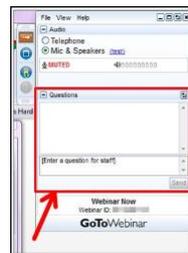


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**“Why am I muted?”**

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Learn what determines the color of beer and how color is measured in the brewing industry.



**Getting Ahead Through Chemistry: Great Beer and Frothy Foam**  
Learn about the psychophysics, physics and chemistry of beer foam in pursuit of the perfectly presented pint.



**More Advanced Beer and Brewing Tips**  
Join Dr. Charlie Bamforth as he expounds on his premise and continues the research into the science and technology that takes us from barley to beer.



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<http://bit.ly/BeerTurbidity>

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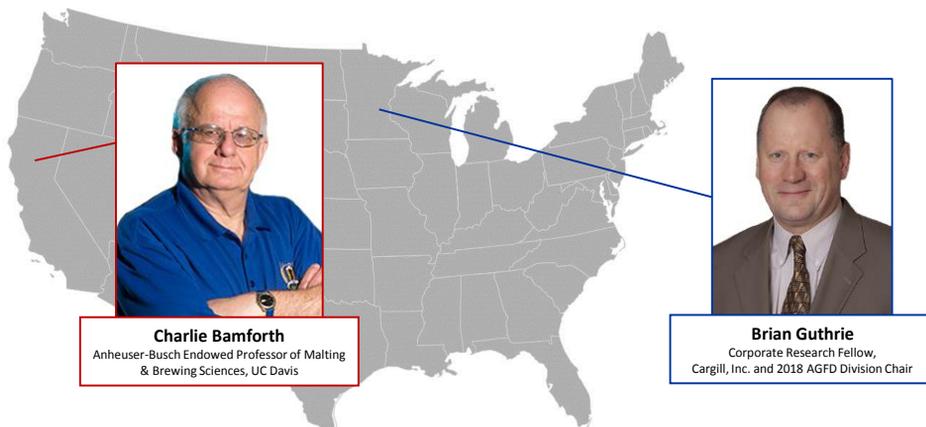


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## Cloudiness in Beer: Considerations and Chemistry



**Charlie Bamforth**  
Anheuser-Busch Endowed Professor of Malting & Brewing Sciences, UC Davis

**Brian Guthrie**  
Corporate Research Fellow,  
Cargill, Inc. and 2018 AGFD Division Chair

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ACS Technical Division  
Agricultural & Food Chemistry (AGFD)

# Cloudiness in BEER

Considerations and  
Chemistry

Featuring Charlie Bamforth  
Distinguished Professor of Malting & Brewing Sciences at UC Davis

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## Audience Challenge Question



ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

**Which of these appeals to you most:**

- The one on the left
- The one on the right
- No preference
- I would like both please!





## Same beer, different bars, same day





**84 No Preference:**  
they generally wanted  
more information





## Turbidity in Fresh Beer

- Yeast
- Bacteria
- “Non-biologicals”



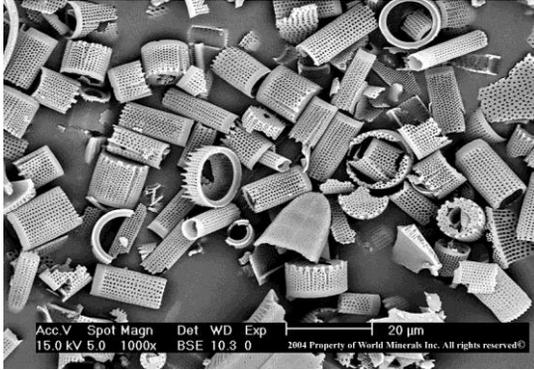
## Removing Turbidity From Beer

- Filtration
- Clarification agents

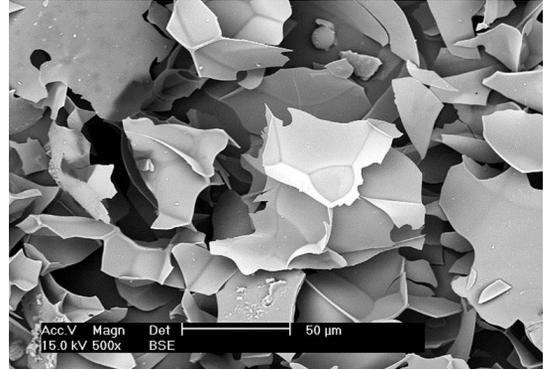




## Powder-based Filtration



Diatomaceous Earth



Perlite

### Audience Challenge Question



ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

### what is isinglass?

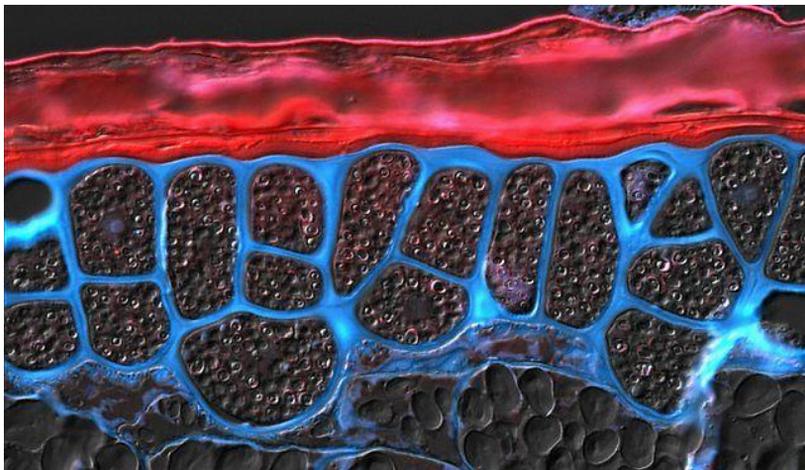
- Keratin
- Collagen
- Elastin
- Hordein
- A popular new style of beer



## Development of Turbidity Problems Over Time



## Precipitates



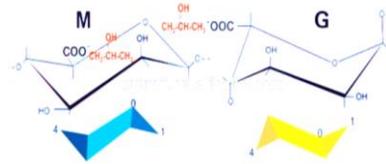
$\beta$ -Glucan



## Interaction of Incompatible Additions



+



propylene glycol alginate

### Audience Challenge Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT



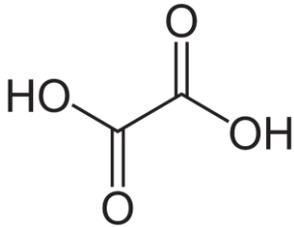
**A problematic substance for brewers is also which molecule that gives the mouth-puckering character to rhubarb?**

- Acetaldehyde
- Diacetyl
- Oxalic acid
- Rhubarbium acid
- Ferulic acid





## Bits



**Experience Timeless Taste**

"A beer that lifelong lager drinkers and craft faithful...can agree on without a whole lot of compromise." – **MarketWatch**

Highest consumer-rated American Lager  
– **BeerAdvocate**

Ranks in the 95th percentile amongst American Lagers – **RateBeer**

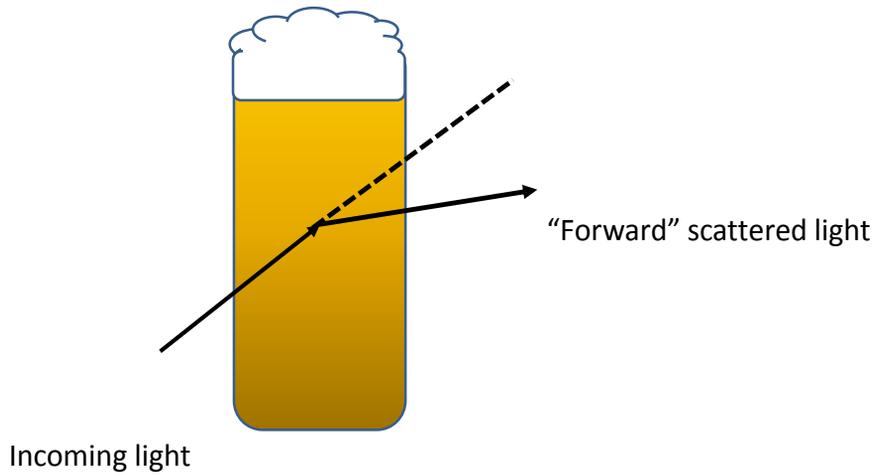
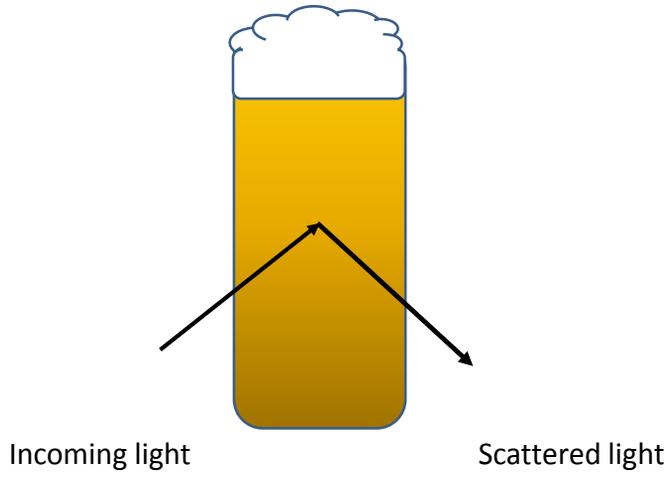
Best American Lager – **Deadspin**

**THE BEER**



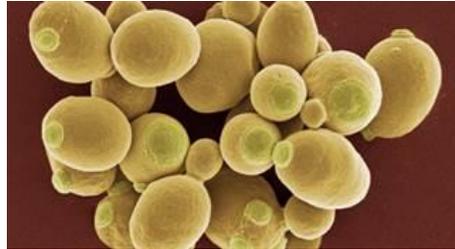
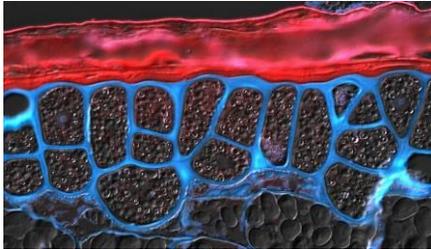
## Invisible Haze

INVISIBLE





## Sources of Invisible Haze



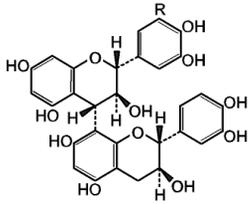
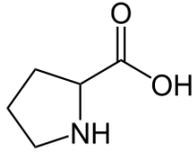
## Non-Biological Haze vs. Biological Haze

$\beta$ -glucan  
Pentosan (arabinoxylan)  
Starch  
Oxalate  
Dead Bacteria  
Can lid lubricants  
Proteins - polyphenols





# Chill Haze and Permanent Haze



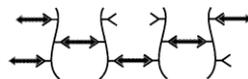
Procyanidin B-3 (R = H)  
Prodelphinidin B-3 (R = OH)



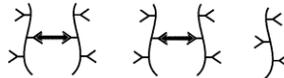
Photo Credit: <https://www.stonebrewing.com/blog/miscellany/2011/chill-hazethe-more-you-know>



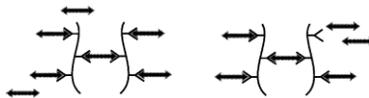
# Siebert



[Polyphenol] = [Protein]



[Polyphenol] < [Protein]



[Polyphenol] > [Protein]

↔ Polyphenol molecule

Y Protein molecule with fixed number of polyphenol binding sites (i.e. haze-active)



Material	Stain	Discussion
Carbohydrate	Niagara Sky Blue 6B	Carbohydrate stains blue
	Thionin	Non-charged polysaccharides such as starch stain violet/blue, whereas acid polysaccharides such as alginates will stain rose-pink
Starch	Iodine/potassium iodide	Blue indicates the amylose component of starch. Reddish-brown indicates the amylopectin component.
$\beta$ -Glucan	Congo Red	Red coloration
Protein	Orange G	Stains protein yellow-brown
	Eosin yellow	Stains protein pink
Yeast cell wall material	Lactophenol Blue	Blue coloration

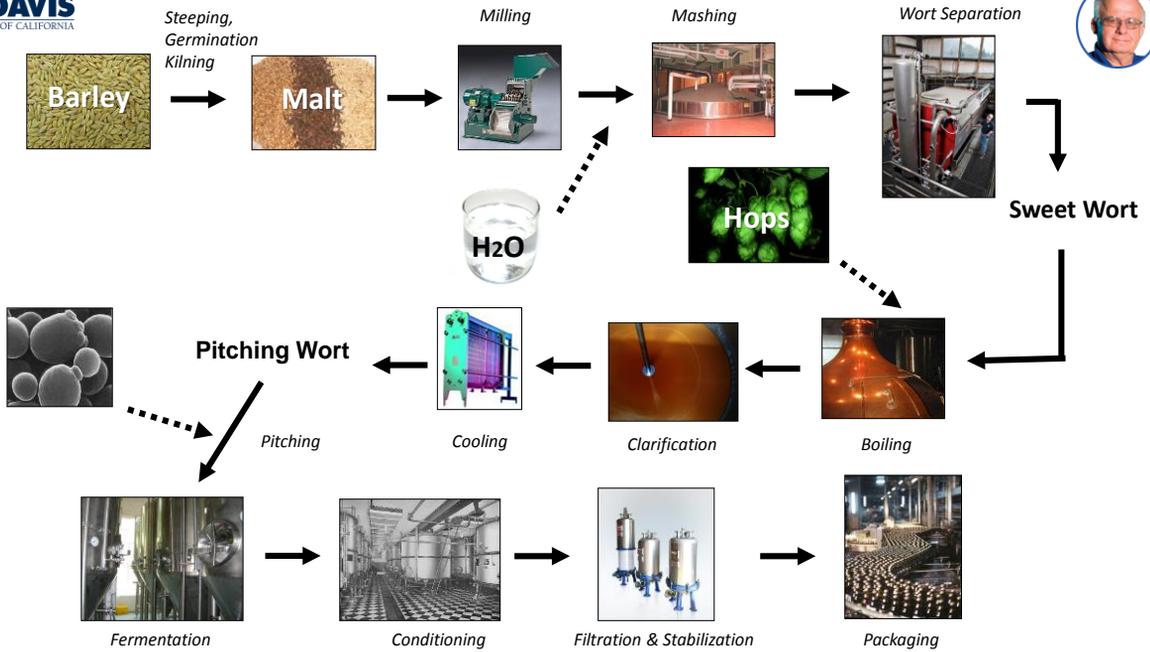
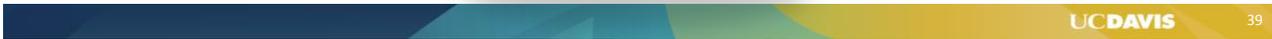


## Microbiological Analysis





# A Holistic Approach





## Grist Materials

- Rice, corn, high maltose syrup and sucrose: no haze-forming stuff
- Higher protein and polyphenol malts: more of this stuff
- $\beta$ -Glucan and arabinoxylan from poorly modified malts
- $\beta$ -Glucan from oats, rye and torrefied and flaked barley
- Arabinoxylan from wheat grist items
- Low proanthocyanidin barleys/malts



## Malting



Homogeneous modification (cell walls, protein, starch)

## Hop Bill



- Polyphenols also in hops
- The more hop solids used in the brew the more polyphenols
- If the aim is to deliver a high IBU from a relatively low alpha hop, you will be adding a lot more polyphenol
- Hop extracts are devoid of polyphenols

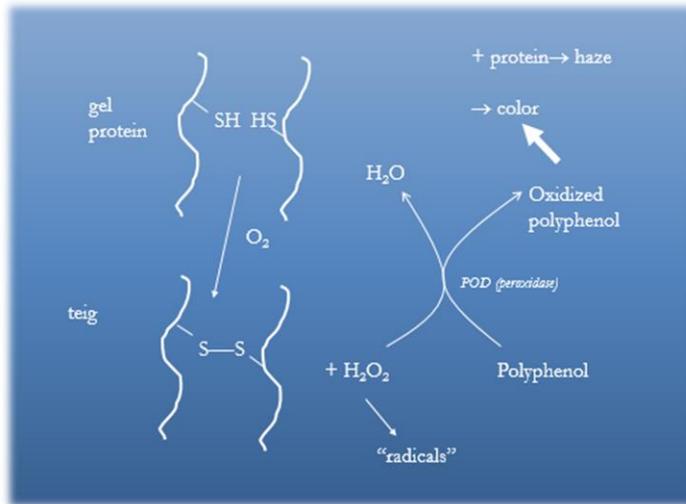


## Mashing



- Low temperature stand
- Amylolysis
- Calcium
- Oxidation





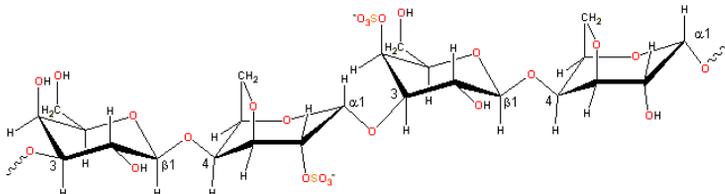
## Wort Boiling



The more vigorous the boil, the better the hot break formation



Irish Moss



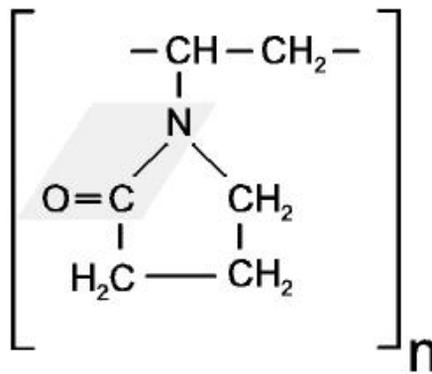
## Cold Conditioning



- “Chilling out” and settling
- Isinglass
- Temperature versus time



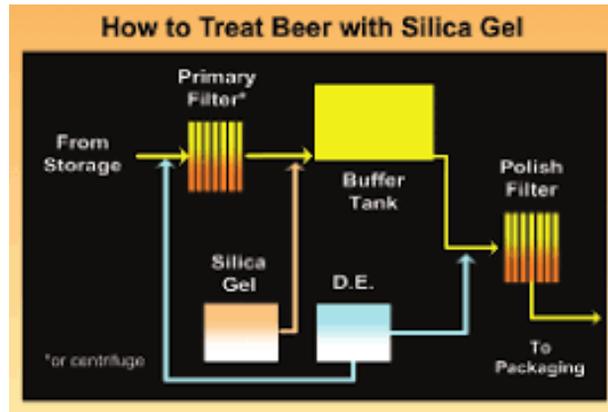
## Removal of Polyphenol



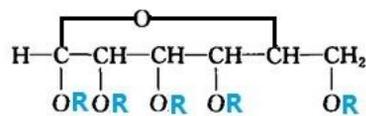
PVPP



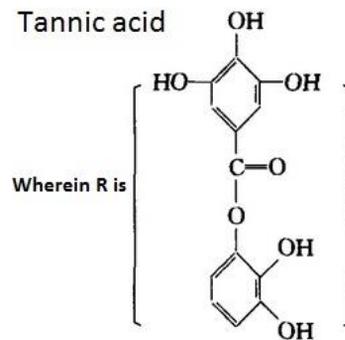
# Removal of Polypeptide/1



# Removal of Polypeptide/2

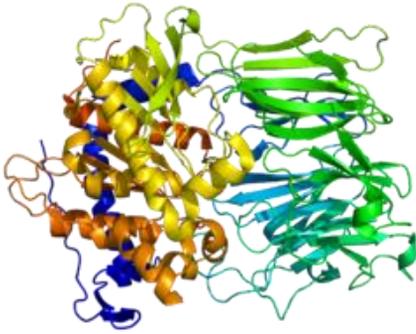


Tannic acid





## Removal of Polypeptide/3



## Packaging

- Low oxygen
- Low iron, copper and manganese
- Packaging materials (or indeed lines) should not contribute materials that can give clarity problems e.g. lubricants, oils, dust





## What about Beers that are Supposed to be Turbid?

- More challenging!
- Yeast counts and flocculation
- Additions



## Cleaning and Hygiene

- Manual or Cleaning in Place
- Plant design and accessibility





## Cleaning and Hygiene



[cwbamforth@ucdavis.edu](mailto:cwbamforth@ucdavis.edu)

Check out some on-line classes on beer quality – search

**UC DAVIS  
EXTENSION**

**Online Beer Quality Series**



### *Cloudiness in Beer: Considerations and Chemistry*

**Charlie Bamforth**  
Anheuser-Busch Endowed Professor of Malting & Brewing Sciences, UC Davis

**Brian Guthrie**  
Corporate Research Fellow,  
Cargill, Inc. and 2018 AGFD Division Chair

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