SUPERS students deliver therapeutic light to kill cancer cells in a dish.

Introducing SUPERS: training the next generation of radiation scientists

Radiation is used by scientists in many everyday applications, from imaging to nuclear power plants. Experts have identified a shortfall in the number of skilled radiation scientists in the field. In response to this, **Dr Sydney M. Evans** and colleagues at Perelman School of Medicine, University of Pennsylvania have provided undergraduates from the all over the US and territories with the opportunity to gain valuable knowledge and laboratory skills as part of the Summer Undergraduate Program to Educate Radiation Scientists (SUPERS).

With the increasing prevalence of radiation in modern society, from imaging to radiotherapy, airport x-ray detectors to nuclear power plants, training adequate numbers of skilled radiation scientists is of great importance. In our everyday lives, radiation is used for such diverse tasks as producing electricity at power plants, sterilising medical supplies on hospital operating tables, and ensuring the safety of foods. In addition, use of x-ray-based imaging is very common in health care.

Radiation science is not only important for advancing the efficiency and safety of the various routine applications of radiation in society, but also to be prepared for accidents or attacks potentially involving radiation. Having experts skilled at communicating the often complex nature of these risks to the public is of paramount importance to ensure that responses to these types of incidents are considered appropriate and proportionate.

BEATING THE RADIATION SKILLS GAP

In the early 2000s, specialists in radiation biology, oncology and physics identified a shortfall in skilled experts able to carry out and communicate research in their fields, and experienced a decrease in government support for training over the preceding three decades.

In the aftermath of the 9/11 attacks and the increased focus on terrorism as a pertinent threat, radiation experts expressed concern over the numbers of scientists, physicians and emergency services with the skills and experience to deal with a possible attack or accident involving radiation. Recommendations from the Radiation Research Society (RRS) to remedy this included an onus on providing new training opportunities for graduates and undergraduate students. A 2003 review paper in the journal *Radiation Research* identified the need for radiation researchers to collaborate in shaping the future of radiation science, noting that "the diversity of interests and expertise, the breadth of career opportunities, and the ability to apply research to human needs are among the greatest strengths of this field." The writers concluded that while areas of immediate concern such as nuclear terrorism and cancer survivorship will attract people to this field, mentoring and support of young scientists are crucial to sustained excellence.

The program aims to address the need to increase diversity within the radiation research community by offering opportunities to students from communities currently under-represented in science

THE SUPERS PROGRAM

Dr Sydney M. Evans is a Professor of Radiation Oncology at the Perelman School of Medicine, part of the University of Pennsylvania. As well as her substantial research into tumour physiology, over the course of her career Dr Evans has educated many medical and veterinary students in the fields of radiology and radiation oncology. In 2009, as a response to the need to increase the number of trained radiation scientists working in healthcare, industry and research, Dr Evans and colleagues at the University of Pennsylvania started the Summer Undergraduate Program to Educate Radiation Scientists (SUPERS).

Drs Koumenis, Tuttle and Evans were awarded a government grant from the National Institutes of Health (NIH) to set up the SUPERS Radiation Scientists program with two primary aims. By the end of the lecture course the student should have a better understanding of where their project fits in the broader field of radiation science. The goal is to give talented undergraduate students the chance to engage with basic science and translational cancer research, especially as associated with the use of radiation. Secondly the program aims to help address the need to increase diversity within the radiation research community by offering opportunities to students from communities currently under-represented in science.

THE STRUCTURE OF SUPERS

Rising juniors and seniors from worldwide Universities apply using our on-line program application (https://www.med.upenn.edu/

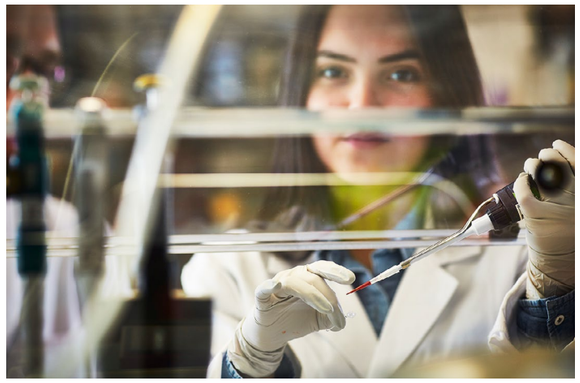
supers/program.html). Excellent academic standing and an interest in pursuing a Masters or PhD level career in STEM fields are required. The SUPERS program takes place over a ten-week period during the summer academic recess, with participants typically spending 3-5 hours per week in lectures and approximately 35 hours a week in a laboratory conducting independent research.

SUPERS gives undergraduate students an experience of independent hypothesis-based research, as well as three lectures per week. Lectures in ethics in science and basic concepts in radiation and imaging are featured. Together with the discussion of current literature and presentation of their research methods and findings to peers, SUPERS students gain extra training in advanced areas of science.

Examples of recent student research projects include using radiation to measure oxygen levels in tumour cells, improving the accuracy of tumour imaging and examining the effect of space radiation on skin cells.

Student Joe B. of the 2010 and 2011 summer groups believes that these lectures provided knowledge and understanding not available in the normal undergraduate program. Joe says: "the weekly lectures covered many topics that were not discussed in any of my undergraduate biology classes. These lectures contributed significantly to understanding my individual research project and my understanding of cancer and radiation biology as a whole." Joe has since gone on to pursue a PhD from the University of Pennsylvania in oncologic science.

There are also opportunities to participate in journal clubs, where students are encouraged to discuss current and relevant academic literature. Students present their research ideas in a lecture format midway through the course, then present their conclusions to their colleagues at a retreat in the final week of SUPERS.



Above: Dr Sydney Evans (second row, far left) with students from the 2011 SUPERS class.

Left: Individual research projects are the core of the SUPERS program. In this photo, Bruna B. (SUPERS 2017-18) is looking for circulating tumour cells in blood samples.

SUPERS' SUCCESS

Now in its ninth year, 545 students have applied to SUPERS since its inception, with complete and relevant applications having increased steadily from 28 in 2010, to 102 in 2017. The school welcomes a class of between ten and 16 students each summer, including the opportunity for rising juniors to apply for a second summer when they are rising seniors.

In accordance with one of the stated aims of the program, SUPERS alumni include the under-represented in science populations. This compares favourably to data based on the US census, USA graduate students, NIH principal investigators and the membership of the Health Physics Society.

The classes from 2009 to present enrolled 26% minority students, 28% Pell grant recipients (awarded to those who could not otherwise afford to attend college), 48% female students and 2% students with disabilities recognised under the American Disabilities Act (ADA).

As well as welcoming a diverse range of students, Dr. Evans has watched as alumni progress in their careers and utilise the skills developed during SUPERS. Of the 73 graduated alumni, 31 are pursuing a PhD or combined MD/PhD, including seven of whom are studying fields directly related to imaging, medical physics or cancer biology. Another 30 SUPERS alumni are studying for an MD and/or a Masters level degree in a STEM field.

Dr Evans and the SUPERS team at the University of Pennsylvania are now looking to build on their success and renew their funding beyond 2019, to continue to train and inspire the next generation of radiation scientists.

• To find out more about the SUPERS program visit www.med.upenn.edu/supers/program.html

Talented undergraduates are given the chance to engage with basic science and translational cancer research

Q&A

What's the most important thing you aim for students to take away from their time in SUPERS?

The majority of the SUPERS students have had minimal experience in bench science (other than labs for their coursework) and are unclear whether they want to pursue basic science as part of their career. Having a 'real' bench project has been eye opening for most of the students. Other students have come to SUPERS with the idea that they want to pursue an MD/PhD. Meeting graduate students and professors who have had this experience is immensely helpful. We have found in exit interviews that the students have a much better idea whether they want to include a PhD-level degree in their future.

How does participation in the SUPERS help prepare your students for a career in the field?

As noted above, it first gives them a real experience that is critical for choosing their career. Doing bench science is very difficult and often students come to the end of their SUPERS summer with minimal data or data that does not fit their hypothesis. This is eye opening for students going into research but is very generalisable to life circumstances where the quest is as important as the outcome. Finally, our SUPERS make life-long friends and colleagues, including with the faculty and their mentors.

One of your aims is to increase diversity within your field. Why do you think working towards a diverse research community is important?

First, it is clear that working in teams is very effective in accomplishing goals. It is also the case that scientists coming from different backgrounds can contribute new ideas and perspectives, increasing the likelihood of success and generalisability. Secondly, under-represented populations do not have access to real life science activities (in some cases any science exposure); this roadblock is seen in the under-representation of these groups in people working in STEM fields.

In what areas of your field do you see the greatest challenges in the coming years in terms of training scientists to be able to tackle pressing problems within radiation science?

Unfortunately, the answer is financial. The NIH funding for our program has decreased since its inception and more importantly, we are limited in what we can spend our grant dollars on. For example, we cannot use the funds to subsidise living expenses. This is very problematic since one of the goals of this program is to give access to students with financial challenges. The School of Medicine, the Office of Diversity and inclusion and the division of Radiation Biology have each contributed to SUPERS funding, so we can continue to attract the best students.

What plans do you have for the future of SUPERS? Are you looking to make any changes to the structure or aims of the program?

We will re-submit in 2019 for our grant funding for another five years. The overall structure and aims will not change, although we are currently discussing ways to improve the student experience. I would like to be able to invite foreign students into the program and will seek funding. Similarly, I would like to see other institutions implement 'SUPERS-like' programs and I would be willing to help them toward that goal.

SUPERS gives undergraduate students an experience of independent hypothesis-based research, as well as lectures on the ethics of science

Detail

RESEARCH OBJECTIVES

The research objectives for this program are to expose talented undergraduate students to radiation biology, physics and cancer imaging research, and in so doing, stimulate them to pursue careers in cancer and radiation-related research. The program strives to accept students of colour, those who are financially underprivileged, female, are first in their family to attend college and/or have disabilities.

FUNDING

• National Institutes of Health (NIH)

COLLABORATORS

• Costas Koumenis, PhD
• Steven Tuttle, PhD

BIO

Dr Sydney M. Evans is a Professor in the Perelman School of Medicine, Department of Radiation Oncology. Her primary research interests are in tumour (especially brain) physiology, particularly the presence and effect of tumour cell hypoxia (low oxygen) and novel blood-borne microvesicles. During her career, Dr Evans has educated many medical and veterinary, students and residents in both radiology and radiation oncology.

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