# Making organic chemistry fun, meaningful, and accessible

*Many undergraduate students perceive organic chemistry modules as make-or-break courses in their university career. They often resort to rote memorisation, which not only alienates them but prevents them understanding the discipline in depth. Social and economic factors may also be significant barriers in the study of this fundamental subject. With examples drawn from her extensive teaching experience, Dr Irosha N Nawarathne, Lyon University, Arkansas, USA, illustrates how organic chemistry can be made more meaningful and accessible, while encouraging the element of diversity in the classroom.*

Ask most science undergraduates around the world about organic chemistry and it will become apparent that many students describe it as one of the most challenging and cumbersome subjects. Depending on how the content is presented, even the most proficient learners might perceive this very important discipline as an endless collection of lists of reactions and detailed mechanisms that they feel they ought to memorise to get past the hurdles of complex assignments, laboratory reports, and exams.

Dr Irosha N Nawarathne, associate professor of chemistry at Lyon University, Arkansas, USA, has made it her mission to make the learning of organic chemistry more accessible to students from all walks of life. Her hands-on learning approach favours deep understanding over memorisation of notions and facts. At the core of Nawarathne's method is the belief that it is a key responsibility of teaching staff to ensure that students of organic chemistry are engaged in and draw inspiration from an organic chemistry curriculum that is presented to them as relevant and stimulating, with examples that illustrate how aspects of this key subject permeate the reality that surrounds us.




## ROTE MEMORISATION: A BARRIER TO DEEP LEARNING

In 2022, Nawarathne authored an article in the *Journal of Chemical Education*, demonstrating how the inclusion of relevant examples from everyday life in every aspect of the organic chemistry curriculum can improve the students' attainment in the subject, improving both the engagement with the discipline and the retention of the most difficult concepts. 'Organic chemistry has a reputation of being a difficult subject,' acknowledges Nawarathne. 'There are no problem-solving algorithms; it requires three-dimensional thinking; and it has an extensive new vocabulary.' She highlights how most students feel that they have no option but to approach organic chemistry by relying on rote learning, with minimal effort to embark on a more meaningful learning journey.

Organic chemistry constitutes the very fabric of all living things and, according to the author, educators can and should facilitate how students reframe their perception of the subject. Teaching staff should place relevant content at the heart of the curriculum, considering the everyday experiences and career aspirations of the students. This should also be reflected through the delivery of engaging practical activities and in the design of assessment tasks. Nawarathne illustrated the advantages of her novel approach in her 2022 article, presenting the readers with a series of measurable outcomes. She hopes that many educators can incorporate her methods in their teaching practice, making organic chemistry interesting and worth studying in the minds of their students.


By shifting the focus of alkenes and their reactions to real-world applications, Nawarathne hopes to change how students perceive organic chemistry.

## ALKENES EVERYWHERE

Often, one of the first topics introduced to students of organic chemistry is the chemical structure and reactivity of alkenes, compounds made of hydrogen and carbon who possess at least one pair of carbons joined together by a 'double bond'. This type of bond, which consists of two pairs of negatively charged electrons that act like glue between two atoms, confers alkenes with a particularly strong reactivity, while the higher density of electrons can manifest in a tendency for conjugated (elongated) alkenes to form coloured compounds, due to the electrons acquiring higher energy levels when hit by light.

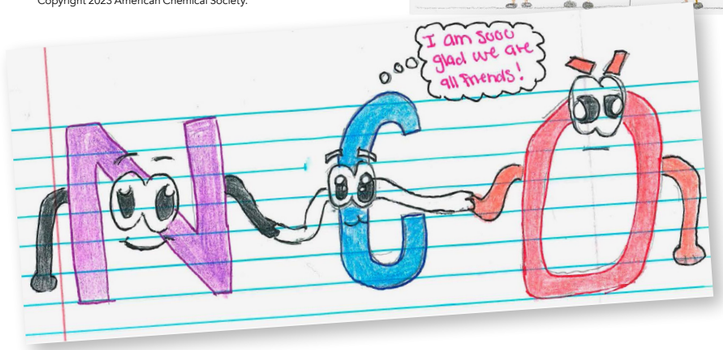
'Alkenes and their reactions were introduced to an introductory organic chemistry class by incorporating simple yet attractive laboratory experiments and assignments in a span of two weeks prior to introducing chapter content on alkenes and alkene reactions,' explains Nawarathne. She planned the assessment section of the course to include assignments where students had the opportunity to measure the nutritional values of brightly coloured foods, or to research the chemical composition in the leaves that leave so many people awestruck during the autumn season. The activities also

***Nawarathne shows how diversity is fundamental both in the biochemical landscape, as well as in vibrant and well-functioning communities.***


Nawarathne aims to engage students by drawing inspiration from an organic chemistry curriculum that is presented to them as relevant and stimulating, with examples that illustrate how aspects of this key subject permeate the reality that surrounds us.


Nawarathne's unique approach compares the diversity of carbon-based molecules to social diversity. In the two examples, the students related diversity in organic chemistry to social diversity very effectively.






included laboratory tasks where the students would measure the light absorbed by plant pigments or explore the absorbent properties of the materials contained in common diapers.

In organic chemistry, the study of alkenes is fundamentally important for the understanding of reaction mechanisms. By shifting the focus on relevance to real-world applications, Nawarathne hopes to change how students perceive organic reactions, steering away from rote learning. To measure the impact of her didactic method, Nawarathne surveyed the students both before and after the two-week introductory materials were presented. It was apparent from the students' responses that the use of familiar examples improved their interest in learning about alkenes (and other functional groups), as well as facilitating knowledge retention and deep understanding of the topic.

**SOCIAL AND MOLECULAR DIVERSITY**

The barriers to learning organic chemistry and wider scientific subjects are not just limited to the way the curriculum is presented. Social factors have a significant impact on students' prior exposure to scientific vocabulary and methodologies, as well as on the ability to rationalise complex, abstract concepts, formulate hypotheses, and solve problems through the use of schemes, diagrams, and chemical equations. Nawarathne believes that educators can minimise the impact of these obstacles, actively encouraging a culture of openness and diversity in the organic chemistry class.

In a 2019 article in the *Journal of Chemical Education*, Nawarathne illustrated ways to promote an inclusive environment for undergraduate students of organic chemistry, so they could embrace diversity in the classroom and society at large. She reported that she deliberately introduced sections of the organic chemistry curriculum that are focused on the importance of diversity at the molecular level.

***Educators can actively encourage a culture of openness and diversity in the organic chemistry class.***

'Carbon is the most inclusive atom we can think of in chemistry, it bonds with anything and everything. We discuss examples of how carbon bonds with itself, other non-metals, and metals to form the most useful compounds around us, including what we are made out of provided all biological molecules are organic and based on carbon,' explains Nawarathne, adding that these lessons were followed by a class discussion around the importance of diversity in society and an assignment on the topic of molecular and social diversity. Analysing the students' responses from surveys taken prior to and after the course introduction to molecular diversity, the author concluded that not only were students more aware of social diversity, but that this, in turn, improved their in-depth knowledge of carbon bonding.

**MAKING SCIENCE ACCESSIBLE**

Nawarathne believes that to attract talent in scientific disciplines among a diverse cohort of learners, it is fundamental that the teaching of organic chemistry rids itself of some of the most obsolete methods that require students to memorise endless sets of reactions and mechanisms, with little focus on content relevance and deep understanding of the physical and chemical properties of the most important classes of carbon compounds.

She also advocates for actively promoting inclusion among learners; drawing a parallel between chemical species and different individuals in society, she shows how diversity is fundamental both in the biochemical landscape, as well as in vibrant and well-functioning communities. Nawarathne has adapted the content of the organic chemistry courses she teaches at Lyon University to remove many of the barriers to learning that prevent many talented students from achieving a fulfilling career in the scientific field. Nawarathne plans to systematically monitor the impact of her pedagogy on student achievement and hopes that other educators can draw inspiration from her methods for the teaching of organic chemistry and other scientific disciplines.



# Behind the Research

## Dr Irosha N Nawarathne

**E:** irosha.nawarathne@lyon.edu **T:** +1 870 307 7218 **W:** www.lyon.edu/iroshanawarathne

## Research Objectives

Using relevant day-to-day examples and applications, Dr Irosha Nawarathne aims to make organic chemistry meaningful and accessible.

## Detail

**Address**
2300 Highland Road, Batesville, AR, 72501, USA

**Bio**

Dr Nawarathne received her BSc in chemistry from University of Colombo, Sri Lanka, and her PhD in bioorganic chemistry from Michigan State University, East Lansing. She was a research fellow at the College of Pharmacy, University of Michigan, Ann Arbor, before moving to Arkansas for her independent career at Lyon College, Batesville, where she is an associate professor.

**Funding**

Arkansas INBRE program, supported by a grant from the National Institute of General Medical Sciences, (NIGMS), P20 GM103429 from the National Institutes of Health.

**Collaborators**

Dr Nawarathne would like to thank Raunak Banerjee, Amanda Ford, Natalie Milligan, Tharanga MK Wijetunge, Kristi Price, and LaShawna Miller for their contributions. The gratitude extends to the students in Autumn 2020 and Autumn 2021 organic chemistry classes for their contribution in completing the assignment and/or the pre- and post-surveys, and Autumn 2016 and Autumn 2018 organic chemistry classes for their efforts completing the diversity assignment and the pre- and post-surveys.

## References

Nawarathne, I, (2022) Alkenes, brought to you in familiar faces. *Journal Chemical Education*, 99, 3418–23. doi.org/10.1021/acs.jchemed.2c00103

Nawarathne, I, (2019) Introducing diversity through an organic approach. *Journal Chemical Education*, 96, 2042–9. doi.org/10.1021/acs.jchemed.8b00646

## Personal Response

***What attracted you to advocate for inclusiveness and to your research field in general?***

"I fall into the categories of first-generation student in college, an immigrant and a very small minority in graduate school in the US, and a petite woman of colour in the physical sciences. I choose humanity over any categories. I advocate against discriminatory words, actions, and judgement, and the systematic and insidious biases in the sciences; seek opportunities to provide full learning experiences to all types of people in my classroom (widely defined); actively promote retention of underrepresented groups in chemistry by providing mentorship and guidance while encouraging all parties to achieve to the fullest. As much as I continuously value and support the morals such as equity, diversity and inclusivity, I urge a day that no one feels the need for specifying those ideals to their community because those morals should be obvious expectations from any sensible person. My advocating efforts for inclusiveness are my contributions for that wishful society."