Additional Priority Idea

Regenerative Medicine

Can we develop regenerative medicine to create ultra-personalized therapies and non-invasive medical procedures?

Regenerative Medicine seeks to repair, replace, or regenerate cells, tissues, and organs to improve the human condition. This is increasingly critical due to our aging society and advances in general surgical and trauma care. Many individuals now survive severe injuries and require sophisticated follow-up reconstructive or reparative procedures. Regenerative Medicine builds upon modern developments in genomics. It develops and uses novel biomaterials. It exploits advances in immunobiology and mechanobiology. It relies increasingly on advanced cell therapies, particularly stem cells. It can be enhanced by high resolution medical imaging and computational modeling. Regenerative Medicine has significant promise to produce manifold biological discoveries as well as to transform clinical care via a personalized approach to medicine and surgery. It also has tremendous potential both to generate ex vivo patient-specific models of disease that are useful for basic science research or drug screening and to engineer biosensors that can detect biological or chemical threats. Regenerative Medicine thus has tremendous potential to build on and advance basic science, engineering, and clinical care.

Regenerative medicine has already yielded an array of cutting-edge approaches for restoring cellular and tissue function to improve human health. The FDA has approved applications ranging from artificial skin to tissue engineered blood vessels. Additional exciting outcomes are arising from autologous stem cell therapies (derived from a patient’s stem cells). These are combined with novel biomaterials-based scaffolds to repair, replace, or regenerate tissue and organ function - using either sophisticated bioreactors to generate the biological implant or direct implantation in the patient to provide the precise microenvironment to promote restoration. Continued breakthroughs in genome editing, immunobiology, bioengineering, data science, computational technology, nanotechnologies, and personalized medicine promise to transform how we understand and treat aging, disease, and injury. Regenerative Medicine will continue to be an increasingly essential, integrative approach for achieving true advances.

Building on transformative discoveries in stem cell and developmental biology, Regenerative Medicine stands as one of the great frontiers of modern science. Recent advances in our fundamental understanding of the pathways involved in tissue repair and regeneration, combined with remarkable progress in adult stem cell biology, have enabled great progress in medicine. The discovery of induced pluripotent stem cells (iPSCs) has enabled remarkable stem-cell based research, including patient-specific disease modeling in a dish and screening for novel therapeutic agents for illnesses spanning cancer and macular degeneration to osteoarthritis and even organ transplantation. These breakthroughs are just beginning to translate to clinical practice and represent the first steps into an exciting and vast novel territory in medical science.

Regenerative Medicine at Yale

Yale already stands as a leader in fundamental allied areas, including genetics, immunobiology, and stem cells, as well as in the many clinical disciplines that will be impacted by Regenerative Medicine – from Pediatrics to Neurosurgery, Cardiology to Orthopedics, Dermatology to Pulmonary Medicine. Yale also has renowned basic scientists, bioengineers, material scientists, and clinicians who have made fundamental discoveries in tissue engineering and have realized first-in-human applications. Indeed, there are only two FDA-approved clinical trials for tissue engineered blood vessels in the US – one for treating a common congenital defect of the heart and one for treating end-stage renal failure patients. Both arose from multi-disciplinary research and development at Yale.
In addition to these allied strengths in fundamental research and clinical medicine, Yale already ranks among the most innovative institutions in the world in tissue engineering, nanomedicine, and regenerative medicine. These areas at Yale also benefit immensely from our strengths in physiological systems, including cardiovascular, musculoskeletal, neurological, and pulmonary. For example, the first RMAT (Regenerative Medicine Advanced Therapy) designation in the United States was awarded for a tissue-engineered artery (Human Acellular Vessel) that was developed by a Yale PI for use as an arterial bypass or reconstruction. This vessel is now in phase III clinical trials for treatment of end-stage kidney failure patients – this is only the second phase III trial for an engineered tissue in the United States. Additional efforts at Yale include tissue engineering of conduits for congenital heart surgery, engineering a replacement trachea or lung, engineered heart tissue for personalized diagnostics and treatment planning, and regenerative treatment of nerve fibers to relieve chronic pain. Regenerative Medicine thus has potential to impact many areas of clinical care through its significant translational potential.

In addition to the scientific and clinical impact of Yale Regenerative Medicine, the substantial attention garnered by these fields could have a major impact on students—these fields and their practical applications are major drivers of interest in the interface of life and physical sciences and engineering at undergraduate and graduate levels. Furthermore, Regenerative Medicine, including tissue engineering, nanotechnology development, and patient-specific cell-based therapies, has a strong potential for commercialization.

The USSC recognizes that Yale could leverage these ongoing strengths to become a leader in both the basic research that underlies regenerative medicine and its practical and clinical applications, particularly given allied strengths within clinical medicine at Yale.