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BOOK REVIEW

Handbook of Glycomics

(R. D. Cummings and J. M. Pierce (eds.), Academic Press, Elsevier, 2009, 473 pp., $94.95)

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The term "glycomics" appeared rather recently when scientists recognized that glycobiology is a very important part in life science. Glycomics is the systematic study of all glycan structures of a given cell type or organism. Currently the term "glycomics" is analogous to terms "genomics" and "proteomics", and it is a subset of glycobiology.

This book of six sections including 17 chapters was written by a large international group of well-known experts in glycobiology and related areas. The first section (chapters 1-3) deals with structural analysis of glycoconjugates. Chapter 1 (Y. Meschref and M. Novotny) describes *N*-glycan separation, purification, and analysis by capillary electrophoresis (CE), mass spectrometry (MS), and various types of liquid chromatography. Here it is pointed out that in the last decade significant progress has been achieved in structural analysis of *N*-glycans using optimization of CE-MS including separation of sugar isomers. In chapter 2, L. Wells describes the complexity of *O*-glycans and their analysis using glycoproteomics approaches. Unlike *N*-linked glycans, *O*-glycan structures have no common core structure and there is no single enzyme that can remove all, or even most, of the *O*-linked glycans from a complex mixture. For all of these reasons, *O*-linked glycan analysis is much more complicated than that for *N*-linked glycans. In chapter 3, F. Zhang et al. review the complexity of glycosaminoglycan (GAG) structural analysis. The authors' focus on structure analysis of GAGs relies on highly efficient isolation/purification techniques and high-sensitivity, very informative analysis using modern MS techniques, structural information, monosaccharide composition, number and position of sulfo groups, composition of disaccharide blocks, and sequence of highly charged sulfated carbohydrates. It is pointed out that accumulation of MS data of various oligosaccharides might be useful to establish a library of sulfated oligosaccharide sequences. There it is also emphasized that progress in structure analysis of GAGs should dramatically improve our knowledge about their biological functions and help in understanding relationships between structure and functional activity of these important biopolymers.

Section II, "Glycotranscriptomics", includes two chapters. In chapter 4 (R. Cummings and D. Smith) the authors discuss isotopic labeling of glycans for quantitative analysis including the strategy of isotope labeling and isotope-coded reagents for glycan analyses and analytical approaches. Chapter 5 (A. Nairn and K. Moremen) presents data and ideas that help to understand the global regulation of glycan structures in animal systems. There is consideration of enzyme systems required for activated sugar precursor biosynthesis and transport, glycan biosynthesis, modification, and catabolism, and glycan recognition by lectins. Cloning strategies and related methods for identifying respective glycan-related genes are also discussed.

In section III, "Protein–glycan interactions", chapter 6 (D. Smith and R. Cummings) and chapter 7 (J. Hirabayashi) deal with glycan microarrays for identification of glycan recognition by glycan-binding proteins and lectins, and chromatographic and mass spectrometric techniques are used to define glycan–protein interactions, respectively.

Section IV, "Glycobioinformatics", includes chapter 8 (W. York et al.), which highlights integrating glycomic information and databases, and chapter 9 (K. Hashimoto and M. Kanehisa), which specifically focuses on the KEGG approach for integration of glycomics databases. The Kyoto Encyclopedia of Genes and Genomes (KEGG) is an integrated knowledge base for understanding higher-level functions of cellular processes and organism behaviors. KEGG consists of genomic, chemical, and systemic functional information, and the KEGG GLYCAN resource for glycomics research is also organized according to these three. Chapter 10 (R. Ranzinger et al.) describes the European Glycomics Portal, which promotes integration of glycan-related data from many sources.

Section V, "Glycomes", includes five chapters and starts with chapter 11 where P. Redelinghuys and P. Crocker provide an overview regarding our current understanding of the immune cell glycan repertoire (glycome), changes of this repertoire during the activation and differentiation of immune cells, and influences of

their interactions with various endogenous lectins. The significance of these events within the immune response is also discussed. Chapter 12 (S. North et al.) deals with whole-system analysis of the *N*- and *O*-glycomes of mouse and human tissues. The authors point out that the glycome of these tissues is vital for investigating the roles that glycans play in cell communication.

Chapter 13 (M. Sharrow et al.) summarizes genetic and structural analysis of the glycoproteins and glycolipids of *Drosophila melanogaster*. Chapter 14 (E. Davidson) considers the participation of glycoconjugates in malaria parasite invasion including the role of human host saccharides and specific domains on the parasite's surface. These host domains are usually anionic in nature and involve heparan sulfate, chondroitin sulfate, and sialyl residues. Specific domains on parasite surface proteins have been identified that are involved in these phenomena and confirm the charge-based nature of their primary interactions. Direct glycosylation of parasite proteins is primarily through the attachment of glycosylphosphatidylinositol anchors, a predominant mechanism for surface immobilization of parasite proteins. The anchors have Man4 structure and are immunogenic in humans. Explicit identification of any protein of the parasite that contains *N*- or *O*-linked saccharides has not been accomplished, although a small amount of high mannose structures might be present. The parasite does not contain sialic acid or *N*-acetylglucosamine; intermediates in the dolichol pathway beyond UDP-GlcNAc and GDP-Man are not detectable. Chapter 15 (I. van Die and R. Cummings), "Glycomics in unraveling glycan-driven immune responses by parasitic helminths", provides an overview of the glycan structures that are synthesized by selected helminth species belonging to the *Platyhelminthes* and *Nematoda* phyla and their contribution to induction or modulation of the host's immune responses. These authors also review novel glycomic approaches that will facilitate the development of applications of helminth glycans in diagnosis and treatment of helminth infections and, possibly, other inflammatory diseases.

The final section of the book, section VI "Disease glycomes", includes two chapters, 16 (J. Pierce) and 17 (H. Freeze and E. Eklund), where cancer glycomics and human glycosylation disorders (HGD) are reviewed. Considering cancer glycomics, the author of chapter 16 stresses that new technologies are now being applied to identify specific glycan, glycopeptide, and glycoprotein differences found in cancer patient's sera when compared to sera of healthy controls. In all cases, however, results have to be used to work toward finding markers from the earliest stages of cancer. Detection of circulating antibodies to cancer-specific glycopeptides is clearly an exciting area of experimentation, particularly since these antibodies have the potential to detect very early stage disease and perhaps be used for screening purposes. Developing assay systems to test the association of specific glycan or glycoprotein glycoform expression in sera with the presence of early stage cancer and putting these associations to test in large-scale trials are now major challenges for the field of cancer glycomics. The final chapter 17 of this section highlights HGD. There is an introduction to known HGDs, currently including more 35 diseases, and information on the nature of the defects and how they are diagnosed and sometimes treated. The authors also indicate where there are gaps in our understanding of the basic mechanisms, what tools are needed, and strategies that basic scientists might adopt to position themselves to address the unanswered questions.

Overall, this book is well presented; each chapter contains very valuable figures, an up-to-date bibliography, and tables and charts including 22 color plates at the end of the book. The subject index is useful for fast orientation in the numerous topics discussed in the book. A remarkable feature of this book is very wide range of highlighting scientific directions that currently unite in glycomics.

This book will no doubt serve as an excellent comprehensive overview and will be handy reference book for scientists and teachers in glycobiology, biochemistry, molecular biology, biotechnology, and medicine.

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