EDITORIAL

Bridging Molecules and Medicine: The Convergence of Structural Biology and Pathology

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The advancement of modern medicine increasingly relies on the integration of molecular and clinical sciences. Among these, structural biology and pathology represent two complementary fields through which we understand diseases. Structural biology reveals the architecture of life at the molecular level, while pathology captures the consequences of molecular disruption at the tissue and organismal levels. The dialogue between these two major disciplines forms the backbone of translational biomedical research, transforming molecular discoveries into clinical relevance. Structural biology elucidates the three-dimensional conformation and molecular details of proteins, nucleic acids, and macromolecular complexes using state-of-the-art techniques such as X-ray crystallography, cryo-electron microscopy (cryo-EM), and NMR spectroscopy (1, 2) . These technologies have unveiled how conformational changes, mutations, and molecular interactions dictate biological function and dysfunction. Pathology, on the other hand, interprets how these molecular disturbances culminate in morphological changes, leading to cellular injury, inflammation, degeneration, or malignancy. Together, these two disciplines are deeply intertwined, forming a unified single narrative that links molecular mechanism to disease phenotypes.

The significance of this relationship is evident across multiple disease contexts. In cancer biology, structural analyses of key regulatory proteins such as p53 and Ras have revealed how single amino acid substitutions destabilise protein folding, impair DNA-binding or GTP-hydrolysis, and ultimately promote uncontrolled cellular proliferation (3). In neurodegenerative diseases, for examples, cryo-EM structures of amyloid-β, tau, and α-synuclein aggregates have provided direct molecular explanations for the histopathological features long recognised in Alzheimer's and Parkinson's diseases (4). Similarly, the structural characterisation of viral surface glycoproteins, such as influenza hemagglutinin or the SARS-CoV-2 spike, has revolutionised vaccine design and public-health preparedness (5). Structural investigations of misfolded α1-antitrypsin have clarified the pathogenesis of hepatic cirrhosis through the intracellular accumulation of polymerised proteins within hepatocytes (6), while fibrillar architectures revealed by cryo-EM correspond closely with histological amyloid staining patterns. This mutual reinforcement between form and function, molecule and morphology, continues to redefine how diseases are diagnosed, classified, and managed.

As Southeast Asia, including Malaysia, continues to strengthen its capabilities in biomedical imaging, molecular diagnostics, and structural biology, there is growing potential to integrate these advances into clinical and pathological practice. Bridging structural insights with patient-centred observations will accelerate precision medicine, enabling early detection, targeted therapy, and mechanistic understanding of disease processes specific to our populations. By uniting the expertise of molecular scientists, clinicians, and pathologists, we underscore the continuum that connects atoms to organs, biochemistry to pathology, and discovery to healthcare delivery. The integration of structural biology and pathology exemplifies how multidisciplinary collaboration can transform scientific knowledge into tangible improvements in human health.

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