

Unlocking Biological Insights Through AI-driven Multi-Omics Integration.

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Background: Multi-omics data integration is critical for understanding complex biological systems, but traditional approaches face scalability and interpretability challenges.

Methods: We present two complementary frameworks: • MultiOmicsBind - A deep learning framework using ImageBind-inspired binding modality for efficient $O(n)$ complexity multi-modal contrastive learning • OmicsNet - A network-based approach for visualizing and analyzing multi-omics relationships.

Results: MultiOmicsBind successfully integrates static + temporal multi-omics profiles to capture dynamic molecular changes during biological processes to reveal disease progression. OmicsNet maps multi-omics regulatory networks and uncovers conserved functional modules that coordinate cellular responses across transcriptomic, proteomic, metabolomic and imaging modalities.

Conclusions: These frameworks provide scalable, interpretable solutions for multi-omics integration, enabling both hypothesis-driven and data-driven discovery in systems biology.

