Brewing yeast – theory and practice

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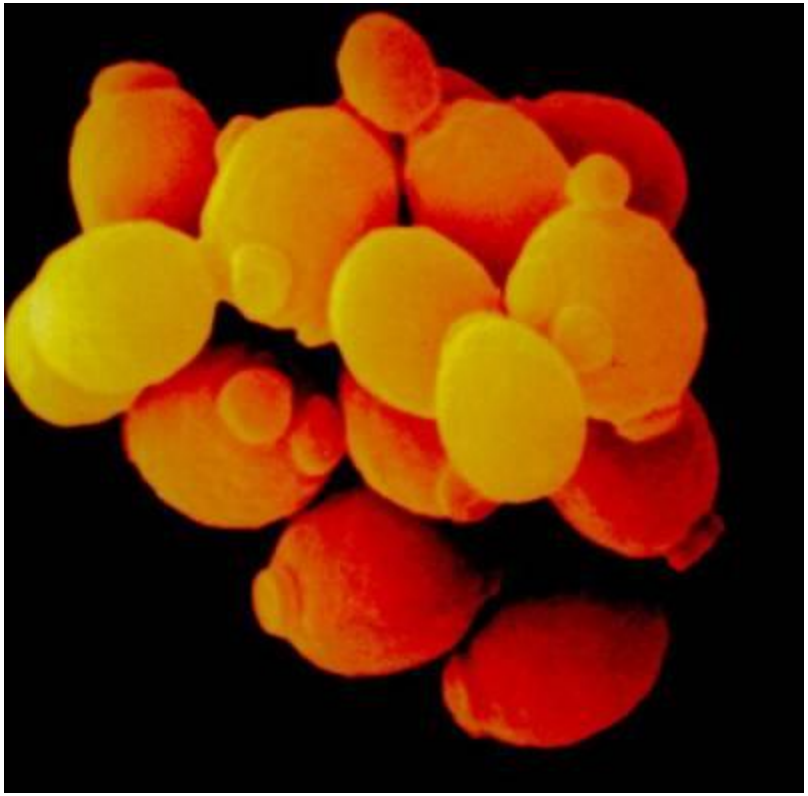
Topics

- What is brewing yeast?
- Yeast properties, fermentation and beer flavour
- Sources of yeast
- Measuring yeast concentration

The nature of yeast

- Yeast are unicellular fungi
- Characteristics of fungi:
    - Complex cells with internal organelles
    - Similar to plants but non-photosynthetic
    - Cannot utilise sun as source of energy so rely on chemicals for growth and energy

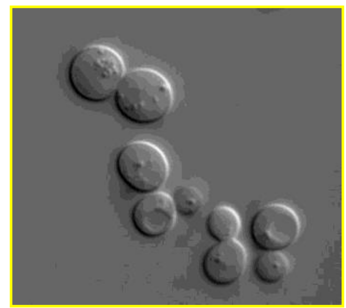


Classification of yeast

Kingdom — Fungi

Moulds

Yeast



Mushrooms / toadstools

> 500 yeast genera — Genus *Saccharomyces* (Means “Sugar fungus”)

Species — *S. cerevisiae* (ale yeast) — *S. pastorianus* (lager yeast)

Strains — Many thousands!

Biology of ale and lager yeasts

- Two types indistinguishable by eye
- Domesticated by man and not found in wild
- Ale yeasts – *Saccharomyces cerevisiae*
    - Much older (millions of years) than lager strains in evolutionary terms
    - Lot of diversity in different strains
- Lager strains – *Saccharomyces pastorianus* (previously *S. carlsbergensis*)
    - Comparatively young (probably < 500 years)
    - Hybrid strains of *S. cerevisiae* and wild yeast (*S. bayanus*)
    - Not a lot of diversity

Characteristics of ale and lager yeasts

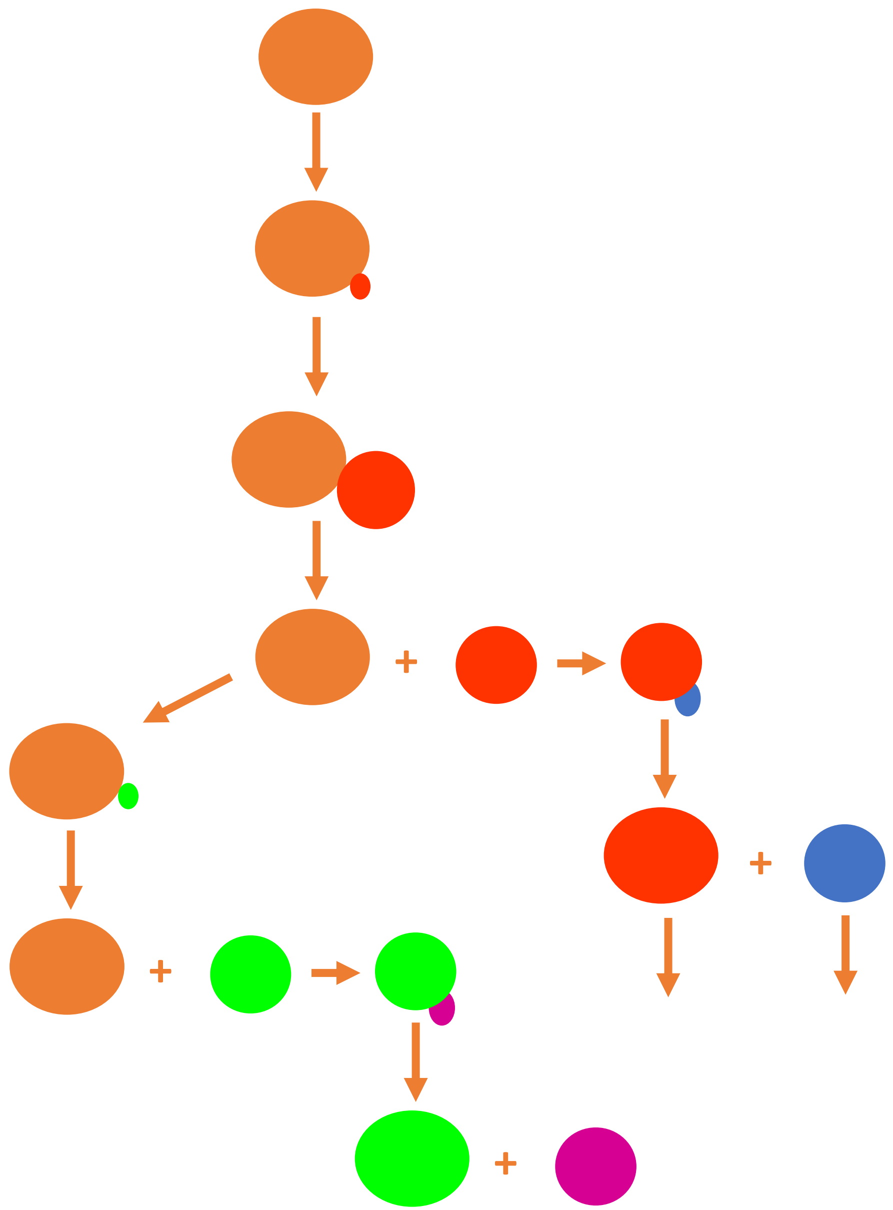
Ale

- Often form top crops
- Ferment at higher temperature (18 - 22^{o}C)
  - Quicker fermentations (few days)
- Can grow up to 37^{o}C
- Fine well in beer
- Cannot use sugar melibiose

Lager

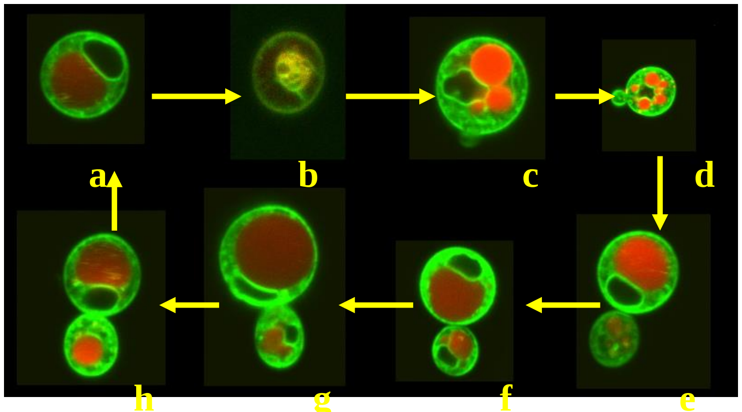
- Usually form bottom crops
- Ferment well at low temperatures (5 – 10^{o}C)
  - Slower fermentations (1 – 3 weeks)
- Cannot grow above 34^{o}C
- Do not fine well in beer
- Can use sugar melibiose

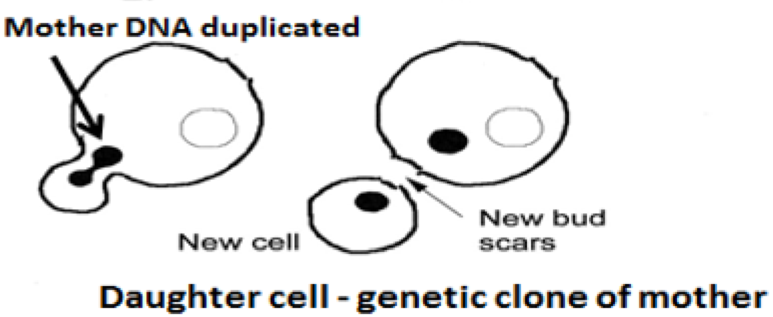
Growth of yeast cells via budding



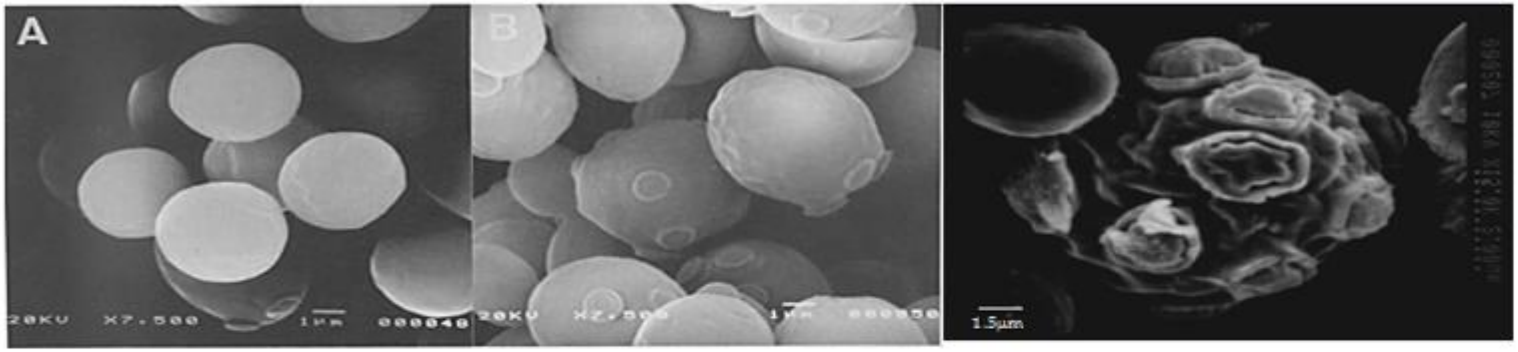
Yeast cells

- Each cell is *ca* 5 – 10 microns in diameter (1 micron = 1 millionth of a metre)
- Cells multiply by budding





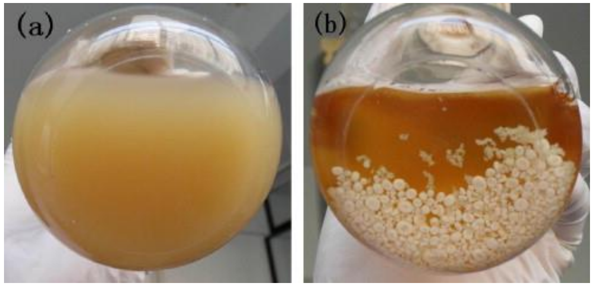
Yeast and ageing - cells can only bud a certain number of times before death occurs.



DAUGHTERS MOTHERS GRANDMA

Yeast dispersion and flocculation

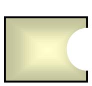
- Flocculation – ability of yeast cells to bind together
- Flocculence - inherent genetic property of yeast strain
  - Some are flocculent and some are not!
  - Most brewing strains are at least moderately flocculent
- Flocculation – expression of flocculence
  - The process by which it occurs
  - Determined by expression of flocculation genes
  - Clumping characteristic turned on or off

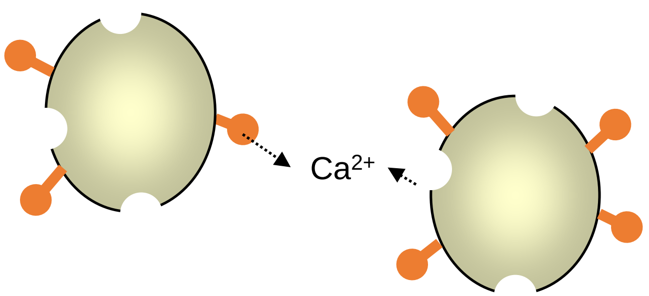


How does flocculation work?

- Involves interaction between adjacent yeast surfaces
  - Calcium mediated process – activate the flocculins
- Receptors are present in ALL yeast cells
  - Flocculent and non-flocculent

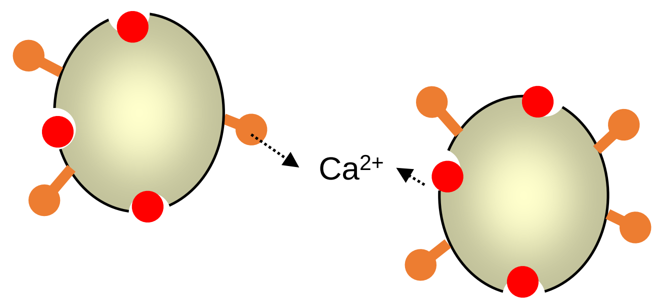
 Zymolectin protein (Flocculin)

 Mannan receptors



Effect of wort sugars

- Sugars present in the wort can also bind to the receptor sites
  - Prevents flocculins attaching and causes cells to ‘deflocculate’



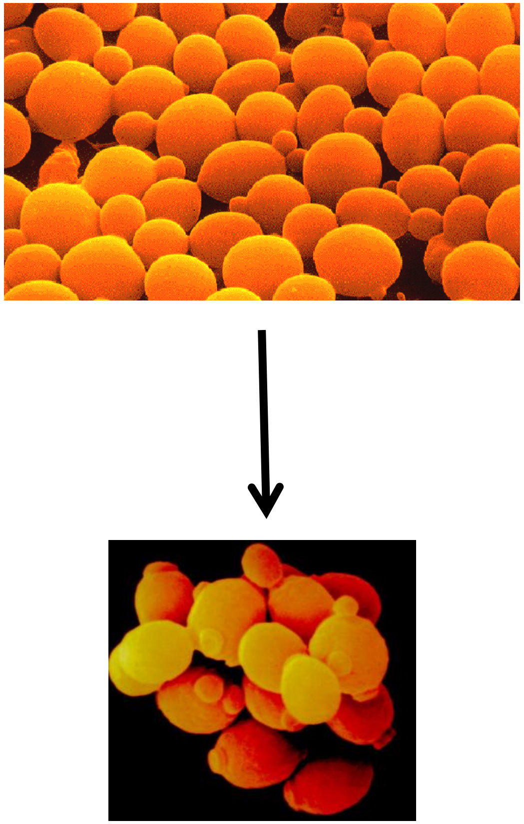
Zymolectin protein (Flocculin)

Mannan receptors

Wort sugar

Flocculation works to advantage of brewer

- Sugars (including glucose, maltose and sucrose) block receptor sites and cause yeast cells to de-flocculate
    - Ensures cells are dispersed at start of fermentation



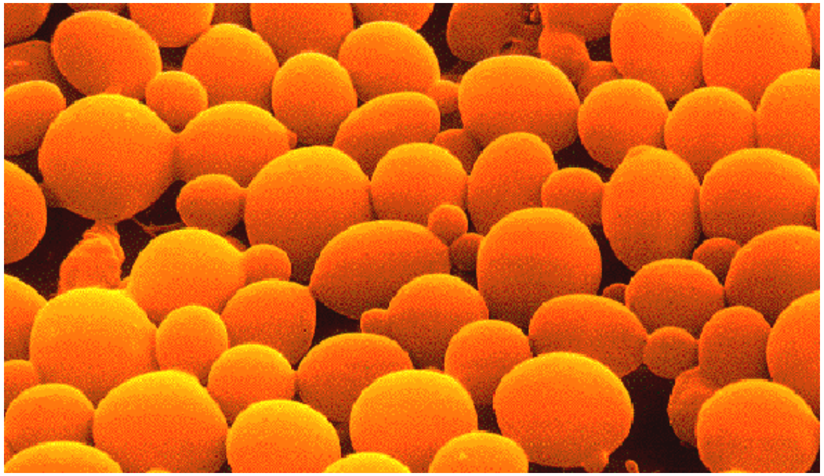
- Disappearance of sugars allows flocculation (but requires the presence of calcium)
    - Crop formation occurs when all sugar has been fermented by yeast

Cropping characteristics

- Ale strains have more hydrophobic surface
  - Traps CO_2 bubbles
  - Causes clumps to rise
- Lager strains have less hydrophobic surface
  - Form clumps and drop out to bottom
- Differences are not absolute

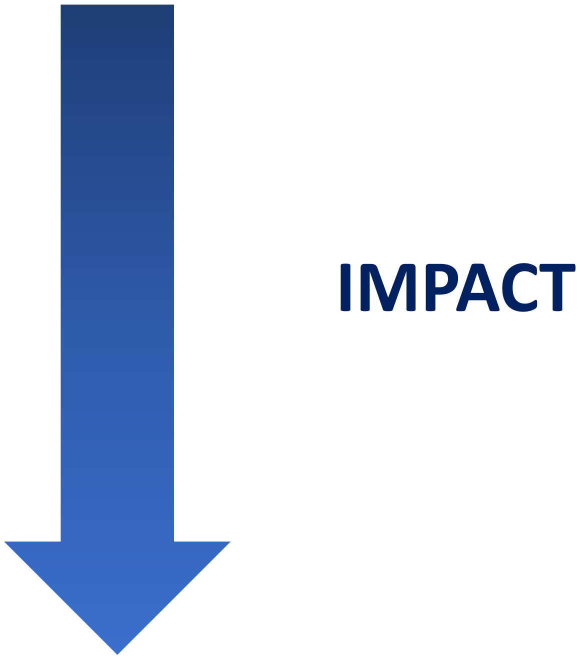
Brewing yeast strains

- Many thousands of individual strains, both ale and lager
- Result of slight differences in genome (DNA)
- Differences produce differences in fermentation behaviour and beer properties
- Most brewing companies use own proprietary strains



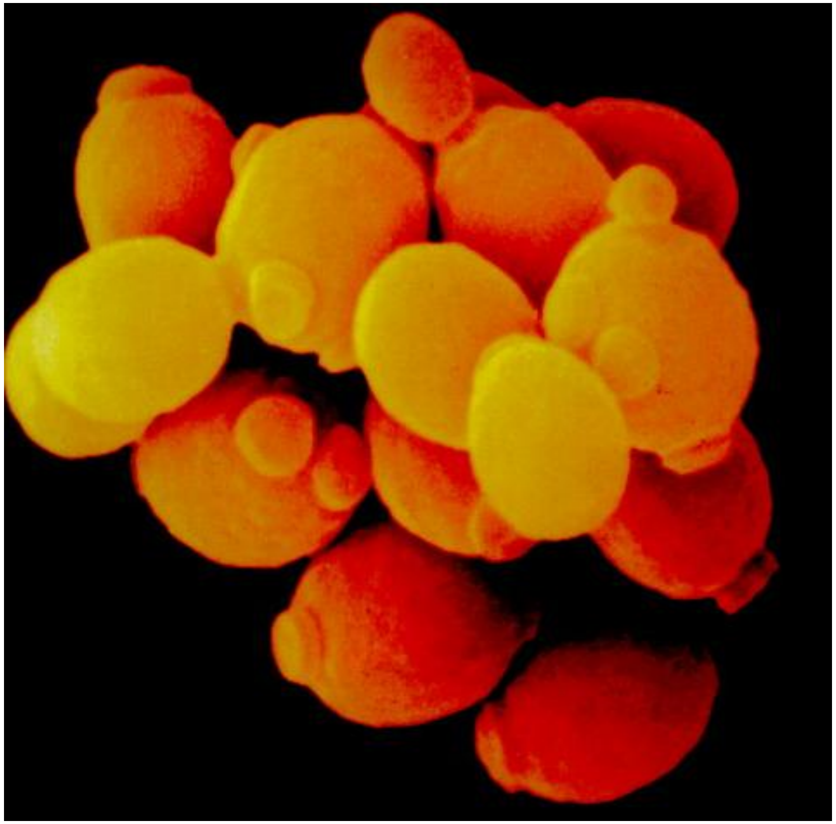
What contributes to beer flavour?

- Grist materials
- Hops
  - Bittering
  - Aroma types
- Liquor
- Yeast?



Contribution of yeast

- Conversion of sugar to alcohol and CO_2
- During fermentation
  - Yeast removes many undesirable wort components
  - Yeast produces many thousands of flavour-active beer components



Yeast beer flavour compounds

- Ethanol (alcohol)
- CO_2

- Higher alcohols
- Esters
- Organic acids
- Glycerol

- Warming
- Mouth tingle

- Wine, warming
- Fruity, floral
- Sharp
- Fullness

Does the yeast strain matter?

- Identical samples of filtered green beer (made with same yeast strain)
- Bottled after seeding with different yeast strains
- Bottle conditioned under identical conditions

Yeast strain	Tasting notes
UK Ale 1	Fruity, warming
UK Ale 2	Estery, floral
UK Ale 3	Sulphidic, dry
US West coast ale	Vanilla, sweet
Nottingham ale	Thin, bland
Munich strain	Malty, mellow
Lager 1	Herbal
Lager 2	Bland, faint ester
Champagne strain	Catty, antiseptic
Cider strain	Sweet, toffee
Belgian Saison	Fruity, estery

Choice of yeast strain

- Need to consider all attributes of strain
  - Ability to ferment
  - Impact on flavour
  - Cropping behaviour
  - Flocculation characteristics
  - Temperature dependence
  - Alcohol tolerance
  - Genetic stability

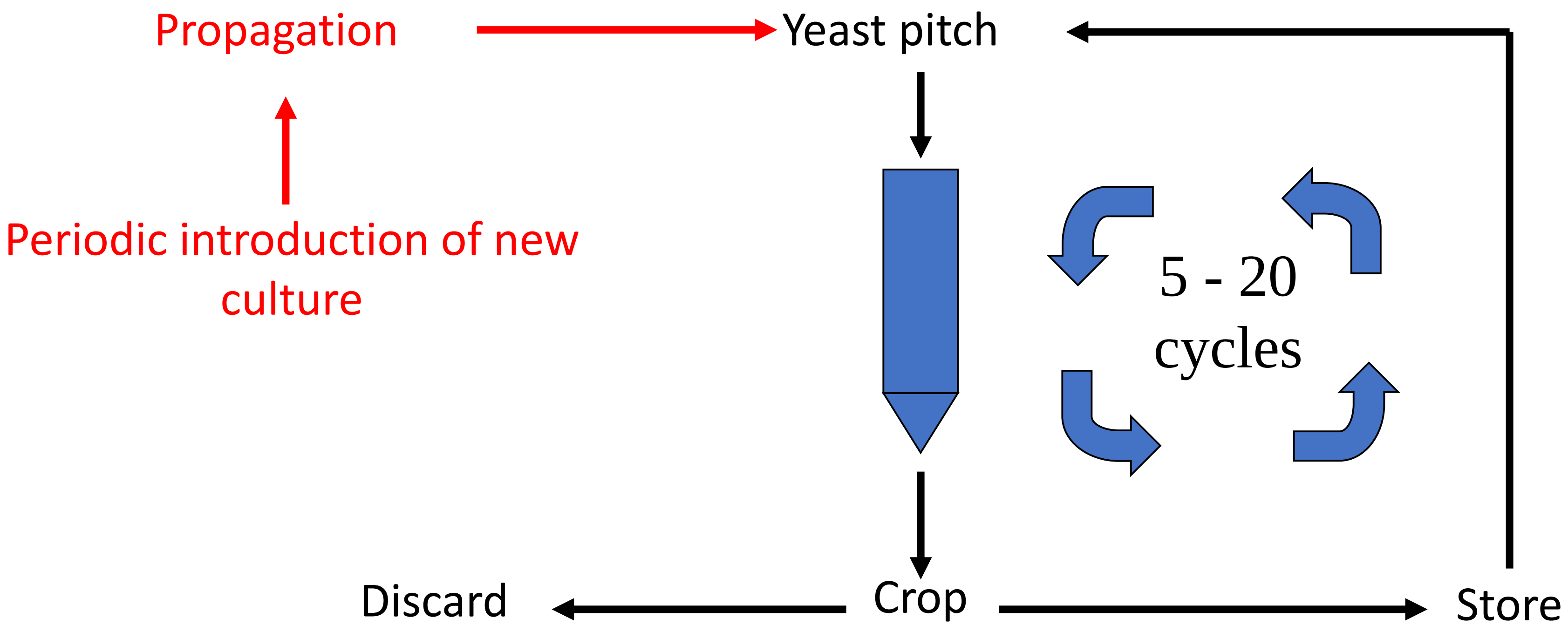
- Impact on beer
  - Appropriate strain for chosen beer style
    - Could be single pure strain or mixture of yeast and possibly bacteria
- Impact on process
  - Choice of fermentation system
  - Strain used for primary fermentation not always best for cask or bottle conditioned beers

Sources of yeast

- Traditional process uses "wet yeast"
  - Sourced either in bulk or as a pure lab culture
    - Purchase from brewery
    - Commercial brewing yeast suppliers
    - Yeast culture collections

- Dried yeast
  - Many brewing strains available in dried form
    - Suitable strains for most beer styles
    - Supplied in vacuum packs in various sizes to suit brewing scale

Wet yeast handling



Wet yeast handling

- Complex and testing operation
  - Big emphasis on good hygiene
  - Cropped yeast must be stored appropriately
    - 2 – 4^{o}C, 5 days max
  - Brewery propagation plant
    - Requires lab facilities
  - Wort must be oxygenated / aerated
- "Free" yeast supply
- Independent of dried yeast suppliers
- Wide choice of strain
- Can contract out propagation to third party supplier

Dried yeast operation

Vacuum packs

Re-hydrate

Pitch

Crop and discard

Crop and retain

Re-pitch

Becomes conventional wet operation

Dried yeast handling

- Much simpler operation
  - Unopened vacuum packs stable for *ca* 1 year if held in fridge
  - Pitching rate control via addition of known weight
  - No need to crop and store
  - No need for wort oxygenation / aeration
- Constant on-cost of yeast
- Quality dependent on supplier
- More limited choice of strain
- Exposure to air in dried form results in rapid death
  - Store opened packs wrapped to exclude air and in deep freeze
- Must carry out rehydration step properly

Ideal rehydration procedure

- Use 10x boiled tap water or treated brewing liquor at *ca* 30°C for ale strains [DO NOT USE DEIONISED WATER OR WORT}
- Sprinkle yeast on surface [DO NOT STIR]
- Leave for 15 min
- Stir gently and leave for 5 min
- Dilute with water to lower temp to pitching temp.
- Pitch
- NEVER PITCH DRIED YEAST DIRECTLY INTO WORT

Yeast and oxygen

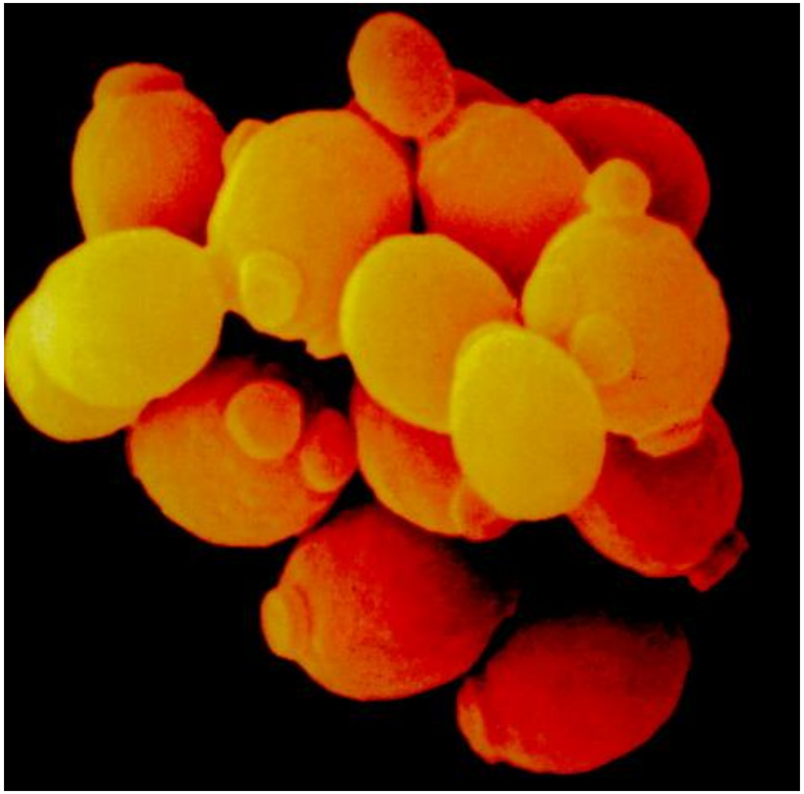
- Yeast requires oxygen for proper growth in fermentation
- Consequence of serial cropping and repitching
- Oxygen is used for synthesis of membrane lipids in initial aerobic phase
- Subsequent growth in anaerobic phase dilutes lipids between mother and daughter cells
- Resultant lack of proper membrane function eventually limits growth
- Dried yeast is pre-loaded with lipids and does not require wort oxygenation if only used once

Measuring yeast concentration

- Required for:
  - Control of pitching rate
  - Monitoring end fermentation counts
  - Control of cask / bottle conditioning counts

- Measured directly via microscopic yeast counts or indirectly as wet cell mass (wt/vol or wt/wt or vol/vol)

- Additional determination of proportion of living cells (viability) allows correction for pitching rates and monitor of yeast quality



Assessing yeast concentrations

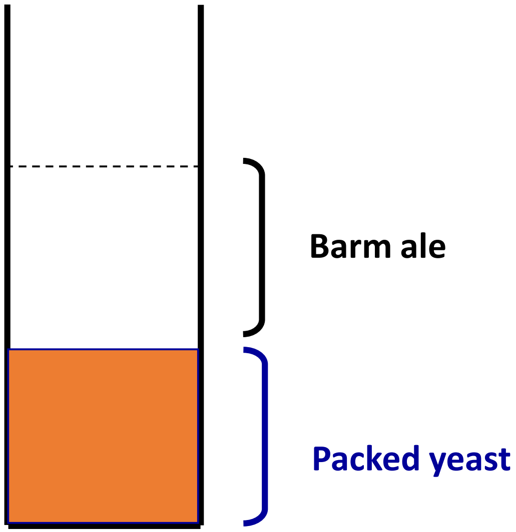
- Typical pitching rate:
  - 1lb pressed yeast per UK barrel @1040
    - Equivalent to 2.8g/litre
  - In terms of cell numbers:
    - Roughly equivalent to 10 million cells per ml
  - Can use either cell mass or cell count

Analysis of slurry for solids

- Usual to use centrifuge
  - Spin known weight slurry
  - Pour off barm ale
  - Weigh packed yeast

- Quick method
  - Take known weight of slurry
  - Place in graduated container
  - Allow yeast to settle and assess solids content

Analysis based on yeast weight



Example:

Total weight slurry = 50g
Weight yeast = 20g

Yeast concentration = 20/50 x 100

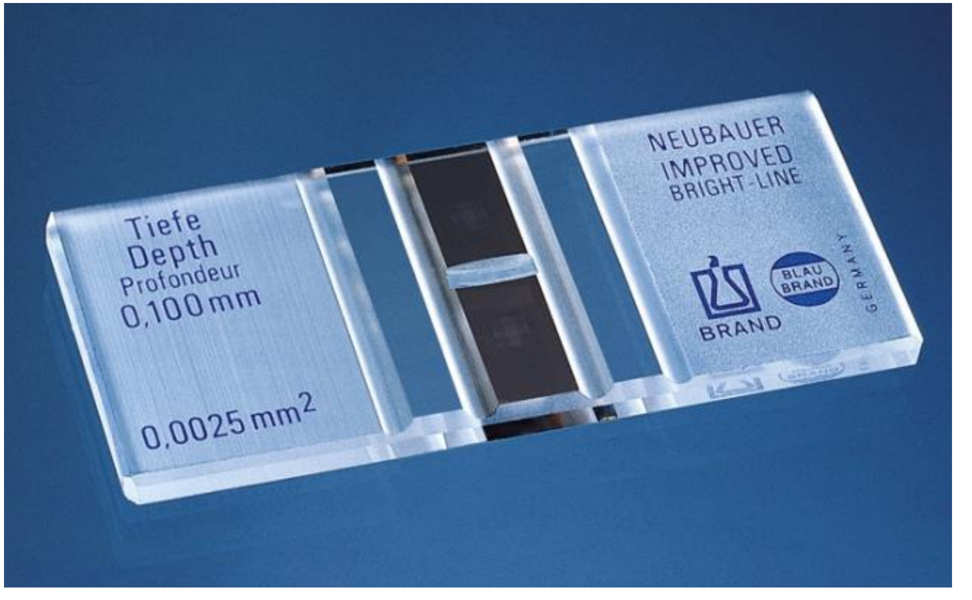
= 40% w/w

Analysis of slurries by cell count

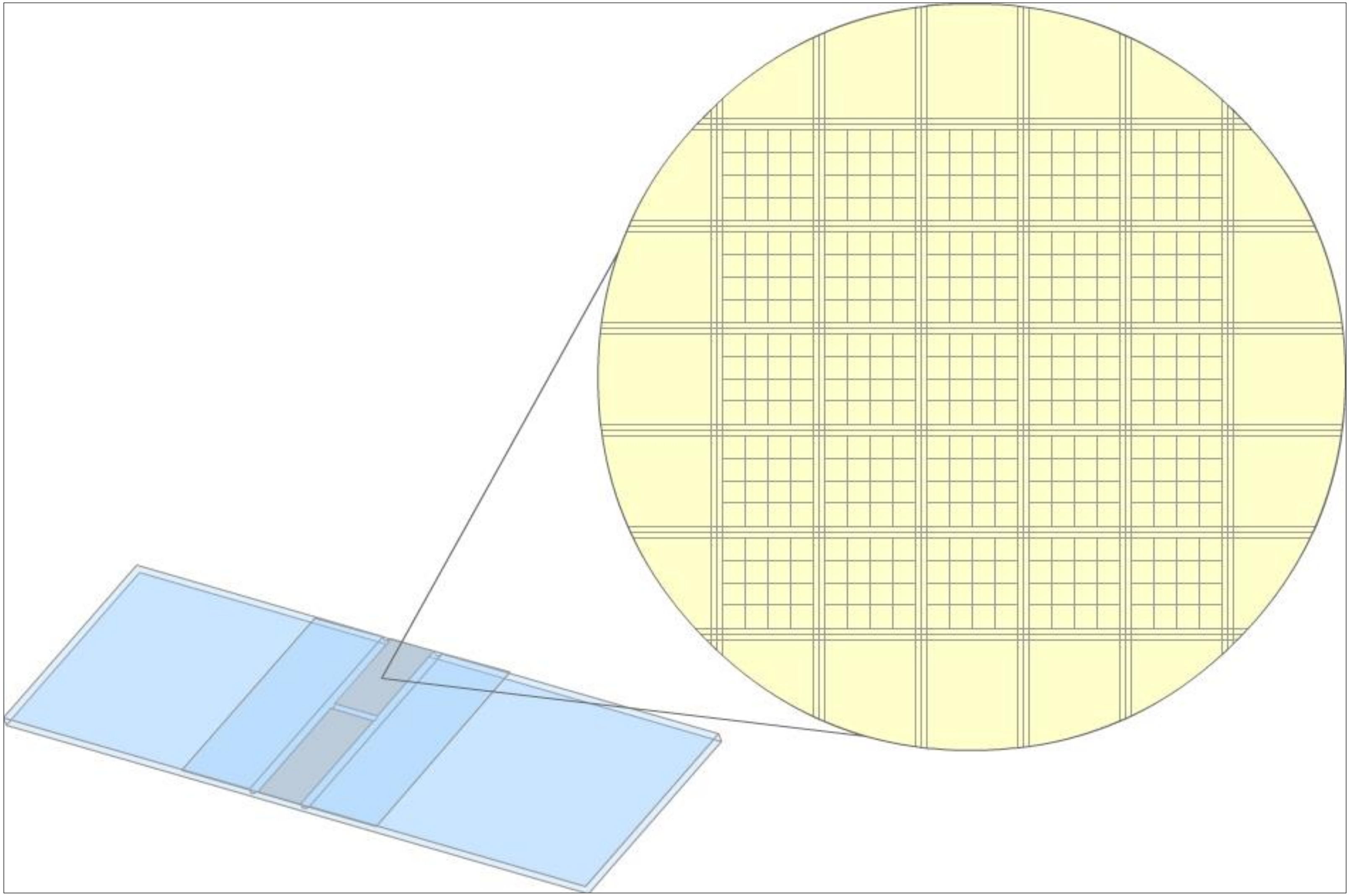
- Use microscope to count individual yeast cells in sample of slurry

- Use special slide - haemocytometer
  - Contains chambers of known volume
  - Contains grids to make counting easier

- Can use with dyes which differentiate between live and dead cells
  - Allows calculation of viability
    - $\frac{\text{Dead cells}}{\text{Total cells}} \times 100 = \%$ viability



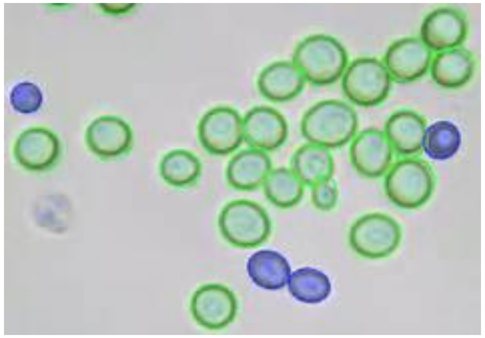
Haemocytometer



Assessment of viability

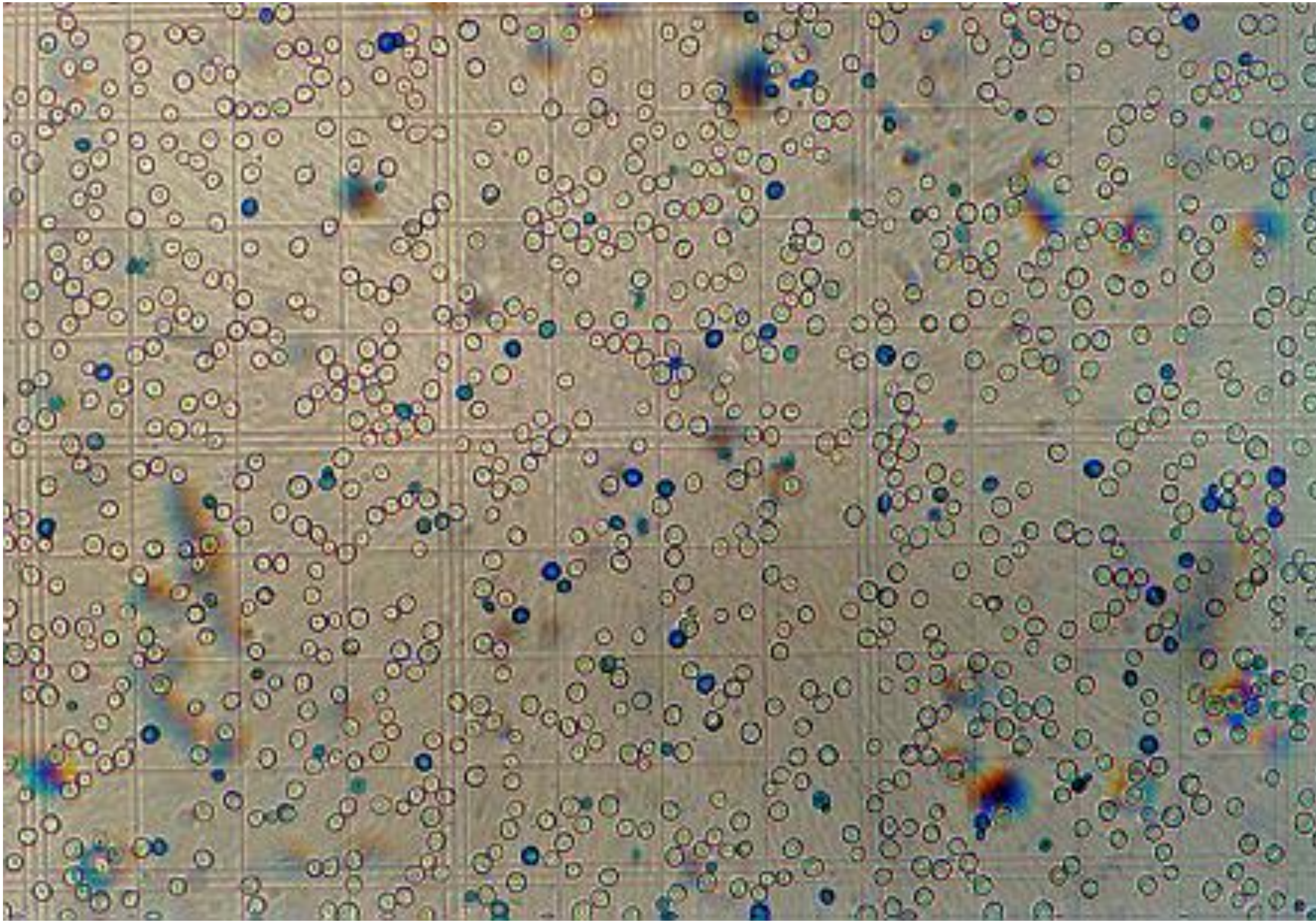
- Industry standard method uses dye, methylene blue

- Live cells are colourless
- Dead cells stain blue



Use of haemocytometer

- Prepare diluted suspension of slurry
- Mix slurry with equal volume of methylene blue solution
- Count total number of cells
- Count blue stained cells
- Calculate no. cells in original slurry
- Calculate viability



Summary

- Yeast is the brewery's most precious asset!

- Choose the correct strain
  - Beer style
  - Brewery plant
  - Brewing process
- Guard its welfare carefully