

# Alcohols

# Learning Outcomes

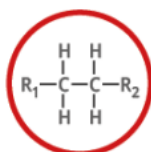
1. Apply intermolecular forces to describe the structure-function relationship of straight-chain alcohols with respect to antibacterial activity
2. Explain, at the chemical level, alcohol poisoning
3. Connect alcohol reactivity to ethanol metabolism and the breathalyzer test
4. At Home: Apply knowledge of intermolecular forces: rank alcohols in order of boiling point and select from a pair which molecule is more soluble in water.

# Common Functional Groups

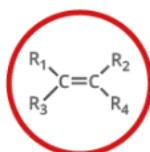
## FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

FUNCTIONAL GROUPS ARE GROUPS OF ATOMS IN ORGANIC MOLECULES THAT ARE RESPONSIBLE FOR THE CHARACTERISTIC CHEMICAL REACTIONS OF THOSE MOLECULES. IN THE GENERAL FORMULAE SHOWN BELOW FOR EACH FUNCTIONAL GROUP, 'R' REPRESENTS THE REST OF THE MOLECULE, AND 'X' REPRESENTS ANY HALOGEN ATOM.

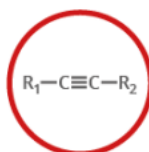
● HYDROCARBONS 
 ● SIMPLE OXYGEN HETEROATOMICS 
 ● HALOGEN HETEROATOMICS 
 ● CARBONYL COMPOUNDS 
 ● NITROGEN-BASED 
 ● SULFUR-BASED 
 ● AROMATIC



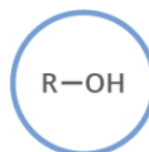
**ALKANE**  
Naming: -ane  
e.g. ethane



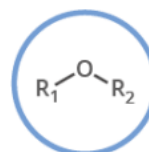
**ALKENE**  
Naming: -ene  
e.g. ethene



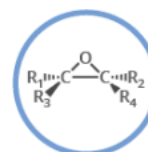
**ALKYNE**  
Naming: -yne  
e.g. ethyne



**ALCOHOL**  
Naming: -ol  
e.g. ethanol



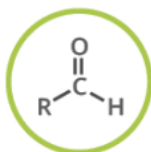
**ETHER**  
Naming: -oxy-ane  
e.g. methoxyethane



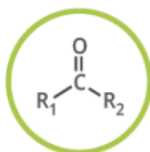
**EPOXIDE**  
Naming: -ene oxide  
e.g. ethene oxide



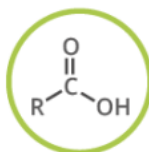
**HALOALKANE**  
Naming: halo-  
e.g. chloroethane



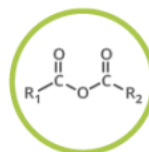
**ALDEHYDE**  
Naming: -al  
e.g. ethanal



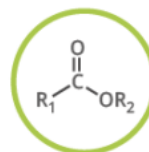
**KETONE**  
Naming: -one  
e.g. propanone



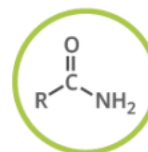
**CARBOXYLIC ACID**  
Naming: -oic acid  
e.g. ethanoic acid



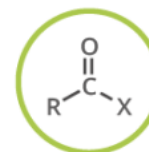
**ACID ANHYDRIDE**  
Naming: -oic anhydride  
e.g. ethanoic anhydride



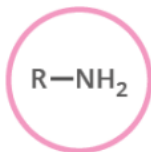
**ESTER**  
Naming: -yl -oate  
e.g. ethyl ethanoate



**AMIDE**  
Naming: -amide  
e.g. ethanamide



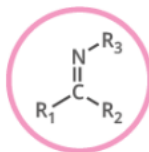
**ACYL HALIDE**  
Naming: -oyl halide  
e.g. ethanoyl chloride



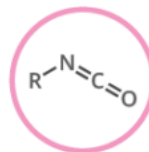
**AMINE**  
Naming: -amine  
e.g. ethanamine



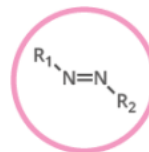
**NITRILE**  
Naming: -nitrile  
e.g. ethanenitrile



**IMINE**  
Naming: -imine  
e.g. ethanimine



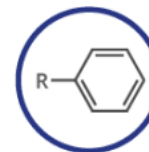
**ISOCYANATE**  
Naming: -yl isocyanate  
e.g. ethyl isocyanate



**AZO COMPOUND**  
Naming: -azo-  
e.g. azoethane



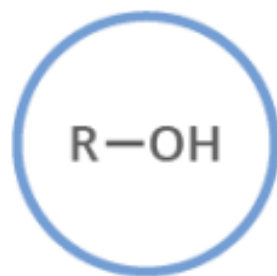
**THIOL**  
Naming: -thiol  
e.g. methanethiol



**ARENE**  
Naming: -yl benzene  
e.g. ethyl benzene



# Alcohols



ALCOHOL  
*Naming: -ol*  
e.g. ethanol

# Daily Life Alcohols

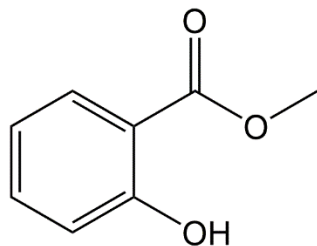




# Daily Life Alcohols

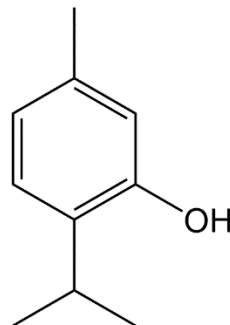


# Daily Life Alcohols

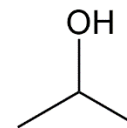


Methyl Salicylate  
Methyl 2-Hydroxybenzoate

Listerine

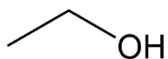


Thymol  
5-Methyl-2-(propan-2-yl)phenol



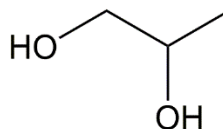
Isopropyl Alcohol (IPA)  
2-Propanol

Rubbing Alcohol



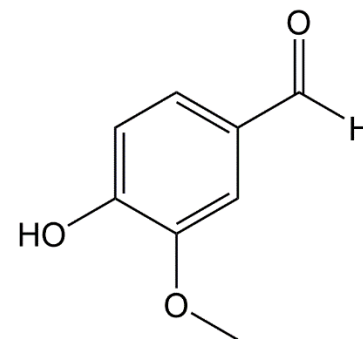
Ethanol

Cooking Extracts  
Wine  
Beer



Propylene Glycol  
Propane-1,2-diol

Rum Extract



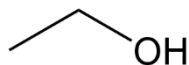
Vanillin  
4-Hydroxy-3-methoxybenzaldehyde

Vanilla Extract

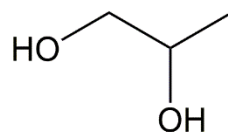
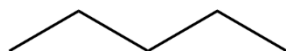
# Problem 1

Explain, at the molecular level, why the active flavor agents for rum and vanilla extracts are dissolved in a water-ethanol solvent blend as opposed to a solvent such as pentane?

Ethanol

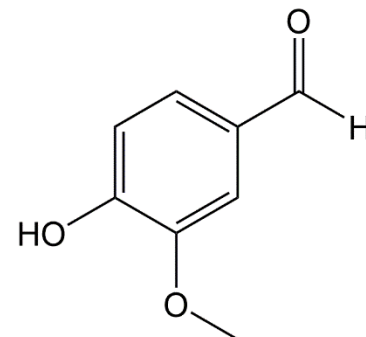


Pentane



Propylene Glycol  
Propane-1,2-diol

Rum Extract



Vanillin  
4-Hydroxy-3-methoxybenzaldehyde

Vanilla Extract



# Disinfectants and Antiseptics

## A BRIEF SUMMARY OF DISINFECTANTS & ANTISEPTICS

**Key:** USED FOR ANTISEPSIS USED TO DISINFECT SURFACES USED FOR STERILISATION (E.G. MEDICAL INSTRUMENTS) USED FOR PRESERVATION

<p><b>ALCOHOLS</b></p> <p>USED IN ALCOHOL-BASED SANITARY HAND GELS PRESENT IN HOSPITALS</p> <div> <chem>CCO</chem> ETHANOL         </div> <div> <chem>CC(C)O</chem> ISOPROPANOL         </div> <div> </div> <p>Kill many bacteria and fungi, and some viruses, when used at suitably high concentrations (usually 60-90% solution). Slow-acting, and evaporate easily, so lack residual action. Can't be used to sterilise.</p>	<p><b>ALDEHYDES</b></p> <p>MAINLY USED FOR DISINFECTION &amp; STERILISATION OF MEDICAL INSTRUMENTS</p> <div> <chem>C=O</chem> FORMALDEHYDE         </div> <div> <chem>O=CC=O</chem> GLUTARALDEHYDE         </div> <div> </div> <p>Show broad activity against bacteria, fungi, and viruses. Not used for general antiseptics, due to their high toxicity. Due to the relatively long contact times required to disinfect, other agents are often preferred.</p>	<p><b>BIGUANIDES</b></p> <p>USED IN CREAMS &amp; FOR SKIN ANTISEPSIS IN SURGICAL PROCEDURES</p> <div> <chem>Clc1ccc(cc1)Nc2c[nH]c3c2Nc4c[nH]c5c4Nc6c[nH]c7c6Nc8c[nH]c9c8Nc10c[nH]c11c10Nc12c[nH]c13c12Nc14c[nH]c15c14Nc16c[nH]c17c16Nc18c[nH]c19c18Nc20c[nH]c21c20Nc22c[nH]c23c22Nc24c[nH]c25c24Nc26c[nH]c27c26Nc28c[nH]c29c28Nc30c[nH]c31c30Nc32c[nH]c33c32Nc34c[nH]c35c34Nc36c[nH]c37c36Nc38c[nH]c39c38Nc40c[nH]c41c40Nc42c[nH]c43c42Nc44c[nH]c45c44Nc46c[nH]c47c46Nc48c[nH]c49c48Nc50c[nH]c51c50Nc52c[nH]c53c52Nc54c[nH]c55c54Nc56c[nH]c57c56Nc58c[nH]c59c58Nc60c[nH]c61c60Nc62c[nH]c63c62Nc64c[nH]c65c64Nc66c[nH]c67c66Nc68c[nH]c69c68Nc70c[nH]c71c70Nc72c[nH]c73c72Nc74c[nH]c75c74Nc76c[nH]c77c76Nc78c[nH]c79c78Nc80c[nH]c81c80Nc82c[nH]c83c82Nc84c[nH]c85c84Nc86c[nH]c87c86Nc88c[nH]c89c88Nc90c[nH]c91c90Nc92c[nH]c93c92Nc94c[nH]c95c94Nc96c[nH]c97c96Nc98c[nH]c99c98Nc100c[nH]c101c100Nc102c[nH]c103c102Nc104c[nH]c105c104Nc106c[nH]c107c106Nc108c[nH]c109c108Nc110c[nH]c111c110Nc112c[nH]c113c112Nc114c[nH]c115c114Nc116c[nH]c117c116Nc118c[nH]c119c118Nc120c[nH]c121c120Nc122c[nH]c123c122Nc124c[nH]c125c124Nc126c[nH]c127c126Nc128c[nH]c129c128Nc130c[nH]c131c130Nc132c[nH]c133c132Nc134c[nH]c135c134Nc136c[nH]c137c136Nc138c[nH]c139c138Nc140c[nH]c141c140Nc142c[nH]c143c142Nc144c[nH]c145c144Nc146c[nH]c147c146Nc148c[nH]c149c148Nc150c[nH]c151c150Nc152c[nH]c153c152Nc154c[nH]c155c154Nc156c[nH]c157c156Nc158c[nH]c159c158Nc160c[nH]c161c160Nc162c[nH]c163c162Nc164c[nH]c165c164Nc166c[nH]c167c166Nc168c[nH]c169c168Nc170c[nH]c171c170Nc172c[nH]c173c172Nc174c[nH]c175c174Nc176c[nH]c177c176Nc178c[nH]c179c178Nc180c[nH]c181c180Nc182c[nH]c183c182Nc184c[nH]c185c184Nc186c[nH]c187c186Nc188c[nH]c189c188Nc190c[nH]c191c190Nc192c[nH]c193c192Nc194c[nH]c195c194Nc196c[nH]c197c196Nc198c[nH]c199c198Nc200c[nH]c201c200Nc202c[nH]c203c202Nc204c[nH]c205c204Nc206c[nH]c207c206Nc208c[nH]c209c208Nc210c[nH]c211c210Nc212c[nH]c213c212Nc214c[nH]c215c214Nc216c[nH]c217c216Nc218c[nH]c219c218Nc220c[nH]c221c220Nc222c[nH]c223c222Nc224c[nH]c225c224Nc226c[nH]c227c226Nc228c[nH]c229c228Nc230c[nH]c231c230Nc232c[nH]c233c232Nc234c[nH]c235c234Nc236c[nH]c237c236Nc238c[nH]c239c238Nc240c[nH]c241c240Nc242c[nH]c243c242Nc244c[nH]c245c244Nc246c[nH]c247c246Nc248c[nH]c249c248Nc250c[nH]c251c250Nc252c[nH]c253c252Nc254c[nH]c255c254Nc256c[nH]c257c256Nc258c[nH]c259c258Nc260c[nH]c261c260Nc262c[nH]c263c262Nc264c[nH]c265c264Nc266c[nH]c267c266Nc268c[nH]c269c268Nc270c[nH]c271c270Nc272c[nH]c273c272Nc274c[nH]c275c274Nc276c[nH]c277c276Nc278c[nH]c279c278Nc280c[nH]c281c280Nc282c[nH]c283c282Nc284c[nH]c285c284Nc286c[nH]c287c286Nc288c[nH]c289c288Nc290c[nH]c291c290Nc292c[nH]c293c292Nc294c[nH]c295c294Nc296c[nH]c297c296Nc298c[nH]c299c298Nc300c[nH]c301c300Nc302c[nH]c303c302Nc304c[nH]c305c304Nc306c[nH]c307c306Nc308c[nH]c309c308Nc310c[nH]c311c310Nc312c[nH]c313c312Nc314c[nH]c315c314Nc316c[nH]c317c316Nc318c[nH]c319c318Nc320c[nH]c321c320Nc322c[nH]c323c322Nc324c[nH]c325c324Nc326c[nH]c327c326Nc328c[nH]c329c328Nc330c[nH]c331c330Nc332c[nH]c333c332Nc334c[nH]c335c334Nc336c[nH]c337c336Nc338c[nH]c339c338Nc340c[nH]c341c340Nc342c[nH]c343c342Nc344c[nH]c345c344Nc346c[nH]c347c346Nc348c[nH]c349c348Nc350c[nH]c351c350Nc352c[nH]c353c352Nc354c[nH]c355c354Nc356c[nH]c357c356Nc358c[nH]c359c358Nc360c[nH]c361c360Nc362c[nH]c363c362Nc364c[nH]c365c364Nc366c[nH]c367c366Nc368c[nH]c369c368Nc370c[nH]c371c370Nc372c[nH]c373c372Nc374c[nH]c375c374Nc376c[nH]c377c376Nc378c[nH]c379c378Nc380c[nH]c381c380Nc382c[nH]c383c382Nc384c[nH]c385c384Nc386c[nH]c387c386Nc388c[nH]c389c388Nc390c[nH]c391c390Nc392c[nH]c393c392Nc394c[nH]c395c394Nc396c[nH]c397c396Nc398c[nH]c399c398Nc400c[nH]c401c400Nc402c[nH]c403c402Nc404c[nH]c405c404Nc406c[nH]c407c406Nc408c[nH]c409c408Nc410c[nH]c411c410Nc412c[nH]c413c412Nc414c[nH]c415c414Nc416c[nH]c417c416Nc418c[nH]c419c418Nc420c[nH]c421c420Nc422c[nH]c423c422Nc424c[nH]c425c424Nc426c[nH]c427c426Nc428c[nH]c429c428Nc430c[nH]c431c430Nc432c[nH]c433c432Nc434c[nH]c435c434Nc436c[nH]c437c436Nc438c[nH]c439c438Nc440c[nH]c441c440Nc442c[nH]c443c442Nc444c[nH]c445c444Nc446c[nH]c447c446Nc448c[nH]c449c448Nc450c[nH]c451c450Nc452c[nH]c453c452Nc454c[nH]c455c454Nc456c[nH]c457c456Nc458c[nH]c459c458Nc460c[nH]c461c460Nc462c[nH]c463c462Nc464c[nH]c465c464Nc466c[nH]c467c466Nc468c[nH]c469c468Nc470c[nH]c471c470Nc472c[nH]c473c472Nc474c[nH]c475c474Nc476c[nH]c477c476Nc478c[nH]c479c478Nc480c[nH]c481c480Nc482c[nH]c483c482Nc484c[nH]c485c484Nc486c[nH]c487c486Nc488c[nH]c489c488Nc490c[nH]c491c490Nc492c[nH]c493c492Nc494c[nH]c495c494Nc496c[nH]c497c496Nc498c[nH]c499c498Nc500c[nH]c501c500Nc502c[nH]c503c502Nc504c[nH]c505c504Nc506c[nH]c507c506Nc508c[nH]c509c508Nc510c[nH]c511c510Nc512c[nH]c513c512Nc514c[nH]c515c514Nc516c[nH]c517c516Nc518c[nH]c519c518Nc520c[nH]c521c520Nc522c[nH]c523c522Nc524c[nH]c525c524Nc526c[nH]c527c526Nc528c[nH]c529c528Nc530c[nH]c531c530Nc532c[nH]c533c532Nc534c[nH]c535c534Nc536c[nH]c537c536Nc538c[nH]c539c538Nc540c[nH]c541c540Nc542c[nH]c543c542Nc544c[nH]c545c544Nc546c[nH]c547c546Nc548c[nH]c549c548Nc550c[nH]c551c550Nc552c[nH]c553c552Nc554c[nH]c555c554Nc556c[nH]c557c556Nc558c[nH]c559c558Nc560c[nH]c561c560Nc562c[nH]c563c562Nc564c[nH]c565c564Nc566c[nH]c567c566Nc568c[nH]c569c568Nc570c[nH]c571c570Nc572c[nH]c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# Disinfectants and Antiseptics

Key:



USED FOR ANTISEPSIS



USED TO DISINFECT SURFACES



USED FOR STERILISATION (E.G. MEDICAL INSTRUMENTS)



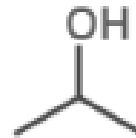
USED FOR PRESERVATION

## ALCOHOLS

USED IN ALCOHOL-BASED SANITARY HAND GELS PRESENT IN HOSPITALS



ETHANOL

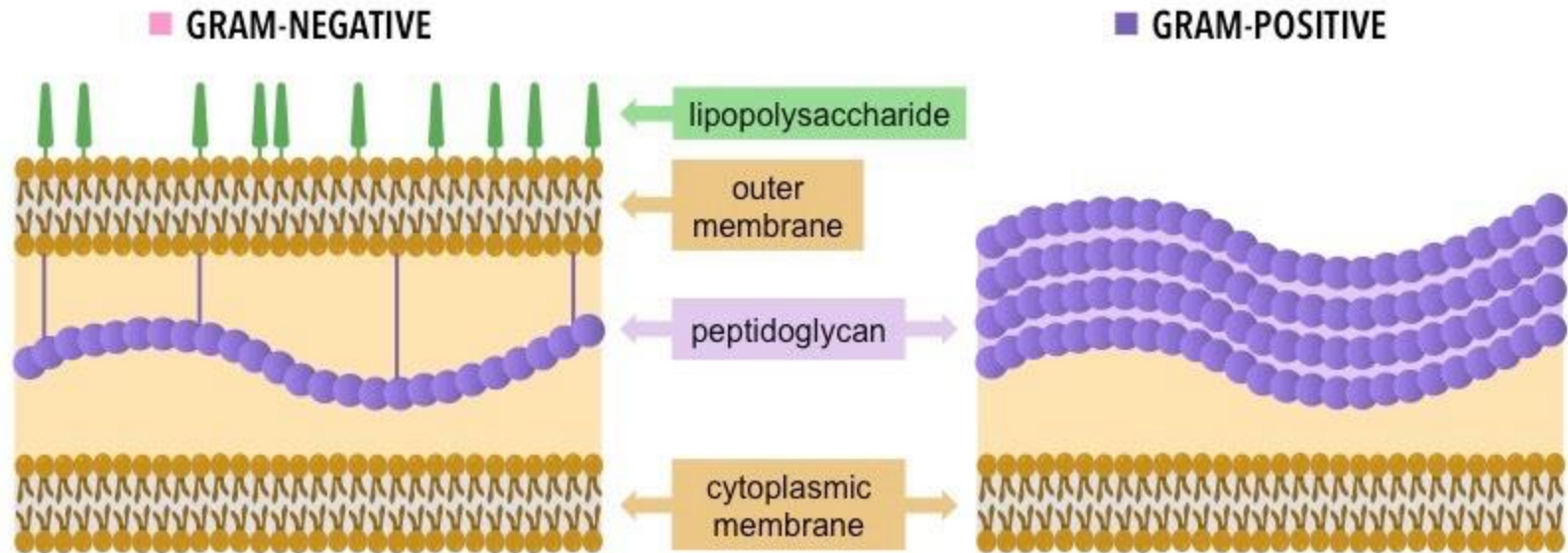


ISOPROPANOL

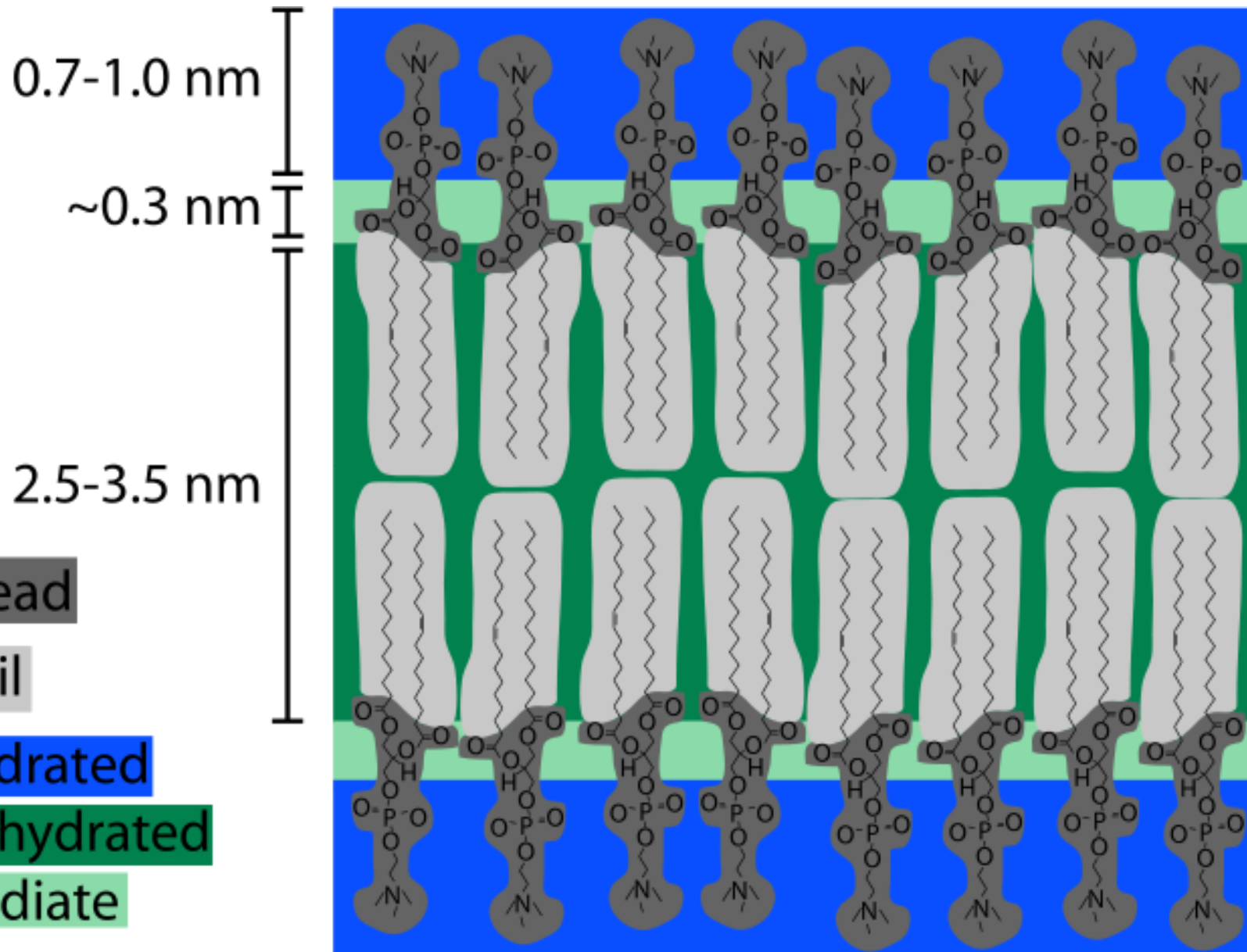


Kill many bacteria and fungi, and some viruses, when used at suitably high concentrations (usually 60-90% solution). Slow-acting, and evaporate easily, so lack residual action. Can't be used to sterilise.

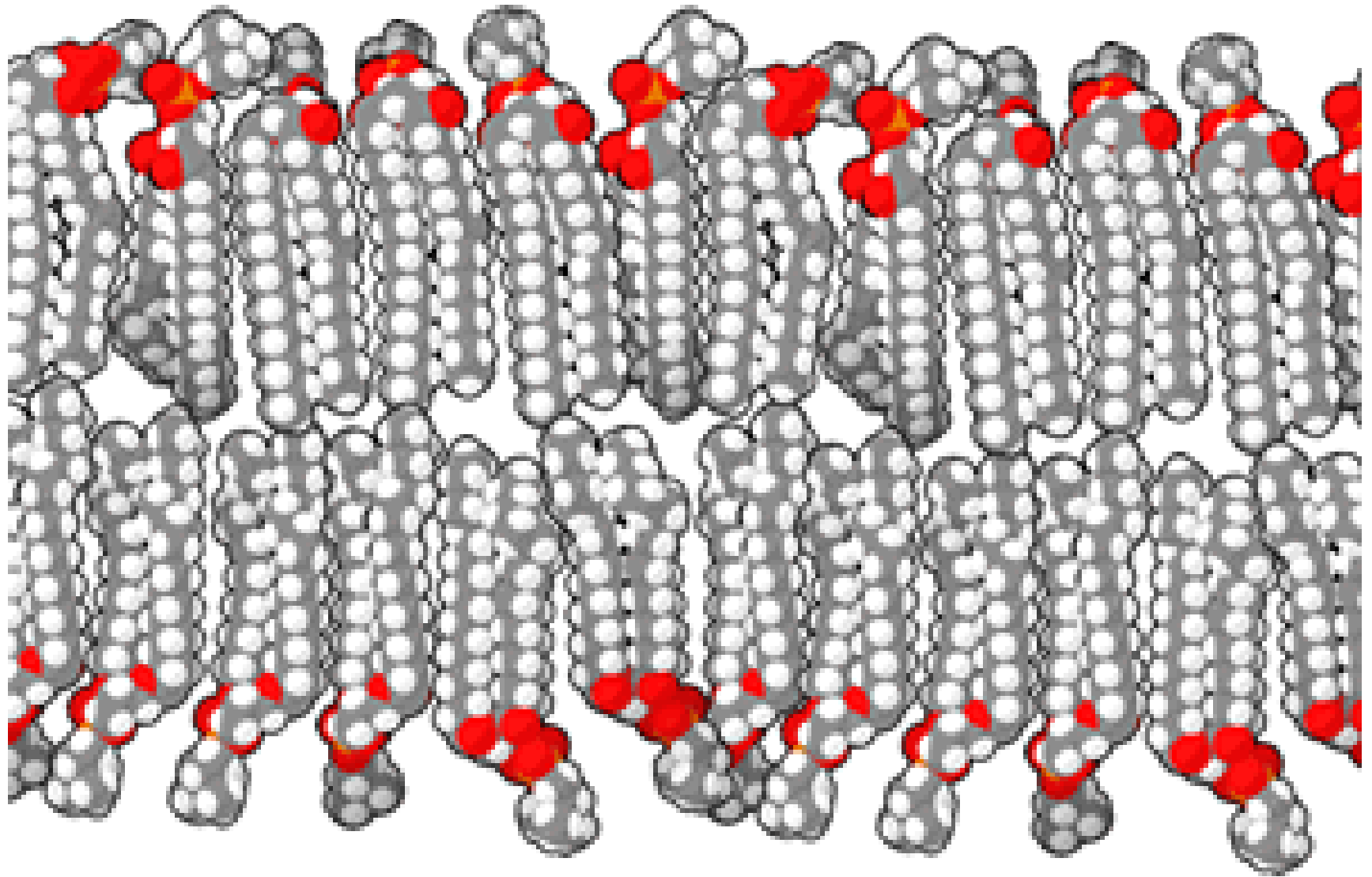
# Bacterial Cell Walls



# Bacterium Cell Membrane Architecture



# Bacterium Cell Membrane Architecture





# Ethanol Lipid Bilayer Simulation

<https://www.youtube.com/watch?v=9RmeDPqYUMI>



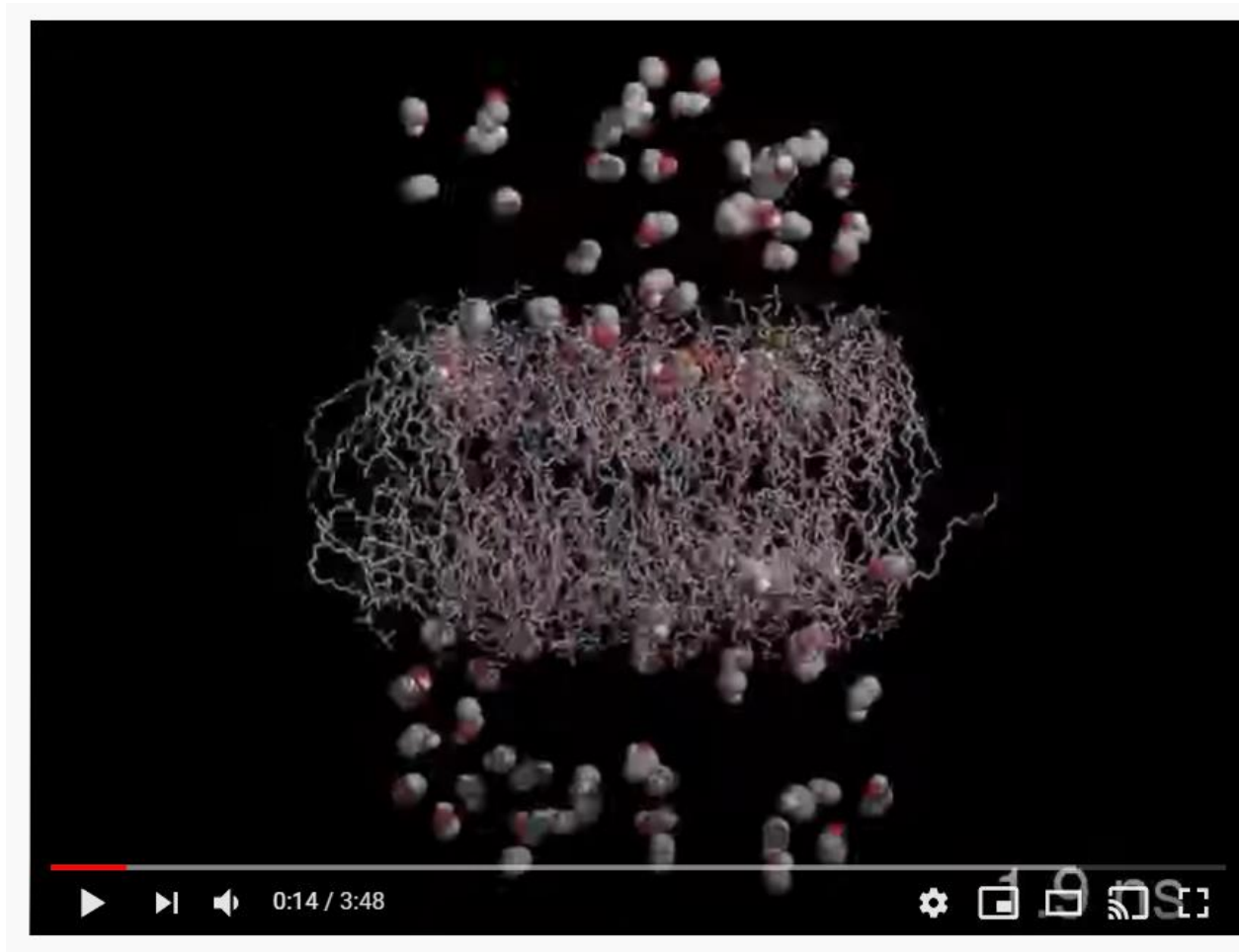
Ethanol interacting with a membrane

15,036 views • Apr 30, 2009

👍 49    🗨️ 2    ➦ SHARE    ≡+ SAVE    ...

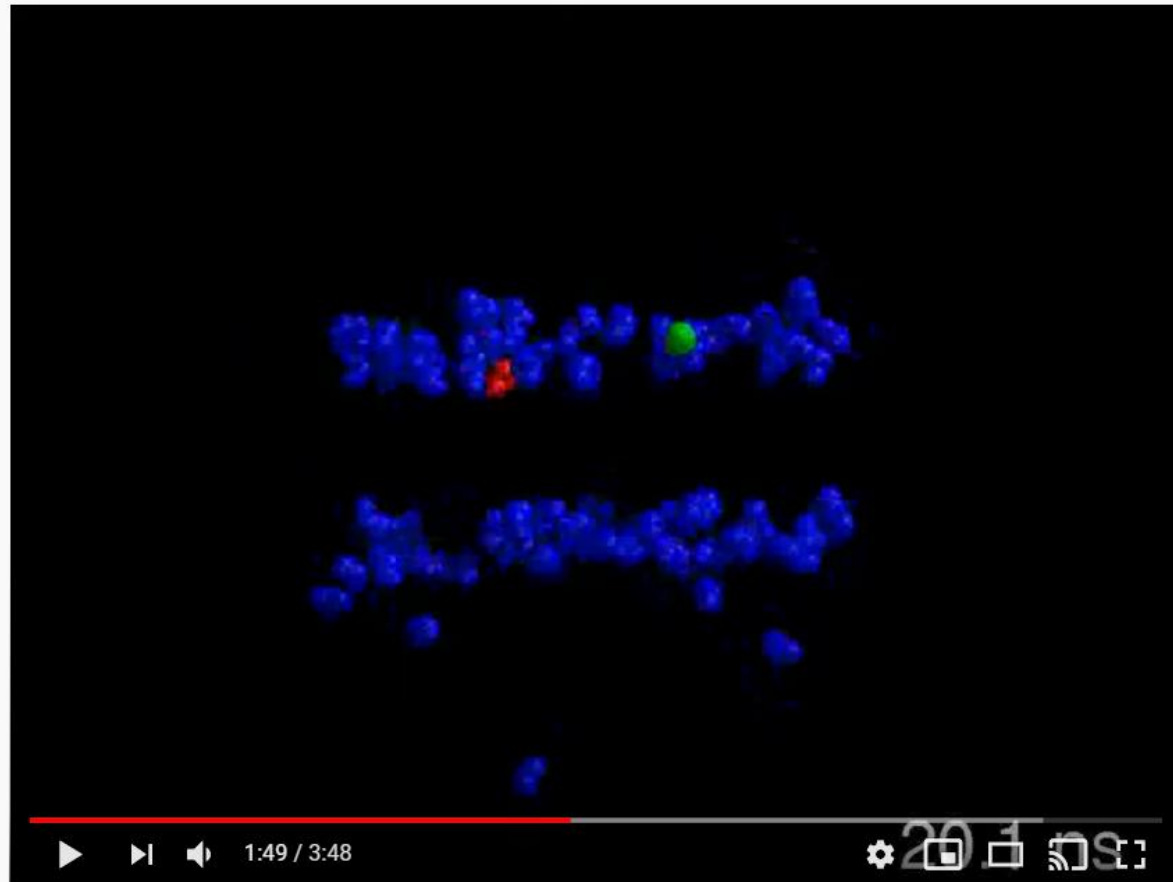
# Ethanol Lipid Bilayer Simulation

Watch 0:00 to 0:20

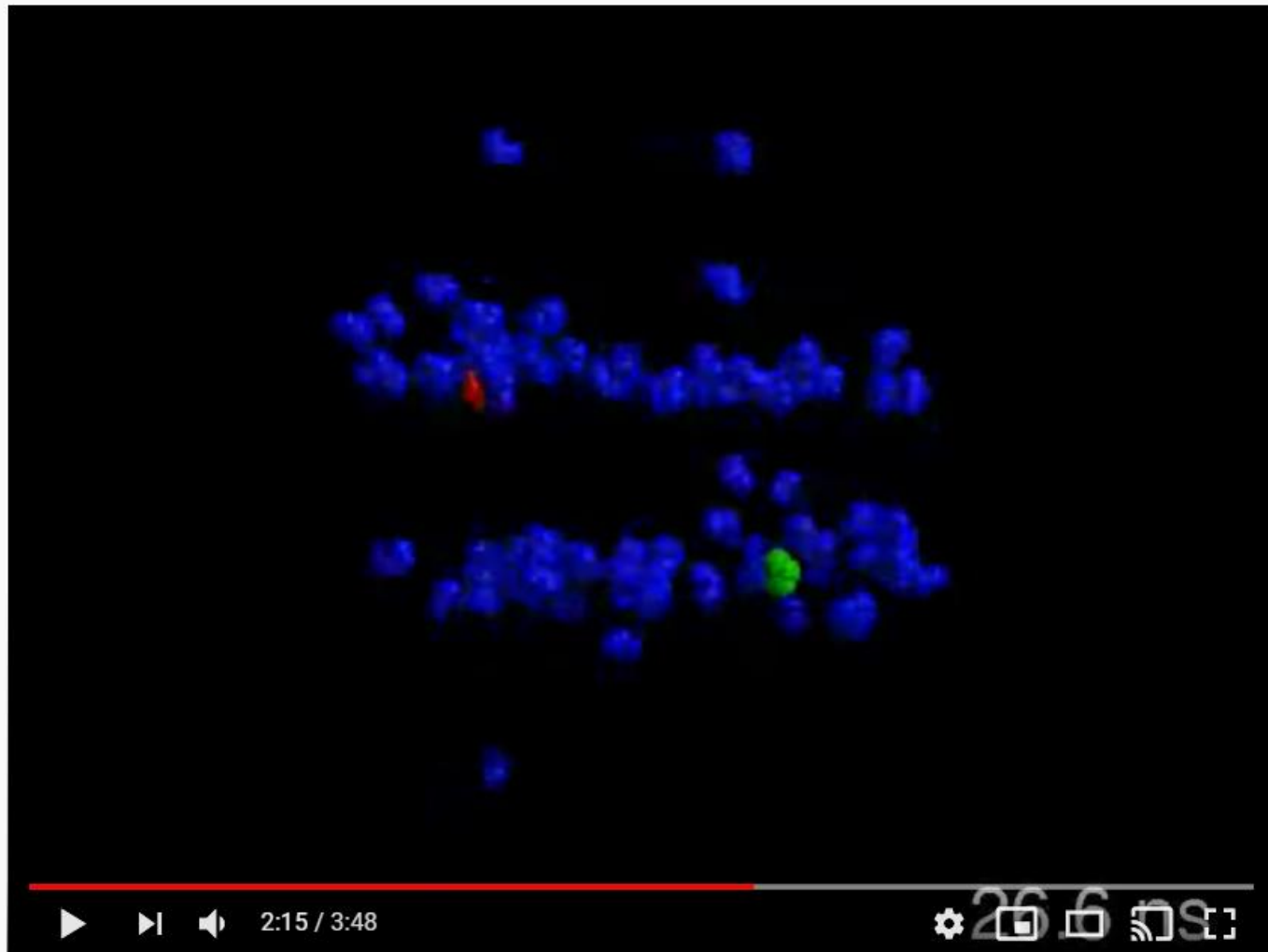


# Ethanol Lipid Bilayer Simulation

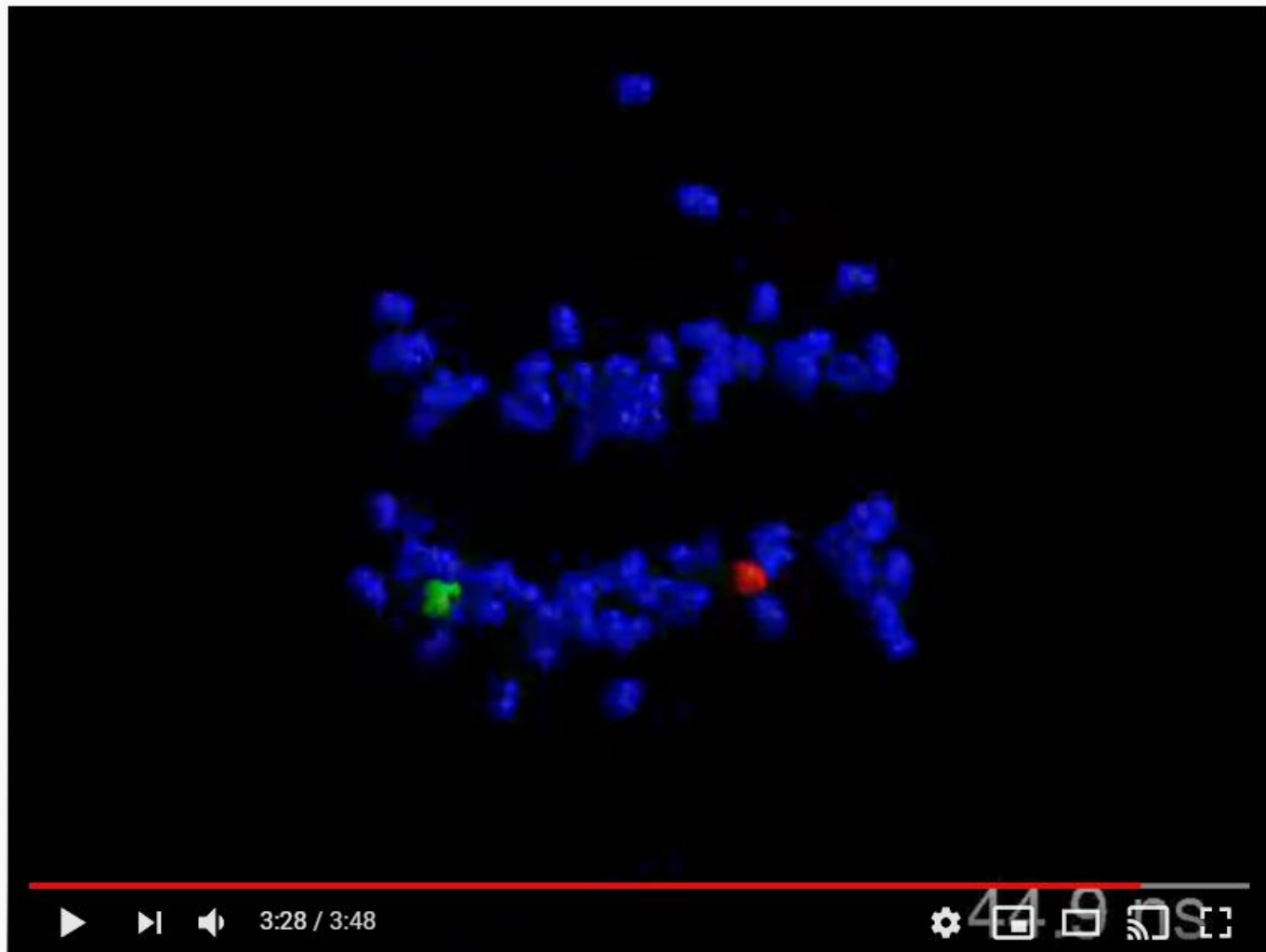
Watch 1:30 to 2:30



# What Occurs at 2:15?



# What Can You Conclude At 3:28?

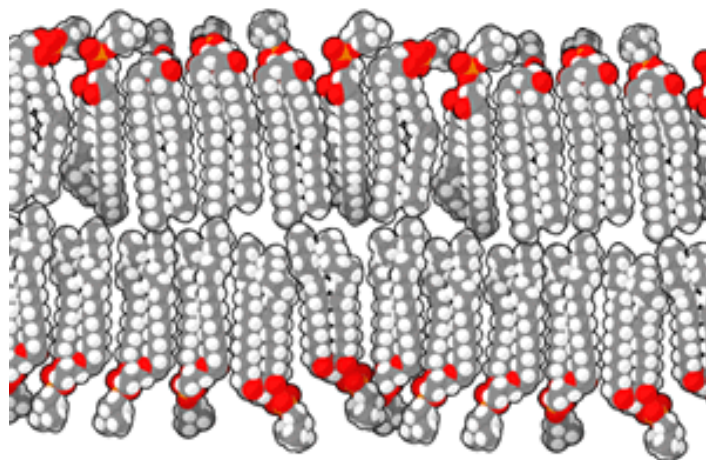




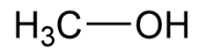
# Problem 2

Do you think an alcohol with a longer alkyl chain than ethanol will penetrate the bacterial membrane 1) faster, 2) the same, or 3) slower? Explain.

# Problem 2



Methanol



Ethanol



Propanol



Butanol



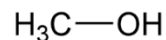
Octanol



# Problem 3

As the number of carbon atoms in the alkyl chain increases, what impact do you think this has on the alcohol's antibacterial potency?

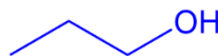
Methanol



Ethanol



Propanol



Butanol

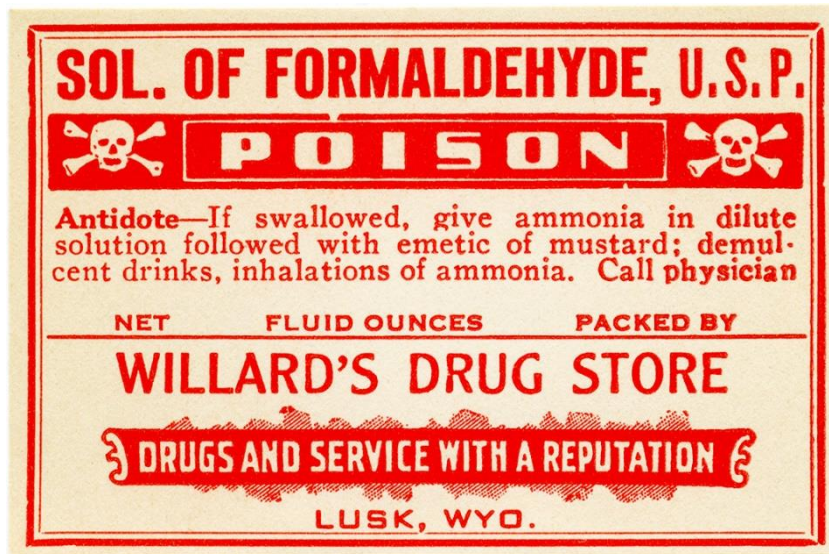


Octanol



# Problem 4

What is your definition for alcohol poisoning?



# Alcohol Poisoning

## Life-threatening signs of alcohol poisoning include:



Inability to wake up



Vomiting



Slow breathing  
(fewer than 8 breaths per minute)



Irregular breathing  
(10 seconds or more between breaths)



Seizures



Hypothermia  
(low body temperature),  
bluish skin color, paleness

## What is a “standard drink” in the US?



12 ounces  
of beer  
5% Alcohol



8 ounces  
of malt liquor  
7% Alcohol



5 ounces  
of wine  
12% Alcohol

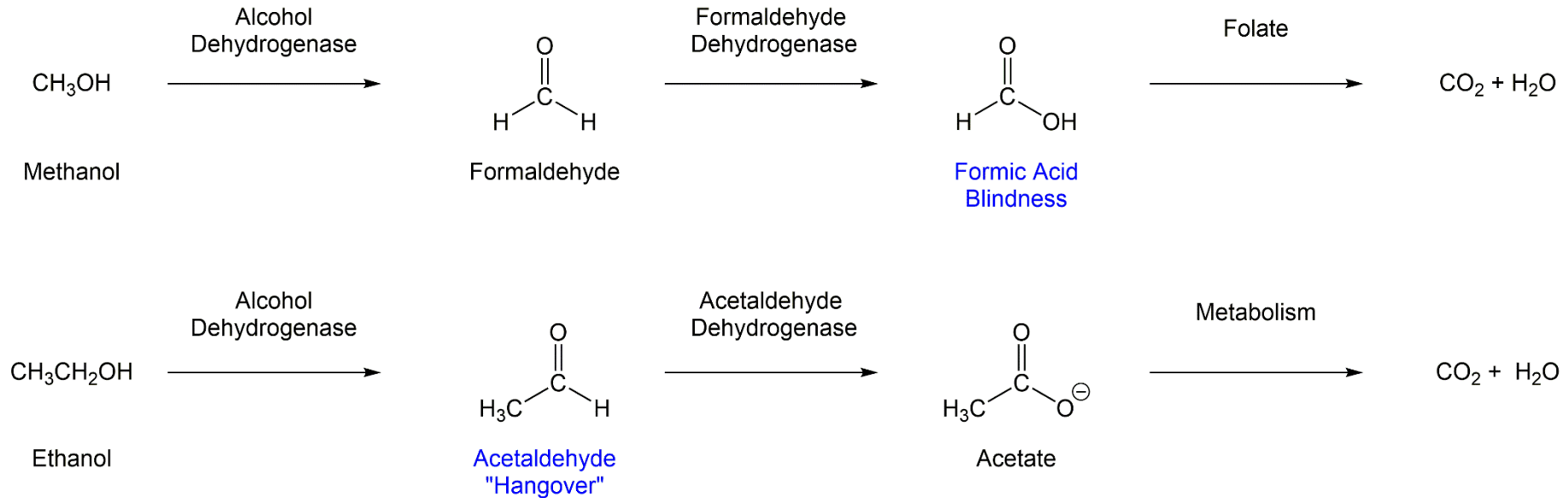


1.5 ounces of distilled spirits  
40% alcohol (80 proof)  
e.g., vodka, whiskey, gin, rum

SOURCE: National Institute for Alcohol Abuse and Alcoholism.



# Metabolism (Oxidation) of Methanol and Ethanol By Liver Alcohol Dehydrogenase



# Formic Acid Toxicity

## ANT VENOM AND PHEROMONES

Ant bites and stings can cause intense pain. Here, we highlight some of the chemical components in ant venom that are responsible and zero in on molecular signals the insects use to communicate.

### ANT VENOM

**71%**  
OF ANTS ARE  
STINGING SPECIES

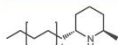
**DRY VENOM  
PRODUCED**  
**10–300 µg**

#### FORMIC ACID



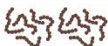
Formic acid is the main component of many ant venoms, present at concentrations of up to 70% by volume.

#### ALKALOIDS



Some ant species, including fire ants, have alkaloids in their venoms. These compounds can have toxic effects.

#### PEPTIDES



Cytolytic peptides penetrate and destroy cells. Neurotoxic peptides, less common in ant venom, target ion channels.

#### PROTEINS



Proteins can act as neurotoxins. They can also cause inflammation, act as allergens, and promote venom diffusion.

### PAIN AND ITS APPROXIMATE DURATION

INCREASING PAIN →

**SOUTHERN  
FIREANT**  
5 min

**ARMY  
ANT**  
5 min

**RED IMPORTED  
FIREANT**  
5 min

**BULLET  
ANT**  
300 min

Source: Schmidt Sting Pain Index



Credit: Shutterstock

### ANT PHEROMONES

Ants secrete pheromones. These are chemicals used to communicate with other ants for a variety of purposes, including to warn them and to signal food.



#### ALARM

#### FORMIC ACID



Secreted to warn other ants of dangers such as predators



#### TRAILS

#### PYRAZINES

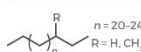


Used as a scent trail to guide other ants to food sources



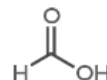
#### REPRODUCTION

#### HYDROCARBONS



Secreted by queens to stop the reproduction of workers

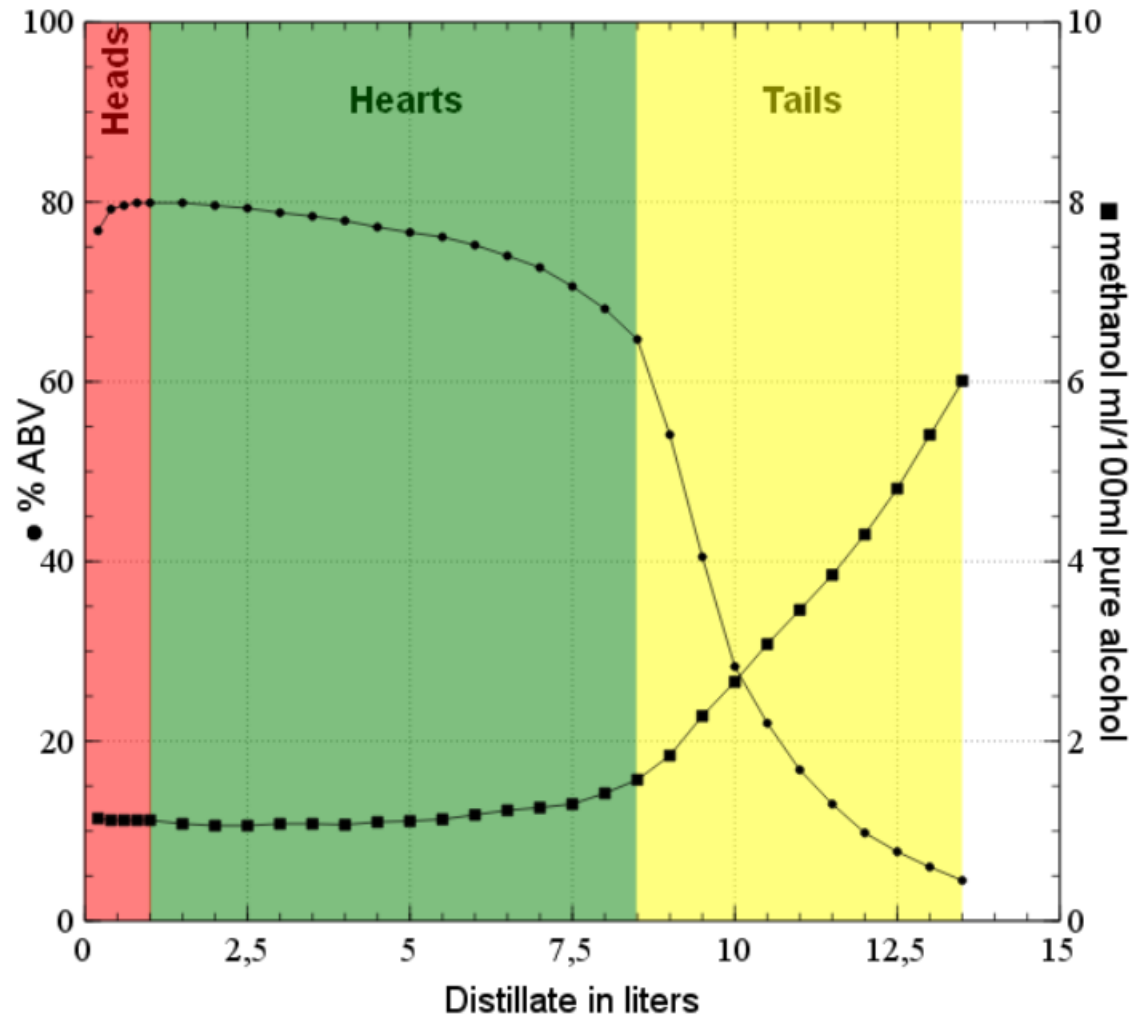
### FORMIC ACID



Formic acid is the main component of many ant venoms, present at concentrations of up to 70% by volume.



# Alcohol Distillation

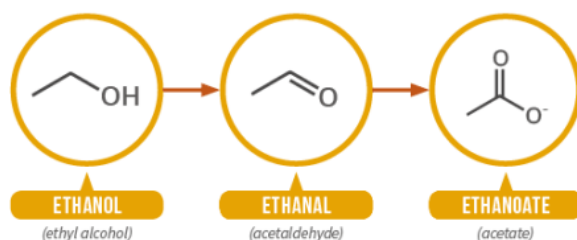


Raw material: 130 l fermented williams pear 5,7% ABV methanol concentration 1,6 ml/100 ml p.a.

# Metabolism of Ethanol

## THE CHEMISTRY OF A HANGOVER

For most of us, a hangover is the price to pay for a night of drinking. However, we still don't know what exactly it is that causes them. In this graphic, we look at what happens to alcohol in your body, and some of the prime suspects for causing your hangover.



### WHAT HAPPENS TO ALCOHOL IN YOUR BODY?

In the liver, ethanol is converted to acetaldehyde by the alcohol dehydrogenase enzyme, and then subsequently converted into acetate by the aldehyde dehydrogenase enzyme. Acetate can be broken down into carbon dioxide and water, then eliminated from the body. On average, the liver can break down alcohol at the rate of one unit (8 grams or 10 millilitres of pure alcohol) every hour.

1

### DEHYDRATION

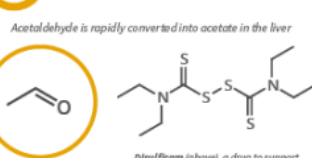


During alcohol intoxication, release of the anti-diuretic hormone (ADH) vasopressin is decreased, resulting in increased urination.

Alcohol has a diuretic effect on the body, increasing urine production. Alcohol-induced dehydration has been suggested as a cause for some hangover symptoms, but research suggests it isn't a major factor.

2

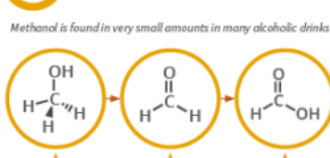
### ACETALDEHYDE



Acetaldehyde, produced by the breakdown of alcohol, has toxic effects that could cause hangover symptoms. However, acetaldehyde concentration doesn't significantly correlate with hangover severity.

3

### CONGENERS



Congeners are compounds other than ethanol in drinks. These include alcohols such as methanol, which breaks down into toxic formaldehyde and formic acid. Congeners can increase hangover severity.

4

### IMMUNE SYSTEM

Cytokines are small proteins released by cells which affect other cells. They play an important role in the immune system.



**CYTOKINES INCREASED BY ALCOHOL CONSUMPTION**  
In particular, IL-12 & IFN- $\gamma$  concentration changes show significant correlations with hangover severity

Alcohol causes changes in cytokine concentrations in the immune system. Studies have shown the effects caused by some cytokines are very similar to those of a hangover, strongly supporting their role.



# Breathalyzer Test



Ethanol

**Potassium  
Dichromate**

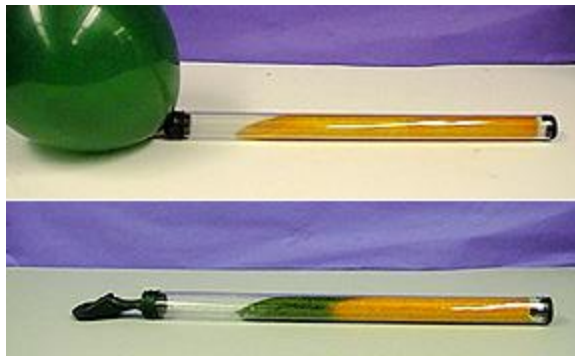
Sulfuric  
Acid

**Chromium (III)  
Sulfate**

Acetic  
Acid

Potassium  
Sulfate

Water

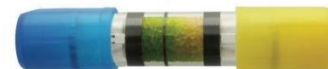


No colour change: **No Alcohol detected**



Some colour change: **Alcohol Present**

You may be impaired. Alcohol levels can rise as well as fall after drinking. **Do not Drive** - wait 60 mins and test again.



**Over the Line - DO NOT DRIVE**

You are Illegal to drive in Scotland, France & Ireland and most likely over the higher limit in England/Wales as well.

