

DEPARTAMENTO DE QUÍMICA INORGÁNICA

Tutorial sobre [Symmetry@Otterbein](https://symotter.org/)
(Página Web de Simetría Molecular de la Universidad de Otterbein)
<https://symotter.org/>

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Se trata de una página web desarrollada por el Prof. Dean H. Johnston de la Universidad de Otterbein, Westerville (Ohio, USA). Está diseñada para ayudar a los estudiantes a aprender simetría molecular y a ayudar a los profesores a enseñar estos conceptos. Es utilizada por miles de estudiantes y profesores a nivel mundial. Proporciona una larga lista de moléculas y permite visualizar sus elementos y operaciones de simetría.

El aspecto de la página principal es el siguiente:

Symmetry Resources at Otterbein University

Welcome to the world of symmetry! The resources contained within this web site are designed to help students learn concepts of molecular symmetry and to help faculty teach concepts of molecular symmetry. The materials are designed for a variety of levels, so look around and see what we have to offer. Choose from the following pages:

- [Symmetry Tutorial](#) - An interactive point group symmetry tutorial. Guides students through all of the symmetry elements and operations, with interactive displays and animations.
- [The Symmetry Gallery](#) - A collection of over 120 unique molecules and polyhedra with interactive display of all symmetry elements and animation of all operations. The molecules are organized by point group, so you can select examples to demonstrate particular symmetry elements. Includes links to the chemical literature when available.
- [The Symmetry Challenge](#) - Using the same set of molecules from the Gallery, the Challenge includes a [flow chart](#) that details the process of determining the point group of each molecule. A great way to practice the point group determination process.

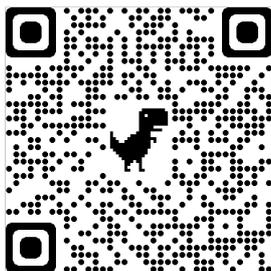
Updates: January 2021 - The NGL-based version is now live along with many additional updates. *Note:* this version may not be compatible with older versions of some browsers. If needed, the JSmol version of the site is available at <https://symotter.org/jsmol>.

October 2020 - A new version of the site using the NGL (WebGL-based) viewer for improved visualization and animations is undergoing testing.

June 2019 - The completely new version is now live. The number of changes are too numerous to list here, but the Symmetry Challenge is totally revamped and there are many new features in the Gallery and Tutorial. The website is much more responsive and should be easier to use on mobile devices. If for any reason you want to use the old version, it can still be found at [Symmetry@Otterbein \(old\)](#). A more complete discussion of the updates can be found at the [Symmetry@Otterbein Blog](#).

July 2016 - A new web site for displaying [crystallographic symmetry](#) in selected spacegroups is now live. (Presented at the 66th Annual Meeting of the American Crystallographic Association, Denver, CO).

System Requirements: All pages require a modern browser with Javascript enabled. These pages have been tested with Microsoft Edge (Windows, macOS), Safari (macOS, iOS), Chrome (macOS, Windows, iOS, Android) and Firefox (macOS, Windows, Linux, iOS, Android). **Note:** The current website only works with Chromium-based versions of Microsoft Edge (released January 2020). Some issues have been observed with Safari versions prior to version 14.0.



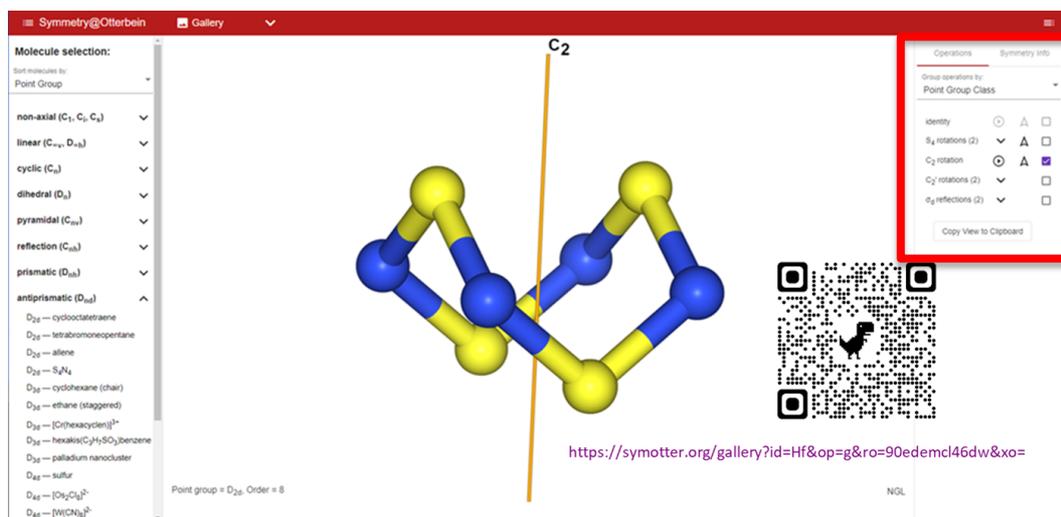
Este recurso incluye unas breves instrucciones para su manejo (en el apartado [User Guide](https://symotter.org/info/guide), <https://symotter.org/info/guide>) y está dividido en tres partes: i) “[Symmetry Tutorial](#)”, ii) “[The Symmetry Gallery](#)” y iii) “[The Symmetry Challenge](#)”, que se describen a continuación.

a) “Symmetry Tutorial”

Este apartado explica los distintos elementos y operaciones de simetría, apoyándose en ejemplos interactivos y animados.

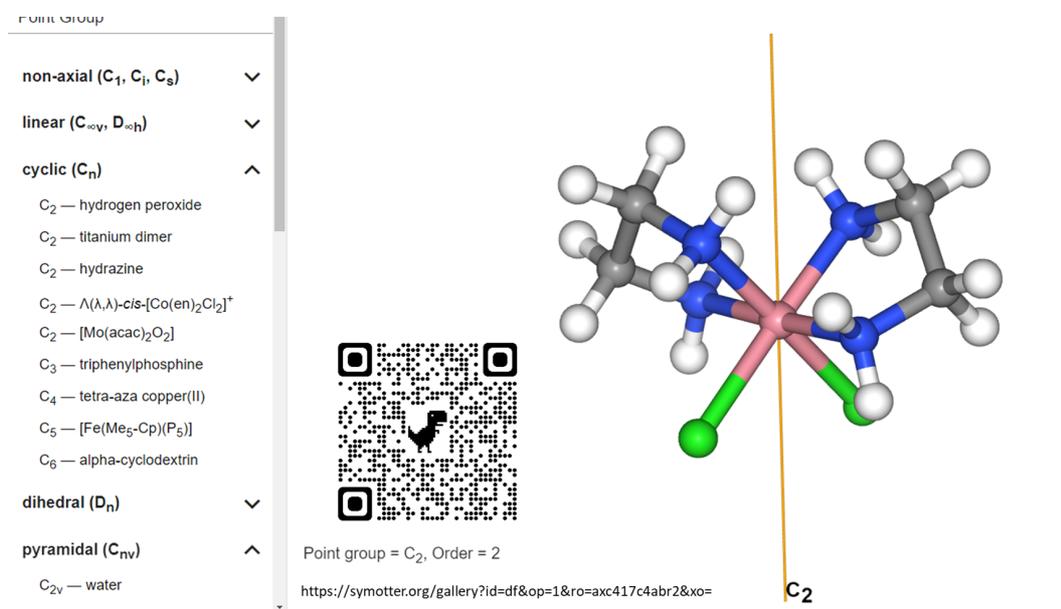
b) “**The Symmetry Gallery**”. Este apartado incluye cerca de 120 moléculas y poliedros con demostración interactiva de todos sus elementos de simetría, así como la animación de todas las operaciones de simetría. Las moléculas están ordenadas por grupo puntual, así que se puede elegir los ejemplos que interesen para visualizar elementos de simetría concretos. A continuación, se muestran algunos ejemplos.

- **Point group $D_{2d} - S_4N_4$**



En el margen superior derecho, aparecen unas casillas que permiten seleccionar un elemento de simetría para visualizarlo en la pantalla.

- **Point group $C_2 - \Lambda(\lambda,\lambda)\text{-cis-[Co(en)}_2\text{Cl}_2]^+$**



c) “**The Symmetry Challenge**”: empleando las mismas moléculas incluidas en “The Symmetry Gallery”, este apartado fomentará la autoevaluación del alumnado en la determinación del grupo puntual al que pertenece cada molécula.

Elegimos una molécula y vamos contestando las preguntas sobre simetría que nos plantea la aplicación. Una vez terminado el ejercicio, la página nos lo corrige indicando en qué paso o pasos nos hemos equivocado y proporcionándonos las respuestas correctas.

Estas páginas son compatibles con Macs y PCs, así como con dispositivos móviles. Requieren navegadores modernos que deben tener habilitado JavaScript. Se ha comprobado su funcionamiento correcto con Microsoft Edge (Windows, macOS), Safari (macOS, iOS), Chrome (macOS, Windows, iOS, Android) y Firefox (macOS, Windows, Linux, iOS, Android)

Dispone de una guía de instrucciones en inglés (<https://symotter.org/info/guide>). De esta manera, su uso también fomentará el dominio de este idioma. Además, este recurso incluye una lista de páginas web de interés (<https://symotter.org/info/refs>).

Home

- Rose, A. S.; Hildebrand, P. W. NGL Viewer: A Web Application for Molecular Visualization. *Nucleic Acids Res.*, 2015, 43, W576–W579. DOI

Jmol and NGL Visualization Resources

- [Jmol](#) - the home page for the Jmol project. Jmol is a free, open source molecule viewer for students, educators, and researchers in chemistry and biochemistry. It is cross-platform, running on Windows, Mac OS X, and Linux/Unix systems.
- [Jmol Interactive Script Documentation](#) - the definitive resource for up-to-date information on Jmol scripting commands with extensive examples and information about new features.
- [NGL](#) - GitHub page for the NGL Viewer, a web application for molecular visualization using WebGL.

Symmetry Resources on the Web

- [Molecular Structures of Organic Compounds - Symmetry and Point Groups](#) - Description. Author: Stefan Immel, Technical University of Darmstadt, Germany, Last update: 17 August 2018
- [Character tables for chemically important point groups](#) - an excellent resource that includes Javascript code to reduce reducible representations to their irreducible representations as well as give information about the symmetry of molecular vibrations. Author: Achim Geleßus, Jacobs University Bremen, Germany, Last update: 23 May 2018
- [SymmetryApp](#) is a JAVA program designed to help students learn about symmetry elements and their operations. Authors: David E. Meyer and Andrew L. Sargent, East Carolina University, USA, see *J. Chem. Educ.* 2007, 84, 1551.
- [Symmetry & Point Groups](#) - a set of visualizations and quizzes on symmetry and point groups in chemistry. Java and Flash required. Authors: Ali Korkmaz and William S. Harwood, Indiana University, USA, Created: 2004, see *J. Sci. Educ. Tech.* 2004, 13(2), 243-253 (link)
- [Molecular Symmetry Examples](#) - A short discussion of molecular symmetry with numerous examples and very nice ray-traced images of a wide variety of symmetrical molecules and objects. Author: Victor Luña, Universidad de Oviedo, Spain, Last update: 21 July 2005
- [Point Group Symmetry](#) - A very nice collection of information on point group symmetry with numerous molecular examples of various point groups. Also includes 3D objects as point group examples. Interactive molecules require Java. Author: Jonathan Goss, University of Newcastle upon Tyne, UK, Accessed: April 2019
- [Molecular Symmetry: An Interactive Guide](#) - An introduction to symmetry elements and operations with examples including various metal complexes. Java required. Max J. Addison, Merton College, Oxford, UK; Henry S. Rzepa, David P. Rzepa, and Sheldrick, William, Imperial College, London, UK, 2004