

Clinical + Molecular Data Integration

EHR Integration

Electronic health records with omics data

Lab Values

Clinical laboratory measurements

Imaging Reports

Radiology and pathology findings

Molecular Profiles

Genomic, transcriptomic, proteomic data

Temporal Alignment

Synchronizing time-series clinical and molecular data

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EHR Integration

Electronic Health Record (EHR) integration with omics data represents a paradigm shift in precision medicine, enabling comprehensive patient profiling that combines traditional clinical information with molecular-level insights.

Key Components

- **Patient Demographics:** Age, sex, ethnicity, and family history integrated with genetic predisposition data

 Patient Demographics & History



 Genomic Data (WGS/WES)



 Gene Expression (RNA-seq)

- **Clinical History:** Past diagnoses, medications, and treatments correlated with molecular response patterns
- **Omics Layers:** Genomic variants, gene expression profiles, and epigenetic modifications
- **Standardization:** FHIR (Fast Healthcare Interoperability Resources) standards for data exchange

Clinical Applications

- Pharmacogenomic decision support for drug selection and dosing
- Risk stratification based on genetic and clinical factors
- Early disease detection through molecular biomarkers
- Personalized treatment pathway recommendations

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Protein Data (Proteomics)

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Treatment Response Data

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✓ Integrated EHR-Omics Profile

2 Lab Values

Clinical laboratory measurements provide quantitative biomarkers that can be directly correlated with molecular profiles to reveal disease mechanisms and predict treatment outcomes.

Laboratory Data Types

Hemoglobin
12.5 g/dL

WBC
8,200/ μ L

Glucose
105 mg/dL

Creatinine
1.1 mg/dL

ALT
35 U/L

CRP
2.5 mg/L

- **Hematology:** Complete blood count (CBC), differential counts, coagulation studies
- **Clinical Chemistry:** Metabolic panels, liver and kidney function tests, electrolytes
- **Immunology:** Cytokine levels, antibody titers, inflammatory markers
- **Tumor Markers:** PSA, CA-125, CEA, AFP for cancer monitoring
- **Molecular Tests:** PCR results, viral loads, ctDNA measurements

Integration Strategies

- Correlate lab abnormalities with gene expression changes
- Identify molecular pathways underlying clinical phenotypes
- Monitor treatment response through serial measurements
- Predict lab value trends using molecular signatures

 PSA
4.2 ng/mL

 ctDNA
0.15%

Correlated with Gene Expression Profiles

3 Imaging Reports

Medical imaging provides structural and functional information that, when integrated with molecular data, enables radiogenomics—the study of relationships between imaging features and genomic patterns.

 Radiology Report: 3.2cm mass, irregular margins



Imaging Modalities

- **CT/MRI:** Tumor size, morphology, and anatomical relationships
- **PET Scans:** Metabolic activity and molecular targeting (FDG-PET, PSMA-PET)
- **Pathology Imaging:** Digital histopathology and immunohistochemistry
- **Functional Imaging:** Perfusion, diffusion, and spectroscopy data

Radiogenomics Applications

- Predict molecular subtypes from imaging features using AI
- Non-invasive assessment of tumor heterogeneity
- Correlate imaging biomarkers with gene signatures
- Monitor spatial-temporal evolution of disease
- Guide biopsy sites based on molecular likelihood

Pathology: Adenocarcinoma, Grade 2/3

IHC: ER+, PR+, HER2-

NGS: PIK3CA mutation detected

Expression: Luminal A signature

Integrated Radiopathologic-Molecular Diagnosis

4 Molecular Profiles

Multi-omic molecular profiling captures the complete molecular state of a patient's disease, spanning from DNA variations to protein expression and metabolic signatures.

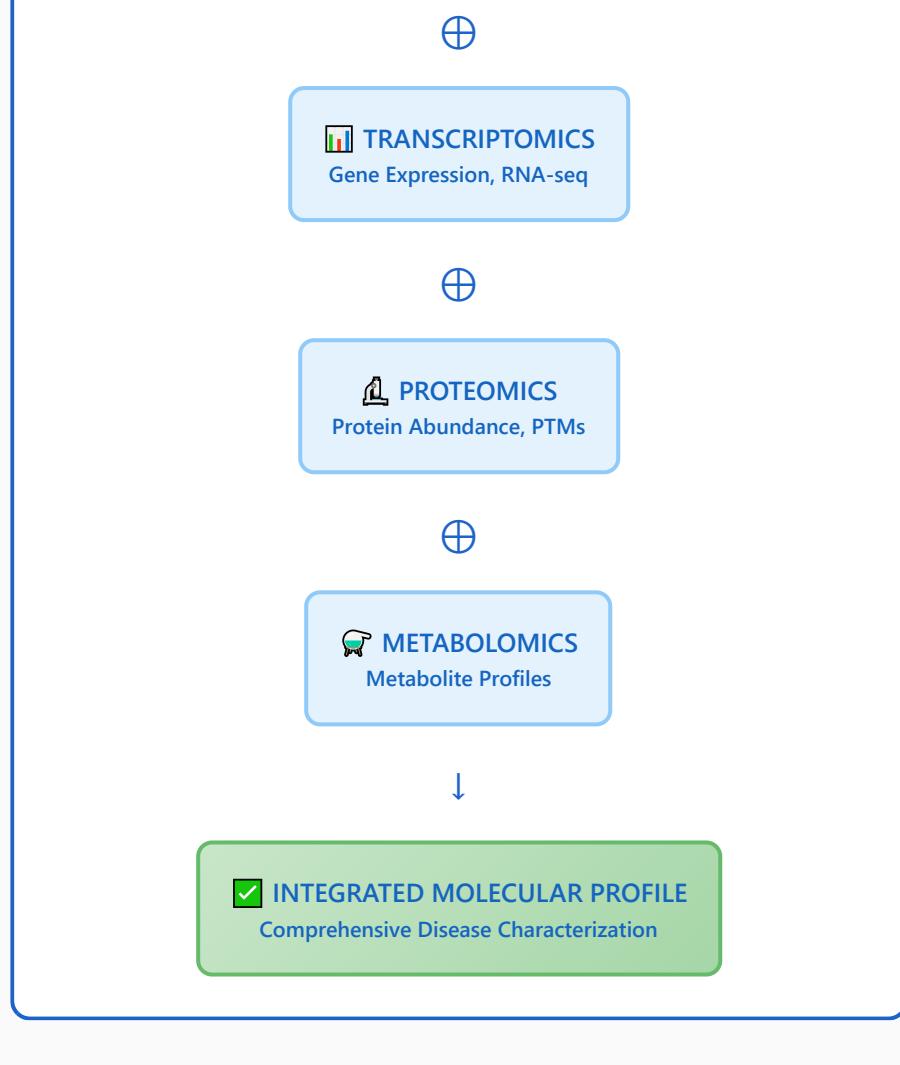
GENOMICS
Variants, CNVs, SVs

Omics Data Layers

- **Genomics:** Germline and somatic mutations, CNVs, structural variants (WGS/WES)
- **Transcriptomics:** Gene expression levels, splice variants, fusion transcripts (RNA-seq)
- **Epigenomics:** DNA methylation, histone modifications, chromatin accessibility
- **Proteomics:** Protein abundance, post-translational modifications
- **Metabolomics:** Small molecule metabolites and metabolic pathway activity

Integration Framework

- Multi-omics network analysis to identify disease drivers
- Pathway enrichment across molecular layers
- Molecular subtype classification for precision therapy
- Biomarker discovery through integrated analysis



5 Temporal Alignment

Temporal alignment is critical for understanding disease progression, treatment response, and the dynamic interplay between clinical and molecular changes over time.

Day 0: Diagnosis | Baseline Labs | Initial Genomic

Temporal Data Challenges

- **Asynchronous Sampling:** Clinical labs, imaging, and molecular assays performed at different times
- **Variable Intervals:** Irregular follow-up schedules and missing data points
- **Treatment Effects:** Therapy-induced changes complicate temporal patterns
- **Biological Lags:** Time delays between molecular changes and clinical manifestations

Alignment Strategies

- Dynamic time warping for irregular time series
- Interpolation methods for missing timepoints
- Landmark analysis anchored to clinical events (diagnosis, treatment start)
- Longitudinal modeling with mixed-effects approaches
- Causal inference to separate temporal correlation from causation

Profiling

Day 14: Treatment Start | CBC, CMP | Baseline ctDNA

Day 30: Follow-up Labs | CT Scan | ctDNA Monitoring

Day 60: Response Assessment | PET Scan | RNA-seq Analysis

Day 90: Labs | Tumor Markers | Molecular Response Profile

Outcome: Complete Response | Normalized Labs | MRD Negative