ROLE OF SURFACE COATING ON ACCUMULATION OF CADMIUM SULFIDE QUANTUM DOTS IN SOYBEAN PLANTS AND STRESS MECHANISMS

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6TH SUSTAINABLE NANOTECHNOLOGY ORGANIZATION CONFERENCE
LOS ANGELES, CA

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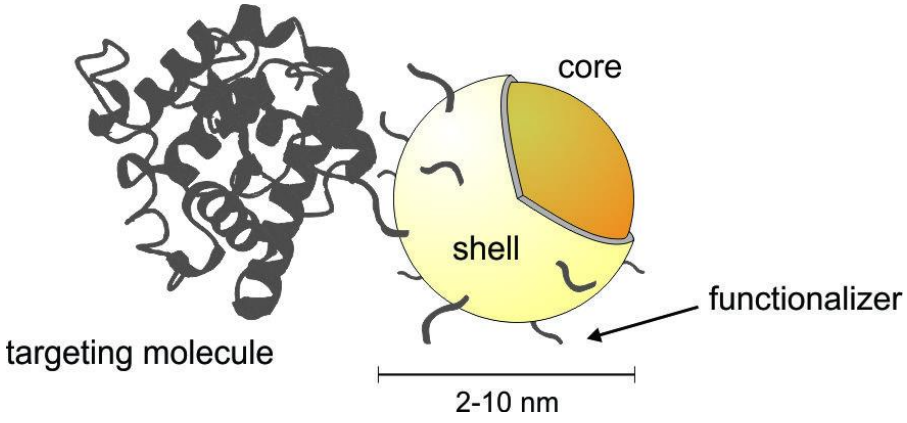
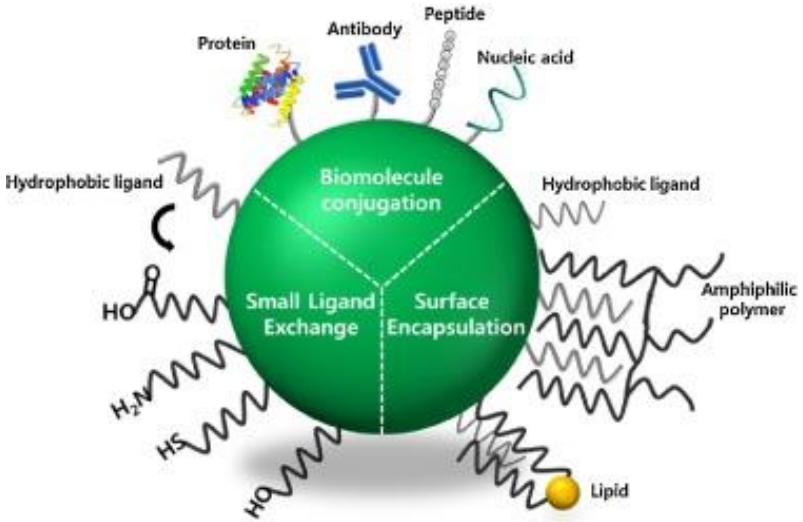
QUANTUM DOTS: BRIGHT AND VERSATILE

- Zero dimensional, few nanometers wide
- High photoluminescence quantum yield
- Broad absorption coupled with narrow emission, and strong photostability
- Semiconductor core (CdSe, CdS, CdTe) encapsulated at times in a shell eg. ZnS), and further functionalized with ligands depending on application

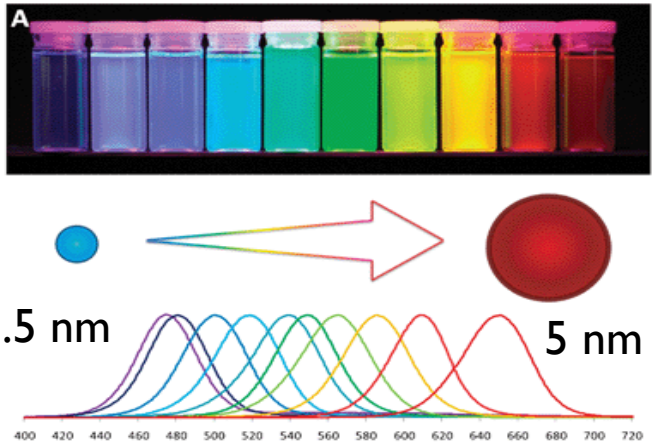


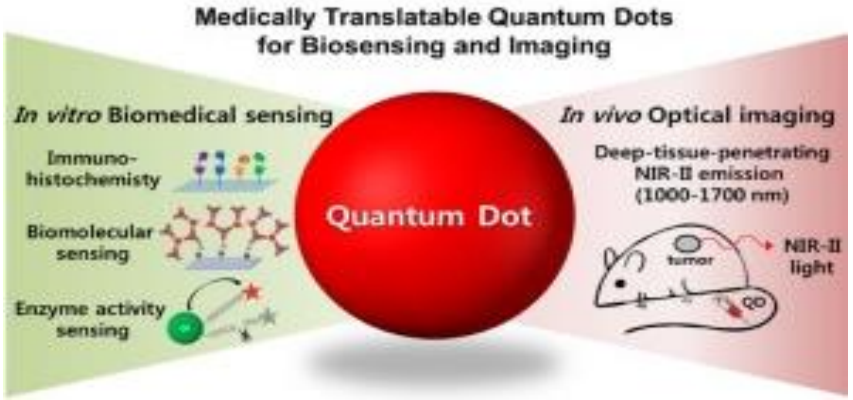
Fontes et al. 2012



Park et al. 2017

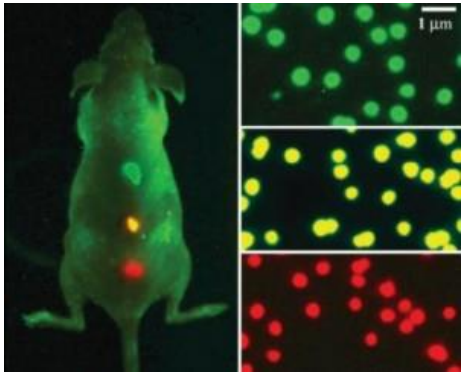
QUANTUM DOT APPLICATIONS





Park et al. 2017

Colloidal quantum dots irradiated with a UV light. Different sized quantum dots emit different color light due to quantum confinement.



Gao X, Nie S. Anal. Chem. 2004

Pathogen and contaminant detection in plants

QD MARKET IS GROWING FAST!!

MAGNOLIA

Add to Compare

Samsung - 75" Class (74.5" Diag.) - LED - Curved - 2160p - Smart - 4K Ultra HD TV with High Dynamic Range

Model: QN75Q8CAMFXZA | SKU: 5758300

See More Options

4.2 (21)

FREE delivery as soon as Mon, Nov 6

Need it installed? Delivery + Installation as soon as Wed, Nov 8 in 93107.

Store Pickup: Order now & Goleta will have it ready for pickup by Wed, Nov 8.

PRICE MATCH GUARANTEE

$4,499.99

SAVE $500

Was $4,999.99

Add to Cart

MAGNOLIA

Add to Compare

Samsung - 65" Class (64.5" Diag.) - LED - Curved - 2160p - Smart - 4K Ultra HD TV with High Dynamic Range

Model: QN65Q8CAMFXZA | SKU: 5786402

See More Options

4.5 (12)

FREE delivery as soon as Mon, Nov 6

Need it installed? Delivery + Installation as soon as Wed, Nov 8 in 93107.

Store Pickup: Unavailable within 73.8 miles of Goleta - Update Location

$2,999.99

SAVE $500

Was $3,499.99

Add to Cart

MAGNOLIA

Add to Compare

Samsung - 55" Class (54.6" Diag.) - LED - Curved - 2160p - Smart - 4K Ultra HD TV with High Dynamic Range

Model: QN55Q7CAMFXZA | SKU: 5758118

See More Options

4.8 (47)

FREE delivery as soon as Mon, Nov 6

Need it installed? Delivery + Installation as soon as Wed, Nov 8 in 93107.

Store Pickup: Unavailable within 73.8 miles of Goleta - Update Location

PRICE MATCH GUARANTEE

$1,799.99

SAVE $400

Was $2,199.99

Add to Cart

OPEN-BOX
from $1,349.99

MAGNOLIA

Add to Compare

Samsung - 88" Class (88" Diag.) - LED - 2160p Smart - 4K Ultra HD TV with High Dynamic Range

Model: QN88Q9FAMFXZA | SKU: 5762018

See More Options

Not Yet Reviewed

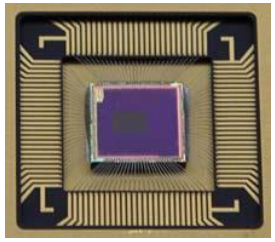
Getting more soon

FREE Delivery: Estimated 7-9 weeks for 93107.

PRICE MATCH GUARANTEE

$19,999.99

Add to Cart



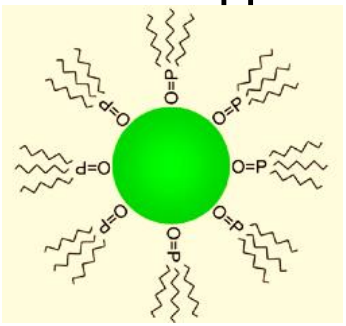
Quantum bits: This camera sensor chip contains a layer of quantum dots that absorbs light before it reaches the silicon.

EXPERIMENTAL DESIGN: NANOMATERIAL

Drs. Marco Villani, Andrea Zappettini

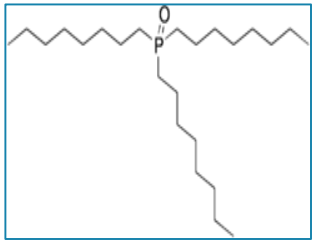
Cadmium sulfide QDs (QD)

- QD-Bare (Uncapped)
- QD-TOPO (trioctylphosphine oxide)
- QD-PVP (polyvinylpyrrolidone)
- QD-MAA (mercaptoacetic acid)
- QD-GLY (glycine)



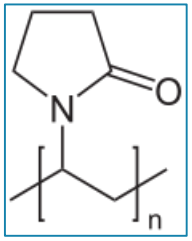
Non-specific binding

Trioctylphosphine oxide



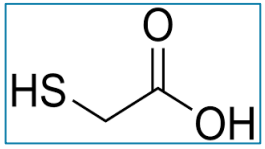
neutral

Polyvinylpyrrolidone



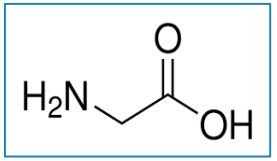
steric hindrance

Mercaptoacetic acid



negative

Glycine



amino group

EXPERIMENTAL DESIGN: PLANT EXPOSURE

Soybean plants grown in vermiculite for 14 days

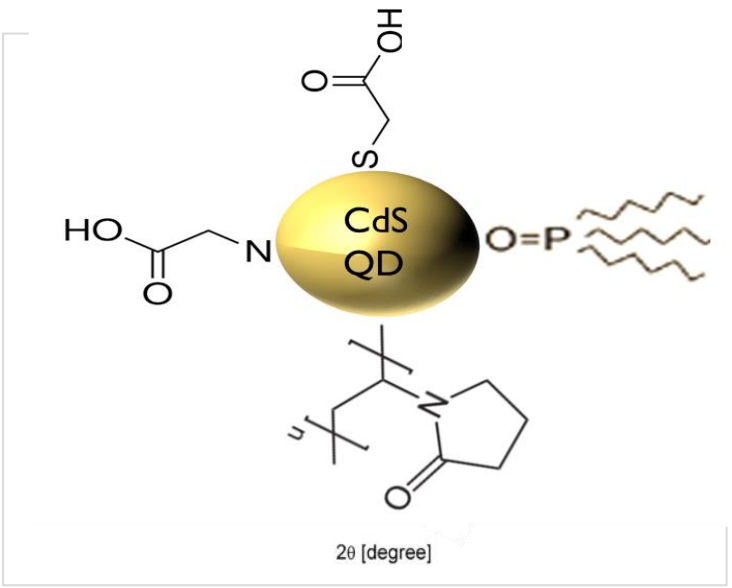
Treatments

- Control
- 50, 100, 200 mg Cd/L vermiculite for each QD
- 100 mg Cd/L vermiculite: CdS bulk
- 10 mg Cd/L vermiculite: $CdCl_2$

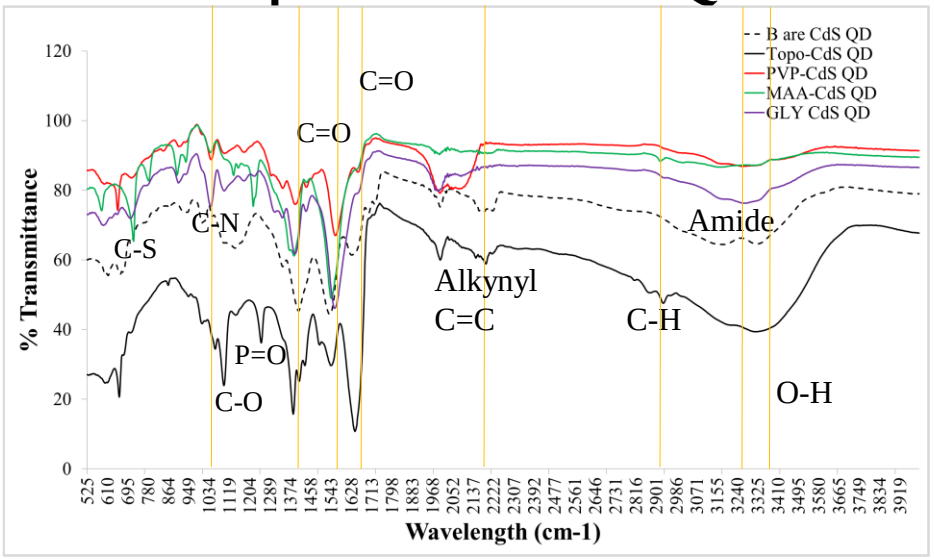
2 min sonication

- Physiological parameters
- Cd content in tissues
- Cd content in subcellular compartments
- Macro and micro nutrients
- Photosynthetic pigment
- Antioxidant enzymes: SOD, CAT, APX, GPX
- FTIR of soybean roots
- Lignin content
- Total Phenol and flavonoid contents
- Gene expression by qRT- PCR

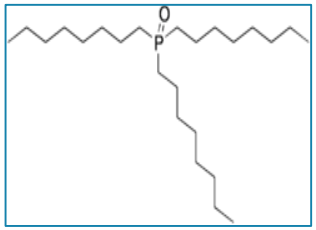
CHARACTERIZATION OF THE CdS QDs



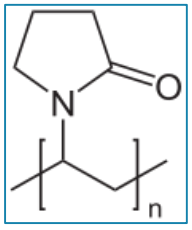
FTIR spectra of the CdS QDs



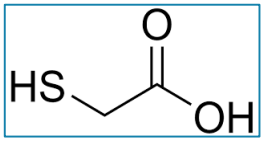
Trioctylphosphine oxide



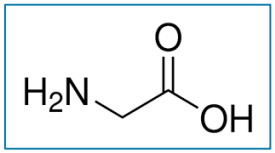
Polyvinylpyrrolidone



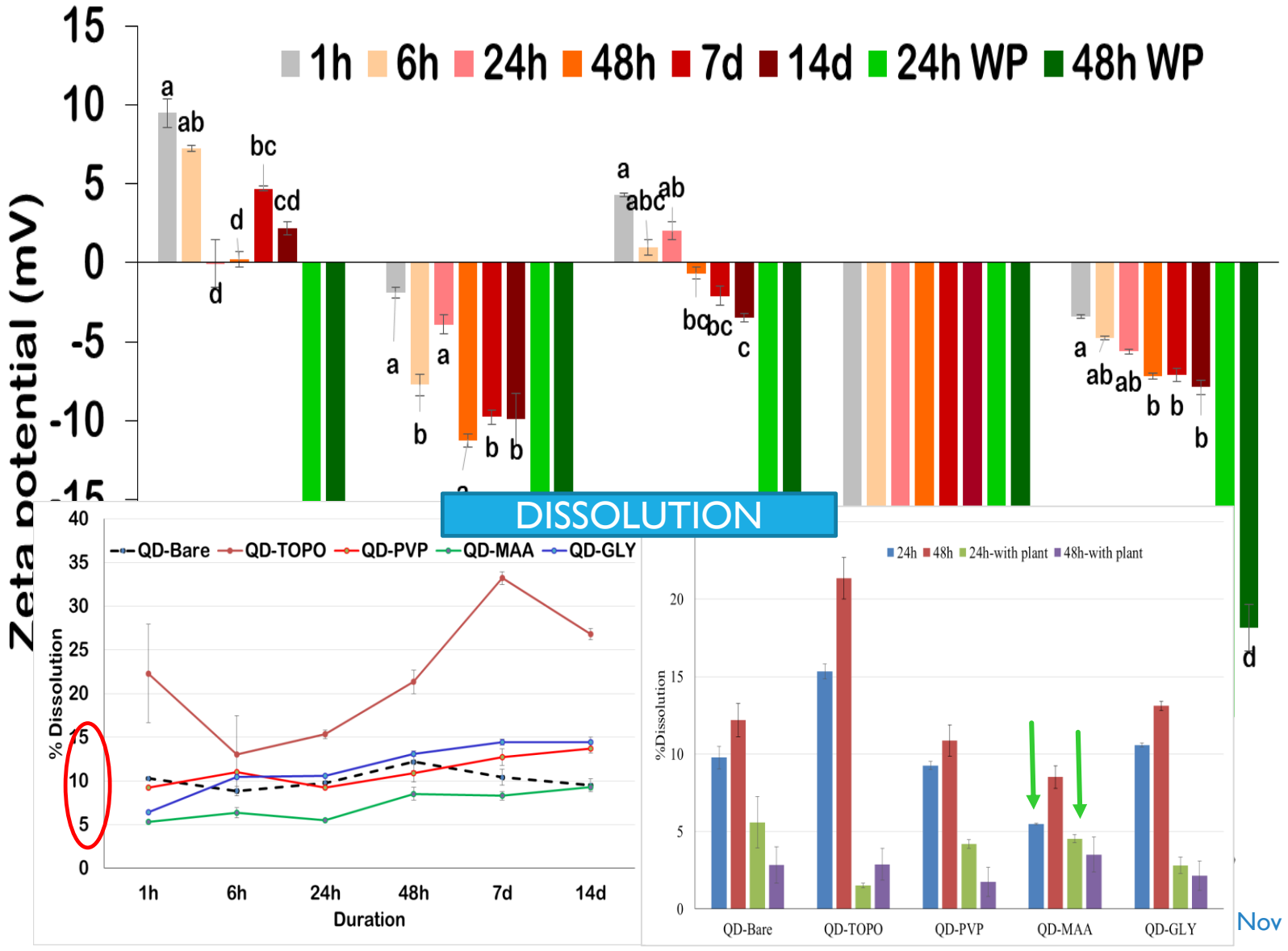
Mercaptoacetic acid



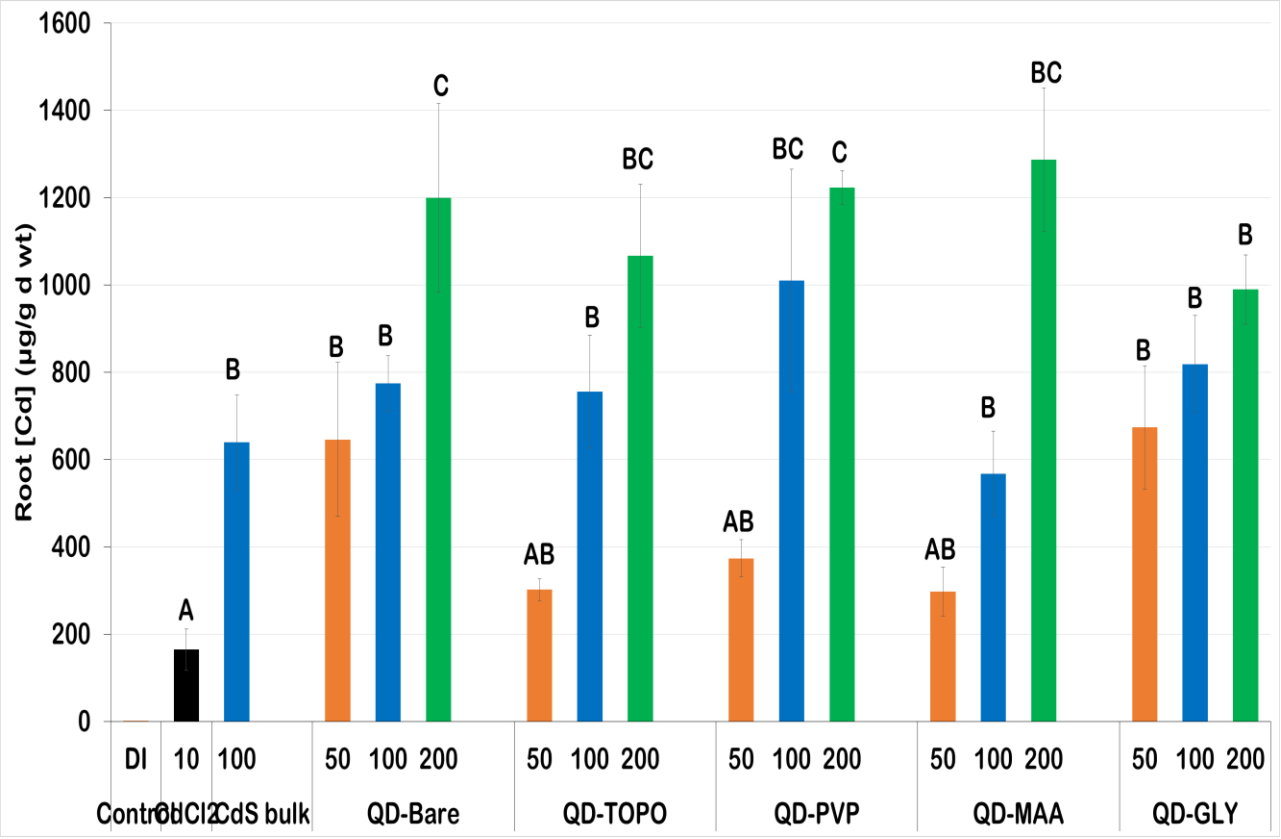
Glycine



NANOMATERIAL CHARACTERIZATION IN WATER

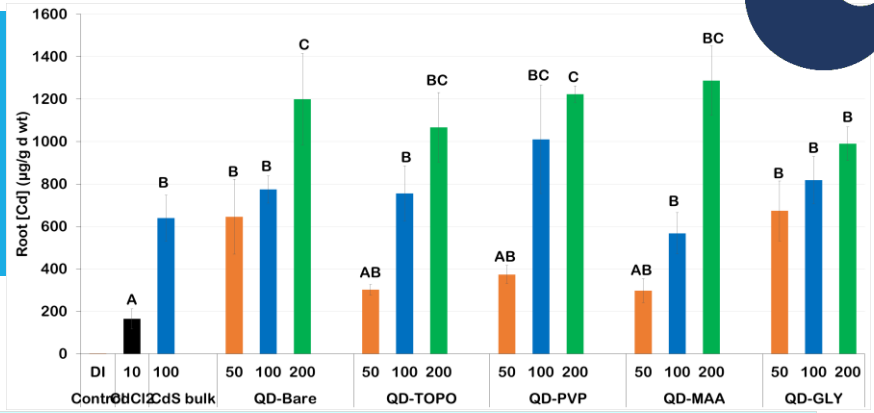


CADMIUM UPTAKE AND ACCUMULATION



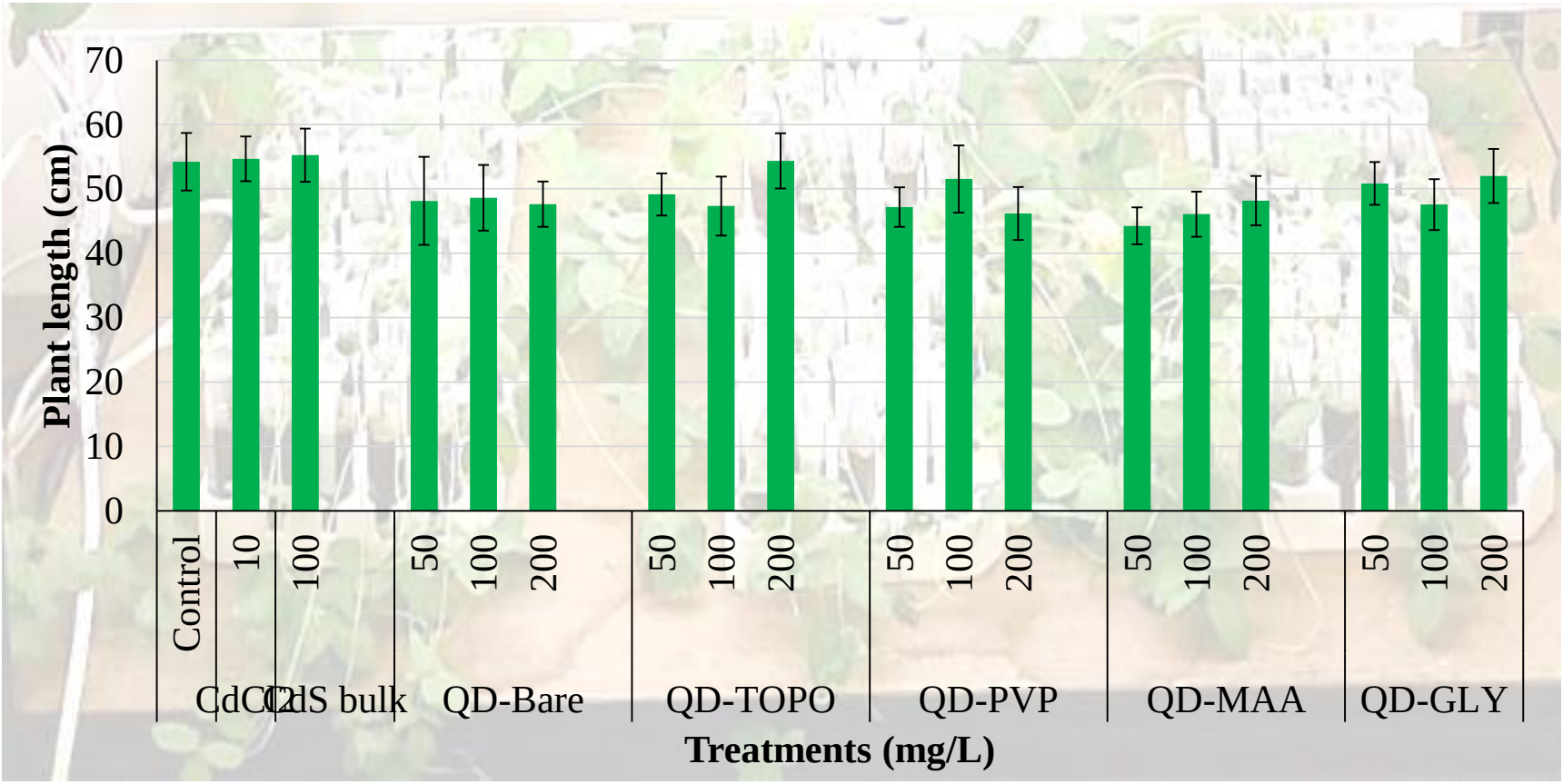
- No nano-specific effect
- CdS associated more with the roots than the Cd^{2+} ions

CADMIUM TRANSLOCATION



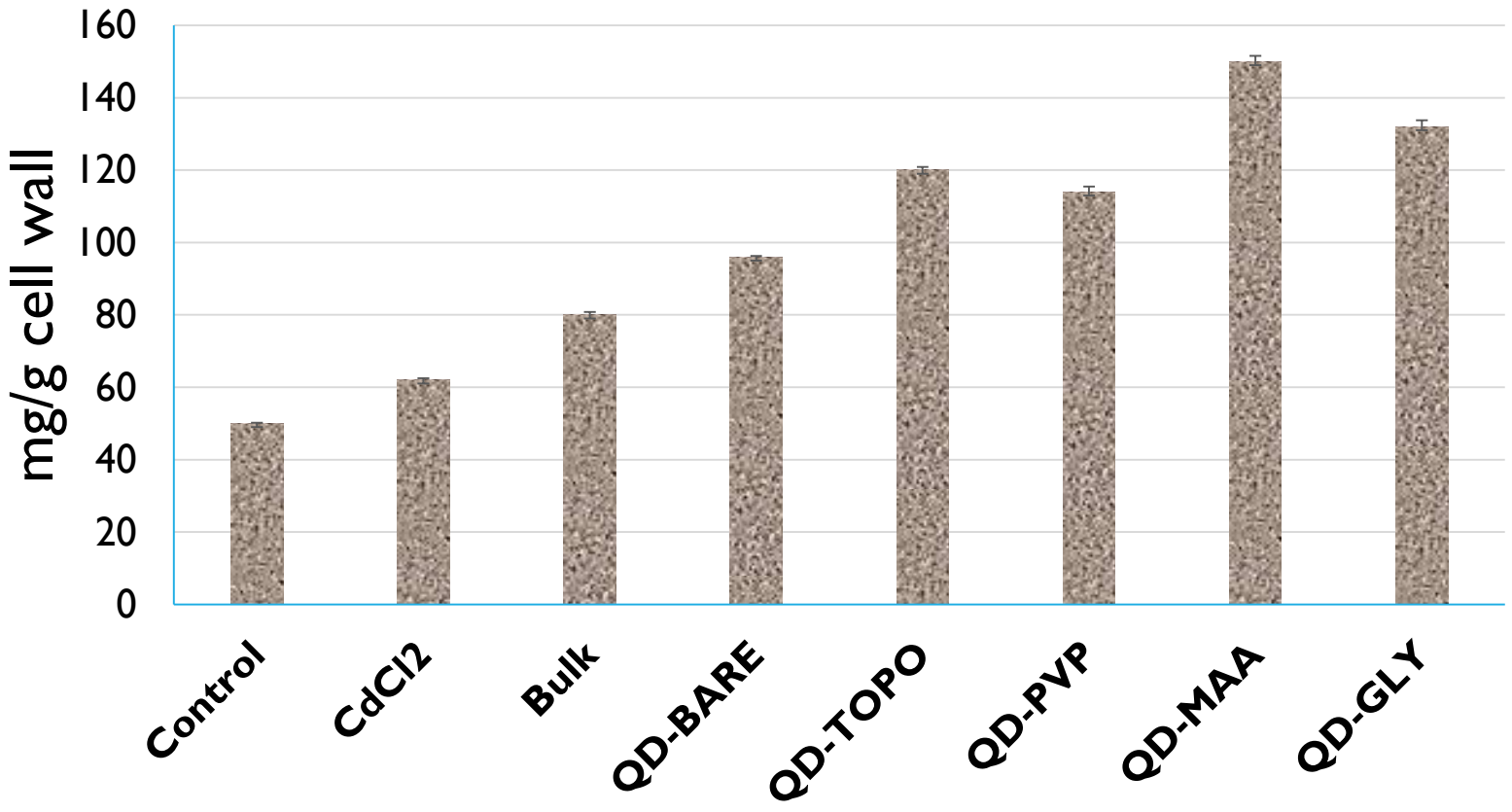
Low dissolution, still high conc. in shoots at 100 mg/L for comparison

PHYSIOLOGICAL RESPONSE

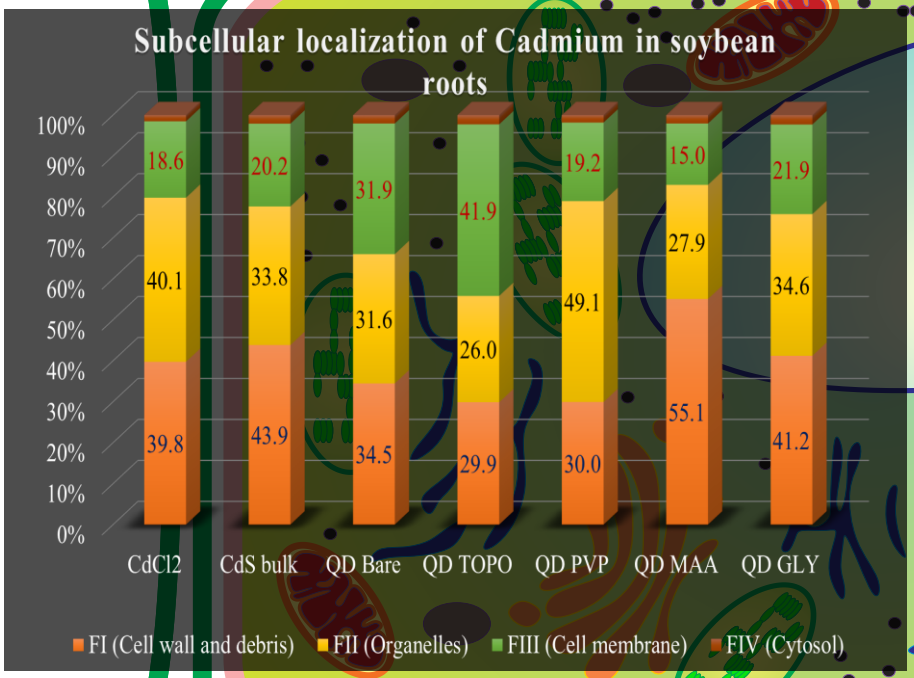


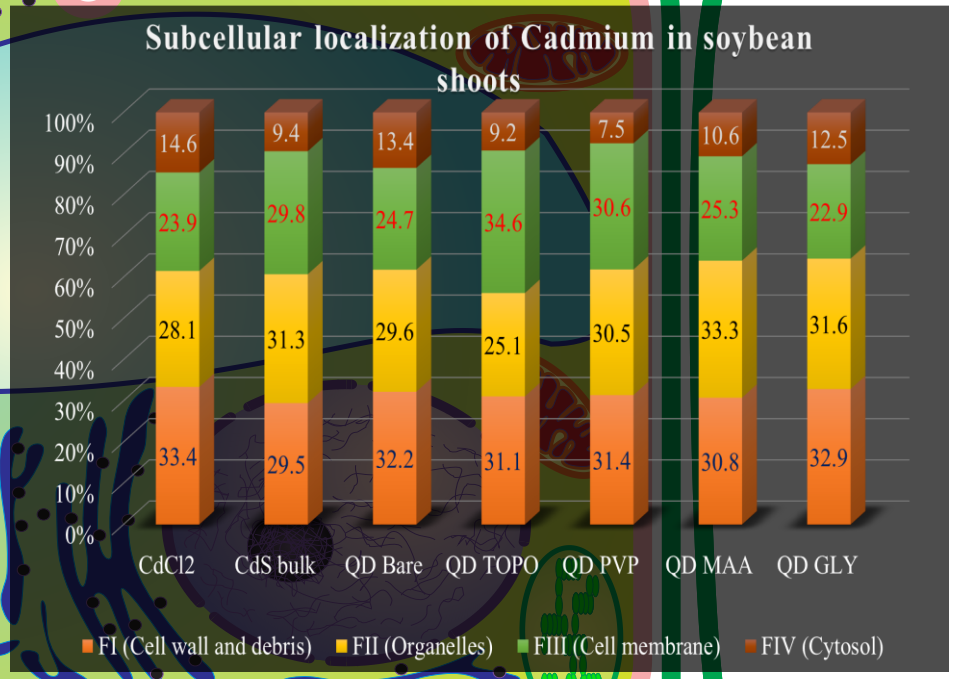
ROOT MORPHOLOGY

LIGNIN CONTENT IN SOYBEAN ROOTS

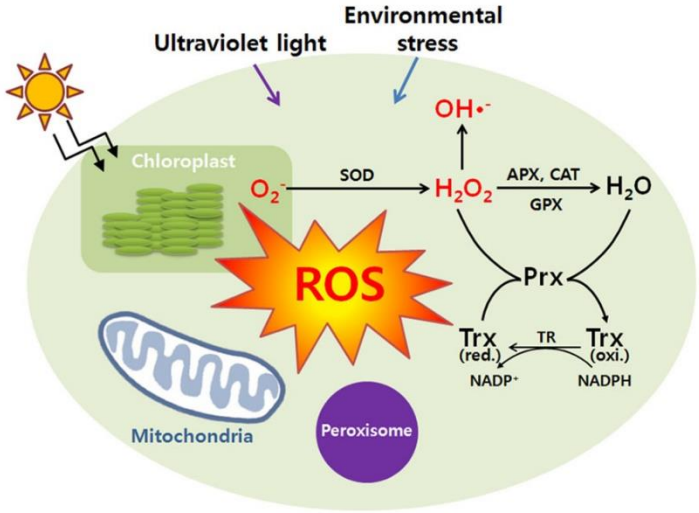


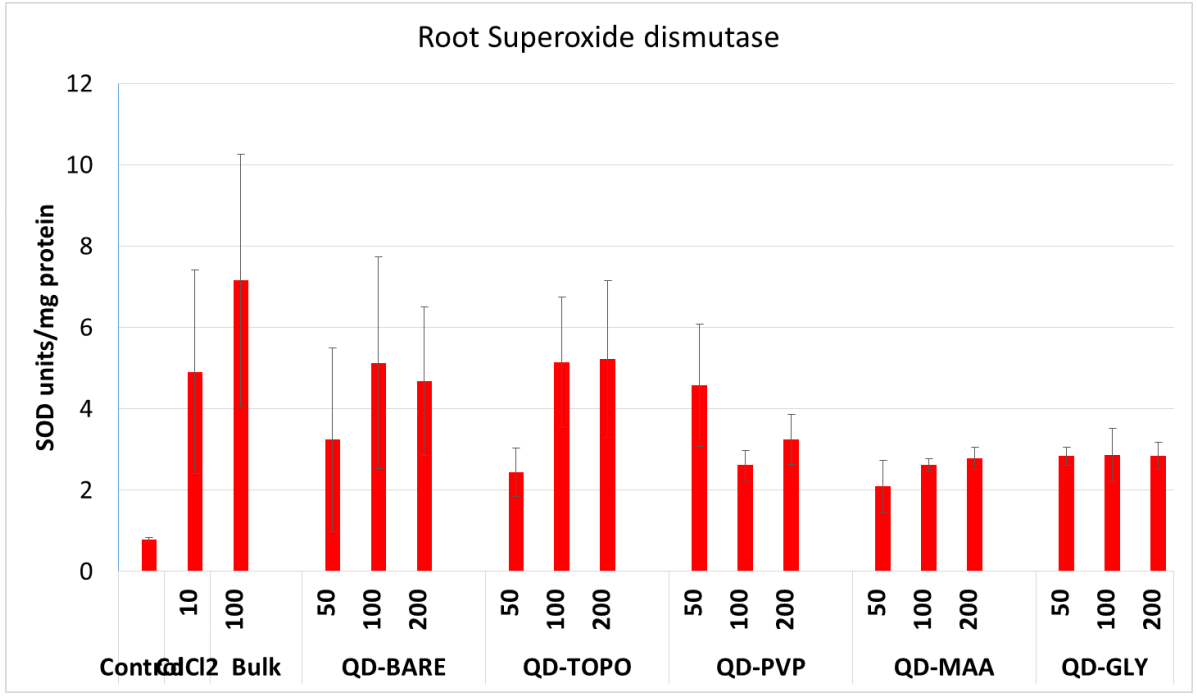
SUBCELLULAR LOCALIZATION OF CADMIUM





OXIDATIVE STRESS RESPONSE



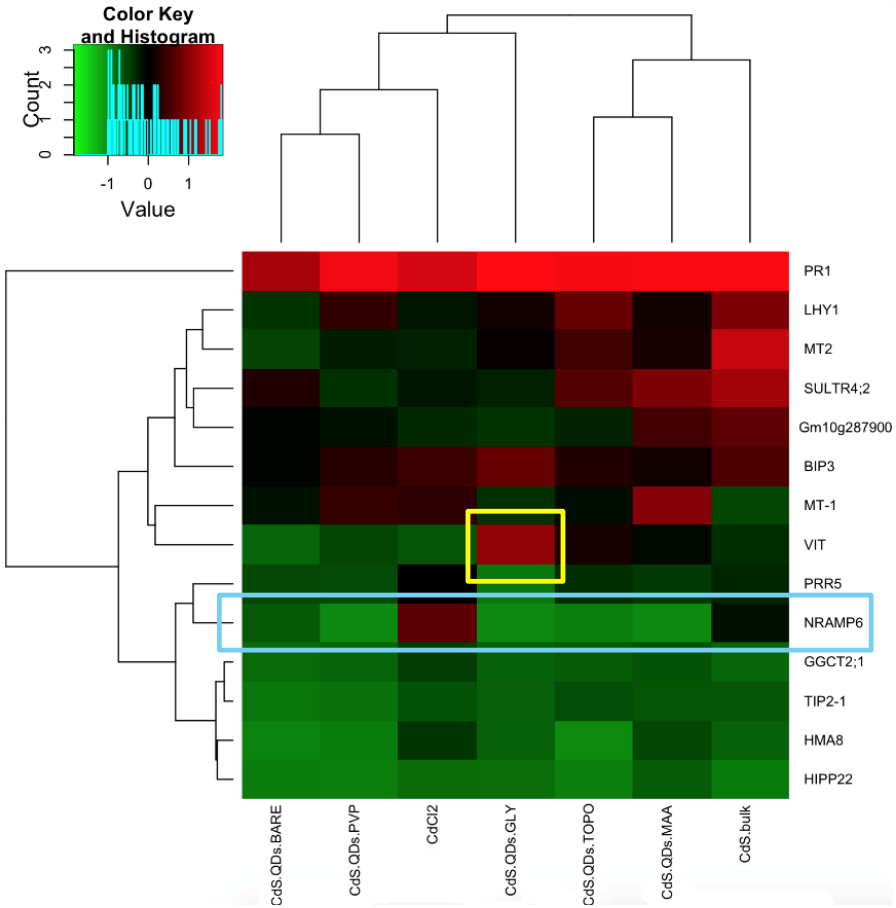


Enzymatic antioxidants
Activity increased:

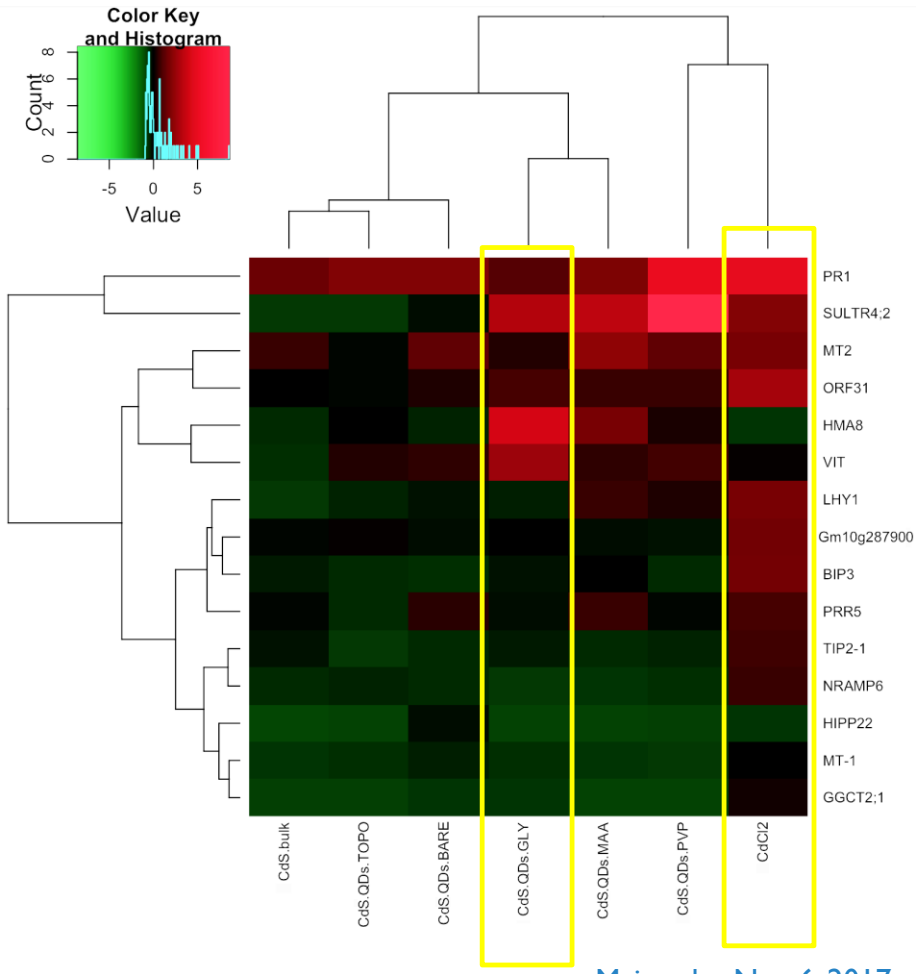
- Superoxide dismutase
- Ascorbate peroxidase
- Guaiacol peroxidase
- Catalase

GENE EXPRESSION IN EXPOSED SOYBEANS

ROOTS



SHOOTS



CONCLUSION

- QD-TOPO had highest dissolution compared with to other QDs
- QD-MAA was the most stable in solution
- Except QD-PVP, translocation of all QDs decreased with dose, more adsorption on roots (steric properties did not restrict QD-PVP);
- Cd accumulation in roots subcellular compartments:
  - Cell wall: MAA >Bulk >GLY >CdCl2 >Bare >PVP >TOPO
  - Cell membrane: TOPO >Bare >GLY >Bulk >PVP >CdCl2 > MAA
  - Organelles: PVP>CdCl2>GLY>Bulk>Bare >MAA >TOPO
- Lignin in roots enhances in all the QD treatment to protect the plants
- Superoxide dismutase in roots effectively combats the oxidative stress in roots
- Heavy metal transporter genes in roots of QD-Gly was downregulated unlike QD-Bare
- Unlike CdCl2, all QD treatments showed upregulation of another heavy metal transporter, NRAMP6
- All Cd treatments had downregulation of pathogenesis related gene

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Research | Education | Responsibility

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White research group

Dr. Arturo Keller
Keller research group

Dr. Chuanxin Ma

Dr. Luca Pagano

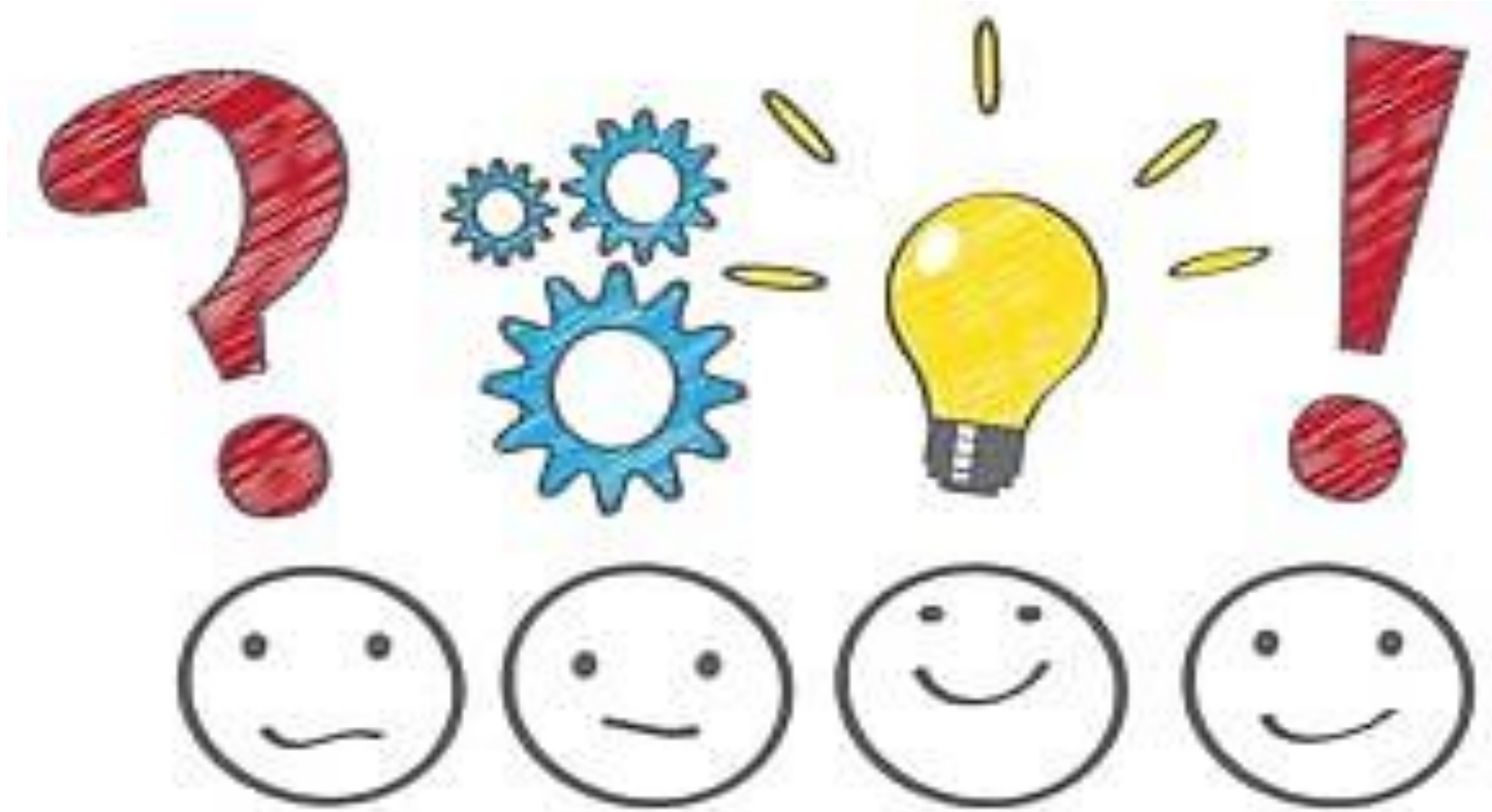
imem

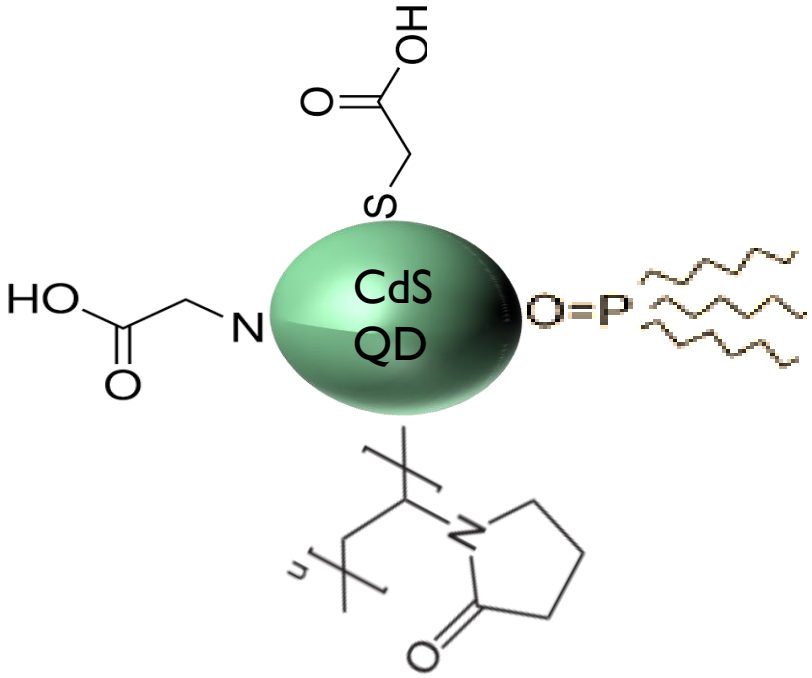
Agilent Technologies

Dr. Nubia Zuversa-Mena

Dr. Marco Villani
Dr. Andrea Zappettini

THANK YOU !!!




OH
O
S
HO
O
N
CdS
QD
O=P
n
N
O