

**valuesets**

# **A LinkML-based Framework for Standardized Enumerations with Semantic Grounding**

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# The Problem: Data Standardization is Hard

Every project reinvents the wheel with inconsistent representations:

```
# Different datasets, same concept
vital_status = "alive"      # Dataset A
vital_status = "LIVING"    # Dataset B
vital_status = 1            # Dataset C
vital_status = "A"         # Dataset D
```

**Result:** Thousands of incompatible representations blocking data integration

# The Semantic Chasm

Despite massive infrastructure investment:

- **NLM VSAC:** 1,520+ clinical value sets
- **NCI Thesaurus:** 192,000 cancer concepts
- **NIH CDEs:** 142,000+ common data elements
- **HL7 FHIR:** Healthcare terminology standards

**Yet:** Scientific software still uses ad-hoc enumerations

**Why?** Complexity gap between terminology services and everyday programming

## The Gap: What Exists vs What Developers Need

Existing Systems Provide	Developers Actually Need
Runtime services	Compile-time artifacts
Comprehensive coverage	Common values quickly
Authentication & servers	Zero dependencies
Healthcare-focused	Cross-domain support
Complex APIs	Native enums with IDE support

# valuesets: Bridging the Gap

**Core Idea:** Compile semantically-grounded value sets into type-safe native code

A collection of common, standardized enumerations that:

- Link every value to ontology terms
- Provide Python-first convenience with multi-language support
- Built on LinkML standards
- Have zero runtime dependencies

## "Stealth Semantics" in Action

```
from valuesets.enums.core import VitalStatusEnum

status = VitalStatusEnum.ALIVE
print(status.value)           # "ALIVE"
print(status.get_meaning())   # "NCIT:C37987"
print(status.get_description()) # "Living or alive"

# Semantic interoperability across systems
if status1.get_meaning() == status2.get_meaning():
    process_compatible_records()
```

Simple interface, semantic power when needed

## Rich Metadata & Ontology Mappings

```
from valuesets.enums.bio.structural_biology import StructuralBiologyTechnique

technique = StructuralBiologyTechnique.CRYO_EM
print(technique.get_description())
# "Cryo-electron microscopy"

print(technique.get_meaning())
# "CHMO:0002413" (Chemical Methods Ontology)

print(technique.get_annotations())
# {'resolution_range': '2-30 Å typical', ...}
```

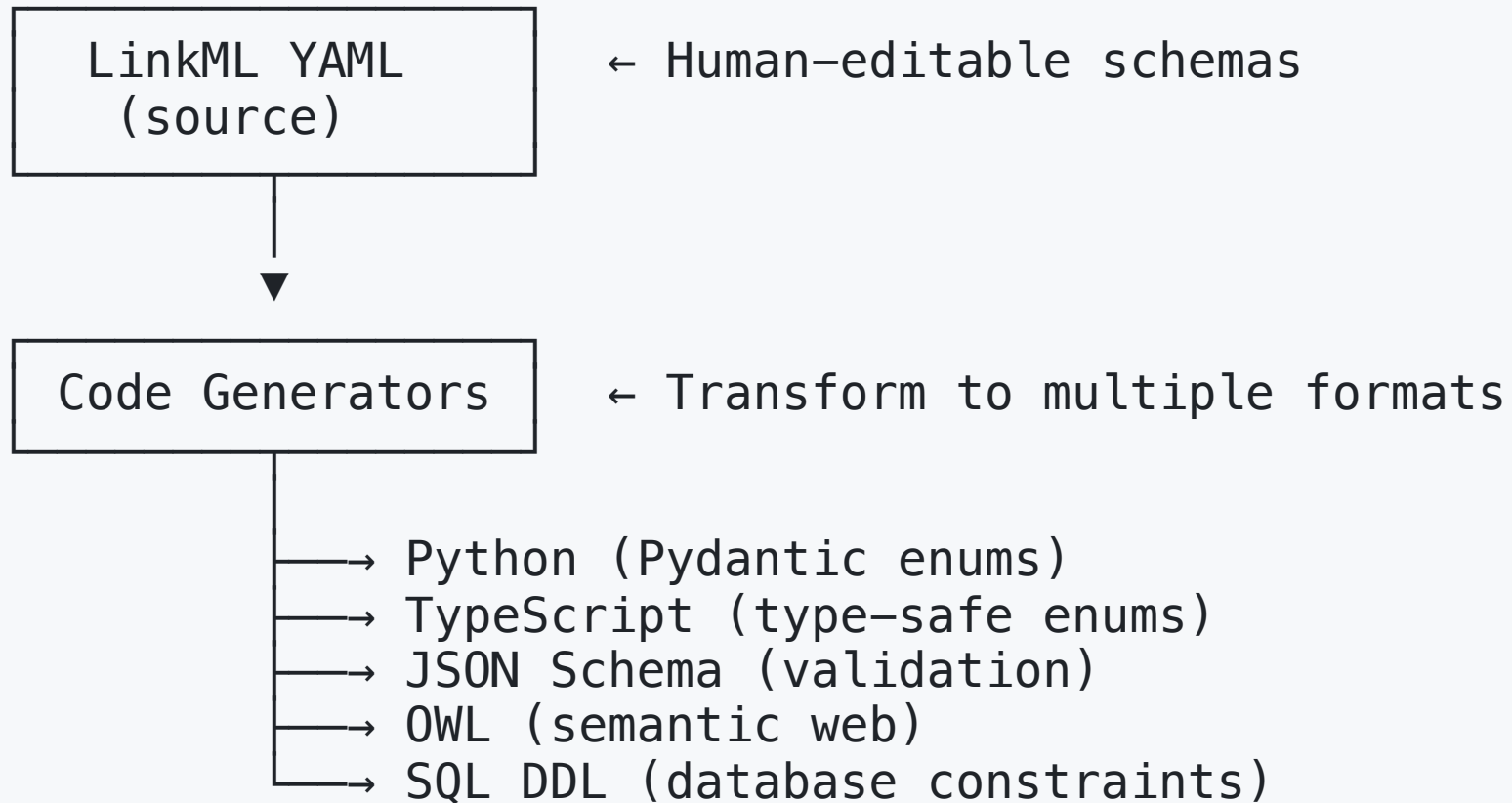
# Cross-Domain Coverage

**322 enumerations across 22 domains:**

- **Biology (127):** Taxonomy, cell biology, structural techniques
- **Physical Sciences (48):** Chemical elements, materials, structures
- **Data Science (43):** Statistical tests, ML models, quality metrics
- **Healthcare (29):** Clinical findings, vital status, demographics
- **Computing (23):** File formats, languages, maturity levels
- **Geographic & Temporal (31):** Countries, time zones, spatial relations

**78% have ontology mappings → 8,743 semantic links**

# Architecture: Build-Time not Runtime



# Progressive Semantic Enhancement

## Three levels of usage:

1. **~90% of use cases:** Simple type-safe enumerations

```
status = VitalStatusEnum.ALIVE # Just works
```

2. **~9% of use cases:** Access metadata for Uls/docs

```
label = status.get_description()
```

3. **~1% of use cases:** Full semantic integration

```
ontology_term = status.get_meaning() # "NCIT:C37987"
```

## Comparison with Established Systems

System	Scope	Access	Size	Advantage
<b>VSAC</b>	Clinical QM	API (auth)	Service	Cross-domain, no auth
<b>NCIt</b>	Cancer	500MB OWL	Service	Lightweight, simple
<b>FHIR</b>	Healthcare	Term. server	Service	Compile-time, no server
<b>valuesets</b>	Cross-domain	Native packages	<50MB	Developer-friendly

valuesets **complements** not replaces - provides practical bridge

# Design Principles

1. **Semantic Grounding:** Every value links to ontologies
2. **Developer Ergonomics:** Native enums, full IDE support
3. **Modular Organization:** Import only what you need
4. **Extensibility:** Add new enums without breaking changes
5. **Multi-format:** JSON Schema, OWL, SQL, native code
6. **FAIR Compliance:** Persistent IDs, metadata, open access

# LinkML: The Foundation

```
enums:  
  VitalStatusEnum:  
    description: Status indicating whether individual is alive or deceased  
    permissible_values:  
      ALIVE:  
        description: Living or alive  
        meaning: NCIT:C37987  
      DECEASED:  
        description: Dead or deceased  
        meaning: NCIT:C28554  
      UNKNOWN:  
        description: Vital status is not known  
        meaning: NCIT:C17998
```

Human-readable → Machine-processable → Multiple outputs

# Integration Patterns

Four primary adoption strategies:

1. **Direct Adoption:** Greenfield projects
2. **Mapping Layer:** Legacy system translation
3. **Hybrid Approach:** Dev/test vs. production
4. **Semantic Bridge:** Ontology integration

All paths support incremental adoption

# FAIR Data Principles

valuesets is FAIR-compliant:

- **Findable:** w3id.org permalinks, rich metadata
- **Accessible:** Open source, multiple formats
- **Interoperable:** LinkML, OWL, JSON-LD, FHIR
- **Reusable:** Clear licensing, documented provenance

Published as OWL ontology: <https://w3id.org/valuesets/valuesets.owl.ttl>

# OWL Rendering in Protege

ValueSetEnum > BioDomainEnum > CellCycleSchemaEnum > CellCycleCheckpoint > SPINDLE\_CHECKPOINT

Active ontology x Entities x Individuals by class x DL Query x

Annotation properties Datatypes Individuals

Classes Object properties Data properties

Class hierarchy: SPINDLE\_CHECKPOINT

Asserted

- owl:Thing
  - ValueSetEnum
    - AcademicDomainEnum
    - AnalyticalChemistryDomainEnum
      - MassSpectrometrySchemaEnum
        - AnalyticalControlType
        - ChromatographyType
        - DerivatizationMethod
        - MassSpectrometerFileFormat
        - MassSpectrometerVendor
        - MetabolomicsAssayType
          - METABOLITE\_QUANTITATION\_HPLC
          - TARGETED\_METABOLITE\_PROFILING
          - UNTARGETED\_METABOLITE\_PROFILING
  - BioDomainEnum
    - BioEntitiesSchemaEnum
    - BiologicalColorsSchemaEnum
    - CellCycleSchemaEnum
      - CellCycleCheckpoint
        - G1\_S\_CHECKPOINT
        - G2\_M\_CHECKPOINT
        - INTRA\_S\_CHECKPOINT
        - SPINDLE\_CHECKPOINT
      - CellCyclePhase
      - CellCycleRegulator
      - CellProliferationState
      - DNADamageResponse

SPINDLE\_CHECKPOINT — GO:0031577 — [http://purl.obolibrary.org/obo/GO\\_0031577](http://purl.obolibrary.org/obo/GO_0031577)

Annotations Usage

Annotations: SPINDLE\_CHECKPOINT

Annotations +

- rdfs:label  
SPINDLE\_CHECKPOINT
- skos:definition  
Spindle checkpoint (M checkpoint)
- aliases  
SAC, spindle assembly checkpoint
- dcterms:title  
spindle checkpoint signaling
- function  
ensures proper chromosome attachment

Description: SPINDLE\_CHECKPOINT

Equivalent To +

SubClass Of +

- CellCycleCheckpoint

General class axioms +

SubClass Of (Anonymous Ancestor)

- G1\_S\_CHECKPOINT or G2\_M\_CHECKPOINT or INTRA\_S\_CHECKPOINT or SPINDLE\_CHECKPOINT

Instances +

# Quality Assurance

Automated validation on every commit:

Validation Type	Coverage	Purpose
Syntax	100% schemas	LinkML compliance
Semantic	All mappings	Ontology term verification
Cross-reference	All namespaces	External reference resolution
Completeness	All enums	Missing descriptions/mappings
Consistency	All values	Duplicate detection

# Dynamic Enums (Coming Soon)

**Current:** Static values with ontology mappings

**Future:** Runtime expansion from ontologies

```
CellTypeEnum:  
  reachable_from:  
    source_ontology: obo:cl  
    source_nodes:  
      - CL:0000540  # neuron  
    relationship_types:  
      - rdfs:subClassOf
```

Hybrid: static core + dynamic expansion for comprehensive coverage

# Future Directions

## Coverage Expansion:

- Social sciences, engineering, humanities

## Technical Enhancements:

- Web-based validation APIs
- AI-assisted mapping tools
- Enhanced dynamic enum support

## Governance:

- Domain-specific editorial committees
- Formal deprecation policies
- Maturity level indicators

# Sustainability Through Simplicity

## Technical Sustainability:

- Zero runtime dependencies
- No infrastructure costs
- Works offline, on laptops

## Social Sustainability:

- Low barrier to contribution (edit YAML)
- Community-driven development
- Clear exit strategies

## Economic Sustainability:

- No hosting/licensing costs

## By the Numbers

Metric	Count
Enumerations	322
Permissible Values	7,512
Ontology Namespaces	117
Semantic Mappings	8,743
Domain Modules	22
Schemas	68
Ontology Mapping Coverage	78%

# Quick Start

```
# Install
pip install valuesets

# Use immediately
from valuesets.enums.bio.taxonomy import CommonOrganismTaxaEnum
from valuesets.enums.core import VitalStatusEnum

human = CommonOrganismTaxaEnum.HUMAN
print(human.get_meaning()) # "NCBITaxon:9606"

status = VitalStatusEnum.ALIVE
print(status.get_meaning()) # "NCIT:C37987"
```

**5-minute experience:** Value within 5 minutes of discovery

# Contributing

We welcome contributions from:

- **Domain Experts:** Add value sets for your field
- **Developers:** Improve tooling, fix issues
- **Users:** Report missing enums, share use cases

## Process:

1. Edit YAML schema files
2. Add ontology mappings (use OLS)
3. Include descriptions and examples
4. Submit pull request

See: `CONTRIBUTING.md`

## Development Commands

```
# Using just command runner
just --list      # Show all commands
just test       # Run tests
just doctest    # Run doctests
just validate   # Validate schemas
just site       # Build documentation
```

All managed through modern development workflows

## Resources

- **Docs:** <https://linkml.io/valuesets/>
- **Repository:** <https://github.com/linkml/common-value-sets>
- **PyPI:** <https://pypi.org/project/valuesets/>
- **OWL Ontology:** <https://w3id.org/valuesets/valuesets.owl.ttl>
- **LinkML:** <https://linkml.io/>

## Key Insight

"The problem is not missing standards but mismatched abstractions"

**valuesets bridges the gap:**

- Terminology services → Terminology artifacts
- Runtime flexibility → Compile-time guarantees
- Institutional deployment → Developer laptops

Making semantic standards accessible to everyday programming

# valuesets

## Making Data Standardization Simple, Semantic, and Scalable

Try it today:

```
pip install valuesets
```

Questions?

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# Appendix: Example Domains

## Biological Sciences:

- Taxonomy (NCBI), Cell types (CL), Cell cycle (GO)
- Gene Ontology evidence codes
- Structural biology techniques (CHMO)
- Model organisms

## Data Science:

- Statistical tests (STATO)
- ML model types, dataset splits
- Data quality indicators

## Clinical/Healthcare:

## Appendix: Semantic Web Integration

```
from valuesets.enums.bio.cell_cycle import CellCyclePhase

# Generate SPARQL query
phase = CellCyclePhase.S_PHASE
go_term = phase.get_meaning() # "GO:0000084"

sparql = f"""
SELECT ?gene ?function
WHERE {{
    ?gene cellCyclePhase <{go_term}> .
    ?gene hasFunction ?function .
}}
"""
```

Seamless integration with knowledge graphs

# Appendix: Multi-Language Support

## Current:

- Python (Pydantic enums)
- TypeScript (type-safe)
- JSON Schema
- OWL/RDF

## Planned:

- Java
- R
- Julia
- Rust

LinkML generates idiomatic code for each language

# Credits & Acknowledgments

## Contributors:

- **Christopher J. Mungall** - Lawrence Berkeley National Laboratory
- **Justin Reese** - Lawrence Berkeley National Laboratory

## Built with:

- **LinkML** - Linked Data Modeling Language
- **linkml-project-copier** - Project template
- **OBO Foundry** - Biological ontologies
- **OLS/BioPortal** - Ontology lookup services

Open source • MIT License • Community-driven