

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2021 to **Benjamin List** and **David W.C. MacMillan** "for the development of asymmetric organocatalysis".

The Nobel Prize 2021 in Chemistry

An ingenious tool for building molecules

Building molecules is a difficult art. Benjamin List and David MacMillan have been awarded the Nobel Prize in Chemistry 2021 because they provided molecule constructors with a sharp new tool: organocatalysis. This has had a great impact within pharmaceutical research and made chemistry greener.

Many research areas and industries depend on chemists' ability to build new and functional molecules, for anything from substances in solar cells that capture light, or which store energy in batteries, to molecules that can provide lightweight running shoes or which slow the progression of a disease.

To build molecules, chemists need catalysts. These are substances that control and drive chemical reactions, but do not become part of the final product. For example, catalysts in cars transform toxic exhaust fumes into harmless molecules. Our bodies contain thousands of catalysts in the form of enzymes, which chisel out the molecules necessary for life.

Catalysts are therefore an important tool for chemists, but researchers long believed that, in principle, only two types were available: metals and enzymes. Benjamin List and David MacMillan received the Nobel Prize in Chemistry 2021 because in 2000, independently of each other, they developed a third form of catalysis. It is called asymmetric organocatalysis and builds upon small organic molecules.

The concept is as simple as it is ingenious, and the use of organocatalysts has exploded, primarily because these catalysts can drive asymmetric catalysis. When molecules are built, situations often arise in which two molecules can form, which – just like our hands – are each other's mirror image. Often, chemists only want one of them, particularly when producing pharmaceuticals. Using organocatalysts, it is relatively simple to control chemical reactions so that practically only one of these mirror images is created. This is why organocatalysis is so beneficial in pharmaceutical research.

Benjamin List thinks outside the box...

Enzymes catalyse chemical reactions in our bodies; they consist of hundreds of amino acids, but often only a few of these are involved in the chemical reaction. Benjamin List started to wonder whether a whole enzyme was really necessary to produce a catalyst.

...with a revolutionary result

Instead of using an entire enzyme, Benjamin List tested whether an amino acid called proline – in all its simplicity – could catalyse a chemical reaction. The results exceeded his expectations. Proline could even catalyse an asymmetric reaction, which was revolutionary.





David MacMillan abandons sensitive metals...

David MacMillan worked with metal catalysts, but these are easily destroyed by moisture and oxygen, which is why they are rarely used in industry. MacMillan therefore started to wonder if less sensitive catalysts could be developed.

...and develops a ground-breaking catalyst

He designed numerous simple organic molecules with properties similar to those of metal catalysts. When he tested whether they could catalyse a chemical reaction, they worked brilliantly. One of the catalysts was even excellent at assymetric catalysis.





Organocatalysts have a bright future

Organocatalysis has developed rapidly since 2000, with Benjamin List and David MacMillan remaining at the forefront of this field. They have shown that these catalysts can drive many chemical reactions that produce a wide variety of molecules, ranging from ones that can capture light in solar cells to potential pharmaceuticals. In this way, organocatalysts are bringing the greatest benefit to humankind.

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Organocatalysts have a stable framework of carbon atoms. Active chemical groups are attached to this framework, and often contain oxygen, nitrogen, sulphur or phosphorus. These are common elements, so the catalysts are both environmentally friendly and cheap to produce. The blue molecule is proline. The green molecule is MacMillan's first organocatalyst.

Benjamin List

Born 1968 in Germany. Director of the Max-Planck-Institut für Kohlenforschung, Germany. David W.C. MacMillan Born 1968 in the UK. Professor at Princeton University, USA.



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