



What is Delta-8 THC?? Cannabinoid Chemistry 101

National Conference on Weights and Measures

Annual Meeting - Rochester, NY

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July 21, 2021

Just to be clear...

- I am a chemist and not a lawyer so:
- This presentation will not discuss the legal aspects of $\Delta 8$ -THC or DEA's current position.
- This presentation will not discuss whether $\Delta 8$ -THC is considered “synthetic” or “naturally occurring.”
- This is not a position statement on any issues before the NCWM.
- Lastly, this should only be considered a scientific sharing exercise.

Cannabis Syllabus

- What is *Cannabis*?
- “Mother” Cannabinoid
- Decarboxylation
- Relationship between CBD and THC
- What does “Total” mean?
- Dry Weight vs. Wet Weight
- What does “Delta-9” mean?
- Relationship between “Delta-8” and “Delta-9”
- CBD to Delta-8 THC
- Cannabinoid Chemistry 202...



Cannabis

- *Cannabis sativa* is the taxonomic name for the plant.
- The concentration of Total Δ 9-Tetrahydrocannabinol (Total Δ 9-THC) is critical when considering the varieties of *Cannabis sativa*.
- Hemp – (Total Δ 9-THC) 0.3% or less
 - Not really a controversial term, “hemp”
- Marijuana/cannabis – (Total Δ 9-THC) Greater than 0.3%
 - Controversial term, “marijuana”
 - Some states prohibit the use of this term whereas some states have it in their laws.
 - Some states use the term “cannabis.”
 - Not italicized
 - Lower case “c”

Cannabis in Florida

- Hemp – (Total $\Delta 9$ -THC) 0.3% or less
 - Regulated by FDACS
- Marijuana – (Total $\Delta 9$ -THC) greater than 0.3%
 - Medical Marijuana
 - Regulated by Florida Department of Health
- “Adult Use” currently not legal



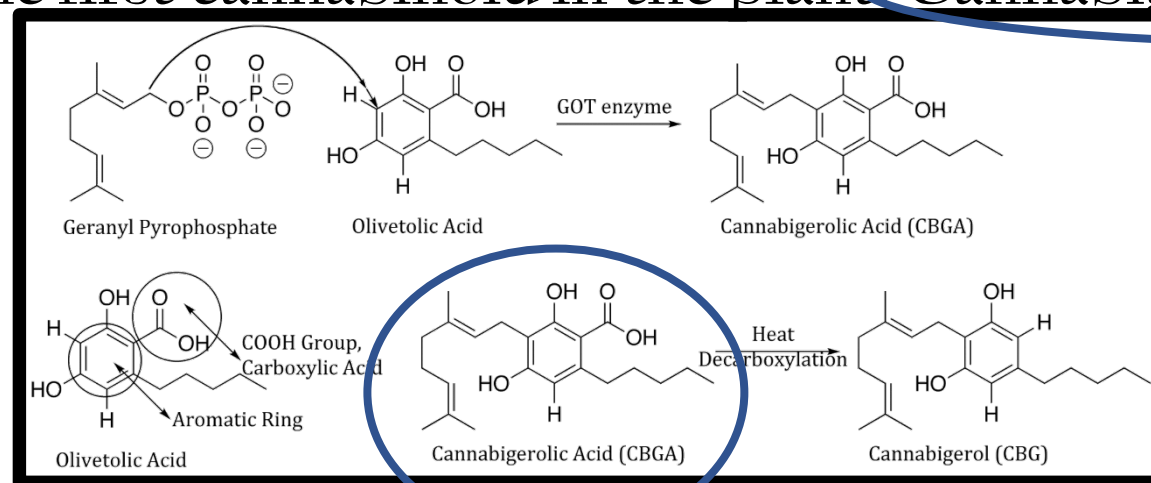
FDACS Hemp Laws & Rules

Section 581.217, Florida Statutes

Food Rule 5K-4.034	Effective 1/1/2020
Dairy Rule 5K-10.006	Effective 1/1/2020
Feed Rule 5E-3.003	Effective 1/1/2020
Seed Rule 5E-4.006	Effective 2/2020
Cultivation Rule 5B-57.014	Effective 4/2020

In the Beginning...

- The precursors to natural cannabinoids are Geranyl Pyrophosphate and Olivetolic Acid, which are produced themselves through a series of biosynthetic reactions. These two bond with the assistance of an enzyme and create the first cannabinoid in the plant Cannabigerolic Acid (CBGA).



- Source: <https://weedmaps.com/learn/the-plant/how-cannabinoids-terpenes-flavonoids-are-made>

Still, in the Beginning...

- Cannabigerol (CBG) is one of more than 120 identified cannabinoid compounds found in the plant genus *Cannabis*. Cannabigerol is the non-acidic form of **cannabigerolic acid (CBGA), the parent molecule from which other cannabinoids are synthesized.** Cannabigerol is a minor constituent of cannabis. During plant growth, most of the cannabigerol is converted into other cannabinoids, primarily tetrahydrocannabinol (THC) or Cannabidiol (CBD) leaving about 1% cannabigerol in the plant.
 - *Reference: Wikipedia*

Naturally Occurring Cannabinoids

- Cannabichromenes
 - Cannabichromene (CBC)
 - Cannabichromenic acid (CBCA)
 - Cannabichromevarin (CBCV)
 - Cannabichromevarinic acid (CBCVA)
- Cannabicyclols
 - Cannabicyclol (CBL)
 - Cannabicyclic acid (CBLA)
 - Cannabicyclovarin (CBLV)
- Cannabidiols
 - Cannabidiol (CBD)
 - Cannabidiol monomethylether (CBDM)
 - Cannabidiolic acid (CBDA)
 - Cannabidiorcol (CBD-C1)
 - Cannabidivarin (CBDV)
 - Cannabidivarinic acid (CBDVA)
- Cannabielsoins
 - Cannabielsoic acid B (CBEA-B)
 - Cannabielsoin (CBE)
 - Cannabielsoin acid A (CBEA-A)
- Cannabigerols
 - Cannabigerol (CBG)
 - Cannabigerol monomethylether (CBGM)
 - Cannabigerolic acid (CBGA)
 - Cannabigerolic acid monomethylether (CBGAM)
 - Cannabigerovarin (CBGV)
 - Cannabigerovarinic acid (CBGVA)

More Naturally Occurring Cannabinoids

- Cannabinols and cannabinodiols
 - Cannabinodiol (CBND)
 - Cannabinodivarin (CBVD)
 - Cannabinol (CBN)
 - Cannabinol methylether (CBNM)
 - Cannabinol-C2 (CBN-C2)
 - Cannabinol-C4 (CBN-C4)
 - Cannabinolic acid (CBNA)
 - Cannabiorcool (CBN-C1)
 - Cannabivarin (CBV)
- Cannabitriols
 - 10-Ethoxy-9-hydroxy-delta-6a-tetrahydrocannabinol
 - 8,9-Dihydroxy-delta-6a-tetrahydrocannabinol
 - Cannabitriol (CBT)
 - Cannabitriolvarin (CBTV)
- Delta-8-tetrahydrocannabinols
 - Delta-8-tetrahydrocannabinol (Δ^8 -THC)
 - Delta-8-tetrahydrocannabinolic acid (Δ^8 -THCA)
- Delta-9-tetrahydrocannabinols
 - Delta-9 Tetrahydrocannibinol (THC)
 - Delta-9-tetrahydrocannabinol-C4 (THC-C4)
 - Delta-9 tetrahydrocannabinolic acid A (THCA-A)
 - Delta-9-tetrahydrocannabinolic acid B (THCA-B)
 - Delta-9-tetrahydrocannabinolic acid-C4 (THCA-C4)
 - Delta-9-tetrahydrocannabiorcol (THC-C1)
 - Delta-9-tetrahydrocannabiorcolic acid (THCA-C1)
 - Delta-9-tetrahydrocannabivarin (THCV)
 - Delta-9-tetrahydrocannabivarinic acid (THCVA)

And More Naturally Occurring Cannabinoids

- Miscellaneous cannabinoids
 - 10-Oxo-delta-6a-tetrahydrocannabinol (OTHC)
 - Cannabichromanon (CBCF)
 - Cannabifuran (CBF)
 - Cannabiglendol
 - Cannabiripsol (CBR)
 - Cannbicitran (CBT)
 - Dehydrocannabifuran (DCBF)
 - Delta-9-cis-tetrahydrocannabinol (cis-THC)
 - Tryhydroxy-delta-9-tetrahydrocannabinol (triOH-THC)
 - 3,4,5,6-Tetrahydro-7-hydroxy-alpha-alpha-2-trimethyl-9-n-propyl-2,6-methano-2H-1-benzoxocin-5-methanol, or OH-iso-HHCV.

Sources: Hemp Gazette and Rudolf Brenneisen, author of the "Chemistry and Analysis of Phytocannabinoids and Other Cannabis Constituents"

The diagram illustrates the biosynthesis of cannabinoids from Cannabigerolic Acid (CBGA). It shows two main pathways:

- Top Pathway (THC synthesis):**
 - CBGA** (Cannabigerolic Acid) is converted to **Δ^9 -THCA** (Tetrahydrocannabinolic Acid) by the enzyme **THCA Synthase**.
 - Δ^9 -THCA** undergoes **Decarboxylation** (indicated by **Heat**) to form **Δ^9 -THC** (Tetrahydrocannabinol) and release **Carbon Dioxide ($O=C=O$)**.
- Bottom Pathway (CBD synthesis):**
 - CBGA** (Cannabigerolic Acid) is converted to **CBDA** (Cannabidiolic Acid) by the enzyme **CBDA Synthase**.
 - CBDA** undergoes **Decarboxylation** (indicated by **Heat**) to form **CBD** (Cannabidiol) and release **Carbon Dioxide ($O=C=O$)**.

Chemical structures are provided for each molecule, showing the progression from the common precursor CBGA to the final products, THC and CBD, with the loss of carbon dioxide during decarboxylation.

Florida Department of Agriculture and Consumer Services

A Little More Chemistry

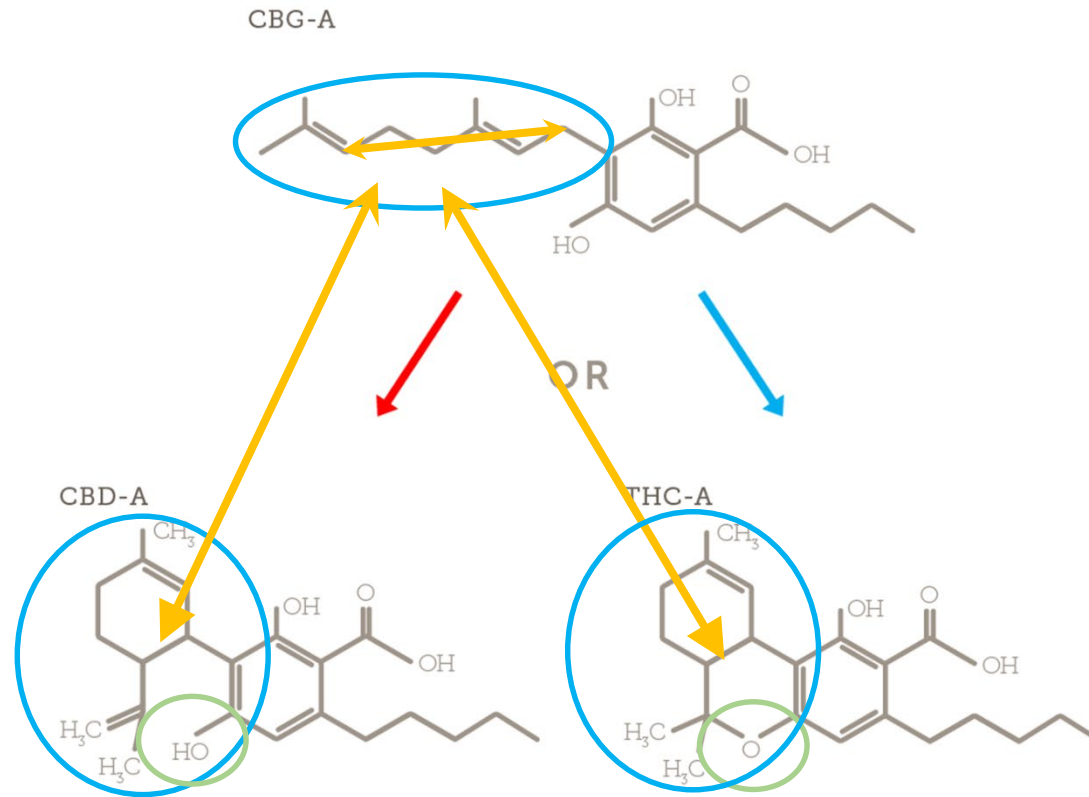

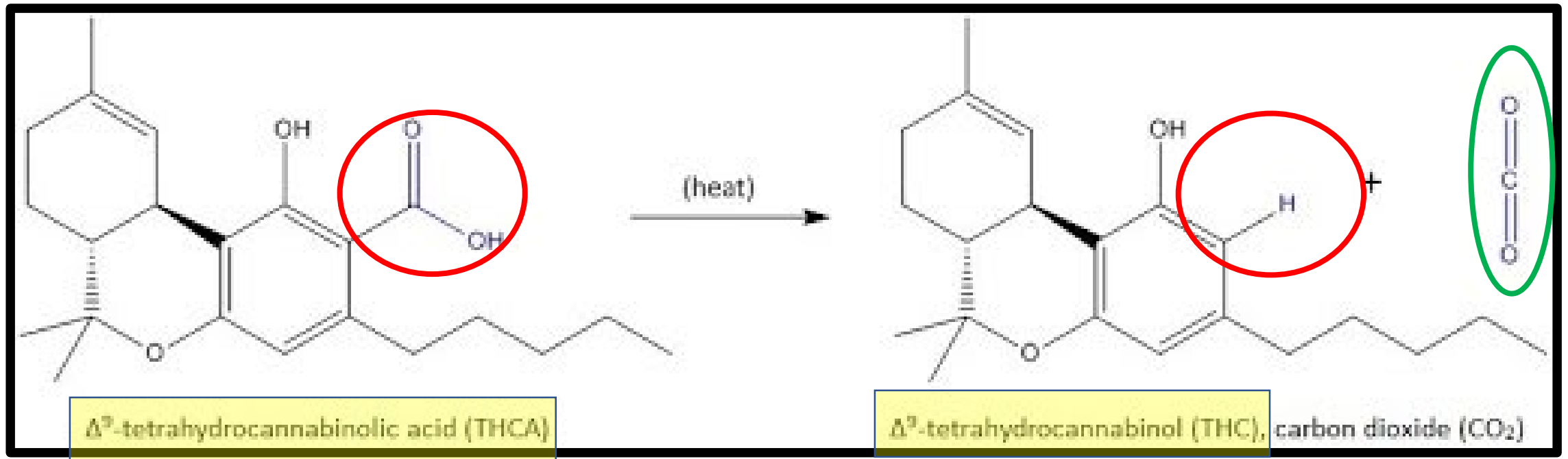


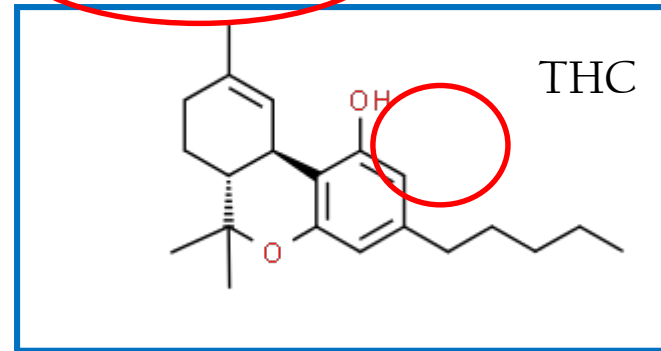
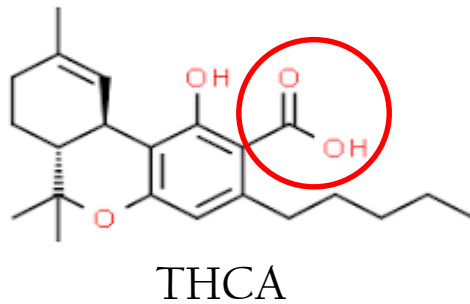
Image Source: 

Decarboxylation



THCA to Tetrahydrocannabinol (THC)

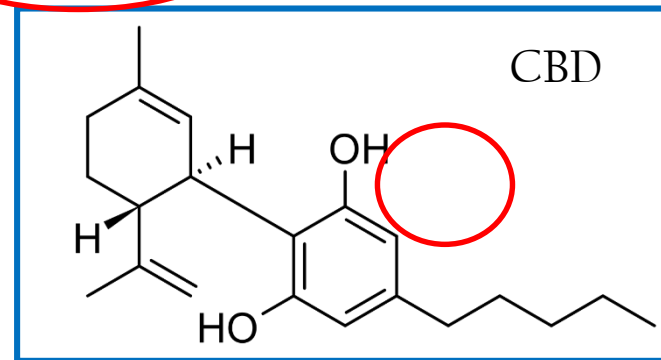
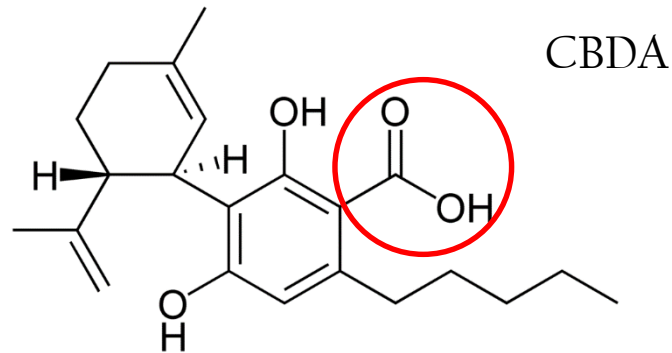
- Organic molecule derived through decarboxylation of Tetrahydrocannabinolic acid (THCA)
- THCA Molecular Formula: $C_{22}H_{30}O_4$ Molecular Weight: 358.5 g/mol



- Tetrahydrocannabinol (THC)
- THC Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol

CBDA to Cannabidiol (CBD)

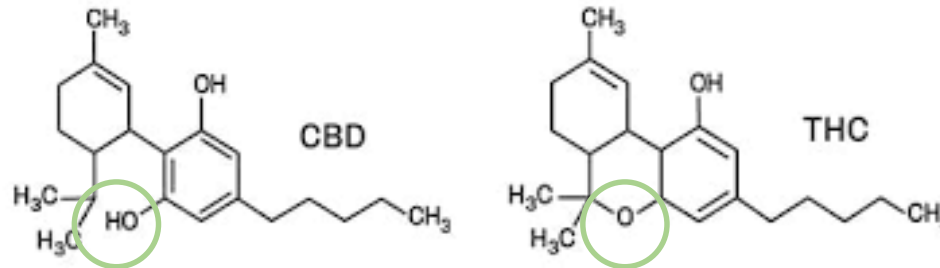
- Organic molecule derived through decarboxylation of Cannabidiolic acid (CBDA)
- CBDA Molecular Formula: $C_{22}H_{30}O_4$ Molecular Weight: 358.5 g/mol



- Cannabidiol (CBD)
- CBD Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol

Comparing CBD and THC

- Tetrahydrocannabinol (THC)
- THC Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol



- Cannabidiol (CBD)
- CBD Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol
- CBD and THC are isomers

What is Total Δ9-THC?

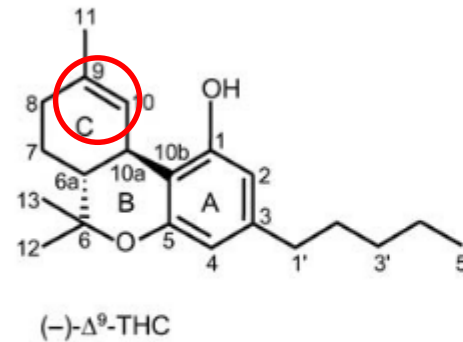
- THCA to THC conversion is not an equilibrium
- Occurs readily with heat/time
- [Total Δ9-THC] = [Δ9-THC] + (0.877[Δ9-THCA])
- Where does “0.877” come from?
- Recall: M.W. THCA = 358.5 g/mol and M.W. THC = 314.45 g/mol
- $314.45/358.5 = 0.877$
- In other words: THC is 87.7% as heavy as THCA
- THCA included in total as it is easily converted to THC

Dry Weight

- Applies to lab results (wet weight v dry weight)
- Removes mass contribution from moisture in calculations
- Higher moisture content means bigger difference between wet and dry weight reported concentrations
- Ovens remove moisture and other chemicals with a similar or greater volatility
- Other techniques (e.g. Karl Fischer) can single out moisture
- Difference in harvested crops and finished products

What is Total Δ 9-THC?

- Delta “ Δ ” is antiquated
- Not used in IUPAC
- Double bond in alkenes
- Number refers to location

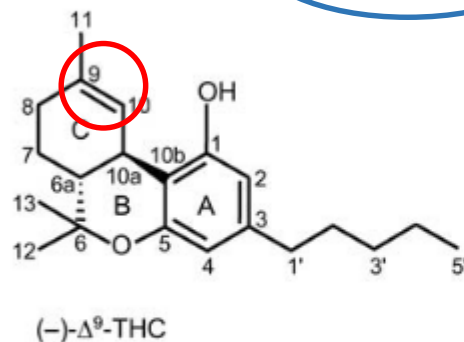


Delta-9-THC

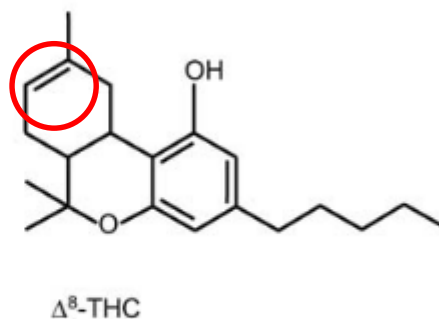
Comparing $\Delta 8$ -THC and $\Delta 9$ -THC

- $\Delta 9$ -Tetrahydrocannabinol (THC)

- Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol



Delta-9-THC



Delta-8-THC

- $\Delta 8$ -Tetrahydrocannabinol (THC)

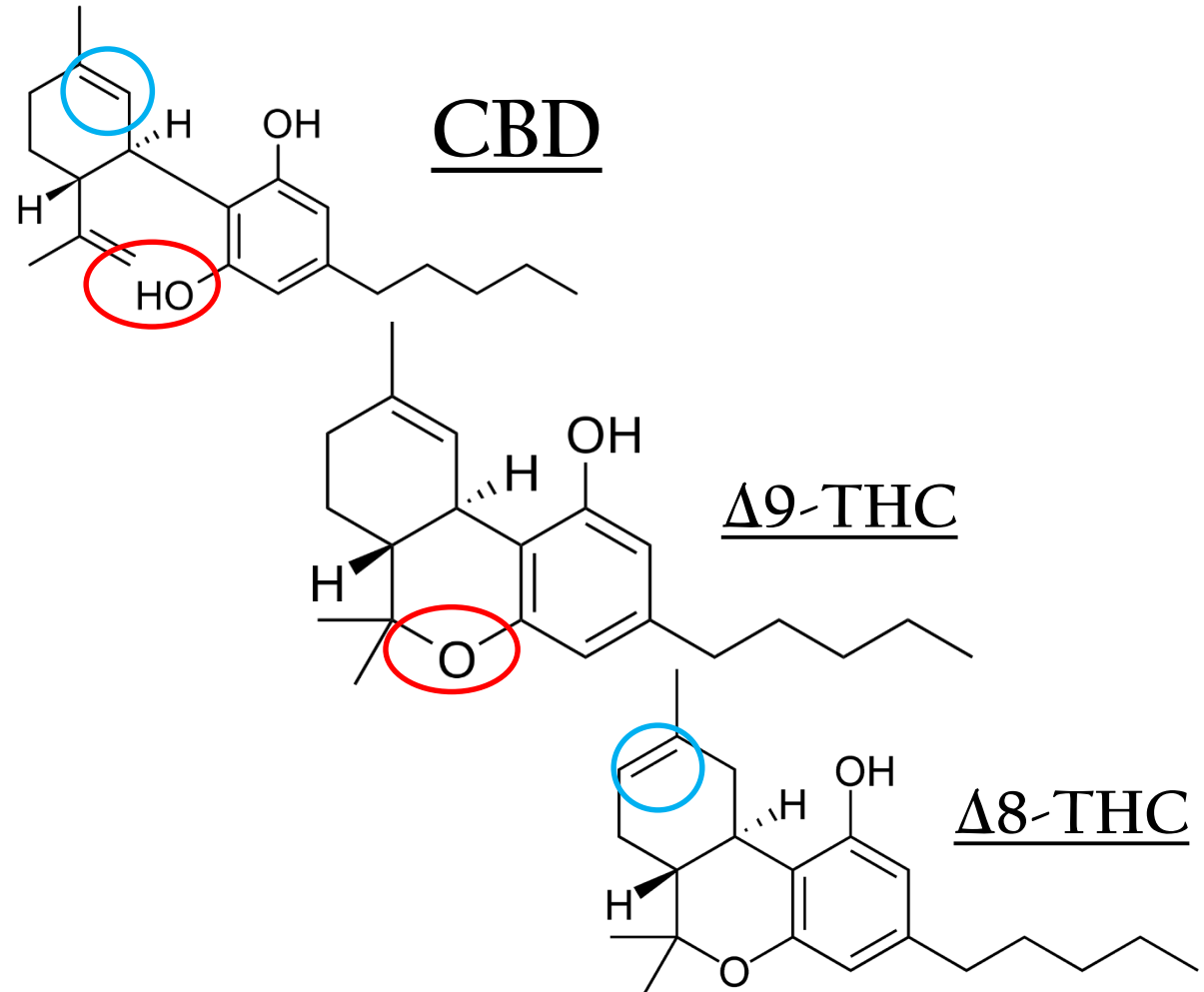
- Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol

Comparing CBD, $\Delta 8$ -THC, and $\Delta 9$ -THC

- Cannabidiol (CBD)
 - Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol
- $\Delta 9$ -Tetrahydrocannabinol ($\Delta 9$ -THC)
 - Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol
- $\Delta 8$ -Tetrahydrocannabinol ($\Delta 8$ -THC)
 - Molecular Formula: $C_{21}H_{30}O_2$ Molecular Weight: 314.45 g/mol
- CBD, $\Delta 8$ -THC, and $\Delta 9$ -THC are all isomers.

Conversion of CBD to Δ8-THC

- Two-Step Process:
 - Close Ring
 - Move Bond
- Conditions:
 - Heat
 - Acid
 - Catalyst
- Challenges:
 - Drive reaction to completion
 - Presence of other THC isomers
 - Presence of residual compounds



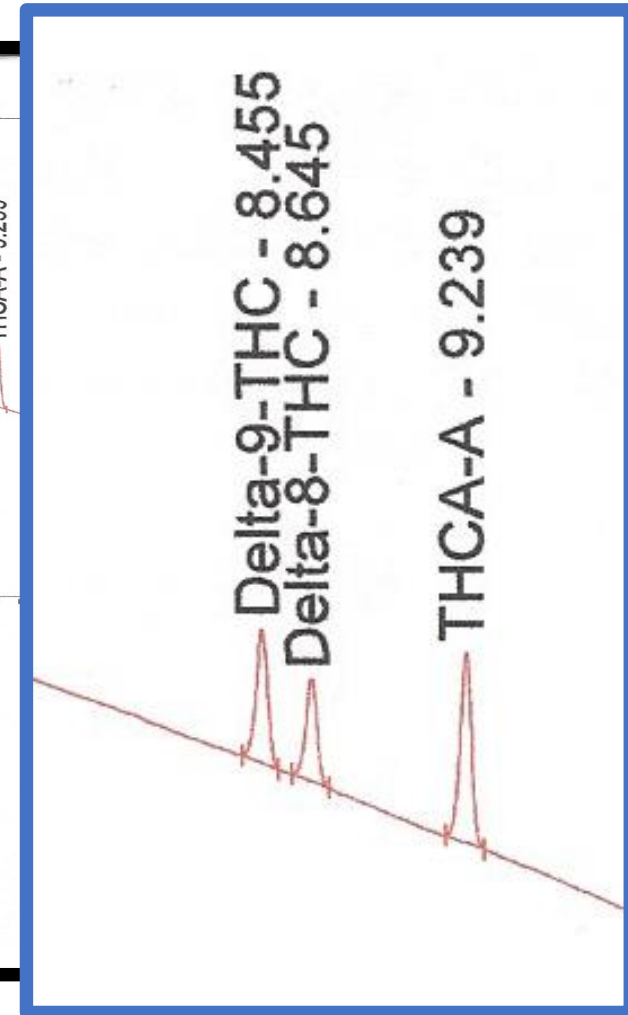
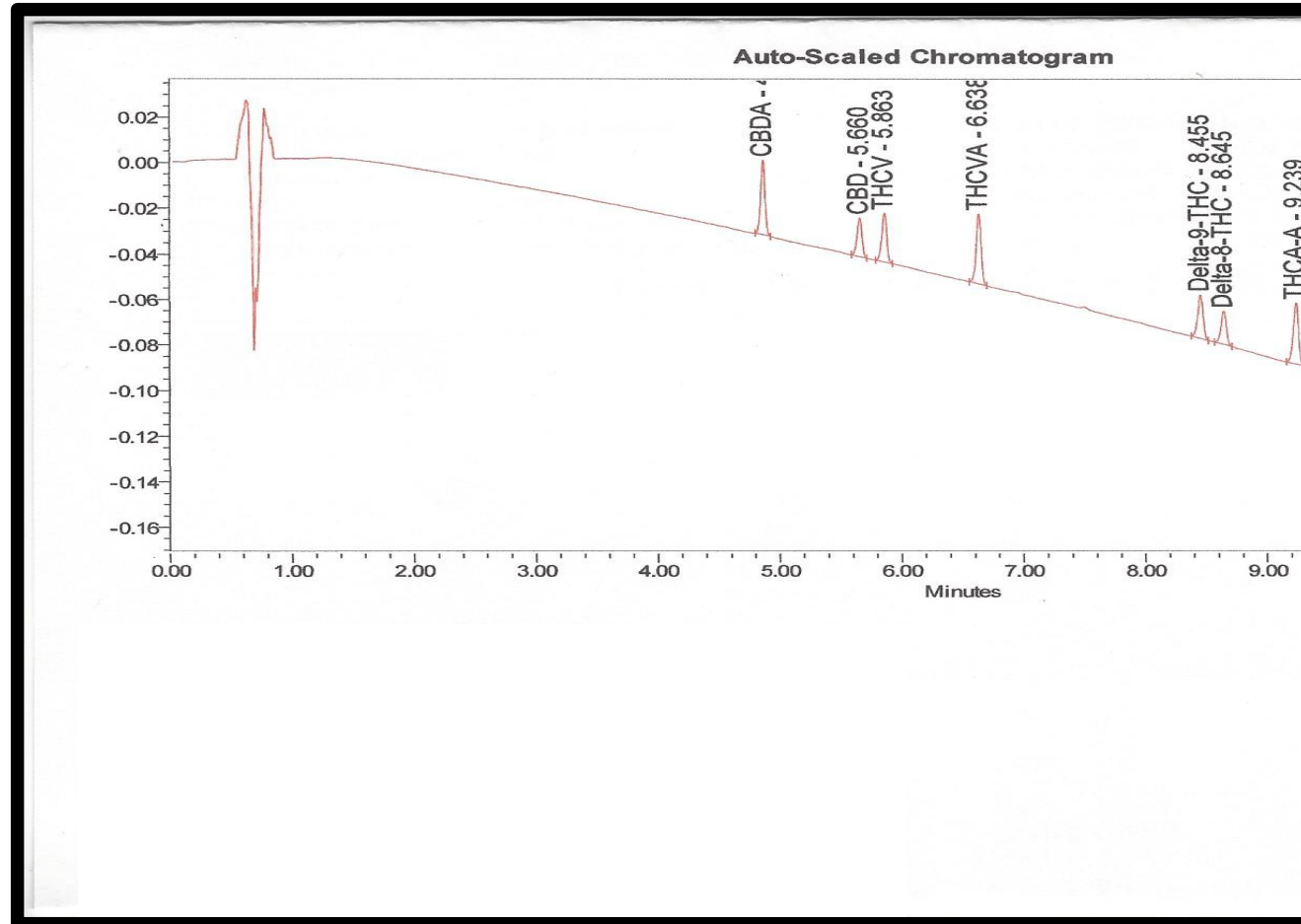
Cannabinoid Chemistry 202...

- Are we ready???
- This will not be on the test!

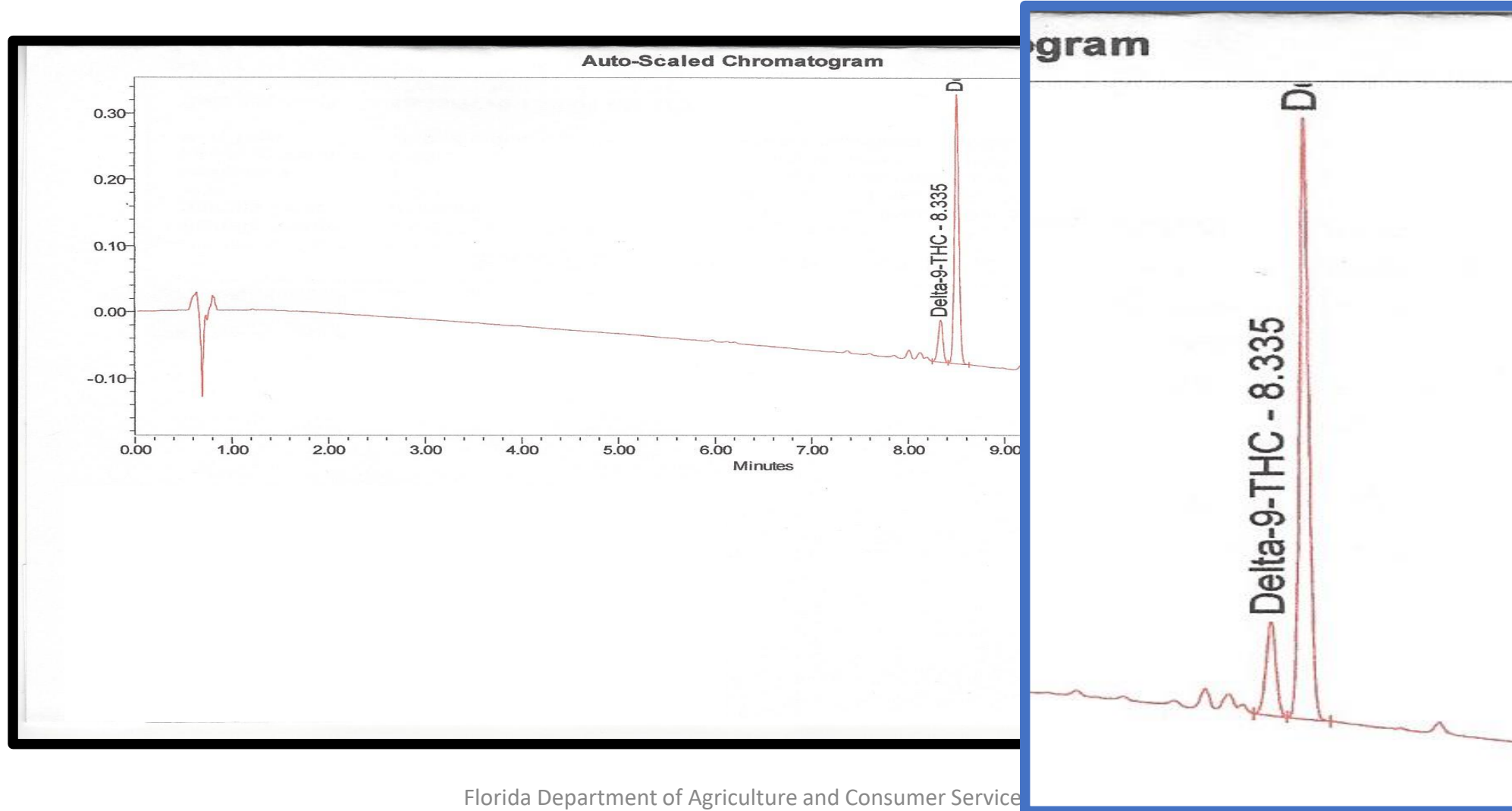
CBD Converted to $\Delta 8$ -THC

- Potential to have $\Delta 9$ -THC present in significant concentrations.
- Products would test “hot” for $\Delta 9$ -THC.
- Some have reported a “mystery molecule” that appears to be $\Delta 9$ -THC, but contend it is not $\Delta 9$ -THC.
 - Unaware of postulated identity of the “mystery molecule” though.
- FDACS has analyzed samples reported to contain only $\Delta 8$ -THC (and no $\Delta 9$ -THC).
 - Found presence of $\Delta 9$ -THC above 0.3% with many above 10% THC.
- LC-UV and LC-MS results agree for $\Delta 9$ -THC concentration.

Standard Chromatogram (LC-UV)



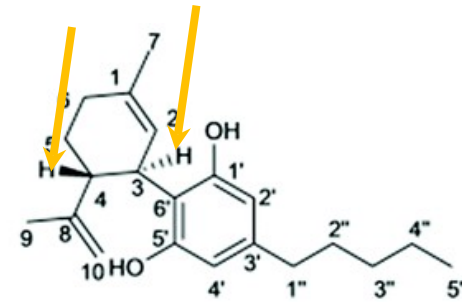
Sample Chromatogram (LC-UV)



“Mystery Peak”

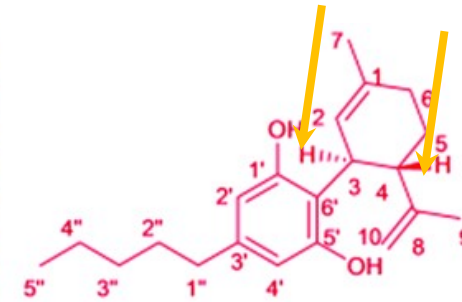
- Presuming for this exercise that a different compound is present, what could it be?
- It could be something that only appears sporadically in products and has yet to be identified.
 - Lacking confirmation and postulated identity at this time.
- It could be a stereoisomer of Δ^9 -THC.
 - *Source: Dr. Chris Hudalla from ProVerde Lab - Analytical Cannabis Expo East; Oct 2020.*
 - Still Δ^9 -THC.
- Is there another option?
 - It could actually be Δ^9 -THC and not a different compound.

Stereoisomers



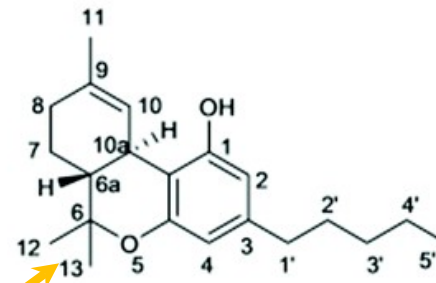
(-)-(R,R)-CBD

(-)-2



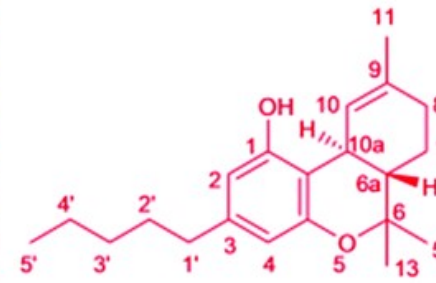
(+)-(S,S)-CBD

(+)-2



(-)-(R,R)-Δ⁹-THC

(-)-4



(+)-(S,S)-Δ⁹-THC

(+)-4

Summary

- CBD, $\Delta 8$ -THC, $\Delta 9$ -THC are isomers.
 - Eliminating “THC and its isomers” also includes CBD.
- $\Delta 9$ -THC has shown to be present in many of the $\Delta 8$ -THC products.
- Quality chemistry, chemists and labs are a necessity.
- $[\text{Total THC}] = [\text{THC}] + (0.877[\text{THCA}])$ would include $\Delta 8$ -THC, $\Delta 9$ -THC, and any other “delta” isomer of THC, but not CBD.
- *Cannabis* Syllabus, complete!

Questions?



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