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Understanding and harnessing asymmetry across scientific disciplines

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Asymmetry is a fundamental feature of nature and a powerful principle governing the structure, behavior, and functionality of physical, chemical, biological, and engineered systems. From the microscopic arrangement of atoms and molecules to the macroscopic architecture of materials and biological organisms, asymmetry plays a critical role in determining how systems form, evolve, interact, and respond to external stimuli. It manifests itself in diverse phenomena, including chirality, symmetry breaking, directional mechanical responses, nonreciprocal transport, enantioselective chemical reactions, and biological laterality. Understanding the origins, mechanisms, and consequences of asymmetry is therefore essential not only for advancing fundamental science but also for developing innovative materials, technologies, and functional systems.

In materials science and engineering, structural and functional asymmetry provides important opportunities to tailor mechanical properties, deformation mechanisms, interfacial behavior, and transport characteristics. Asymmetric defects, interfaces, microstructures, and hierarchical architectures can fundamentally alter the responses of materials to mechanical, thermal, electrical, magnetic, and chemical stimuli. These characteristics offer new possibilities for designing advanced materials and structures with directional functionality, enhanced performance, and unprecedented combinations of properties. Similarly, symmetry breaking and asymmetric interactions are central to numerous physical phenomena, ranging from matter–antimatter asymmetry and asymmetric dark matter to nonlinear optics, photonics, low-dimensional materials, and nonreciprocal functional systems.

In chemistry, asymmetry is central to molecular chirality, stereoselective transformations, and asymmetric catalysis. The ability to control molecular configurations and reaction pathways is fundamental to synthesizing complex molecules, pharmaceuticals, and bioactive compounds. In biological systems, asymmetry is equally pervasive, spanning molecular chirality, membrane organization, developmental patterns, anatomical laterality, and asymmetric physiological functions. These phenomena provide important insights into the origins and evolution of biological complexity and inspire the development of bioinspired materials, biomedical technologies, and advanced biomechanical systems. Meanwhile, advances in computational science, theoretical modeling, and artificial intelligence are creating new opportunities to characterize, understand, and predict asymmetric phenomena across multiple length and time scales.

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1. The evolving research landscape of asymmetry

Research on asymmetric phenomena has developed extensively across multiple scientific disciplines, with significant contributions appearing in established journals specializing in chemistry, physics, materials science, biology, and interdisciplinary research. In chemistry, molecular chirality and asymmetric synthesis have long been major research areas, supported by dedicated publications such as *Chirality* and numerous leading journals in synthetic chemistry. In physics, symmetry breaking, parity violation, matter–antimatter asymmetry, and nonreciprocal phenomena remain fundamental subjects of investigation. Meanwhile, growing interest in chiral materials, asymmetric interfaces, and directional functional responses has stimulated important advances in materials science, condensed matter physics, photonics, and nanotechnology. In biological sciences, molecular chirality, developmental laterality, membrane asymmetry, and asymmetric physiological functions continue to provide important insights into the organization and functionality of living systems.

The existence of interdisciplinary journals, including *Symmetry*, reflects the broad scientific recognition of symmetry and asymmetry as fundamental concepts across the natural sciences and engineering. More recently, dedicated publications and initiatives focusing on asymmetry have further highlighted its importance as a unifying scientific concept. These developments demonstrate that asymmetry is evolving beyond a descriptive characteristic of scientific systems into a powerful principle for understanding and controlling their behavior. Advances in chiral functional materials, nonreciprocal transport, asymmetric catalysis, bioinspired structures, and multiscale computational approaches illustrate the growing connections among traditionally distinct research communities.

Despite these advances, research on asymmetry remains distributed across different disciplinary publications, often with distinct terminology, theoretical frameworks, experimental methodologies, and scientific objectives. Opportunities therefore exist to strengthen communication among these communities and develop more integrated perspectives on the origins, mechanisms, quantitative characterization, and functional consequences of asymmetry. In particular, connecting structural and molecular asymmetry with emergent physical properties, mechanical responses, chemical selectivity, and biological functions may reveal common principles that are difficult to recognize within individual disciplines. Such connections can also inspire new approaches to materials design, functional system development, and technological innovation.

2. The scope and vision of *Asymmetry*

Against this scientific background, *Asymmetry* aims to provide an interdisciplinary platform for advancing fundamental understanding and practical applications of asymmetric phenomena, mechanisms, and systems. The journal welcomes original research articles, comprehensive reviews, and forward-looking perspectives spanning materials science and engineering, physics, chemistry, biology, computational science, and related interdisciplinary fields.

The journal's scope encompasses five interconnected research areas. The first focuses on asymmetric materials, structures, and engineering applications, including structural and functional asymmetry, mechanical behavior, deformation mechanisms, asymmetric defects and interfaces, and the design of advanced materials and structures. The second addresses asymmetry in physics and functional systems, covering fundamental symmetry breaking, matter–antimatter asymmetry, asymmetric dark

matter, optical and electronic phenomena, low-dimensional materials, and directional or nonreciprocal physical responses. The third explores asymmetric synthesis and catalysis, including molecular chirality, enantioselective and diastereoselective transformations, chiral catalysts, stereochemical characterization, and the mechanisms of asymmetric chemical reactions. The fourth focuses on asymmetric biological systems and biomechanical applications, encompassing biological chirality, developmental and morphological asymmetry, mechanobiology, membrane organization, physiological laterality, and biomedical applications. The fifth emphasizes computational approaches for asymmetric systems, including theoretical analysis, multiscale modeling, numerical simulation, and machine learning for understanding, characterizing, and predicting asymmetric phenomena across scientific disciplines.

A defining principle of *Asymmetry* is that asymmetry, chirality, directional response, nonreciprocity, or symmetry breaking must be central to the scientific question rather than merely an incidental characteristic of the investigated system. Accordingly, the journal seeks contributions that move beyond simply identifying asymmetric structures or behaviors to explain why asymmetry emerges, how it influences system evolution and functionality, and how it can be controlled or exploited. Particular emphasis is placed on studies that establish clear mechanistic insights, develop quantitative approaches to characterize asymmetry, reveal relationships between asymmetric structures and functional responses, or demonstrate innovative strategies for harnessing asymmetry in advanced technologies.

An important objective of the journal is to encourage research that bridges traditional disciplinary boundaries. For example, the relationship between crystallographic asymmetry and mechanical behavior in structural materials, the influence of molecular chirality on macroscopic physical properties, the role of symmetry breaking in functional electronic and optical systems, and the emergence of biological asymmetry through molecular and mechanical interactions represent exciting opportunities for interdisciplinary discovery. Integrating experimental observations with theoretical understanding, computational modeling, and data-driven approaches will be particularly valuable in establishing new conceptual frameworks and predictive capabilities.

We envision *Asymmetry* as a forum for scientific discovery and interdisciplinary exchange, bringing together researchers who investigate the origins, mechanisms, manifestations, and applications of asymmetry at multiple length and time scales. By fostering connections among fundamental science, quantitative modeling, materials and molecular design, and technological innovation, the journal seeks to advance a broader understanding of how asymmetry shapes the natural world and how it can be harnessed to address emerging scientific and engineering challenges.

We warmly invite researchers from around the world to contribute their innovative findings, critical insights, and visionary perspectives to *Asymmetry*. Through the collective efforts of the scientific community, we hope to establish the journal as an internationally recognized platform for advancing the understanding of asymmetry as a fundamental principle of nature and a powerful foundation for future scientific discoveries and technological innovations.