The Tribology of Wine: Mouthfeel, Tannins and Bubbles

Nicholas D. Spencer

ETH Emeritiertenstamm, Hotel Wartmann, 30. January, 2023

Outline

- What is tribology?
- What is in wine?
- Tannins
- Mouthfeel of wine
- A tribological study of red wine
- What about bubbles?

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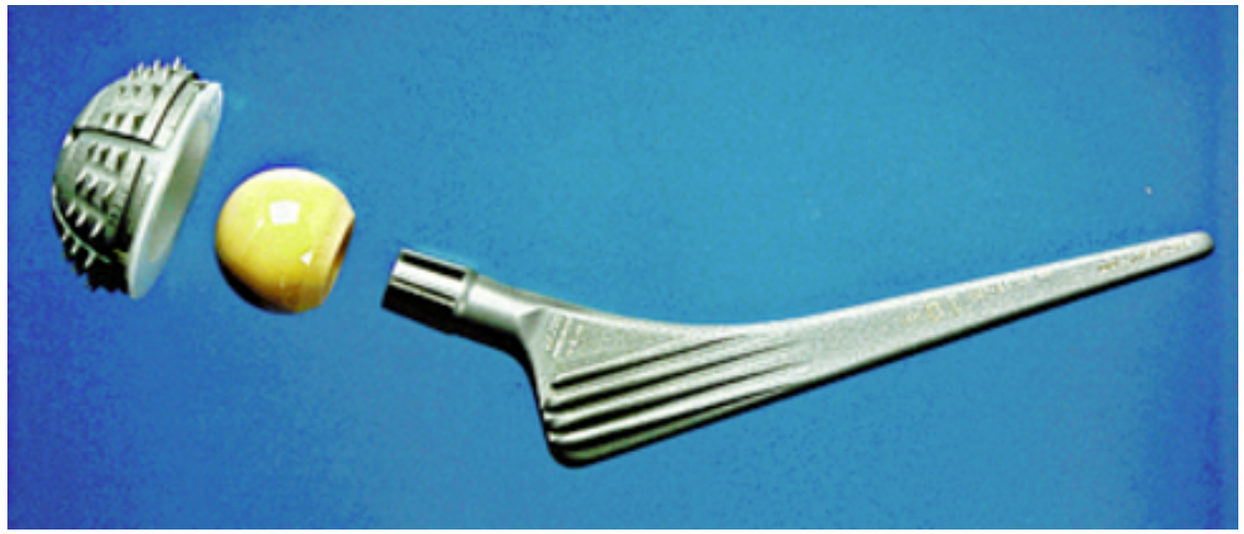
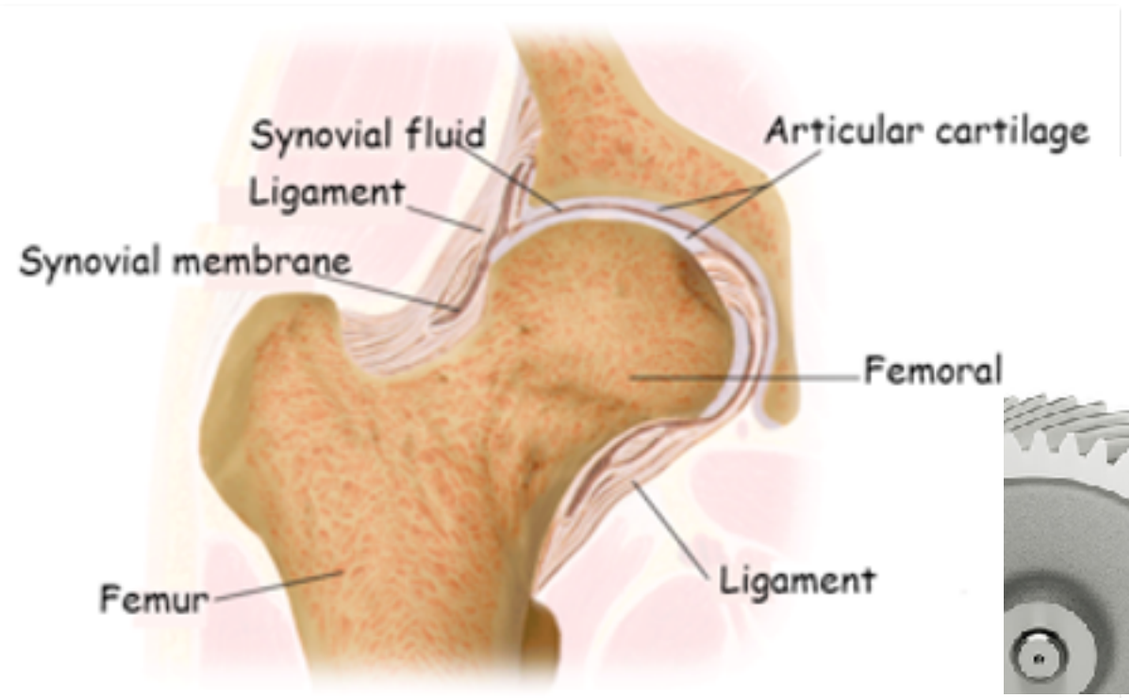
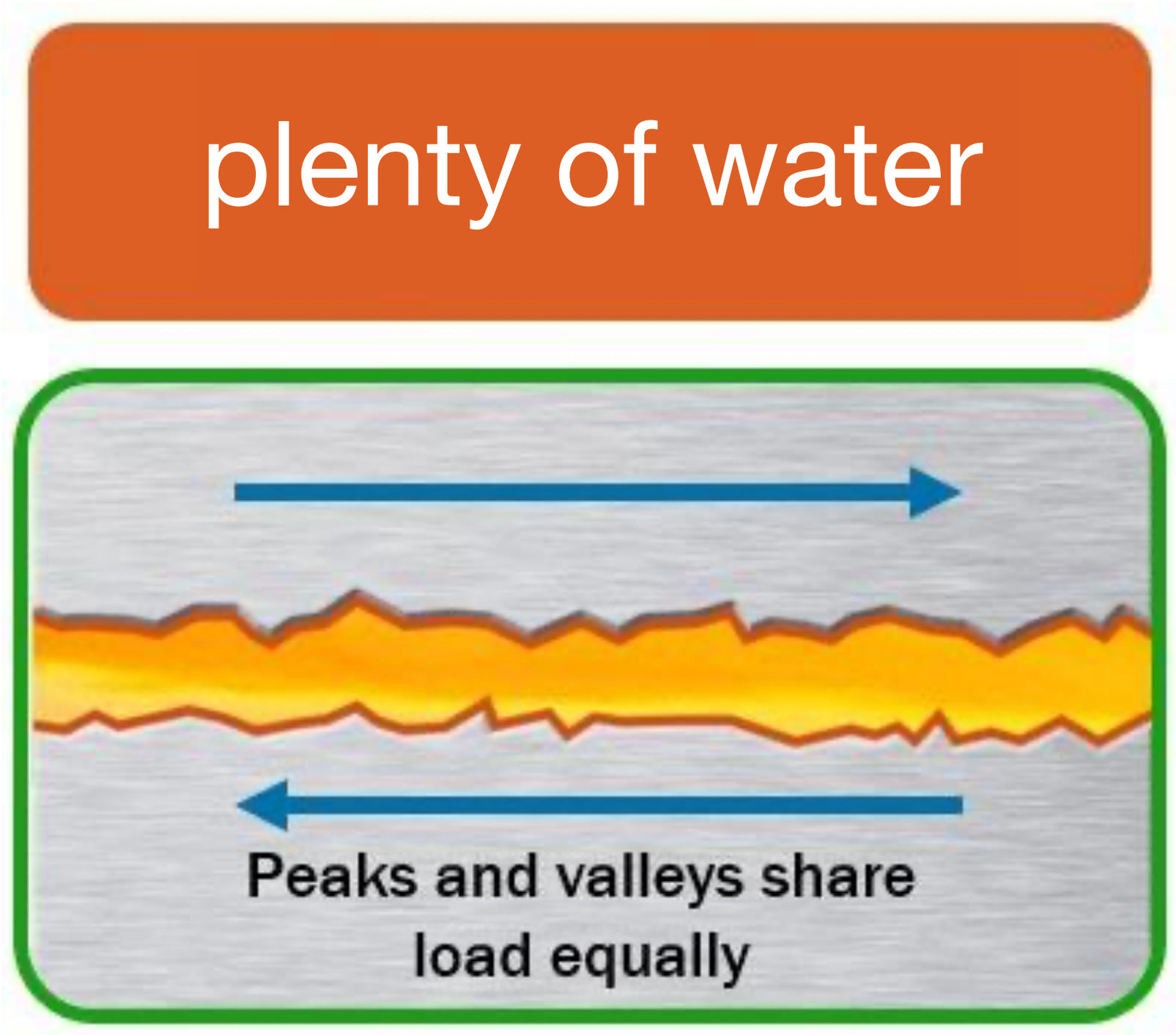
Tribology



Friction (Reibung),
Lubrication (Schmierung)
Wear (Verschleiss)



Lubrication with water



Lubrication with water

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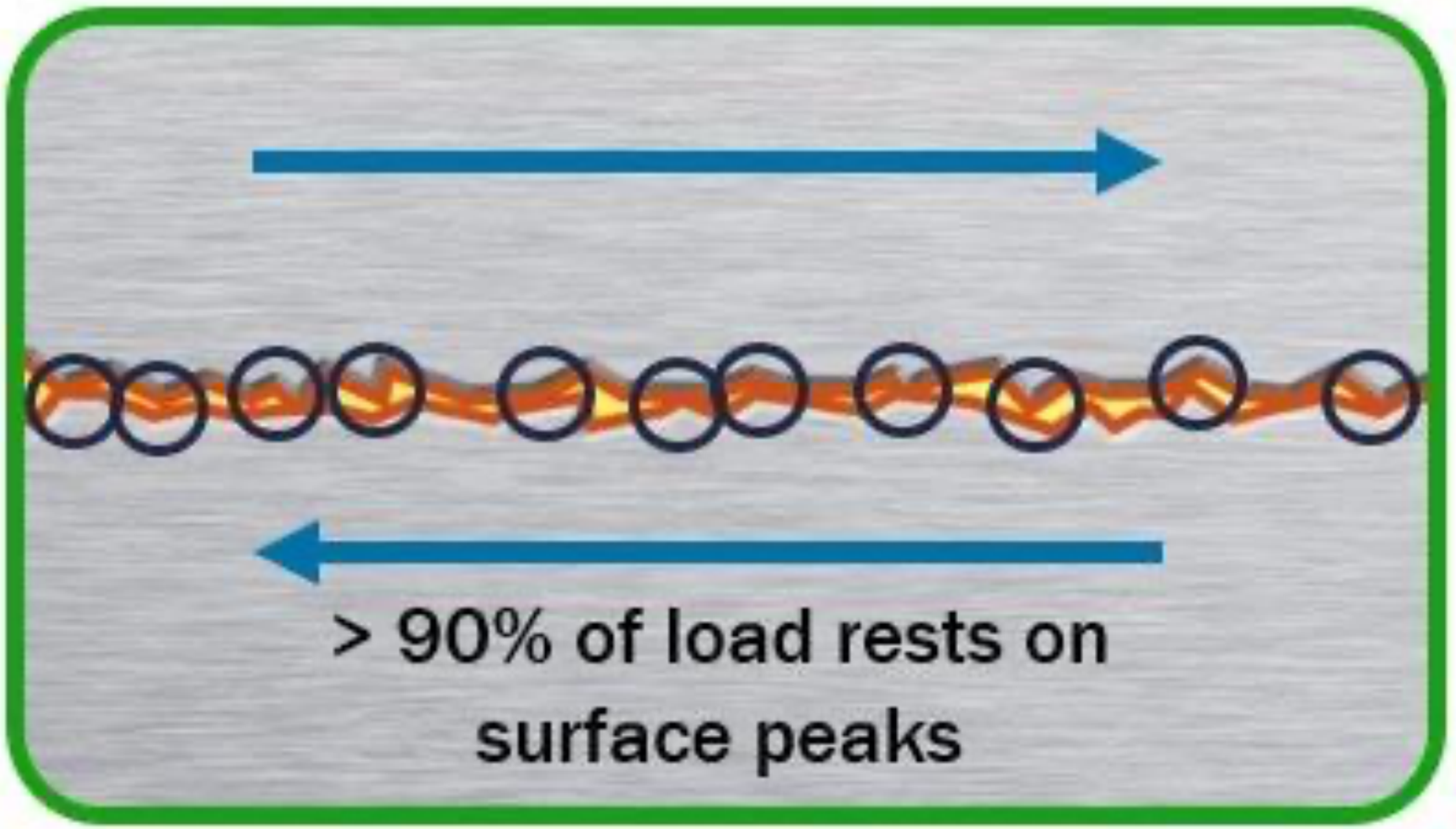
Lubrication with water

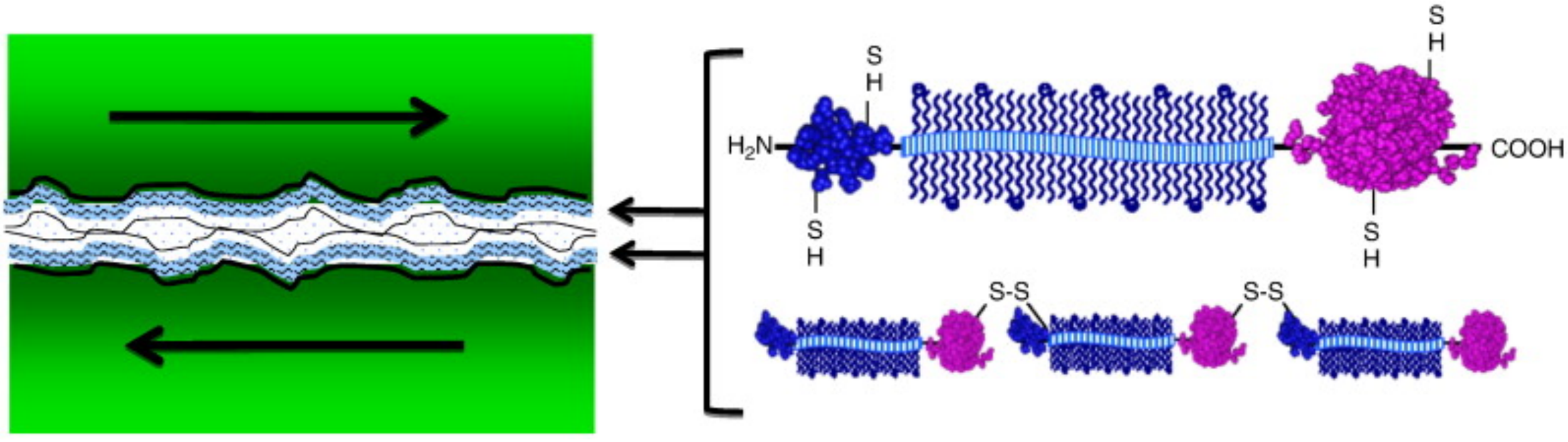
not enough water/
load too high



Lubrication with saliva

Saliva contains <u>mucins</u> (sticky proteins)

These stick to the surface of the tongue and the palette to make a slippery layer that holds the sliding surfaces apart —even when only little fluid present



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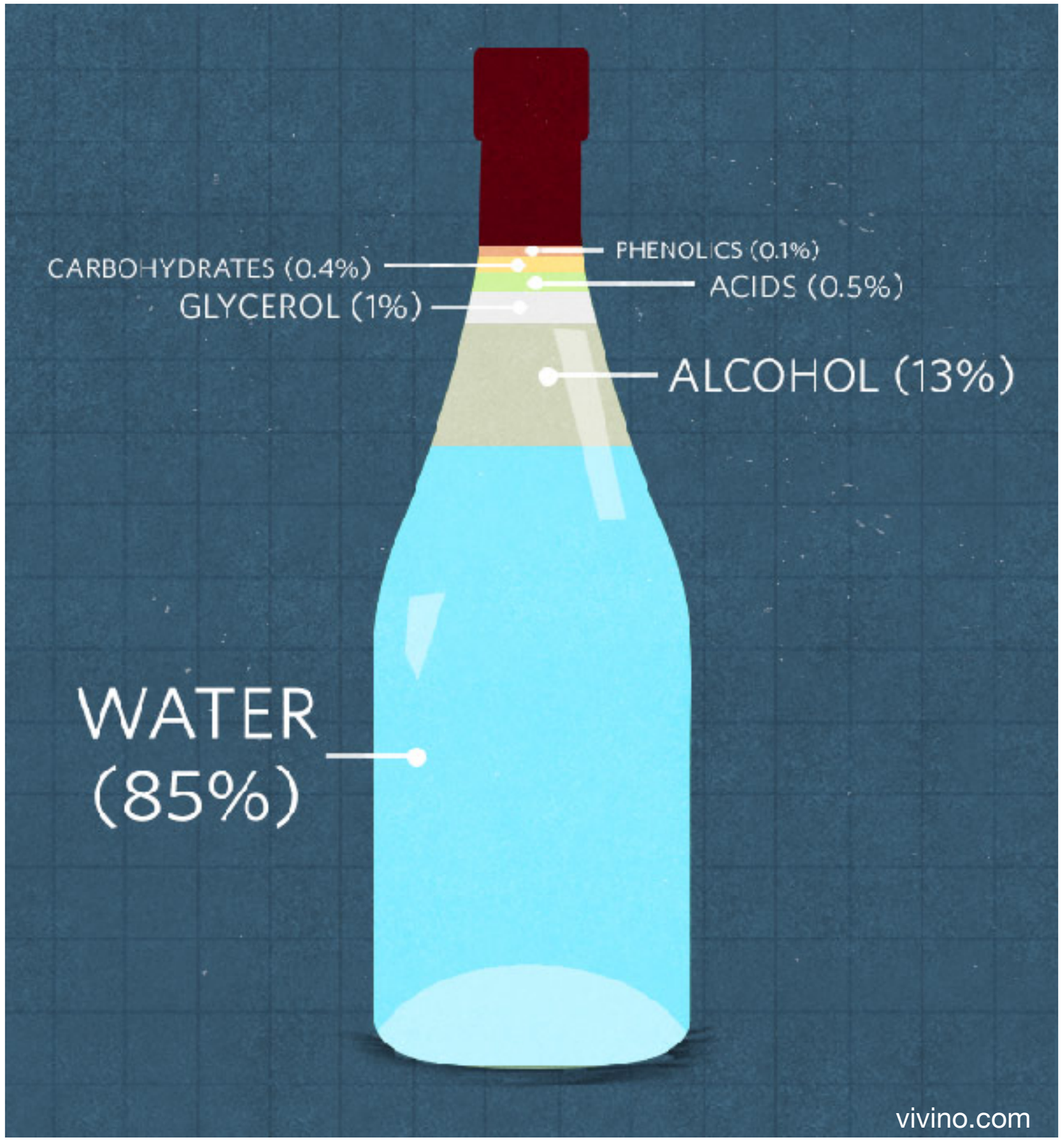

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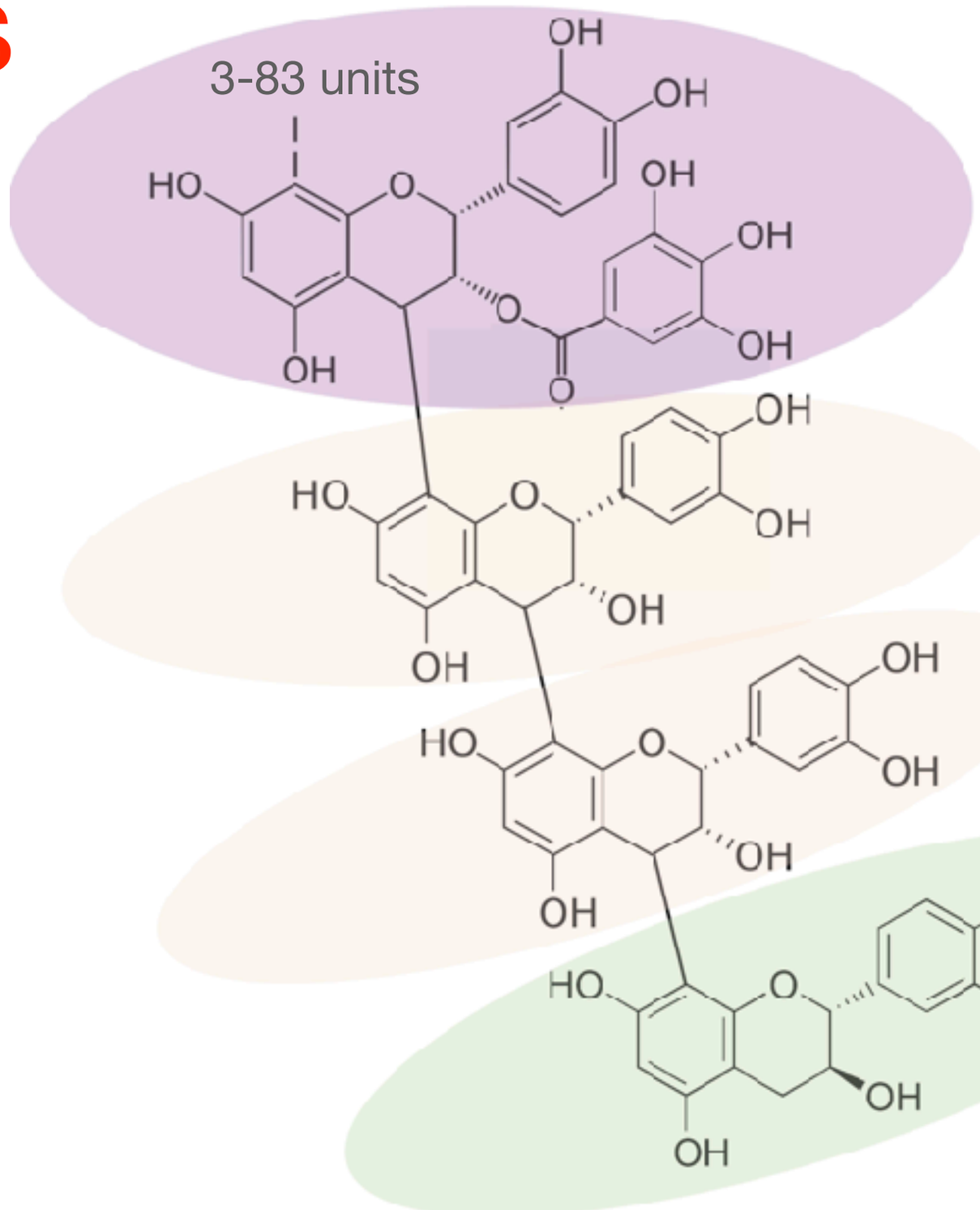
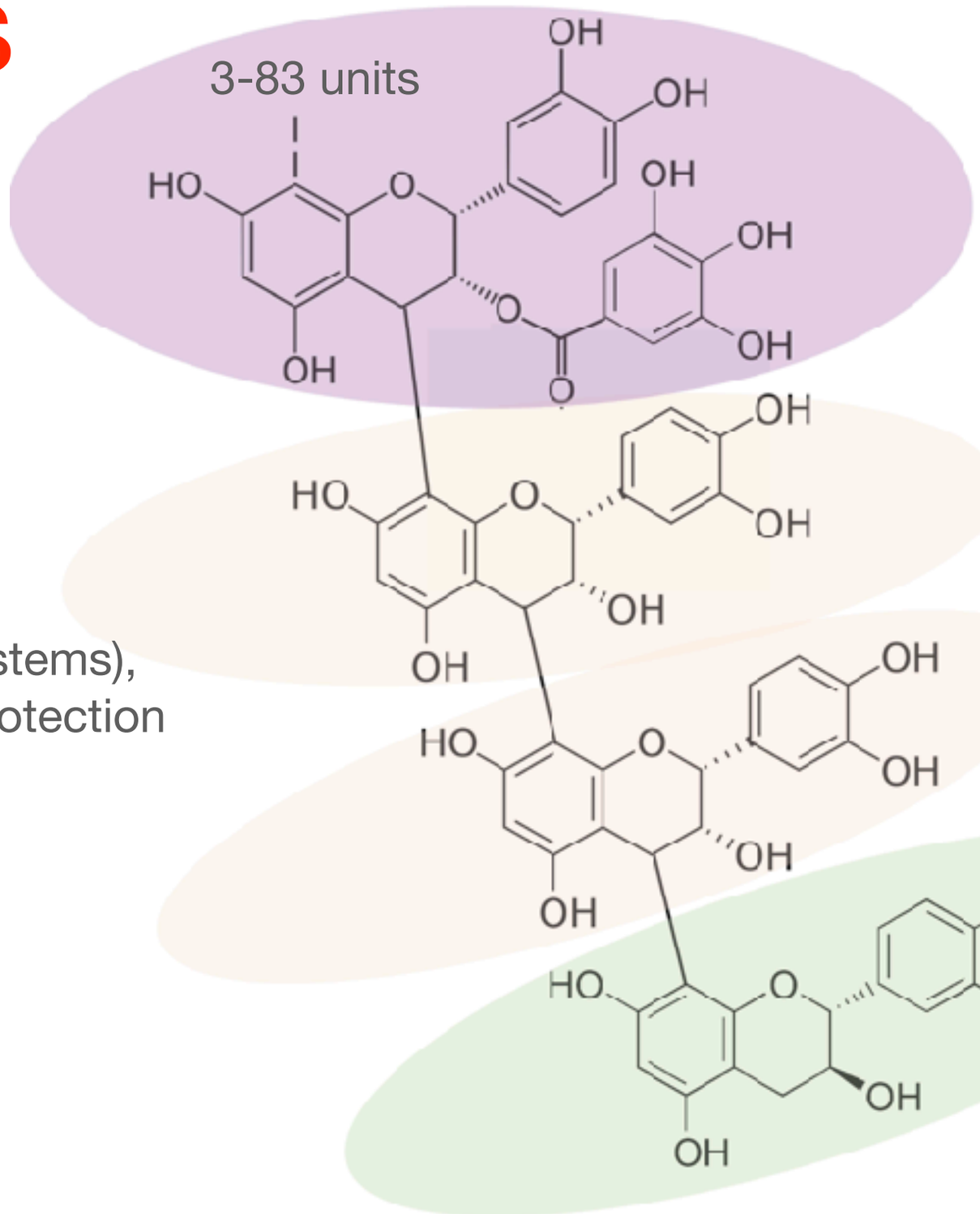


The Tribology of Red Wine, W.T. Tysoe and N.D. Spencer *Tribology & Lubrication Technology*; *2020;* 76(12) pp68-70

Tannins

In grapes (skins, pips, stems), tannins are a natural protection against herbivores.



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<u>Tannins bind to proteins</u>, and are used to manufacture leather—"tanning".

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Tannins are polyphenol compounds that are responsible for mouthfeel in wine

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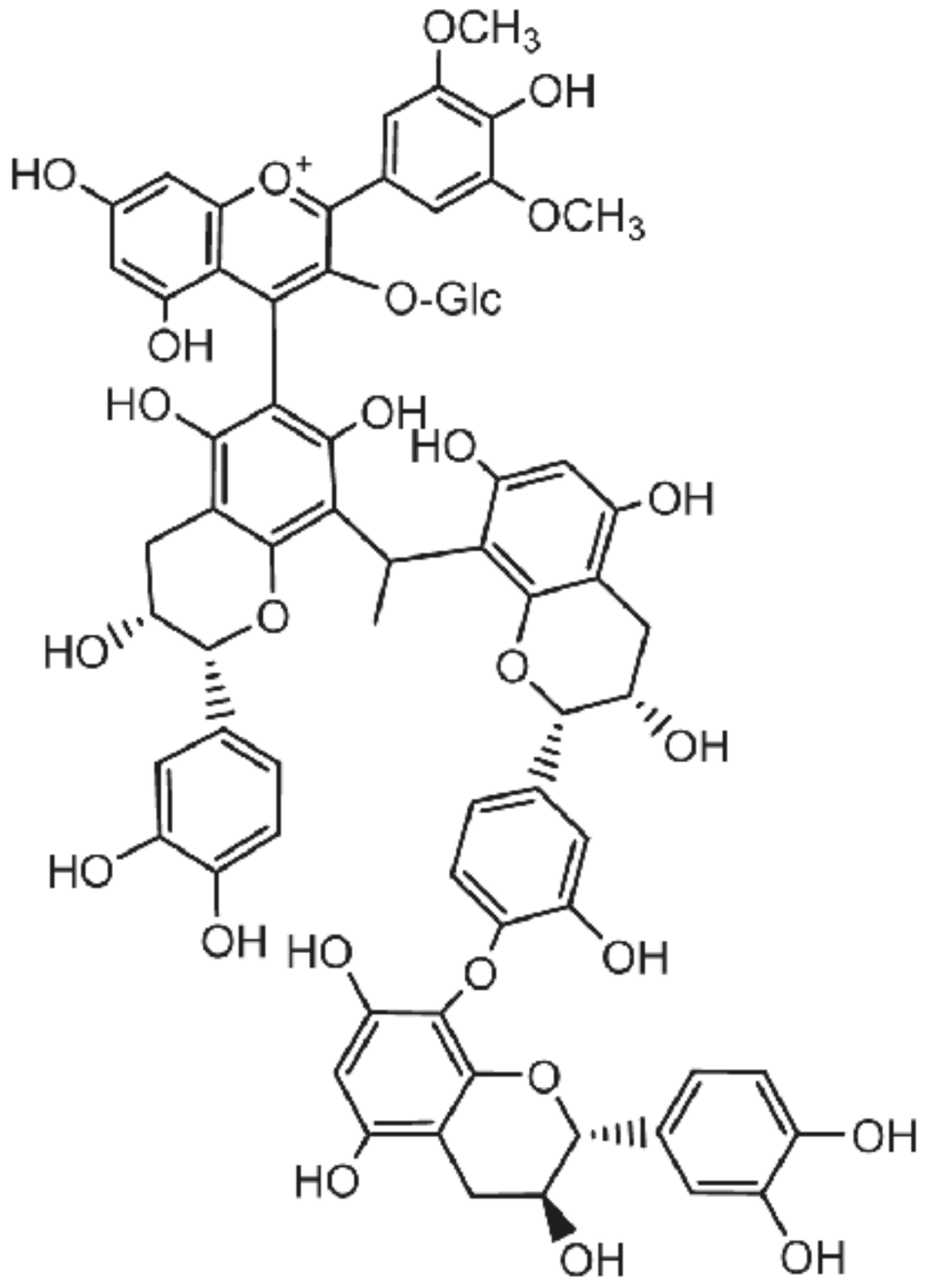
Wine Tannins

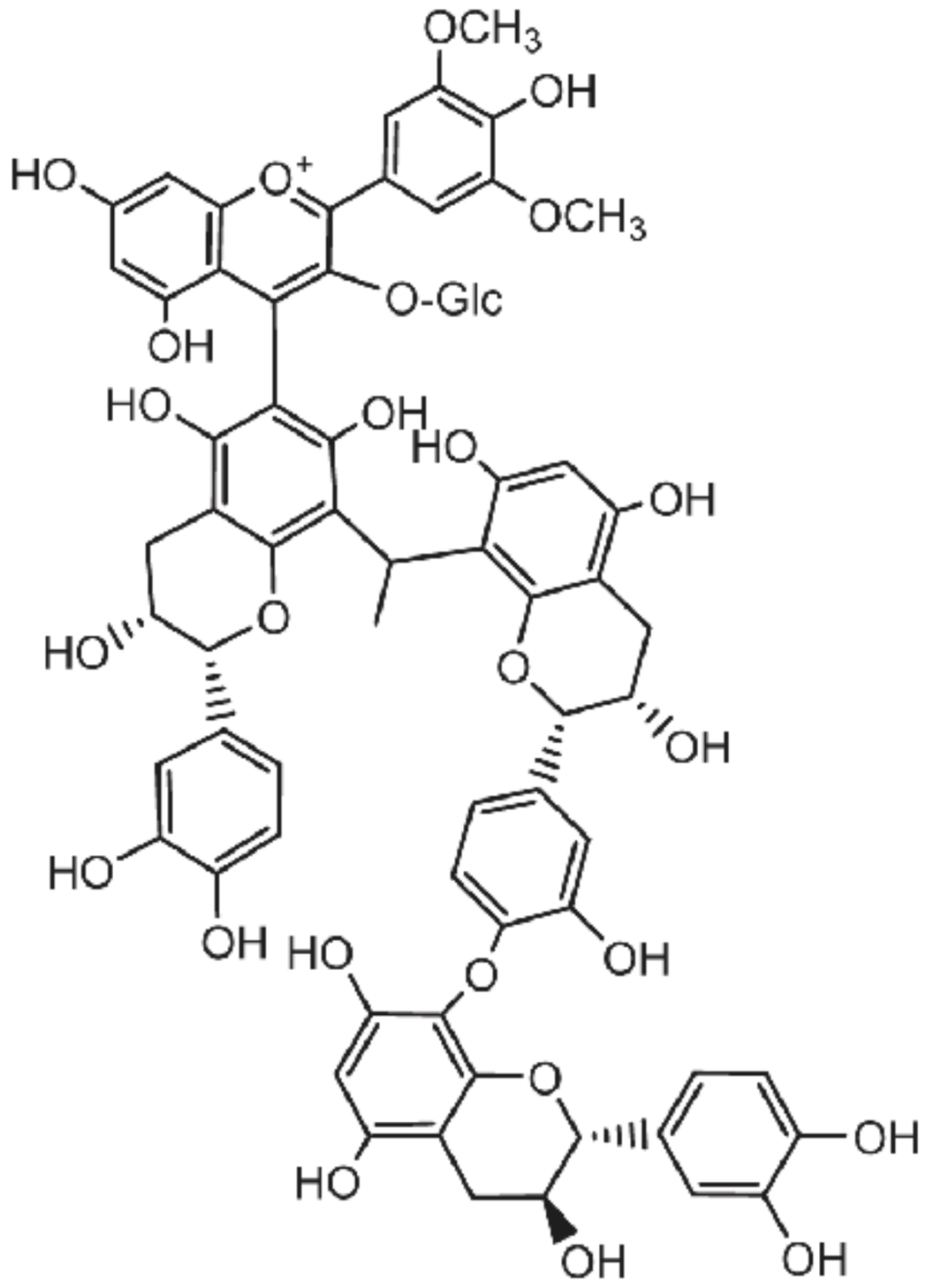


Smith P.A. et al, Australian Journal of Grape and Wine Research 21, 601–614, 2015

Wine Tannins

The winemaking process modifies tannins:

- Reactions with anthocyanins to produce stable pigmented polymers
- depolymerization, repolymerization
- oxidation
- condensation reactions
- reaction with each other and within themselves!



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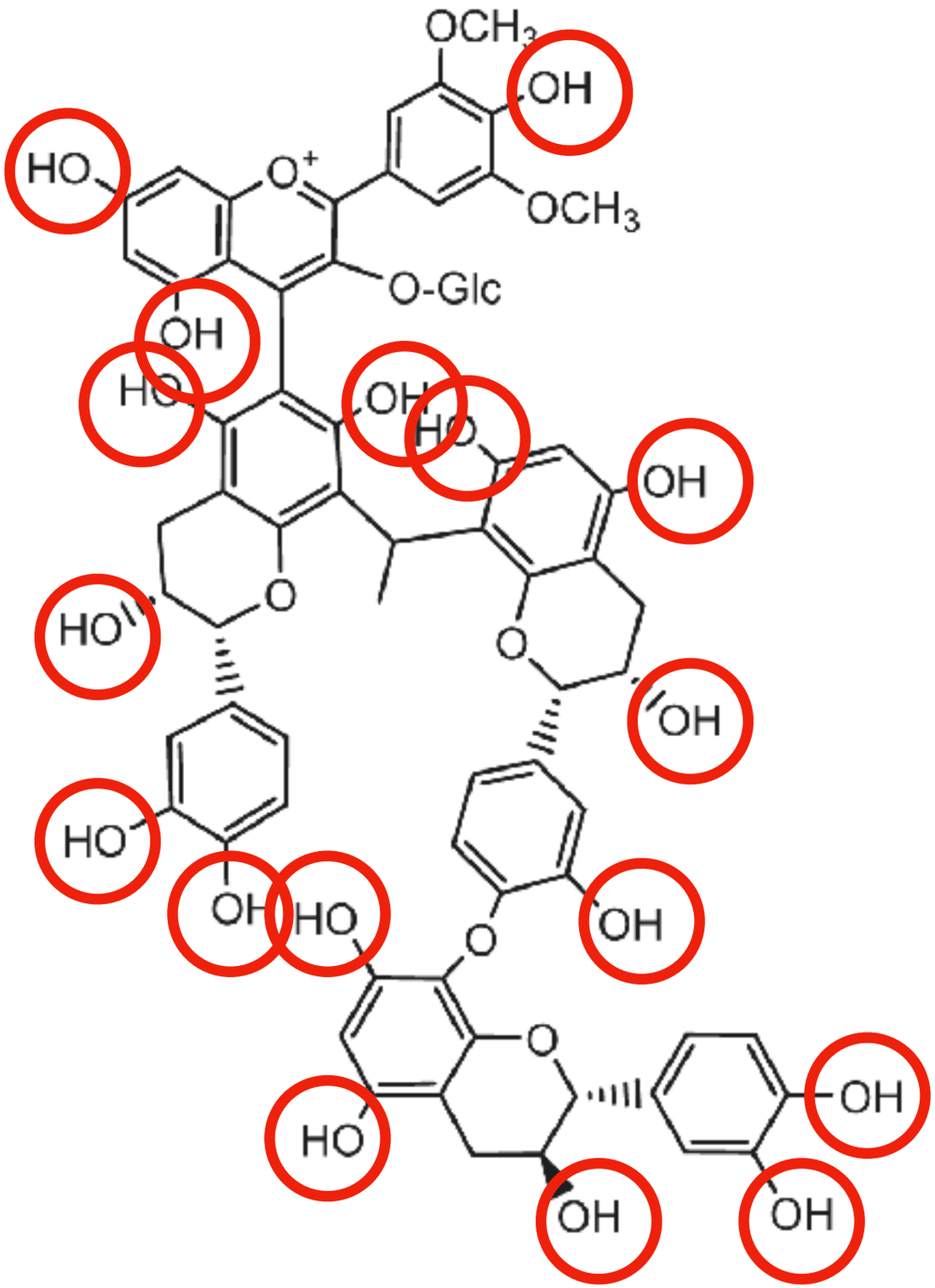

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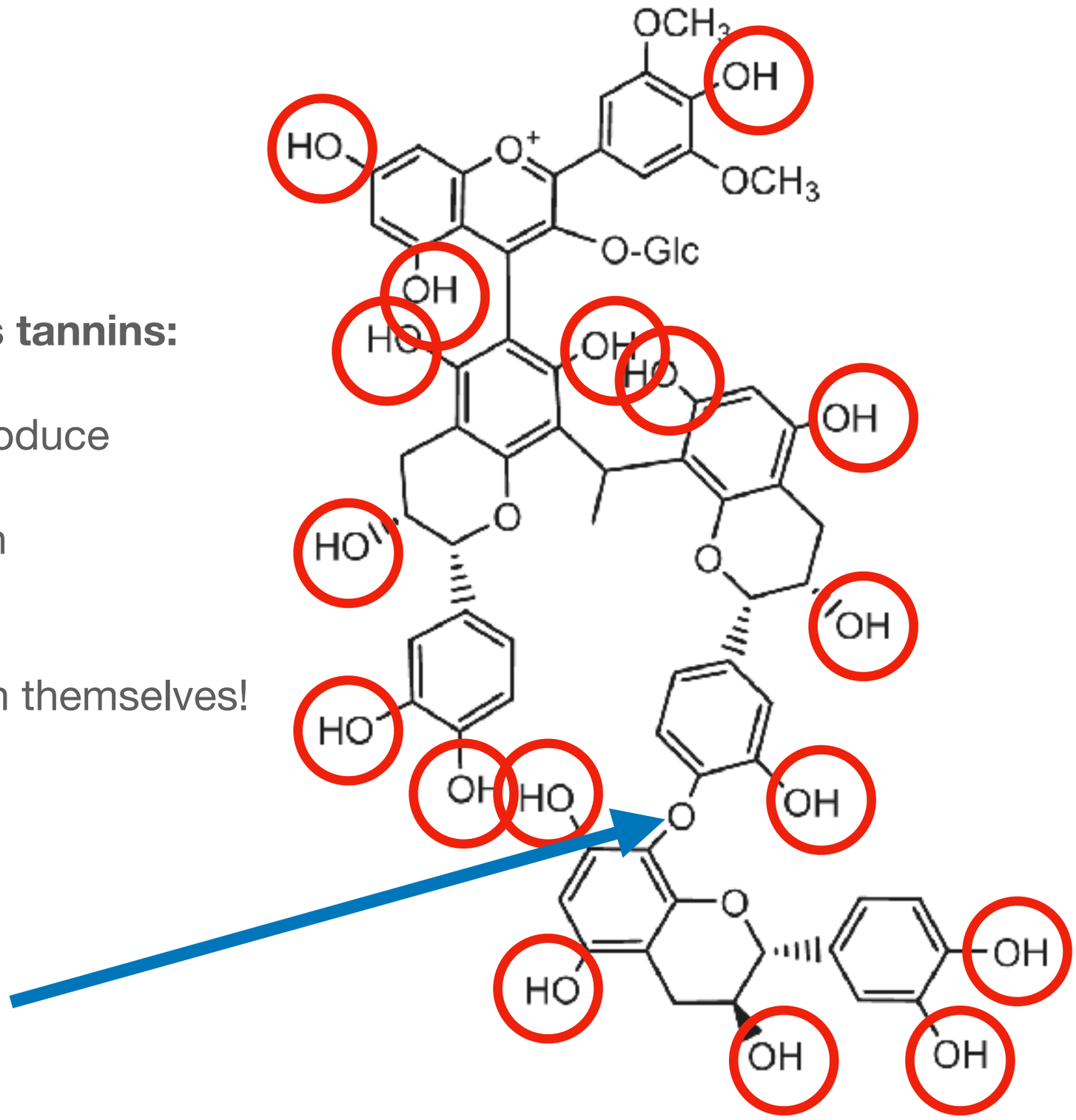

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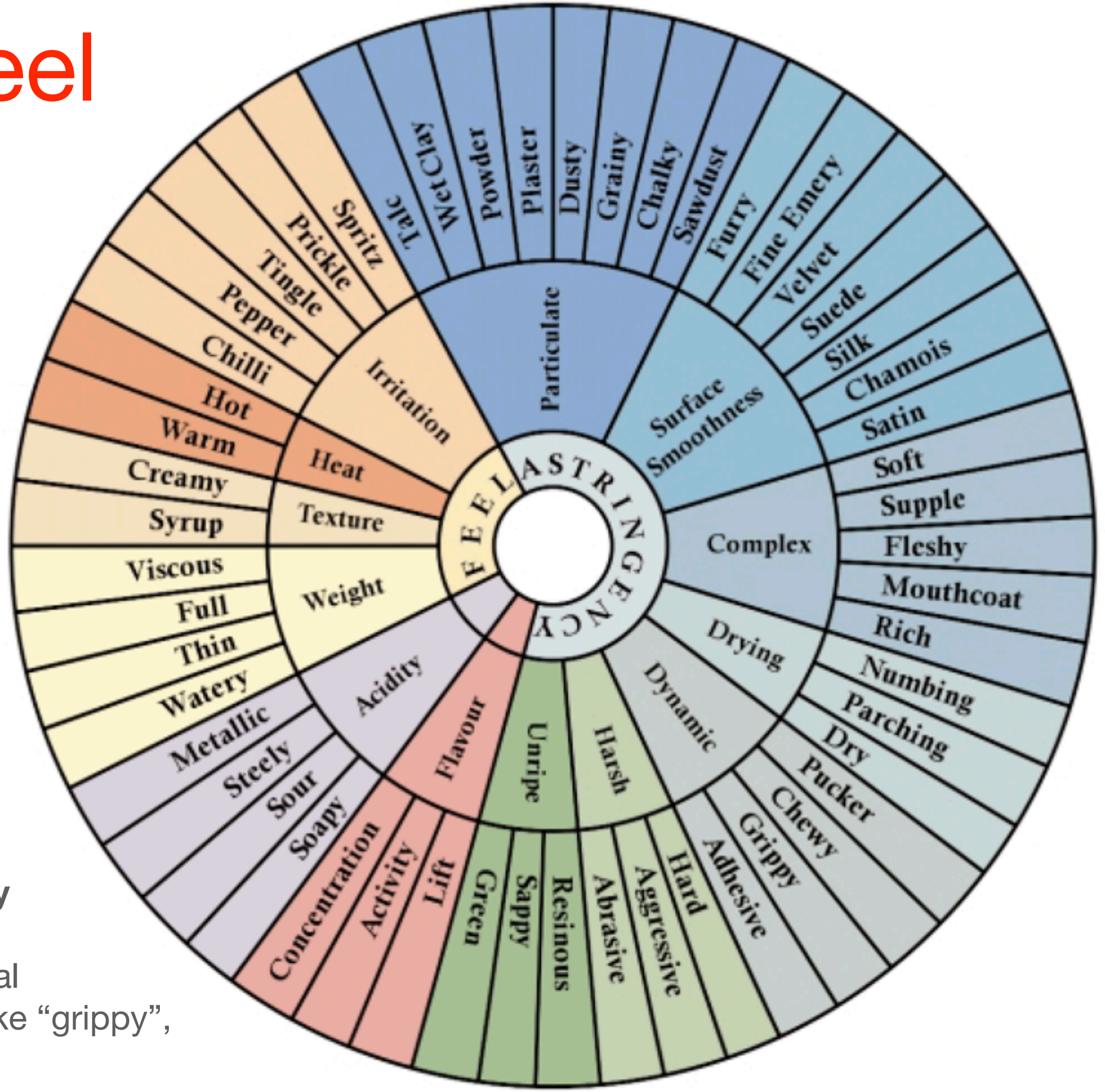

Tannins add **astringency** to wine, described by wine tasters using several dozen different words, like “grippy”, “pucker”, or “drying”

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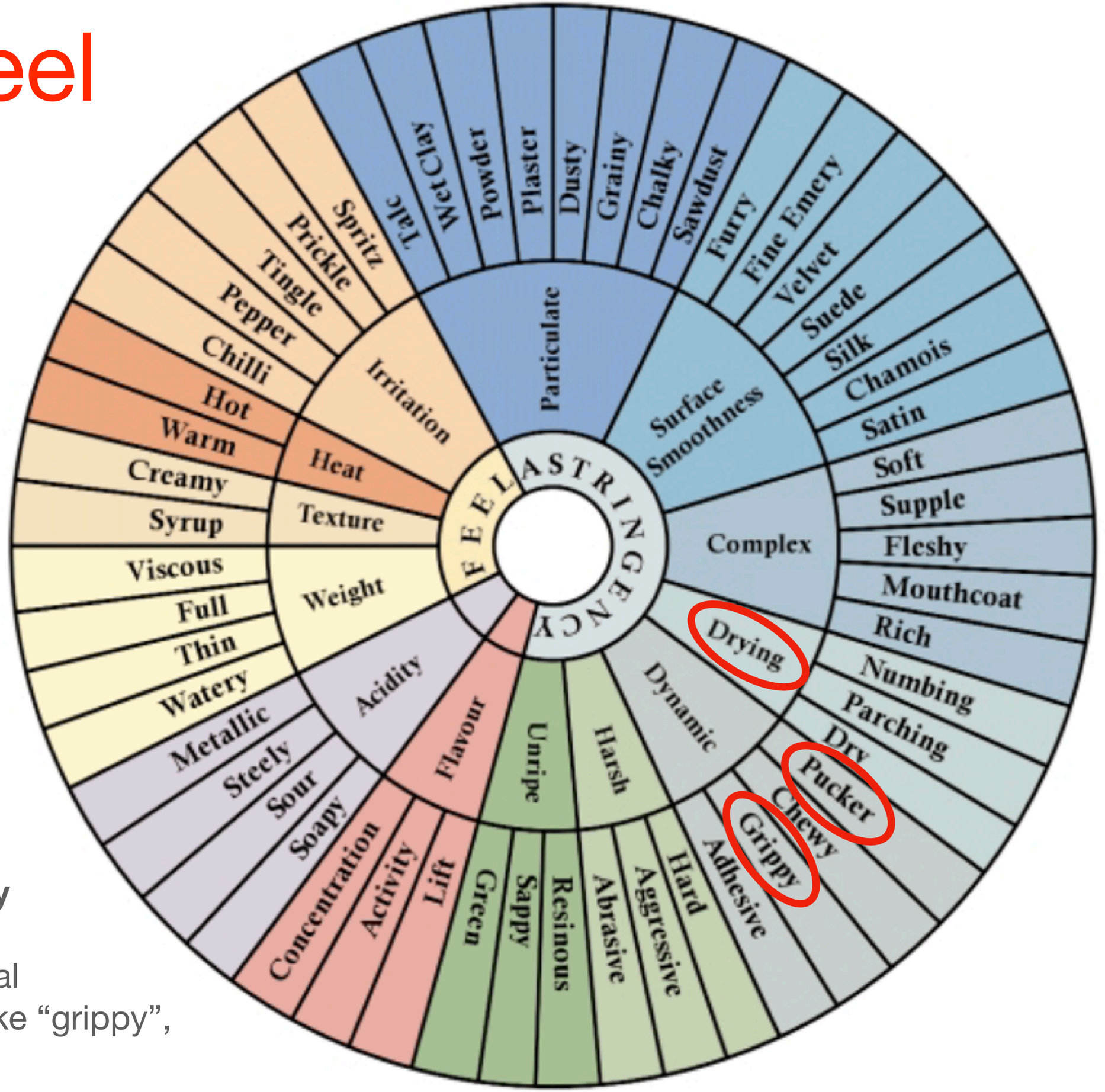

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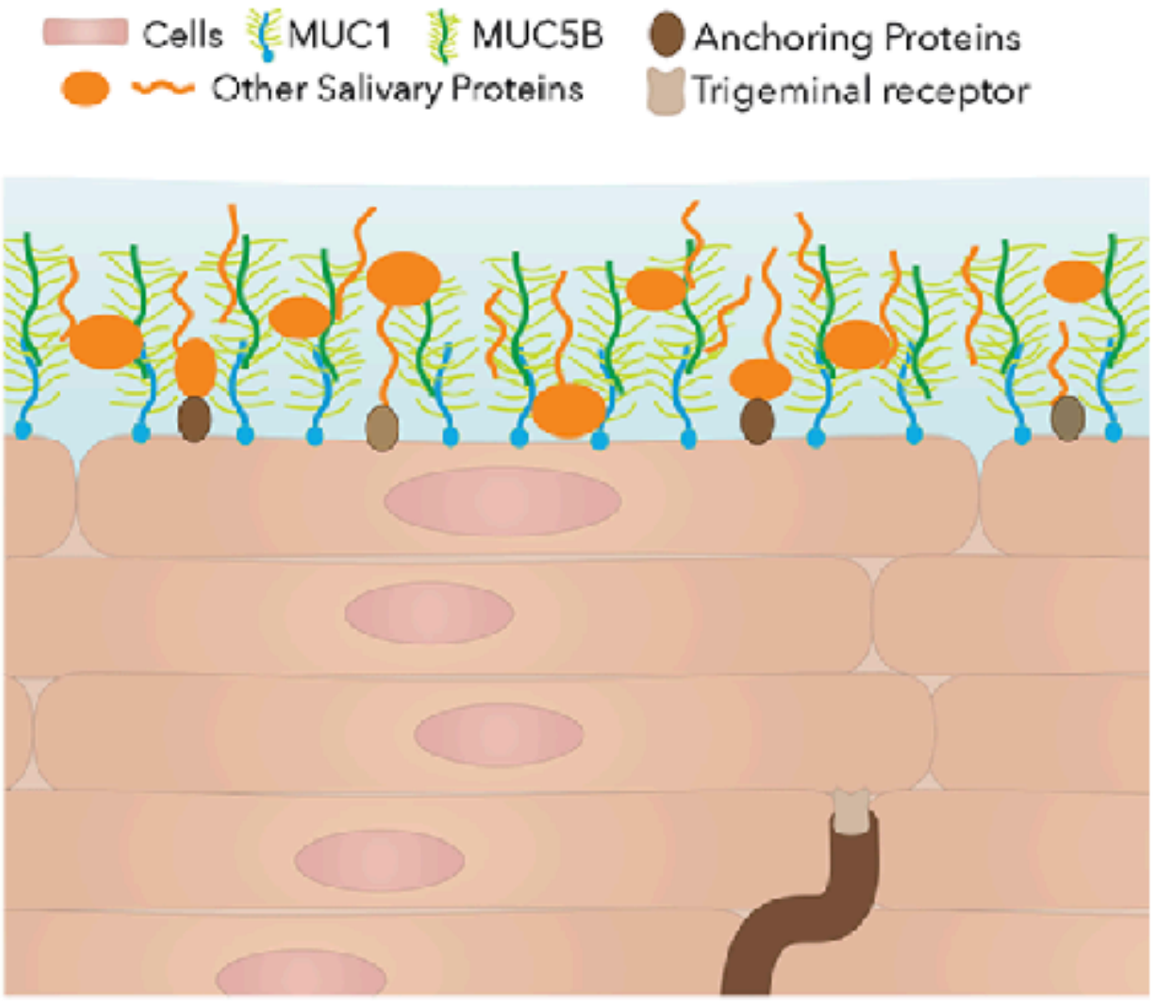
Tannins and Saliva

Normal tongue surface with lubricating mucin layer



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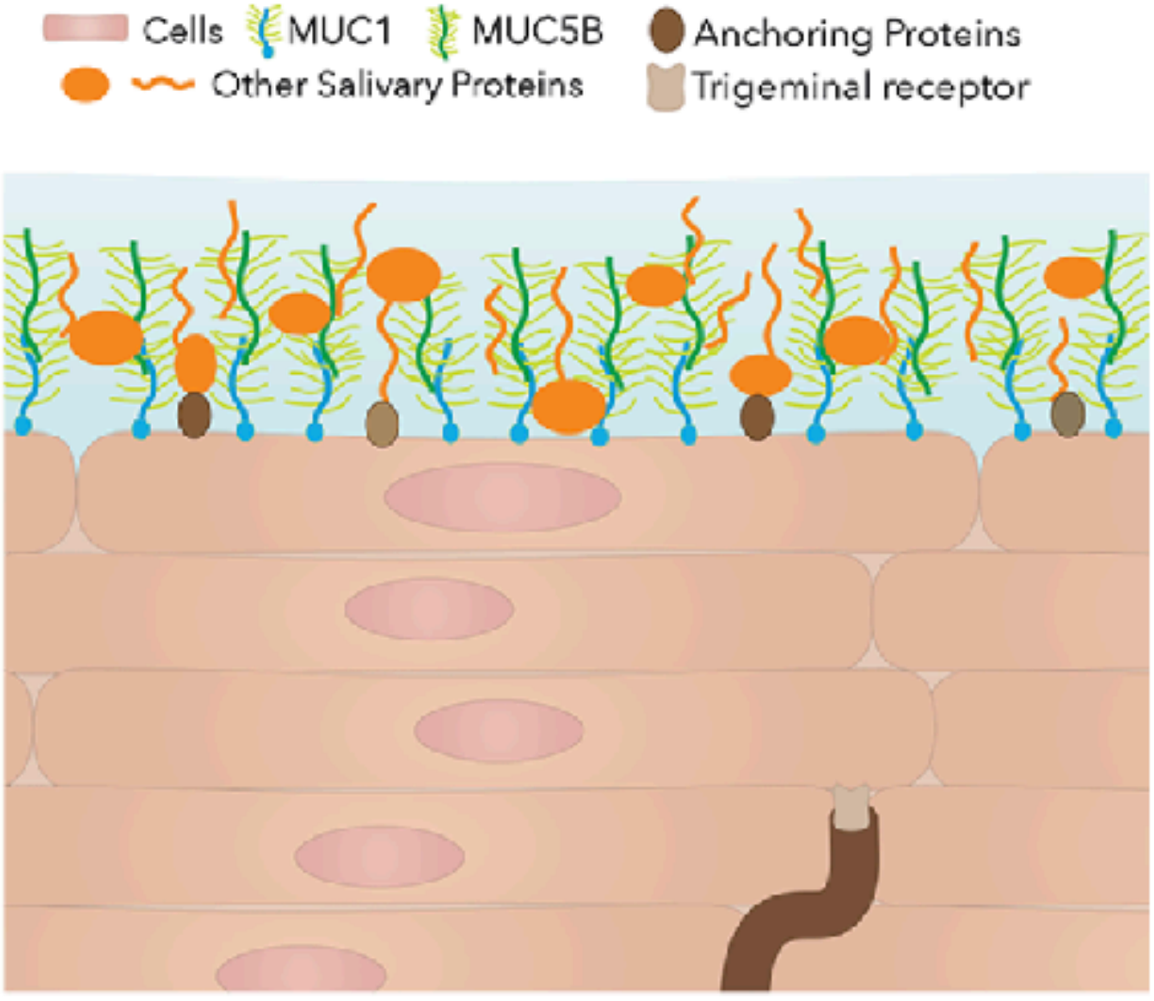
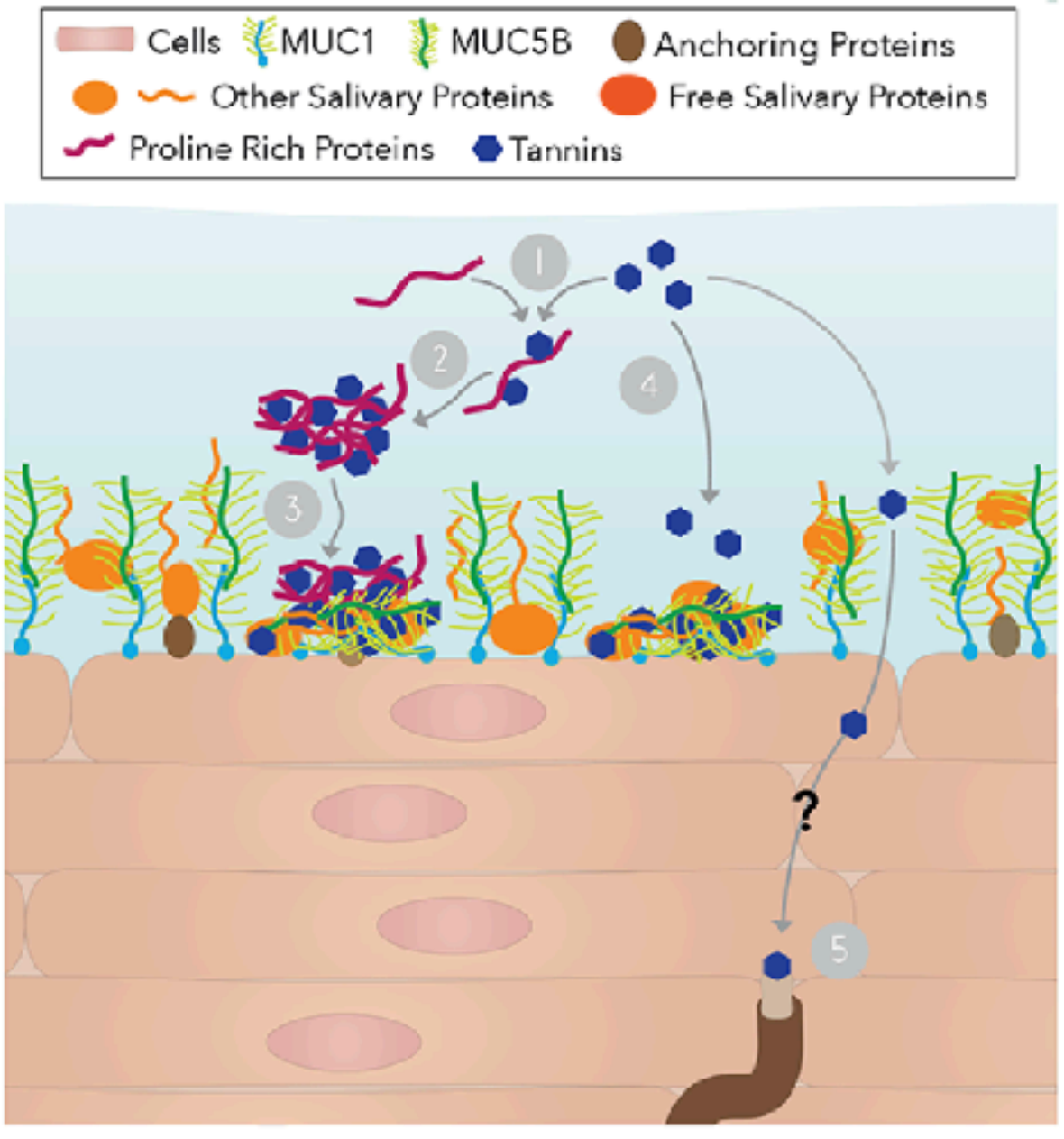


Tongue surface with tannins



Tannins bind (proline-rich) salivary proteins in the mouth, leading to impaired lubrication, and making it feel grippy, puckering, dry!

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Model wines: controlled acidity and tannin concentrations

- Water
- Ethanol
- Grape seed tannin extract
- Maltodextrin
- Tartaric Acid

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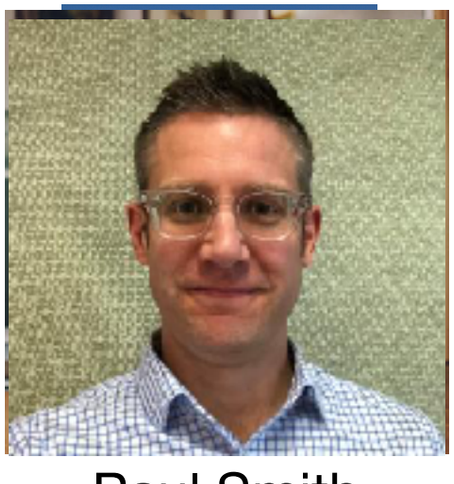

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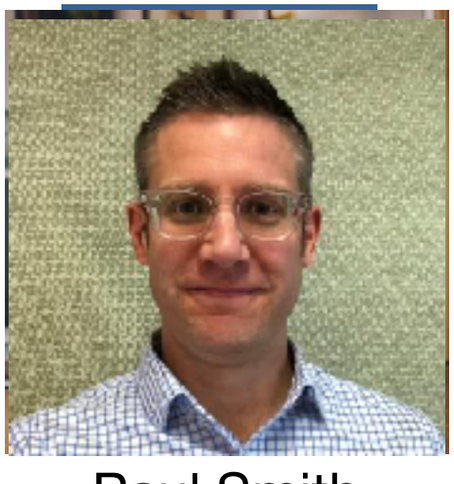

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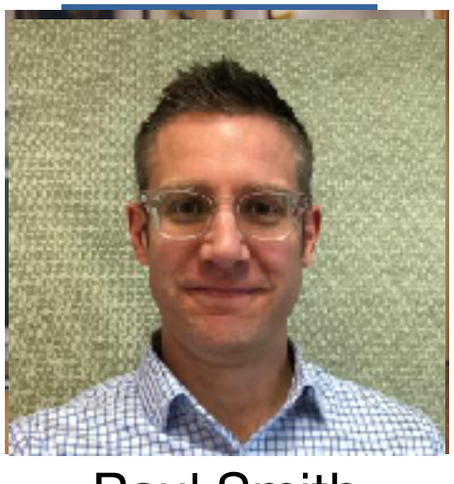

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Taste panel assessment: evaluation for “drying”, “rough”, and “pucker”

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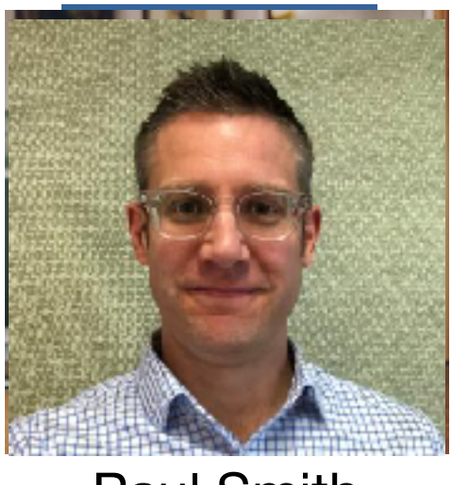

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Tribological testing of wine

Understanding “drying” and “pucker”

Static Experiments:

Friction Coefficients: 0 is no friction, ≈1 is high friction (tyre on dry road)

Wines ≈ **0.85**
Saliva ≈ **0.06**
Model Wine/saliva mixtures: **0.5 - 0.85**
(Higher tannin showed higher friction)

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Correlation with taste panel:

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Correlation with taste panel:

Higher friction correlates with “drying”, not with “pucker”

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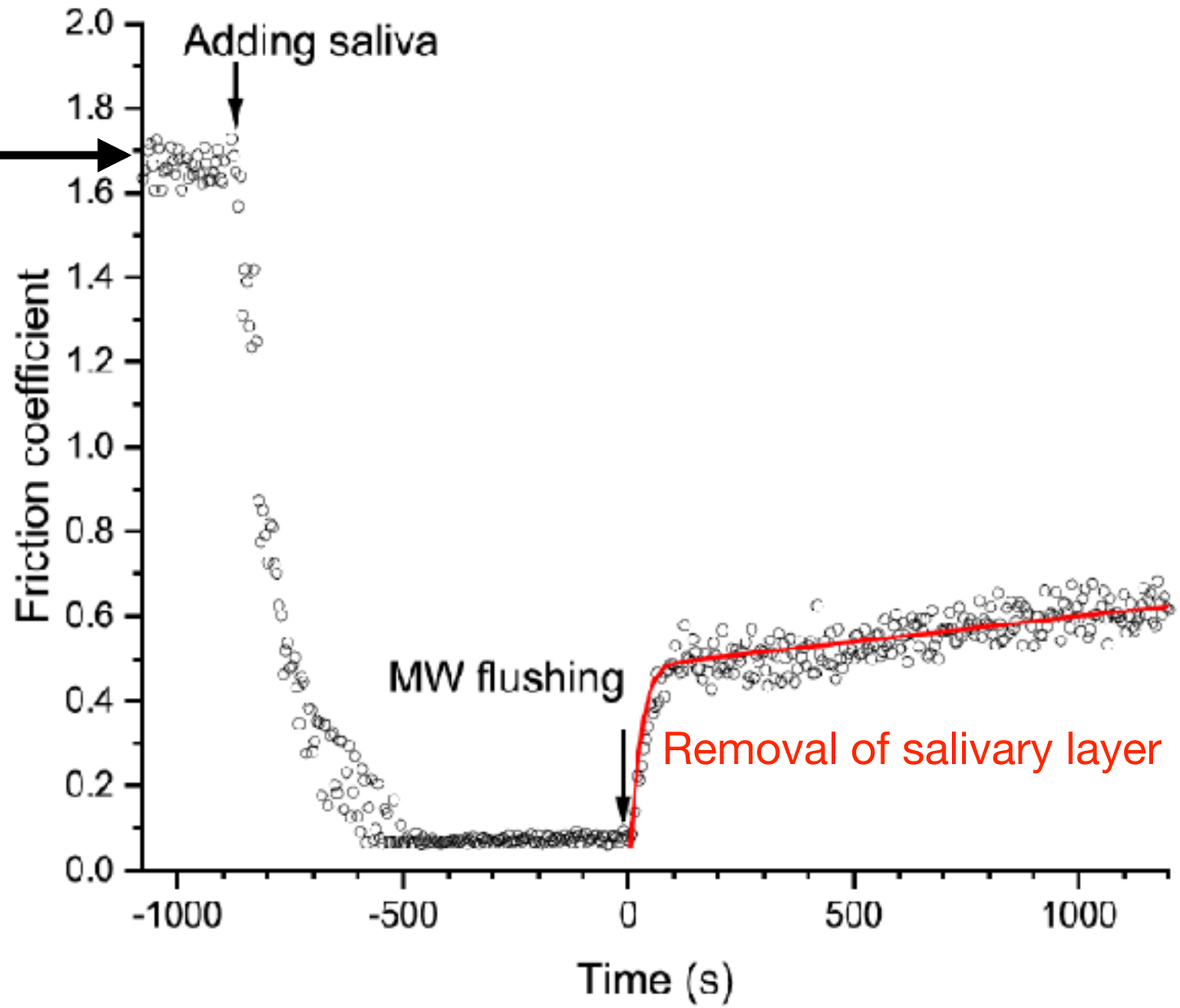
High friction of silicone rubber against silicone rubber



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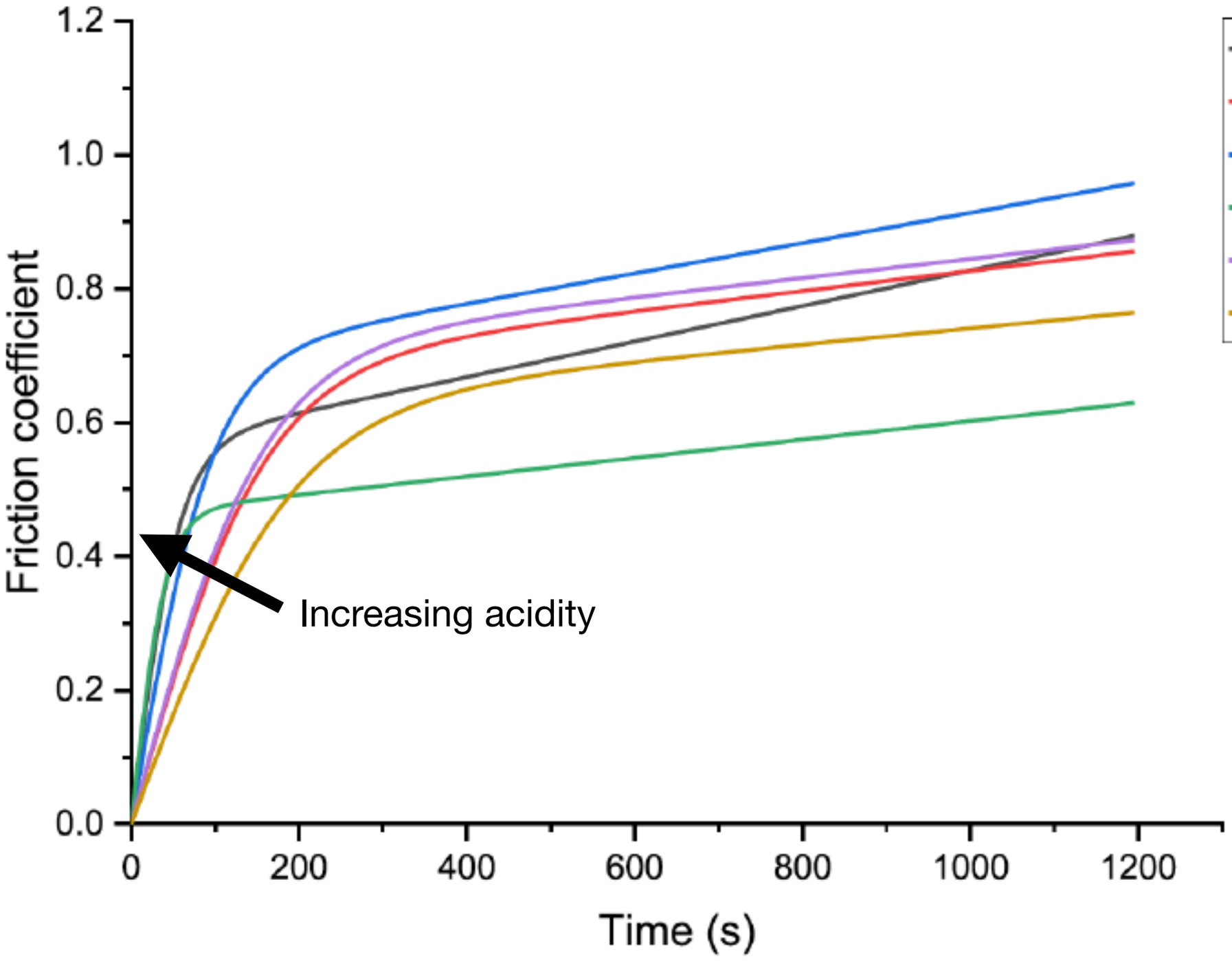

Model Wines

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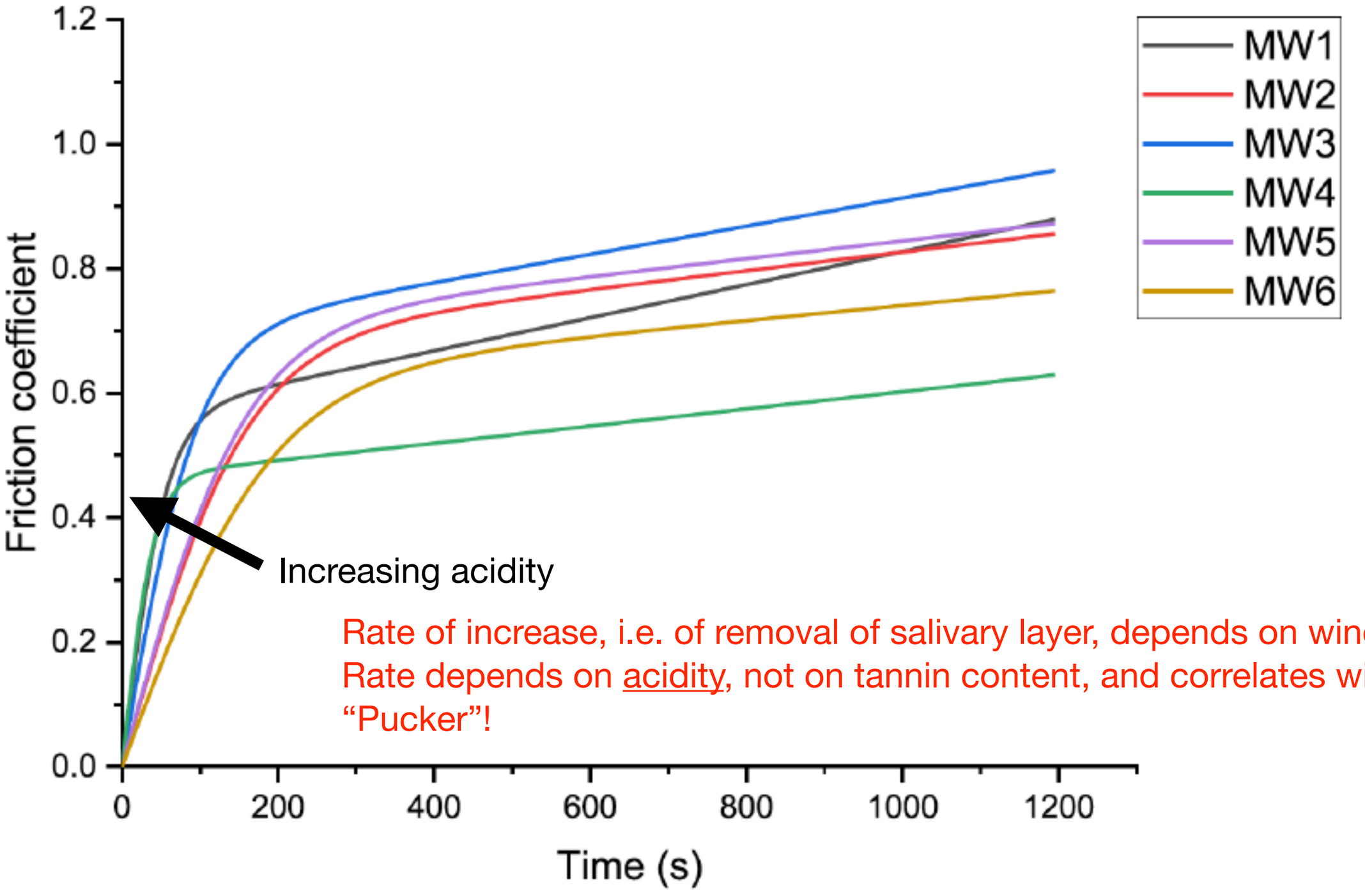

Rate of increase, i.e. of removal of salivary layer, depends on wine composition.
Rate depends on acidity, not on tannin content, and correlates with “Pucker”!

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Outline

- What is tribology?
- What is in wine?
- Tannins
- Mouthfeel of wine
- A tribological study of wine
- What about bubbles?

Tribological testing of wine

Understanding the role of carbonation (bubbles!) on mouthfeel

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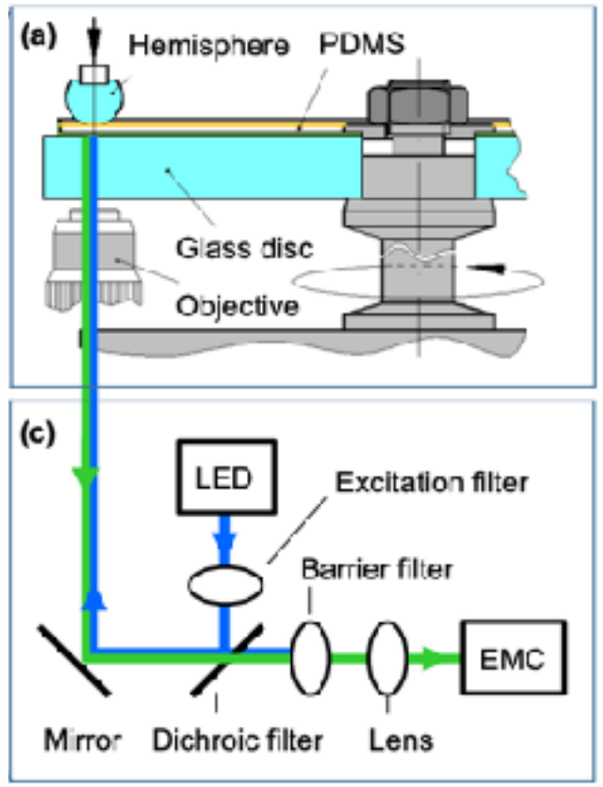

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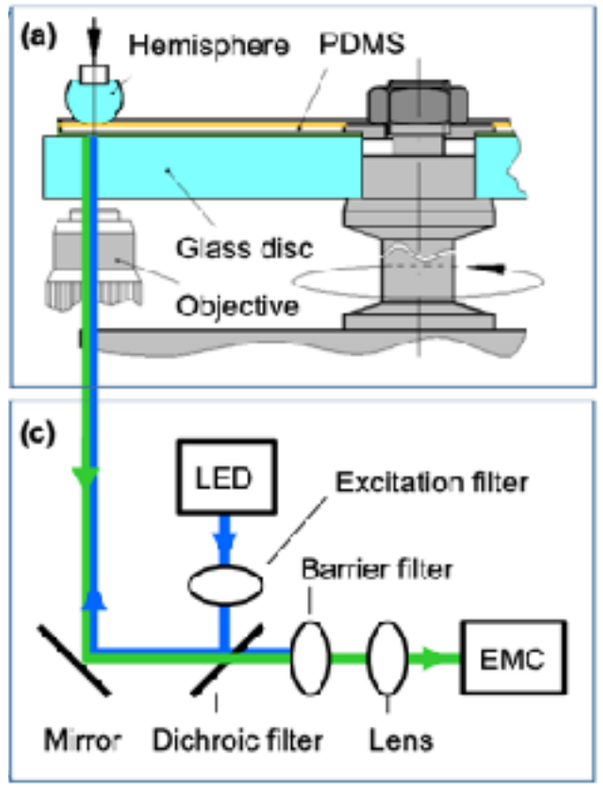

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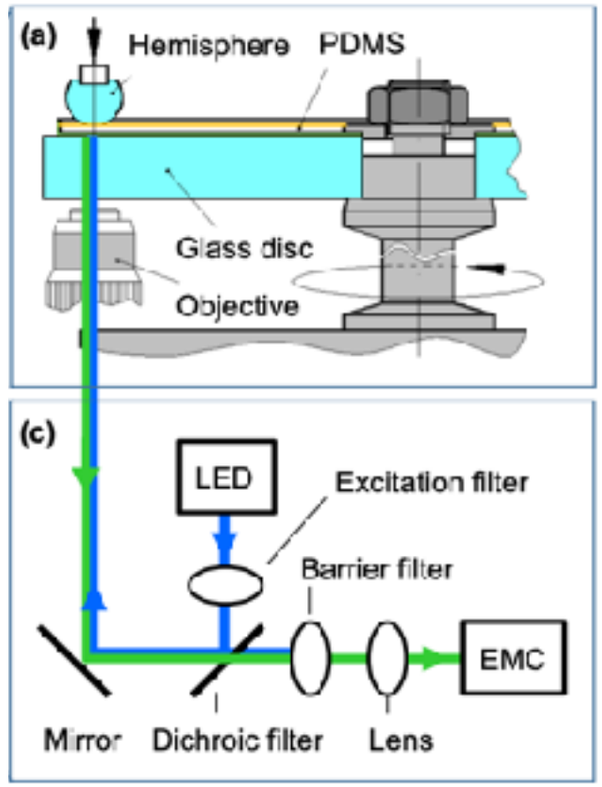

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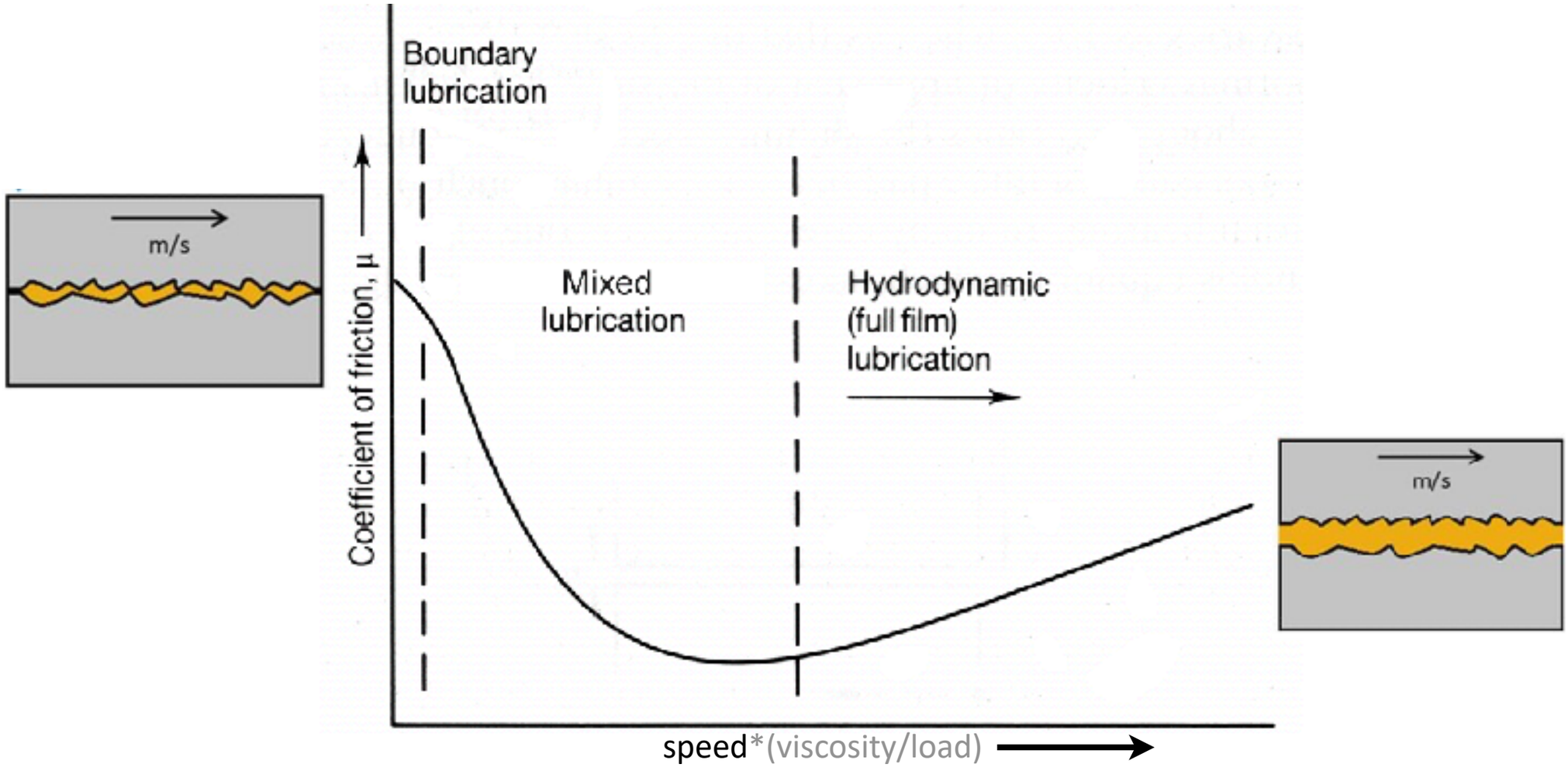

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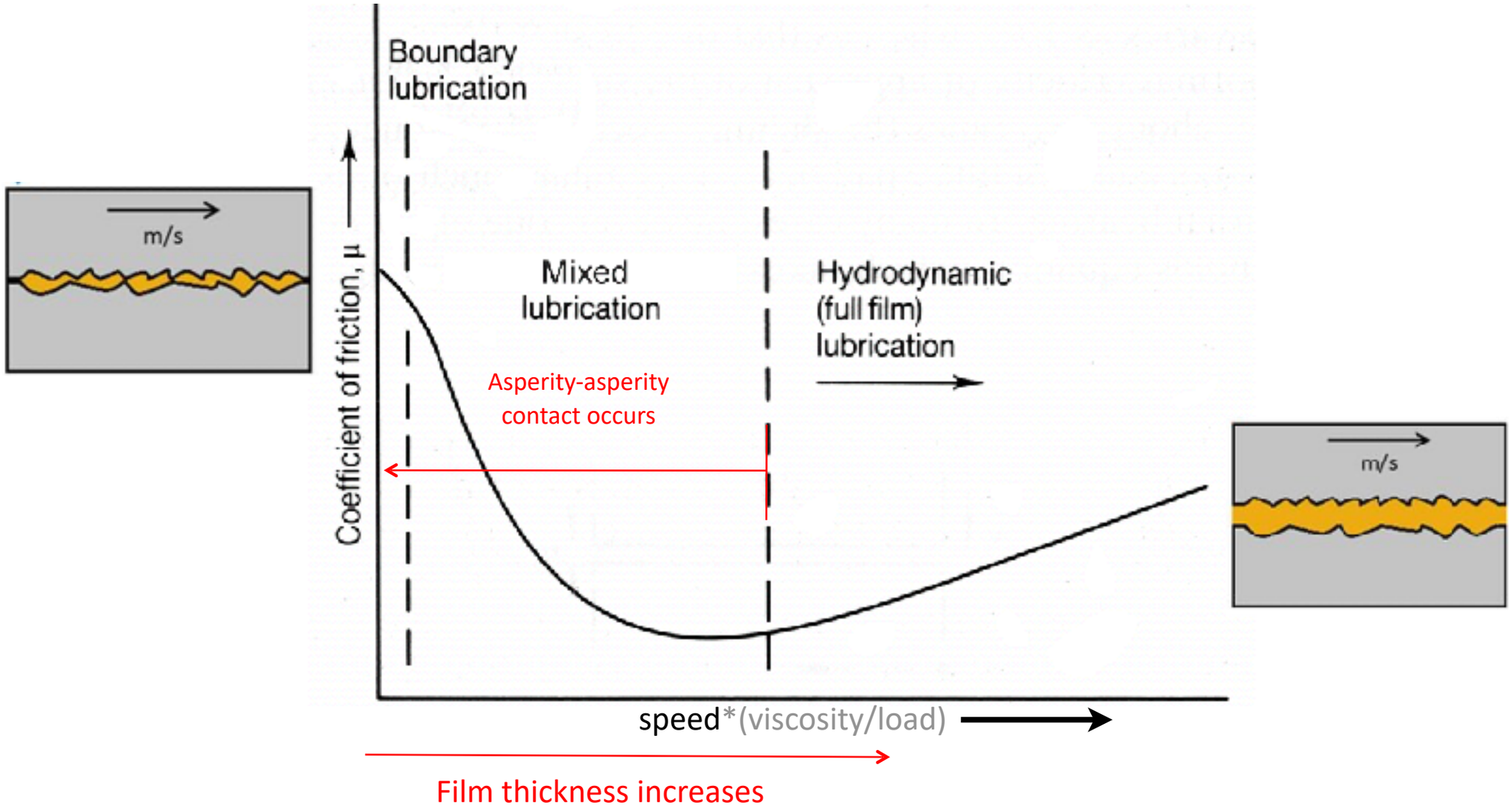

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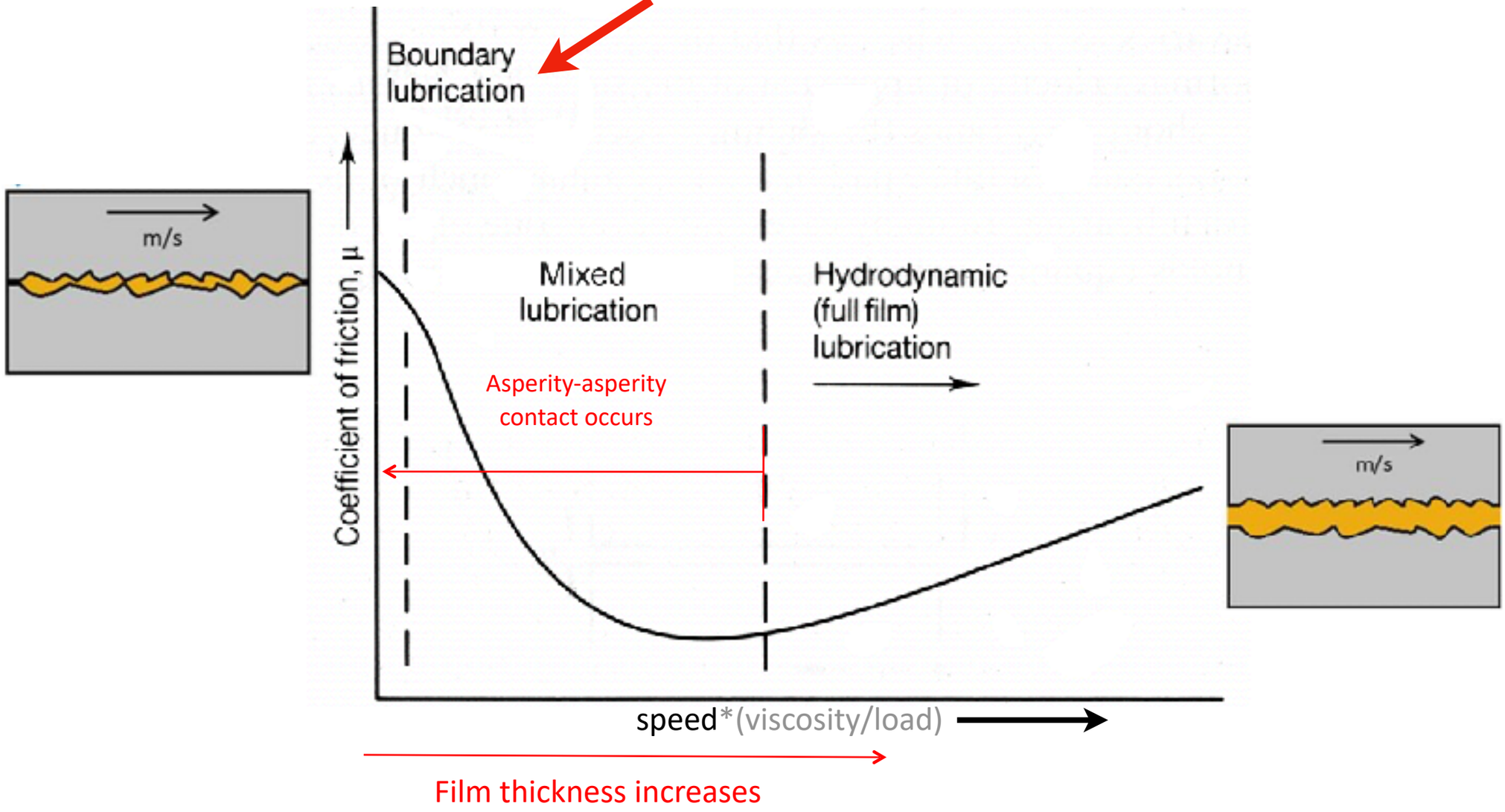

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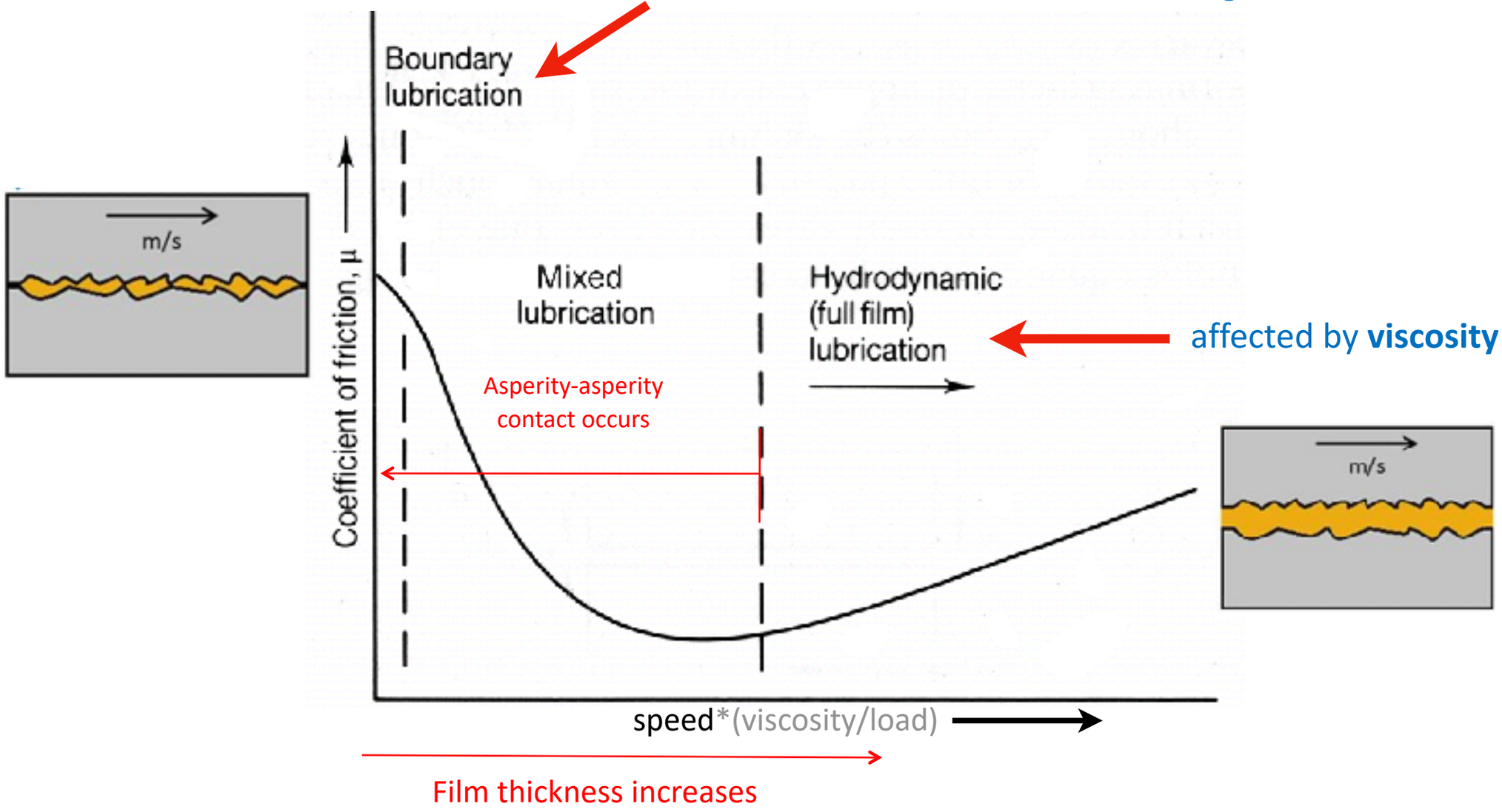

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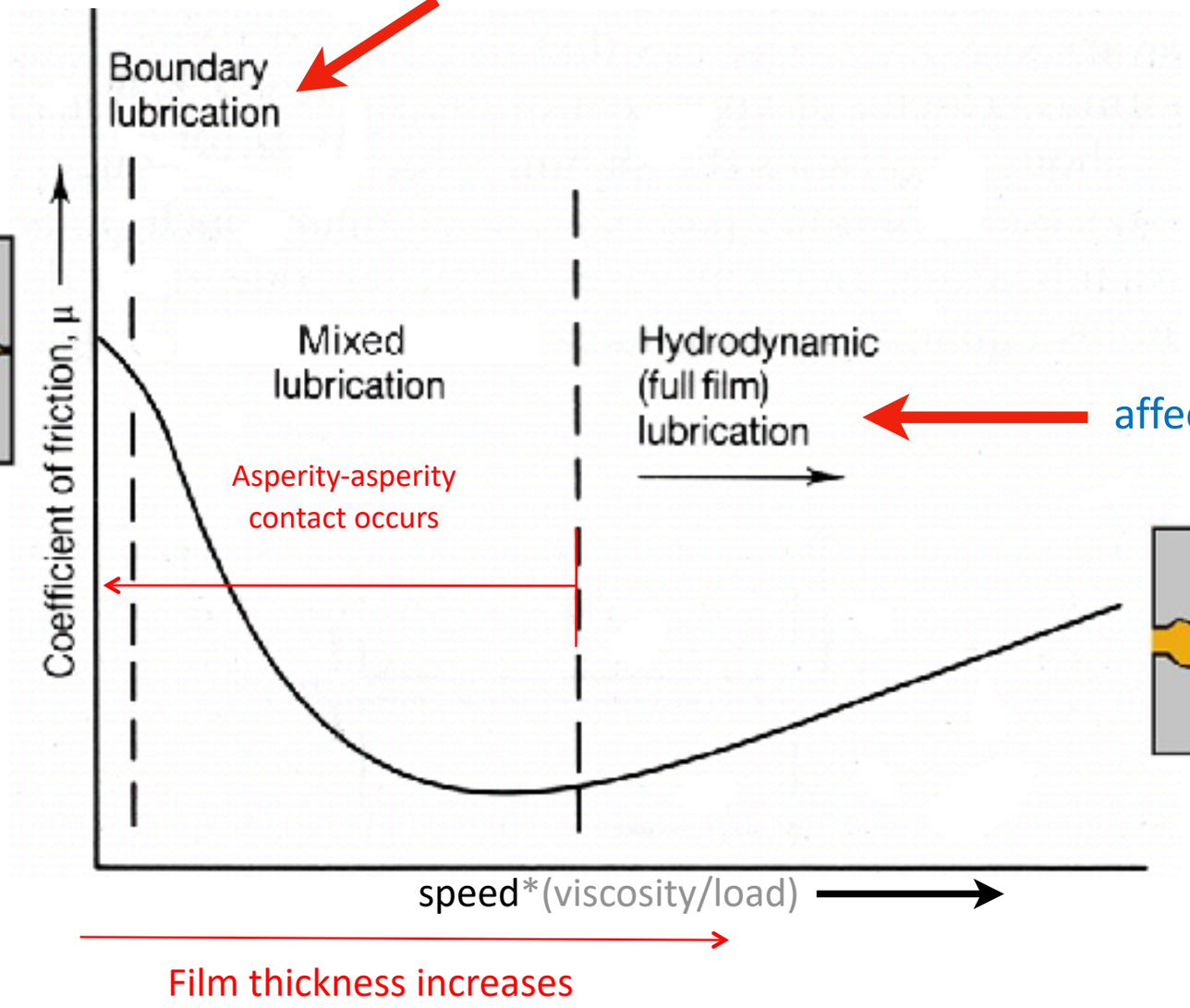
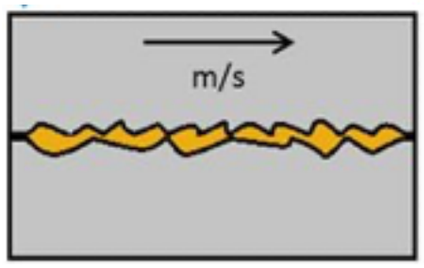
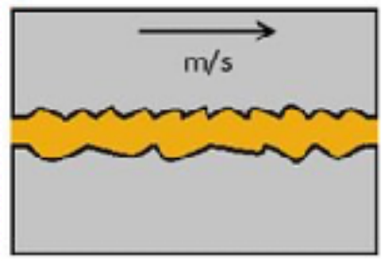




affected by **viscosity**



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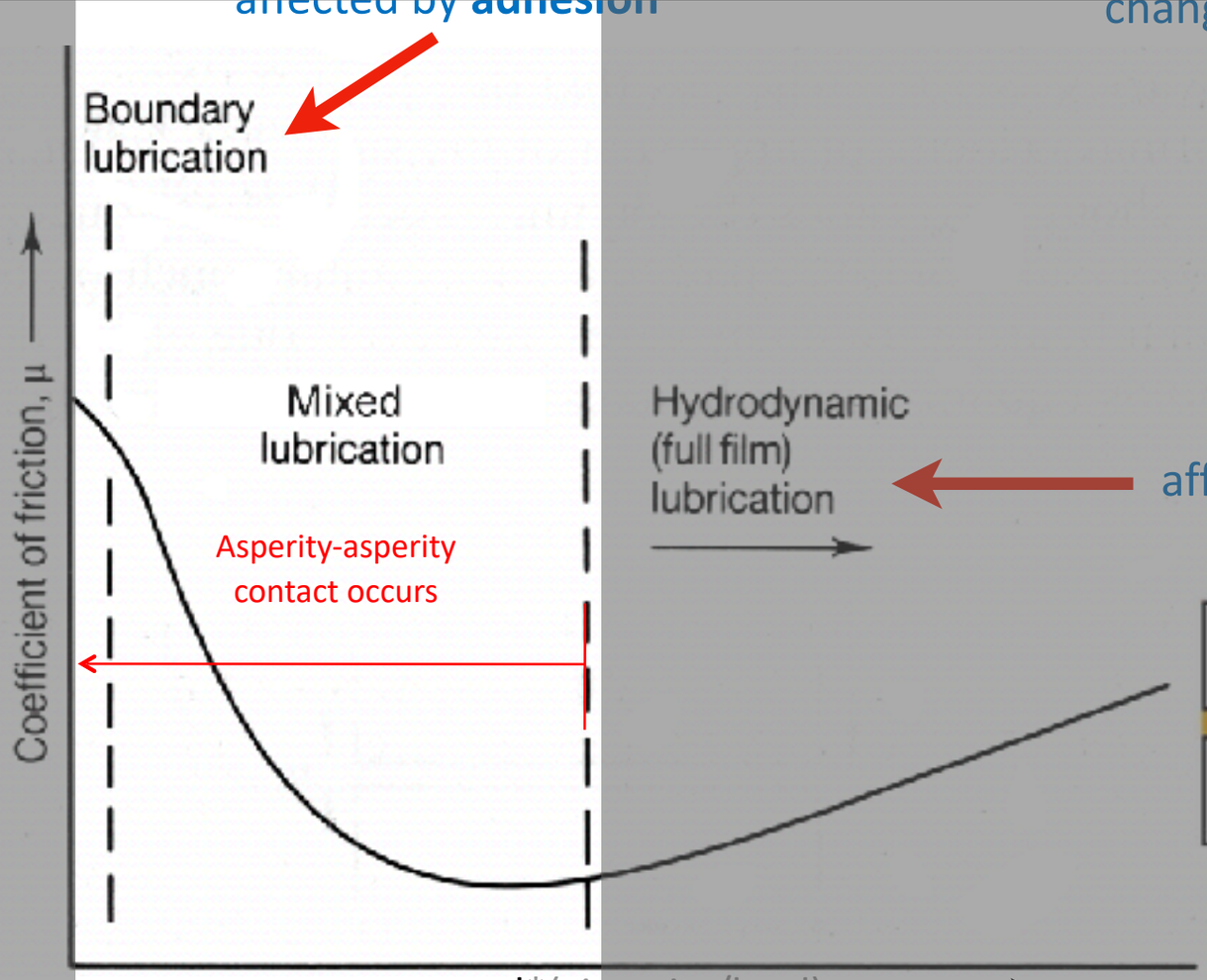
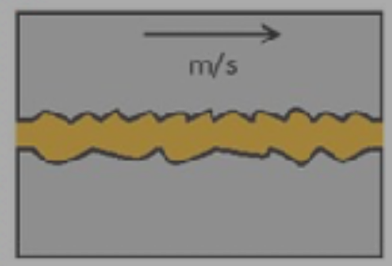


Asperity-asperity contact occurs

affected by **viscosity**



Film thickness increases

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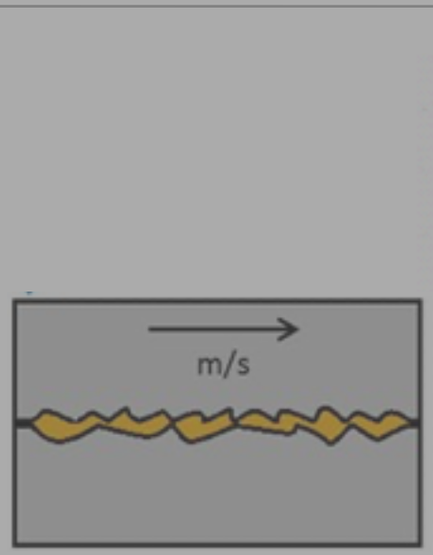

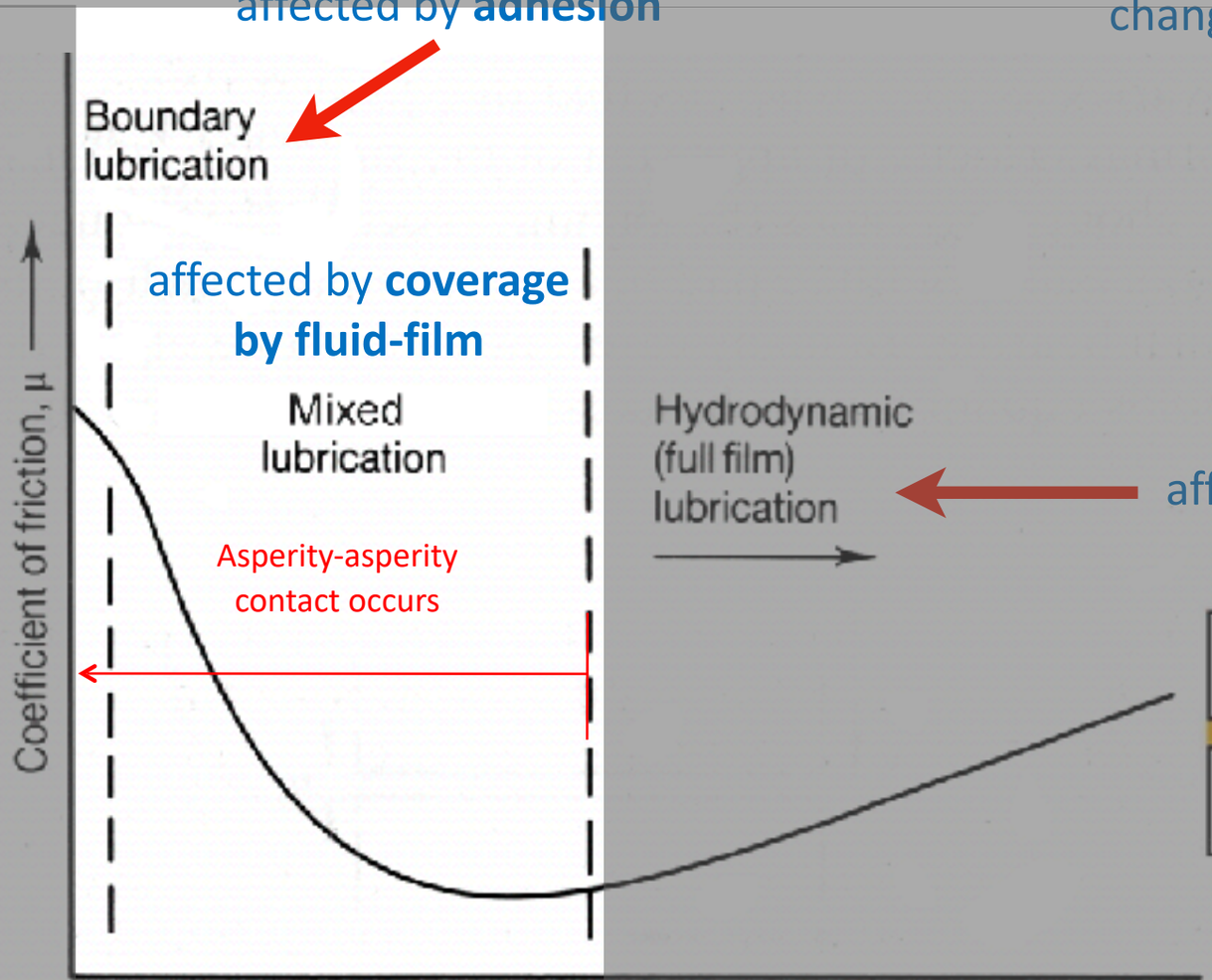

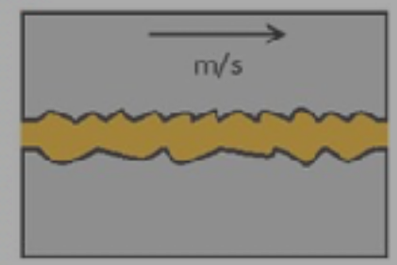

Tribological testing of wine

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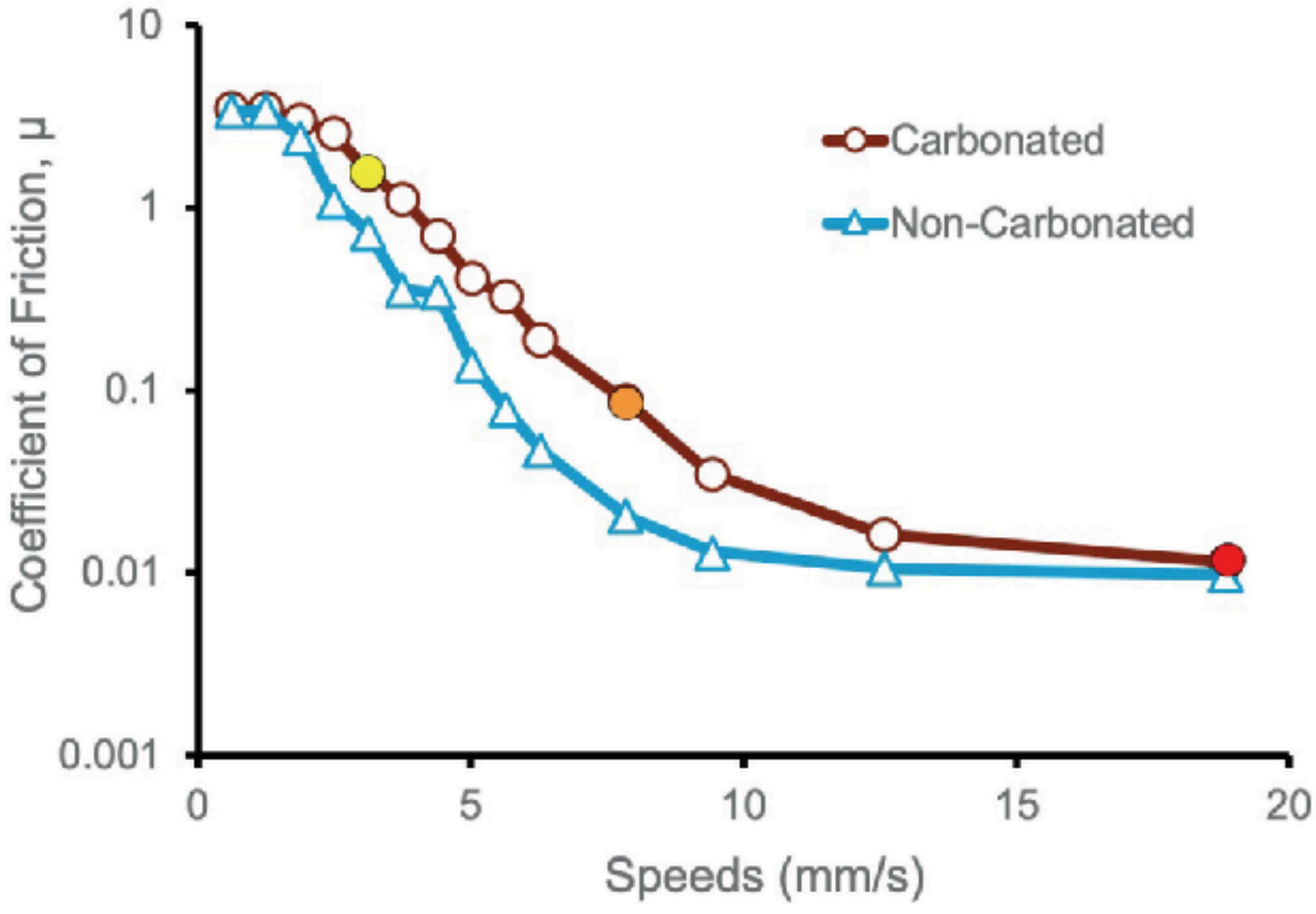
Friction Results with Water:

Water lubrication ± CO_2

Stribeck curve different, but only in the mixed regime (partial fluid-film lubrication)



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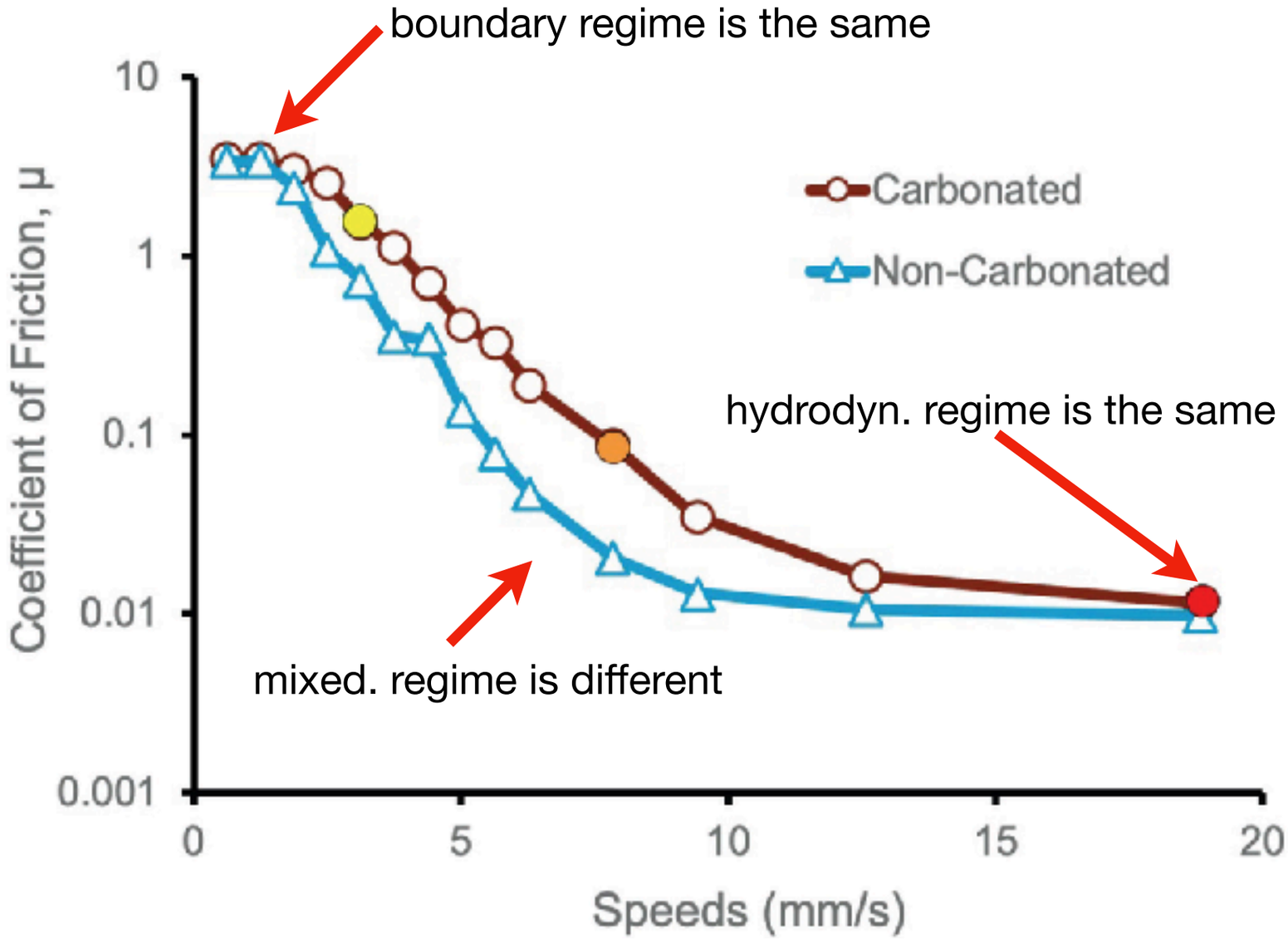

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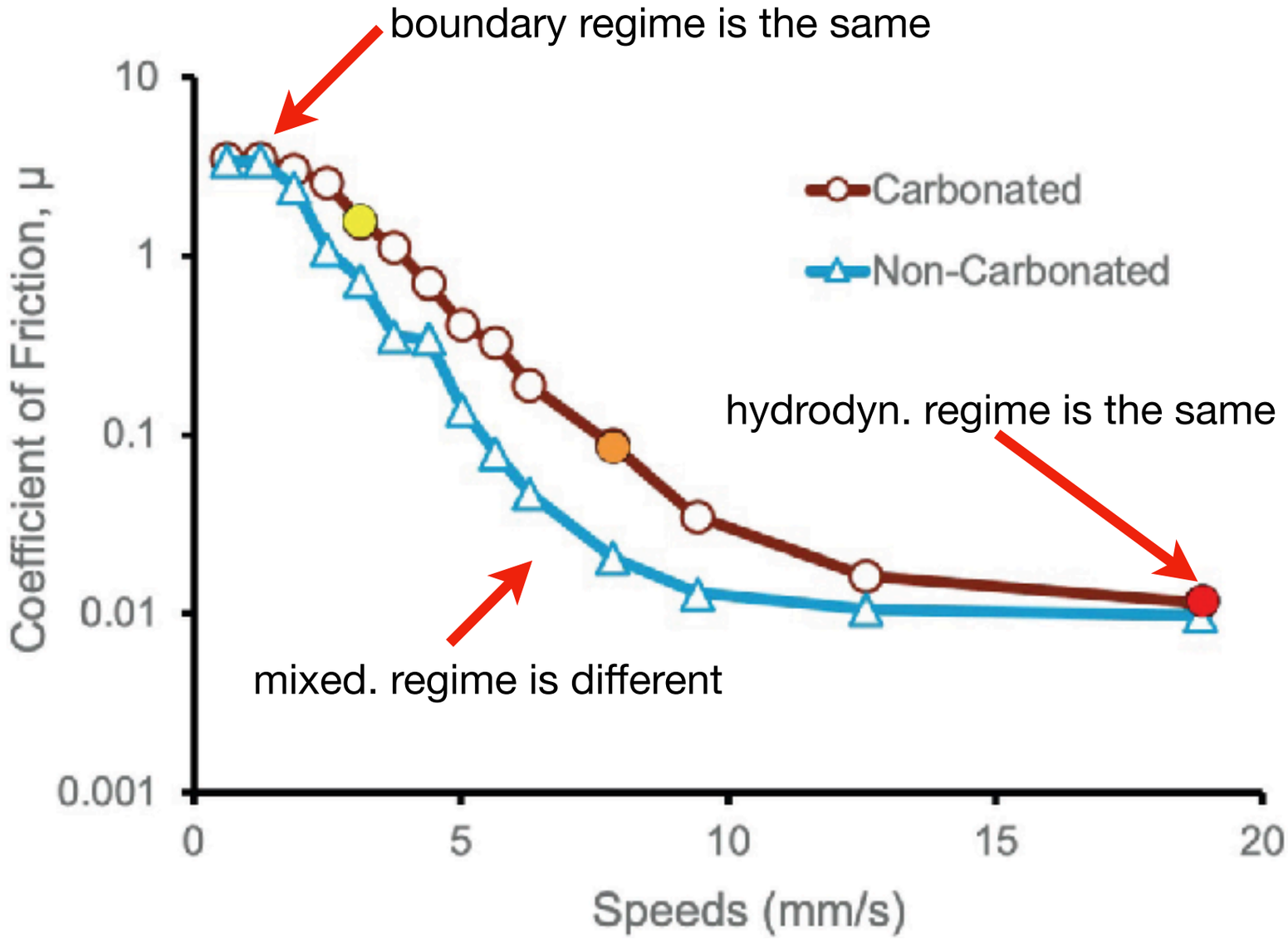

Therefore, Adhesion and Viscosity are not affected by carbonation!

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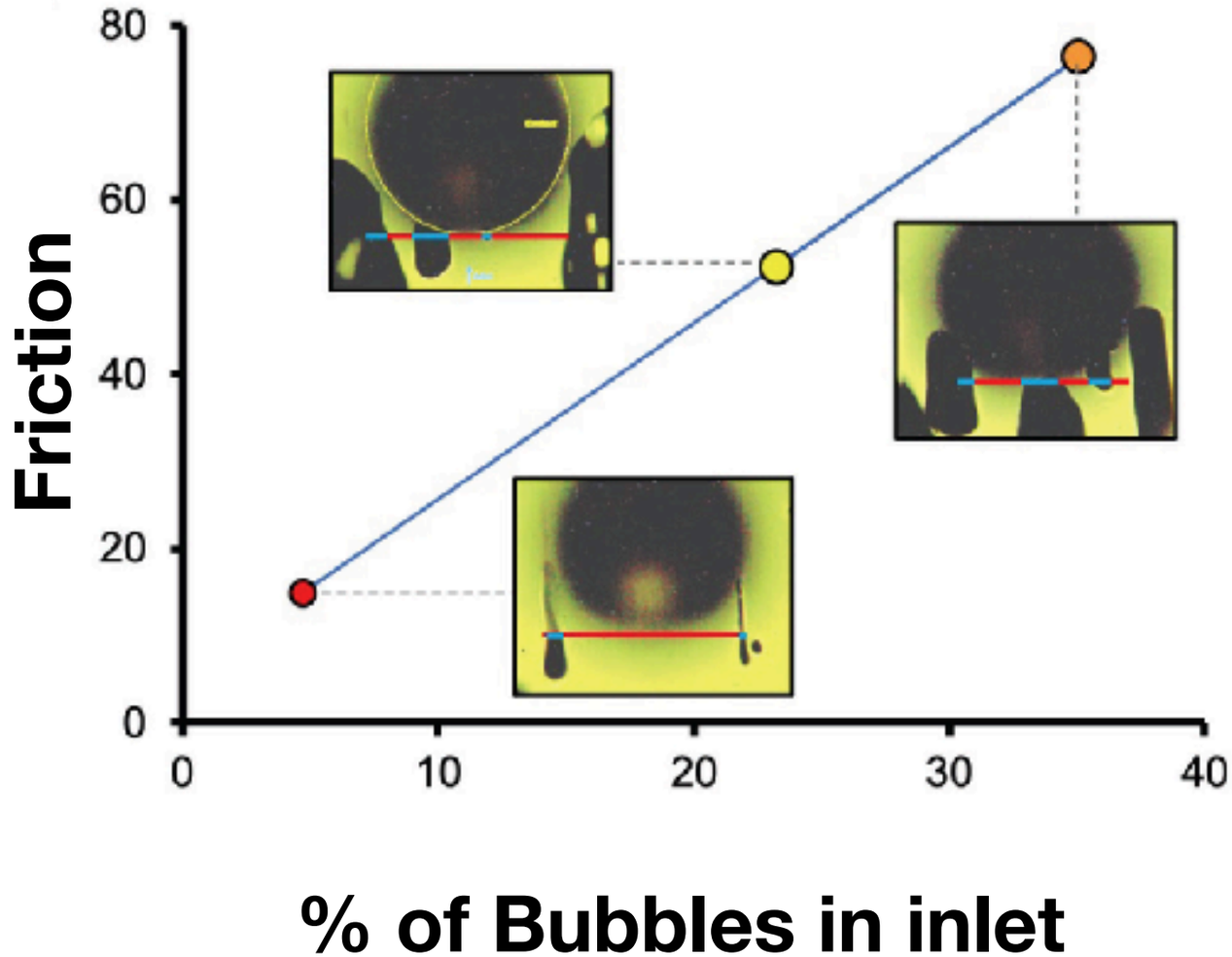

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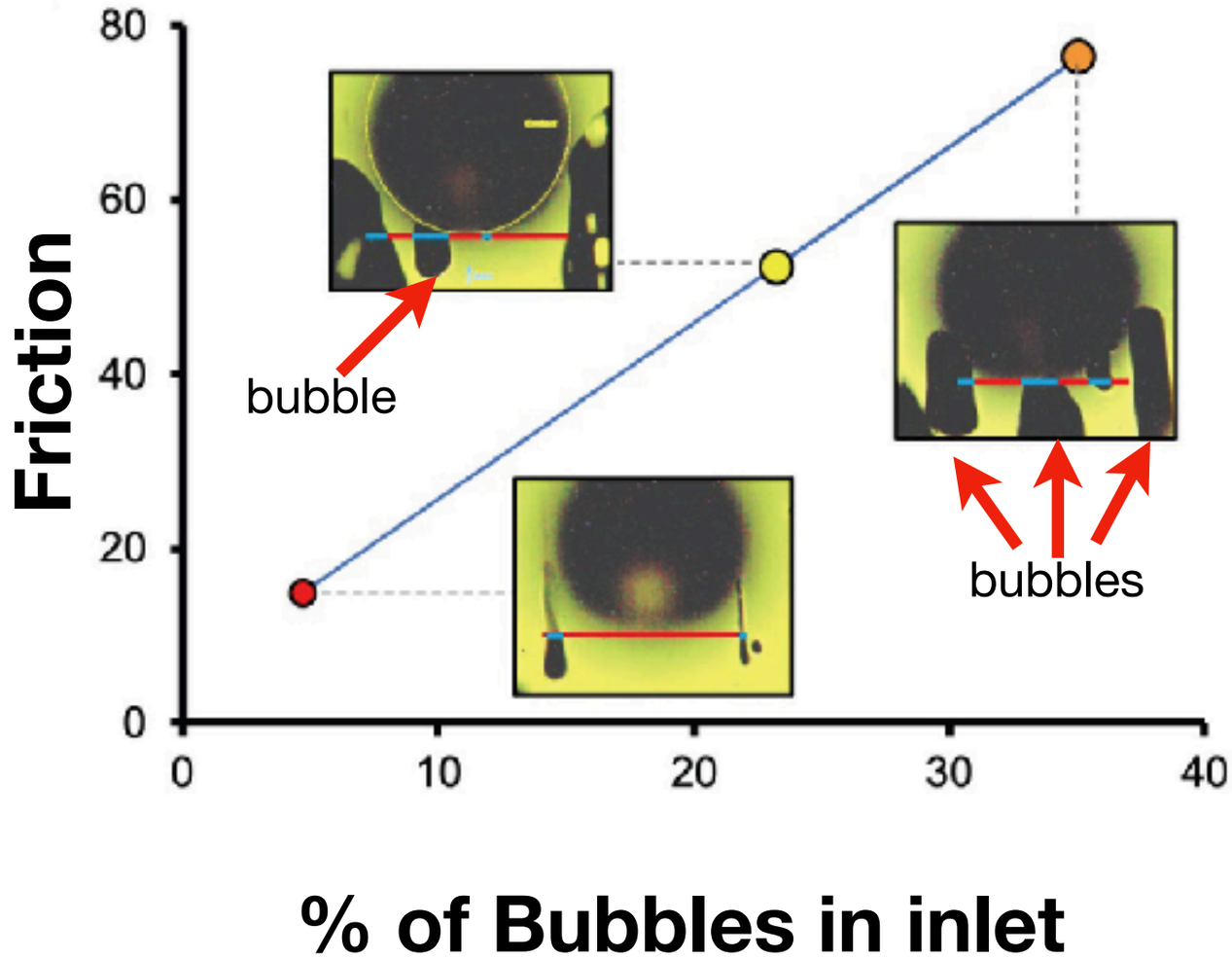

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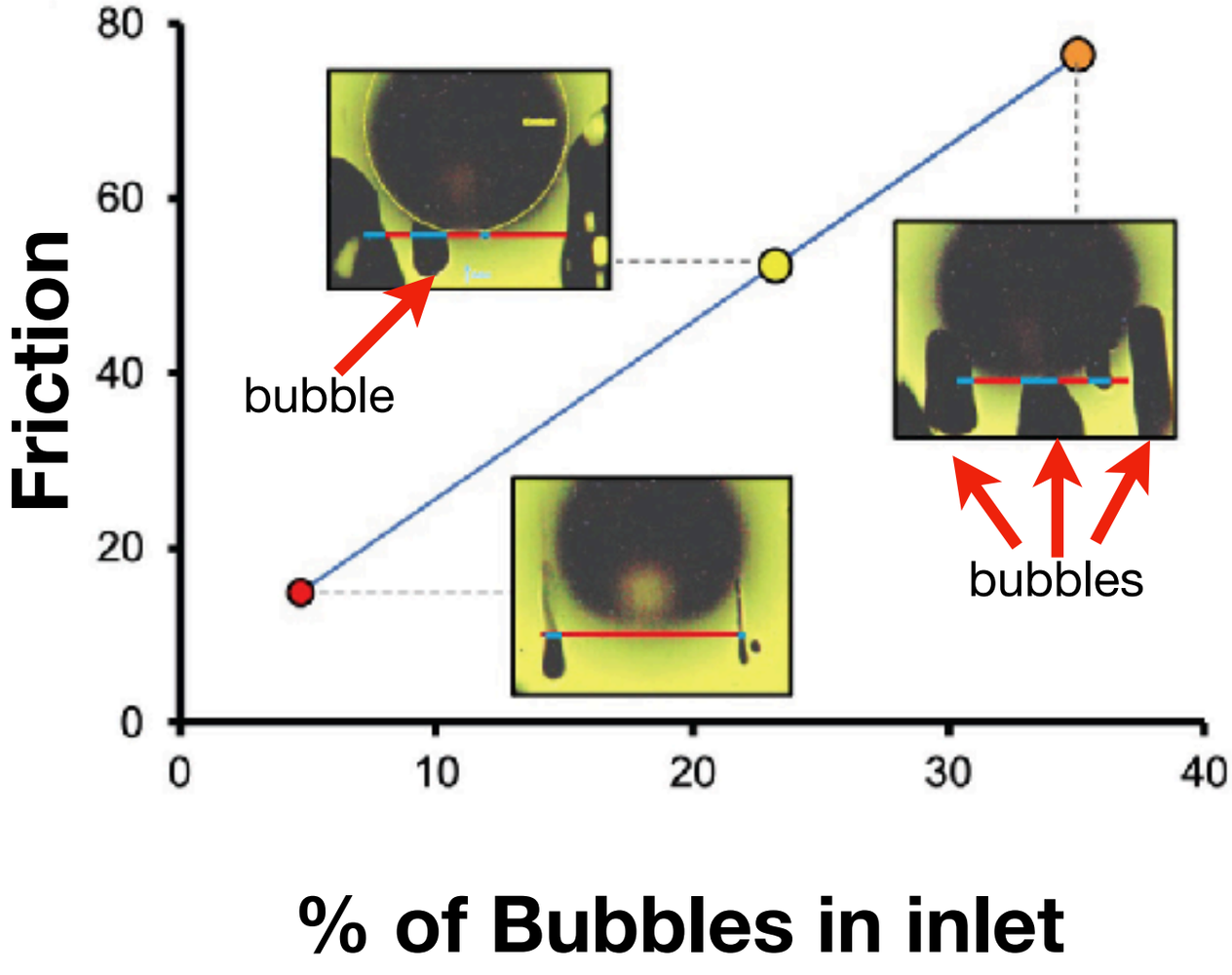
CO_2 bubbles found at the contact inlet: the increase in friction was proportional to the fraction of the contact covered with bubbles.



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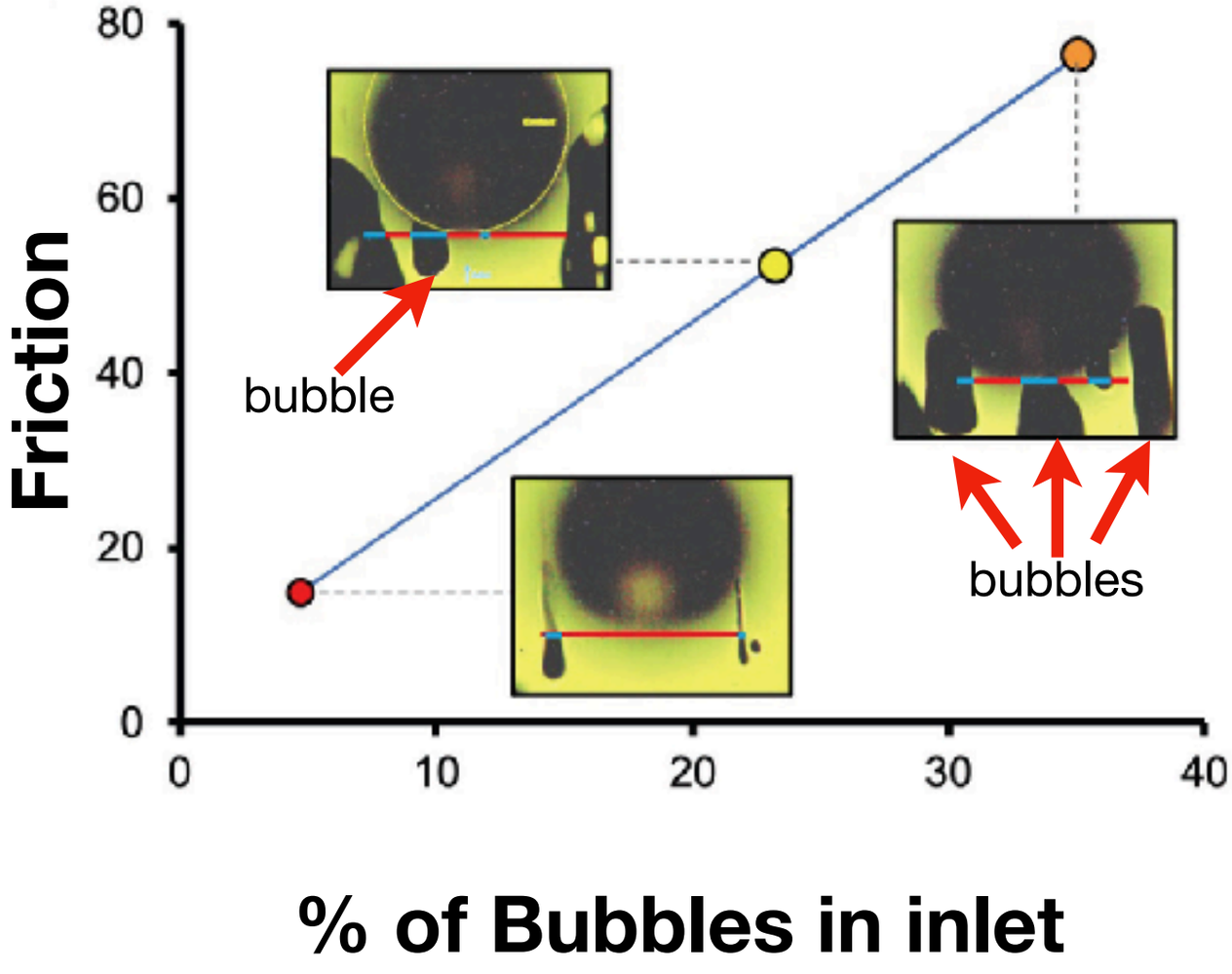

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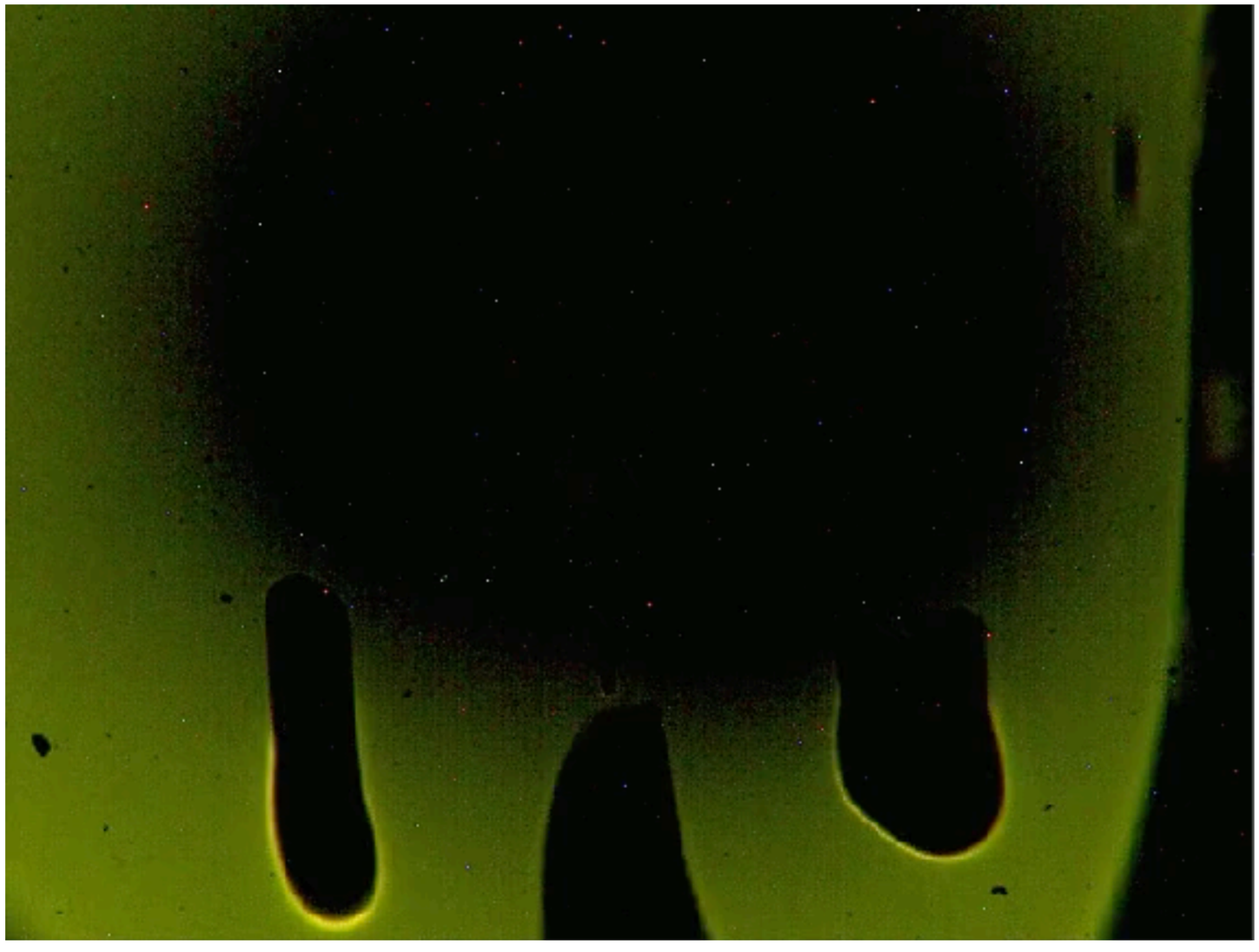

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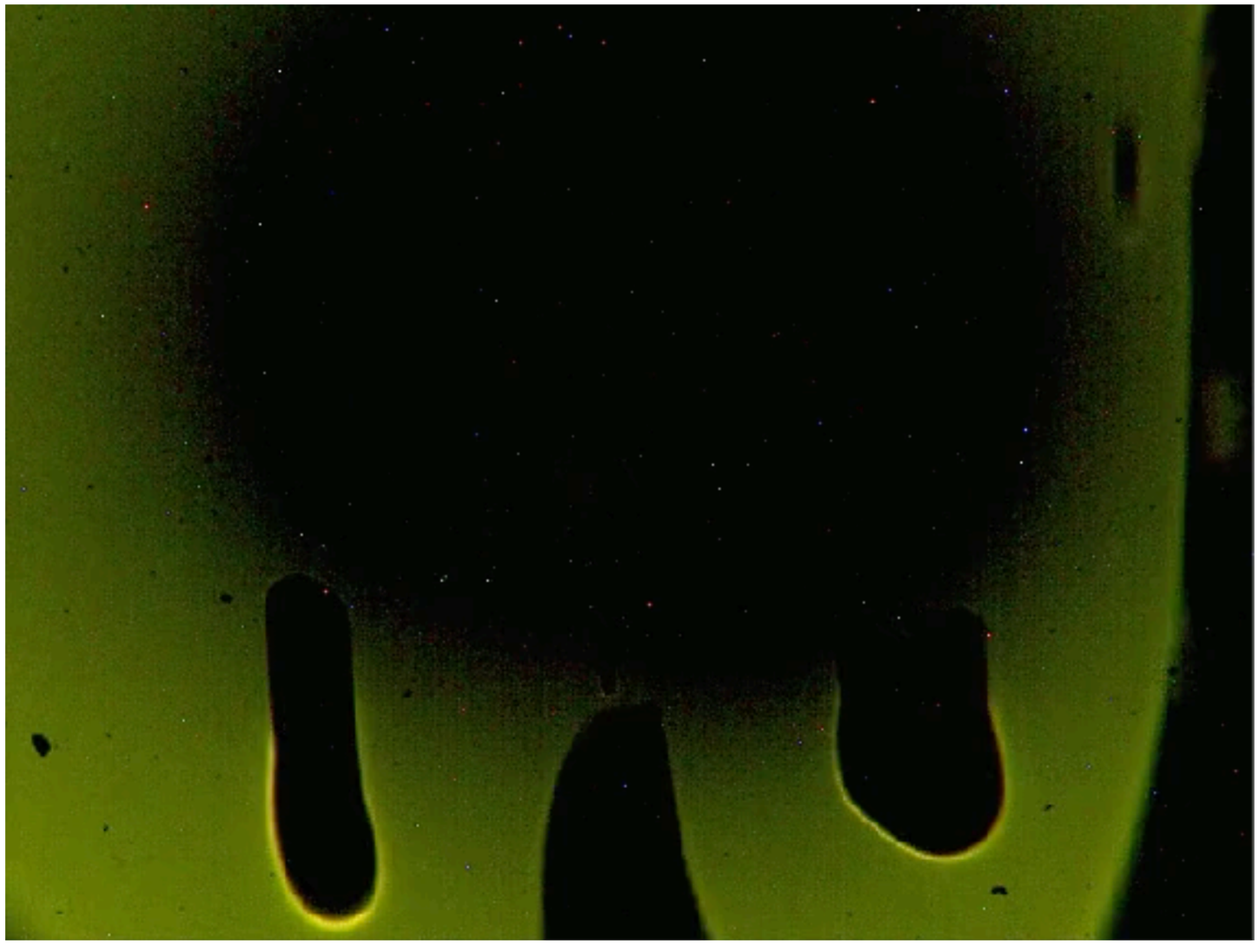

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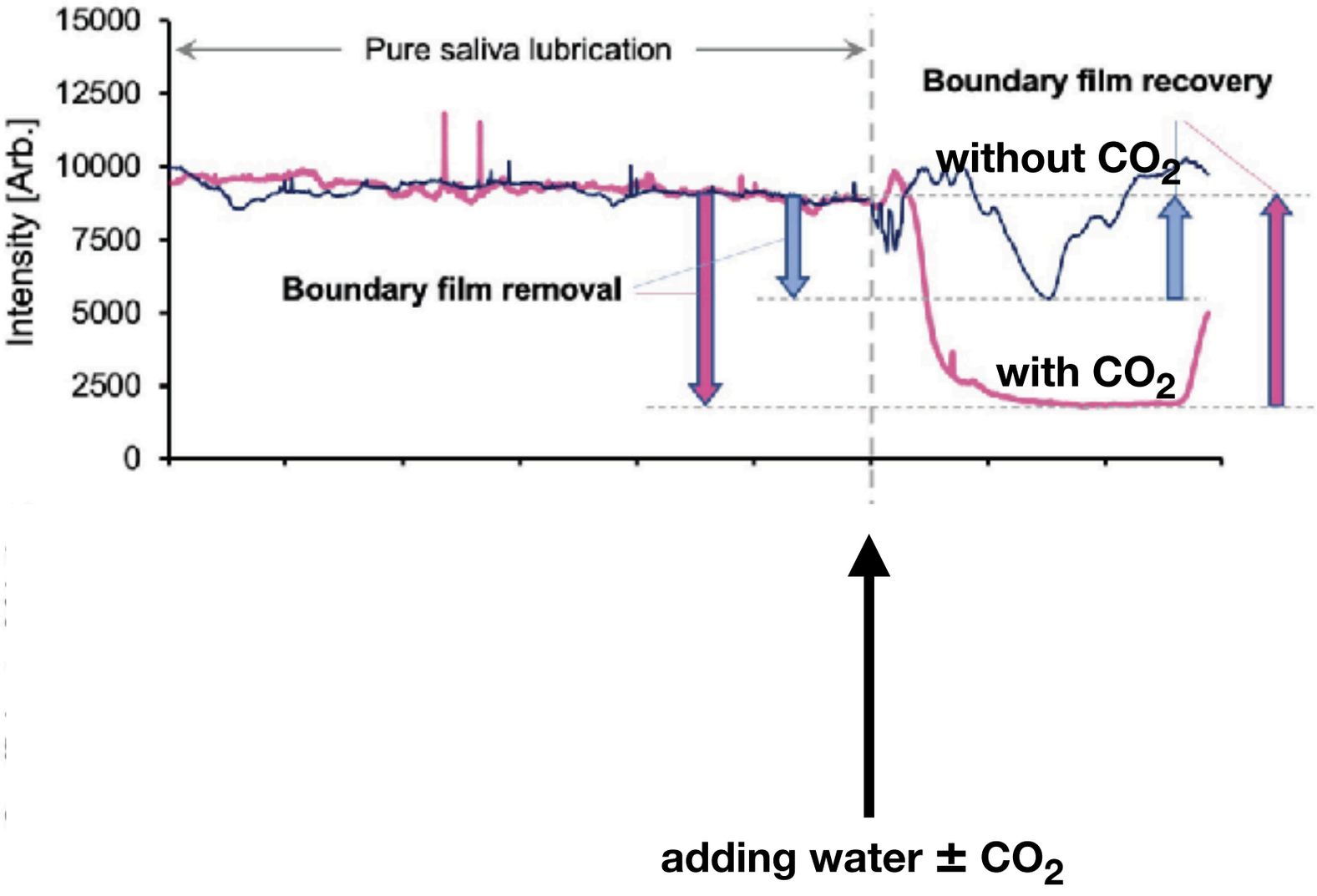
Friction/Fluorescence Results with Saliva:

Effect of adding water ± CO_2 to a fluor.-saliva-covered surface



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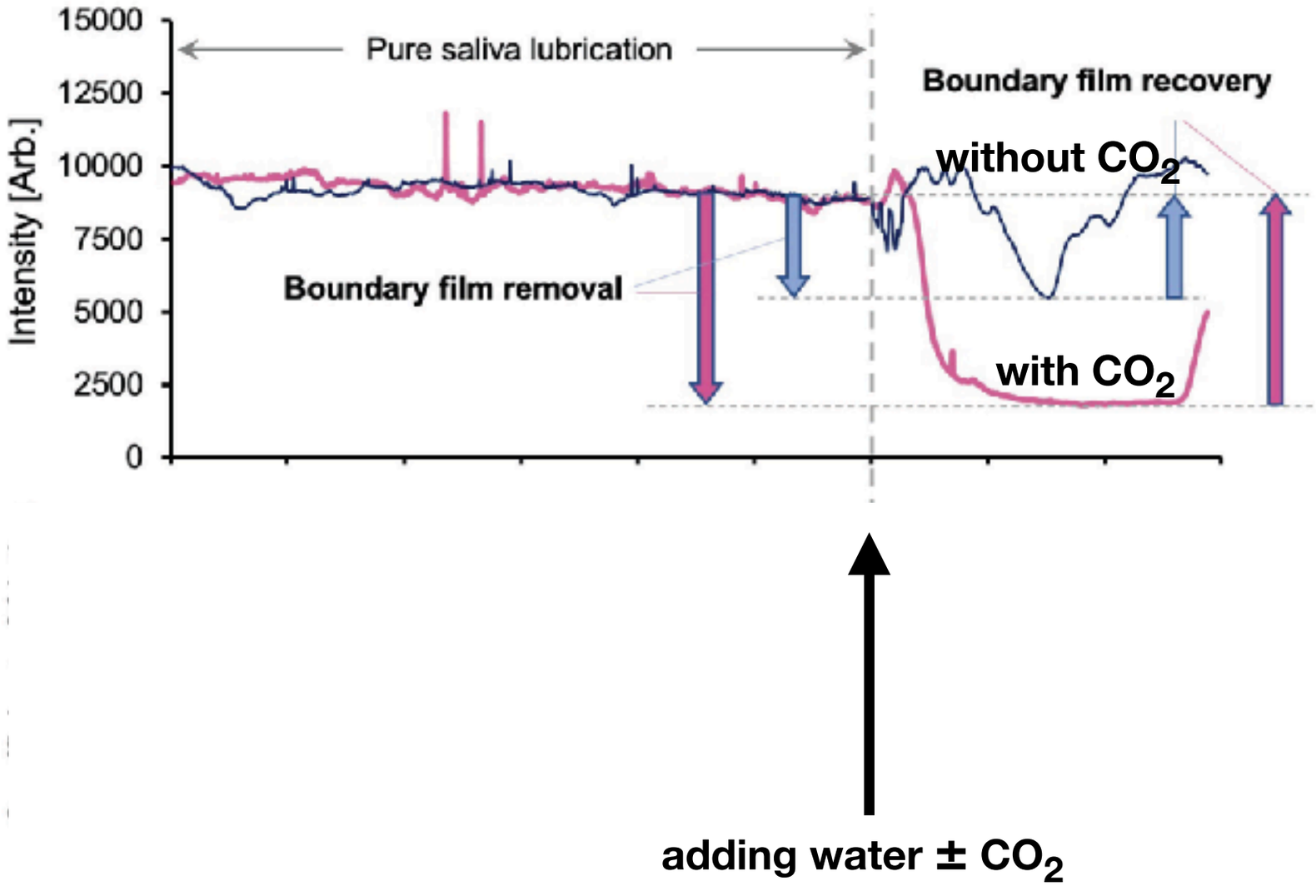

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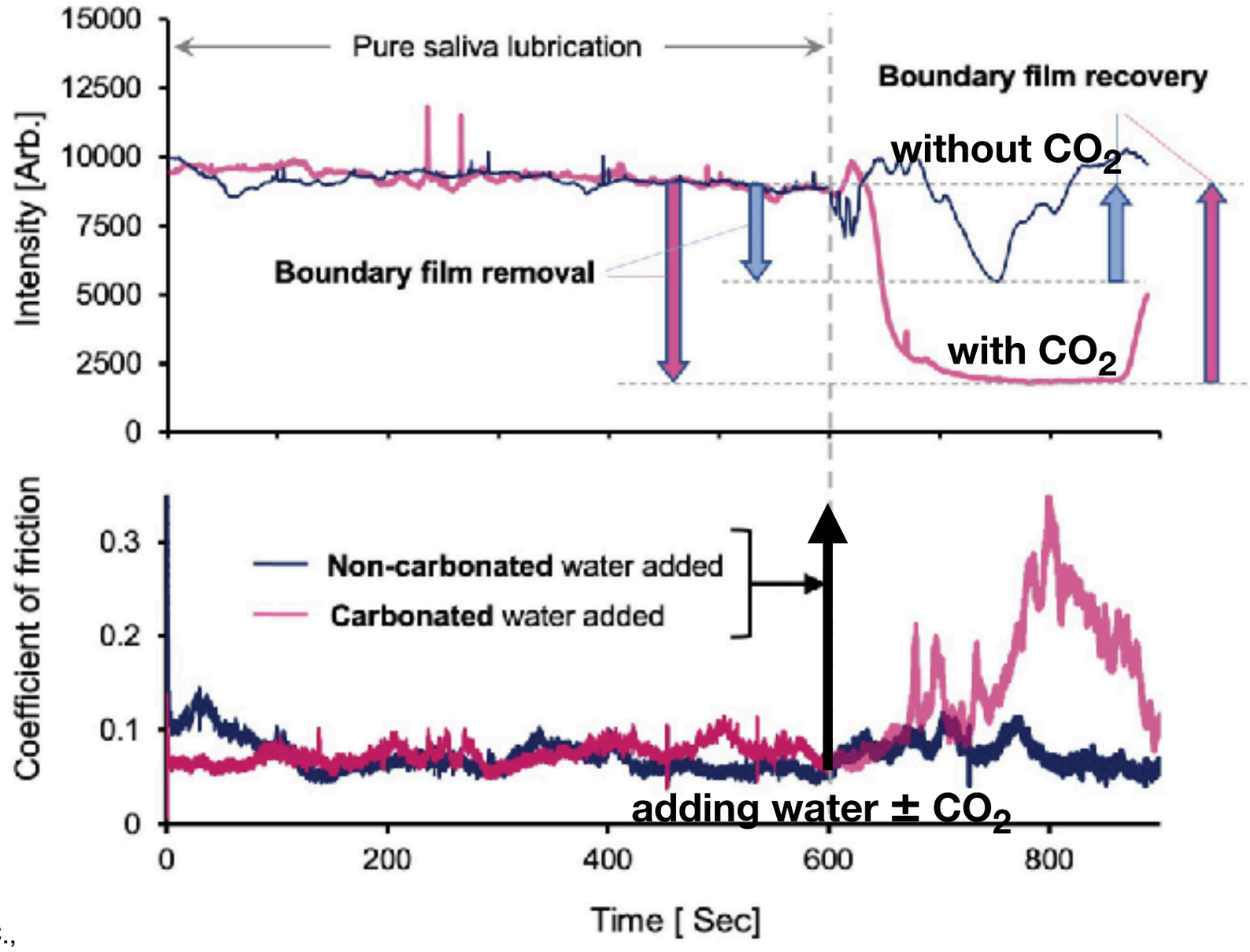
This leads to higher friction for carbonated beverages!



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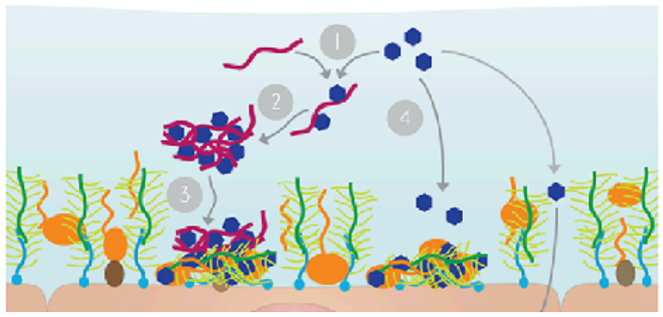
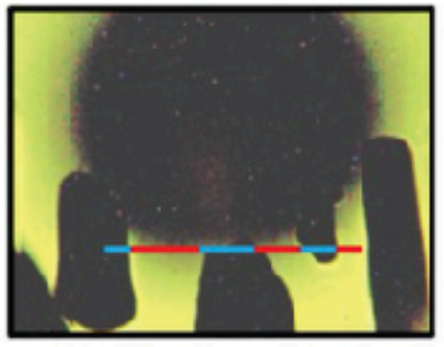
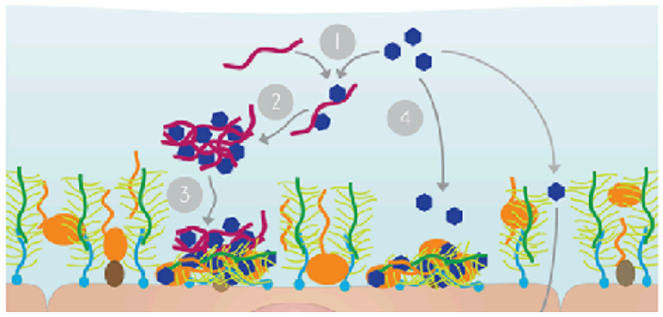
Tannins and Carbonation

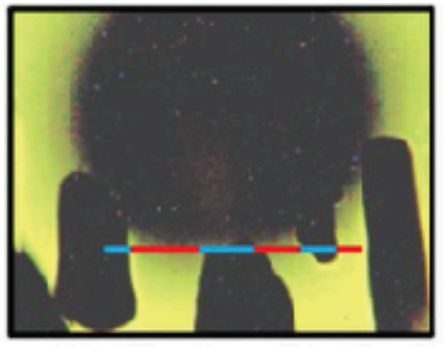




Tannins and Carbonation

In the end, they have similar effects:

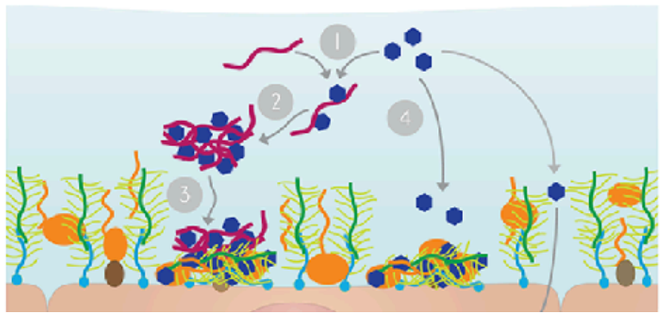


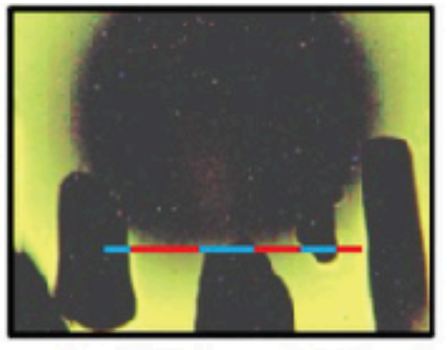


Tannins and Carbonation

In the end, they have similar effects:

- Tannins bind saliva to prevent lubrication, so high friction in the mouth results (drying, pucker with red wines)

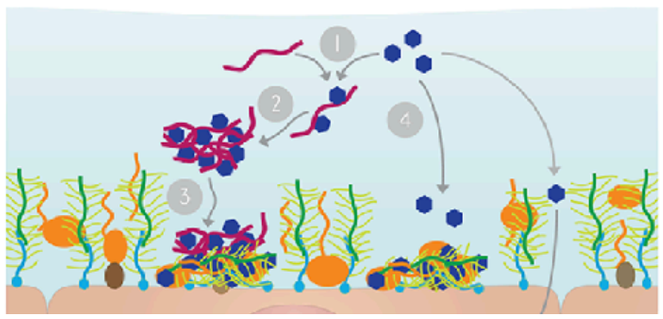


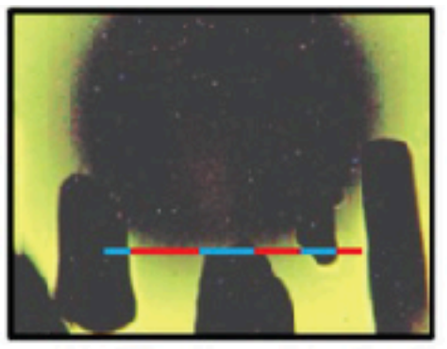


Tannins and Carbonation

In the end, they have similar effects:

- Tannins bind saliva to prevent lubrication, so high friction in the mouth results (drying, pucker with red wines)
- Carbonation leads to CO_2 bubbles forming in the tongue-palette contact, which prevent the saliva from lubricating, also leading to a drying sensation





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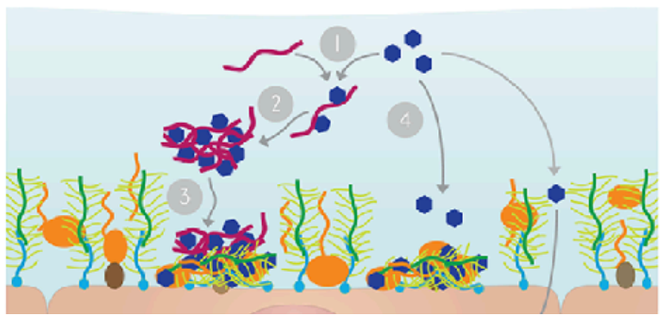

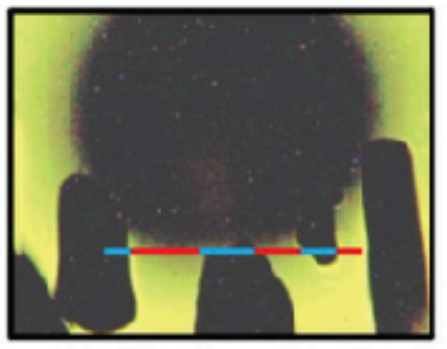

zum Wohl!