

Hof van Wageningen - NL

Start: Wednesday | Oct 12th | 5:00 pm

End: Friday | Oct 14th | 1:00 pm

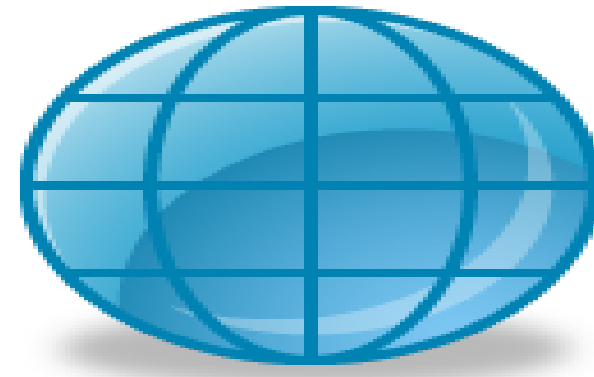
syngenta

Plant Phenotyping : *Picture this with machine vision*

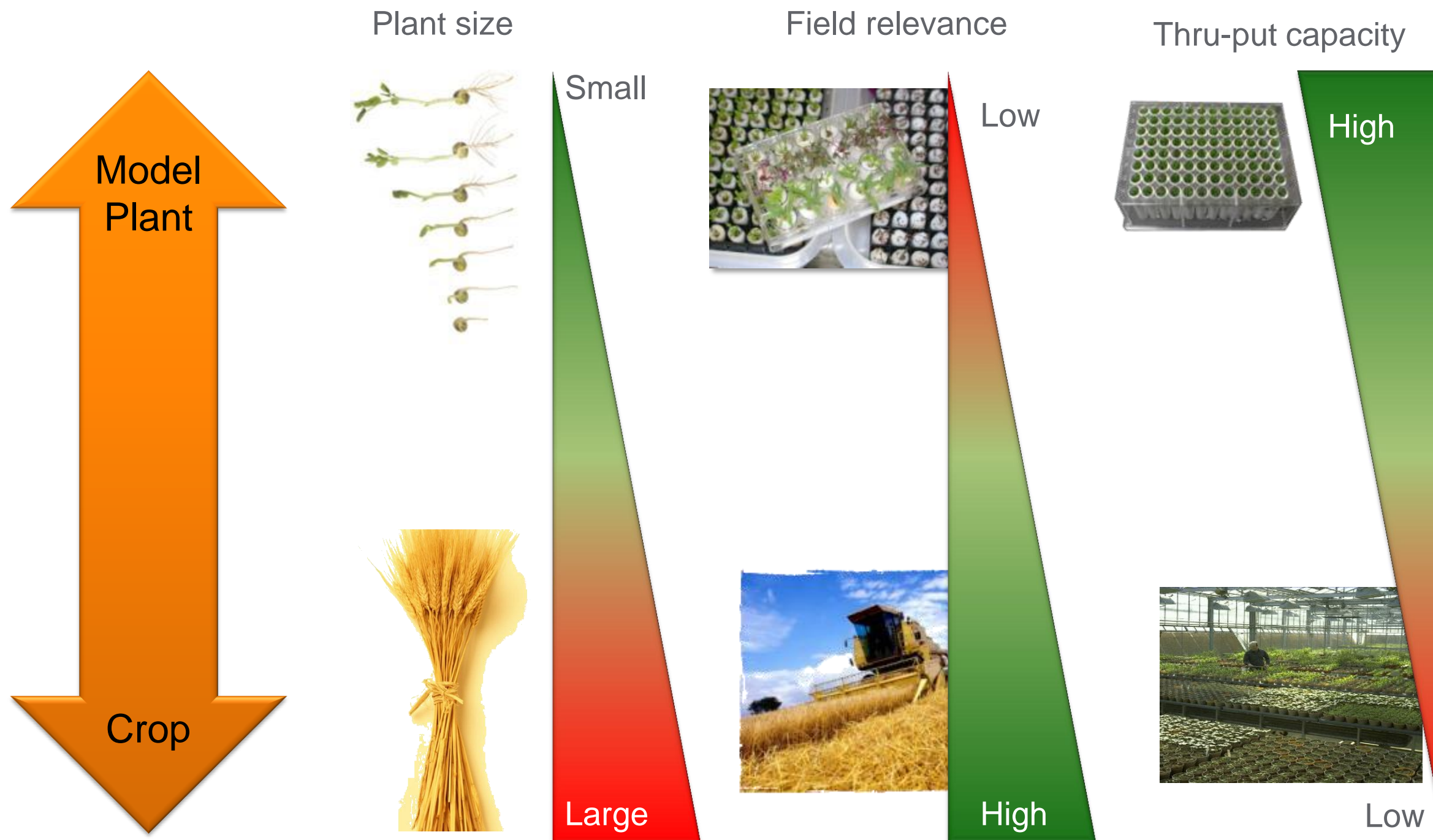
Rob Lind

Outline

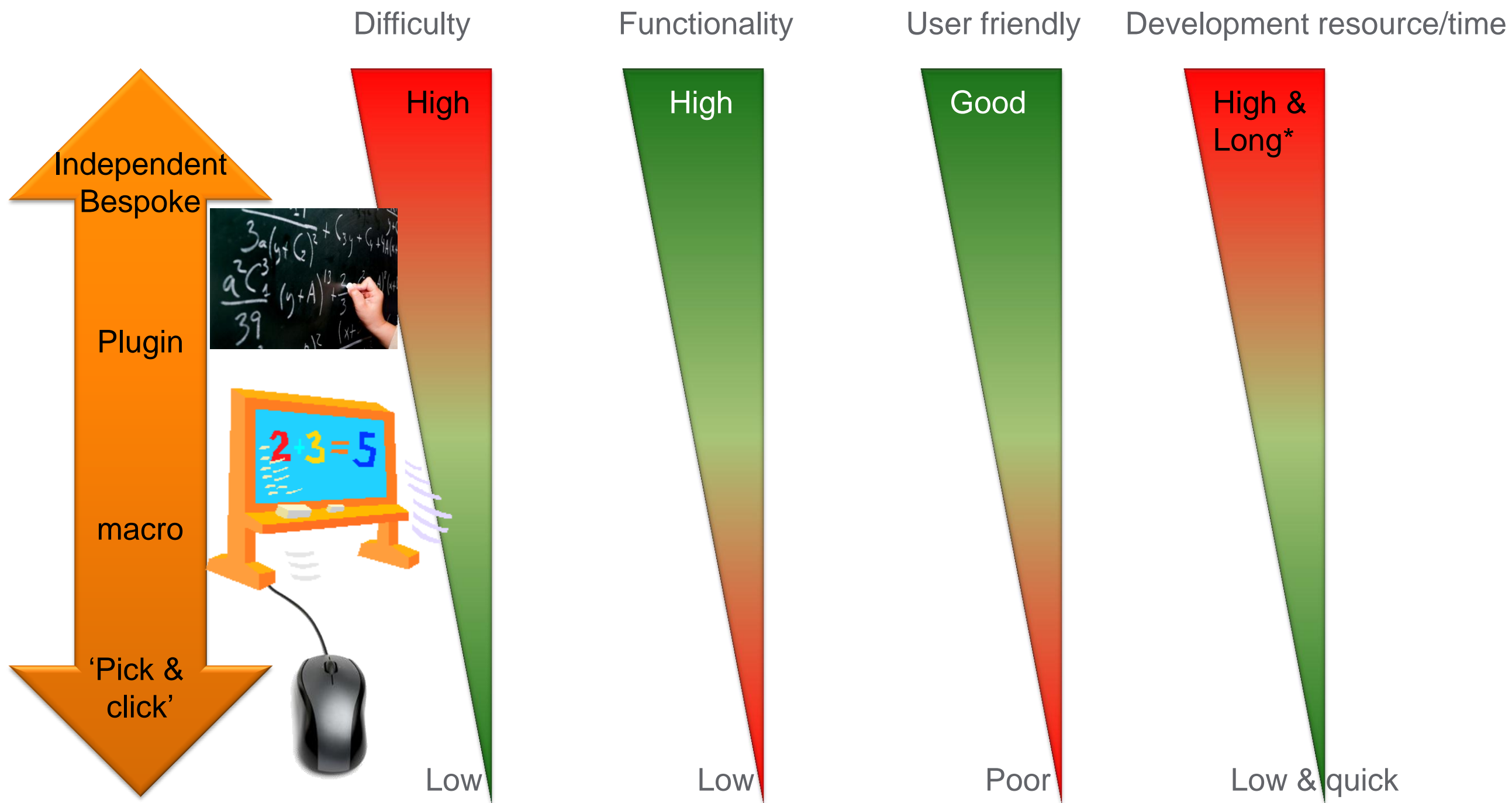
- *Challenges and perspectives*
 - Plant phenotyping
 - Machine vision software/hardware
 - Syngenta image analysis network
- *Phenotyping Stories from the Syngenta imaging network*
 - Root phenotyping
 - Fruit and vegetable phenotyping and the challenges of colour quantification
- *Concluding remarks*



Current Challenges in plant phenotyping



Current Challenges in imaging software development



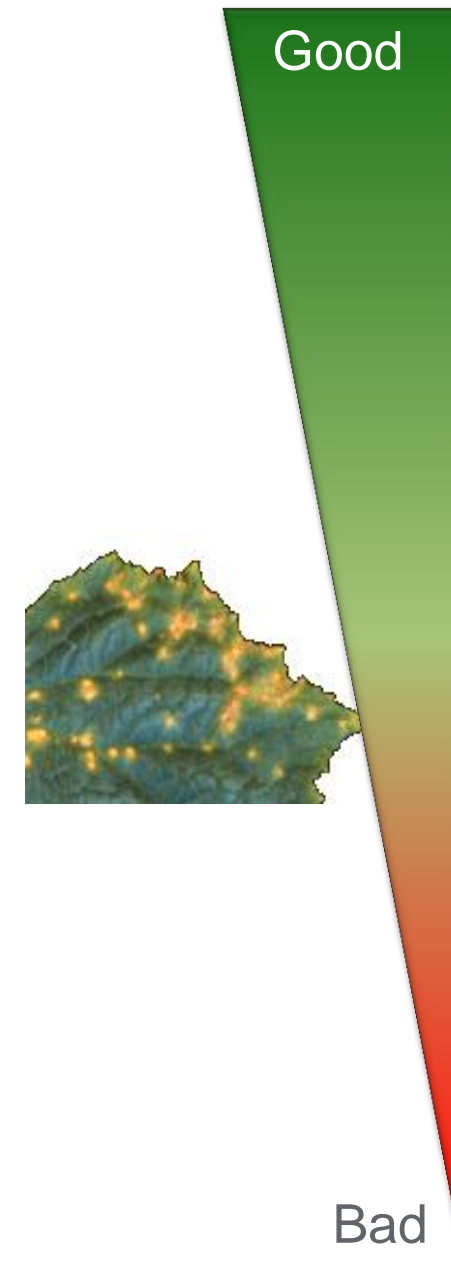
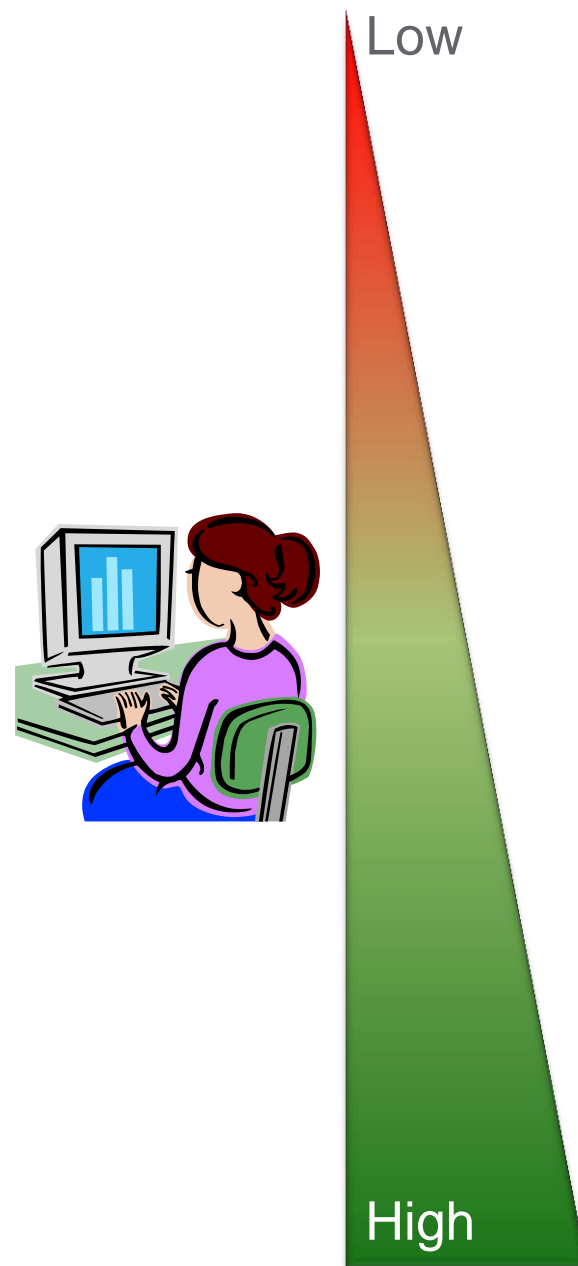
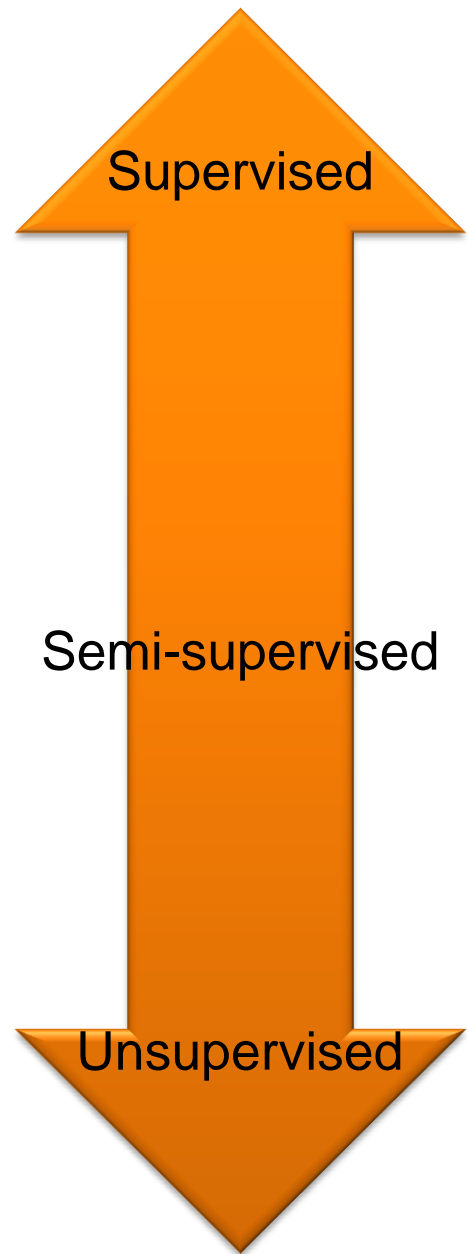
*Off the shelf solutions available

Current Challenges in plant phenotyping software use

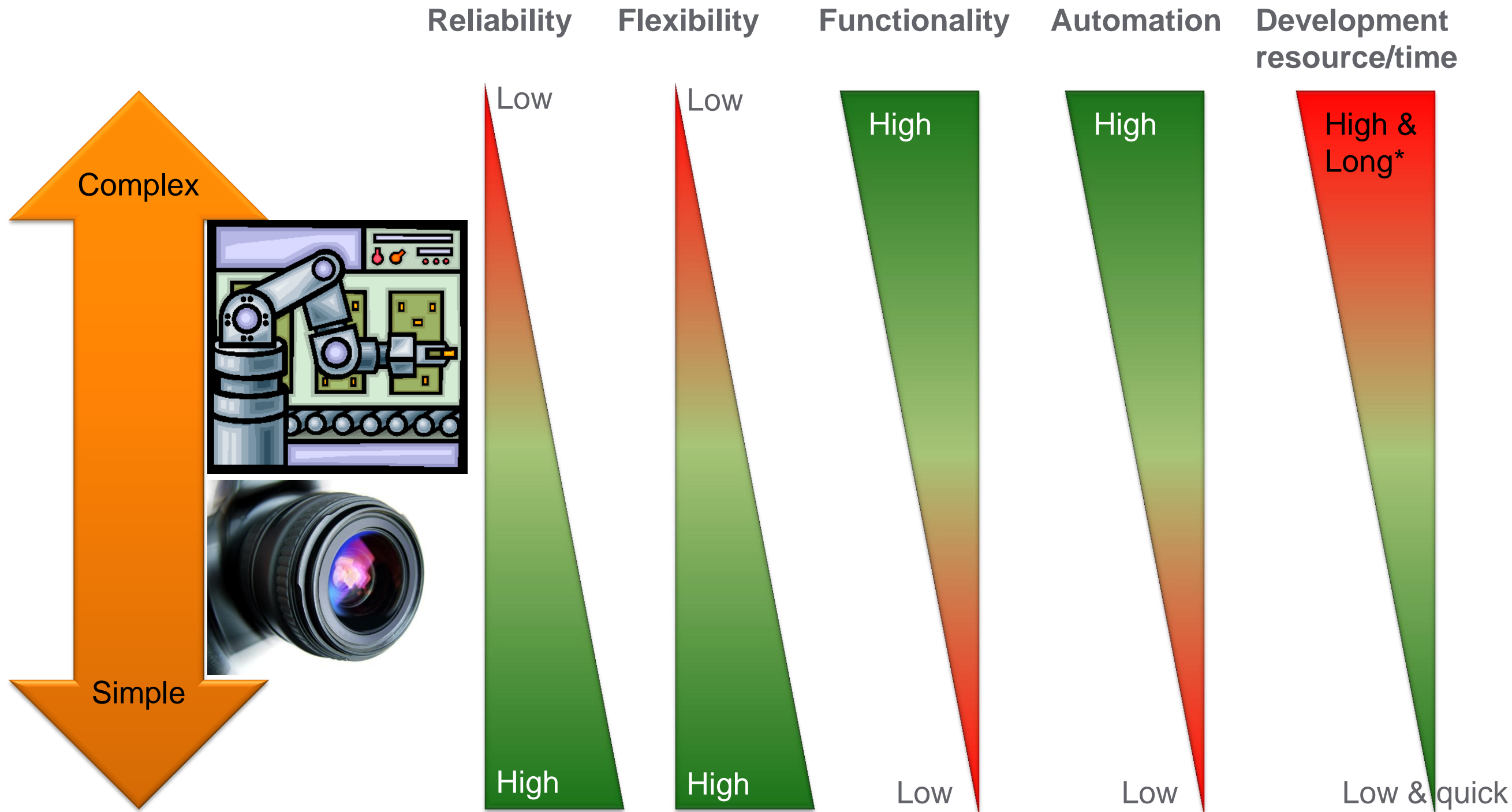
Thru-put capacity

Quality control

Dealing with the unexpected

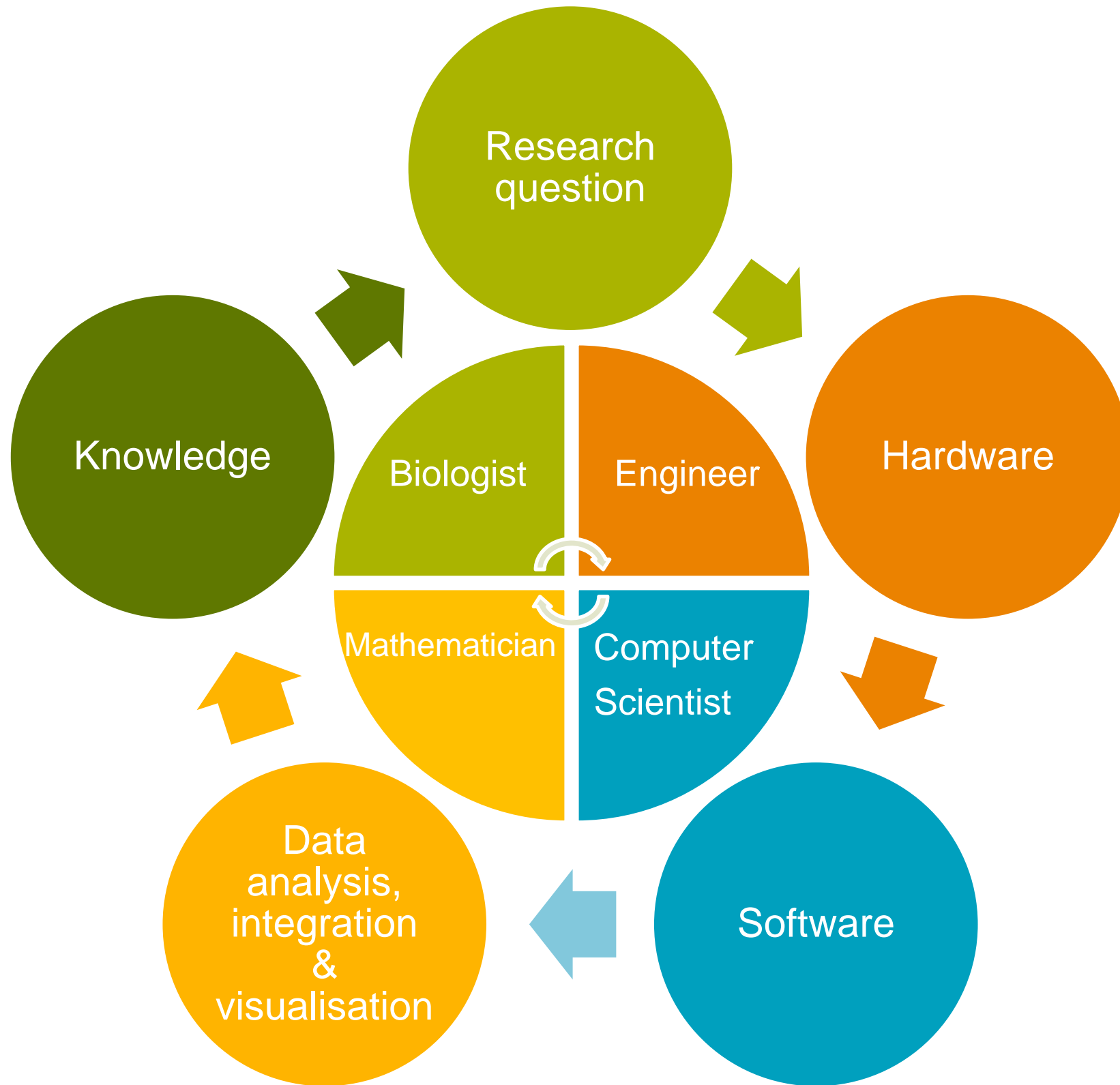


Current Challenges in imaging hardware

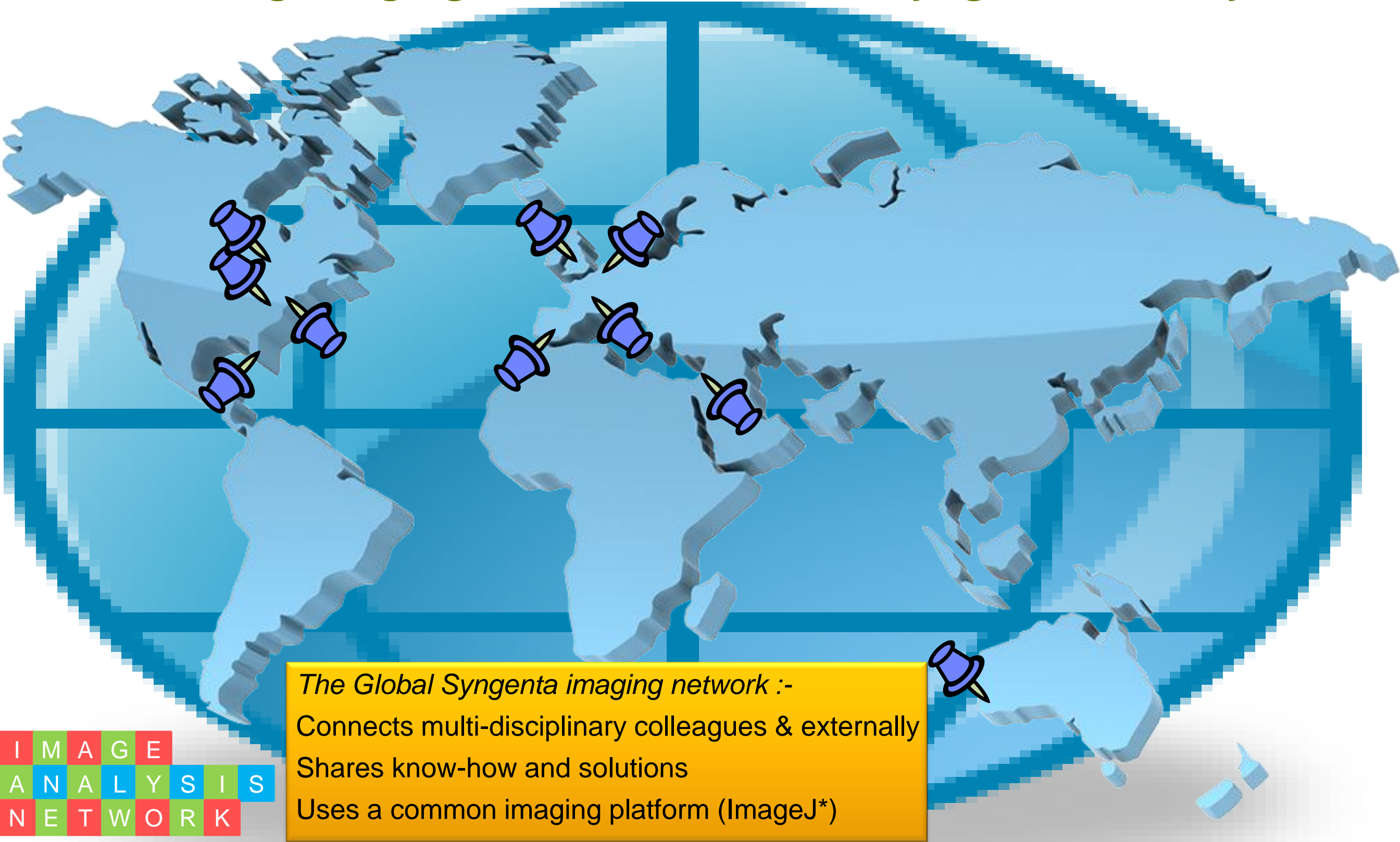


*Off the shelf solutions available

Challenges to capitalise on image analysis



Networking imaging enthusiasts across Syngenta and beyond...



Phenotyping Stories from the Syngenta imaging network

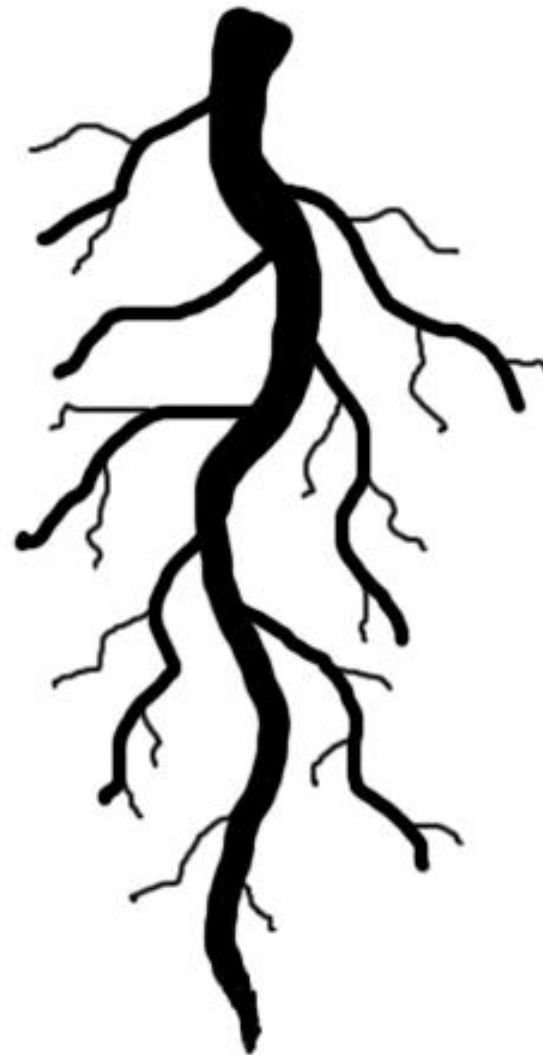


- One seventh of the global tomato market is grown using our seeds which equals 16.5 million tonnes
 - or 8 average size tomatoes per person per week

Roots architecture and parameters

Local root architecture (Always retained)

- Number of root tips
- Branching order/number
- Total length
- Root thickness

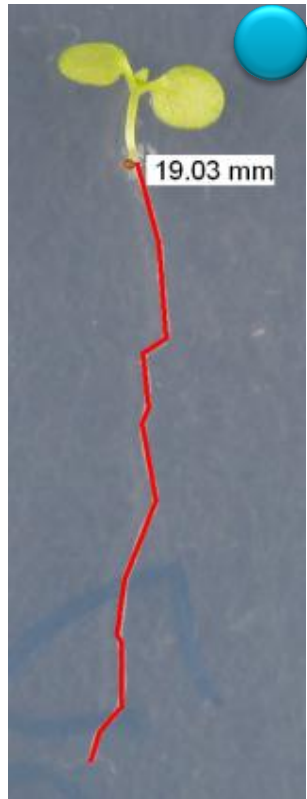
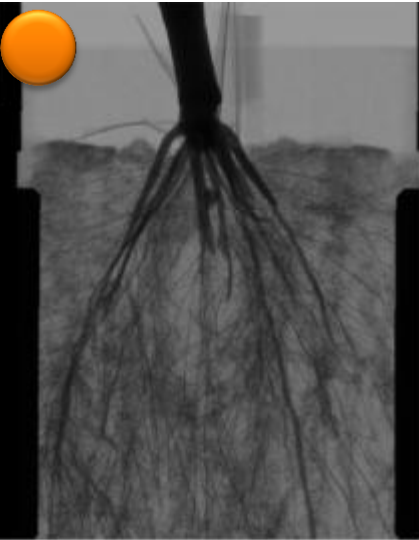


Global root architecture (Lost in destructive assessment)

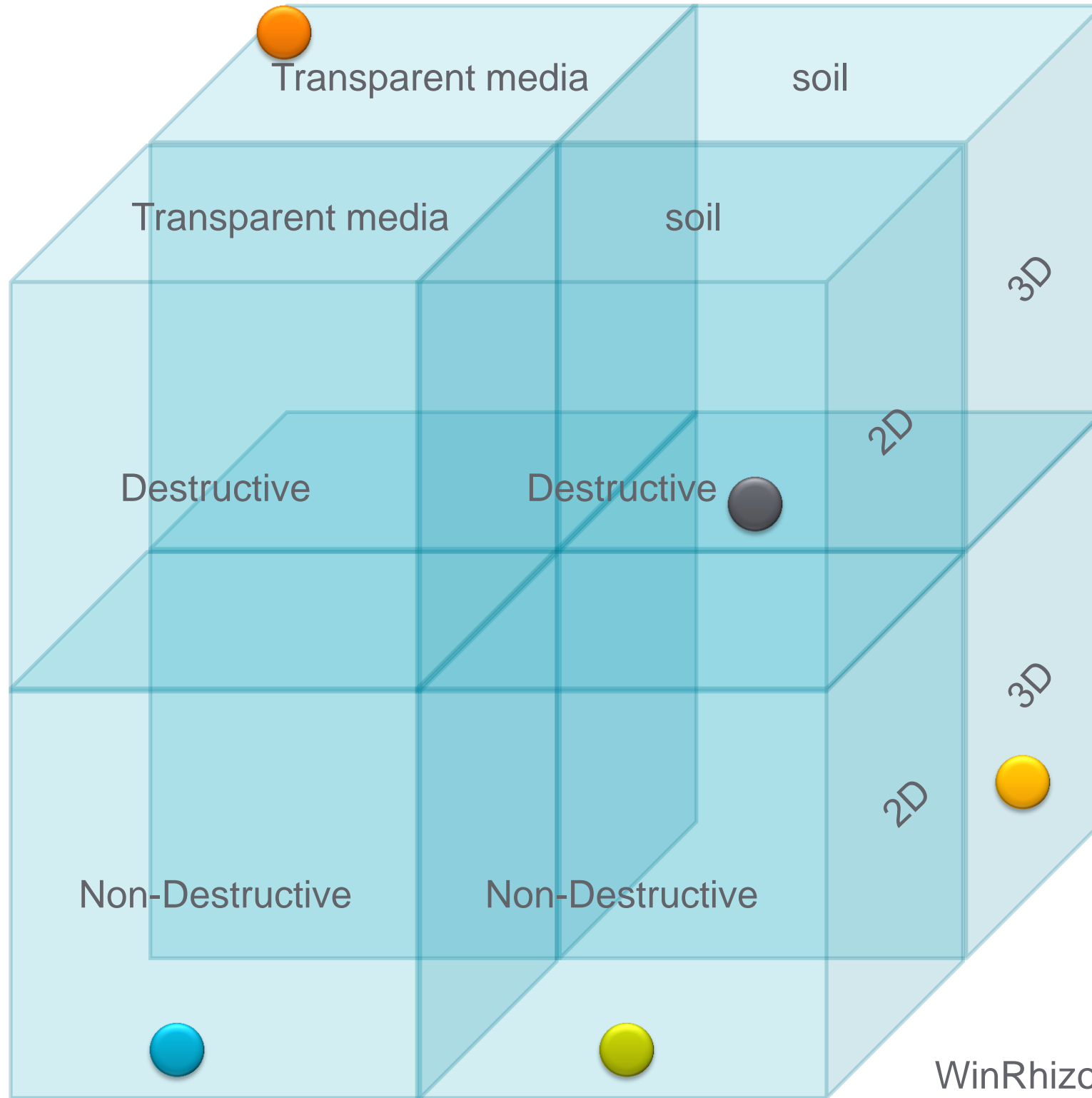
- Max width & Height
- Centre of gravity
- Roots crossing depth transects

Imaging roots : Matrix of choices

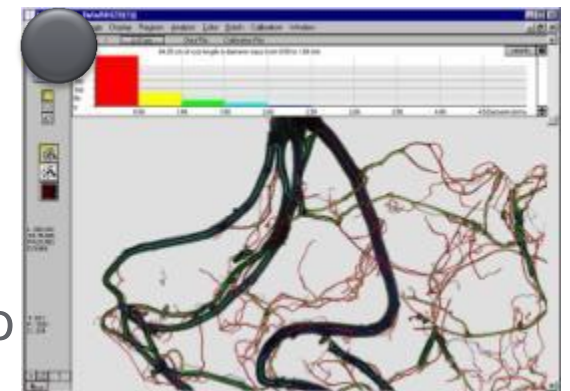
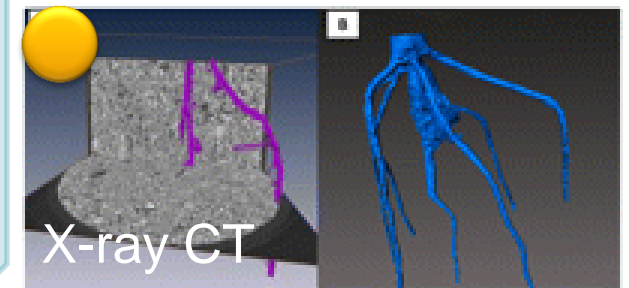
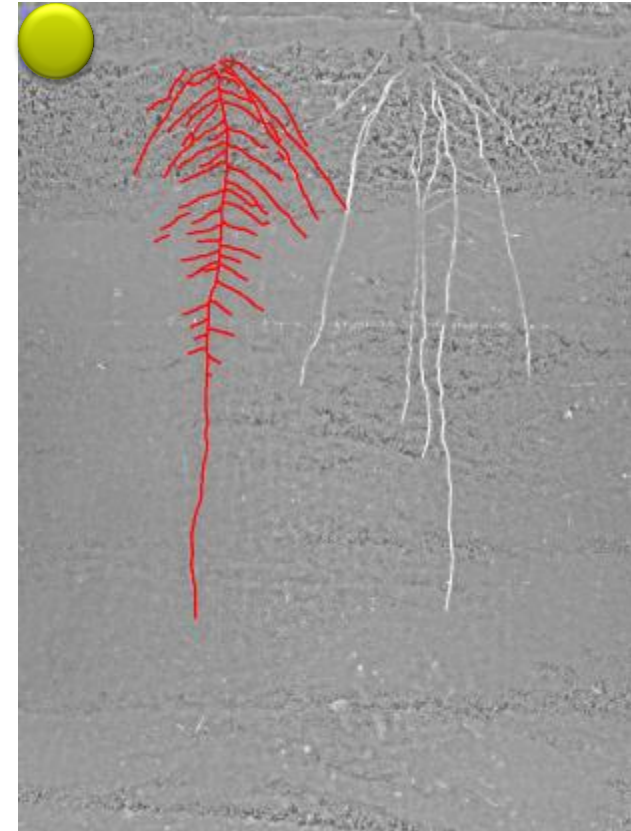
RootViz FS



Agar system



Rhizo boxes



WinRhizo

<http://www.phenotypescreening.com/news.html> <http://www.nottingham.ac.uk/biosciences/people/sacha.mooney> <http://www.regent.qc.ca/products/rhizo/RHIZO.html>

Fruits and vegetables – colour and much more!



- Colour, shape and texture of fruits and vegetables are important phenotypic characteristics to measure
- Colour is particularly demanding to measure consistently due to:-
 - Lighting
 - Sensor performance of camera
 - Reflectance
 - 3D objects
 - Calibration

roundness



roughness



dimensions



colour



texture



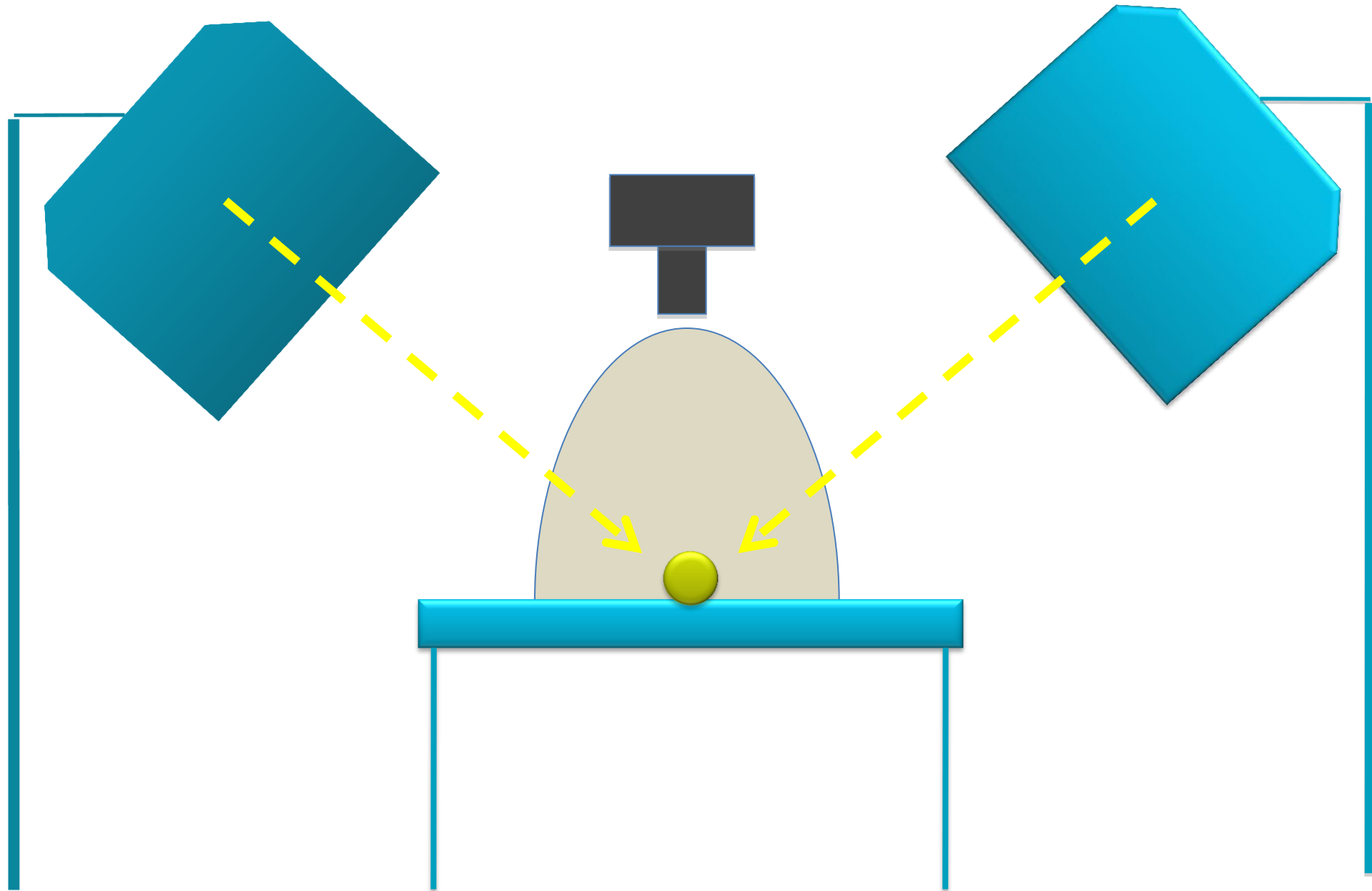
enclosure



counting



Capturing consistent colour images



- The angle of illumination and the use of light diffusers and a diffusing tent ensures an even lighting on the subject

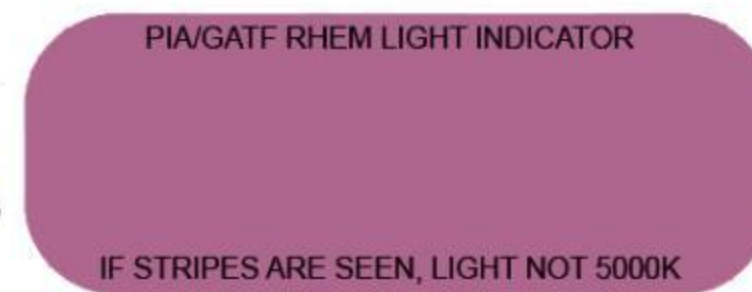
Colour perception

- **Metamerism**

- Phenomena where two objects with different reflectance spectra appear to be the *same* color.
- The perception of colour is not only a function of the object's spectral reflectance, but is also affected by the illumination source and the sensitivity of the detector (eye or camera).



INCANDESCENT LIGHT



5,000K LIGHT

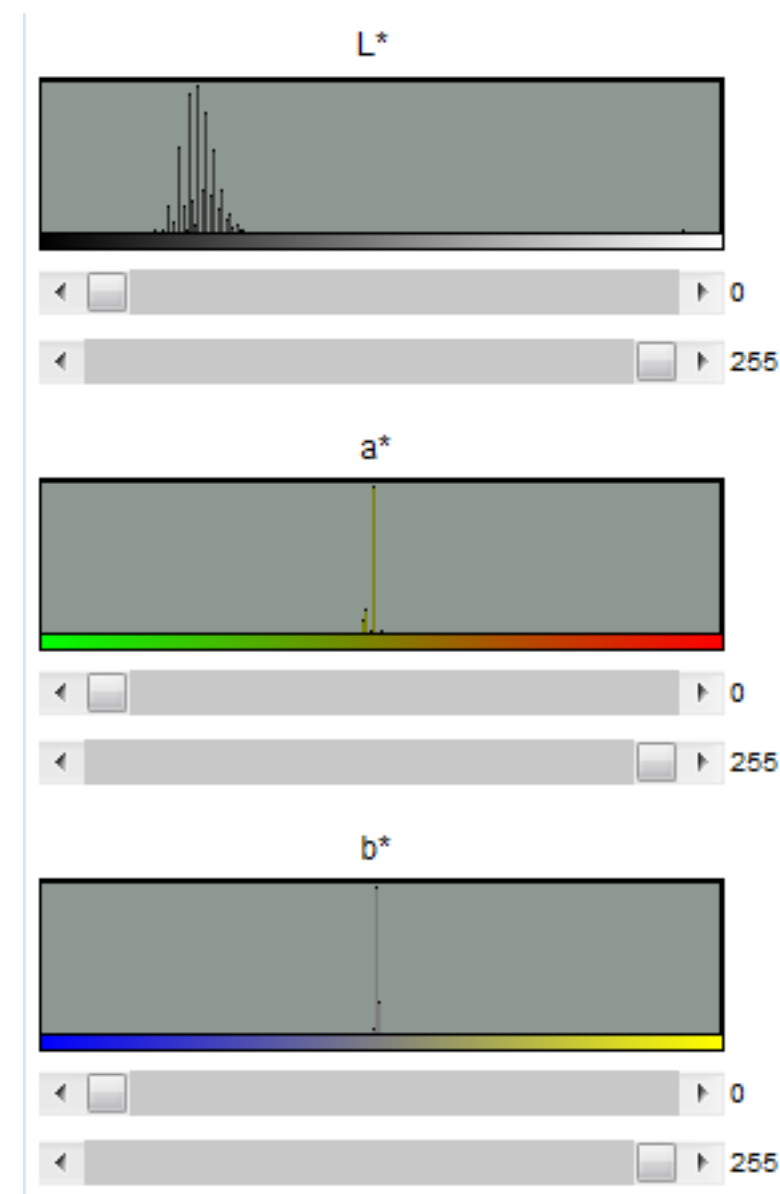


COOL WHITE FLUORESCENT LIGHT

<http://qualityinprint.blogspot.com/2010/05/issue-of-metamerism-in-print-production.html>

Colour theory and the CIE L*a*b* colour space

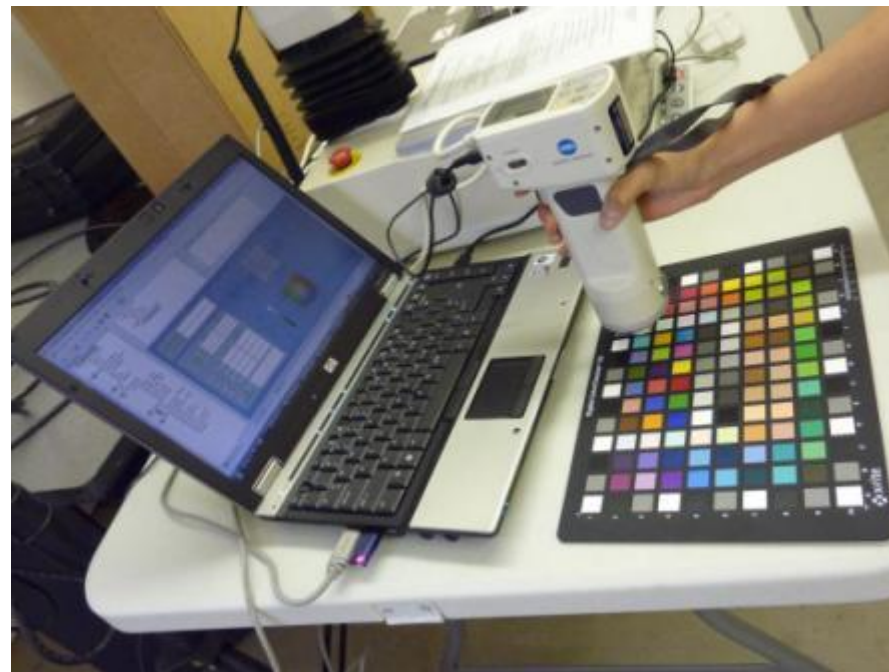
- **Grassmann's First Law**
 - German Mathematician, 1809 to 1877.
 - "To specify a colour, three elements are necessary and sufficient"
- Many different colour space models available e.g. Red Green Blue, Hue Saturation Brightness
- To match human perception of colour the CIE L*, a*, b* was developed in 1976 and is commonly used to define colours in image processing



CIE = Commission International de l'Eclairage

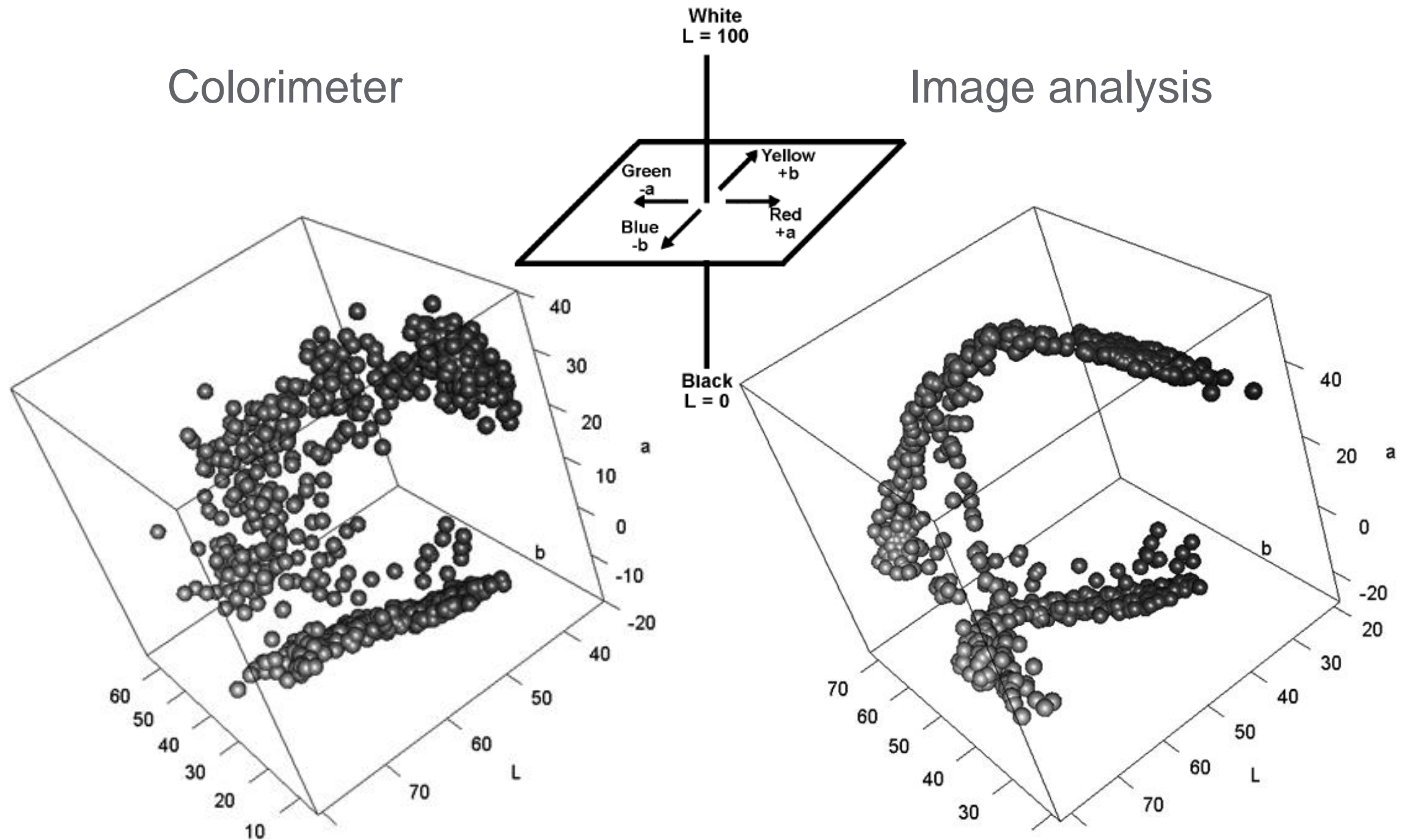
Colourimeters vs image processing

- Handheld colorimeters make accurate colour measurements at individual spots on the fruit surface.
- Digital camera technology allows for rapid characterisation of the appearance of many spots on the fruit surface or of multiple fruits in the same scene.
- For accurate colour information, standardised digital imaging equipment, procedures, and calibration methods must be developed.



L*a*b* plots comparing a colourimeter to image analysis

- Notice more spread in colorimeter, and slightly duller colours



Calibration of colour images

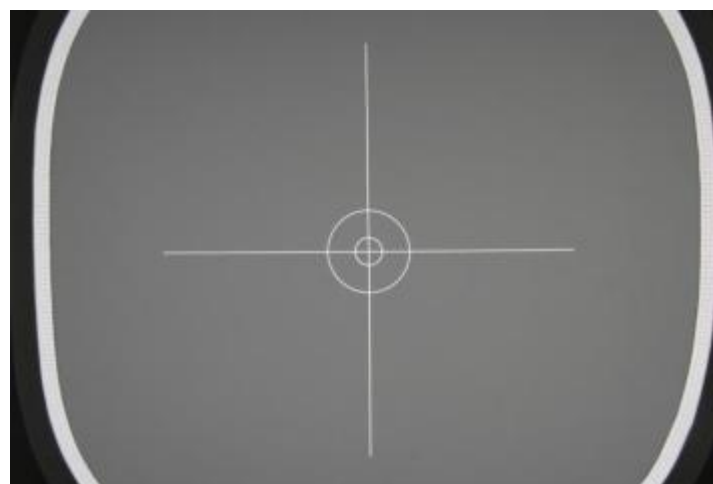
Calibration colour chart



White balance calibration

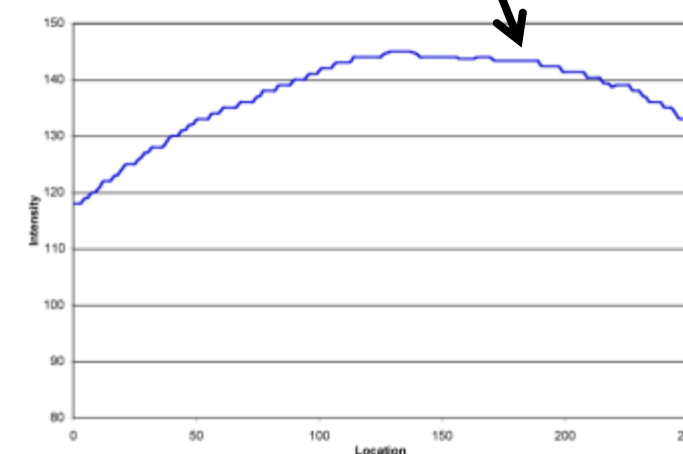
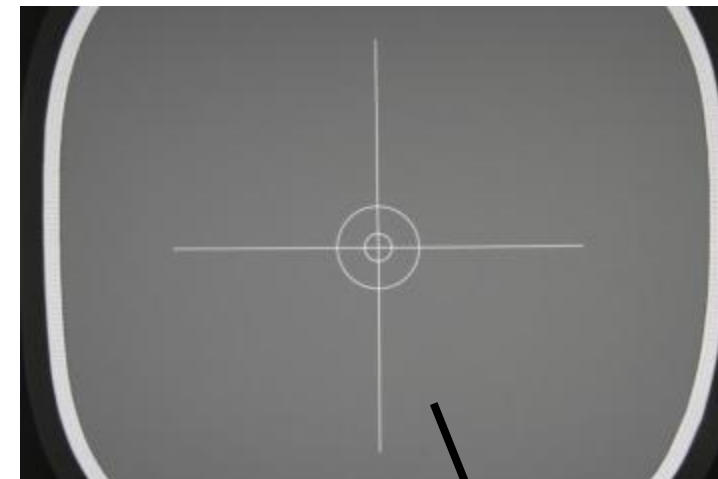


Before white balancing



After white balancing

Lighting uniformity calibration



Uncorrected intensity profile

Once calibration has been performed colours can be accurately compared

Concluding remarks

- To meet the challenges in plant phenotyping through imaging technologies requires connecting biologists, computer scientists, mathematicians and engineers into a network
- Choosing the right biological system (model vs crop), imaging hardware, image analysis routines (which parameters) and data integration allows research questions to be addressed
- To compare subjective parameters, such as colour, a careful calibration of the imaging system is essential