

FOR THE LOVE OF BEER

An overview of Beer and The Brewing Process



Sponsored by the FOSSILS and LAGERS

Hosted by the New Albanian Brewing
Company

Presented by

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May 5 through June 30, 2011

Syllabus

May 5th

- Course Overview
- History of Brewing
- Introduction to Ingredients
 - Barley Malt
 - Hops
 - Water
 - Yeast

Beer List

1. Light Lager
 - a. Lite American Lager
 - b. Standard American Lager
 - c. Premium American Lager
 - d. Munich Helles
 - e. Dortmunder Export
2. Pilsner
 1. German Pilsner
 2. Bohemian Pilsener
 3. Classic American European

Syllabus (cont.)

May 12th

Brewing Process

- Mashing
- Lauter & Sparge
- Hop Additions & Boil
- Cooling & Break Separation
- Fermentation

Beer List

3. European Amber Lager
 1. Vienna Lager
 2. Oktoberfest/Märzen
4. Dark Lager
 - a. Dark American Lager
 - b. Munich Dunkel
 - c. Schwartzbier
5. Bock
 - a. Maibock/Helles Bock
 - b. Traditional Bock
 - c. Doppelbock
 - d. Eisbock

Syllabus (cont.)

May 26th

- Detecting Aromas/Flavors
- Evaluating Beers
- Judging Techniques
- Overview of Beer Styles

Beer List

6. Light Hybrid Beer
 - a. Cream Ale
 - b. Blonde Ale
 - c. Kölsch
 - d. American Wheat/Rye Beer
7. Amber Hybrid Beer
 - a. North German Altbier
 - b. California Common
 - c. Düsseldorf Altbier
8. English Pale Ale
 - a. Standard/Ordinary Bitter
 - b. Special/Best/Premium Bitter
 - c. Extra Special/Strong Bitter (English Pale Ale)

Syllabus (cont.)

June 2nd

Beer List

- 
9. Scottish and Irish Ale
- a. Scottish Light 60 Shilling
 - b. Scottish Heavy 70 Shilling
 - c. Scottish Export 80 Shilling
 - d. Irish Red Ale
 - e. Strong Scotch Ale
10. American Ale
- a. American Pale Ale
 - b. American Amber Ale
 - c. American Brown Ale

Beer List (continued)

11. English Brown Ale
- a. Mild
 - b. Southern English Brown
 - c. Northern English Brown
12. Porter
- a. Brown Porter
 - b. Robust Porter
 - c. Baltic Porter

Syllabus (cont.)

June 9th

Beer List

13. Stout

- a. Dry Stout
- b. Sweet Stout
- c. Oatmeal Stout
- d. Foreign Extra Stout
- e. American Stout
- f. Russian Imperial Stout

14. India Pale Ale (IPA)

- a. English IPA
- b. American IPA
- c. Imperial IPA

Beer List (continued)

15. German Wheat and Rye Beer

- a. Weizen/Weissbier
- b. Dunkelweizen
- c. Weizenbock
- d. Roggenbier

Syllabus (cont.)

June 23rd

Beer List

16. Belgian and French Ale
 - a. Witbier
 - b. Belgian Pale Ale
 - c. Saison
 - d. Bière de Garde
 - e. Belgian Specialty Ale

Beer List (continued)

17. Sour Ale
 - a. Berliner Weisse
 - b. Flanders Red Ale
 - c. Flanders Brown Ale (Oud Bruin)
 - d. Straight (Unblended) Lambic
 - e. Gueuze
 - f. Fruit Lambic

Syllabus (cont.)

June 30th

Beer List

- 18. Belgian Strong Ale
 - a. Belgian Blond ale
 - b. Belgian Dubbel
 - c. Belgian Tripel
 - d. Belgian Golden Strong Ale
 - e. Belgian Dark Strong
- 19. Strong Ale
 - a. Old Ale
 - b. English Barley Wine
 - c. American Barley Wine
- 20. Fruit Beer

Beer List (continued)

- 21. Spice/Herb/Vegetable Beer
 - a. Spice, Herb or Vegetable Beer
 - b. Christmas/Winter Specialty Spiced Beer
- 22. Smoke-Flavored and Wood Aged Beer
 - 21. Classic Rauchbier
 - 22. Other Smoked Beer
 - 23. Wood-Aged Beer
- 23. Specialty Beer

Syllabus (cont.)

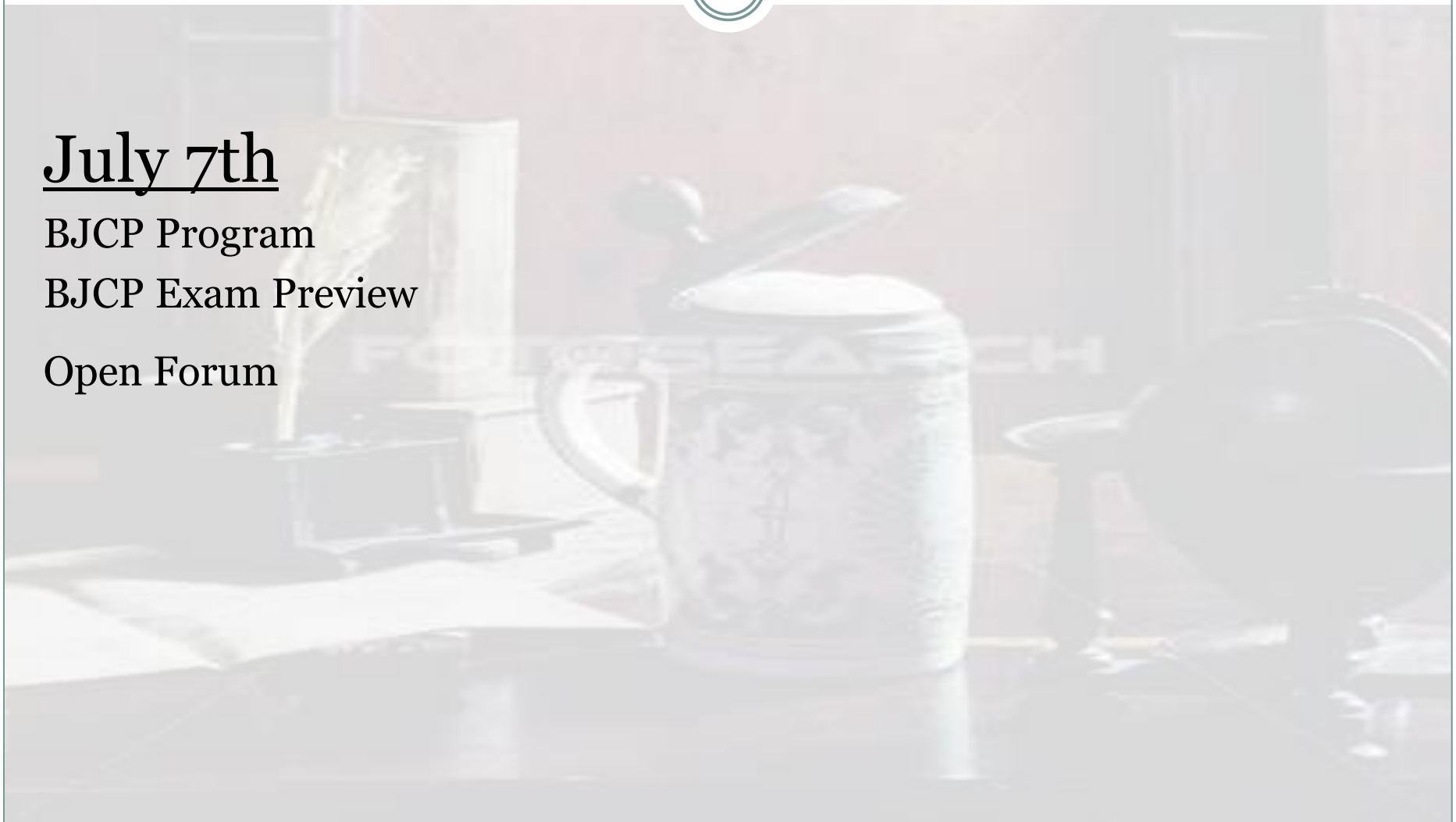


July 7th

BJCP Program

BJCP Exam Preview

Open Forum



Syllabus (cont.)

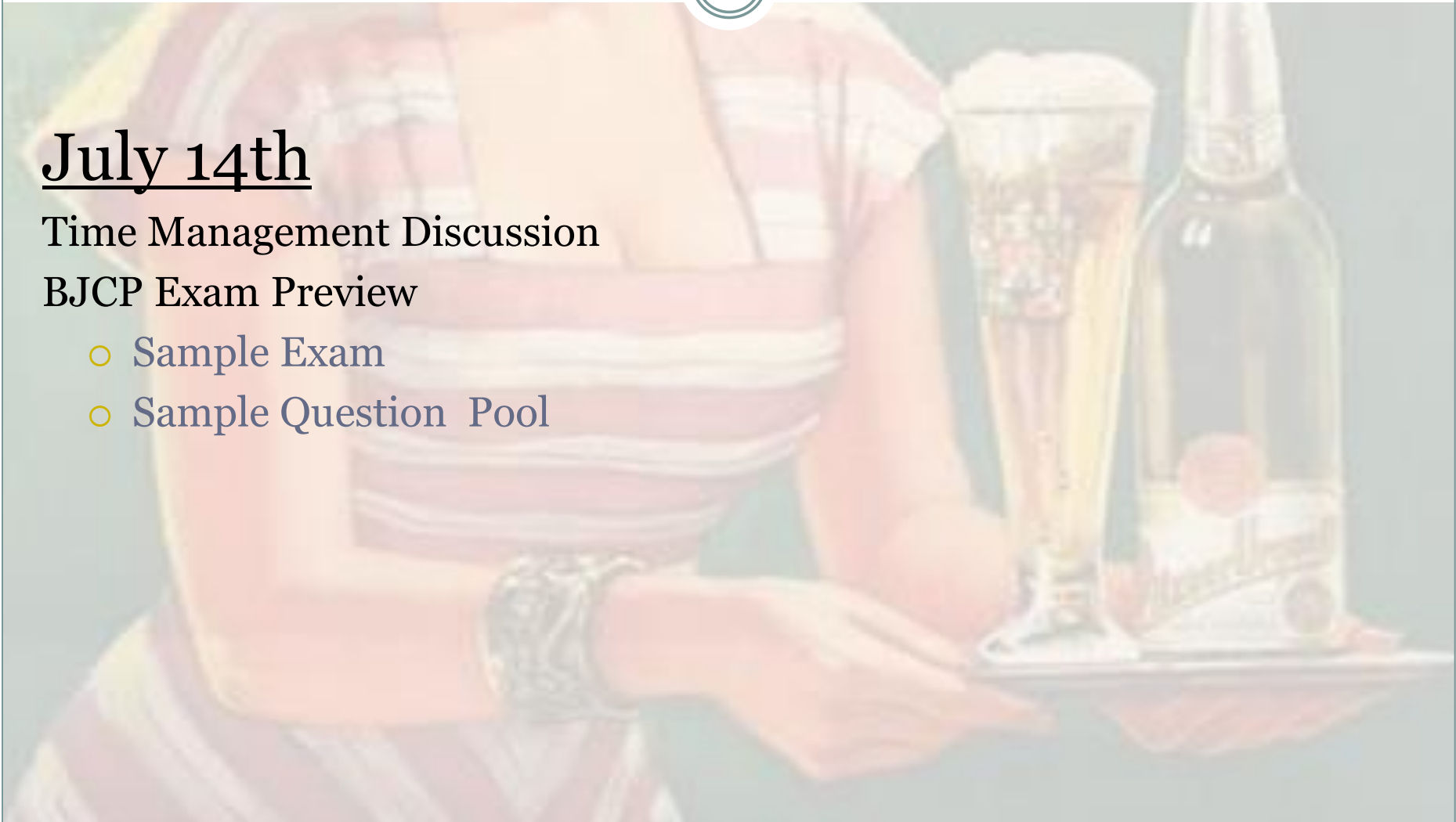


July 14th

Time Management Discussion

BJCP Exam Preview

- Sample Exam
- Sample Question Pool



Syllabus (cont.)

July 19st

Overview of Brewing Questions

Overview of Flavors & Flaws

- Defining flavors/flaws
- Causes
- How to avoid
- Examples in various styles



Syllabus (cont.)



July 21st

Review of Beer Styles

Review Methods of Presentation

- Define
 - ✦ Statistics and Full Four Part Verbal Description
- History, Unique Characteristics & Location
- Compare and Contrast with Other Styles

1A. Lite American Lager

- **Aroma:** Little to no malt aroma, although it can be grainy, sweet or corn-like if present. Hop aroma may range from none to a light, spicy or floral hop presence. Low levels of yeast character (green apples, DMS, or fruitiness) are optional but acceptable. No diacetyl.
- **Appearance:** Very pale straw to pale yellow color. White, frothy head seldom persists. Very clear.
- **Flavor:** Crisp and dry flavor with some low levels of grainy or corn-like sweetness. Hop flavor ranges from none to low levels. Hop bitterness at low level. Balance may vary from slightly malty to slightly bitter, but is relatively close to even. High levels of carbonation may provide a slight acidity or dry "sting." No diacetyl. No fruitiness.
- **Mouthfeel:** Very light body from use of a high percentage of adjuncts such as rice or corn. Very highly carbonated with slight carbonic bite on the tongue. May seem watery.
- **Overall Impression:** Very refreshing and thirst quenching.
- **Comments:** A lower gravity and lower calorie beer than standard international lagers. Strong flavors are a fault. Designed to appeal to the broadest range of the general public as possible.
- **Ingredients:** Two- or six-row barley with high percentage (up to 40%) of rice or corn as adjuncts.
- **Vital Statistics:** OG: 1.028 – 1.040 IBUs: 8 – 12 FG: 0.998 – 1.008 SRM: 2 – 3 ABV: 2.8 – 4.2%
Commercial Examples: Bitburger Light, Sam Adams Light, Heineken Premium Light, Miller Lite, Bud Light, Coors Light, Baltika #1 Light, Old Milwaukee Light, Amstel Light



Miller
Good call.

History of Brewing



- **Wild Barley Harvested** 17,000 BC
 - Grain Heads Shatter
 - Mature Grain Falls to Ground
 - Unripe Grain Unsuitable for Malting
- **Barley Domesticated** 7,000 BC
 - “Selective Breeding”
 - ✦ Plants with tough Rachis Hold Grain
 - ✦ Mature Grain Suitable for Planting

History (Continued)



- **Development of Pottery** 6,000 BC
 - Needed to Hold Large Volumes of Liquid
 - Needed to Withstand Heat
 - Somewhat Anaerobic and Antiseptic Fermentation
- **Discovery of Malting** 6,000 BC?
 - Malting to This Point Still Happenstance
 - Pottery use Allowed Heat by Sun
 - ✦ Skins, Wood, etc. Cooled by Evaporation
 - ✦ Heating by Stones Poorly Controlled

History (Continued)



- **Elevation to High Art** 3,500 BC
 - All Brewmasters Were Women
 - High Art in Mesopotamia & Egypt
 - Two Prominent Deities Ninkasi & Siris to Protect & Honor
 - Beer & Bread Staples of Life
- **Barley Culture & Brewing Spread** 1st to 8th Century
 - Carried by Roman & Christian Expansion
 - Barley well adapted to mid & north Europe
 - Climate more suited to “controlled” brewing

History (Continued)



● Viking Influence

8th to 10th Century

- Culture Centered on Conquest & Ale
- Ale Main Basis of Commerce
- Heaven or “Valhalla” Great Ale House in the Sky
- Goddesses “The Valkyries” Barmaids in Valhalla
- Plundered Most of Europe and Middle East
- Carried Their Love of Ale With Them
- Gruit the Main “Seasoning” of Ale



The Gruuthuse Brugge, Belgium



History (Continued)



- **Monastic Influence** 11th to 15th Century
 - Men First Appear as Brewers
 - Primary Occupation for Many
 - Significant Advances in Equipment & Technique
 - Larger Scale Brewing Developed
 - Hops Used Widespread
 - Controlled by the Church



15th Century Brewing Tools



15th Brew Kettle



15th Century Fermenters



1516 AD



- # Head Control By Government e Control for Summer ned Ingredients urity Law mmerce for over Two ential Today

History (Continued)



● Industrial Revolution 18th Century

- Instrumentation Developed
- Steam Power Harnessed
- Cities Expanded Dramatically
- Demand for Beer Increased
- Once Again Major Commodity for Trade
 - ✦ IPA & Imperial Stout
 - ✦ Stouts from Ireland
 - ✦ Export Styles from Germany



1B. Standard American Lager



- **Aroma:** Little to no malt aroma, although it can be grainy, sweet or corn-like if present. Hop aroma may range from none to a light, spicy or floral hop presence. Low levels of yeast character (green apples, DMS, or fruitiness) are optional but acceptable. No diacetyl.
- **Appearance:** Very pale straw to medium yellow color. White, frothy head seldom persists. Very clear.
- **Flavor:** Crisp and dry flavor with some low levels of grainy or corn-like sweetness. Hop flavor ranges from none to low levels. Hop bitterness at low to medium-low level. Balance may vary from slightly malty to slightly bitter, but is relatively close to even. High levels of carbonation may provide a slight acidity or dry "sting." No diacetyl. No fruitiness.
- **Mouthfeel:** Light body from use of a high percentage of adjuncts such as rice or corn. Very highly carbonated with slight carbonic bite on the tongue.
- **Overall Impression:** Very refreshing and thirst quenching.
- **Comments:** Strong flavors are a fault. An international style including the standard mass-market lager from most countries.
- **Ingredients:** Two- or six-row barley with high percentage (up to 40%) of rice or corn as adjuncts.
- **Vital Statistics:** OG: 1.040 – 1.050 IBUs: 8 – 15 FG: 1.004 – 1.010 SRM: 2 – 4 ABV: 4.2 – 5.3%
Commercial Examples: Pabst Blue Ribbon, Miller High Life, Budweiser, Baltika #3 Classic, Kirin Lager, Grain Belt Premium Lager, Molson Golden, Labatt Blue, Coors Original, Foster's Lager

Brewing Ingredients



- **Malt**
 - Barley Malt
 - Other Grains
- **Hops**
 - Parts of Hop Plant
 - Hop Varieties
- **Water**
 - Importance of Water
 - Mineral Adjustment
- **Yeast**
 - Yeast Characteristics
 - Types of Yeast

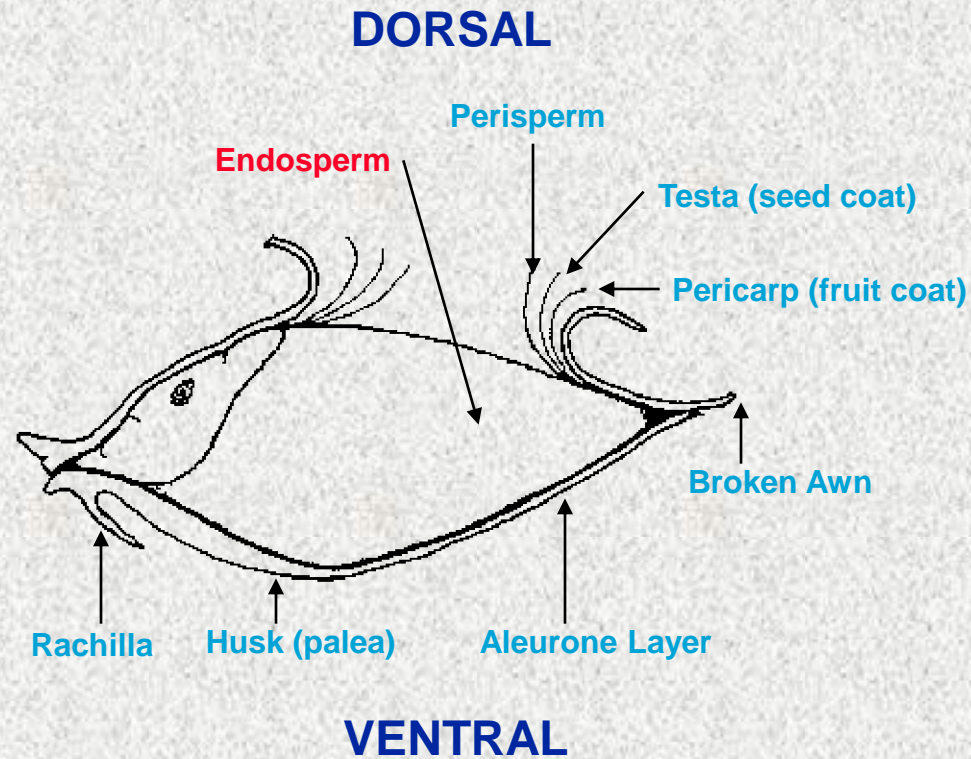


Barley Malt



- **Why Barley?**
 - Husk Protects Grain
 - High Diastatic Power
 - Husk Aids in Lautering
 - Full & Complex Flavor
- **What is Barley ?**
 - Mature Seed of Gramineae Hordeum
- **Major Parts of Kernel**
 - Endosperm
 - Embryo
 - Husk

Cross Section of a Kernel



Types of Barley



- **Wild Barley - *Hordeum Sponteneae***
 - No Use in Malting
- **Two Row - *Hordeum Distichon* L.**
 - Primary European Malting Barley
 - Larger Endosperm
 - Lower Diastatic Power
- **Six Row - *Hordeum Vulgaere* L.**
 - Primary U.S Malting Barley
 - High Yields
 - High Diastatic Power
- **Four Row - Variant of Six Row**
- **Naked or Huskless Barley**

View of Barley Head

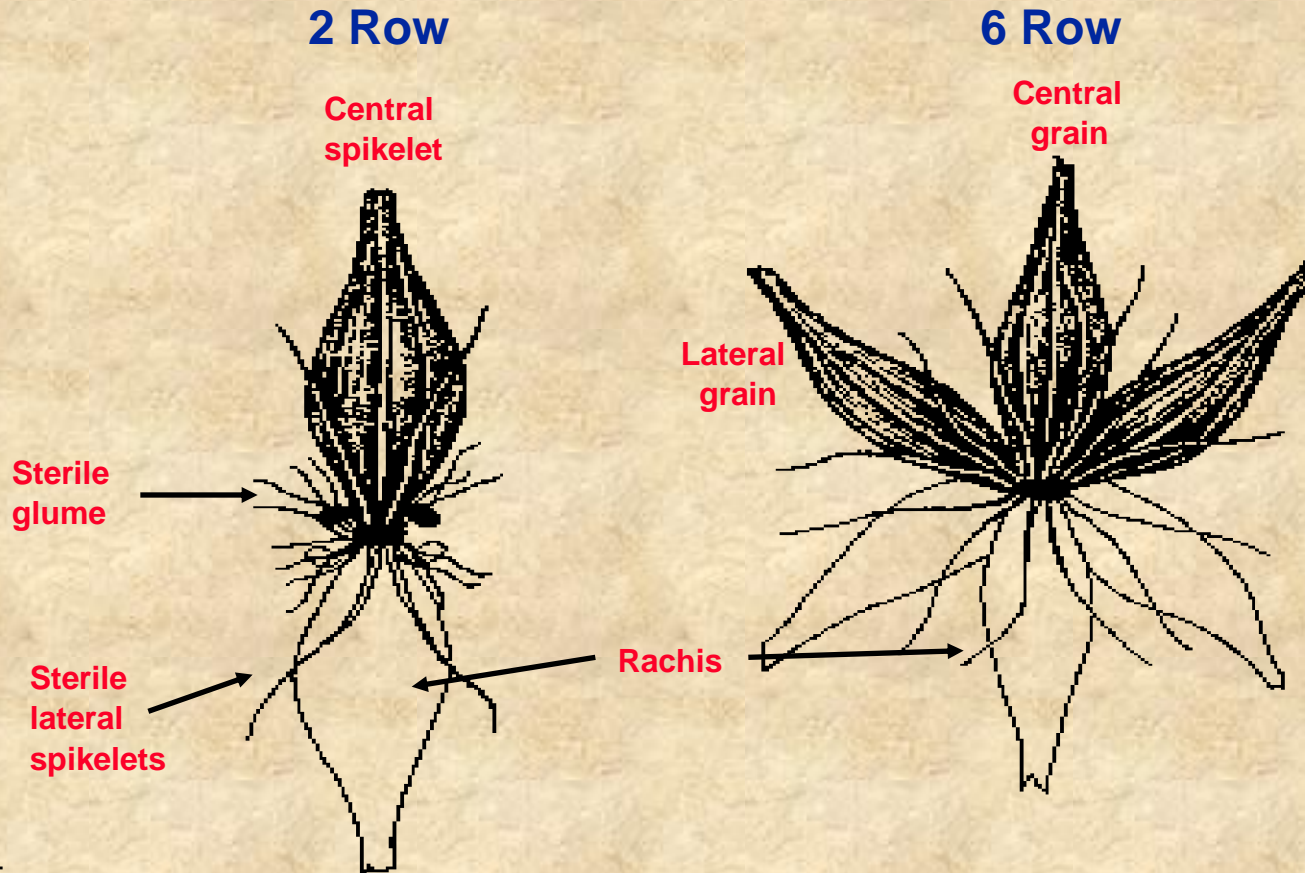


Photo Comparison of Kernels

California Coast Six Row

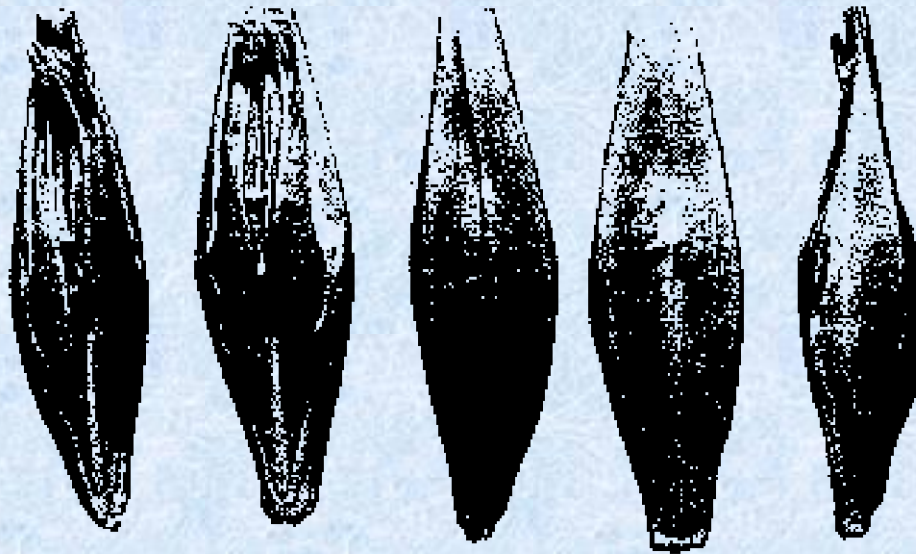
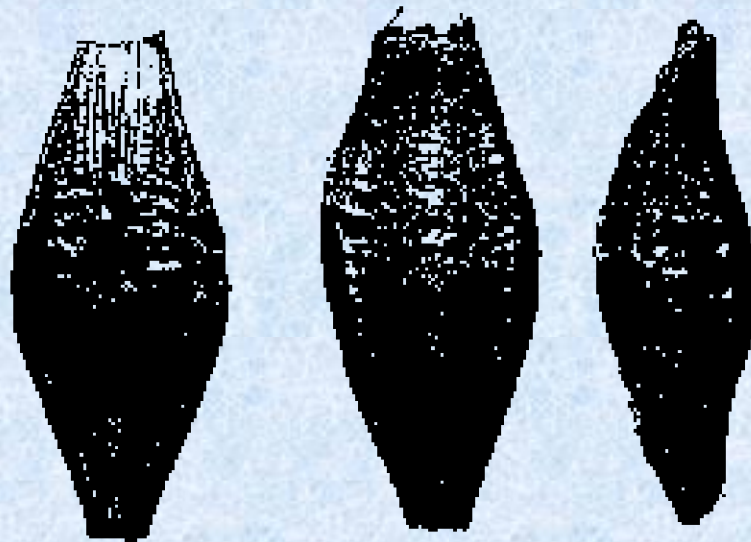


Photo Comparison of Kernels

**Moravian
Two Row**



1C. Premium American Lager



- **Aroma:** Low to medium-low malt aroma, which can be grainy, sweet or corn-like. Hop aroma may range from very low to a medium-low, spicy or floral hop presence. Low levels of yeast character (green apples, DMS, or fruitiness) are optional but acceptable. No diacetyl.
- **Appearance:** Pale straw to gold color. White, frothy head may not be long lasting. Very clear.
- **Flavor:** Crisp and dry flavor with some low levels of grainy or malty sweetness. Hop flavor ranges from none to low levels. Hop bitterness at low to medium level. Balance may vary from slightly malty to slightly bitter, but is relatively close to even. High levels of carbonation may provide a slight acidity or dry "sting." No diacetyl. No fruitiness.
- **Mouthfeel:** Medium-light body from use of adjuncts such as rice or corn. Highly carbonated with slight carbonic bite on the tongue.
- **Overall Impression:** Refreshing and thirst quenching, although generally more filling than standard/lite versions.
- **Comments:** Premium beers tend to have fewer adjuncts than standard/lite lagers, and can be all-malt. Strong flavors are a fault, but premium lagers have more flavor than standard/lite lagers. A broad category of international mass-market lagers ranging from up-scale American lagers to the typical "import" or "green bottle" international beers found in America.
- **Ingredients:** Two- or six-row barley with up to 25% rice or corn as adjuncts.
- **Vital Statistics:** OG: 1.046 – 1.056 IBUs: 15 – 25 FG: 1.008 – 1.012 SRM: 2 – 6 ABV: 4.6 – 6%
Commercial Examples: Full Sail Session Premium Lager, Miller Genuine Draft, Corona Extra, Michelob, Coors Extra Gold, Birra Moretti, Heineken, Beck's, Stella Artois, Red Stripe, Singha

Malting Process



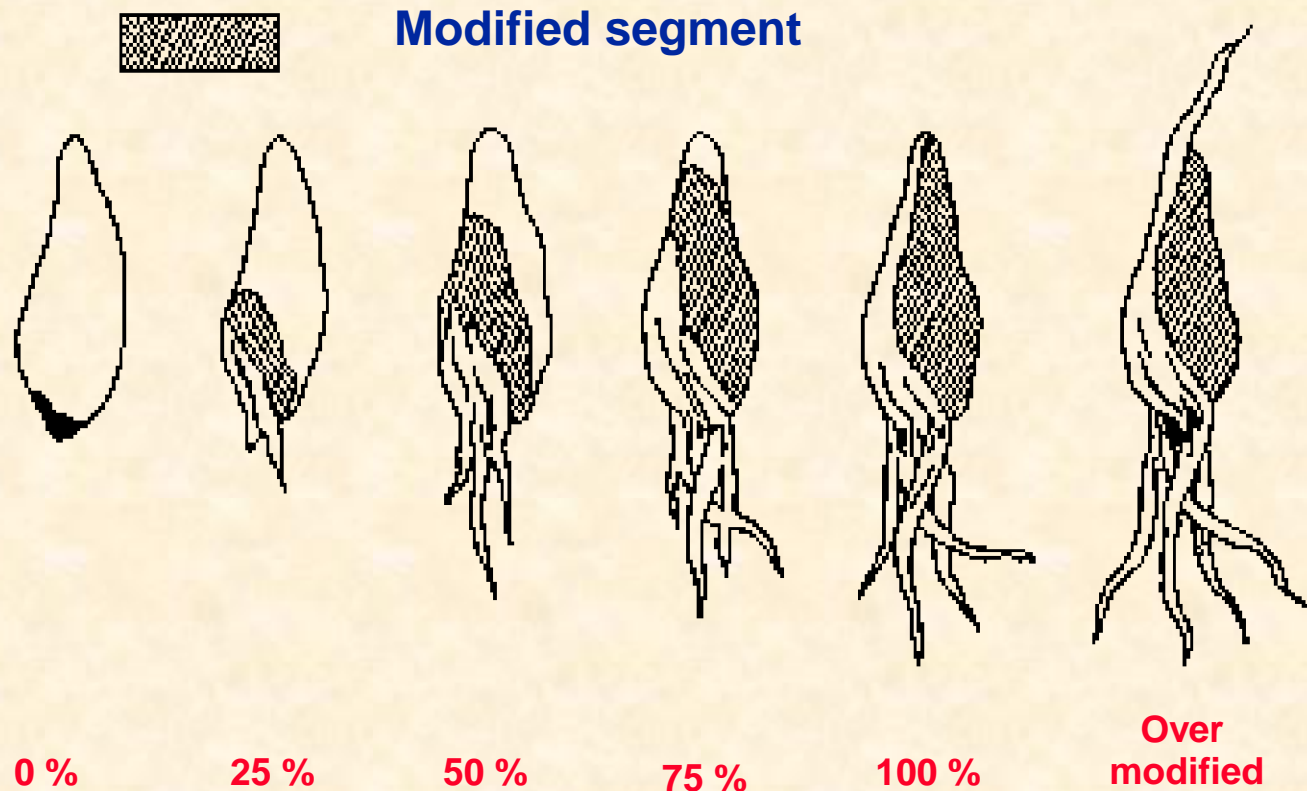
- What is Malt?
 - Controlled Sprouting of Grain, Particularly Barley
 - Starches and Sugars Become Accessible (Modification)
 - Enzyme Activity Greatly Enhanced
 - Husk and Outer Protective Coating More Permeable
 - Precise Termination of Plant Growth
- Steeping
 - Grain Soaked to Moisture Level of 35-37%
 - ✦ 55 to 65° F. for 8 to 16 hours
 - Air Rest Stimulates Vigorous Growth - 12 to 24 Hours
 - Spray Wetting to Moisture Level of 43-45%
 - ✦ Needed to Support Growth During Germination

Malting Process (cont.)



- **Germination and Sprouting of Grain**
 - Endosperm becomes Modified - Glassy & Steely to White & Mealy
 - α -Glucosidase in Aleurone Layer Increases
 - β -Amylase in Subaleurone Layer - Solubility Increases
 - α -Amylase Synthesized in Large Amounts
- **Terminating Germination**
 - Grain is Dried at Moderate Temp. 114-140°F.
 - High Air Flow Reduces “Free Moisture” to ~25%
 - Flow Reduced to Allow Moisture Migration to ~12%
 - Evaporation Cools Grain Internal Temp 70-100°F.
 - Air Temp. Increased to 150-165°F. to “Hand Dry” Stage
 - ✦ 6-8% Moisture Level

Modification and Growth of the Acrospire



Kilning



- Reduces Final Moisture to 2-3%
- Develops Flavor and Color of Malt
- Final Characteristics Determined By:
 - Moisture Content at Start of Kiln
 - Duration of Kiln
 - Temperature of Kiln
 - Kilning Media (Indirect or Direct Smoke)
- Basic Types
 - Pale Malts 130-180°F. Single Stage
 - Vienna and Munich 145°F. then Raised to 210-245°F.
 - Crystal 150-170°F. While at 40-50% Moisture Level
 - Chocolate & Black Final Roast at 420-450°F.

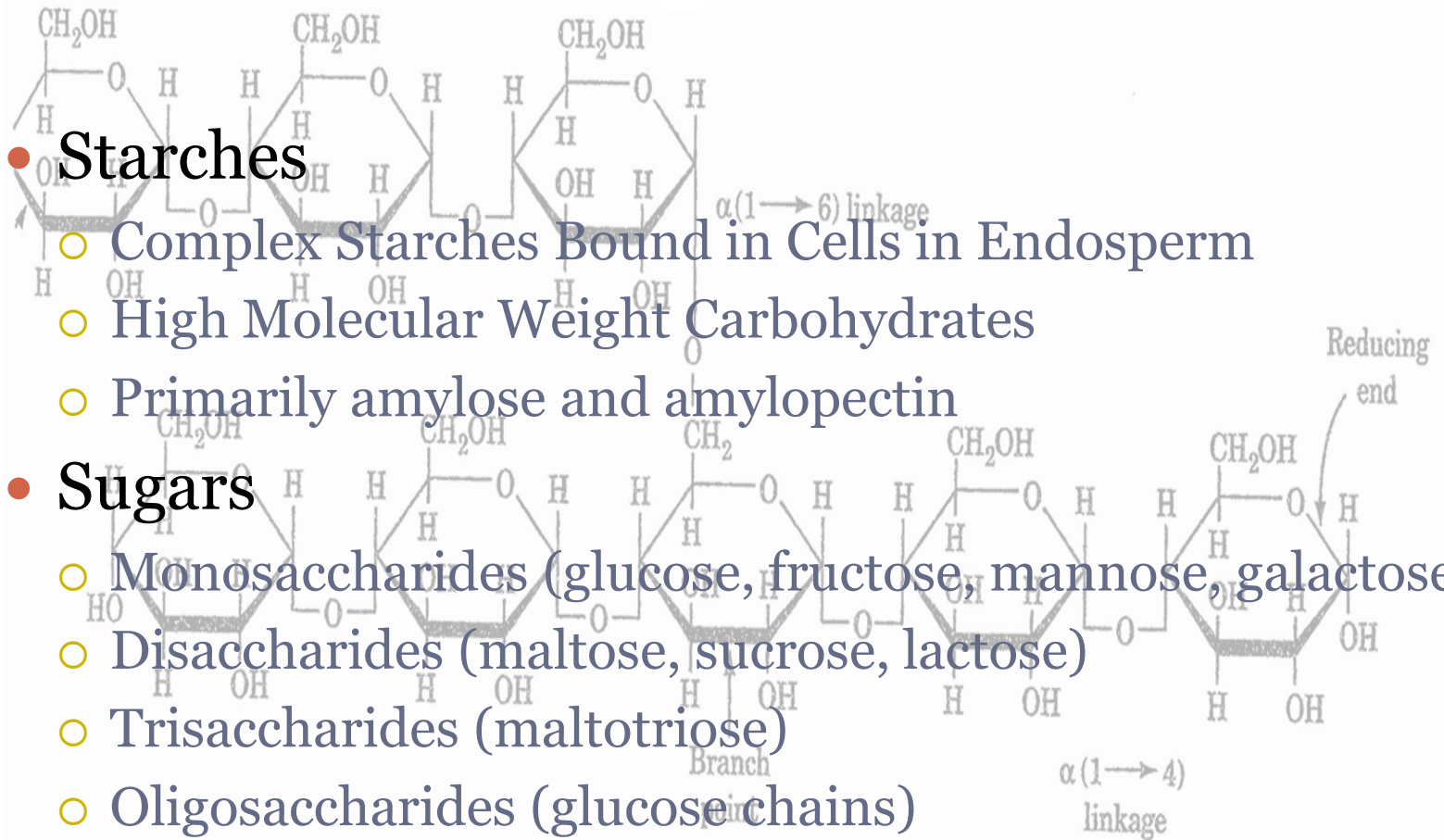
Malt Components

• Starches

- Complex Starches Bound in Cells in Endosperm
- High Molecular Weight Carbohydrates
- Primarily amylose and amylopectin

• Sugars

- Monosaccharides (glucose, fructose, mannose, galactose)
- Disaccharides (maltose, sucrose, lactose)
- Trisaccharides (maltotriose)
- Oligosaccharides (glucose chains)



Malt Components (cont.)



- **Enzymes**

- Diastatic – (α -Amylase, β -Amylase, α -1,6-Glucosidase)

Hydrolysis of starches into fermentable sugars

- Proteolytic - Reduce HMW proteins to valuable amino acids

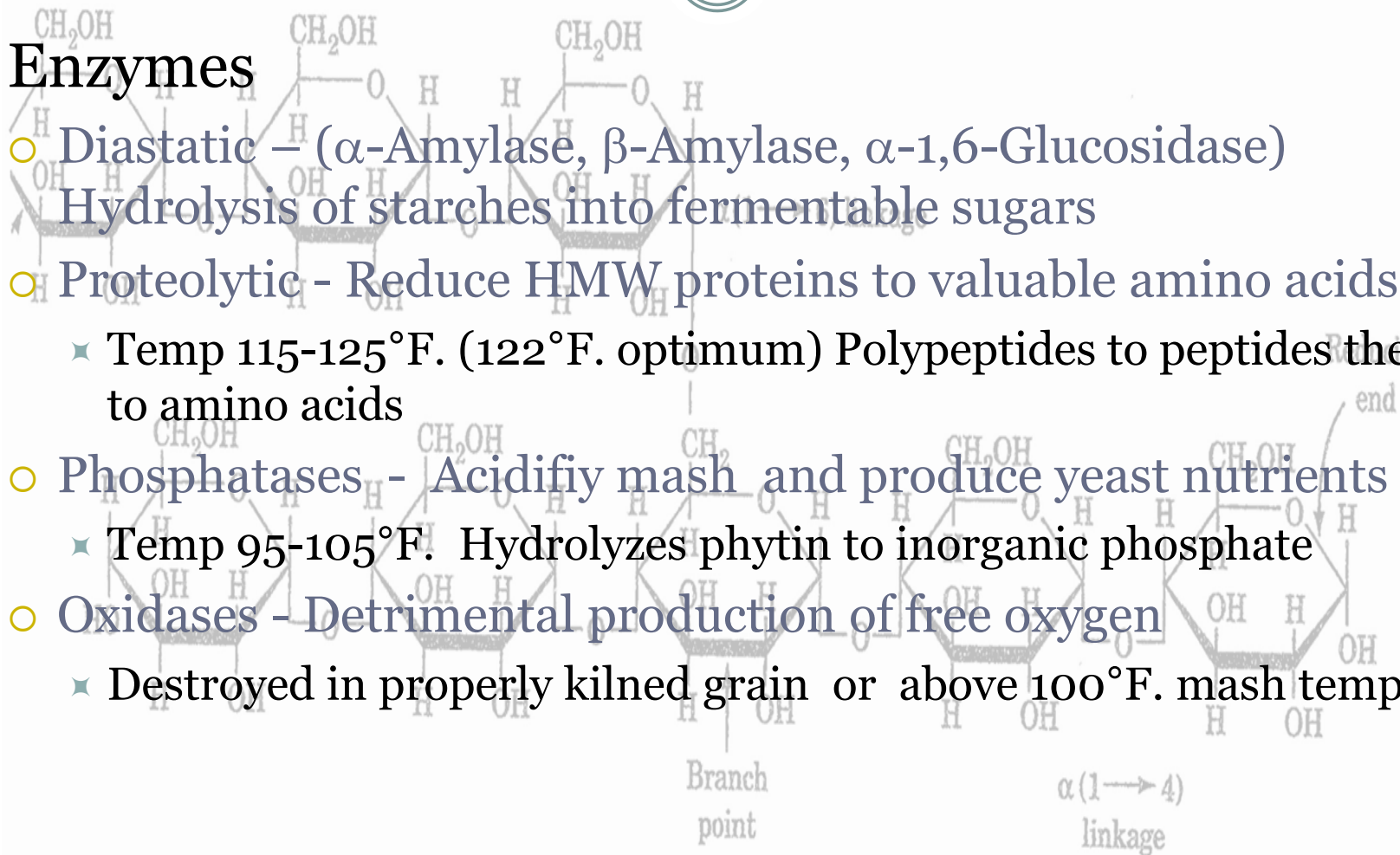
- ✦ Temp 115-125°F. (122°F. optimum) Polypeptides to peptides then to amino acids

- Phosphatases - Acidify mash and produce yeast nutrients

- ✦ Temp 95-105°F. Hydrolyzes phytin to inorganic phosphate

- Oxidases - Detrimental production of free oxygen

- ✦ Destroyed in properly kilned grain or above 100°F. mash temps.



Malt Components (cont.)



- **Proteins**
 - HMW proteins form hazes, particularly chill haze
 - Must be reduced to albumins for head retention and amino acids for yeast nutrition
- **Tannins**
 - Reside primarily in husk of grain
 - Polyphenols cause astringency
 - Cause permanent hazes in finished beer
- **Cellulose**
 - Reside primarily in husk and in starch cell walls
 - Hemicellulose degraded to oligosaccharides by *cytase*
 - Partial degradation to gums in undermodified malt causes thick mash

Typical Malt Analyses

PILSEN 2RS MALT

PARAMETER	UNIT	MIN	MAX
Humidity	%		4.6
Extract (dry basis)	%	81.0	
Difference fine – large	%	1.0	2.0
Wort colour	EBC (Lov.)		3.5 (1.8)
Post coloration	EBC (Lov.)		5.7 (2.6)
Total Protein (dry malt)	%	9.5	11.0
Soluble protein	%	4.0	
Kolbach Index	%	38.0	44.0
Hartong 45°	%	35.0	43.0
Viscosity	cp		1.58
Beta-glucans	mg/L		250
Ph		5.6	6.0
Diastatic power	WK	250	
Friability	%	80.0	
Glassiness (whole grains)	%		2.5
PDMS			5.0
NDMA	ppb		2.5
Filtration		normal	
Saccharification time	min		15
Clarity of wort		clear	
Calibration: - above 2.5 mm - rejected	%	90.0	
	%		2.0

1D. Munich Helles



- **Aroma:** Pleasantly grainy-sweet, clean Pils malt aroma dominates. Low to moderately-low spicy noble hop aroma, and a low background note of DMS (from Pils malt). No esters or diacetyl.
 - **Appearance:** Medium yellow to pale gold, clear, with a creamy white head.
 - **Flavor:** Slightly sweet, malty profile. Grain and Pils malt flavors dominate, with a low to medium-low hop bitterness that supports the malty palate. Low to moderately-low spicy noble hop flavor. Finish and aftertaste remain malty. Clean, no fruity esters, no diacetyl.
 - **Mouthfeel:** Medium body, medium carbonation, smooth maltiness with no trace of astringency.
 - **Overall Impression:** Malty but fully attenuated Pils malt showcase.
 - **Comments:** Unlike Pilsner but like its cousin, Munich Dunkel, Helles is a malt-accentuated beer that is not overly sweet, but rather focuses on malt flavor with underlying hop bitterness in a supporting role.
 - **History:** Created in Munich in 1895 at the Spaten brewery by Gabriel Sedlmayr to compete with Pilsner-style beers.
 - **Ingredients:** Moderate carbonate water, Pilsner malt, German noble hop varieties.
 - **Vital Statistics:** OG: 1.045 – 1.051 IBUs: 16 – 22 FG: 1.008 – 1.012 SRM: 3 – 5 ABV: 4.7 – 5.4%
- Commercial Examples: Weihenstephaner Original, Hacker-Pschorr Münchner Gold, Bürgerbräu Wolznacher Hell Naturtrüb, Mahr's Hell, Paulaner Premium Lager, Spaten Premium Lager, Stoudt's Gold Lager

Hops



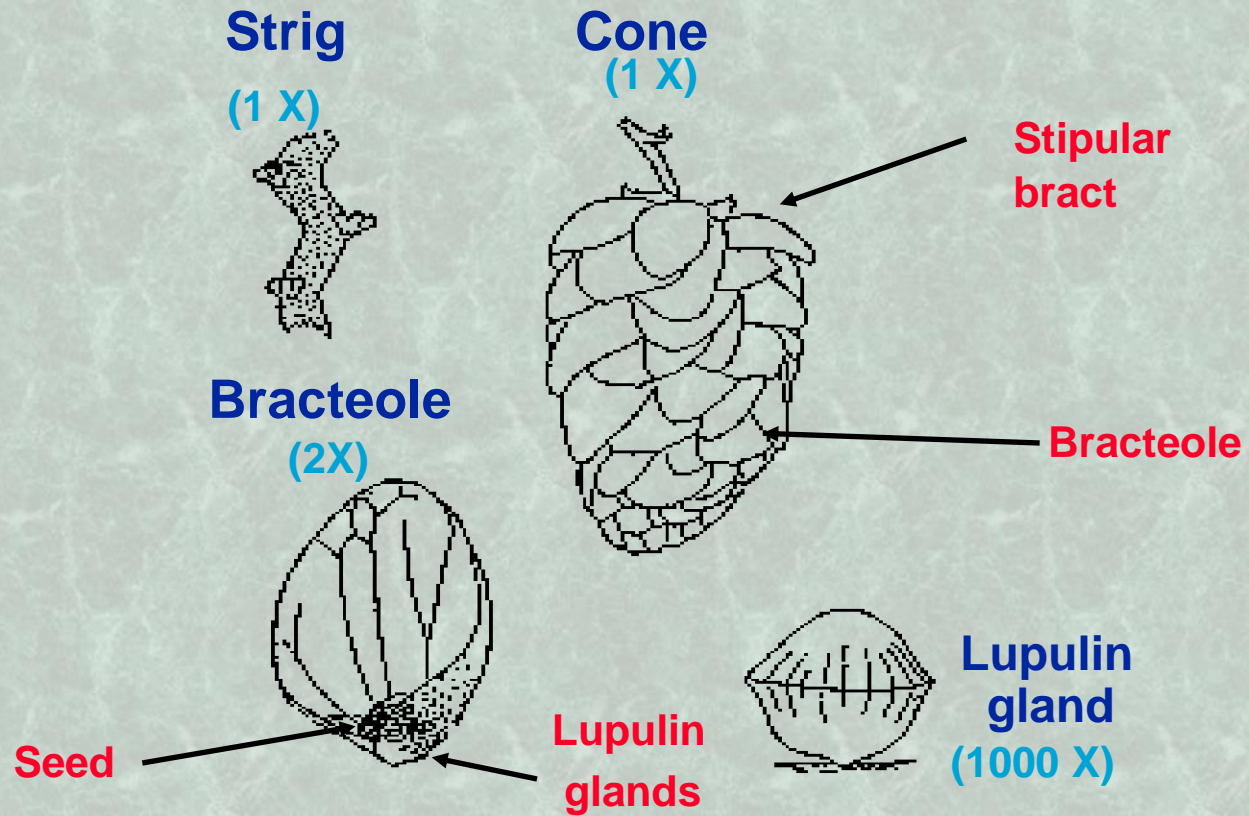
- **What Are Hops?**

- *Humulus lupulus* - Perennial Herb
- Primary Bittering , Flavoring and Aromatic Ingredient in Beer
- Original Usage in Eastern Europe (Bohemia)
- Now Cultivated in Temperate Regions Throughout the World

- **Hop Plant**

- Dioecious Plant - only female cultivated
- Propagated via rizhomes
- Vines or “Bines” grow to height of 20 feet or more
- Cones or Strobiles are borne on the Rachis or Strig
- Cone made of of “pedals” Bracts or Bracteoles
- Lupulin Glands are at base of Bracteoles
 - ✦ Lupulin Glands contains bitter resins and essential oils

View of Hop Strobile



Hop Components



- **Alpha Acids –**

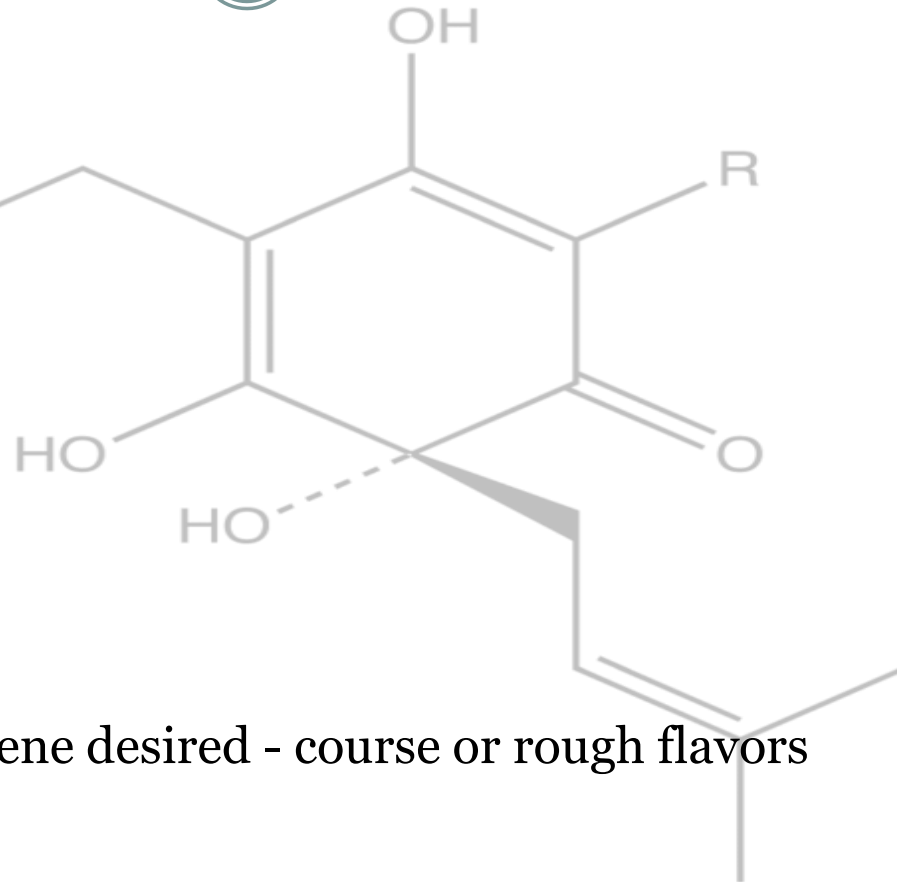
- Humulone
- Adhumulone
- Cohumulone

- **Beta Acids –**

- Lupulone
- Adlupulone
- Colupulone

- **Hop Oils –**

- Myrcene
 - ✦ Less than 50% Myrcene desired - course or rough flavors
- Humulene
- Carophyllene
- 3 to 1 or higher humulene to Carophyllene ratio desired



Alpha & Beta Acids



- **Alpha Acids**

- Content ranges from 2 to 15%
- Must be isomerized to be soluble in wort
- Cohumulone produces harsh bitterness
- Susceptible to oxidation, particularly at high temperatures
- Oxidized alpha acids produce skunky aroma

- **Beta Acids**

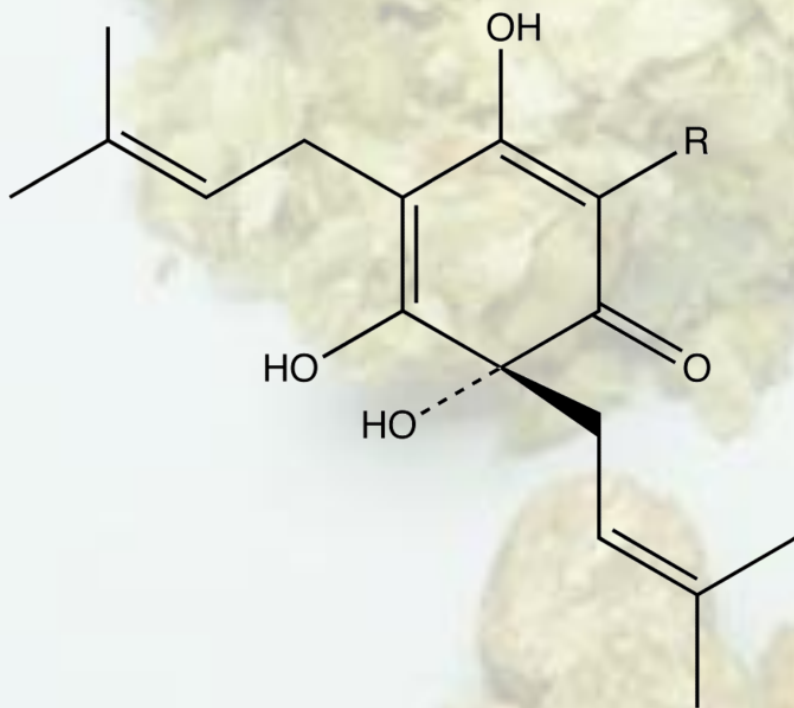
- Poorly isomerized - provide little or no bittering
- Some bitterness when oxidized

Hop Varieties

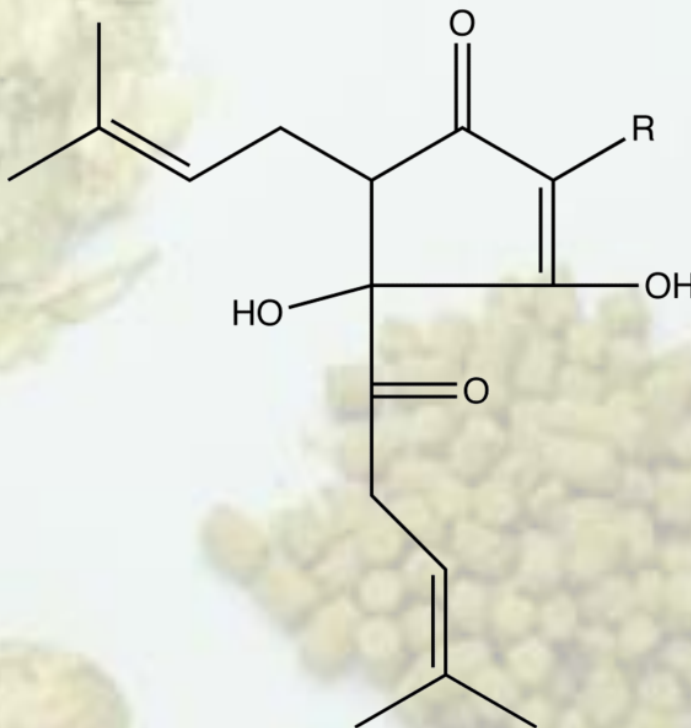


- **Bittering Hops**
 - Moderate to high alpha acid content
 - Alpha to Beta Acid ratio greater than 1
 - Most varieties originated from Brewer's Gold
- **Aroma Hops**
 - Moderate to low alpha acids
 - Alpha to Beta Acid ratio less than 1
 - Wide range of flavors and aromas
 - ✦ Central European - Noble Hops
 - ✦ England - Kent strains more floral & subtle
 - ✦ US - Bold, assertive citrusy, course

Isomerization of α -acids



Humulone



Iso-humulone

Hop Usage



- Bitterness in Finished Beer Standardized
 - International Bitterness Unit= 1.0mg/Liter of iso-alpha acids
 - Estimated in brew calculations as:

$$\text{IBU} = [(\alpha\text{-acid}_n \times \text{ounces}_n \times \text{UF}_n) \times 7462] / [\text{FV} \times (1 + \text{GA})]$$

Where UF is Utilization Factor based on length of boil, FV is Final Volume and GA is Gravity Adjustment calculated as:

$$\text{GA} = (\text{Final Gravity} - 1.050) / 0.22 \text{ for final gravity greater than } 1.050$$

- Homebrew Bittering Units (HBU) = α -acids X ounces

Examples of Hops

Bittering

Type	Typical Alpha Acids	Alpha/Beta Ratio	Total hop oil%	Myrcene%	Humulene %
Brewers Gold	5-8	1.9	1.5	65	12
Centennial	10-12	2.6	1.9	50	14
Chinook	12-14	3.8	2.0	40	22
Cluster	5.5-5.8	1.3	0.6	50	16
Eroica	11-13	2.7	1.1	60	1.0
Galena	12-14	1.6	1.0	55	12
Northern Brewer	7-10	2.0	1.8	30	25
Nugget	12-14	2.7	2.0	57	15
Perle	7-9.5	1.8	0.8	50	31

Aroma

Type	Typical Alpha Acids	Alpha/Beta Ratio	Total hop oil%	Myrcene%	Humulene %
Cascade	4.5-7	1.0	1.2	50	13
Czech Saaz	3-4.5	1.0	0.6	22	42
East Kent Goldings	4.0-5.5	2.3	0.6	23	44
Fuggles	4.5-5.5	1.8	1.8	26	37
Hallertauer Mittlefrüh	3.5-5.5	1.0	1.0	32	40
Styrian Goldings	4.5-6	2.0	0.8	30	36
Tettnanger	3.5-5.5	1.0	0.8	22	22
Willamette	4-6	1.4	1.2	50	25

1E. Dortmunder Export

- Aroma: Low to medium noble (German or Czech) hop aroma. Moderate Pils malt aroma; can be grainy to somewhat sweet. May have an initial sulfury aroma (from water and/or yeast) and a low background note of DMS (from Pils malt). No diacetyl.
- Appearance: Light gold to deep gold, clear with a persistent white head.
- Flavor: Neither Pils malt nor noble hops dominate, but both are in good balance with a touch of malty sweetness, providing a smooth yet crisply refreshing beer. Balance continues through the finish and the hop bitterness lingers in aftertaste (although some examples may finish slightly sweet). Clean, no fruity esters, no diacetyl. Some mineral character might be noted from the water, although it usually does not come across as an overt mineral flavor.
- Mouthfeel: Medium body, medium carbonation.
- Overall Impression: Balance and smoothness are the hallmarks of this style. It has the malt profile of a Helles, the hop character of a Pils, and is slightly stronger than both.
- Comments: Brewed to a slightly higher starting gravity than other light lagers, providing a firm malty body and underlying maltiness to complement the sulfate-accentuated hop bitterness. The term "Export" is a beer strength category under German beer tax law, and is not strictly synonymous with the "Dortmunder" style. Beer from other cities or regions can be brewed to Export strength, and labeled as such.
- History: A style indigenous to the Dortmund industrial region, Dortmunder has been on the decline in Germany in recent years.
- Ingredients: Mineraally water with high levels of sulfates, carbonates and chlorides, German or Czech noble hops, Pilsner malt, German lager yeast.
- Vital Statistics: OG: 1.048 – 1.056 IBUs: 23 – 30 FG: 1.010 – 1.015 SRM: 4 – 6 ABV: 4.8 – 6.0%
Commercial Examples: DAB Export, Dortmunder Union Export, Dortmunder Kronen, Ayinger Jahrhundert, Great Lakes Dortmunder Gold, Barrel House Duveneck's Dortmunder, Bell's Lager, Dominion Lager, Gordon Biersch Golden Export, Flensburger Gold

Water



- **Importance**

- 85-95% of Beer is water
- Affects mash, boil, ferment, color clarity & taste
- Biological purity essential
- Mineral content defines type of beer
- Certain minerals essential for yeast nutrition

Water (cont.)



- **Mineral Content**

- Practically all water has dissolved minerals
- Amount of dissolved minerals defines “hardness”
- Calcium Carbonate (CaCO_3) produces “temporary hardness”
- Permanent hardness produced by:
 - ✦ Gypsum or Calcium Sulphate (CaSO_4)
 - ✦ Epsom Salts or Magnesium Sulphate (MgSO_4)
 - ✦ Table Salt or Sodium Chloride (NaCl)
 - ✦ Many others but not normally used in brewing

Important Brewing Regions



City	Calcium (Ca^{+2})	Magnesium (Mg^{+2})	Bicarbonate (HCO_3^{-1})	SO_4^{-2}	Na^{+1}	Cl^{-1}	Beer Style
Pilsen	10	3	3	4	3	4	Pilsener
Dortmund	225	40	220	120	60	60	Export Lager
Vienna	163	68	243	216	8	39	Vienna Lager
Munich	109	21	171	79	2	36	Oktoberfest
London	52	32	104	32	86	34	British Bitter
Edinburgh	100	18	160	105	20	45	Scottish Ale
Burton	352	24	320	820	44	16	India Pale Ale
Dublin	118	4	319	54	12	19	Dry Stout

Chemistry Quickly



- Water is ion soup
- Water molecule (H_2O) has both + and - affinity
- Dissolved salts ionize and have affinity for H_2O
- CaSO_4 disassociates into Ca^{++} and SO_4^{--}
 - Ca^{++} reacts with Phosphates from malt yielding H^+ ions
 - Results in acidified mash
- CaCO_3 disassociates into Ca^{++} and CO_3^{--}
 - CO_3^{--} strongly alkaline and buffers solution
 - CO_3^{--} precipitates when brewing water is vigorously boiled

Water Adjustment



- One gram per gallon of water:
 - CaSO_4 yields 61.5 ppm Ca^{++} and 147 ppm SO_4^{--}
 - MgSO_4 yields 37 ppm and 145 ppm SO_4^{--}
 - NaCl yields 104 ppm Na^+ and 160 ppm Cl^-
 - CaCl_2 yields 72 ppm Ca^+ and 160 ppm Cl^-
 - CaCO_3 yields 106 ppm Ca^{++} and 157 ppm CO_3^{--}
- Use to calculate desired mineral content

Mineral Effects on Beer



- Ca - acidifies mash, aids gelatinization, yeast nutrient, improves clarity
- Mg - yeast nutrient, roundness of flavor, astringent in excess (>30 ppm)
- Na - salty, enhances flavor, lethal to yeast above 50 ppm
- K - salty, laxative above 10 ppm, inhibits enzyme activity
- I - metallic, inky taste, affects yeast, causes haze above 1 ppm
- Mn - unpleasant, astringent taste at low levels (<1 ppm)
- SO₄ - dry, pleasant taste (150 ppm) sharply bitter in excess (500 ppm)
 - ✦ needed for highly hopped beer for clean bitterness
- CO₃ - buffers mash, hinders gelatinization, causes haze, harsh flavor
- Cu and Z beneficial in trace quantities (<1 ppm) as yeast nutrient

Other Potential Nasties



- **Coliform bacteria & other organics**
 - foul tasting, lethal to yeast and potentially to humans
- **Turbidity & colloidal vegetative residue**
 - causes permanent haze, impedes run-off
- **Heavy metals**
 - metallic flavors at best, lethal to yeast and not too good for humans
- **Free chlorine**
 - lethal to yeast, combines with phenols to form bad medicinal flavors
- **Sulfur**
 - precursor to DMS (corn-like) and SO_2 flavors and aromas (rotten eggs)



2A. German Pilsner (Pils)

- **Aroma:** Typically features a light grainy Pils malt character (sometimes Graham cracker-like) and distinctive flowery or spicy noble hops. Clean, no fruity esters, no diacetyl. May have an initial sulfury aroma (from water and/or yeast) and a low background note of DMS (from Pils malt).
- **Appearance:** Straw to light gold, brilliant to very clear, with a creamy, long-lasting white head.
- **Flavor:** Crisp and bitter, with a dry to medium-dry finish. Moderate to moderately-low yet well attenuated maltiness, although some grainy flavors and slight Pils malt sweetness are acceptable. Hop bitterness dominates taste and continues through the finish and lingers into the aftertaste. Hop flavor can range from low to high but should only be derived from German noble hops. Clean, no fruity esters, no diacetyl.
- **Mouthfeel:** Medium-light body, medium to high carbonation.
- **Overall Impression:** Crisp, clean, refreshing beer that prominently features noble German hop bitterness accentuated by sulfates in the water.
- **Comments:** Drier and crisper than a Bohemian Pilsener with a bitterness that tends to linger more in the aftertaste due to higher attenuation and higher-sulfate water. Lighter in body and color, and with higher carbonation than a Bohemian Pilsener. Modern examples of German Pilsners tend to become paler in color, drier in finish, and more bitter as you move from South to North in Germany.
- **History:** A copy of Bohemian Pilsener adapted to brewing conditions in Germany.
- **Ingredients:** Pilsner malt, German hop varieties (especially noble varieties such as Hallertauer, Tettnanger and Spalt for taste and aroma), medium sulfate water, German lager yeast.
- **Vital Statistics:** OG: 1.044 – 1.050 IBUs: 25 – 45 FG: 1.008 – 1.013 SRM: 2 – 5 ABV: 4.4 – 5.2% Commercial Examples: Victory Prima Pils, Bitburger, Warsteiner, Trumer Pils, Old Dominion Tupper's Hop Pocket Pils, König Pilsener, Jever Pils, Left Hand Polestar Pilsner, Holsten Pils, Spaten Pils, Brooklyn Pilsner

Yeast



- What Is Yeast?
 - Fungi of the genus *Saccharomyces*
 - Two principal types used in Brewing
 - ✦ *S. cerevisiae* - Top Fermenting
 - ✦ *S. uvarum* (*carlsbergensis*) - Bottom Fermenting

Yeast History



- Three landmark events occurred in 1841
 - Yeast identified by Mitcherlich as essential to fermentation
 - Pastuer reveals alcohol by-product of CO₂ production from sugars
 - Sedlmayer & Dreher establish bottom fermentation in Munich
- Emil Hanson isolated pure cultures in 1883
- By turn of the century majority of beer is lager

Yeast Characteristics



- **Saccharomyces cerevasiae**
 - “Top Fermenting” - clings and clumps - forms thick top layer
 - Optimum temperature 55 to 75°F.
 - Rapid fermentation cycle and relatively short conditioning
 - Ferments mostly simple sugars - not melibiose
 - Moderate to high ester formation common
- **Saccharomycese uvarum**
 - “Bottom Fermenting” forms small colonies which remain in suspension
 - Optimum temperature 45-55°F.
 - Long fermentation cycle followed by long conditioning (lagering)
 - Low ester formation

Requirements for Fermentation



- Optimum pH - 5.0 to 5.5
- Proper temperature for yeast strain
- Ample oxygen for respiration phase
- Necessary nutrients
 - glycogen reserves within cell
 - amino acids and trace minerals in solution
- Source of carbon - simple carbohydrates
- Viable and adequate concentration of starter
 - 12-16 million cells per millimeter
 - 0.5 to 0.6 ounces of thick slurry per gallon of wort (ales)
 - two to three times as much for lagers or high gravity wort

2B. Bohemian Pilsner



- **Aroma:** Rich with complex malt and a spicy, floral Saaz hop bouquet. Some pleasant, restrained diacetyl is acceptable, but need not be present. Otherwise clean, with no fruity esters.
- **Appearance:** Very pale gold to deep burnished gold, brilliant to very clear, with a dense, long-lasting, creamy white head.
- **Flavor:** Rich, complex maltiness combined with a pronounced yet soft and rounded bitterness and spicy flavor from Saaz hops. Some diacetyl is acceptable, but need not be present. Bitterness is prominent but never harsh, and does not linger. The aftertaste is balanced between malt and hops. Clean, no fruity esters.
- **Mouthfeel:** Medium-bodied (although diacetyl, if present, may make it seem medium-full), medium carbonation.
- **Overall Impression:** Crisp, complex and well-rounded yet refreshing.
- **Comments:** Uses Moravian malted barley and a decoction mash for rich, malt character. Saaz hops and low sulfate, low carbonate water provide a distinctively soft, rounded hop profile. Traditional yeast sometimes can provide a background diacetyl note. Dextrins provide additional body, and diacetyl enhances the perception of a fuller palate.
- **History:** First brewed in 1842, this style was the original clear, light-colored beer.
- **Ingredients:** Soft water with low mineral content, Saaz hops, Moravian malted barley, Czech lager yeast.
- **Vital Statistics:** OG: 1.044 – 1.056 IBUs: 35 – 45 FG: 1.013 – 1.017 SRM: 3.5 – 6 ABV: 4.2 – 5.4% Commercial Examples: Pilsner Urquell, Krušovice Imperial 12°, Budweiser Budvar (Czechvar in the US), Czech Rebel, Staropramen, Gambrinus Pilsner, Zlaty Bazant Golden Pheasant, Dock Street Bohemian Pilsner

Fermentation Cycle



- **Respiration**

- Rapid uptake of oxygen
 - ✦ Used to produce sterols for cell wall modification
- glycogen depleted as cell growth begins
- Cell walls become permeable
- Enzymes needed for carbon metabolism produced
- Assimilation of fermentable sugars and amino acids begin
- CO₂ , esters & diacetyl produced - no alcohol

Fermentation Cycle (Cont.)



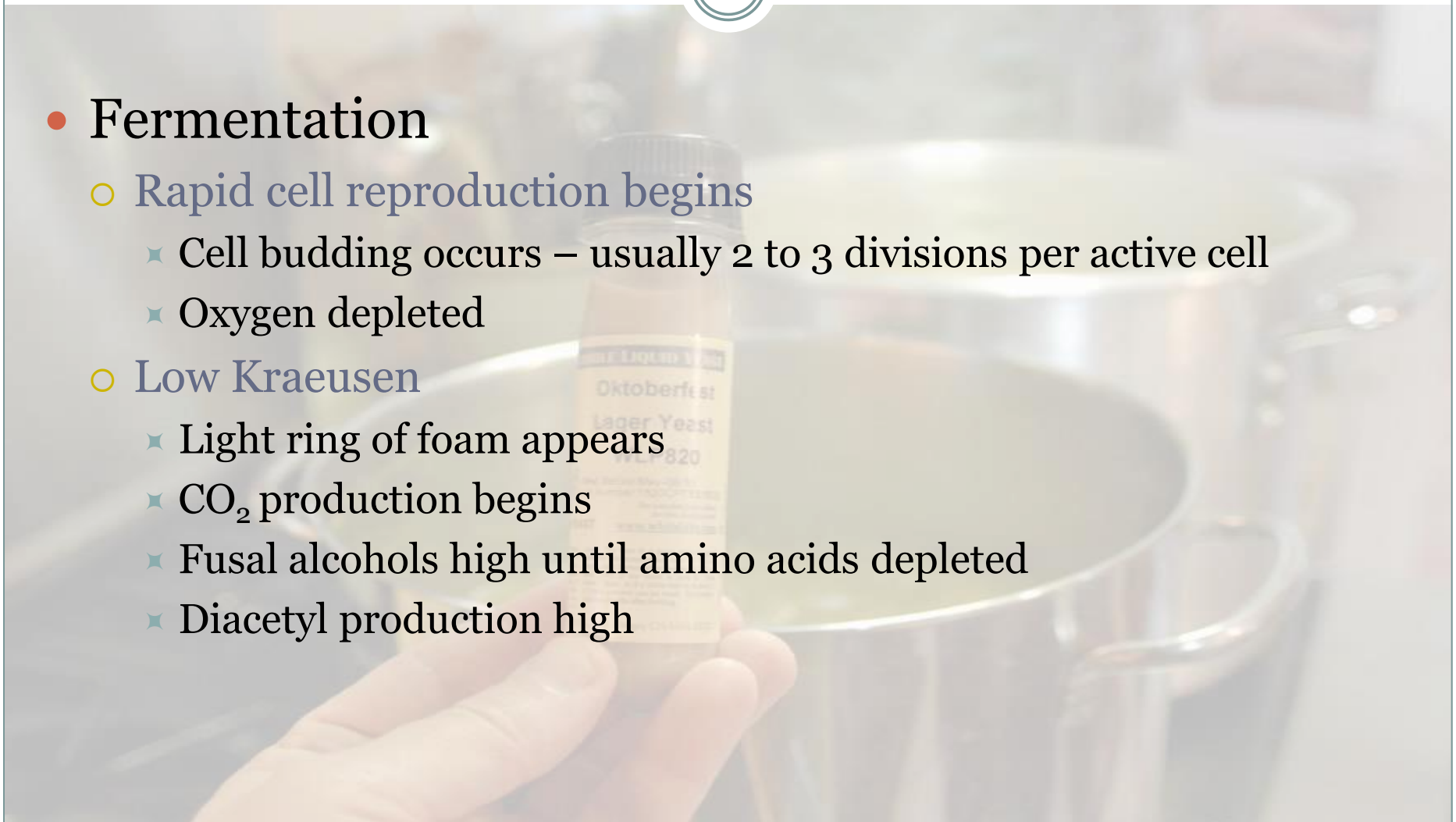
- Fermentation

- Rapid cell reproduction begins

- ✦ Cell budding occurs – usually 2 to 3 divisions per active cell
 - ✦ Oxygen depleted

- Low Kraeusen

- ✦ Light ring of foam appears
 - ✦ CO₂ production begins
 - ✦ Fusel alcohols high until amino acids depleted
 - ✦ Diacetyl production high

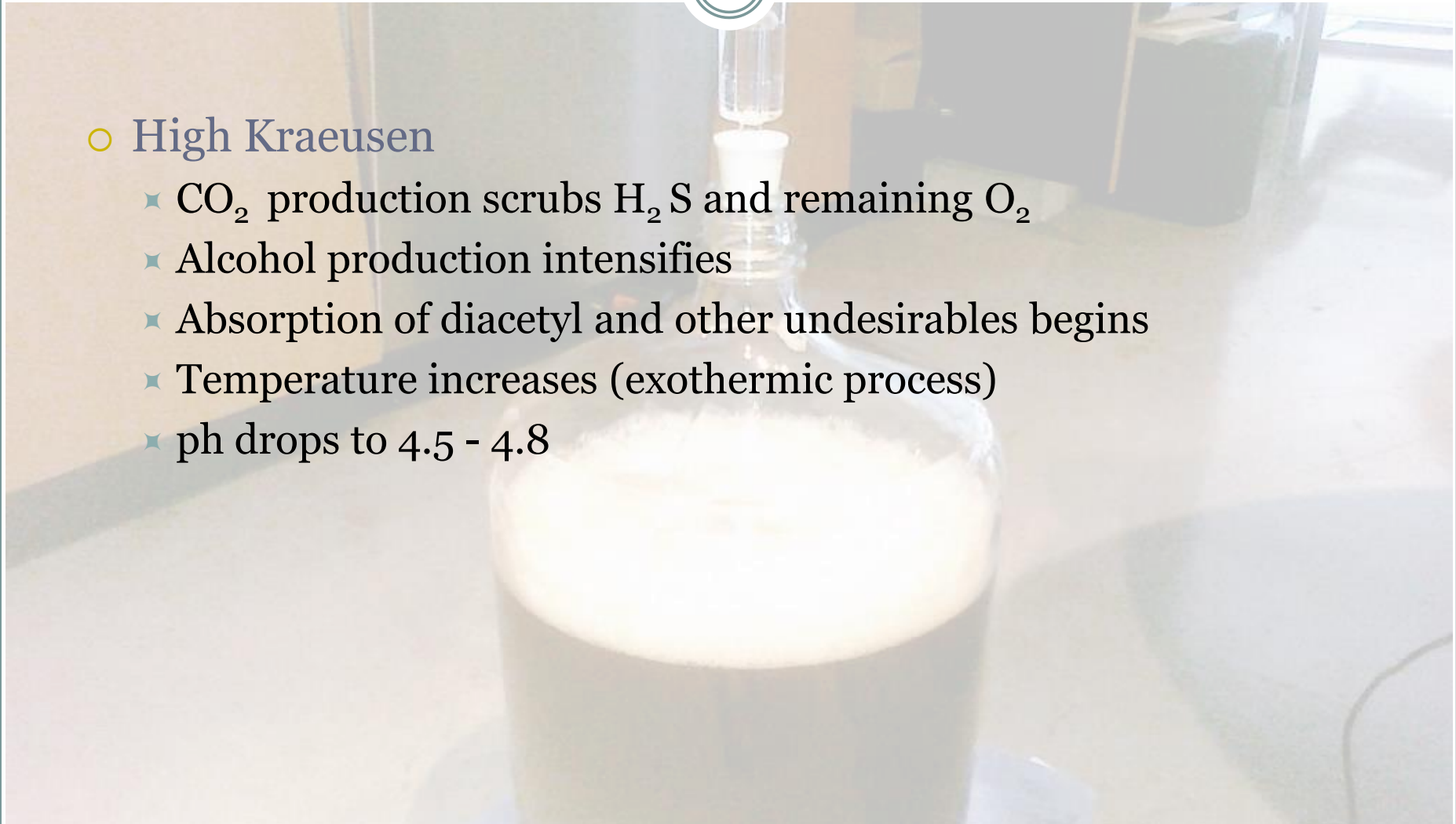


Alcohol production begins



○ High Kraeusen

- ✦ CO_2 production scrubs H_2S and remaining O_2
- ✦ Alcohol production intensifies
- ✦ Absorption of diacetyl and other undesirables begins
- ✦ Temperature increases (exothermic process)
- ✦ pH drops to 4.5 - 4.8



Fermentation Cycle (Cont.)

- **Sedimentation**

- Life cycle reaction to reduced sugars, lower pH
- Reproduction ceases
- Alcohol production decreases
- Cell walls become less permeable
- Glycogen produced and stored within cell
- Denser cells fall from suspension

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Desirable Characteristics

- Temperature range
 - Ale or Lager strain
- Attenuation
 - Strength of fermentation
- Flocculation
 - How well and how quickly sediments
- Diacetyl production low and absorption high
- Ester production is suitable for type of beer
- Phenol production low (except for selected strains)

Other Fermentation Media



- **Saccharomyces delbrukii - weisbier**
 - Old designation - actually *S. cerevisiae*
 - Produces selected phenols (clove, vanilla, bubblegum)
 - Produces selected esters (Isoamyl Acetate or banana-like)
- **Saccharomyces bayanus - Belgian ales**
 - Floral/herbal esters, apricot, nutty
 - Primary ferment, utilizing glucose, maltose & maltotriose
 - Always used with *S. cerevisiae*
- **Brettanomyces bruxcellensis – Lambics**
 - Predominant in Brussels
 - Secondary ferment, (8 to 24 months) utilizing higher sugars
 - Ethyl acetate, ethyl lactate, horsey, leather

Other Fermentation Media (cont.)



- **Brettanomyces lambicus – Lambics**
 - Found more in countryside; around Brussels
 - Secondary ferment, (8 to 24 months) utilizing higher sugars
 - Ethyl acetate, acetic acid, horsey, sweaty
- **Enterobacteriaceae - Lambics**
 - Rod Shaped Gut bacteria
 - Species Citrobacter, Enterobacter, Kelbsiella, Hafnia
 - Early (3 to 7 days) mixed acid fermentation utilizing glucose only
 - Flavors – sweet, honey, fruity, some acids (lactic) off flavors scrubbed by CO₂
- **Kloekera apiculata – Lambics**
 - Early fermenting yeast, utilizing glucose only
 - Secretes proteases that break down proteins
 - Minor flavor contributions of floral esters stripped later by CO₂

Other Fermentation Media (cont.)



- **Pediococcus damnosus - Lambics**
 - Primary producer of lactic acid sourness
 - Secondary ferment, (3 to 8 months)
 - Favors warmer temperatures of summer months
 - Tolerant to antiseptic qualities of hops (most others are not)
 - Moderate production of diacetyl, most of which is reduced
- **Lactobacillus delbrukii - Berliner weiss**
 - Found normally on grain and pale malts
 - Active over wide temperature range (90 to 160°F+)
 - Produces clean, tart lactic sourness
 - Primary bacteria active in sour mash
 - One of primary bacteria used in yogurt production

2C. Classic American Pilsner

- **Aroma:** Low to medium grainy, corn-like or sweet maltiness may be evident (although rice-based beers are more neutral). Medium to moderately high hop aroma, often classic noble hops. Clean lager character, with no fruitiness or diacetyl. Some DMS is acceptable.
- **Appearance:** Yellow to deep gold color. Substantial, long lasting white head. Bright clarity.
- **Flavor:** Moderate to moderately high maltiness similar in character to the Continental Pilsners but somewhat lighter in intensity due to the use of up to 30% flaked maize (corn) or rice used as an adjunct. Slight grainy, corn-like sweetness from the use of maize with substantial offsetting hop bitterness. Rice-based versions are crisper, drier, and often lack corn-like flavors. Medium to high hop flavor from noble hops (either late addition or first-wort hopped). Medium to high hop bitterness, which should not be coarse nor have a harsh aftertaste. No fruitiness or diacetyl. Should be smooth and well-lagered.
- **Mouthfeel:** Medium body and rich, creamy mouthfeel. Medium to high carbonation levels.
- **Overall Impression:** A substantial Pilsner that can stand up to the classic European Pilsners, but exhibiting the native American grains and hops available to German brewers who initially brewed it in the USA. Refreshing, but with the underlying malt and hops that stand out when compared to other modern American light lagers. Maize lends a distinctive grainy sweetness. Rice contributes a crisper, more neutral character.
- **Comments:** The classic American Pilsner was brewed both pre-Prohibition and post-Prohibition with some differences. OGs of 1.050-1.060 would have been appropriate for pre-Prohibition beers while gravities dropped to 1.044-1.048 after Prohibition. Corresponding IBUs dropped from a pre-Prohibition level of 30-40 to 25-30 after Prohibition.
- **History:** A version of Pilsner brewed in the USA by immigrant German brewers who brought the process and yeast with them when they settled in America. They worked with the ingredients that were native to America to create a unique version of the original Pilsner. This style died out after Prohibition but was resurrected as a home-brewed style by advocates of the hobby.
- **Ingredients:** Six-row barley with 20% to 30% flaked maize to dilute the excessive protein levels. Native American hops such as Clusters, traditional continental noble hops, or modern noble crosses (Ultra, Liberty, Crystal) are also appropriate. Modern American hops such as Cascade are inappropriate. Water with a high mineral content can lead to an inappropriate coarseness in flavor and harshness in aftertaste.
- **Vital Statistics:** OG: 1.044 – 1.060 IBUs: 25 – 40 FG: 1.010 – 1.015 SRM: 3 – 6 ABV: 4.5 – 6% Commercial Examples: Occasional brewpub and microbrewery specials