

Accessibility of STEM Diagrams

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Progressive Accessibility
Solutions
Birmingham, UK
progressiveaccess.com



MathJax
Consortium
mathjax.org



Chakshumathi Eyes Free Science Summer Camp, 24 April 2020

Slides and material at: progressiveaccess.com/summercamp

Accessibility of STEM Diagrams

- Using accessible diagrams on the Web
- Generating accessible diagrams

- I give introduction to our work, explain some of the technical details.
- Let you work with different types of accessible diagrams
 - Chemistry, Physics, Statistics
- Let you generate some accessible chemistry diagrams
- Followed by a question, feedback, discussion session

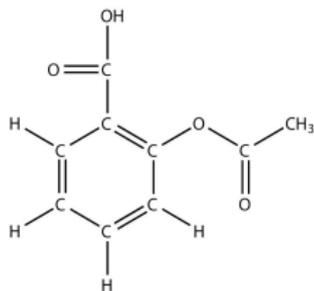
What you need

- A browser (Chrome is generally best)
- A screen reader

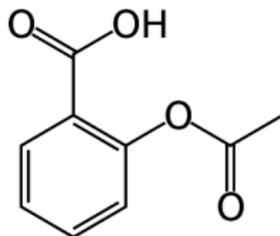
Goal of our Work

- Diagrams are an important teaching means in STEM
- Accessibility is key to inclusive education
- Avoid additional hurdles for both authors and readers
- **Fully automatic** to reduce need for human intervention
- Source independence
 - Do not rely on the benevolent, educated author
- Tool Independence
 - Do not force readers to use a specialist software tool
- Platform independence
 - Accessible with all browsers, screen readers, on all platforms

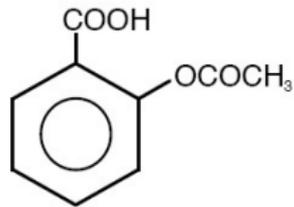
Chemistry Examples



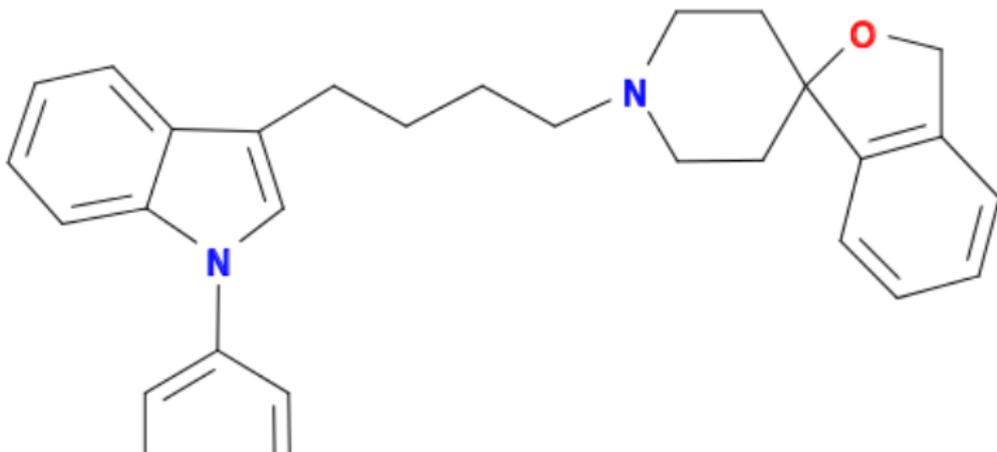
Displayed formula.



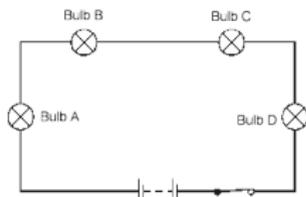
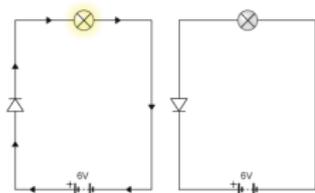
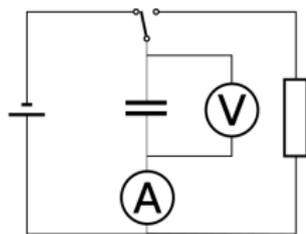
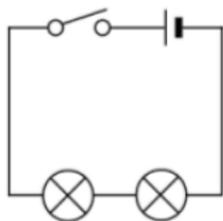
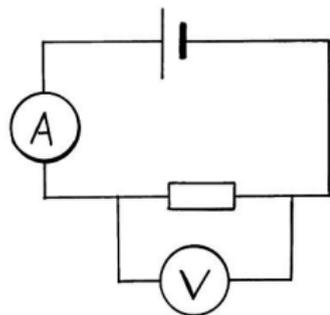
Skeletal formula.



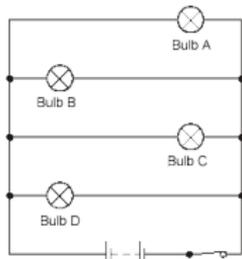
Structural formula.



Physics: Electric Circuits Examples

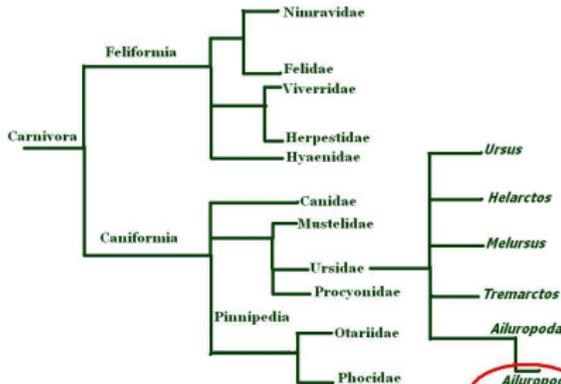
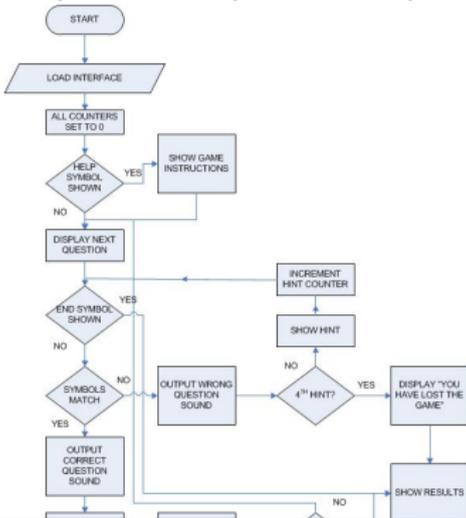
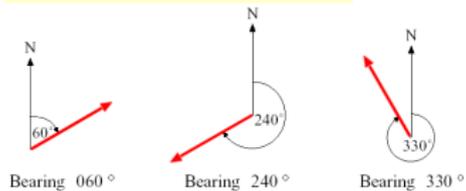
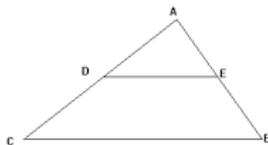
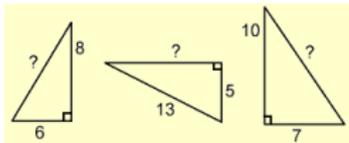


Circuit 1



Circuit 2

Future: Other Subject Areas



Automatic Generation of Accessible SVG

- Start with (bitmap) images of diagrams or some graphical specification
- Understand their content
- Enrich information specifically for teaching
- Generate “content-heavy” SVG

Do all this fully automatically without user interaction

As example I will use Chemistry

Input: A bitmap image of a molecule diagram

- 1 Image analysis and recognition
- 2 Generation of annotated SVG
- 3 Semantic enrichment
- 4 Accessible diagram via browser front-end

MolRec system implemented for diagram recognition on patent databases

- Initial preprocessing: Binarisation, noise reduction...
- Connected component extraction and labelling
- Optical Character recognition and removal
- Separation of bond elements
 - Walk skeleton diagram structure
 - Identify and break junction points
- **Result** is a set of geometric primitives:
Character groups, lines, circles, triangles

Diagram Recognition

- Rule based system
- Rewrites bag of geometric primitives into a graph representation
- Example:
 - 1 Let l_1, l_2 be distinct line segments of a minimum length.
 - 2 If l_1 is nearly parallel to and in a neighbourhood of l_2 .
 - 3 No other line segment is nearly parallel to l_1 or l_2 .

⇒ Then (l_1, l_2) form a double bond.

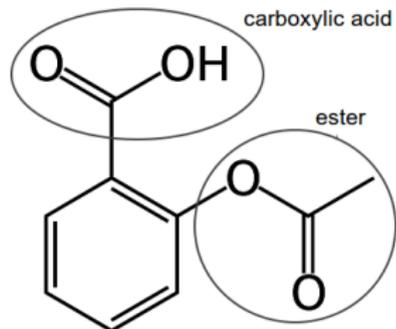


- **Result** is a Chemical Markup File (CML or MOL)

- Many solutions for generating SVG from chemical markup
- But they only draw!
- And in the process destroy any structure or chemical knowledge
- Build our own SVG generator with emphasis on
 - Grouping meaningful units together (e.g., double bonds)
 - Retaining names given to components in the chemical markup (IDs of atoms, bonds, etc.)
- **Result** annotated and grouped SVG

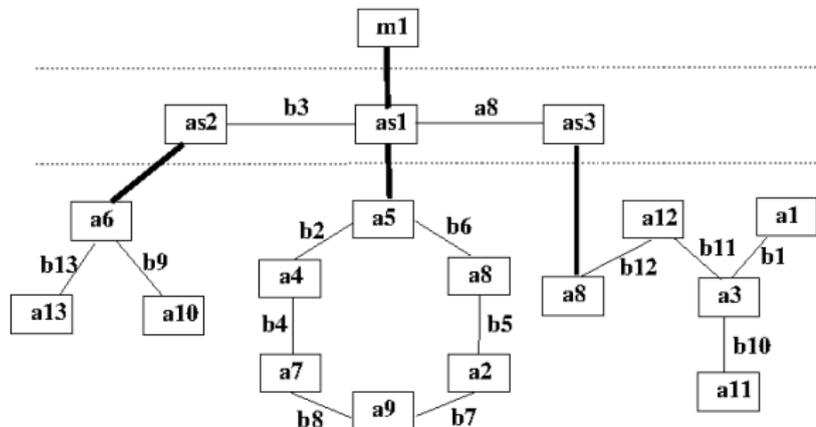
Semantic Enrichment

- Take basic chemical markup: Enrich it with derived knowledge and structure it accordingly
- Detect major building blocks of the molecule
 - Aliphatic chains
 - Ring systems: Isolated and fused
 - Functional groups
- Order blocks and atoms by chemical conventions
- Naming and description
 - Cactus webservice
 - Basic descriptions via atoms, bonds, substitutions



Abstraction Graph

- Represent molecule as multi-layered graph
- 3-4 layers of abstraction



- Molecule
- Block
- Atom

- Additional layer in case of fused ring systems
- **Result** semantically enriched CML File

- Simple navigation model with arrow keys
- Screen Reader Support:
 - Generate speech output on different levels
 - Display of speech output using subtitling
- Low Vision/Learning Disability Support:
 - Highlighting of inspected components
 - Optional zooming and magnification of components
 - Changing contrast, colour configurations
- l18n support

We will now work with three accessible diagrams:

- Chemistry: Examine Aspirin molecule at <https://progressiveaccess.com/chemistry/generic.html?mole=data/aspirin-enr>
- Physics: Examine the circuit at https://progressiveaccess.com/chemistry/generic.html?mole=data/physics/Capacitor_resistor_series
- Statistics: Examine the boxplot at <https://progressiveaccess.com/chemistry/generic.html?mole=data/boxplots/Ozone>

Each page contains the key for explorer and should be pretty self-explanatory.

Interactive Session 1: Using Web accessible diagrams

- Please go to one of the diagrams
- Focus on the diagram
- Press <A> to enter navigation mode
- Navigate with the arrow keys
 - <Down> Explore next lower level in the diagram.
 - <Up> Move up one level.
 - <Right> Navigate the diagram forward.
 - <Left> Navigate back in the diagram.
- <X> Toggles explanation mode between expert and novice.
- <Escape> Lets you leave exploration mode.

Generating Accessible Diagrams

- We provide a simple web front end to generate accessible diagrams
- The idea is to upload A bitmap image or a specification code (in the case of chemistr diagrams)
- Then after a little while get the accessible diagram

- 1 Upload the image or code
- 2 Have it recognised
- 3 Navigate the recognised image
- 4 Alternatively:
 - Download the recognised image
 - Possibly print it on an embosser.

- Go to <https://live.progressiveaccess.com/>
- Create an account
- Log in with the credentials
- You should see a simple upload menu
- Choose the Chemistry option

- Go to the Wikipedia page for Paracetamol.
- Find either Smiles, Inchi or InchiKey in the knowledge box.
 - This is the box on the top right of the page.
 - Note that these identifiers are hidden and can be revealed with a show button.
 - Copy the respective identifier, make sure to copy it fully!
- Enter the key into the input box of the our page.
- Choose the correct radio button and hit submit.
- After a while you should see the navigatable diagram.
- Examine it.