Enviable Heritage to Impressive Future – The Impact of Brewing on Science

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Group Chief Brewer

SABMiller PLC

Brewing Science Faces Key Challenges In Attracting Talent:

Brewing Science Brain Drain - Competing Sectors

Mixed Messages In Recent Decades

We Tend To Be Understated

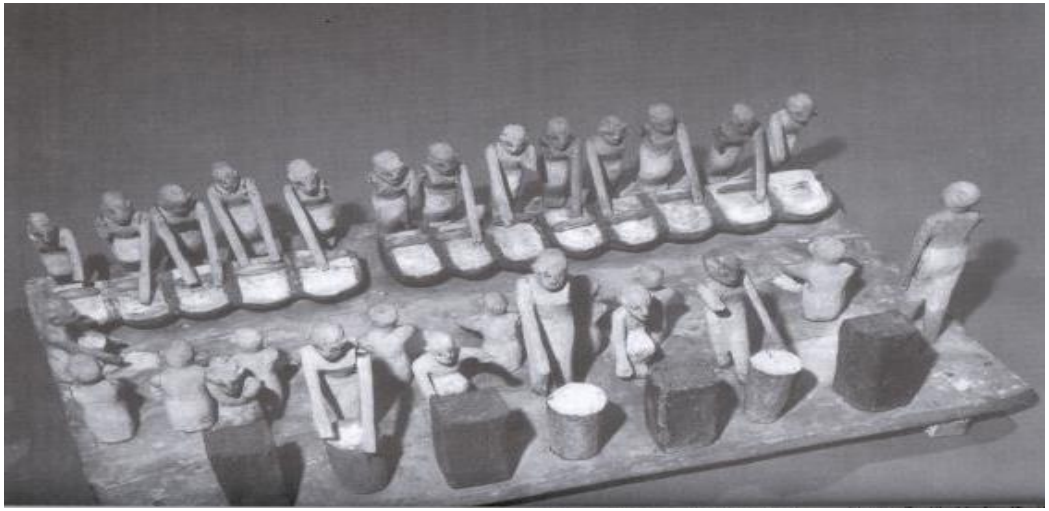
How Do We Mitigate That Risk?

Share the impact that brewing has had on science

Recording Recipes and Processes

Recording Product Formulations And Processes

A Mesopotamia text (3000 B.C.) showing calculations of basic ingredients required for the production of different types of beer.



A wooden funerary model from the tomb of King Nebhetepre Montuhotep (1980 BC)

Bringing History To Life

Tutankhamun Ale

- In 1990, Cambridge archaeologist Dr. Barry Kemp unearthed Queen Nefertiti's Royal Brewery.
- He found ten brewing chambers buried beneath the Egyptian sand.
- Traces of ancient beer residue were analyzed the residues to quantify the 3,250-year-old recipe.

American Timeline For Context

First Brewing Steps In The USA

Historical Context: USA

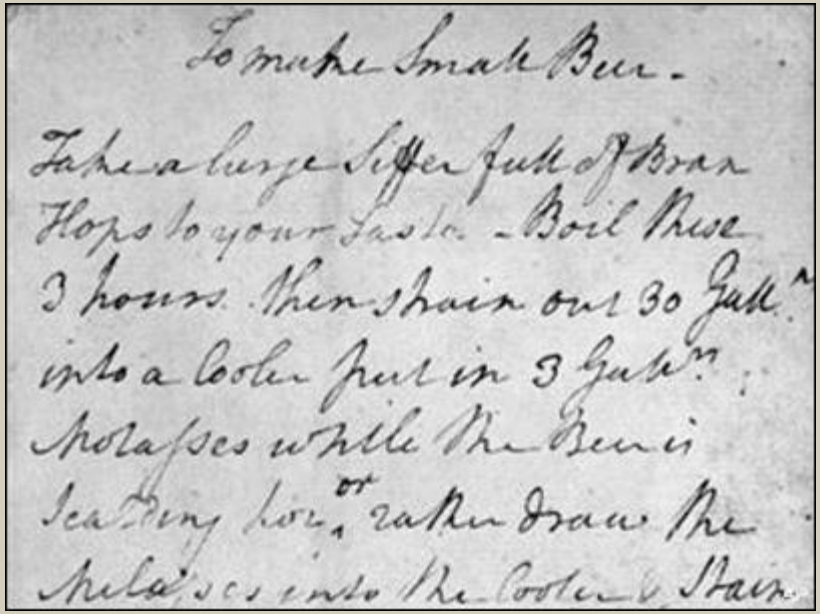
1587 – Virginia colonists brew first ale using corn

1607 – First import of beer from England

1609 – First talent search for London Brewers to relocate to Virginia to set up breweries

1734 – Mary Lisle takes over Edinburgh brewhouse in Philidephia

1754 – George Washington enters a beer recipe in his notebook.

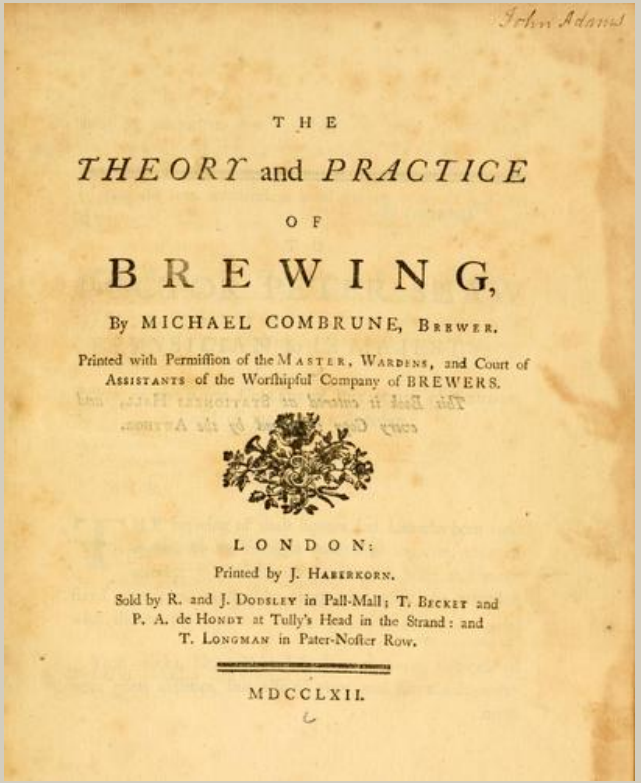

To make Small Beer.

Take a large Siffer full of Bran
Hops to your Taste - Boil these
3 hours. Then strain out 30 Gall.
into a Cooler put in 3 Gall.
Molasses while the Beer is
Scalding hot, or rather draw the
Molasses into the Cooler & strain

Documentation of Science

Historical Context: UK

1762 – Michael Combrune in London attempts to write the first technical manual.



The Role of Organisations In Science

- Worshipful Company of Brewers
  - Formed in 13th Century
  - Formerly recognised in 1438 by Royal Charter from Henry VI

Medieval Advances

- Monks and indeed village brewers knew the importance of the beer barm (foaming head)

- It had to be transferred from brew to brew.

Medieval Advances

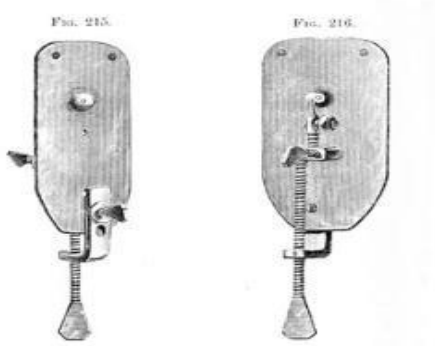
- Monks knew the importance of the beer barm (foaming head)
- It was transferred from brew to brew and stored on dried twigs

From Mithfield Decretals In 1340

Antonie van Leeuwenhoek

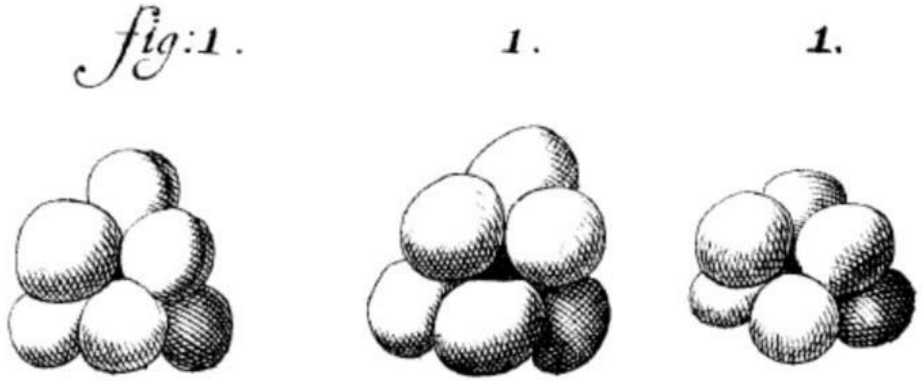
In 1673 developed the first microscope

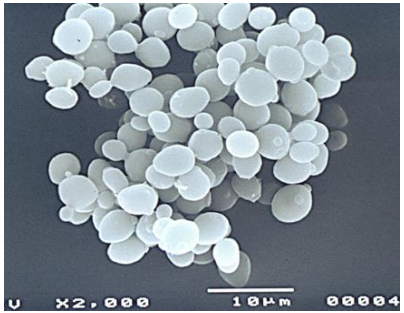
- He aspired to see the hidden world of the small……in beer
- He shared his invention with other scientists at the Royal Society
- They were less than complimentary



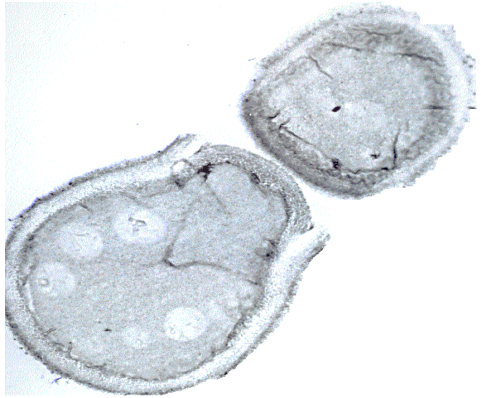
The Role of Organisations In Science

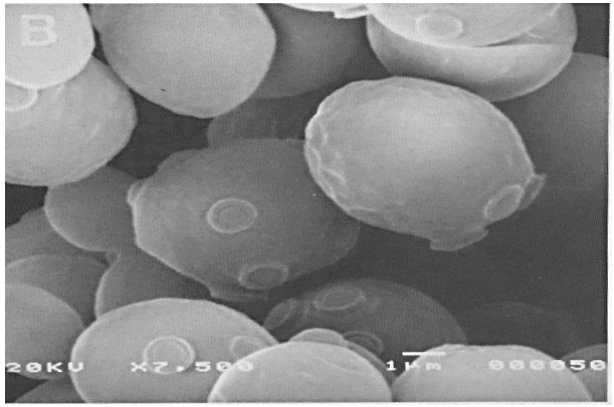
- Royal Society
  - Founded in 1660
  - Royal Charter in 1662

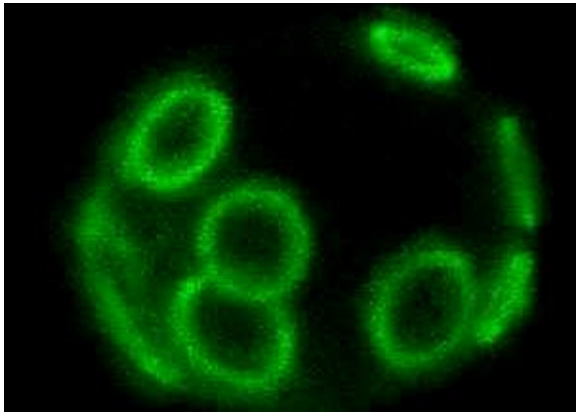




What We Can See Now

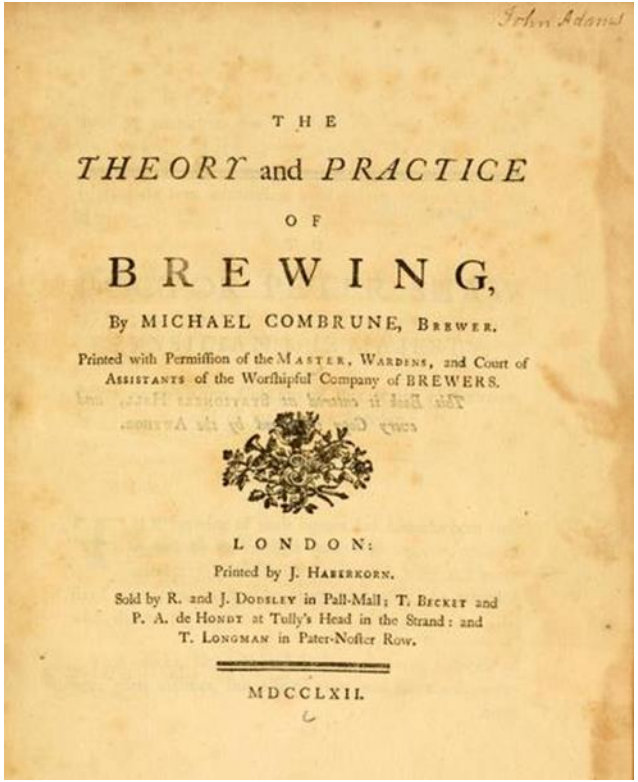






We Can Lay Claim To……

Thermometer
Michael Combrune (d.1773)



THE

THEORY and PRACTICE

OF

BREWING,

By MICHAEL COMBRUNE, Brewer.

Printed with Permiſſion of the Master, Wardens, and Court of Assistants of the Worſhipful Company of BREWERS.

LONDON:

Printed by J. Haberkorn.

Sold by R. and J. Dodsley in Pall-Mall; T. Becket and P. A. de Hondt at Tully's Head in the Strand: and T. Longman in Pater-Noſter Row.

MDCCLXII.

Crisis: Taxes and Excise

- UK
  - Customs
    - Levies based on import or export of goods, including beer
    - Primarily to raise funds for royal use
    - Linked to value of product
    - Initially codified by King John (1203)
  - Excise
    - Internal system of raising funds within the country
    - Not linked to value of product
    - Set up by Long Parliament in 1643 to fund Cromwell's army
    - Brewers needed methods of measurement

Introduction of measurement

- Measurement of Beer “Strength”
  - Excise judged beers strong or small based on tasting
  - Brewers countered by diluting strong beer with some small beer and selling the mixture as strong; therefore, saving duty

“Saccharometer” which allowed accurate measurement of wort strength

The Saccharometer

Saccharometer
James Baverstock (1741-1815) and
John Richardson (1743-1815)

THE
PHILOSOPHICAL PRINCIPLES
OF THE
Science of Brewing;
CONTAINING
THEORETIC HINTS on an improved Practice
OF
BREWING MALT-LIQUORS;
AND
Statical Eſtimates of the *Materials* for *Brewing*,
OR
A TREATISE on the APPLICATION
AND
USE of the SACCHAROMETER;
BEING
New Editions, corrected, of thoſe Treatiſes,
With the Addition of
The Use of the Saccharometer
Simplified, &c. &c.

By JOHN RICHARDSON.

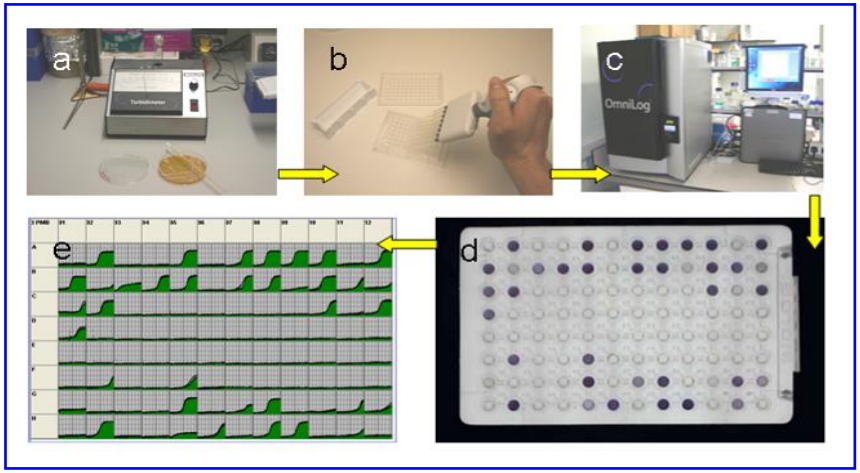
YORK:

PRINTED BY A. WARD, FOR G. G. AND J. ROBINSON, PATER-NOSTER-ROW, LONDON; T. BROWNE, HULL; C. ELLIOT, EDINBURGH; LUKE WHITE, DUBLIN; AND T. WHITE, CORK.

MDCCLXXXVIII.

Novel Instruments: Lab On A Chip

Omnilog: Screening of Strains



Yeast cell growth and metabolism

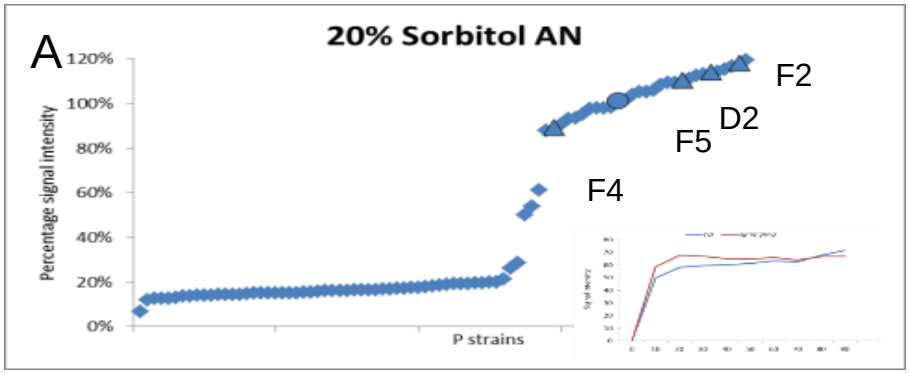
NADH

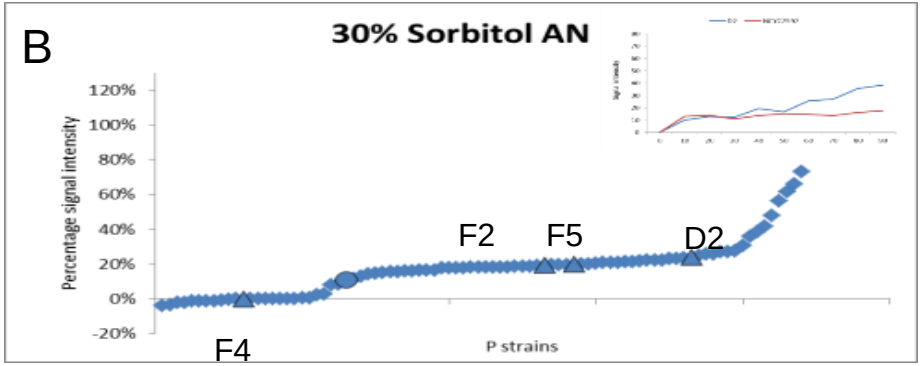
TV Colourless → TV Colour

TV = Tetrazolium violet

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Rapid Assessment Of Tolerance Of Strains To Stress



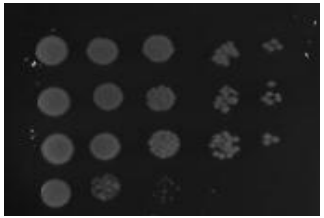


Industrial strain tolerance to osmotic stress in the presence of sorbitol (A) 20% and (B) 30% at 24 hours incubation at 30^0C in anaerobic conditions. Inset is the data for the entire incubation period for X1 (Control) and the more efficient sugar utilising parental strain (D2) in anaerobic condition. Spot plates for exemplar strains is also shown (C).

C

20% SORBITOL
D2
F2
F5
X1

20% SORBITOL



10^6 10^5 10^4 10^3 10^2

Units and Laws

James Joule – A Brewing Physicist

- Joule became a manager of the brewery in 1854.
- Science was a hobby
- He investigated the feasibility of replacing the brewery's steam engines with the newly invented electric motor.
- In 1838, he published his first scientific papers on electricity. Joule is best known for his research in electricity and thermodynamics.
- In 1840 he formulated Joule’s Law.

Joule's Law

Joule's Law

"the amount of heat produced each second in a conductor by a current of electricity is proportional to the resistance of the conductor and to the square of the current"

The unit of energy called the joule is named after him; it is equal to 1 watt-second, or 10 million ergs, or about 0.000948 British thermal units.

$$P = \frac{E^2}{R}$$

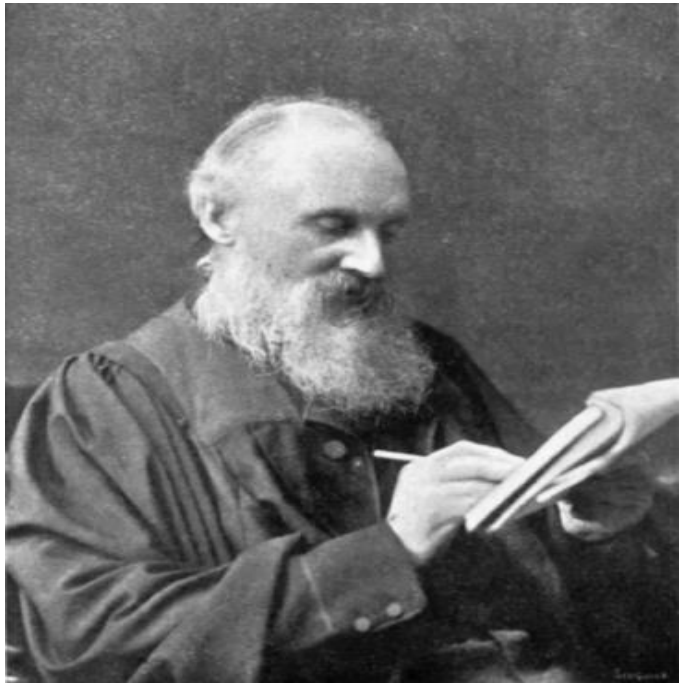
$$P = I^2R$$

Power is proportional to the *square* of either voltage or current

Cool Science

Together with the physicist William Thomson (later Baron Kelvin), Joule found that the temperature of a gas falls when it expands without doing any work.

This principle, which became known as the Joule-Thomson effect, underlies the operation of common refrigeration and air conditioning systems.



Søren Peder Lauritz Sørensen

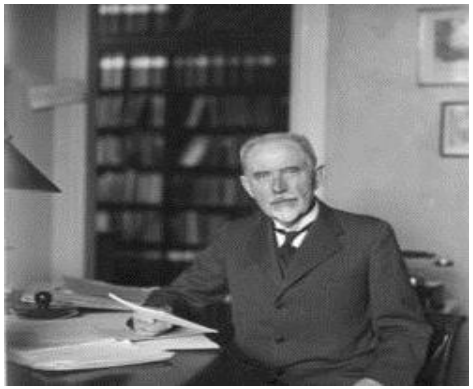
Søren Peder Lauritz Sørensen (9 January 1868 – 12 February 1939) was a Danish Chemist.

From 1901 to 1938 he was head of the Carlsberg Laboratory in Copenhagen.

Sørensen studied the effect of ion concentration on proteins. He introduced the pH-scale as a simple way of expressing this in 1909.

His publication described two new methods for measuring acidity.

- One method based on electrodes
- A second involved comparing the colours of samples in the presence of a preselected set of indicators.



The Age of the Brewing Chemist

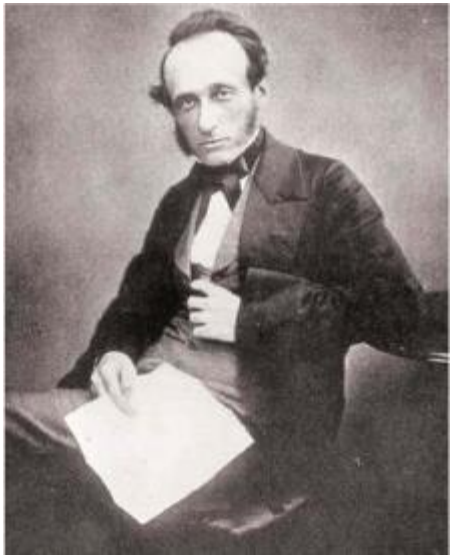
Science Wasn't Always Successful

Robert Warington worked for Trumans Brewery

In a paper presented to the Chemical Society in 1845

Attempted to turn porter into pale ale by treatment with charcoal.

He noted that it worked well in removing the color but also removed most of the flavor and bitterness.

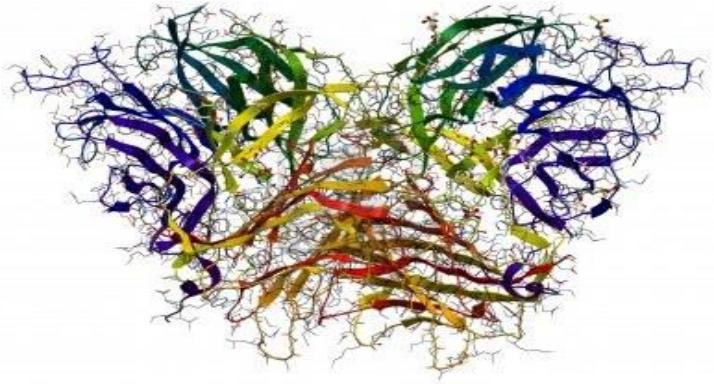


Cornelius O'Sullivan

- An Irish man, who studied Chemistry in Berlin and joined Bass Brewers in 1866.

- In 1872 he considered the transformation products of Starch and "rediscovered" maltose and then was the first to publish on dextrins before a series of papers on barley, malt and mashing.

- His most famous work was "Invertase: a contribution to the history of an enzyme"



The Age of the Brewing Microbiologist

Fermentation

“He that understands the nature of ferments and fermentation, shall probably be much better able than he that ignores them”.

Robert Boyle (1661)

Speaking at the Royal Society

Improving Beer Quality

Louis Pasteur

Professor of Chemistry at Lille University

Urged by local brewers to help them solve the mystery of souring beer

Etudes Sur La Bierre (1876)

Importance of Single Strain Fermentations

Emil Christian Hansen

Carlsberg Laboratory 1883

Different Strains Produced Different Beers

Wild Yeasts

Single Strain Brews


“Not everything that counts can be counted, and not everything that can be counted counts.”
Albert Einstein

William Gosset

Born in England William Gosset read Chemistry and Mathematics at Oxford. On graduating in 1899, he joined the brewery of Arthur Guinness and Son in Dublin, Ireland.

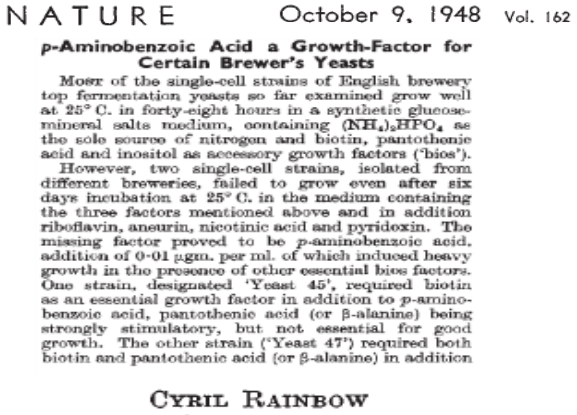
Gosset would apply his statistical knowledge — both in the brewery and on the farm — to the selection of the best yielding varieties of barley.

In collaboration with Pearson and after much pleading with the Company he was allowed to publish their formula under a pseudonym ("Student").

His formula was the Student’s T-Test.

How Do We Encourage The Very Best Scientists To Join Our Sector?

Personal Experience



NATURE October 9, 1948 Vol. 162

p-Aminobenzoic Acid a Growth-Factor for Certain Brewer's Yeasts

Most of the single-cell strains of English brewery top fermentation yeasts so far examined grow well at 25° C. in forty-eight hours in a synthetic glucose-mineral salts medium, containing $(NH_4)_2HPO_4$ as the sole source of nitrogen and biotin, pantothenic acid and inositol as accessory growth factors ('bios').

However, two single-cell strains, isolated from different breweries, failed to grow even after six days incubation at 25° C. in the medium containing the three factors mentioned above and in addition riboflavin, aneurin, nicotinic acid and pyridoxin. The missing factor proved to be *p*-aminobenzoic acid, addition of 0·01 μgm. per ml. of which induced heavy growth in the presence of other essential bios factors. One strain, designated 'Yeast 45', required biotin as an essential growth factor in addition to *p*-amino-benzoic acid, pantothenic acid (or β-alanine) being strongly stimulatory, but not essential for good growth. The other strain ('Yeast 47') required both biotin and pantothenic acid (or β-alanine) in addition

CYRIL RAINBOW

THE MONOPOLIES COMMISSION

Beer

A Report on the Supply of Beer

UNIVERSITY OF CAMBRIDGE

Creating the Next Generation of Brewing Scientists

Former ASBC International Director
Award of Distinction 2008

Creating the Next Generation of Brewing Scientists

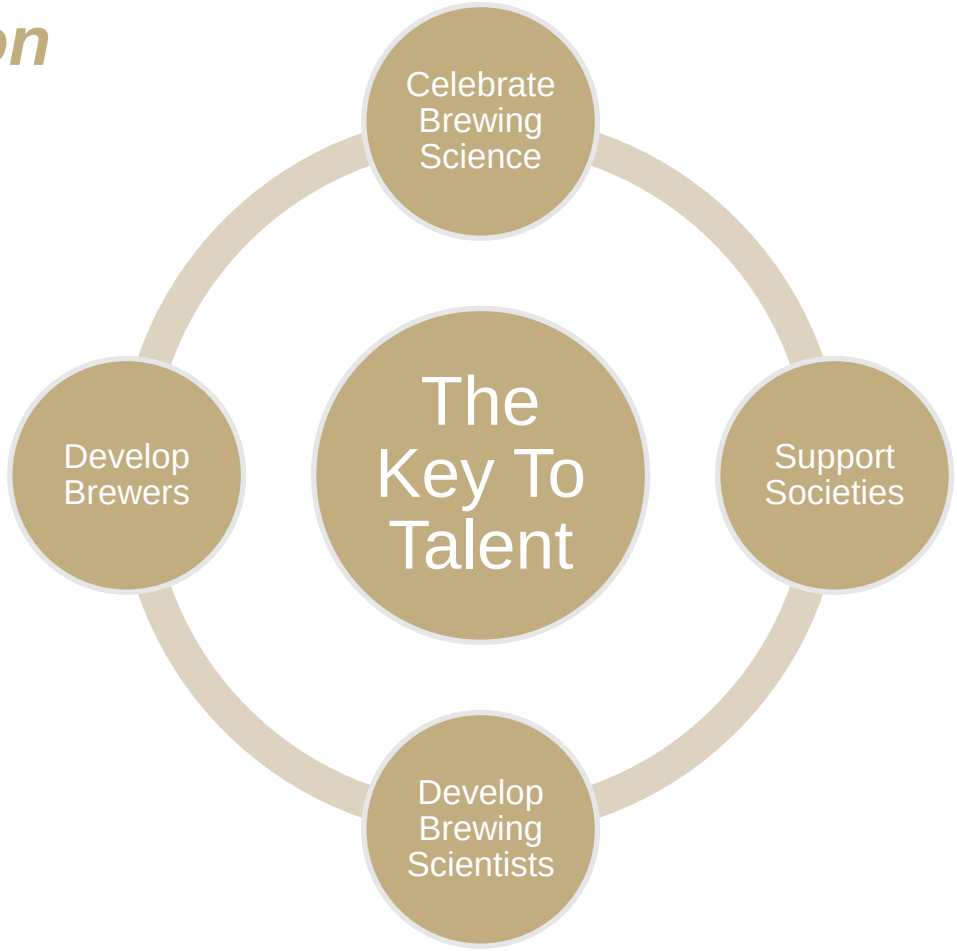
THE ROYAL SOCIETY

SAB MILLER

THE ROYAL SOCIETY

SABMiller Royal Society Exchange Programme

In Conclusion



The Future of Beer is Brewing Science

Thank you for your kind attention