

# **Ontology Web Services for Semantic Applications**

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#### Introduction

Researchers have turned to the Semantic Web to integrate, summarize, and interpret disparate knowledge. Ontologies provide the domain knowledge to drive such data integration and information retrieval, on the Semantic Web. The successful creation of semantic applications in the health and life sciences requires services that provide software applications with access to ontologies over the Web. The National Center for Biomedical Ontology (NCBO), one of seven National Centers for Biomedical Computing created under the NIH Roadmap, has developed BioPortal, which provides access to one of the largest repositories of biomedical ontologies both via Web browsers and Web services (via RESTful services). The BioPortal Ontology Web services allow programmatic access, download and traversal of ontologies in software applications, the NCBO Annotator Web service "tags" text automatically with terms from BioPortal ontologies, and the NCBO Resource Index provides an ontology based search of public data resources.

The Ontology Web services provide access to ontologies, their characteristics, information about different versions, ontology downloads, navigation of the class hierarchy and details of each class. Developers can to embed this functionality in software applications, such as the Microsoft Word 2007's Ontology Add-in, used to mark up a research article at the time of writing or ISAcreator, used to annotate experimental metadata.

The NCBO Annotator Web service processes text to recognize relevant biomedical ontology terms. Users can customize the Web service to limit results to a particular ontology (e.g. SNOMED CT) or to a certain UMLS semantic type (e.g. T017 for 'Anatomical Structure'). The concept recognition engine, MGREP, was developed by the National Center for Integrative Bioinformatics and is combined with BioPortal Ontology Web services to create the NCBO Annotator service to make the task of creating ontology-based annotations accessible for any biomedical researcher.

BioPortal indexes several biomedical data repositories available online (e.g., GEO, ClinicalTrials.gov, PharmGKB) on the basis of their textual metadata, and links their records to ontology terms. These linkages take advantage of the semantic relationships in BioPortal, including subsumption relationships among ontology entities and mappings between entities in different ontologies. The NCBO Resource Index Web service allows biomedical investigators to use ontology terms to search programmatically the resulting index of online public repositories. For example, one can search for all experiments and clinical trials corresponding to 'malignant melanoma' from GEO and ClinicalTrials.gov.

# **Web Service Access**

- Prefix for NCBO Web Services: http://rest.bioontology.org/{application}
- List of Web Services

http://bioontology.org/wiki/index.php/NCBO\_REST\_services •Access via Code (Perl, Java, Flash, Ruby, etc.), User Interface, Browser, or Widget

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-61						- <ontologybean> <id>40133</id></ontologybean>		
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## **BioPortal Web Services**

#### **Resource Index Web Service**

- Prefix for Resource Index Web Service http://rest.bioontology.org/resource\_index/
- Description
  - Provides an ontology-based index of publicly available biomedical resources.
  - Currently indexed resources include: Array Express, ARRS Goldminer, Biositemaps, caNanoLab, ClinicalTrials.gov, Conserved Domain Database, DrugBank, Gene Expression Omnibus, Molecular Imaging and Contrast Agent Database, NextBio, OMIM, Pathway Commons, PharmGKB, PubChem, Reactome, Research Crossroads, Stanford Microarray Database, UniProt, and WikiPathways
- For more information see: http://www.bioontology.org/wiki/index.php/Resource\_Index

Annotate All Mappings All Resources

BioPortal offers researchers a one-stop shop on the Web for biomedical ontologies. The Web services provided by BioPortal are available at www.bioontology.org/wiki/index.php/NCBO\_REST\_services and the BioPortal technology is open-source and domain-independent.

# **BioPortal Ontology Library**

- Total number of ontologies: 173
- Number of classes/types: 1,438,792
- Ontology formats: OWL, OBO format, Rich Release Format, Protégé frames

O BioPortal	Browse	Search	Projects	Annota	ate All Mappings	All Resources			<u>Sign</u>	<u>In Register Help</u>	p/About <mark>Send</mark>
🛇 Amphibian taxonomy											
Access all ontologies the <u>OBO Foundry</u> , or o Add a new biomedical	that are availat ontologies from t l ontology to BioP	ole in BioPortal: You he <u>Cancer Biomedica</u> ortal using the Subn	ı can filter this list al Informatics Grid nit New Ontology li	by category to ( <u>caBIG</u> ). <u>Subsc</u> nk (you need to	display ontologies relevant ribe to the BioPortal RSS fe sign in to see this link).	for a certain domain (try selectin ed to receive alerts for submissio	g "Anatomy or Experimental Conditions" in the "Filter by category" mer ons of new ontologies, new versions of ontologies, new notes, and new	u below). You can also filter onto projects. You can subscribe to fe	ologies that belon eds for a specific	g to a certain group : ontology at the indi	i such as ontolog ividual ontology
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ONTOLOGY NAME	Proteom OBO Fou	ics Standards Initiat Indry (OBO Foundry)	ive (PSI)		VERSION		AUTHOR	UPLOADED ON	GROUP	STATUS	
ABA Adult Mouse Bra (ABA)	in The WH	0 Family of Internati	ional Classification	s (WHO-FIC)	1.0		Allen Institute for Brain Science	08/08/2009		Explore	
African Traditional M (ATMO)	<u>Nedicine</u>			OBO Format	1.101		Ghislain Atemezing	06/28/2009		Explore	
<u>Amino Acid</u> (amino-acid)				OWL	1.2		Nick Drummond, Georgina Moulton, Robert Stevens, Phil Lord	04/25/2009		Explore	
Amphibian gross ana (AAO)	tomy			OBO Format	1.8		AmphiAnat list	07/30/2008	OBO Foundry	Explore	
Amphibian taxonomy (ATO)	!			OBO Format	See Remote Site		AmphiAnat list	11/02/2009		Explore	
Amphibian taxonomy (ATO)	!			OBO Format	See Remote Site		AmphiAnat list	12/09/2009			
Animal natural histor (ADW)	y and life history	!		PROTEGE	See Remote Site		Http://animaldiversity Administrators	04/27/2009			
Ascomycete phenotyp (APO)	pe ontology			OBO Format	1.10		SGD curators	12/14/2009		Explore	
Basic Formal Ontolog (BFO)	<u>IV</u>			OWL	1.1			07/24/2009		Explore	
Basic Vertebrate Ana (basic-vertebrate-gro	<u>tomy</u> oss-anatomy <u>)</u>			OWL	1.1			01/16/2007		Explore	
<u>Bilateria anatomy</u> (BILA)				OBO Format	See Remote Site		Thorsten Heinrich	04/13/2009			
Biological imaging m (FBbi)	ethods			OBO Format	1.1		Image Administrators	07/30/2008		Explore	
Biomedical Resource (BRO)	Ontology			OWL	2.7.1		Trish Whetzel, Csongor Nyulas, Natasha Noy	09/29/2009		Explore	
<u>BioPortal Metadata</u> (BPMetadata)				OWL	0.2		Natasha Noy	03/05/2009		Explore	

- Prefix for BioPortal Web Services http://rest.bioontology.org/bioportal/
- Ontology Web services
  - List metadata for all ontologies
  - List all versions of an ontology
  - Download ontologies
  - List all ontology categories
  - List all ontology groups
- Search Web service
  - Search for terms from all BioPortal ontologies
  - Search for term within a subtree of an ontology
- Term Web services
  - Get term by id
  - Get all root terms for an ontology
  - Get all terms from an ontology
- Hierarchy Web services
  - Get parents/children of a term
  - Get path to roots/leaves of a term
  - Get siblings of a term
- RDF Generation Web service
  - Generate a N3 RDF file
- Notes Web service
  - Get comments for a term
  - Get all comments for an ontology
- Mapping Web service
  - Get mappings for a term
  - Get all mappings for an ontology

## **Annotator Web Service**

- Prefix for Annotator Web Service http://rest.bioontology.org/obs/annotator/
- Description

NCI Thesaurus Version 09.07 Malignant Neoplasm   Link Here   D Subscribe										
View Ontology Summary	Details	Visualization	Notes (0)	Mappings (7)	Resource Index					
Jump To: Go	This tab shows records in public data sources that we have automatically annotated with the terms associated with the class Malignant Neoplasm or its subclasses based on the textual descriptions of those records.									
<ul> <li>Common Carcinoma</li> <li>Common Carcinoma</li> <li>Common Cenre Cell Ti</li> <li>Common Hematopoie</li> <li>Melanocytic Skin Nec</li> <li>Melanoma</li> <li>Crystic Neoplasm</li> <li>Encapsulated Neoplasm</li> <li>Encapsulated Neoplasm</li> <li>Metastatic Neoplasm</li> <li>Necrotic Neoplasm</li> <li>Neoplasm by Cause</li> <li>Neoplasm by Cause</li> <li>Neoplasm by Obsolete CL</li> <li>Neoplasm by Obsolete CL</li> <li>Neoplasm by Cause</li> <li>Non-fncapsulated Neoplasm</li> <li>Papillary Neoplasm</li> <li>Primary Neoplasm</li> <li>Primary Neoplasm</li> <li>Secondary Neoplasm</li> <li>Secondary Neoplasm</li> <li>Solid Tumor</li> <li>Solid Tumo</li></ul>	E	ArrayExpre expression	ArrayExpress is a public repository for microarray data, which is aimed at storing MIAME-compliant data in accordance with MGED recommendations. The ArrayExpress Data Warehouse stores gene-indexed expression profiles from a curated subset of experiments in the repository.							
	ARRS GoldM technique,	ARRS GoldMiner provides instant access to images published in selected peer-reviewed radiology journals. This new, web-based system allows viewers to search for images by findings, anatomy, imaging technique, and patient age and sex.								
	ITEMAPS	Biositemaps represent a mechanism for computational biologists and bio-informaticians to openly broadcast and retrieve meta-data about biomedical data, tools and services (i.e., biomedical resources) over the Internet.								
	anoLab ab	caNanoLab	callanoLab is a data sharing portal designed to facilitate information sharing in the biomedical nanotechnology research community to expedite and validate the use of nanotechnology in biomedicine.							
	rials.gov ials.gov	ClinicalTrial participate, want to lear	ls.gov provides re locations, and ph rn more about clir	gularly updated information about federally and privately supported clinical research in human volunteers. ClinicalTrials.gov gives you information about a trial's purpose, who may none numbers for more details. The information provided on ClinicalTrials.gov should be used in conjunction with advice from health care professionals. Before searching, you may nical trials.	Annotations: 1605					
	d Domain (CDD)	The Conser NCBI databa	The Conserved Domain Database (CDD) contains protein domain models imported from outside sources, such as Pfam and SMART, and curated at NCBI. CDD contains over 12,000 such models and is linked to other NCBI databases, including protein sequences, bibliographic citations, and taxonomy.							
	Drug DrugBank	Bank of prugBank is offered to the public as a freely available resource. Use and re-distribution of the data, in whole or in part, for commercial purposes requires explicit permission of the authors and explicit acknowledgment of the source material (DrugBank) and the original publication.		Annotations:83						
	Gene Express Gene Express DataSets	ion Omnibus	A gene exp	ression/molecular	r abundance repository supporting MIAME compliant data submissions, and a curated, online resource for gene expression data browsing, query and retrieval.	Annotations:260				
	MICAD	9	Molecular Ir	maging and Contra	ast Agent Database	Annotations:482				
<u>1</u>										

## **Ontology Recommender Web Service**

- Description
  - The Ontology Recommender helps users identify biomedical ontologies or terminologies that are most relevant to their data based on analysis of free text or keywords. The underlying method uses annotations generated with the NCBO Annotator Web service to score the ontologies. Higher scores correspond to ontologies with the highest number of annotations.
- For more information, see: http://www.bioontology.org/wiki/index.php/Ontology\_Recommender\_Web\_service

# **Ontology Widgets**

O BioPortal Browse Search Projects Annotate All Mappings All Resources

- Ontology widgets provide ready-to-use code to access your ontology of interest from your Web site
- For more information, see: http://www.bioontology.org/wiki/index.php/Ontology\_Widgets

Sign In Register Help/About Send I

BioTop	OWL	dev	Stefan Schulz	11/29/2009		Explore
<u>BIRNLex</u> (birnlex)	OWL	1.3.1	William Bug	03/24/2008		<u>Explore</u>
<u>Bleeding History Phenotype</u> [BHO]	OWL	0.3.1	Andreas Mauer	08/26/2009		<u>Explore</u>
Breast Cancer Grading Ontology (BCGO)	OWL	1.4	Emina Szocs	06/26/2009		
BRENDA tissue / enzyme source (BTO)	OBO Format	1.3	BrendaTissue Administrators	09/18/2009		Explore
<u>C. elegans development</u> (WBIs)	OBO Format	1.3	Worm_development Administrators	07/30/2008	OBO Foundry	<u>Explore</u>
<u>C. elegans gross anatomy</u> (WBbt)	OBO Format	1.46	Http://brebiou Administrators	12/19/2009	OBO Foundry	<u>Explore</u>
C. elegans phenotype (WBPhenotype)	OBO Format	1.108	Http://tazendra Administrators	12/18/2009	OBO Foundry	<u>Explore</u>
Cancer Research and Management ACGT Master Ontology	OWL	1.0	Mathias Brochhausen	04/27/2009		Explore
Cardiac Electrophysiology Ontology (EP)	OWL	1.0	Raimond L. Winslow, PhD	04/27/2009		<u>Explore</u>
<u>Cell Behavior Ontology</u> (CBO)	OWL	0.0	Benjamin Zaitlen	05/05/2009		<u>Explore</u>
Cell Cycle Ontology (A. thaliana) (CCO)	OBO Format	1.02	Erick Antezana	09/03/2008		<u>Explore</u>
<u>Cell Cycle Ontology (H. sapiens)</u> (CCO)	OBO Format	1.01	Erick Antezana	05/27/2008		<u>Explore</u>
Cell Cycle Ontology (S. cerevisiae) (CCO)	OBO Format	1.01	Erick Antezana	05/27/2008		<u>Explore</u>

## **RESTful Web Services**

- Representational state transfer (REST) is a software architecture style
- Uses HTTP methods
- Each URL represents an object
- Operations include
  - GET to retrieve a resource
  - POST to create a resource
  - PUT to update a resource
  - DELETE to remove a resource
- Lightweight, easy to develop

• The NCBO Annotator annotates or "tags" free-text data with terms from BioPortal and UMLS ontologies. The current entity recognizer used by the Annotator is Mgrep, developed by the National Center for Integrative Biomedical Informatics. Plans are underway to include an additional entity recognizer, MetaMap from the National Library of Medicine. The annotation is performed in two steps; direct annotations via matching the input text with the preferred name or synonyms of ontology terms and expanded annotations taking into account the ontology hierarchy and mappings.

Documentation

• For more information and sample clients, see: http://www.bioontology.org/wiki/index.php/Annotator\_Web\_service

#### **Annotator Web Service Workflow**



RCI Thesaurus								
NCI Thesaurus Subscribe to updates								
Metadata         Views (1)         Projects (2)         Reviews (0)         Metrics         Ontology Widgets								
Adding NCBO Widgets for NCI Thesaurus to Your Site Step 1: Select a widget								
Widget Description	Widget Demonstration							
Type a term in NCI Thesaurus ont JUMP TO Get Code	Jump To:							
Fill in a field in your form with a Get Code	Example 1 (start typing the term name to get its full URI) Example 2 (get the ID for a term) Example 3 (get the preferred name for a term)							
Get Code	O BioPortal							
Visualize NCI Thesaurus ontology VisualiZation Get Code	NCI Thesaurus       Ontology       Layouts       Nodes       Arcs       Help         Find:       Cutaneous Melanoma       Co       Image: Color of the second se							

# **Applications Using NCBO Web** Services

- Partial listing of applications using NCBO Web Services:
  - BioLit
  - Biositemaps Editor
  - BioPortal
  - caNanoLab
  - ECG Gadget
  - ISAcreator
  - Jinx
  - Microsoft Word Add-in
- NCBO Term Retriever
- Protégé
- Rat Genome Database
- SysMO

**Acknowledgements** 

BioPortal is developed by the National Center for Biomedical Ontology (NCBO), one of seven National Centers for Biomedical Computing under the NIH Roadmap. BioPortal is developed in conjunction with partners at the University of Victoria and the Mayo Clinic. For more information on NCBO and working with the Center, visit http://www.bioontology.org/ or email support@bioontology.org.