Annual Review of Biomedical Engineering, 2011. Martin L. Yarmush, James S. Duncan and Martha L. Gray (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 13. x + 566 pp. Price: US$ 80.

In the last few decades, human diseases as well as human health care have stimulated significant research activities in the field of engineering and medicine. Commensurate with this, considerable research is underway in the area of biological, chemical and physical sciences. In order to illustrate the need for biomedical research, it may be noted that there are more than 0.3 million cases every year of total knee replacement and more than 0.1 million cases every year of total hip arthroplasty in India. The available articulating joint-implants generally offer a trouble-free life for about 10–20 years, which is inadequate considering the increased lifespan for humans. Therefore, a search for ideal prosthetic materials is currently being made. It has also been recognized that the scarred cardiac muscle results in heart failure in millions of heart-attack survivors worldwide. In 2009, an estimated 785,000 Americans had a new coronary attack and about 470,000 had a recurrent heart attack leading to a coronary event. Thus researchers have put considerable efforts to understand the molecular biology aspects of some of the life-threatening diseases; and engineers have attempted to develop various diagnostic tools as well as synthetic implant materials to assess the disease state or to repair the damaged tissues respectively. The quantification aspect in the disease diagnosis has enabled better health care or more timely treatment. The above research perspective has been reflected in more biology-related research in multiple engineering disciplines, chemistry and physics. The impact of such research has been aptly documented in this volume. This volume contains 21 chapters, all of which principally cover three major broad areas: (i) *in vitro*/*in vivo* diagnostic models for toxicity, cancer and heart attack; (ii) various imaging techniques to assess or image diseased organs or tissues, and (iii) synthetic implant materials based on tissue engineering approaches.

Among various diseases impacting human life, cardiac disease and cancer are among the life-threatening ones, while a large number of patients also suffer from orthopaedic, i.e. bone/joint-related diseases. Significant evolution in materials science and engineering in terms of developing the potential scaffold for health care has been recorded during last few decades. Depending upon the anatomical location in the body, metals, ceramics, polymers and their composites with acceptable biocompatible property are being used as artificial implants. In most cases, complicated revision surgery is needed after a few years of implantation. The selection and design of a suitable material for hard tissue replacement with long-term durability and without significant degradation in physical and mechanical properties is the major area of research in orthopedics.

In the case of myocardial infarction, i.e. heart attack, the cardiac tissues are largely damaged. The functionality of cardiomyocytes (a specialized contractile muscle cell that generates part of the myocardium tissue of the heart) and neurons (an electrically excitable cell that processes and transmits certain information by electrical and chemical signalling in the heart) depends on the property of continuous conductivity. However, such conductivity may break down during heart disease or malfunction. For instance, a myocardial infarction, usually occurs because a major blood vessel supplying blood to the left ventricle of the heart is suddenly blocked by an obstruction, such as a blood clot. During myocardial infarction, part of the cardiac muscle, or myocardium, is deprived of blood and therefore oxygen, which destroys cardiomyocytes and neurons leaving dead tissue as well as denervation of the myocardium. In particular, nerve damage to cardiac tissue can result in nerve sprouting in the left ventricle and development of arrhythmias. In recent years, various techniques have been developed to promote cardiomyocyte and neuron growth around dead tissues after a myocardial infarction.

At least seven chapters in this volume focus on tissue engineering-based approaches to develop synthetic implants for replacement of various damaged tissues and organs. In the case of some fatal injuries, there is damage to the noses of people. In the chapter by Stitzel *et al*., various sensor types for artificial noses, e.g. electrical, gravimetric and optical sensors are reviewed towards the sensitivity for food and beverage. This chapter provides fundamental principles of the application of electrical/optical/gravimetric sensors and, in particular, mentions various materials to be used as electrical sensors. Overall the chapter is found to be appropriate for development of artificial nose-like sensors for environmental and industrial monitoring, explosive and nerve agent detection, and medical diagnostics.

It has been widely recognized that the failure of an entire organ precedes the death of a person. In order to enhance the mortality of a person, the recent years have witnessed the development of a promising tissue engineering or regenerative medicine-based approach towards the replacement of functional organs like heart, liver and lung. Badylak *et al*. have reported various aspects of developing three-dimensional tissue-engineering scaffold, including selection of appropriate cells, techniques for recellularization process and design of bioreactors. This interesting approach essentially involves removal of cells from infected organs and thereafter seeding/reseeding of tissue-specific cells, so that the extracellular matrix remaining after the decellularization process can combine with seeded cells to result in entire functional organs. The biological protocols for refabrication of important organs are provided in this chapter. Typically, decellularization of various organs takes place over the time period of 21 h to 7 weeks.

Although various drug-delivery methods are being studied widely in the last few decades, RNA interference (RNAi) technology involving *in vivo* delivery of lipid-based nanoparticles is a relatively new approach. Essentially, RNAi is described as an effective gene-slicing pathway in which small RNA molecules mediate the degradation of target mRNA. The chapter by Henry and Liu describes the mechanism of RNA interference as well as the kinetic and physical barriers as far as effective delivery to the cell is concerned. Various geometrical and chemical aspects of the complex *in vivo* silicon RNA delivery are also described. Importantly, a mathematical treatment is provided to describe the pharmacokinetic parameters related to the shedding kinetics of the silicon RNA-containing nanoparticles.

The development of synthetic materials for cardiovascular applications is important to treat critical diseases like

myocardial infarction. The chapter by Li and Henry reports the recent advances in anti-thrombogenic approaches for surface modification to develop better biomaterials for cardiovascular tissue-engineering applications. After introducing various materials for vascular grafts, stents and heart vessels, the chapter discusses the biochemical mechanism of thrombosis. Amongst various surface-modification approaches, the use of anti-coagulants like heparin and hirudin appears to be effective for various polymeric substrates. The restriction in platelet adhesion and activation is critical to produce non-thrombogenic implants. The adsorption of nitric oxide, polyethylene glycol, or phosphoryl choline or albumin is reported to be effective. Amongst cell-based approaches, *in vitro* or *in situ* endothelialization or seeding of bone-marrow mesenchymal stem cells can be used to mediate thrombosis.

Despite the significant progress in the field of medical sciences, heart attack is still considered as a serious killer. This is primarily because of the fact that it is difficult to regenerate the diseased cardiac tissues. Vunjak-Novakovic and colleagues have discussed various bioengineering approaches for heart regeneration as well as described challenges related to the *in vitro* and *in vivo* biocompatibility assessment of what they call as a 'perfect tissue-engineered graft'. Apart from the biocompatibility properties, it has been mentioned that an ideal graft should have sufficient electrical and micro-mechanical properties to ensure the natural contractile nature of myocardium. Recently, the development of polylactic-polyglycolic acid–carbon nanofibre (PLGA–CNF) biocomposites has received wider media attention for its potential to be used as new-generation cardiac patch materials.

Like heart attack, human vision damage is also another important challenge. In a chapter focusing on the biomechanics of the cornea and related implant design, Ruberti *et al*. have discussed nonlinear elasticity as well as viscoelasticity of cornea *ex vivo*. It has been shown that the elastic modulus at a corneal thickness of 0.9 mm can vary between 0.19 and 0.58 MPa. Various corneal biomaterials, including polymethyl methacrylate (PMMA), porous polymeric hydrogel as well as type-III cross-linked collagen gel are mentioned as corneal stromal replacement biomaterials. In an interesting chapter, the analysis of the microscale strain of the damaged cardiovascular tissues is presented along with the intrinsic wave imaging techniques to probe such strain values.

Several chapters in this volume (at least six) cover the medical diagnostic approaches to visualize the fine-scale structure of diseased organs/tissues, as well as to quantify the disease state. While the chapter by Glocker *et al*. describes the fundamental aspects of image registration in all the advanced imaging approaches, the chapter by Vartholomers reports how MRI-based nanorobotic systems can be useful in therapeutic and diagnostic applications. Among various diagnostic approaches, one of the emerging techniques is the microfluidic-based approach. Using physiologically based pharmacokintetic models, Esch *et al*. have provided an overview of various microfabrication approaches to develop cell-based *in vitro* systems, which are currently being used to study the drug interactions as well as multiorgan metabolic interactions. In another interesting chapter, Yanik and co-workers describe how microfluidic devices can be used to image and manipulate various model organisms, like *Caenorhabditis elegans* and zebrafish. Such investigations have relevance for behavioural studies of neuronal circuits to high-throughput screening. Another area of the application of microfluidic devices is aptly covered in the chapter by McCalla and Tripathi. This chapter reports how microfluidic technology can be beneficially utilized to detect various disease markers such as antigens, RNA and DNA with a greater sensitivity, which is aided by a broad spectrum of amplification techniques.

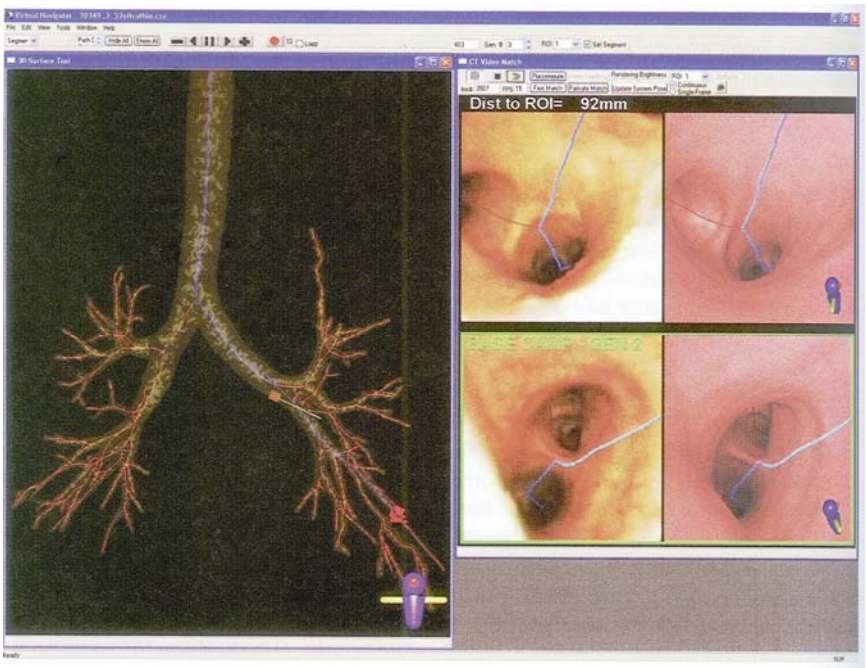

Image-based registration system for tracked bronchoscopy. Image courtesy of William Higgins, Ph D, Penn State University.

Brain injury is widely considered as an important traumatic injury. The chapter by Morrison III *et al*. initially discusses the physical injury mechanisms of the brain tissues and thereafter describes the *in vitro* models and how various compounds can be effective in treating traumatic brain injury. In another important chapter, Studholme has reported how MRI-based approaches can be useful in investigating dynamically (time-dependent) changing foetal brain growth patterns in three dimension, and such studies have great relevance for basic neuroscience and clinical diagnosis.

Computer tomography (CT)-based techniques are becoming increasingly popular in the field of biomedical engineering. Fundamentally, CT is described as a 3D X-ray imaging method that involves obtaining X-ray position images at many angles of view around an axis through an object and then applying a tomographic reconstruction algorithm to produce a series of thin tomographic

images of continuous trans-axial slices through the investigated object. Depending on temporal and spatial resolution, CT-based techniques can be used to image objects over a wide length scale. For example, a mouse or an entire liver can be imaged using mini-CT, while nano-CT can be used to image cellular organelles (less than 1 μm). Ritman has described various functional components of a typical CT scanner and also explained the rationale for use of small animal model. Importantly, this chapter also discusses various classes of micro-CT approaches, e.g. attenuation-based scanning, fluorescence-based scanning, scatter-based scanning and phase contrast scanning. Various examples are provided to explain how CT-based techniques can be effectively utilized to image the lung of a rabbit or the kidney of a rat.

The fundamental molecular biology aspect of various diseases is also discussed in this volume. Among various life-threatening diseases, cancer still remains one of the greatest challenges for mankind, despite several years of research on cancer drug molecules as well as various clinical diagnostic treatments. It has been widely recognized that a quantitative assessment of the initiation, progression and treatment of cancer is the need of the hour. After describing the cancer modelling on both biological timescale and length scale, the chapter by Deisbauck *et al*. describes various multi-scale modelling approaches of cancer. In particular, the discrete continuum as well as hybrid modelling methods are shown to describe various aspects, including ROS generation and its influence on the proliferative index of cancer cells as well as dose-dependant cell viability in various timescales. In an interesting chapter, LeDuc and co-workers describe how to experimentally probe the intercellular and extracellular microenvironments of the cell, as well as recent development in techniques to assess how a cell can respond to any changes in the external environment. Overall, the approaches described in this chapter are expected to be useful to reverse-engineer the cellular processes. In studying molecular biology aspects of various diseases, the function of various cellular organelles is strongly considered. Zwerger *et al*. have painstakingly described how the changes in structure and composition of a cell nucleus, which is tightly integrated to the surrounding cellular structure, can cause many human diseases, such as cardiomyopathy and cancer. Hess has reported fundamental mechanobiological aspect of the functioning of molecular motors. The scaling laws to describe the motion of biomolecular motors are described and such analysis can be useful to design synthetic molecular motors.

The volume is appropriately indexed. It would be a valuable asset to institutions as well as researchers in the field of medical biotechnology, and bioengineering as well as clinicians. The volume is expected to leave an impact in the area of medical research.

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Annual Review of Genetics, 2010. Allan Campbell, Michael Lichten and Gertrud Schübach (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 44. xii + 477 pp. Price: US$ 84.

It is rare indeed to come across an *Annual Review of Genetics* (*ARG*), where one could find so many articles of interest in a single volume. This volume is an exception. There are several articles of interest to the layman in modern molecular biology and quite a few articles are of direct relevance to my own field of specialization as well. Over the years, the reviews in *ARG* have become a pleasure to read since these are not mere catalogues of recent findings. The synthesis of concepts, enumeration of future directions and unanswered questions make the reading of these reviews a pleasure. The listing of future issues and research directions at the end of each article is of immense use to active researchers to ponder over the subject.

The article on the genomic enzymology of antibiotic resistance is a fresh attempt to rejuvenate the old field of drug discovery. The authors apply the concept of genomic enzymology to 'antibiotic resistome' and explain the plasticity of antibiotic resistance in bacterial systems. The idea that antibiotics are in fact not antibiotics at all in the concentrations produced in the environment, but rather signalling molecules, and the observation that there is a vast reservoir of antibiotic resistance genes in the non-pathogens that can contribute to antibiotic resistance in pathogens, make this field an important area of future research. The origin of antibiotic resistance as an autoimmune mechanism to resist the toxic metabolites produced by the host organism gains additional insight from these new concepts on antibiotic resistance.

The article on biofuel production by recombinant *Escherichia coli* brings out the usefulness of the bacteria in pathway engineering. The atom efficiency of the ethanol-producing, engineered *E. coli* is rather impressive. The state-of-the-art strain producing 46 g l^{-1} ethanol over 72 h in minimal medium containing a mixture of C5 sugars and betaine, is as good as any ethanol producer as of now. The recombinant *E. coli* carrying 2-ketacid decarboxylase and an alcohol dehydrogenase produces a variety of short-chain alcohols from fermentable sugars. The review on bacterial contact-dependent delivery secretion system is stimulating. The authors review the current literature on T4 injection mechanism that delivers DNA into the bacterial cell also. This type-VI secretion system brings back the classical studies of the phage biologists, who shaped the modern molecular biology using incredibly simple experiments. Unlike type-V secretion systems, types III, IV and VI deliver the molecules using a complex organelle that spans the membrane of the target cells. The protein–protein communication at the tip off the needle and the host cell is an active area of research, and will be interesting to explore. The article on homologous recombination in eukaryotes is well organized, and focuses on post-translational modifications and their role in the modulation of interaction of proteins in the recombinosome. Another aspect that has emerged recently is the reversible nature of recombination intermediates, which is responsible for the flexibility of the pathway. The role of anti-recombination mechanisms modulated by motor proteins providing flexibility to the process is examined in detail.

Integrons are genetic elements that accumulate antibiotic resistance elements by sequential capture. The activation of these elements is regulated by SOS response implying a direct role of stress in