Transcriptomics: Open Access
ISSN: 2329-8936
OPEN ACCESS Freely available online
Short Communication

Glycome Expanding Horizons in Glycobiology and Systems Medicine

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DESCRIPTION

The glycome refers to the complete set of glycans, glycoproteins, glycolipids, and other carbohydrate-based structures present within a biological system at a given time. It represents one of the most structurally complex and dynamically regulated molecular layers in living organisms. Unlike nucleic acids and proteins, glycans are not directly encoded by a template sequence, but are instead assembled through enzymatic processes influenced by cellular context, metabolic state, and environmental signals. This makes the glycome highly adaptable and responsive, reflecting both genetic and non-genetic factors in biological systems. Glycans are found on the surface of nearly all eukaryotic cells, where they form a dense and functional coating known as the glycocalyx. This structure plays a central role in cell cell communication, adhesion, and signaling. It also serves as a molecular interface between cells and their external environment. Through interactions with lectins and other glycan-binding proteins, glycans mediate essential biological processes such as immune recognition, inflammation, and tissue organization. In pathogens, glycan structures are often exploited to facilitate host attachment and invasion, demonstrating their importance in infectious disease mechanisms. In human health and disease, alterations in the glycome are increasingly recognized as important biomarkers and functional contributors to pathology. Cancer cells frequently exhibit abnormal glycosylation patterns that support tumour growth, metastasis, and immune evasion. These glycan changes include increased branching, altered sialylation, and truncated glycan structures that affect cell signaling and adhesion. Similarly, inflammatory diseases and autoimmune disorders are associated with dysregulated glycosylation patterns that influence immune cell behavior and cytokine activity. Glycan structures are being explored as diagnostic markers for early disease detection and prognostic evaluation. This has led to the development of glycoengineering approaches aimed at modifying therapeutic antibodies to enhance their efficacy and reduce adverse immune reactions. Such advances illustrate the growing translational importance of glycomics in modern immunotherapy and vaccine design. These tools have made it possible to profile glycomes across different tissues, developmental stages, and disease conditions. However, the analysis of glycan structures remains technically due to their structural complexity and lack of direct genetic encoding. Unlike DNA or proteins, glycans cannot be easily amplified or predicted from sequence data, requiring advanced analytical workflows and computational interpretation. Single-cell glycomics is an emerging field that aims to resolve glycan heterogeneity at the level of individual cells. Single-cell approaches have revealed that glycosylation patterns can differ significantly even among genetically identical cells, reflecting functional specialization and micro environmental influences. This heterogeneity is particularly important in cancer biology, where cellular diversity contributes to tumour progression and treatment resistance. Glycan diversity reflects adaptation to different biological pressures. Comparative glycomics has shown that glycan structures vary widely across species, yet certain conserved motifs are maintained due to their essential biological roles. These conserved glycan structures often participate in fundamental processes such as protein folding, developmental signaling, and immune recognition. In biotechnology and pharmaceutical sciences, glycome research plays an increasingly important role in drug development and biologics production. Glycosylation affects the stability, solubility, and immunogenicity of therapeutic proteins. Controlling glycan structures is a key aspect of biopharmaceutical engineering. Glycoengineered drugs are now being developed to improve therapeutic performance in conditions such as cancer, autoimmune disorders, and infectious diseases. Additionally, biosimilar production requires precise replication of glycan profiles to ensure safety and efficacy. The glycome research is expected to focus on integrative glycoscience, spatial glycomics, and clinical translation. Spatial glycomics will enable visualization of glycan distribution within tissues, providing insight into cellular microenvironments and disease architecture. Combined with artificial intelligence, these technologies may allow predictive modelling of glycan function in health and disease. In conclusion, the glycome represents a highly complex and dynamic molecular system that plays a fundamental role in biological regulation, disease development, and therapeutic innovation. Its integration into systems biology has expanded understanding of cellular communication and molecular diversity. As analytical technologies and computational tools continue to evolve, glycomics is expected to

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Received: 01-Dec-2025, Manuscript No. TOA-25-41965; **Editor assigned:** 03-Dec-2025, PreQC No. TOA-25- 41965 (PQ); **Reviewed**: 16-Dec-2025, QC No. TOA-25-41965; **Revised:** 23-Dec-2025, Manuscript No. TOA-25- 41965 (R); **Published**: 30-Dec-2025, DOI: 10.35248/2329-8936.25.10.223.

Citation: Almeida S (2025). Glycome Expanding Horizons in Glycobiology and Systems Medicine. Transcriptomics. 10:223.

become an increasingly important discipline in biomedical research, offering new insights into health, disease mechanisms, and therapeutic design.

REFERENCES

1. Varki A. Biological roles of glycans. Glycobiology. 2017;27(1): 3-49.
2. Reily C, Stewart TJ, Renfrow MB, Novak J. Glycosylation in health and disease. Nat Rev Nephrol. 2019;15(6):346-366.
3. Ohtsubo K, Marth JD. Glycosylation in cellular mechanisms of health and disease. Cell. 2006;126(5):855-867.
4. Varki A, Cummings RD, Aebi M, Packer NH, Seeberger PH, Esko JD, et al. Symbol nomenclature for graphical representations of glycans. Glycobiology. 2015;25(12): 1323-1324.
5. Fisher P, Spencer H, Thomas-Oates J, Wood AJ, Ungar D. Modeling glycan processing reveals golgi-enzyme homeostasis upon trafficking defects and cellular differentiation. Cell Rep. 2019;27(4):1231-1243.
6. Scallon BJ, Tam SH, McCarthy SG, Cai AN, Raju TS. Higher levels of sialylated Fc glycans in immunoglobulin G molecules can adversely impact functionality. Mol Immunol. 2007;44(7): 1524-1534.
7. Spahn PN, Hansen AH, Hansen HG, Arnsdorf J, Kildegaard HF, Lewis NE. A Markov chain model for N-linked protein glycosylation–towards a low-parameter tool for model-driven glycoengineering. Metab Eng. 2016;33:52-66.
8. Varki A. Biological roles of glycans. Glycobiology. 2017;27(1): 3-49.
9. Medley BJ, Low KE, Irungu JD, Kipchumba L, Daneshgar P, Liu L, et al. A "terminal" case of glycan catabolism: Structural and enzymatic characterization of the sialidases of Clostridium perfringens. J Biol Chem. 2024;300(10):107750.
10. Wang H, Liu X, Zhang X, Zhao Z, Lu Y, Pu D, et al. TMPRSS2 and glycan receptors synergistically facilitate coronavirus entry. Cell. 2024;187(16):4261-4271.