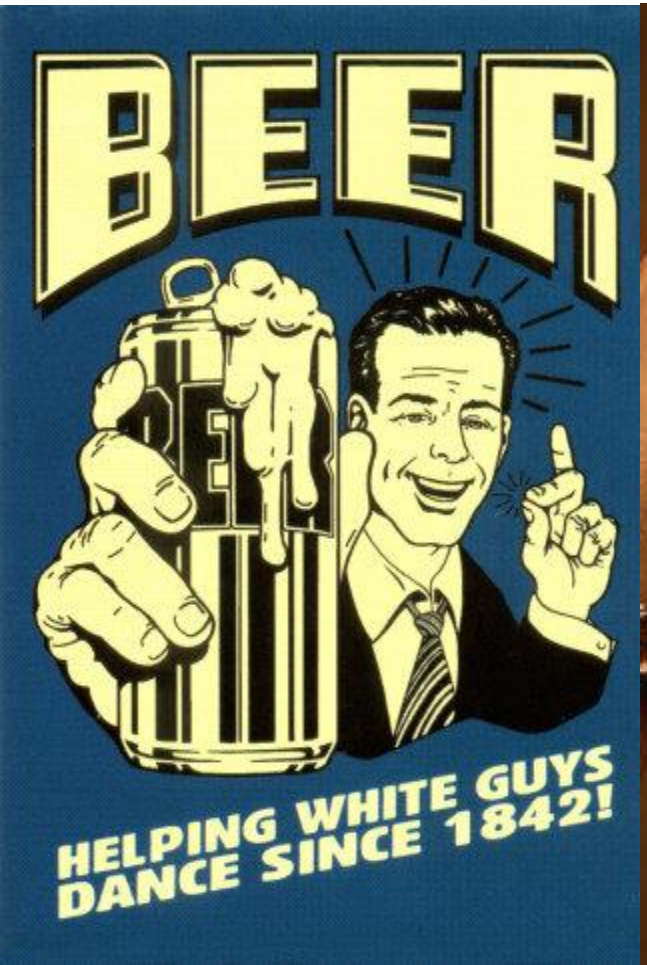
Brew Science on tap

March 6, 2014

Kevin Donato, PhD

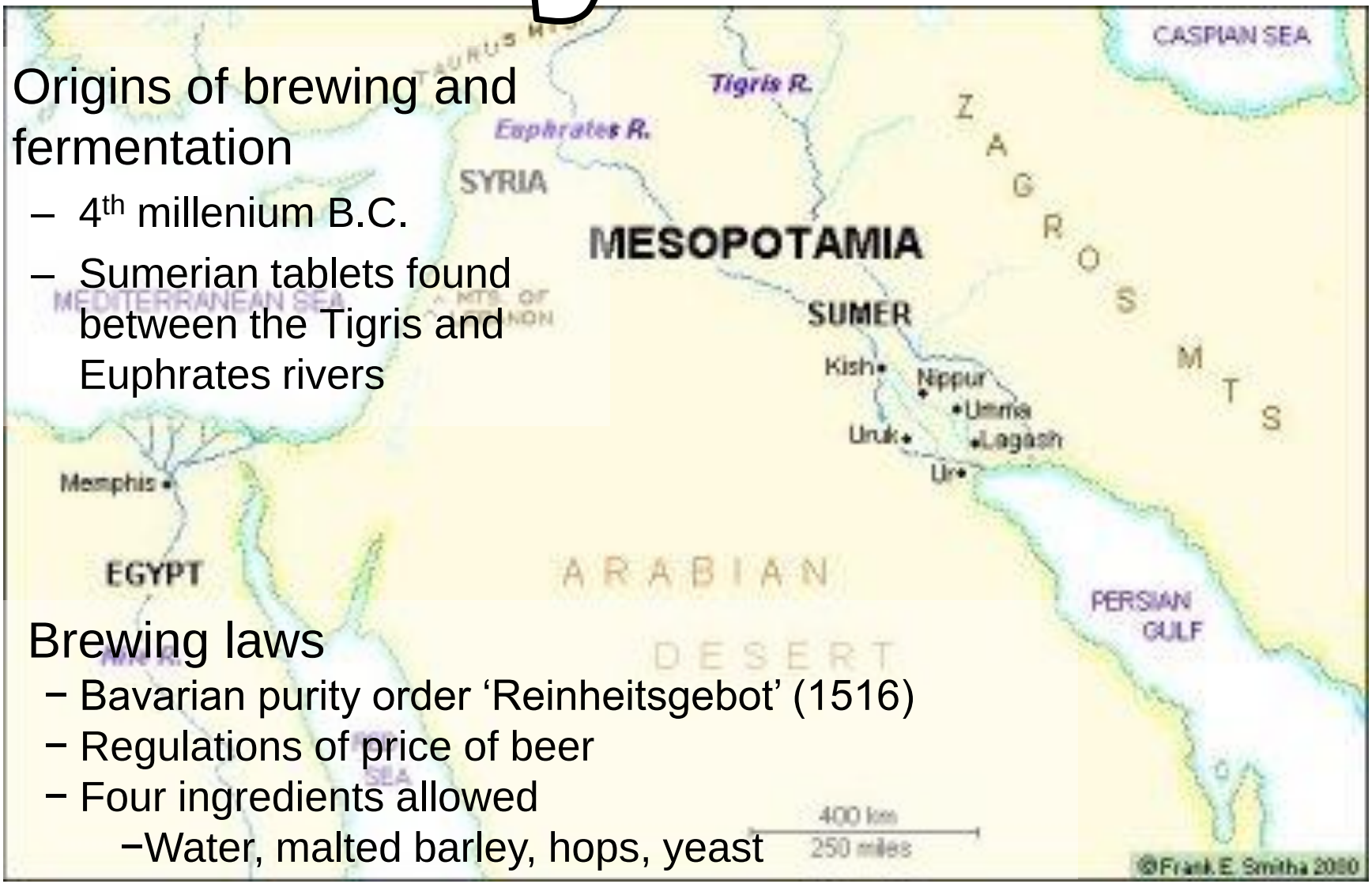


Outline

- Historical origins of brewing practice
- The basic brewing process walkthrough
- Microbiology and biochemistry – favourable vs. undesirable
- Taste different styles of beer!

History

- Origins of brewing and fermentation
  - 4th millenium B.C.
  - Sumerian tablets found between the Tigris and Euphrates rivers



- Brewing laws
  - Bavarian purity order ‘Reinheitsgebot’ (1516)
  - Regulations of price of beer
  - Four ingredients allowed
    - Water, malted barley, hops, yeast

Hornsey (1999) Brewing

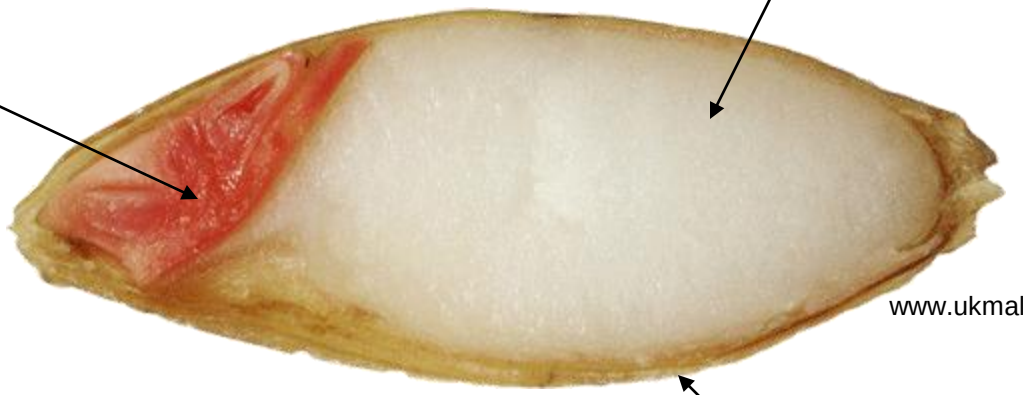
Outline of the brewing process

- Malting and Mashing
- Lautering and Sparging
- Hopping
- Fermentation
- Carbonation
- Fining

Donato 2008; at The Brew Kettle, Richmond Hill, ON

Malting

First step to starch conversion



www.ukmalt.com/graphics/transcorn.gif

The embryo uses sugar from the starch reserve for energy

- Soak for 8 hours and drain
- Germination → embryo produces amylases (enzymes that break down starch)
- Kilning process halts germination

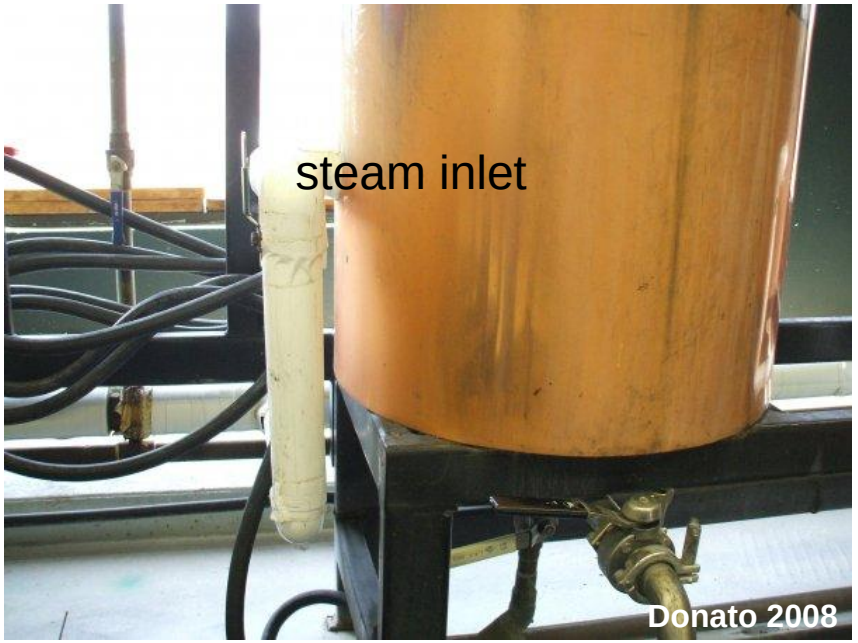
  → optimize amylase expression without digesting of the starch

Mashing

- Malted barley grains are milled to expose starch
- Hot water is added
- Enzymatic conversion

Importance of temperature control!

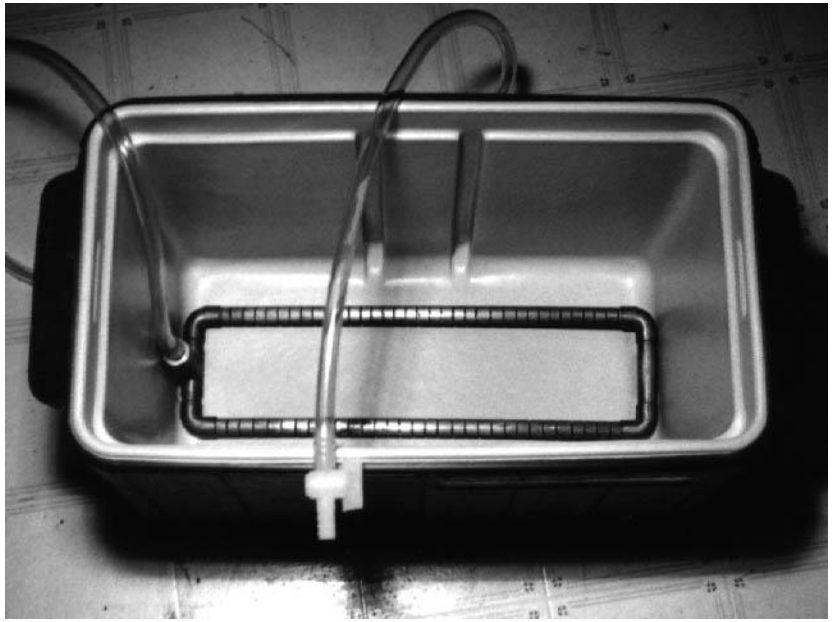
Maximum amyolysis occurs at 64-65°C



Lautering and Sparging

- **The process to remove the liquid portion of the mash**
- **Sprinkling hot water over the mash to wash more sugar into the extract**
- **The resulting liquid is called *sweet wort***

http://surrealstudio.net/Beer/sparging.jpg



http://www.howtobrew.com/images/f162.jpg

Hopping

- **The sweet wort is brought to boiling temperature and hops are added**
- **Flower buds, member of the *Cannabaceae* family**
- **Add bitterness and aromatics**

International Bittering Units (IBU)
ppm of alpha-acids

Goldings

Fragrant aromatic.

Saaz

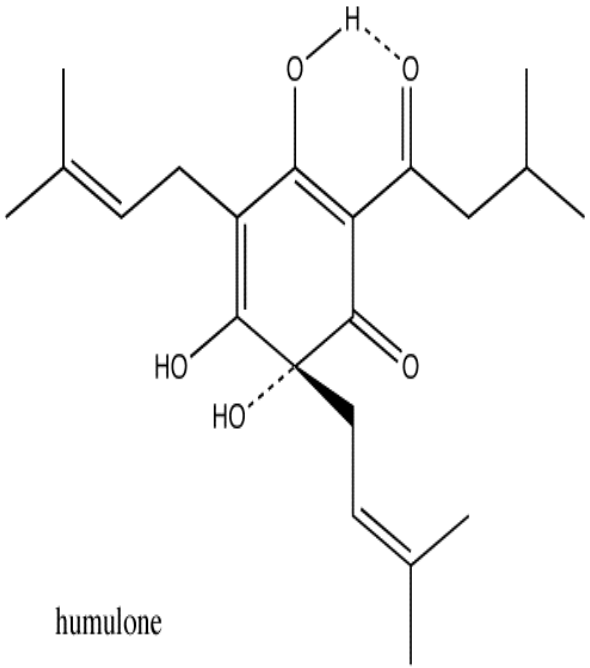
Very mild with pleasant hoppy notes, earthy, spicy, and herbal.

Humulus lupulus

The wort now has the basic flavours to make beer!

Palmer 2008 Brew Your Own Magazine

Biochemistry and organoleptics of hops



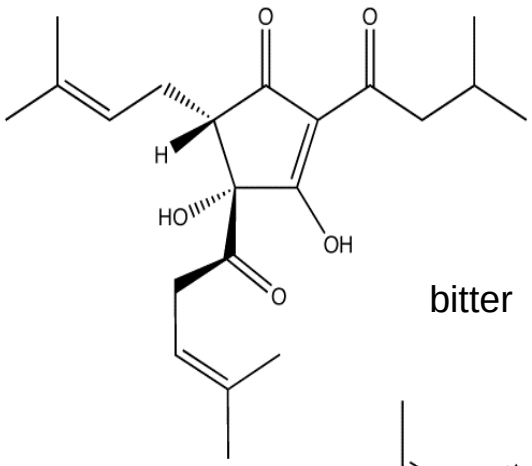
humulone

mildly bitter

HO⁻

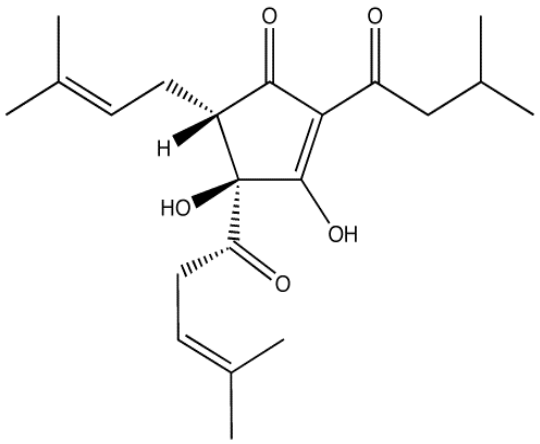
Δ

heat + alkaline conditions



cis-isohumulone

bitter



trans-isohumulone

Varnam and Sutherland 1999

De Keukeleire and Verzele 1971

Adjuncts and Flavouring

Non barley fermentables or flavouring ingredients

- Wheat
- Corn
- Fruits (raspberry, orange peel, strawberry)
- Honey
- Cocoa
- Spices (coriander, cinnamon, cumin)

Preparing for Fermentation

- Rapid cooling to desired temperature for yeast growth and elimination of “bad aftertaste”
  - *Di**m**e*thyl*s*ulfide (‘burnt corn’)
    - Derived from S-methylmethionine, grain germination
- Micro oxygenation
  - Required for synthesis of cell membranes

Now the wort is ready to ferment!

Bamforth (2005) Food, Fermentation and Micro-organisms

Specific gravity as a measure of sugar content and potential alcohol

- Density of a liquid relative to that of distilled water (1.000 kg/L). Corresponds to a potential alcohol

  More sugar = more density = more potential alcohol

- Wort ~1.030 – 1.060
- Finished beer ~1.010

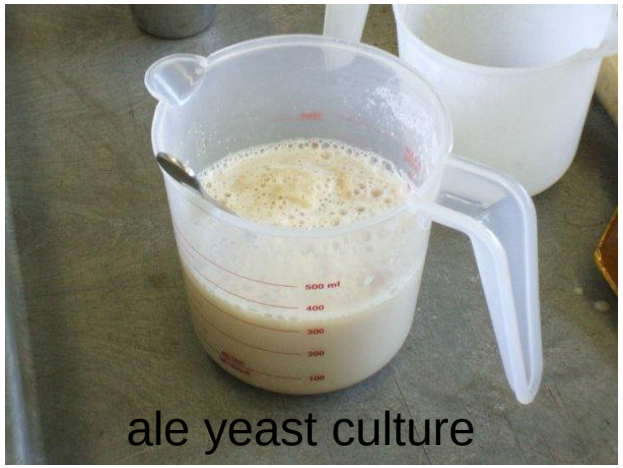
  Approx 3.5 - 7.5% alc/vol

- Adjust volume of the wort with water or boiling duration to achieve desired S.G.

http://www.santamariasun.com/images/cms/sized/cover.beer.hydrometer.10-1.jpg

Fermentation

- The distinguishing feature between ales and lagers
- Emil Hansen (Carlsberg laboratory, 1879) – single yeast cell isolation and subculture


ale yeast culture

	Ale	Lager
Buoyancy (flocculation)	Top fermenting (low)	Bottom fermenting (high)
Temperature	20°C (5 days)	8°C (up to two weeks)
α-galactosidase	-ve	+ve (digests melibiose)

Hornsey (1999) Brewing

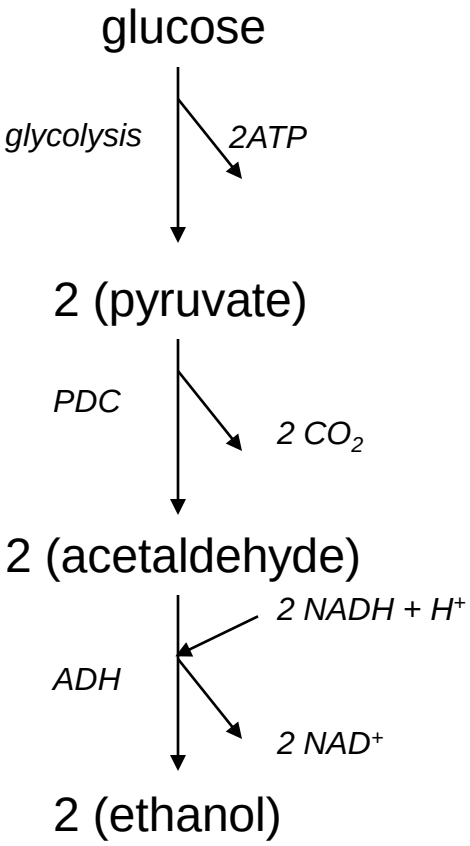
Walker (1998) Yeast Physiology and Biotechnology

Sugar utilization

Louis Pasteur (1857) – Correlates aerobic/anaerobic environment with respiration/fermentation

Herbert Crabtree (1928) – High glucose levels repress respiration and favour fermentation

Wort is a high glucose, microaerobic (low oxygen) environment



Preferential use of saccharides (sugars)

- sucrose (glucose-fructose, *invertase*)
- maltose (glucose-glucose, *maltase*)
- maltotriose (glc-glc-glc)
- melibiose (glucose-galactose, *galactosidase*)
- Larger sugars (dextrins) are not digested and create body (‘maltiness’)

Bamforth (2005) Food, Fermentation and Micro-organisms

Walker (1998) Yeast Physiology and Biotechnology

Polishing up

- Dropped temperature

  (-1 to -2°C, few weeks) encourages precipitation of proteins or removal by filtration
- Isinglass (collagen finings)
  - Net +ve charge in beer attracts net –ve charge in yeast membranes
- Some styles are kept *sur lie* (on the lees)


Conical lagering tank

~ala-pro-**arg**-gly-**glu**-hyp-pro~

This is an amino acid sequence repeat of collagen. In an acidic enironment like beer this sequence is positively charged.

Bamforth (2005)

Adding the 'fizz'

- Most finished beer has a certain measure of dissolved CO_2
- Pressurized CO_2 or N_2 (keg or widget)
- Natural (longer lasting and finer effervescence)
  - Addition of ‘priming sugar’ and yeast for a second fermentation
  - Bottles are capped to trap the CO_2, causing it to dissolve into the liquid

Comparative Exercise

- Colour
- Clarity
- Carbonation
- Nose
- Taste, body
- Finish

Perfection is in the pour!

- The ‘head’: a foam cap which forms at the surface of the beer
- Begin pouring by tilting the glass at a 45° angle
- The remaining depth of the glass should be filled while it is straight up

Lagers

Czech Pilsner

Very hoppy in character

Dry, and highly carbonated helps cleanse the palate

Ales

Lightly hopped, smooth, can be fuller bodied

Dense head produced by a nitrogen widget

Yin

Wheat beer: ‘Weissbier’, white beer

On the yeast: *Sur lie, hefeweissbier*

Often add coriander and orange peel for flavouring

Yang

Stout and Porter

Darkly kilned to caramelize the sugars

Accentuated by coffee and dark chocolate nuances

Fruit sensations and Desserts

Wheat beers with fruits as the key flavouring adjunct

strawberry

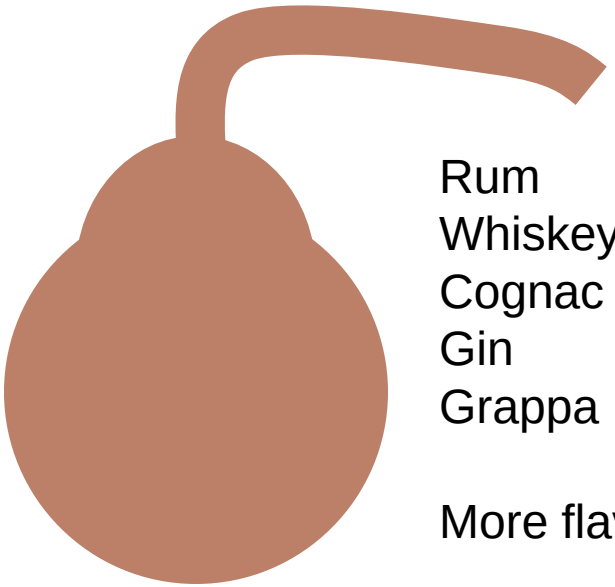
raspberry

Lambic beer – exposed to wild yeast for spontaneous fermentation

Distillation

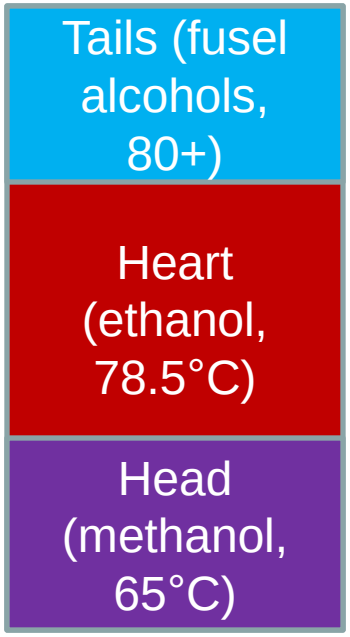
Separation of a mixture of liquids into its component parts based on the differing boiling points of the liquids

Alembic, pot still

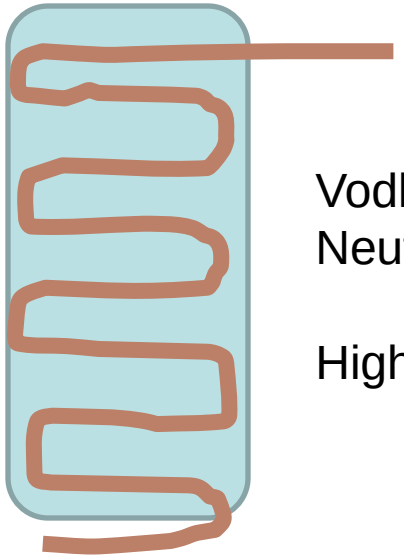


Rum
Whiskey
Cognac
Gin
Grappa

More flavour



Continuous, Coffey still



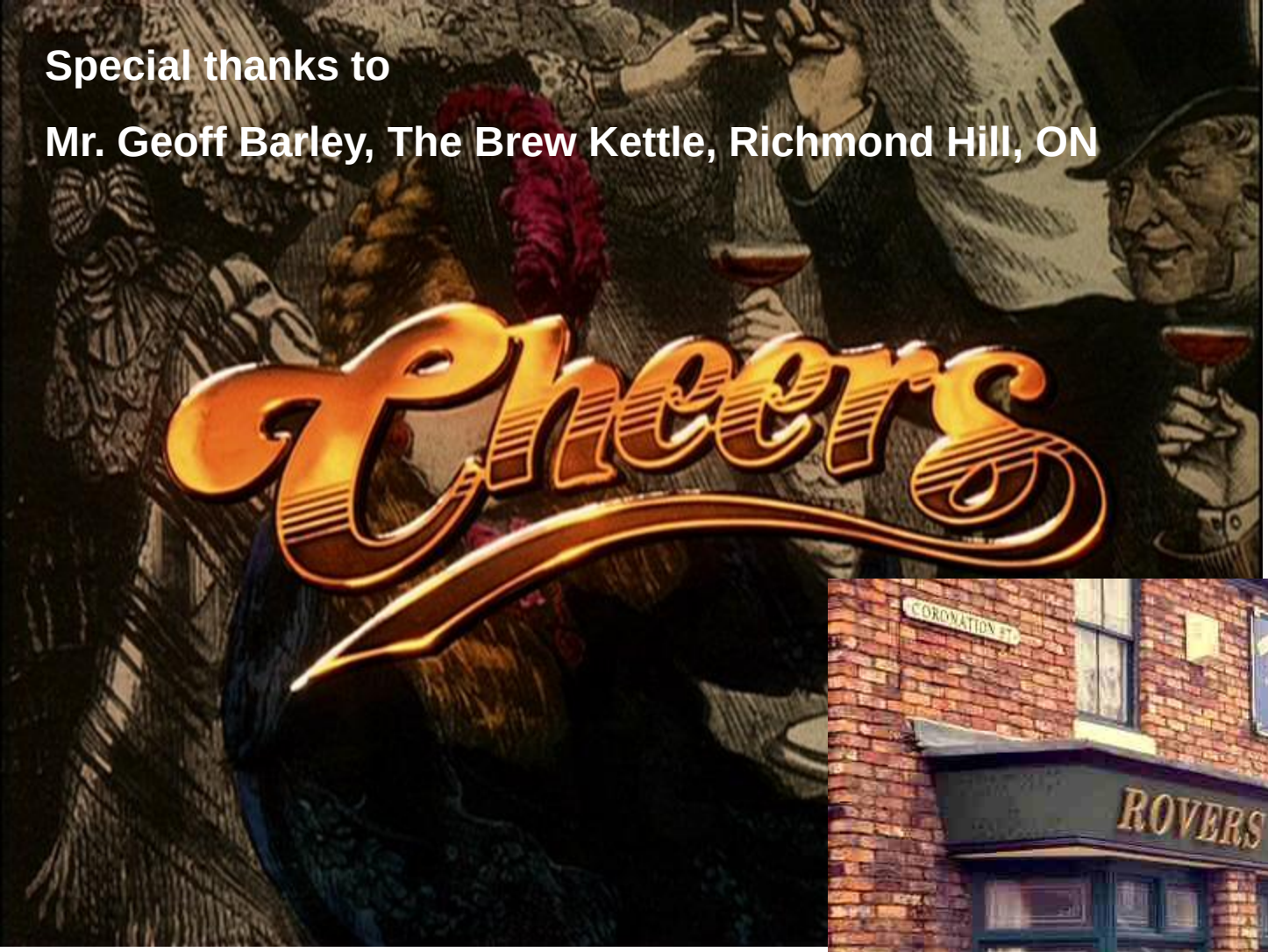
Vodka
Neutral spirits

Higher purity

The main task of the master distiller is to collect the *heart*

Special thanks to

Mr. Geoff Barley, The Brew Kettle, Richmond Hill, ON



Thanks for coming and bottoms up!