

protons and pions, and the like? The article 'Hadronic atoms' by J. Gasser *et al.* addresses this issue. High precision experiments involving studies using high-intensity photon beams are also planned and their prospects are studied. The article 'Chiral dynamics in photopion physics: theory, experiment, and future studies at the HIγS facility' by Aron M. Bernstein *et al.* presents an update on this subject.

Other strongly interacting systems include those that have heavier quarks such as the c and b quarks. Indeed, the article 'Charmless hadronic B meson decays' by Hai-Yang Cheng and James G. Smith presents the state of the science in this field. 'B physics at tevatron' by Christoph Paus and Dmitri Tsybychev is a report on the vast discoveries carried out at the Tevatron.

Standing on its own is the report on the outstanding physics studied in Cornell University in the article 'Physics at the cornell electron storage ring' by Karl Berkelman and Edward H. Thorndike.

The field of elementary particle physics is at the moment poised at the crossroads with the discoveries of the Large Hadron Collider in the immediate future. This machine collides protons on protons to search for physics beyond the standard model, and also has a mode using ions of lead to replicate the conditions of the big bang. The articles 'Unanswered questions in the electroweak theory' by Chris Quigg and 'Radiative corrections for the LHC and the linear collider era' by Eric Laenen and Doreen Wackerroth are important and mandatory reading for any student of this subject.

Despite all the major successes of the theories, one may always wonder how well we know the laws of nature. Can one conceive of simple experiments that can challenge all the known laws? Can these laws be violated by small effects? Martin L. Perl *et al.* review 'Searches for fractionally charged particles' for which currently there is no experimental evidence, while Stefano Libreati and Luca Maccione review the status of 'Lorentz violation: motivation and new constraints', where the signals of such violation would imply that the special theory of relativity would require modification.

In summary, the collection of 21 articles in the volume captures the most central developments in the fields of nuclear

and particle physics in the recent times, and is a valuable addition to every library.

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B. ANANTHANARAYAN

*Centre for High Energy Physics,  
Indian Institute of Science,  
Bangalore 560 012, India  
e-mail: anant@cts.iisc.ernet.in*

**Annual Review of Cell and Developmental Biology, 2009.** Randy Schekman, Larry Goldstein and Janet Rossant (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, California, USA. Vol. 25. x + 732 pp. Price: US\$ 234.

The *Annual Review of Cell and Developmental Biology* (ARCDDB) recently published its silver jubilee volume. The series originally started as *Annual Review of Cell Biology* under the editorial leadership of George Palade, Bruce Alberts and James Spudich. Developmental biology was added to its title in 1995 due to multiple, now obvious reasons (see preface to volume 11 by James Spudich). The 25th volume of ARCDDB contains 27 reviews that cover recent progress and current understanding of a wide range of areas in modern biology. The volume does not have an underlying theme; this is natural because cutting-edge research is indeed carried out simultaneously on several fronts.

In spite of the variety in the topics covered, several of the contributions fall under cell differentiation, morphogenesis and cancer, and lipids and membranes. Certain aspects of endocytosis, stem cells, small and piRNAs, and cell signalling are also reviewed. An article each on chromosomes, single cell quantitative time-lapse fluorescence microscopy and innovations in undergraduate biology teaching make the volume interesting to a wider readership.

The 'perspectives' chapter by Joe Ball is a fascinating and inspiring story of his long and continuing career as a biologist. He brings out the enjoyment of doing biology. He tells us how he discovered the technique of *in situ* hybridization of

nucleic acids, now a work-horse of cell, molecular and developmental biology. I rather liked the way he brings out the fact that the choice of model systems depends on the questions one is trying to answer. A biologist, therefore, often ends up using several model systems in his or her career.

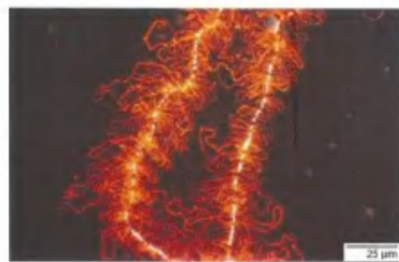
Small RNAs that silence genes at transcriptional and post-transcriptional levels have attracted attention in recent times because in addition to targeting viral genes and transgenes, they also regulate various developmental and physiological processes. X. Chen has written about the biogenesis and role of microRNAs, transacting RNAs and heterochromatic siRNAs in plant development. The role of argonaute proteins that bind miRNAs and siRNAs is discussed. The other phylogenetic group of argonaute proteins is the PIWI subfamily proteins that bind piRNAs. T. Thomson and H. Lin describe PIWI proteins and piRNAs that have been predominantly reported from *Drosophila*, zebrafish and mammals. These molecules play crucial roles in germline development and gametogenesis through regulation of such diverse aspects as epigenetics, transposon activity and DNA integrity.

The crucial roles of lipids in membranes and organelle biogenesis are addressed in several articles. SREBP (sterol regulatory element binding protein) transcription factors are regulators of genes necessary for synthesis and uptake of cholesterol and fatty acids in membrane biogenesis of mammalian cells. The diversity and supply of membrane lipids is regulated through cross-regulatory effects and negative feedback loops. As pointed out by A. Nohturfft and S. C. Zhang, most of our current knowledge in these areas is gained from mammalian and yeast cells. In addition to assembling lipids into membranes, the latter need to be properly shaped for optimum function. Using endoplasmic reticulum (ER) as an example, Y. Shibata and coauthors describe how wedging and scaffolding mechanisms for membrane deformation are employed by proteins, reticulons and DPI/Yop1p to shape ER tubules. The shaping of mitochondria and caveolae is believed to be achieved through similar mechanisms. It is not clear, however, how ultimately the individual characteristic shapes of ER, mitochondria and caveolae are attained. Chloroplasts appear to be excellent models to study lipid transport across membranes. C.

Benning has reviewed studies on intra-membrane lipid transfer in thylakoid membrane system inside chloroplasts. Such lipid transfers become essential under certain physiological conditions, like the phosphate-limiting growth conditions in plants. Discovery of proteins and genes required for thylakoid lipid biosynthesis and transport processes promises exciting times ahead in this area.

Models for intra-Golgi cargo transport are discussed by B. S. Glick and A. Nakano. Golgi cisternae, according to the older model, are considered to be stable components. In this case, the secretory cargoes are transported from one cisterna to another while the resident Golgi proteins are retained in the cisternae. A recent model, on the other hand, predicts assembly of cisternae at the *cis* face of the stack, followed by their progression through the stack and disintegration at the trans-Golgi network (TGN). In this scenario, the resident Golgi proteins are believed to be recycled from older to younger cisternae. It is clear though that a lot more remains to be learnt in this area.

Pathogenic bacteria are known to hijack several of the membrane trafficking pathways of the host eukaryotic cells to gain entry and survive within them. One such pathogen *Listeria monocytogenes* interacts with host cell receptors and on entering the host cell exploits its actin-based motility for spreading from cell to cell (J. Pizarro-cerdá and P. Cossart). This review touches upon the exploitation of membrane receptors and membrane rafts, clathrin, caveolin and actin cytoskeleton of host cells by *Listeria* for its entry, survival and cell to cell spreading. The review by J. B. Sørensen discusses conflicting views on membrane fusion machinery and the fusion pore during exocytosis of synaptic vesicles. Current views on function of SNARE, Munc 18, complexin and synaptotagmin in this process are presented.



A portion of a lampbrush chromosome from the newt *Notophthalmus viridescens*.

Two reviews discuss two different aspects of the synapse. J. A. Dittman and T. A. Ryan use the 'local currency for information at the synapse', the synaptic vesicle, to describe molecular regulation of endocytosis at nerve terminals. This process is predominantly clathrin-mediated and appears to be quite robust because individual components of the machinery are not essential to its function. J. R. Sanes and M. Yamagata illustrate in great detail how multiple mechanisms contribute to precise synapse formation at cellular and sub-cellular levels. *Drosophila* has proved to be an invaluable tool for such studies.

About half of the articles in this collection are devoted to various aspects of stem cells, cell differentiation and migration, and organ formation, almost exclusively in animal models. Stem cells need to renew themselves as well as maintain their developmental potential. S. He *et al.* review in detail the molecular and cellular regulation of promotion and control of stem cell renewal and maintenance of genome integrity. Changes in these regulatory processes with progressing age and their relevance to cancer progression are also discussed. It is now well established that the adult brain contains neural stem cells which continue to give differentiated progeny. The signalling pathways during adult neurogenesis and pathological conditions are reviewed by H. Suh *et al.*

One of the principal ways in which self-renewal, diversity and differentiation of cells are regulated is through modulation of symmetric and asymmetric cell divisions. The intrinsic and extrinsic mechanisms of cell division in *Drosophila* and vertebrates are discussed by S. Tajbakhsh *et al.* They also introduce the concept of template DNA strand segregation (TDSS) and suggest it as one of the mechanisms of asymmetric cell division. Vertebrate retina is one of the systems in which cell differentiation has been extensively studied. M. Agathocleous and W. A. Harris bring out certain basic themes in development, such as context-dependent effects of various signalling molecules. It is believed that about seven conserved signalling pathways govern embryonic development, pattern formation and carcinogenesis in a context-dependent manner. Several factors such as extracellular signals, cell cycle, epigenetic regulation and intracellular signals appear to drive retinal cell differentia-

tion. This is probably true for almost all developmental processes.

Cell migration is another primary process that drives morphogenesis and pattern formation. The review by P. Rørth is dedicated to migration of individual cells and groups of cells under different developmental contexts. Elegant illustrations are used to show how cells migrate collectively under normal and abnormal conditions. Cell-cell and cell-substratum interactions during migration too are discussed. A somewhat related article (R. G. Rowe and S. T. Weiss) is dedicated to the strategies and repertoire of molecules used by cancer cells for their invasive activity. Crucial aspects of tumour cell invasion such as migration and growth of cells, and the role and regulation of membrane-type matrix metalloproteinases (MT-MMPs) in tumour-cell-basement membrane transmigration are discussed.

In the developing embryo, cell differentiation and cell migration coincide with the formation of polarity and body axes. The different models for mouse blastocyst formation, addressing these issues, are discussed by M. H. Johnson. Currently, we seem to have a mechanistic explanation only at the cellular level, though involvement of ezrin, E-cadherin, PAR-proteins and cdx2 is beginning to be appreciated.

One of the amazing things in biology is the maintenance of size and shape of an organism, and by extension, its constituent organs (or is it vice versa?). *Drosophila* wing development is a powerful model for its study. As argued by R. M. Neto-Silva *et al.*, local cell proliferation and survival in discrete regions of the developing wing appear to play a crucial role. Interplay between various signalling pathways, morphogens and transcription factors that control cellular processes are reviewed. The analysis of expression and downstream targets of *Hox* genes continues to provide insights into segmentation of the animal body. In a colourfully illustrated review, T. Alexander *et al.* have described the segmentation of the hindbrain and axial skeleton in vertebrates. A couple of articles on vertebrate systems, one on endoderm development and organ formation and the other on gonad morphogenesis use comparisons between different vertebrate models to describe how morphogenesis, pattern formation and organ specification are achieved. FGF, hedgehog, retinoic

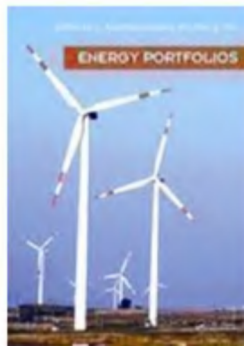
acid, BMP and Wnt pathways are reiteratively used during endoderm organ development. Study of gonad development across species brings out certain interesting facts, for example regardless of sex determining mechanisms, adult testes and ovary structures are similar across species. Also, adult testes and ovary are significantly plastic and this plasticity can be influenced by hormones, loss of germline and social conditions.

The volume includes interesting articles on vernalization in plants, quantitative time-lapse fluorescence microscopy in single cells and innovations in undergraduate biology teaching. The last is aimed at improving 'American competitiveness' but probably has some lessons for us in India. The author W. B. Wood recommends innovative ways (e.g. research-based teaching, student-faculty interactions in class and out-of-class learning activities) to make undergraduate students either aware of life processes (that will help them in their future life as managers, tax-consultants, engineers, technocrats, etc.) or prepare them for a career in biology (scientists, biotechnologists, etc.). Such efforts are beginning to be initiated in India (for example, in the IISERs) but one wonders how and when such innovations could be enjoyed by the large number of students opting for biology in hundreds of colleges across the country.

In summary, the 25th volume of ARCDDB keeps up with the high standards of the series and almost every biologist will find at least parts of it interesting and of useful reading. After careful perusal of this book, my feeling has been that of one who has just finished an intense aerobics session: exhausted but with a feeling of exhilarating satisfaction. If you like the feeling or think that you might, go ahead and read the book.

SURENDRA GHASKADBI

*Division of Animal Sciences,  
Agharkar Research Institute,  
G.G. Agharkar Road,  
Pune 411 004, India  
e-mail: ghaskadbi@gmail.com*



**Energy Portfolios.** U. Aswathanarayana and Rao S. Divi (eds). CRC Press, Balkema, AK Leiden, The Netherlands. 2009. 334 pp. Price: US\$ 124.95.

Energy is essential for economic and social development of a region or a nation. The availability of secure and affordable energy supplies decides the stability and prosperity of a nation. However, consumption of fossil fuels is the major cause of air pollution and climate change. Five countries (USA, China, Russia, Japan and India) account for 55% of the global energy related carbon emissions. The threat posed to sustainability by greenhouse gas emissions and deterioration of the natural resource base (for example, oil crisis and fuelwood scarcity) has caused worldwide concern. Improving energy efficiency and de-linking economic development from energy consumption (particularly of fossil fuels) is crucial for sustainable development of a region. The energy sector, on one hand, is a part of the economy and on the other hand it itself consists of parts such as energy supply and energy demand interacting with each other. Both these interactions are of immense complexity. Energy is required for all the economic activities. Energy supplies are necessary for both intermediate production as well as final consumption. So, economic development is dependent on the energy system of the country. In turn, the implementation of technologies or improvement of the energy system is dependent on economic factors such as capital costs and energy prices. Also, the demand-supply balance involves the flow of energy from source as primary energy to service as useful energy. At each stage of the energy flow, technologies are involved with different conversion efficiencies and losses.

Energy has always been a major component in the day-to-day life of humans. More than a billion people in industrial-

ized countries (about 20% of the world's population) consume nearly 60% of the total energy supply whereas about five billion people in developing countries consume the other 40% of the total energy supply. The two billion low-income people (US\$ 1000 annual income per capita or less) scattered in rural areas and scanty towns use only 0.2 toe (tonne oil equivalent) of energy per capita annually, whereas about a billion rich people (US\$ 22,000 annual income per capita or more) use nearly 25 times more, at 5 toe per capita annually.

Every country is striving for economic growth through energy intensive paths. Energy intensities are useful indicators in describing the energy used for entire production chains. The combination of sectoral energy intensities with demands for sectoral outputs provides insight into total energy use in an economy. Changes in energy use reflect the combined effects of changes in energy intensities in various sectors and changes in the volume and structure of demand. Energy needed per unit of production (referred to as energy intensity or specific energy consumption) shows the sensitivity of products or sectors to changes in energy prices. Temporal analyses or a historical study of energy intensities provides information about changes caused by energy-price changes and their effects on total energy use. The paradox when dealing with energy is that it is needed for man to live and develop, and at the same time, unplanned developmental activities focusing more on fossil fuels is affecting the environment he is living in. Moreover, the evolution of societies, the economic growth and the way countries develop lead to an increasing demand for energy. Two problems arise with increasing energy consumption: first, pollution associated with energy consumption increases leading to unknown changes in world climate that could have tremendous repercussions, and second, fossil fuels commonly used are not renewable. Even if people are concerned about the future of the planet, the power of money and need for economic growth dominate the debate. Studies have been made on the different resources, nuclear power and environment-friendly energies like solar, wind and others in order to replace fossil fuels, and more generally on non-renewable energies<sup>1</sup>.

The energy use per capita has been used as an index of a nation/region's