



SAINTS PERSPECTIVES

Things Exceptional (Nobel Prizes)

The Nobel Prize in Chemistry 2021

6 October 2021.

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2021 to:

Benjamin List - Max-Planck-Institut für Kohlenforschung,
Mülheim an der Ruhr, Germany

David W.C. MacMillan - Princeton University, USA

“for the development of asymmetric organocatalysis”

Description

An ingenious tool for building molecules

Building molecules is a difficult art. **Benjamin List** and **David MacMillan** are awarded the Nobel Prize in Chemistry 2021 for their development of a precise new tool for molecular construction: **organocatalysis**. This has had a great impact on pharmaceutical research, and has made chemistry greener.

Many research areas and industries are dependent on chemists' ability to construct molecules that can form elastic and durable materials, store energy in batteries or inhibit the progression of diseases. This work requires **catalysts**, which are substances that control and accelerate chemical reactions, without becoming part of the final product. For example, catalysts in cars transform toxic substances in exhaust fumes to harmless molecules. Our bodies also contain thousands of catalysts in the form of enzymes, which chisel out the molecules necessary for life.

Catalysts are thus fundamental tools for chemists, but researchers long believed that there were, in principle, just two types of catalysts available: **metals and enzymes**.

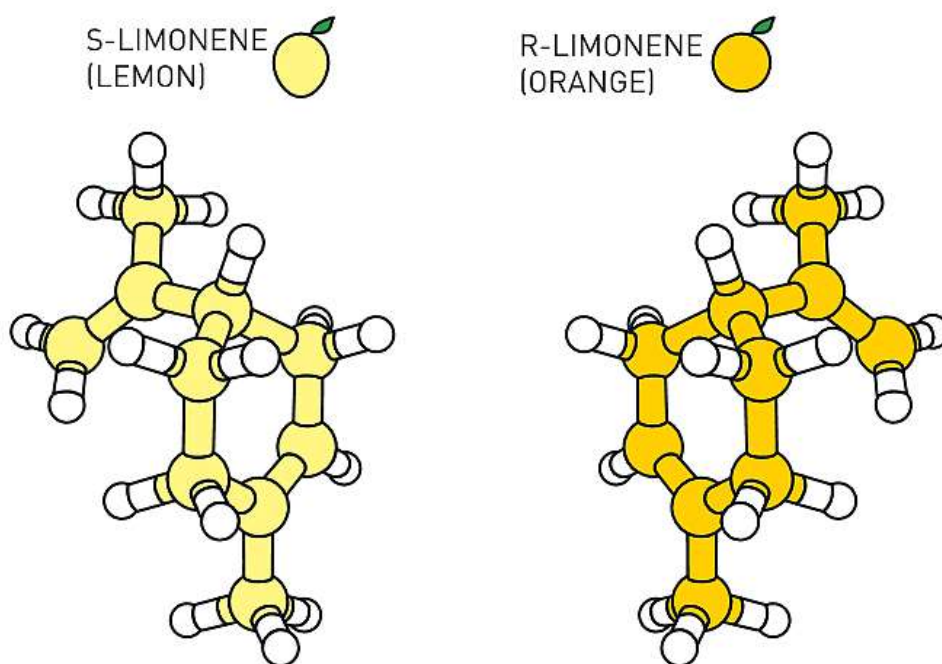


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Benjamin List and David MacMillan are awarded the Nobel Prize in Chemistry 2021 because in 2000 they, independent of each other, developed a third type of catalysis.

It is called asymmetric organocatalysis and builds upon **small organic molecules**.



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Limonene Molecule

“This concept for catalysis is as simple as it is ingenious, and the fact is that many people have wondered why we didn’t think of it earlier,” says Johan Åqvist, who is chair of the Nobel Committee for Chemistry.

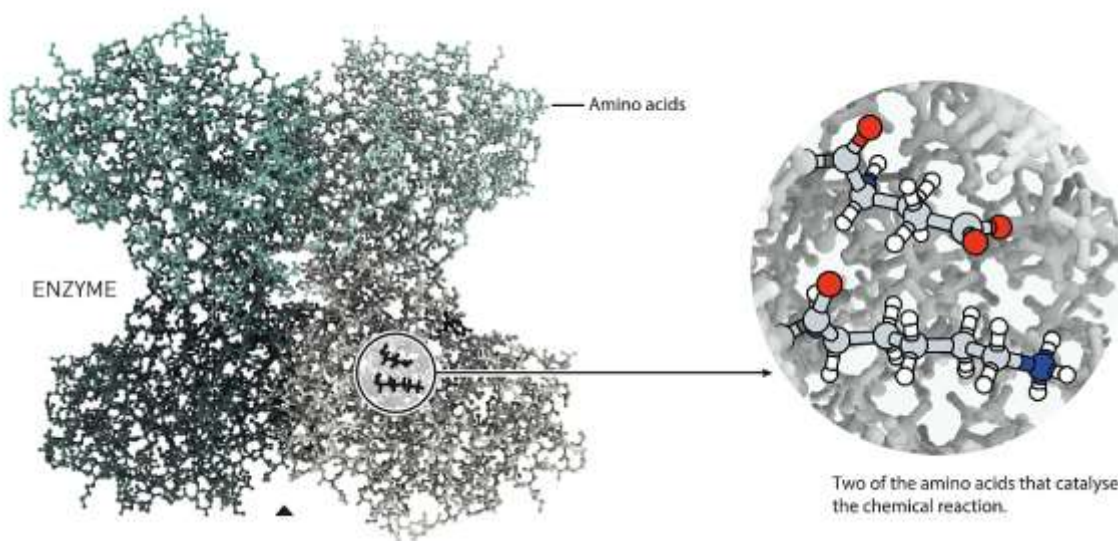
Organic catalysts have a stable framework of carbon atoms, to which more active chemical groups can attach. These often contain common elements such as oxygen, nitrogen, sulphur or phosphorus. This means



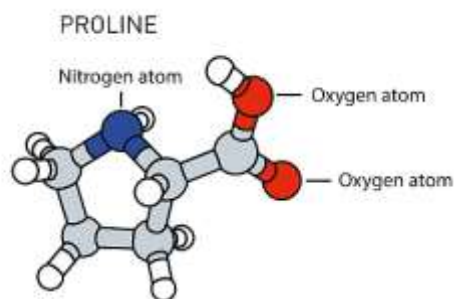
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that these catalysts are both environmentally friendly and cheap to produce.



- 1 Enzymes consist of hundreds of amino acids, but frequently only a few of these are involved in the chemical reaction. Benjamin List started to wonder whether an entire enzyme was really required to obtain a catalyst.
- 2 Benjamin List tested whether an amino acid called proline – in all its simplicity – could catalyse a chemical reaction. It worked brilliantly. Proline has a nitrogen atom that can provide and accommodate electrons during chemical reactions.



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Proline Molecule

The rapid expansion in the use of organic catalysts is primarily due to their ability to drive asymmetric catalysis. When molecules are being built, situations often occur where two different molecules can form, which – just like our hands – are each other's mirror image.

Chemists will often only want one of these, particularly when producing pharmaceuticals.

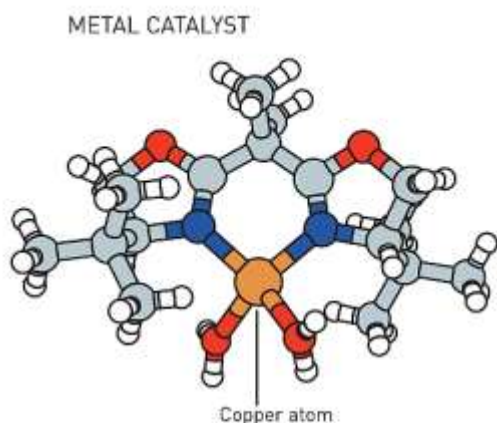


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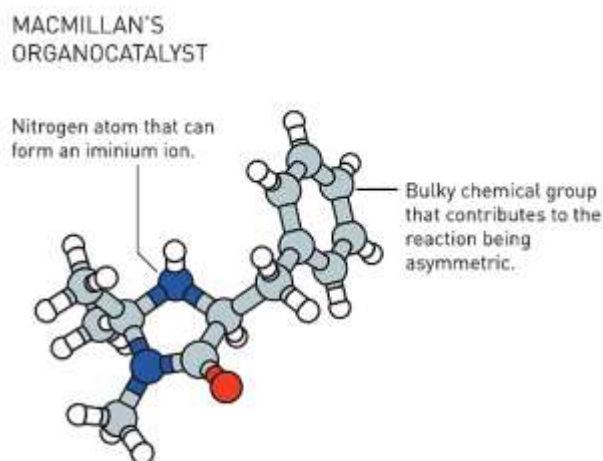
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Organocatalysis has developed at an astounding speed since 2000. Benjamin List and David MacMillan remain leaders in the field, and have shown that organic catalysts can be used to drive multitudes of chemical reactions.

Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells. In this way, organocatalysts are bringing the greatest benefit to humankind.



1 David MacMillan worked with metal catalysts that were easily destroyed by moisture. He therefore started to wonder whether it was possible to develop a more durable type of catalyst.



2 He designed some simple molecules that could create iminium ions. One of these proved to be excellent at asymmetric catalysis.

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Organocatalyst

Continued



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About the Winners

Benjamin List, born 1968 in Frankfurt, Germany. Ph.D. 1997 from Goethe University Frankfurt, Germany. Director of the Max-Planck-Institut für Kohlenforschung, Mülheim an der Ruhr, Germany.

David W.C. MacMillan, born 1968 in Bellshill, UK. Ph.D. 1996 from University of California, Irvine, USA. Professor at Princeton University, USA.

Prize amount:

10 million Swedish kronor, to be shared equally between the Laureates.