Type them into questions box!

“Why am I muted?”
Don’t worry. Everyone is muted except the presenter and host.
Thank you and enjoy the show.

Contact ACS Webinars ® at acswebinars@acs.org

Join a global community of over 150,000 chemistry professionals

Find the many benefits of ACS membership!

Benefits of ACS Membership

**Chemical & Engineering News (C&EN)**
The preeminent weekly digital and print news source.

**NEW! ACS SciFinder**
ACS Members receive 25 complimentary SciFinder® research activities per year.

**NEW! ACS Career Navigator**
Your source for leadership development, professional education, career services, and much more.


Contact ACS Webinars® at acswininars@acs.org

https://www.linkedin.com/company/american-chemical-society
“A very fine ACS Webinar: Andrew Waterhouse was able to capture the essence of wine reactions throughout the winemaking process and present these in a highly condensed but effective webinar.”

**Fun of the Week**

Even J. Lemieux, Ph.D., FCIC  
President, EJL Consulting  
ACS member 30 years strong!


Learn from the best and brightest minds in chemistry! Hundreds of webinars on diverse topics presented by experts in the chemical sciences and enterprise.

**Recordings** are an exclusive ACS member benefit and are made available to registrants via an email invitation once the recording has been edited and posted.

**Live Broadcasts** of ACS Webinars® continue to be available to the general public every Thursday from 2-3pm ET!

www.acs.org/acswebinars
An individual development planning tool for you!

ChemIDP.org

Culinary Chemistry Archive: 29 Delicious Recordings and Counting!

What Makes Wine Tickle? Key Reactions that Create this Delightful Breakthrough
Andrew Waterhouse delves into the two types of aromatic compounds that give wine much of its taste and health benefits.

How to Make Chocolate for your Special Valentine: Flowers Bloom, Chocolate Shouldn't
Rich Horst is returning to share how to properly make chocolate and avoid the mostly-looking “bloom” that can occur when it is done incorrectly.

Kitchen Chemistry: We're Getting a Lot to Learn from Professional and Recreational Cooks
Join Matt Harding, a Professor of Chemistry at American University as he explains some of the intricate chemical transformations through various cooking techniques and food preparation.

Thanksgiving Chemistry for your Family's Feast
Guy Crosby returns to show how a little chemistry can improve your holiday meal.

Ice Cream Chemistry
Rich Martin returns to explain the surprisingly complex chemistry of everyone’s favorite summer treat.

Halloween Candy Chemistry: Caramels, Gummies, jellies, and Candy Corn
Join us as Rich Martin returns to dive deeper into the chemistry of your favorite sweet treat!

Garlic and Other Alliums: The Love and the Science
Eric Block explains the colorful history of alliums as well as the science of why they make us cry, give us horrible breath and taste so wonderful.

Color Chemistry: Red and White Beer for St. George’s Day
Learn what determines the color of beer and how color is measured in the brewing industry.

The Chemistry of Cocktails: Bruleing and Loucheing and Fire Oh My!
Dr. Darcy Gentleman discusses the chemistry of cocktails and quenches your thirst for knowledge.

Wine Science: Designing Great Wines
Join Dr. Stuart Eber as he explains the chemistry of wine, from the vineyard to your palate.

Barrels of Chemistry: Decoding How Oak Affects Wine Flavor
Learn how the hints of cream, smoke, spice and vanilla that hide in your wine have less to do with the grape and more to do with the wood.

Sous Vide Cooking and Chemistry
Discover a form of cooking that can make the toughest cuts of meat come out tender, juicy and medium rare with Douglas Baldwin.

https://www.acs.org/content/acs/en/acs-webinars/culinary-chemistry.html
ACS Division of Agricultural & Food Chemistry

AGFD brings together persons particularly interested in the chemistry of agricultural and food products, both raw and finished; to foster programs of general papers and symposia on special topics dealing with this field of chemistry; to promote such other activities as will stimulate activity in and emphasize the importance of research in agricultural and food chemistry.

Find out more about the ACS AGFD! http://agfd.sites.acs.org

Upcoming ACS Webinars
www.acs.org/acswebinars

Thursday, May 31, 2018
Advanced Nano-Delivery Systems: Facilitating Tumor Delivery and Mitigating Resistance
Co-produced with the ACS Division of Medicinal Chemistry and the American Association of Pharmaceutical Scientists

Experts
Mansoor Arjii
Northeastern University
Venkat Krishnamurthy
AstraZeneca

Thursday, June 6, 2018
Refugees, Displaced Scientists, and Chemistry Communities: Creative Approaches to Support Chemical Practitioners
Co-produced with ACS International Activities as part of the ACS Science and Human Rights Initiative

Experts
Jeff Wilkesman
University of Carabobo
Admir Misic
Massachusetts Institute of Technology
Robin Perutz
The University of York
Dorothy Phillips
Director-at-Large
ACS Board of Directors

Contact ACS Webinars ® at acswebinars@acs.org
“Ready to Drink Yet? The Chemistry of How Wine Flavor Changes During Aging”

Gavin Sacks
Associate Professor of Enology, Department of Food Science, Cornell University

Beth Burzynski
PhD Candidate in Food Science, Cornell University

Slides available now and an invitation to view the recording will be sent when available.
www.acs.org/acswebinars

This ACS Webinar is co-produced with ACS Division of Agricultural & Food Chemistry

“Ready to Drink Yet?”
The Chemistry of How Wine Flavor Changes During Aging

Gavin L. Sacks
Associate Professor of Enology
Department of Food Science
Cornell University

Moderator: Beth Burzynski, PhD Candidate in Food Science, Cornell University
Let’s get started... consider the range of wine labels available to US consumers.

This is a wine label.

Wine labels can include info on:
- Producer/brand
- Production region (e.g. Bordeaux)
- Grape variety (e.g. Chardonnay)
- Vintage year
- Alcohol content, “contain sulfites”, government warnings

In the US, wine labels must be pre-approved prior to bottling or importation by the Tax and Trade Bureau (TTB).

Audience Challenge Question
ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

How many different wine labels are approved for sale each year in the United States?

- 2,000 to 4,000
- 6,000 to 10,000
- 15,000 to 30,000
- 40,000 to 60,000
- 75,000 to 125,000

Image: mnn.com
Premium wine is a “craft” product, not a “commodity”
Variation in sensory (and thus chemistry) is expected

**Taste (Gustation)**
salty, bitter, sweet, acidic, and umami compounds

**Smell (Olfaction)**
Volatile compounds, of which 50-75 create most wine-like aromas

**Touch (Chemesthesia)**
Compounds responsible for pungency, cooling, astringent, viscous and related tactile sensations

**Appearance**
Pigments (mostly red and yellow) or light-scattering haze particles

**Popular appeal of wine - Explanations**
- Its variation
- Its deliciousness, particularly with food
- Its sense of place
- It contains ethanol
- Its mystique, including its longevity

The reputation for “age-ability” persists even though the majority of wines are meant to be, and are, consumed within 0.5-2 years of production

*(the occasional bottle of 170-year old shipwrecked Champagne excepted)*
“Age-worthy” does not have a well agreed upon definition among enologists

**Working definition:** “assuming two wines (A and B) are equally liked at some time point, Wine A ‘ages better’ if it is better liked than Wine B at a later time point.”

Maybe, youthful characteristics are preserved in Wine A
- Desirable sensory compounds could be more stable
- Fewer undesirable compounds could form

Or, new “aged” characteristics appear in Wine A
- Undesirable sensory compounds could be lost more rapidly during storage
- More desirable compounds could form

---

**This Talk:** We will consider case studies of wines that vary in how they age

**But, first let’s talk about some basic wine chemistry**
Chemically, what’s in a typical dry red wine?

- Ethanol (11%)
- Water (86%)
- Everything else (3%)

Everything else, a non-comprehensive list

- Glycerol (6-12 g/L)
- Organic acids (5-8 g/L) → wine pH is 3-4
- Hexose sugars (0.5-3 g/L)
- Minerals, e.g. K⁺ (0.5-2 g/L)
- Important odorants (ng/L to mg/L)
- Phenolics (0.5-2 g/L)
  -Anthocyanins [color]
  -Tannins [astringency]
- Sulfur dioxide (20-40 mg/L)
- Glutathione (15-100 mg/L)

Reducing compounds (nucleophiles)

Adapted from Understanding Wine Chemistry; Waterhouse, Sacks, and Jeffery. 2016

What reactions can happen at pH 3-4, 10-12% EtOH, reducing conditions, 20 °C, over 6-24 months?

Reactions involving water or ethanol, often acid catalyzed

- Hydrolysis, ethanolysis (below)
- H₂O/EtOH addition or elimination

\[
\begin{align*}
\text{EtOH} + \text{H}_2\text{O} & \rightarrow \text{EtOH}_2\text{O} + \text{H}_2\text{O} \\
\text{H}_2\text{O} & \rightarrow \text{H}_2\text{O}_2
\end{align*}
\]

Other textbook reactions, e.g. Grignard? Not likely 😊

Reactions between wine nucleophiles and electrophiles

- Example nucleophiles = SO₂/HSO₃⁻, H₂S, thiols, polyphenols
- Example electrophiles = carbonyls (e.g. acetaldehyde); tannin hydrolysis products; quinones

Image: mcgrawhill.com
Case Study 1: Varietal wines “not aging well” due to loss of desirable compounds

Muscat-type wines vs. Gewürztraminer

Both types of wines have floral aromas when young, but they have different reputations for aging

Consider two monoterpane-rich, “floral” smelling grape varieties, with dissimilar fates during aging

Muscat-type grapes,
e.g. Moscato bianco from Asti

“Serving recommendations [for Moscato d’Asti] ..drink it young and fresh!” - winefolly.com

Key odorant = linalool ("lily-of-the-valley")

Gewürztraminer

“While you often can drink Gewürztraminers young, some benefit from 2-4 years worth of aging.” - wineintro.com

Key odorant = (-) cis-rose oxide “rose/litchee"
The key “floral” monoterpenes in Muscat-type wines, e.g. linalool, are unstable in wine matrix

Linalyl glycosides
Non-odorous precursors

Partial release during fermentation
Slow non-enzymatic release during storage

$\frac{t}{2}$ @ wine pH = months

Linalool
“lily-of-the-valley”
Threshold = 50 ppb

α-Terpeniol
“resin, pine”
Threshold = 400 ppb

Acid catalyzed ring closure

$\frac{t}{2}$ @ wine pH = weeks

By comparison, the key Gewürztraminer monoterpene is stable or increases during storage

Monoterpene diol precursors
Odor threshold = very high

Enzymatic reduction
Acid-catalyzed ring closure

$\frac{t}{2}$ @ wine pH = months

(−) cis-rose oxide
“rose/litchi”
Threshold = 0.5 ppb

Stable

Koslitz, et al JAFC 2008
Belitz, Grosch, Schieberle 2004
Recap: Wines with strong floral aromas often do not “age well” if you desire the odor to stay floral

- Monoterpenes, particularly linalool, contribute “floral” aromas, but are not stable in aqueous acidic matrices (WINE!)
  - In particular, Muscat-type varieties (e.g. Muscat bianco)
  - Stonefruit notes of some wines (e.g. Viognier) do not persist
- A monoterpene exception: cis-rose oxide
  - Gewürztraminer can continue to have “litchee” aromas, even with age

Case Study 2: Production practices lead to desirable odorants that are readily lost during storage

Beaujolais Nouveau vs. Standard red wines

Beaujolais Nouveau is known for intense “cherry, banana” type aromas and is intended for sale within weeks of fermentation
Red winemaking: The 30 second story

Standard Red Wine Maceration
Grapes are crushed and fermented by yeast in the presence on skins and seeds

Carbonic Maceration (common for Beaujolais Nouveau)
Whole grape clusters are blanketed in CO$_2$, grapes auto-ferment to ~2% alcohol. Then, grapes are pressed, and juice is fermented to dryness by yeast

Several differences in odorant concentrations between carbonic (CM) and standard maceration, including...

Isoamyl acetate
"Cherry/banana" Higher in CM wines

Isovaleric acid
"Cheesy, sweaty" Lower in CM wines (although, below sensory threshold in most wines)


Data from Antalick, et al. AJEV 2014.
Ester hydrolysis / Esterification in Wine
Just like in your Organic Chem I Class

\[
\begin{align*}
\text{Ester} & \quad + \quad \text{H}_2\text{O} \quad \xrightarrow{H^+} \quad \text{Fatty acid} \quad + \quad \text{R'}\text{OH} \\
\end{align*}
\]

\[K_{eq} = \frac{[\text{alcohol}][\text{fatty acid}]}{[\text{ester}][\text{H}_2\text{O}]} \approx 0.25 \quad \text{Literature estimate}\]

Working through the math...and assuming \([\text{EtOH}] = \sim 2\text{M or 12\% v/v}, \text{acetic acid} = \sim 5 \text{mM, } [\text{H}_2\text{O}] = \sim 50\text{M}\)

- **Isoamyl acetate** “banana”
  \[
  \text{CH}_3\text{CH}(...\text{CH}_2\text{CH}_2\text{CH}_3)\text{CO}_2\text{H} + \text{H}_2\text{O} \quad \xrightarrow{-\text{H}_2\text{O}} \quad \text{CH}_3\text{CH}(...\text{CH}_2\text{CH}_2\text{CH}_3)\text{CH}_2\text{OH} + \text{CH}_3\text{CO}_2\text{H}
  \]

- **Acetic acid**

- **Isoamyl alcohol**

**Isoamyl acetate and other acetate esters decrease during storage**

- **Ethyl isovalerate** and some other ethyl esters can increase during storage

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\text{CO}_2\text{H} & \quad + \quad \text{EtOH} \quad \xrightarrow{-\text{H}_2\text{O} + \text{H}_2\text{O}} \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\text{CH}_2\text{OH} & \quad \text{Ethyl isovalerate} \quad \text{“strawberry”}
\end{align*}
\]
**Organic Chem I, cont., kinetics**

Ester hydrolysis/esterification follow pseudo-first order kinetics in wines

At pH 3.6, $T=25^\circ C$, $t_{1/2}$ for hydrolysis of an ester is **3-5 months**

$t_{1/2}$ for esterification of a fatty acid is **1-2 yrs**

**How to slow down ester reactions?**
- Raise pH (causes other problems)
- Store cold, especially during transit
- **Drink quickly!**
  - *Beaujolais on Thanksgiving*

**Recap:** wines which rely heavily on acetate esters will likely “not age well”

Examples of wines with high acetate esters
- *Beaujolais Nouveau* and other carbonic wines
- ‘Tropical fruity’ whites, e.g. many Pinot Grigio, Sauvignon blanc, and stainless steel Chardonnay

**Standard red winemaking**
= more branched chain fatty acids
= more branched chain ethyl ester formation during storage

From Antalick, et al AJEV 2014
An aside on additional hydrolytic reactions, before returning to case studies...

“Is it good aging? Or bad aging”?  

Dimethyl sulfide (DMS) and 1,1,6-trimethyldihyronaphthalene (TDN)

DMS, TDN . . . do we want these forming in our wines?

Hypothetical responses of two consumers (#1, #2) to spiked wine

“only the dose makes a thing not a poison”  - Paracelsus
Can we accelerate these aging reactions through some sort of physiochemical treatment?

OK, we have reactions that can occur during storage...

Which of these approaches to accelerated aging have been patented?

More than one correct answer may exist

- Agitation
- High-temperature
- Ionizing radiation
- Ultrasound
- Electric Currents

Image: Wikimedia Commons
“Rapid aging” approaches do not appear to duplicate conventional aging (say, in a 12 °C cellar)

Example 1: UV or gamma ray irradiation generates free radicals → volatile sulfur compound formation → “burnt hair” aromas

Example 2: High temperature storage promotes different reactions at different rates → Wine reactions differ in activation energies

Unfortunately, higher temperatures often accelerate unwanted reactions to a greater extent!

<table>
<thead>
<tr>
<th>Reaction in beverage model system</th>
<th>Activation energy, $E_a$ (kJ/mol)</th>
<th>Fold-increase in reaction rate compared to 12 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid hydrolysis of proanthocyanidins (tannins)</td>
<td>45</td>
<td>At 30 °C 3 At 50 °C 9</td>
</tr>
<tr>
<td>Esterification or ester hydrolysis</td>
<td>62</td>
<td>At 30 °C 5 At 50 °C 22</td>
</tr>
<tr>
<td>Hydrolysis of SMM to DMS</td>
<td>186</td>
<td>At 30 °C 106 At 50 °C 10250</td>
</tr>
<tr>
<td>Acid hydrolysis of anthocyanin pigment</td>
<td>118</td>
<td>At 30 °C 19 At 50 °C 350</td>
</tr>
<tr>
<td>Formation of ethyl carbamate from urea and ethanol</td>
<td>118</td>
<td>At 30 °C 19 At 50 °C 350</td>
</tr>
</tbody>
</table>

- Possibly desirable
- Unlikely to be desirable
Case Studies 3 and 4, Oxidation:
Why do wine producers use SO₂?
And why are reds thought to age better than whites?

Audience Challenge Question
ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

In the current model of wine oxidation, which wine component directly reacts with O₂?

- [Fe(III)] complexes
- SO₂ (in the form of bisulfite, HSO₃⁻)
- Polyphenolics, particularly condensed tannins
- Glutathione and related sulfhydryls
- Alcohols, particularly ethanol
Distribution of \( \text{SO}_2 \) species in wine

- At wine pH, most \( \text{SO}_2 \) in exists as bisulfite
- Smaller portion (<5%) exists as ‘molecular’ \( \text{SO}_2 \)
- Almost no sulfite, \( \text{SO}_3^{2-} \)
- Some bisulfite is covalently bound to wine electrophiles like acetaldehyde

Role of sulfur dioxide (\( \text{SO}_2 \)) in wine

- **Anti-microbial**: neutral, “molecular” form can cross the cell membrane
  - Inside cell, pH>5
  - \( \text{SO}_2 \rightarrow \text{HSO}_3^- \)
- **Anti-oxidant**: Bisulfite (\( \text{HSO}_3^- \)) reacts with products of oxidation
  - In wine, pH<4
  - \( \text{SO}_2 \rightarrow \text{HSO}_3^- \)
  - Lower pH favors molecular form

Best predictor of aroma quality = low levels of off-odorants from spoilage organisms or oxidation (San Juan, et al; *JAFEC 2012*)

- Methional, “baked potato”
  - Via abiotic oxidation
- Acetic acid
  - Via microbial spoilage
Focus on abiotic oxidation during aging
How is $O_2$ getting into a bottled wine?

Same Semillon wine with one of 14 closures

Oxygen can . . .
- Be present in headspace during bottling
- Migrate through or around the closure

Wine Oxidation – Production of $H_2O_2$

$$
\begin{align*}
[Fe(II)] & \quad O_2 \quad [Fe(III)-O_2^+]^{2+} \\
H_2O_2 & \quad \cdot OH & \quad 2 [Fe(III)] + H_2O_2 \\
\end{align*}
$$

Typical wine: $\sim 1$ mg/L Fe

“Fenton reaction”

Oxidized aromas
(“baked potato, bruised apple, cardboard”)

From Understanding Wine Chemistry, 2016
Wine Oxidation – Formation of Quinones

- Oxidation of diphenols to quinones by [Fe(III)] is not thermodynamically favorable in wine
- Wine nucleophiles “trap” quinones and drive oxidation forward
- By comparison most distilled spirits are low in nucleophiles (and often transition metals and phenolics, too). Oxygen consumption is very slow

Quinones can react with many nucleophiles, including desirable “fruity” smelling thiols

- 3-SH is critical for the fruitiness of many wines, particularly Sauvignon blanc
- Result: loss of quality, unless another nucleophile is present (enter SO₂)

Adapted from Danilewicz, AJEV 2012

Nikolantonaki and Waterhouse, JAFC 2012

Image: Wikimedia Commons
The role of SO₂ as a wine antioxidant - Scavenge wine oxidation products

Scavenge H₂O₂ and aldehydes

\[
\text{HSO}_3^- + \text{H}_2\text{O}_2 \rightarrow \text{HSO}_4^- + \text{H}^+ + \text{H}_2\text{O}
\]

Scavenge quinones

\[
\text{quinone} + \text{HSO}_3^- \rightarrow \text{quinone}^- + \text{SO}_3^- + \text{H}_2\text{O}
\]

The ability to rapidly scavenge H₂O₂ is unique to HSO₃⁻.
Once HSO₃⁻ is mostly depleted (< 10 mg/L), oxidation products accumulate.

So why would red wines potentially age better than white wines?

• In part, red wines are less dependent on thiols as key aroma compounds.
• Also, polyphenols (anthocyanins, tannins) can react with oxidation products, e.g. malodorous carbonyls, or quinones.

Ex:

\[
\text{Malvidin-3-glucoside (anthocyanin)} + \text{Acetaldehyde} \rightarrow \text{Vitisin B}
\]
Recap: Antioxidants like SO$_2$ and/or polyphenols may help a wine age better, but not because they directly react with O$_2$

- Oxidation of wine is catalyzed by the presence of transition metals like Fe(II)

- Oxidation generates H$_2$O$_2$ and polyphenol quinones.
  - These species can result in loss of desired aroma compounds, production of oxidized aroma compounds (mostly carbonyls), and browning
  - SO$_2$ (as bisulfite) can react directly with H$_2$O$_2$, quinones, and carbonyls
  - Polyphenols can react with quinones and carbonyls

- Counterintuitively, the presence of SO$_2$ and polyphenols increases the rate at which O$_2$ is consumed

There’s much left to learn about wine aging...

Some recent exciting work from the literature
Ongoing Studies: What happens to condensed tannins (chemically, sensorially) during aging?

- Condensed tannins, aka proanthocyanidins
  - Polymers of flavan-3-ols, e.g. catechin
  - Present in grape skins and seeds – at higher concentrations in red wines

- Responsible for “astringency” (drying, puckering sensation) in wines
  - Mechanism = non-specific covalent binding of proteins, including salivary proteins

During storage, tannins can undergo both acid-catalyzed and electrophile/nucleophile reactions

- How do these reactions affect tannin sensory attributes?
  - Decrease in astringency, most likely?
  - Other changes, i.e. decrease in in-mouth persistence (“stickiness”)?

**Ongoing Studies:** What else forms during storage and contributes to the “bouquet” of aged wines?

- From before: certain ethyl esters, TDN, DMS
- Recent papers using GC-O/MS have suggested additional candidates

<table>
<thead>
<tr>
<th>Piperitone</th>
<th>1-methylpyrrole-2-methanethiol</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Minty”</td>
<td>“Hazelnut”</td>
</tr>
<tr>
<td>Found in aged red wines</td>
<td></td>
</tr>
</tbody>
</table>

**Ongoing Studies:** Why do wines differ in relative amounts of key malodorous compounds following oxidation?

Methional (“baked potato”) and phenylacetaldehyde (“honey”) have been implicated as key wine oxidation odorants

- Low sensory thresholds
- Relatively weak SO₂ binders as compared to other aldehydes

Wines can differ by over an order of magnitude in the amount of these aldehydes formed during oxidation and HSO₃⁻ loss

Does high bound methional explain why some wines “age badly”?
Wrapping Up: Take-Home Messages

• “Aging well” is a not single concept
  o New desirable compounds could be formed; or else lost more slowly
  o Or, new undesirable compounds could be avoided; or else lost more quickly
  o And, what’s desirable to one consumer may not be to another

• A limited number of types of reactions can occur in aging. Key classes
  o Solvent-mediated, such as ester hydrolysis/esterification
  o Reactions between nucleophiles and electrophiles, e.g. addition of bisulfite to oxidation products

• There’s much to learn still: Tannin changes, odorants responsible for aged wine aroma, differences in observed oxidation products among wines

Still Thirsty?: If you like this talk, and want to learn more, consider the textbook

Understanding Wine Chemistry

Andrew L. Waterhouse, Gavin L. Sacks, and David W. Jeffery

Published in 2016 by John Wiley & Sons
References
Ma, Lingjun, Bennett Addison, and Andrew Waterhouse. 2018. 'Condensed tannin reacts with SO2 during wine aging, yielding flavan-3-ol sulfonates', J Agric Food Chem, in press.
Nikolantonaki, Maria, and Andrew L Waterhouse. 2012. 'A method to quantify quinone reaction rates with wine relevant nucleophiles: A key to the understanding of oxidative loss of varietal thiols', Journal of Agricultural and Food Chemistry, 60: 8484-91.
ACS Division of Agricultural Food Chemistry

AGFD brings together persons particularly interested in the chemistry of agricultural and food products, both raw and finished; to foster programs of general papers and symposia on special topics dealing with this field of chemistry; to promote such other activities as will stimulate activity in and emphasize the importance of research in agricultural and food chemistry.

Find out more about the ACS AGFD! http://agfd.sites.acs.org

Upcoming ACS Webinars
www.acs.org/acswebinars

Thursday, May 31, 2018
Advanced Nano-Delivery Systems: Facilitating Tumor Delivery and Mitigating Resistance
Co-produced with the ACS Division of Medicinal Chemistry and the American Association of Pharmaceutical Scientists

Experts
Mansoor Amiji
Northeastern University
Venkat Krishnamurthy
AstraZeneca

Thursday, June 6, 2018
Refugees, Displaced Scientists, and Chemistry Communities: Creative Approaches to Support Chemical Practitioners
Co-produced with ACS International Activities as part of the ACS Science and Human Rights Initiative

Experts
Jeff Wilkesman
University of Carabobo
Admir Masic
Massachusetts Institute of Technology
Robin Perutz
The University of York
Dorothy Phillips
Director-at-Large
ACS Board of Directors

Contact ACS Webinars ® at acswinbinars@acs.org
"Ready to Drink Yet? The Chemistry of How Wine Flavor Changes During Aging"

Gavin Sacks  
Associate Professor of Enology,  
Department of Food Science, Cornell University

Beth Burzynski  
PhD Candidate in Food Science, Cornell University

Slides available now and an invitation to view the recording will be sent when available.  
www.acs.org/acswebinars

This ACS Webinar is co-produced with ACS Division of Agricultural & Food Chemistry

Culinary Chemistry Archive: 29 Delicious Recordings and Counting!

What Makes Wine Tickle Key Reactions that Create this Delightful Sensory Experience  
Andrew Waterhouse delves into the two types of chemical compounds that give wine much of its taste and health benefits.

How to Make Chocolate for your Special Valentine: Flowers Bloom, Chocolate Shouldn’t  
Rich Horst is returning to share how to properly make chocolate and avoid the moldy looking "bloom" that can occur when it is done incorrectly.

Kitchen Chemistry: We’ve Got a Lot to Learn from Professional and Recreational Cooks  
Join Matt Harding, a Professor of Chemistry at American University as he explains some of the intricate chemical transformations through various cooking techniques and food preparation.

Thanksgiving Chemistry for your Family’s Feast  
Guy Crosby returns to show how a little chemistry can improve your holiday meal.

Ice Cream Chemistry  
Rich Horst returns to explain the surprisingly complex chemistry of everyone’s favorite summer treat.

Halloween Candy Chemistry: Caramels, Gummies, jellies, and Candy Corn  
Join us as Rich Horst returns to dive deeper into the chemistry of your favorite sweet treat!

Garlic and Other Alliums: The Love and the Science  
Eric Block explains the colorful history of alliums as well as the science of why they make us cry, give us horrible breath and taste so wonderful.

Color Chemistry: Red and White Beer for St. George’s Day  
Learn what determines the color of beer and how color is measured in the brewing industry.

The Chemistry of Cocktails: Blueting and Laughing and Fire Oh My!  
Dr. Darcy Gentleman discusses the chemistry of cocktails and quenches your thirst for knowledge.

Wine Science: Designing Great Wines  
Join Dr. Stuart Eberle as she explains the chemistry of wine, from the vineyard to your palate.

Barrels of Chemistry: Decoding How Oak Affects Wine Flavor  
Learn how the hints of cream, smoke, spice and vanilla that hide in your wine have lost to do with the grape and more to do with the wood.

Sous Vide Cooking and Chemistry  
Discover a form of cooking that can make the toughest cuts of meat come out tender, juicy and medium rare with Douglas Baldwin.

https://www.acs.org/content/acs/en/acs-webinars/culinary-chemistry.html
“A very fine ACS Webinar: Andrew Waterhouse was able to capture the essence of wine reactions throughout the winemaking process and present these in a highly condensed but effective webinar.”

Fan of the Week
Even J. Lemieux, Ph.D., FCIC
President, EJL Consulting
ACS member 30 years strong!


Be a featured fan on an upcoming webinar! Write to us @acswebinars@acs.org

Contact ACS Webinars ® at acswebinars@acs.org
Benefits of ACS Membership

**Chemical & Engineering News (C&EN)**
The preeminent weekly digital and print news source.

**NEW! ACS SciFinder**
ACS Members receive 25 complimentary SciFinder® research activities per year.

**NEW! ACS Career Navigator**
Your source for leadership development, professional education, career services, and much more.


ACS Webinars® does not endorse any products or services. The views expressed in this presentation are those of the presenter and do not necessarily reflect the views or policies of the American Chemical Society.

Contact ACS Webinars® at acswebinars@acs.org
Upcoming ACS Webinars
www.acs.org/acswebinars

Thursday, May 31, 2018

**Advanced Nano-Delivery Systems: Facilitating Tumor Delivery and Mitigating Resistance**
Co-produced with the ACS Division of Medicinal Chemistry and the American Association of Pharmaceutical Scientists

Experts

- Mansoor Amiji
  Northeastern University
- Venkat Krishnamurthy
  AstraZeneca

Thursday, June 6, 2018

**Refugees, Displaced Scientists, and Chemistry Communities: Creative Approaches to Support Chemical Practitioners**
Co-produced with ACS International Activities as part of the ACS Science and Human Rights Initiative

Experts

- Jeff Wilkesman
  University of Carabobo
- Admir Masic
  Massachusetts Institute of Technology
- Robin Perutz
  The University of York
- Dorothy Phillips
  Director-at-Large
  ACS Board of Directors

Contact ACS Webinars ® at acswebinars@acs.org