

# 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

## 1 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)



 Treatment Response Data





 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/ $\mu$ 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

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## 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.

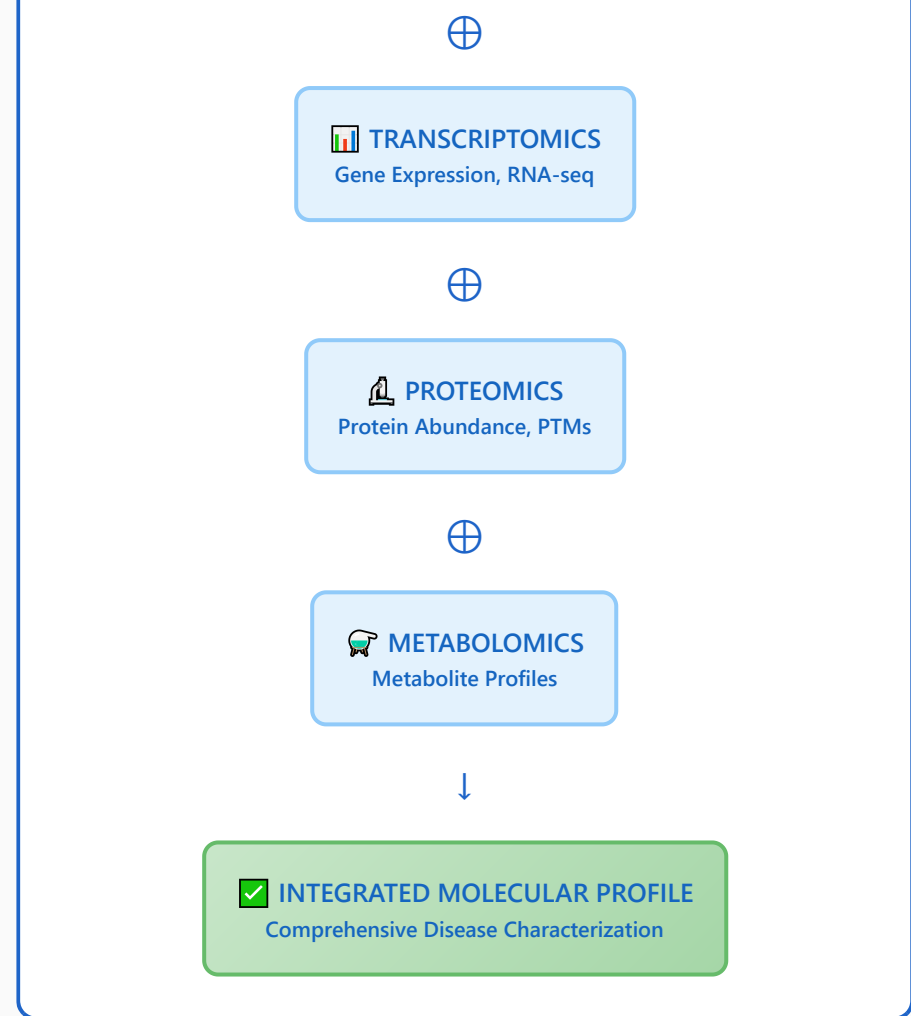
 **GENOMICS**  
Variants, CNVs, SVs

## 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

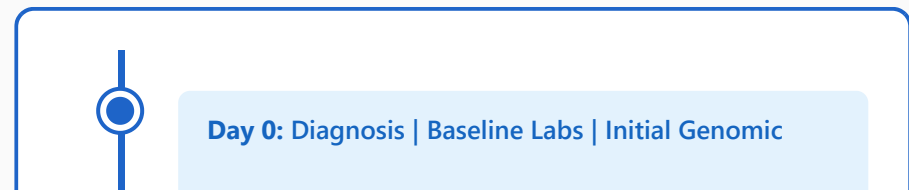
## Integration Framework

- 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.



## 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