The Best Career of 2011?

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US News and World Politics recently ranked biomedical engineering as one of the 50 best careers in 2011, and ranked it as the top technology job of the year. With an improving economy and greater demand for biomedical research and advancement, biomedical engineers have found a plethora of opportunity to pursue their work. This increased availability comes with increased funding and a virtually unlimited scope of possibility, which is reflected in biomedical engineering's high placement in the rankings. US News and World Politics' ranking methodology considers factors such as job growth projections, salary data, job satisfaction, turnover, impending retirements, and employment prospects when compiling their list.[1] According to the Labor Department, "No single occupation is expected to have more job growth over the next decade or so. Employment of biomedical engineers is expected to grow by a whopping 72 percent—adding nearly 12,000 jobs—between 2008 and 2018."[2] But aside from all the economic advantages and available resources, what is it that really makes biomedical engineering an outstanding career? Venturing briefly into the work of biomedical engineers and some of the advancements they made in 2011 alone would certainly reveal why biomedical engineering is truly a field characterized by increased growth, importance, necessity, and limitless bounds.

WHAT IS BIOMEDICAL ENGINEERING?

Biomedical engineering is the bridge that unites the once orthogonal fields of medicine and engineering. It seeks to utilize engineering principles and design concepts to model or solve medical and biological problems, thereby improving healthcare diagnosis, monitoring, and therapy.[2] Just as the healthcare field is subdivided into numerous specialties, the interdisciplinary field of biomedical engineering is broken up into various subdivisions. Biomedical engineers research and work on an array of clinical and engineering applications, including the design of medical instrumentation and regenerative tissue growth, and the development of biocompatible prostheses and pharmaceutical drugs. These are just some of many of the tasks biomedical engineers face. The increased attention and funding that biomedical engineering in recent years has led to fruition, as each passing year leaves a myriad of publications and breakthroughs, many of which hold immense implications on the future of healthcare. A couple examples are described below.

SYNTHETIC WINDPIPE TRANSPLANT

Back in 2008 surgeons in Spain successfully performed the world's first tissue engineered whole-organ transplant on a 30-year-old woman. The only problem is that the surgery required a donor trachea. With 50,000 to 60,000 people diagnosed with cancer of the larynx in Europe each year, half of whom doctors say are suitable for a whole organ tissue transplant, donor organs are hard to come by.[3] In fact, in 2010 a total of 6,521 patients died in the United States while waiting for organ transplants, which means an average of 18 people die every day because of a shortage of donor organs, while every 11 minutes a new person is added to the organ transplant waiting list.[4]

Last July in Sweden, however, surgeons were able to carry out the first ever synthetic whole organ transplant, eliminating the need for a donor organ. The patient was a 36-year-old geology student studying for a PhD whose windpipe, despite aggressive chemotherapy and radiotherapy, was impeded by a golf ball sized tumor that was blocking his breathing and would soon cause his death. Fortunately, building off research on clinical transplantations of tissue engineered airways by a team lead by Dr. Macchiarini, the lead surgeon of this operation,[5] biomedical engineers, scientists, and other experts in London were able to use 3D scans of the patient to construct a seamless copy of his trachea out of glass, which was then soaked in a solution of stem cells taken from the patient's bone marrow. This allowed the synthetic porous windpipe to be seeded with the patient's own tissue, eliminating the problem of rejection.[6]

After two days, the tailored trachea was ready for transplant, and was surgically implanted into the patient. Bone marrow cells and lining cells taken from the patient's nose were also inserted, which successfully divided and grew into the synthetic windpipe scaffold, turning the synthetic trachea into an organ indistinguishable from an original, healthy organ. The surgery was successful, and after several months, the patient is still fine. As Professor Macchiarini, the lead surgeon of the groundbreaking operation, said, "Thanks to nanotechnology, this new branch of regenerative medicine, we are now able to produce a custom-made windpipe within two days or one week…The beauty of this is you can have it immediately. There is no delay. This technique does not rely on a human donation."[7] The biomedical engineers, scientists, and surgeons that masterminded this process have opened a door for all future surgeries, and have created hope for the thousands of patients waiting on new organs.[8]

MAPPING A HEART'S ELECTRICAL ACTIVITY IN ONE HEARTBEAT

Engineers and researchers at Washington University in St. Louis made a breakthrough in a completely different subfield of biomedical engineering. Just this last August, they were able to develop a new technique called Electrocardiographic Imaging (ECGI), which uses a special algorithm to produce movies of the distinctive ventricular tachycardia excitation waves by analyzing just one heartbeat. These excitation waves are those produced during an abnormally fast heart rhythm

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in the ventricles. Ventricular tachycardia (VT) is a fast and abnormal heart rate, which can lead to ventricular fibrillation, a condition that causes about 400,000 sudden deaths in the United States each year.

ECGI is especially promising because it uses noninvasive methods to gather a plethora of information in a short amount time. The technique combines computerized tomography (CT) with 250 electrocardiograms recorded by electrodes placed on a vest across the patient's torso to chart the location and type of ventricular tachycardia. It was tested on 25 VT patients, and was able to correctly identify the type and origin of each patient's VT.

ECGI greatly facilitates the diagnosis of VT. Existing noninvasive diagnosis of VT relies on the conventional ECG, which can only provide general information about the heart's electrical activity. Locating the source of a patient's VT requires hours of invasive mapping using a probe that is inserted into the heart and moved about to detect electrical aberrations. In contrast, ECGI can locate the source of an arrhythmia to an accuracy of about 6 millimeters, and thus can potentially save hours of mapping and an invasive operation. The hope is that ECGI will someday become a routine procedure to test for and identify patients at risk of developing VT, as well as a follow up tool for VT patients.[9]

COMPUTATIONAL MODELING TO UNDERSTAND GENOMES

A team of biomedical engineers from the University of Virginia, Wageningen University in the Netherlands, and Helmholtz Center for Infection Research in Germany recently developed a computational model that clearly identifies substantial modulations between different genomes, DNA and RNA. The team modeled the genome of the pathogen Pseudomonas aeruginosa, a bacterium responsible for 10% of hospital acquired infections. Their research is a novel approach to combatting the bacteria and improving treatment, especially for burn victims and those with cystic fibrosis or compromised immune systems, to which the bacterium can be particularly injurious.

This team of researchers is at the cross works of computer science and biology. They have been mapping the genomes of multiple organisms for several years, and can now detect the activity of specific genes under varying circumstances, and have integrated this information to create models to predict which genes activate which cell functions. This information is crucial to understanding how cells will respond to medicine or how they will react to different environments or stimulants.

As with any computational model, there are limitations to this science. As researchers collect more information and perfect their modeling techniques and algorithms, the models should improve, and hopefully one day there will be a model that accurately describes the functioning of the bacterium.[10]

CONCLUSION

Clearly aside from the US News and World Politics criterion, biomedical engineering is an exciting career because of the implications its research and results have on improving healthcare. The above examples are just a few from a vast sea of promising research that culminated this year. Doctors from the Texas Heart Institute are creating and testing a pulseless artificial heart, a team from Northwestern University is testing the ability of diamonds to accurately deliver and retain drugs at tumor sites, engineers at Johns Hopkins University are creating new materials to restore damaged soft tissue and aid in facial reconstruction, and the list goes on.[11]

As history has shown, technological process increases at an exponential rate, so the attention and efforts being put into biomedical engineering now have immense implications for the future of healthcare. There may one day be "organ factories" that manufacture and sell custom made organs to patients in need. Engineers may develop highly advanced imaging technologies that can noninvasively detect virtually any medical problem. Scientists may develop materials almost identical to those found in our own body, and integrate them into patients' bodies during surgeries. And ultimately, there may be a model that accurately characterizes and predicts human body function. With such high goals, the horizon is distant for biomedical engineering.

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