Second Generation ChitosanS as Reliable, Dual-Use Plant Biostimulants

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bulk

bio-active

bio-mimetic

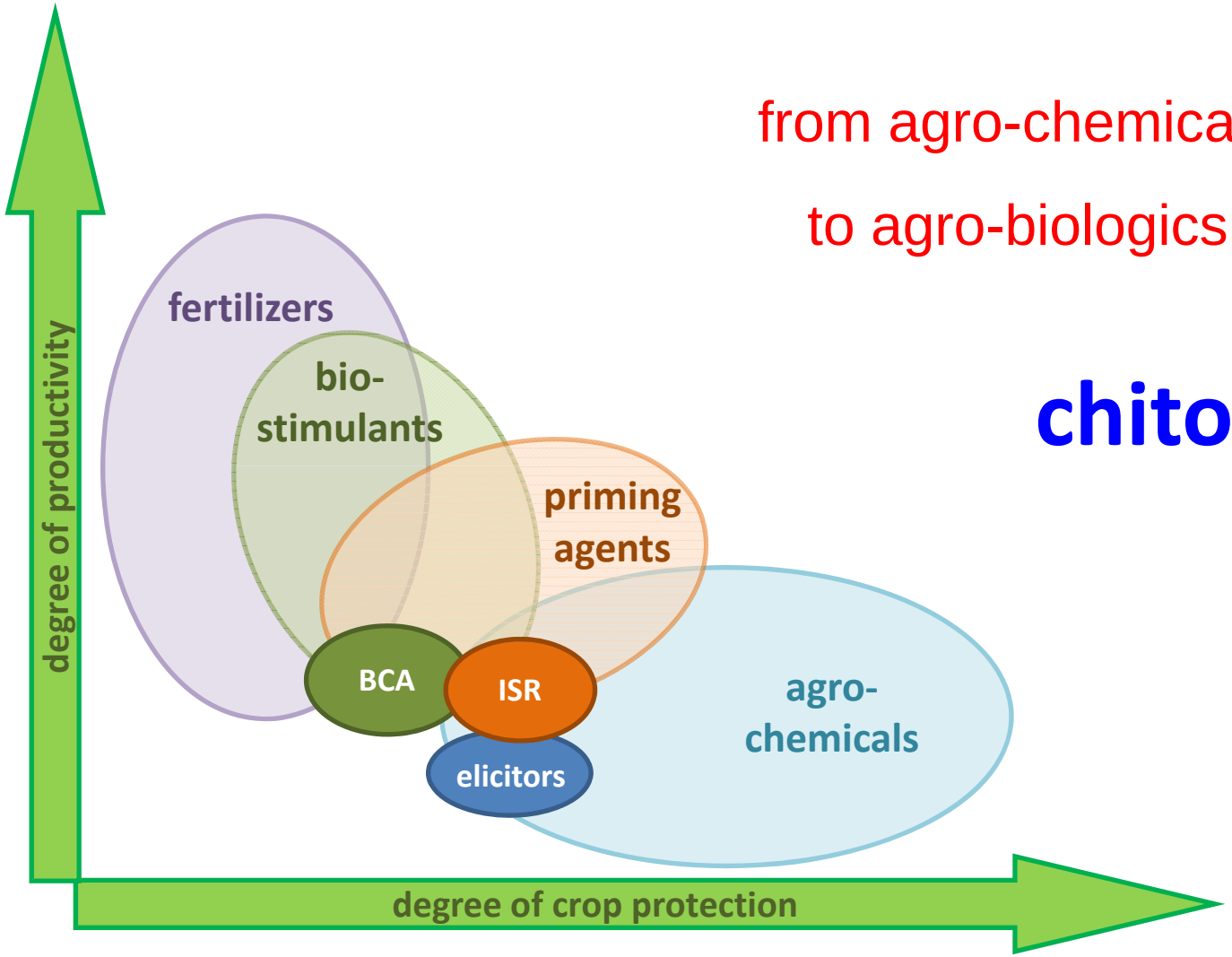
bio-inspired

bio-engineered

bio-smart

Braunschweig – PPPHE 2017

plant productivity and plant protection



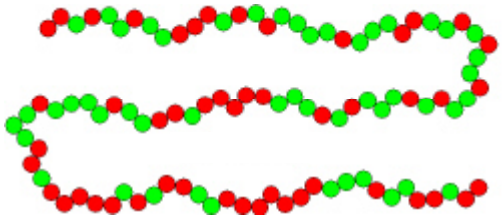
from agro-chemicals

to agro-biologics

chitosan ?

• GlcNAc • GlcN

chitin → **chitosanS**



DP 100

DA 50%

plant strengthening

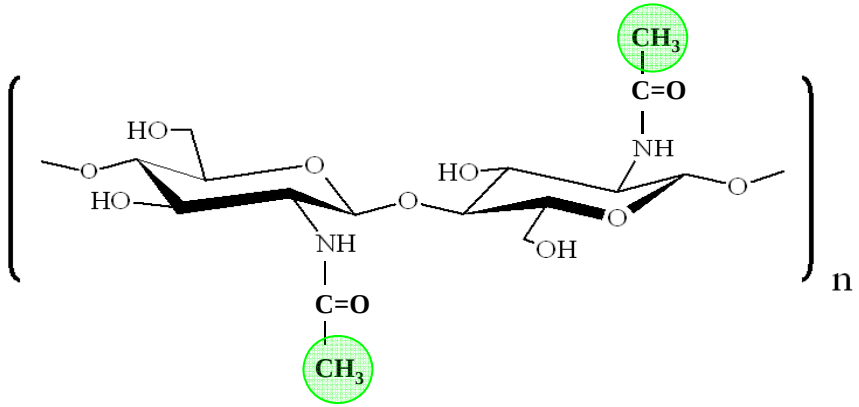
Dr. Dominique Gillet

Mahtani Chitosan
India

we need to know:
structure / function relationships

chitosan structure

chitin

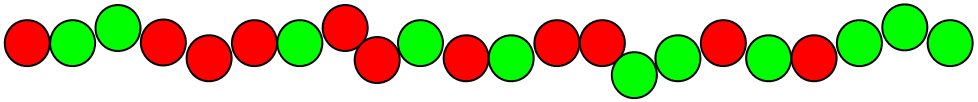


GlcNAc

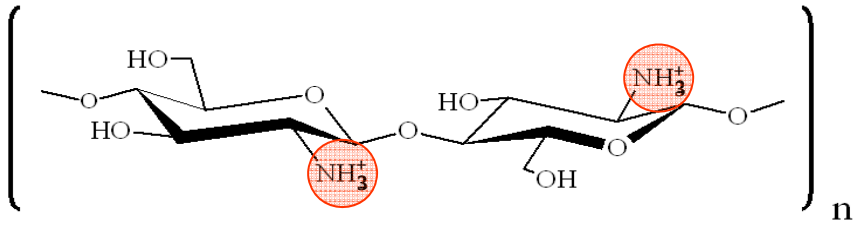
A

hydrophobic

partially acetylated chitosans



chitosan



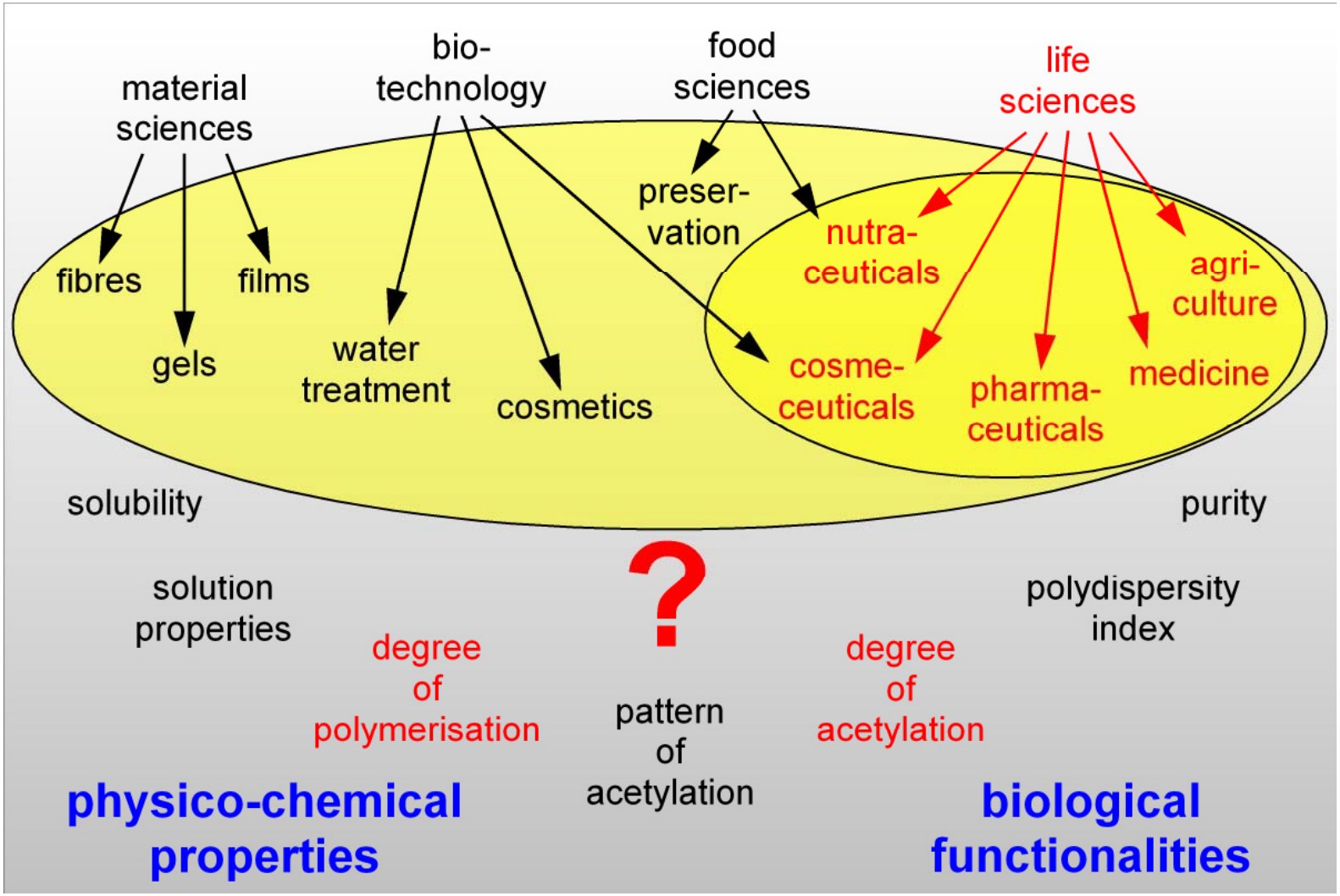
GlcN

D

hydrophilic
polykationic

(acidic pH)

structure-function relationships of chitosans



chitosan functions

plant cells

animal/human cells

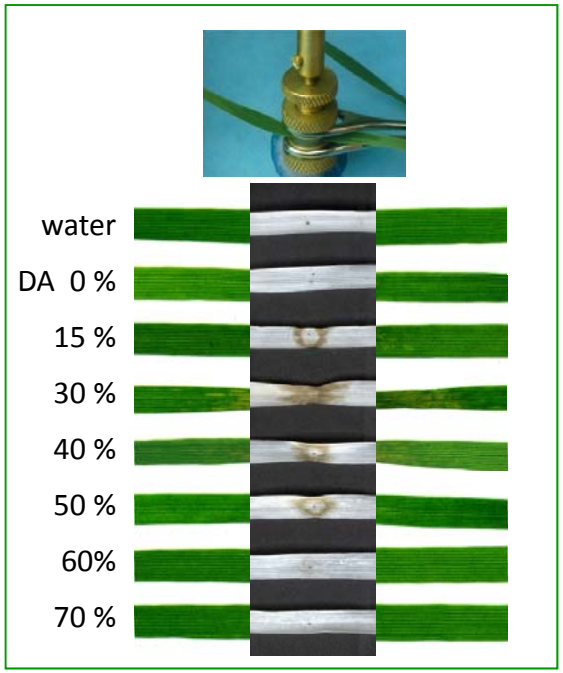
plant stengthening activities

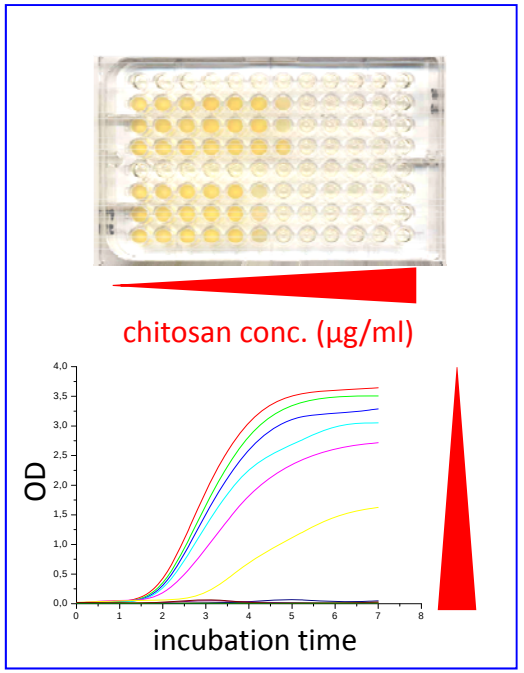
wound healing activities

chitosans

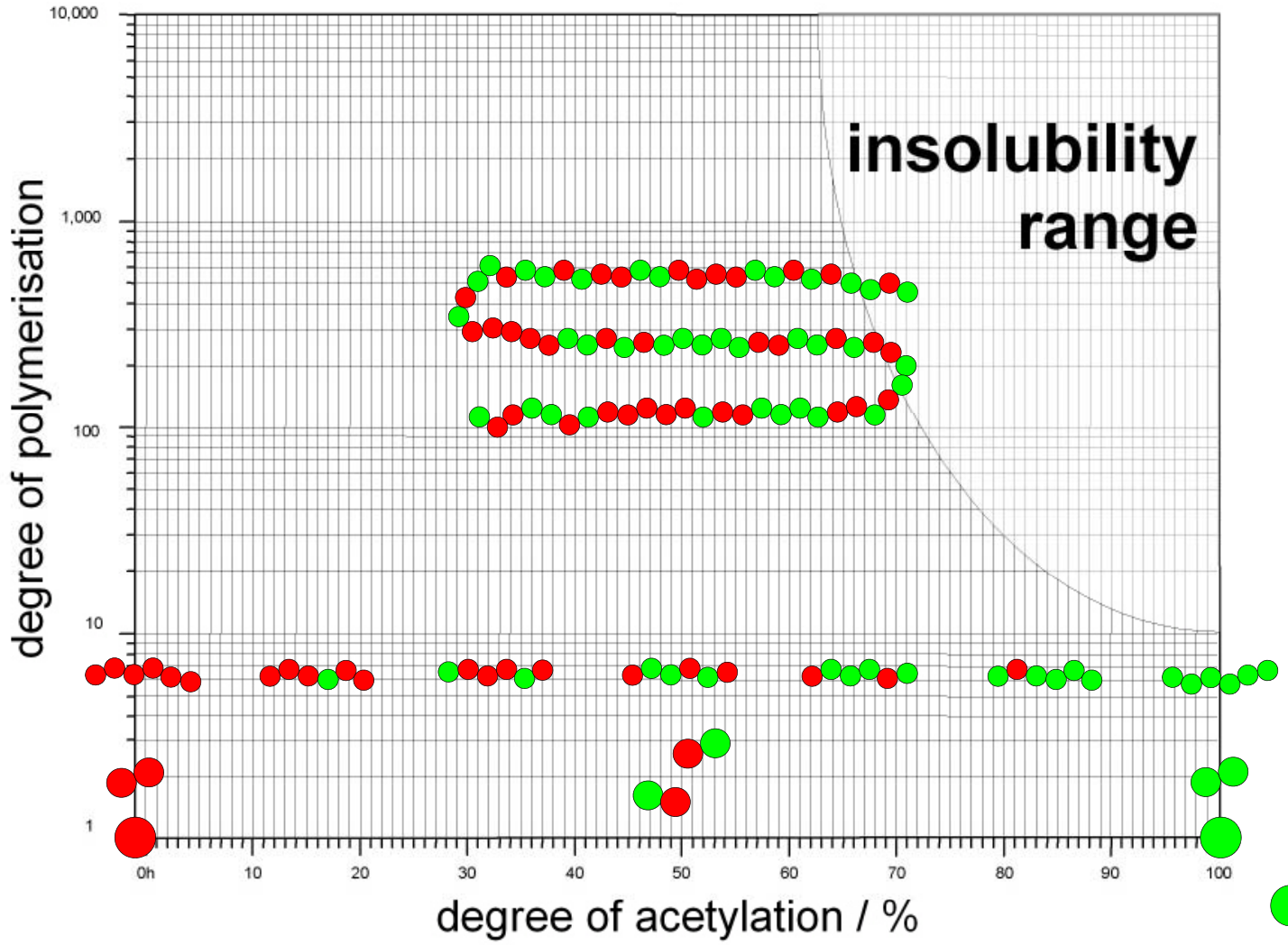
anti-microbial activities

micro-organisms

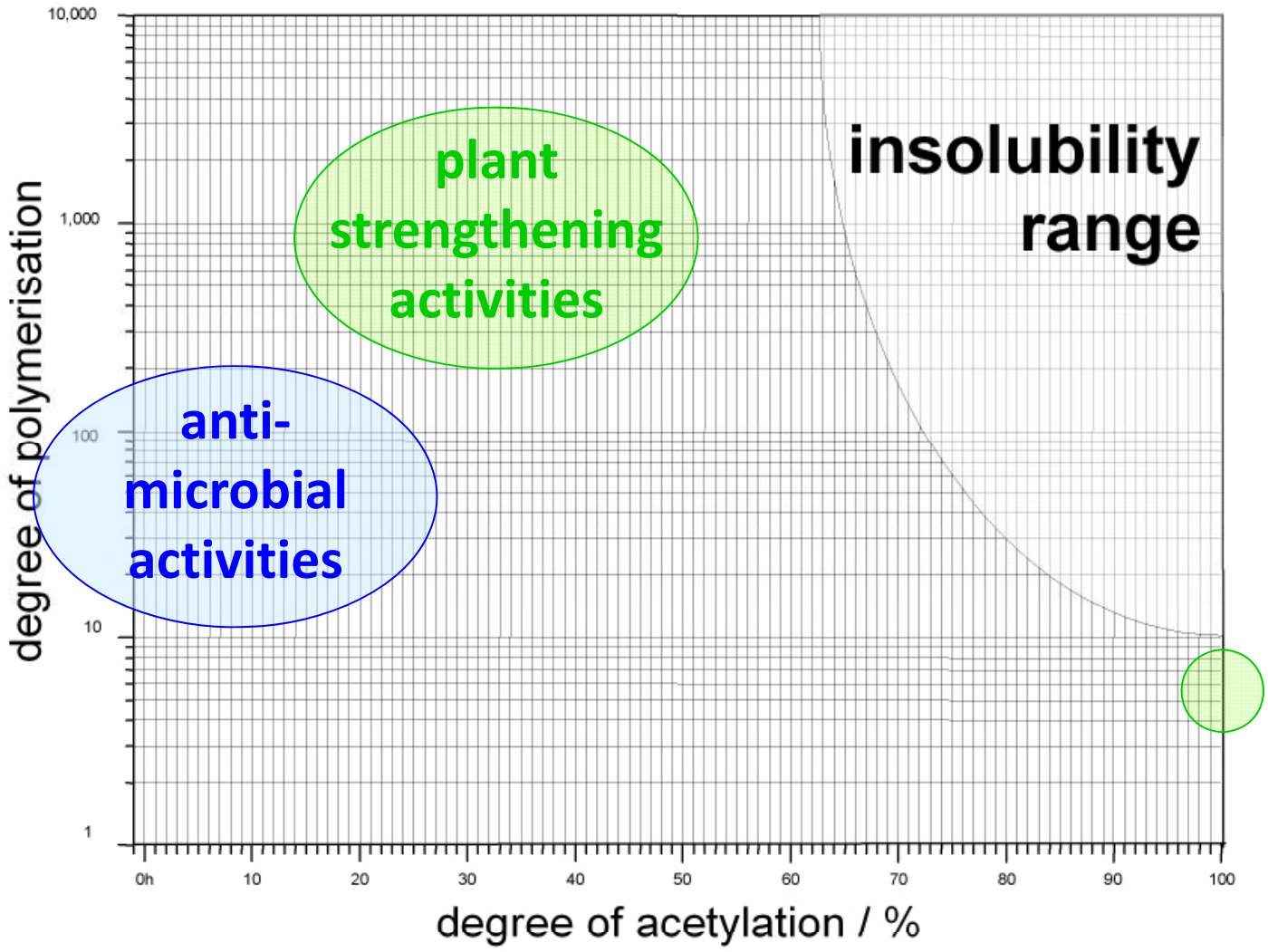




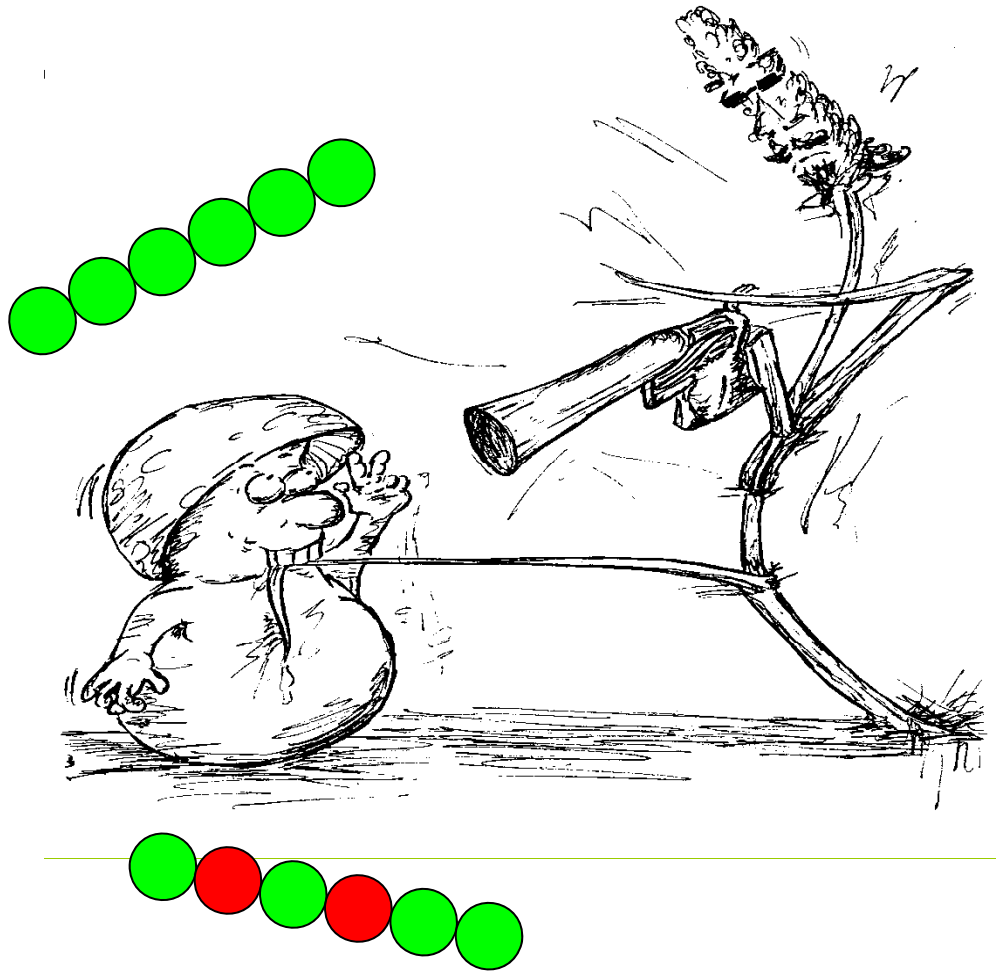
the chitosan matrix



structure / function relationships of chitosanS



towards cellular modes of action



„pathogen !“
(= „stopp all activities,
and defend yourself“)

„pathogen ?“
(= „keep going, but
prepare for defense“)

chitosanS for seed dressing and foliar spray

40 kg ha^{-1}

40 g ha^{-1}

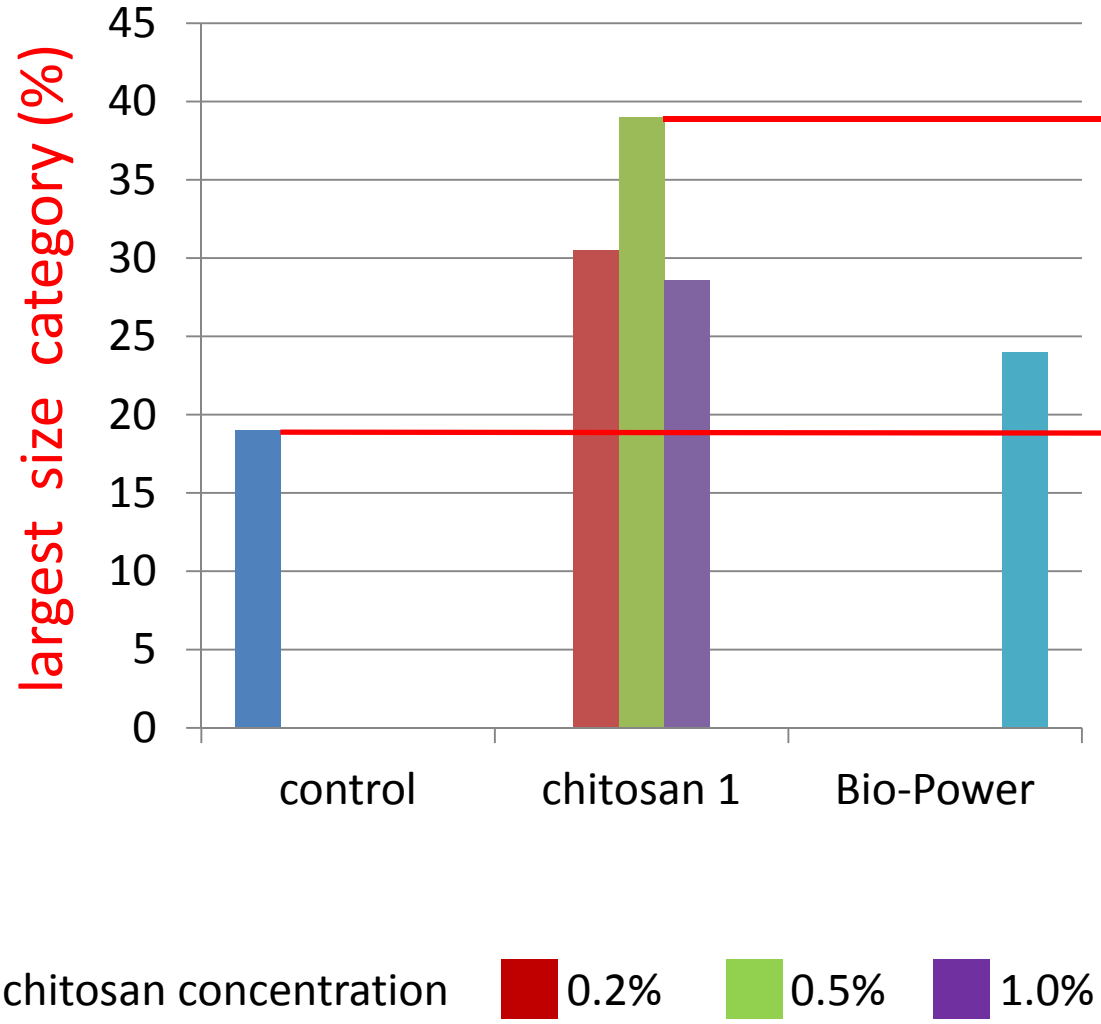
partial disease protection & yield increase (+ ≥ 25%)

nano 3BIO

Westfälische Wilhelms-Universität Münster

with **Dominique Gillet** et al.

field trials in Morocco: tomatoes



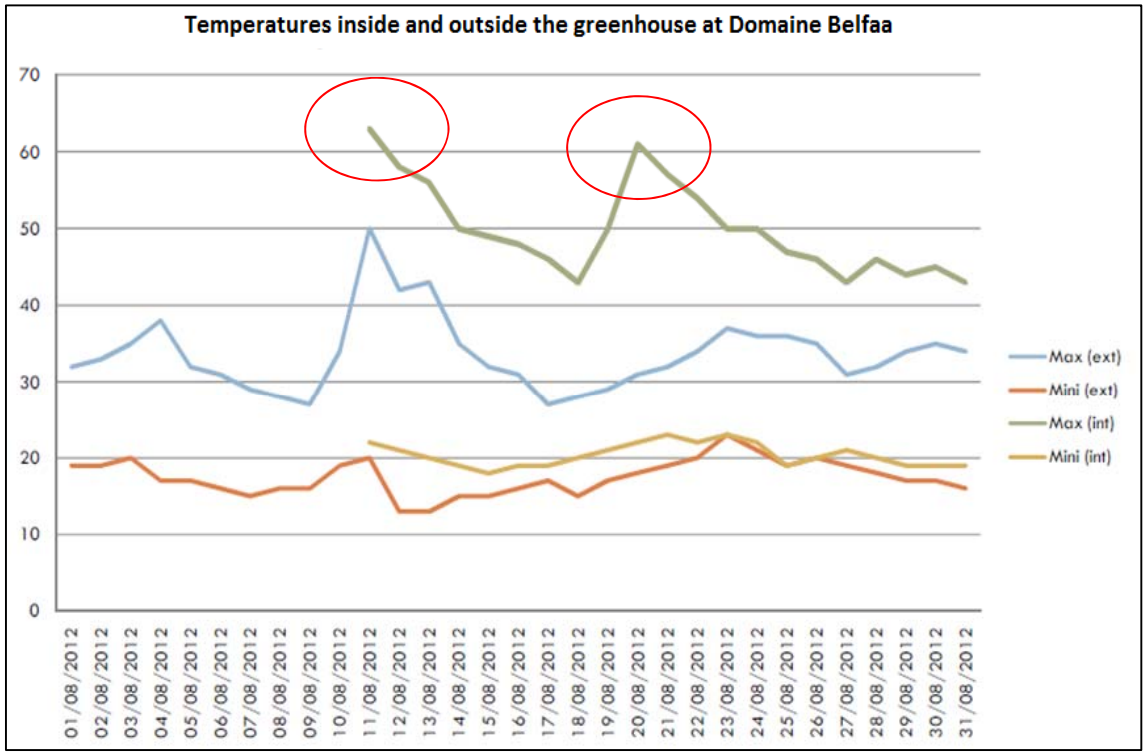
higher yield
better quality
(larger fruits)

+ 105%

field trials in Morocco: tomatoes

abiotic stress (heat) tolerance

largest size category (%)



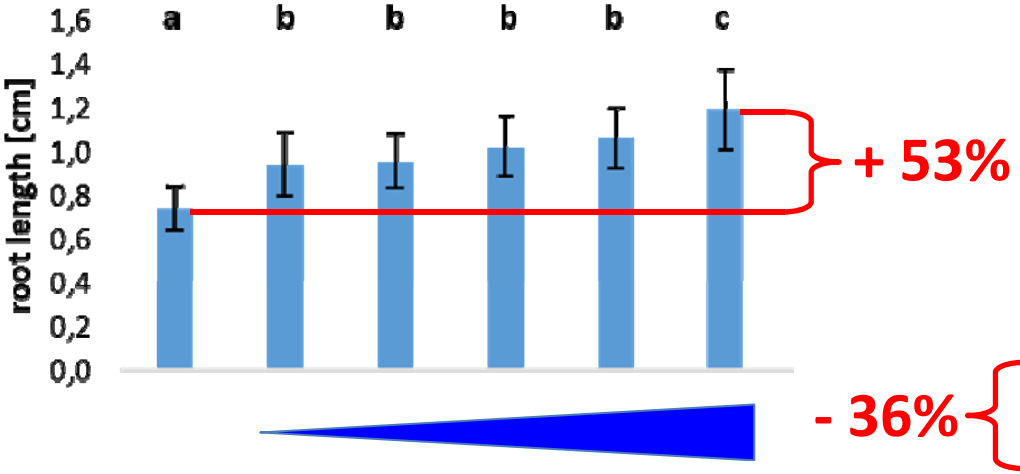
higher yield
better quality
(larger fruits)

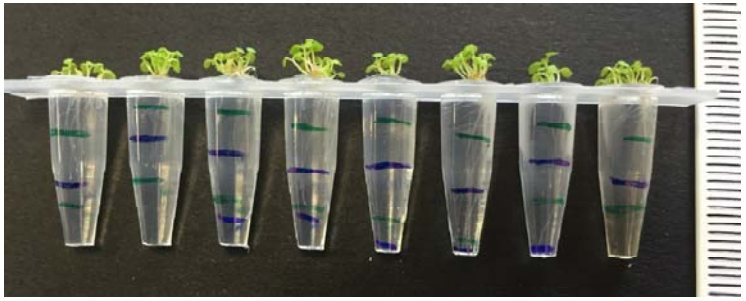
105%

chitosan concentration 0.2% 0.5% 1.0%

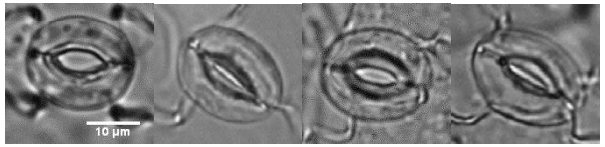
chitosan induces drought stress tolerance

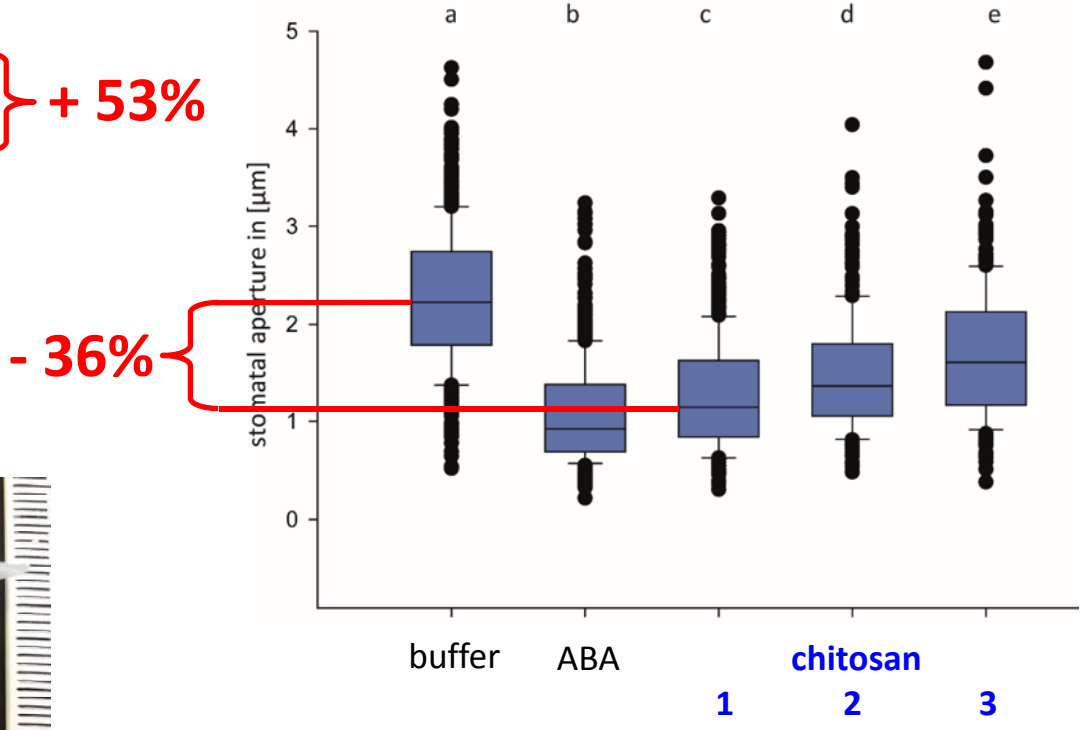
root growth promotion



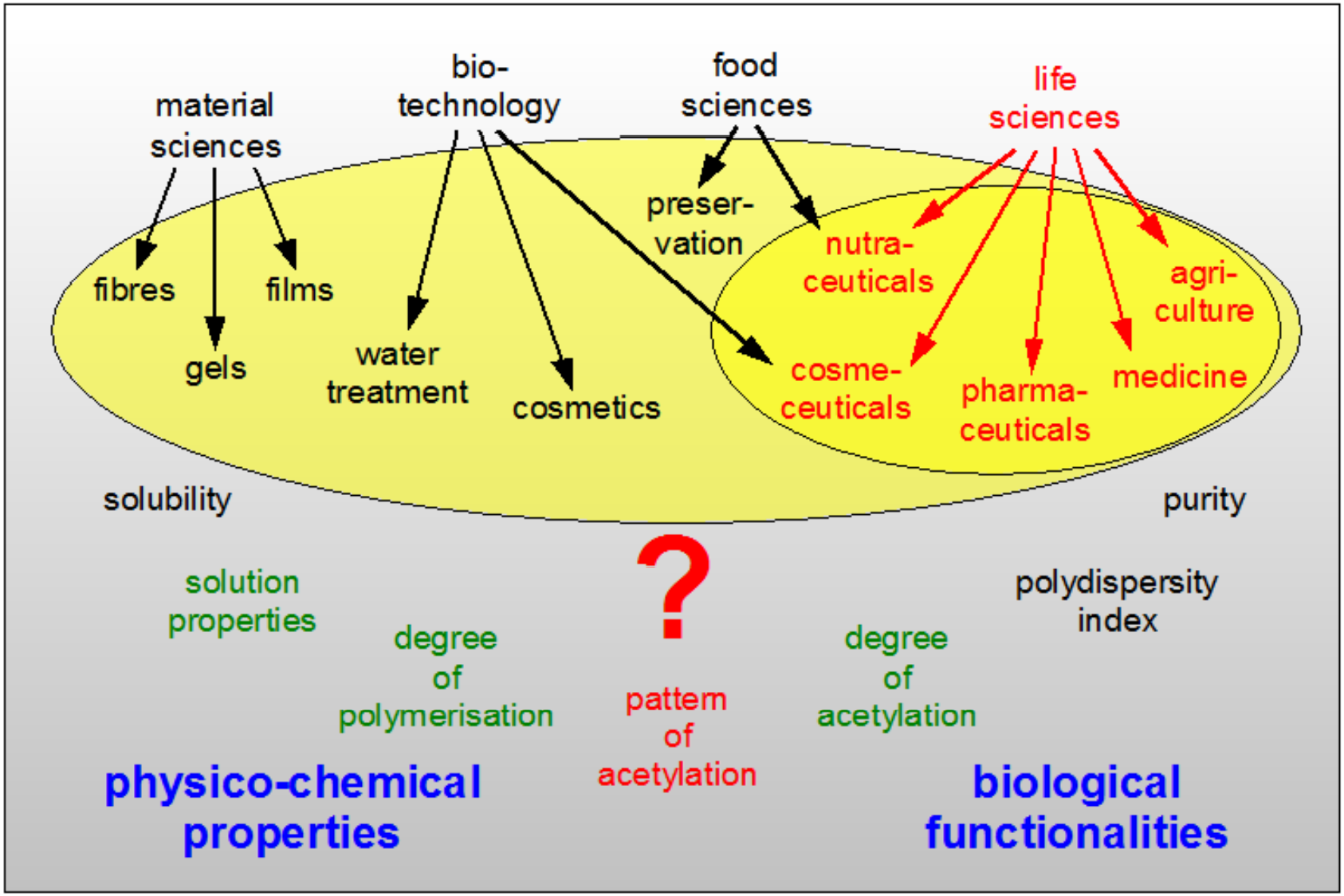


stomatal closure

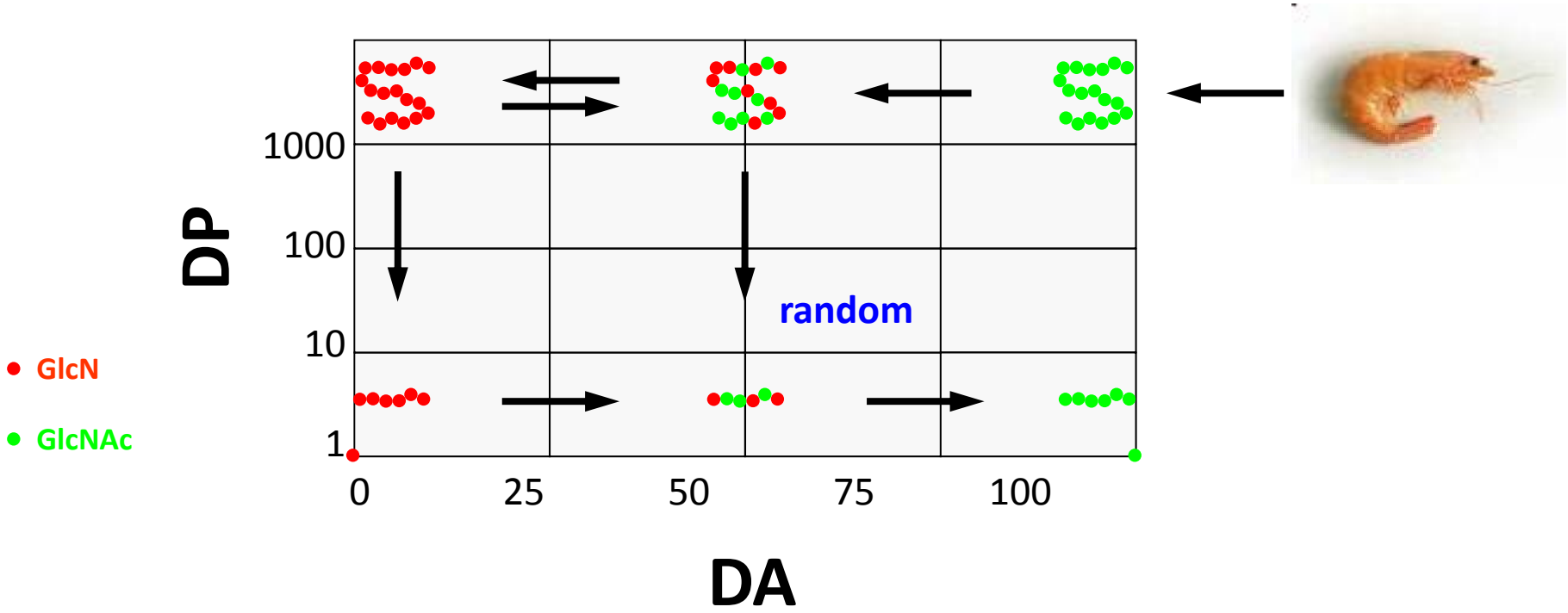




structure-function relationships of chitosans



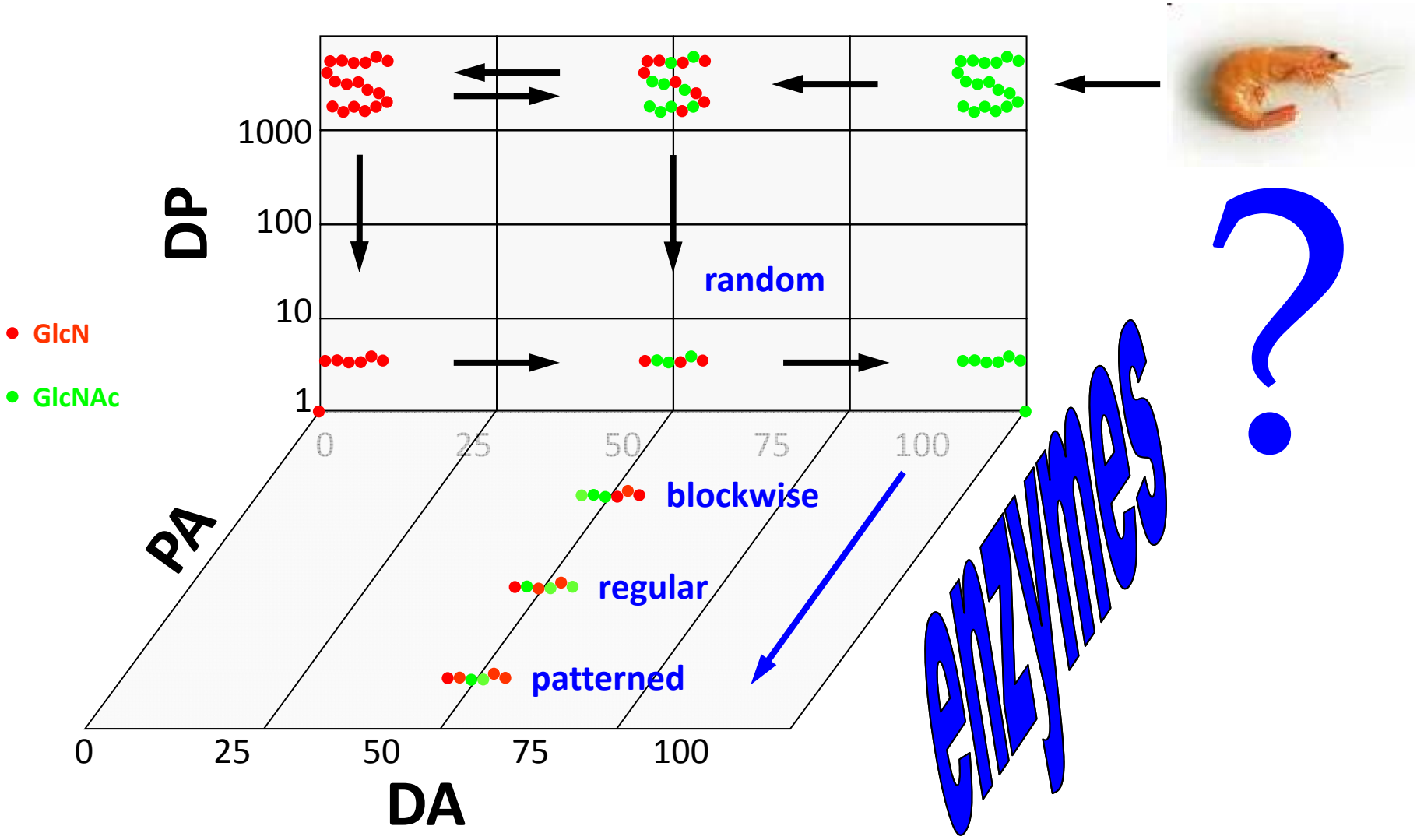
chemical preparation of chitosans: 2D matrix



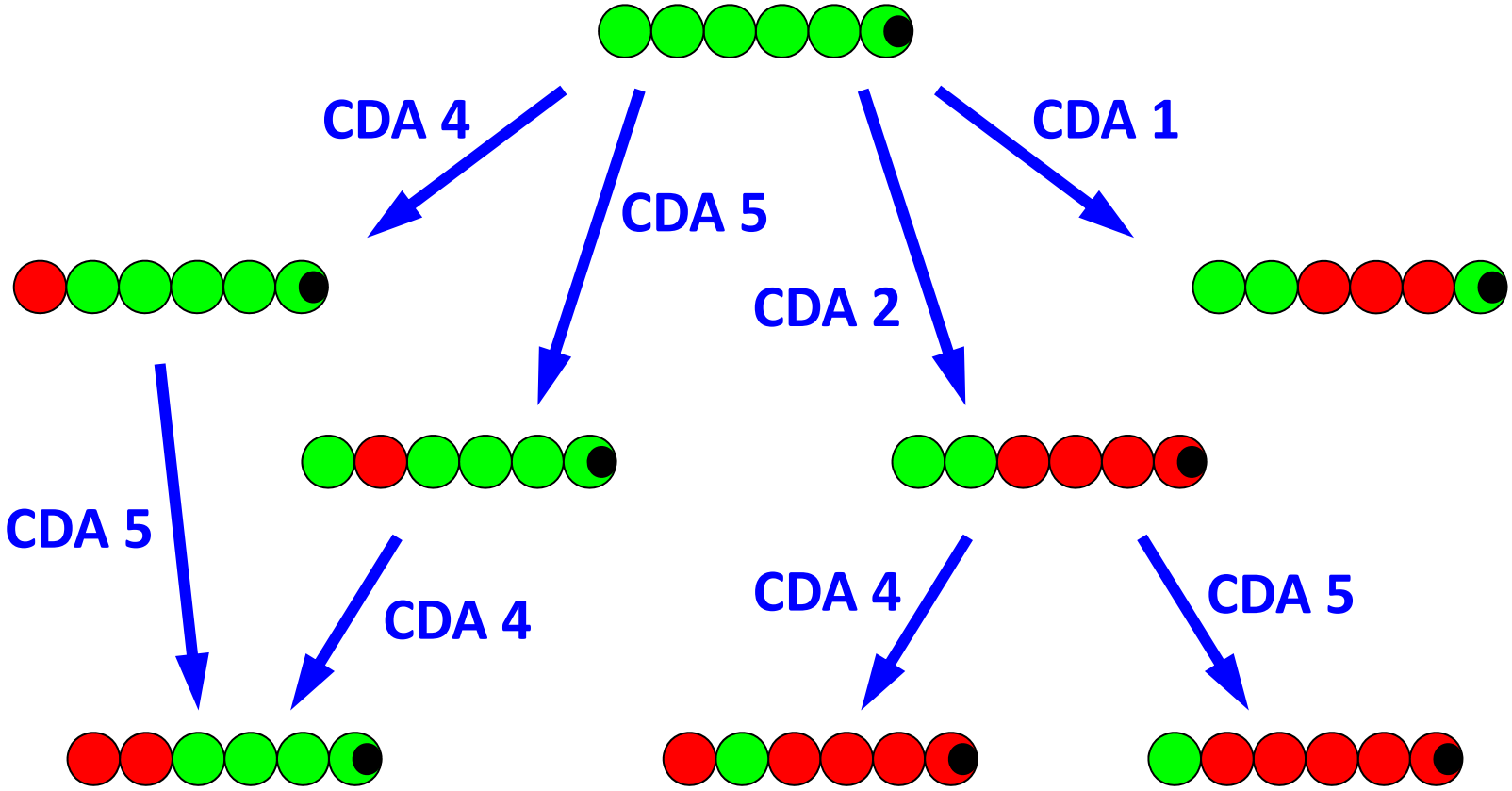
chemical - de-N-acetylation
- de-polymerisation
- re-N-acetylation

yield chitosan oligo- and polymers with **random PA**

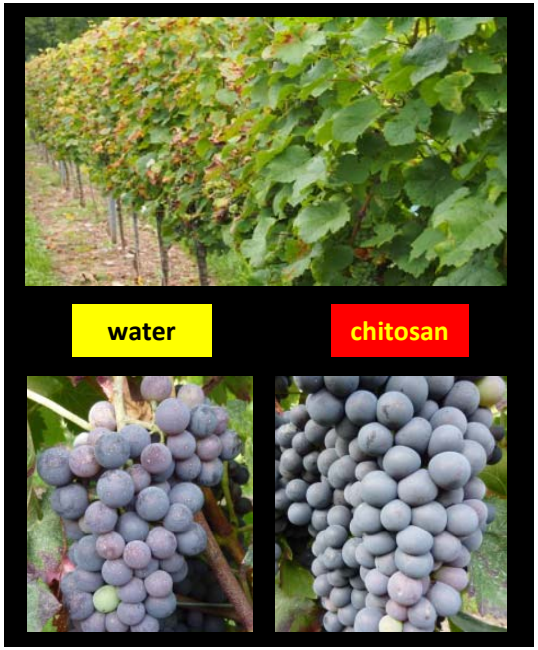
enzymatic modification of chitosans: 3D matrix

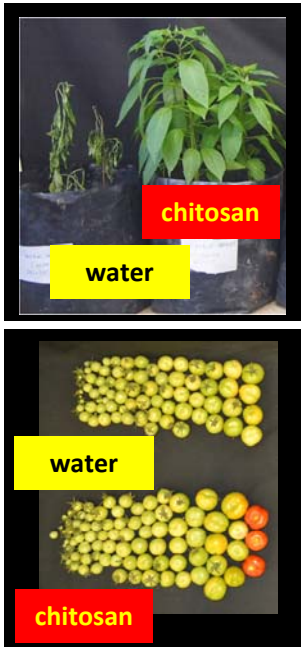


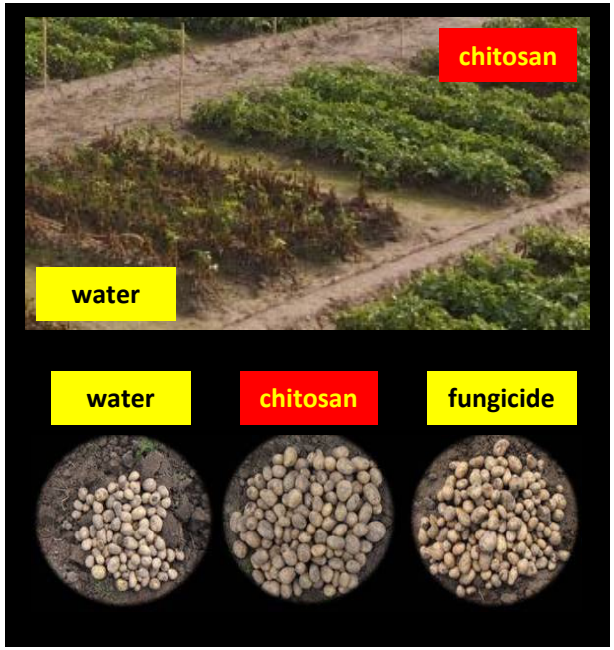
regio-selective chitin deacetylases

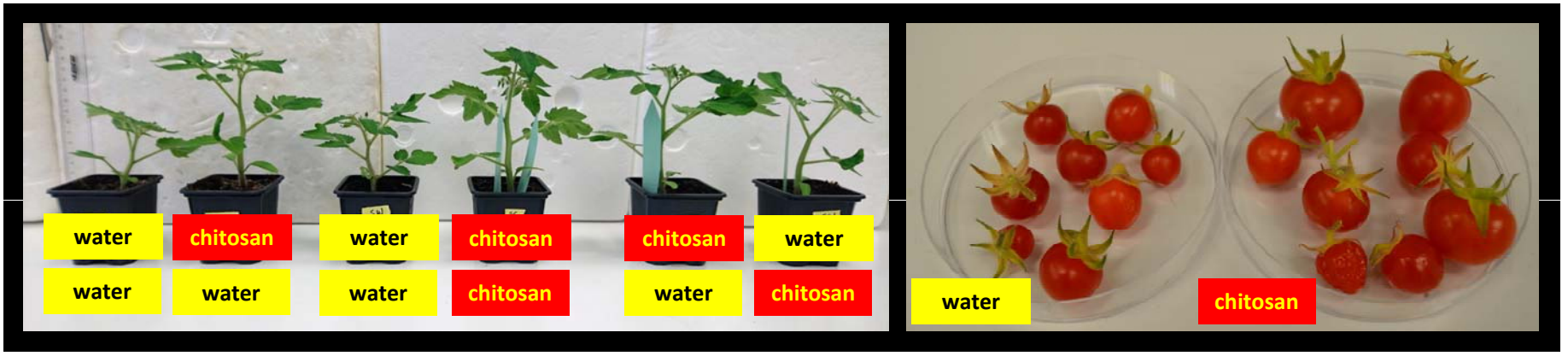


applications of well-defined chitosanS









nano 3BIO

Westfälische Wilhelms-Universität Münster

with **Dominique Gillet**, **Jatinder Kumar**, **David Nannen** et al.

chitosanS for sustainable agriculture

some chitosanS can inhibit growth of microbial pathogens

some chitosanS can induce disease resistance in plants

some chitosanS can induce stress tolerance in plants

some chitosans can promote growth & development in plants

chitosanS for sustainable agriculture

some chitosanS can inhibit growth of microbial pathogens

- these chitosanS are plant protectants

some chitosanS can induce disease resistance in plants

- these chitosanS were plant strengtheners
- these chitosanS are now plant protectants

some chitosanS can induce stress tolerance in plants

some chitosans can promote growth & development in plants

chitosanS for sustainable agriculture

some chitosanS can inhibit growth of microbial pathogens

- these chitosanS are plant protectants

some chitosanS can induce disease resistance in plants

- these chitosanS were plant strengtheners
- these chitosanS are now plant protectants

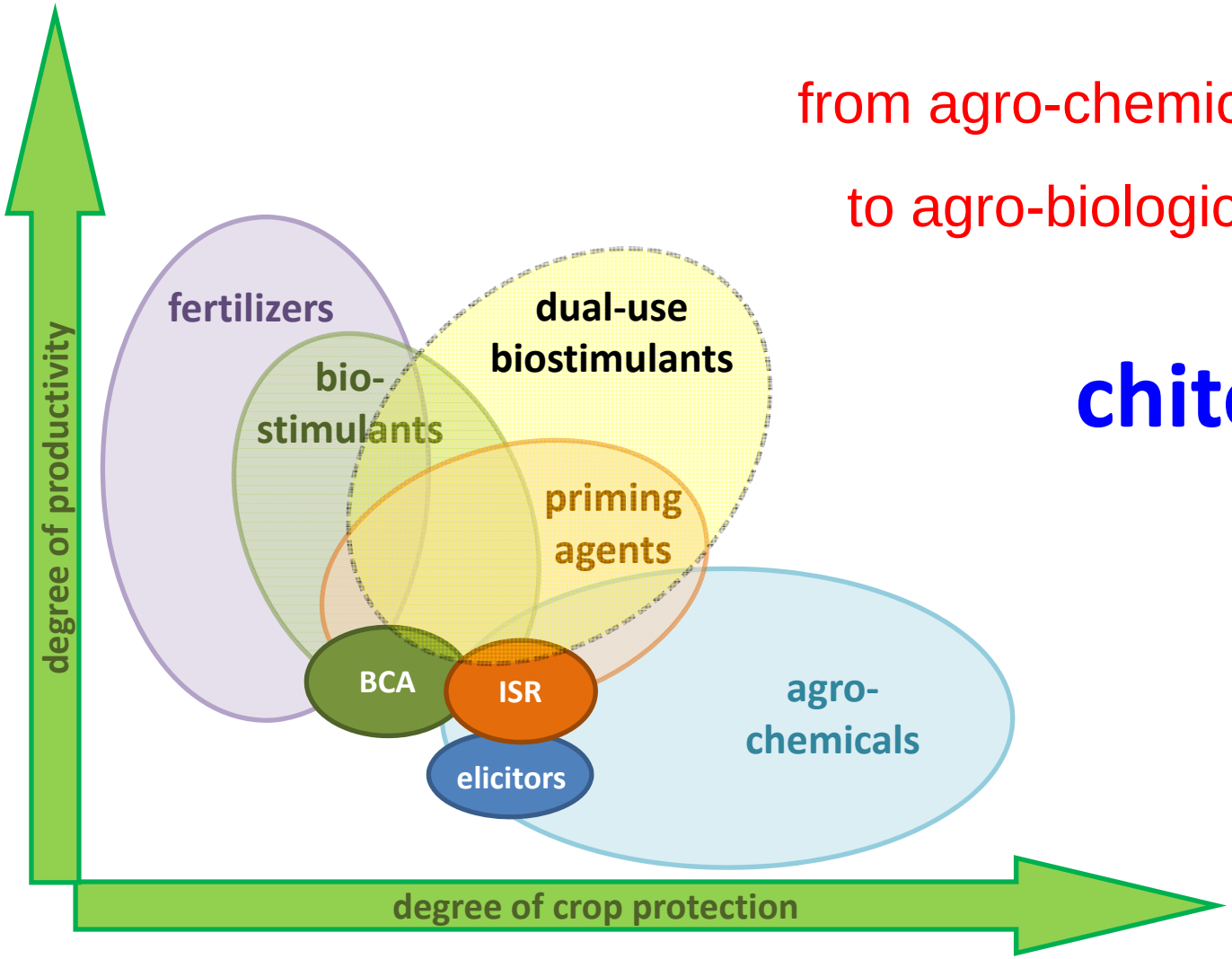
some chitosanS can induce stress tolerance in plants

- these chitosanS will be plant biostimulants

some chitosans can promote growth & development in plants

- these chitosanS will be plant biostimulants

chitosans for knowledge-based plant protection



from agro-chemicals

to agro-biologics

chitosanS !

thanks

The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 613931

from 1st generation chitosan to 2nd generation chitosanS

first generation chitosan

- rather poorly defined mixture of polymers, of varying purity and varying composition
- mostly unfit for the development of successfully marketable products

This chitosan was dominating the market for decades and is still widespread today.

second generation chitosanS

- well defined in terms of their DP and DA, with known molecular structure-function relationships
- more suitable for the development of reliable products

These chitosans are now increasingly appearing on the market.

from 2nd to 3rd generation chitosanS

second generation chitosanS

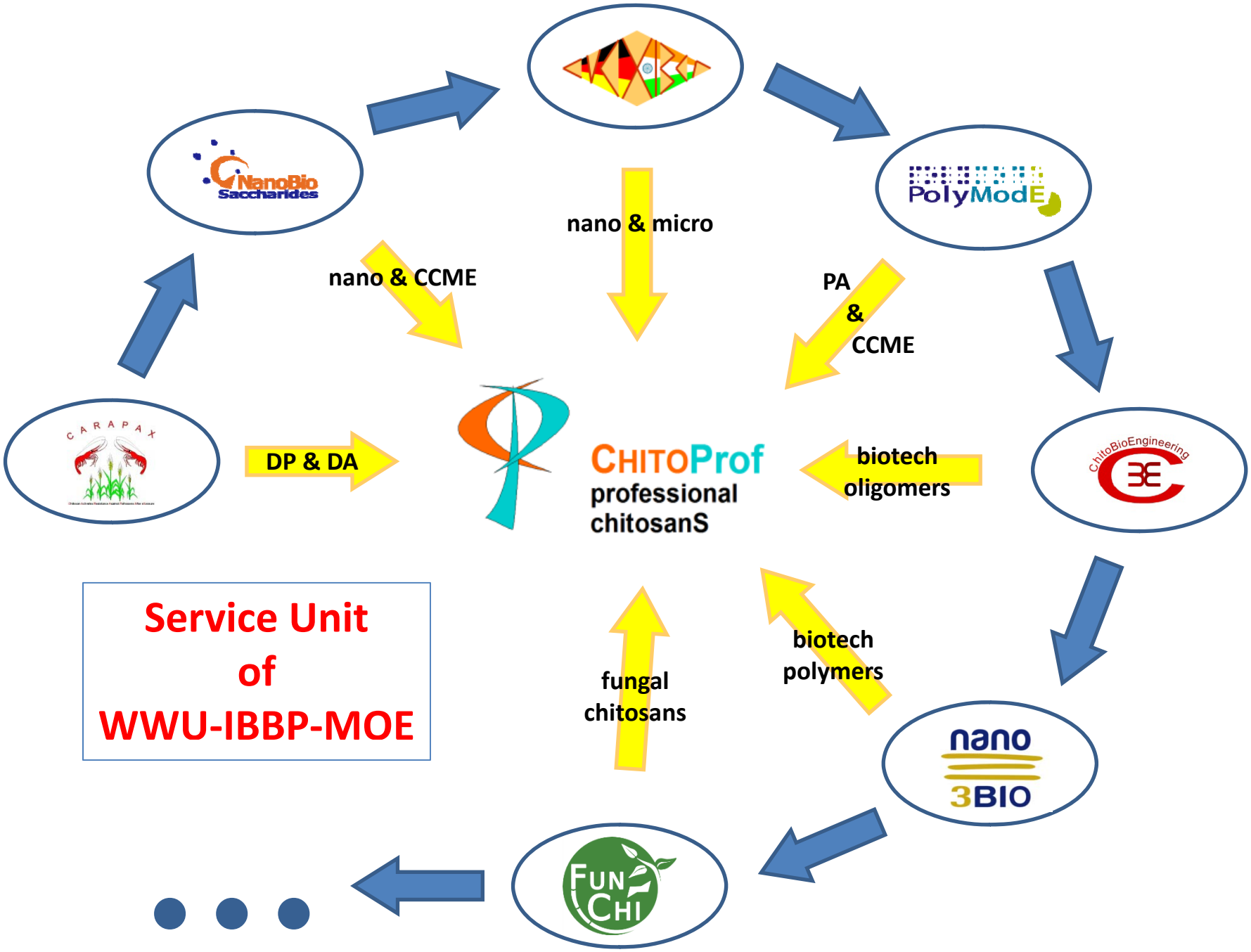
- well defined in terms of their DP and DA,
  with known molecular structure-function relationships
- more suitable for the development of reliable products

These chitosans are now increasingly appearing on the market.

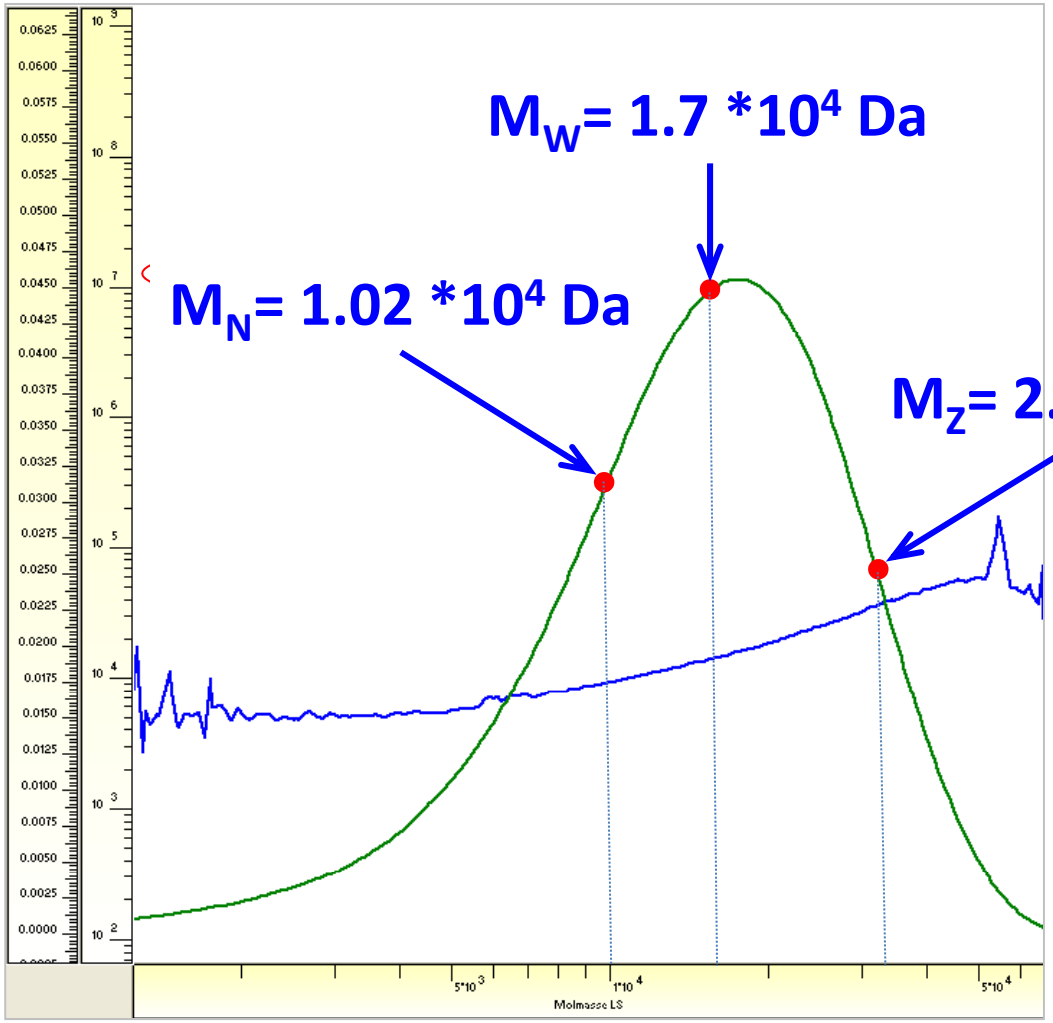
third generation chitosanS

- less polydispers polymers and monodispers oligomers,
  with well-defined, non-random PA,
  nano-formulated if required,
  with defined biological activities
  and known cellular modes of action

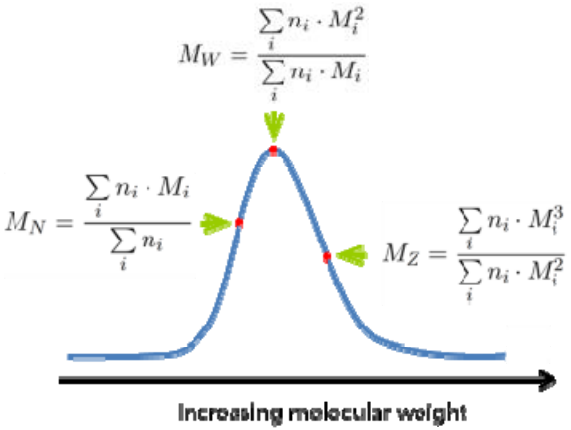
These chitosans will create new market opportunities in future.


NanoBio Saccharides
PolyModE
CARAPAX
ChitoBioEngineering
nano 3BIO
FUN CHI
nano & micro
nano & CCME
PA & CCME
DP & DA
biotech oligomers
biotech polymers
fungal chitosans
CHITOProf
professional chitosanS
Service Unit of WWU-IBBP-MOE

DP analysis of chitosan polymers using SEC-MALLS



$I_P = M_W/M_N = 1.68$

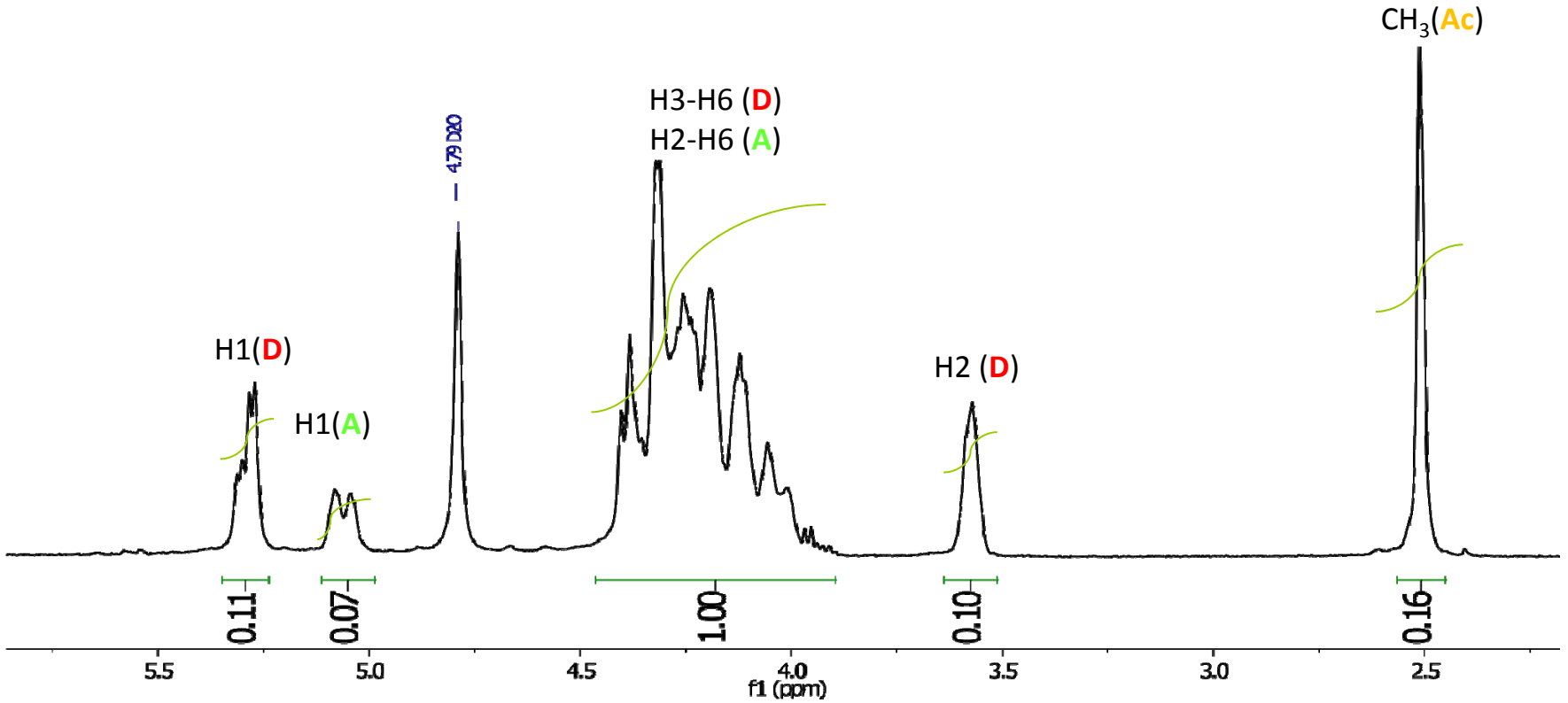


according to ASTM International Method F2260-03

DA analysis of chitosan polymers using ^{1}H-NMR

$$\%DA = \frac{7(I_{H1(A)} + I_{CH_3(A)})}{4(I_{H1(D)} + I_{H2-H6(A+D)}) + I_{H1(A)} + I_{CH_3(A)}} * 100$$

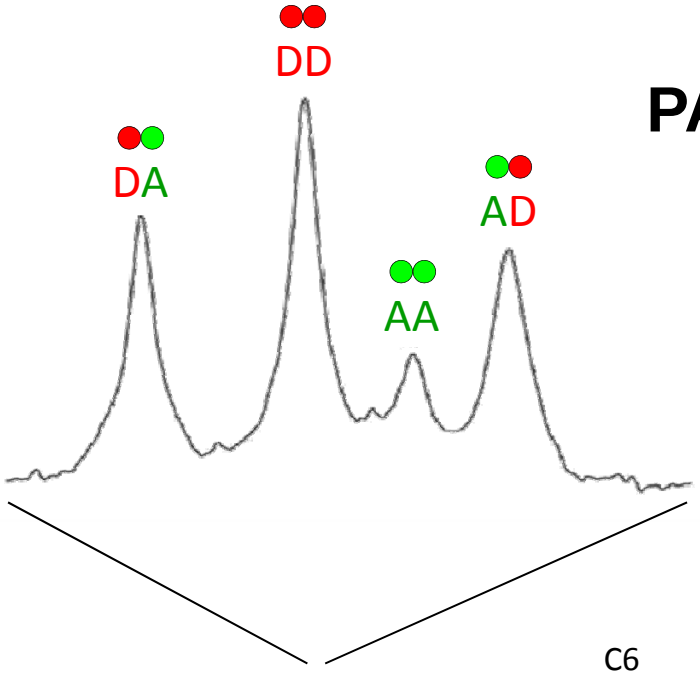
DA = 30%



according to ASTM International Method F2260-03

PA analysis of chitosan polymers using ^{13}C-NMR

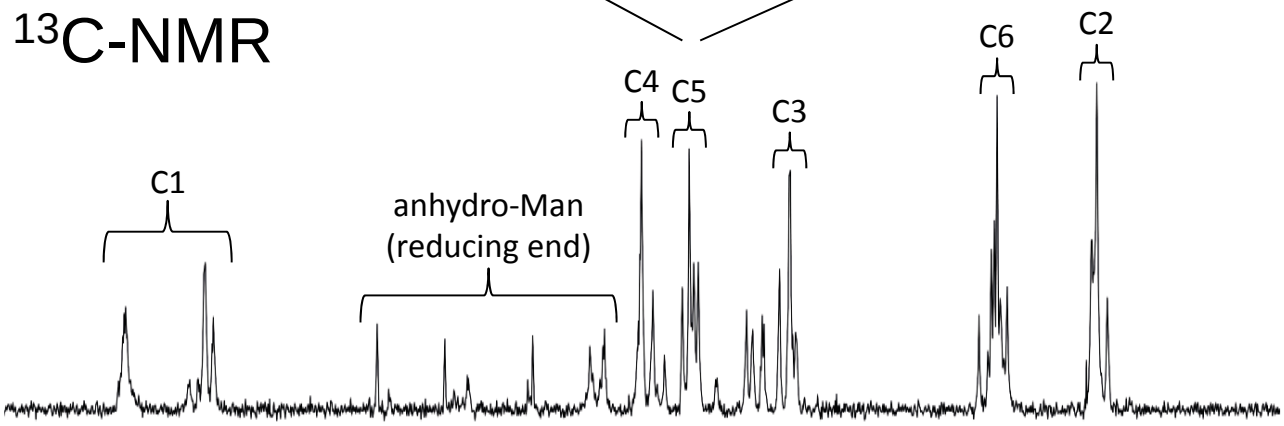
C5 region



$$PA = \frac{F_{DA}}{F_{DD} + F_{DA}} + \frac{F_{AD}}{F_{AA} + F_{AD}}$$

random PA = 1
block PA < 1
regular PA > 1

^{13}C-NMR



DP, DA, PA analysis of chitosan oligomers using HPLC-MS^n

CHITOProf professional chitosanS