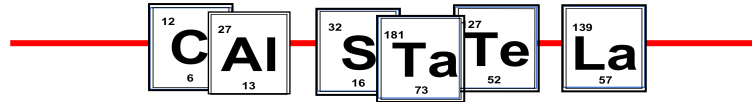


# “Refocusing Undergraduate Science Education”

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**Carlos G. Gutiérrez**

**Distinguished Professor of Chemistry, Emeritus, & Founding Director  
Minority Opportunities in Research Programs**



**The **M**inority **O**pportunities in **R**esearch (**MORE**) Programs:**  
a confederation, established in 2000, of efforts with the common goal of preparing underrepresented Cal State LA students for success in PhD programs.

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**NIH MARC U-STAR Honors BS to PhD**  
Linda M. Tunstad, Director

**NIH RISE BS to PhD and MS to PhD**  
Krishna Foster, Director

**NIH Bridges to the Baccalaureate CC to 4-Yr**  
Linda M. Tunstad, Director

**NIH MS Bridge to the PhD**  
Robert Vellanoweth, Director

**NSF LSAMP-BD. Directors:**  
Katrina Yamazaki/Andre Ellis/C. Gutiérrez

**Carlos Gutiérrez, Founding Director;**  
**Vicki Kubo-Anderson Coordinator Emeritus**

# Results of Cal State LA MORE Research Training Programs

Dr. Lorilee Tallorin	PhD in Chemistry, 2016, UC San Diego
Dr. Jeff Celaje	PhD in Chemistry, 2016, U of Southern California
Dr. Omar Moreno	PhD in Physics, 2016, UC Santa Cruz
Dr. Rosa Padilla	PhD in Mechanical Engineering, 2016, UC Irvine
Dr. Roxana Leos	PhD in Public Health, 2016, UCLA
Dr. Deisy Contreras	PhD in Biomedical Sciences, 2016, Cedars-Sinai Med
Dr. Velveth Klee	PhD in Material Science and Engineering, 2016, UCR
Dr. Maira Soto	PhD in Pharma & Translational Sci, 2017, USC
Dr. Janet Garcia	PhD in Learning, Dev and Cog, 2017, UC Irvine
Dr. Judith Alvarado	PhD in Materials Science, 2017, UC San Diego
Dr. Trinidad Cisneros	PhD in Microbiology, 2017, Stanford U
Dr. Cynthia Reyes	PhD in Neuroscience, 2017, UC San Diego
Dr. Carlos Anguiano	PhD in Psychology, 2017, Washington State U
Dr. Mecca Madany	PhD in Biomedical Sciences, 2017 Cedars-Sinai Med
Dr. Abdullah Madany	PhD in Biomedical Science , 2017, UC Riverside
Dr. Michelle Palacios	PhD in Micro/Immunology, 2017, UNC Chapel Hill
Dr. José Cenicerros	PhD in Mathematics, 2017, Louisiana State U
Dr. Selma Cuya	PhD in Molec Pharm, 2017, U Alabama, Birmingham
Dr. Joey Contreras	PhD in Biomedical Sciences, 2017 IUPUI
Dr. Danielle Barrios	MD-PhD in Biology, 2017, 2015 UC San Diego
Dr. Henry Valle	PhD in Chemistry, 2018, Mississippi State U
Dr. David Guzman	PhD in Materials Engineering, 2018, Purdue U
Dr. Melo Jean Encinas	PhD in Science Education, 2018, UCLA
Dr. Steven Halaby	PhD in Biochem, Cell, & Molecular Bio, 2018, Cornell U
Dr. Ricardo Albay	PhD in Molecular Bio & Biochemistry, 2018, UC Irvine
Dr. Eli M. Espinoza	PhD in Chemistry, 2018, UC Riverside
Dr. Michelle Roa	PhD in Chemistry, 2018, UC Irvine
Dr. Schetema Stevens	PhD in Chemistry, 2018, U Nevada Las Vegas
Dr. Nicholas Derimow	PhD in Materials Science, 2019, UC Riverside
Dr. Wendy Ochoa	PhD in Psychology, 2019, UC Irvine
Dr. Nancy Lainez	PhD in Biomedical Science, 2019, UC Riverside

- Since its 2000 inception, **172 MORE** alumni have **earned the PhD**; another **166 are in strong PhD programs** nationwide.
- The 2017 NSF Survey of Earned Doctorates lists Cal State LA as the top baccalaureate institution of origin of Hispanic science PhD recipients among BS/MS colleges/universities in the continental US. Cal State LA **MORE undergraduate are 80% of these students.**
- The **Office of the President of the University of California** lists Cal State LA as the number one BS origin institution among the 23 campuses of the California State University whose underrepresented minority student alumni earned science PhDs at the 10 campuses of the University of California over the past 20 years. **85% were MORE undergraduates.**
- The Obama White House Initiative on Educational Excellence for Hispanics noted the **Cal State LA MORE Programs as a 2015 Bright Spot in Hispanic STEM Education.**

**What about the 95% of undergraduates that will not participate in MARC or RISE or even in undergraduate research?**

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**We need to do through the curriculum for *all* Cal State LA students what we have done for individual MARC and RISE participants.**

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**But there is a disconnect, dissonance, between how science is done and how science is taught.**

**SCIENCE** is a *creative human activity for understanding the world*. It is inspired by observation of nature and by imagination, which leads to research questions. Its practice is based on the scientific method of setting and testing hypotheses to gain insights into possible answers to these questions.

It is also the *organized body of knowledge* gained through such researches.

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- In science education, we focus largely on the *organized body of knowledge* part at the expense of the *genitive, participatory, creative human activity part*.

This is particularly true at the freshman and sophomore levels, the gateways to the scientific professions. And this is where we lose about half of science students, especially from underrepresented minority communities.

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- What does it mean to teach mostly content in an age where a student has, through their smart phone, access to more science content than can be learned in several lifetimes? Why should they memorize facts when this can be outsourced to the cloud? What is the lasting value of what we teach students?

Should we not **TEACH biology or chemistry** the way we **DO biology or chemistry**? The most important thing we can model for our students is how scientists think about and do their work. **Pedagogy must demonstrate epistemology!**

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**Questioning is at the core of science.** It is surprising then, that we do not explicitly teach students how to formulate, develop and improve their own disciplinary questions.

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“[Paulo] Freire argued that a radical pedagogical structure is needed that is both empowering and humanistic . . . **Unlike the pedagogy of the answer**, which reduces learners to mere receptacles for prepacked knowledge, the **pedagogy of the question** gives a way to challenge the constraints that relegate people to mere objects.”

Neal Bruss and Donaldo P. Macedo

*Toward a pedagogy of the question: Conversations with Paulo Freire*

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We, perhaps, need to move undergraduate science education **from an answer-based enterprise** (the professor asks questions, and the student answers them) **to a question-based one** where we **also teach students to formulate, develop, and improve their own disciplinary questions, . . . and answer these.**

We might consider teaching science not only as a catalog of exceptionally significant research results that have become the canon of the discipline, but **also as a creative human activity for understanding the world by means of the scientific method.**

We must move students from being **consumers of information generated by others**, to **intellectual participants capable of being creators.**

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We must interrupt the false narrative that science is only for those lucky few chosen by the Science Gods, the “born scientists” who have an innate gift **(for memorization?)**; that “you either have it, or you don’t”.

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“One is not born a genius, one becomes a genius.”

- Simone de Beauvoir

*“Which **questions** do I need to ask to get insights into ...”*



- How does the structure of R affect the reaction?
  - How does the nature of X affect the reaction?
  - How does the nature of Y affect the reaction?
  - How can we determine the molecularity of the reaction?
  - How can we tell if the reaction is reversible?
  - How does solvent affect the reaction?
  - What have other investigators written about this?
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“The scientist is not a person who gives the right answers.  
[S]he is one who asks the right **questions**.”

- Claude Levi-Strauss

“The principal goal of education is to create [individuals] who are **capable of doing new things**, not simply repeating what other generations have done – men [and women] who are **creative, inventive and discoverers.**”

- Jean Piaget

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We must prepare our students to be intellectual risk-takers, to be adventuresome! We should **let them in on the fun, beauty, adventure and joy of science early on, while we can still capture their imagination.** Give them good reasons to study hard! Literally, teach them to question. **Questioning is one part of creativity that can be taught.**

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The hypothesis here is that if **all** students have a **good question-based preparation in science**, the **diverse** pool of those that have the talent and drive to pursue PhD studies, as well as other science-based career alternatives, will significantly increase. From this larger pool will come many talented scientists, physician-scientists, clinical practitioners and informed citizens.