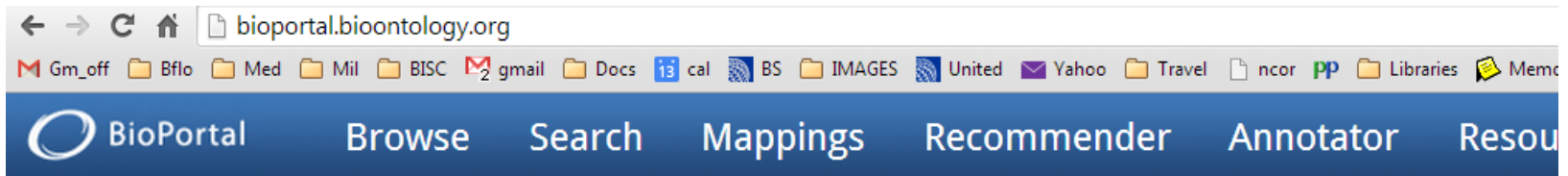


Building Ontologies with Basic Formal Ontology

Barry Smith

March 17, 2017



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Most Viewed Ontologies

Ontology	Views
SNOMED Clinical Terms	13,601
National Drug File	9,320
MedDRA	4,254
International Classification of Diseases	3,415
NCI Thesaurus	1,528

Latest Notes

[Wet Mass \(Santa Barbara Coastal Observation Ontology\)](#)
about 1 month ago by leinfelder
This could be considered Wet Weight as well.

[test \(Chemical Entities of Biological Interest Ontology\)](#)
about 1 month ago by steschu
test by stefan to see whether bioportal notes arrive

[New Term Proposal-lzXVqSUMoQCQc \(Radiology Lexicon\)](#)

Browse

Access all ontologies that are available in NCBO BioPortal: You can filter this list by category to display ontologies relevant for a certain domain. You can also filter ontologies that belong to a certain group. [Subscribe to the NCBO BioPortal RSS feed](#) to receive alerts for submissions of new ontologies, new versions of ontologies, new notes, and new projects. You can subscribe to feeds for a specific ontology at the individual ontology page. Add a new ontology to NCBO BioPortal using the Submit New Ontology link (you need to [sign in](#) to see this link).

Showing 19 of 19 Sort: Popular

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- Entry Type**
- Ontology (19)
 - Ontology View (0)
 - CIMI Model (0)
 - NLM Value Set (0)

Uploaded in the Last

Category

Group

- Format**
- OWL (18)
 - UMLS (1)

Organization ontology (ORGO)

ORGO describes a core ontology for organizational structures, aimed at supporting linked data publishing of organizational information across a number of domains

Uploaded: 8/8/16

classes
15

FALCON Ontology (FALCONTO)

FALCON ontology comes to play a pivotal role, offering a semantic model

Uploaded: 9/14/16

classes
41

PROMISE Semantic Object Model (SOM)

PROMISE semantic object model was made for supporting Closed-Loop Product Lifecycle Management.

Uploaded: 8/9/16

classes
62

IT Service Management Ontology (ITSMO)

classes



<http://bioportal.bioontology.org/search?q=obesity>

Class Search

Search for a class in multiple ontologies [?](#)

Search

[advanced options](#)

Matches in:

[Obesity - Systematized Nomenclature of Medicine - Clinical Terms \(SNOMEDCT\)](#)

<http://purl.bioontology.org/ontology/SNOMEDCT/414916001>

[details](#) - [visualize](#) - [22 more from this ontology](#)

[Obesity - National Cancer Institute Thesaurus \(NCIT\)](#)

<http://ncicb.nci.nih.gov/xml/owl/EVS/Thesaurus.owl#C3283>

Having a high amount of body fat (body mass index [BMI] of 30 or more).

[details](#) - [visualize](#) - [4 more from this ontology](#)

[obesity - Human Disease Ontology \(DOID\)](#)

http://purl.obolibrary.org/obo/DOID_9970

OMIM mapping confirmed by DO. [SN].

[details](#) - [visualize](#)

Class Search

Search for a class in multiple ontologies [?](#)

[advanced options](#)

[Matches in 35 ontologies](#)

[Obesity - Systematized Nomenclature of Medicine - Clinical Terms \(SNOMEDCT\)](#)

<http://purl.bioontology.org/ontology/SNOMEDCT/414916001>

[details](#) - [visualize](#) - [22 more from this ontology](#)

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[details](#) - [visualize](#) - [4 more from this ontology](#)

[obesity - Human Disease Ontology \(DOID\)](#)

http://purl.obolibrary.org/obo/DOID_9970

OMIM mapping confirmed by DO. [SN].

[details](#) - [visualize](#)

Additional References from other Ontologies

[obesity - Natural Products Ontology \(NATPRO\)](#)

http://www.owl-ontologies.com/NPOntology.owl#DOID_9970

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Obesity, unspecified - Suggested Ontology for Pharmacogenomics \(SOPHARM\)](#)

http://www.loria.fr/~coulet/ontology/sopharm/version2.1/disease_ontology.owl#DOID_1480

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Obesity - Medical Dictionary for Regulatory Activities \(MEDDRA\)](#)

<http://purl.bioontology.org/ontology/MEDDRA/10029883>

[details](#) - [visualize](#) - [7 more from this ontology](#)

[Obesity - Human Phenotype Ontology \(HP\)](#)

http://purl.obolibrary.org/obo/HP_0001513

[details](#) - [visualize](#)

Additional References from other Ontologies

[Obesity - Bone Dysplasia Ontology \(BDO\)](#)

http://purl.org/obo/owl/HP#HP_0001513

[details](#) - [visualize](#) - [1 more from this ontology](#)

[obesity - Experimental Factor Ontology \(EFO\)](#)

http://www.ebi.ac.uk/efo/EFO_0001073

An eating-related disorder in which excess body fat has accumulated to such an extent that health may be negatively affected. It is commonly defined as a body mass index (weight divided by height squared) of ...

[details](#) - [visualize](#) - [3 more from this ontology](#)

Additional References from other Ontologies

[obesity - Cell Line Ontology \(CLO\)](#)

http://www.ebi.ac.uk/efo/EFO_0001073

An eating-related disorder in which excess body fat has accumulated to such an extent that health may be negatively affected. It is commonly defined as a body mass index (weight divided by height squared) of ...

[details](#) - [visualize](#)

[obesity - Cell Culture Ontology \(CCONT\)](#)

http://www.ebi.ac.uk/efo/EFO_0001073

[Obesity - Medical Subject Headings \(MESH\)](#)

<http://purl.bioontology.org/ontology/MSH/D009765>

A status with BODY WEIGHT that is grossly above the acceptable or desirable weight, usually due to accumulation of excess FATS in the body. The standards may vary with age, sex, genetic or cultural background. ...

[details](#) - [visualize](#) - [3 more from this ontology](#)

Additional References from other Ontologies

[Obesity - Robert Hoehndorf Version of MeSH \(RH-MESH\)](#)

<http://phenomebrowser.net/ontologies/mesh/mesh.owl#G07.100.100.160.120.699.500>

[details](#) - [visualize](#) - [15 more from this ontology](#)

[Obesity - Online Mendelian Inheritance in Man \(OMIM\)](#)

<http://purl.bioontology.org/ontology/OMIM/MTHU000250>

[details](#) - [visualize](#) - [23 more from this ontology](#)

[Obesity - International Classification of Diseases, Version 10 \(ICD10\)](#)

<http://purl.bioontology.org/ontology/ICD10/E66>

[details](#) - [visualize](#) - [2 more from this ontology](#)

[Obesity - Read Codes, Clinical Terms Version 3 \(CTV3\) \(RCD\)](#)

<http://purl.bioontology.org/ontology/RCD/C380>

[details](#) - [visualize](#) - [9 more from this ontology](#)

[Obesity - Neuroscience Information Framework \(NIF\) Standard Ontology \(NIFSTD\)](#)

http://ontology.neuinfo.org/NIF/Dysfunction/NIF-Dysfunction.owl#nbc_dys_20090302

An eating-related disorder in which excess body fat has accumulated to such an extent that health may be negatively affected. It is commonly defined as a body mass index (weight divided by height squared) of ...

[details](#) - [visualize](#) - [3 more from this ontology](#)

[OBESITY - Coding Symbols for a Thesaurus of Adverse Reaction Terms \(COSTART\)](#)

<http://purl.bioontology.org/ontology/CST/OBESITY>

[OBESITY - World Health Organization \(WHO\) Adverse Reaction Terminology \(WHO-ART\)](#)

<http://purl.bioontology.org/ontology/WHO/0397>

[details](#) - [visualize](#)

[obesity - Physician Data Query \(PDQ\)](#)

<http://purl.bioontology.org/ontology/PDQ/CDR000467910>

[details](#) - [visualize](#)

[Obesity - Common Terminology Criteria for Adverse Events \(CTCAE\)](#)

<http://ncicb.nci.nih.gov/xml/owl/EVS/ctcae.owl#Obesity>

[details](#) - [visualize](#)

[obesity - Computer Retrieval of Information on Scientific Projects Thesaurus \(CRISP\)](#)

<http://purl.bioontology.org/ontology/CSP/0467-3154>

excessively high accumulation of body fat or adipose tissue in relation to lean body mass; the amount of body fat (or adiposity) includes concern for both the distribution of fat throughout the body and the

...

[details](#) - [visualize](#)

[Obesity - MedlinePlus Health Topics \(MEDLINEPLUS\)](#)

<http://purl.bioontology.org/ontology/MEDLINEPLUS/C0028754>

Obesity means having too much body fat. It is different from being overweight, which means weighing too much. The weight may come from muscle, bone, fat, and/or body water. Both terms mean that a person's ...

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Obesity - Portfolio Management Application \(PMA\)](#)

http://www.bioontology.org/pma.owl#PMA_936

excessively high accumulation of body fat or adipose tissue in relation to lean body mass; the amount of body fat (or adiposity) includes concern for both the distribution of fat throughout the body and the

...

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Obesity - Neuroscience Information Framework \(NIF\) Dysfunction Ontology \(NIFDYS\)](#)

http://ontology.neuinfo.org/NIF/Dysfunction/NIF-Dysfunction.owl#nbc_dys_20090302

An eating-related disorder in which excess body fat has accumulated to such an extent that health may be negatively affected. It is commonly defined as a body mass index (weight divided by height squared) of ...

[details](#) - [visualize](#) - [1 more from this ontology](#)

[obesity - Bleeding History Phenotype Ontology \(BHO\)](#)

<http://www.semanticweb.org/ontologies/2010/10/BPO.owl#obesity>

[details](#) - [visualize](#)

[Obesity - Galen Ontology \(GALEN\)](#)

<http://www.co-ode.org/ontologies/galen#Obesity>

[details](#) - [visualize](#)

[Obesity - Resource of Asian Primary Immunodeficiency Diseases \(RAPID\) Phenotype Ontology \(RPO\)](#)

<http://www.semanticweb.org/ontologies/2012/5/Ontology1338526551855.owl#Obesity>

[details](#) - [visualize](#)

[obesity - Alzheimer's disease ontology \(ADO\)](#)

<http://scai.fraunhofer.de/AlzheimerOntology#obesity>

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Obesity - KB Bio 101 \(AURA\)](#)

<http://www.projecthalo.com/aura#Obesity>

[details](#) - [visualize](#)

[Obesity - Bilingual Ontology of Alzheimer's Disease and Related Diseases \(ONTOAD\)](#)

<http://doe-generated-ontology.com/OntoAD#C0028754>

Excès de poids par augmentation des graisses stockées dans le corps. Elle peut provenir de facteurs héréditaires, d'une alimentation mal équilibrée et trop importante, ou de problèmes hormonaux. L'obésité ...

[details](#) - [visualize](#) - [2 more from this ontology](#)

[obesity - Human Dermatological Disease Ontology \(DERMO\)](#)

http://purl.obolibrary.org/obo/DERMO_0002752

[details](#) - [visualize](#)

[Obesity \[Disease/Finding\] - National Drug File - Reference Terminology \(NDFRT\)](#)

<http://purl.bioontology.org/ontology/NDFRT/N0000002200>

[details](#) - [visualize](#)

[large body habitus artifact - Radiology Lexicon \(RADLEX\)](#)

<http://www.owl-ontologies.com/RADLEX.owl#RID11305>

An artifact resulting from a patient with a large body size or body mass.

[details](#) - [visualize](#)

[obese - Mammalian Phenotype Ontology \(MP\)](#)

http://purl.obolibrary.org/obo/MP_0001261

[details](#) - [visualize](#)

[Obesity, unspecified - International Classification of Diseases, Version 9 - Clinical Modification \(ICD9CM\)](#)

<http://purl.bioontology.org/ontology/ICD9CM/278.00>

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Other obesity - International Classification of Diseases, Version 10 - Clinical Modification \(ICD10CM\)](#)

<http://purl.bioontology.org/ontology/ICD10CM/E66.8>

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Genetic obesity - Orphanet Rare Disease Ontology \(ORDO\)](#)

http://www.orpha.net/ORDO/Orphanet_77828

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Truncal obesity - Fanconi Anemia Ontology \(IFAR\)](#)

<http://www.semanticweb.org/ontologies/2012/11/abnormalities.owl#phenodb:0048>

GROWTH and BUILD: Other growth characteristics > Truncal obesity

[details](#) - [visualize](#)

[Generalized obesity - Disease core ontology applied to Rare Diseases \(HRDO\)](#)

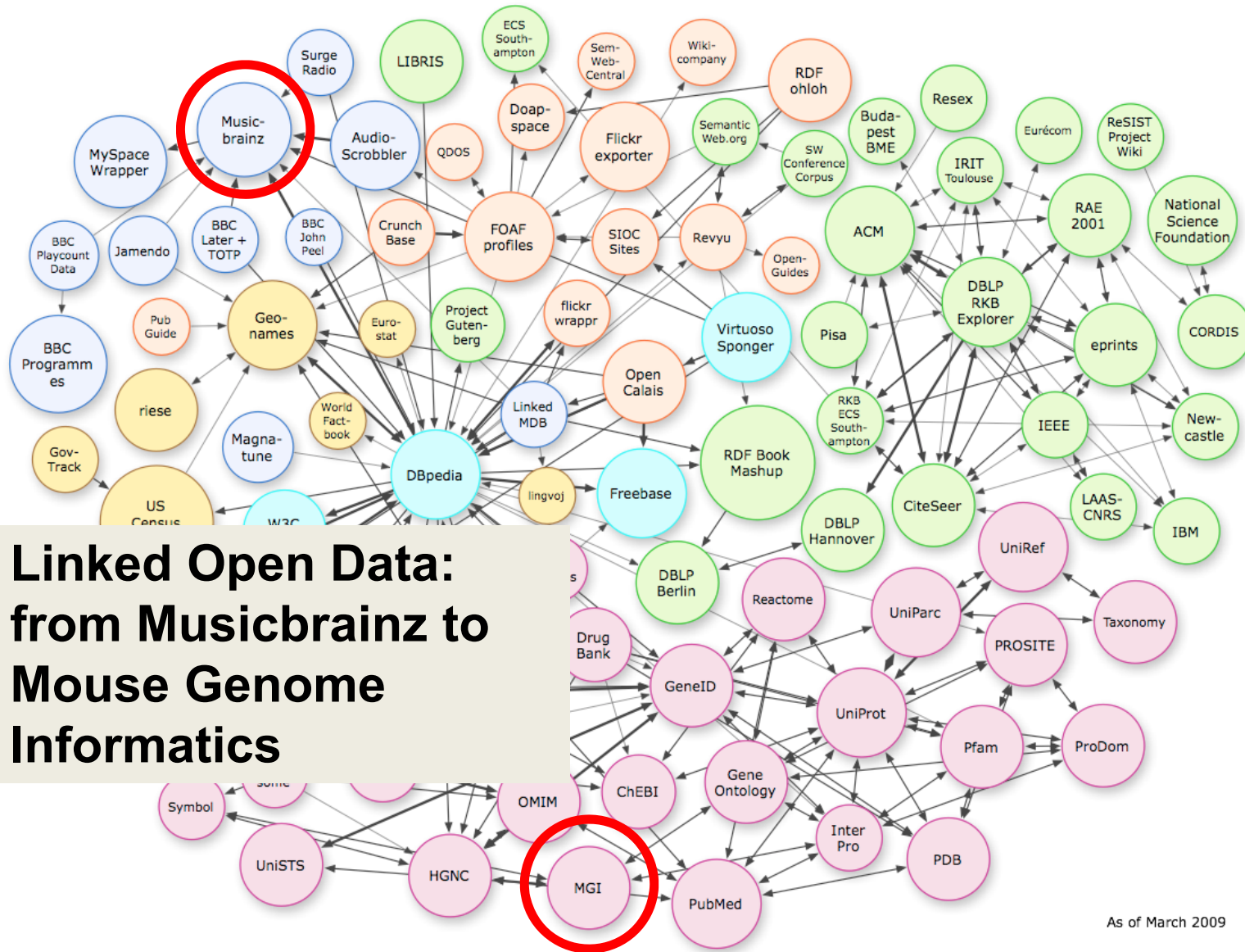
http://www.limics.org/hrdo/rdfns#sgn_id_53100

[details](#) - [visualize](#) - [1 more from this ontology](#)

[Constitutional obesity - Systematized Nomenclature of Medicine, International Version \(SNMI\)](#)

<http://purl.bioontology.org/ontology/SNM/D6-11110>

[details](#) - [visualize](#) - [2 more from this ontology](#)



As of March 2009








Building Ontologies with Basic Formal Ontology

By [Robert Arp](#), [Barry Smith](#) and [Andrew D. Spear](#)

Overview

In the era of “big data,” science is increasingly information driven, and the potential for computers to store, manage, and integrate massive amounts of data has given rise to such new disciplinary fields as biomedical informatics. Applied ontology offers a strategy for the organization of scientific information in computer-tractable form, drawing on concepts not only from computer and information science but also from linguistics, logic, and philosophy. This book provides an introduction to the field of applied ontology that is of particular relevance to biomedicine, covering theoretical components of ontologies, best practices for ontology design, and examples of biomedical ontologies in use.

 Paperback | \$30.00 | £20.95 | ISBN: 9780262527811 | 248 pp. | 7 x 9 in | 32 b&w illus. | August 2015

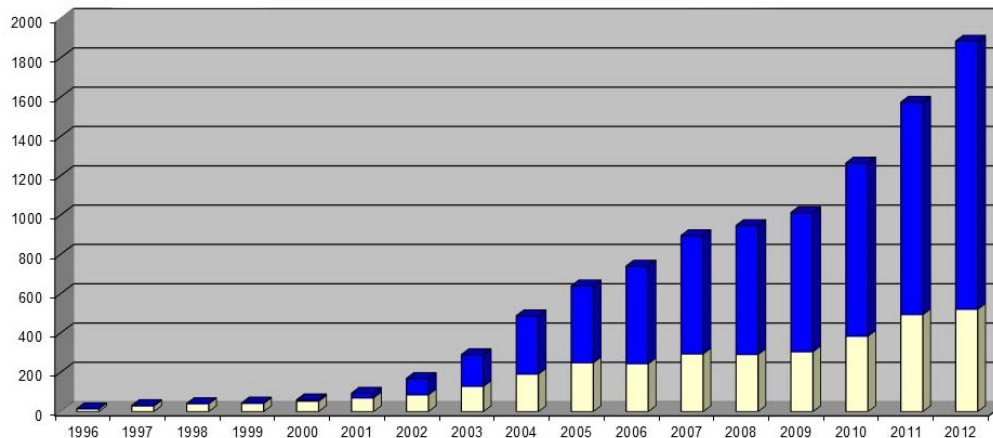
After defining an ontology as a representation of the types of entities in a given domain, the book distinguishes between different kinds of ontologies and taxonomies, and shows how applied ontology

<http://ontology.buffalo.edu/BOBFO>

Background to BFO

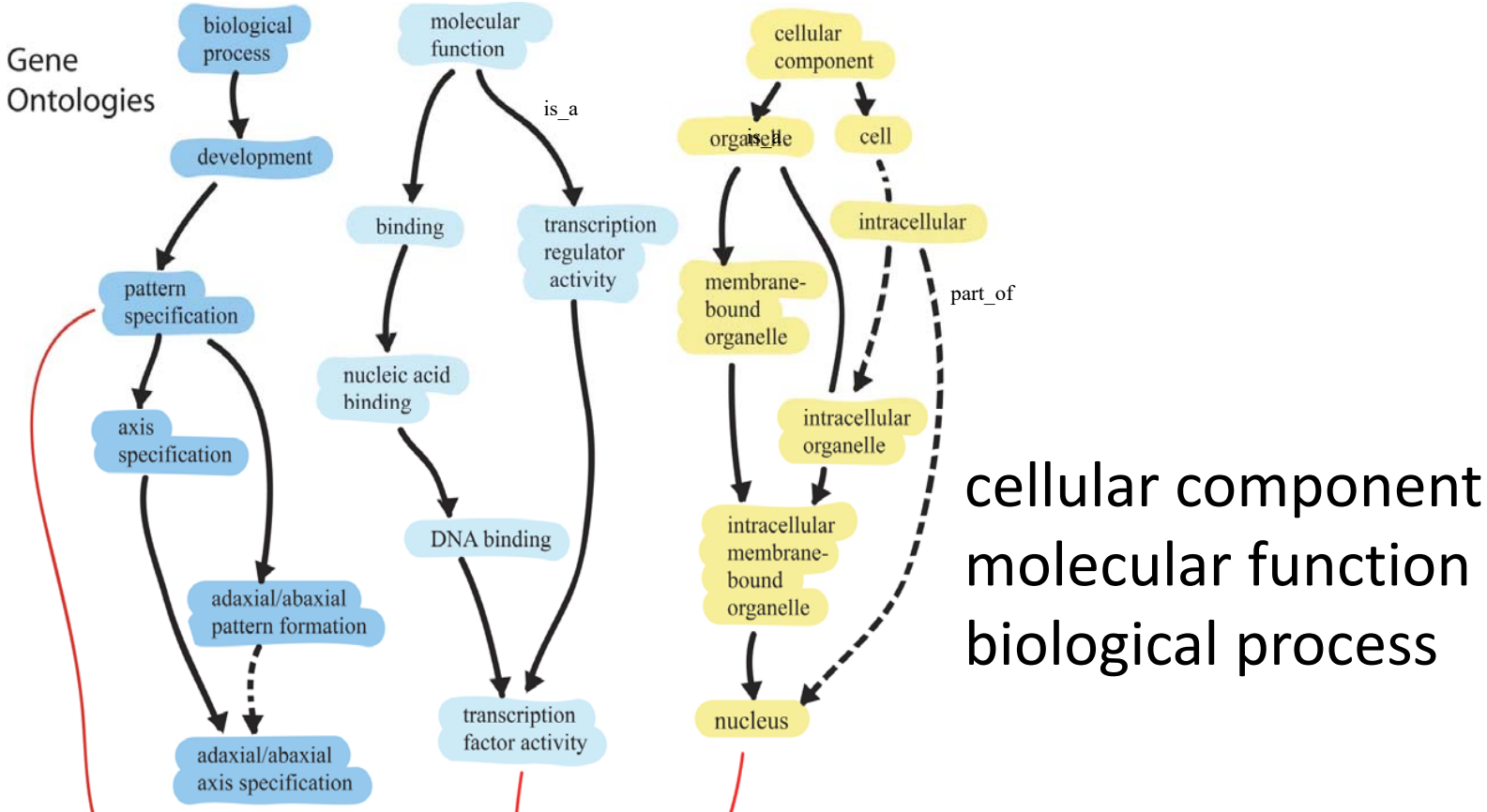
The Gene Ontology (GO) is a controlled, logically structured vocabulary to be used for consistent tagging of omics data and literature

- to make these data discoverable, combinable and analyzable with the aid of computers

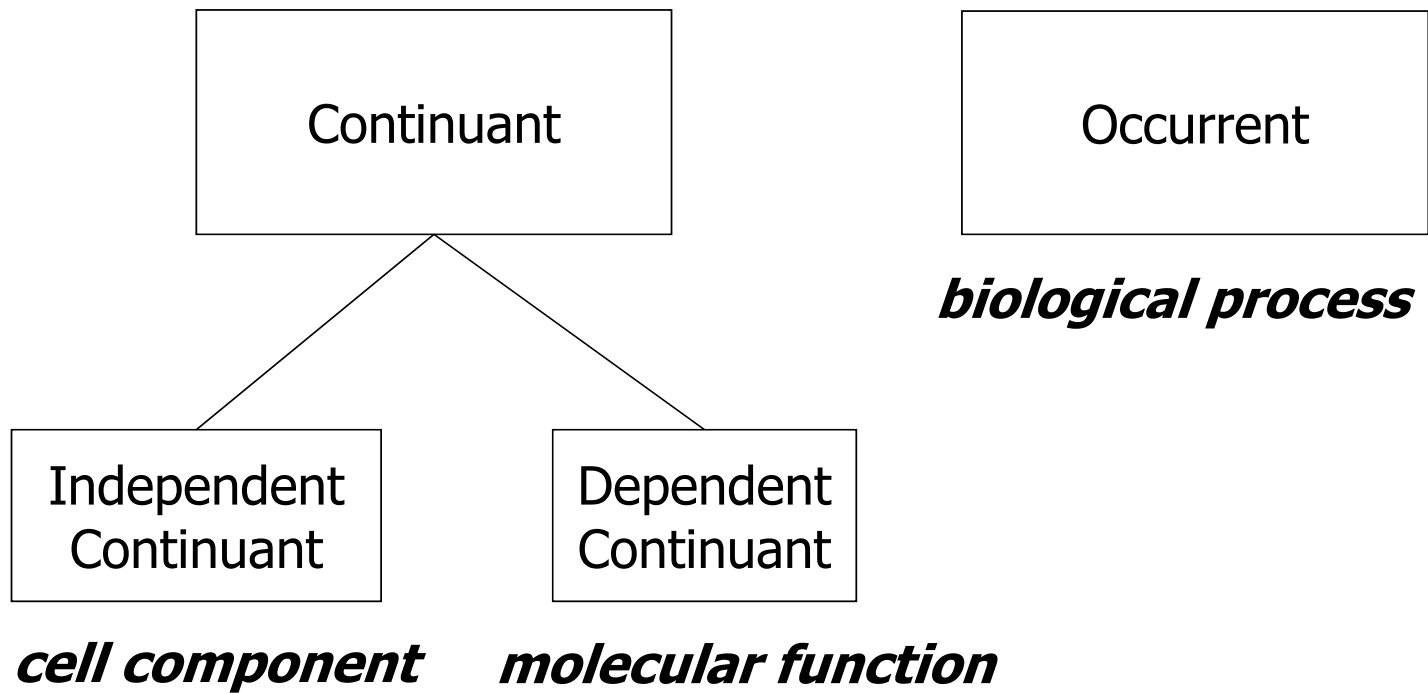


Uses of
'ontology'
in PubMed
abstracts

GO's three sub-ontologies



BFO and the 3 Gene Ontologies (GO)



RELATION TO TIME GRANULARITY	CONTINUANT				OCCURRENT
	INDEPENDENT		DEPENDENT		
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Biological Process (GO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)		
MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)		Molecular Function (GO)	Molecular Process (GO)	

Original OBO (Open Biomedical Ontologies) Foundry
(Gene Ontology in yellow)

OBO Foundry grows to encompass further domains

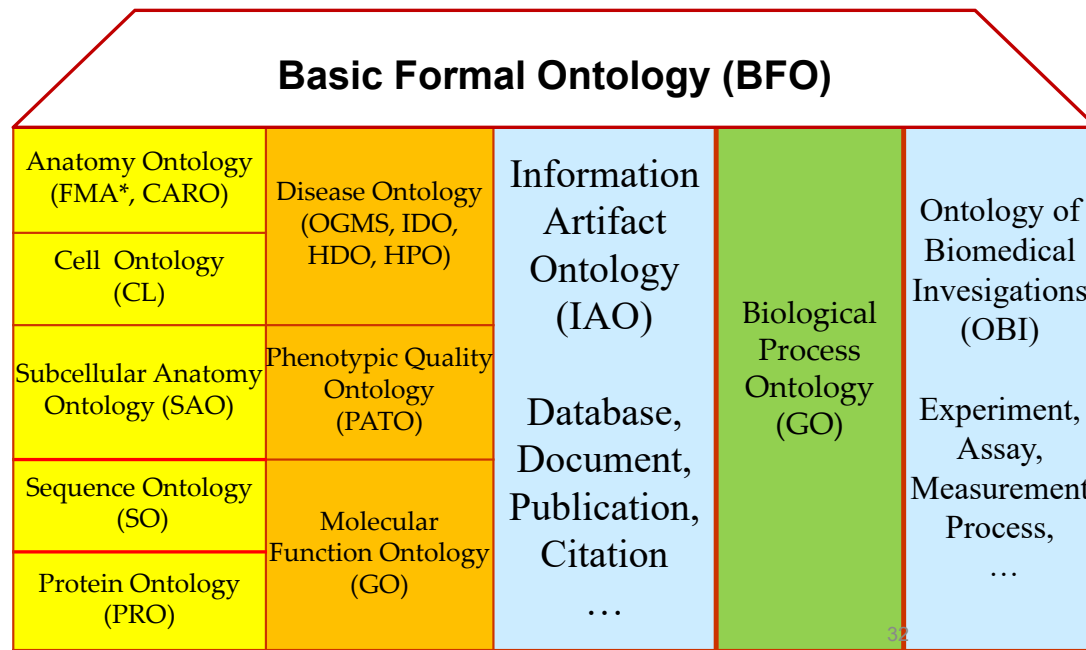
Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Environment Ontology	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Biological Process (GO)
Cell (CL)	Cellular Component (FMA, GO)		Cellular Function (GO)		
Molecule (ChEBI, SO, RnaO, PrO)			Molecular Function (GO)	Molecular Process (GO)	

Population and Community Ontology (PCO)		Organ Function (FMP, CPRO)	Population Phenotype	Population Process
Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)		Phenotypic Quality (PaTO)	Biological Process (GO)
Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)		
Molecule (ChEBI, SO, RnaO, PrO)		Molecular Function (GO)	Molecular Process (GO)	

Organism NCBI Taxonomy	Anatomical Entity (FMA, CARO)	Environment Ontology (ENVO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	IAO Software, Algorithms, ... Sequence Data, EHR Data ...	Biological Process (GO)	OBI
Cell (CL)	Cellular Component (FMA, GO)		Cellular Function (GO)				

- Environments (ENVO)
- Populations, Communities (PCO)
- Information Artifacts (IAO)
- Experiments and Investigations (OBI)

A cohesive hierarchy of standards OBO Foundry ontologies extending downwards from BFO



RELATION TO TIME GRANULARITY	CONTINUANT				OCCURRENT
	INDEPENDENT		DEPENDENT		
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Biological Process (GO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)		
MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)		Molecular Function (GO)		Molecular Process (GO)

Original OBO Foundry ontologies
(Gene Ontology in yellow)

RELATION TO TIME	CONTINUANT				OCCURRENT
	INDEPENDENT		DEPENDENT		
GRANULARITY					
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Organism-Level Process (GO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)		Cellular Process (GO)
MOLECULE	Molecule (ChEBI, SO, RNAO, PRO)		Molecular Function (GO)		Molecular Process (GO)

rationale of OBO Foundry coverage

How to build an ontology

import BFO into ontology editor such as Protégé
work with domain experts to create an initial mid-level classification

find ~50 most commonly used terms corresponding to types in reality

arrange these terms into an informal *is_a* hierarchy according to this universality principle

$A \text{ is_a } B \equiv$ every instance of A is an instance of B

fill in missing terms to give a complete hierarchy
(leave it to domain experts to populate the lower levels of the hierarchy)

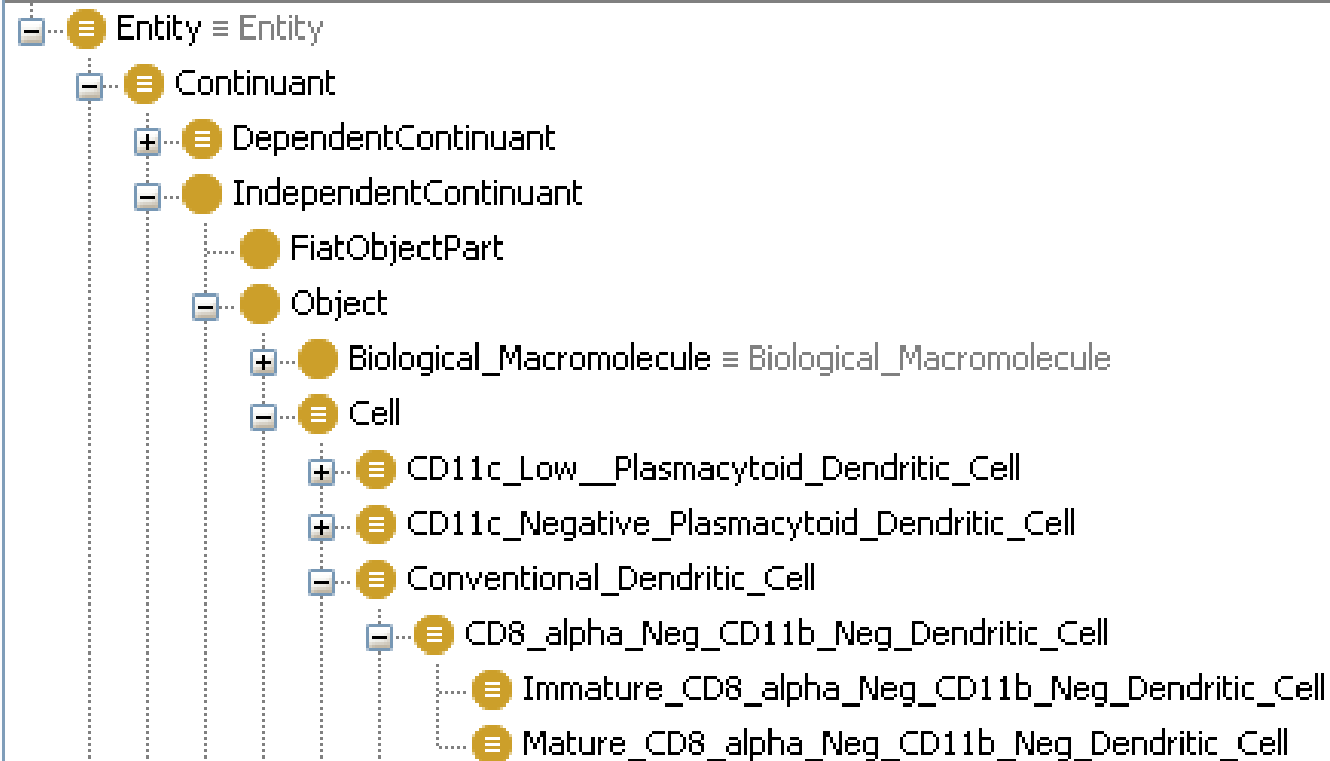
Example: The Cell Ontology

SUBCLASS EXPLORER

For Project: ● DC_CL

Asserted Hierarchy

owl:Thing



Common Reference Ontologies for Plants (cROP)

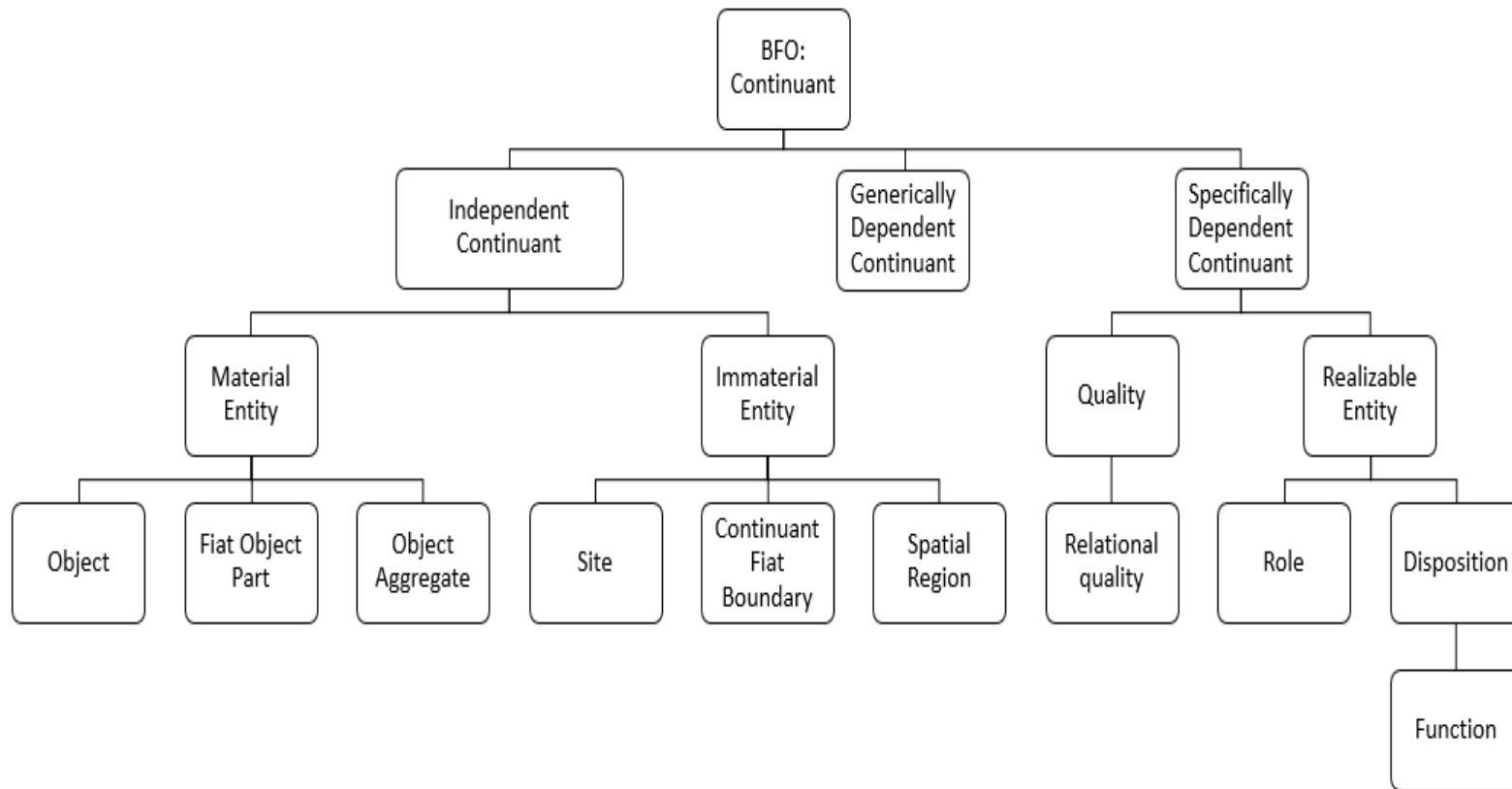
Environment Ontology (ENVO)						
Plant Environmental Conditions (EO)						
Population and Species	NCBI, uBio, USDA-GRIN PCO, etc.	Plant Stress Ontology (PSO)	Population Phenotype		Population-Level Process	
Organ and Organism	Plant Anatomy (PO)		Plant Trait (TO) Plant Disease (PDO)	Phenotype (PATO) Disease (IDO, etc.)	Plant Development Stage (PO)	Biological Process (GO)
Cell	Plant Cell (PO) Cell (CL)					
Cellular Component	Cellular Component (GO)		Molecular Function (GO)		Molecular Process (GO)	
Molecule	Molecular Entity (CHEBI, PR)					

Ontologies re-using BFO

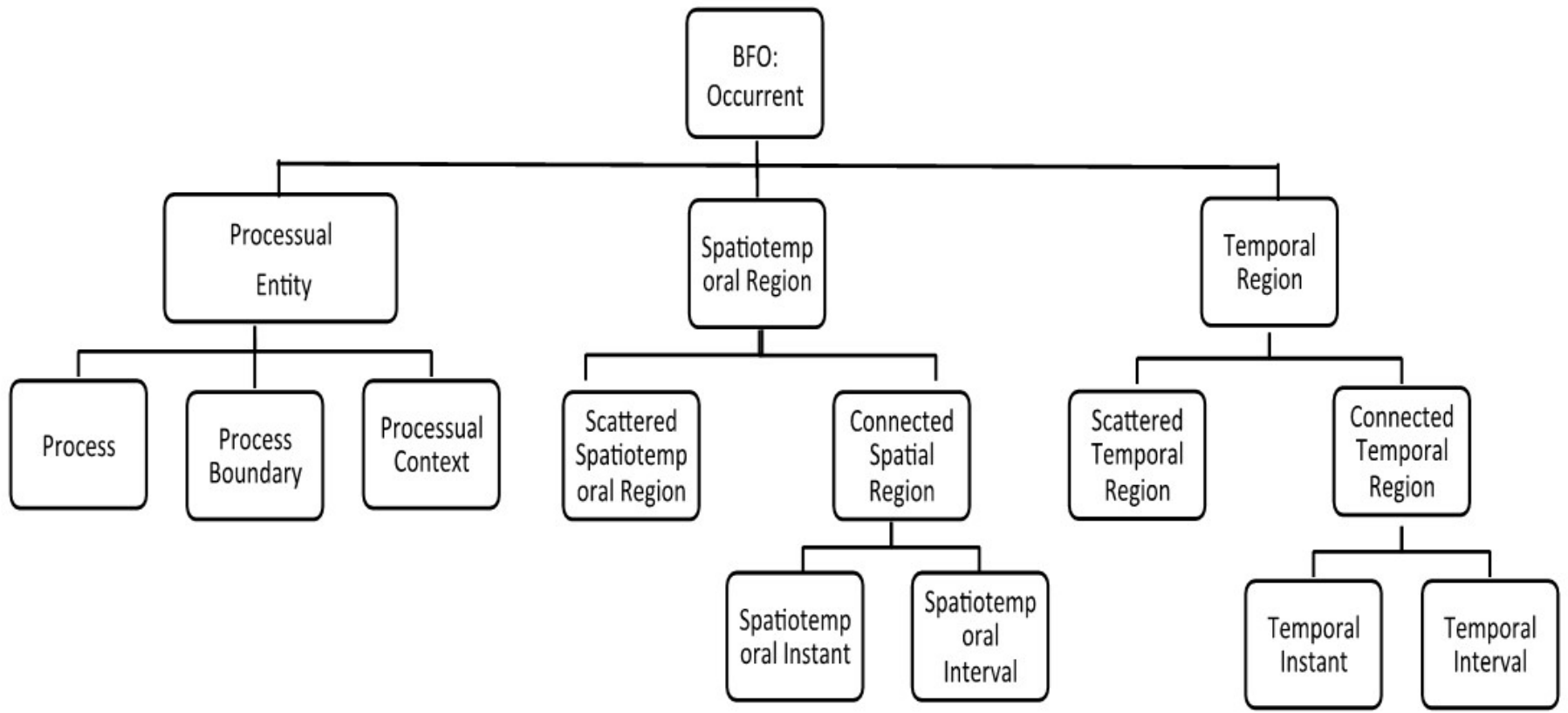
ACGT Master Ontology (ACGT MO)
Alzheimer Disease Ontology (ADO)
Adverse Event Ontology (AEO)
Adverse Event Reporting Ontology (AERO)
AFO Foundational Ontology
Actionable Intelligence Retrieval System (AIRS)
Bank Ontology
Beta Cell Genomics Application Ontology (BCGO)
BioAssay Ontology
Bioinformatics Web Service Ontology
Biological Collections Ontology (BCO)
Biomedical Ethics Ontology
Biomedical Grid Terminology (BiomedGT, retired)
BioTop: A Biomedical Top-Domain Ontology
BIRNLex: controlled terminology for annotation of BIRN data sources
Blood Ontology (BLO)
Body Fluids Ontology (BFLO)
Bone Dysplasia Ontology
Cancer Cell Ontology (OncoCL)
Cancer Chemoprevention Ontology (CanCo)
Cardiovascular Disease Ontology (CVDO)
Cell Behavior Ontology (CBO)
Cell Cycle Ontology
Cell Expression, Localization, Development and Anatomy Ontology (CELDA)

Environment Ontology (ENVO)
Epidemiology Ontology (EO)
Epilepsy and Seizure Ontology (EPSO)
Evolution Ontology (EO)
Experimental Factor Ontology (EFO)
EXperimental ACTions Biomedical Protocol Ontology (EXACT2)
Exposé: An Ontology for Data Mining Experiments
Flybase Drosophila Anatomy Ontology (FBbt)
Fission Yeast Phenotype Ontology (FYPO)
Flower-Visiting Domain Ontology (FV),
Flower-Visiting Behavior Application Ontology (FVB)
Foundational Model of Anatomy (FMA) Ontology
Gastrointestinal Endoscopy Ontology (GIEO)
Gene Regulation Ontology (GRO)
General Information Model (GIM)
Genomic Feature and Variation Ontology (GFVO)
Gestalt: Federated Access to Cyber Observables for Detection of Targeted Attack
Health Data Ontology Trunk (HDOT)
Human Interaction Network Ontology (HINO)
Human Physiology Simulation Ontology (HuPSON)
Infectious Disease Ontology (IDO)
Information Artifact Ontology (IAO)
Informed Consent Ontology (ICO)
Interaction Network Ontology (INO)

BFO: Continuant Ontology



BFO Occurrent Ontology










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<http://ontology.buffalo.edu/BOBFO>

examples of the BFO/OBO Foundry approach extended into other domains

NIF Standard	Neuroscience Information Framework
eagle-I	Integrated Semantic Framework / CTSA Connect
IDO Core / IDO extensions	Infectious Disease Ontology Suite
cROP / Planteome	Common Reference Ontologies for Plants

Examples of BFO/OBO Foundry approach extended into yet further domains

UNEP Ontology Framework	United Nations Environment Programme
USGS National Map Ontologies	United States Geological Survey
Joint Doctrine Ontologies	US Air Force Research Labs / Training and Doctrine Command (TRADOC)
TRIP Ontologies	Federal Highway Administration (FHWA) Transportation Research Informatics Platform (TRIP)
Common Core Ontology	Common IC Ontology, Air Vehicle Platform Ontology, ...

IOF testbeds for BFO methodology

1. John McDowell (BAE Systems) – BFO-driven intelligence information-system interoperability
2. Clare Paul (AFRL) – MatOnto Materials Ontology
3. Dimitris Kiritsis (EPFL) – Product Life Cycle Ontology
4. Farhad Ameri (Texas State) – Manufacturing Diagnosis Ontology
5. Rahul Rai – Functionally Graded Materials Ontology and Additive Manufacturing Ontology
6. Barry Smith – DMDII / CHAMP supply chain connectivity