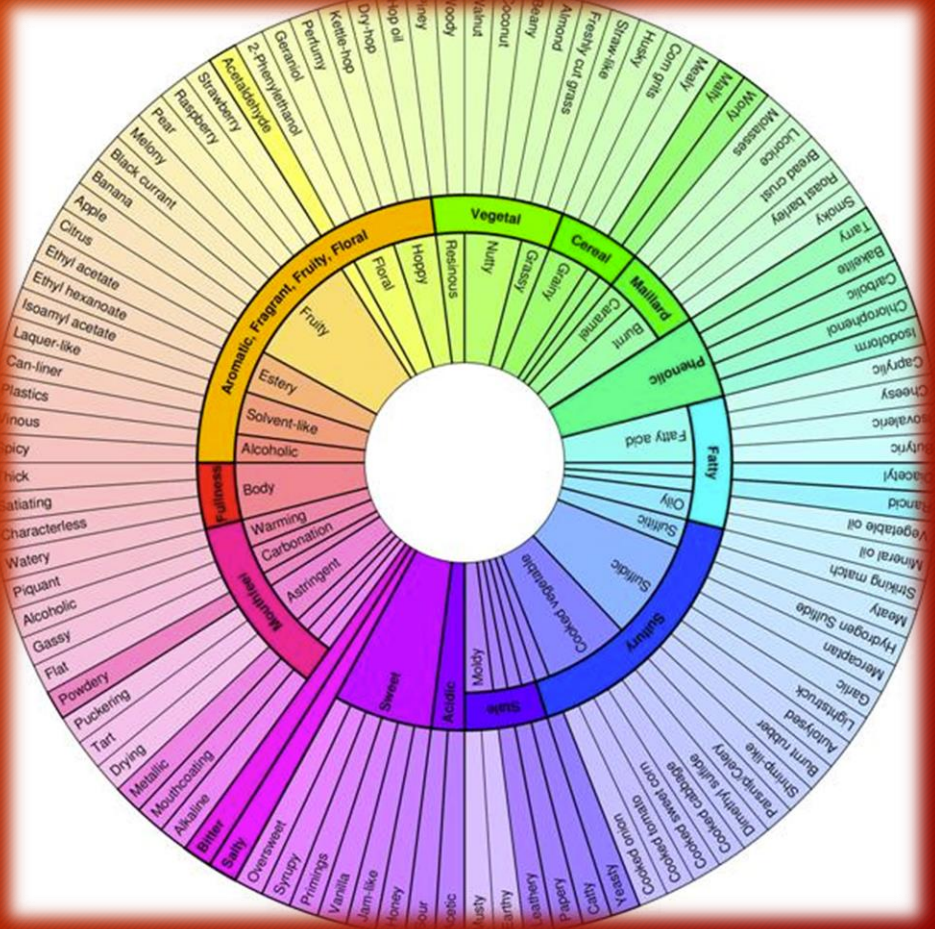
Grainy
Bready

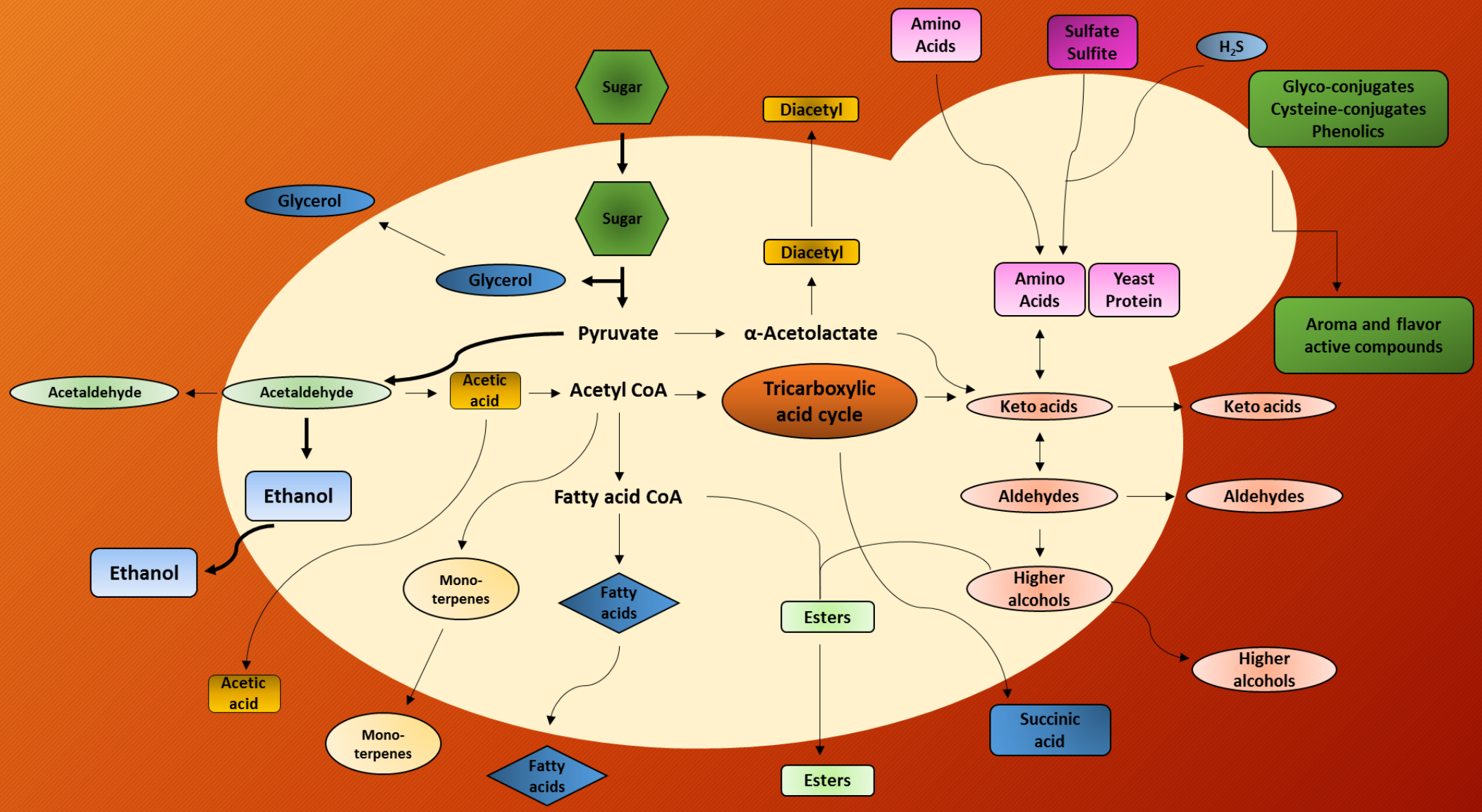
Worty
Caramel

Yeast Produce over 500 Flavor Active Compounds!

The byproducts: (besides ethanol and CO2)

- Esters
- Alcohols (fusel)
- Vicinal diketones (diacetyl, 2,3-pentandione)
- Aldehydes (acetaldehyde)
- Organic acids
- Sulfur compounds
- Fatty acids




Sugar
Sugar
Glycerol
Glycerol
Diacetyl
Diacetyl
Amino Acids
Sulfate Sulfite
H_2S
Glyco-conjugates
Cysteine-conjugates
Phenolics
Aroma and flavor active compounds
Amino Acids
Yeast Protein
Pyruvate
α-Acetolactate
Acetaldehyde
Acetaldehyde
Acetic acid
Acetyl CoA
Tricarboxylic acid cycle
Keto acids
Keto acids
Ethanol
Ethanol
Fatty acid CoA
Aldehydes
Aldehydes
Mono-terpenes
Fatty acids
Esters
Higher alcohols
Higher alcohols
Acetic acid
Mono-terpenes
Fatty acids
Esters
Succinic acid

Yeast Flavor & Aroma

Remain at Levels Produced After Primary Fermentation

- Esters
- Higher alcohols
- Sulfur dioxide
- Phenols

Decline During Beer Maturation

- Acetaldehyde
- Diacetyl

Yeast Flavor Development

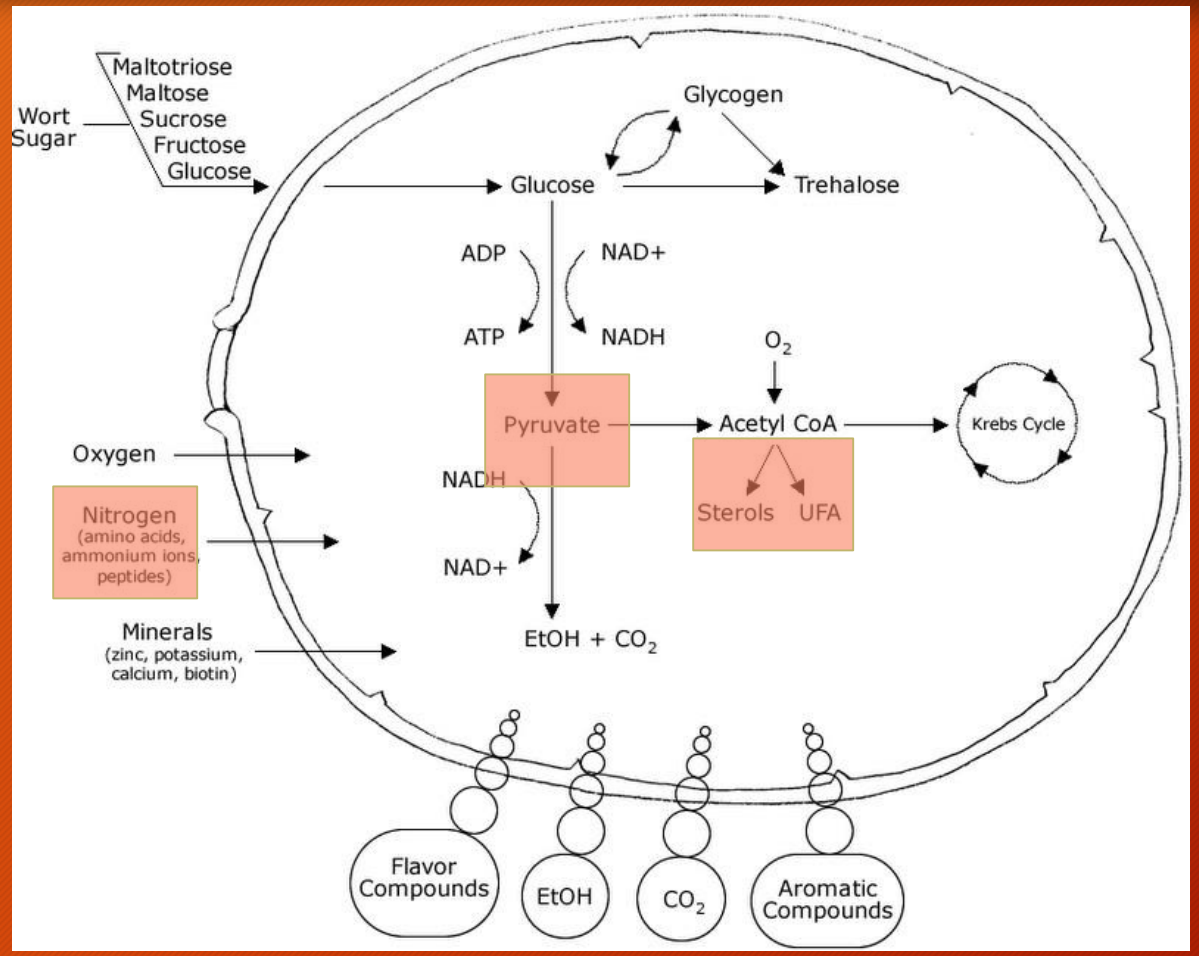


Fig 2.3 Yeast: The Practical Guide to Beer Fermentation, White and Zainasheff 2010

Esters

Flavors - fruity, banana, apples, perfume, solvent, nail polish remover

- Formation
- Reaction of alcohol group and acid group in the yeast cell
- Alcohol part comes from ethanol and fusel alcohols
- Acid part comes from various acids that are inside the yeast (acetyl-CoA compounds)
- Reaction is catalysed by an enzyme (alcohol acetyltransferase)

Esters

Control

- **Ester synthesis not that simple.**
- No direct relationship between yeast growth and ester synthesis.
- Strain dependent

Formation depends on:

- The amount of the acid (acetyl-CoA compounds)
- The amount and activity of the enzyme (Alcohol acetyltransferase)
- The amount of the higher alcohol
- Low temperature = low esters
- More Oxygen = low esters
- Highly yeast strain dependent
- More problematic in very strong beers
- May be symptom of Acetobacter

Higher (Fusel) Alcohols

Flavor- alcoholic, spicy, vinous, warm

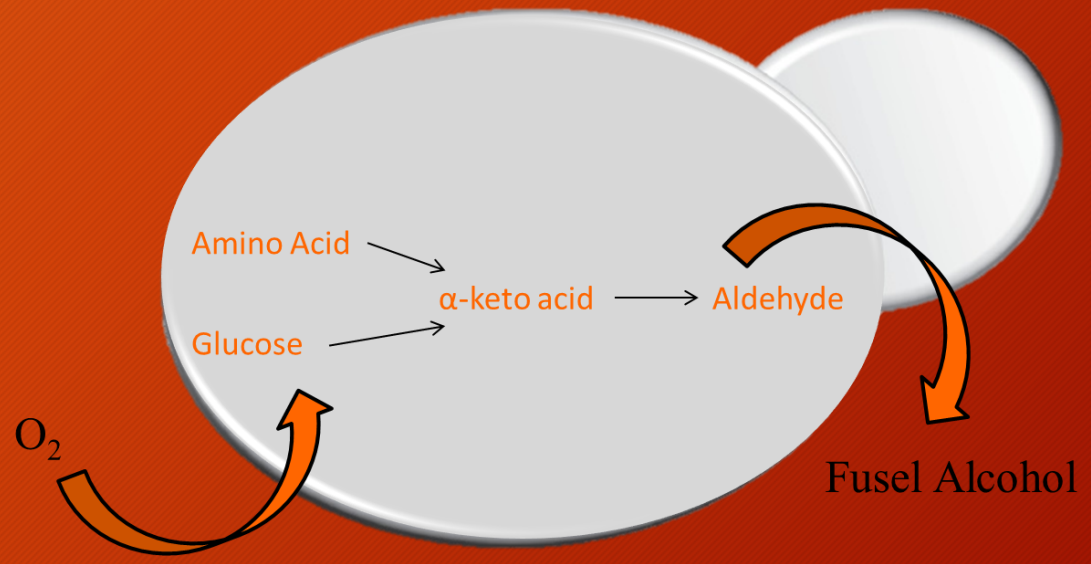
Formation

- Intermediates in amino acid metabolism
- Produced during uptake of amino acids
- Produced from glucose when yeast needs to make amino acids
- Directly related to yeast growth

Higher (Fusel) Alcohols

Control

- Any conditions that stimulate yeast growth will stimulate fusel alcohol production
  - Aeration
  - Lipid (fat) content of the wort
  - Trub
  - Agitation
  - Temperature



Sulfur Compounds

Flavor - sulfury, rotten eggs, burnt rubber, striking a match

Formation

- Intermediates in amino acid metabolism
- When yeast needs to make sulfur containing amino acids

Control

- Wort oxygen content (more is better)
- Fermentation temperature
- Yeast “health”

Phenolic Compounds

Some yeasts are able to convert phenol carbon acids into phenols in the beer

- **Phenolic Off Flavor (POF)** – POF positive yeasts are generally unwanted in brewing (wild yeast characteristics)
  - **Exception -** Bavarian Hefeweizen style where the phonol 4-Vinyl Guiacol is a desired compound due to its clove character as well as some Belgian beers

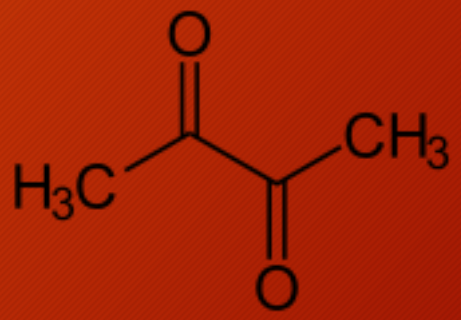
Flavor – Clove, solvent, plastic, bandaid, smoke (Wild/Belgian!)

Formation:

- During primary fermentation
- POF positive yeasts decarboxylate cinnamic acid derivates in wort to produce vinylphenols

Diacetyl

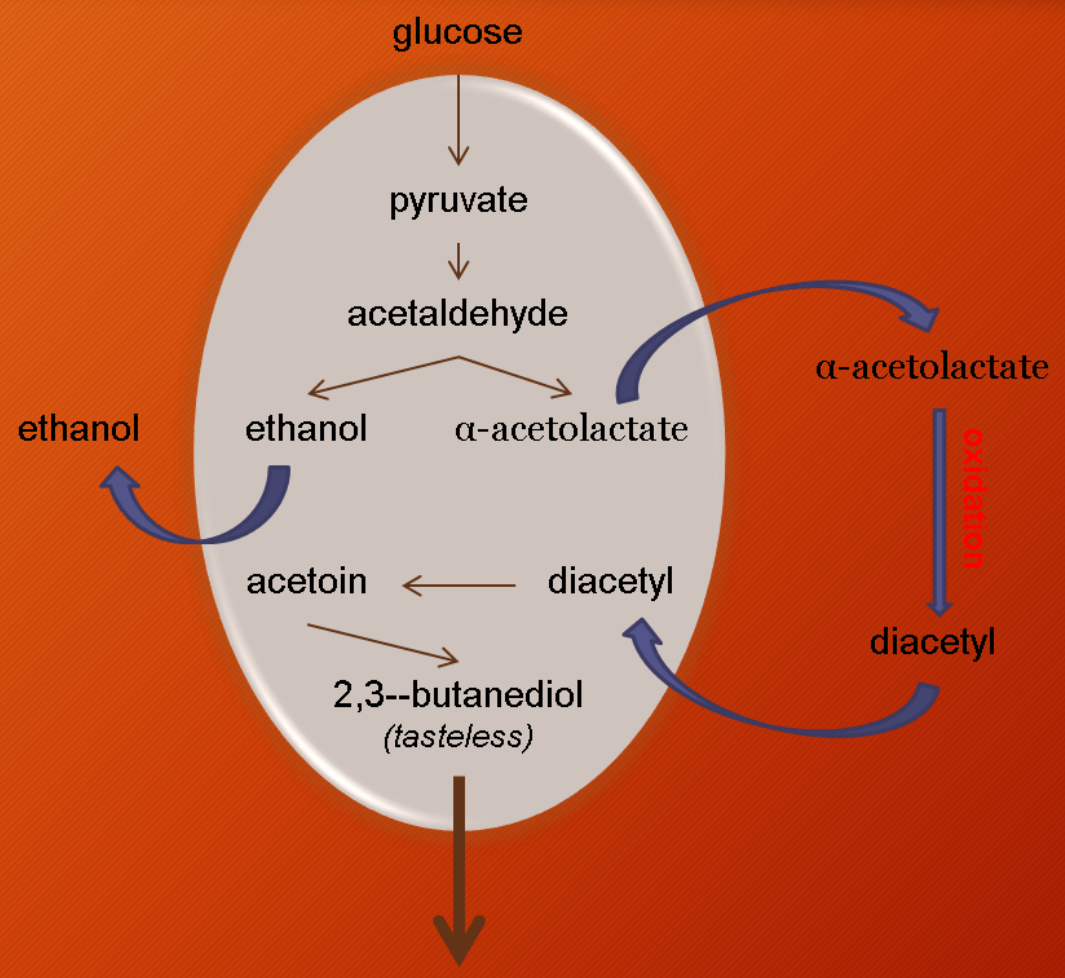
Flavor - Buttered popcorn, butterscotch, sweet yogurt, slick mouthfeel



Formation:

- Precurser (α-AL) produced during primary fermentation
- α-AL is converted to diacetyl outside cell
- Diacetyl is again taken up and metabolized by yeast during maturation
- Reaction related to amino acid synthesis
- pH and temperature dependent

Importance of Conditioning Time



Acetaldehyde

Flavor – Grassy, green apples

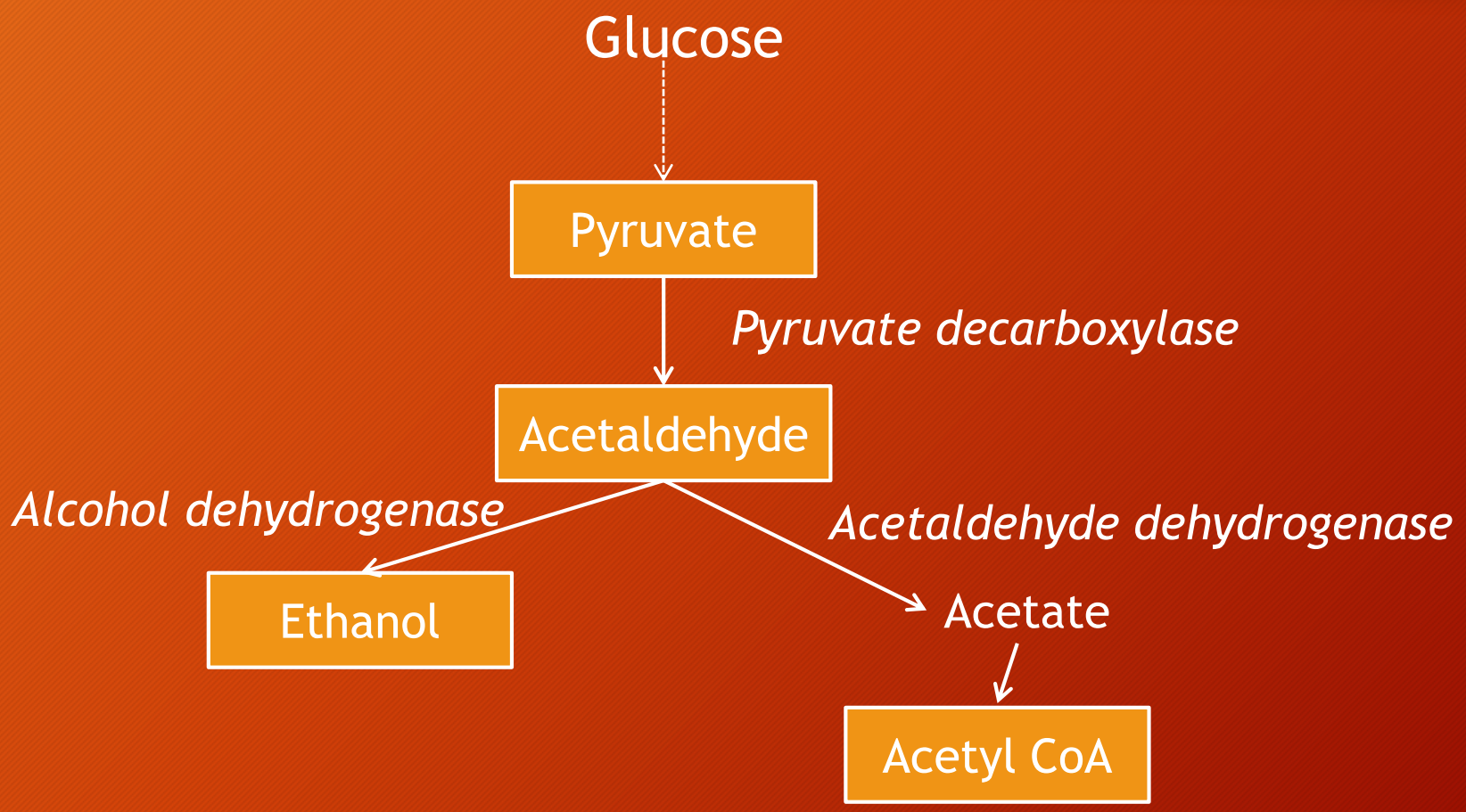
Formation:

- During primary fermentation, then reduced during maturation
- Intermediate of alcoholic fermentation pathway
- Metabolized to ethanol during maturation

Control:

- Healthy yeast
- Adequate conditioning time
- Temperature

Importance of Conditioning Time



Conclusions & Take Away

- Yeast metabolism is a complex biological process
  - Don’t worry about understanding the complex details!
  - The more you know the better you can control your fermentations
    - Controlled fermentations = Better Beer!

A Guided Tasting

Thank you!

Questions?

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