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Editorial

The living bridge - applications of physiological principles in biomedicine

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Editorial

In the ever-evolving landscape of biomedicine, physiology continues to act as the quiet architect behind many transformative advances [1]. While molecular biology often captures attention and technology impresses with precision, physiology offers the deeper narrative of how life actually unfolds within the human body [2]. It translates complexity into meaning, connecting structure with function and data with experience. The classical idea of homeostasis, though nearly a century old, still frames our understanding of how the body maintains internal stability amid constant change [1].

The relevance of physiological principles has grown even stronger in modern biomedicine, especially as healthcare moves toward a patient-centered approach [3]. Understanding disease today requires more than identifying molecular targets; it demands insight into how entire systems respond, compensate, and sometimes fail. Physiology provides this integrative lens, linking molecules to organs and organs to the lived reality of illness. Even in the age of high-throughput biology and big data, the question remains fundamentally physiological: how does this affect function [2]?

Cardiovascular physiology remains a cornerstone of clinical reasoning. Concepts such as pressure gradients, vascular resistance, and cardiac output continue to guide the management of conditions like hypertension and shock. These principles are not relics of the past but active tools in modern care, shaping decisions in critical settings [4]. Interestingly, newer approaches now blend these classical principles with artificial intelligence, creating hybrid models that retain physiological interpretability while leveraging computational power [5].

Respiratory physiology similarly underpins advances in critical care. The understanding of lung compliance, gas exchange, and ventilation-perfusion relationships has directly influenced ventilatory strategies, particularly in acute respiratory distress [6]. Even during global health crises such as COVID-19, biomedical innovations in diagnostics and monitoring were grounded in physiological understanding of respiratory function and systemic responses [7].

The evolution of physiology from static homeostasis to dynamic adaptability has opened new pathways toward precision medicine [1]. Each individual expresses a unique physiological profile shaped by genetics, environment, and lifestyle. This variability influences disease progression and therapeutic response. Modern medicine increasingly recognizes that effective care must align with this individuality, integrating physiological variability into clinical decision-making rather than averaging it out [3].

At the frontier of biomedical innovation, physiological principles continue to guide emerging technologies [2]. Biomaterials such as polysaccharides and chitosan nanoparticles are being engineered to interact harmoniously with biological systems, enabling targeted drug delivery and regenerative therapies. These materials are designed not just for compatibility, but for functional integration with physiological processes such as inflammation, healing, and cellular signaling [8,9].

Three-dimensional bioprinting has taken this a step further by attempting to recreate physiological microenvironments. Hydrogels that mimic extracellular matrices allow cells to behave as they would *in vivo*, supporting tissue engineering and disease modeling [10]. Similarly, microneedle technologies enable minimally invasive access to interstitial fluid, opening new avenues for real-time physiological monitoring and personalized therapeutics [11].

Biosensors and wearable technologies are quietly redefining how physiology is measured outside the clinic. Continuous monitoring of parameters such as oxygenation, pressure, and metabolic markers reflects a shift from episodic to dynamic assessment of health. These tools are most effective when grounded in accurate physiological interpretation, ensuring that data reflects meaningful biological states rather than isolated numbers [12].

In parallel, computational medicine is undergoing a transformation. Prediction models and synthetic data approaches are increasingly used to simulate disease processes and treatment outcomes. However, their success depends heavily on embedding physiological realism into algorithms. Models that integrate physical laws with machine learning are emerging as powerful tools because they respect the constraints of real biological systems rather than treating them as abstract data patterns [13].

Equally compelling is the rise of organoids and tissue models that emulate human physiology in controlled environments. These systems allow researchers to study disease mechanisms and drug responses with unprecedented precision, bridging the gap between experimental models and human biology [14].

Conclusion

Progress in biomedicine is often described in terms of discovery, but its true strength lies in understanding. Identifying molecules, pathways, and technologies is only the beginning; integrating them into the living system is where physiology becomes indispensable [2]. It offers a framework that is both scientific and humane, reminding us that medicine is ultimately about function, adaptation, and lived experience [1].

As we move deeper into an era defined by artificial intelligence, biomaterials, and precision therapeutics, physiology remains the steady compass. It ensures that innovation does not drift away from biological reality. In this sense, physiology is not merely foundational; it is continuously formative, shaping the present and guiding the future of biomedicine [1,2].

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