

“ Making it organic: the Garg Lab’s approach to excellence in research while teaching the next generation of chemists

The Garg Lab at UCLA is a testament to the synergy between groundbreaking research in organic chemistry and innovative STEM education. We caught up with Professor Neil Garg to explore how and why the Garg Lab excels in both realms, challenging the notion that teaching and world-class research are mutually exclusive endeavours and how we need to push for innovation in the STEM education pipeline.

Neil Garg, a prominent figure in organic chemistry, leads the Garg Lab. With a bachelor’s degree in chemistry from New York University and a PhD at Caltech, Neil is currently a distinguished professor at UCLA. He has received an impressive list of accolades during his career, including the AAAS Bhaumik Award for Public Engagement with Science and Fellowship in esteemed scientific societies.

The Garg Lab

We asked Neil to start us off by summarising the research focus of the Garg Lab.

Research focus

“There are two parts to this: fundamental research and applied research.”

Fundamental research

“A majority of what we do is on the fundamental side, and within that, we mostly challenge existing or long-standing ways of thinking.

“When somebody takes organic chemistry, it’s a new language with a lot of rules. Sometimes, these rules aren’t challenged for decades or a hundred years. Say you have a type of organic structure that looks

weird or strained, and the rules say that it can’t exist. We would challenge that thinking and figure out how we can make those structures.” Garg published one such example in the journal *Nature* last year.

“We then think about how to make the process practical for someone like an organic chemist at a big pharmaceutical company, making the chemistry easy for them to use and build future drugs.”

Applied research

“On the applied side, we have projects focusing on innovative approaches to creating complex molecules, like the synthesis of lissodendoric acid.” Neil is referring to an achievement that was published in the journal *Science* and garnered a great deal of media attention for the Lab: being the first chemists to synthesise an ocean-based molecule that could fight Parkinson’s.

“But we also have projects that are more proactively trying to identify drugs or molecules that could be potentially useful for human health, which is much more toward the side of drug discovery.

“The breathalyser chemistry is a totally different example.” Here, Neil is referring to the Lab’s initial discoveries toward the ultimate goal of creating a breathalyser to detect recent THC consumption (from marijuana use) that resulted in the spin-off company *ElectraTect*. “I was explaining about fuel cell technology for alcohol breathalysers at a public lecture. An attorney in the audience came up to me and asked me why this couldn’t be done for THC. It was a good question, a modern problem, and members of my research lab were really interested. We started working on it, figured out the basic chemistry, published and patented it and then launched a company to take the technology forward.”

A passion for education

Neil explains more about ‘life’ in the Lab for both himself and the students. He reveals an ongoing journey of curiosity, experimentation and education. It’s the education angle that, in this interview at least, really sets Neil on fire.

“We think about innovation in research, and that’s such a high bar in academia, but we just don’t have that type of dialogue in academia when we think about education.

“In the academic landscape, the teaching component is something people always talk about as being valuable, but at institutions that pride themselves on research, teaching can be seen as a distraction.

“I did not teach undergraduates at UCLA for the first few years. When that time passed, there was an opportunity to teach chemistry to the pre-med students, and I signed up to do it. I didn’t have many expectations and felt like it would be a distraction from getting research done, but it was great! The students were awesome and very creative. I could give them really hard problems they would solve, and to have 400 people enjoying organic chemistry together was so motivating for me!”

Neil adds: “Just as we put innovation focus into research, we really need to do the same thing with education.”



The need to innovate STEM education

"What do I mean by innovation and education? Well, what is innovation in research? It's this lofty term. In education, the most innovative thing can't be having a flipped classroom or a Zoom course.

"I would offer that teaching children organic chemistry is a long-term issue of working on the STEM education pipeline. We start with naturally curious little kids who love science, but there's some point where it goes from fun colours and explosions to just being too hard."

Solving the college chemistry problem

Neil believes that the jump to university/college level chemistry is too great, causing anxiety, fear of the subject, and ultimately, 'dropping out'. In fact, if it wasn't for a particularly inspirational teacher, Neil could have dropped chemistry himself.

"I qualified for the honours chemistry course at NYU. Even though it would be hard, I decided to take it. As I went through the course, I had no idea what was going on. I remember studying with friends, and in my head, I was just going to drop the course. So, I studied with them, but I had no stress—I wasn't worried about it.

"Then, in my first exam, I got the highest score in the class. The professor, Marc Walters, wrote a fair exam, but there's all this student-driven anxiety and stress. Once that was gone, it was easy, and then I got a lot more confident.

"Obviously, I didn't drop the course; I stuck it out. Then, when I went to take organic chemistry, the professor, Yorke Rhodes, spent the entire lecture on the first day saying, 'This class has little to do with organic chemistry. It's problem-solving. Don't believe anything you heard. It's not about just sitting down and memorising; it's about understanding the language and learning how to solve tough problems.'

"This is what I do when I teach. Even to the pre-med students, I say, 'This has little to do with chemistry. It's about problem-solving and creativity.' That was important to me to separate that stress and anxiety.

The language of chemistry

Neil emphasises the 'language of chemistry' consistently. "Chemistry is its own language; once I learned the rules, it just clicked with me.

"I remember talking to a young UCLA student who was a great musician, and he was teaching one of our kids how to play the piano. I really struggled with it as a kid, and it blew my mind. How can you do this with all these keys? What is it, 88 keys? But he explained that it was

only a small set of keys, and those keys repeated, and then I got it! You just need to learn the language and practice."

Neil holds a passionate belief that we need to start teaching the language of chemistry at an early age to reduce the fear and make learning more enjoyable. "Kids learn languages much more easily than adults, so why can't we teach kids organic chemistry?"

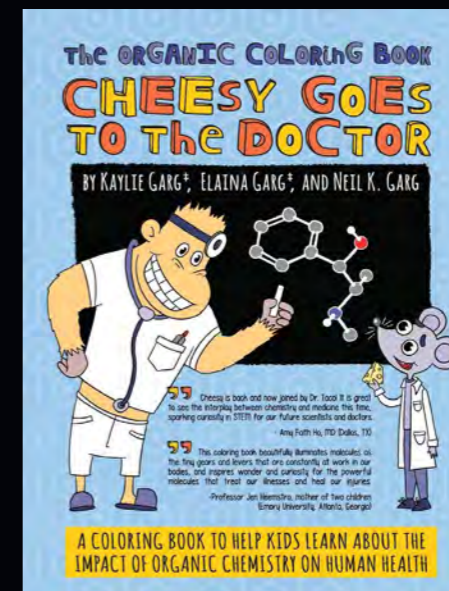
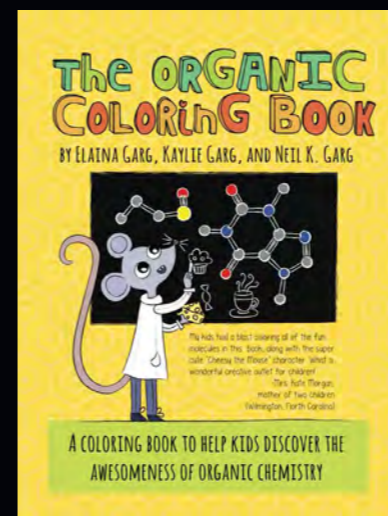
The education experimentalists

"I really consider ourselves to be educational experimentalists. Some people research how people learn. We develop new tools, me and members of the Garg Lab, and we work with younger students to get their feedback.

"If educational tools are helpful for students, then they will use them; if not, then they won't. So, we're less on the side of trying to understand how people learn. There are other experts that do that. We develop tools we think will be useful and allow people to use them.

"We try to make our educational tools free and put them online. A lot of the students in my lab work on these projects. That's become a part of what we do. All of the amazing IT work is done by my friend from graduate school, Dr Daniel Caspi, at his company [Element26, Inc.](https://www.element26.com/)"

Neil attributes the success of their education experiments to the creativity and commitment of students. "In the large organic chemistry class, we had students make these music videos: choose your favourite song, make a parody and don't just come up with the lyrics but make a music video here in Los Angeles. The students were really good at this! Just seeing that innovation, that creativity and students having fun with organic chemistry." That ability to breathe fun into education has been at the forefront of the ideation and development of educational materials released by the Lab.



O-Chem reactivity book

The O-CHEM (Re)activity book is free to download for anybody who likes mazes, word searches and spot the difference activities. <https://garg.chem.ucla.edu/ochem-re-activity>.

Chem Kids

Chem Kids is a week-long UCLA summer programme that was piloted in August 2023. Students aged between 10 and 12 enjoyed sessions filled with puzzles, games and more. The result? More than 90 per cent of the Chem Kids said they believed other kids their age could learn organic chemistry.

Innovation experiments

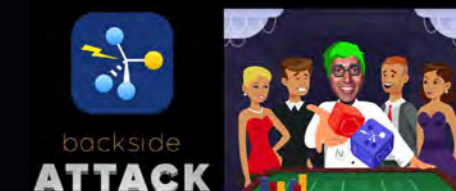
Colouring books (child and adult)

The organic colouring book series is available via Amazon at "the lowest price it will allow me to set it," Neil emphasises.

"The Organic Colouring Book was published in 2017. My daughters and I wrote that one together. The idea is that kids can colour anything, so now they have some idea what the molecules look like. We did a follow-up edition focusing on medicines. There's a mouse character, so that's called *Cheesy Goes to the Doctor*. Then we did one called the *Adult Organic Colouring Book*, which has some more controversial things in it, like alcohol. That was created with a graduate student and a postdoc during the pandemic." <https://www.amazon.com/dp/B08NXL4SWP>.

"These kids are incredibly smart. They're inspiring. Sure, organic chemistry is hard. But if you can get a 10-year-old to understand it, then maybe it's not so hard. Maybe we just need to change how and when we teach it."

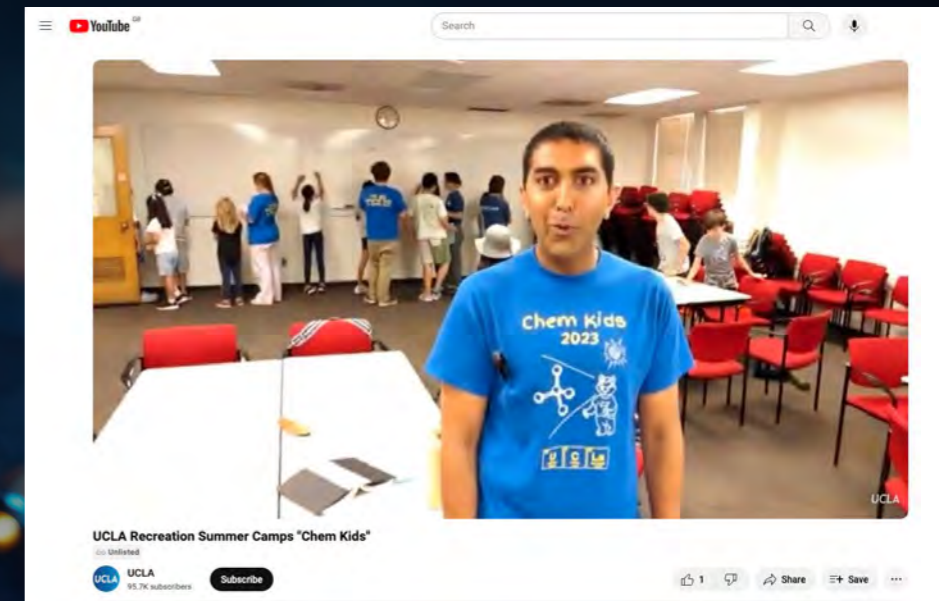
Backside attack app



The Backside Attack app teaches college entry students some of the fundamentals of organic chemistry through game-play.

The app is free to download from the Apple store.

"It probably took us two years to develop. Once we figured out how to create something like this, we have been able to build similar resources more regularly." <https://apps.apple.com/us/app/backside-attack/id1278956096>.



See: Organic chem for kids? UCLA program immerses youngsters in notoriously challenging subject @ https://youtu.be/R_57kR5vegg?si=sQY1I4wRhVJslFmv.



Use of VR

Students can have a hard time visualising 3D molecules. “We developed tools

to do that with students. We can now transition to VR because that technology is really blossoming, and it's becoming cheaper. There's a little bit of a catch: the headsets are expensive, but if the university can provide the headsets, then we can make the rest free. People can use the headsets and controllers to 'hold' the molecules. We even have little kids do it this summer at ChemKids—little kids in the VR headsets interacting with DNA and its double-helix. It was awesome.” See: <https://garg.chem.ucla.edu/virtual-reality>.

Conclusion

In light of the quality and quantity of output from the Garg Lab, it should prove a considerable challenge for anyone to perpetuate the argument that teaching comes at the expense of research and innovation.

Evidence of the Garg Lab being a significant player in pushing the boundaries of organic chemistry is found in its numerous high-quality publications. The cherry on the cake? The worldwide interest in their work on the synthesis of complex molecules such as lissodendoric acid and (-)-N-Methylwelwitindolinone C isonitrile. “There were at least 15 to 20 labs around the world trying to make that molecule,” reflects Neil in a contented manner.

How do they manage it? We can only assume that Neil's infectious enthusiasm, curiosity and love of fun spill over to his students. We encourage you to check out the many videos on the Garg Lab website for proof.

To wrap up, Neil ended on a note of appreciation to his co-workers (students). “They're really the crux of everything. Yes, it's the interplay between all of us, but they're really at the heart of what we do. They provide creative ideas, excitement, enthusiasm and perseverance in working on really tough problems. They make me want to be a better teacher and to his mentors, and most importantly, his co-workers (students).”

Read more about the Garg Lab at <https://garg.chem.ucla.edu/>.



Image: UCLA Garg Lab team.

PROJECT NAME

Garg Lab

SPECIALIST AREAS

Organic chemistry
Medicinal chemistry
Drug detection
STEM education
Public engagement

PROJECT LEAD

Dr Neil Garg is a Distinguished Professor of Chemistry and holds the Kenneth N. Trueblood Chair at the University of California, Los Angeles (UCLA). With a passion for organic chemistry, he leads a dynamic research lab focused on innovative synthetic methods and strategies. Professor Garg is dedicated to nurturing the next generation of scientists, emphasising the need for innovation throughout the STEM pipeline and teaching organic chemistry from an early age.

THE GARG LAB

The Garg Lab, nestled within UCLA's Chemistry and Biochemistry department, is a pioneering force in organic chemistry research. Under the guidance of Professor Neil Garg, the Lab has achieved breakthroughs in synthetic methodologies, notably contributing to the total synthesis of complex molecules like lissodendoric acid and (-)-N-Methylwelwitindolinone C isonitrile. This accomplishment showcases the Lab's commitment to advancing the field.

PROJECT CONTACT

Professor Neil Garg
Department of Chemistry & Biochemistry,
UCLA, Los Angeles, CA 90095-1569, USA

✉ garg@chem.ucla.edu

🌐 <https://garg.chem.ucla.edu/>

