

A biologists' perspective on ontology utility

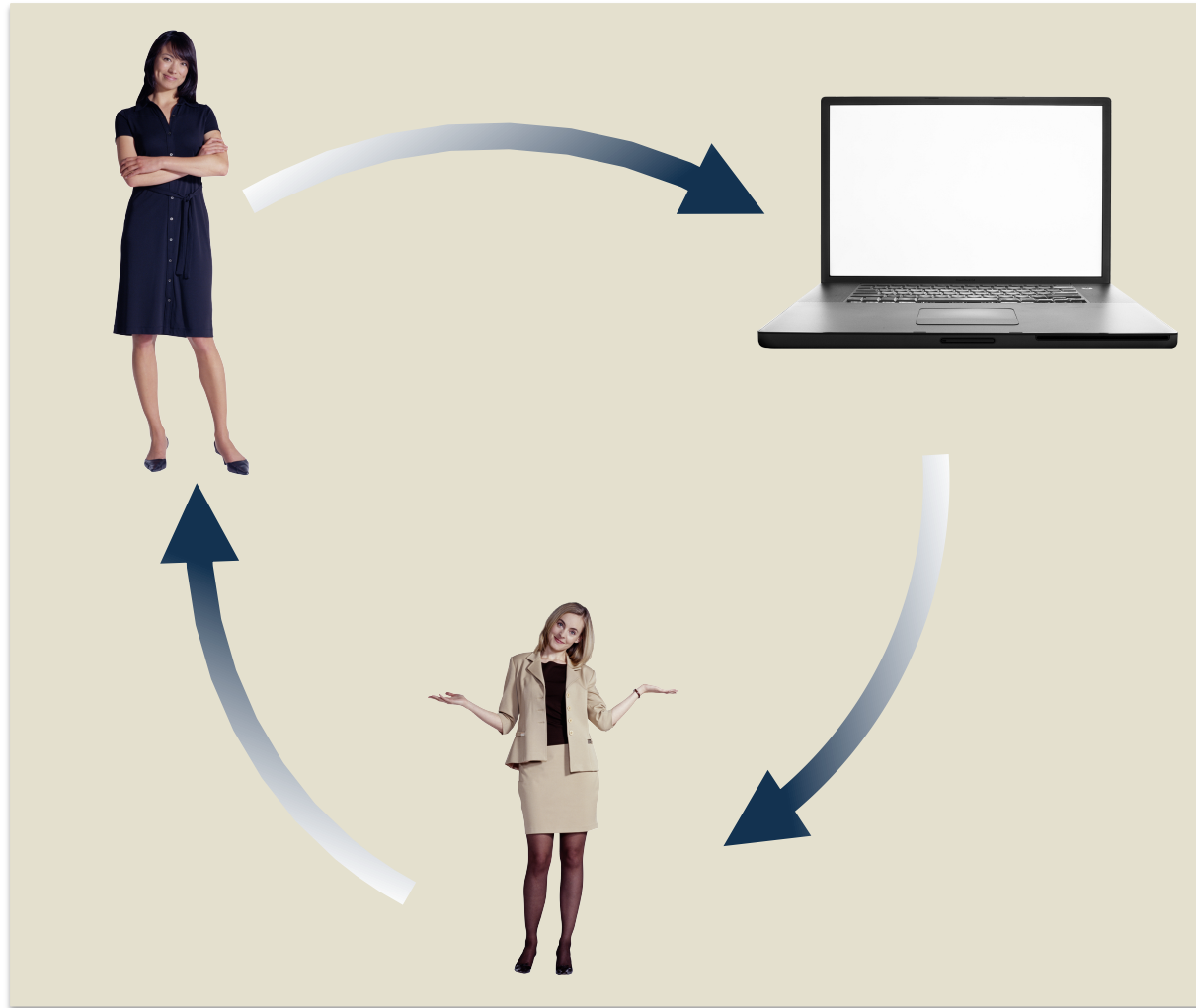
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What do biologists need from an ontology?

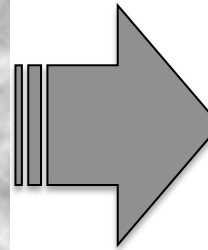
Need it to communicate with each other and computers



What do biologists need from an ontology?

Need to apply ontologies to data:

- Annotation
- Structuring
- Mapping



Name	Type	Strain
CD4 knockout	Mouse	C57BL/6
OTI	Mouse	C57BL/6
CD4 knockout	Rat	Wistar

IN A CONSISTENT MANNER

Search and classify data:

Query:

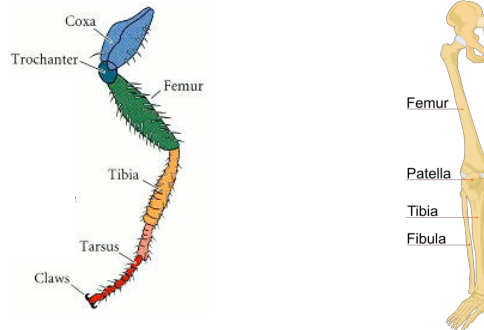
Find organisms on C57BL/6 background

Name	Type	Strain
CD4 knockout	Mouse	C57BL/6
OTI	Mouse	C57BL/6

Biologists have issues

Biology is particularly challenging due to moving conceptual targets (e.g. gene, allele)

Biologists like to re-use the same labels left and right



Biologists often don't agree on how to define key concepts!

**How to achieve these goals and
address these issues?**

Quality textual documentation and definitions

Seems simple . . .

Quality textual documentation and definitions

- Definitions must not only describe a concept, but allow determination of real instances
 - Requires consideration of specific and precise concepts to be defined
 - This is where listing out properties and their use for definition are very helpful
- => Need a 'concept first approach' to definition creation**

A 'Concept-First Approach' Example

- Terminology of molecular labels is inconsistent: 'probe', 'tracer', 'detector', 'reporter', used variably to describe reagents with different characteristics
- Conformance to varied label conventions has led to confusion, ambiguity, and inconsistency in different ontologies
- Throw out the labels and consider the biologically important axes:

Axis 1 = Targeting: ability to specifically associate with a molecular target

Axis 2 = Detectability: ability to emit or produce some detectable signal

A 'Concept-First Approach' Example

Axes applied to yield a set of principled subclasses, and a more descriptive labeling scheme is applied

AXIS 2: DETECTABILITY

		YES	NO
<u>AXIS 1: TARGETING</u>	NO	COVALENT REPORTER (Alexafluors, radioactive nucleotides)	COVALENT TRACKER (biotin, digoxigenin)
	YES	TARGETED REPORTER (DAPI, coomassie, labeled oligo probes)	TARGETED TRACKER (unlabeled antibodies, oligo probes)

Results vetted by members of different stakeholder communities

Label Bias

- A common source of problems is developers imposing assumptions about the semantic content of a label.
- Best to avoid using terms with varied and ambiguous meaning as primary labels . . .
 - e.g. ‘molecular probe’, ‘cell line’,. . . or be careful to document this ambiguity, and give a precise definition that is clear about its specific view
- OBO Foundry principle suggests use of numeric URIs which helps avoid label bias.
 - e.g. URIs not like <http://xyzweb.org/ont/core#Position>
 - But instead like: http://xyzweb.org/ont/core_43888887

Evaluating text definitions

- Are all classes and properties defined? Do they avoid use of figurative or obscure language? Are there citations?
- Are essential features for distinguishing from other classes included?
 - Aristotelian/genus-differentia structure is good for this
 - Especially important for imported classes
- Is circularity avoided?
 - e.g. 'specimen collection objective' defined as the 'objective to collect a specimen'
- Are there clear instances in reality? Test against a set of candidate instances

Testing Definitions Against Instances

Example: 'genetic material'

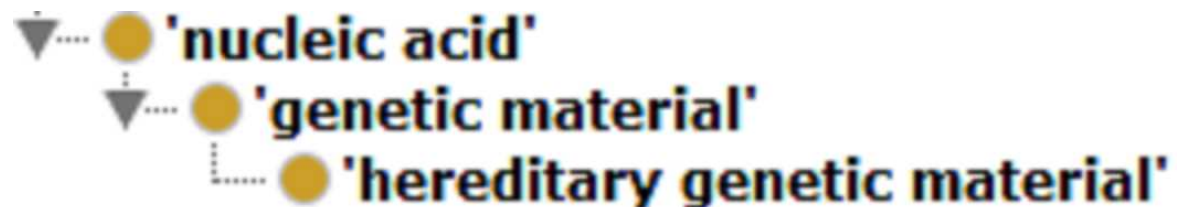
- complex and nuanced concept, subject to varied interpretations
- precise definition needed for use in diverse research communities (genomics, experimental biology, model organisms)
- many definitions found on web are correct but vague and insufficient (not precise enough to delineate instances in reality)
- e.g. *“material of plant, animal, microbial or other origin containing functional units of heredity”*

Testing Definitions Against Instances

- A more precise definition
 - “a nucleic acid macromolecule that is part of a cell or virion and has the disposition to be replicated and inherited by descendants.”
- Start testing against instances
 1. chromosomal DNA in dividing cells
 2. chromosomal DNA in post-mitotic cells
- Problem encountered already: a disposition for replication is not relevant in post-mitotic cells
- Solution: Refine Definition
 - “a nucleic acid macromolecule that is part of a cell or virion and is inherited from an immediate ancestor, or incorporated in a manner that it has the disposition to be replicated and inherited by descendants.”

Testing Definitions Against Instances

- Continue testing against instances
 3. a gene targeting DNA construct transfected into a cell
 4. a transiently transfected DNA expression construct
 5. a microinjected siRNA oligo in a cell
- Problem: some instances expected to be grouped with genetic material, but don't meet our strict definition
- Solution:
 1. Rename original class with more descriptive label 'hereditary genetic material', and
 2. Implement new 'genetic material' as a more inclusive parent class



Other Textual Documentation

- Does the ontology include extensive synonyms?
- Does the ontology include other internal documentation such as edit history? Creator/editor? Status? Modeling notes?
- Are there examples of usage? Counter examples?
 - Sometimes a concept is so complex that a definition cannot disambiguate exclusion or inclusion.

Example of a difficult to define entity

Reagent:

a material entity that bears a reagent role by virtue of it being intended for application in a scientific technique to participate in (or have molecular parts that participate in) a chemical reaction that facilitates the generation of data about some distinct entity, or the generation of some distinct material specified output

A ph meter probe fits our best definition, but is not considered a reagent by biologists =>> document!

Is there complete metadata?

- Can use scripts to check ontology for a number of important metadata bits
 - missing definitions, labels, source, example of usage
 - duplicate labels
 - mismatched synonyms
- Inclusion of some sort of curation status or metadata complete annotation to indicate readiness of entities

2. Quality logical expressions

- No true path violations
 - Common mistakes are to forget that the distant ancestors definitions apply, and misunderstandings about transitive properties. These are not always caught by reasoners.
- A balance of realism and practicality
 - Are the concepts as expressed in the text definition aligned with the logical expressions?
 - Are there many concepts used in logical expressions for which there would be no instances collected?
 - Does the inferred classification makes sense biologically?

3. Ontology reuse

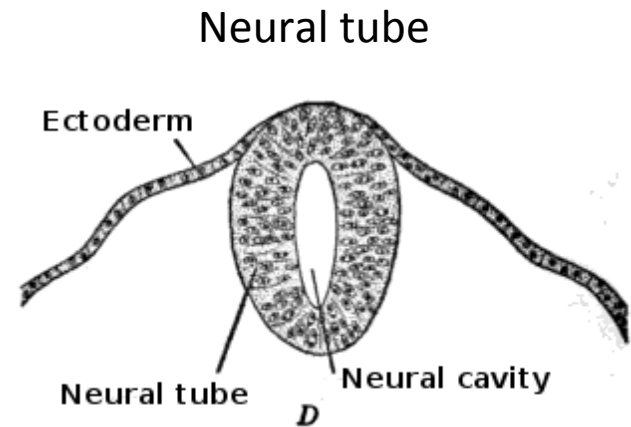
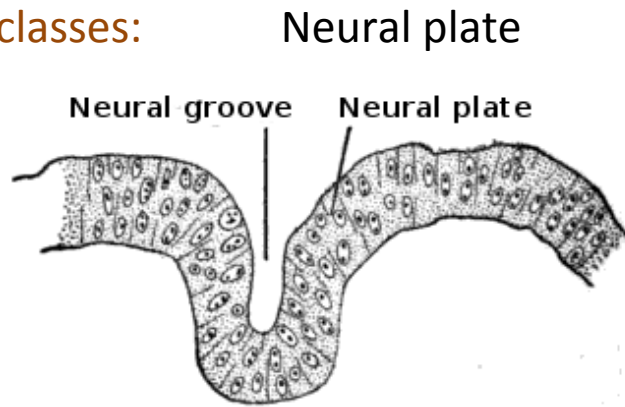
- Is the ontology orthogonal to others (an OBO principle)?
- Does the ontology reuse entities from other ontologies at key intersection points?
- Does the ontology include a subset of external entities with the closure, or import entire external ontologies?

Testing the ontology against data

- It is important to validate the ontology against real data. But this is the intrinsic talk, you might say.....
- Data often tells you that your ontology has errors.

Iterative data-ontology evaluation

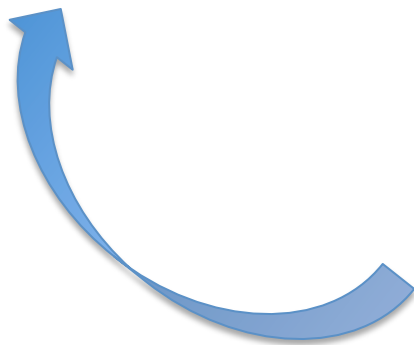
Ontology classes:



Ontology stage class definitions:

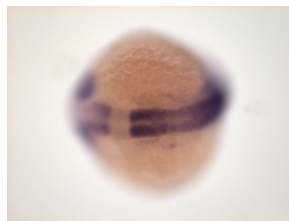
5-9 somites->10-13 somites

10-13 somites->prim5

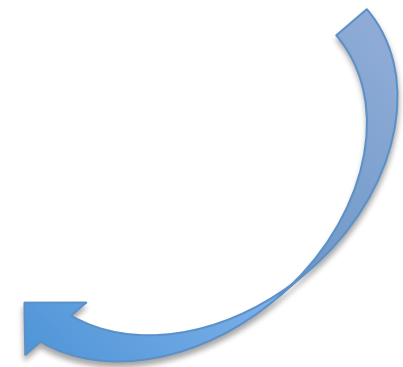


Instance data:

Neural tube



9 somites



Neural plate or neural tube?

Ongoing intrinsic issues for development of biological ontologies

- Lacking tools to enable visualization/editing via other transitive relations
- Better ability to synchronize pieces of ontologies reused in another ontology
- Standards for documentation, annotation properties and layering/import approaches for documenting in ontologies themselves, mechanisms for linking out to trackers/lists, wikis
- Better ways to roll together text definitions from dependent classes

Special Thanks

Matt Brush

Scott Hoffman

Pioneers in our group to make all ontologies usable by more people.