

Geometry-aware AI, Multi-modal Integration, And Digital Twin Modeling For Alzheimer's Disease And Related Dementias

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Geometry-aware AI, multimodal integration, digital twin modeling, pharmacological simulation, and dementia-aware prosthetic/assistive-safety context can be unified in BViDAL SaMD as a review-only framework for Alzheimer's disease and related dementias.

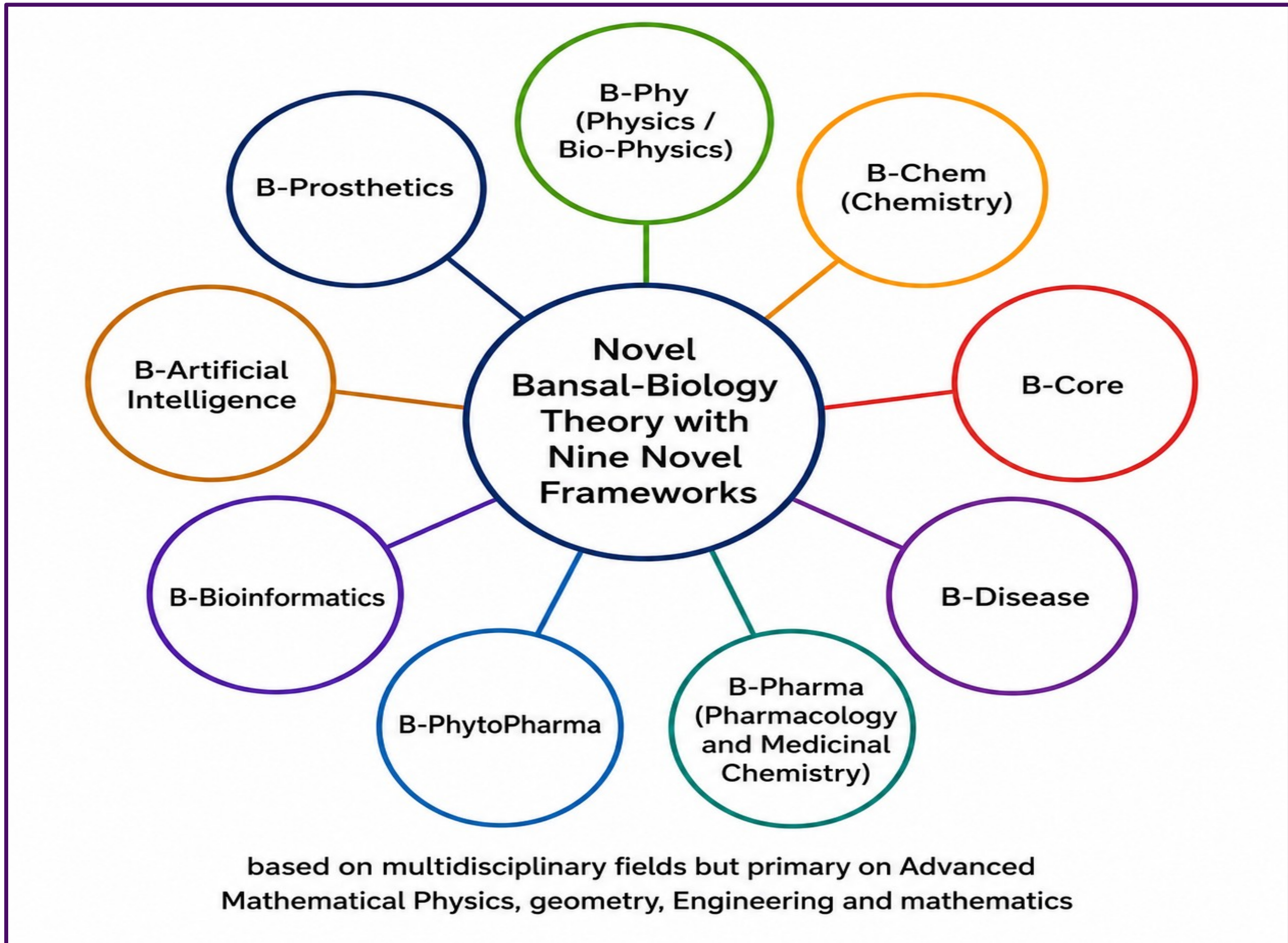
INTRODUCTION

Artificial intelligence and digital twin approaches in dementia research are often limited by black-box modeling, weak interpretability, and insufficient physiological grounding. At the same time, multimodal data integration across genomics, biomarkers, biosignals, imaging, and clinical measures remains fragmented, making it difficult to construct unified and clinically meaningful models of Alzheimer's disease and related dementias.

METHODS

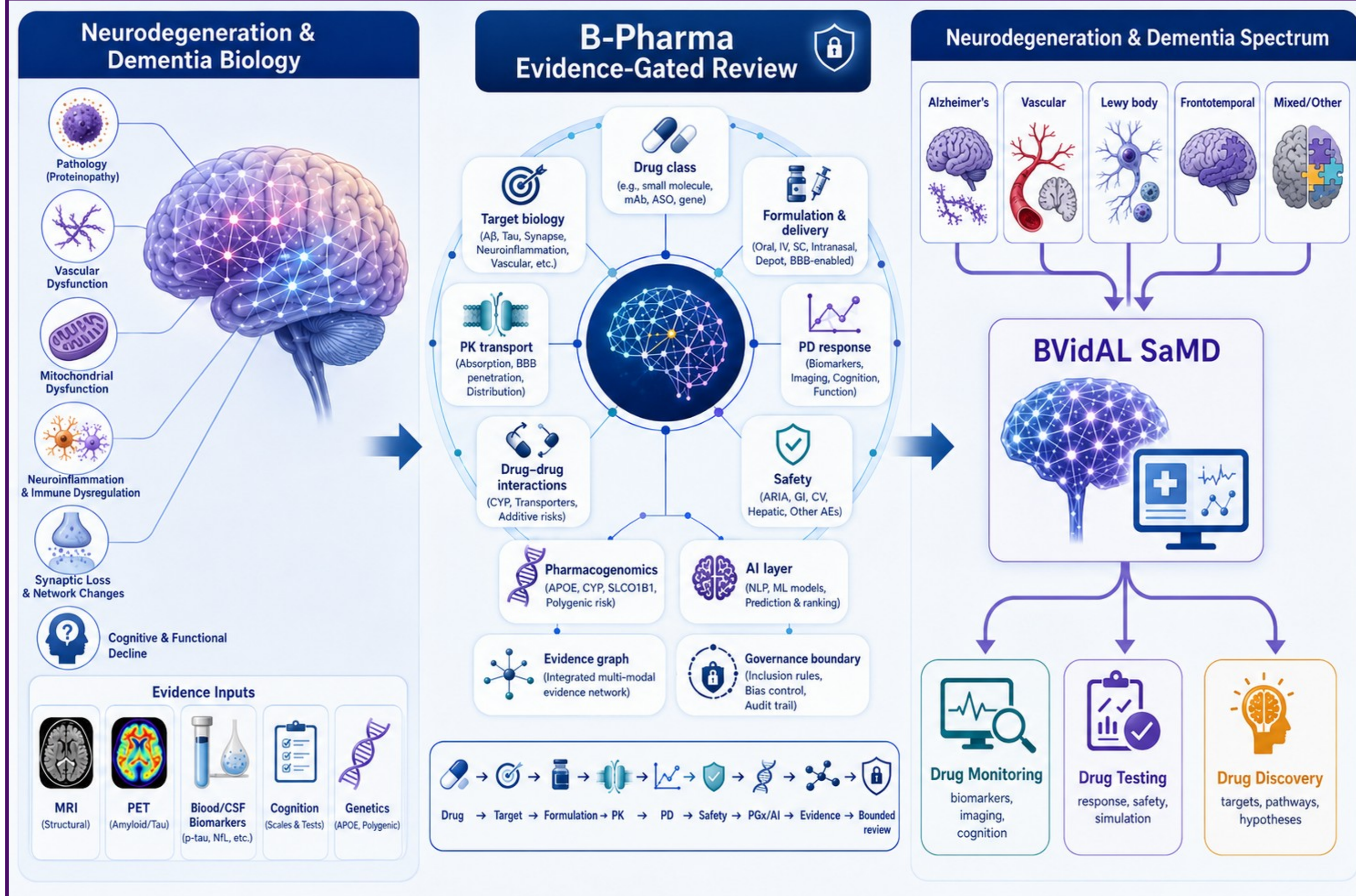
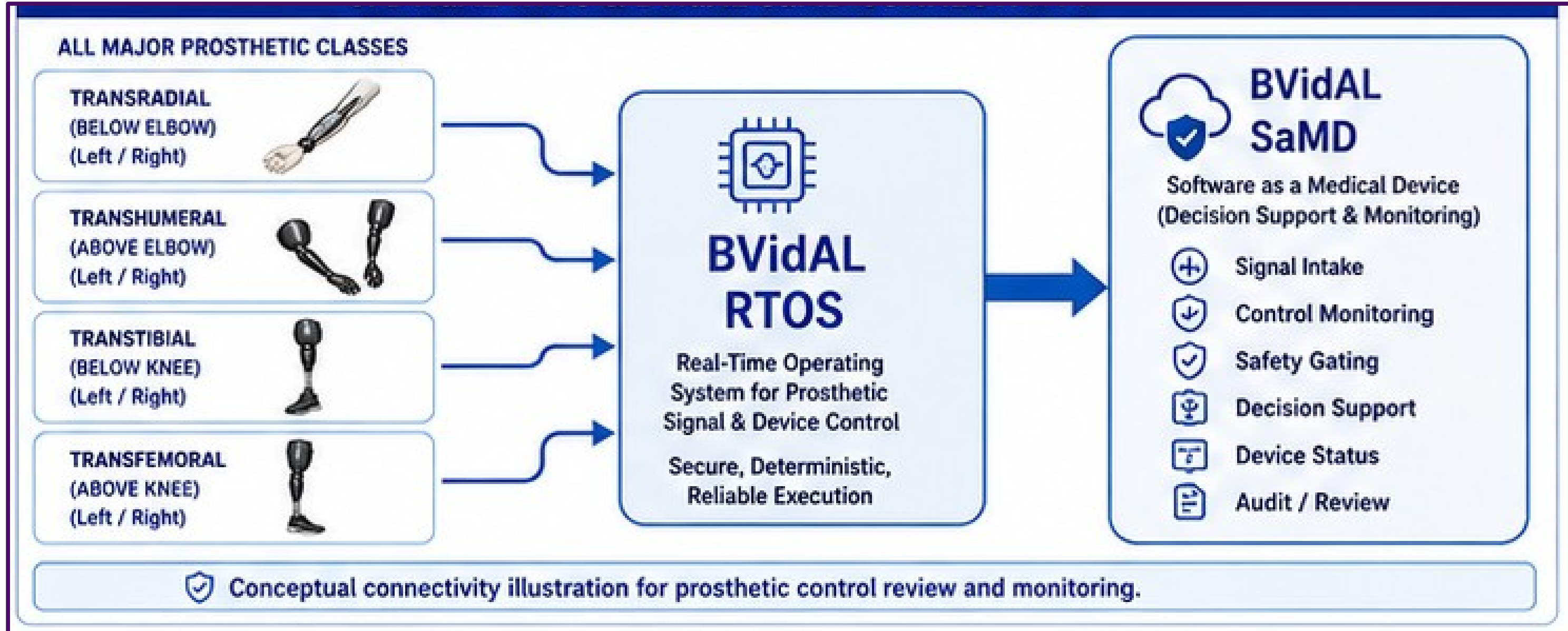
Proposed Novel B-Bio Theory, Frameworks and Pillars on SaMD- BViDAL Clinical Software Suite

I propose a unified framework within B-Bio (Bansal Biology) in which B-AI functions as the artificial intelligence component for interpretable modeling and B-Bioinformatics supports multi-modal integration across biological scales. In this formulation, AI and machine learning models act as structured projection operators on genomics, biomarkers, biosignals, imaging, and clinical data mapped to a geometry-admissible biological manifold. Unlike conventional black-box learning, B-AI is constrained by physiological state geometry, so that multimodal integration remains biologically structured and interpretable. On this basis, patient-specific digital twins are represented as evolving trajectories of unified biological state, enabling simulation of disease progression and therapeutic response.

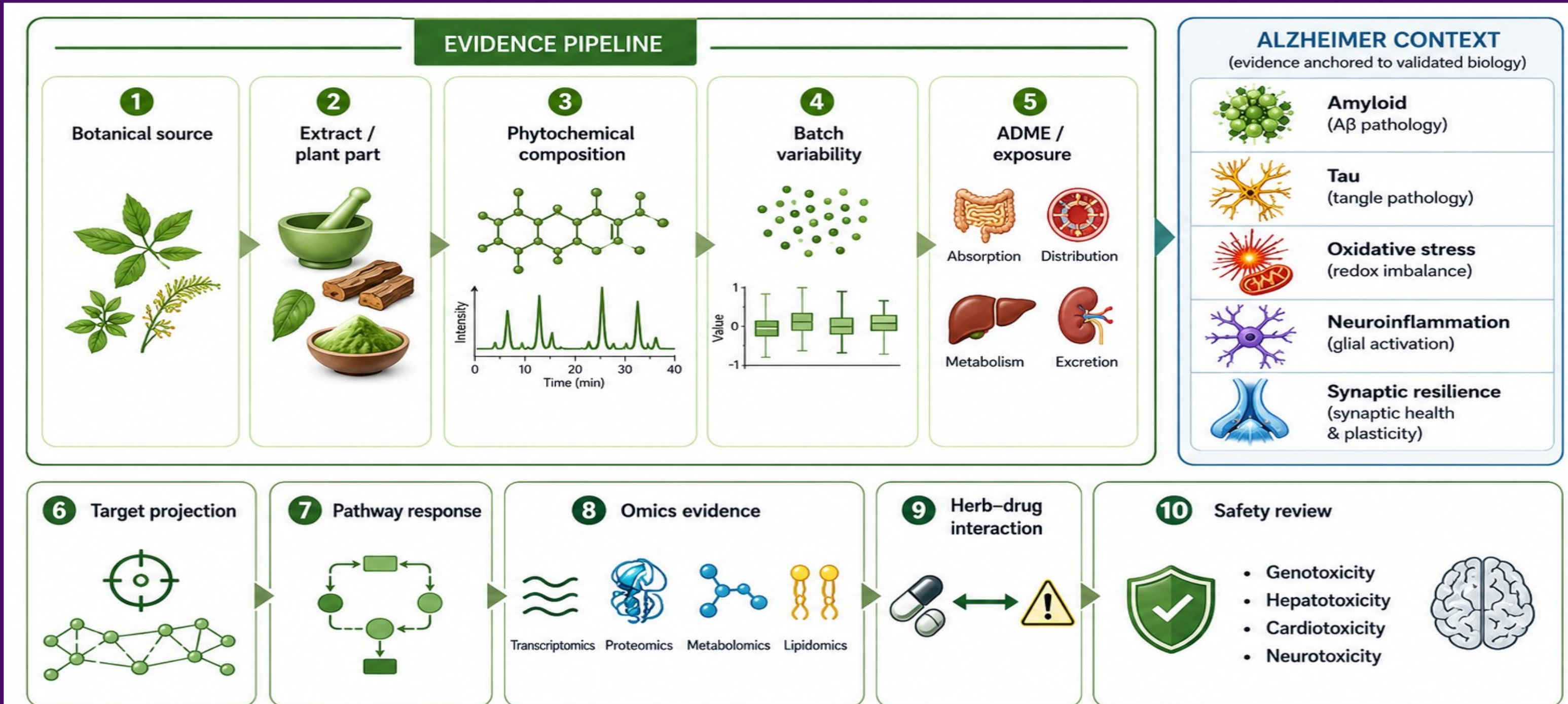
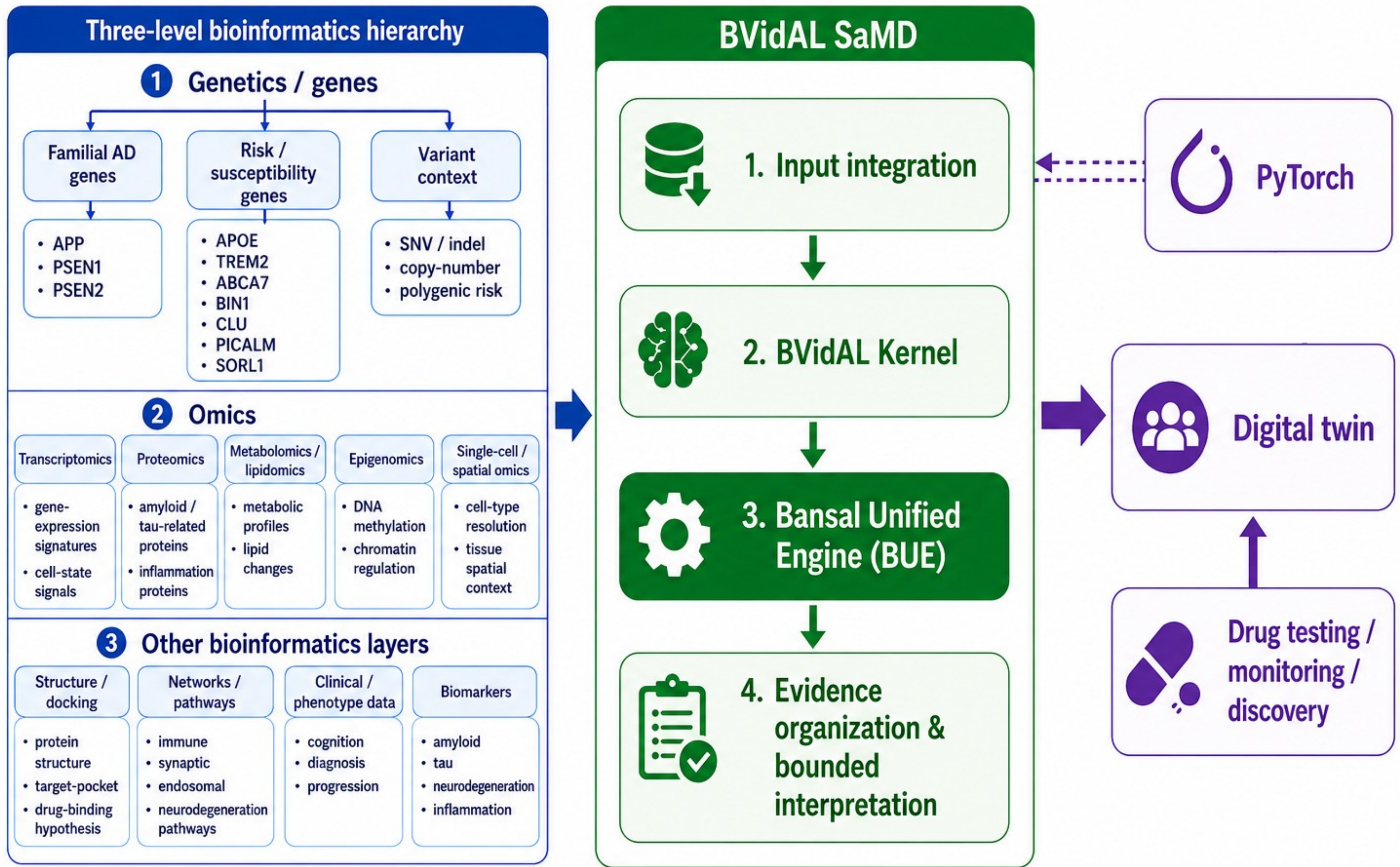


Results

The merged framework supports interpretable, physiology-constrained AI outputs that remain consistent with known neurobiological mechanisms. It enables multimodal data from molecular, cellular, imaging, biomarker, prosthetic/assistive-safety, and clinical levels to be unified within a single geometric structure, reducing fragmentation and improving robustness. Patient-specific digital twins emerge as structured representations of evolving disease state, allowing simulation of progression, intervention scenarios, therapeutic response, and assistive-support requirements. The framework also supports incorporation of transport dynamics, pharmacological dynamics, and dementia-aware prosthetic or assistive-technology safety boundaries, enabling broader modeling of personalized disease trajectories, functional support, and review-only intervention planning.



Bioinformatics evidence hierarchy connected to BViDAL SaMD



Conclusion

This integrated geometry-aware AI and digital twin framework provides an interpretable and regulator-aligned alternative to conventional black-box approaches in dementia research. By unifying multimodal integration, patient-specific modeling, clinically meaningful prediction, pharmacological-response modeling, and dementia-aware prosthetic or assistive-safety context within a single physiology-constrained structure, it supports precision medicine, therapeutic evaluation, functional-support modeling, and personalized digital twin analysis in Alzheimer's disease and related dementias.

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