some model bacteria, trigger various responses, including the formation of biofilms and host colonization processes. Tian *et al.*[6] bring a eukaryote perspective to QS by discussing its mechanisms and roles in fungi. QS in fungi regulates processes like host colonization similar to that in bacteria, in addition to eukaryote-specific functions such as meiosis and apoptosis, but use a different suite of molecular signatures of cell density. This might even allow some fungi to disrupt QS pathways used by certain bacteria, suggesting that QS pathways in fungi might have a role to play in interspecies and interkingdom signalling across microorganisms.

Among the most prominent signalling systems in bacteria is that mediated by the small molecule (p)ppGpp. It is well known that this molecule binds to RNA polymerase, powerfully inhibiting the transcription of various genes, particularly those involved in resource-expending translation. A review by Bange *et al.*[7] explains how the action of (p)ppGpp extends beyond this by binding and directly regulating the activities of a wide range of proteins and even RNA molecules. These proteins are involved in ribosome biogenesis and maturation as well as in the process of translation, among others. The range of dissociation constants for (p)ppGpp binding across its binding partners suggests the prioritization of targets for regulation at different cellular concentrations of the molecule.

Other articles present mechanisms by which various steps in gene expression and activity are regulated. For instance, how is stoichiometric protein synthesis achieved? How are RNases, which can degrade RNA indiscriminately, deployed in a regulated manner? Taken together, this volume of the *Annual Review of Microbiology* does justice to Kolter's unified view of the field by assembling a series of articles representing the state-of-the-art in microbial ecology, molecular evolution and molecular processes of adaptation.

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In her introductory remarks, Ruth Lehman (one of the editors of this book) brings out the multiple difficulties we faced during the COVID-19 pandemic and how research in life sciences has taken centre stage over the past couple of years. Scientists rose to the occasion, more than did their bit, to understand the various aspects of this disease and helped develop effective vaccines in record time. Most of us, however, suffered in our research output and wet laboratory scientists had to face their problems. For example, I had nightmares about losing my two-decade-old clonal culture of hydra (fortunately, due to the efforts of a dedicated technical officer, it survived). The pandemic also taught us to keep abreast with advances in other areas of human activity, especially science. Normally, primarily due to lack of time, one misses out on reading about interesting works in other areas of research. This is where the *Annual Reviews* series has come to one's rescue. This volume is one such collection of fine articles that I would strongly recommend everyone to peruse. All the articles are certainly not on the same theme, which is understandable because the subjects of cell and developmental biology are vast, but each has something interesting to offer. There are 22 articles which review diverse cellular and developmental phenomena in organisms from bacteria to mammals. These include the role of cytoskeletal components, mechanobiology, cell signalling in animals and plants, regeneration, infection, the spread of viruses, etc.

The first few articles cover the trends in the molecular understanding of structural and functional aspects of cell shape, organelle biogenesis and assembly, phagocytosis and T-cell activation. How a limited number of proteins is responsible for generating the rod shape in bacteria is described from the data obtained from *in vitro* and *in vivo* studies. The current models that attempt to explain the rod-shape formation, maintenance and regulation have been discussed. Microtubules, one of the cytoskeletal components, play multiple roles in all types of cells. Patterning of microtubules inside the cells has been used to describe principles of self-organization in the biological context. Comparing cytoplasmic partitioning in frog eggs before cytokinesis and the longer-lasting syncytia in early *Drosophila* embryos is interesting and illuminating. A detailed description of the self-assembly of the centrosome is the topic of another article. Minute details of the structural organization of the centrosome have been discussed. Up-to-date information on the dynamics of centrosome assembly in cells is reviewed. Changes in the centrosome during development and disease processes have also been discussed. While concentrating on the biochemical events that drive various cellular processes, one often tends to ignore the importance of mechanical sensing in biological processes. This point has been dealt with in an article devoted to activation of T cells, which is important for adaptive immune response. State-of-the-art microscopy and related techniques show how mechanical cues drive T-cell activation through a large number of molecular components. The article on the regulation of phagocytosis makes interesting reading. Phagocytosis is a dynamic process that responds to various cues in an extremely versatile fashion. The combination of a vast array of signals from targets and receptors on phagocytes makes the process dynamic and versatile. Additionally, in the authors' words, 'An exquisite extra layer of complexity is introduced by the coexistence of "eat-me" and "don't-eat-me" signals on targets and of corresponding "eat" or "don't-eat" receptors on the phagocyte surface.'

The work of Lin Margulis on endosymbiosis, which was not well received initially and was apparently rejected by several journals, has changed our understanding of evolution. McCutcheon discusses how intracellular bacterial infections can lead to endosymbiotic relationships. With some interesting examples, he discusses how bacteria escape rejection by the host cell, how their genomes are modified, and finally, though yet to be well understood, how host cells might tolerate these 'permanent guests' that eventually help their hosts in different ways. Understanding how the host tolerates only

certain bacterial species (either inside the cells or in the gut or on the skin), but not many others remains a mystery. Kerviel *et al*. describe a novel method by which DNA and RNA viruses infect their hosts and argue, quite convincingly, why extracellular vesicles (EVs) with viruses should be identified as a separate form of an infectious unit. EVs can carry many virus particles that might enhance replication, may hide viruses from the host immune response as well as help them escape through generation of genetic diversity. Understanding how such EVs spread and how they can be detected is crucial for effective strategies in public health.

Wnt signalling is one of the signalling pathways used by cells in multicellular organisms to interact with one another. It plays a crucial role in many biological processes during development and carcinogenesis. Albrecht *et al*. review recent findings on the effects of Wnt signalling through the trafficking of the Wnt receptor. Though our current understanding of Wnt signalling mainly revolves around the stabilization of β-catenin and its entry into the nucleus followed by transcriptional activation of target genes, several recently appreciated roles of Wnt signalling are yet to be widely appreciated. These include WNT-induced stabilization of proteins (WNT-STOP) that regulate the degradation of several proteins, induction and regulation of macropinocytosis and stimulation of lysosomal degradation. The versatility of the Wnt signalling pathway, along with that of the other six basic signalling pathways (TGF-β, Hedgehog, Notch, JAK/STAT, receptor tyrosine kinase (RTK) and nuclear hormone pathways), is such that these seven pathways are sufficient for the building and maintenance of a metazoan body plan. One would assume that, in the years to come, additional functions of these signalling pathways in various biological contexts will be discovered.

The process of fertilization, which leads to the fusion of the male gamete with the female gamete, is highly regulated. This is understandable. Take the example of organisms like sea urchins or amphibians, in which fertilization takes place in water where more than one species might coexist. Sperm must recognize and fertilize the ovum of its own species. Deneke and Pauli discuss the fusion of mammalian sperm and ovum. Though the emphasis is on mammalian fertilization, evolutionary aspects of various factors involved in fertilization are discussed. The factors seem to be conserved only in mammals and higher vertebrates. IZOMO and JUNO are the only interacting proteins identified and studied so far in mammalian fertilization. While IZOMO is present in the sperm, JUNO, which was discovered much later, is its interacting partner on the oocyte. This interacting pair is conserved in all mammals, including humans. Incidentally, IZOMO is named after a Japanese shrine dedicated to marriage and JUNO is named after the Roman goddess of marriage and fertility. In the case of fertilization in fish, the interesting protein Bouncer plays a significant role. This protein is expressed in zebrafish oocytes and is essential for fertilization (as studied in mutant zebrafish). Sperm from another fish, medaka, cannot fertilize zebrafish eggs *in vitro*, but if these eggs are made to express medaka Bouncer, the medaka sperm can fertilize them. This provides an effective mechanism for species-specific recognition of the ovum by the sperm. However, quite intriguingly, the mammalian homolog of Bouncer is present only in the mammalian sperm and not the ovum. Although the process of fertilization was first observed in the 1850s, a lot more studies are needed for a better understanding. This is important not only from the point of view of understanding nature, but also because of the possible implications of such knowledge in the treatment of infertility on the one hand and developing effective contraceptives on the other.

The regeneration of lost tissues and organs in animals always has interested biologists. Several animals belonging to different phyla are capable of regenerating lost parts of the body. Some animals like hydra, planaria, starfish, etc. also exhibit whole-body regeneration. There are many apparent similarities in the mechanisms of regeneration in animals with diverse taxa. Wnt signalling, for example, has been shown to be activated in regeneration in a large number of taxonomically distant animals. One of the articles critically discusses the common/conserved cell types, signalling pathways and molecules during regeneration in animals from different phyla and tries to find common grounds for regenerative ability. Though regeneration is now being studied in many organisms, the author makes a strong case for 'increasing taxonomic sampling'. Unless regeneration is studied in as many representatives as possible from each taxon, it will be difficult for a meaningful comparative framework to evolve. This is in fact true for all of biology. Model systems or research organisms have been beneficial and continue to do so, but, in the final analysis, a 'model' system is a good model only for itself.

There are a few other equally interesting articles on a panoply of topics: selective as opposed to bulk autophagy, dynamics of chromatin structure during development, nuclear mechanical transduction, the crucial role of glycocalyx in cell morphogenesis, regulation of non-muscle myosin II in cell division and migration, calcium signalling in animals, plants and fungi, nutrient signalling in plants, mechanical forces that drive morphogenesis in animals, evolution of the cerebral cortex, evolution of visual opsin genes in teleost fishes and its relevance to lifestyle and life cycle, regulatory mechanisms in the development of sexually dimorphic nervous systems in animals and the utility of the worm and fruit fly models in them, and, finally, how the nervous system, adipose tissue and the immune system together control obesity.

Several articles discuss hypotheses, experimental findings and conclusions in the context of comparative studies and evolution, which makes reading them interesting and thought-provoking. A special mention needs to be made of the large number of illustrations that, apart from being highly informative, are aesthetically pleasing. All in all, this is an impressive collection of review articles on contemporary biology.

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