Origins of Beer Flavors

AMERICAN BREWERS GUILD
BREWING SCHOOL

Sources of Beer Flavor

- Base Malt
- Specialty Malt
- Adjuncts
- Water
- Hops
- Yeast
- Process
- Aging and Staling

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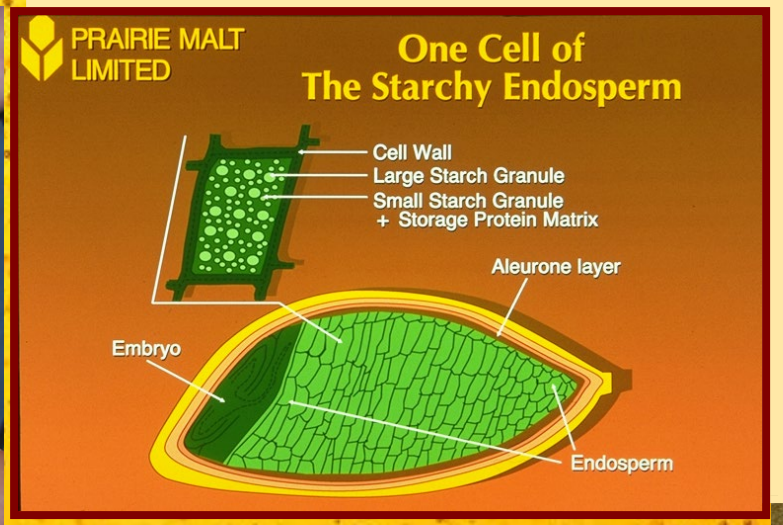
Base Malt



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Base Malt

- Source of fermentable and non fermentable extract
  - Glucose, fructose, sucrose, maltose, maltotriose are fermentable.
  - Dextrins, glucans and pentosans are non fermentable.
- Soluble protein contributes to haze, foam and yeast nutrition
  - Large polypeptides combine with oxidized polyphenols (also from the malt) to form temporary and permanent haze.
  - Medium polypeptides form a stable foam in reactions involving hop compounds and water chemistry.
  - Amino acids are vital for yeast nutrition and contribute directly to ester, higher alcohol and sulfur compound production during fermentation.

Base Malt

- Flavors and off flavors related to kilning.
  - Domestic malt is produced with a view to minimizing color and maximizing enzymes in the malt.
  - Europe is the same but to a slightly lesser degree.
  - UK malt is produced to minimize moisture and increase flavor in the malt.
  - Longer kilning increases color and flavor, and reduces the potential for DMS in the beer
- Stale flavors
  - The origin of many stale beer flavors is malt. Several organic acids leading directly to carbonyl compounds have been identified.

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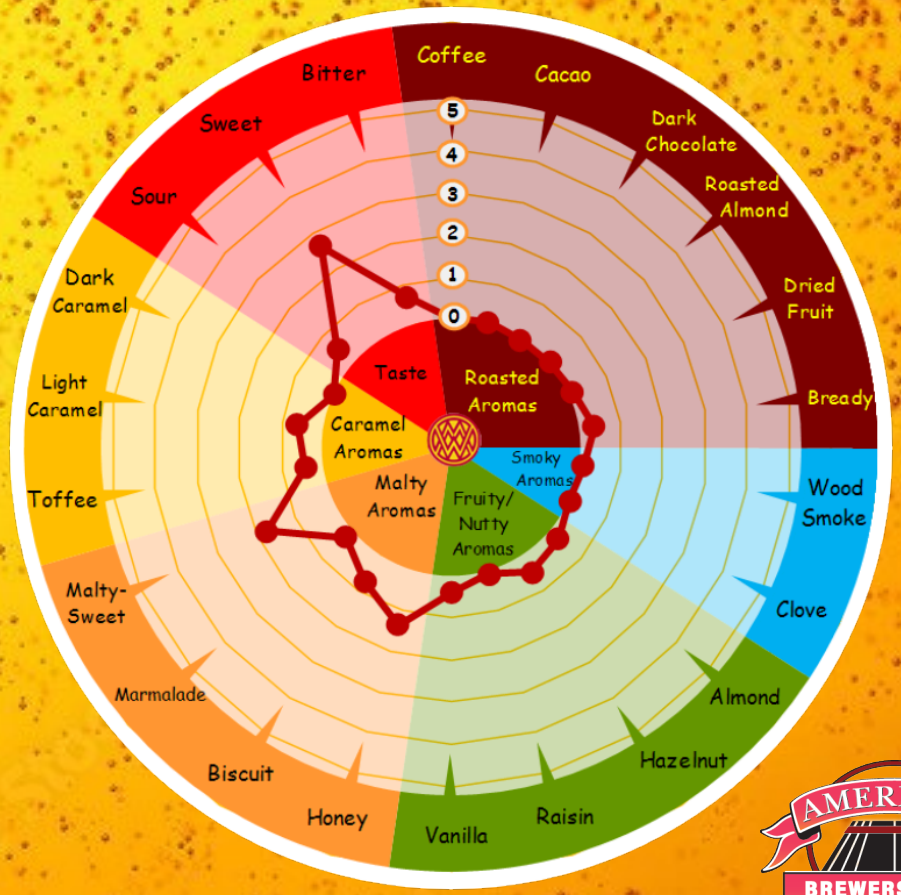
Specialty Malts

Specialty Malt

Two types exist

- Kilned malts
  - Vienna, Munich, Amber, Chocolate, Roasted/Black malts, Roasted barley.
- Roasting drum malts
  - Domestic caramel, English crystal, German cara-, with a wide range of colors.
- Grainy, bready, toffee, caramel, coffee, chocolate, burnt, smoky flavors.



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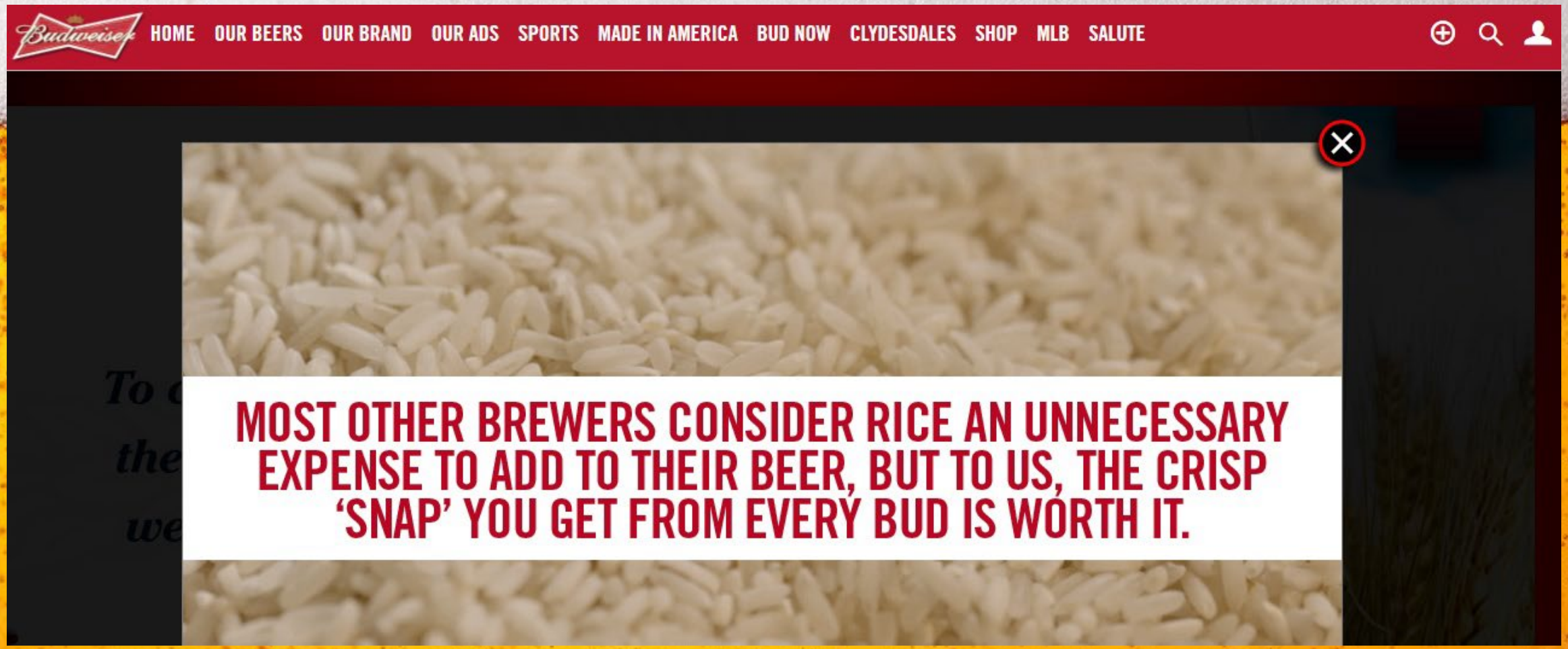
Adjuncts



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Adjuncts

- Unmalted cereal adjunct
  - Barley, wheat, oats, rye, corn.
  - Not gelatinized, high in glucans, historically used to dilute malt nitrogen, or to save money. Often used with extraneous enzymes.
- Malted adjuncts
  - Wheat, rye, oats.
  - Added for flavor contributions, head retention, body and mouthfeel

Water

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Water

- Water chemistry affects beer characteristics.
- Famous beers from around the world came to prominence based on water chemistry.
  - Burton-on-Trent, Dublin, London, Pilsen, Dusseldorf, St Louis.
- Gypseous waters enhance bitterness and hop accented beer.
- Chloride waters enhance malt sweetness and mouthfeel.
- Alkaline waters balance the acidity of roasted grains and enhance the drinkability of dark beers.


Hops

Hops

- Provide bitterness, flavor and aroma.
- Some hop varieties define a style
  - Czech pilsner with Saaz, ESB with EKG, American Pale Ale and Cascade.
- New evidence that there are different qualities to bitterness ie harsh, dull, sharp, lingering etc
- Hops added in the middle of the boil undergo biotransformations to release glycosidically bound flavor and aroma compounds.
- Whirlpool hopping to provide 30-40% of the IBUs in a beer.
- Advanced dry hopping techniques.
  - New research into the density of hop pellets specifically for dry hopping, hop cannons, hop slurries.
- New hop products
  - Hop powders, CO_2 extracts.

Hops

- Hop compounds are adsorbed onto yeast cell wall.
  - It's long been known that isomerized α acids attach to the cell wall of yeast. New evidence suggests that aroma and flavor compounds may too.
- Hop aroma compounds rapidly oxidize.
- Hop aroma derives from terpenes and sesquiterpenes, oxygenated terpenes and sesquiterpenes, sulfurs, aldehydes + ketones, esters, and fatty acids. *
- Hundreds of flavor compounds are present in hop oil. Many compounds are present in multiple forms (isomers). Each compound has its own aroma threshold concentration. Many compounds do not contribute any aroma to beer. *

(* from a talk by Tom Nielson of Sierra Nevada from CBC 2008 in San Diego)

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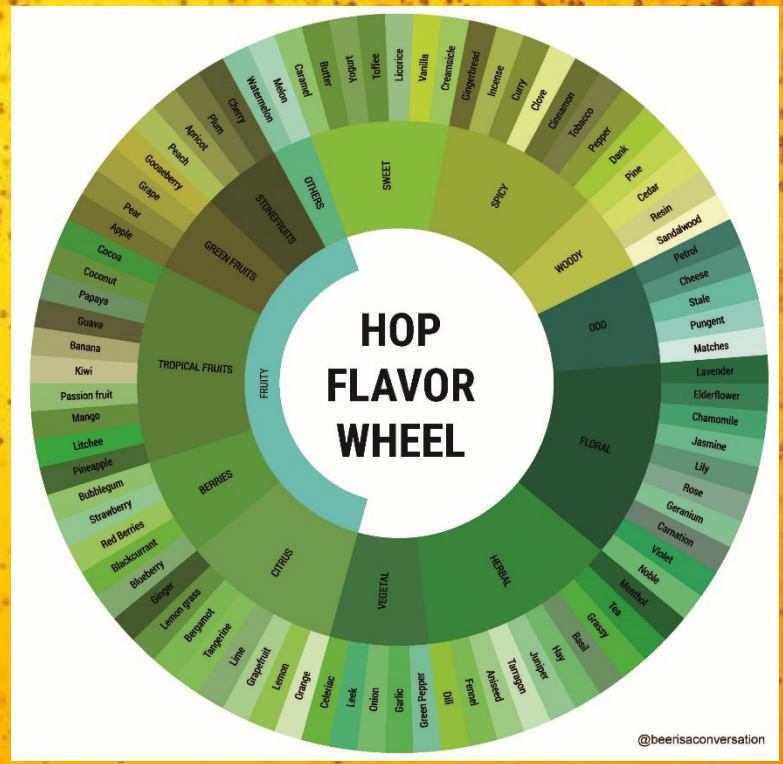
Hops
-potential flavors in beer

- Floral
- Herbal
- Citrus
  - Orange
  - Tangelo
  - Lemon
  - Lime
- Piney
- Grapefruit
- Cheesy
- Fruity
- Tropical Fruit
- Skunky
- Onion
- Tomato Plant / Catty
- Vegetative
- Minty
- Grassy
- Metallic
- Pineapple
- Bready
- Spicy
- Woodsy



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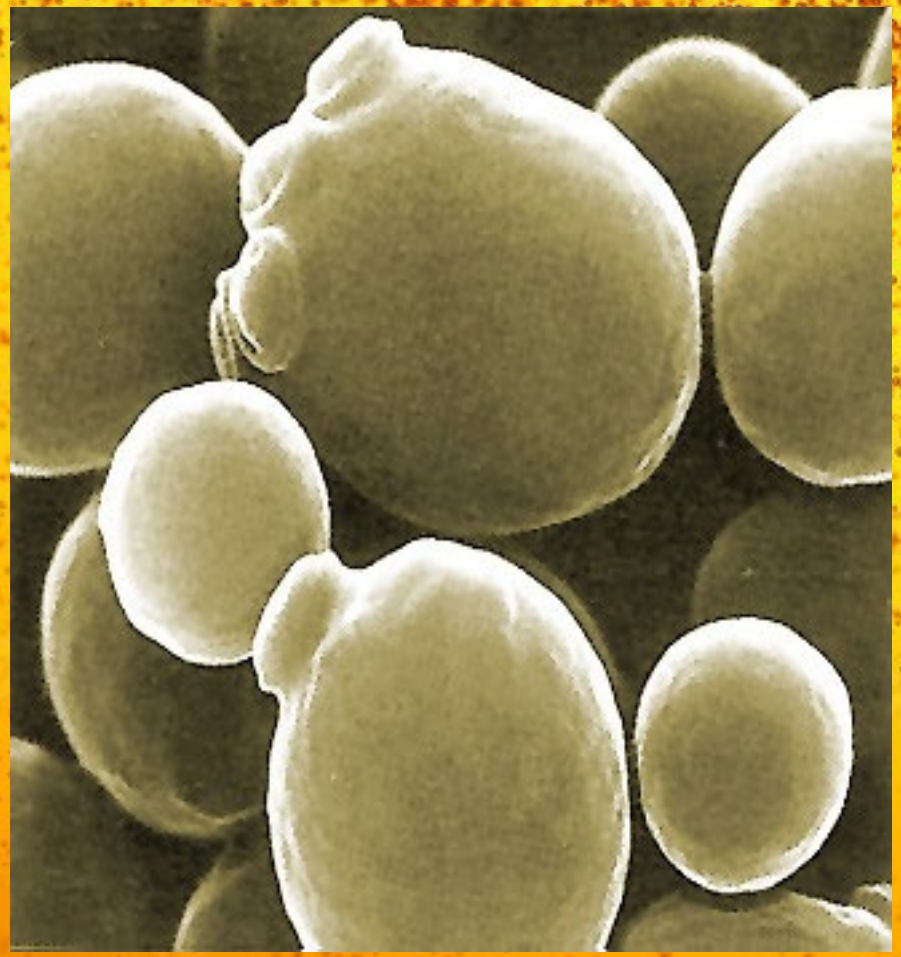
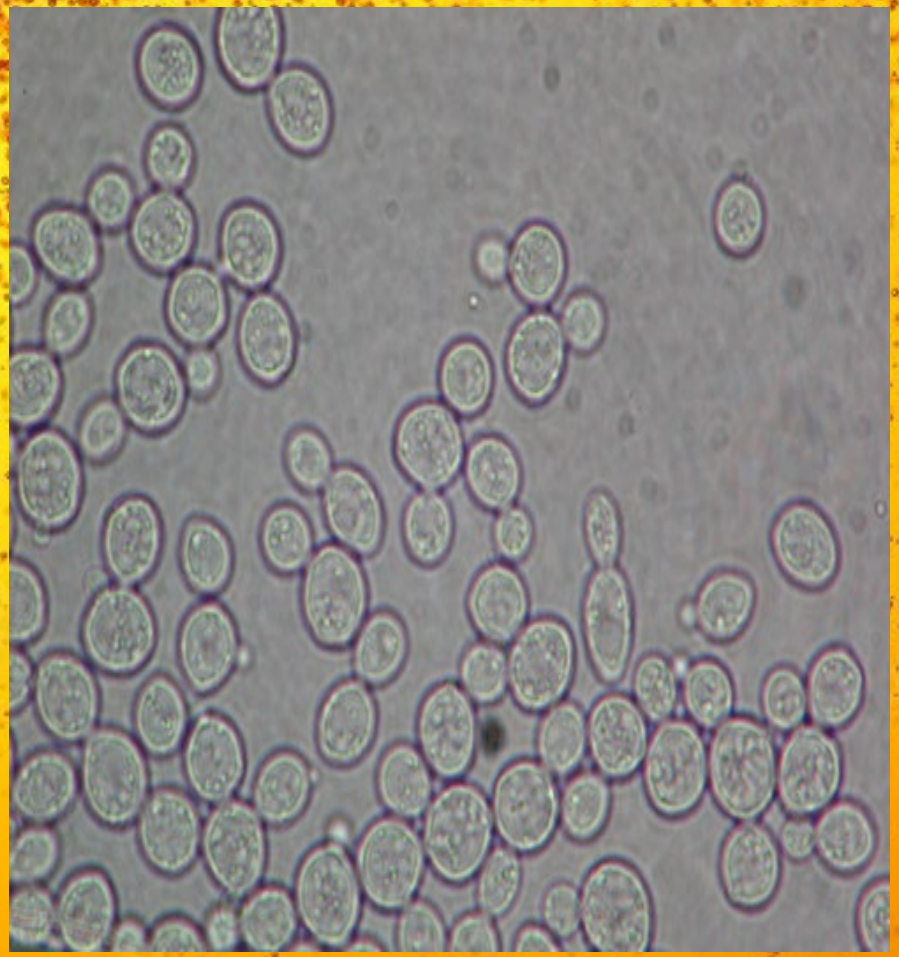
Yeast





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Yeast

Yeast produce:

Esters: fruity flavors produced early in fermentation and not removed during maturation. The amount produced is heavily influenced by yeast health, pitching rate, fermentation temperature, and wort properties.

Higher Alcohols: fruity, boozy, winey flavors, produced early in the fermentation and not removed during maturation. The amount produced is heavily influenced by yeast health, pitching rate, temperature and wort properties.

Vicinal Diketones: buttery flavors produced early in fermentation and then removed by yeast during maturation. The amount produced is heavily influenced by fermentation temperature, wort aeration, yeast selection and fermentation management by the brewer.

Aldehydes: green apple or pumpkin like flavor created during primary fermentation, then removed by healthy yeast during maturation. The amount is heavily influenced by yeast health and fermentation management by the brewer.

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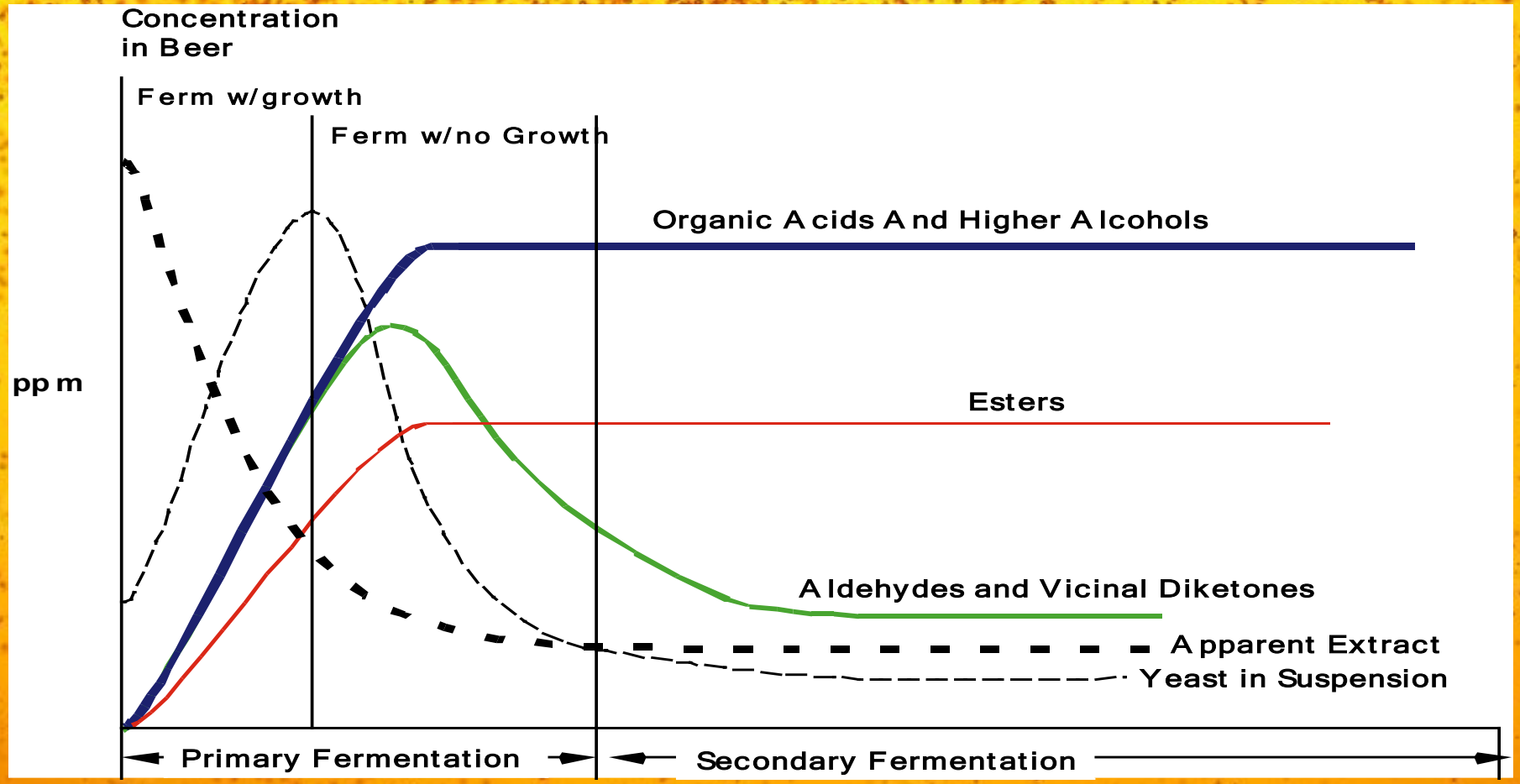
Yeast

Sulfur compounds: H_2S and SO_2 are produced late in primary fermentation then may be “scrubbed” from the beer during maturation either mechanically, chemically or by yeast. The amount produced is influenced by wort properties, and by fermentation management by the brewer.

Organic acids: organic acids oxidize to form stale flavors

Phenols: certain yeast strains are capable of re-arranging phenolic compounds chemically to produce more flavorful phenols ie ferulic acid to 4-vinyl guaiacol in hefe-weizens and Belgian strains.

Yeast



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Yeast

Brewers have control over:

Pitching rate
- 1 million cells per ml per °Plato

Wort properties
- wort sugar spectrum, degree of attenuation, FAN, wort aeration, hot/cold break removal.

Yeast Strain
- attenuation, ester production, flocculation, VDKs.

Temperature
- affects rate of fermentation.

Pressure
- affects production of sulfur compounds particularly.

Vessel Geometry
- effects rate of fermentation and removal of volatiles.

Yeast Health, viability and vitality
- harvesting and storage

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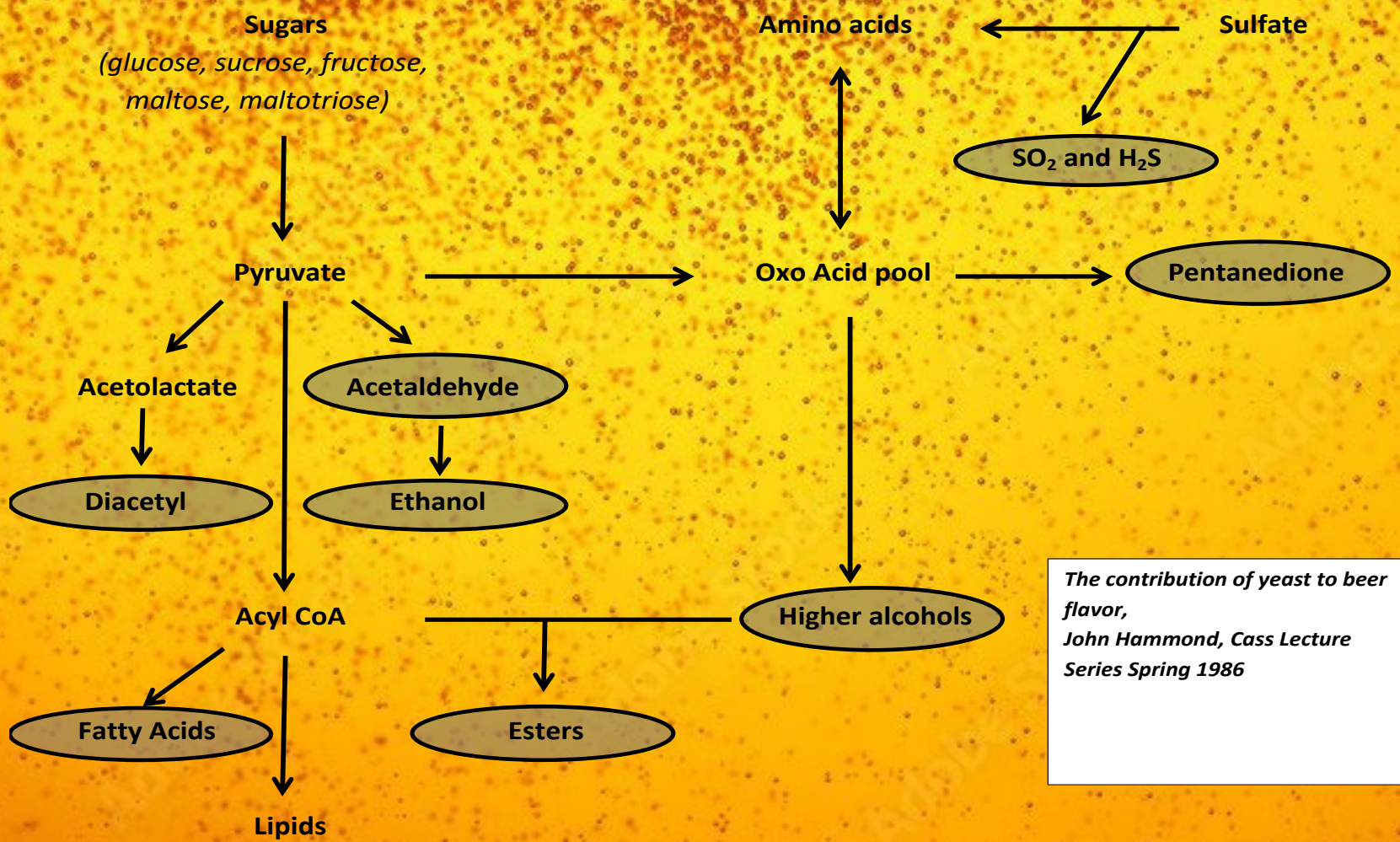
Yeast



The contribution of yeast to beer flavor,
John Hammond, Cass Lecture Series Spring 1986

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Process

Process

- Mash temperature impacts the degree of fermentability
  - 149 F → 2 Plato finishing gravity….. 156 F → 3.5 Plato beer
  - Extract recovery heavily influences beer flavor.
  - Poor run off can lead to over extraction of astringent polyphenols.
  - High sparging temperature can lead to over extraction of gummy beta glucans.
- Poor boiling can lead to DMS in the beer.
- Poor boiling leads to poor hop extraction performance.
- Poor wort cooling leads to increased DMS and unpredictable bitterness and aroma.

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Aging and Staling

Aging and Staling

The main pre-cursors to stale beer flavor are

melanoidins, lipids, higher alcohols, isohumulones, phenols, polyphenols, amino acids, esters, and proteins.

ie malt, hops and yeast.

and are present at up to 10,000 times the concentrations of the stale flavors they result in.

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Thank you

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