The Cell Component Ontology (CCO)

Peifen Zhang

The Arabidoposis Information Resource

What is CCO

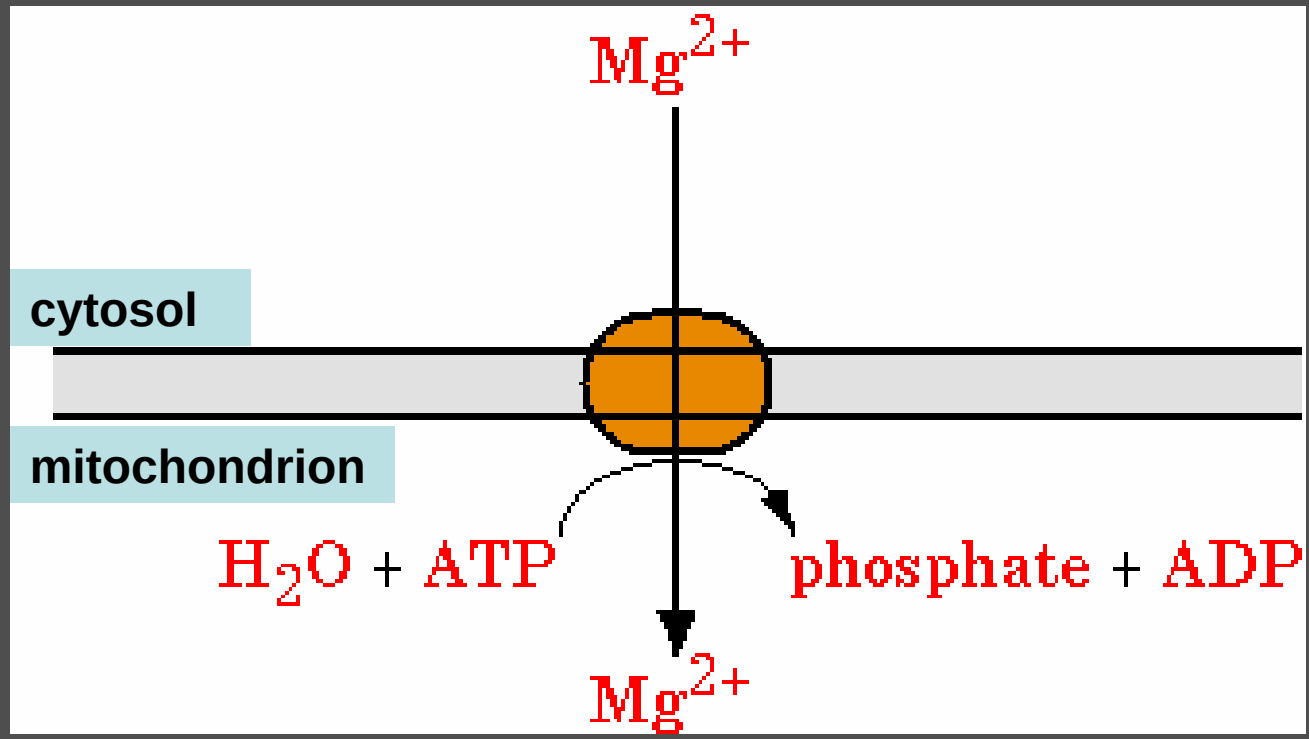
- A controlled vocabulary of terms describing cellular components and compartments
- and relationships between these terms

Motivation

- Simple enough to describe the subcellular location of small molecule metabolism (160 terms)
- Comply with the basic principles in Pathway Tools Ontologies, where each term has to be classified according to is-a relationship, and classified to only one top-level classification term
- Needs for other relationships such as “surrounds/surrounded-by”

Use Case

- Annotate enzymes and transporters
- Robust query
  - find all membrane-associated enzymes and reactions
- Sophisticated query
  - find out how many membranes a compound has to cross to be transformed to another compound
- Generate graphic display of compartmentation of pathways and transporter reactions


Mg^{2+}
cytosol
mitochondrion
H_2O + ATP
phosphate + ADP
Mg^{2+}

Development of The CCO

- Choose and define terms
- Classify terms
- Other relationships between terms
- Other attributes of a term

The Principles in Choosing Terms

- Relevant to small molecule metabolism
  - excluding terms such as cell plate, cytoskeleton
- Create a species-specific term only when the term has distinct attributes
  - plasmamembrane (sensu Animalia)
    - surrounded-by extracellular matrix
  - plasmamembrane (sensu Magnoliophyta)
    - surrounded-by cell wall

Linking to GO

- Many terms and their definitions were selected from the cell component terms from GO
- They have cross-reference links to GO using GO ID as the external ID
- A few cases where terms not linked to GO due to definition disagreement, i.e. **cell envelope (sensu Bacteria)**
  - **CCO:** the cell membrane (plasma membrane) and cell wall plus an outer membrane if one is present
  - GO: everything external to, but not including, the cytoplasmic membrane of bacteria, encompassing the periplasmic space, cell wall, and outer membrane if present.
- New CCO terms were submitted to GO

The is-a Class Hierarchy

- Classifies terms to what type of concept a term is, i.e. membrane, space
- The broader concepts appear on the top level of the hierarchy, whereas more specific concepts are grouped under the broader concepts

  organelle -> membrane-bound organelle -> plastid -> chloroplast

- Eight top-level concepts (terms)

  cell fraction (i.e. microsome), cell surface matrix (i.e. cell wall), envelope (i.e. mitochondrial envelope), membrane, organelle, space (i.e. vacuole lumen), suborganelle compartment (i.e.Golgi cisterna), and super component (i.e. cytoplasm)

The Component-of Relationship

- Describes whether one term is a physical constituent of another term
- The inverse relationship is "**components**"

mitochondrial membrane is a component of **mitochondrion**

mitochondrion has components **mitochondrial membrane, mitochondrial lumen, mitochondrial intermembrane space** etc

The Surrounded-by Relationship

- Provides relative positional information of two terms within a cell
- The inverse relationship is “surrounds”

mitochondrial inner membrane is surrounded-by **mitochondrial inter-membrane space**, **mitochondrial inter-membrane space** is surrounded-by **mitochondrial outer membrane**

- The relationship is transitive

mitochondrial inner membrane is surrounded-by **mitochondrial outer membrane**

- **CELLULAR_COMPONENT**
  - **cell fraction**
  - **cell surface matrix**
  - **envelope**
  - **membrane**
  - **organelle**
  - **space**
    - **endoplasmic reticulum lumen**
    - **endosome lumen**
    - **microbody lumen**
    - **periplasmic space**
    - **plastid intermembrane space**
    - **plastid stroma**
    - **thylakoid lumen**
      - cytosol
      - extracellular space
      - Golgi lumen
      - lysosome lumen
      - mitochondrial intermembrane space
      - mitochondrial lumen
      - nuclear lumen
      - perinuclear space
      - vacuolar lumen
      - vesicle lumen
  - **suborganelle compartment**
  - **super component**

The Term Details

Class: CCO-VACUOLE / vacuole

Superclasses: membrane-bound organelle

Instances: lytic vacuole, storage vacuole

Slots:

- **COMMENT**
- **COMMON-NAME**: vacuole
- **COMPONENT-OF**: CCO-CYTOPLASM
- **COMPONENTS**: CCO-VAC-MEM, CCO-VAC-LUM
- **DEFINITION**: A closed structure, found only in eukaryotic cells, that is completely surrou by unit membrane and contains liquid material.
- **DEFINITION-REFERENCE**: Gene Ontology Consortium
- **GOID**: GO:0005773
- **HISTORY**
- **SENSU**
- **SURROUNDED-BY**: CCO-CYTOSOL
- **SURROUNDS**
- **SYNONYMS**

Availability

- Built-in with Pathway Tools
- Stand-alone downloads
- http://bioinformatics.ai.sri.com/CCO/

Acknowledgements

- TAIR
  - Sue Rhee (PI)
- SRI
  - Peter Karp (PI)
  - Suzane Paley (developer)
  - Pallavi Kaipa (developer)

Reviewers: Wolf Frommer, Tanya Berardini, Leonore Reiser, Ron Caspi

Funding: NIH