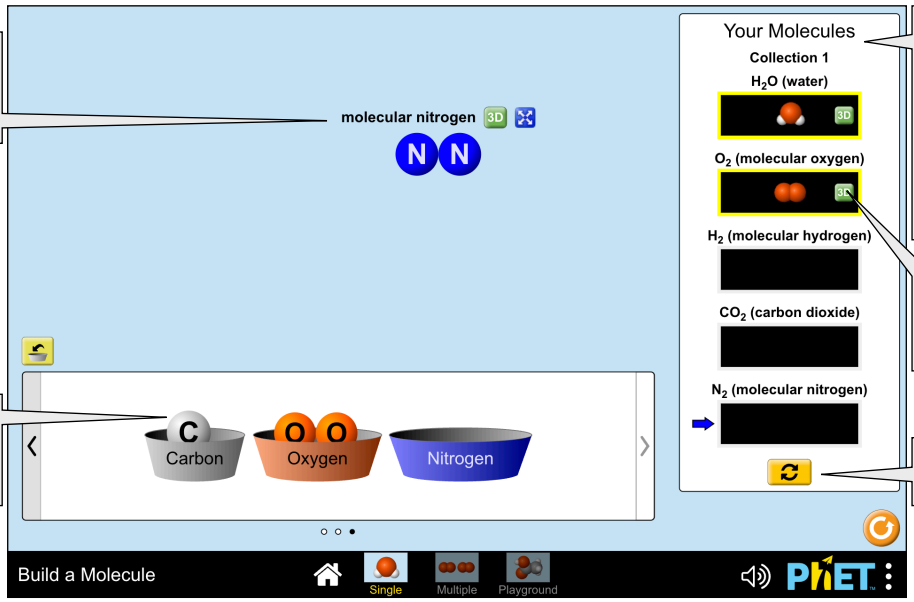
PhET Tips for Teachers

Build a Molecule

The ***Build a Molecule*** simulation allows students to build molecules from atoms, discover their molecular formulas and chemical names, and view their structures in 3D.

Single Screen

Construct simple molecules from atoms and create a collection.



DISPLAY molecule name

GRAB atoms from buckets

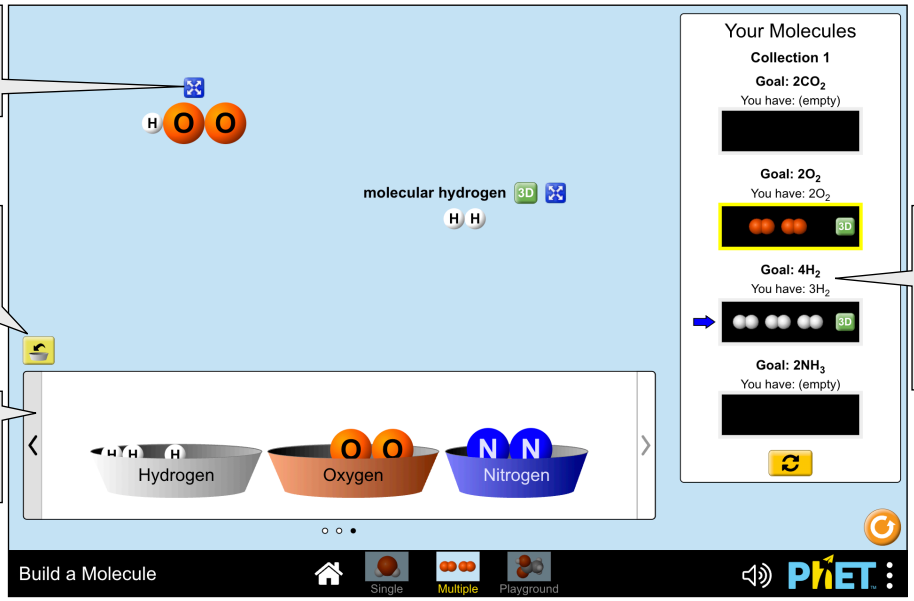
COLLECT molecules, once complete, a new collection appears

VIEW 3D structure

RESET collection

Multiple Screen

Build and collect multiple molecules to discover the meaning of coefficients.



BREAK molecule apart

RETURN atoms to buckets

EXPLORE different kits

COMPARE your molecule collection to the goal

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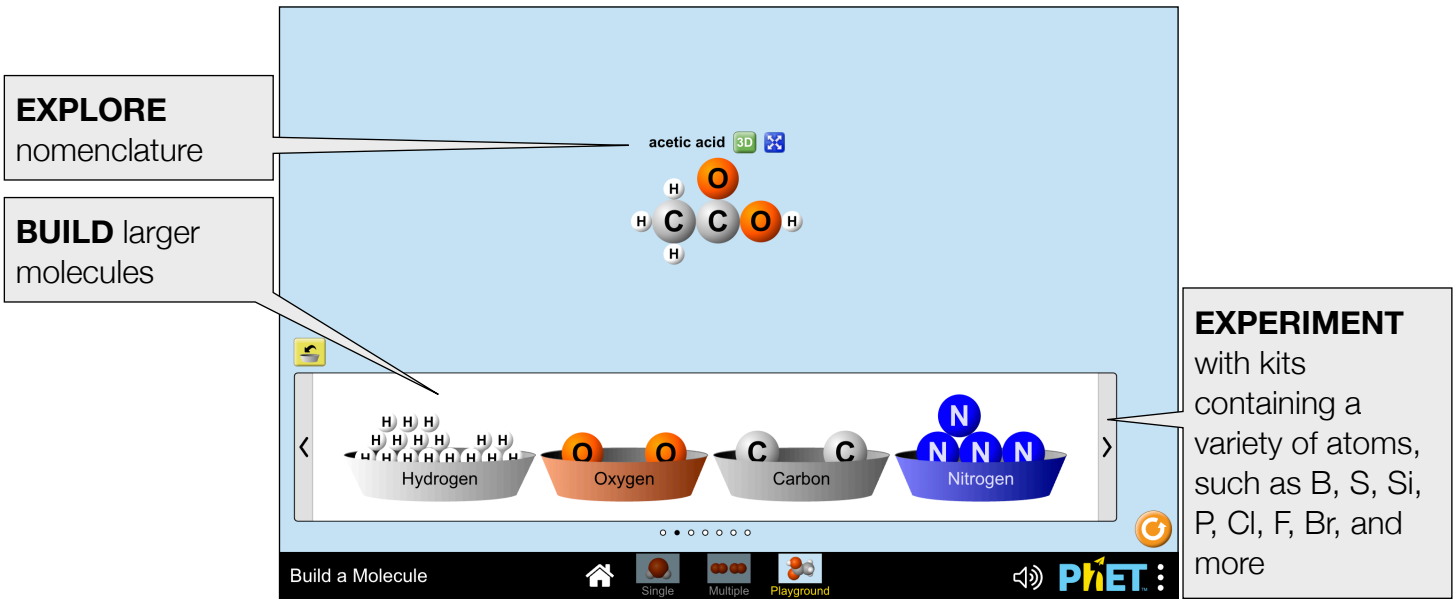
Playground Screen

Construct larger molecules, including organic and other biologically-important molecules. Find patterns in the names of similar compounds, or compare the connectivity of different compounds.



Insights into Student Use

- The first two screens have a built-in challenge for students to fill the collection boxes with the specified molecule. The Single screen is scaffolded to help students naturally figure it out how this works. Once they build their first molecule that can be put in the collection box, the box will flash and an arrow appears to show them where to put the molecule. The first collection box is the same for all students, but after they complete it, they will get a different, randomly-selected collection box to fill.
- It's not typically necessary to describe what the coefficient means before letting students explore the Multiple Screen. When challenged to fill the collection boxes, they usually figure it out within a few minutes.
- We've seen 5th grade students build Lewis Dot structures intentionally to look more like the 3D model after using this simulation. For example, when making water, we've observed students intentionally add the hydrogens to the right and left side rather than one on top and one to the right (or left) after seeing the molecule in 3D.

Suggestions for Use

Sample Challenge Prompts

- Describe the difference between a molecule name and a chemical formula.
- Explain the difference between the coefficient and a subscript in a chemical formula.
- Complete a set number of collection boxes.
- Build a molecule given its chemical formula.
- Generate the chemical formula from the pictorial representation of the molecule.

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Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Build a Molecule, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:
https://phet.colorado.edu/sims/html/build-a-molecule/latest/build-a-molecule_all.html?screens=1,2&initialScreen=2

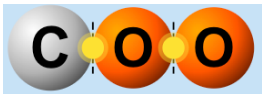
To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/build-a-molecule/latest/build-a-molecule_all.html?locale=es&screens=1,2&initialScreen=2

Query Parameter and Description	Example Links

`screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center.	`screens=1`
	
	`screens=2,1`

`initialScreen` - opens the sim directly to the specified screen, bypassing the home screen.	`initialScreen=1` `initialScreen=3`
`locale` - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
`audio` - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	`sound=muted` `sound=disabled`
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`

Complex Controls



- To disconnect an atom, click or tap on it and its connections will highlight in yellow. Sever the bond by clicking on the yellow highlight.
- To break apart an entire molecule, use the blue button that appears above the molecule.

Model Simplifications

- We use a Lewis Dot-like representation for molecules in the play area. When building a molecule, we recommend starting with the central atom and then adding the outer atoms one at a time. It doesn't generally matter which side of the of central atom you build onto. For example, the hydrogens in a water molecule can be placed 180° or 90° apart. Both are valid structures.
- The molecules that appear in the collection boxes have translatable names, such as "water" and "ozone". Other molecule names are not translatable.

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- For each molecule, we display the IUPAC Traditional name from the PubChem database. This way, H_2O will be called “water” rather than “dihydrogen oxide”. Organic compounds with common names will display their common name (e.g. isopropanol), but organic compounds without a common name with be shown with the systematic name (e.g. propan-1-ol).
- We don’t show the bonding as you build a molecule (but you can see them in the 3D view), as this simulation was primarily designed for middle school students. This means that some structures you build may have multiple names depending on the bonding (and if it is a radical). For structures that could correspond to more than one molecule, one only name and 3D structure are used, so if you built it many times, it will always be given the same name and show the same 3D structure, but it may not always be the most commonly found molecule of the possible options.
- On the Playground screen, there are 9000+ possible named structures. A small fraction of these are radicals, and when built, their 3D structure cannot be accurately rendered, resulting in missing “sticks” in the ball-and-stick representation.
- Molecules with resonance bonding may not accurately render in the 3D view. For example, phosgene (CCl_2O) will show appropriate trigonal planar geometry but the C-O bond will appear to be a shorter single bond, though it is often rendered as a double bond.
- It is possible to build some structures that aren’t named molecules, such as C-C-C, but impossible to build others, such as Cl-Cl-Cl. This is because C-C-C can appear as a part of a larger molecule (such as propane), while there aren’t any molecules in the database comprised of a chain of 3 chlorine atoms.

See all published activities for Build a Molecule here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

Rouinfar, June 2023