

Gramene - Exploring Function through Comparative Genomics & Network Analysis

Transnational collaboration



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- Gramene is a Comparative Database for Plants since 2001
- 67 plant genomes with gene family trees, sequence alignments, synteny, homologs (EBI-Ensembl)
- Gene expression (EBI-Atlas)
- Pathways (OSU-Reactome)
- Automated ingestion of functional annotations from publications (ASPB)



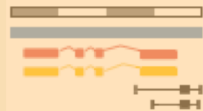


New cereals:
African Tef &
Durum Wheat

67 reference
Genomes



~2.5M gene
annotations



>100K
gene trees



299 whole-
genome
alignments

ATCGAGCT
ATCCAGCT
ATCGAGAT

66 synteny
maps



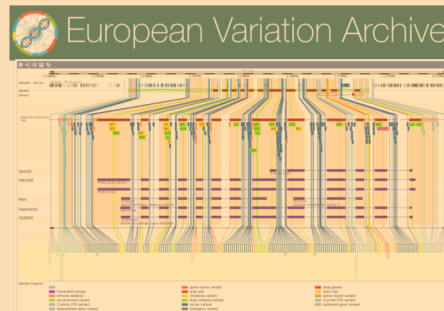
Expression



805 experiments in
24+ species

**Integrated search
and visualization**

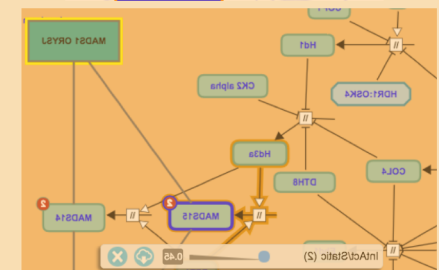
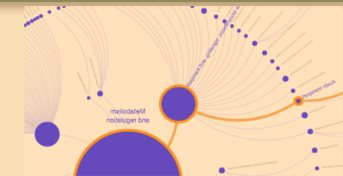
Variation



~223.7M SNPs
in 12 genomes

Pathways

305 curated rice
projected to
97 species



Gramene.Org



Search for genes, species, pathways, ontology terms, domains...



2264698 genes in 61 genomes ▾

Gramene Portals



Genome Browser

Gene Trees, Homologs, Synteny,
Whole-Genome Alignments



Plant Reactome

Browse and analyze metabolic and regulatory pathways

Pathways



Tools

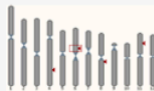
Tools for processing both our data and yours



Plant Expression ATLAS

Bro

Gene Expression



BLAST

Query our genomes with a DNA sequence

Tools &
External Data



Gramene Mart

An advanced query interface powered by BioMart



Track Hub Registry

A global centralised collection of publicly accessible track hubs

Outreach and Training

Outreach, Education & Training



Bulk Downloads

FTP download of our data



Archive

Legacy tools and data (markers, Cyt pathways, etc)

Latest News

Gramene will be at Plant Biology 2019 – Hope to see you in San Jose, CA! Fri, 26 Jul 2019

Community Annotation Poster at SUNY Old Westbury's 2019 Student Research Day Conference Tue, 04 Jun 2019

Saturday DNA: Get to Know GMOs! - A WiSE event Tue, 04 Jun 2019

Plant domestication and the secrets in a plant's genome for 4th graders Mon, 03 Jun 2019

Announcing Gramene Knowledgebase release #61 with new and updated plant genomes and pathways Thu, 02 May 2019

Workshop on Cereal Genomics at CSHL, October 15 - 21, 2019. Apply by Aug 15 Thu, 25 Apr 2019

Annotation Jamboree for rs. St. Louis, MO. March 13-14, 2019 Wed, 17 Apr 2019

Announcing Gramene release #60: New & updated genomes, pathways and other features Fri, 08 Feb 2019



Gene & Protein Expression



What can I do with Gramene?

- Is my gene conserved in other species? Can I identify function of a novel gene through homology?
- Where and when is my gene expressed?
- Is my gene in a metabolic pathway? Is the pathway conserved in other crops?
- Have genetic variants been identified in my gene? Can I access germplasm lines with naturally occurring or introduced genetic variants in my gene?

Work Example

1. Identify the sorghum ortholog of the maize *tassel seed1* (*ts1*) gene
2. Reduce the complexity of the gene's family tree, focusing on species of interest (Zm, Sb, Si, Os, At)
3. Visualize synteny between species
4. Explore gene structure and identify functional annotations associated with this gene family
5. Explore patterns of gene expression
6. Identify pathways associated with the gene
7. Explore genetic variation in *ts1* and find induced EMS-mutants in sorghum

Find orthologs & paralogs



Search: *ts1* or *tassel seed1*

3 genes in 2 genomes

Gene | tassel seed1

Show All Species

Pick Species from List

tassel seed1 Zm00001d003533 GRMZM2G104843Zea mays

Lipoxygenase

Location Expression Homology Pathways X-refs

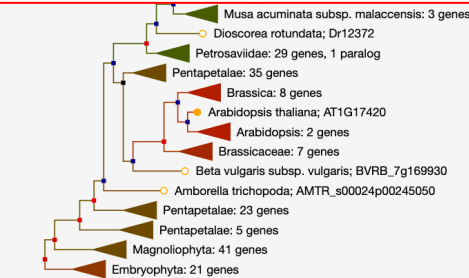
Compara Gene Tree

This phylogram shows the relationships between this gene and others similar to it, as determined by Ensembl Compara.

Display mode

Alignment overview: Proteins color-coded by InterPro domain. Resize slider to zoom in.

Sorghum ortholog: **SORBI_3006G095600 [msd2]**



Search Gramene

Show All Homologs 205

Show Orthologs 104

Show Paralogs 3

For specific tasks,
check out our YouTube
video tutorials

<https://goo.gl/ln9RLD>

Os04g0447100 *Oryza sativa Japonica Group*

LOX3 *Arabidopsis thaliana*



Gene Trees: Focus on species of interest

=> *Prune unwanted species*

tassel seed1 Zm00001d003533 GRMZM2G104843Zea mays

Lipoxygenase

Location Expression Homology Pathways X-refs

12 genes in 8 genomes

Show All Species

Pick Species from List

LOX3 Arabidopsis thaliana
Lipoxygenase 3, chloroplastic

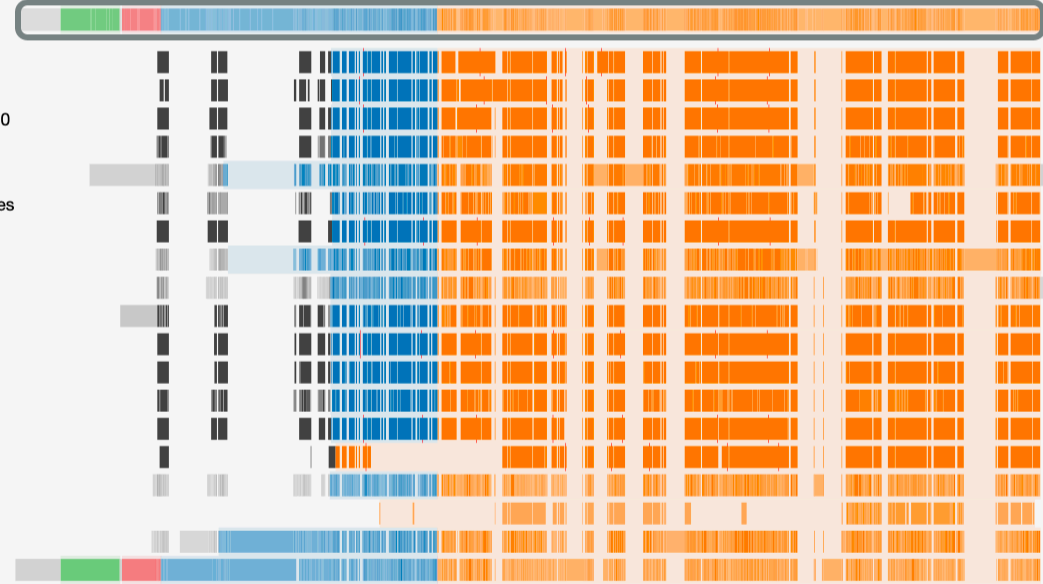
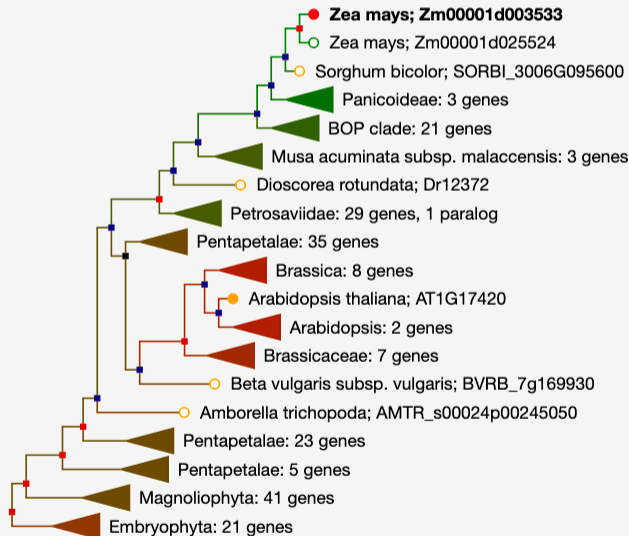
Compara Gene Tree

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Display mode



Alignment overview: Proteins color-coded by InterPro domain. Resize slider to navigate.



Gene Trees: Focus on species of interest

=> *Prune unwanted species*



tassel seed1 Zm00001d003533 GRMZM2G104843Zea mays

Lipoxygenase

Model Species Homolog

LOX3 Arabidopsis thaliana

Lipoxygenase 3, chloroplastic

Location Expression **Homology** Pathways X-refs

Compara Gene Tree

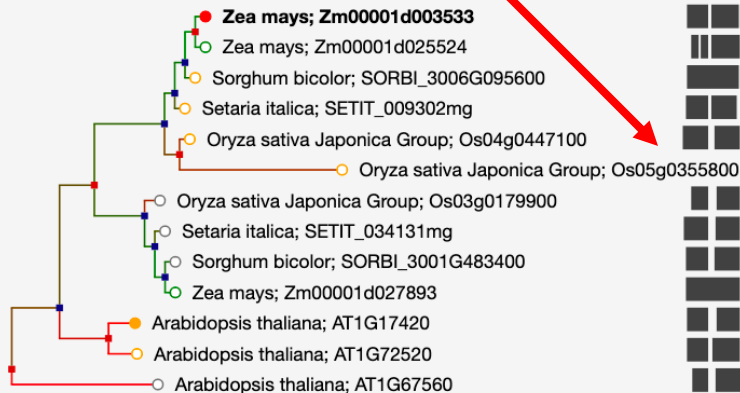
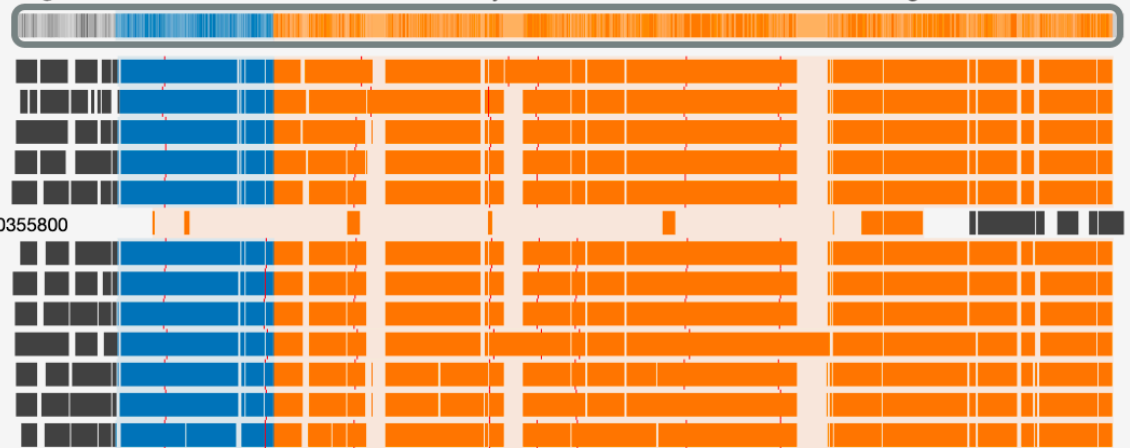
Artifact or Biology?

This phylogram shows the relationship between genes identified by Ensembl Compara

Display mode

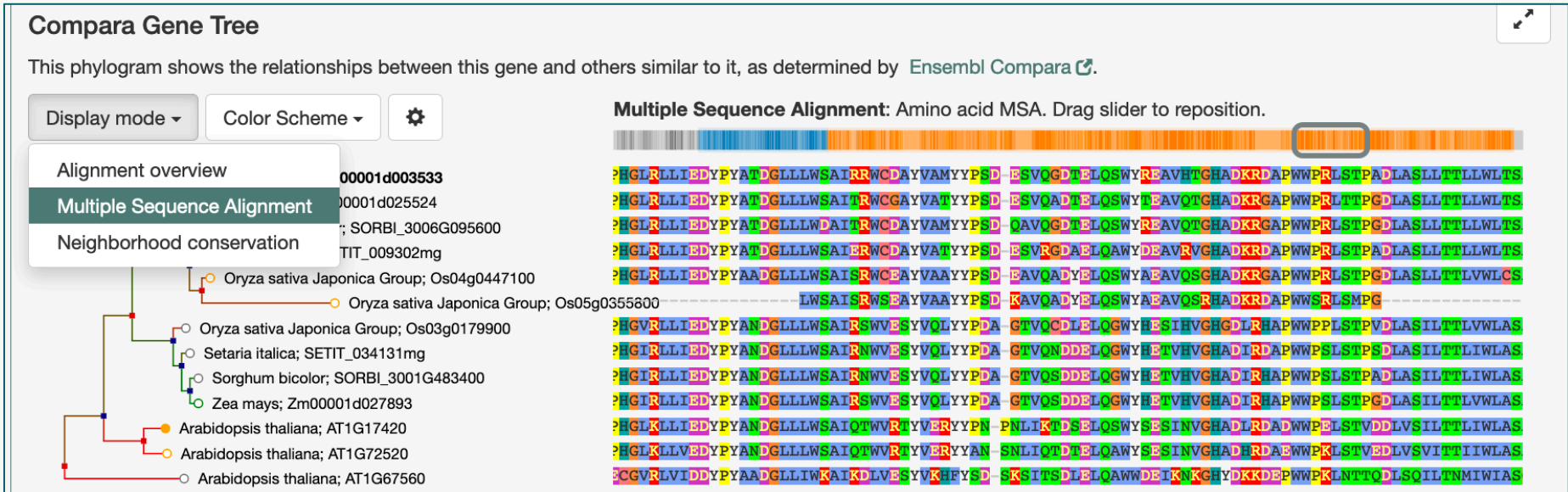


Alignment overview: Proteins color-coded by InterPro domain. Resize slider to navigate.

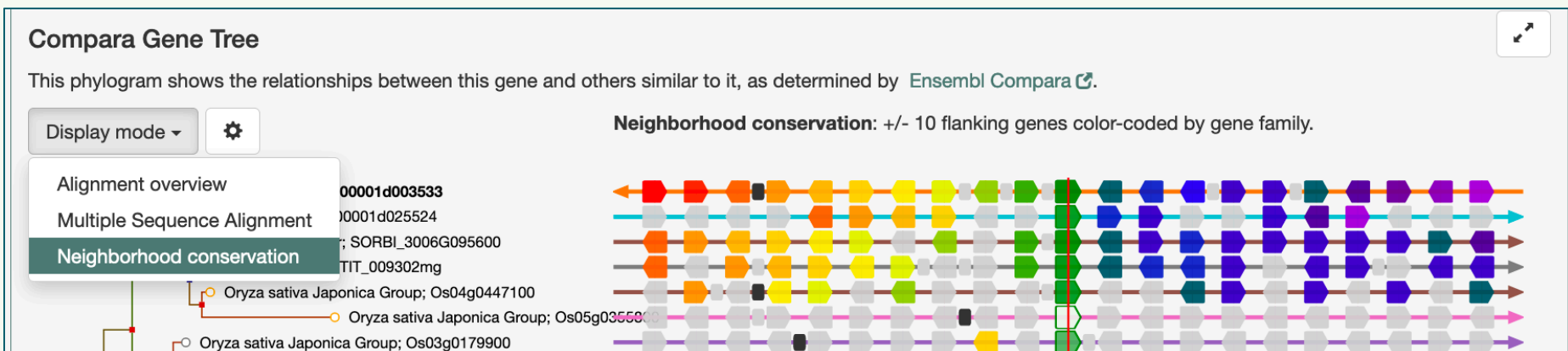


Explore a gene family tree

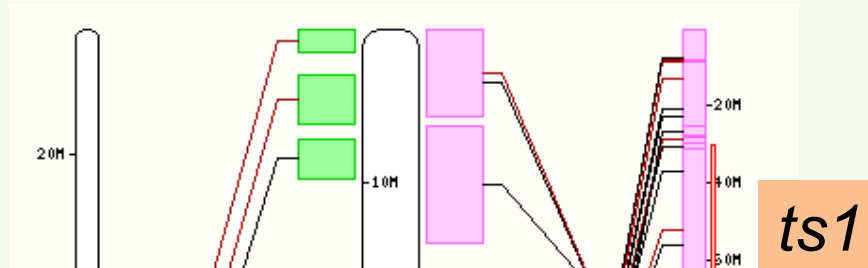
=> *Zoom In to view aligned amino acids*



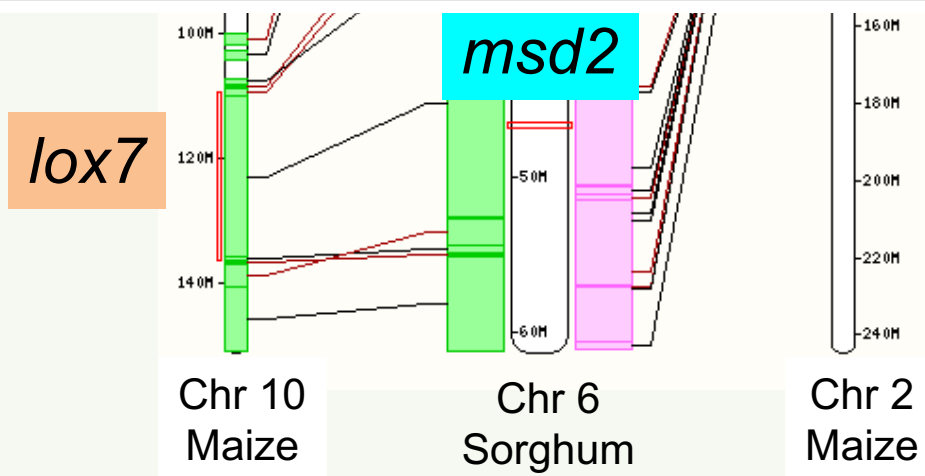
=> *Zoom Out to view conserved gene neighborhoods*



Explore synteny



| Show/hide columns | | Filter | | |
|--|-------------------------------------|---|--|-----------------------------------|
| <i>Sorghum bicolor</i> genes | Location | <i>Zea mays</i> homologues | Location | |
| SORBI_3006G095600 (SORBI_3006G095600) | 6:46566240-46571064 | → tassel seed1 (Zm00001d003533) | 2:47105187-47109372 | Region Comparison |
| | | → lipoxygenase7 (Zm00001d025524) | 10:121268606-121272616 | Region Comparison |



- Comparative Region View
- Download Gene Lists

Explore gene structure

=> Identify protein domains



tassel seed1 Zm00001d003533 GRMZM2G104843Zea mays [↗](#)

Lipoxygenase

Model Species Homolog

LOX3 *Arabidopsis thaliana*

Lipoxygenase 3, chloroplastic

Location Expression **Homology** Pathways X-refs

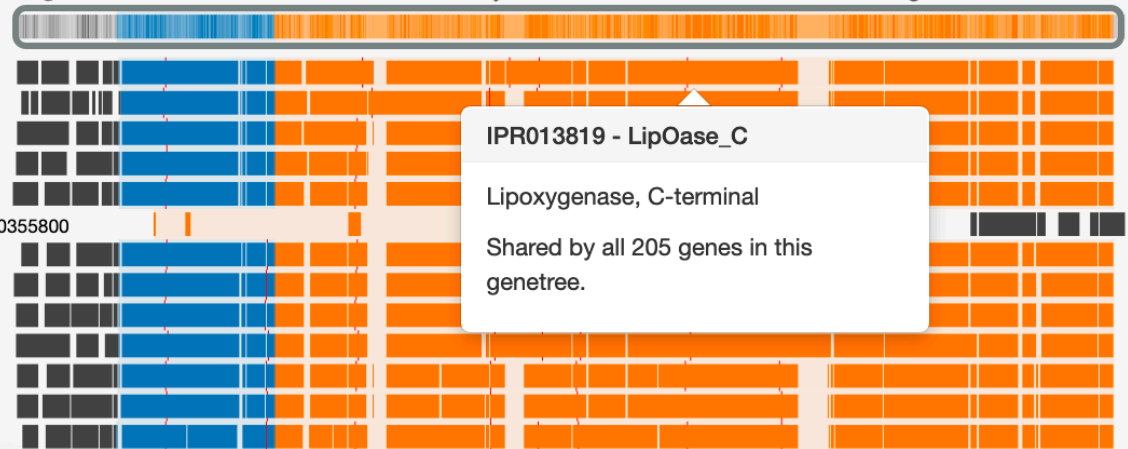
Compara Gene Tree

This phylogram shows the relationships between this gene and others similar to it, as determined by [Ensembl Compara](#) [↗](#).

Display mode ▾



Alignment overview: Proteins color-coded by InterPro domain. Resize slider to navigate.

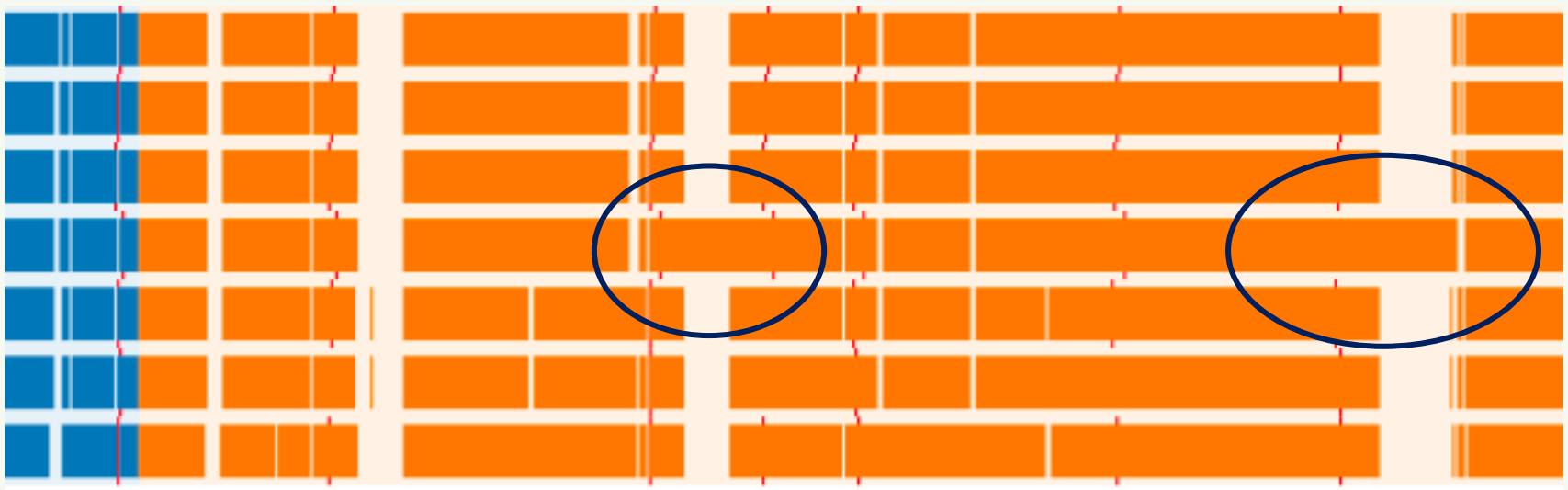


Explore gene structure

=> *Identify splice junctions*

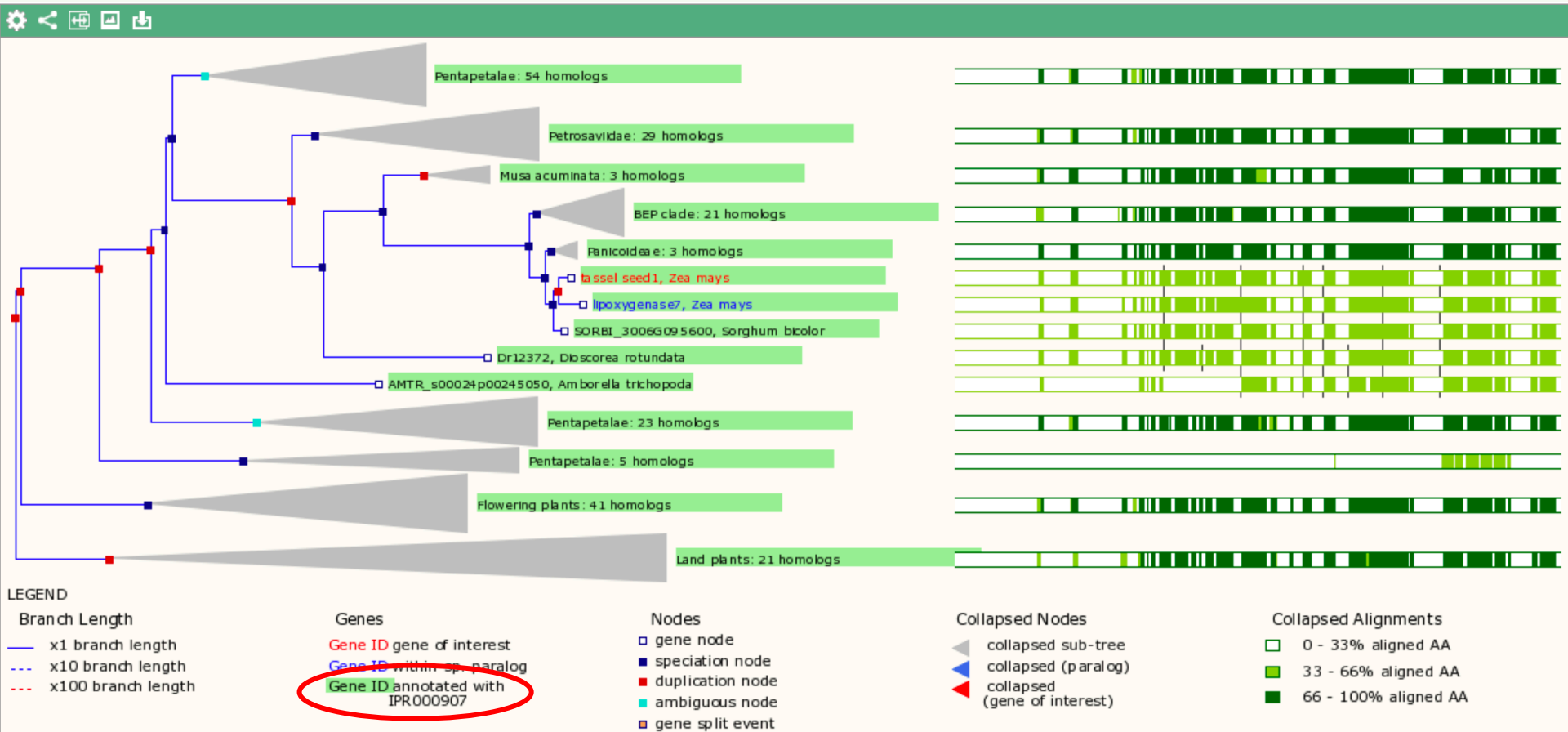


Artifact or Biology?



Explore functional gene structure

=> Highlight InterPro & GO annotations



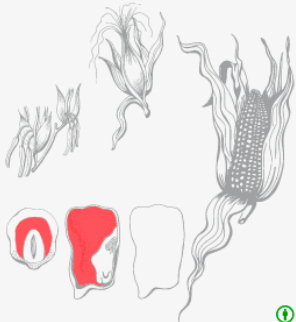
View patterns of gene expression

=> Visualize & download expression data from 800+ experiments in >24 plant species (EBI-Atlas)

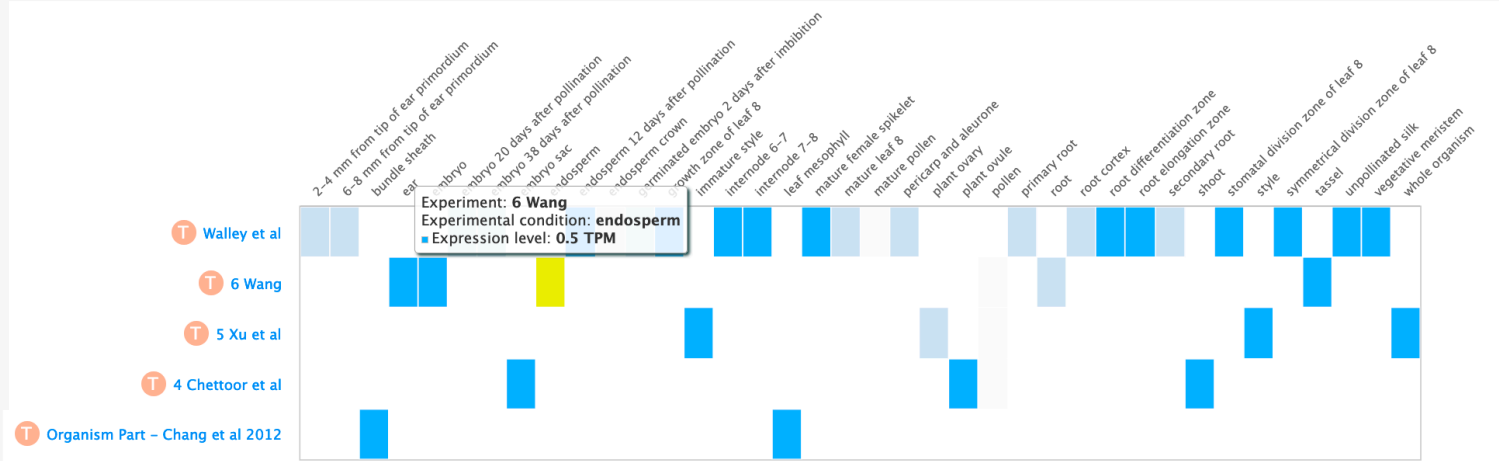
Location **Expression** Homology Pathways X-refs

Showing 5 experiments:

↓ By experiment type Filters Download



endosperm

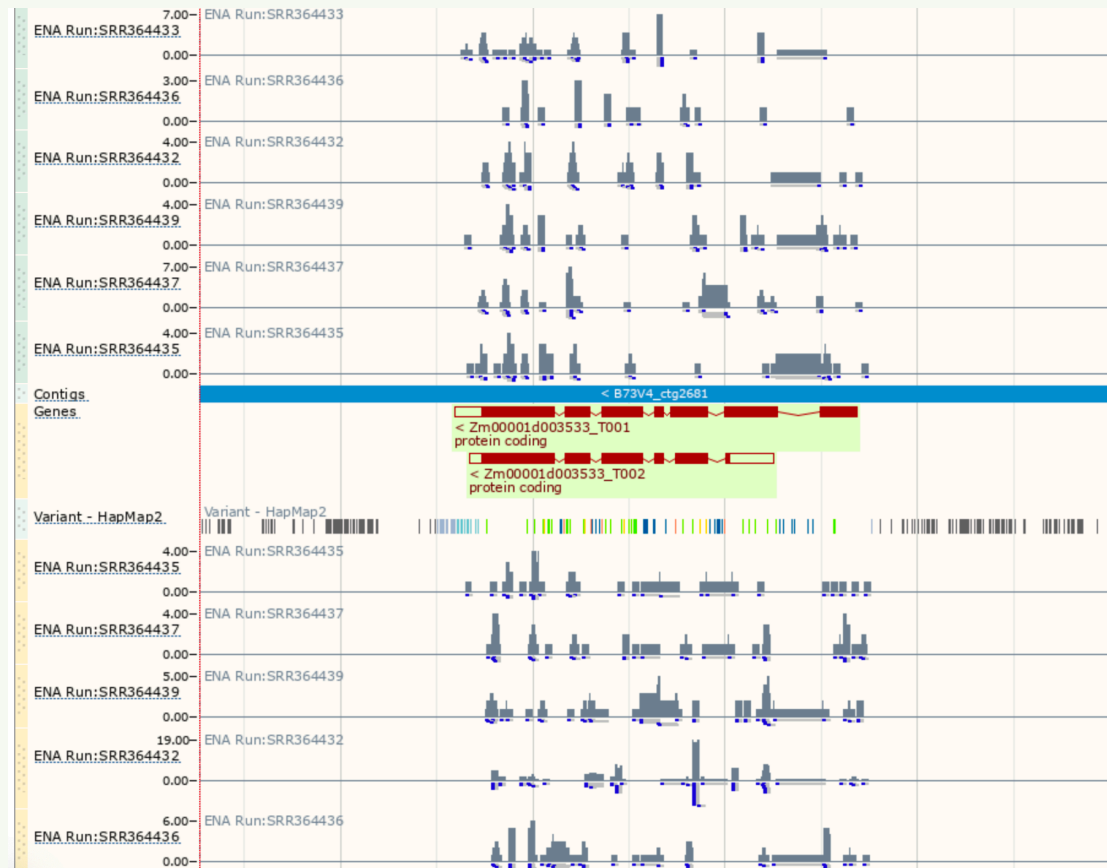


Legend: High (dark blue), Medium (medium blue), Low (light blue), Below cutoff (grey), No data available (white). P Proteomics, T Transcriptomics.



Project publicly available transcriptomics data

=> Find patterns of gene expression from 4,100 public RNA-Seq studies in Track Hub



RNA-Seq Experiment: SRP009313 – Parent-of-origin effects on gene expression & DNA methylation in the maize endosperm.

Identify pathways associated with my gene

tassel seed1 Zm00001d003533 GRMZM2G104843 *Zea mays* [Model Species Homolog](#)

LOX3 *Arabidopsis thaliana*
Lipoxygenase 3, chloroplastic

Lipoxygenase

Location Expression Homology Pathways X-refs

▼ Metabolism and regulation
▼ Hormone signaling, transport, and metabolism
▼ Jasmonic acid biosynthesis
O2+linolenate->13-HPOT
▼ Secondary metabolism
▼ 13-LOX and 13-HPL pathway
O2+linolenate->13-HPOT
Lipoxygenase
▼ Divinyl ether biosynthesis II (13-LOX)
Lipoxygenase

Event Hierarchy:
Circadian rhythm
Growth and developmental
Metabolism and regulation
Generation of precursor
Amino acid metabolism
Amine and polyamine bi
Carbohydrate metabolis
Cofactor biosyntheses
Detoxification
Hormone signaling, tra
IAA biosynthesis I
IAA biosynthesis II
IAA biosynthesis VI (v
Brassinosteroid biosy
Cytokinins 7-N-glucoside biosynthe
Cytokinins 9-N-glucoside biosynthe
Cytokinins-O-glucoside biosynthes
Jasmonic acid biosynthesis
Allene-oxide cyclase
12-oxophytodiolenate reductase
a phosphatidylcholine+H2O->a
O2+linolenate->13-HPOT
Jasmonic acid signaling
GA12 biosynthesis
Gibberellin biosynthesis I (non C-3
Gibberellin biosynthesis II (early C
Gibberellin biosynthesis III (early C
Ethylene biosynthesis and signalin

Pathways for: *Zea mays*

Picea abies
Pinus taeda
Populus trichocarpa
Prunus persica
Selaginella moellendorffii
Setaria italica
Solanum lycopersicum
Solanum tuberosum
Sorghum bicolor
Synechocystis sp. PCC 6803
Theobroma cacao
Trifolium pratense
Triticum aestivum
Triticum dicoccoides
Triticum turgidum
Triticum urartu
Vigna angularis
Vigna radiata
Vitis vinifera
✓ *Zea mays*

Analysis: Tour: Layout:

1-acylglycerophosphocholine
ALA
13-HPOT

phospholipase
Linoleate 13S-lipoxygenase

Zm00001d003533 - 0 entities fl...

Description Molecules 9/26 Structures Expression Analysis Downloads

Analysis results are shown here when an analysis has been run. To start an analysis, click on the Analyse Data button in the top bar.

Search Gramene
All genes in this Reaction

Links to other resources
Plant Reactome Gene
Plant Reactome Reaction

=> Explore Pathway & Overlay Omics Data



ftp://ftp.gramene.org/pub/gramene/outreach/cshl_cereals_workshop2019/



Thank you & Contact Us!

- Outreach: <http://gramene.org/outreach>
- Slides, exercises, brochures, posters:
<ftp://ftp.gramene.org/pub/gramene/outreach>
- E-mail: feedback@gramene.org
- Collections in  **Plantae** and  **YouTube**
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