



# 3D Modeling in Chemistry Education

**Ari Myllyviita**

**MSc (Chem.Ed.), BSc (Chem.), BEd (soc.pedag.)**

**Lecturer (Chem & Math), Teacher educator, e-Writer**

**Viikki Teacher Training School of University of Helsinki**

**Research associate, University of Johannesburg, South Africa**



## Kemian opetus

- [Kemian opettajan blogi, Edmodo](#)
- [Peda.net](#)
- [Etäluokka](#)

## Viikin normaalikoulu

- [Koulun etusivu, eNorssi](#)

## Hankkeet

- [Kemikaalivaraston hoitajien koulutus -hanke, blogi](#)
- [OPStuki2016 \(arviointi\)](#)

## Tärkeät HY-linkit

- [HY-Flamma, Flamma-päivitys](#)
- [Email, Wilma](#)
- [HY-Wiki, Moodle, Blog](#)
- [HY - SAP, Tuhat, Proha, Raportit](#)
- [Viikki-streamaus](#)

## Yhteystiedot

# TYÖPÖYTÄ

*“Nothing is more dangerous than a dogmatic worldview—nothing more constraining, more blinding to innovation, more destructive of openness to novelty”*

Gould, Stephen J., (1995). Dinosaur in a haystack: Reflections in natural history.

 	  	<p>Helka(HY),  <a href="#">Helmet</a>  <a href="#">Päiväri</a></p>
 	  <p><b>TSL</b> <b>KSL</b>  <a href="#">kouluttajafoorumi.net</a>          TIETY-kouluttajakoulutuksen aineistoja</p>	

Yhteydenpitoa ja kalentereita

[www-domain -cPanel](#); [Thomson-verkko](#)

## Ajankohtaista

- **Lecture 7.10.19 - [ICT and modeling in Science edycation](#)**
- **Lecture 30.9.19 - [Science education in Finland](#)**
- **ChemEd2019 -event, Naperville, ÚSA, [PIRE-project and Teachers' PD](#)**
- **LUMA-päivät 2019, TVT oman opetuksen kehittämisessä**
- **EDUCA 19, [MAOL-kemian tv-tuento](#)**
- **ASE-conferense 19, [How to use ICT and Social Media in Chemistry Education](#)**
- **EASE/ASET - conference - presentation: [Chemistry Education - Individual](#)**



# Viikki Teacher Training School of Helsinki University

950 pupils and students

Primary school  
Lower and Upper secondary schools

100 teachers

250 student teachers





# Viikki Teacher Training School of University of Helsinki

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- Is one of the oldest schools in Finland. Founded in 1869.
- Since 1924 it has been training future teachers, and in 1969 the school became co-educational.
- In 1974 it became part of the teacher training unit of the Department of Education of the University of Helsinki, and along with that role, the school has also provided further education for in-service teachers.
- The school consists of the 9-year comprehensive school (ages 6 to 15), primary school and lower secondary school levels (Basic Education), and the upper secondary school (ages 16 to 18).
- Pupils (ca 940), teachers (ca 100) and teacher trainees (ca 250) from the pre-school level to the upper secondary school level now operate in the same school building.
- The school also emphasises the importance of experimentation and research in a natural school context.
- Our school participates in many local, national and international projects in general and teacher education.

# Teacher training at the university level - history

- In Finland
  - The training of subject teachers has been conducted at the university level since the early 19th century .
  - The training of class teachers (primary) was transferred over to be carried out by universities in the early 1970s.
  - The training of kindergarten teachers in universities began in 1995.





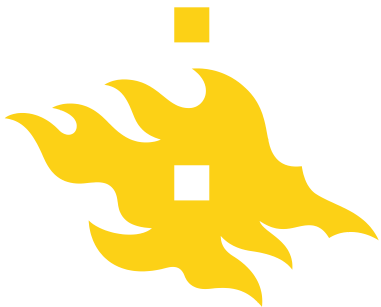
# Research-based Teacher Education

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- Every teacher in Finland has a masters' degree as a minimum requirement. Teacher training is organized in a unique way in eight universities in different parts of Finland.
- Universities have their autonomy but they have something in common: Every student teacher attends a teaching practice in the University Teacher Training School (TTS).
- The TTSs that belong to the faculties of education of the universities play a central role in the training of prospective teachers.



# Pedagogical choices...



# The whole picture of Chemistry education

## Pedagogical tools

Modeling  
Simulations  
Visualization  
Concept (language)  
Experiments  
Inquire learning

## Cognitive tools

To support studying (concept maps)  
Documenting (work reports, posters)  
Virtual learning environments

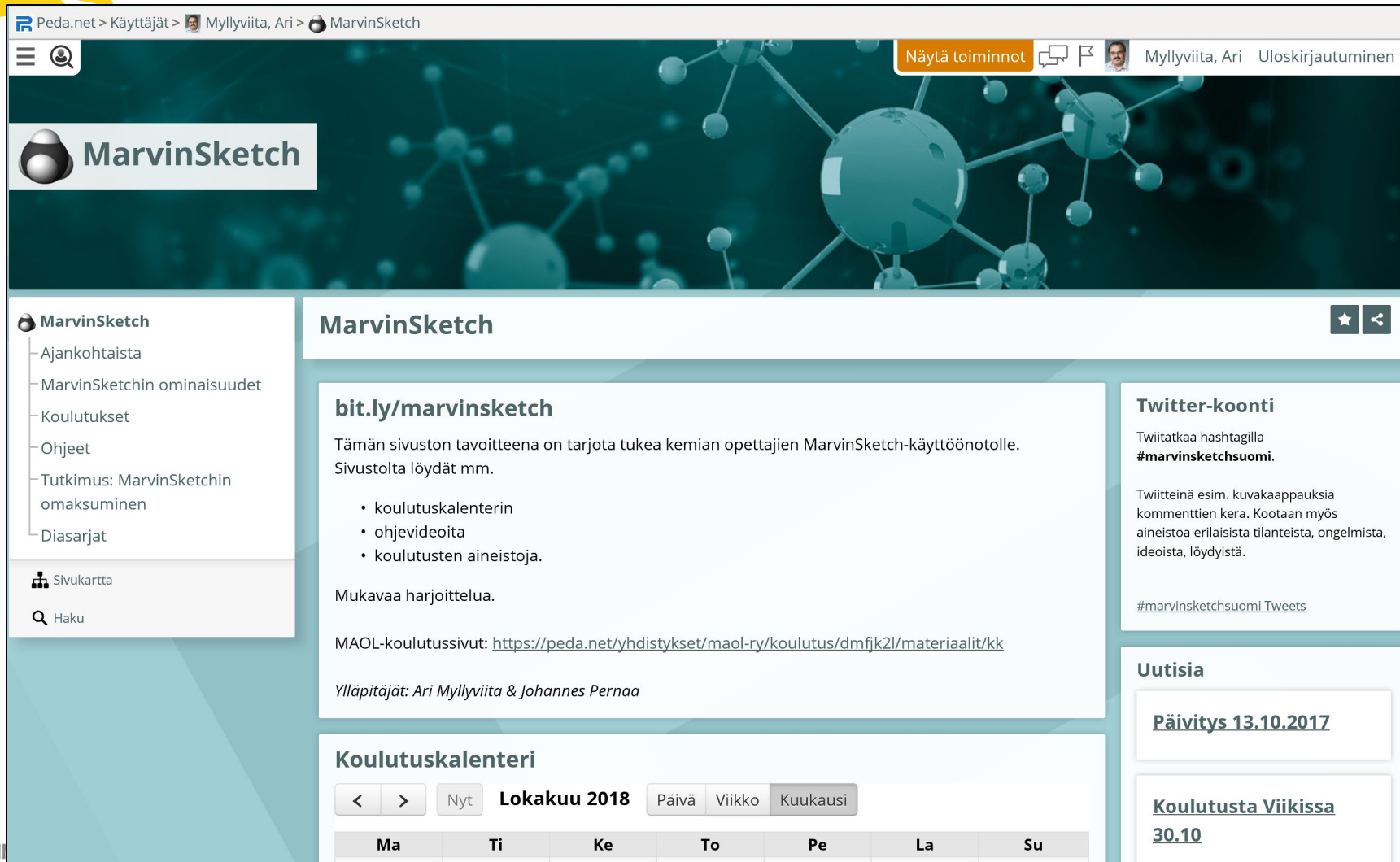
## Metacognitive tools

Reflection (blogs, e-diary) – teacher identity  
Self-regulation  
Self-assessment  
Evaluation

# Nature of Science

# MarvinSketch -pages

<https://peda.net/p/myllyviita/marvinsketch> tai <http://bit.ly/marvinsketch>



Peda.net > Käyttäjät > Myllyviita, Ari > MarvinSketch

Näytä toiminnot

MarvinSketch

MarvinSketch

- Ajankohtaista
- MarvinSketchin ominaisuudet
- Koulutukset
- Ohjeet
- Tutkimus: MarvinSketchin omaksuminen
- Diasarjat

Sivukartta

Haku

## MarvinSketch

### bit.ly/marvinsketch

Tämän sivuston tavoitteena on tarjota tukea kemian opettajien MarvinSketch-käyttöönololle. Sivustolta löydät mm.

- koulutuskalenterin
- ohjevideoita
- koulutusten aineistoja.

Mukavaa harjoittelua.

MAOL-koulutussivut: <https://peda.net/yhdistykset/maol-ry/koulutus/dmfjk2/materiaalit/kk>

Ylläpitäjät: Ari Myllyviita & Johannes Perna

### Koulutuskalenteri

< > Nyt **Lokakuu 2018** Päivä Viikko Kuukausi

Ma	Ti	Ke	To	Pe	La	Su
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### Twitter-koonti

Twitatakaa hashtagilla **#marvinsketchsuomi**.

Twitteinä esim. kuvakaappauksia kommenttien kera. Kootaan myös aineistoa erilaisista tilanteista, ongelmista, ideoista, löydystä.

[#marvinsketchsuomi Tweets](#)

### Uutisia

**Päivitys 13.10.2017**

**Koulutusta Viikissa 30.10**

# Spectroscopy –pages (Chem2)

<https://peda.net/p/myllyviita/spektroskopia>

Peda.net > Käyttäjät > Myllyviita, Ari > Spektroskopiaa – IR, NMR ja MS

Näytä toiminnot

Myllyviita, Ari Uloskirjautuminen

Myllyviita, Ari

## Spektroskopiaa – IR, NMR ja MS

- Sivut
  - Spektroskopiaa – IR, NMR ja MS**
    - Tuntemattoman molekyylin määrittäminen
    - Tehtävät – Infrapunaspektroskopia (IR)
    - Spektritehtävät – NMR-spektroskopia
    - Spektritehtävät – Massaspektrometria
  - Omat linkit
  - Omat tilaukseni
  - Arviointihistoria
  - Arvioinnit
  - Yhteydet
  - Viestit

### Miksi spektroskopiaa?

Spektroskopia on nykyaikainen laboratoriomenetelmä, jolla selvitetään tuntemattomien aineiden rakenteita, tunnistetaan alkuaineita, varmistetaan reaktioiden tuotteita ja mahdollisesti analysoidaan myös tiettyjen aineiden pitoisuuksia. Spektroskopia perustuu eri aallonpituuksilla olevan säteilyn (ultravioletti, näkyvä valo, infrapuna) vastaanottamiseen tai lähettämiseen. Molekyyli, atomi tai joku rakenneosasta vastaanottaa säteilyä, esimerkiksi näkyvää valoa, ja se voidaan mitata. Tai toisessa tilanteessa molekyyli tai atomi emittoi (lähettää) absorboidun (vastaanotetun) aallonpituuden. Tämä voidaan mitata.

Spektroskopiaa on useita eri lajeja, jotka esitellään yksityiskohtaisemmin Orbitaali 2 -kirjan luvussa "Aineen rakenteen analyysimenetelmät".

### Atomiansorptiospektrofotometria - AAS

Atomiansorptiospektrofotometriasta on Orbitaali 2 -kirjassa lyhyt esittely. AAS-menetelmää käytetään alkuaineiden määrittämisessä, mm. pitoisuuksien määrittämiseksi. Ilmiö on tuttu liekkikokeiden yhteydestä.

### Spektrien lähde

Spektrit on otettu [SDBS-tietokannasta](#).

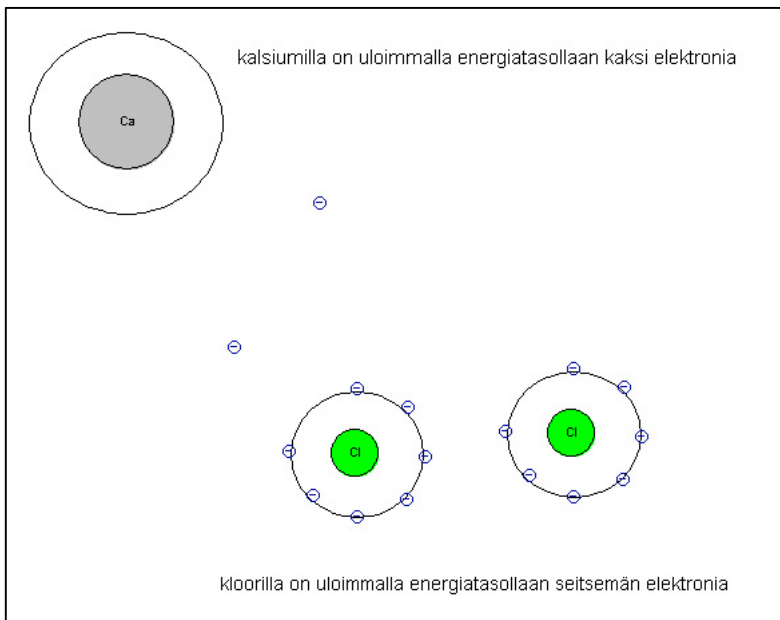


# Modeling in Chemistry

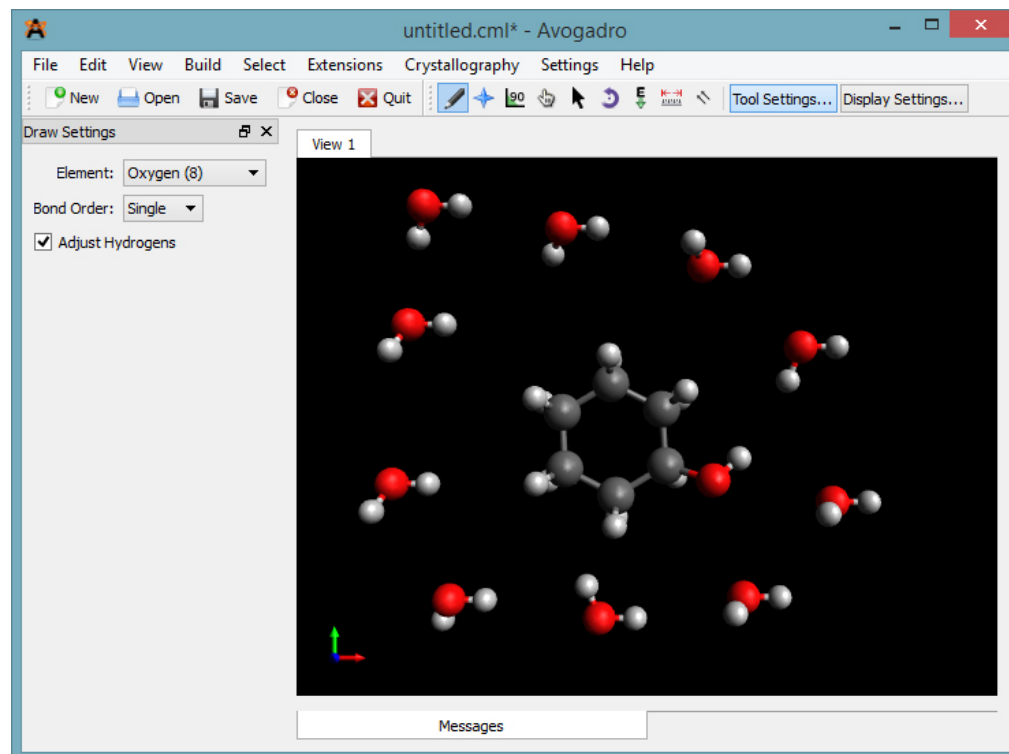
Animations, simulations ...



# Modeling and animations



ChemSenseAnimator



Avogadro, ChemSketch,  
MarvinSketch, MolView (online)



# Modeling – theoretical and research approaches

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“A model is a readily perceptible entity by means of which **the abstractions of a theory** may be brought to bear on some aspects of the world-as-experienced **in an attempt to understand it.**” (Gilbert). There are two types of models:

- **mental models**
  - Mental models are representations that we build in order to explain or predict a situation, they are often “forerunners of misconceptions” (Kind, 2004). Mental models are created in the moment when they are needed and are then discarded when they are no longer needed.
- **material models.**
  - Material models are expressed mental models (Gilbert et al., 2000) that are built to communicate with other individuals. Material models can be **symbolic, experimental, or iconic.**



# Modeling – theoretical and research approaches

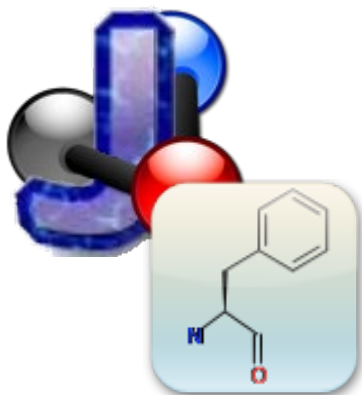
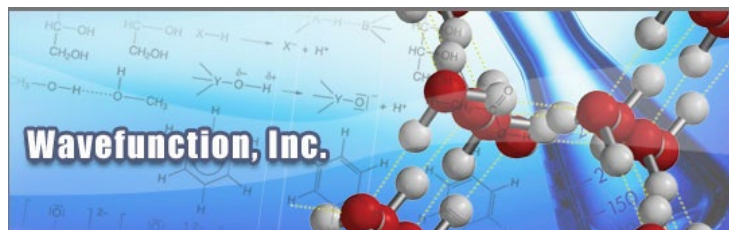
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- The use of modern computer-based molecular modelling has proven to be **highly productive in chemical research** (Justi & Gilbert, 2002).
- Computer-based molecular modelling opens various possibilities for teaching chemistry (Aksela & Lundell, 2008). Barak and Dori (2005) found that using computer-based models helped promote students' understanding of chemistry at four levels: the macroscopic, microscopic, symbolic and chemical process levels.
- They also found that computer based visual models helped students **understand chemical concepts, theories, and molecular structures.**



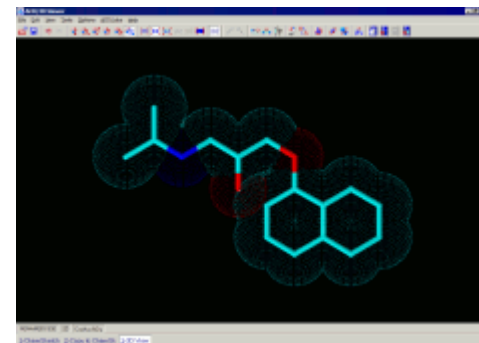
# 3D-Modeling programs

- Modeling program
  - Spartan, HyperChem
  - Free: **ChemSketch**, ArgusLab, Symyx Draw, **Avogadro**, MarvinSketch
  - <http://pelu.jns.fi/iroi/kem/rakennus/> (online-program)

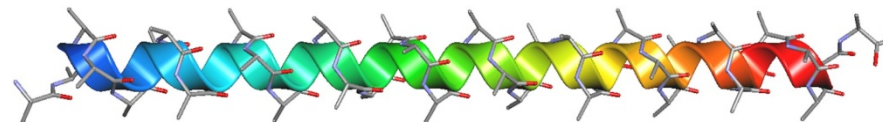


[www.wavefun.com](http://www.wavefun.com) (Spartan)  
[www.hyper.com](http://www.hyper.com) (Hyperchem)

[www.acdlabs.com](http://www.acdlabs.com) (ChemSketch)  
[www.arguslab.com](http://www.arguslab.com) (ArgusLab)



## ArgusLab

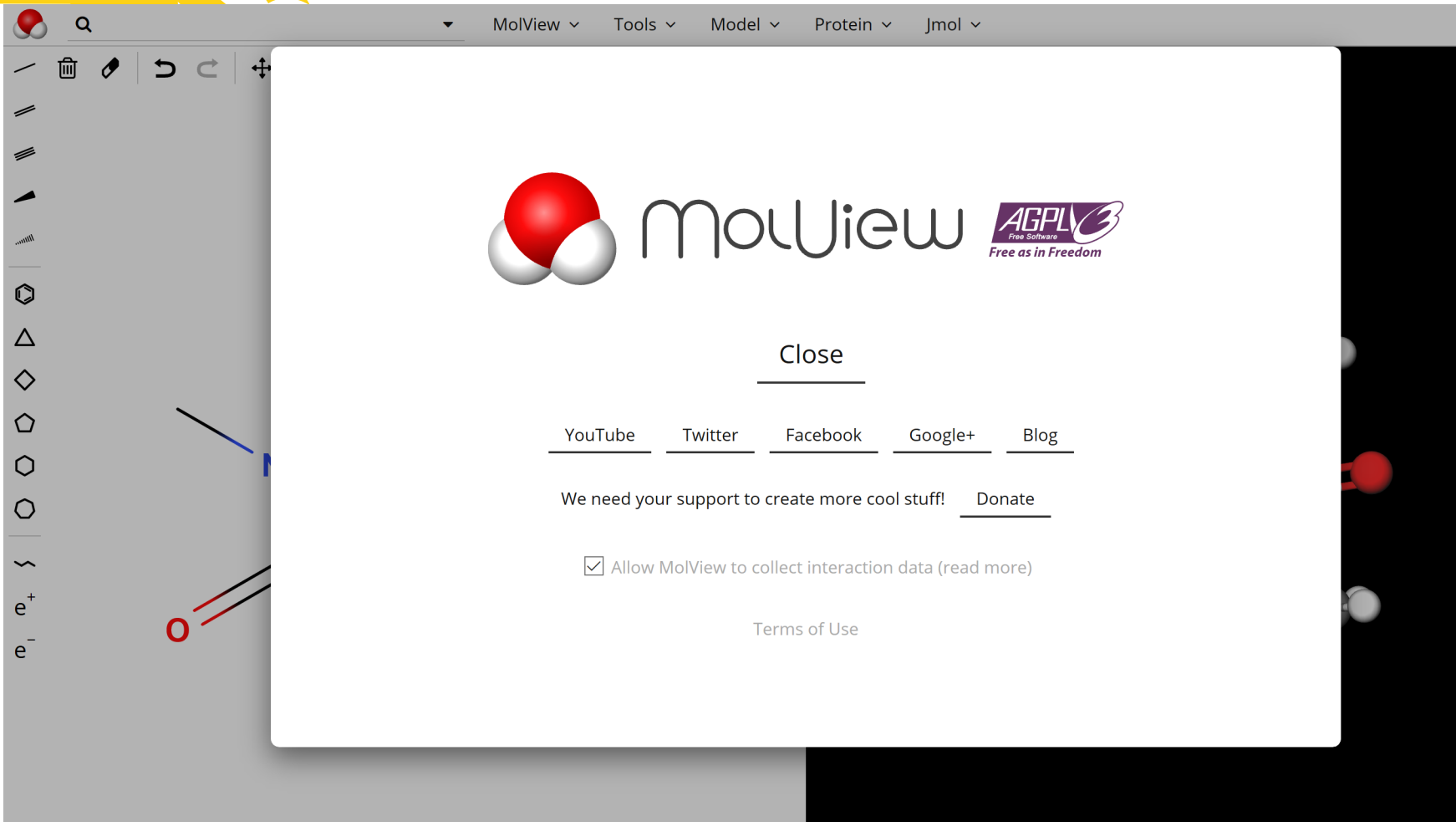




# Molview

**Suitable for secondary education (lower and upper)**

# Molview.org -ohjelma



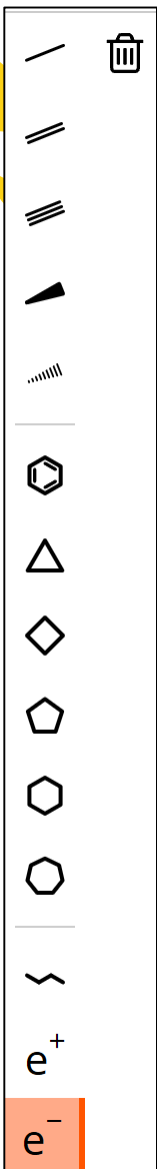
The screenshot shows the MolView application interface. At the top, there is a navigation bar with dropdown menus for "MolView", "Tools", "Model", "Protein", and "Jmol". Below the navigation bar is a toolbar with various icons for editing and viewing. The main content area displays the MolView logo, which consists of a red and white sphere, the text "MolView", and the AGPL 3 logo with the text "Free Software" and "Free as in Freedom". Below the logo, there is a "Close" button. Underneath, there are five social media links: "YouTube", "Twitter", "Facebook", "Google+", and "Blog". Below these links, there is a text prompt: "We need your support to create more cool stuff!" followed by a "Donate" button. At the bottom of the dialog, there is a checkbox labeled "Allow MolView to collect interaction data (read more)" which is checked. Below the checkbox, there is a link for "Terms of Use".



# Select the element or the ready made structure

The screenshot shows the Jmol software interface. At the top, there are menu items: MolView, Tools, Model, Protein, and Jmol. Below the menu is a toolbar with various icons. A yellow box with the text "Press this button first" has an arrow pointing to the trash can icon in the toolbar. Another yellow box with the text "CHOOSE" has an arrow pointing to the element selection menu. The element selection menu is a vertical list of elements: C, H, N, O, P, S, F, Cl, Br, I, and ... . To the right of the menu is a 3D ball-and-stick model of a complex organic molecule with a central ring system, blue nitrogen atoms, and red oxygen atoms.

# Different menus



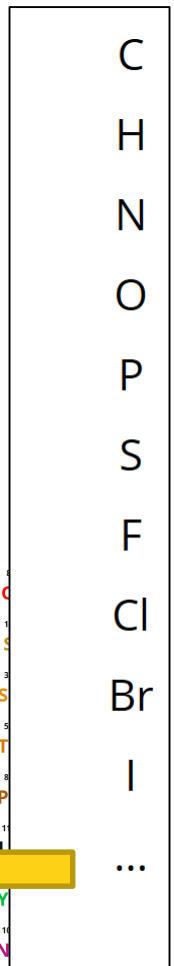
Trash – Erase - Undo/redo –  
 Choose – Color - CH-bonds –  
 Focus – Clean and 2D → 3D

Different bonds  
 Structures  
 Charge

Elements

Periodic Table

1 H																	5 B	6 C	7 N	8 O	
3 Li	4 Be											9 F	10 Ne	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr				
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe				
55 Cs	56 Ba	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn					
87 Fr	88 Ra	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uu	116 Lv	117 Ts	118 Og					
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu							
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 N								



Q ibupro

Ibuprohm	Compound
Ibuprofen	Compound
Ibuproxam	Compound
Ibuprocin	Compound
Ibuprofen sodium	Compound
Ibuprofen piconol	Compound
Ibuprofen Alcohol	Compound
Ibuprofen sodium salt	Compound
Ibuprofen methyl ester	Compound
Ibuprofen guaiacol ester	Compound
Iron	Mineral
Boron	Mineral
Fibrin	Blood Plasma Proteins
HU Protein	Genetic Information

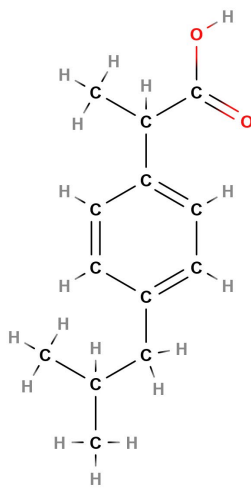
# IBUPRO-seach

Pyrope
Zircon
Auricupride
Cupronyite
Cuprospinel
Burtite
Cuprite
Sulphur
Antibody
Ribosome
Prefoldin

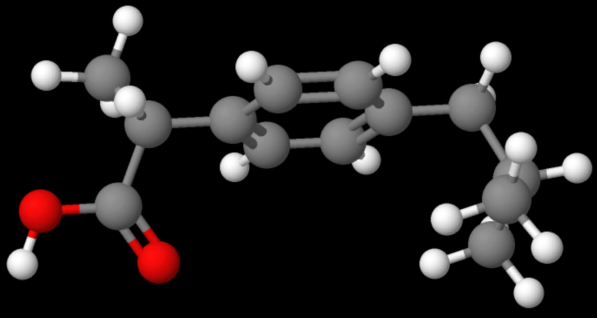
Q Ibuprofen

MolView Tools Model Protein Jmol

2D to 3D

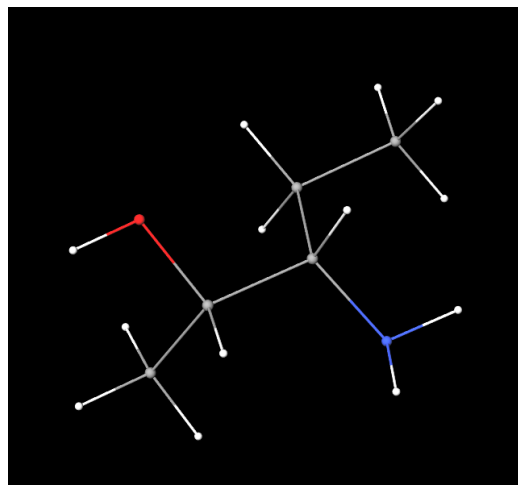
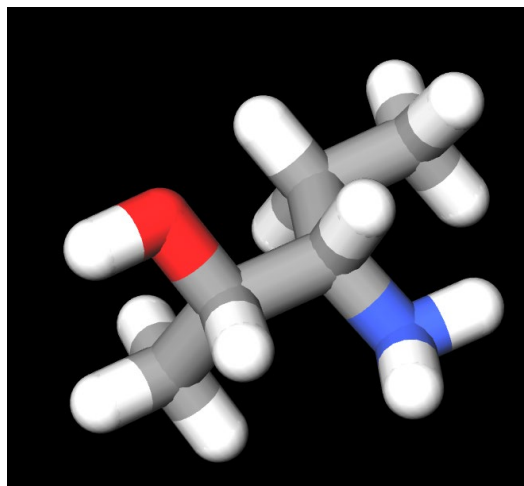
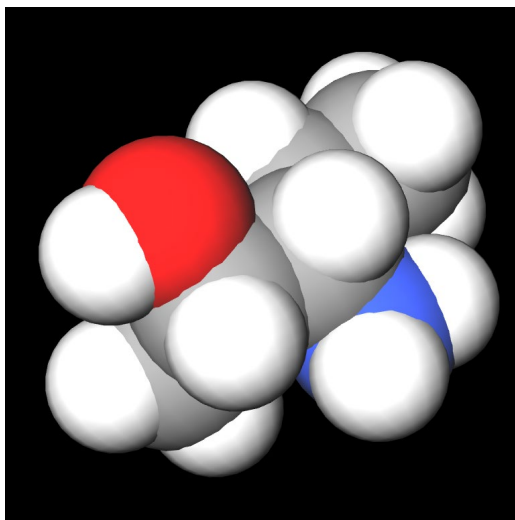


Legend: C, H, N, O, P, S, F, Cl, Br, I, ...





# MOLVIEW –different representations



Model ▾ Protein ▾ Jmol

↻ Reset

**REPRESENTATION**

- Ball and Stick
- Stick
- van der Waals Spheres
- Wireframe
- Line

**BACKGROUND**

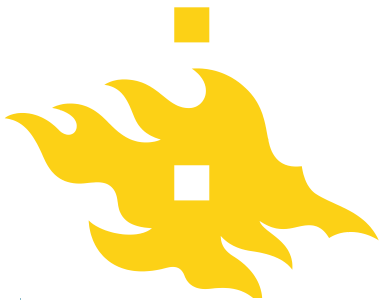
- Black
- Gray
- White

**ENGINE**

- GLmol
- Jmol
- ChemDoodle

**CRYSTALLOGRAPHY**

- Load unit cell
- Load 2×2×2 supercell
- Load 1×3×3 supercell



# Proteins



Q Aldolase



MolView

Tools

Model

Protein

Jmol

Protein

Jmol

Show bio assembly

## CHAIN REPRESENTATION

Ribbon

Cylinder and plate

B-factor tube

C-alpha trace

Bonds

## CHAIN COLOR SCHEME

Secondary structure

Spectrum

Chain

Residue

Polarity

B-factor





# Electron Density

MolView Tools Model Protein Jmol

2D to 3D

C  
H  
N  
O  
P  
S  
F  
Cl  
Br  
I

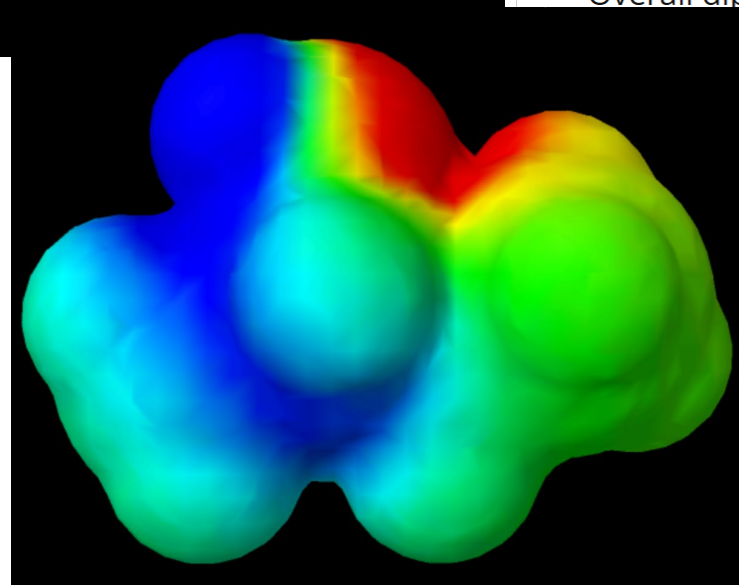
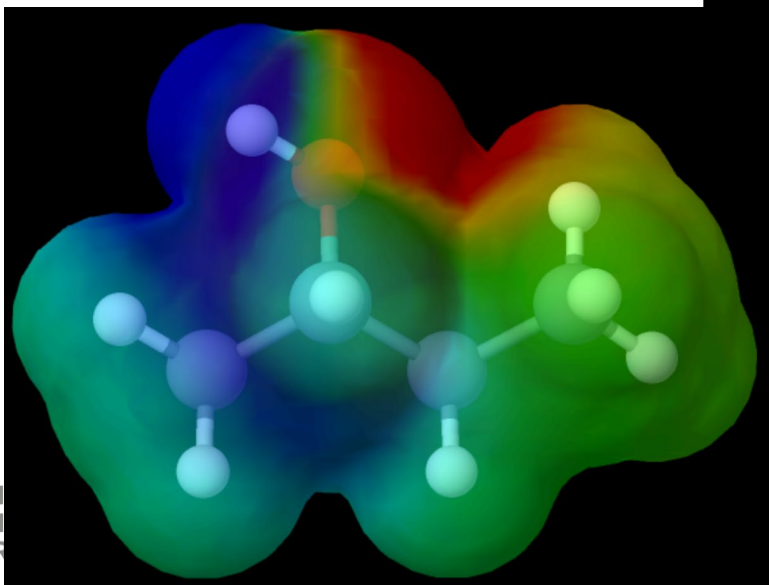
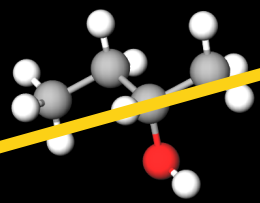
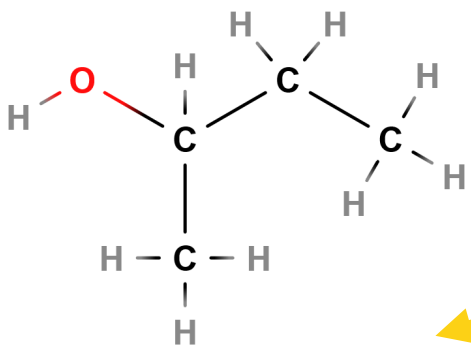
Jmol

High Quality  
Clean

CALCULATIONS

MEP surface lucent  
MEP surface opaque  
Charge  
Bond dipoles  
Overall dipole

minimization





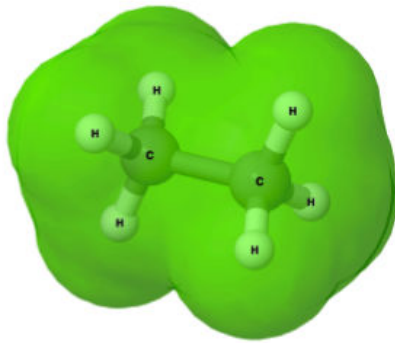
# Polar Covalent Bonding → weak bonds

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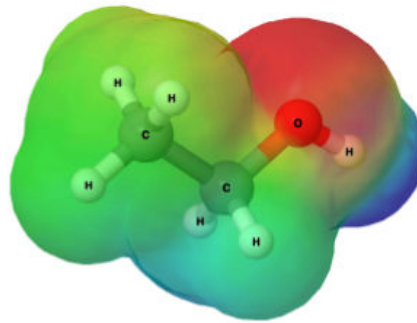
- Covalent bonding between unlike atoms results in unequal sharing of the electrons.
  - One atom pulls the electrons in the bond closer to its side.
  - One end of the bond has larger electron density than the other.
- The result is a **polar covalent bond**.
  - Bond polarity
  - The end with the larger electron density gets a partial negative charge.
  - The end that is electron deficient gets a partial positive charge.



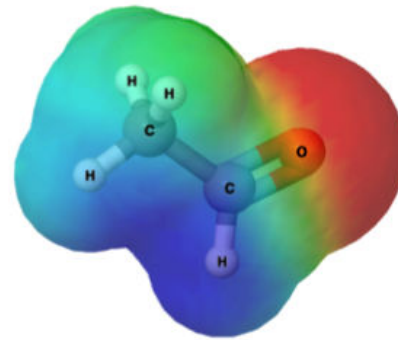
# Using 3D-modeling programs – Polarity - Electronegativity



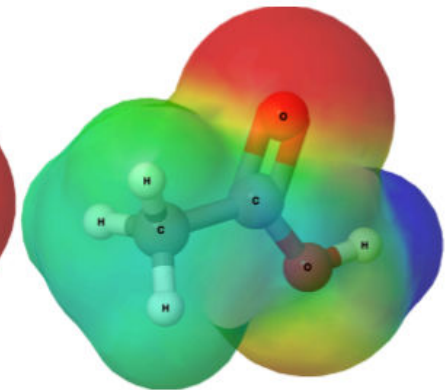
Ethane



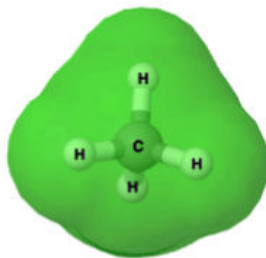
Ethanol



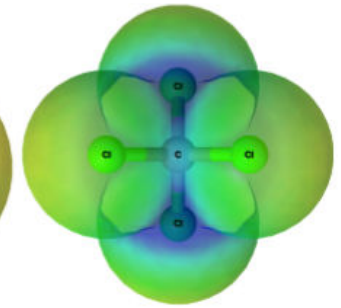
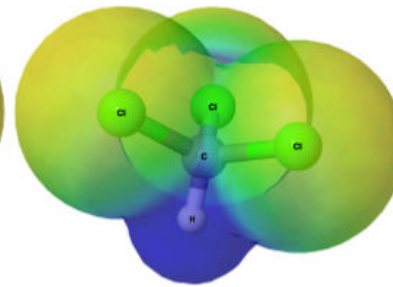
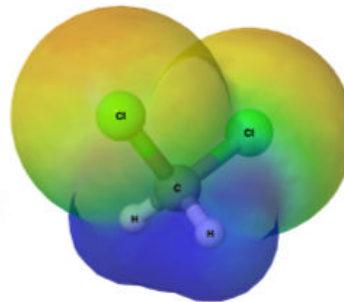
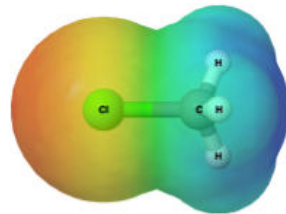
Ethanal



Ethanoic acid



Methane



Tetrachloromethane



# Bond angles

Jmol

High Quality

Clean

## CALCULATIONS

MEP surface lucent

MEP surface opaque

Charge

Bond dipoles

Overall dipole

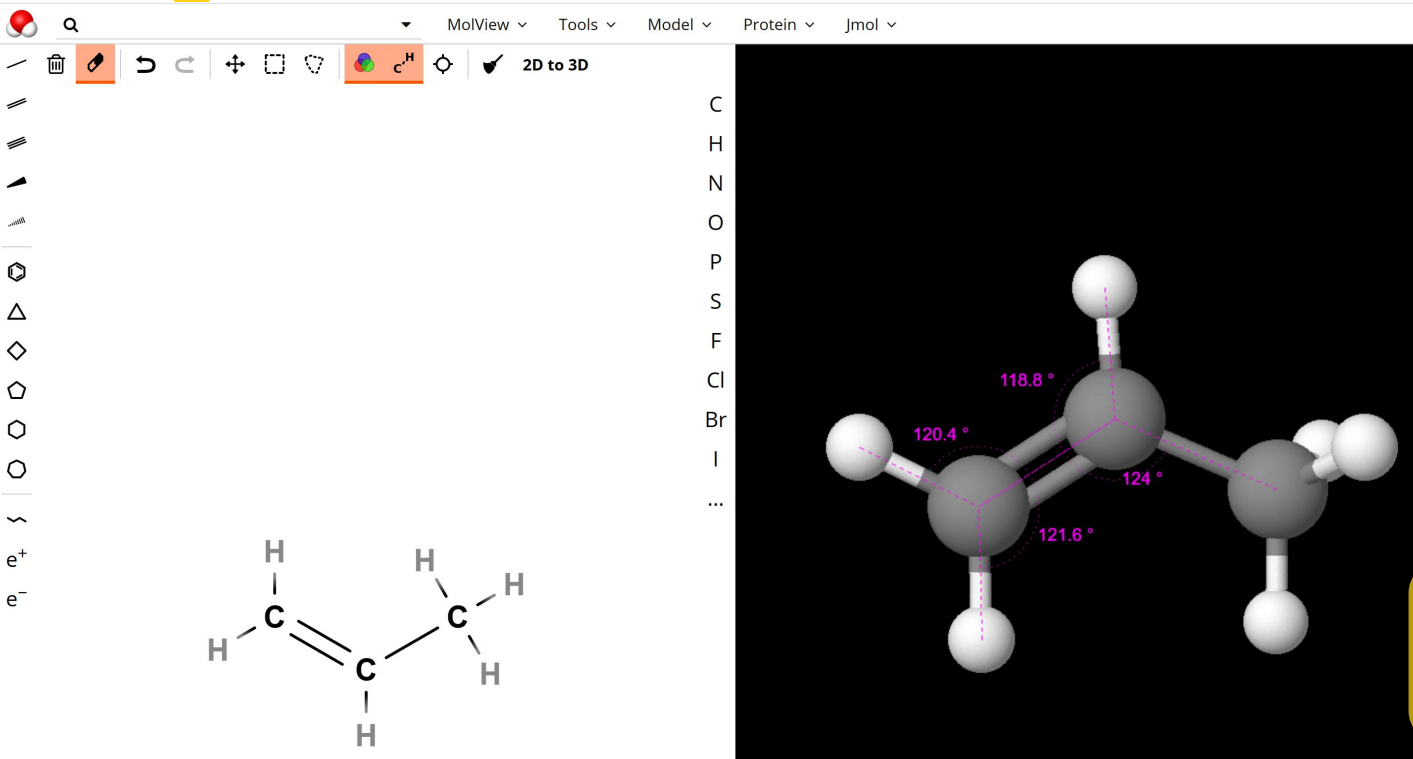
Energy minimization

## MEASUREMENT

Distance

Angle

Torsion





# Ionic structures



Show last search results

## ADVANCED SEARCH

PubChem Compounds

RCSB Protein Data Bank

Crystallography Open Database



Q sodium



MolView Tools

- Sodium *Compound*
- Sodium alum *Mineral*
- Sodium iodide *Compound*
- Sodium acetate *Compound*
- Sodium bromide *Compound*
- Sodium nitrite *Compound*
- Sodium chloride *Compound*
- Sodium fluoride *Compound*
- Sodium benzoate *Compound*
- Sodium butyrate *Compound*
- Sodium salicylate *Compound*
- Rhodium *Mineral*
- Cesium *Mineral*



Q Sodium chloride

MolView Tools Model Protein Jmol

MolView Tools Model Protein Jmol

Return

Sodium chloride

[1000041](#)

Details

Chemical name

Sodium chloride

Molecular formula

ClNa

sodium chloride

[2104025](#)

Details

Chemical name

sodium chloride

Molecular formula

ClNa

Sodium chloride

[2311042](#)

Details

Chemical name

Sodium chloride

Molecular formula

ClNa

cobalt(II) dicarbonate tri...

[2018287](#)

Details

Chemical name

cobalt(II) dicarbonate trisodium chloride

Molecular formula

C<sub>2</sub>ClCoNa<sub>3</sub>O<sub>6</sub>

diaquabis(1,10-phenant...

[8102063](#)

Details

Chemical name

diaquabis(1,10-phenanthroline-k<sup>2</sup>\*N,N')sodium chloride

Molecular formula

1-(6,7,9,10,12,13,15,16-O...

[1507358](#)

Details

Chemical name

1-(6,7,9,10,12,13,15,16-Octahydro-5,8,11,14,17-pentaoxabenzocyclopentadecen-2-yl)-3-phenyl-urea sodium chloride complex



2D to 3D

HM: F m -3 m #225

C

H

N

O

P

S

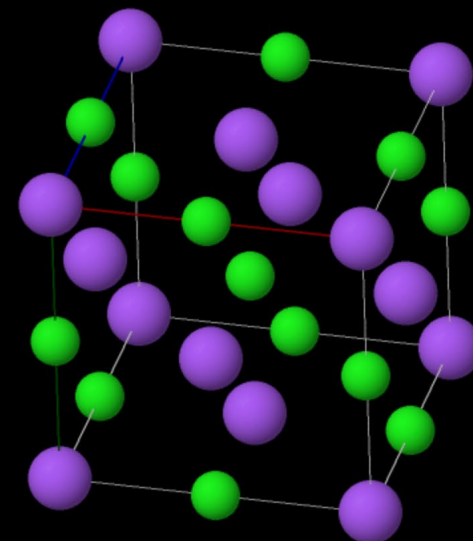
F

Cl

Br

I

...





# MarvinSketch

[bit.ly/marvinsketch](https://bit.ly/marvinsketch)

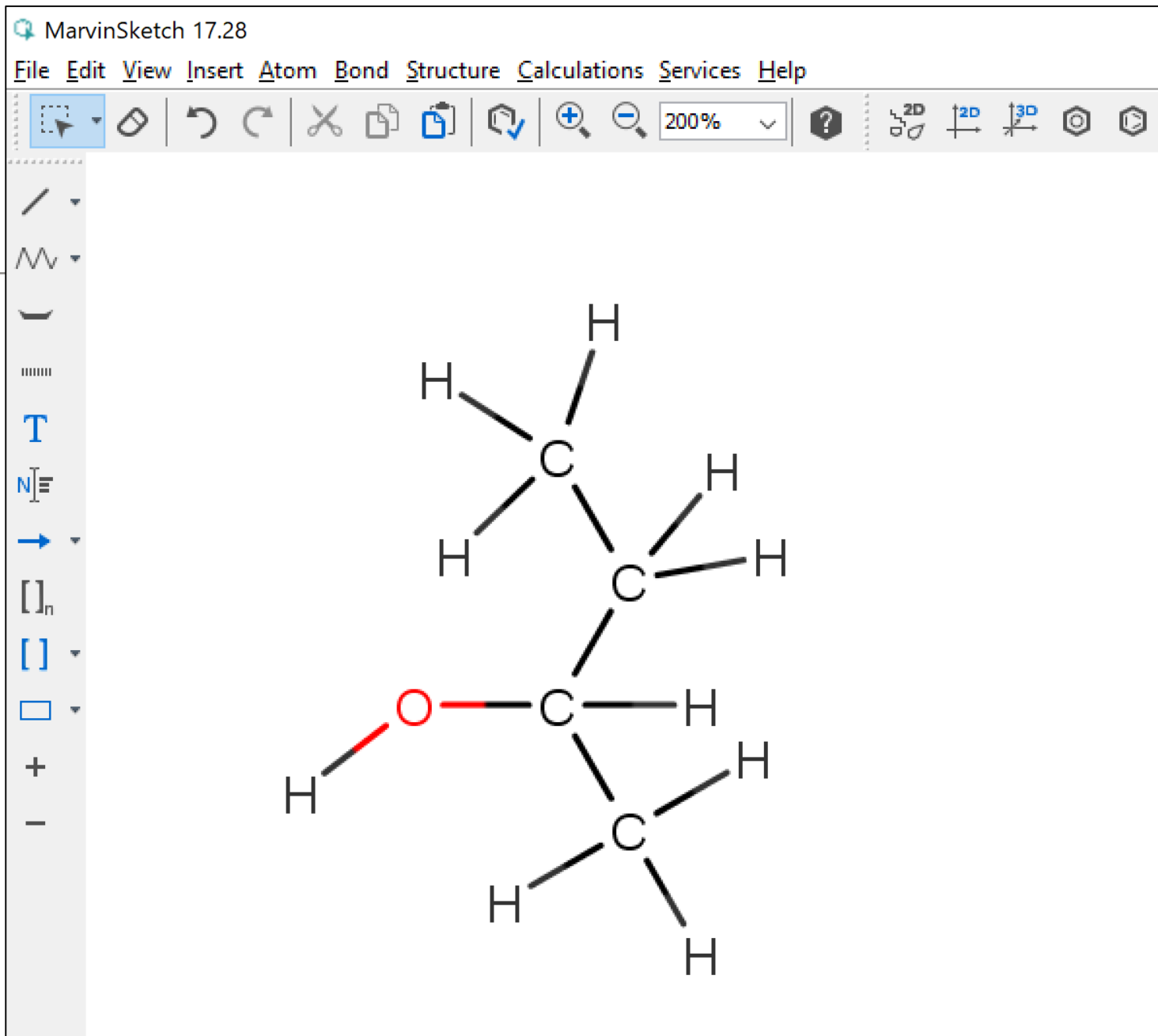
(MarvinSketch –pages, in Finnish)

<https://peda.net/yhdistykset/maol-ry/koulutus/dmfjk2l/materiaalit/kk/työpaja-2>

(MAOL - ICT –training pages)



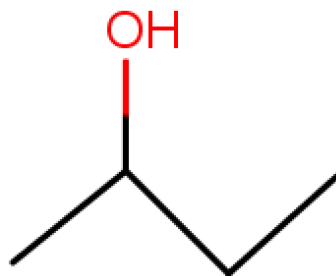
# Marvin-Sketch



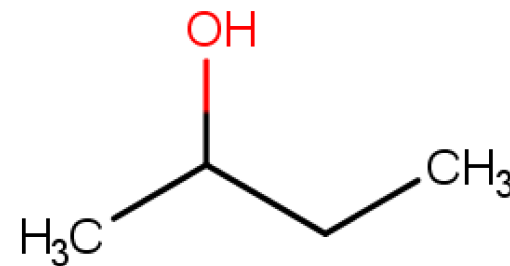
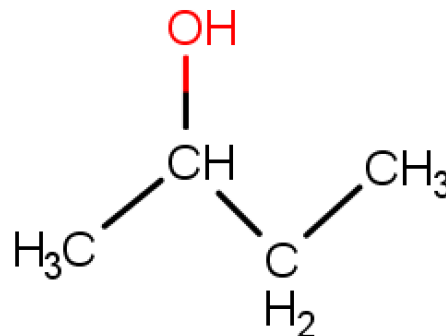
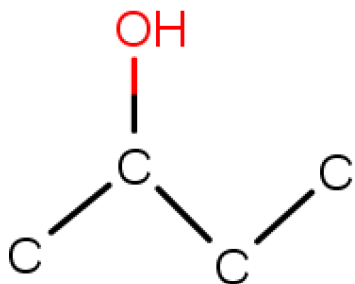
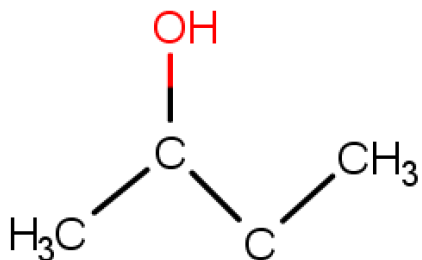
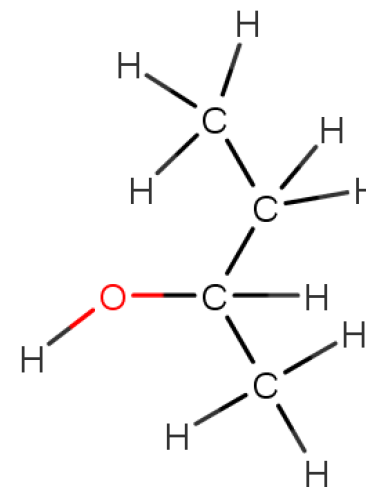


# Skeletal formula or full structural formula?

THIS



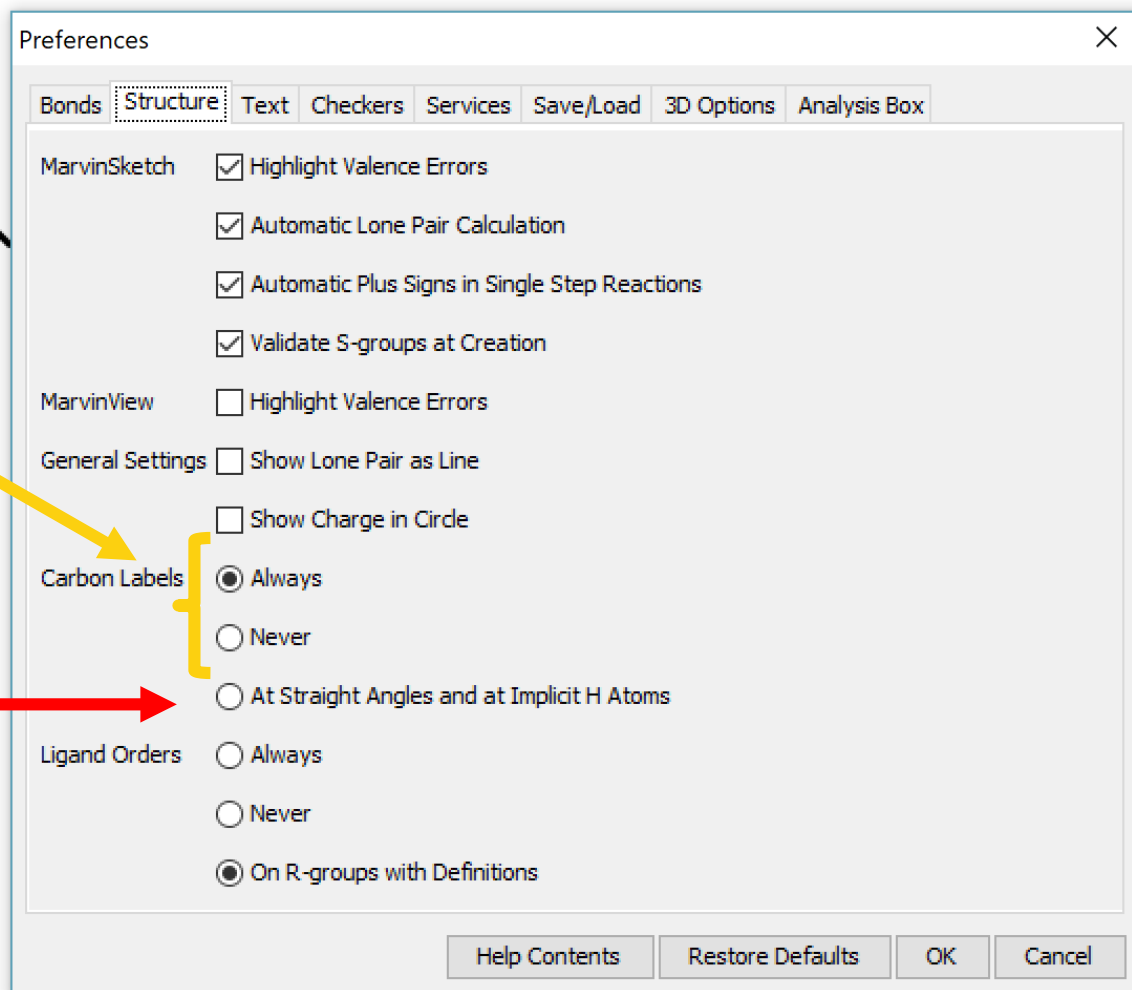
OR THIS



# STAGE 1: Carbon labels or not?

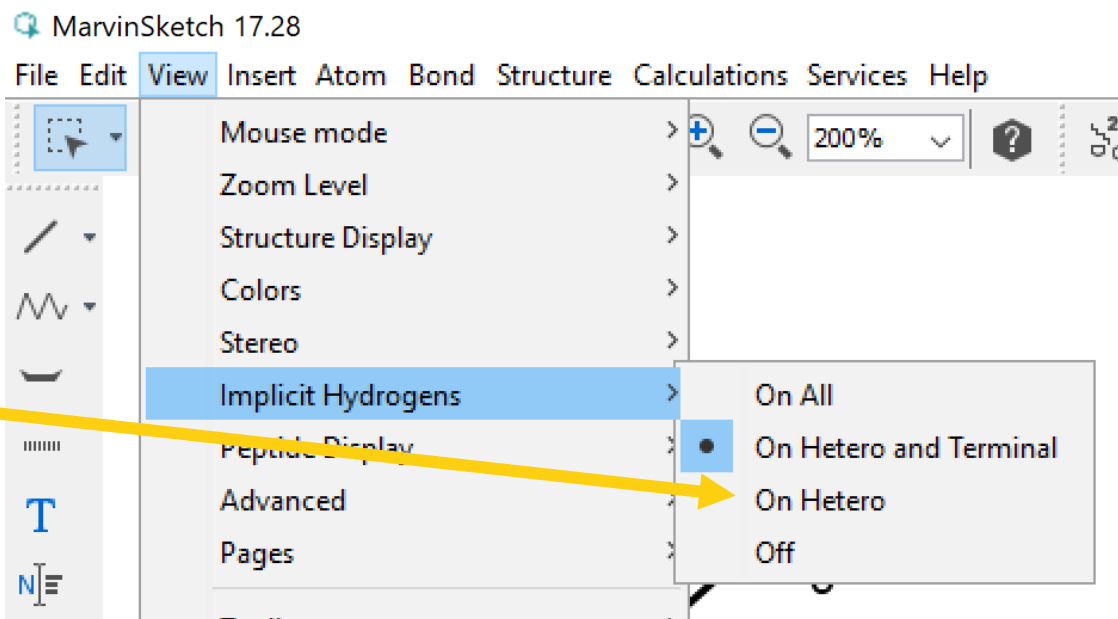
- Skeletal or structural formula
- Do we show CARBONS or not

NOT THIS



# STAGE 2: "Implicit Hydrogens" only with Hetero-atoms

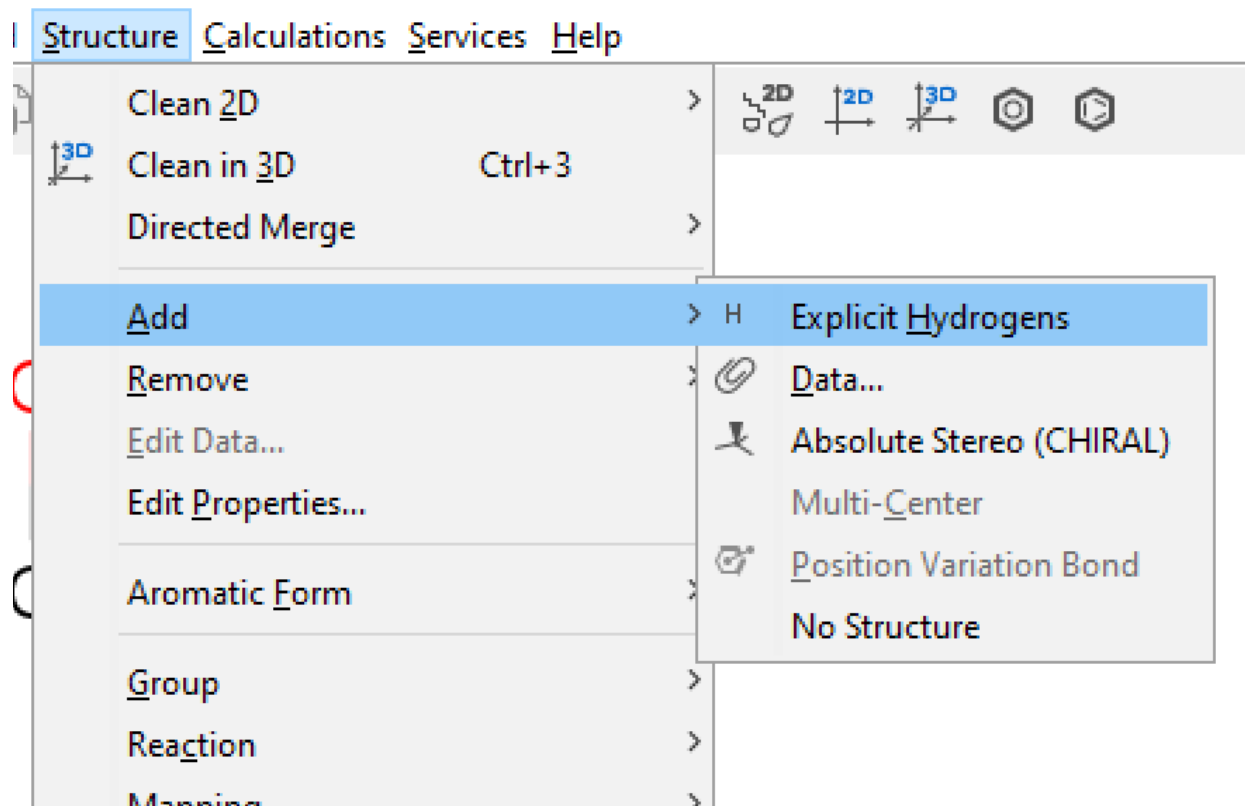
- "Implicit Hydrogens" only with Hetero-atoms (functional groups)





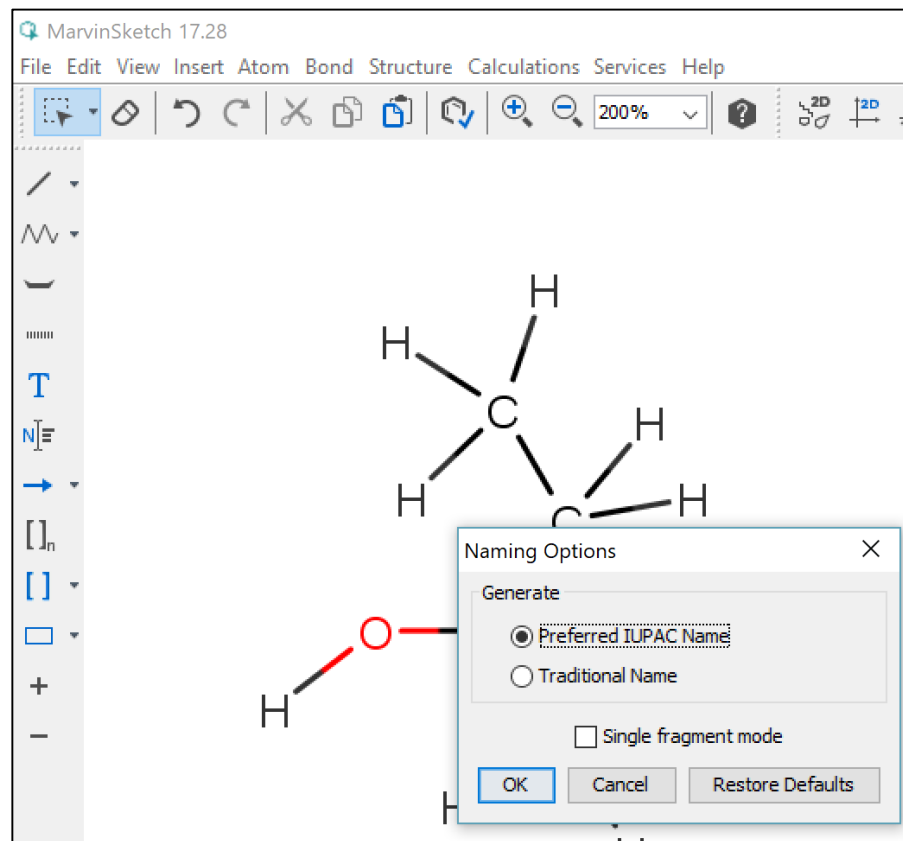
# STAGE 3: If you want a full structure →

- **Structural formula:**  
"Carbon labels"  
ALWAYS  
(Preferences - choice). AND
- Structure-menu  
**Add Explicit Hydrogens**



# MarvinSketch generates name for molecules

- How we teach naming after this? Why?
- MarvinSketch creates the names (IUPAC and Trivial names) and also creates the structure from the name



# Lone Pairs (electrons)

View In + Atom Bond Structure Calculations Services Help

Mouse mode > [Zoom] 200%

Zoom Level >

Structure Display >

Colors >

Stereo >

Implicit Hydrogens >

Peptide Display >

Advanced >

Pages >

Toolbars >

✓ Menubar F11

✓ Status Bar

Grid Shift+F9

Guidelines Ctrl+Shift+F9

Editor style >

Atom Numbering >

✓ Atom Properties

✓ Atom Mapping

Bond Lengths

Lone Pairs

✓ R-groups

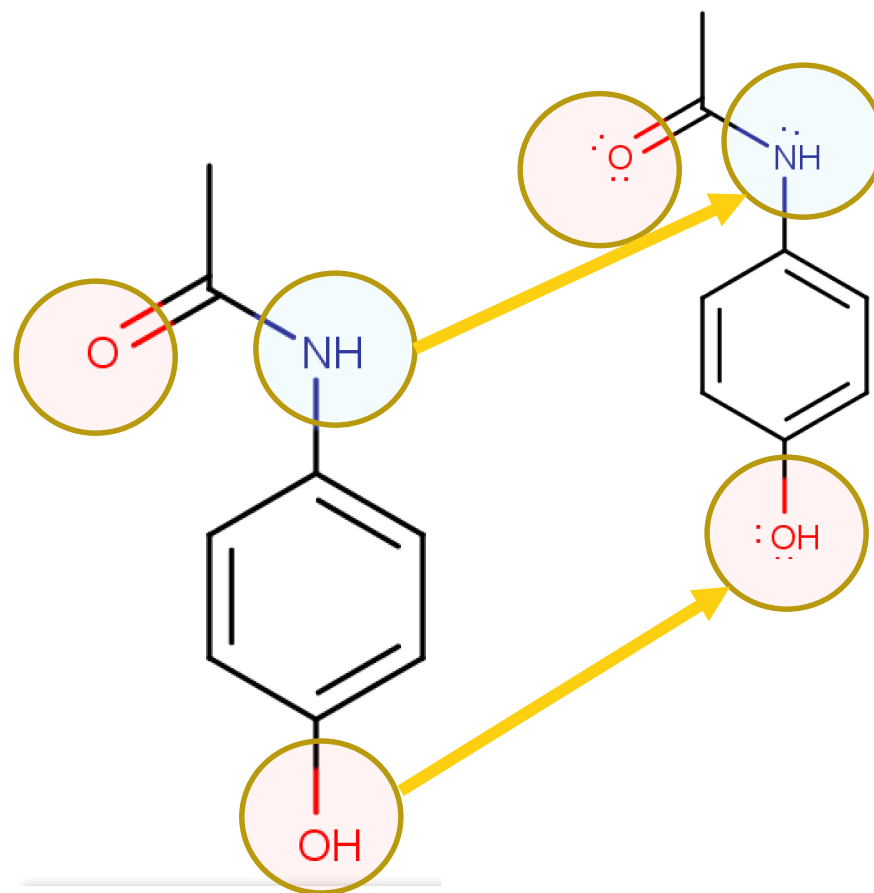
R-Logic

✓ Valence

✓ Ligand Error

✓ S-group Attachments

**CHOOSE**

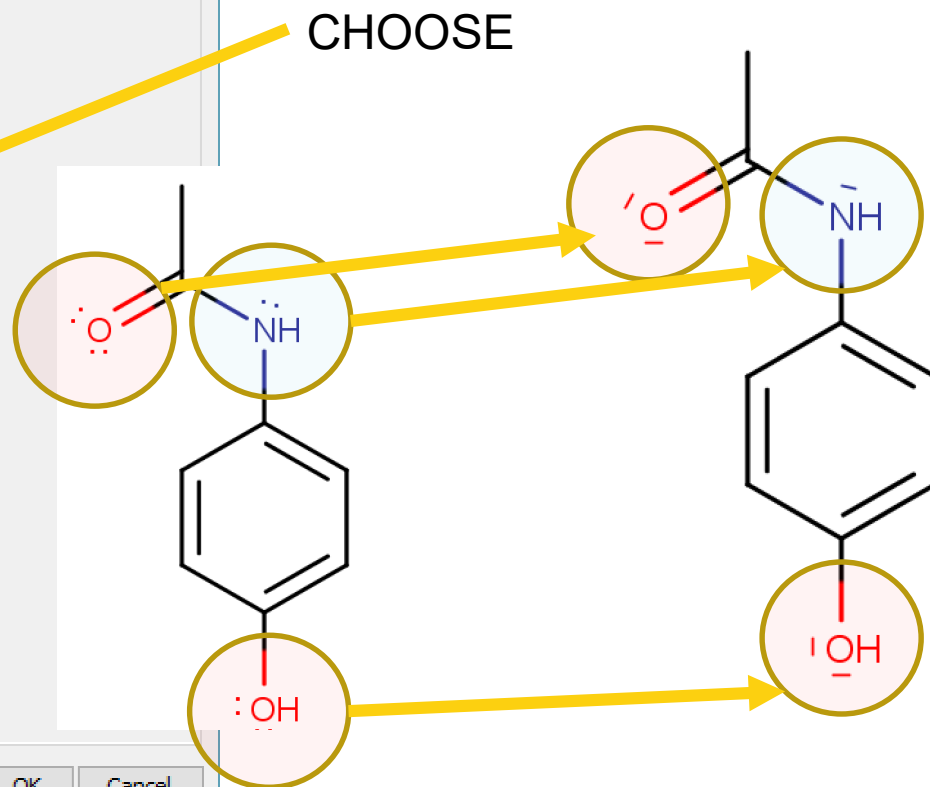
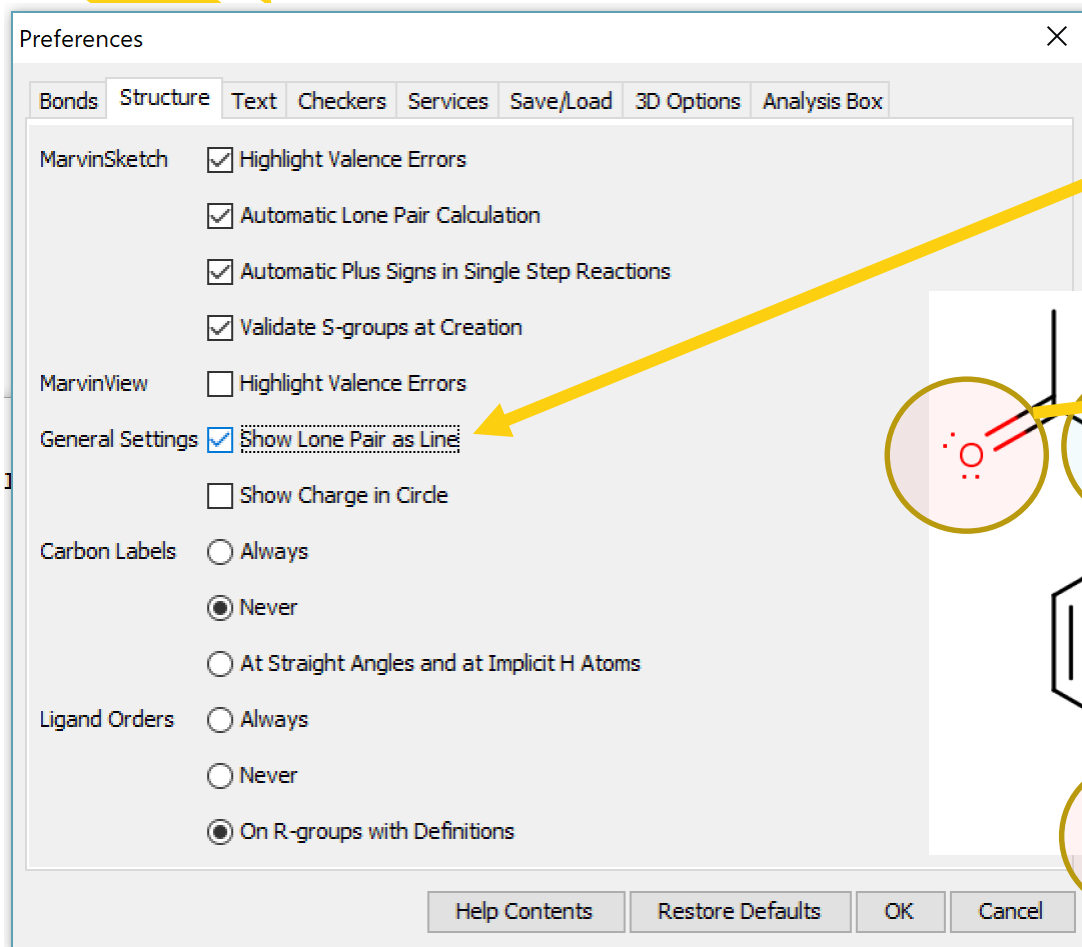


Naming

Preferred IUPAC Name = N-(4-hydroxyphenyl)acetamide

The image shows a window titled 'Naming' with the text 'Preferred IUPAC Name = N-(4-hydroxyphenyl)acetamide'. Below the text is a chemical structure of N-(4-hydroxyphenyl)acetamide with a methyl group (CH<sub>3</sub>) attached to the carbonyl carbon.

# Lone Pair as line





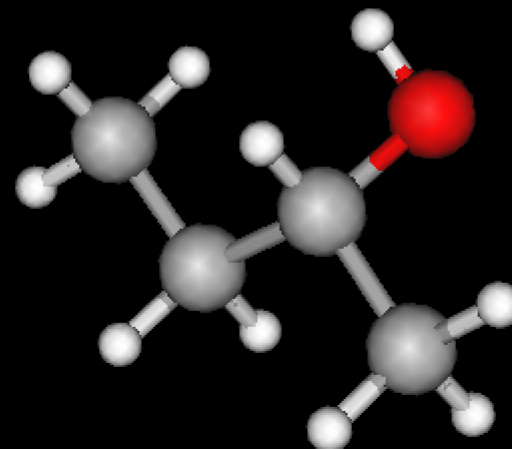
# MarvinSketch and 3D



# Ctrl+shift+M = MarvinSpace

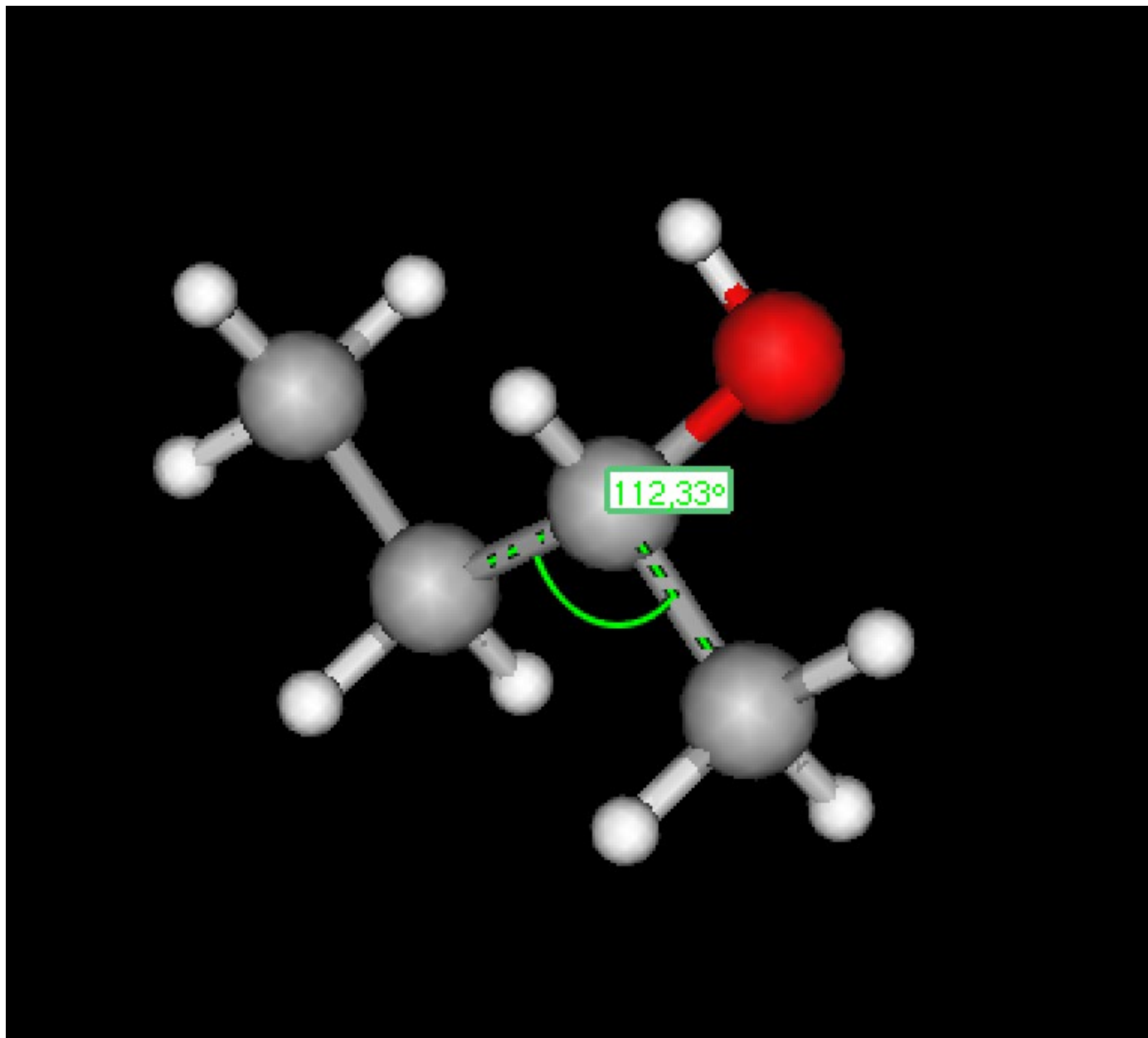
MarvinSpace

File Edit Display Show Animation Layout Alignment Help





## Angles of three atoms



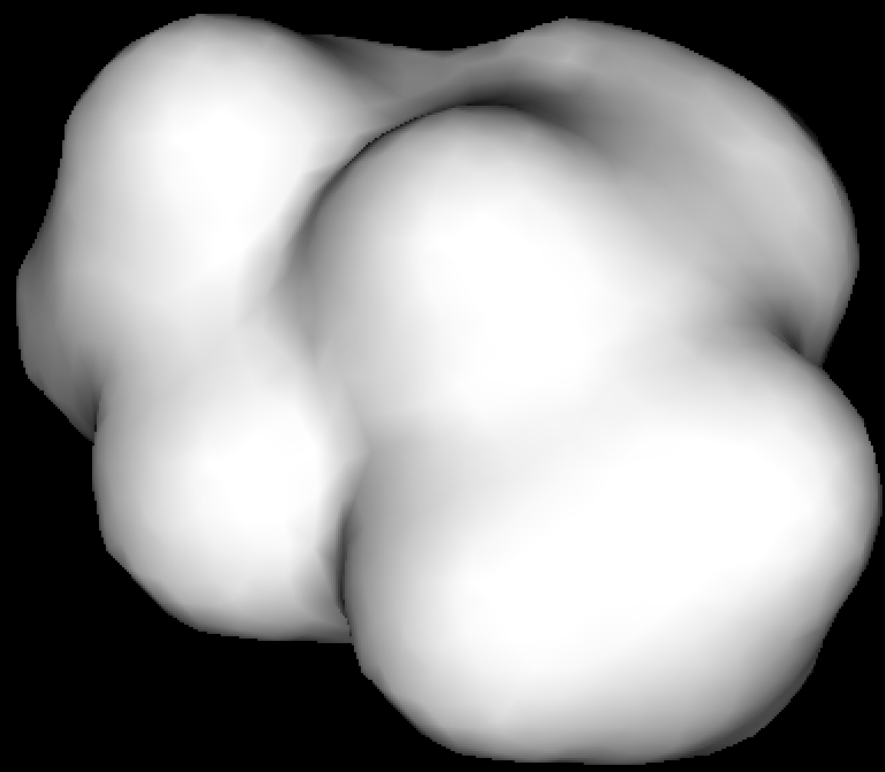


- Labels
- Surface
- Secondary Structure
- Labels on selection
- Coordinate System

- Connolly
- van der Waals
- Solvent accessible
- Blobby

Depth cue    Clipping planes    Isosurface 0,025

Explaining electron density  
(this we can see by special microscope)





MarvinSpace

File Edit **Display** Show Animation Layout Alignment Help

1Å

Draw Type > Ligand >  
Color Type > MacroMolecule >  
Quality > Water >  
Depth cue > Ion >  
Anti-alias > Pharmacophore Point >  
Options... > Pharmacophore Arrow >  
Surface >  
Secondary Structure >  
Labels >

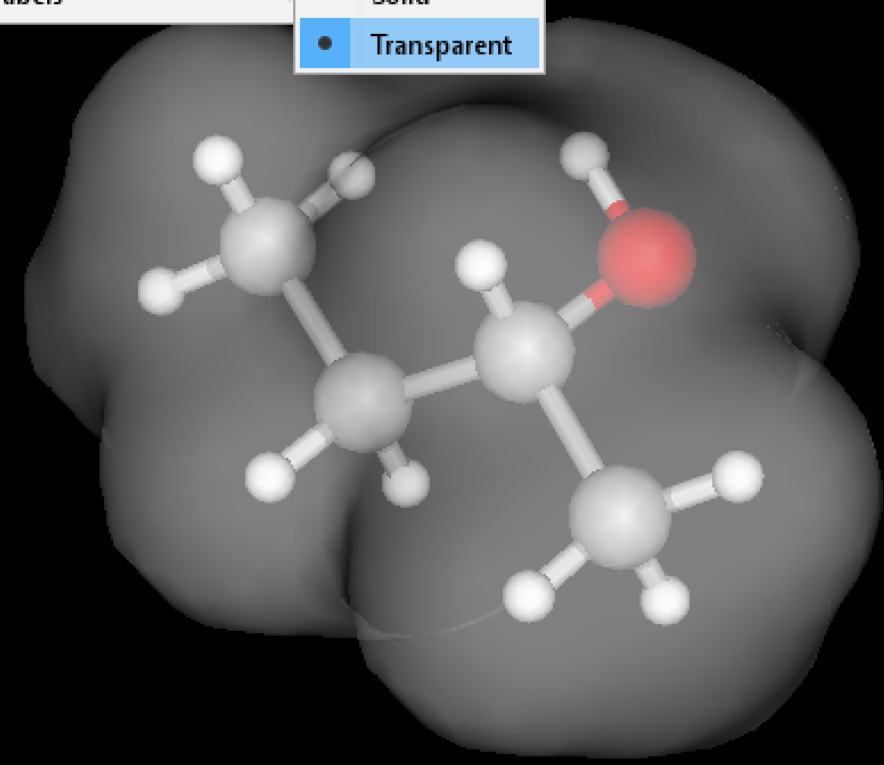
Dot  
Mesh  
Solid  
• Transparent

Depth cue

Clipping planes

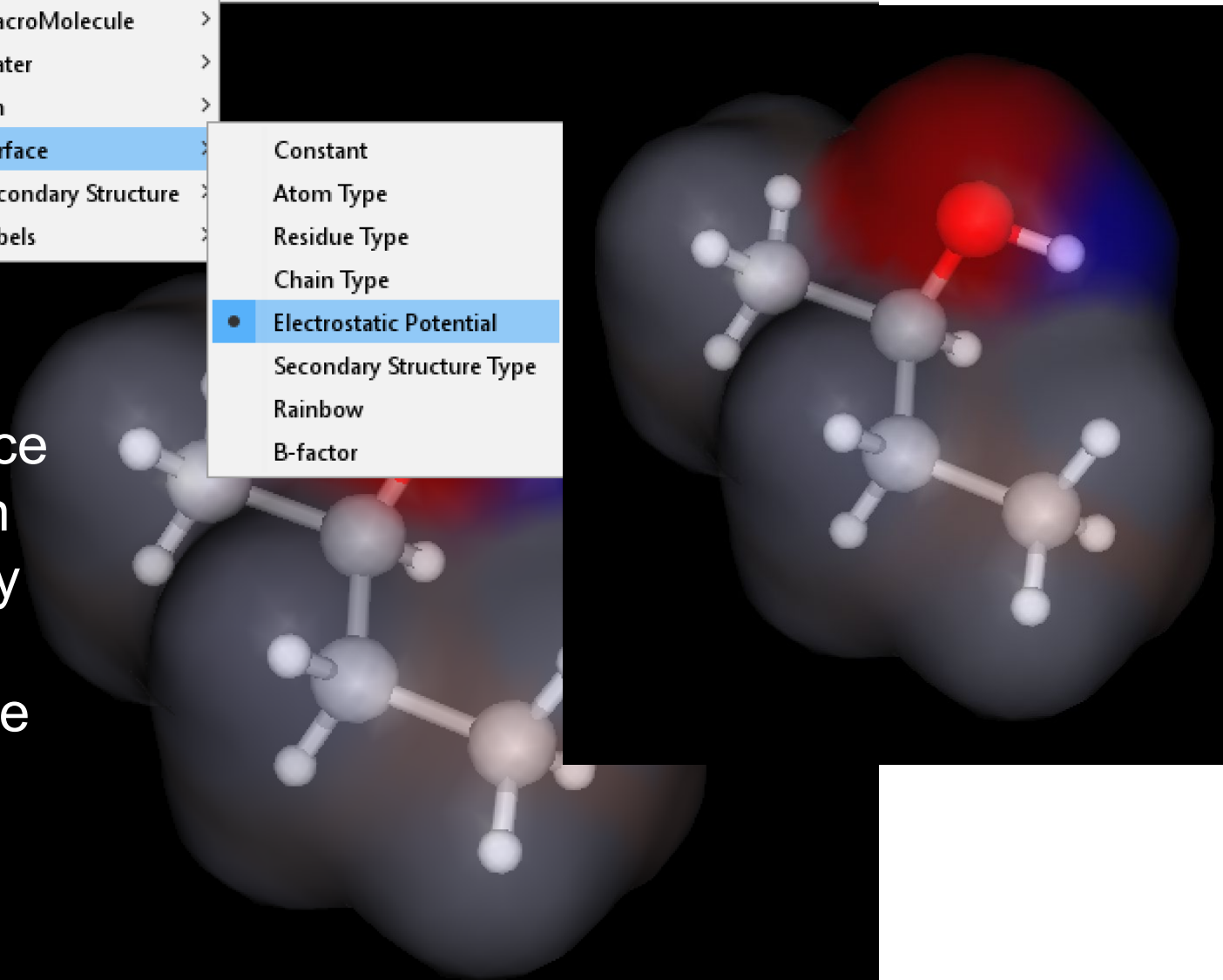
Is

See the molecular structure inside "the cloud of electrons")





See the influence  
of differences in  
electronegativity  
→  
A polar molecule





# Simulations, Animations

# ChemSense Animator

<https://chemsense.sri.com/download/>



**ChemSense** *visualizing chemistry*

tools for investigating, visualizing, and discussing chemistry in the classroom

[home](#) [contact](#) [sitemap](#)



## About

### The Project

ChemSense studied students' understanding of chemistry, and developed software and curriculum to help students investigate chemical systems and express ideas in animated chemical notation.

[>>learn more](#)

### News

ChemSense software is available for [download](#) and the source code is available as [open source](#). Related work continues under [NanoSense](#), which offers curriculum units on nanoscience.

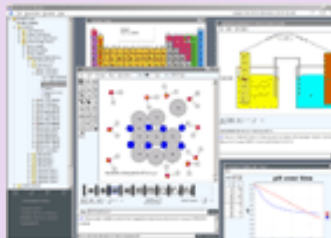
[>>news archive](#)



## On the Computer

### Software and Probeware

The ChemSense software supports the sharing, viewing, and editing of a variety of chemistry representations.



The ChemSense Studio

Probeware is used in some activities for real-time data collection and display.

[>>learn more](#)



## In the Classroom

### Activities and Use

The ChemSense curricular framework highlights collaborative investigations, representational competence, and chemical change.

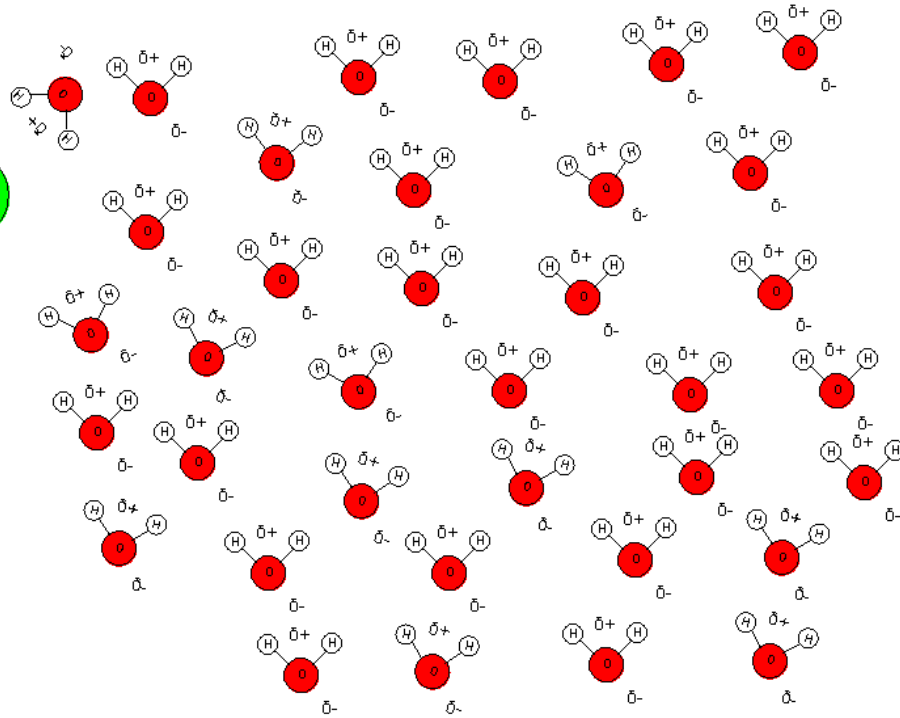
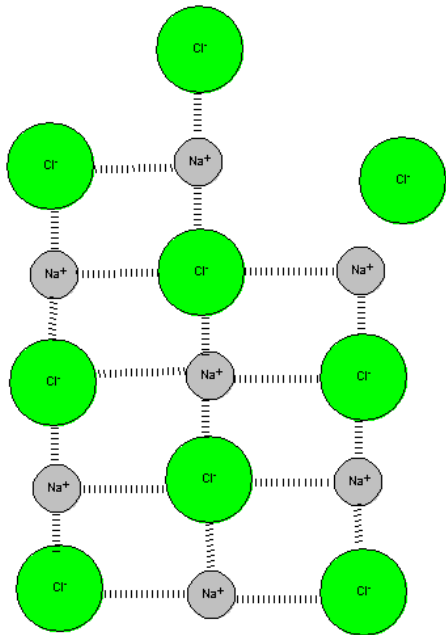


High school students investigating solubility.

We've conducted multi-week studies in our partner high school and college classrooms.

[>>learn more](#)

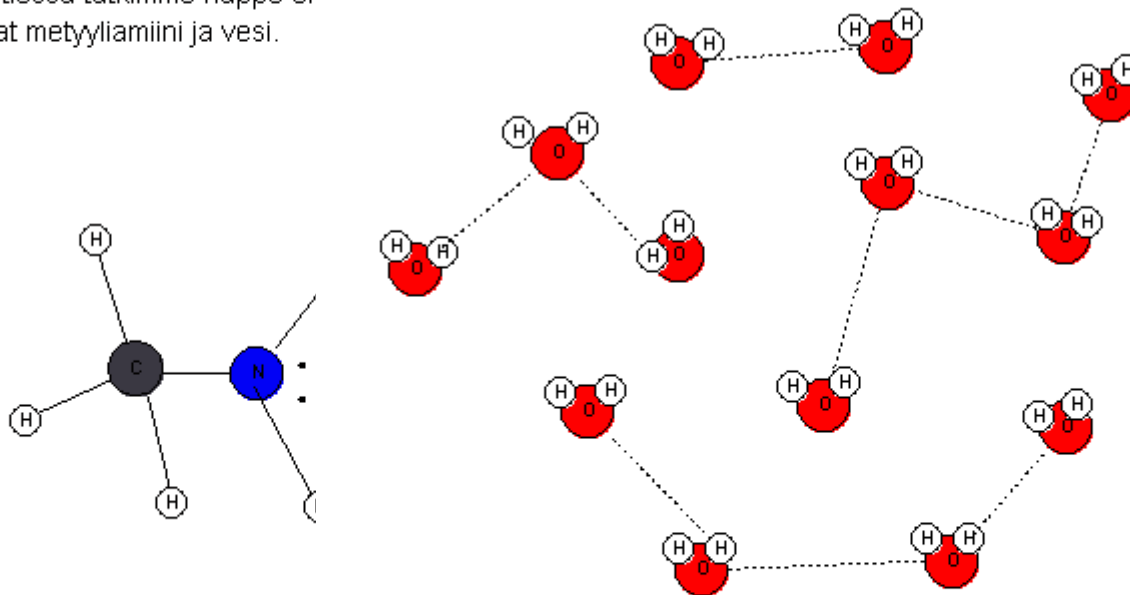







# Show also mistakes and misundestandinds

Tässä animaatiossa tutkimme happo er  
Yhdisteinä ovat metyyliamiini ja vesi.





# Home page: [www.myllyviita.fi](http://www.myllyviita.fi)



Etusivu Kasvatustiede ICT and social media CV ja historiaa Blogini kemianopetuksen sivut

## Kemian opetus

- [Kemian opettajan blogi](#), [Edmodo](#)
- [Peda.net](#)
- [Etäluokka](#)

## Viikin normaalikoulu

- [Koulun etusivu](#), [eNorssi](#)
- [yläkoulun ops](#), [lukion ops](#) (vanhat)

## Hankkeet

- [Norssiope.fi](#), [blogi](#)
- [OPStuki2016](#), [LOPStuki2016](#)

## Tärkeät HY-linkit

- [HY-Flamma](#), [Flamma-päivitys](#)
- [Email](#), [Wilma](#)
- [HY-Wiki](#), [Moodle](#), [Blog](#)
- [HY - SAP](#), [Tuhat](#), [Proha](#), [Raportit](#)
- [HYvink-Tilavaraus](#)
- [Viikki-streamaus](#)










## Yhteystiedot

### Ari Myllyviita

Helsingin Yliopiston Viikin

## TYÖPÖYTÄ

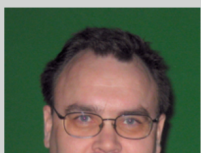
*“Nothing is more dangerous than a dogmatic worldview—nothing more constraining, more blinding to innovation, more destructive of openness to novelty”*  
Gould, Stephen J., (1995). Dinosaur in a haystack: Reflections in natural history.

 	  	<a href="#">Helka(HY)</a> , <a href="#">Helmet</a> <a href="#">Päivyri</a>
 	  <a href="#">kouluttajafoorumi.net</a> TIETY-kouluttajakoulutuksen aineistoja	

## Ajankohtaista

- ASE-conference 19**, How to use ICT and Social Media in Chemistry Education
- EASE/ASET -conference - presentation:** [Chemistry Education - Individual Learning Paths and The Flipped Classroom Pedagogy](#) (with Tea Kantola)
- Ryhmänohjaus - TVT-kemian opetuksessa** (päivitetty 8.11.18)
- [Molview.org -sivuston käyttö yläkoulun kemian opetuksessa](#) -luento
- [MarvinSketch -artikkeli](#) Dimensiossa 4/2918
- PIRE-project, [presentation slides](#)
- [Mentorointi-sivusto](#) (University of Johannesburg)
- ASE-conference 18**, Liverpool: ["Create](#)

## Yhteydenpitoa ja kalentereita



[www-domain -cPanel](#); [Thomson-verkko](#)

[Facebook](#), [Second Life](#), [Doodle Wikispaces](#), [Blogger](#) (kemia) [Dropbox](#) - [DROPitTOme](#), [Omat twiitit](#)



**Ari Myllyviita**

**[ari.myllyviita@viikinnormaalikoulu.fi](mailto:ari.myllyviita@viikinnormaalikoulu.fi)**

**[www.myllyviita.fi](http://www.myllyviita.fi)**