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An open source knowledge graph ecosystem for the life sciences

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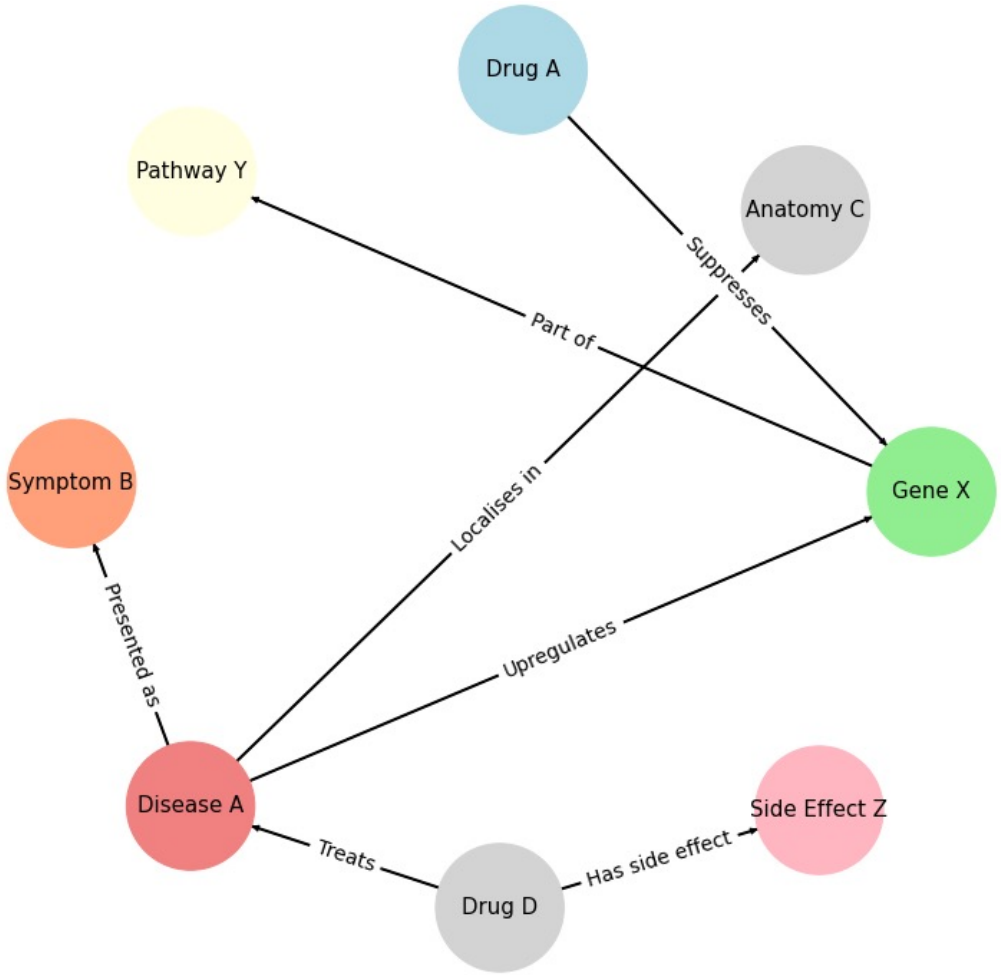
Introduction – A Knowledge Graph?



Introduction – Knowledge Graph Construction Types

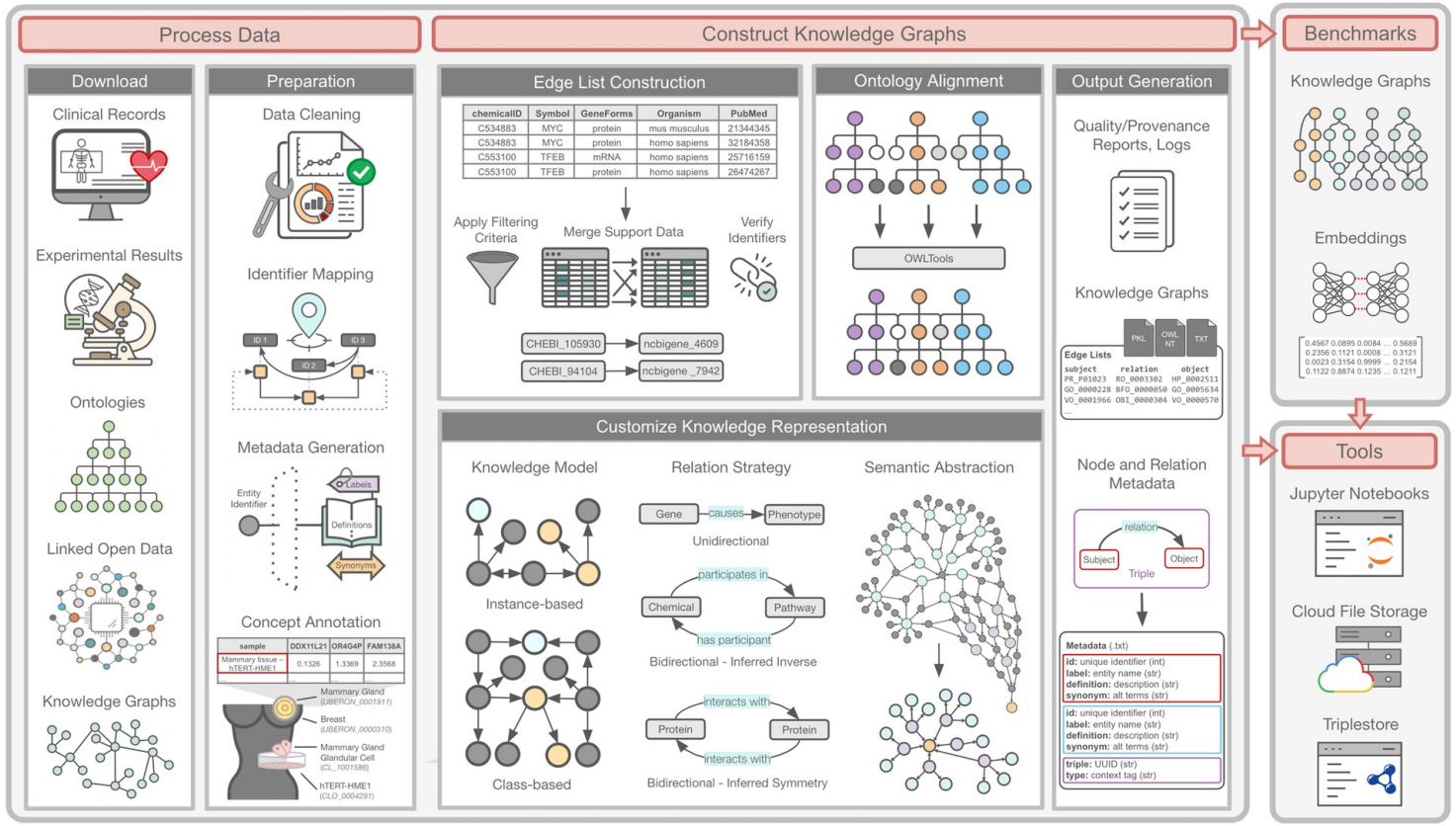
- Construction of Knowledge Graph has 3 different approaches:
  - Simple: Joining nodes as a series of edges
  - Hybrid: Join nodes as a series of edges to existing ontologies
  - Complex: Use of formal semantics with/without formal/existing ontologies

Introduction – What's the problem and the solution?

- **Problem:** Integrating data across different scales (genes, proteins, diseases) is crucial for biomedical research, but the ever-growing data available makes it difficult.

- **PheKnowLator:** A new framework that allows researchers to build KGs with customisable knowledge representation (simple, hybrid, complex). It uses FAIR principles (Findable, Accessible, Interoperable, Reusable) for KG construction.

Methods - Overview



- The **PheKnowLator** ecosystem aims to provide more comprehensive resource to aid with the construction of KGs in the Life Sciences into three components:

    1. **Component 1: KG Construction Resources**
    2. **Component 2: Benchmarking KGs**
    3. **Component 3: KG Tools**

- The **PheKnowLator** ecosystem was also assessed against functionality, availability, usability, maturity and reproducibility

Methods – Component 1: Knowledge Graph Construction Resources

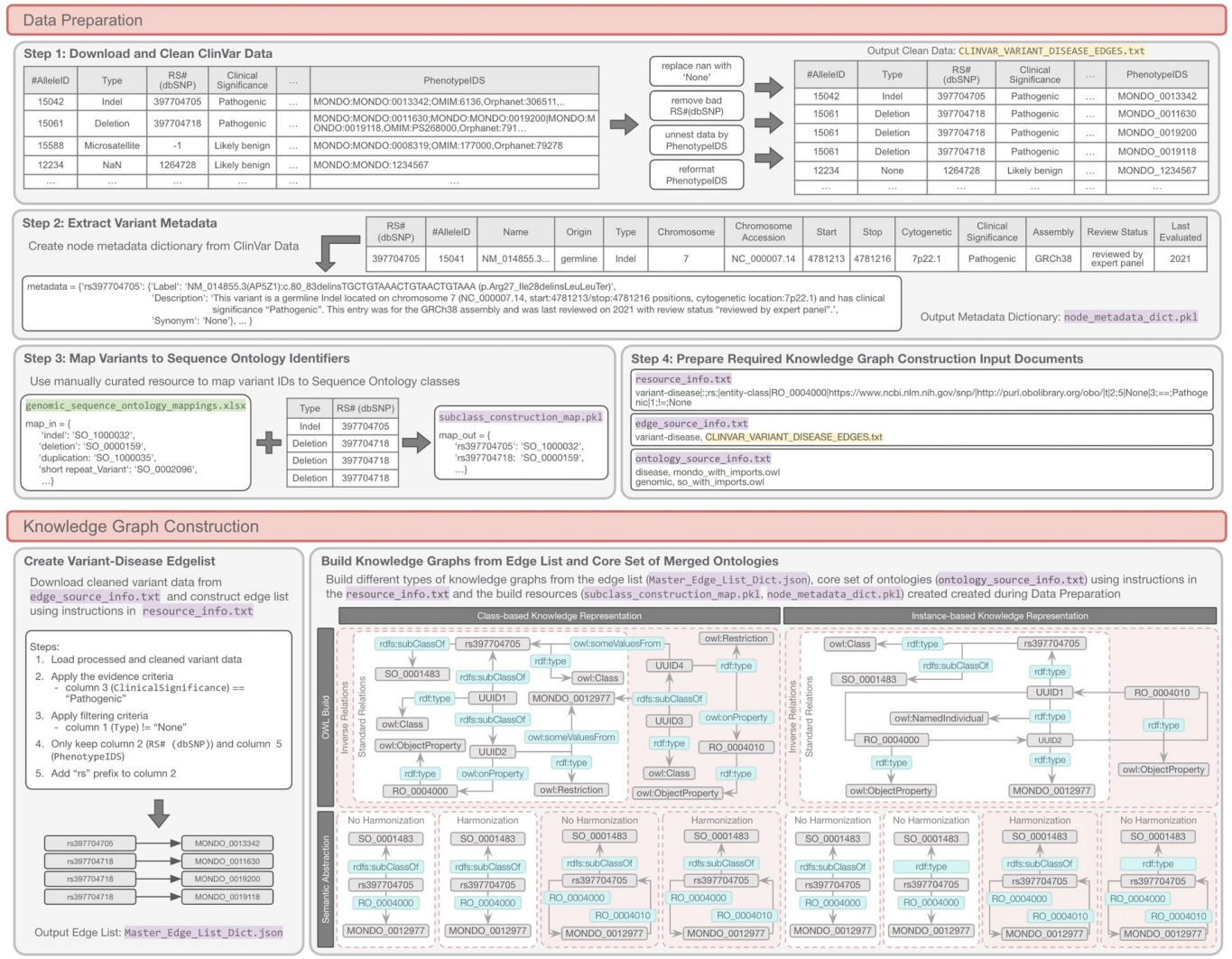
- This component is the foundation of PheKnowLator; uses various resources and algorithms to construct heterogenous KGs and has 3 key features:

1. **Processing Data:**
   - Download Data
   - Preparation of Data

2. **Constructing KGs**
   - Edge List Construction
   - Ontology Alignment
   - Customisable Knowledge Representation

3. **Output Generation**

Methods – Component 2: Knowledge Graph "Benchmarks"



- This component focuses on creating and using pre-built knowledge graphs (KGs) for benchmarking purposes
- With PheKnowLator, there can be generation of different **variations** of a KG based on <u>user-selected parameters</u>, which focus on 3 aspects of the KG:
  - Knowledge Model
  - Relation Strategy
  - Semantic Abstraction
- Component also provides embeddings
- Benefits of "benchmarking" include comparing KG structures and evaluation of downstream tasks

Methods – Component 2: Knowledge Graph "Benchmarks"

Knowledge Model	Relation Strategy	Semantic Abstraction	Variation
Class-based	Standard	OWL-NETS Only	Variation 1
Class-based	Standard	OWL-NETS + Harmonization	Variation 2
Class-based	Inverse	OWL-NETS Only	Variation 3
Class-based	Inverse	OWL-NETS + Harmonization	Variation 4
Instance-based	Standard	OWL-NETS Only	Variation 5
Instance-based	Standard	OWL-NETS + Harmonization	Variation 6
Instance-based	Inverse	OWL-NETS Only	Variation 7
Instance-based	Inverse	OWL-NETS + Harmonization	Variation 8
(Repeat above options without Semantic Abstraction)			Variation 9-12

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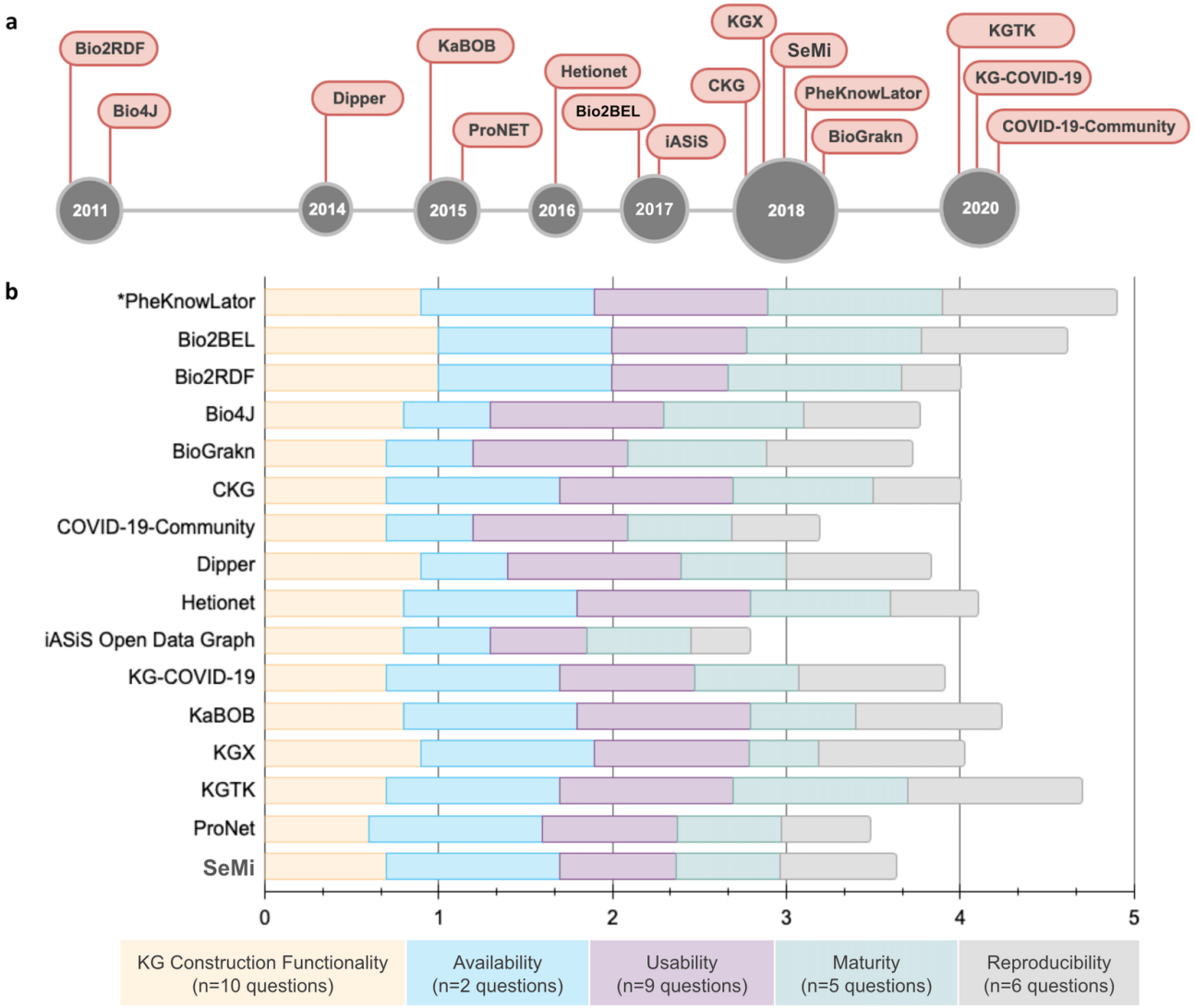
Methods – Component 3: Knowledge Graph Tools

- Component 3 provides the tools needed to analyse the KGs generated by the PheKnowLator ecosystem
- There are 5 main tools offered:
  - Jupyter Notebooks
  - Cloud-based storage
  - APIs
  - Triplestores
  - SPARQL Endpoint

Methods – FAIR Data Principles & Evaluation

- The ecosystem is built on the FAIR data principles
  - **Findability**
  - **Accessibility**
  - **Interoperability**
  - **Reusability**

Results: Systematic comparison of open-source KG construction methods



- A survey assessed 15 open-source methods on: **functionalities, availability, usability, maturity and reproducitbility** – **PheKnowLator** performed competitively across all these criteria

- PheKnowLator differentiated from these other methods in the following 4 areas:
  - Tools for assessing ontology quality
  - Logging / documentation of metadata for KG construction
  - Customisable knowledge representation for advancing reasoning techniques
  - Ability to generate multiple KG versions for benchmarking purposes

Results: Human disease knowledge graph benchmark comparison and construction performance

- 12 different KG variations were constructed for a large human disease KG

- 4 key findings
  1. Size varied depending on the chosen parameters
  2. All the benchmark KGs were **highly sparse**
  3. Semantic abstraction with instance-based models resulted in larger KGs with higher average degree
  4. Knowledge model harmonisation had minimal impact on class-based models w/ semantic abstraction

Discussion

1. PheKnowLator aims to create a unique system for creating biomedical / life science KGs

2. Strengths of this work:
    1. Customisation
    2. Advanced Analysis
    3. Real-World Applications

3. Limitations of this work:
    1. KG Method Comparison Needs Improvement
    2. Performance Metrics Incomplete
    3. Integration with New Standards
    4. Outdated Tools
    5. Validating Large KGs Challenging
    6. User-friendliness Enhancements Needed

Discussion – cont.

1. Application of this work:
    1. Identifying causal factors in diseases
    2. Predicting potential drug interactions
    3. Exploring connections between microbes and disease
    4. Developing new tools for biomedical research

Usefulness to our work?

- Identification of new research pathways

- LLMs: KnowMedLM
  - We can use this tool to build customised KGs to train LLMs for **specific biomedical tasks**

  - Better reasoning / inference to enable better prediction capabilities, i.e. of potential drug interactions based on known relationships

Thank you

PheKnowLator Tutorial - Entity Linking

https://github.com/callahantiff/PheKnowLator/blob/master/notebooks/tutorials/entity_search/Entity_Search.ipynb

PheKnowLator Paper

https://www.nature.com/articles/s41597-024-03171-w

PheKnowLator GitHub

https://github.com/callahantiff/PheKnowLator/tree/master