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We will start momentarily at 2pm ET




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Have Questions?



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Learn the basics:

Tapping into the Chemistry of Beer and Brewing

<http://acswebinars.org/bamforth>

Go advanced:


Advanced Chemistry of Beer and Brewing

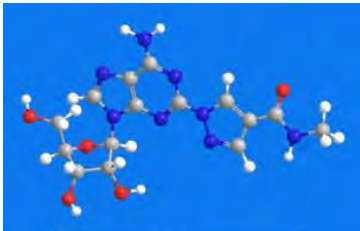
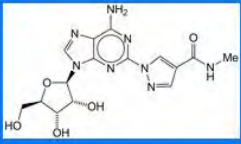
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Molecule of the Week



I can let molecules into mouse brains.


What molecule am I?

Visit www.acs.org to find out!


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Designer Babies
 Thursday, March 22, 2012
 Darren Griffin, Professor of Genetics at the University of Kent, UK.



Job Searching with Social Media
 Monday March 26, 2012 & Tuesday March 27, 2012
 3 Great Events:


- Job Searching with Social Media
- Surviving Chemistry with Humor
- Eminent Scientist Lecture



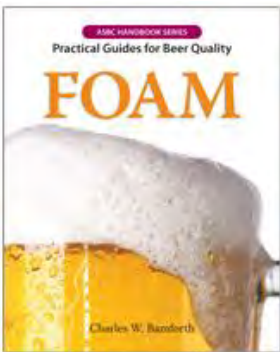
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You could be the lucky winner!



FOAM
 Practical Guides for Beer Quality
 Charles W. Bamforth



One attendee will receive a signed copy of Charlie's latest book, *Foam!*

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April 19, 2012
The Chemistry Magic Behind Popcorn
 Sara Risch, Popz.



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ACS WEBINARS™
 March 15, 2012



More Advanced Beer and Brewing – Tips, Tricks, and Tidbits You Wish You Knew

Charlie Bamforth
 UC Davis

Steve Carlo
 Chemist, Homebrewer

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More Advanced Beer and Brewing

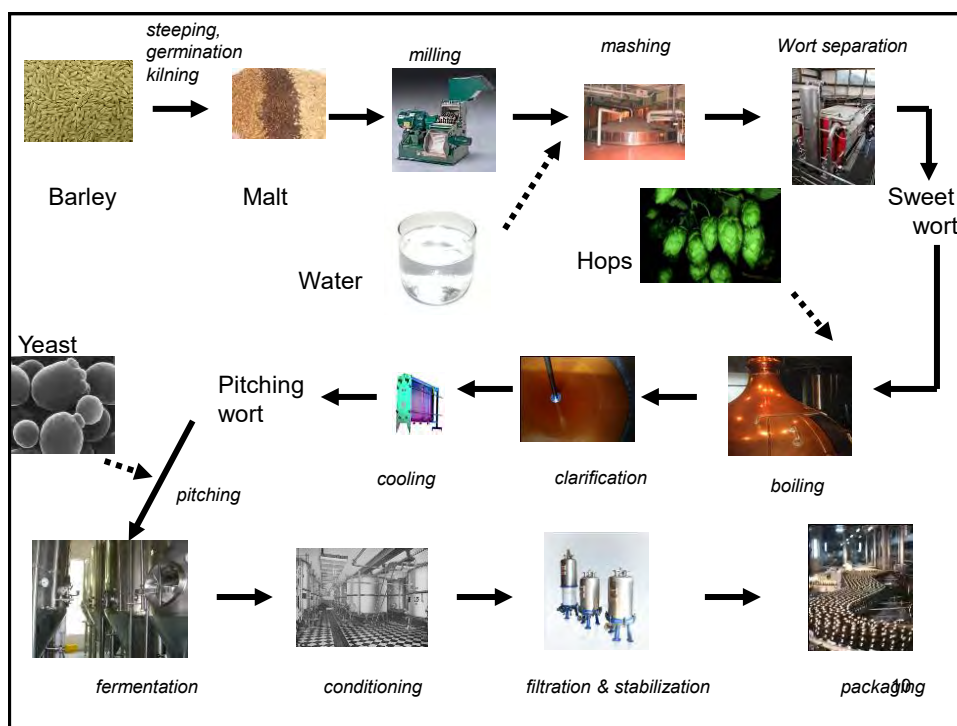
Charlie Bamforth



March 15, 2012



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Malt and hops – the soul and spice of beer



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90% of beer: barley malt is key grist component



~9% of beer: wheat malt is key grist component



~1% of beer: sorghum malt is key grist component



In each of these basic types there may also be “supporting” adjuncts, but malt is invariably >50% of the grist

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Why barley?



- history
- contribution to beer character
 - flavor, foam, clarity etc
- husk



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Barley

Part of the grass family

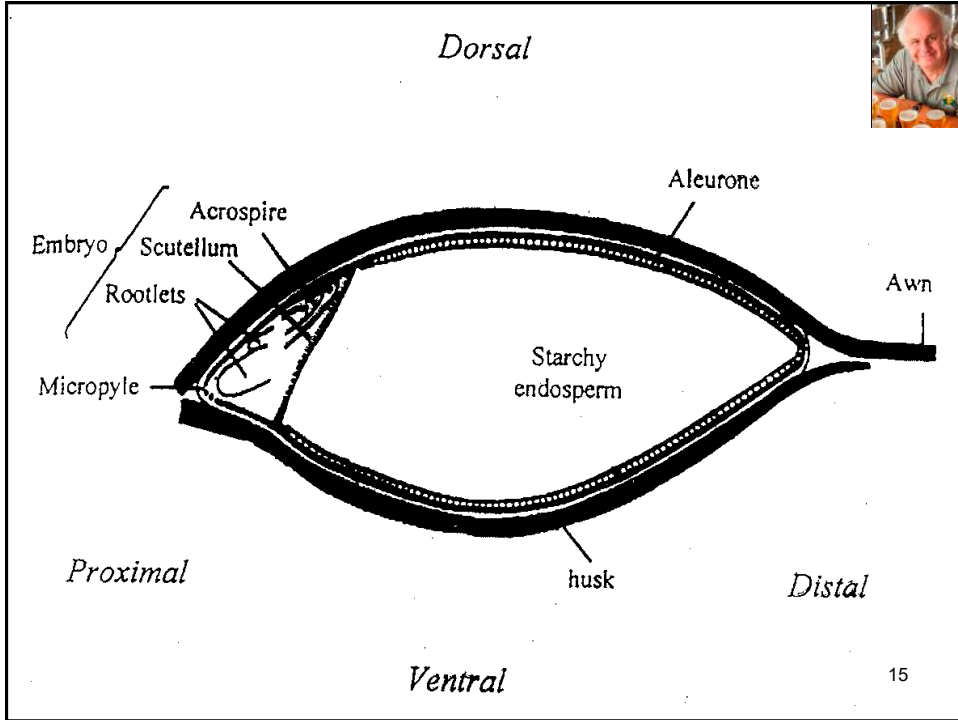
Hordeum vulgare 6 row

Hordeum distichon 2 row

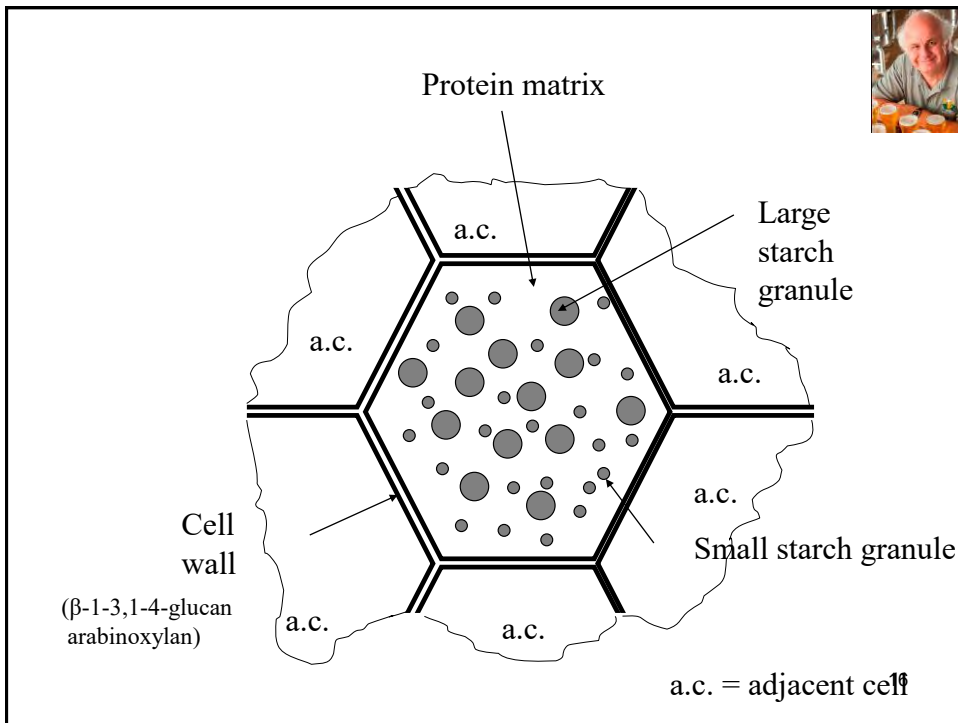


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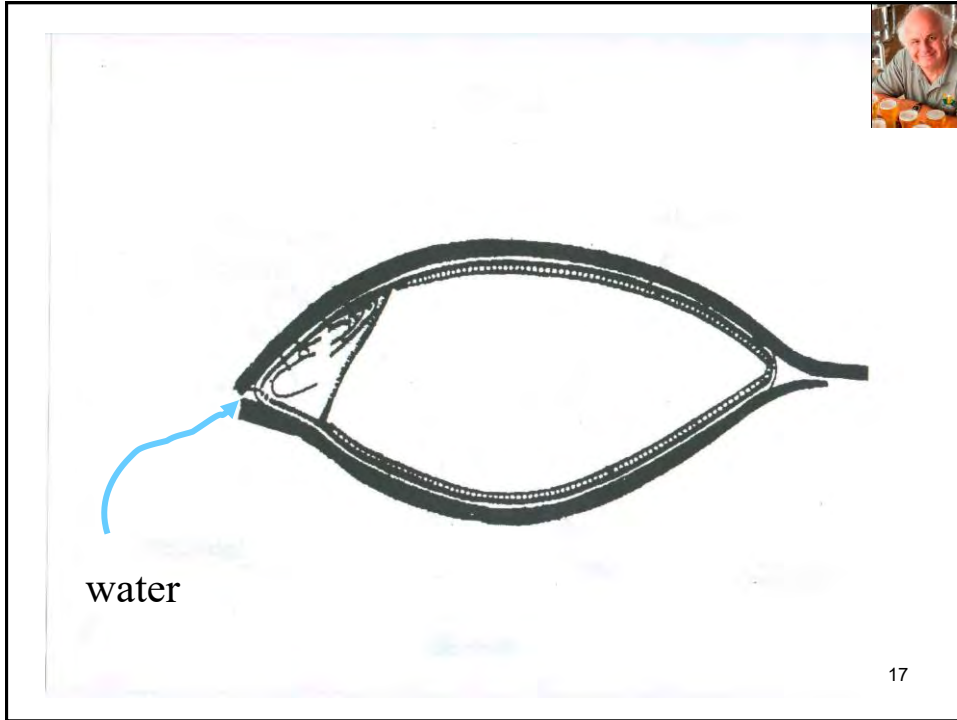
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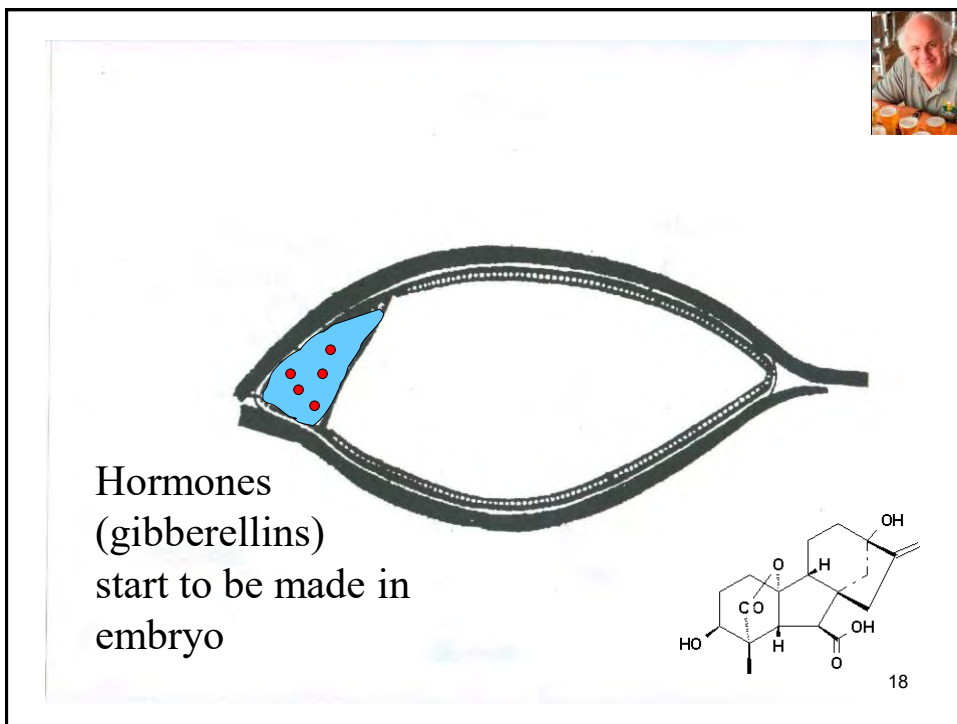
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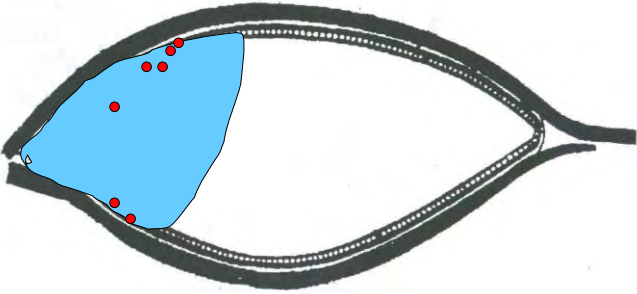


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Hormones migrate to aleurone

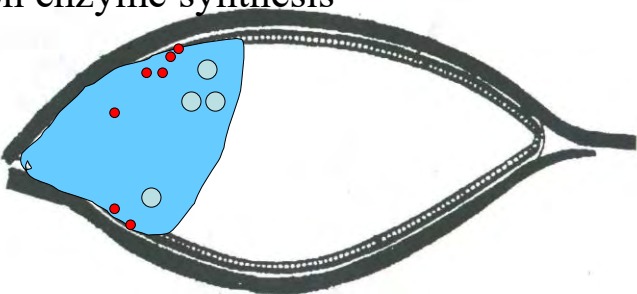


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This diagram illustrates the initial stage of hormone migration in a barley grain. A blue shaded region on the left represents the scutellum, and a red shaded region on the right represents the aleurone layer. Several red dots, representing hormones, are shown moving from the scutellum towards the aleurone layer. The grain's outer layers, including the pericarp and seed coat, are shown in black.

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Hormones switch on enzyme synthesis

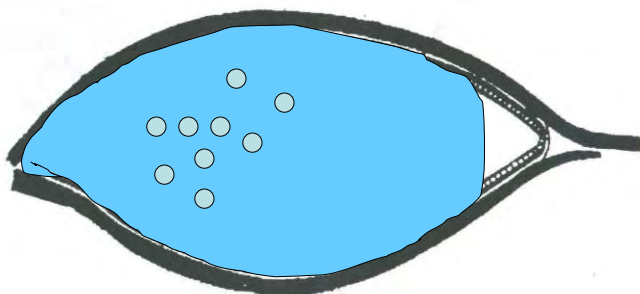


20

This diagram illustrates the second stage of hormone action. The hormone molecules (red dots) have reached the aleurone layer. In addition to the red dots, several light blue circles are now present within the aleurone layer, representing the synthesis of enzymes. The overall structure of the grain remains the same as in the previous diagram.

20

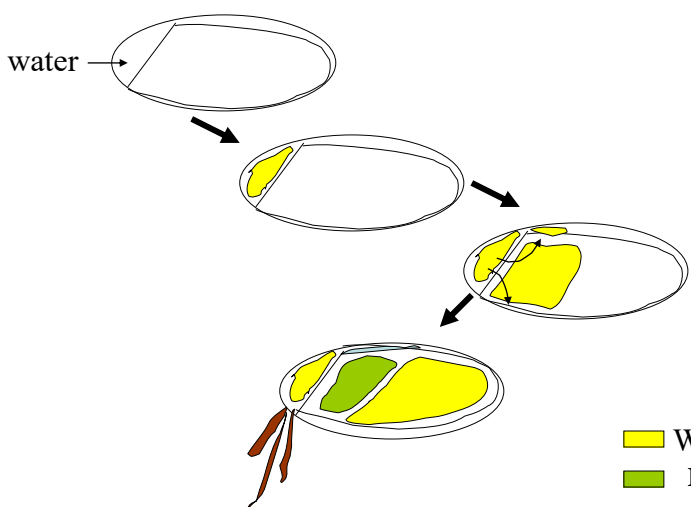
Enzymes diffuse through endosperm, now that it has been wetted. Break down endosperm



Sugars and amino acids produced diffuse back to embryo

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21



water

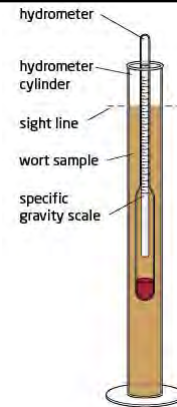
- Water distribution
- Modification
- Rootlets
- Acrospire

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Result: cell walls largely gone;
protein ~ 50% gone;
starch exposed

When the malt is later (in the brewery)
milled into particles and extracted with hot
water, the starch-breaking enzymes produced
in germination break down the starch to make
a syrupy solution of sugars with a high
specific gravity. The higher the specific gravity,
the more sugars – the more **“Extract”**



$$\text{Specific gravity} = \frac{\text{weight of solution}}{\text{weight of water}}^{23}$$

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Value of the barley crop in descending order (2010; thousand dollars):



1. Idaho 185,932
2. Montana 159,526
3. North Dakota 156,780
4. Colorado 30,583

*Total Canadian production is
~ 3 times more than total in US*



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What constitutes a good barley for malting and brewing?

- low N (i.e. low protein)
- high yield
- infection and infestation resistant
- high extract potential
- trouble-free processing - brewhouse, downstream



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Some diseases of barley

Mildew
 Take-all
 Eyespot
Fusarium
 'Rust'



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Brewing grists



Passionate \longleftrightarrow Pragmatic \longleftrightarrow Presumptuous

*All
Malt*

*Malt &
Adjuncts*

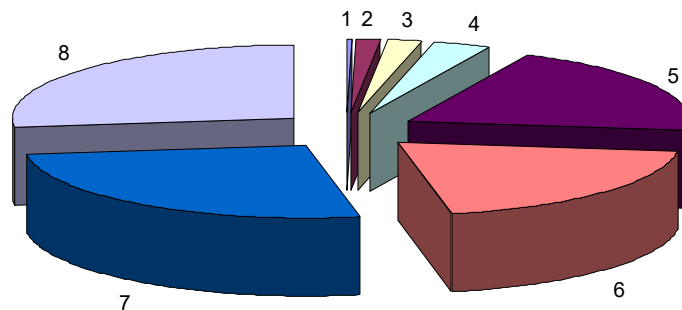
Barley

*Any source
of alcohol*

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The costs (%) in brewing beer

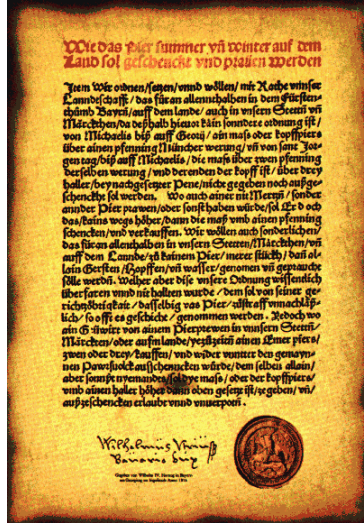


1 = hops; 2 = adjuncts; 3 = minor ingredients; 4 = malt; 5 = production; 6 = sales and marketing; 7 = packaging; 8 = tax

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Reinheitsgebot 1516



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Adjuncts



- “Wort extenders” – more wort, stronger wort: e.g. high maltose syrup, Candi sugar
- Lower color, less malt astringency: e.g. rice
- Distinctive flavors and product diversity: e.g. roast barley
- Enhanced quality – e.g. foam: wheat-derived adjuncts
- Environmental....

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Environmental issues



Water availability and usage
 Carbon dioxide emissions
 Volatile organic compounds
 Energy demands
 Uses for co-products – spent grains, yeast, filter aid etc
 Reduced inputs in agriculture
 Genetically-modified organisms



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Where do we start?



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C Footprint of One Beer



1. Electricity of refrigeration at retail
2. Production and transportation of glass
3. Production and transportation of malt

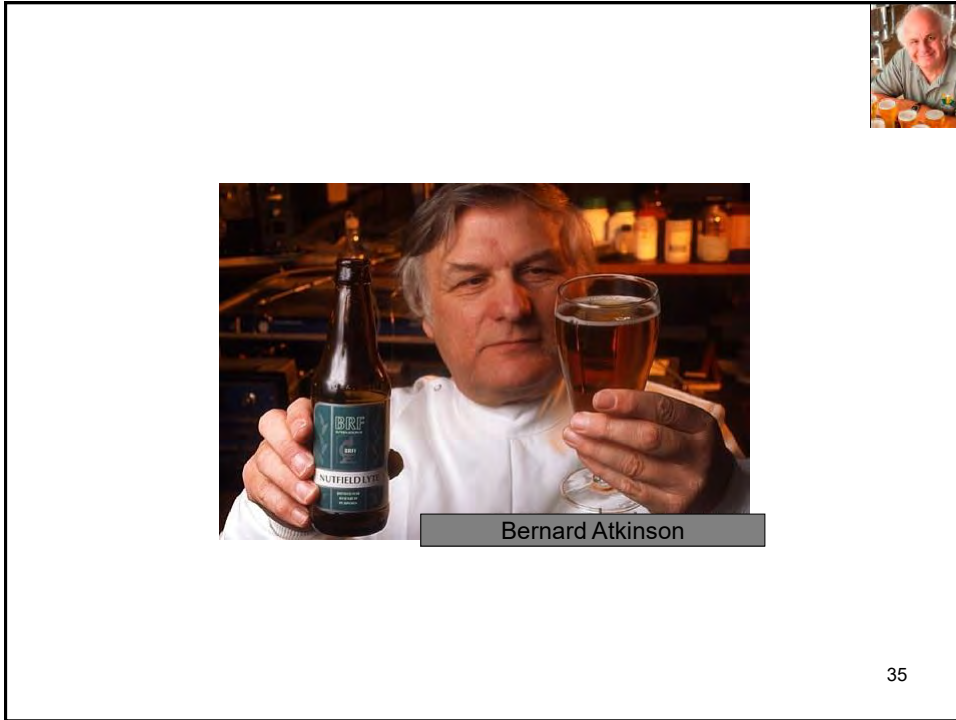
These three account for **68.4%** of emissions

Of the remainder, **25.1%** is accounted for by

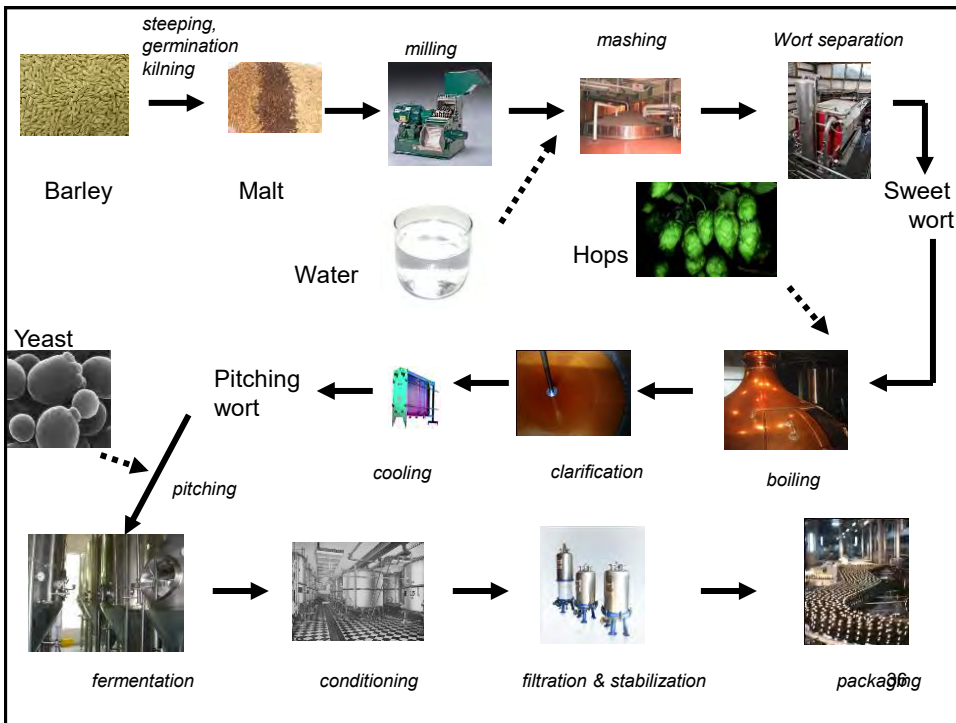
1. Production and transportation of paper
2. CO₂ for carbonation
3. Refrigeration in consumers' homes
4. Distribution transportation
5. Natural gas consumed in brewery operations

34

34



35



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Corn Syrup Process



- All corn sugar adjunct
- Hop extract
- Yeast
- Water
- “Beer” Flavoring and Coloring
- Quillaia extract (saponin powder) as a foaming agent
- Process begins at the boil
- Includes packaging



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“New Paradigm” Process



- Corn based pure ethanol (E100)
- Pre-Isomerized Hop extract
- Water
- “Beer” Flavoring and Coloring
- Quillaia extract (saponin powder) as a foaming agent
- Process starts at blending
- Includes packaging



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Conclusions



Percentage Reduction Versus Conventional Process (%)

Variable	Syrup Process	E100 Process
SEC	2.8%	35.9%
Water Usage	11.4%	73.1%
Effluent Output	3.0%	65.9%
Carbon Dioxide	10.2%	47.5%
Cost	8.4%	56.8%

SEC = Specific Energy Consumption

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glycerol
 beer flavor
 malt extract
 maltodextrin
 corn sugar
 citric acid
 dried beer extract
 caramel color
 yucca extract
 iso-alpha acids
 hop oil
 carbon dioxide
 water



40

40



A panel of 46 beer drinking consumers ranging in age from 21 to 50 years old evaluated the beer, twice. In both cases they scored their liking for the beer on a standard 9-point hedonic scale with 1= like extremely, 5=neither like nor dislike and 9=dislike extremely

First: no explanation

Second: The beer was "manufactured"

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Before mean = 5.9, range 2 to 9

After mean = 6.2, range 3 to 9

The two mean values were not significantly different at $p < 0.05$.

The consumers in general disliked the beer somewhat.

'Soulless' and very low in flavor.



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Malternatives



Happoshu



Third Category






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Hops

Less than 1% of cost of beer

Enormous effect on quality

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Female plant

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Lupulin

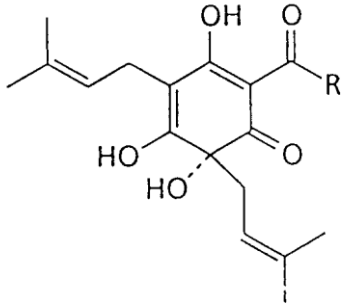


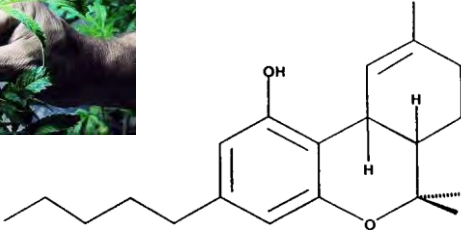
Resin – bitterness



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Hop resin

47

47

Lupulin

Resin – bitterness

Oil – aroma



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Training hops

50

50



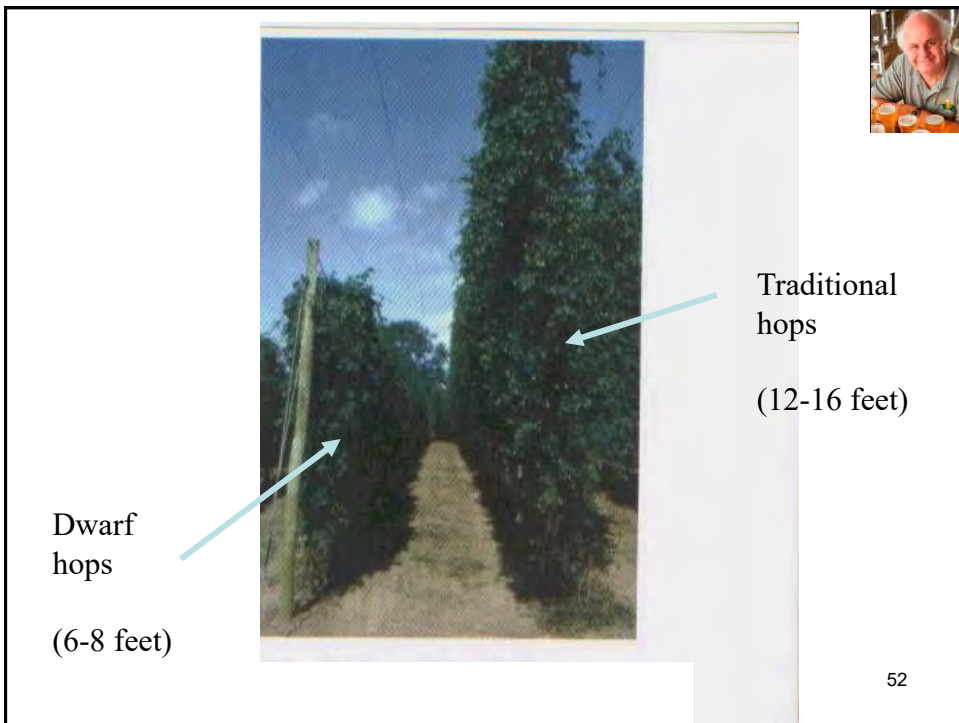
Fuggles

Cascade

Saaz

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51



Dwarf hops
(6-8 feet)

Traditional hops
(12-16 feet)

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52



53

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Hop producing country	Hop output (2005, tonnes)
Germany	34,438
United States	23,494
China	10,576
Czech Republic	7,831
Poland	3,414
Slovenia	2,539
United Kingdom	1,693
Spain	1,537
Ukraine	1,474
France	1,372
New Zealand	900



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Major growth locations in USA:

Washington (Yakima),
Oregon (Willamette Valley, Grant's Pass),
Idaho (Coldwell, Bonner's Ferry).



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Hallertau most famed region – N of Munich.

Also Western Czech Republic – Bohemia



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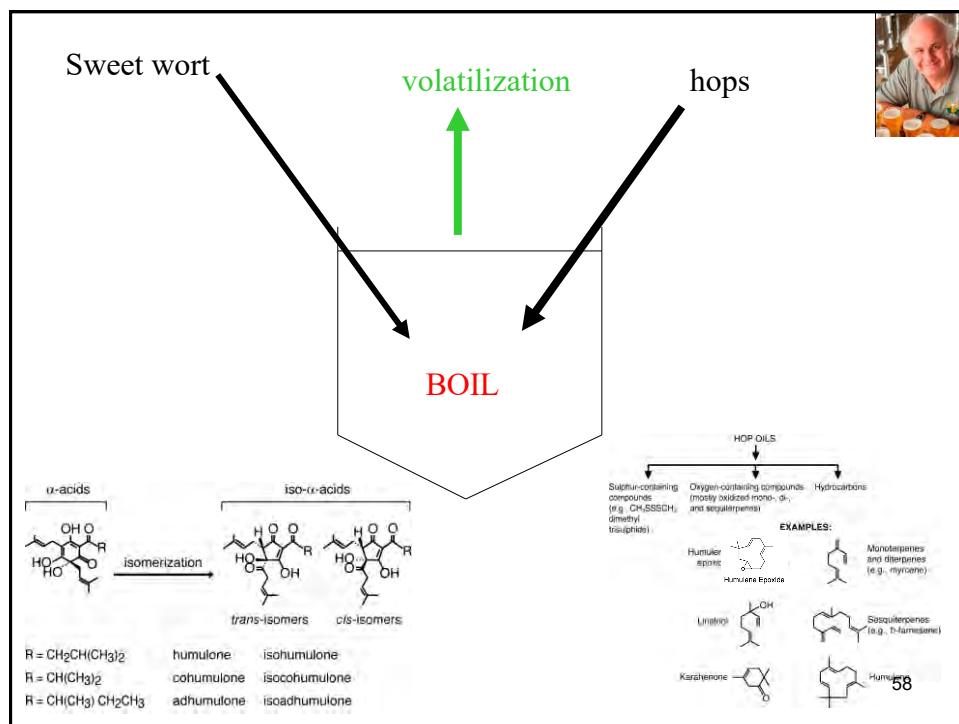
Bitter hops

Aroma hops

Dual purpose hops





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Late hopping



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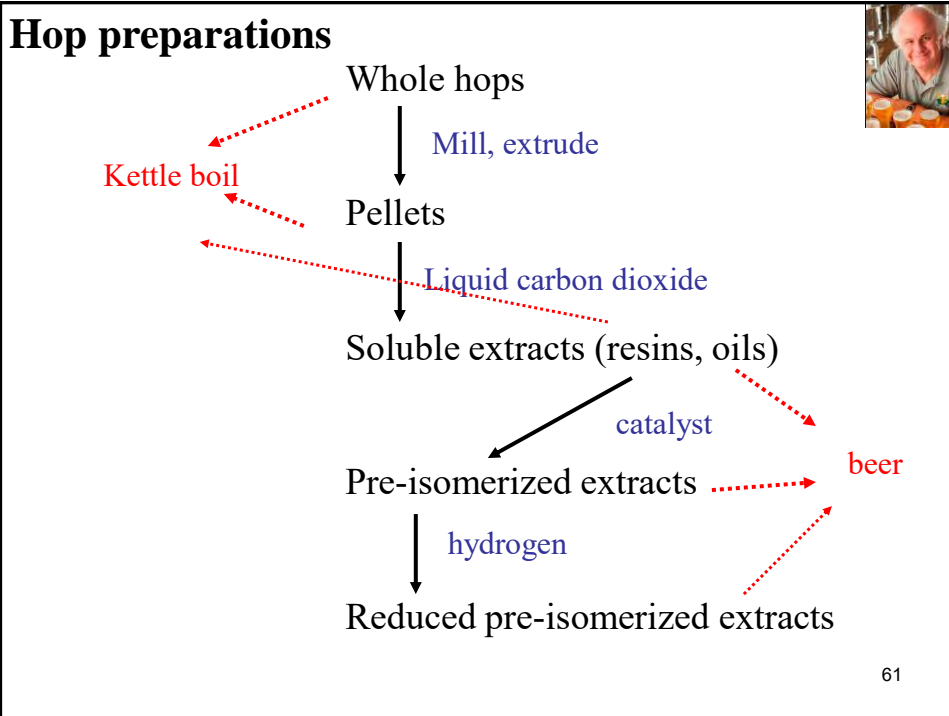
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Dry hopping



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A photograph of a modern building with a large glass facade and a prominent gabled roof, illuminated at night. The building is surrounded by a paved area and some greenery.

And keep a look out for more one-week science of Practical Brewing Extension classes in 2013

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March 15, 2012



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Charlie Bamforth
UC Davis



Steve Carlo
Chemist, Homebrewer

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The Chemistry Magic Behind Popcorn
Sara Risch, Popz.


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Thursday, March 22, 2012
Designer Babies
 Darren Griffin, Professor of Genetics at the University of Kent, UK.




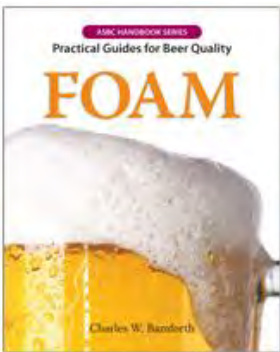
Monday March 26, 2012 & Tuesday March 27, 2012
Job Searching with Social Media
 3 Great Events:
 - Job Searching with Social Media
 - Surviving Chemistry with Humor
 - Eminent Scientist Lecture

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And the winner is...





Congratulations!

Winner of an autographed copy of *Foam!*

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