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CSE 736- DATABASE SEMINAR

Data Integration and Genomic Medicine

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Bio2RDF: Towards a mashup to build bioinformatics knowledge systems

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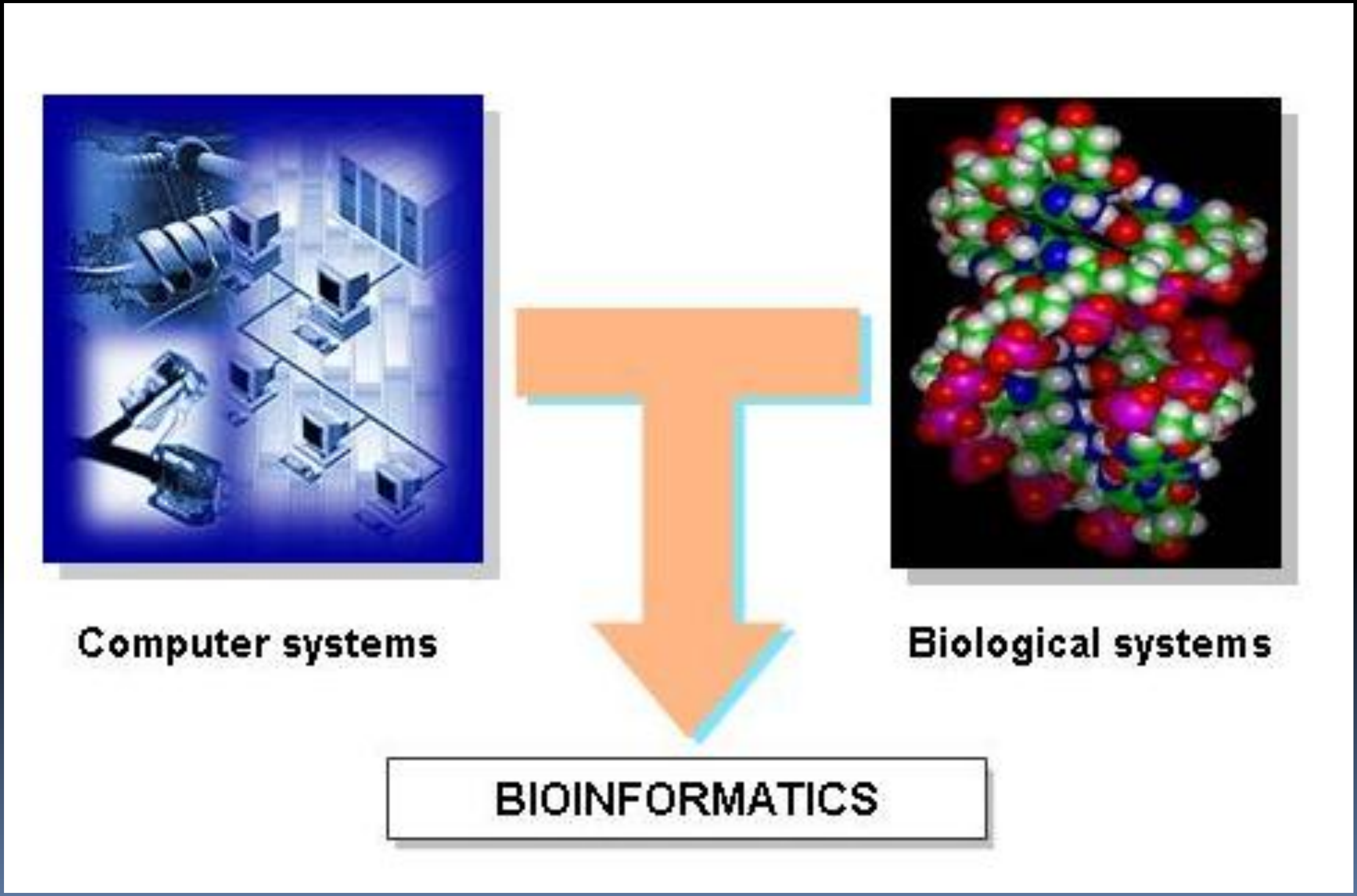
What is Bioinformatics ???

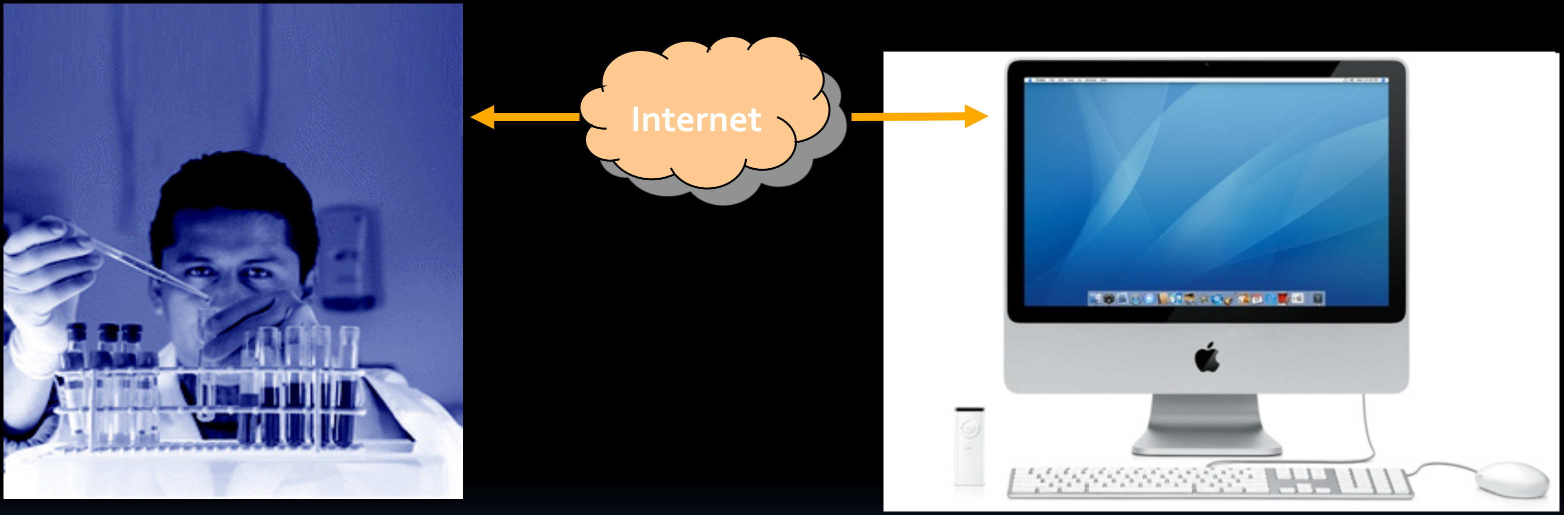


Computer systems

Biological systems

BIOINFORMATICS

Why Bioinformatics ???



Descriptive, observational science

→ Hypothesis driven

Predictive information Science

→ "Discovery" driven

RESEARCH

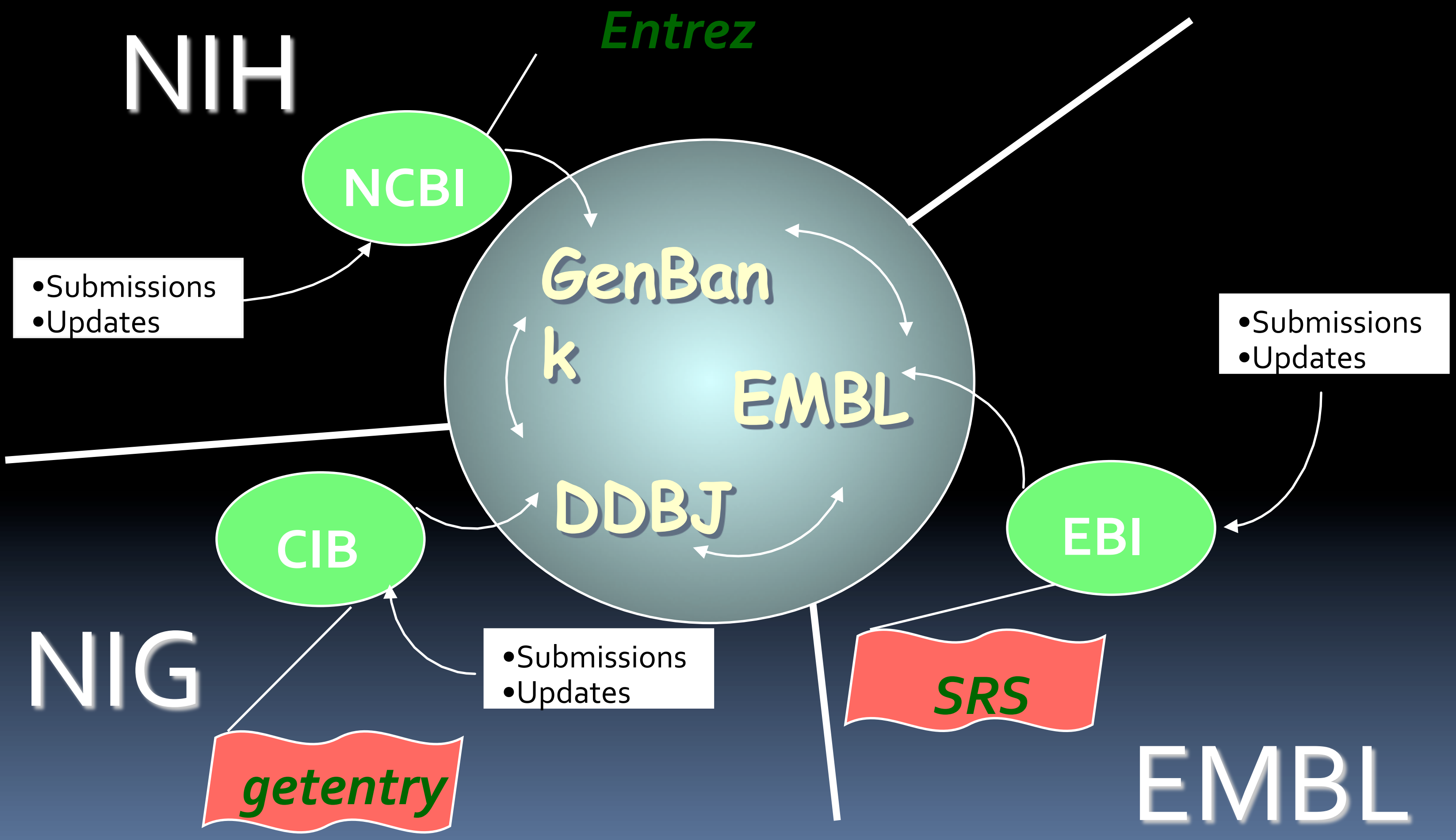
SEARCH

If not for Bioinformatics !!

- Structural Plasticity of the Human Genome (Copy number variants)
- Individual Human Variation (when a mutation is not a mutation!)
- Alternate Splicing
- Non-Coding RNAs (genes?)

None of these most important genetic discoveries would have been possible !!!

Data Integration.. Why is that important ??



Common Data Integration Architectures

- Data Warehouses
  - 👍 Fast queries and clean data
  - 👎 Stale Data,Complex Schema
- Database Federation
  - 👍 Current Data, Flexible architecture
  - 👎 Slower queries, Complex Schema, unclean Data
- Database federation with mediated schema
  - 👍 Current Data, Flexible architecture, schema tailored to users
  - 👎 Slower queries, complex schema, unclean data,mapping from source schema to mediated schema required

Peer data management systems

- 👍 Current Data,Flexible Architecture,Schema Tailored to users, Mapping between schemas distributed across peers
- 👎 Experimental, slower queries, unclean data

Two Dimensions of Data Integration

The Integration Axis

(Where the data resides)

Data and Knowledge Representation

Integration Architecture

- Data Warehouse
  - Faster Queries – non trivial for biologists since performance is often the key
  - Handling Volumes: The volume of data in this field is simply too high to handle. Updates suffer and Maintenance becomes an issue
  - Schema Restrictions: The restriction of inability to create a global schema is a deterrent since data is extremely rich
  - Best suited for specific and narrow areas of research . Eg. UCSC Genome Browser,BioMolQuest..

- Database Federations
  - Common Data Model – maintains a common data model and relies on schema mapping for integration
  - Federations relieve the temporal problems of a data warehouse since they reside at the source and are updated constantly
  - Some of the extremely difficult queries could be solved using database federations

- Database Federations with Mediated Schema
  - Dealing with Various Source Schema- This drawback of database federations is dealt by having a database federation with mediated schema
  - Federations as Middleware – The federations with mediated schema act as middleware, where data sources are mapped to mediated schema
  - Best suited to situations when researchers need to ask complex questions spanning disparate knowledge resources.

- Peer Data Management Systems
    - Tailored and Focused Mediated Schema – Developing such schemas and integrating is PDMS.
    - Each Data source provides a semantic mapping to one or more peers
    - Addresses the problem of creating a global mediated schema
    - Technology still in evolutionary stage

Data and Knowledge Representation

- Relational Schemas
  - Traditional model of table with tuples and attributes
  - Well understood and robust, but is modeling complex
  - Hierarchically structured biological data is difficult to model
  - Most common and ubiquitous

- Semi Structured Data
  - Free from rigid structures
  - Data with a series of labels and associated values
  - More natural modeling of Biological data due to features like nesting
  - Complex relationships are still difficult to model
  - XML, RDF are examples

- Ontology
  - Defined as a “specification of a conceptualization”
  - Best suited to represent semantic web
  - Specify objects classes, relationships and functions
  - Well suited for representing biological data

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  <Gene symbol="CREB-17A" organism="D. melanogaster">
    <Sequence>ACTGCGACCGCCCTGCGCT</Sequence>
    <Sequence>ACTGCGACGGCCCAGCGCT</Sequence>
    <Product>cAMP-regulated enhancer-binding protein</Product>
    <Function id="0007616" status="confirmed"><Term>long-term memory</Term></Function>
  </Gene>
  <Gene symbol="CER" organism="D. melanogaster">
    <Sequence>TTCCGTCGCTAGCT</Sequence>
    <Function id="0007616" status="inferred"><Term>long-term memory</Term></Function>
  </Gene>
</GeneList>
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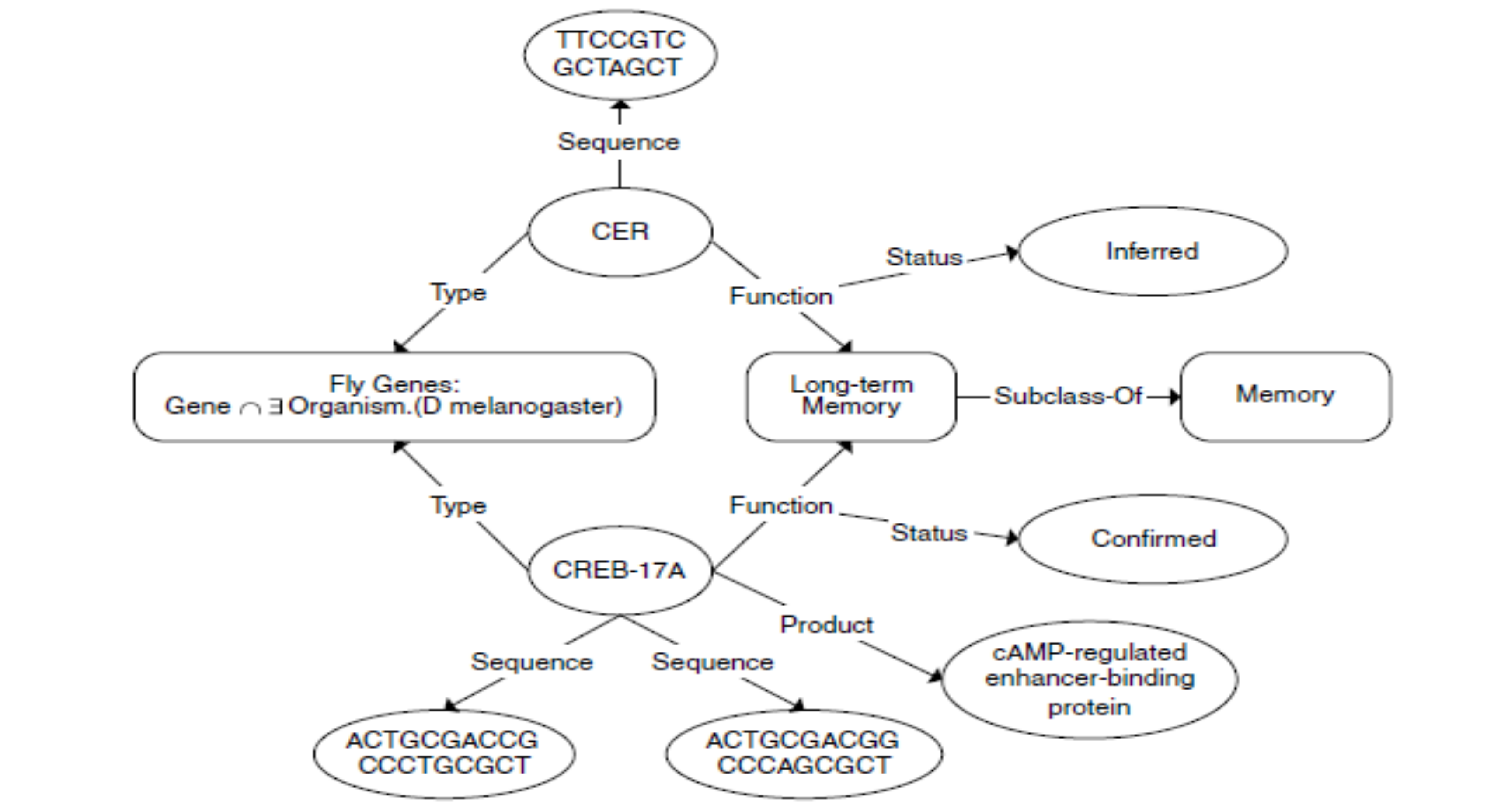
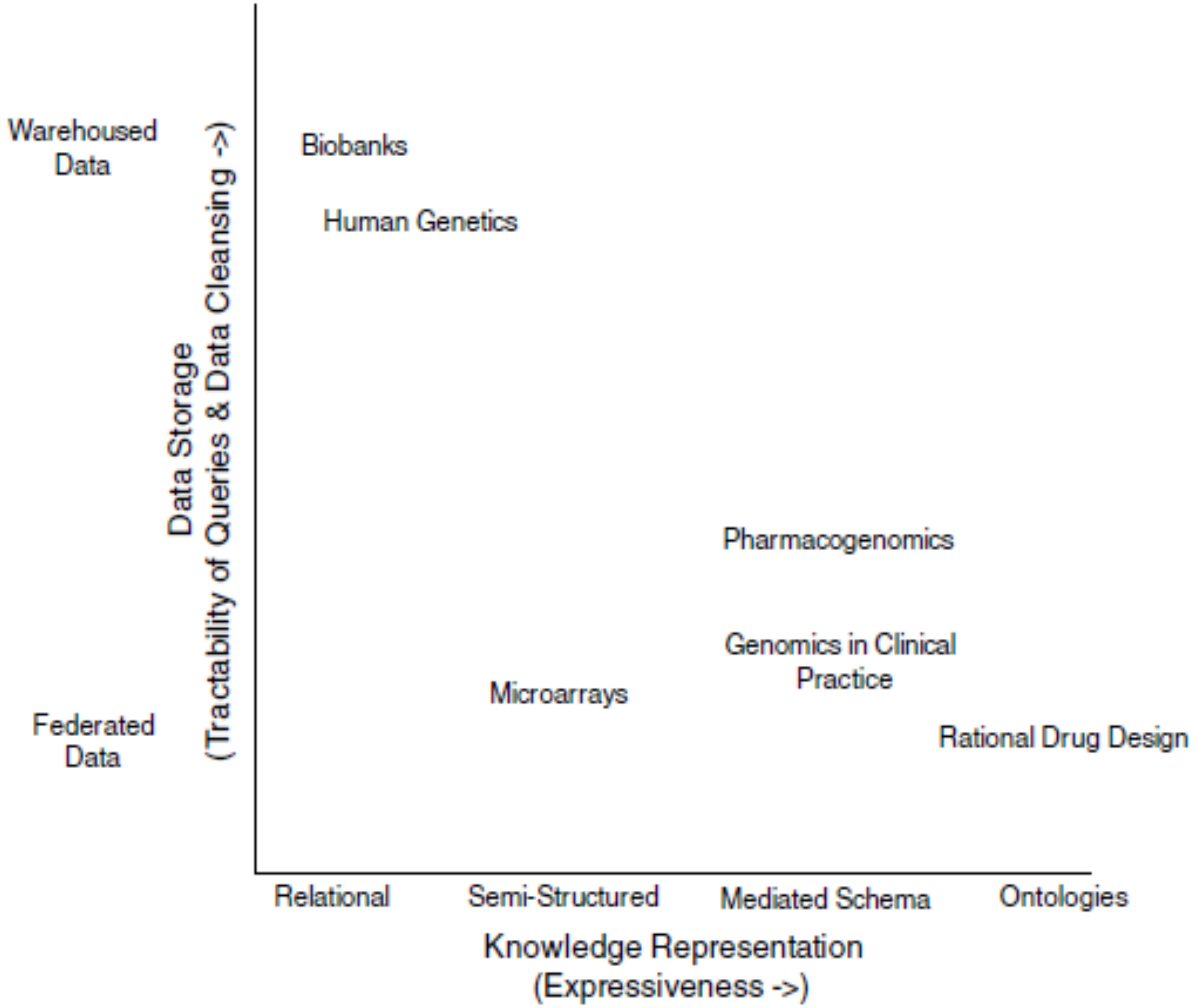


Genomic Medicine with relevance to Data Integration

- Modern Human Genetics
  - Researchers “Swim a sea of data” to study diseases and their links to genes
  - Lack of Standards, Presence of huge number of data sources makes it even more difficult
  - Queries often vague and highly complex, require join of multiple databases
  - Difficulties in combining clinical and genetic information

- Microarray Studies
  - Genes represented as spots on microarrays
  - For each experiment, external annotation needed which often come from public databases
  - Need integrated information to perform studies effectively

Application of Data Integration concepts to genomic medicine



BioBanks

- Also known as a biorepository
- A place that collects, stores, processes and distributes biological materials and the data associated with those materials
- Stored as Relational Tables
- http://www.ukbiobank.ac.uk – a public biobank

MicroArrays

- A multiplex technology used in molecular biology and in medicine
- It consists of an arrayed series of thousands of microscopic spots of DNA oligonucleotides, called features
- A repository containing microarray gene expression data is the Microarray database

Genomics in Clinical Practice and Rational Drug Design

- Technologies of Future !!! Not yet completely developed
- Some breakthrough achieved.. Drugs like Relenza to treat influenza
- Rational drug design is the creation of drugs based on the structure of the drug receptor
- Drug Design is based on the structure of the protien

Gaps in DI research to facilitate genomic medicine

- Data Availability
  - Clinical data still scarce in comparison to bioinformatics data
- Privacy
  - Issues of “De-Identification” still an issue
  - Every DNA is a Unique fingerprint
- Data issues
  - Most data available as Natural Text, More mining required

- Lack of Standards
  - Too much data, Too little standards
  - Integration of diverse complex data types including genomic,proteonomic,clinical, pharmological and chemical requires standards for proper semantic integration of heterogenous data

Questions ?????