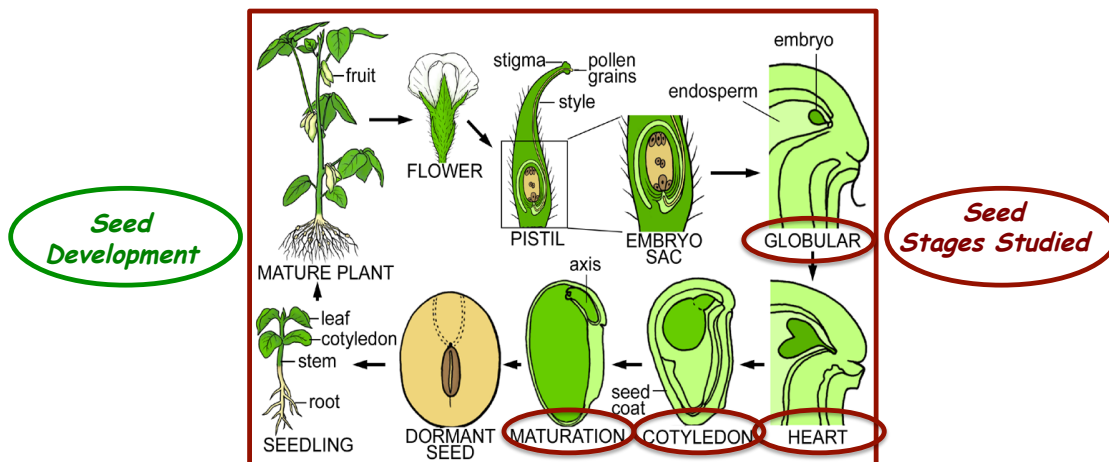


What Are the Functions of Soybean Seed Compartments?

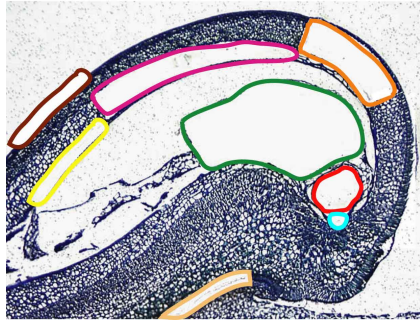
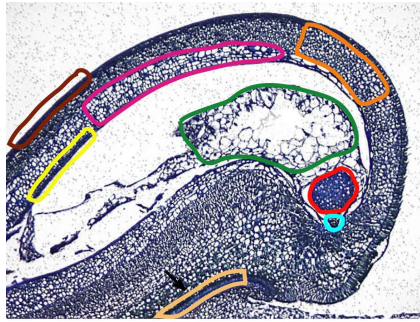
Jungim Hur
Goldberg Lab, UCLA
Seed Institute Meeting
11-11-2011

What Are the Major Questions?

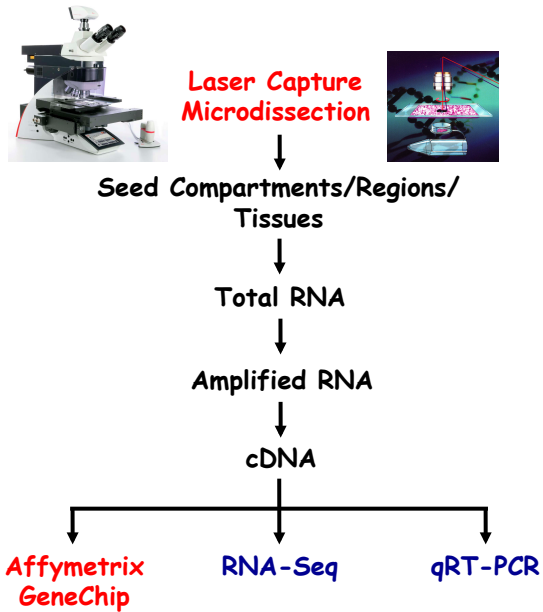


- What are the **genes and regulators** that are active in specific seed compartments throughout soybean seed development?
- How does **gene activity change** during seed development?
- What **biological processes** are unique or prevalent in different seed compartments throughout development?
- What are the **genes** required to make a seed?

How Did We Study Gene Activity in Different Seed Compartments during Development?



Soybean Globular-Stage Seed



Diversity of Oil Seed Plants

Why Soybean? - A Reminder

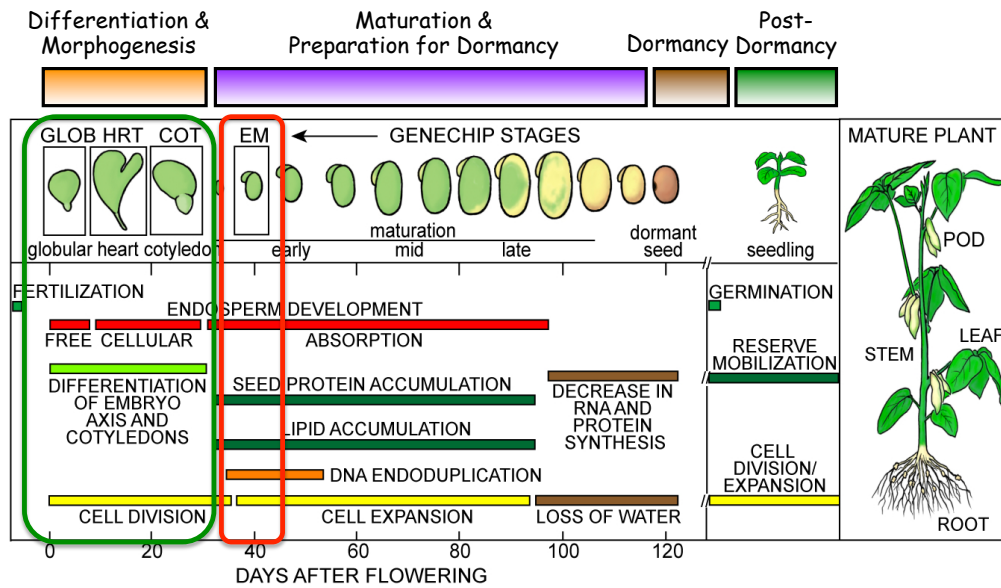
- **Second Major US Crop**
- **Total Crop Value \$32Billion**
(50% Value Exported)
- **Major Food Source**
- **Important Biofuel Source**
(Biodiesel ~20% of US Soybean Oil Production)
- **Excellent Model Plant**
(Transformation, Knockdowns, Genetics)
- **Genome Sequenced**
- **Seed Gene Expression Data**

Soybean

Sunflower

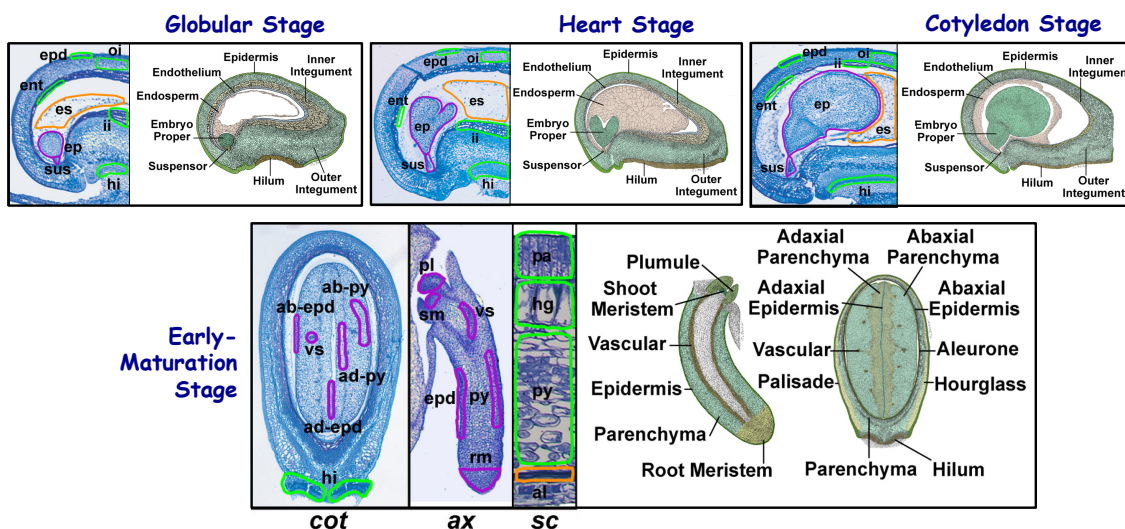
Oilseed Rape

What Soybean Developmental Stages Were Studied?







- The **differentiation** of the embryo, endosperm, and seed coat happens at *Globular, Heart, and Cotyledon stage*
- The developmental program is switched to **storage protein deposition and preparation for dormancy** at *Early-Maturation stage*

What Soybean Seed Compartments, Regions, and Tissues Were Studied?

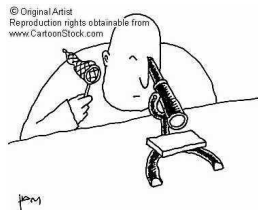
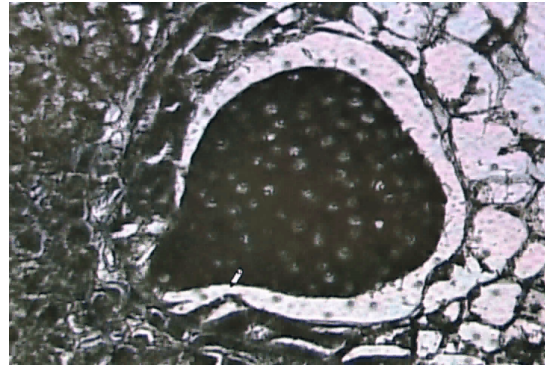


40 Different Soybean Seed Compartments, Regions, and Tissues throughout Soybean Seed Development Were Studied

How Many LCM Sections Were Captured and How Many Hours Were Spent for LCM Capturing?

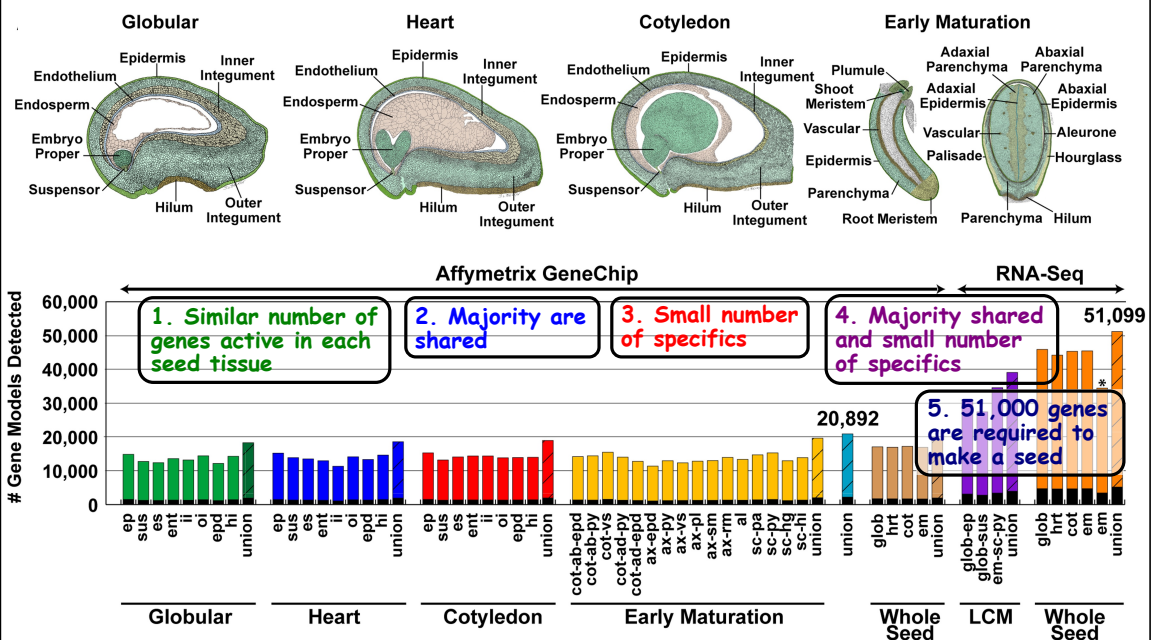
Developmental Stage	Number of LCM Captures
 Globular	5,832
 Heart	2,230
 Cotyledon	2,254
 Early-Maturation	7,912
Total	18,228

Globular Stage Embryo Proper and Suspensor



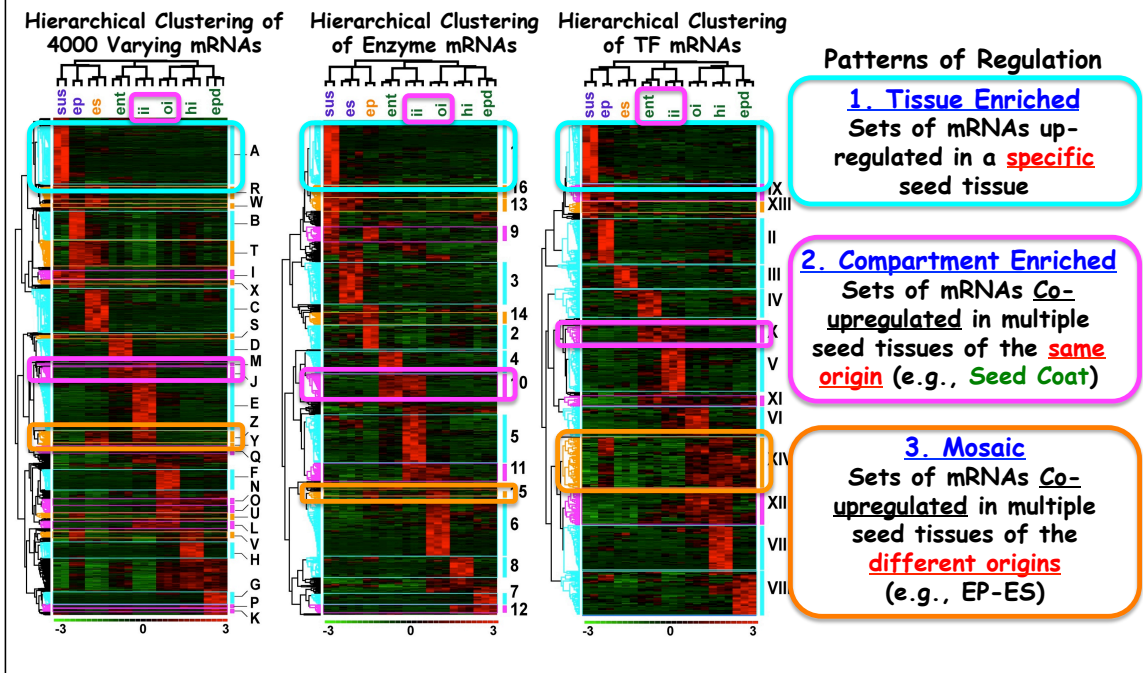
Person-Hour Spent for LCM Capturing:
608 hr

What Are the Genes Active in Soybean Compartments, Regions, and Tissues throughout Development?



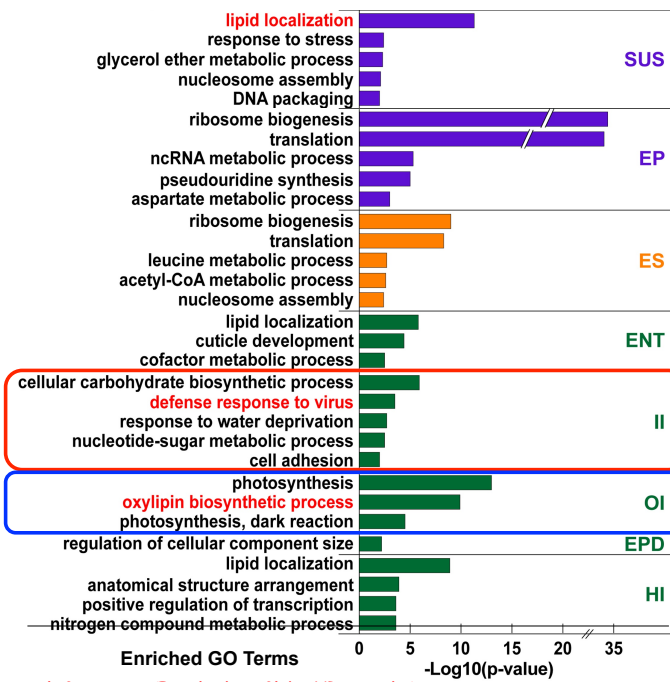
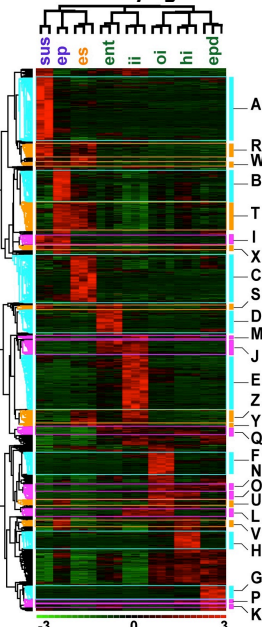
*Total RNA was amplified using NuGEN Ovation RNA-Seq System

How Are mRNAs Regulated in Different Seed Compartments, Regions, and Tissues during Soybean Development? An Example-The Globular Stage



What Biological Processes Are Prevalent or Unique in Different Seed Compartments at Globular Stage?

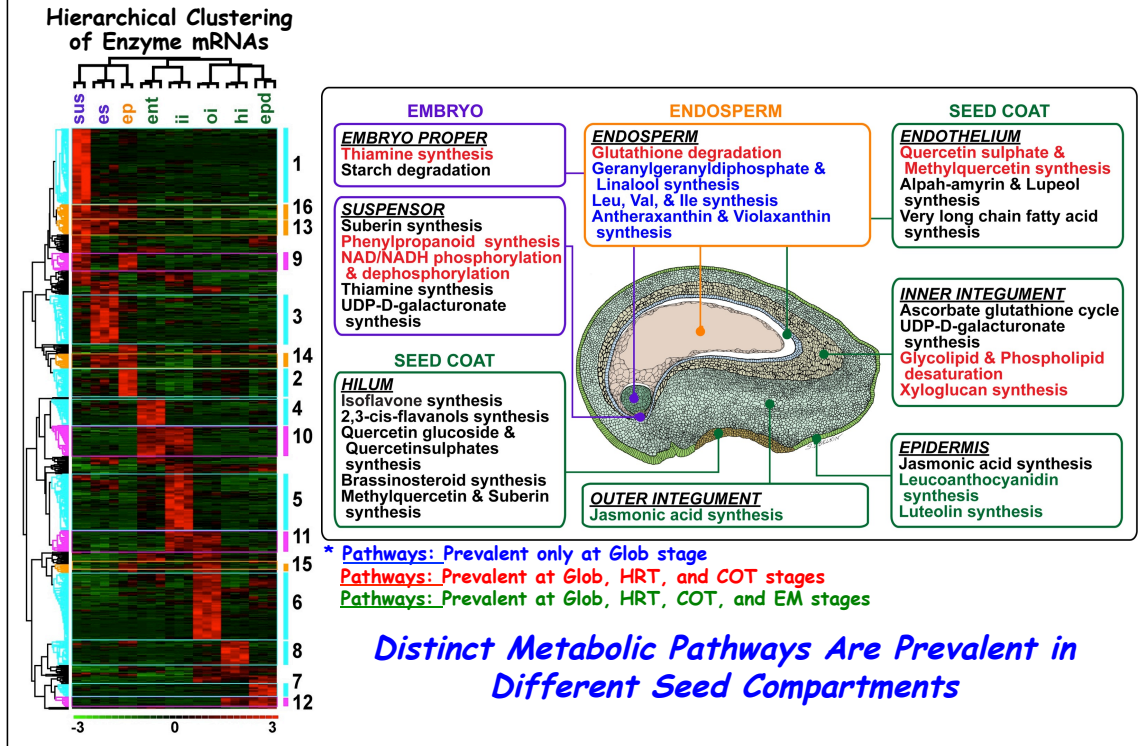
Hierarchical Clustering of 4000 Varying mRNAs



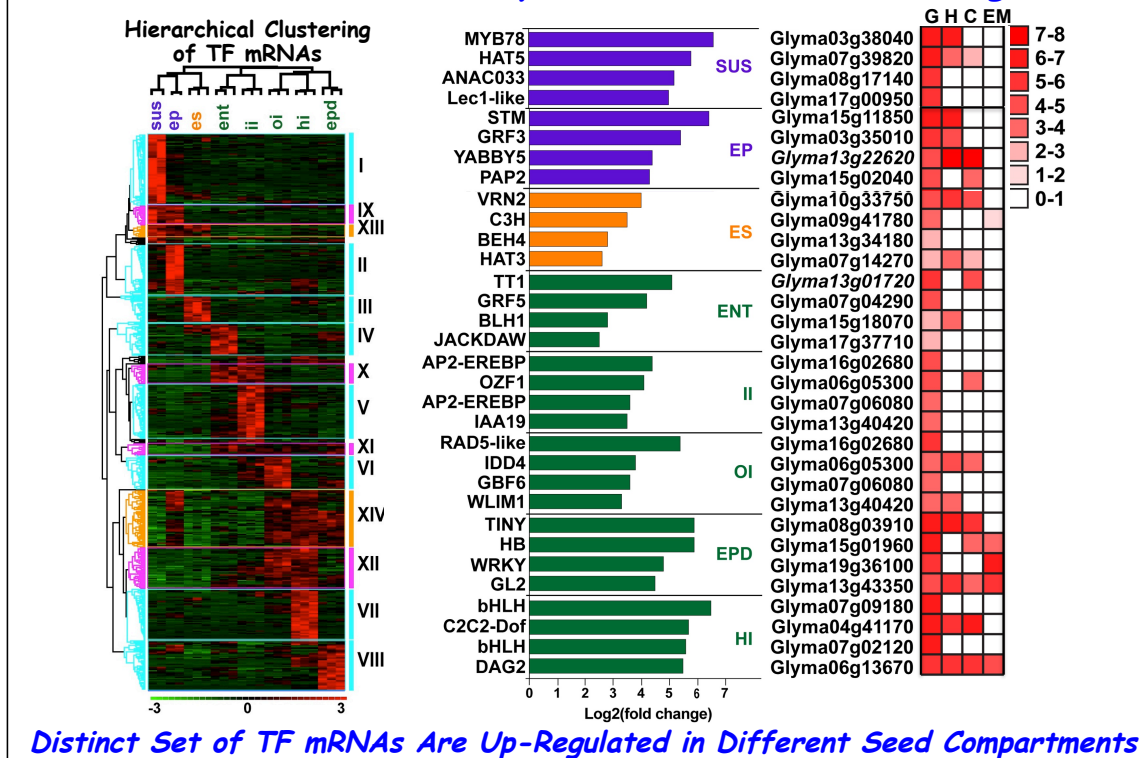
* GO Terms Enriched at Glob, HRT, and COT stages

Distinct GO Terms Are Enriched in Different Seed Compartments

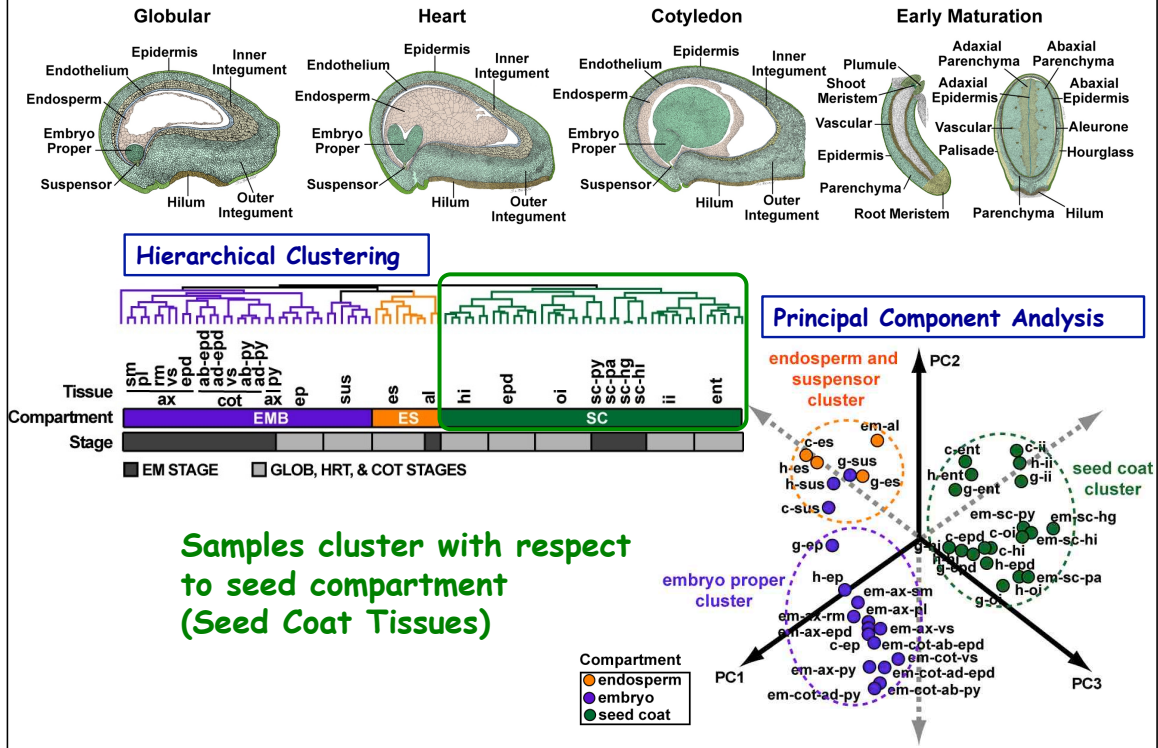
What Metabolic Pathways Are Prevalent or Unique in Different Seed Compartments at Globular Stage?



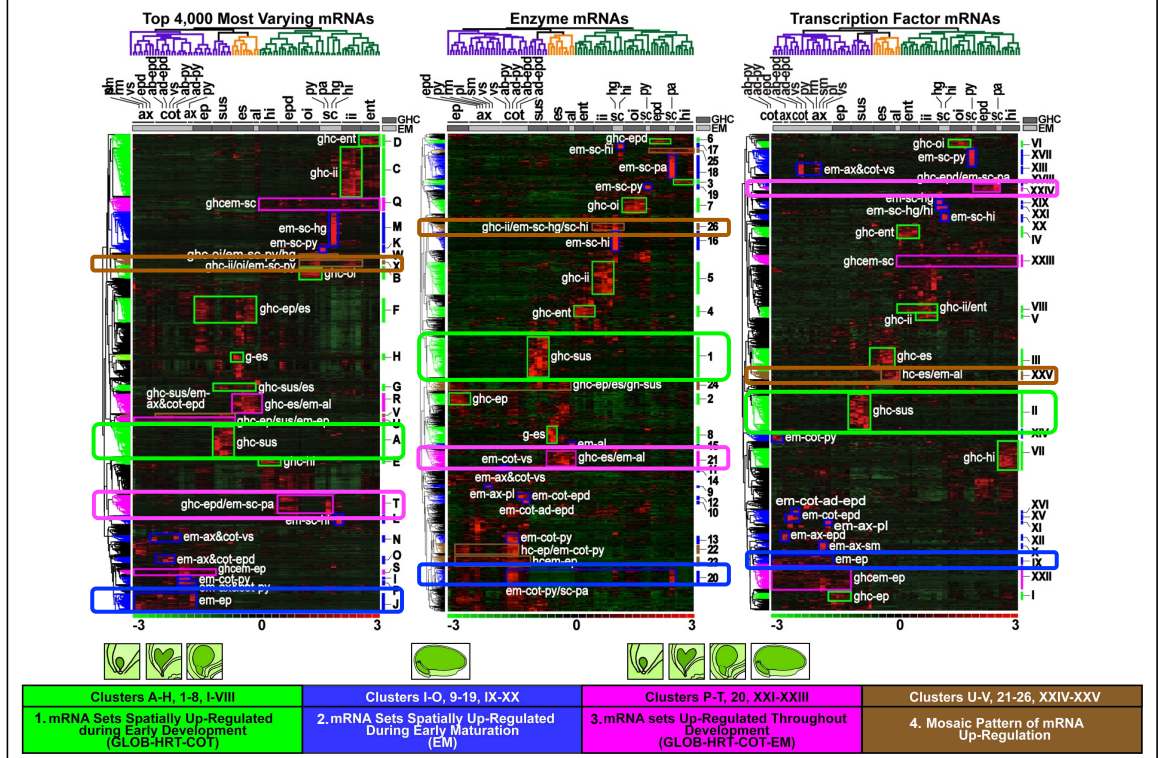
What Transcription Factor mRNAs Are Prevalent or Unique in Different Seed Compartments at Globular Stage?



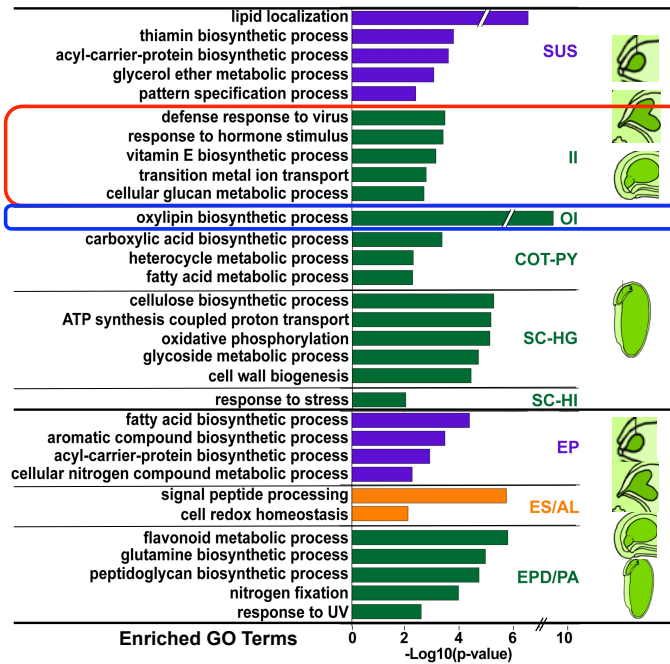
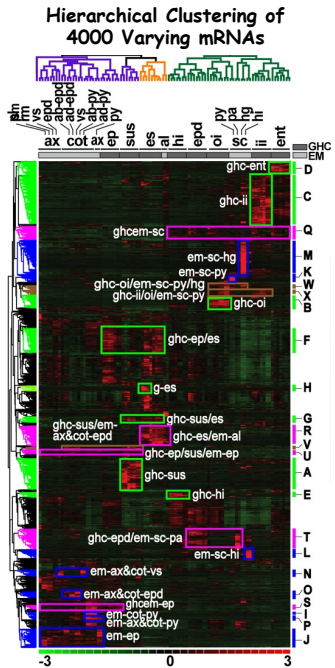
What Biological Relationships Are Observed among 40 Different Seed Compartments throughout Development?



What Are the Major Temporal and Spatial mRNA Accumulation Patterns throughout Seed Development?

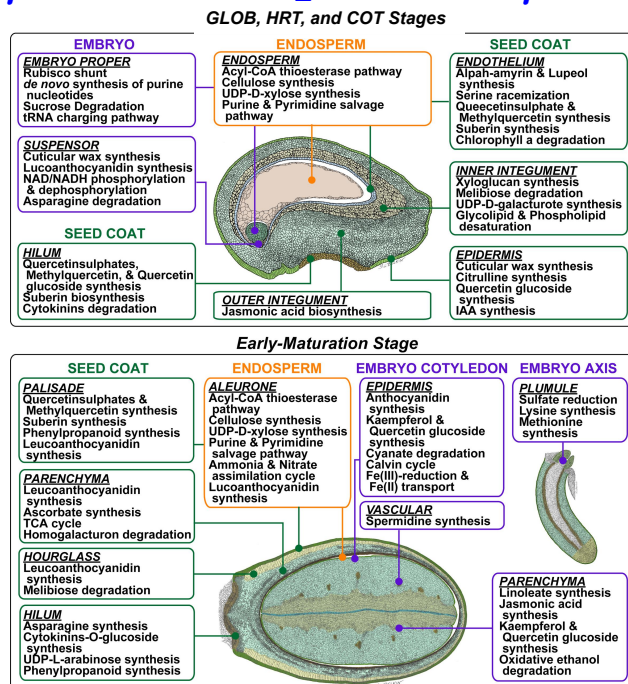
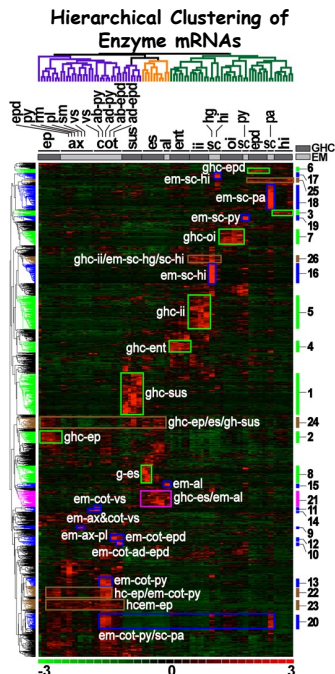


What Biological Processes are Prevalent or Unique in Different Seed Compartments throughout Development?



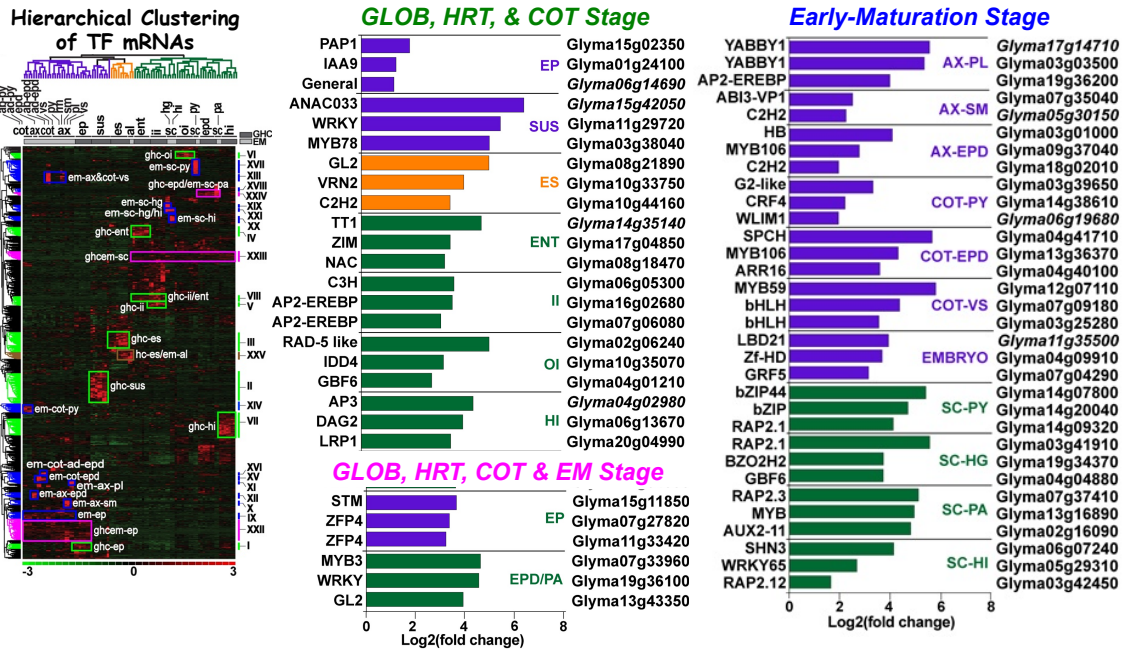
Biological Processes are Compartmentalized Spatially and Temporally during Soybean Seed Development

What Metabolic Pathways are Prevalent or Unique in Different Seed Compartments throughout Development?

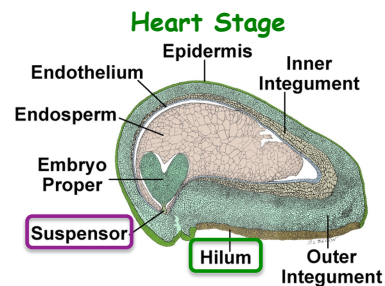
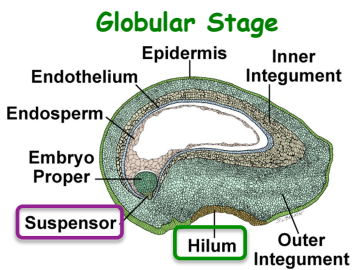


Metabolic Pathways are Compartmentalized Spatially and Temporally during Soybean Seed Development

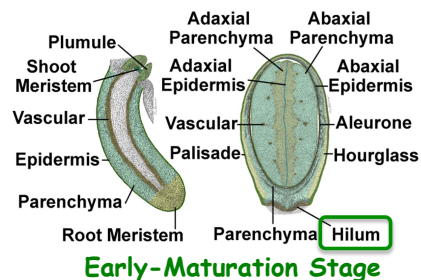
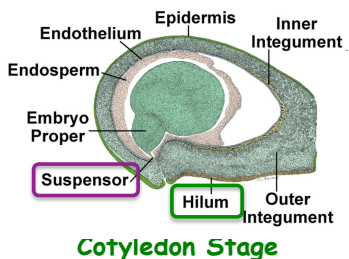
What Transcription Factor mRNAs Are Prevalent or Unique in Different Seed Compartments throughout Development?



Transcription Factor mRNAs are Compartmentalized Spatially and Temporally during Soybean Seed Development



What are the Functions of Soybean Seed Compartments during Development? Anything New Uncovered?



What Is the Function of the Suspensor?



Biological Process/
Metabolic Pathway

Toxin metabolic process
Isoflavone synthesis

Plant cell wall organization

Lipid localization
Cuticular wax & Very long chain fatty acid synthesis
NAD/NADH phosphorylation & dephosphorylation
Thiamine synthesis

Transcription Factor

ANAC073

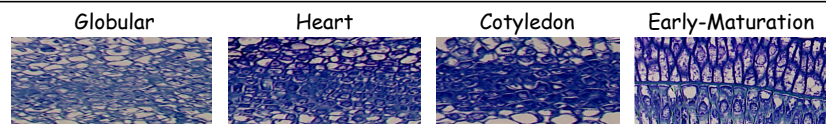
SHY2

WRKY6, WRKY23

ANAC033, MYB78, WRKY47, ERF9, PLT1, Lec1-like, ATHB1, WOX9

Suspensor Could Be Involved in Regulating Defense Response against Pathogen Attack and Stress Response

What is the Function of the Hilum?



Biological Process/
Metabolic Pathway

Isoflavone synthesis

Lipid localization
2,3-cis-flavanols synthesis
Cellulose synthesis

Quercetinsulphates, Methylquercetin, Suberin synthesis
Proanthocyanidin synthesis
Brassinosteroid synthesis
Homogalacturonan degradation

UDP-L-arabinose,
Xylan synthesis
Cuticular wax synthesis

Transcription Factor

HSFB4

ANT, AIL5

AP3, DAG2, BEL1, KNAT4, CPC, SHI

DAG2

HN3, WRKY65,
RAP2.12

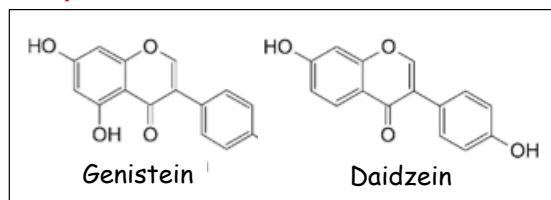
Hilum could be Involved in Regulating Defense Response by Synthesizing Isoflavone, Tannin, and Brassinosteroid

Where Are the Pathways for Soybean Health-Related Products Localized within the Seed?



What are the Health-Related Benefits of Isoflavone?

Isoflavones



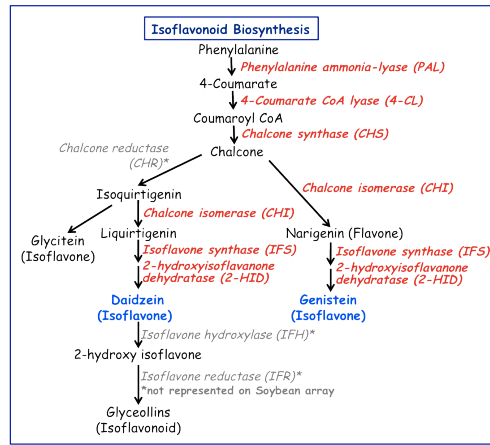
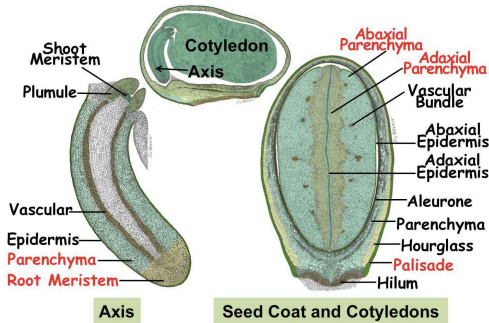
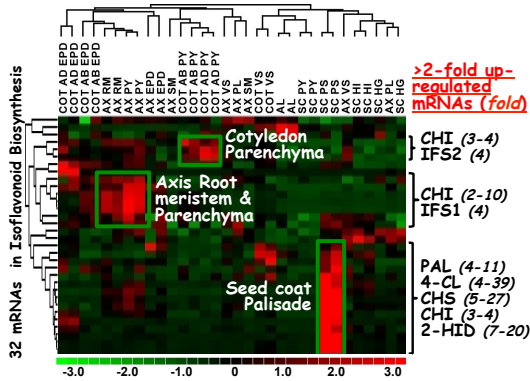
- Soybean is **best known source of Isoflavones**
- The **chemical structure** of Isoflavones is very similar to **Estrogen**

Health Benefits of Isoflavones

- **Ease menopause symptoms**
- **Improve bone health** by increasing bone density
- **Reduce heart disease risk**
- **Reduce cancer risk**

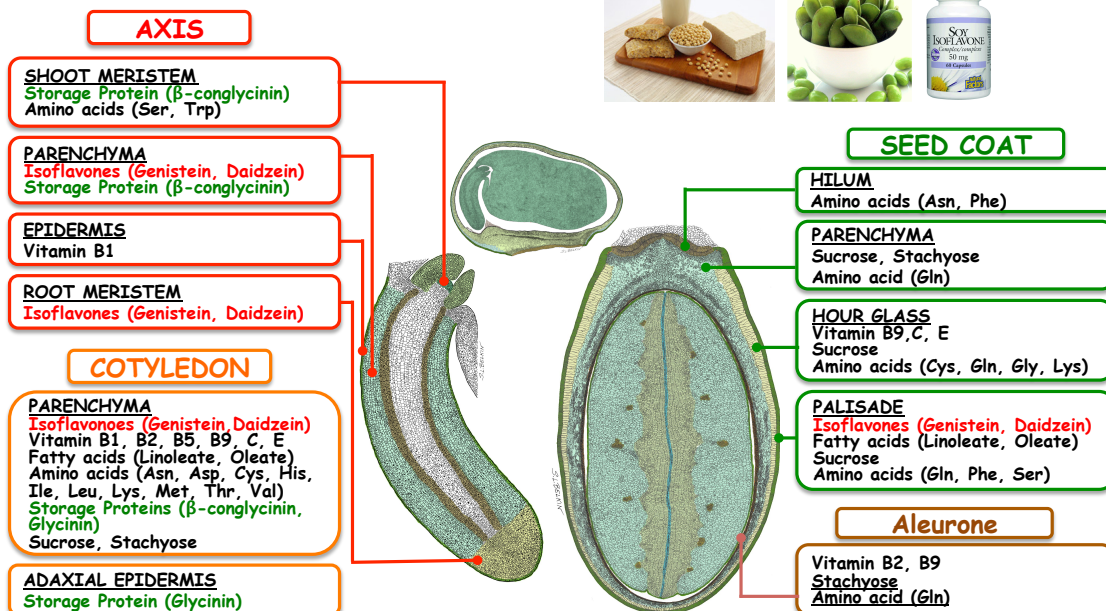


Where Are the Pathways for Isoflavone Biosynthesis Localized Within the Seed?



mRNAs Encoding Enzymes in Isoflavone biosynthesis are up-regulated in Early maturation-stage seed Cotyledon Parenchyma, Axis Parenchyma and Root meristem and Seed coat Palisade.

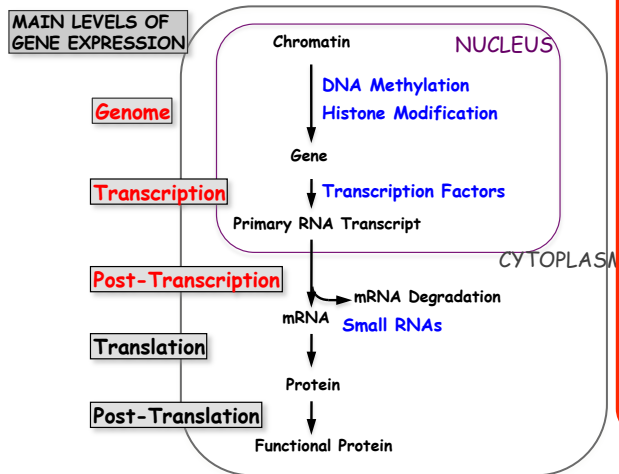
Where Are the Pathways For Soybean Health-Related Products Localized Within the Seed?



mRNAs Encoding Enzymes in Health-Related Metabolic Pathways are Up-Regulated in Specific Seed Tissues

What Questions Are Remained to Answer for Unraveling the Gene Regulatory Networks that are Required to Make a Seed?

* Under Investigation



1. What is the **spectrum of genes** that are active in seed compartments on a **whole-genome basis**?
2. What are the **regulatory processes** required to make a soybean seed?
 - What **microRNAs** are present in specific tissues and what are their targets?
 - What are **epigenetic changes** that occur in the genome in specific tissues?
3. What are the **correlations** between methylome, microRNAs, and compartment specific gene expression?
4. What are the **gene networks** required to program seed differentiation and maturation?

Acknowledgement



Current Lab Members

Bob Goldberg
Min Chen
Kelli Henry
Jungim Hur
Brandon Le
Jer-Young Lin

Former Lab Members

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Chen Cheng
Javier Wagmaister
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Xinjun Wang

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