Understanding Yeast Flocculation

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What we'll learn today:

- What is yeast flocculation?
  - The mechanisms of yeast flocculation – how it works
  - Theories behind flocculation changes within the yeast cell (genetics)
- What affects flocculation?
  - Cellular impacts
  - Environmental impacts
- How can I control or improve it?
  - Troubleshooting flocculation issues
  - Control points

Why does flocculation matter?

- Early flocculating yeast
  - Sediment out of beer too rapidly
  - Under-attenuation
  - Flavor stability issues

- Late or weakly flocculating yeast
  - Flavor issues from yeast remaining in suspension
  - Haze issues
  - Filtration challenges

Yeast Flocculation - Explained

- "…the phenomenon wherein yeast cells adhere in clumps and either sediment rapidly from the medium in which they are suspended or rise to the medium's surface." - *Stewart & Russell (1981)*

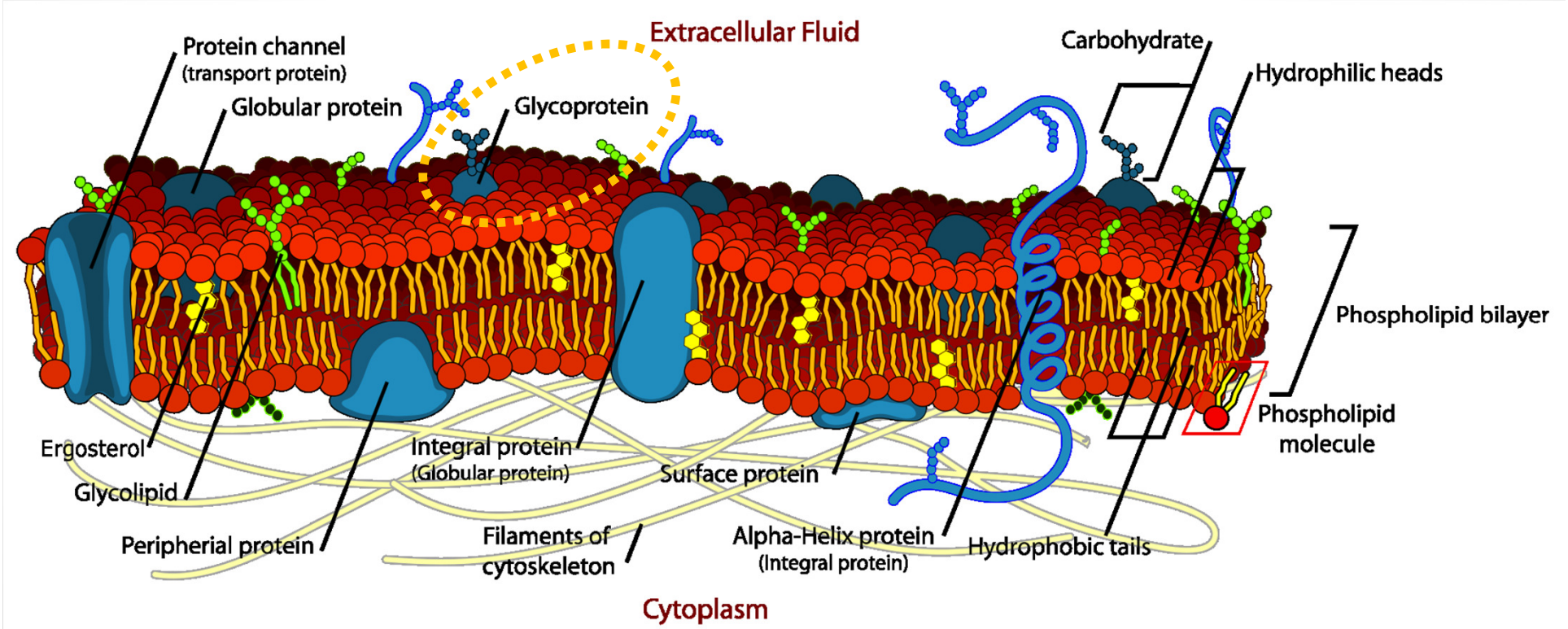
- Reversible process

- Different than chain-formation that occurs in some yeast strains (particularly English Ale yeasts)

Yeast Flocculation - Explained

MAYBE DIFFERENT IMAGE?

First, we need to visit the yeast cell membrane:



Yeast Flocculation - Explained

Genetic theories:
Many theories – which one is right?

- Zymolectin binding
- Hdyrophobic interactions
- Surface charge neutralization
- Influences of Flo1

- Complex mechanism
- Mostly still theory
- Most accepted & confirmed is a combination of theories working together or in competition

Yeast Flocculation - Explained

Definitions:

- Flo1: gene that has been found to control synthesis of certain proteins
- NewFlo: NEED DEFINITION
- Mannose: monosaccharide found in wort

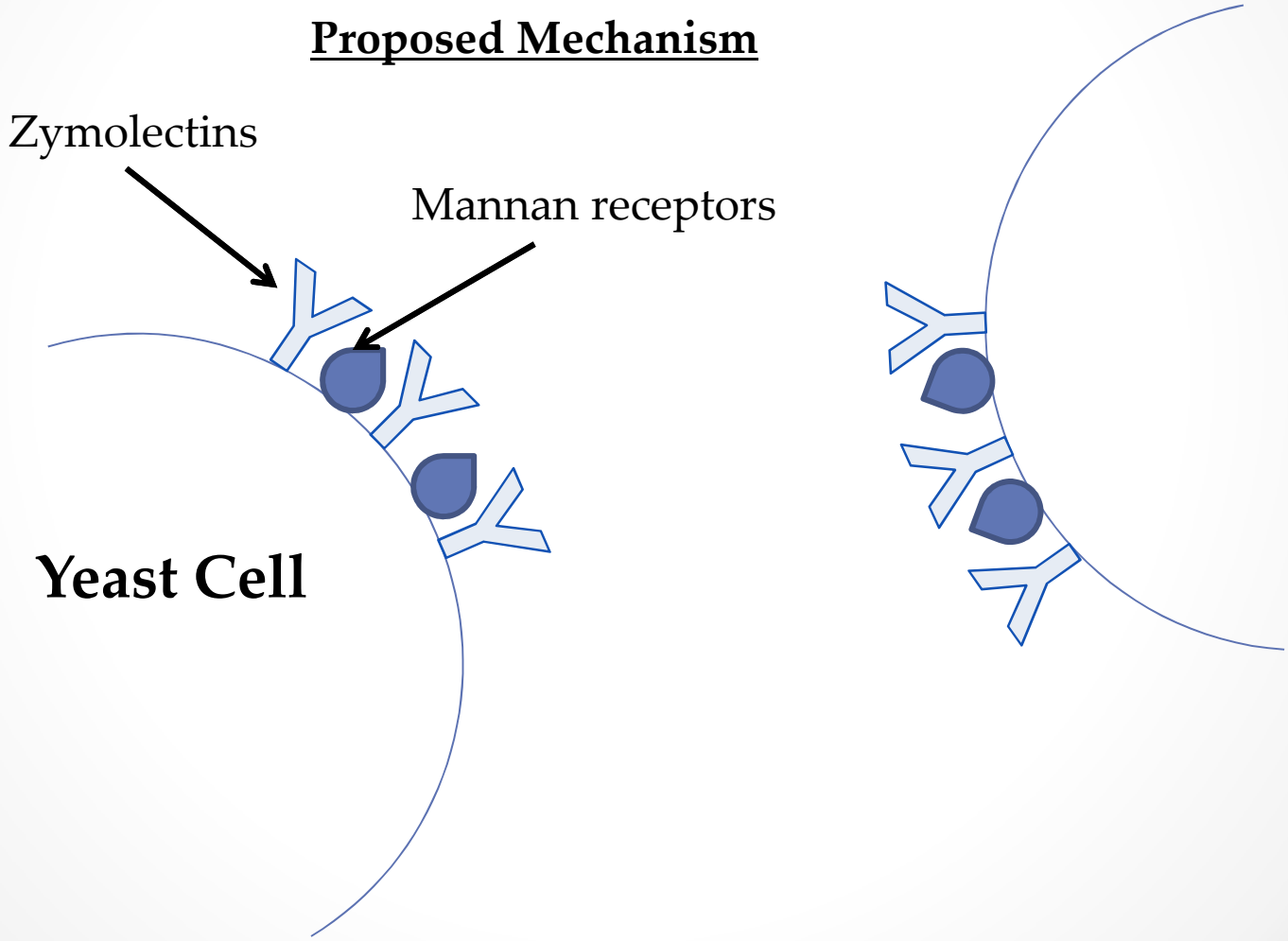
Yeast Flocculation - Explained

Definitions:

- Lectins: "proteins or glycoprotein of non-immune origin which contain at least two sugar-binding sites." – *Goldstein et al., (1980).* In this case, lectin-like proteins called zymolectins
- Zymolectins: "any protein or glycoprotein structures associated with yeast cell walls which contain specific carbohydrate binding domains and whose presence causes or enhances cell flocculation" – *Speers, et al. (1998)*
- Glycoproteins: proteins that contain glycans (large carbohydrate/sugar molecules) with polypeptide (amino acid) side chains.

Yeast Flocculation - Explained

Proposed Mechanism



Yeast Flocculation - Explained

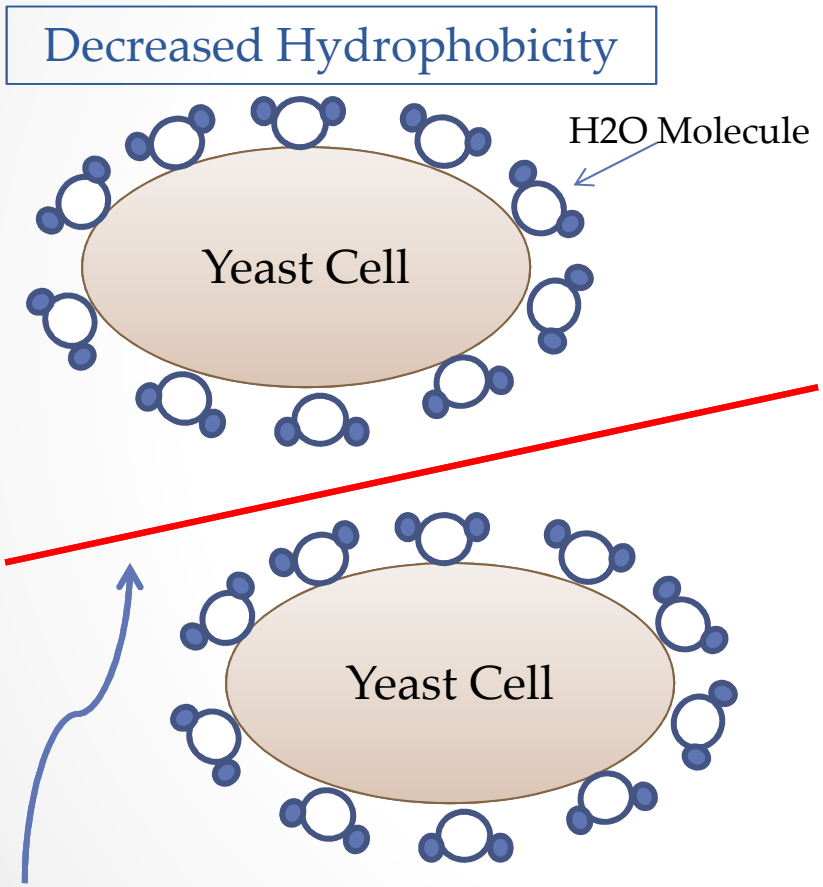
The role of Flo

- Gene that controls synthesis of protein products
- Products are most likely zymolectins
- Length of gene product has been found to correlate with degree of flocculation

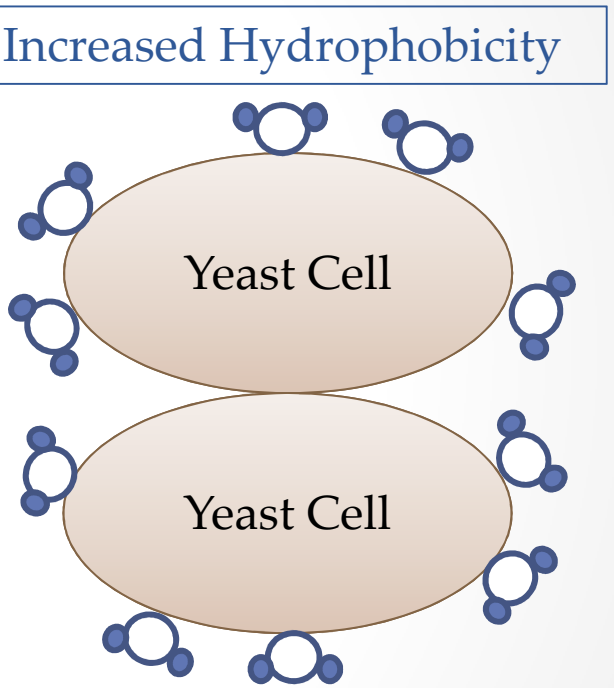
Factors Affecting Flocculation: Cellular

- Cell surface hydrophobicity
  - Extent to which cell surface can repel water
  - Ability of cell to form Hydrogen (H+) bonds (with H2O)

Factors Affecting Flocculation: Cellular



No cell-cell interaction



Allows cells to interact

Factors Affecting Flocculation: Cellular

- Studies have shown:
  - Fatty acids increase hydrophobicity, increasing flocculation
  - Increased temperature has an affect
  - Ethanol concentration has an effect

HOWEVER, evidence is contradictory

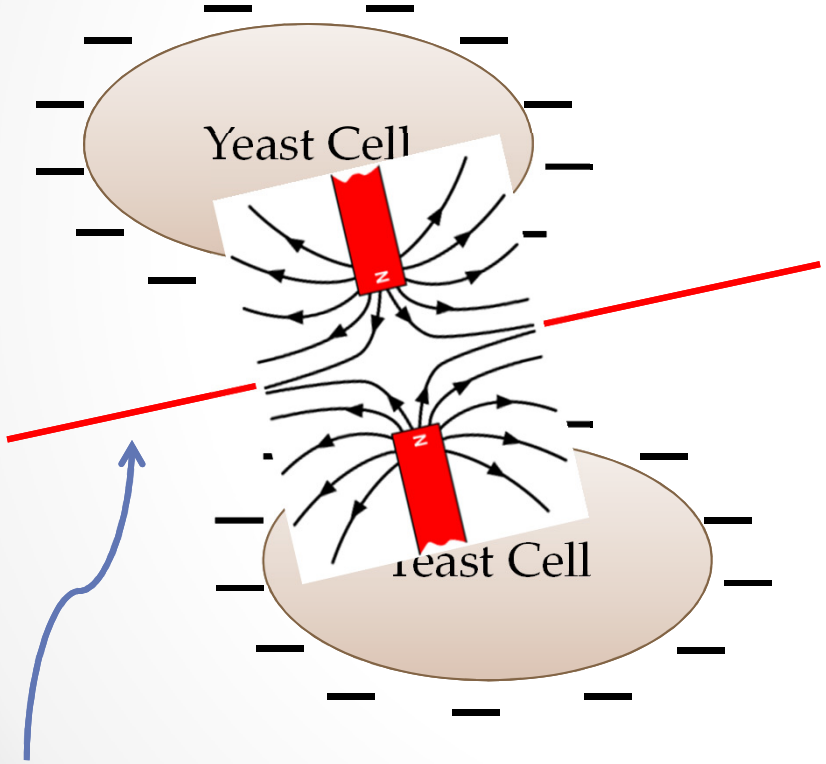
So theory not supported

Factors Affecting Flocculation: Cellular

- Cell surface charge
  - Yeast cells normally negatively charged
  - Like opposes like

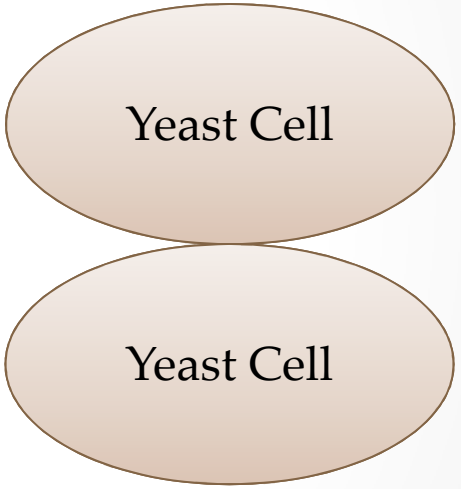
Factors Affecting Flocculation: Cellular

Normal Surface Charge



No cell-cell interaction

Neutralization of Surface Charge

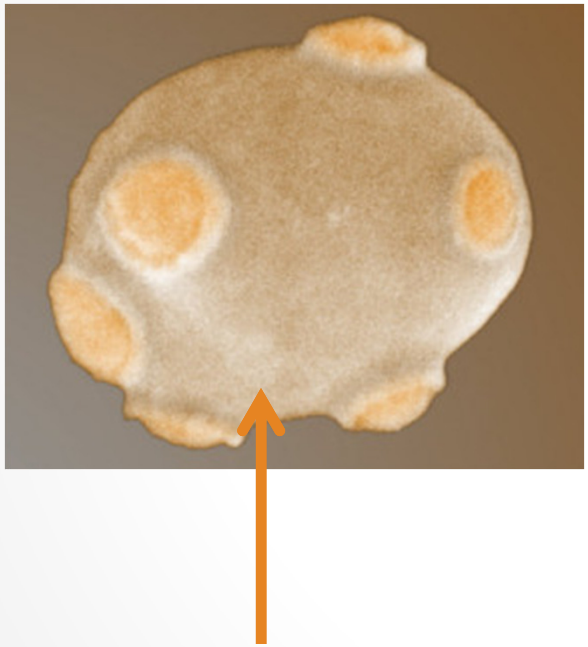


Allows cells to interact

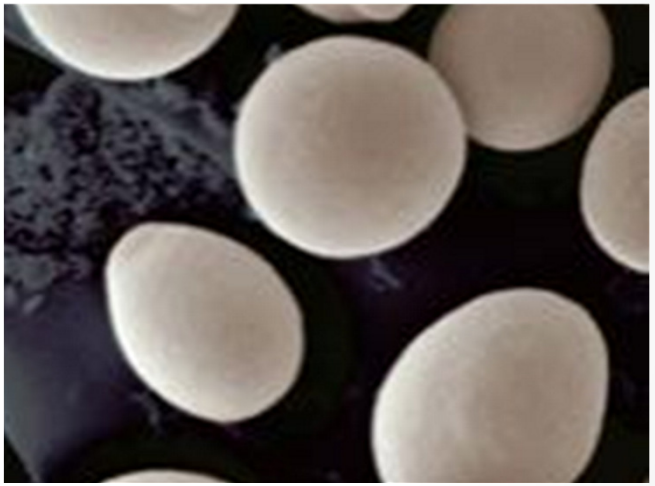
Factors Affecting Flocculation: Cellular

- Age of yeast and # budding cycles
  - Mother cells typically have better flocculation properties than daughter cells
  - Cells too old, lose flocculation properties

Factors Affecting Flocculation: Cellular



VS.



Reduced smooth surface area for lectin binding sites

Factors Affecting Flocculation: Environmental

- Ethanol
- pH
- Temperature
- Pitch rate
- Nutrition
- Mineral content of wort (Ca & Zn)

All affecting the CELLULAR interactions

Control Mechanisms: What Brewers Can Do!

Early Flocculation

Possible causes:

- Poor fermentation
- Not enough turbulence in fermentor
- Premature yeast flocculation (caused by poor quality malt)
- Mutations in yeast culture

Control Mechanisms: What Brewers Can Do!

Early Flocculation

Remedy:

Ensure active and complete fermentation

Have internal standards for malt quality and ways to test for it

Be familiar with behavior of your yeast and identify issues early – be better equipped to troubleshoot

Maintain proper pH throughout fermentation

Control Mechanisms: What Brewers Can Do!

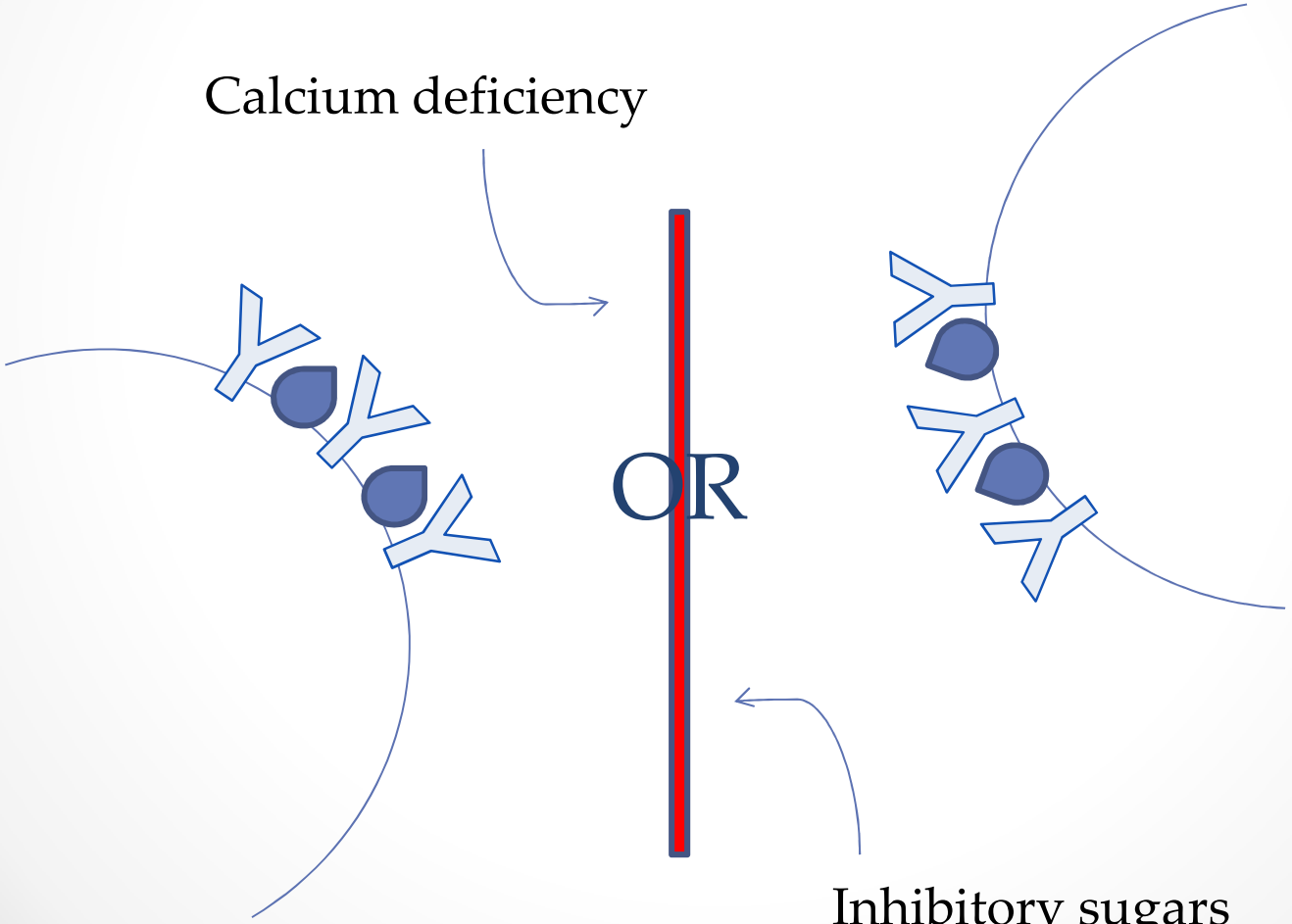
Little or No Flocculation

Possible causes:

- Old yeast populations
- Mutations in yeast culture induced by stress
- Inhibitory compounds in wort
- Deficiency in metal ions

Control Mechanisms: What Brewers Can Do!

Little or No Flocculation



Control Mechanisms: What Brewers Can Do!

Little or No Flocculation

Remedies:

Ensure active and complete fermentations

Maintain proper Calcium levels

Keep a close eye on yeast populations – maintain populations of younger cells

Reduce excessive shear to yeast

Summary

Understand the reasons why, then control them as best as you can

- Maintain wort within specs
- Ensure high quality malt
- Maintain proper nutrition and metal ions in wort
- Maintain consistent pitching rate
- Practice good yeast harvesting techniques
- Keep yeast fresh and young (low generations)
- Maintain a stress-free (as much as possible) environment

Remember fermentation is a complex biological process – things won't always go according to plan

QUESTIONS?

Thank You!

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