



The Plant Ontology A Resource for Plant Genomics

Plant Ontology Consortium Members and Curators*:

Laurel D. Cooper*, Justin Elser, Justin Preece and Pankaj Jaiswal*:

Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR

Ramona L. Walls* and **Dennis W. Stevenson:** The New York Botanical Garden, Bronx, NY

Maria A. Gandolfo: Department of Plant Biology, Cornell University, Ithaca, NY

Ontology Consultants:

Chris Mungall: Gene Ontology, Lawrence Berkeley National Lab, Berkeley, CA

Barry Smith: OBO Foundry, Department of Philosophy, University at Buffalo, NY

www.plantontology.org



The Plant Ontology is...

...a controlled vocabulary



- ▣ all : all [46545] 🌐
- ▣ ⓘ **PO:0025131 : plant anatomical entity [46280]** 🌐
- ▣ ⓘ PO:0025117 : plant anatomical space [4]
- ▣ ⓘ PO:0009011 : plant structure [46280]
- ▣ ⓘ PO:0025161 : portion of plant substance [2]
- ▣ ⓘ **PO:0009012 : plant growth and development stage [38493]** 🌐
- ▣ ⓘ PO:0007021 : plant structure development stage [20900]
- ▣ ⓘ PO:0007033 : whole plant growth stage [36739]

- two aspects
- terms cover the plant domain

Each term has:

- primary name and synonyms
- unique PO ID and url
- definition vetted by experts, with community feedback

plant anatomical entity

Term information ↓ Term lineage ↓ External references ↓ Term annotations ↔	
Term Information	
Accession	PO:0025131
Ontology	plant anatomy
Synonyms	None
Definition	An anatomical entity that is or was part of a plant. [source: CARO:0000000, POC:curators]
Comment	Includes both material entities such as plant structures and immaterial entities such as plant anatomical spaces. CARO:0000000 anatomical entity is defined as: Biological entity that is either an individual member of a biological species or constitutes the structural organization of an individual member of a biological species.

The Plant Ontology is...

...a tool for reasoning across large data sets

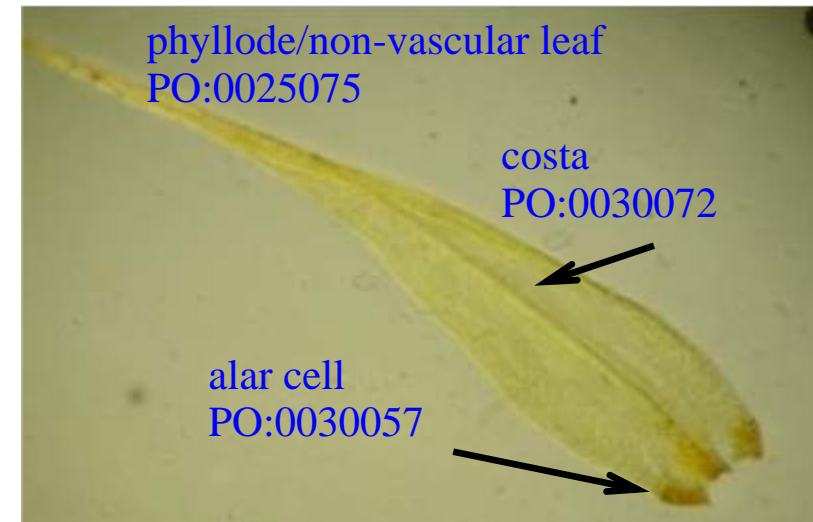
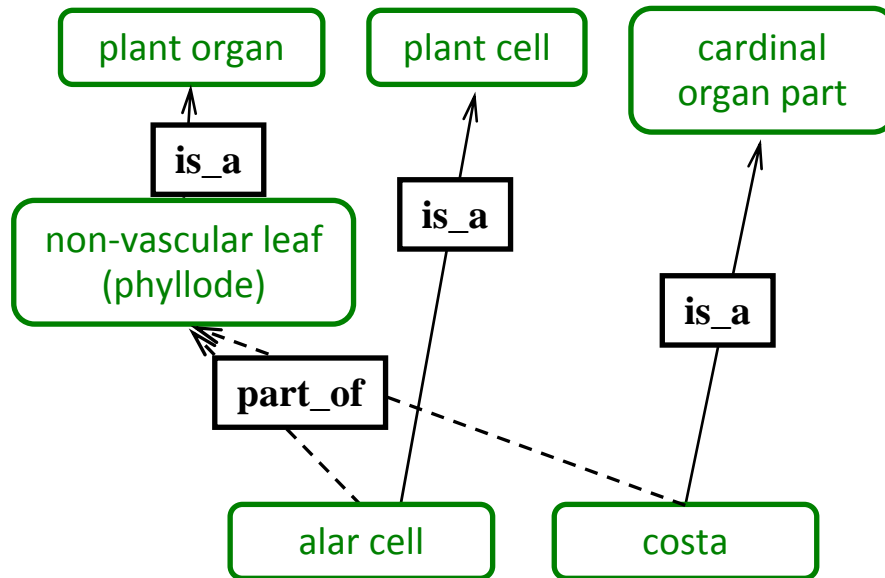


Image: Aisling T. Walsh

Relations among terms allow for reasoning: “Find me all the genes expressed in a phyllode.”

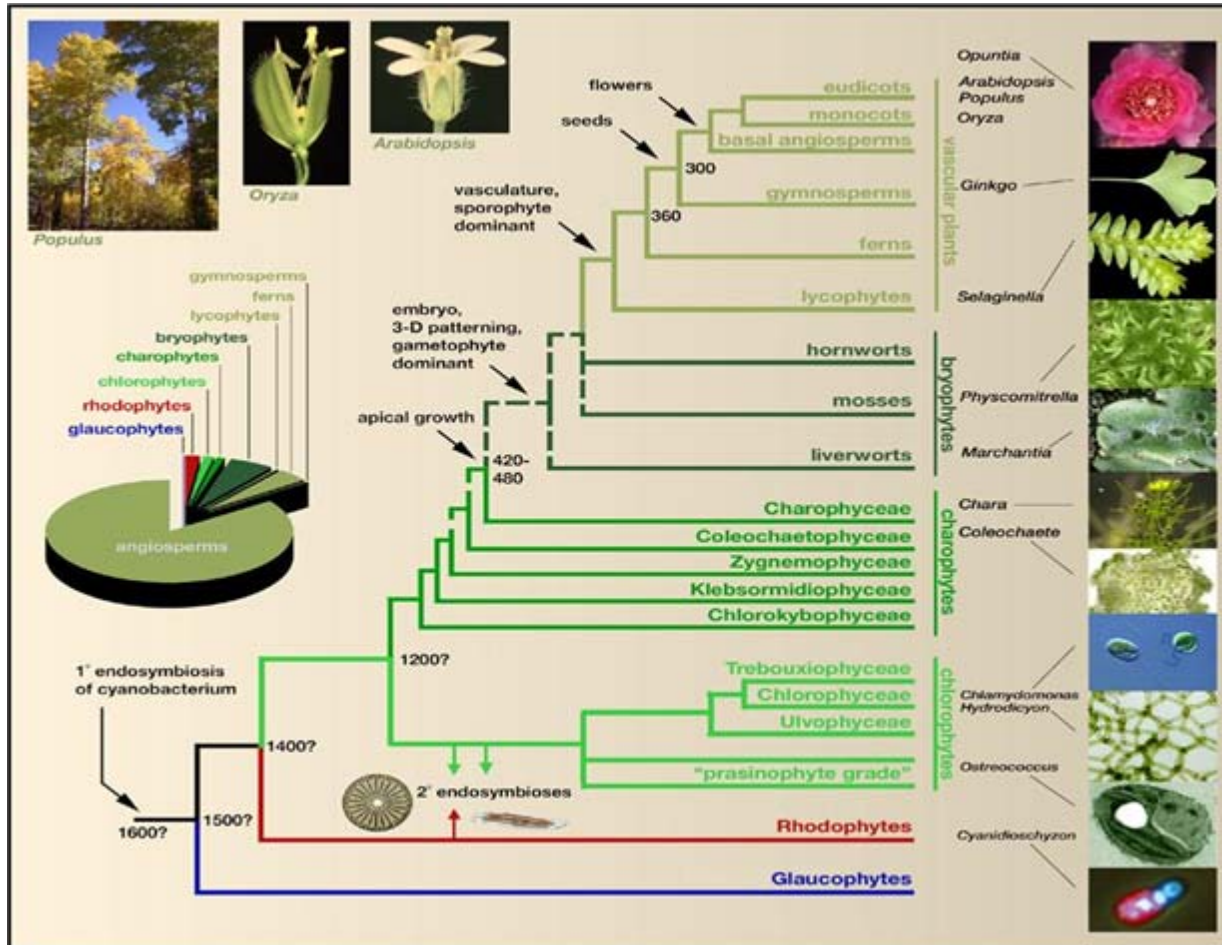


Vision and Goals of the Plant Ontology:

- **Encompass all plants** : including gymnosperms, lycopods, ferns and bryophytes
- **Facilitate comparative genomics** across taxa by linking descriptions to genomics datasets
- **Create mappings (links)** to other ontologies such as the Gene Ontology, CARO and PATO
- **Follow OBO Foundry principles:** openness, format, delimited content, collaborative, etc

Challenges in expanding the Plant Ontology to cover all plants:

Diversity in anatomy, morphology, life cycles, growth patterns



Seed plants
(Angiosperms and Gymnosperms)

Pteridophytes
(Ferns and Lycopods)

Bryophytes
(Mosses, Hornworts and Liverworts)

Algae

Phylogenetic diversity can result in inconsistency in nomenclature:

Instances of leaf: (PO:0025034)



maple leaf

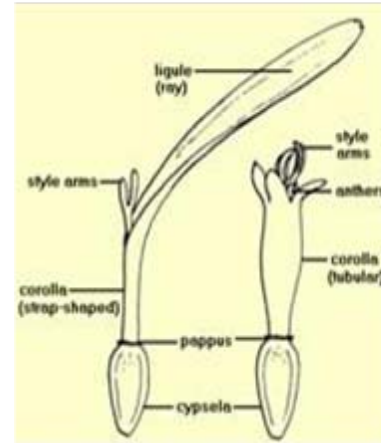


pine needle

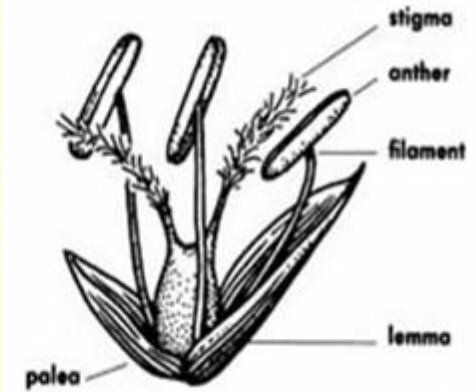


palm frond

Different names are used for the same structure



Asteraceae



Poaceae

Different structures can have the same name e.g. 'floret'

The PO provides consistent terminology for annotation of plant structures and growth and developmental stages across taxa



Recent changes to the PO:

Two branches or subdomains of the PO are now merged:

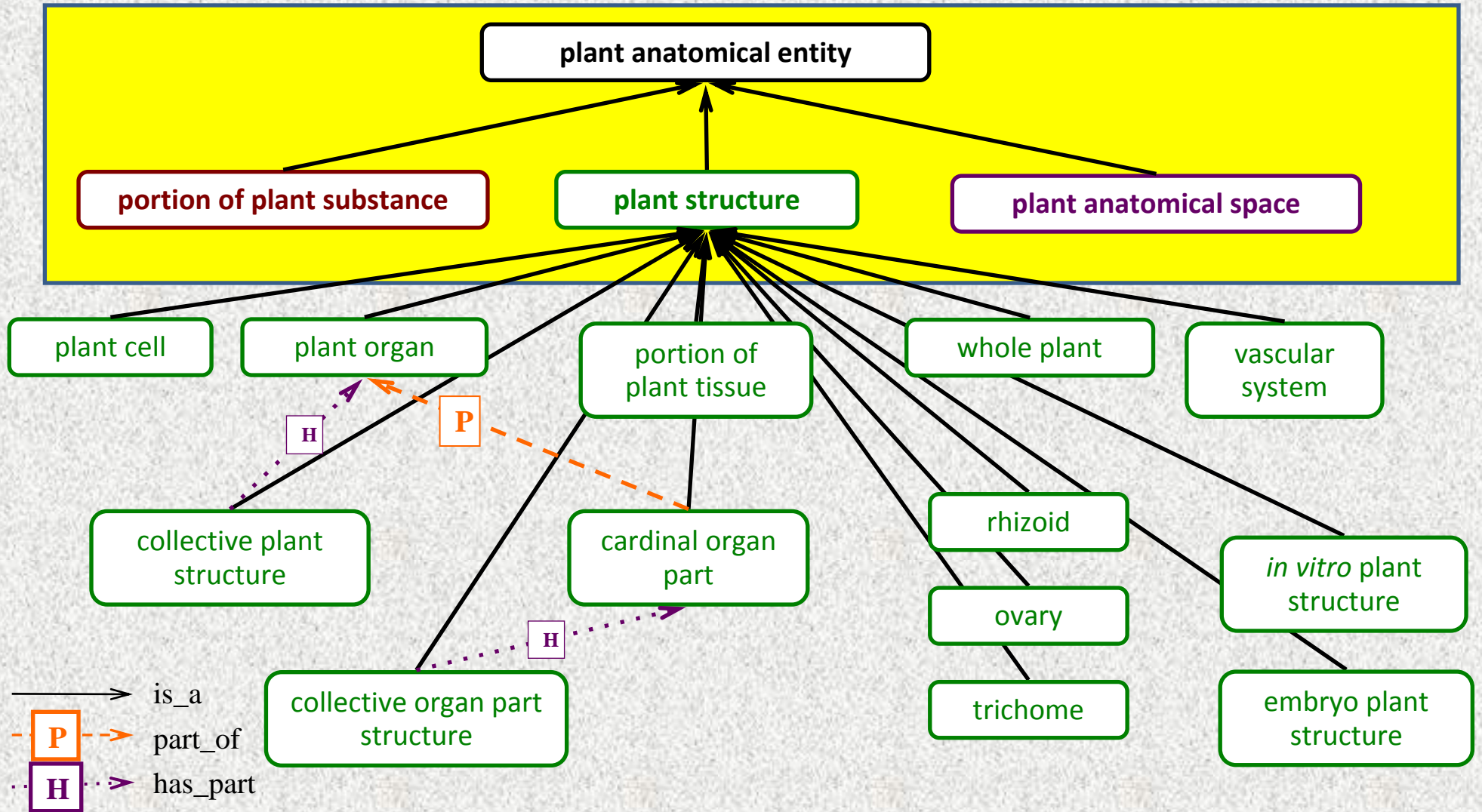
Plant Anatomy

- [-] ⓘ **PO:0025131 : plant anatomical entity [46280]** 🌍
- [+] ⓘ PO:0025117 : plant anatomical space [4]
- [+] ⓘ PO:0009011 : plant structure [46280]
- [+] ⓘ PO:0025161 : portion of plant substance [2]

Plant Structure Development Stage (beta)

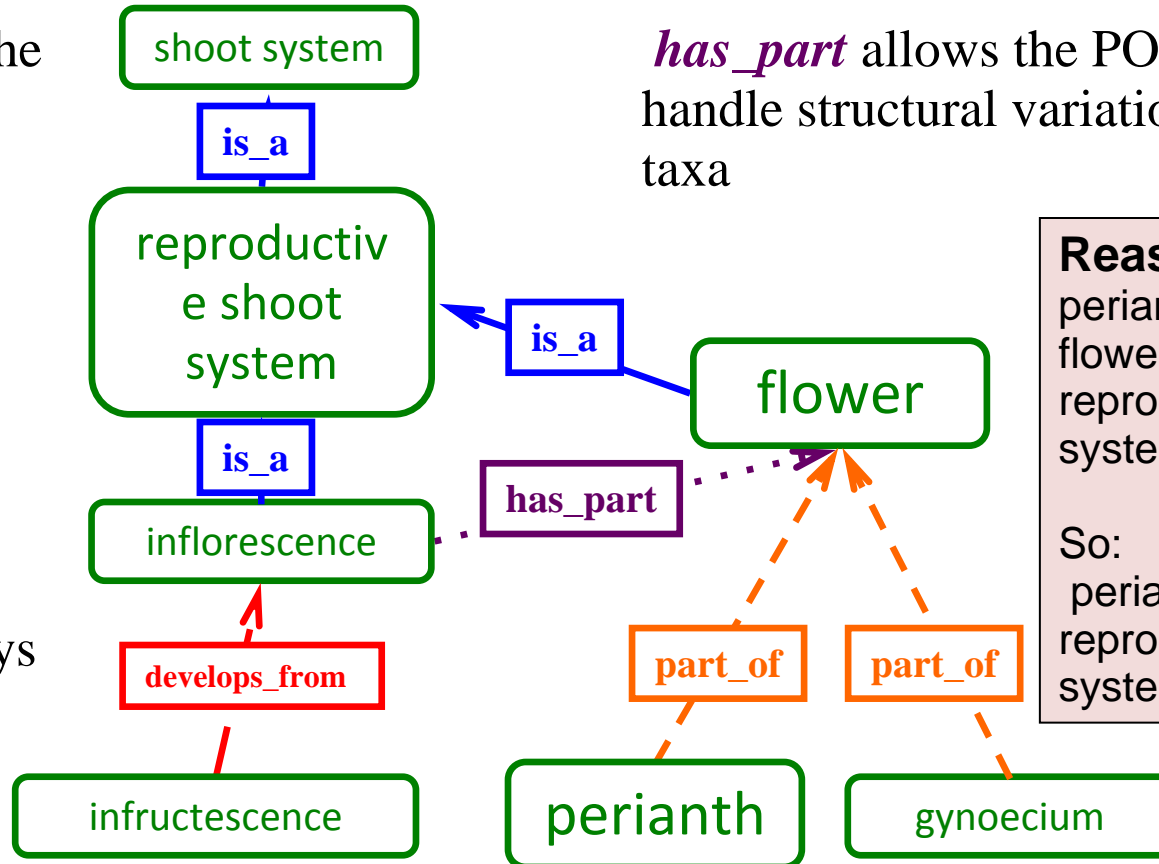
- [-] ⓘ **PO:0009012 : plant growth and development stage [38493]** 🌍
- [+] ⓘ PO:0007021 : plant structure development stage [20900]
- [+] ⓘ PO:0007033 : whole plant growth stage [36739]

Organization of Plant Anatomy Branch



Relations in the PO allow for an accurate expression of biology

is_a and *part_of* are the backbone of all anatomical ontologies

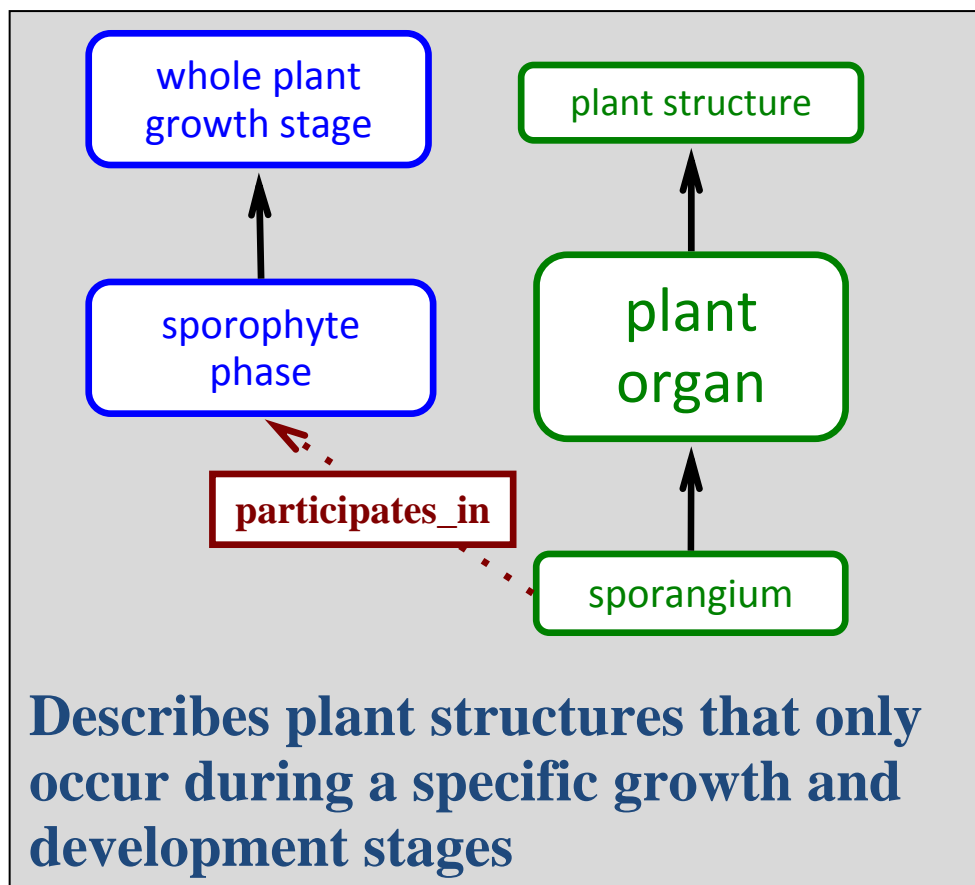


has_part allows the PO to handle structural variation among taxa

develops_from describes shared developmental pathways across all taxa

Reasoner:
 perianth is *part_of* flower which *is_a* a reproductive shoot system.
 So:
 perianth is *part_of* reproductive shoot system

The *participates_in* relation links an anatomical entity to a plant growth or development stage

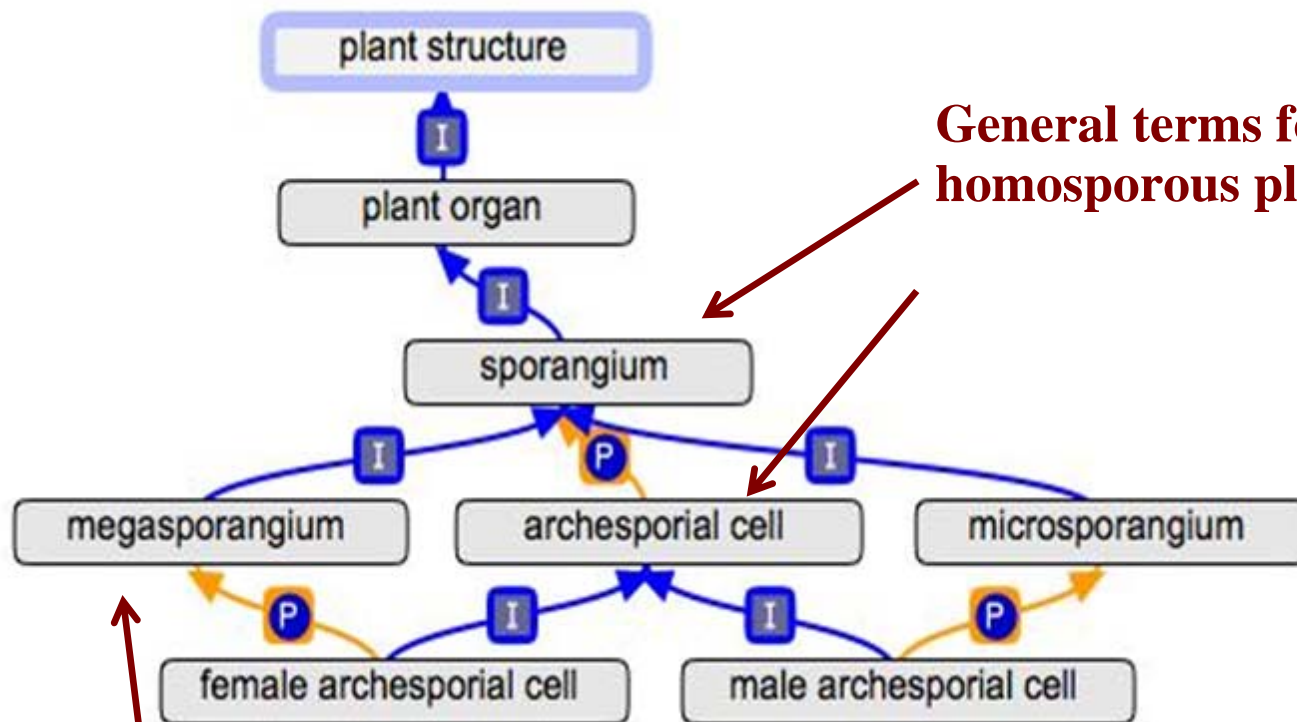


Example:

A **sporangium** *is_a* **plant organ** that produces spores which *participates_in* a **sporophyte phase**



General and more-specific ontology terms span plant kingdom

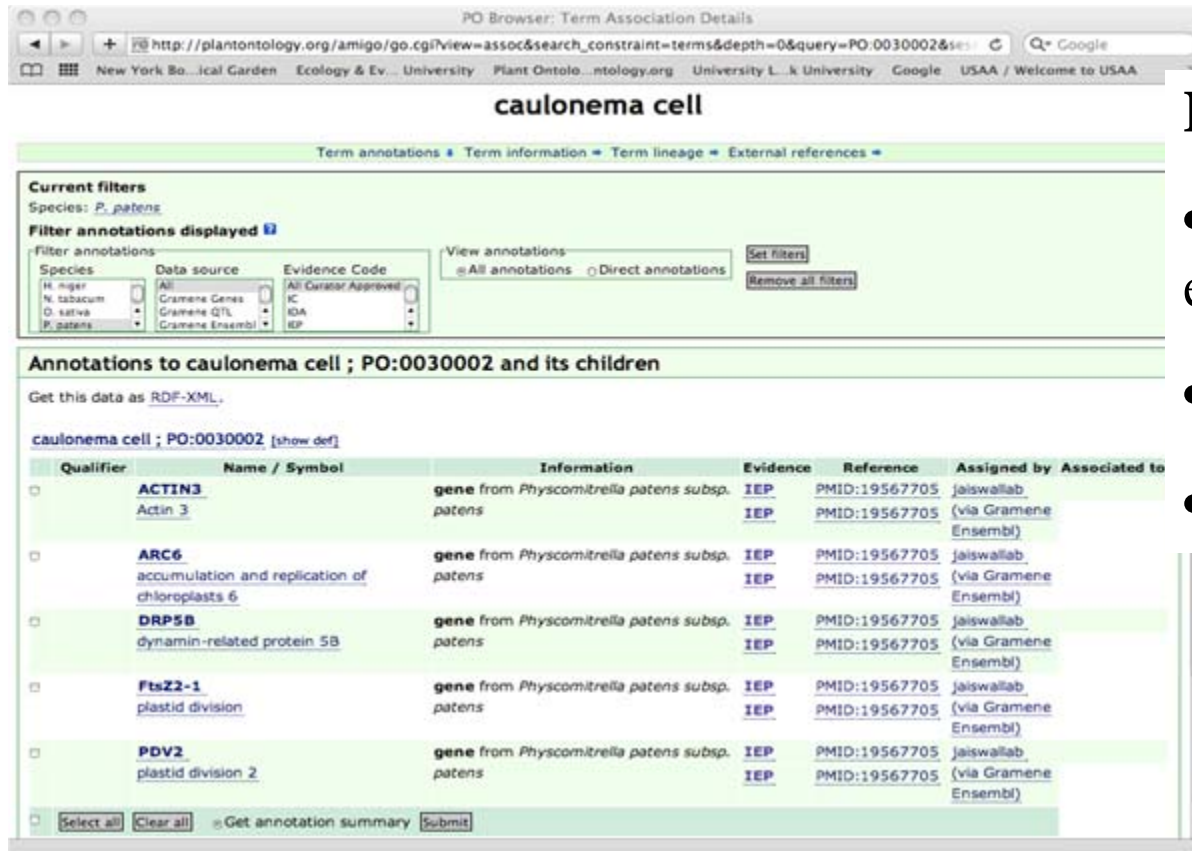


General terms for all plants, or homosporous plants

Specialized child terms for heterosporous plants, such as angiosperms

The Plant Ontology is...

...a database resource for plant science



PO Browser: Term Association Details

http://plantontology.org/amigo/go.cgi?view=assoc&search_constraint=terms&depth=0&query=PO:0030002&ses=

caulonema cell

Term annotations | Term information | Term lineage | External references

Current filters
Species: *P. patens*

Filter annotations displayed

Filter annotations

Species	Data source	Evidence Code
<input type="checkbox"/> <i>H. niger</i>	<input type="checkbox"/> All	<input type="checkbox"/> All Curator Approved
<input type="checkbox"/> <i>N. tabacum</i>	<input type="checkbox"/> Gramene Genes	<input type="checkbox"/> IC
<input type="checkbox"/> <i>D. sativa</i>	<input type="checkbox"/> Gramene QTL	<input type="checkbox"/> IDA
<input type="checkbox"/> <i>P. patens</i>	<input type="checkbox"/> Gramene Ensembl	<input type="checkbox"/> IEP

Annotations to caulonema cell ; PO:0030002 and its children

Get this data as [RDF/XML](#).

caulonema cell ; PO:0030002 [\[show def\]](#)

Qualifier	Name / Symbol	Information	Evidence	Reference	Assigned by	Associated to
<input type="checkbox"/>	ACTIN3 Actin 3	gene from <i>Physcomitrella patens</i> subsp. <i>patens</i>	IEP	PMID:19567705	jaiswallab	(via Gramene Ensembl)
<input type="checkbox"/>	ARC6 accumulation and replication of chloroplasts 6	gene from <i>Physcomitrella patens</i> subsp. <i>patens</i>	IEP	PMID:19567705	jaiswallab	(via Gramene Ensembl)
<input type="checkbox"/>	DRP5B dynamin-related protein 5B	gene from <i>Physcomitrella patens</i> subsp. <i>patens</i>	IEP	PMID:19567705	jaiswallab	(via Gramene Ensembl)
<input type="checkbox"/>	FtsZ2-1 plastid division	gene from <i>Physcomitrella patens</i> subsp. <i>patens</i>	IEP	PMID:19567705	jaiswallab	(via Gramene Ensembl)
<input type="checkbox"/>	PDV2 plastid division 2	gene from <i>Physcomitrella patens</i> subsp. <i>patens</i>	IEP	PMID:19567705	jaiswallab	(via Gramene Ensembl)

[Select all](#) [Clear all](#) [Get annotation summary](#)

Links to associations from:

- gene expression experiments
- EST and QTL datasets
- mutant phenotype screens

~2.2 million associations for 1320 PO terms covering 17 species

The Plant Ontology facilitates comparative plant genomics

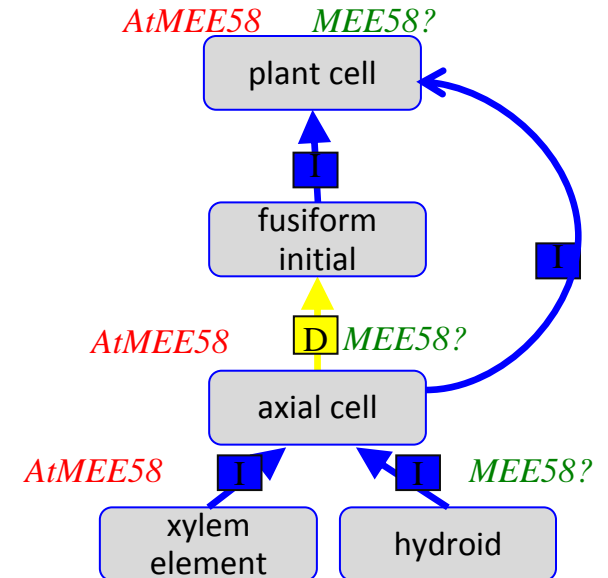
Annotations to leaf primordium ; PO:0000017 and its children

Get this data as [RDF-XML](#).

leaf primordium ; PO:0000017 [\[show def\]](#)

Qualifier	Name / Symbol	Information	Evidence	Reference	Assigned by	Associated to
<input type="checkbox"/>	AN3 AT5G28640	gene from <i>Arabidopsis thaliana</i>	IEP	PMID:15960617	TAIR	GO
<input type="checkbox"/>	ARF4 AT5G60450	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16199616	TAIR	GO
<input type="checkbox"/>	AS2 AT1G65620	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:17559509	TAIR	GO
<input type="checkbox"/>	AT1G13400.1 AT1G13400	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16554365	TAIR	GO
<input type="checkbox"/>	AT1G22840.1 AT1G22840	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16113211	TAIR	GO
<input type="checkbox"/>	ATARP6 AT3G33520	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16155178	TAIR	GO
<input type="checkbox"/>	ATGA2OX2 AT1G30040	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16139211	TAIR	GO
<input type="checkbox"/>	ATGA2OX4 AT1G47990	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:16139211	TAIR	GO
<input type="checkbox"/>	ATH1 AT4G32980	gene from <i>Arabidopsis thaliana</i>	IEP	PMID:17908157	TAIR	GO
<input type="checkbox"/>	ATHB-12	gene from <i>Arabidopsis thaliana</i>	IDA	PMID:15604708	TAIR	GO

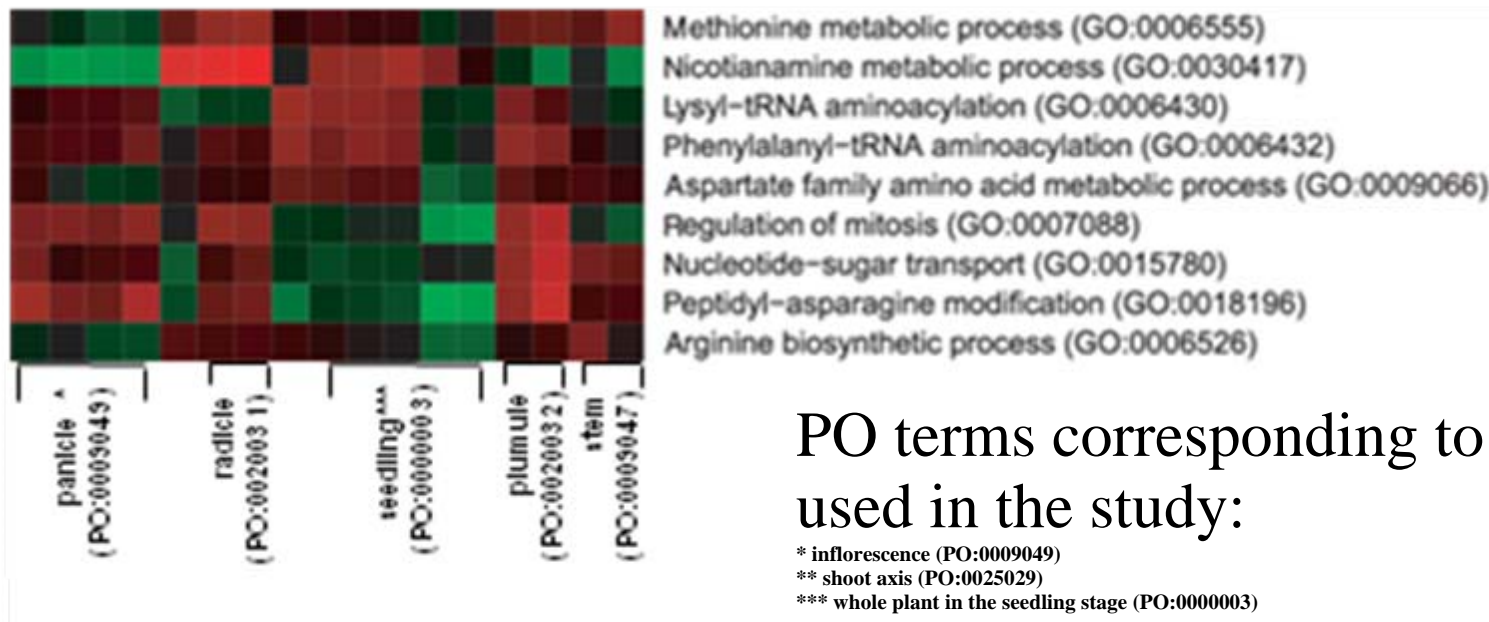
Cross-taxa comparisons:



Annotations allow for data analysis:

Annotations may be created based on microarray, EST, QTL, protein, germplasm, phenotype or other data sets, or whole genome sequencing projects.

Example microarray data set with PO and GO annotations:



PO terms corresponding to synonyms used in the study:

- * inflorescence (PO:0009049)
- ** shoot axis (PO:0025029)
- *** whole plant in the seedling stage (PO:0000003)

Contact us if you are interested in providing and maintaining annotations files for your project



Collaborative development of the PO: descriptors and annotations

Recent Examples:

- Addition of 1.5 million new associations between *Zea mays* (maize) gene models and Plant Ontology terms (October 2011)
- ~80 new anatomy terms for the *Physcomitrella*- Moss Computational Biology Resource
- Added ~ 82,000 new annotations to Moss genomics data (Jan 2012)



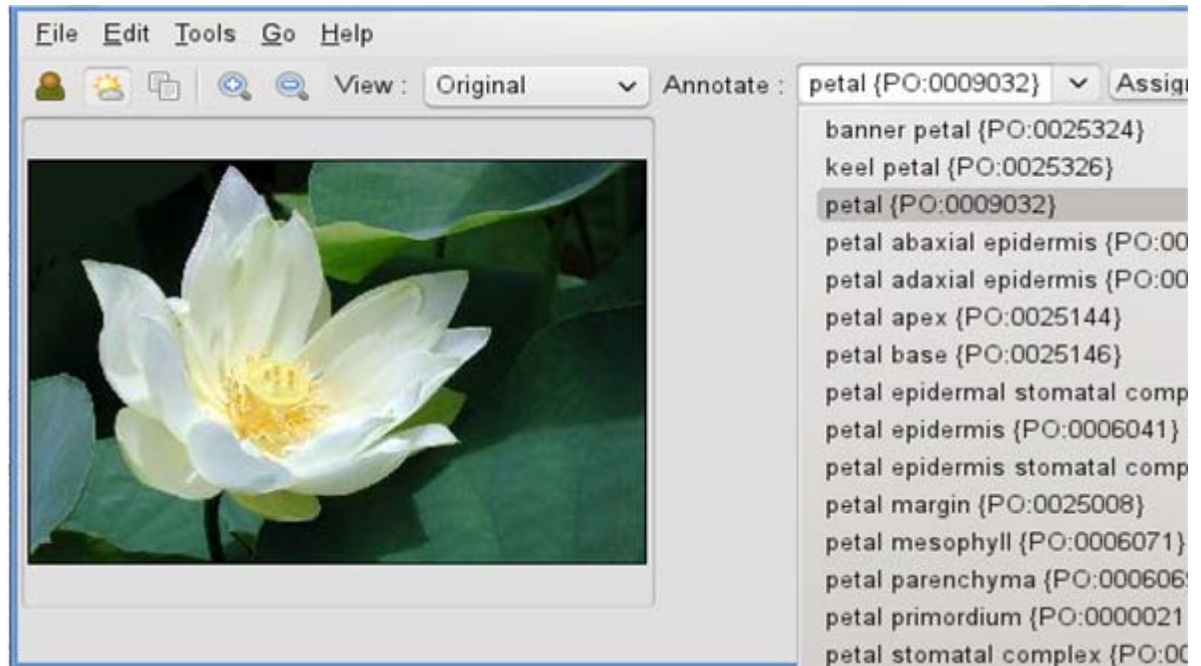
PO Web Services

Plant Ontology terms, synonyms, and definitions are now available via RESTful* web services

Request terms by keyword:

```
{
  - PO_term_search_response: [
    - {
      match: "banner petal",
      match_type: "term",
      accession_id: "PO:0025324"
    },
    - {
      match: "keel petal",
      match_type: "term",
      accession_id: "PO:0025326"
    },
    - {
      match: "petal",
      match_type: "term",
      accession_id: "PO:0009032"
    },
    - {
      match: "petal abaxial epidermis",
      match_type: "term",
      accession_id: "PO:0006052"
    },
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      match: "petal adaxial epidermis",
      match_type: "term",
      accession_id: "PO:0006053"
    },
    - {
      match: "petal apex",
```

...and use the real-time results† in your application



Detailed documentation for application developers is available on the PO web site

* REST: *Representational State Transfer (an architecture for web-based data communication)*

† *Web service results are encoded in JSON, a lightweight data-interchange format*

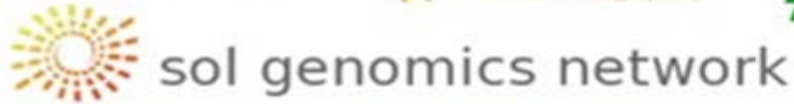
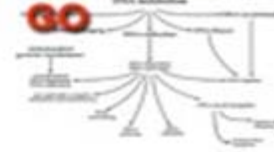


For more information: PO Events at PAG 2012

- **Non-seed plants Workshop:** Saturday, Jan 14th, 5:10 pm, Sunrise room
- **Plant Phenotypes Workshop:** Sunday, Jan 15th, 9:10 am, Golden west
- **Computer Demo:** Monday Jan 16th, 12:50pm
- **Poster # P0939:** Monday Jan 16th: 10:00 am - 11:30 am (even), 3:00 pm - 4:30 pm (odd)
- **Plant Genome Outreach Consortium Outreach booth**
in exhibit hall:
Sunday, Jan 15th, 3 pm – 8:30 pm
Monday, Jan 16th, 9:30 am – 5 pm
Tuesday, Jan 17th, 9:30 am – 3 pm



Participants and Collaborators:



Cell Ontology



Cornell University

