R. Langer

*The author presented on this page has recently published his **10th article** since 2000 in Angewandte Chemie*: "Engineering Substrate Topography at the Micro- and Nanoscale to Control Cell Function": C. J. Bettinger, R. Langer, J. T. Borenstein, *Angew. Chem.* **2009**, *121*, 5512–5522; *Angew. Chem. Int. Ed.* **2009**, *48*, 5406–5415.

Robert S. Langer

Date of birth:	August 29th, 1948
Position:	Institute Professor
Education:	1970 B.S. with distinction, Chemical Engineering, Cornell University (USA) 1974 ScD, Chemical Engineering, "Enzymatic Regeneration of ATP", MIT (USA) 1974–1977 Research Associate, (MA Supervisor, Judah Folkman), Children's Hospital Medical Center, Harvard Medical School, Boston (USA)
Recent Awards:	**2009** Honorary Degree (Harvard University); UCSF Medal; Honorary Degree, Mount Sinai School of Medicine; Distinguished Chemist Award, New England Institute of Chemists; **2008** Millennium Technology Prize; Max Planck Research Award; Prince of Asturias Award for Technical and Scientific Research; Founders Award, AIChE; Acta Biomaterialia Gold Medal; **2007** National Medal of Science; Chemistry of Materials Award, American Chemical Society; Herman F. Mark Award, American Chemical Society, Polymer Chemistry Division; Honorary Doctorate, Yale University; **2006** Honorary Doctorate, Northwestern University; Honorary Doctorate, Albany Medical College; **2005** Von Hippel Award, Materials Research Society; Albany Medical Center Prize in Medicine and Biomedical Research; Dan David Prize, Materials Science; Honorary Doctorate, Uppsala University; Honorary Doctorate, Pennsylvania State University; Honorary Doctorate, University of Nottingham
Current research interests:	Nanotechnology as applied to drug-delivery systems; new polymers for gene therapy; synthesis of new lipids for RNAi delivery; design of super biocompatible materials; developing controlled release systems that can be magnetically, ultrasonically, or electronically triggered to increase release rates; synthesizing new biodegradable polymeric delivery systems that will ultimately be absorbed by the body; creating new approaches for delivering drugs such as proteins and genes across complex barriers in the body such as the intestine, the lung, and the skin; new ways to create tissue and organs including creating new polymer systems for tissue engineering; stem cell research including controlling growth and differentiation; creating new biomaterials with shape memory or surface switching properties; angiogenesis inhibition
Hobbies:	Fitness, sports, and magic

In a nutshell, my research involves … biomaterials and chemical and biomedical engineering.

My work is significant because … it hopefully helps people to live healthier lives.

My favorite subject at school was … math.

When I wake up I … simultaneously exercise (recumbent bike) and go over papers or grants.

I chose chemistry as a career because … When I was a little boy, my parents gave me a Gilbert chemistry set and I loved conducting reactions with the different chemicals. Also, chemistry was my best subject during my first year in college.

My first experiment was … mixing different solutions together and watching them change color as a result of chemical reactions.

My biggest motivation is … seeing how what I do (teaching and research) helps people and hopefully makes the world a healthier, happier place.

In my spare time I … love to spend time with my wife and three children either at home, sporting events, or traveling.

In ten years time I will be … still teaching and doing research (hopefully).

The best advice I have ever been given is … to believe that anything is possible (Judah Folkman).

The part of my job which I enjoy the most is … teaching and mentoring the students and postdocs in my lab.

My favorite food is … anything chocolate, especially dark chocolate.

My favorite book is … the "Last Lone Inventor" by Evan Schwartz.

How is chemistry research different now than it was at the beginning of your career?

There are a number of things that have changed. First, analytical techniques are much better and more sensitive today. Second, there are high-throughput techniques that are being developed, which can accelerate the pace of discovery. Third, there have been enormous advances in molecular biology and cell biology over the last 30 years. These advances have opened the door to enabling chemistry to contribute to biological areas in numerous ways.

Has your approach to chemistry research changed since the start of your career?

It really hasn't changed that much other than the fact that we've done a lot of work in high-throughput areas, which has accelerated some of the research that we are involved with.

Has your approach to publishing your results changed since the start of your career?

It hasn't changed. Early on, I was lucky to be given the advice to try and aim for top journals and I still try to do that.

What do you think the future holds for your field of research?

We are involved in biomaterials, drug delivery, tissue engineering, and nanotechnology. Although I am prejudiced, I think all of these areas have incredibly bright futures. There is just so much research going on and I think this research will lead to new materials as well as fundamental new chemical principles and new applications. For example, it would be great if scientists could create nanoparticles to target drugs to specific sites in the body. It would also be great if we could get large molecules to cross barriers such as skin, the intestines, and the brain. Also, it would be terrific if scientists could come up with synthetic materials that can safely deliver genes and siRNA to cells. From a tissue engineering point of view, I think materials will have an enormous potential impact on providing scaffolds for cells to grow into new tissues and organs. In addition, the understanding of how polymer surfaces contribute to cell behavior is an unsolved problem that will be important for future research.

Have you changed the main focus of your research throughout your career and if so why?

I've always been interested in doing research that will contribute to improving people's health. Early on in my career, the major areas I worked in were angiogenesis research and drug-delivery systems as well as some aspects of enzyme technology. I still work in all of those areas to some extent today, but over time I've become involved in some new areas, including tissue engineering. Also over time, I've become more involved in developing new types of materials that I hope will be useful in science and medicine.

What has been your biggest influence/motivation?

My biggest hope is that we can do work that will really improve the lives of human beings. I think there are two ways to do that. One way is through research and the other is by training future leaders.

What advice would you give to up-and-coming scientists?

I think it's always worthwhile taking chances and doing high risk, high impact research, and that is the advice I give to my students. I also think that it is important to learn how to write research grants well.

What is the secret to publishing so many high quality papers?

I feel very fortunate that I've had many wonderful students and postdocs, as well as great collaborators and advisors. To whatever extent I've been successful, it is really because of these terrific people.

My 5 top papers:

1. "Polymers for the Sustained Release of Proteins and Other Macromolecules": R. Langer, J. Folkman, *Nature* **1976**, *263*, 797 – 800.
   This paper involves our discovery that it was possible to design biocompatible polymer matrices to release ionic species and large molecules continuously and slowly. Before this, scientists generally thought that you could only slowly deliver a few molecules this way: those that were very lipid soluble and of low molecular weight. When we first discovered this, it was met with a lot of skepticism among scientists because many thought it was impossible to do something like this. I like to think that this discovery had a major impact on the field of drug delivery because before this, only a few molecules could be continuously delivered though polymer matrices, and now almost any molecule can be. Phil Ball, a former editor at Nature, in his excellent book (Made to Measure: New Materials for the 21st Century) described this work as follows: "It was widely believed at first that polymer delivery systems would not be equal to this task…But in 1976, Robert Langer and colleagues found that certain polymers, generally ones that were highly hydrophobic (water repellent) such as copolymers of ethylene and vinyl acetate, could be mixed with powdered proteins and formed into microspheres that would release the proteins at a steady, slow rate, persisting sometimes for up to one hundred days. There seemed to be no limit to the size of the molecules that could be released controllably in this way, nor to their nature: proteins, nucleic acids, and polysaccharides (sugar polymers) could all be used."

2. "Tissue engineering": R. Langer, J. Vacanti, *Science* **1993**, *260*, 920 – 926.
We discovered that polymer matrices that were configured as an appropriate 3D scaffold combined with mammalian cells (including stem cells) can create new tissues. This is enabling tissues such as cartilage, bone, skin, urologic replacement tissue, and others to be formed. This approach can thus potentially be used to help patients suffering from tissue loss or organ failure. This paper describes both our approaches to tissue engineering and the field in general. It has been cited nearly 2500 times. There is a US National Academy of Sciences "Beyond Discovery" publication on "Polymers and People." Referring to this work, they wrote "Chemical engineer Robert Langer and physician Joseph Vacanti joined forces in the early 1980s in an effort to create artificial tissues. Within a few years they had grown liver cells on a polymer framework, giving rise to the field of tissue engineering."
3. "Isolation of a Cartilage Factor that Inhibits Tumor Neovascularization": R. Langer, H. Brem, K. Falterman, M. Klein, J. Folkman, *Science* **1976**, *193*, 70 – 72.
This paper describes the discovery and partial purification of the first compound that blocks the formation of new blood vessels (angiogenesis), thereby halting tumor growth. It also describes critical methods of testing such inhibitors using controlled release polymer techniques that are still used today. In 2006, my students held a symposium entitled "Celebrating Thirty Years of Robert Langer's Science" and many of my former students and collaborators came. At the meeting, Judah Folkman spoke and wrote with respect to this discovery that "Early research in tumor angiogenesis was propelled by the pioneering work of Robert Langer who discovered how proteins and other macromolecules could undergo sustained release from polymers that could be implanted into the avascular cornea of animals and into other tissues. This advance provided a general platform for the subsequent discovery and purification of angiogenesis regulatory molecules. It is difficult to imagine how such proteins could have been isolated and their angiogenic activity identified without Langer's contribution." Today angiogenesis has become a thriving field—over a million patients every year are treated for cancer and certain forms of blindness by using drugs that were discovered based on this principle.
4. "Biodegradable Long-Circulating Polymeric Nanospheres": R. Gref, Y. Minamitake, M. T. Peracchia, V. Trubetskoy, V. Torchilin, R. Langer, *Science* **1994**, *263*, 1600 – 1603.
In this paper, we synthesized and designed new nanoparticles that could circulate throughout the body for a long time. I'm excited about this work because now we (in collaboration with my former medical fellow Dr. Omid Farokhzad) have adapted this system to target the nanoparticles to cancer cells and I expect we will be in human clincial trials next year. This is one of the most widely cited medical nanotechnology papers ever written, with approximately 1000 citations.
5. "Semi-Automated Synthesis and Screening of a Large Library of Degradable Cationic Polymers for Gene Delivery": D. G. Anderson, D. M. Lynn, R. Langer, *Angew. Chem.* **2003**, *115*, 3261 – 3266; *Angew. Chem. Int. Ed.* **2003**, *42*, 3153 – 3158.
I was very fortunate that over ten years ago Bob Grubbs called me and told me that he had a wonderful young chemist in his lab who was getting his PhD, Dave Lynn, who wanted to work with me as a postdoctoral fellow. I put Dave in the same office with a terrific young cell biologist, Dan Anderson. Together they came up with the first high throughput synthetic methods for synthesizing and testing polymers for gene therapy delivery. What was exciting about this research is that not only was it a great example of an interdisciplinary collaboration, but the technology itself is leading us and others in all kinds of new directions—not only gene therapy, but by using offshoots of these chemistries, we have applied these techniques to many other areas including materials for siRNA delivery, polymers for controlling stem cell differentiation, and even new products in hair care.

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