NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **UNIT 4**: SPECIAL FOCUS ON CHEMICALS: **ETHANOL**

I) Ethanol as a drug

A congressman was once asked about his attitude toward whiskey. “If you mean the demon drink that poisons the mind, pollutes the body, desecrates family life, and inflames sinners, then I’m against it. But, if you mean the elixir of Christmas cheer, the shield against winter chill, the taxable potion that puts needed funds into public coffers to comfort little crippled children, then I’m for it. This is my position, and I will not compromise.”

Mark Edward Lender and James Kirby Martin, *Drinking History in America: A History*

A) Essentially, a drug is any chemical (or mixture of chemicals) which affects the central nervous

system, causing a biochemical change. A drug can be used for diagnosis, treatment, or prevention,

and, over the course of use, may (or may not,) become addictive.

B) What we term as liquor, is a mixture of ethanol, water, and various flavorings and compounds called

congeners. Today liquor is a governmentally regulated drug.

The 18th amendment to the US Constitution (circa 1920) established the ***prohibition*** of alcoholic

beverages, by outlawing their production, transport and sale. It did not outlaw the consumption or

private possession of liquor!

The 21st amendment to the US Constitution (circa 1933) repealed the 18th amendment.

1) Ethanol (ethyl alcohol or grain alcohol) is the “active ingredient” in most recognized

liquors.

a) Formula: C2H5OH

b) Soluble in water and oddly, it is also soluble in gasoline

c) Flammable (combusts vigorously in the presence of O2)

d) It evaporates easily at most temperatures

e) Methanol, and isopropyl alcohol (rubbing alcohol) are **NOT the** same chemical as

ethanol.

* Check out: <https://www.youtube.com/watch?v=jb4CMnT2-ao> 6 Reactions that Changed the World

(It’s Okay to be Smart)

C) The breakdown of ethanol in the human body

1) Alcohol is a CNS [Central Nervous System] Depressant. It affects the GABA

neurotransmitter the most. GABA = Gamma-aminobutyric acid

a) GABA is involved in the control of muscle movement, co-ordination, and breathing.

Per the National Library of Medicine: GABA is the primary inhibitory neurotransmitter

in the brain, and it is a major inhibitory neurotransmitter in the spinal cord.

Because GABA is the fundamental neurotransmitter for inhibiting neuronal firing, its

function is determined by the neural circuit that it is inhibiting. It is involved in complex

circuits throughout the central nervous system. For example, GABA neurons extend to

other brain areas, inhibiting unwanted motor signals. Another example is that GABA

signaling in the medulla is involved in the maintenance of respiratory rate. **Increased**

**GABA signaling reduces the respiratory rate**. A third example is found in the spinal

cord, where GABA serves in the inhibitory interneurons. These neurons help to integrate

excitatory proprioceptive signals, allowing for the spinal cord to integrate sensory

information and create smooth movements

<https://www.ncbi.nlm.nih.gov/books/NBK513311/#:~:text=GABA%20is%20the%20primary%20inhibitory ,alpha%2Dcells%20to%20beta%20cells>.

* Check Out: <https://thebrain.mcgill.ca/flash/i/i_03/i_03_m/i_03_m_par/i_03_m_par.html>

2) To deal with the presence of alcohol, like most drugs affecting the CNS, alcohol is broken

down in an attempt to deal with its effects. The breakdown of alcohol is what leads to the

most sever issues surrounding what we may term as a hangover.

* The breakdown, or \* **oxidation**, of ethanol occurs in the **liver**.
* An enzyme in the liver called alcohol dehydrogenase \*strips electrons from ethanol to form acetaldehyde.
* A second enzyme, called aldehyde dehydrogenase, converts the acetaldehyde, in the presence of oxygen, to acetic acid, the main component in [**vinegar**](http://recipes.howstuffworks.com/how-vinegar-works.htm).
* The molecular structure of acetic acid looks like this:

**O** <http://recipes.howstuffworks.com/alcohol4.htm> **||   
 H3 C - C - O – H**

II) Alcohol Hangover

A) You must understand that virtually everything taken into the human body must go through the liver

and is in some way treated for disposal or further use. This holds true for ethanol.

Tuning off / disabling vasopressin activity

B) Causes of Production of acetaldehyde toxin

4 issues affecting the development of a hangover

Hangover The effects of glutamine rebound

The presence of congeners in the liquor

**The important chemicals involved: (The Good Guys)**

1) Vasopressin (Anti-Diuretic Hormone or ADH) is a **"good" hormone** to have working,

for you. When vasopressin is disabled (turned off), bad things happen...

2) Glutathione (The King of Antioxidants): A protein made of three amino acids, glycine,

glutamic acid and ***cysteine***. It is a potent \*antioxidant

a) It has an amazing ability to be oxidized and thereby protects surrounding chemicals

from being attacked. Due to its antioxidant ability glutathione has the ability to rid

the body of radicals.

**The important chemicals involved: (The Good Guys who turn out to be sort of Bad Guys)**

3) Glutamine (glū –ta – meen) is another **"good" hormone** ... however, the body's response

with producing glutamine, as alcohol begins to be diminished in concentration, in the body,

is unfortunate.

4) Congeners are a mixed bag. They are “born with” the alcohol. They are not produced by

the activity of alcohol in the body ... rather, they're in the bottle, with the alcohol, due to the

fermentation process.

**The important chemicals involved: (The Bad Guys)**

4) Acetaldehyde (a-seat-a-al-duh-hide) is **a poison**. It is produced from the liver's action on

ethanol. It is a **bad thing to have**.

* + - Check out: <http://www.alcoholscreening.org/> How much is too much?

C) Hangover Causation 1: Turning Off the Positive Activity of Vasopressin (ADH)

**What you need to know:**

A **diuretic** (di-yur-eh-tic) is a chemical which makes you urinate

**Causation:**

**\_\_disabling vasopressin**

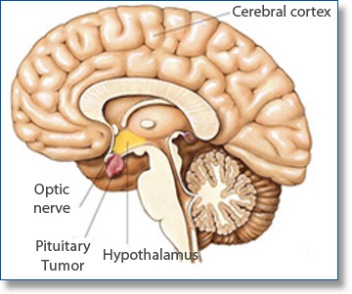
**\_\_\_making toxins**

**\_\_\_regaining glutamine**

**\_\_\_congeners**

An ***anti-diuretic*** is a chemical which helps return fluid to your body.

Vasopressin is also called ***anti*-diuretic hormone (ADH)**.

 When alcohol enters the bloodstream, it causes the **pituitary gland** in the brain to block the creation and/or the release of **vasopressin** (the antidiuretic hormone).

Without this chemical, the kidneys send water directly to the bladder

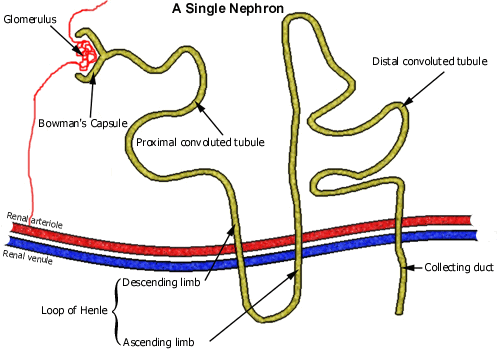
instead of reabsorbing water back into the body. Therefore drinkers

tend to make frequent trips to the bathroom after urinating for the first time

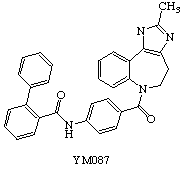
after drinking.

Headaches result from dehydration because the body's organs try to make up for their own water loss by **stealing water from the brain**, causing the brain to decrease in size and pull on the membranes that connect the brain to the skull, resulting in pain.

The frequent urination also expels salts and potassium that are necessary for proper nerve and muscle function; when sodium and potassium levels get too low, headaches, fatigue and nausea can result. Alcohol also breaks down the body's store of glycogen in the **liver**, turning the chemical into glucose and sending it out of the body in the urine. Lack of this key energy source is partly responsible for the weakness, fatigue, and lack of coordination the next morning. In addition, the diuretic effect expels vital electrolytes such as potassium and magnesium, which are necessary for proper cell function. <http://health.howstuffworks.com/hangover2.htm>



Vasopressin opens pores in the Loop of Henle, and this allows water to move back into the body, helping to keep it hydrated.



Vasopressin



All The Important Points

D) Hangover Causation 2: Production of a toxin called, **acetaldehyde** (a-seat-a-al-duh-hide)

... *Okay, this gets a little complicated....*

**Causation:**

**\_\_disabling vasopressin**

**\_\_\_making toxins**

**\_\_\_regaining glutamine**

**\_\_\_congeners**

**What most never understand**: Acetaldehyde is a product of alcohol metabolism **and is more toxic**

than the alcohol!

H O

| ||

H―C―C―H

|

H

ACETALDEHYDE

H H

| |

H―C―C―O―H

| |

H H

ETHANOL

First, when we drink (moderately), alcohol is absorbed readily through the stomach lining (this can

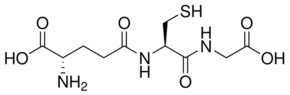
irritate the lining of the stomach ...more later on this....)

The alcohol (now in the bloodstream) eventually gets to the liver, where it is broken down by the

enzyme, alcohol dehydrogenase, turning the alcohol into the dangerous **toxin,** **acetaldehyde**.

The **acetaldehyde** is in turn attacked by another chemical called **glutathione** (which contains high

levels of the amino acid cysteine...[sis-teen: more later on this amino acid]).

Diagram, schematic

Description automatically generated

cysteine (sis-teen) glutathione

<http://www.wacker.com/cms/en/products-markets/products/product.jsp?product=9372> <http://www.sigmaaldrich.com/catalog/product/sial/g4251?lang=en&region=US>

The attack of the cysteine-containing **glutathione** (glū-tah-thigh-own) is a defensive chemical that

attacks the toxic **acetaldehyde** to the **non-toxic** acetate (a substance related to vinegar). The activity of

glutathione destroying acetaldehyde is a GOOD THING!

With very moderate alcohol intake, this process works well, leaving the **acetaldehyde** only a short

amount of time to do its damage. The liver’s stores of **glutathione** however, quickly run out when larger

amounts of alcohol enter the system. The liver’s ability to remove the **acetaldehyde** diminishes, until

more **glutathione** can be made. This down time allows the **acetaldehyde** to build up in the body and

remain for a longer period of time. <http://health.howstuffworks.com/hangover4.htm>

**All of the dangers of acetaldehyde are still unknown**. There is some debate as to whether it

enters into or is produced in the brain.

Once produced, it may inhibit enzymes designed to convert certain neurotransmitters from

aldehydes to acids. The neurotransmitters that accumulate may then react with the acetaldehyde

to form compounds which are startlingly similar to certain morphine-type compounds, **increasing**

**headache, nausea,** **lack of muscle coordination, and drowsiness.**

<http://www.elmhurst.edu/~chm/vchembook/642alcoholmet.html>

Outside of the brain, what seems to occur is that acetaldehyde reaches a saturation point and

it escapes into the blood stream. The accumulated acetaldehyde exerts its toxic effects by

•inhibiting the reactions in the mitochondria, which (if not bad enough) can result in even slower

removal of acetaldehyde (especially in alcoholics) which leads to further liver cell damage in the

forms of hepatitis and cirrhosis.

•interfering with the activation of vitamins <http://www.elmhurst.edu/~chm/vchembook/642alcoholmet.html>

•Research released in April 2014, through the National Institute of Health appears to conclude that

damage a gene involved in mitochondrial repair and muscle regeneration, appears to be the cause

of muscle weakness in chronic alcoholics.

*Additionally*:

•In the journal, *Nucleic Acids Research*, scientists from the National Institute on Alcohol Abuse and

Alcoholism (NIAAA) and the National Institute of Standards and Technology (NIST) report that

drinking alcoholic beverages has been linked to an increased risk of upper gastrointestinal cancer

and other types of cancer. It appears that polyamines – natural compounds essential for cell growth

– react with acetaldehyde to trigger a series of reactions that damage DNA, an event that can lead to

the formation of cancer. <http://alcoholism.about.com/od/cancer/a/blniaaa050803.htm>

Further Reading: *Even Moderate Drinking Can Affect Babies’ IQ* at: <http://tiny.cc/hfwW1> OR

<http://alcoholism.about.com/od/preg/a/blacer060603.htm>

 All The Important Points

E) Hangover Causation 3: The Negative Effects of Glutamine Rebound (glū –ta – meen)

*Warning: (Don't confuse glutathione and glutamine...both are "good" ...but, the*

*loss of one and the quick replenishing of the other cause problems)*

**Causation:**

**\_\_disabling vasopressin**

**\_\_\_making toxins**

**\_\_\_regaining glutamine**

**\_\_\_congeners**

After [alcohol](http://recipes.howstuffworks.com/alcohol.htm) consumption, a person may not [sleep](http://health.howstuffworks.com/sleep.htm) as soundly as normal because their body is

rebounding (coming back) from alcohol's depressive effect on the system.

When someone is **drinking**, alcohol **inhibits vasopressin, but it also inhibits a chemical called**

**glutamine**, **one of the body's natural stimulants**. When the drinker stops drinking, the body

tries to make up for lost time by producing more glutamine than it needs.

The increase in glutamine levels **stimulates the** [**brain**](http://health.howstuffworks.com/brain.htm) **while the drinker is trying to sleep**, keeping

them from reaching the deepest, most healing levels of slumber.

This is a large contributor to the fatigue felt with a hangover.

Severe glutamine rebound during a hangover also may be responsible for tremors, [anxiety](http://healthguide.howstuffworks.com/stress-and-anxiety-dictionary.htm), restlessness,

and increased blood pressure. <http://health.howstuffworks.com/hangover5.htm>



All The Important Points

F) Hangover Causation 4: The Negative Effects of the Presence of Congeners (Latin: *born together*)

**Causation:**

**\_\_disabling vasopressin**

**\_\_\_making toxins**

**\_\_\_regaining glutamine**

**\_\_\_congeners**

Congeners are chemicals *produced along with alcohol*, during fermentation, and maturation (aging).

Generally, darker colored liquors and wines have high concentrations. Such alcoholic drinks include;

whiskey, dark rum, red wines.

Congeners include various esters (recall your lab work), acids (lab work), aldehydes and higher

alcohols.

Strictly speaking they are impurities, but they give many of the darker colored liquors their flavor(s).

Their presence in the final spirit must be carefully judged; too many would make it undrinkable.

Their presence appears to enhance the effects of a hangover. <http://www.whiskymag.com/words/congeners.html>

Interestingly, according to *Alcoholism Clinical and Experimental Research*, congeners may have an

upside. They may help limit the amount of bleeding which occurs in the stomach when whiskey is

drunk.

Citation: Protective Effects of the Whisky Congeners on Ethanol-Induced Gastric Mucosal Damage ([Volume 31 Issue 3](http://www3.interscience.wiley.com/journal/118520167/issue), Pages 390 – 394

Published Online: 23 Jan 2007) http://www3.interscience.wiley.com/journal/118520170/abstract?CRETRY=1&SRETRY=0



All The Important Points

**An important side note** …. but not related directly to the hangover (yet possibly still pertinent …)

The Nausea Factor… A.K.A: **Worshipping at the Porcelain Idol**

Because alcohol is absorbed directly through the stomach, the cells along the inside walls of the

stomach, the stomach lining can become irritated (inflamed). Alcohol also promotes secretion of

hydrochloric acid in the stomach, eventually causing the nerves to send a message to the brain that the

stomach's contents are hurting the body and must be expelled through vomiting (reverse peristalsis).

This mechanism can actually lessen hangover symptoms in the long run because vomiting gets

rid of the alcohol in the stomach and reduces the number of toxins with which the body has to deal.

The stomach's irritation may also be a factor in some of the other unpleasant consequences of

excessive drinking of alcohol, such as diarrhea and lack of appetite. <http://health.howstuffworks.com/hangover5.htm>

The Breathalyzer <http://science.howstuffworks.com/breathalyzer3.htm>

There are three major types of breath alcohol testing devices, and they're based on different principles:

* **Breathalyzer** - Uses a chemical reaction involving alcohol that produces a color change
* **Intoxilyzer** - Detects alcohol by infrared (IR) spectroscopy
* **Alcosensor III or IV** - Detects a chemical reaction of alcohol in a fuel cell

Regardless of the type, each device has a **mouthpiece**, a tube through which the suspect blows air, and a **sample chamber** where the air goes. The rest of the device varies with the type.

The **Breathalyzer** device contains:

* A system to sample the breath of the suspect
* Two glass vials containing the chemical reaction mixture
* A system of photocells connected to a meter to measure the color change associated with the chemical reaction

|  |
| --- |
| breathalyzer-formula |

To measure alcohol, a suspect breathes into the device. The breath sample is bubbled in one vial through a mixture of sulfuric acid, potassium dichromate, silver nitrate and water. The principle of the measurement is based on the following chemical reaction:

In this reaction:

1. The **sulfuric acid removes the alcohol from the air** into a liquid solution.
2. The **alcohol reacts with potassium dichromate** to produce:
   1. Chromium(III) sulfate
   2. potassium sulfate
   3. acetic acid
   4. water

The silver nitrate is a **catalyst**, a substance that makes a reaction go faster without participating in it. The sulfuric acid, in addition to removing the alcohol from the air, also might provide the acidic condition needed for this reaction.

During this reaction, the reddish-orange dichromate ion **changes color** to the green chromium ion when it reacts with the alcohol; the degree of the color change is directly related to the level of alcohol in the expelled air.

To determine the amount of alcohol in that air, the reacted mixture is compared to a vial of unreacted mixture in the **photocell system**, which produces an **electric current** that causes the needle in the meter to move from its resting place.

The operator then rotates a knob to bring the needle back to the resting place and reads the level of alcohol from the knob -- the more the operator must turn the knob to return it to rest, the greater the level of alcohol.