Annotating the Maize B73 Gene Expression Atlas in the Plant Ontology- A Tool for Plant Genomics

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Plant Ontology Is A Controlled But Structured Vocabulary

<table>
<thead>
<tr>
<th>Zm Vegetative Stages</th>
<th>Zm Reproductive Stages</th>
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<tbody>
<tr>
<td>VE emergence</td>
<td>R1 silking</td>
</tr>
<tr>
<td>V1 first leaf</td>
<td>R2 blister</td>
</tr>
<tr>
<td>V2 second leaf</td>
<td>R3 milk</td>
</tr>
<tr>
<td>V3 third leaf</td>
<td>R4 dough</td>
</tr>
<tr>
<td>V(n) nth leaf</td>
<td>R5 dent</td>
</tr>
<tr>
<td>VT tasseling</td>
<td>R6 physiological maturity</td>
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</tbody>
</table>

![Zea mays Ear (Female Inflorescence) Diagram]

- **Plant Ontology** is a controlled but structured vocabulary.
- **Zm Vegetative Stages** include VE emergence, V1 first leaf, V2 second leaf, V3 third leaf, V(n) nth leaf, and VT tasseling.
- **Zm Reproductive Stages** include R1 silking, R2 blister, R3 milk, R4 dough, R5 dent, and R6 physiological maturity.

[www.plantontology.org](http://www.plantontology.org)
Each term has:

- Primary name and synonyms
- Unique PO ID and url
- Definition vetted by community feedback and approved by experts.

**Advantage:** If multiple databases, publications, annotation projects use the same PO_ID. It is easy to track and query the datasets by using the common usage of PO_ID.

**PO facilitates building COMMUNITY STANDARDS**
is_a and part_of are the backbone of all ontologies

develops_from describes shared developmental pathways across all taxons

has_part allows the PO to handle structural variation between taxons

Logical definitions and designated relationships enable computer algorithms to interpret data associations and annotations
How Relationships Help In Comparative Genomics?

“...Here we present a comprehensive atlas of global transcription profiles across developmental stages and plant organs. We used a NimbleGen microarray containing 80,301 probe sets to profile transcription patterns in 60 distinct tissues representing 11 major organ systems of inbred line B73. Of the 30,892 probe sets representing the filtered B73 gene models, 91.4% were expressed in at least one tissue. Interestingly, 44.5% of the probe sets were expressed in all tissues, indicating a substantial overlap of gene expression among plant organs. Clustering of maize tissues based on global gene expression profiles resulted in formation of groups of biologically related tissues...”

On board expertise in whole genome gene expression/systems biology @ MaizeGDB
Jack Gardiner, Ethalinda Cannon, Taner Sen

Sekhon et al Mar 2010 Maize Meeting

Source: Mary Schaeffer
Maize Gene Expression Atlas Annotation

>300,000 NimbleGen probes
B73_V1 based gene models

60 maize tissues
seed to seed

B73_v2 gene models
Mar 2010 released

Jack Gardiner, Ethalinda Cannon, Taner Sen

Source: Mary Schaeffer
PO annotations of source tissue and growth stages

Links to terms for reference:

Genome-wide atlas of transcription

Terms:
anthers R1 B73
cob immature V18 B73
cob pre-pollination R1 B73
silks R1 B73
tassel immaturecoleoptile 6
husk, inner leaf 8th V9 B73
leaf base of leaf tip expanding V7 B73
leaf, 11th V9 B73
leaf, 13th R2 B73
leaf, 13th V9 B73
leaf, 13th VT B73
leaf, 17th and above immature V9 B73
leaves V1 B73
leaf 1st with sheath V3 B73
leaf 1st V1 B73

~1.5 million new associations between Plant Ontology terms and ~35,000 Zea mays gene models from the recent sequencing of the Maize genome (Oct 2011)
Expression Profile of Terpene Synthase Gene Family Across Six Species by using the PO annotations

Tree: MUSCLE
Visualization: iTOL
MaizeCyc Metabolic Pathway Analysis using PO Annotations

Leaf [L]

PO:0009025

(\# of pathways)

A = anther (159)
E = embryo (122)
D = endosperm (106)
L = leaf (199)
R = root (145)

Anther [A]

PO:0009066

Embryo [E]

PO:0009009

Endosperm [D]

PO:0009089

Primary Root [R]

PO:0020127

Source: MaizeCyc project

Sekhon et al. (2011) Plant J 66:552-563

www.plantontology.org
### Acknowledgements

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<th>Plant Ontology</th>
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<tr>
<td>Dennis Stevenson</td>
<td>Mary Schaeffer</td>
<td>Palitha Dharmawardhana</td>
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<td>Alexandra Gandolfo</td>
<td>Jack Gardiner</td>
<td>Marcela Monaco</td>
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<td>Barry Smith</td>
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<td>Chris Mungall</td>
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<td>Daniel Lang</td>
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