purposes during the area assessment. GIS is used for geo-referencing, masking of RS data and estimation of area; GPS is used for collecting reference data on agroforestry which is later used for signature creation and accuracy assessment, and RS data is used for land-use and land-cover analysis and delineation of desired features. However, using RS data for the estimation of agroforestry area is challenging as well as problematic for several reasons[6]. Use of geospatial technologies to estimate agroforestry area has been initiated by the National Research Centre for Agroforestry, Jhansi, using medium resolution data with a methodology in which areas under agroforestry, forest and plantation are separately identified. The methodology will be further refined for accurate assessment of area under agroforestry in the country.

1. NRCAF, Vision 2050. National Research Centre for Agroforestry, Jhansi, 2013, p. 30.
2. Dhyani, S. K., Handa, A. K. and Uma, *Indian J. Agrofor*., 2013, **15**(1), 1–11.
3. FSI, India State of Forest Report. Forest Survey of India (MOEF), Dehradun, 2011.
4. Ravindranath, N. H., Murhty, I. K., Joshi, P., Upgupta, S., Mehra, S. and Srivastava, N., *Curr. Sci.*, 2014, **106**(9), 1201–1206.
5. FSI, India State of Forest Report. Forest Survey of India (MOEF), Dehradun, 2003.
6. Rizvi, R. H., Dhyani, S. K., Ram Newaj, Saxena, A. and Karmakar, P. S., *Indian J. Agrofor.*, 2013, **15**(2), 26–30.

S. K. DHYANI

National Research Centre for Agroforestry (ICAR),
Gwalior Road, Near Pahuj Dam,
Jhansi 284 003, India
e-mail: shivkdhyani@gmail.com

Decellularized heart: a step towards creating personalized bioengineered organs

Shortage of available organs for transplantation in end-stage organ failure has become a major challenge for organ transplantation. Annually, more than 1,000,000 patients die for the want of an organ. Further, in the case of patients who do receive organs, not all transplants are successful due to rejection and other complications. Even if a patient receives perfect match, it can still be rejected and he needs life-long use of immunosuppressors. With this background, for developing appropriate tissue engineering technologies, scientists are struggling to regenerate the whole organ.

Decellularized whole organ represents a new approach to provide three-dimensional architecture and complex natural heart extracellular matrix (ECM). The classical approaches for generating heart tissues have limited applications because of absence of three-dimensional architecture to support the rebuilding of muscles and vascular structures. Decellularization is an emerging technology to fulfil these promises. It is defined as the complete removal of cells and their components from an organ by means of perfusion with the effective specialized reagents without damaging the ECM and three-dimensional vascular architecture. A bioartificial organ developed by decellularized scaffold solves the problem of life-long use of immunosuppressants after organ transplant. It also reduces the risk of rejection, and preserves decellularized extracellular matrix and 3D-scaffold that provides important signal for the engraftment, survival and function of transplanted cells in the new-born organ. The vascular bed in the decellularized bioscaffold allows rapid delivery of oxygen and nutrients.

Discovery of stem cells has boosted confidence in creating bioartificial organs. The major limitations of stem cells are that they need the right architecture, environment and engraftment to perform the function. Ott *et al.*[1] published a landmark paper, which showed perfusion-decellularized bioengineered heart matrix by seeding cardiac and endothelial cells. To establish function, they maintained constructs in a bioreactor. By day-8 under physiological load and electrical stimulation, constructs could generate pump function in a modified working heart preparation. Following this, Ng *et al.*[2] implanted embryonic stem cells in decellularized rat heart. After 14 days, these developed into two different types of cells found in the heart: cardiac-marker expressing cells and endothelial or blood vessel cells. The cell-laden scaffold was then implanted back into the mouse, where it was observed to develop visible blood vessels which are critical for the transport of nutrients and oxygen to the heart, and has posed a major challenge in heart tissue engineering. In a recently published study, Lu *et al.*[3] have demonstrated that spontaneous contraction in bioengineered heart generates mechanical force and responsiveness to drugs. This study also showed that heart ECM promotes cardiomyocytes proliferation and myofilament formation from the repopulated human multipotential cardiovascular progenitor cells.

In summary, the concept of decellularized whole-heart bioengineering approach would revolutionize *in vitro* studies for early events of heart development, which after further advancements may find application in preclinical testing and development of personalized bioartificial heart.

1. Ott, H. C., Matthiesen, T. S., Goh, S. K., Black, L. D., Kren, S. M., Netoff, T. I. and Taylor, D. A., *Nature Med.*, 2008, **14**(2), 213–221.
2. Ng, S. L. J., Narayanan, K., Gao, S. and Wan, A. C. A., *Biomaterials*, 2011, **6**, 65.
3. Lu, T. Y., Lin, B., Kim, J., Sullivan, M., Tobita, K., Salama, G. and Yang, L., *Nature Commun.*, 2013, **4**, 2307.

SIDDHARTHA ROUT[1]
SANDEEP KUMAR VISHWAKARMA[2,3]
ALEEM AHMED KHAN[2,3,*]

[1]*The Heart Institute, and*
[2]*Centre for Liver Research and Diagnostics,*
Deccan College of Medical Sciences,
Kanchanbagh,
Hyderabad 500 058, India
[3]*Salar-E-Millat Sultan Salahuddin Owaisi Centre for Cellular and Molecular Medicine,*
Princess ESRA Hospital,
Sahalibanda,
Hyderabad 500 002, India
**e-mail: aleem_a_khan@rediffmail.com*