

# From strategic science to application

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# Introduction



- Science advances offer huge opportunities for the rural economy
- WP2.1 contains a range of science disciplines and activities
- We have a pipeline from strategic to applied science
- Stakeholders are the ultimate recipient of all the science



# Potato breeding and improvement

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# Potato breeding in the past



- Traditional breeding is a long-term investment (15-45 years)
- Looks to improve traits (physical appearance or properties)
- Traits include disease resistance, flavour, sugar content, texture, shape etc
- Selection for traits often relies on field assessments over many years



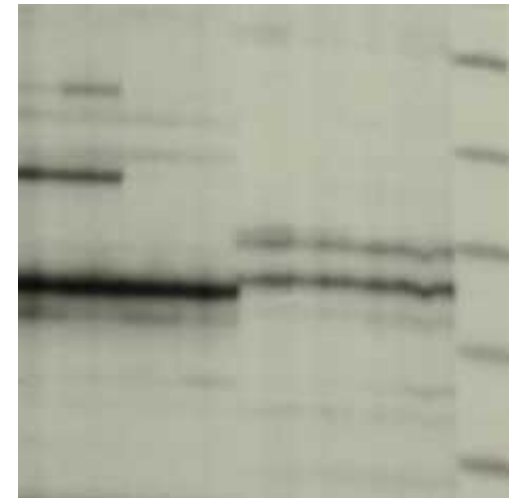
# Potato genetics

- The potato genome can offer a shortcut to trait identification?
- Genetic markers to a particular trait can be identified from genome regions associated with that trait
- These markers allow rapid assessment of breeding material
- Most breeding today incorporates genetic markers for trait analysis



Resistant  
Resistant  
Susceptible  
Susceptible

→  
Molecular  
marker for  
resistance



# Potato genetics

- The ultimate genetic marker is the gene(s) responsible for a trait
- For example, identifying a resistance gene(s) to a particular pest or pathogen
- These gene markers allow you to differentiate or even combine resistances





# How robust / durable is your resistance?



- Late blight is caused by the pathogen *Phytophthora infestans*
- Breeding for late blight resistance has been underway for 150 years
- Very few resistant cultivars are currently available



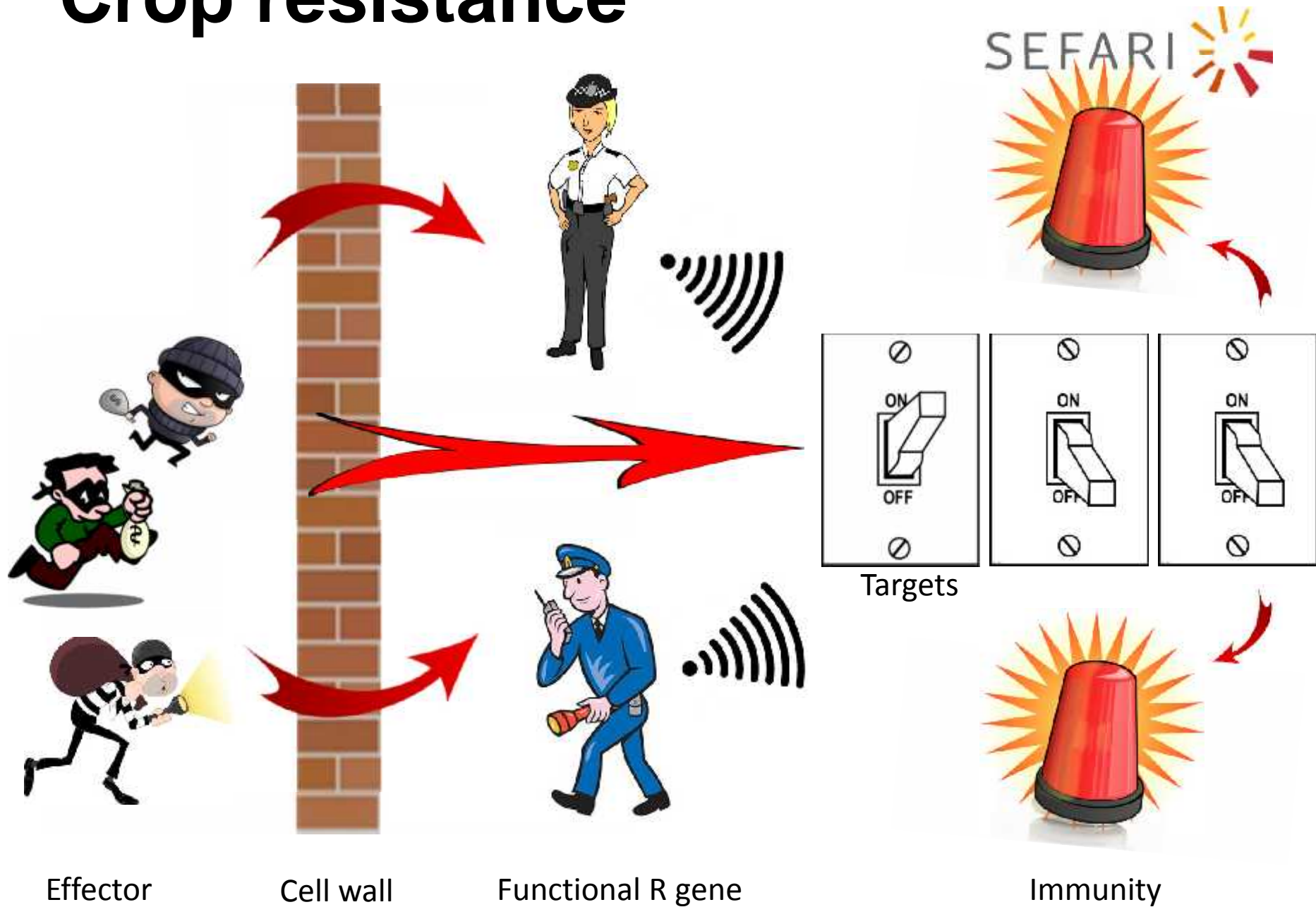
# Developing resistant potatoes



Sarpo mira



# Crop resistance



# Questions – the pathogen

- Which proteins act as effectors?
- Which genotypes of *P. infestans* carry which effectors?
- How do effectors get into the plant?
- What are their targets?
- Are there conserved /essential effectors that make good targets for resistance?



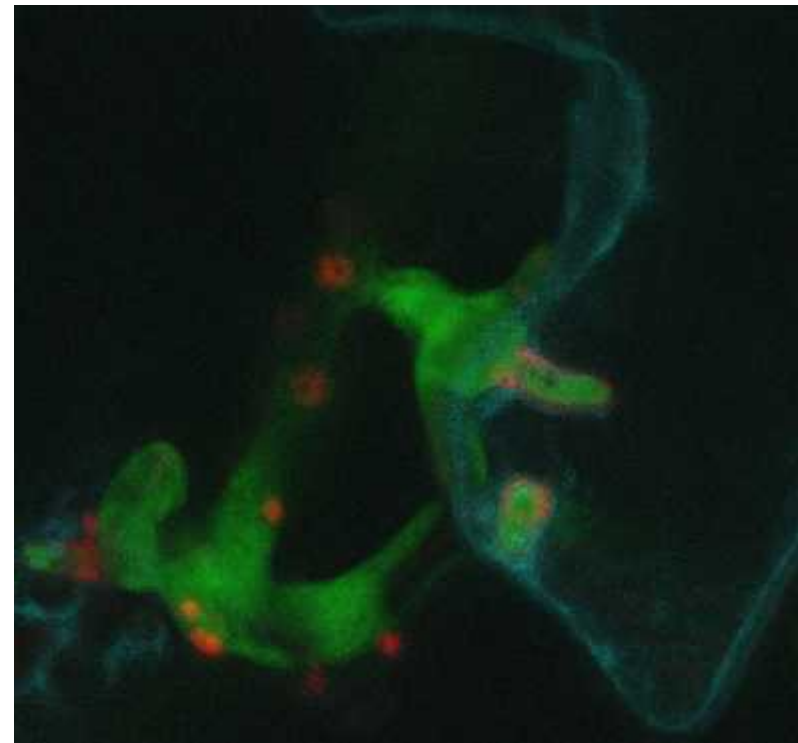
# Questions – the plant

- What R genes are present?
  - Which R genes defend against which effectors?
  - How is immunity controlled by the plant and the pathogen?
  - How do we stop effectors switching off immunity to stop disease?
  - How can we combine complementary resistances?
- Can we develop durable resistance to late blight with this knowledge?





# Identifying effector proteins

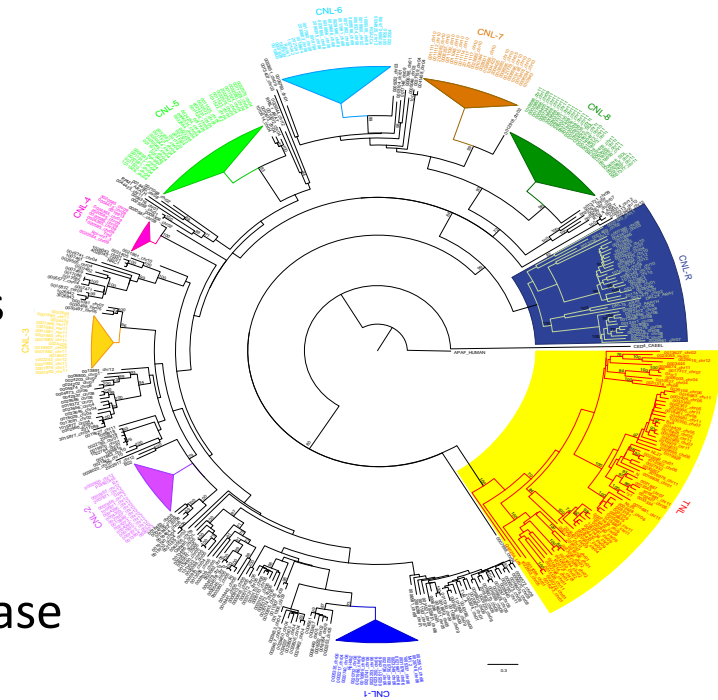




# RenSeq – R gene discovery



- Resistance gene enrichment Sequencing
- Potato genome is 800 million base pairs
- Genome has given us a blueprint of the R genes
- R genes are 0.25% of entire genome
- RenSeq - Preferentially sequence R genes
- Highly cost effective
- Applied to any crop where R genes control disease

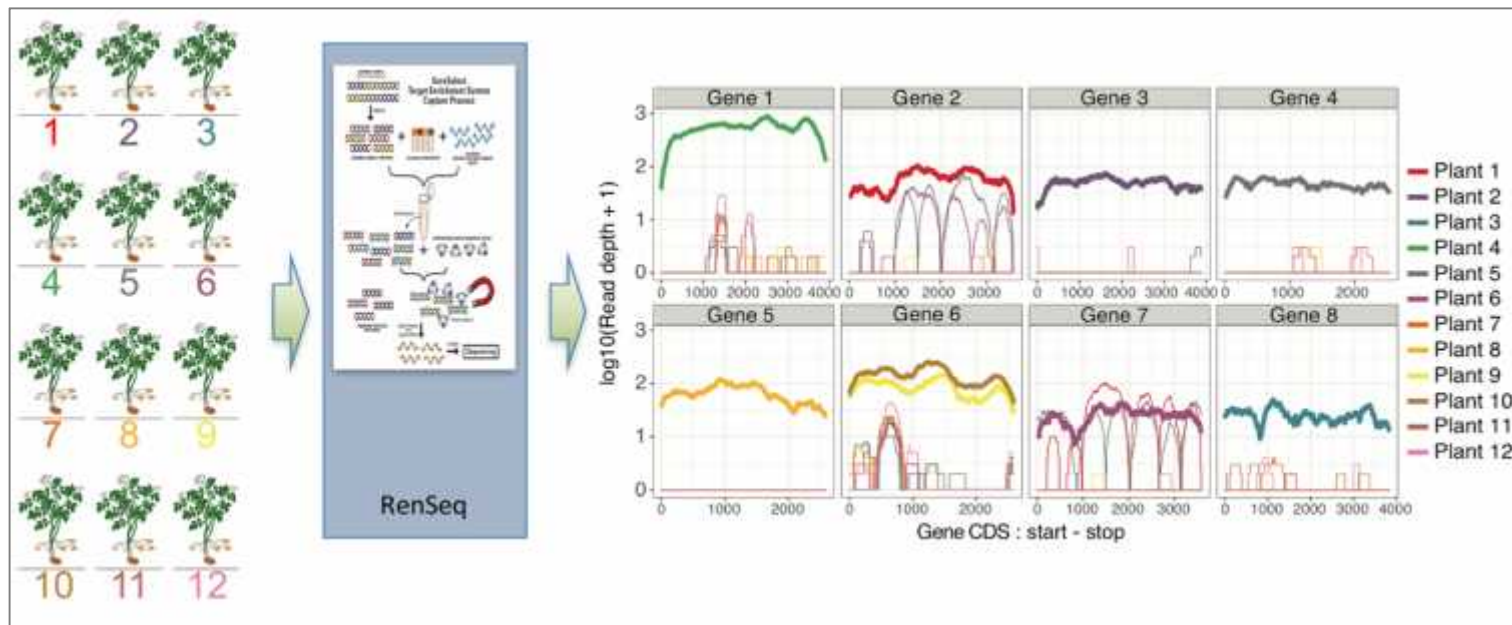




# RenSeq – R gene discovery



- Allowed ALL R genes in genome can be identified
- New R genes discovered (e.g. CPC) and mapped
- Used as a diagnostic tool it can help breeders to:
  - Determine which R genes are in parental material?
  - Following agronomic assessment, help with final cultivar development – best combination of R genes



# How is it helping stakeholders?



- **Now** informing JHL breeding programme
  - Assess R genes in existing material (including new R genes)
  - Efficiently combine these R genes into new breeding material
  - Screen for multiple resistances, e.g. PVY, late blight, PCN

Potato sequence (2011) → RenSeq → Genome-based breeding (2017)

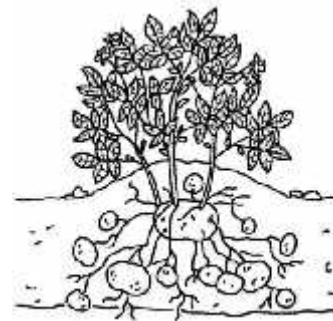
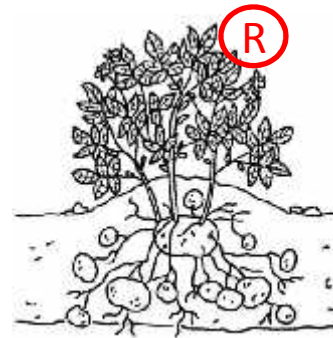
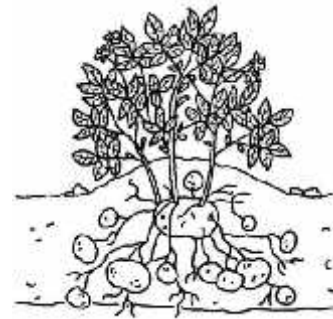
# Saving decades of breeding



New resistance identified



Wild potato species



Existing cultivars

Breeding and deployment

- Save years of breeding
- Avoid negative traits



# Global and historic R gene distribution



- R gene R3a is common in European cultivars but has been overcome by effector evolution
- R3a is not found in US cultivars but evidence suggests that it would be effective against their pathogen populations
- Historic breeding material screened to track R gene origins



# Barley – increasing yield for malting



- Two types of barley: two-rowed and six-rowed
- Six-rowed barley has better yield potential in some environments
- Two-rowed barley has better grain uniformity for malting
- Improved grain uniformity in 6-row barley would provide a higher yield for malting

Two-Rowed



Six-Rowed



# Barley – increasing yield for malting

- Gene (*vrs3*) for six-row has been identified
- Led to six-row barley with better grain uniformity
- Interest from commercial breeding companies – in trial

*Standard six-rowed*  
(*vrs1*, *Vrs5*)



+

*vrs3*



=

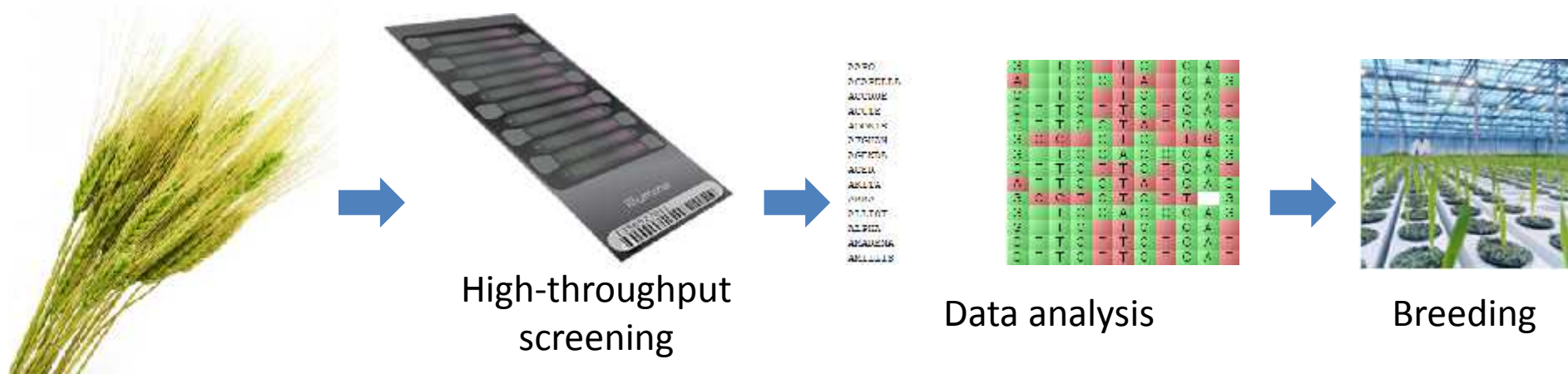
*Improved six-rowed*  
(*vrs1*, *Vrs5*, *vrs3*)



# A new genotyping platform for barley breeders



- Understanding genetic variation in barley allows many potential genetic markers to be developed and screened in a high-throughput assay (chip)
- A 50,000 marker chip developed for use by an international consortium of academics and all major European breeding companies
- Now used by breeders and researchers worldwide and puts Scotland at the forefront of international barley improvement





# Barley – reduced skinning for malting



- Grains of barley have an outer coat (husk)
- Detachment (skinning) of the husk reduces malting efficiency
- Aim is to control skinning through breeding, management and handling
- Undertake phenotypic and genetic analysis in collaboration with breeders



# Barley – reduced skinning for malting



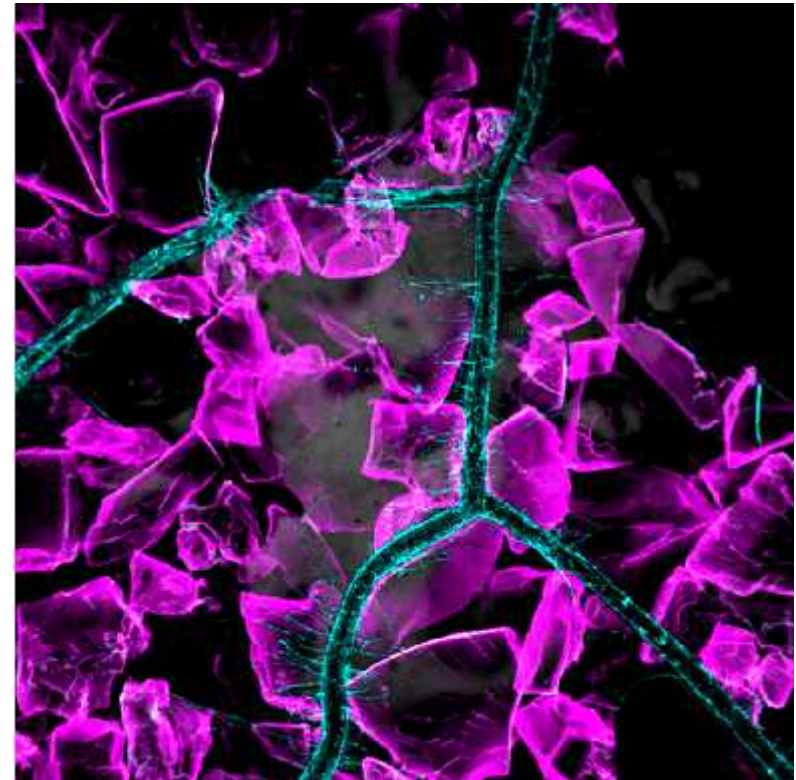
- Investigated genes responsible (lipid biosynthesis) and their regulation
- Identified markers for skinning
- Identified agronomic influences
- Developed new screening technique to distinguish resistance to skinning
- Revised protocols for scoring grain skinning
- Quantified variation in >200 varieties
- Recommended low/high risk varieties to breeders and maltsters



# Artificial soils for crop biotech

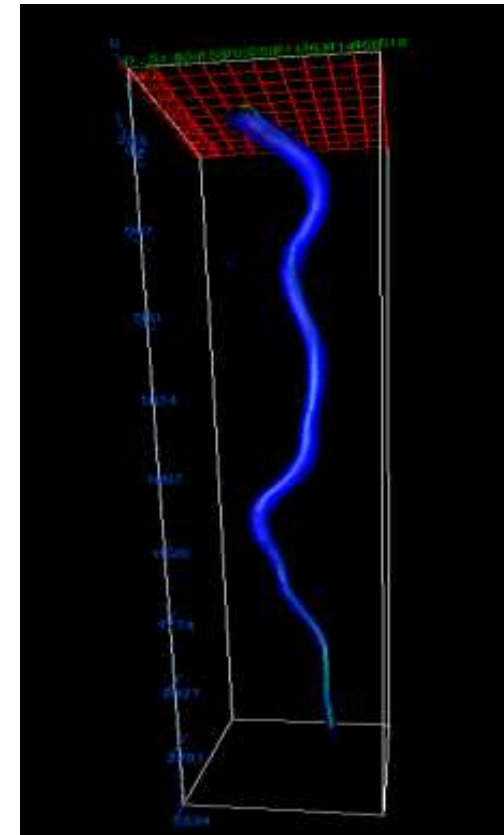
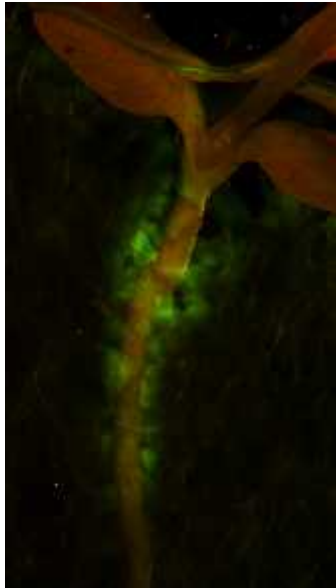


- Artificial matrix for in-depth soil analysis
  - Fertiliser compounds for delivery to roots
  - Efficiency of seed coating
  - Agents against pests and pathogens
  - Breeding more efficient crops
  - Assessment of chemical changes
- Currently an expensive product
- Use of recyclable materials
- Target biotech R&D sector



# Artificial soils for crop biotech

- Analysis of root architecture and movement, e.g. breeding
- Detection of pathogens and their response to chemicals





# Acknowledgements



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