Cannabis Research Coalition

Master The Art Of Drying & Curing Cannabis: PART 2

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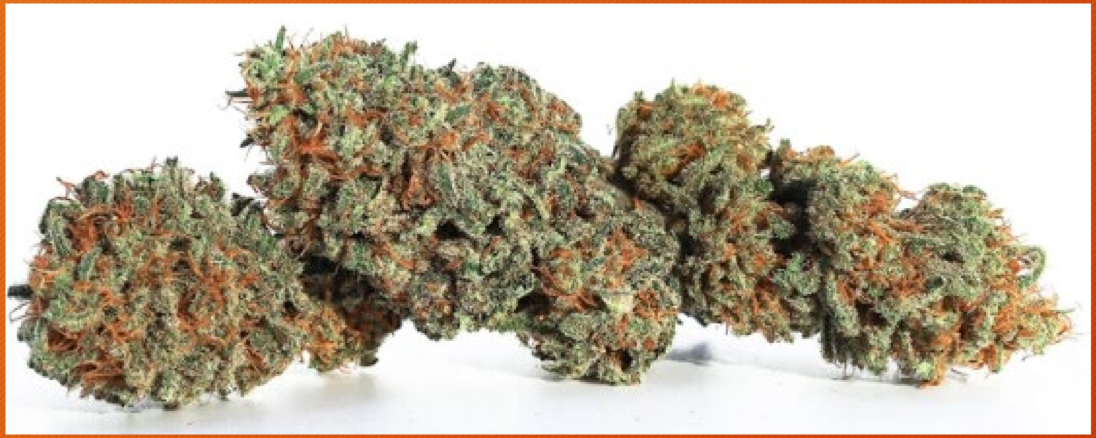
Jim Faust, PhD.
Alex Carver
Mike Alden

The Hemp Mine

Background

The Hemp Mine

South Carolina



Cannabis Research Coalition

We partner with academia and cannabis industry stakeholders to advance the exploration of the cannabis plant and implement science-based research to develop cultivation techniques for sustainability, efficiency and profitability.

crc@thehempmine.com

“We are at an unprecedented time in the history of plant science where we have an incredibly valuable plant for which there is almost zero scientific cultivation research. The opportunities to improve production methods with solid data are vast. It is truly a unique and exciting time to be a horticultural scientist.”

- Jim Faust, PhD.,
Clemson University Flowering Physiology Laboratory

Cannabis Research Coalition

Let's craft the future together.

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Post Harvest Production

Growing

Harvesting & Trimming

Drying
(Slow or Heated)

Curing

Grinding
(optional)

Dried Buds

Extraction
& Purification

Extract

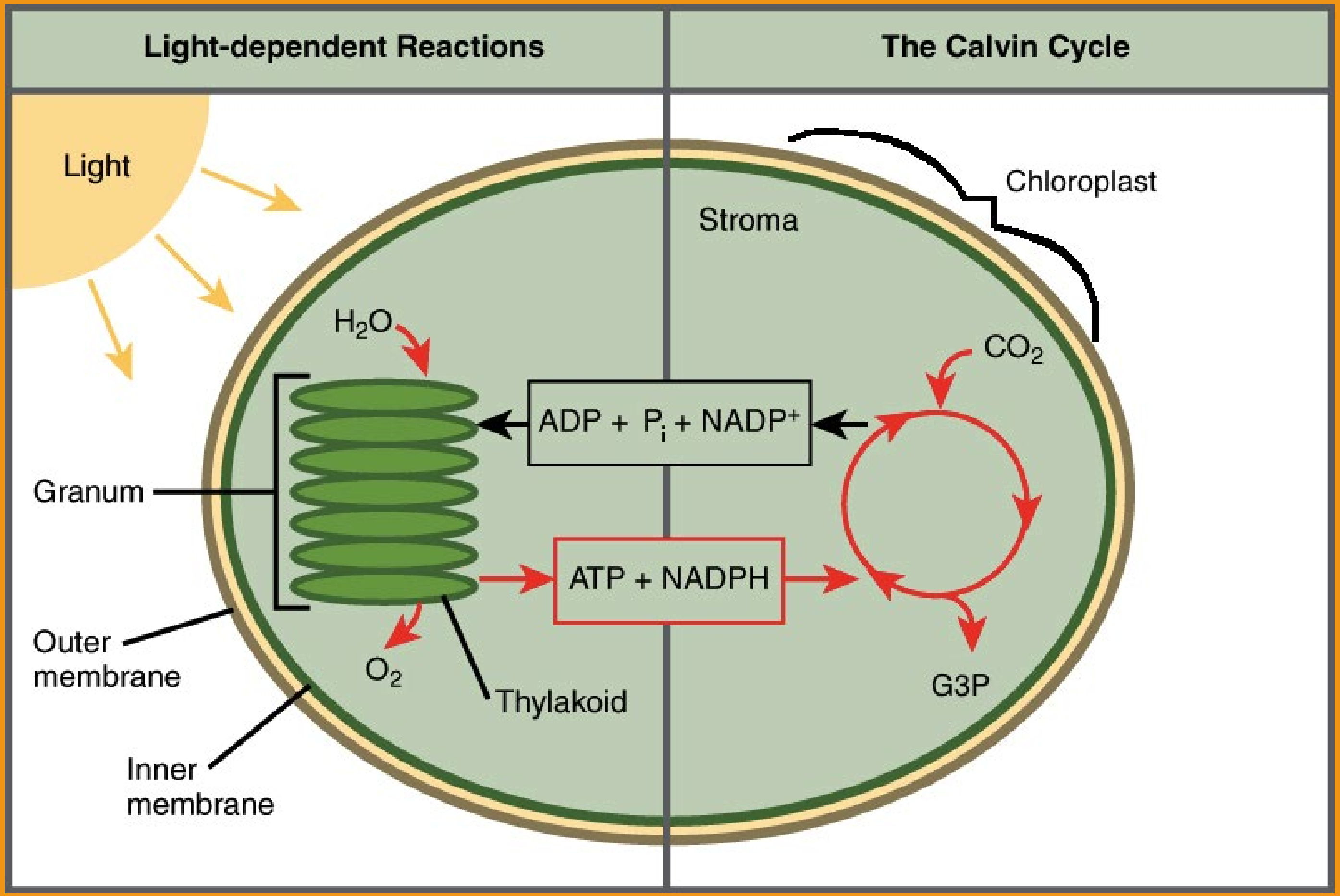
Noelle Joy, UGA

Today's Topics…

- Properly build-out your space for drying and curing
- Understand the drying and curing methods today's operators are using
- Establish climate-controlled temperature, humidity, and airflow set points
- Develop a plan for continual fine-tuning and improvement to your post-harvest process.

How do we "MASTER“ post-harvest?

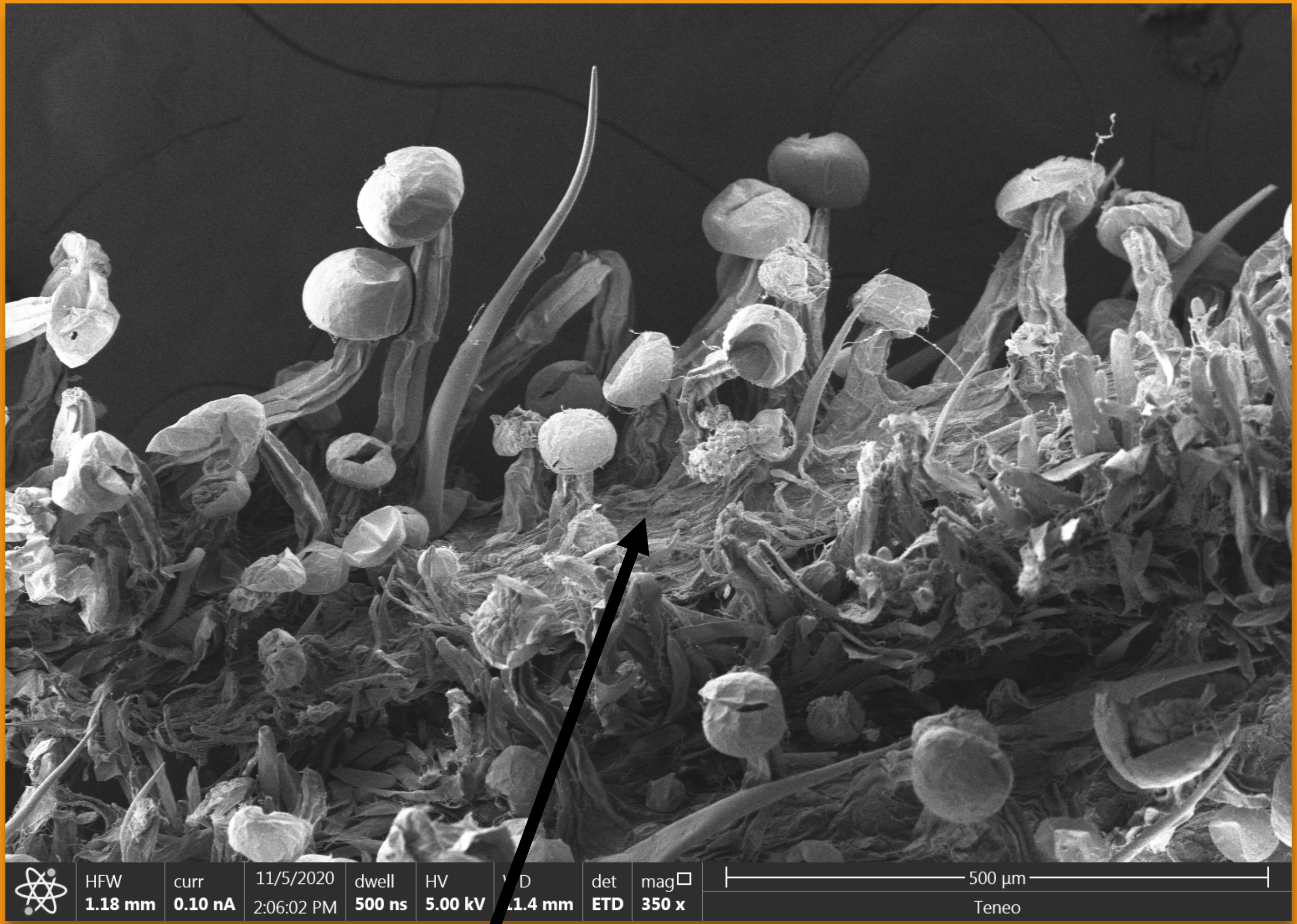
By truly understanding plant physiology in post-harvest.



https://www.khanacademy.org/science/ap-biology/cellular-energetics/photosynthesis/a/intro-to-photosy

Substances in trichomes

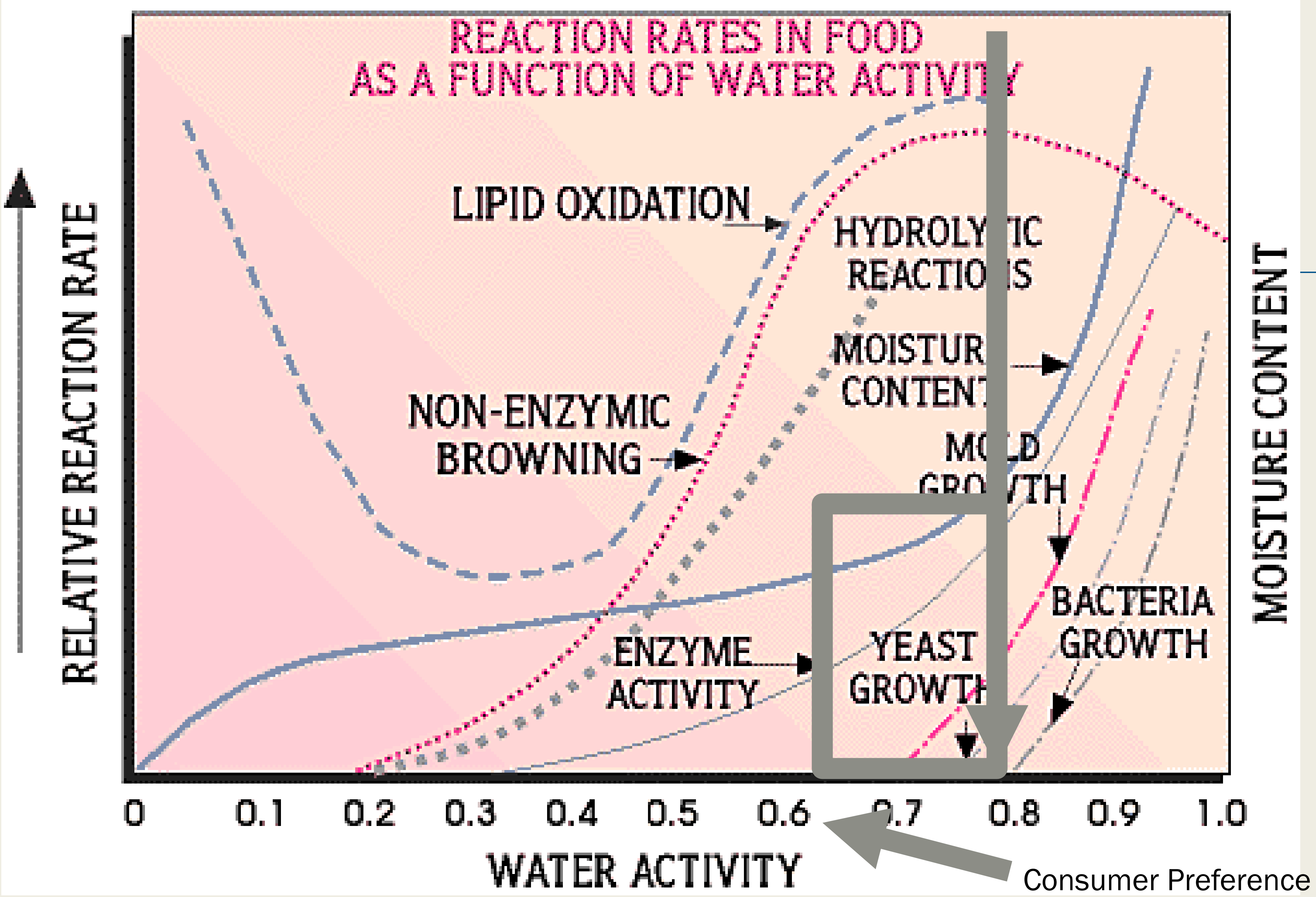
- Terpenoids
  - Monoterpenes
  - Sesquiterpenes
  - Cannabinoids
- Flavonoids
- Methyl ketones
- Acyl sugars



Noelle Joy, UGA

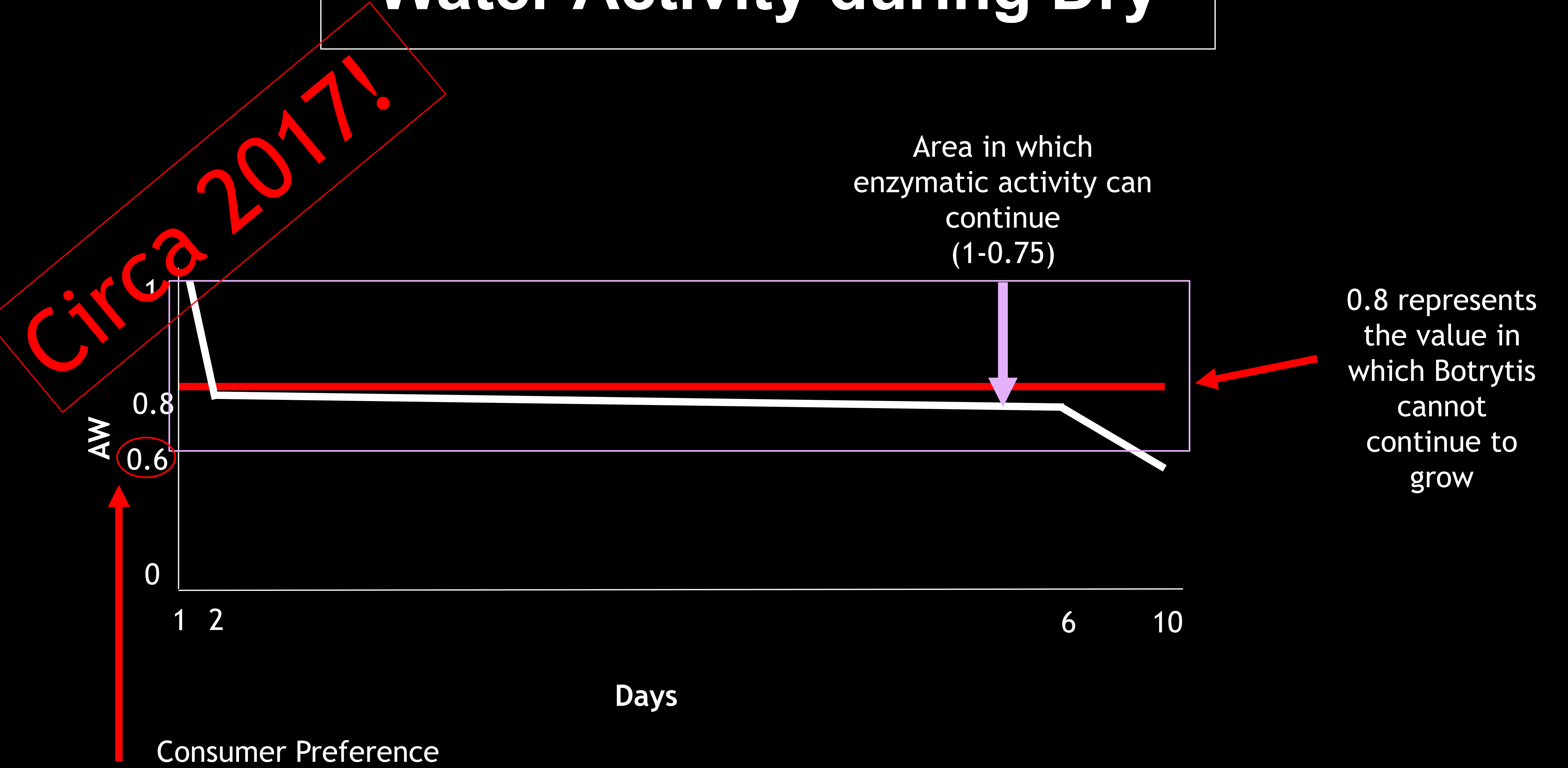
But what else is in plant material?

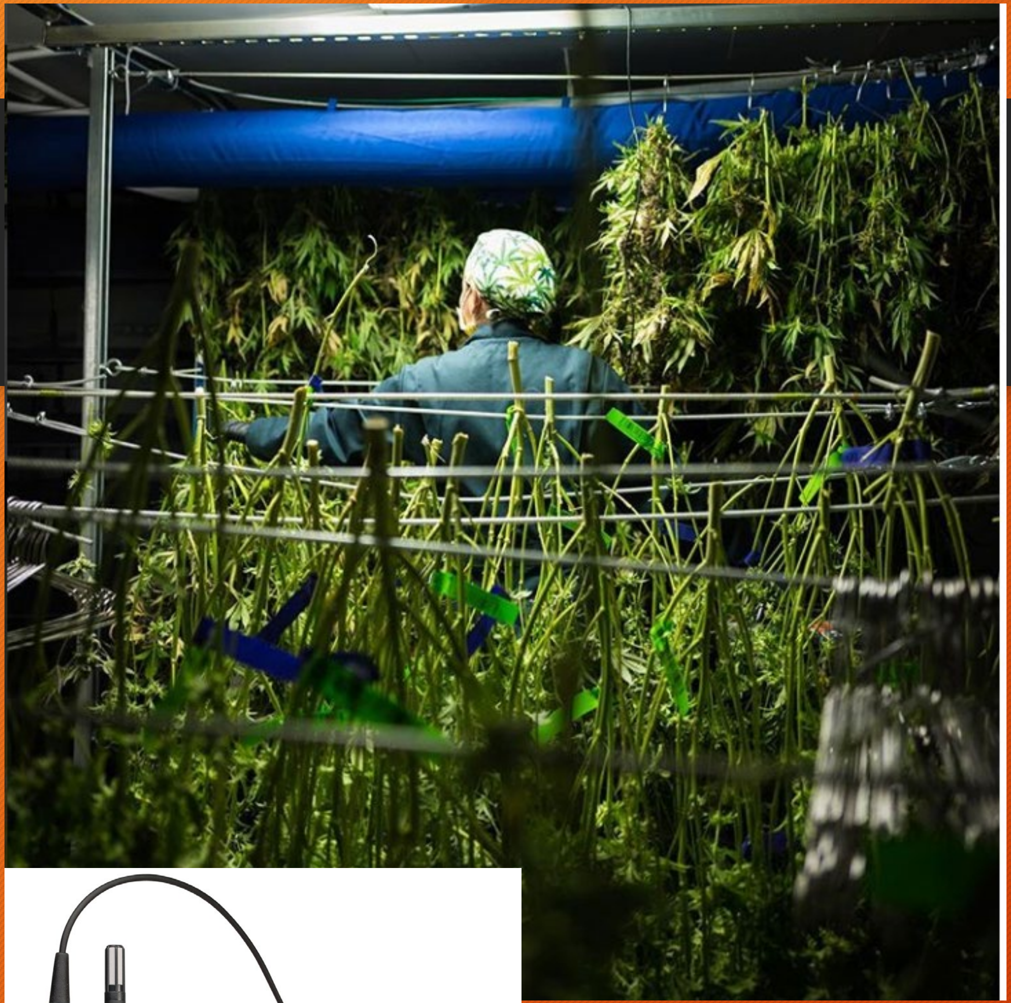
Everything else…



http://people.oregonstate.edu/~calverta/learn/faq/faq_water14.html

Water Activity during Dry

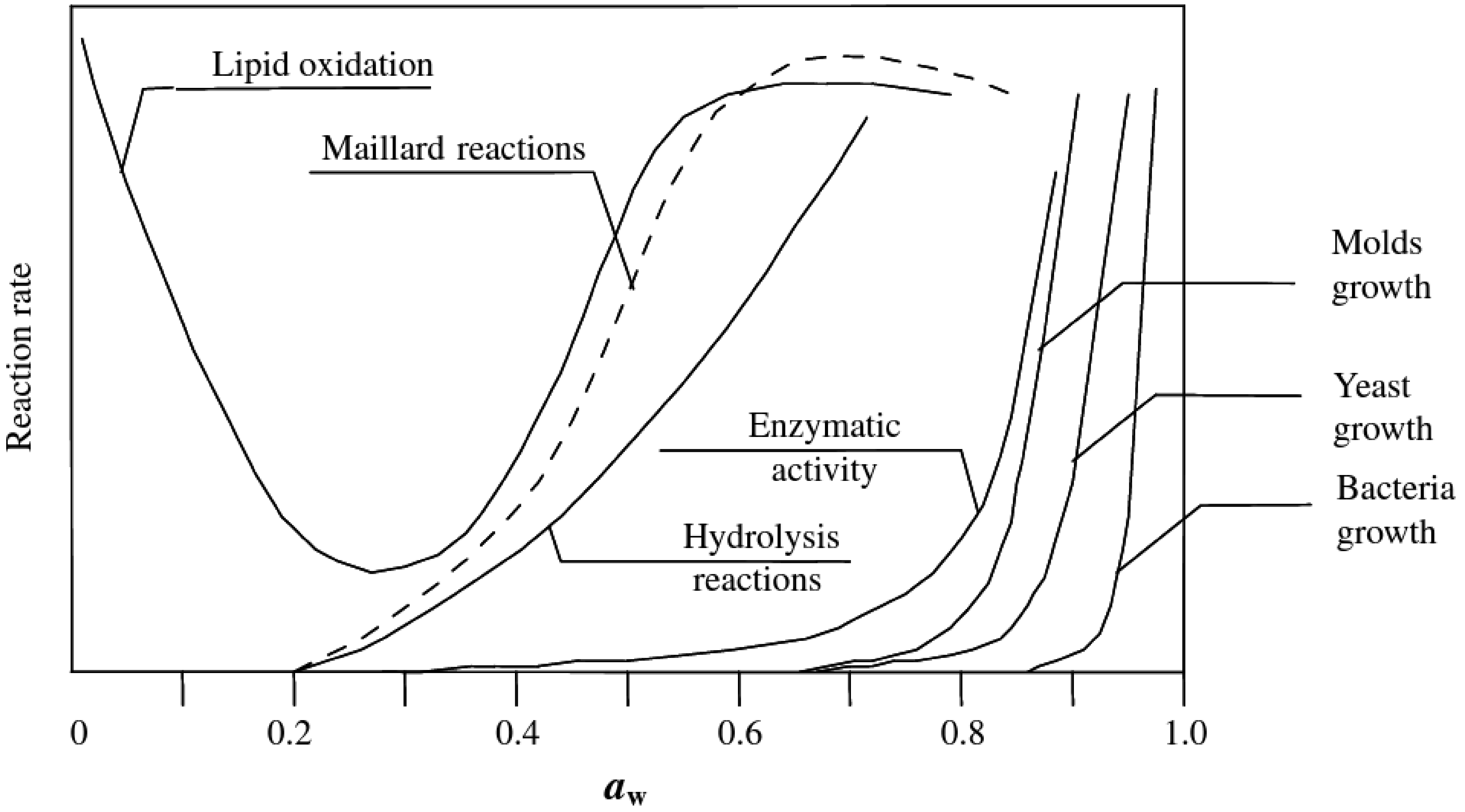




Drying:
Removal of water for preservation

Microorganisms have a limiting water activity level below which they will not grow. Water activity (AW), <u>not moisture content</u>, determines the lower limit of "available" water for microbial growth. Since bacteria, yeast, and molds require a certain amount of "available" water to support growth, harvesting at the proper AW is crucial.

(Range= 0-1)



Lipid oxidation
Maillard reactions
Molds growth
Yeast growth
Bacteria growth
Enzymatic activity
Hydrolysis reactions
Reaction rate
0
0.2
0.4
0.6
0.8
1.0
a_w

How does water escape?

- Cut Ends
- Stomate
- Ruptured Cells
- Hydathode

How does water move through plants?

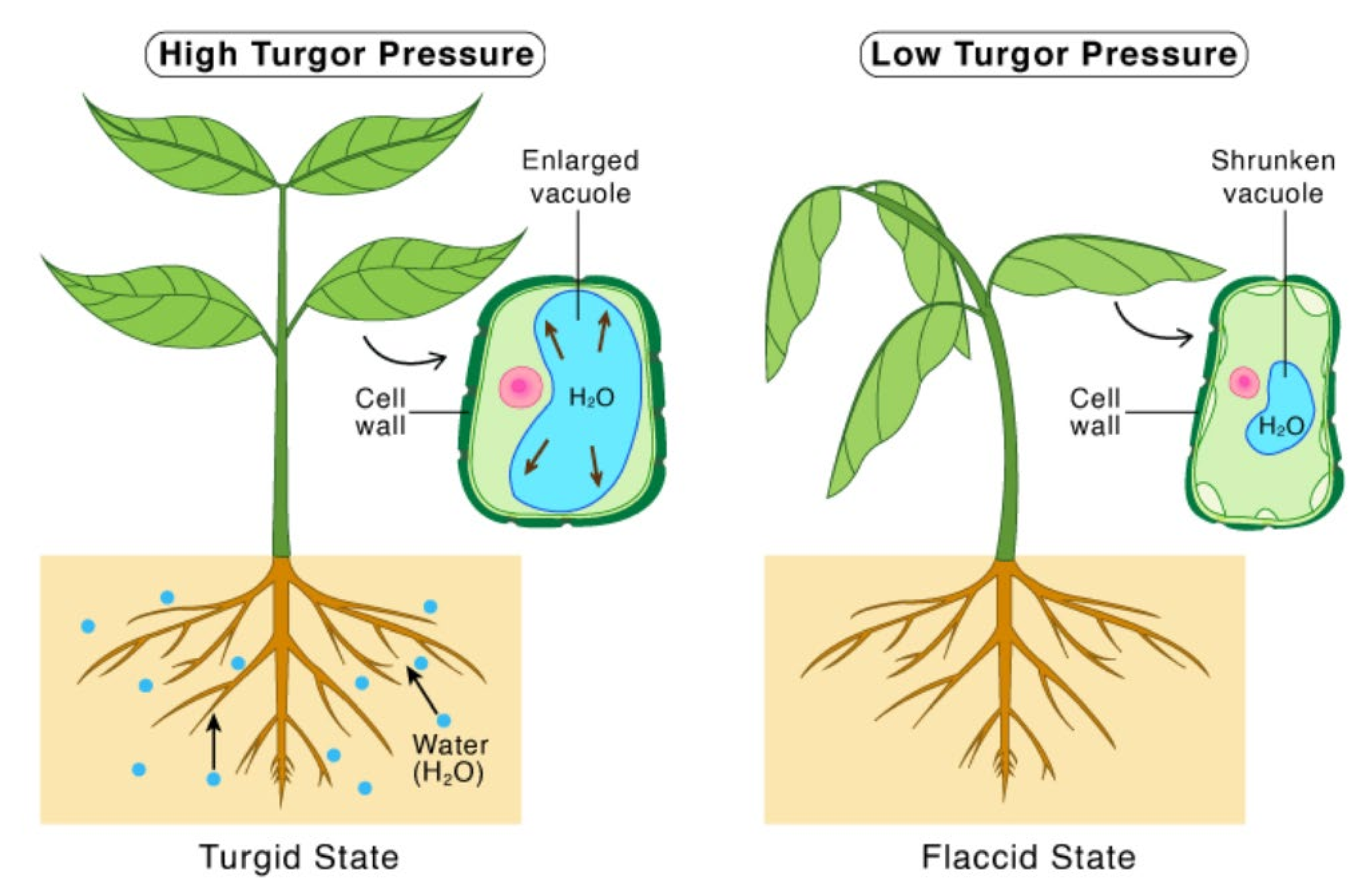
Out through transpiration

Transpiration is a necessary "cost" associated with the opening of the stomata to allow the diffusion of carbon dioxide gas from the air for photosynthesis.

Mass flow of liquid water from the roots to the leaves is driven in part by capillary action, but primarily driven by water potential differences.

Transpiration also cools plants, changes osmotic pressure of cells, and enables mass flow of mineral nutrients and water from roots to shoots.

Water in through roots



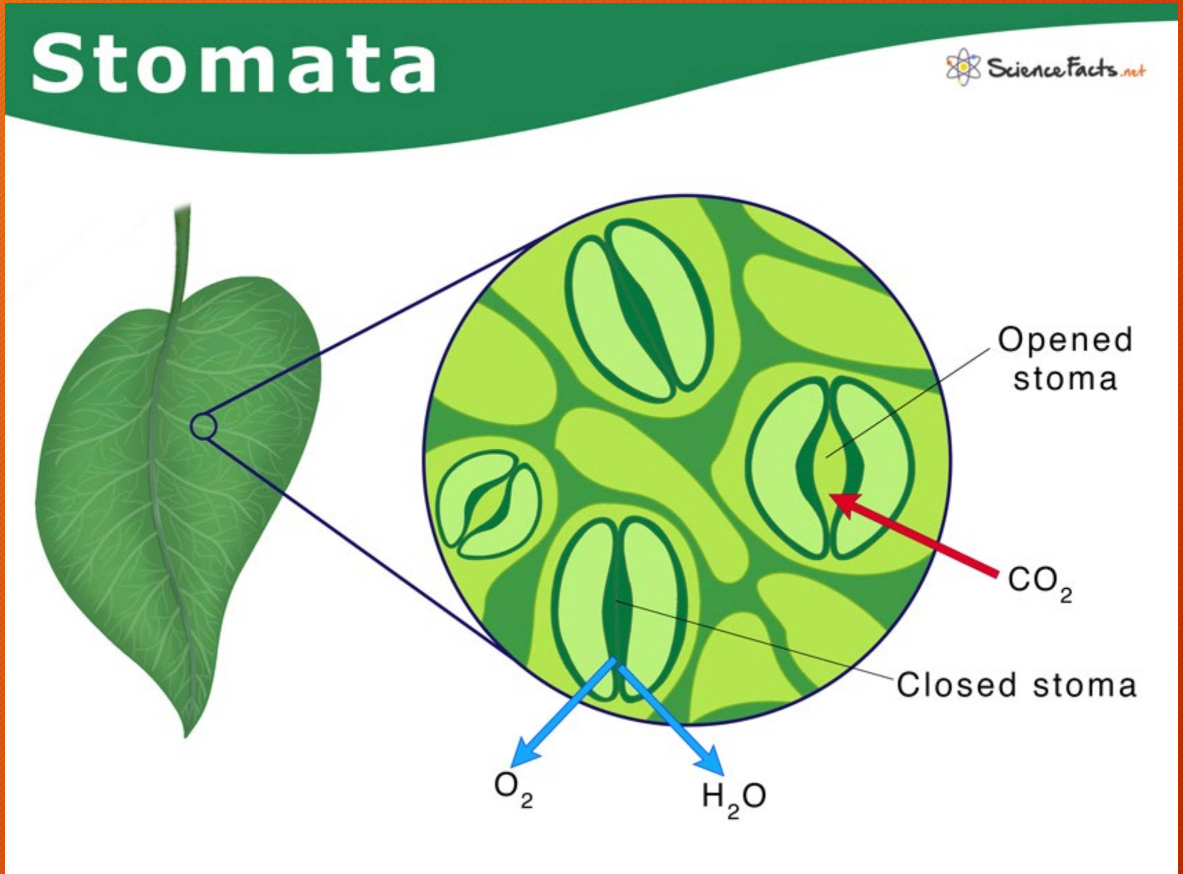
https://www.sciencefacts.net/turgor-pressure.html

How does water move through plants… without roots?

Out through transpiration

Plug aka. capillary embolism

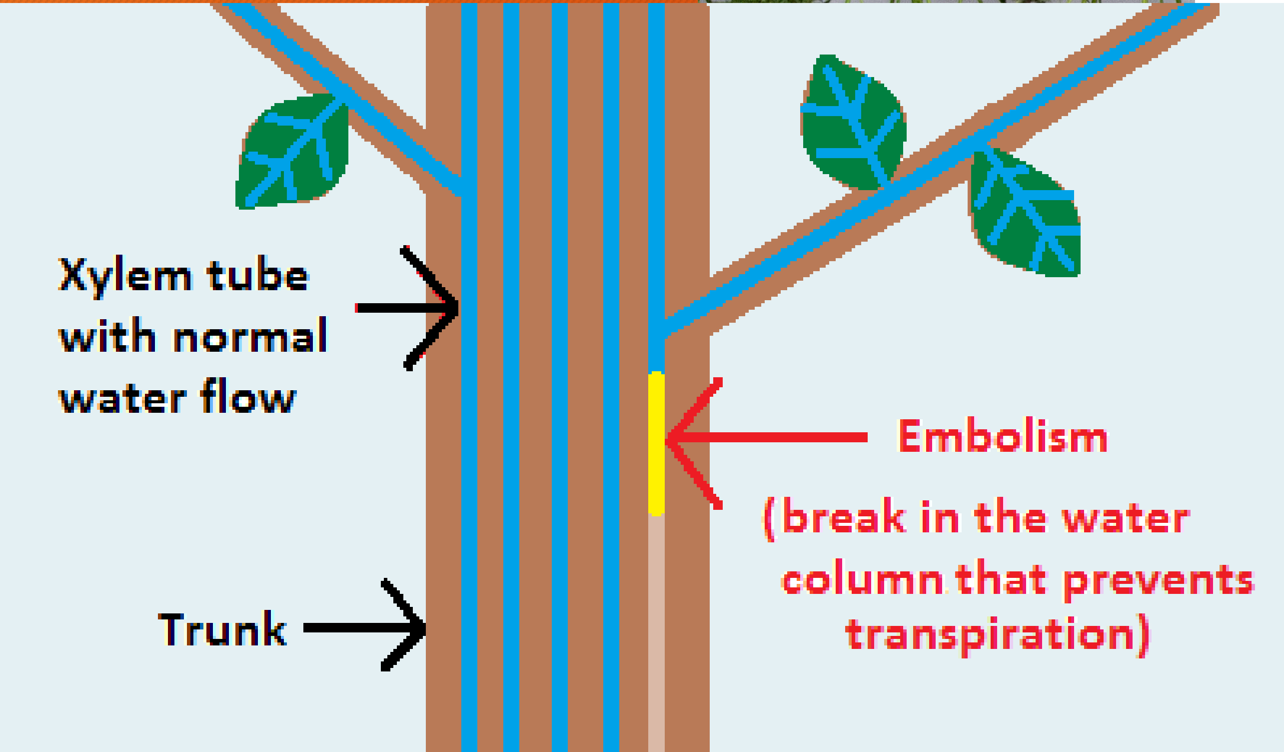
Stomata

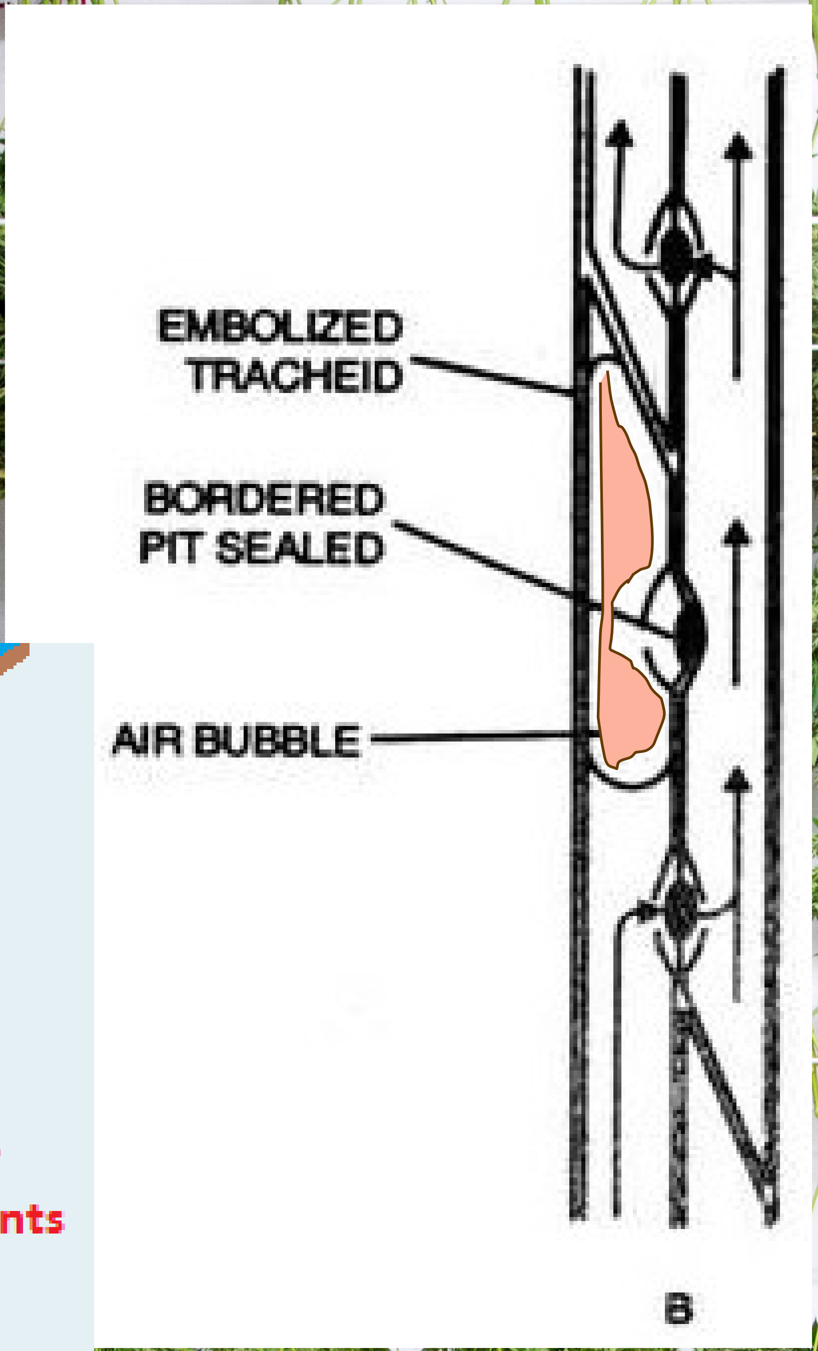


https://www.sciencesource.com/1992144-sem-cannabis-trichomes.html

Cut ends.

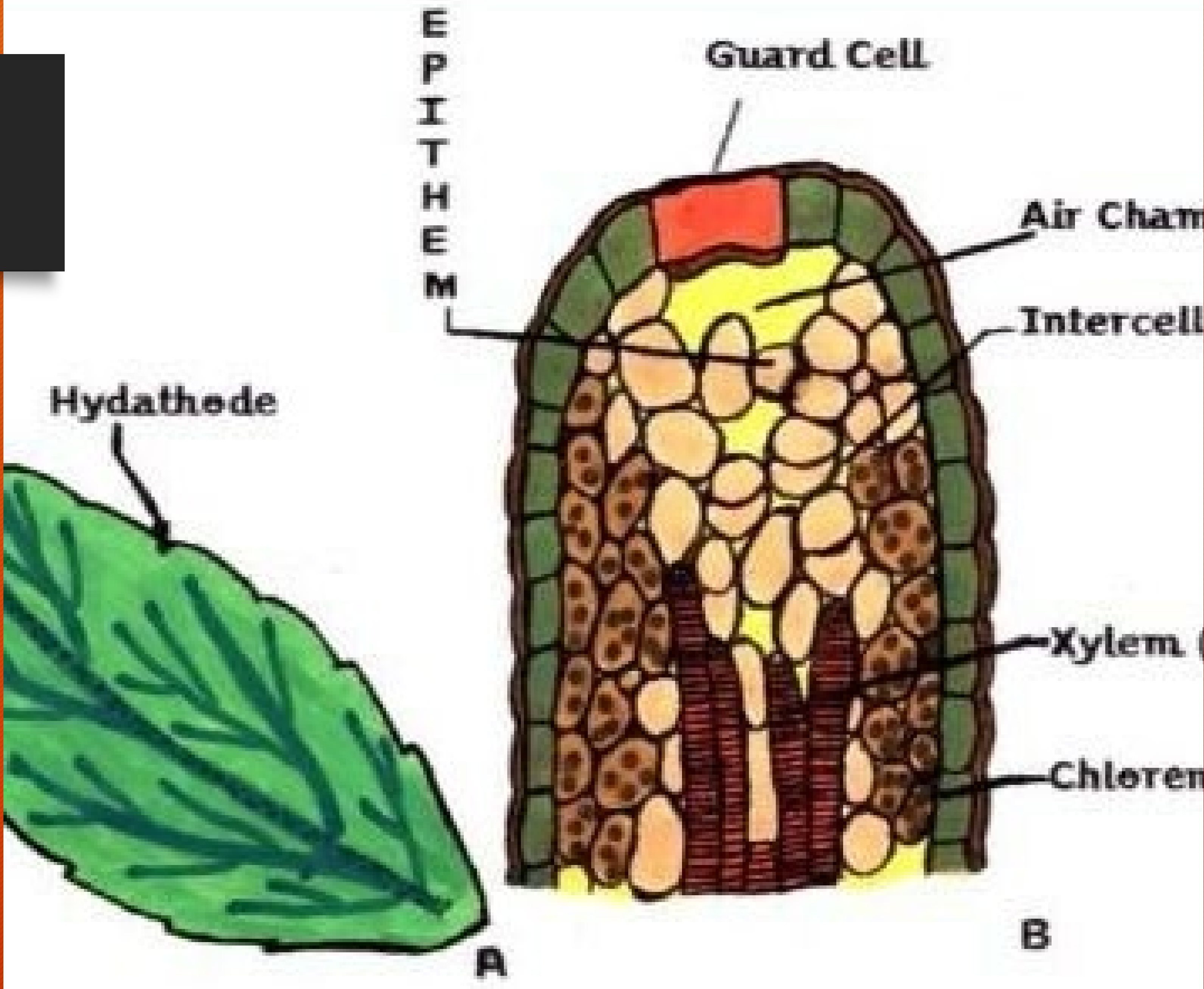
Air enters cut open xylem vessels causing a blockage.





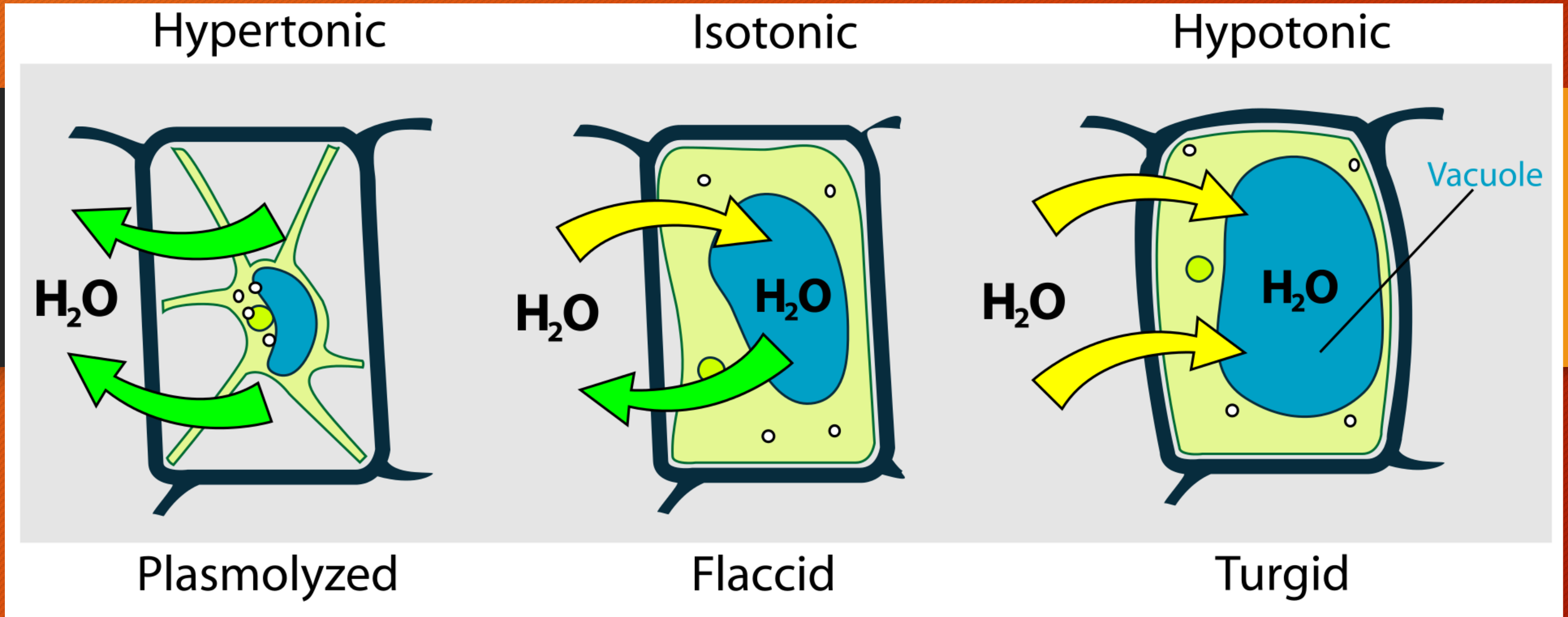
…, Alpha Science International Ltd, Google books 12.03.2017

Hydathode



Guttatin-A Natural Phenomenon:Useful medium for production of Recombinant Proteins. June 2014. Kumar.

Plasmolysis



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4204789/

The softening of the fruit during maturation is due to the activity of hydrolyses on the fruit cell wall polysaccharides, which leads to a modification of the cell wall composition.

Turgor pressure can reach 20 atmospheres (2 Mpa)

When water loss is too fast, the plasma membrane can be damaged resulting in browning.

Bound Water

Strongly bound:

Unfreezable. This water is not available for chemical reactions.

Firmly bound:

Water molecules that are held in the solid matrix by capillary condensation and are present as multilayers above the monolayer. Increased resistance to evaporation

Unbound:

Water present in macro-capillaries and exhibits nearly all the properties of bulk water. Micro-organisms utilize this water causing the contamination to the product

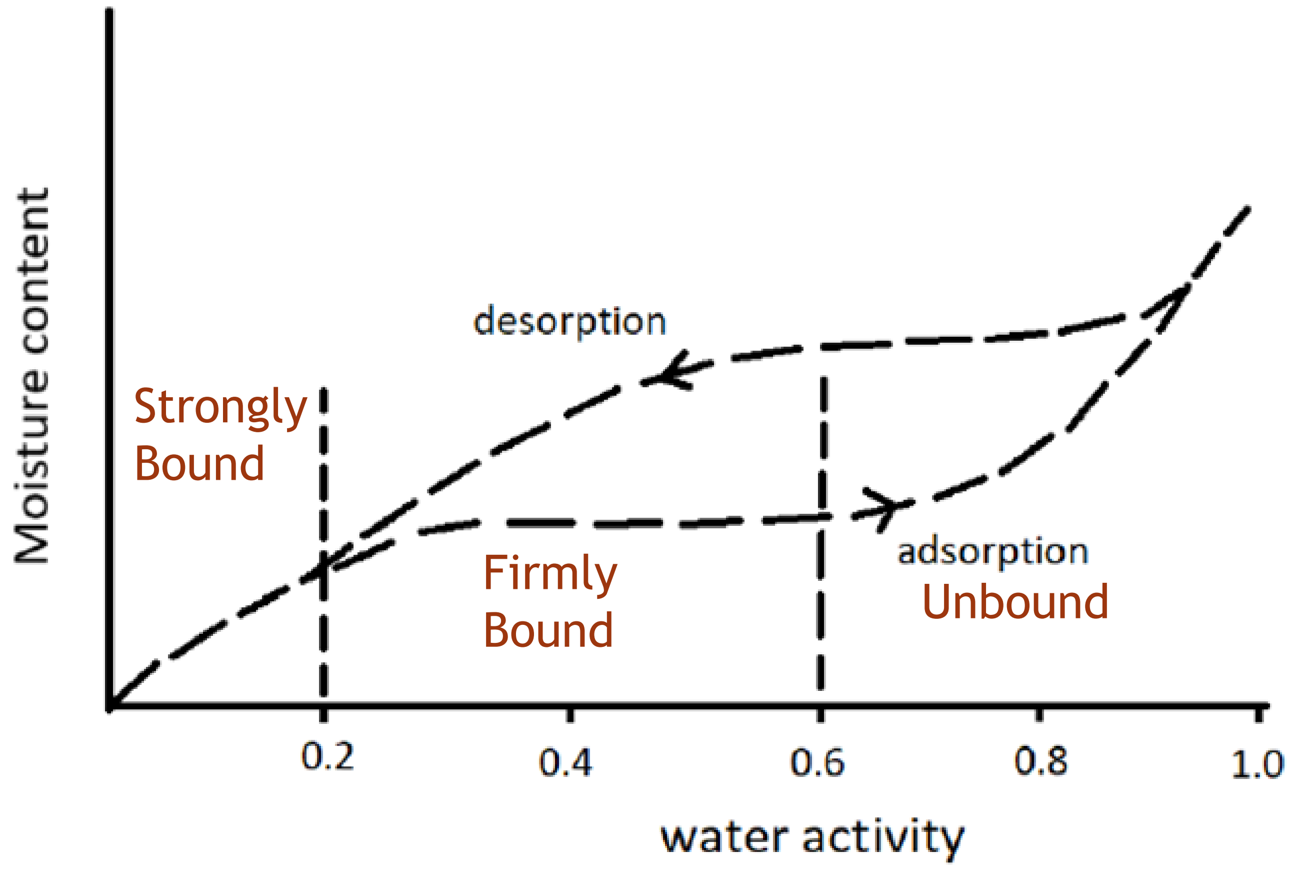
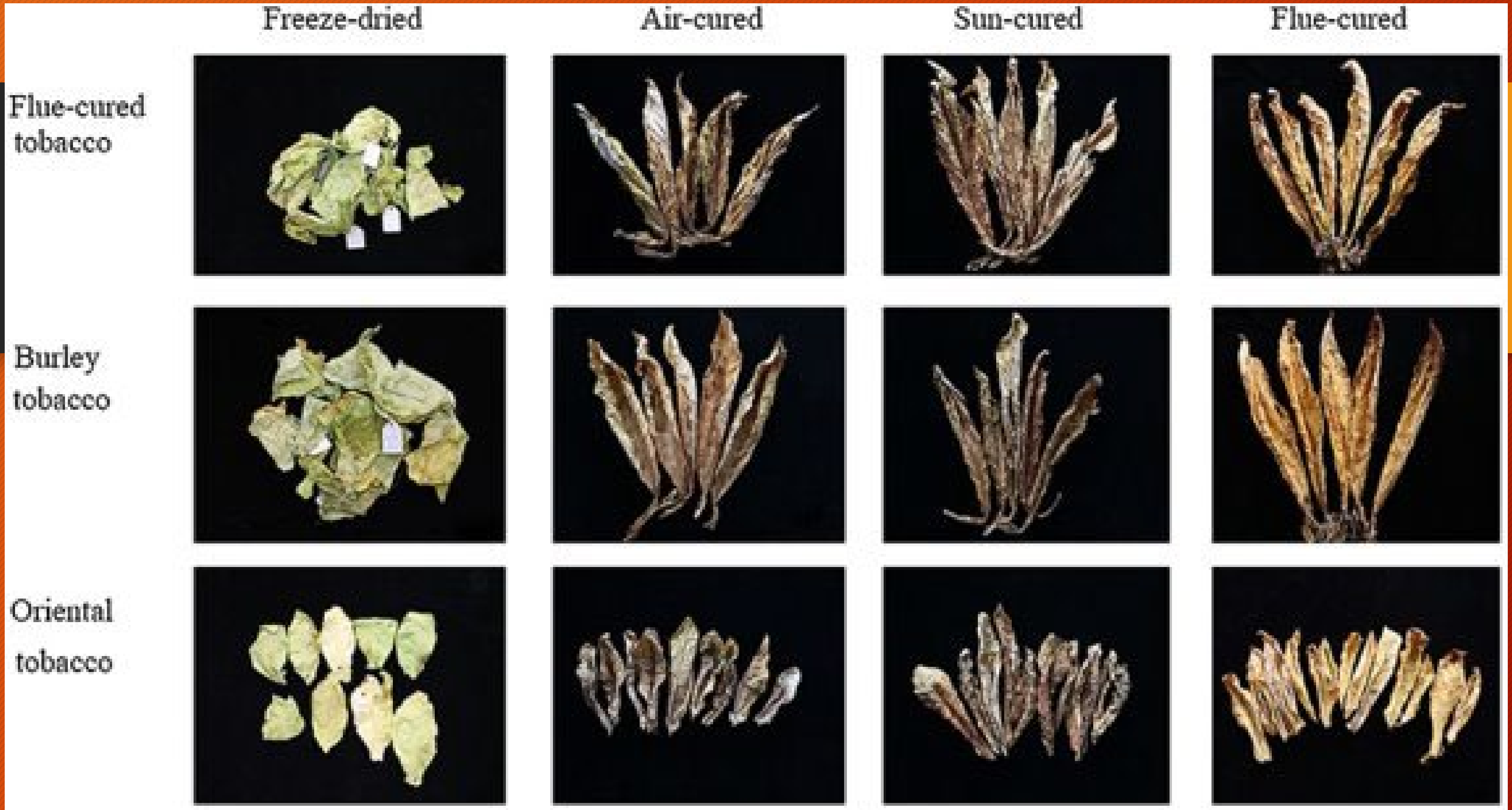


Figure 8 Typical moisture sorption isotherm (drawn by Challa).

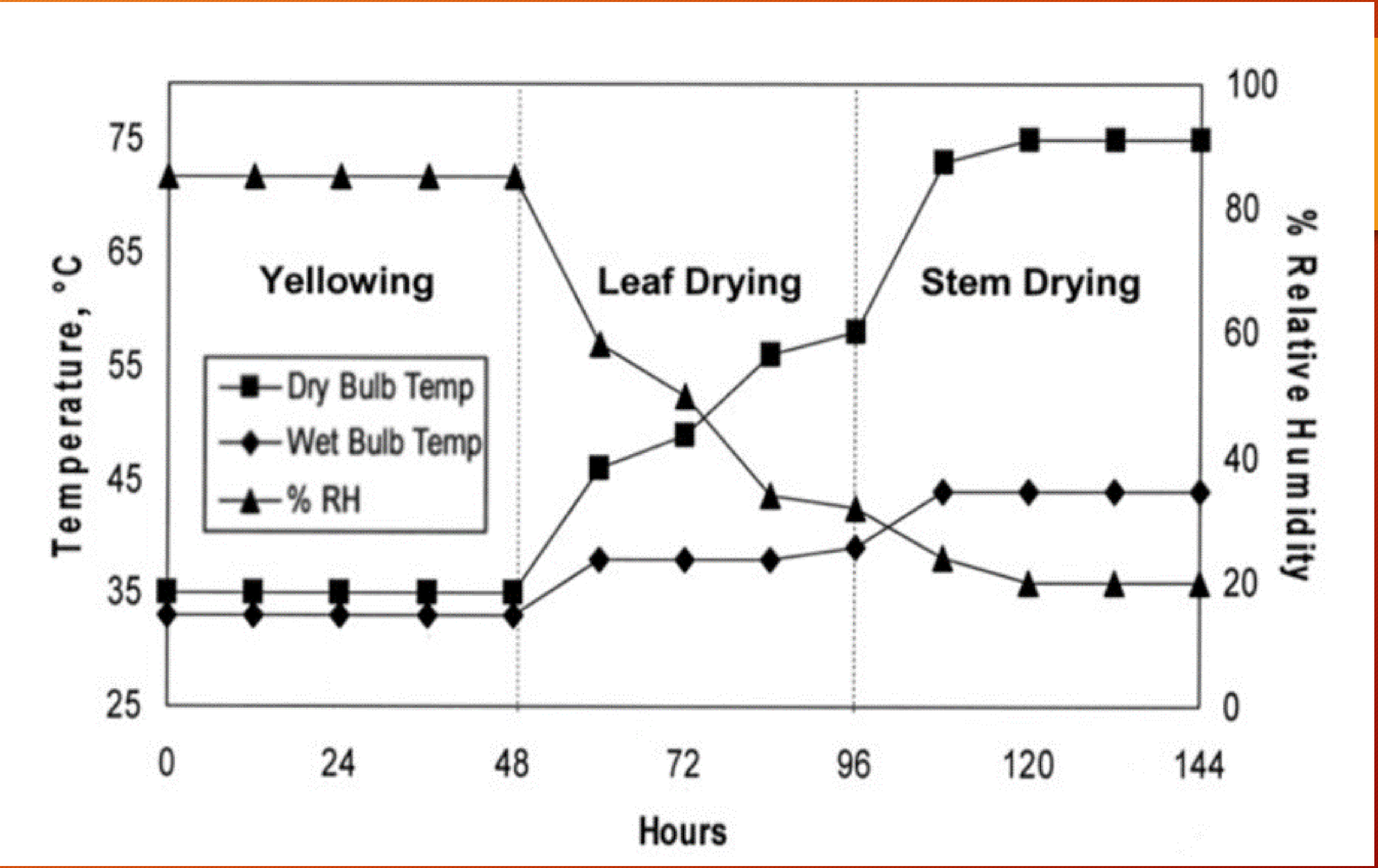
(Al-Muhtaseb et al., 2002).

Browning

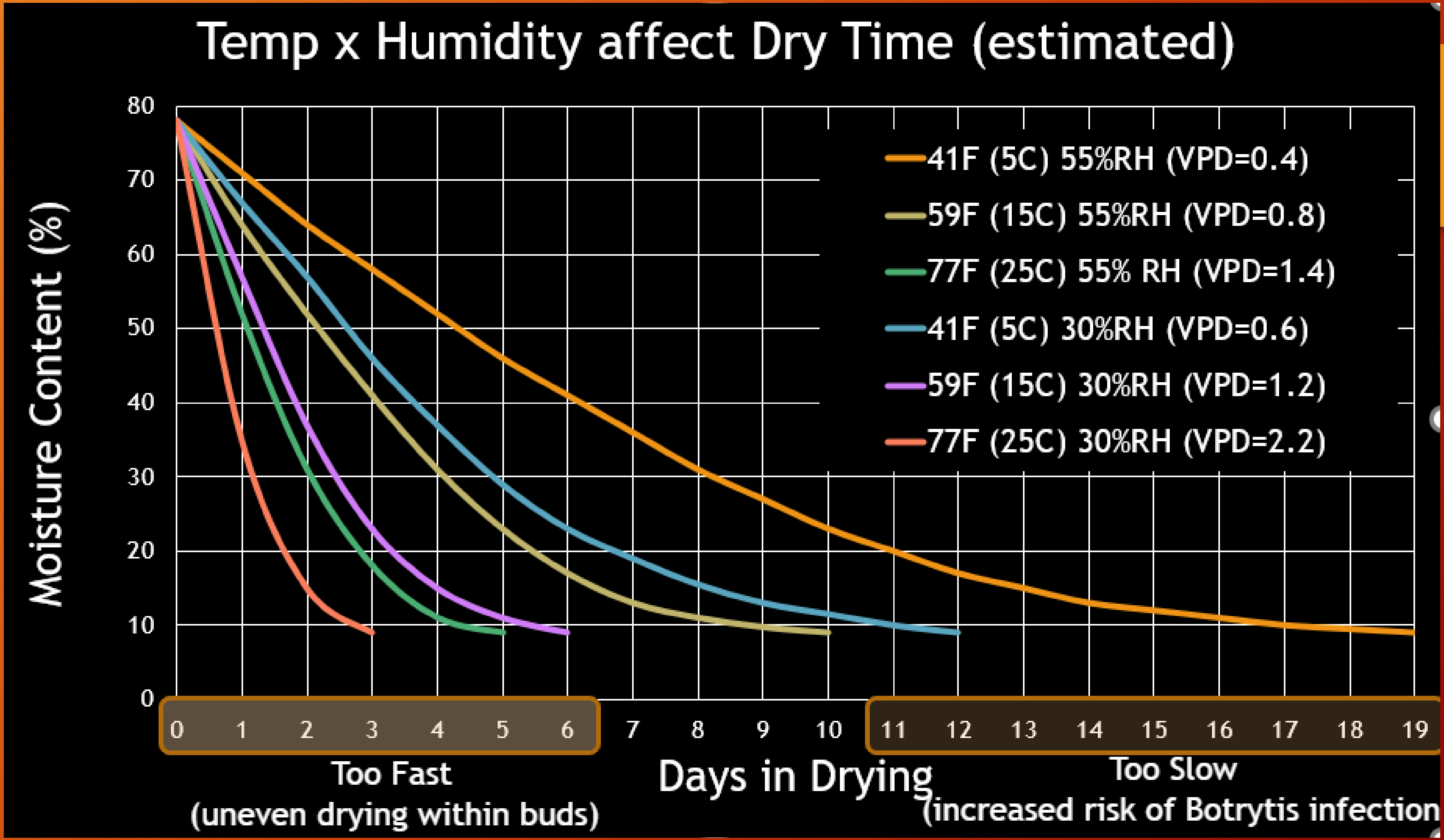


Yellowing: High humidity & high temperature

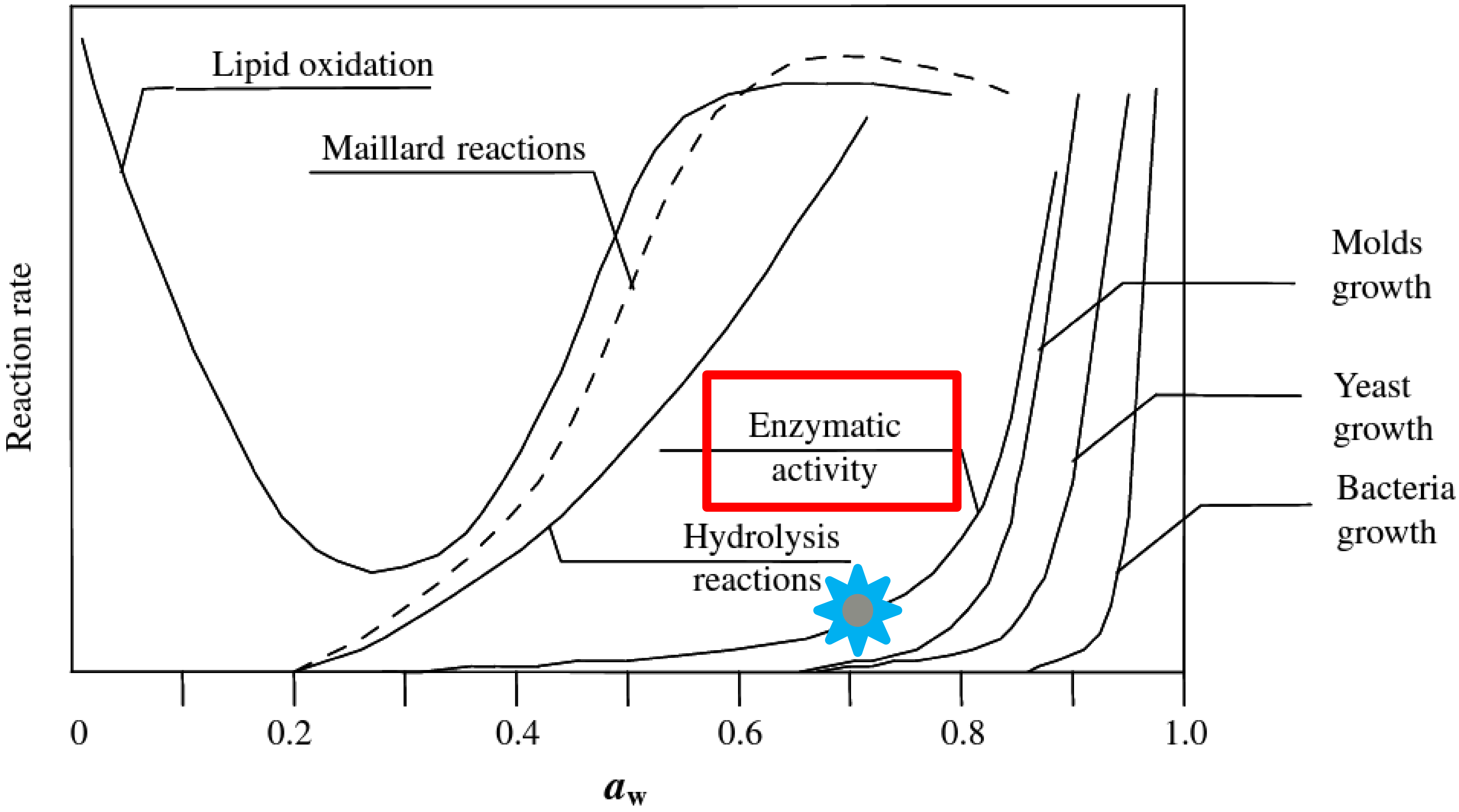
If drying is too fast, the cell membrane breaks and it easily reacts with a large amount of accumulated polyphenols forming a large area of browning.



Influences of different curing methods on chemical compositions in different types of tobaccos.



Temp x Humidity affect Dry Time (estimated)
Moisture Content (%)
80
70
60
50
40
30
20
10
0
41F (5C) 55%RH (VPD=0.4)
59F (15C) 55%RH (VPD=0.8)
77F (25C) 55% RH (VPD=1.4)
41F (5C) 30%RH (VPD=0.6)
59F (15C) 30%RH (VPD=1.2)
77F (25C) 30%RH (VPD=2.2)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Days in Drying
Too Fast
(uneven drying within buds)
Too Slow
(increased risk of Botrytis infection


Lipid oxidation
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growth
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Hydrolysis
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0
0.2
0.4
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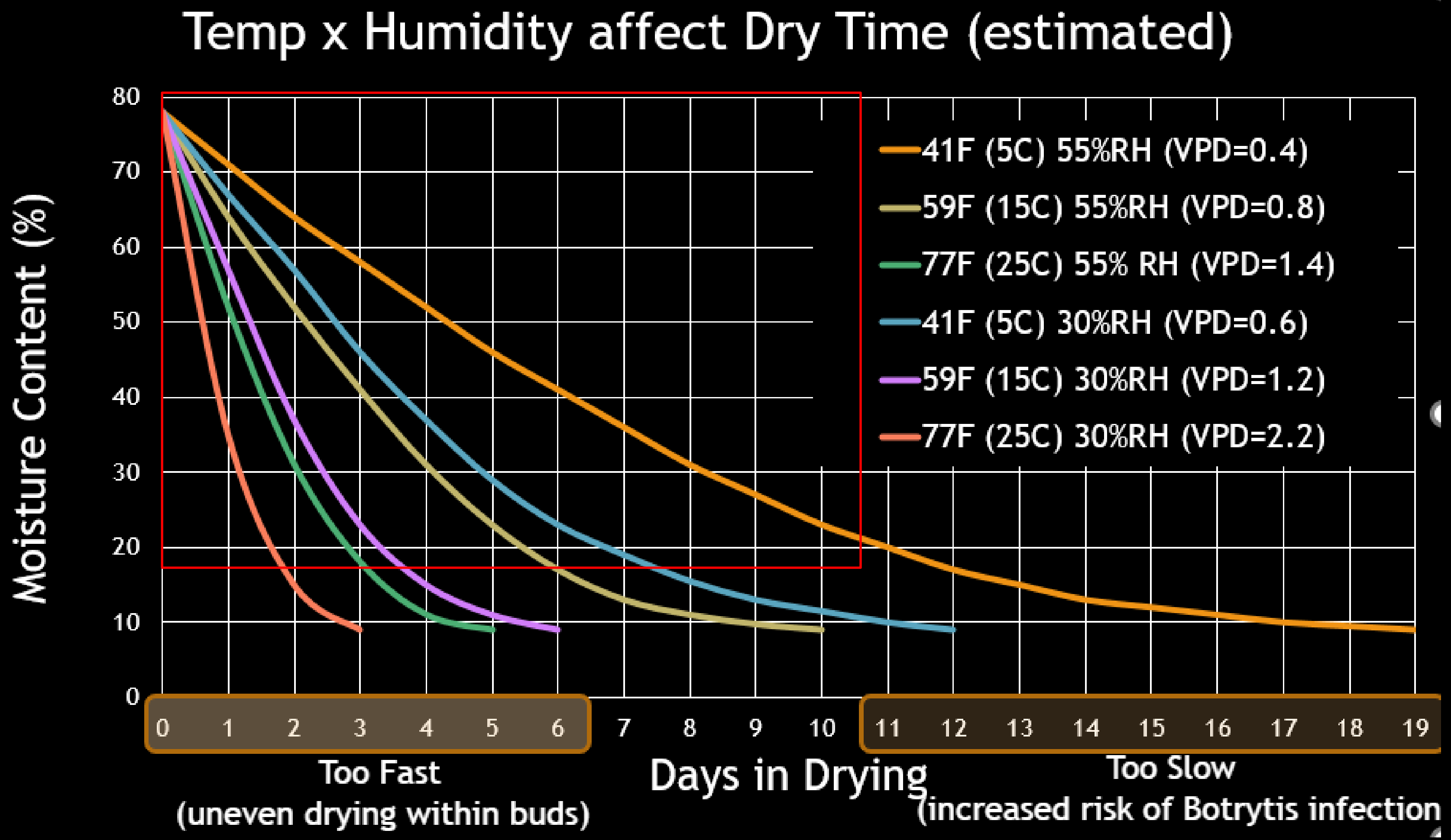
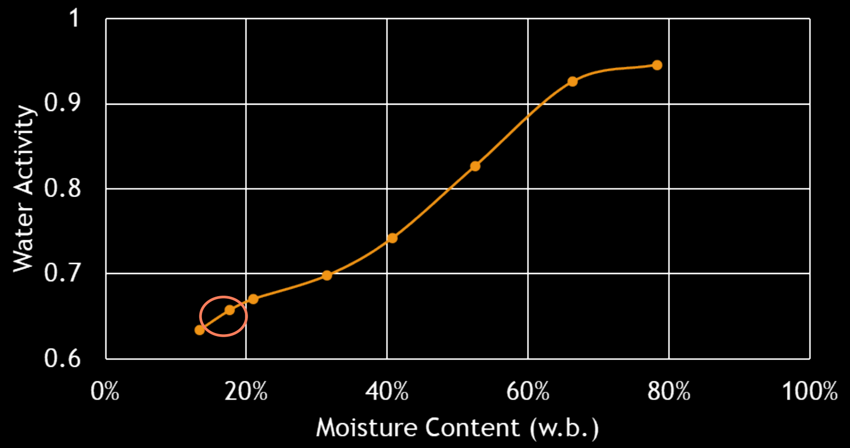
0.8
1.0
a_w

Drying Rates





0.65 aW and above is the highest chance for enzymatic activity

18% moisture content= ~0.65 aw

Carbon metabolites

- Primary metabolite in plants

- Structural:
  - Cellulose
  - Hemicellulose

- Nonstructural (energy):
  - Starch
  - Sucrose

Changes in tobacco

Table 4
The influences of different curing methods on the contents of carbon metabolites in different types of tobaccos.

Tobacco type	Curing method	Starch (%)	Total sugar (%)	Reducing sugar (%)	Fructose (%)	Sucrose (%)	Total carbon content (%)	The loss of the total carbon content
Flue-cured tobacco	Freeze-dried	46.25 ± 0.32Aa	8.08 ± 0.03 Da	5.26 ± 0.01Cc	2.90 ± 0.05Ca	1.27 ± 0.01Bb	43.68 ± 0.27Aa	Control
	Air-cured	8.95 ± 0.05Ca	25.94 ± 0.48Ca	18.78 ± 0.3ABa	9.88 ± 0.06Ba	0.81 ± 0.02Ca	34.22 ± 0.13Dc	8.80 ± 0.04Aa
	Sun-cured	12.57 ± 0.03Ba	26.94 ± 0.35Ba	19.08 ± 0.07Aa	9.79 ± 0.13Ba	0.81 ± 0.00Ca	38.48 ± 0.51Bb	5.68 ± 0.06Ca
	Flue-cured	3.29 ± 0.00Db	32.37 ± 0.39Aa	18.47 ± 0.14Ba	10.59 ± 0.16Aa	2.11 ± 0.05Aa	37.64 ± 0.29Cab	7.14 ± 0.02Ba

Influences of different curing methods on chemical compositions in different types of tobaccos.

SUGARS ARE ADDED TO CIGARETTES!

Plastid Pigments

- Chlorophyll
- Carotenoids

The pigment degradation in post-harvest directly influences appearance, color and generation of aroma components (precursors).

https://www.livescience.com/52487-carotenoids.html

Polyphenols

- Tannins, flavonoids, anthocyanin and simple phenol derivatives.
- Play an important role in influencing the color, growth and development of aroma components.
- The drop of temperature and reduction of time lower the volatilization of aroma components and maintains the polyphenol content in the oriental tobaccos.

https://en.wikipedia.org/wiki/Anthocyanin

Nutes

Potassium

- Osmotic pressure in the curing process.
- A high content of potassium elements contributes to enhancing the combustibility and hygroscopicity
- High potassium = white ash
- Can also improve the scent and aromatic value of flue-cured tobacco by regulating the synthesis of aromatic hydrocarbons in leaves.

Chlorine

- Osmotic pressure in the curing process.
- A too high chlorine content hinders the glucose metabolism and further leads to accumulation of excessive starches, and thus the leaves are thickened and embrittled.
- High ratios reduce flammability and increases hygroscopicity. This reduces their quality by reducing the burning rate and heat retention capacity.

Nitrogen

Nutes

- Essential for growth.
- But…

- Excess nitrogen produces strong and spicy flavors, which are not associated with high nicotine contents.

Nitrogen Metabolites

Notes

- Nitrosamines are organic compounds that we encounter in low levels in our water and foods, including meat, vegetables, and dairy products.
- Fresh tobacco leaves have virtually no nitrosamines.
- During burning, nitrate reacts with alkaloids to form nitrosamines.
- **Nitrosamines = carcinogens**
- Studies have shown that it is highly advisable to not over fertilize nitrogen during growth to reduce nitrogen content at harvest.

- A reason to flush??

Nitrogen Metabolites

Notes

"Both (MJ & tobacco) types of smoke have similar concentrations of particulate matter and toxicants, including carbon monoxide, hydrogen cyanide and nitrosamines, all of which pose potential health risks."

EVIDENCE ON THE CARCINOGENICITY OF Marijuana Smoke. 2009. California EPA.

EVIDENCE ON THE CARCINOGENICITY OF Marijuana Smoke.
2009. California EPA.

Carcinogenic Smoke Constituent	Marijuana Smoke (µg/cigarette)	Tobacco Smoke (µg/cigarette)	* P < 0.05
Acetaldehyde	448±44	872±101	*
Acetamide[1]	Not quantified	Not quantified	
Acrylonitrile	36.6±4.3	13±1.2	*
4-Aminobiphenyl	0.00617±0.00044	0.00156±0.00013	*
Arsenic	0.00244±0.00113	0.00549±0.00033	*
Benz[*a*]anthracene	0.0262±0.0034	0.0305±0.0025	*
Benzene	58.3±5.9	62.2±3.5	
Benzo[*a*]pyrene	0.00867±0.00112	0.0143±0.0012	*
Benzo[*b*]fluoranthene	0.00718±0.00112	0.0108±0.0006	*
Benzo[*j*]fluoranthene	0.00427±0.00083	0.00581±0.00044	*
Benzo[*k*]fluoranthene	0.00152±0.00026	0.00342±0.00032	*
Benzofuran[1]	Not quantified	Not quantified	
1,3-Butadiene	79.5±7.4	64.8±2.2	*
Cadmium	0.00691±0.00134	0.145±0.008	*
Carbazole[2]	0.065	0.0007	*
Catechol	63.9±7.3	170±15	*
Chromium[5]	0.01287±0.00693	0.01287±0.00693	
Chrysene	0.0262±0.0014	0.0388±0.0023	*
Dibenz[*a,h*]anthracene	0.00141±0.00019	0.00115±0.00021	*
Dibenzo[*a,i*]pyrene	0.000356±0.000192	0.000987±0.000145	*
Dibenzo[*a,e*]pyrene	0.000339±0.000183	0.000531±0.000198	
Diethylnitrosamine[3]	<0.0035	<0.0035	
Dimethylnitrosamine[3]	0.05213	0.05918	

Nutes

Phosphorus

- The P content in leaves is positively related to the sugar content=

  a quality parameter

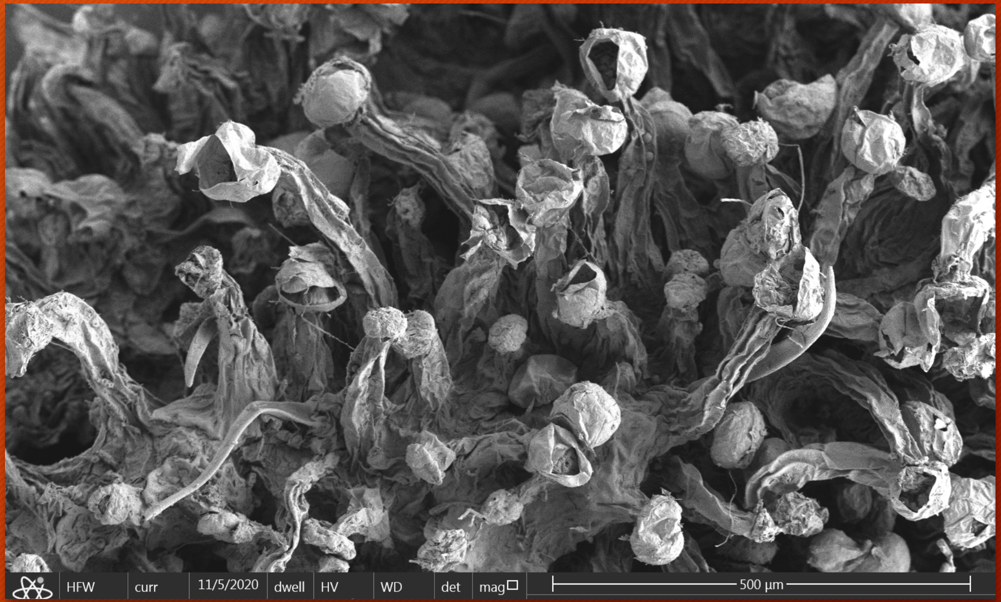
Magnesium

- In tobacco, an increased magnesium content in a leaf (up to 2%) enhances the combustibility and appearance of ash (color and texture), resulting in porous, loose, and light-colored ash.

REHYDRATION = BAD

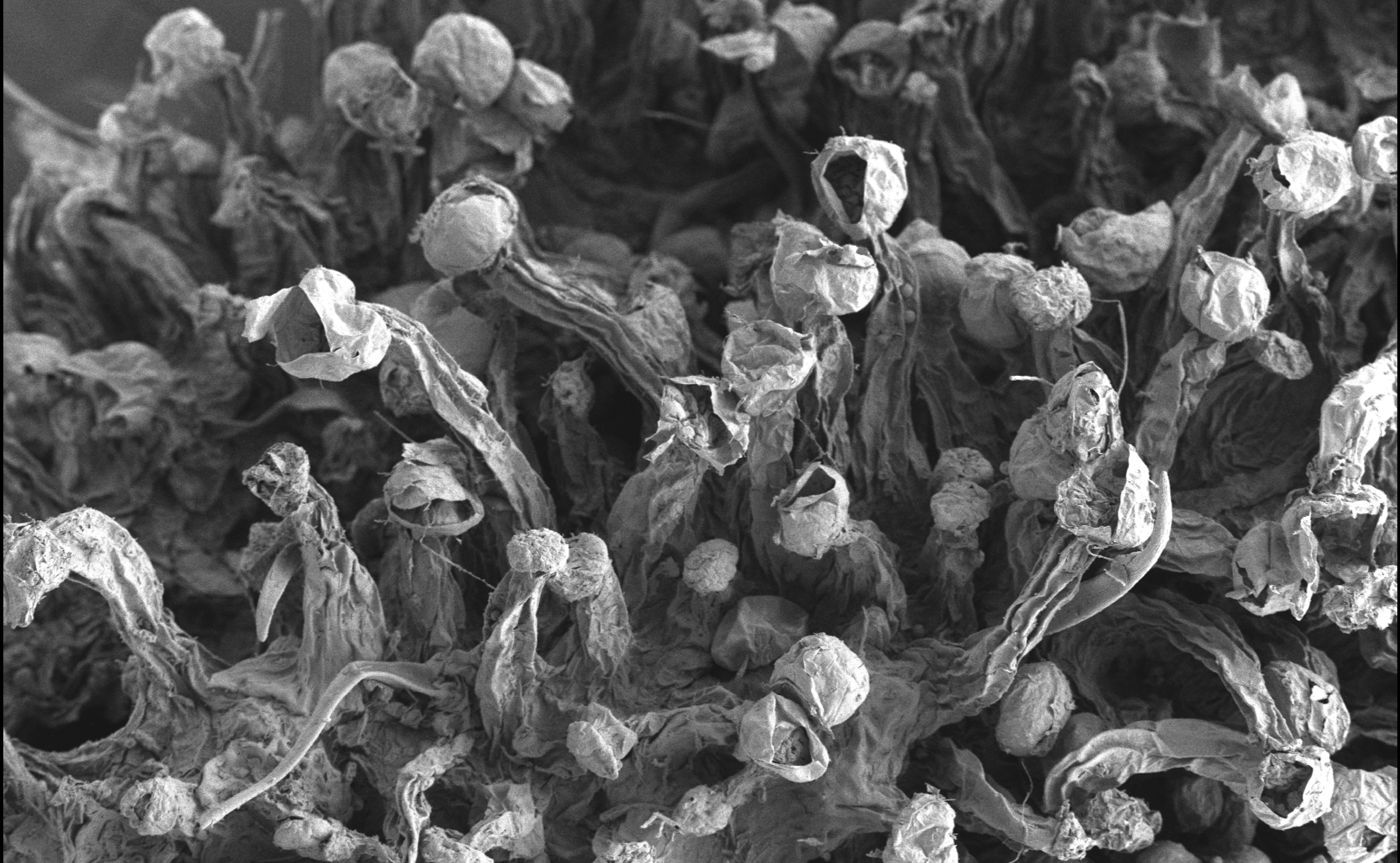
- Rehydration events lead to encapsulation collapse.
- This releases volatile compounds bound within those cells resulting in ruptured cells.
- Is it a good thing if you’re smelling terpenes?

Barn dried



Controlled climate. 60/60

Noelle Joy, UGA



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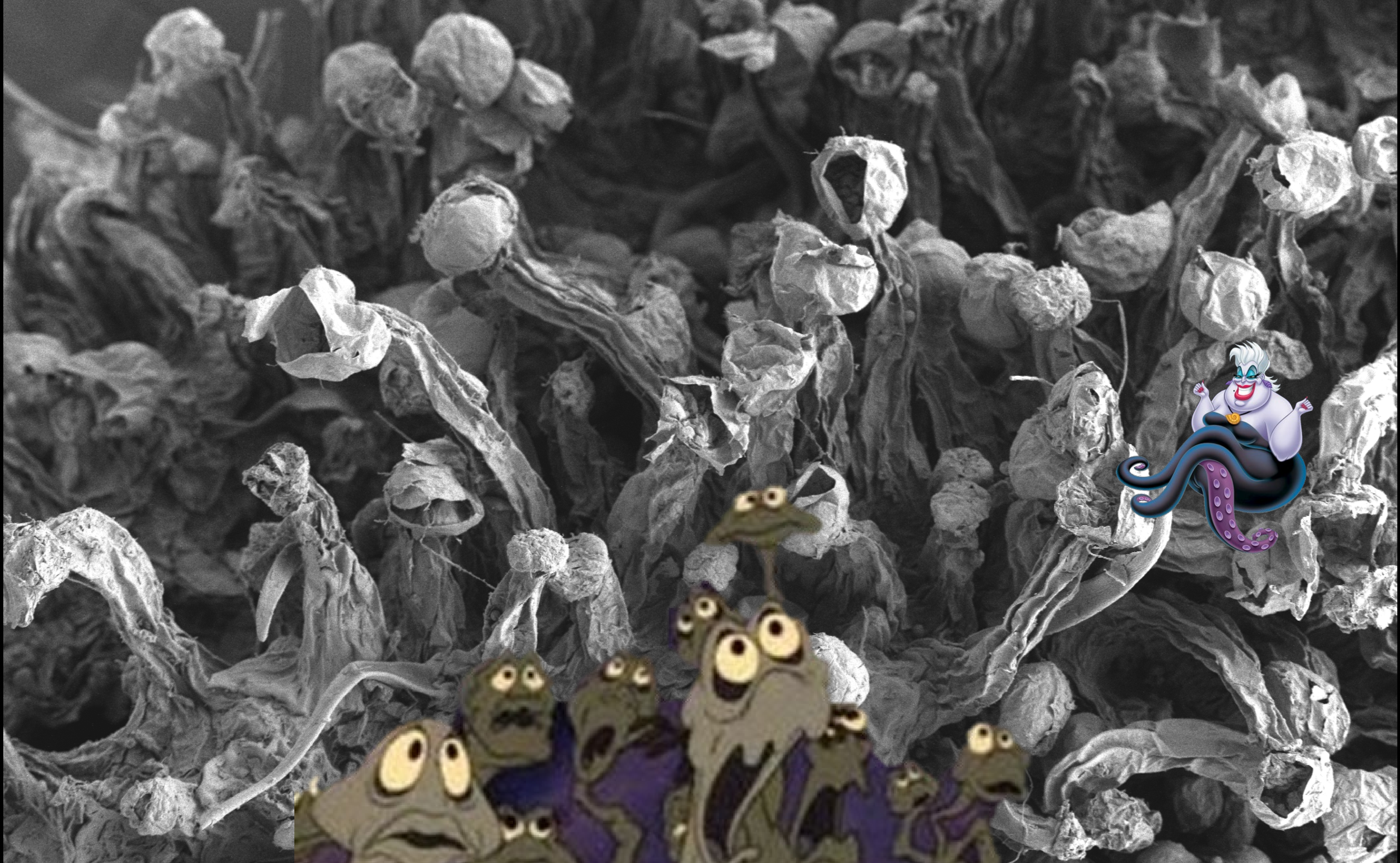
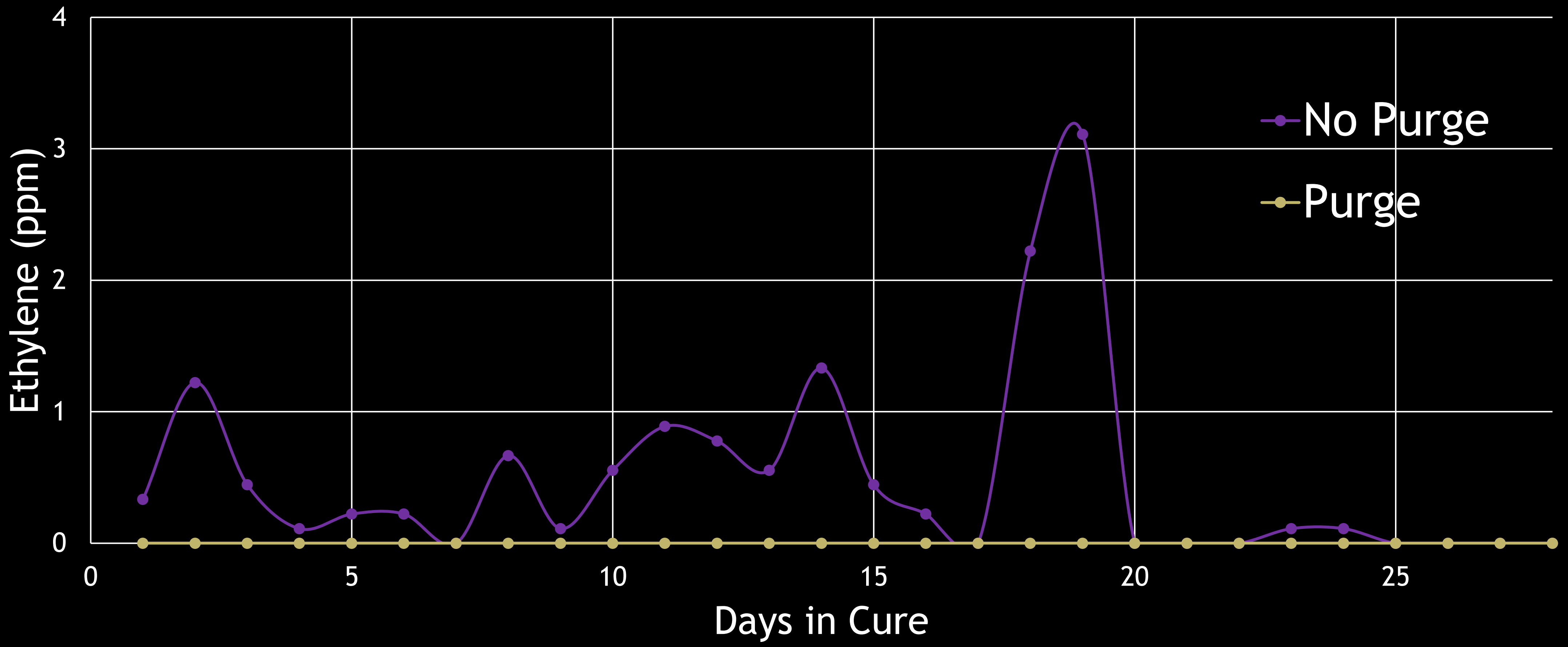


Gases

- Ethylene sensitive (climacteric)
  - senescence is accompanied by a sudden transient increase in ethylene production and respiration
- Ethylene insensitive
  - Little to no increase in ethylene production and respiration

Ethylene



In a second expt., 12 days in sealed jar (no purging), ethylene reached 10-17 ppm.

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QUESTIONS??