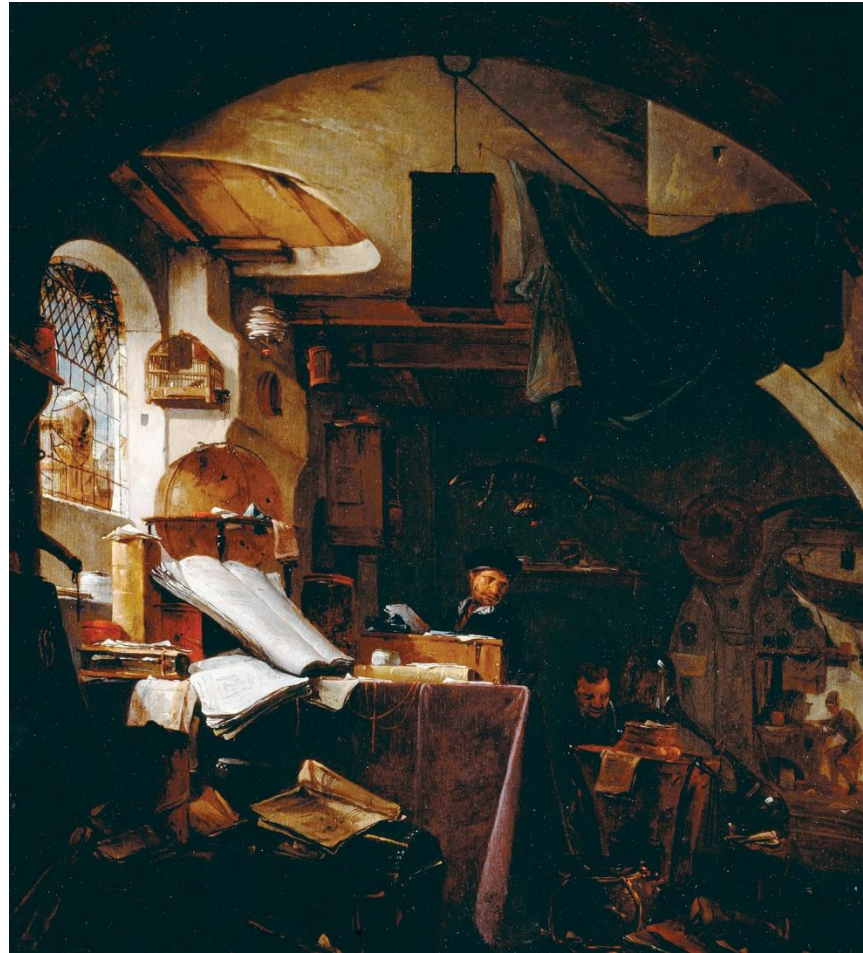


# Alchemy and Organic Chemistry

# Learning Outcomes

1. Describe the connections between alchemy and modern-day chemistry and medicine
2. Describe what an organic compound is
3. Identify elements most often used in organic chemistry
4. Recognize organic structures in industry, biology, and daily life
5. Describe what a functional group is

# Alchemy!!



# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



Lead

Transmutation



Gold

# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

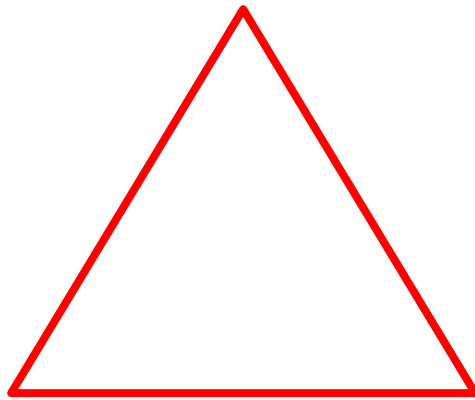
Symbol of eternal cyclic renewal  
“The all is one”



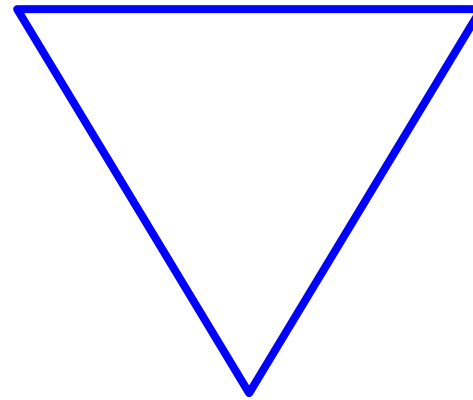
Ouroboros

# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



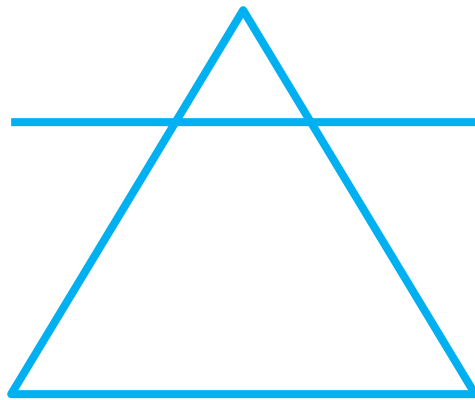
Fire



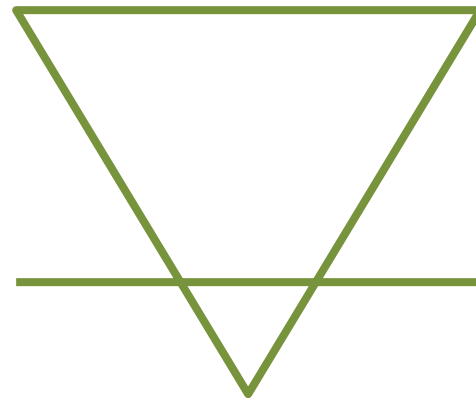
Water

# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



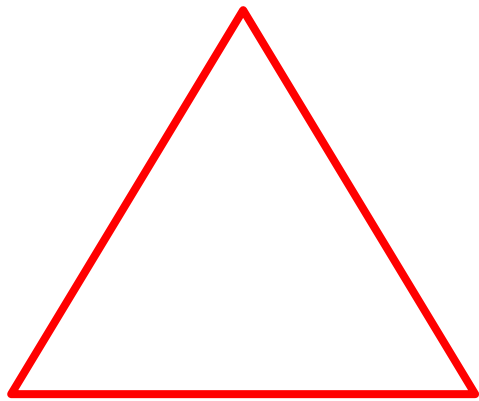
Air



Earth

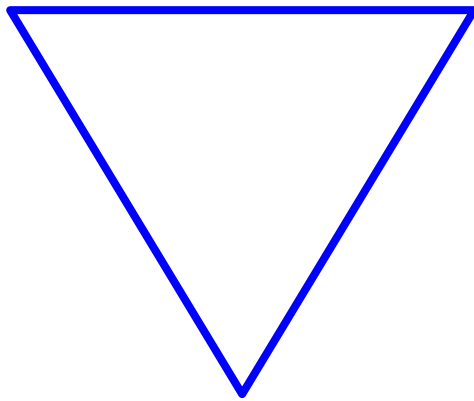
# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



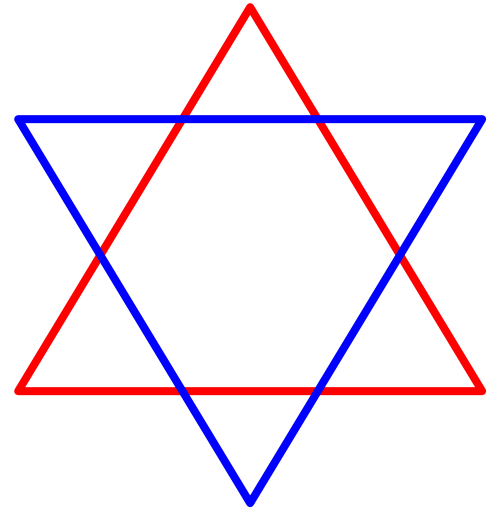
Fire

+



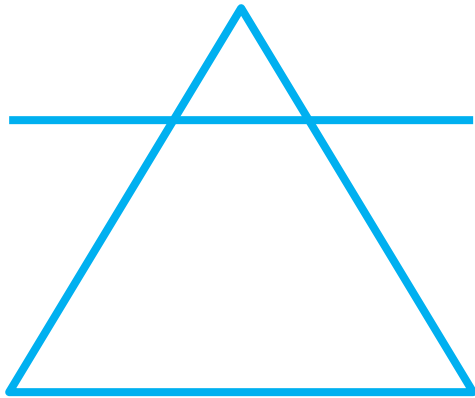
Water

=

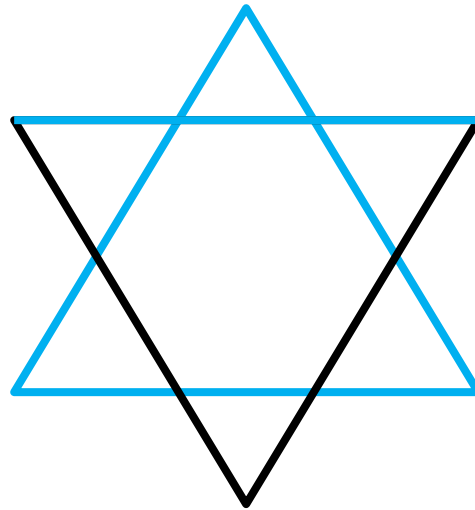


# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

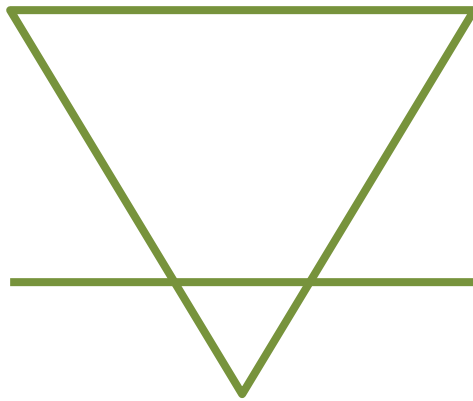


Air

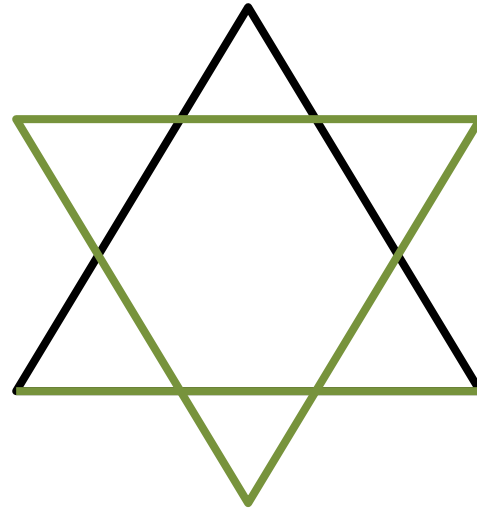


# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

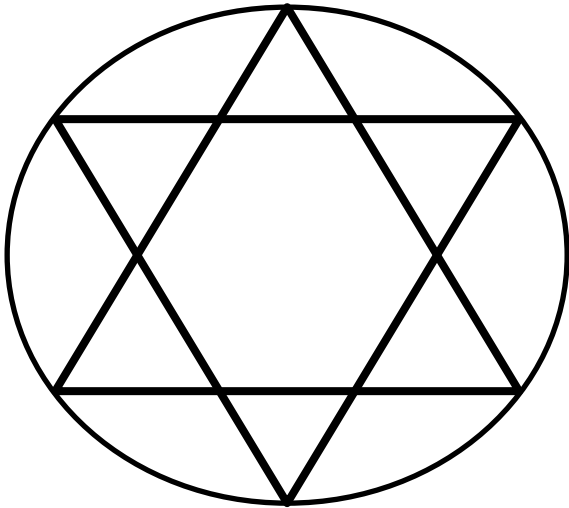


Earth



# Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

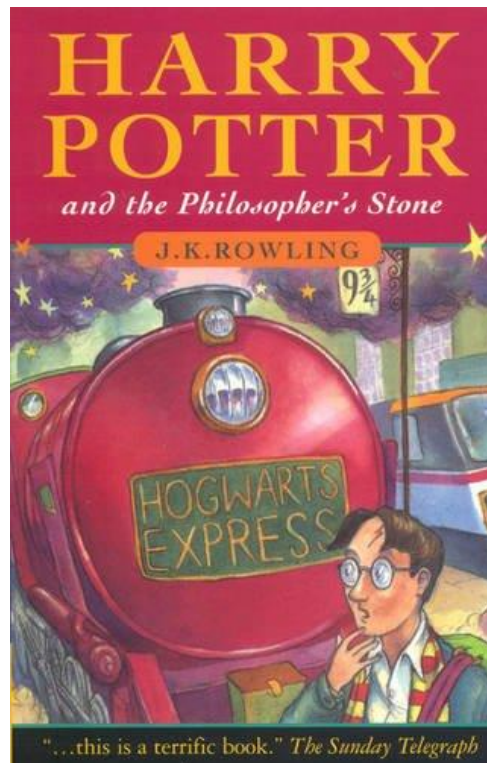
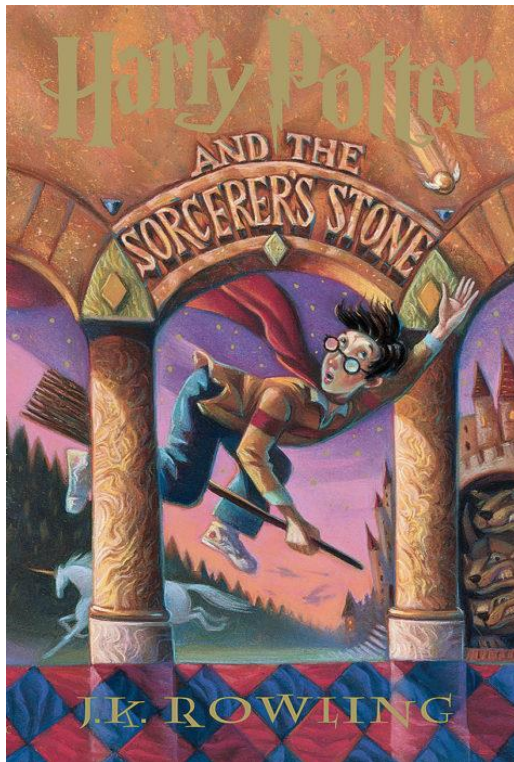


Seal of Solomon

Combination of opposites  
Symbol of balance and transmutation

# Goals of Alchemy

Elixir of Life/Philosopher's Stone: Eternal youth



# Goals of Alchemy

Panacea: A cure-all



# Theophrastus von Hohenheim

Physician and alchemist

One of the first individuals that connected chemistry to medicine

Father of toxicology

*“Only the dose makes the poison”*

Inspiration for the character Von Hohenheim in *Full Metal Alchemist*



Monument to Paracelsus in Beratzhausen, Bavaria



## Paracelsus



1538 portrait by Augustin Hirschvogel

<b>Born</b>	Theophrastus von Hohenheim 1493 or 1494 <sup>[1]</sup> Egg, near Einsiedeln, Schwyz, <sup>[2]</sup> Old Swiss Confederacy (present-day Switzerland)
<b>Died</b>	24 September 1541 (aged 47) Salzburg, Archbishopric of Salzburg (present-day Austria)
<b>Other names</b>	Philippus Aureolus Theophrastus, Doctor Paracelsus
<b>Education</b>	University of Basel University of Ferrara (M.D., 1515/16)
<b>Era</b>	Renaissance philosophy
<b>Region</b>	Western philosophy
<b>School</b>	Renaissance humanism
<b>Notable ideas</b>	Toxicology "The dose makes the poison"
<b>Influences</b>	<a href="#">[show]</a>
<b>Influenced</b>	<a href="#">[show]</a>

# Goals of Alchemy

Alkahest: Universal solvent



# Connections Between Alchemy and Modern Chemistry: Transmutation

Fact or Fiction?: Lead Can be Turned into Gold

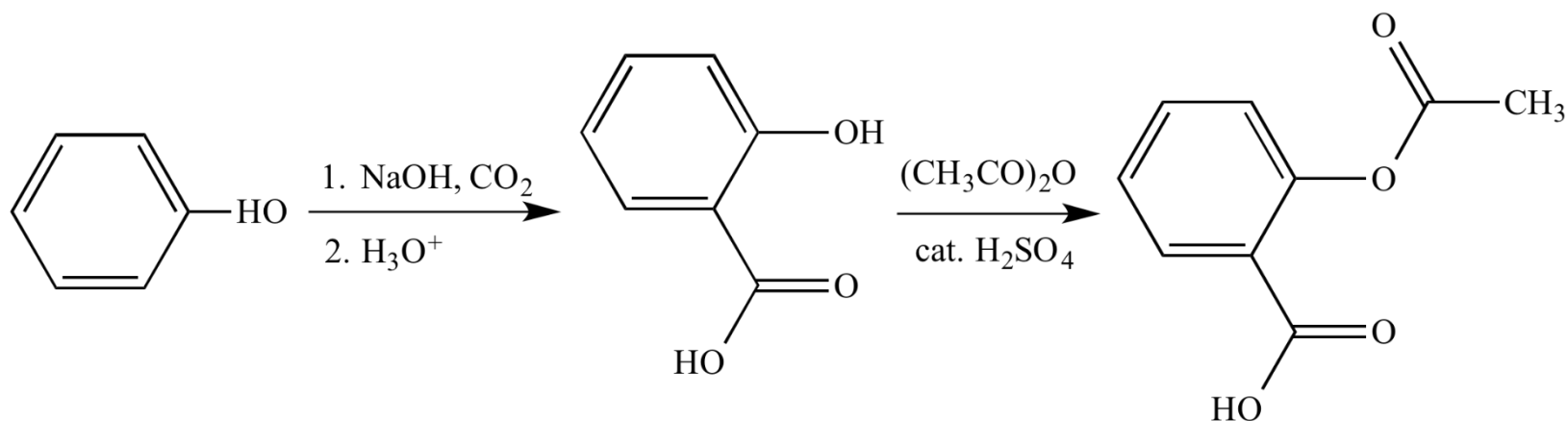
<https://www.scientificamerican.com/article/fact-or-fiction-lead-can-be-turned-into-gold/>

*“It is relatively straightforward to convert lead, bismuth or mercury into gold. The problem is the rate of production is very, very, small and the energy, money, etcetera expended will always exceed the output of gold atoms.”*

*“It would cost more than one quadrillion dollars ( $1 \times 10^{15}$ ) per ounce to produce gold by this experiment.”*

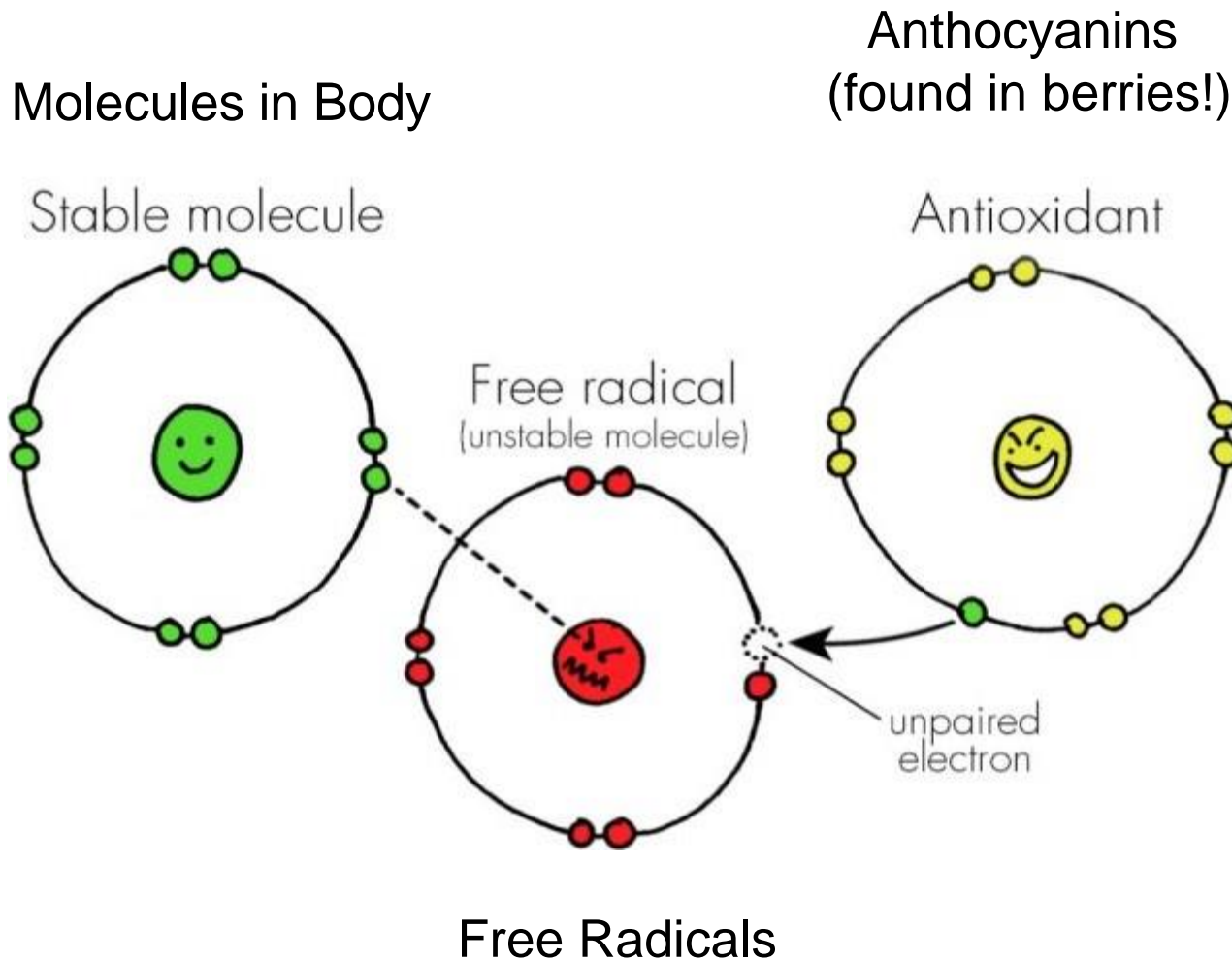
Price of gold on 11-03-2020: 1,896 dollars/ounce

# Connections Between Alchemy and Modern Chemistry: Transmutation



Aspirin!  
(Acetylsalicylic Acid)

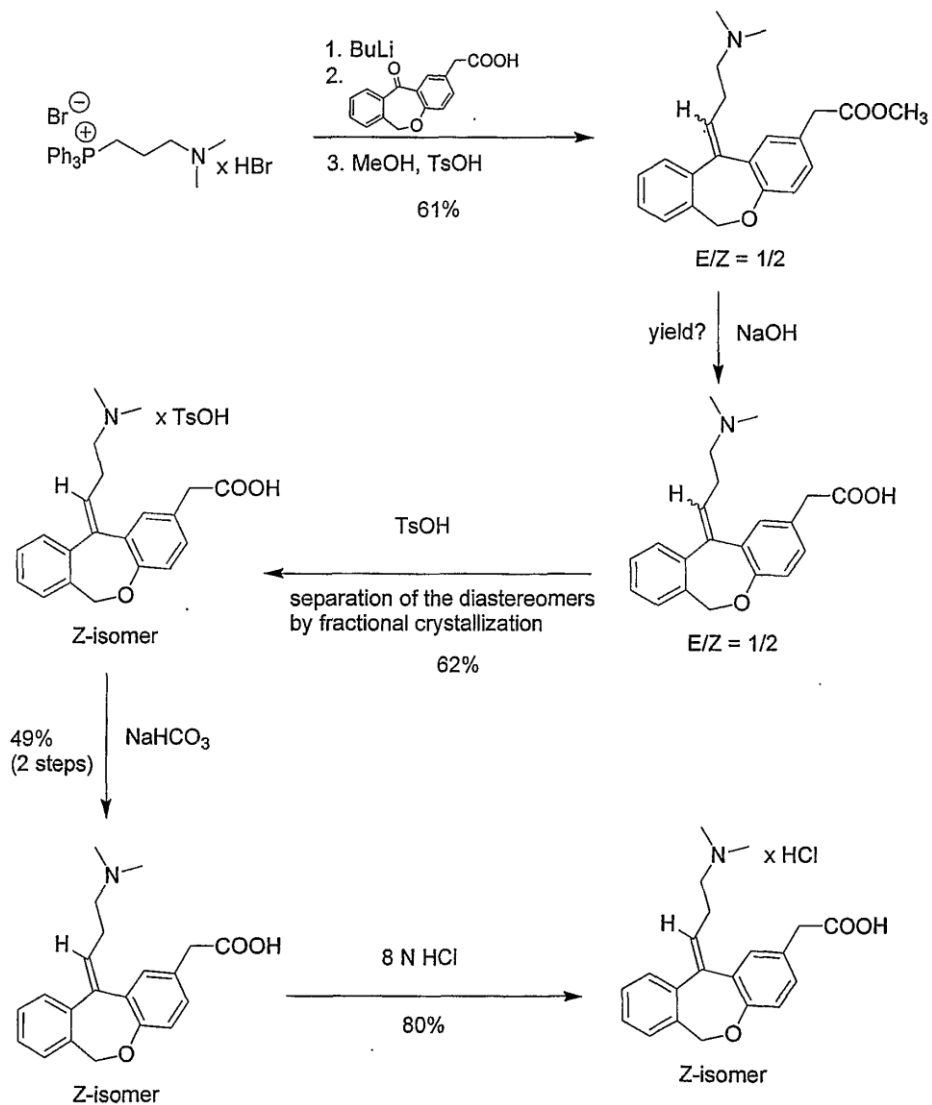
# Connections Between Alchemy and Modern Chemistry: Philosopher's Stone



# Connections Between Alchemy and Modern Chemistry: Panacea



Patanol!  
(Olopatadiene)



# Connections Between Alchemy and Modern Chemistry: Universal Solvent

## Chemical Resistance Chart

This Chemical Resistance Chart is intended to provide general information about the reactions of different glove materials to the chemicals listed. SAS Safety gloves have not been individually tested against these chemicals. Variability in glove thickness, chemical concentration, temperature, and length of exposure to chemicals will affect the performance.

Key: P=Poor, F=Fair, G=Good, E=Excellent, NR=Not Recommended

Chemical	Neoprene	Nitrile	Latex	PVC	Chemical	Neoprene	Nitrile	Latex	PVC
Acetaldehyde	E	P	F	NR	Kerosene	E	E	P	F
Acetic Acid	E	G	G	F	Lactic Acid	E	E	E	E
Acetone	G	NR	G	NR	Lauroic Acid	E	E	G	F
Acetonitrile	F	NR	F	NR	Linoleic Acid	E	E	P	G
Ammonium Hydroxide-30%	E	E	G	E	Linseed Oil	E	E	P	E
Amyl Acetate	NR	E	F	P	Maleic Acid	E	E	P	G
Amyl Alcohol	P	G	G	NR	Methyl Acetate	G	P	P	NR
Aniline	G	NR	P	F	Methyl Alcohol	E	E	G	E
Animal Fats	E	E	P	G	Methylamine	G	E	E	E
Battery Acids	E	E	G	E	Methyl Bromide	NR	NR	NR	NR
Benzaldehyde	NR	NR	F	NR	Methylene Chloride	NR	NR	NR	NR
Benzene	NR	P	NR	NR	Methyl Cellulose	E	F	F	-
Benzoyl Chloride	NR	NR	P	NR	Methyl Ethyl Ketone (MEK)	G	NR	G	NR
Butane	F	E	P	P	Methylisobutyl Ketone	NR	P	F	NR
Butyl Acetate	NR	F	P	NR	Methyl Methacrylate	NR	P	P	NR
Butyl Alcohol	E	E	G	D	Mineral Oil	E	E	P	E
Butyl Cellulose*	E	E	E	NR	Mineral Spirits	G	E	NR	F
Carbon Acid	E	P	P	G	Monoethanolamine	E	E	G	E
Carbon Disulfide	NR	NR	NR	NR	Morpholine	P	NR	G	NR
Carbon Tetrachloride	P	G	NR	NR	Muratic Acid	E	G	G	G
Castor Oil	E	E	E	E	Naphtha VM & P	G	E	NR	P
Cellulose Acetate	E	G	G	NR	Nitric Acid <30%	E	P	G	G
Cellulose Solvent	E	G	E	NR	Nitric Acid 70%	G	NR	F	F
Chlorobenzene	NR	NR	NR	NR	Nitric Acid Red Fuming	NR	NR	P	P
Chloroform	F	F	NR	NR	Nitric Acid White Fuming	NR	NR	P	P
Chloronaphthalene	NR	F	NR	NR	Nitrobenzene	NR	NR	P	NR
Chloroethane VG	NR	F	NR	P	Nitromethane	E	F	G	P
Chromic Acid	F	F	NR	G	Nitropropane	G	NR	E	NR
Citric Acid	E	E	E	E	Octyl Alcohol	E	E	G	F
Cottonseed Oil	E	E	P	G	Oil Acid	E	E	P	F
Cresols	G	G	P	F	Paint Remover	G	G	F	P
Cutting Oil	E	E	F	P	Palmitic Acid	E	G	G	G
Cyclohexane	P	E	P	P	Pentachlorophenol	E	E	P	F
Cyclohexanol	E	E	P	G	Pentane	E	E	P	NR
Dibutyl Phthalate	F	G	P	G	Perchloric Acid 60%	E	E	P	E
Diethylamine	P	F	NR	NR	Potassium Hydroxide <50%*	E	G	E	E
Di-Isobutyl Ketone	P	E	P	P	Printing Ink	G	E	G	F
Dimethyl Formamide (DMF)	G	NR	E	NR	Propyl Acetate	P	P	P	NR
Dimethyl Sulfoxide (DMSO)	E	E	E	NR	Propyl Alcohol	E	E	E	F
Dioctyl Phthalate (DOP)	G	G	P	NR	Perchloroethylene	NR	G	NR	NR
Dioxane	NR	NR	NR	NR	Phenol	E	NR	G	G
Ethyl Acetate	F	NR	P	NR	Phosphoric Acid*	E	E	G	G
Ethyl Alcohol	E	E	E	G	Picric Acid	E	E	G	E
Ethylene Dichloride	NR	NR	P	NR	Propylene Oxide	NR	NR	P	NR
Ethylene Glycol	E	E	E	E	Rubber Solvent	G	E	NR	NR
Ethyl Ether	E	E	NR	NR	Sodium Hydroxide <30%	E	G	E	G
Ethylene Trichloride	P	P	P	NR	Stoddard Solvent	E	E	P	NR
Formaldehyde	E	E	E	E	Styrene*	NR	NR	NR	NR
Formic Acid	E	F	E	E	Sulfuric Acid 95%	F	G	NR	NR
Freon	G	F	NR	NR	Tannic Acid	E	E	E	E
Yrftural	G	NR	E	NR	Tetrahydrofuran (THF)	NR	NR	NR	NR
Gasoline	P	E	NR	P	Toluene	P	G	NR	NR
Glycerine	E	E	E	E	Toluene Di-Isocyanate (TDI)	NR	NR	P	P
Hexane	E	E	NR	NR	Trichloroethylene (TCE)	P	G	NR	NR
Hydraulic Fluid Petro. Based	F	E	P	G	Tricresyl Phosphate (TCP)	F	E	G	F
Hydraulic Fluid Ester Based	P	P	P	P	Triethanolamine 85% (TEA)	E	E	G	F
Hydrazine 65%	E	E	G	E	Tung Oil	E	E	NR	F
Hydrochloric Acid*	G	E	E	E	Turbine Oil	E	G	P	F
Hydrofluoric Acid	G	E	E	E	Turpentine	G	E	P	P
Hydrogen Peroxide	E	E	E	E	Vegetable Oil	E	E	P	F
Hydroquinone	G	E	E	E	Xylene	P	G	NR	NR
Isobutyl Alcohol	E	E	E	F					
Iso-Octane	E	E	NR	P					
Isopropyl Alcohol*	E	E	E	G					

\*Warning: Protective gloves and other protective apparel selection must be based on the user's assessment of the workplace hazards. Glove and Apparel materials do not provide unlimited protection against all chemicals. It is the user's responsibility to determine before use that the Glove and Apparel will resist permeation and degradation by the chemicals (including chemical mixtures) in the environment of intended use. Failure by the user to select the correct protective gloves can result in injury, sickness, or death.



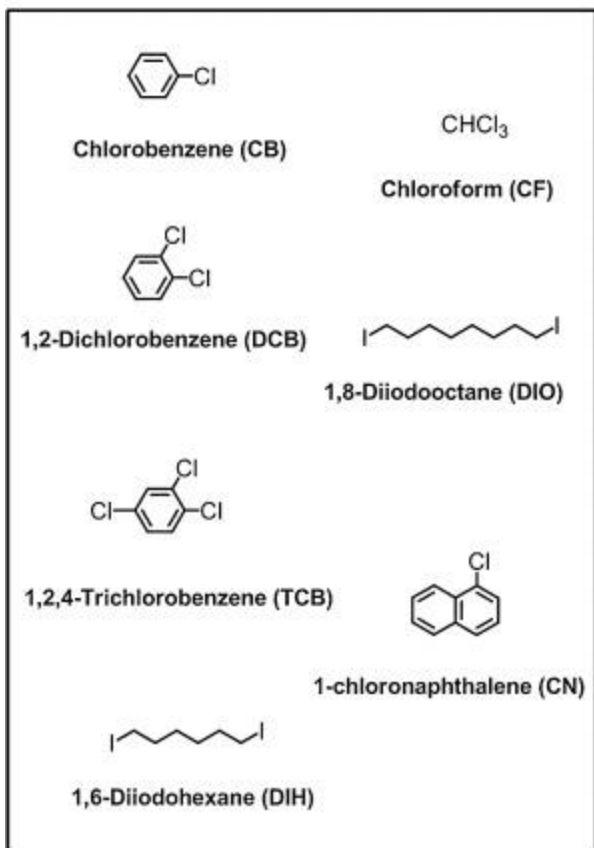
Material contained on this chart is copyrighted material. Any questions, please call All Safety Products, Inc., 562-630-3700, website: [www.allsafetyproducts.com](http://www.allsafetyproducts.com)



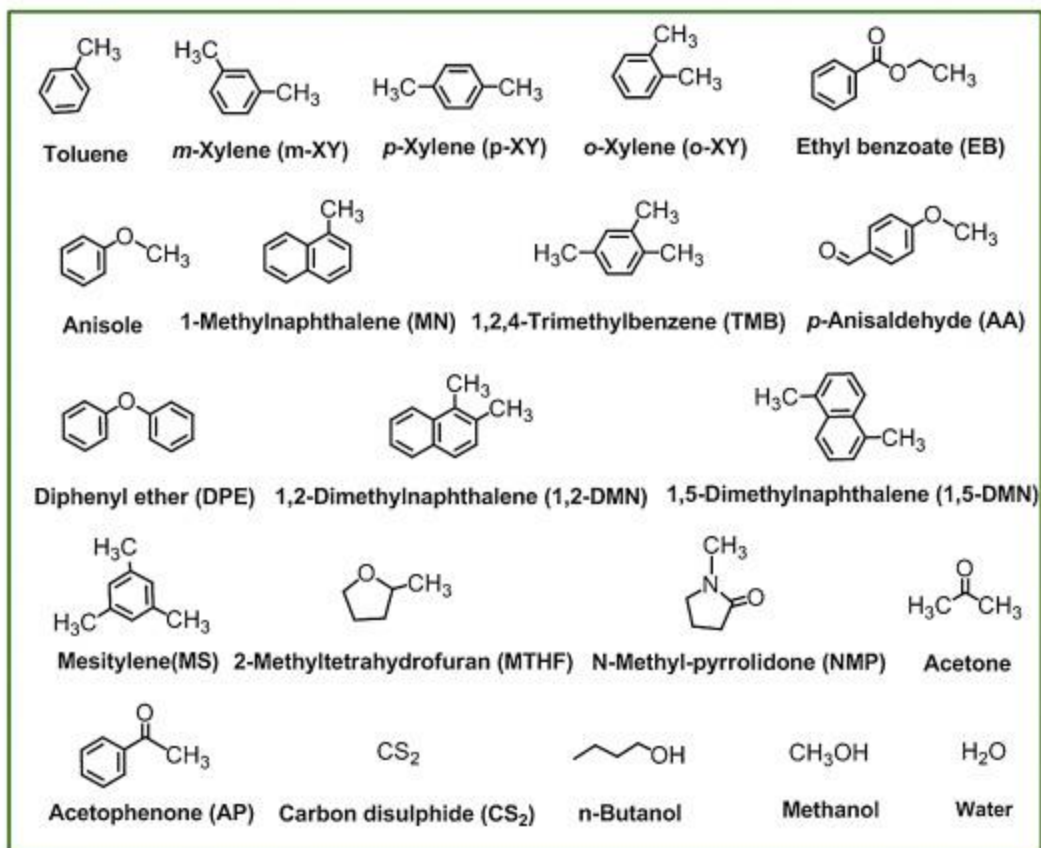
Chemical Resistance Chart

# Connections Between Alchemy and Modern Chemistry: Universal Solvent

## Halogenated Solvents



## Halogen-free/"Green" Solvents



# Organic Compounds

Chemical Compound: Most commonly molecules (ex:  $\text{H}_2\text{O}$ ) or ionic compounds (ex:  $\text{NaCl}$ ,  $\text{LiF}$ )

Organic Compound: Most commonly a chemical compound that ***contains carbon***.

Methane:  $\text{CH}_4$

Tryptophan:  $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$

Pentane:  $\text{C}_5\text{H}_{12}$

1,8-Diodooctane (DIO):  $\text{C}_8\text{H}_{16}\text{I}_2$

Benzene:  $\text{C}_6\text{H}_6$

# Why Are Organic Compounds Called “Organic”

Organic compounds are produced by living matter.

Examples: Oxalic Acid (plant), Urea (kidney)



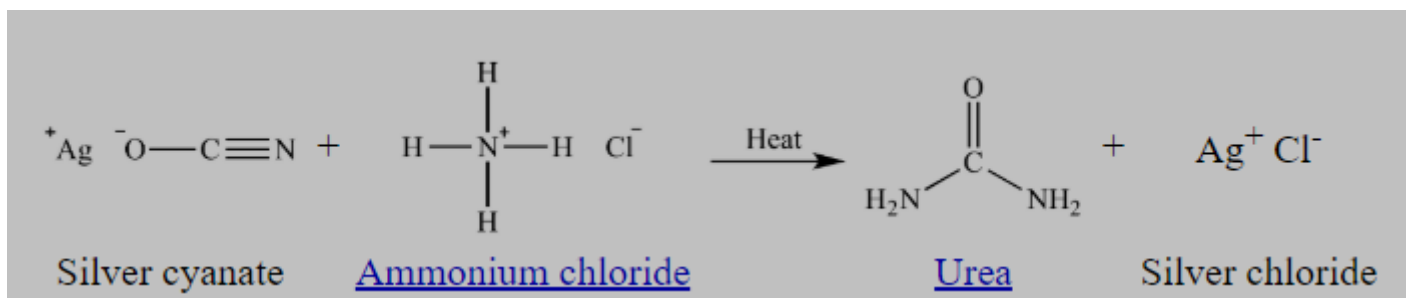
# Vitalism: Why Organic Compounds are Called “Organic”

Vitalism (dates to ancient times and alchemy) teaches the “vital force” of living organisms produce organic compounds

Consumption of the vital principle (ethereal substance), prolongs life; commonly prepared from various components and called an elixir.

Organic substances cannot be prepared from inorganic components

# Vitalism Disproved by Friedrich Wohler's 1828 Synthesis of Urea



# The Organic Chemist's Periodic Table

Elements most often used in organic chemistry:

H	
Li	
Na	Mg
K	

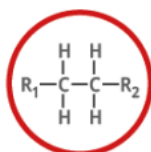
B	C	N	O	F
Al		P	S	Cl
				Br
				I

# Common Functional Groups

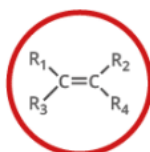
## FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

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



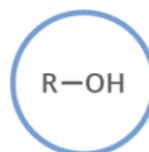
**ALKANE**  
Naming: -ane  
e.g. ethane



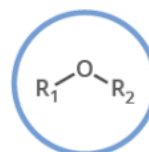
**ALKENE**  
Naming: -ene  
e.g. ethene



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



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



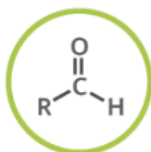
**ETHER**  
Naming: -oxy-ane  
e.g. methoxyethane



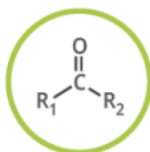
**EPOXIDE**  
Naming: -ene oxide  
e.g. ethene oxide



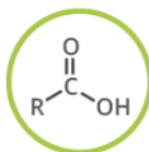
**HALOALKANE**  
Naming: halo-  
e.g. chloroethane



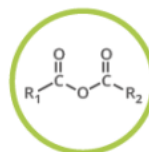
**ALDEHYDE**  
Naming: -al  
e.g. ethanal



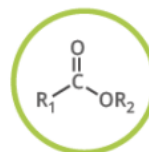
**KETONE**  
Naming: -one  
e.g. propanone



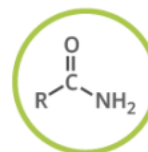
**CARBOXYLIC ACID**  
Naming: -oic acid  
e.g. ethanoic acid



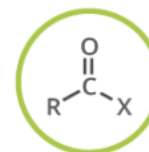
**ACID ANHYDRIDE**  
Naming: -oic anhydride  
e.g. ethanoic anhydride



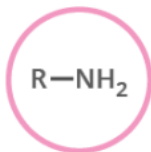
**ESTER**  
Naming: -yl -oate  
e.g. ethyl ethanoate



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



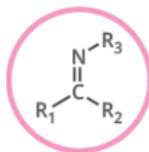
**ACYL HALIDE**  
Naming: -oyl halide  
e.g. ethanoyl chloride



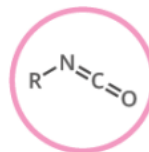
**AMINE**  
Naming: -amine  
e.g. ethanamine



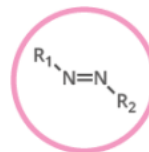
**NITRILE**  
Naming: -nitrile  
e.g. ethanenitrile



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



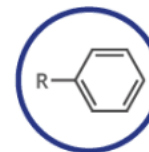
**ISOCYANATE**  
Naming: -yl isocyanate  
e.g. ethyl isocyanate



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



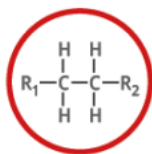
**THIOL**  
Naming: -thiol  
e.g. methanethiol



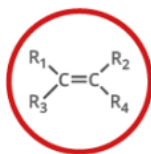
**ARENE**  
Naming: -yl benzene  
e.g. ethyl benzene



# Functional Groups You Need to Know for CHEM 60



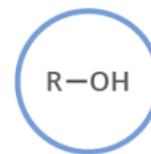
**ALKANE**  
Naming: -ane  
e.g. ethane



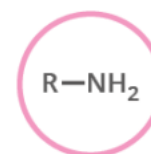
**ALKENE**  
Naming: -ene  
e.g. ethene



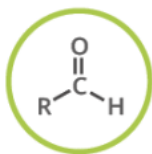
**ALKYNE**  
Naming: -yne  
e.g. ethyne



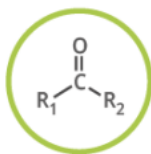
**ALCOHOL**  
Naming: -ol  
e.g. ethanol



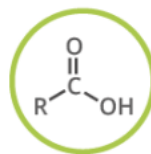
**AMINE**  
Naming: -amine  
e.g. ethanamine



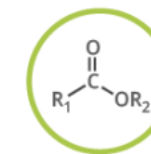
**ALDEHYDE**  
Naming: -al  
e.g. ethanal



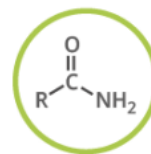
**KETONE**  
Naming: -one  
e.g. propanone



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



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



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

# What is “R”?

R is commonly used to represent “hydrocarbon”.

Example:  $\text{CH}_3\text{CH}_2\text{OH}$  can be represented as  $\text{ROH}$

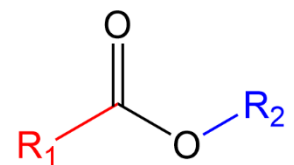
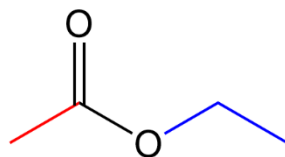
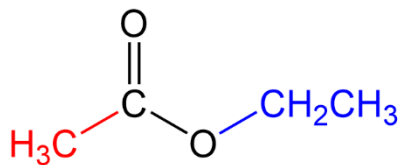
Likewise,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  can also be represented as  $\text{ROH}$

R is used when you want to draw out the specific functional group, but not the rest of the hydrocarbon part.

# $R_1$ and $R_2$

$R_1$  and  $R_2$  are used when the two R groups are not the same.

Example:



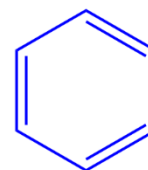
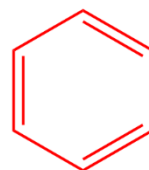
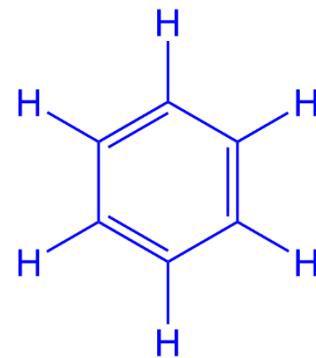
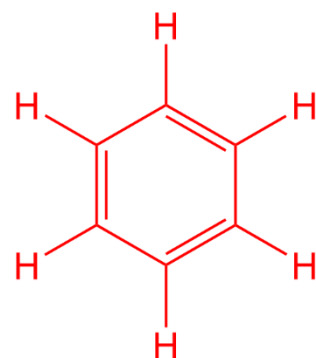
$R_1 = -\text{CH}_3$

$R_2 = -\text{CH}_2\text{CH}_3$

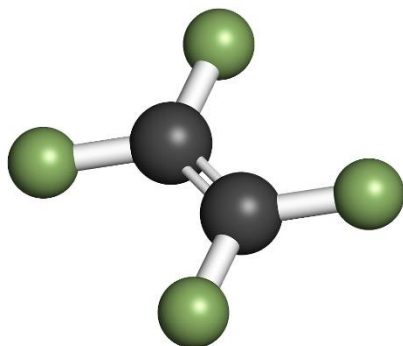
# Benzene Ring

You may see this on OWL homework questions. Presented below are representations of a benzene ring. **All** are equivalent representations.

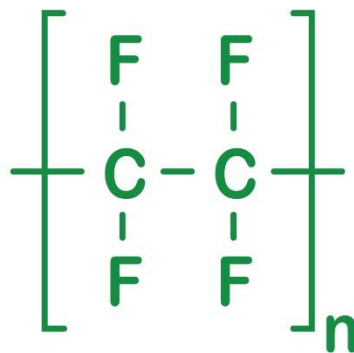
Because the double-bond electrons are moving all around the ring, we can draw two equivalent representations (red and blue). Since the actual benzene is a hybrid of the red and blue representations, the double-bond electrons are represented by the purple structure, where the circle represents the double-bond electrons moving across the entire ring.



# Organic Structures: Industry



Monomer

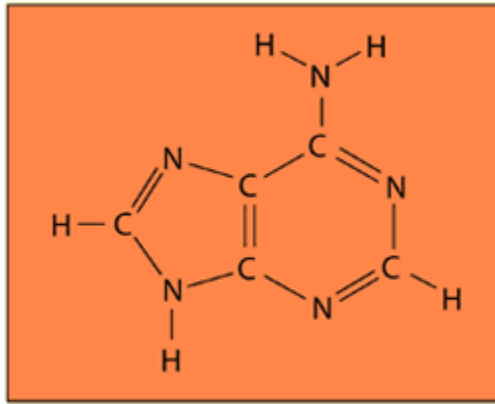


Polymer

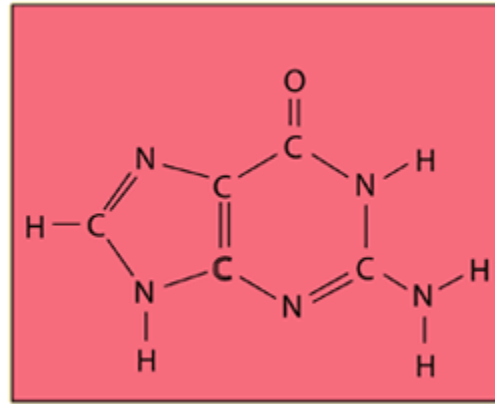


# Organic Structures: Biology

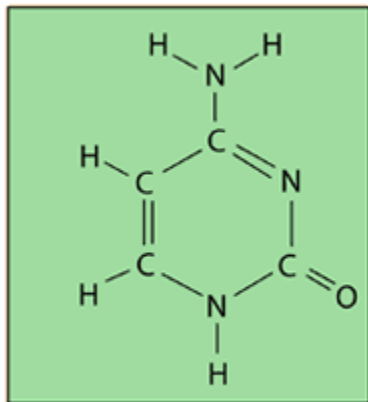
## Nitrogenous Bases



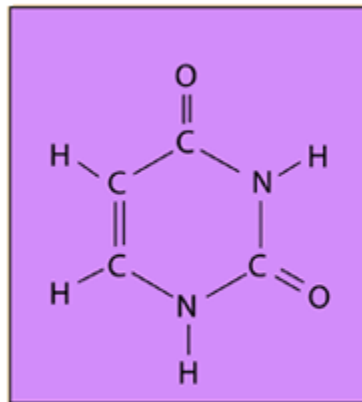
Adenine



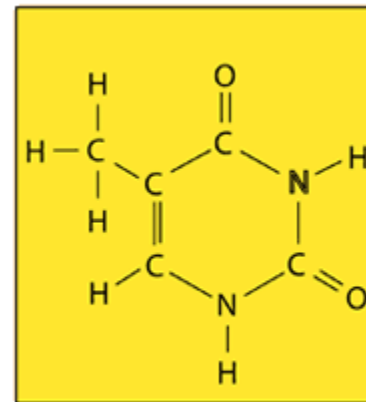
Guanine



Cytosine



Uracil






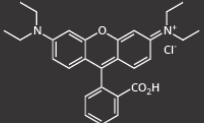
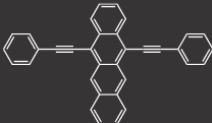

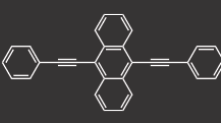



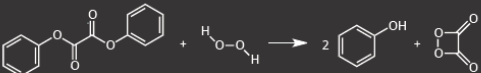
Thymine


# Organic Structures: Daily Life

## Glow Sticks!

### THE CHEMISTRY OF GLOW STICKS

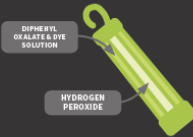
				
RED	ORANGE	YELLOW	GREEN	BLUE
				
RHODAMINE B	5,12-BIS(PHENYLETHYNYL)NAPHTHACENE	RUBRENE	9,10-BIS(PHENYLETHYNYL)ANTHRACENE	9,10-DIPHENYLANTHRACENE






#### HOW DO GLOW STICKS PRODUCE LIGHT?

When glow sticks are bent, the inner glass tube is broken, releasing hydrogen peroxide solution. This then reacts with a diphenyl oxalate, producing 1,2-dioxetanedione; this product is unstable, & decomposes to carbon dioxide, releasing energy. The energy is absorbed by electrons in dye molecules, which subsequently fall back to their ground state, losing excess energy in the form of light.



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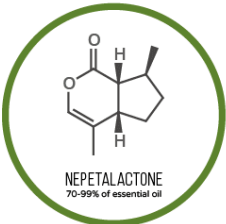



# Organic Structures: Daily Life

## Catnip!

### THE CHEMISTRY OF CATNIP

Why do cats go crazy for catnip? This graphic takes a look at the chemical compound responsible and how it works.



**NEPETALACTONE**  
70-99% of essential oil

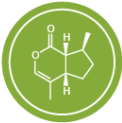



**THE EFFECT OF CATNIP**

- Member of same plant family as mint.
- Effect on cats known since the 1700s.
- Affects both domestic cats and wild cats, including lions, tigers and leopards.
- Is also used as a mild sedative and anti-spasmodic agent in humans.
- Can also be used as an insect repellent.

**THE FELINE RESPONSE**

SNIFFING LICKING CHEWING  
HEAD SHAKING CHIN RUBBING  
CHEEK RUBBING HEADOVER ROLLING  
BODY RUBBING VOCALISATION

**THE CATNIP RESPONSE**

-   
1  
The compound nepetalactone, one of the volatile compounds given off by catnip, enters the cat's nasal tissue.
-   
2  
After entering the nasal tissue, the compound binds to protein receptors, stimulating neurons, which then signal to the brain.
-   
3  
The brain signals the amygdala, (responsible for emotional responses) and the hypothalamus (behaviour responses).
-   
4  
The cat exhibits behaviour similar to that seen in response to cat pheromones. This lasts for about 10 minutes.

**APPROXIMATE PERCENTAGE OF CATS AFFECTED BY CATNIP**

**70%**

The susceptibility of cats to catnip is gene dependent and hereditary, and as such not all cats will exhibit a response. Additionally, young kittens aren't affected until they reach sexual maturity. The response to catnip lasts for approximately ten minutes.

**AGE UNDER WHICH CATS ARE UNAFFECTED**

**6-8 WEEKS**

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