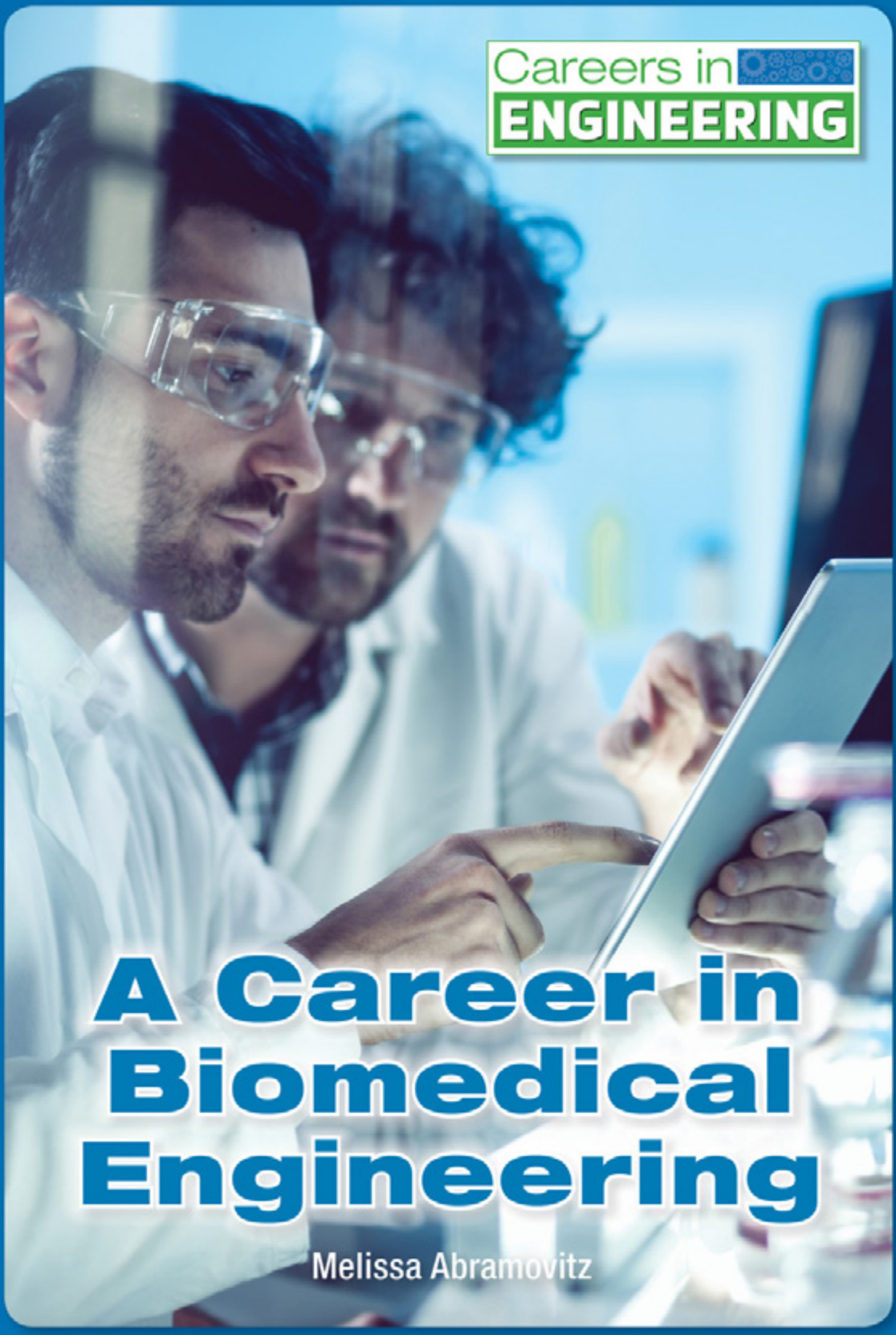
Careers in ENGINEERING

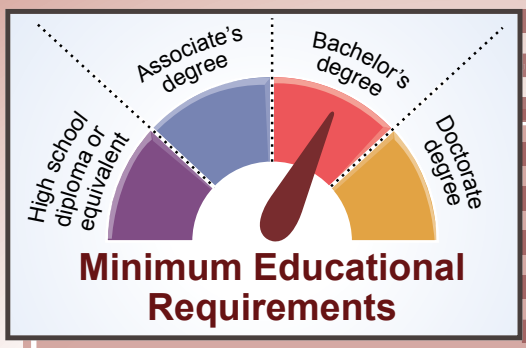


A Career in Biomedical Engineering

Melissa Abramovitz

CONTENTS

BIOMEDICAL ENGINEER AT A GLANCE

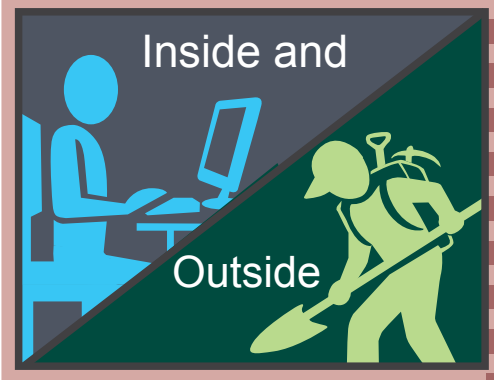


Minimum Educational Requirements

Personal Qualities

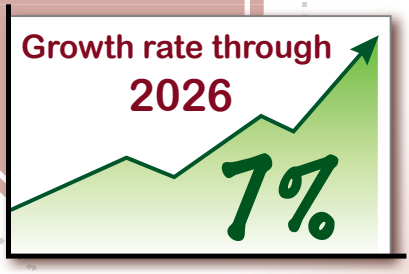
- Analytical, math, and problem-solving skills
- Communication skills
- Creativity
- High ethical standards
- A desire to help others

Working Conditions



Median Pay in 2016 $85,620

21,300
Number of jobs as of 2016



Future Job Outlook

Source: Bureau of Labor Statistics, *Occupational Outlook Handbook*. www.bls.gov.

CHAPTER 5

Advancement and Other Job Opportunities

Biomedical engineers can advance their careers through experience and education. Earning advanced degrees and/or job promotions or transfers to other jobs can result in higher salaries for these engineers. These achievements can also elevate individuals' status within the discipline and increase their influence at a particular company or institution.

Advanced Degrees

Earning a bachelor's degree in biomedical engineering allows many people to find a job right away, but many others continue their education to earn master's or PhD degrees in biomedical engineering or related fields. Some graduates earn a master of business administration (MBA) to gain expertise in the business aspects of biomedical engineering. Others pursue advanced degrees from a medical school (MD, or doctor of medicine) or law school (JD, or doctor of law).

Typically, people with graduate degrees earn higher salaries and can advance to leadership positions within companies or academic institutions. According to Salary.com, in 2017 the median salary for a new biomedical engineer with a bachelor's degree was $50,413 to $55,224 in the United States. A midlevel job for a biomedical engineer with a master's degree and five to ten years of experience paid a median of $88,225 to $94,888. The median salary range for a senior engineer with more than fifteen years' experience and a PhD, MD, or JD was $92,140 to $102,581.

Advancement in Academia

Biomedical engineers with a PhD often become college or university professors who teach and conduct research in their own laboratories. They are often considered to be authorities in their field and may be consulted by private businesses or government agencies to serve as advisers on technical or public health policy issues. Income from consulting can add to a professor's earnings.

Biomedical engineers in academia who obtain patents for the products or techniques they invent can also earn money whenever the rights to use the patented item are sold. Actually, the university and the inventor both obtain these patents and reap the benefits. In many cases professors start their own companies to produce and sell the patented items. Some of these professors end up leaving academia because they earn far more money as entrepreneurs. But many who form companies remain in academia; some hire managers to run the company, and some work part-time at the company. For example, Dr. Kyriacos Athanasiou at the University of California–Irvine has been creating and patenting new drug delivery systems and biomaterials since the 1990s and has created several companies that license the technologies. He says he thought about leaving academia to run these companies, but "I realized that I've never been interested in creating products solely for making money. To me, it's about the excitement and passion of coming up with solutions to some of the most difficult problems that afflict humans"[34] and sharing that excitement with students. So he leaves the business aspects of his companies to managers.

> "I realized that I've never been interested in creating products solely for making money. To me, it's about the excitement and passion of coming up with solutions to some of the most difficult problems that afflict humans."[34]
>
> —Dr. Kyriacos Athanasiou of the University of California–Irvine

Professors who remain at a college or university for a set amount of time can also receive tenure, which provides job security, status, and often more money than untenured positions. The American Association of University Professors defines *tenure* as

Biomedical engineers who want to take on new challenges sometimes turn to academic research and teaching. More money and an enhanced reputation may result for engineers who develop new products or techniques through their research.

"an indefinite appointment that can be terminated only for cause or under extraordinary circumstances" and notes that its main purpose is "to safeguard academic freedom. . . . If faculty members can lose their positions for what they say in the classroom or for what they write in an article, they are unlikely to risk addressing controversial issues."[35] Tenure often allows professors to undertake research that may not provide immediate results, since unlike untenured professors, those with tenure cannot be fired for failing to publish a certain number of research papers each year.

Professors can also advance to lead departments or entire schools. Gilda Barabino, for instance, is the dean of the Grove School of Engineering at the City College of New York, as well as being a professor of biomedical engineering and chemical engineering. She was previously a professor of biomedical engineering and the first vice provost for academic diversity at Georgia Tech, and she is known for her advocacy and efforts to promote diversity nationwide. These efforts stemmed from obstacles she encountered as both a woman and an African American. In fact, a remark by her high school chemistry teacher in the 1970s spurred her decision to pursue a career in science. "She told the class that

Biomedical engineers are thus working to improve these products, and new talent and ideas are needed to support these efforts.

Once better materials are developed, other biomedical engineers are needed to determine the best ways to manufacture the products, market them to hospitals and doctors, and teach surgeons to use them. There is thus an ongoing need for biomedical engineers with different specialties to see products through from idea to use in health care settings.

Emerging Roles for Biomedical Engineers

Biomedical engineers are improving the technologies needed for long-distance telesurgery, but there are still obstacles to overcome. One such obstacle is that telesurgery requires high-speed visual, voice, and computer data communications connections to eliminate delays after a surgeon sends commands to a distant robot. Any delays could result in botched surgeries. Thus, high-speed Internet connections are being used.

However, cybersecurity experts note that Internet-connected communications open telesurgery to hackers. In fact, in 2015 Tamara Bonaci at the University of Washington revealed that her research indicates that telesurgeries which utilize the Raven II robot are subject to cyberattacks. Bonaci is an electrical engineer who studies security issues related to emerging biomedical technologies. "Due to the open and uncontrollable nature of communication networks, it becomes easy for malicious entities to jam, disrupt, or take over the communication between a robot and a surgeon," she states. This could result in patient deaths. Even when Bonaci and her team encrypted the communications, it was still possible for hackers to interfere. This highlights the ways in which new biomedical engineering roles and subspecialties—such as biomedical engineers with expertise in cybersecurity—are emerging all the time.

Quoted in *MIT Technology Review*, "Security Experts Hack Teleoperated Surgical Robot," April 24, 2015. www.technologyreview.com.

Replacing Retirees

Another factor driving the increasing need for biomedical engineers is that a significant number of biomedical engineers in industry and academia are expected to retire by the mid-2020s, creating job openings for new engineers. Recruiting efforts to replace these teachers and researchers are ongoing at universities like Cornell, which states it launched the Faculty Renewal Sesquicentennial Challenge in 2010 "to recruit outstanding new faculty in the face of an unprecedented number of retirements expected over the next decade."[45] This initiative is being funded largely by donations from Cornell alumni who are committed to maintaining Cornell's position as a top university for biomedical engineering studies and research.

> "Medical and biological engineers today are carving out their own path . . . tackling some of the grand challenges facing the US and the world."[47]
>
> —AIMBE

The need for biomedical engineers to replace retiring engineers in academia and industry is not confined to the United States; a 2015 report by Engineers Canada predicted that Canada would experience a shortage of one hundred thousand engineers of all types between 2015 and 2025. In March 2017 an article in the University of Toronto Engineering Department newsletter noted that "across the country, thousands of engineers with decades of experience are about to retire *en masse* [as a group]"[46] and called on universities to train highly qualified engineers, including biomedical engineers, to fill these vacancies.

Forging the Direction of Biomedical Engineering

The newness of biomedical engineering as a formal discipline is also driving the need for new people. According to the American Institute for Medical and Biological Engineering (AIMBE), "Medical and biological engineers today are carving out their own path." The discipline has continued to evolve since it became a recognized branch of engineering in the twentieth century. This

CHAPTER 7

Interview with a Biomedical Engineer

Robert Langer is an institute professor of biological engineering at MIT, where he has taught and done research since 1978, after earning degrees in chemical engineering from Cornell University and MIT. Langer's laboratory at MIT is the largest biomedical engineering laboratory in the world, and he is well known as a biomedical engineering pioneer whose research on drug delivery methods, tissue engineering, biomaterials, biomechanics, and molecular engineering has largely shaped modern progress in these areas. He has written over fourteen hundred research articles and obtained more than one thousand patents. He has also received more than 220 major scientific awards and has founded many biotechnology companies. He spoke with the author about his career.

Q: Why did you become a biomedical engineer?

A: I became an engineer because I was good at math and science. I became a biomedical engineer because I was looking for a way to use my engineering background to help people. Most people who earned chemical engineering degrees in the 1970s went to work for oil companies, but I wanted to do something that would help people more. I received twenty job offers from oil companies like Shell, Chevron, and Exxon, but I wasn't excited about working for an oil company. I wanted to use engineering to make the world a better, healthier place. I was turned down for the teaching and research jobs I applied for, but finally Dr. Judah Folkman offered me a low-paying job in his laboratory at Boston Children's Hospital doing research to stop cancer by preventing it from growing a blood supply. I was the only engineer there, but I loved the work.

SOURCE NOTES

Introduction: A Growing Engineering Field

1. International Federation of Consulting Engineers, "What Is an Engineer?" http://fidic.org.
2. Try Engineering, "What Can I Do with an Engineering Degree?," 2018. http://tryengineering.org.
3. National Human Genome Research Institute, "Biomedical Engineer." www.genome.gov.

Chapter 1: What Does a Biomedical Engineer Do?

4. American Institute for Medical and Biological Engineering, "Navigate the Circuit." http://navigate.aimbe.org.
5. Michael Sivak, "Gastrointestinal Endoscopy: Past and Future," *Gut*, August 2006, p. 1062.
6. University of Wisconsin–Madison, "Tapping the 'Wild Collaboration' Within Biomedical Engineers," February 8, 2017. www.engr.wisc.edu.
7. Quoted in Ellen Crown, "First 'Thought-Controlled' Bionic Leg Funded Through Army Medicine Research," US Army, September 26, 2013. www.army.mil.
8. Quoted in Katharine Miller, "Profiles in Computer Science Courage," *Biomedical Computation Review*, Spring 2011. www.biomedicalcomputationreview.org.

Chapter 2: How Do You Become a Biomedical Engineer?

9. Quoted in US Naval Academy, "Top 5 Reasons to Attend Summer STEM." www.usna.edu.
10. Quoted in W. Mark Saltzman, *Biomedical Engineering*. Cambridge: Cambridge University Press, 2015, p. 618.
11. Gage Greening, "Inside a NASA Internship: Gage Greening Reports from the Johnson Space Center," University of Arkansas Biomedical Engineering department blog, August 1, 2016. https://bmeblog.uark.edu.
12. Penn State Department of Agricultural and Biological Engineering, "Biological Engineering Major," 2018. www.abe.psu.edu.

Accreditation Board for Engineering and Technology (ABET)

415 N. Charles St.
Baltimore, MD 21201
www.abet.org

ABET is a nonprofit organization that accredits college and university programs that grant associate's, bachelor's, and master's degrees in natural and applied sciences, engineering, engineering technologies, and computers. The website contains a list of programs ABET accredits and also has information about the purpose and standards for accreditation.

American Institute for Medical and Biological Engineering (AIMBE)

1400 Eye St. NW, Suite 235
Washington, DC 20005
http://aimbe.org

AIMBE is a nonprofit organization that represents medical and biological engineers and related academic institutions, private industries, and professional engineering societies in advocating for relevant public policy issues. The AIMBE website contains articles that highlight biomedical advances and careers and provides guidance for students interested in these careers.

Biomedical Engineering Society (BMES)

8201 Corporate Dr., Suite 1125
Landover, MD 20785
www.bmes.org

The BMES is a professional society for biomedical engineers and bioengineers. It promotes education and shares knowledge about biomedical engineering with the public. The BMES allows undergraduate and graduate students studying biomedical engineering to join as student members and have access to meetings, workshops, and other resources.

INDEX

Note: Boldface page numbers indicate illustrations.