Understanding raspberry using 'Omics' technologies

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Assisting the raspberry breeding process

- Breeding is a slow process (highly heterozygous, juvenile)
- Difficult to achieve a lot of objectives
- Personal preferences
- Environment/weather
- Reduced actives
- New challenges

Moving targets

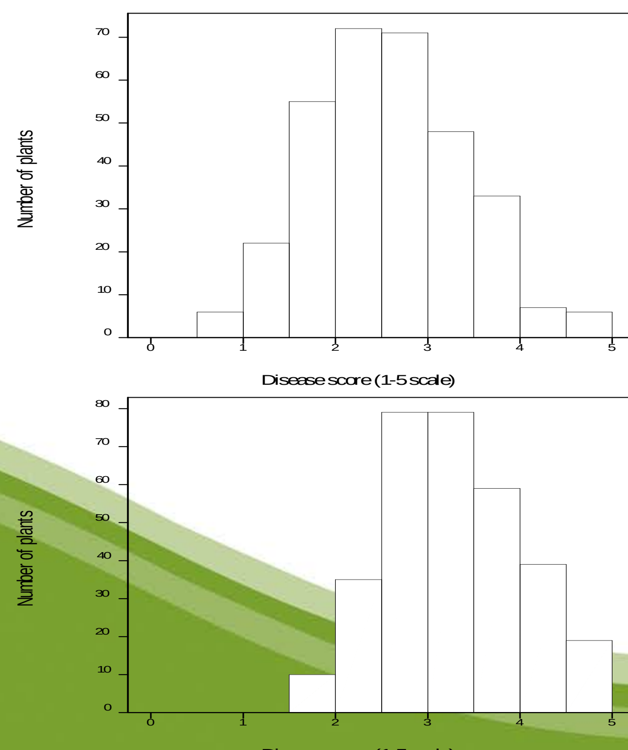
Progress with marker assisted breeding eg. root rot

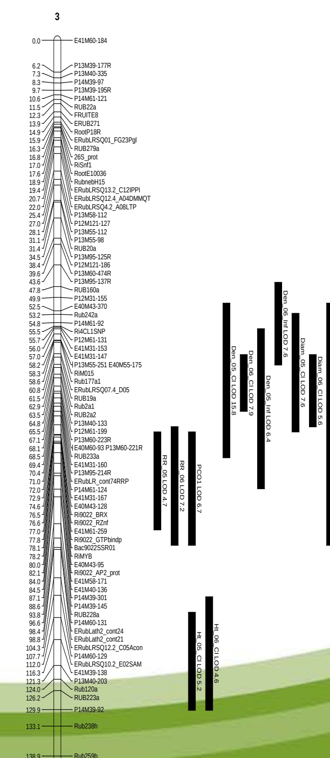
Some progress understanding phenotype –
Mapping raspberry root rot resistance/tolerance

- Linkage map development
- QTL Mapping LG3&6
- Identified marker
- Validation in germplasm
- Marker deployment
- Rub118b for breeding

Resistant susceptible

Graham et al., 2011 TAG



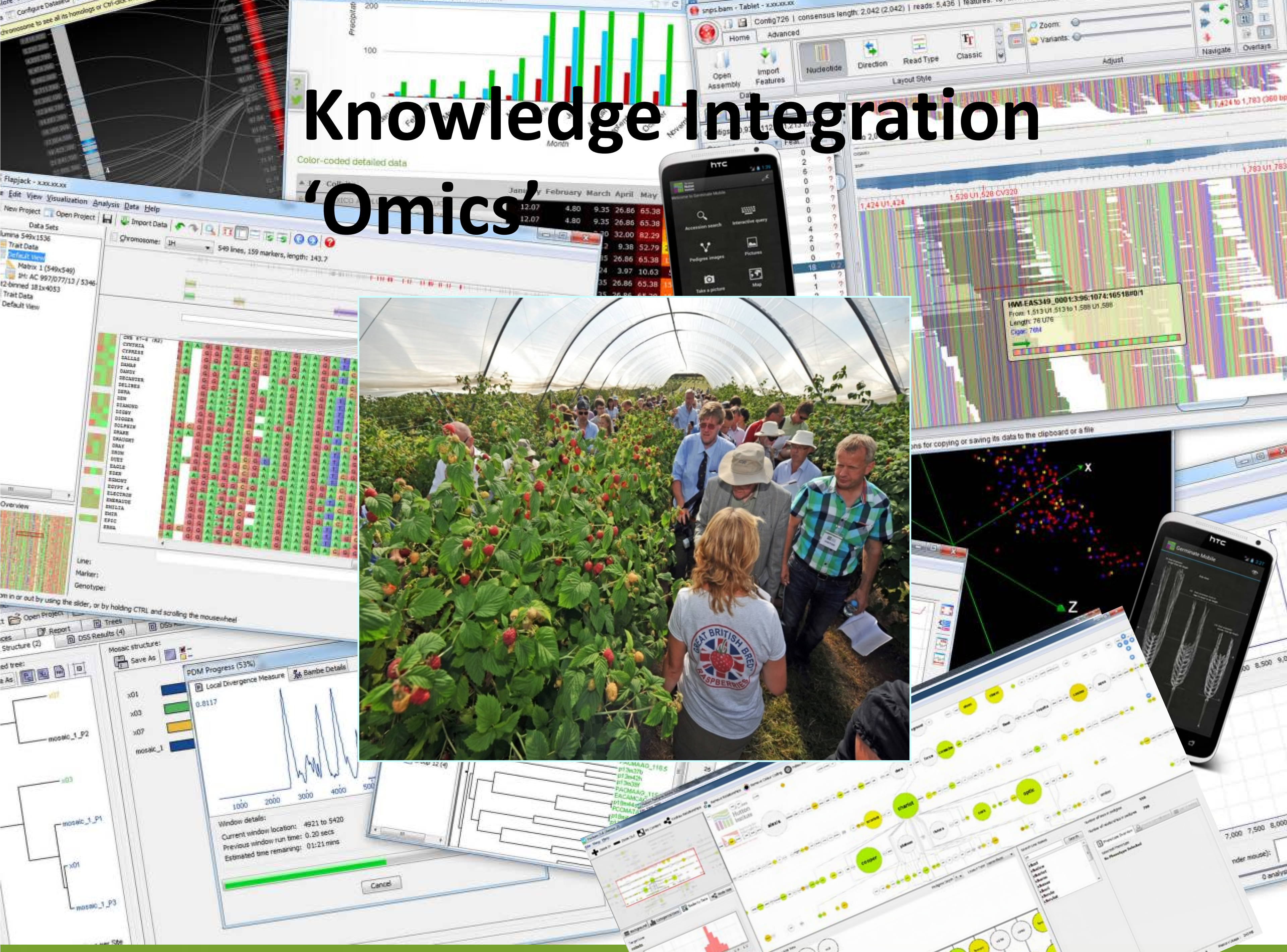


Deployment of markers for resistance to *Phytophthora* root rot

- Markers identified in 2008 (Hortlink 0169)
- Parents with root rot resistance marker identified for crossing in 2009 (25 families)
- Currently >40 selections identified with the marker
- 10 selections fruiting in 5-plant plots in 2013
  - Exceptional root vigour, Two selections with good fruit size, quality and yield
  - Resistance holding in infestation plot

- Better understanding of phenotype

Knowledge Integration
'Omics'



Development, integration and use of "omics" technologies in raspberry breeding

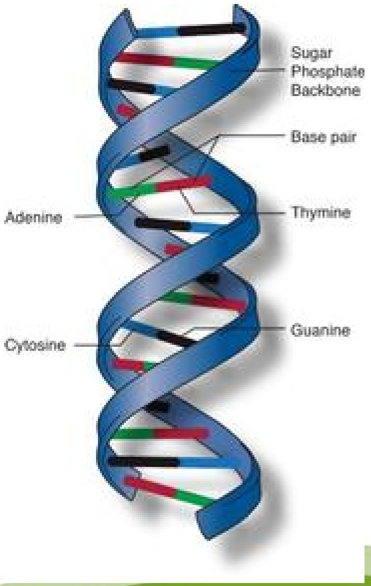
- Genomics
  - Genome assembly and annotation – DNA sequence - information
- Transcriptomics
  - Genes: mRNA transcriptome, alternative splicing, miRNA transcriptome - active part
- Metabolomics
  - Compounds: sugars, acids, volatiles etc – flavour, colour etc
- Phenomics

Response of plant traits to environment/stresses and use of high throughput imaging systems – physical plant traits

Genomics

- **Genomics** - sequencing and analysis of the **genome**.

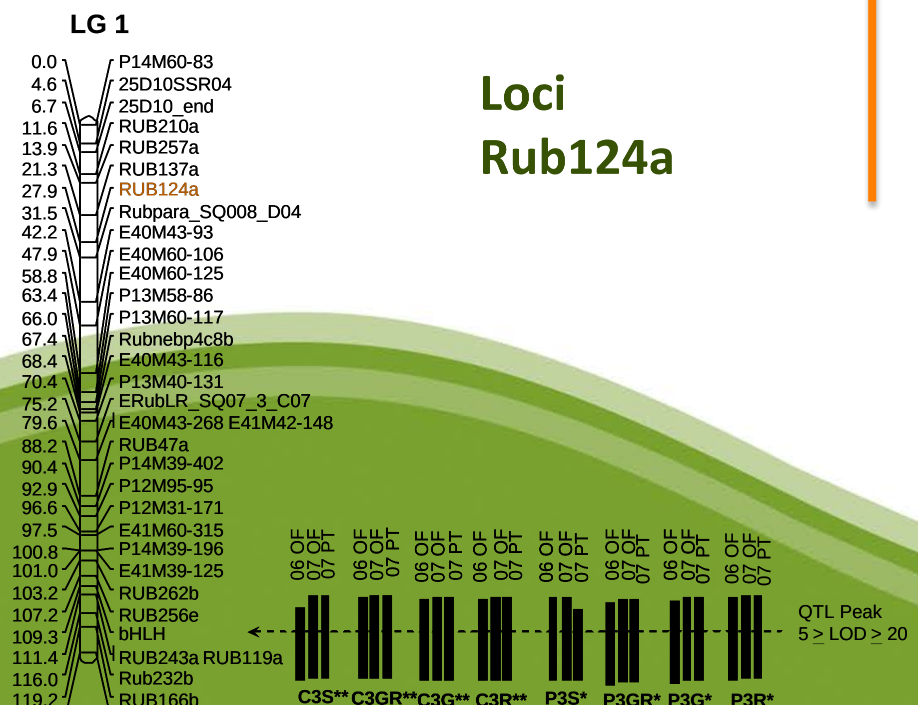
Actual DNA sequence



Raspberry Glen Moy genome sequence

- Allows us to make a physical map of the actual sequence and link to the genetic map and to search regions of genetic map for genes related to traits

Genetic map

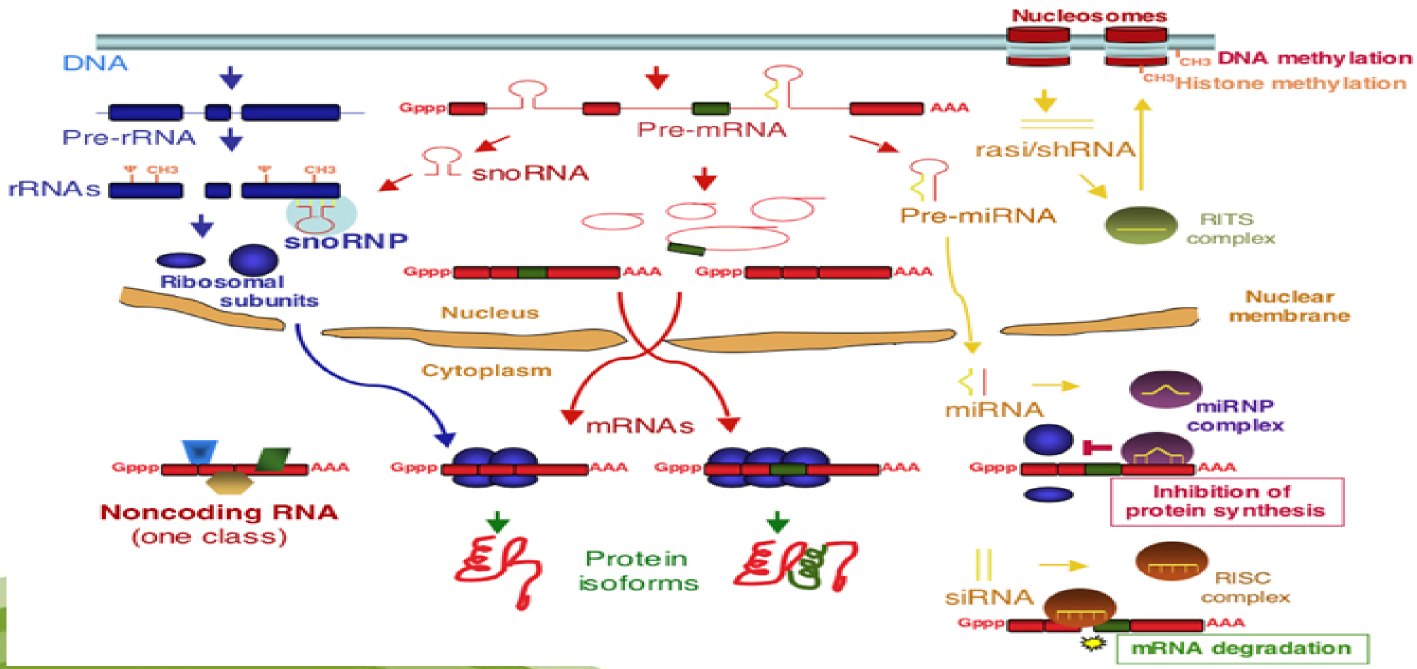


Loci
Rub124a

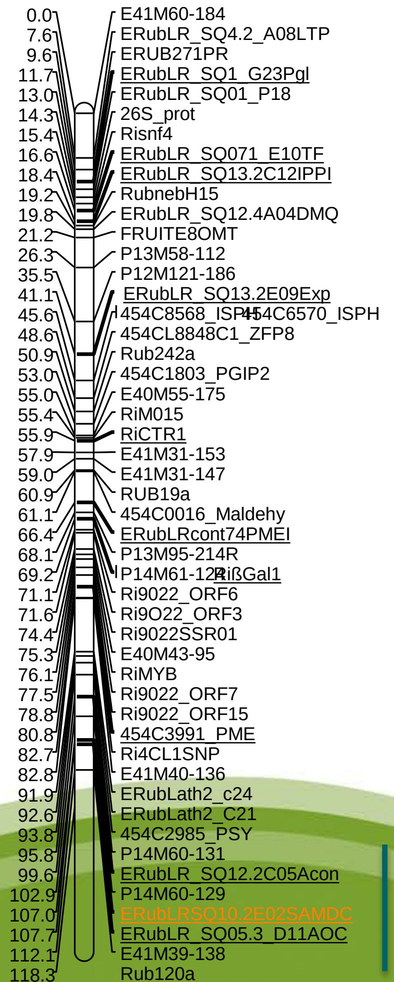
Physical map

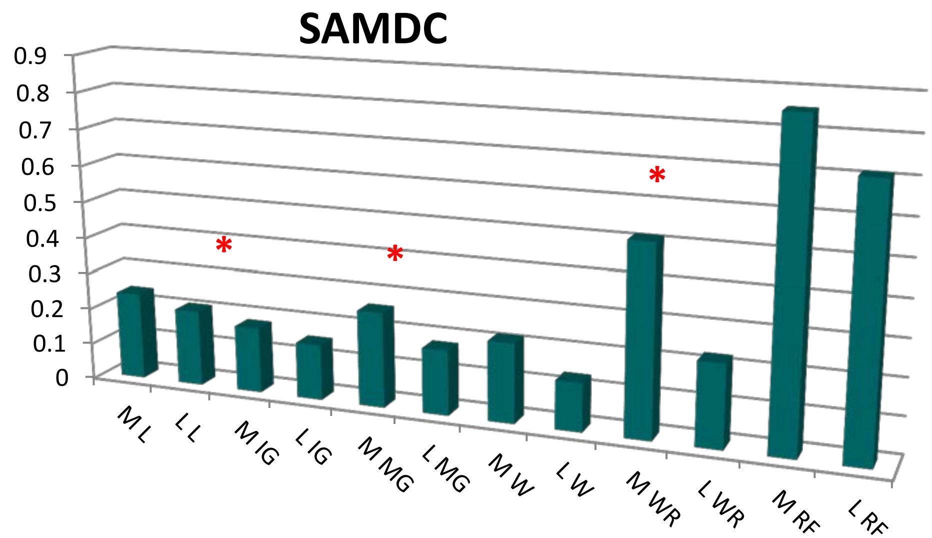
Transcriptomics

- Transcriptomics —RNA transcripts that are produced by the genome, under specific circumstances or in a specific cell



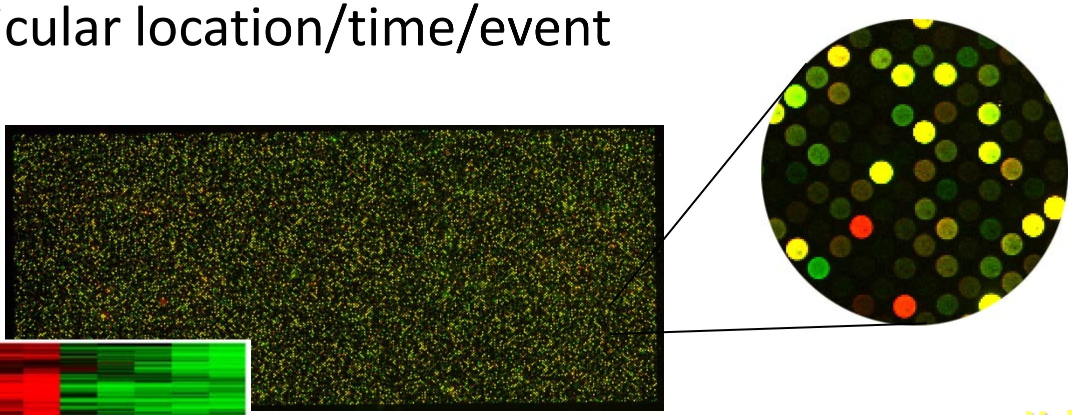
Gene expression and shelf life/softening

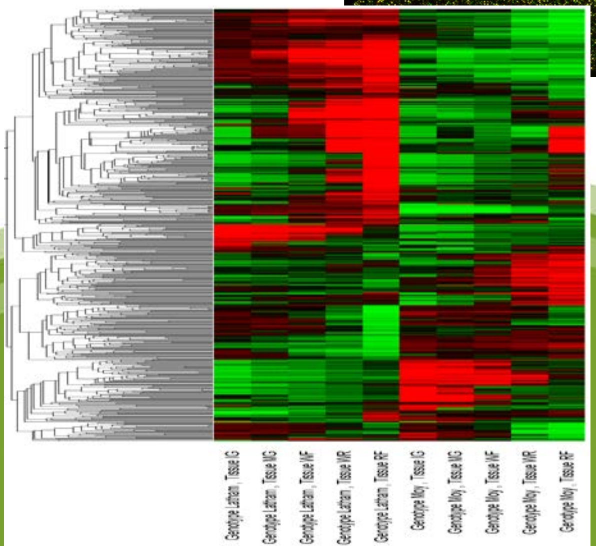




Gene expression - microarray

- 60, 000 genes available on a microarray for gene expression studies
- Allows us to determine which genes are switched on at a particular location/time/event





Yellow: active in A

Green: active in B

Orange: active in both

Fruit development

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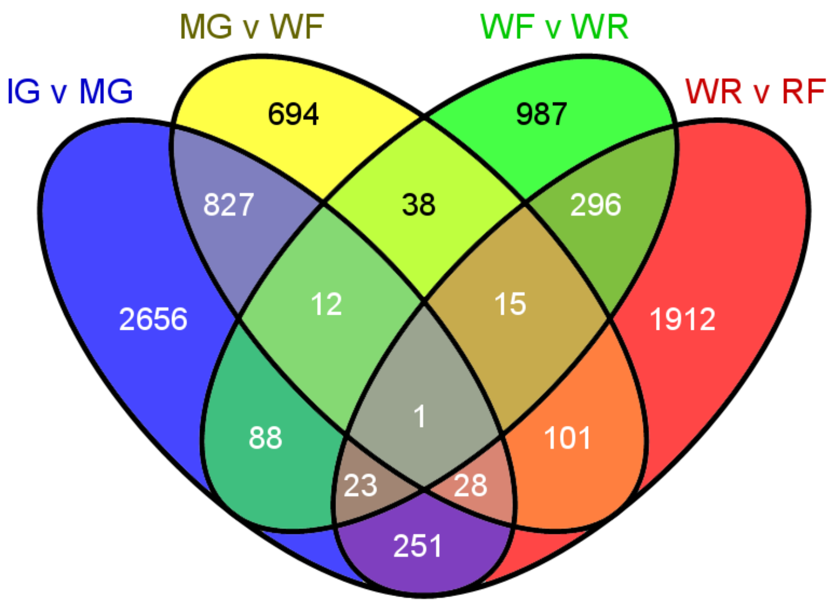
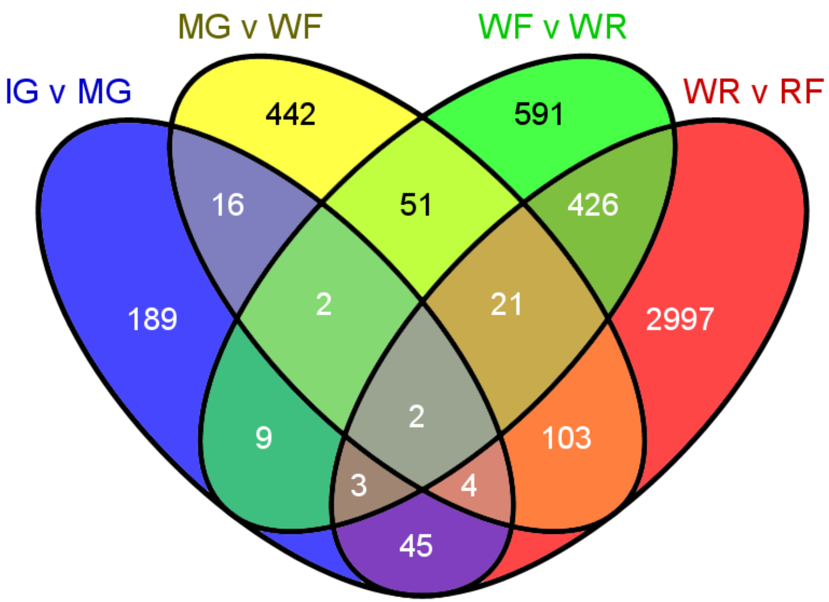


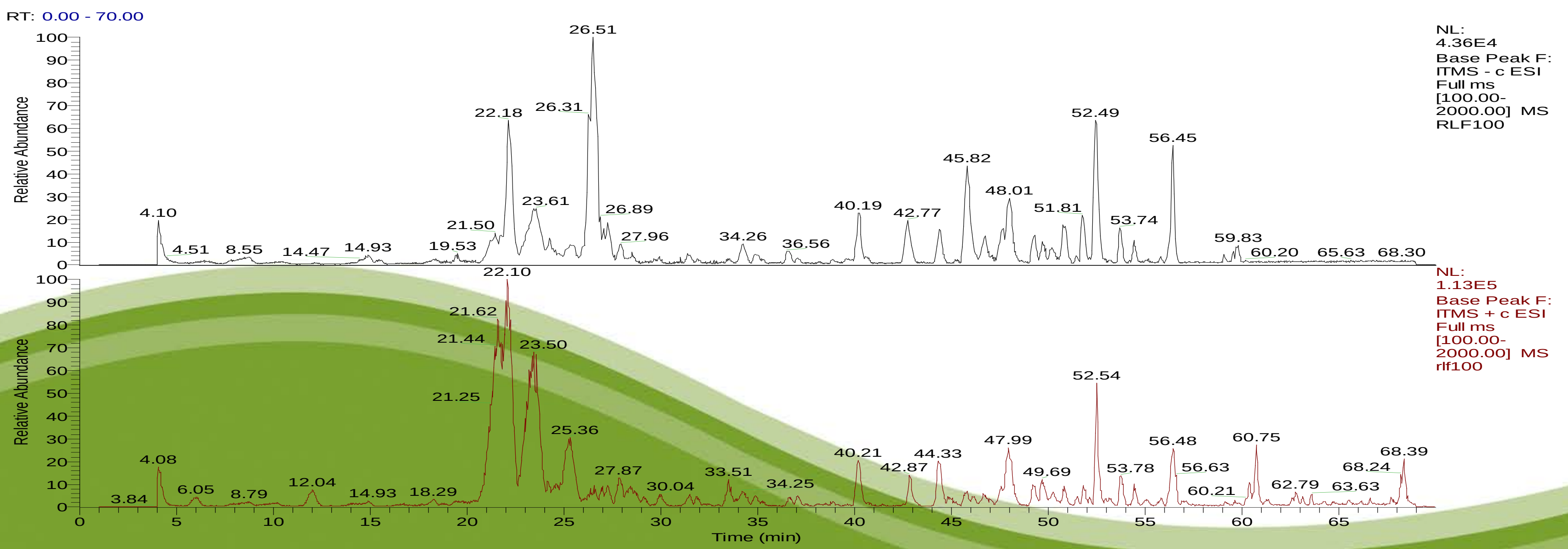
Glen Moy



Latham

Metabolomics

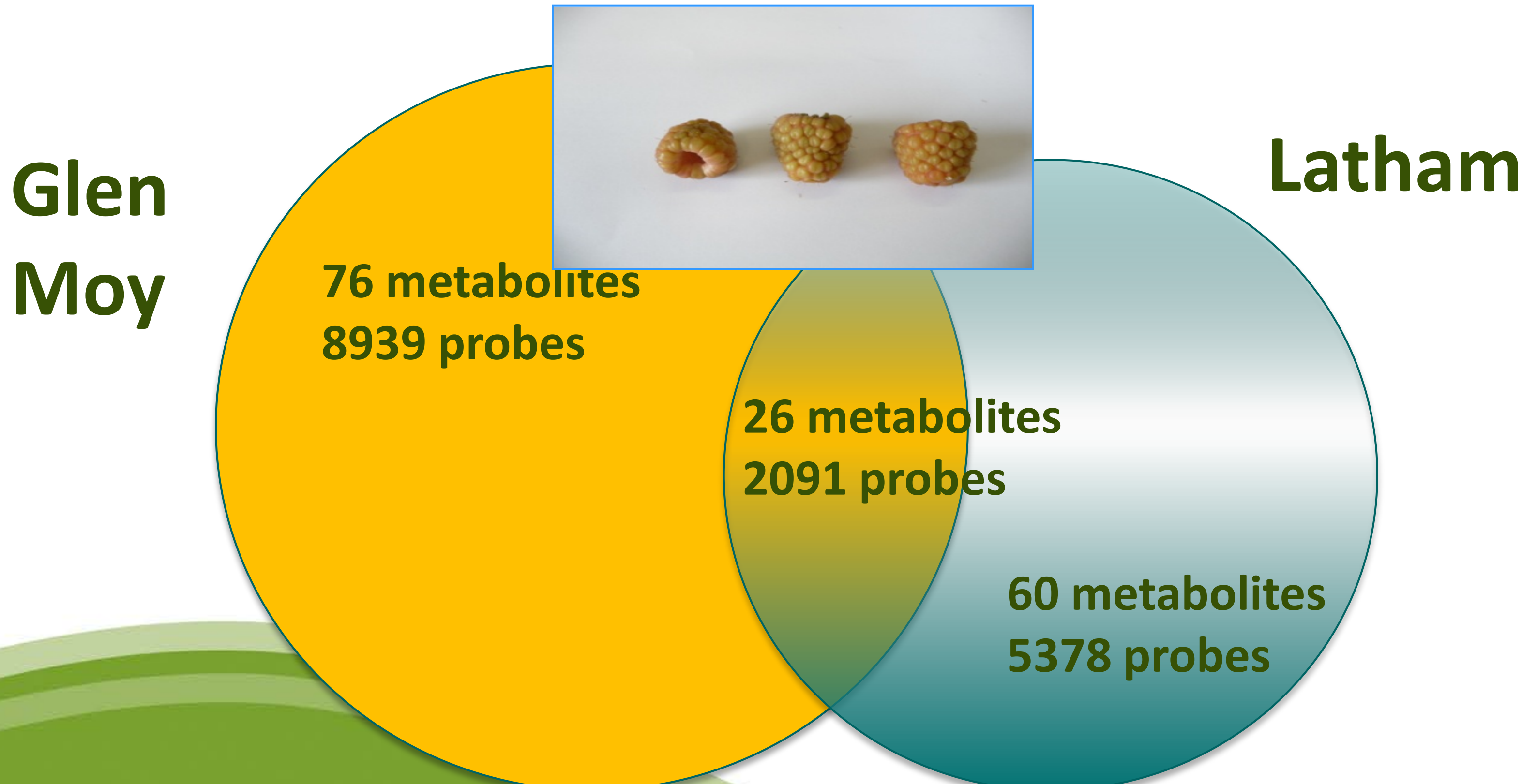
- Metabolites in a biological cell, tissue, organ or organism, which are the end products of cellular processes.
- Metabolic profiling can give an instantaneous snapshot of the physiology of that cell.



Composition

Season	Field 2006		Field 2007		Polytunnel 2007	
Sample	Progeny		Progeny		Progeny	
Volatile	Mean± SEM	Min-Max	Mean ± SEM	Min-Max	Mean ± SEM	Min-Max
b-damascenone	72.29 ± 4.02	0 – 463.8	87.10 ± 6.82	0 – 872.10	64.88 ± 4.71	3.17 - 368.8
b-ionone	13.65 ± 0.53*	0.46 – 47.88	9.83 ± 0.44	0.61 – 44.33	6.43 ± 0.36*	0.25 - 33.02
a-ionone	7.31 ± 0.19*	1.65 – 17.16	3.86 ± 0.14	0.79 – 13.82	5.16 ± 0.24*	0.22 - 21.61
a-ionol	2.24 ± 0.09*	0.16 – 7.28	1.83 ± 0.09	0.24 – 11.68	5.96 ± 0.30*	0.16 - 29.97
Linalool	4.72 ± 0.32*	0.67 – 22.26	2.90 ± 0.17	0.33 – 14.52	4.39 ± 0.20*	0.90 - 29.28
Geraniol	2.64 ± 0.08*	0.68 – 8.87	1.82 ± 0.07	0.44 – 10.74	3.68 ± 0.14*	0.11 - 15.46
(Z)-3-hexenol	22.35 ± 0.34*	0.71 – 28.15	9.06 ± 0.29	0.63 – 28.18	16.70 ± 0.67*	0.07 - 54.03
Acetic acid	1.39 ± 0.06*	0.06 – 8.26	0.64 ± 0.05	0.01 – 4.05	0.72 ± 0.03	0.01 - 3.54
Hexanoic acid	6.54 ± 0.35*	0.89 – 41.68	7.97 ± 0.30	1.71 – 22.88	7.04 ± 0.34	0.28 - 30.84
Acetoin	1.02 ± 0.05	0.09 – 4.74	1.03 ± 0.04	0.10 – 4.79	0.80 ± 0.05*	0.02 – 4.95
Benzyl alcohol	0.59 ± 0.03*	0.15 – 2.18	1.07 ± 0.04	0.09 – 3.16	2.67 ± 0.11*	0 - 9.94

Metabolites & gene expression –ve correlations at 1 stage of fruit development



Phenomics

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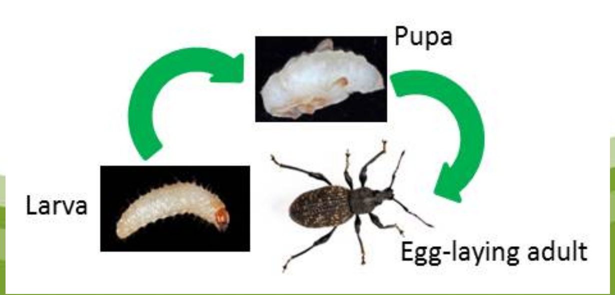
- Plant physical and biochemical traits as they change in response to genetic mutation and/or environmental influences
- Need a way to identify changes induced by stresses – imaging technologies

Vine weevil damage to raspberry

Vine weevil (*Otiorhynchus sulcatus*) is an intractable pest

- Difficult to detect (root-feeding larvae)
- Difficult to treat
- Leads to yield loss
- Economically-damaging



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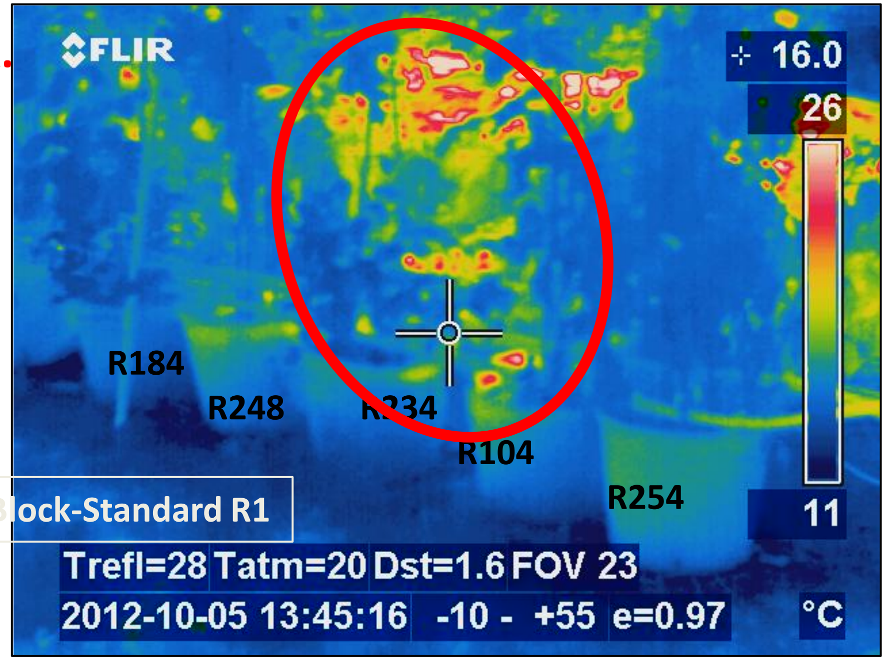
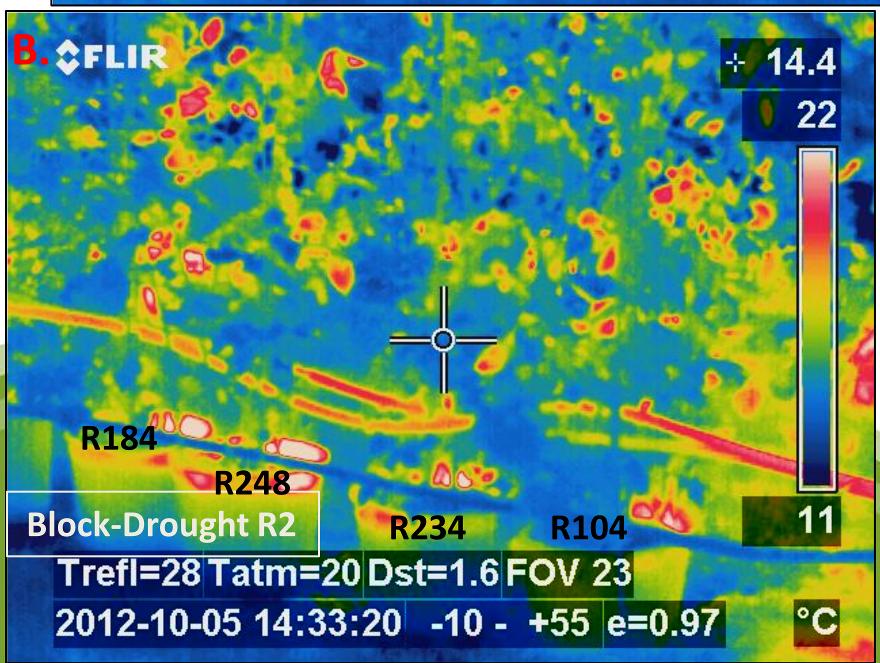
Water stress

A.





- Infrared thermography detects notable differences to water stress in raspberry plants

- R234 has greater water requirement than R254

Using imaging technology to identify water stress +/- pest and disease pressures – data points

Integration of knowledge

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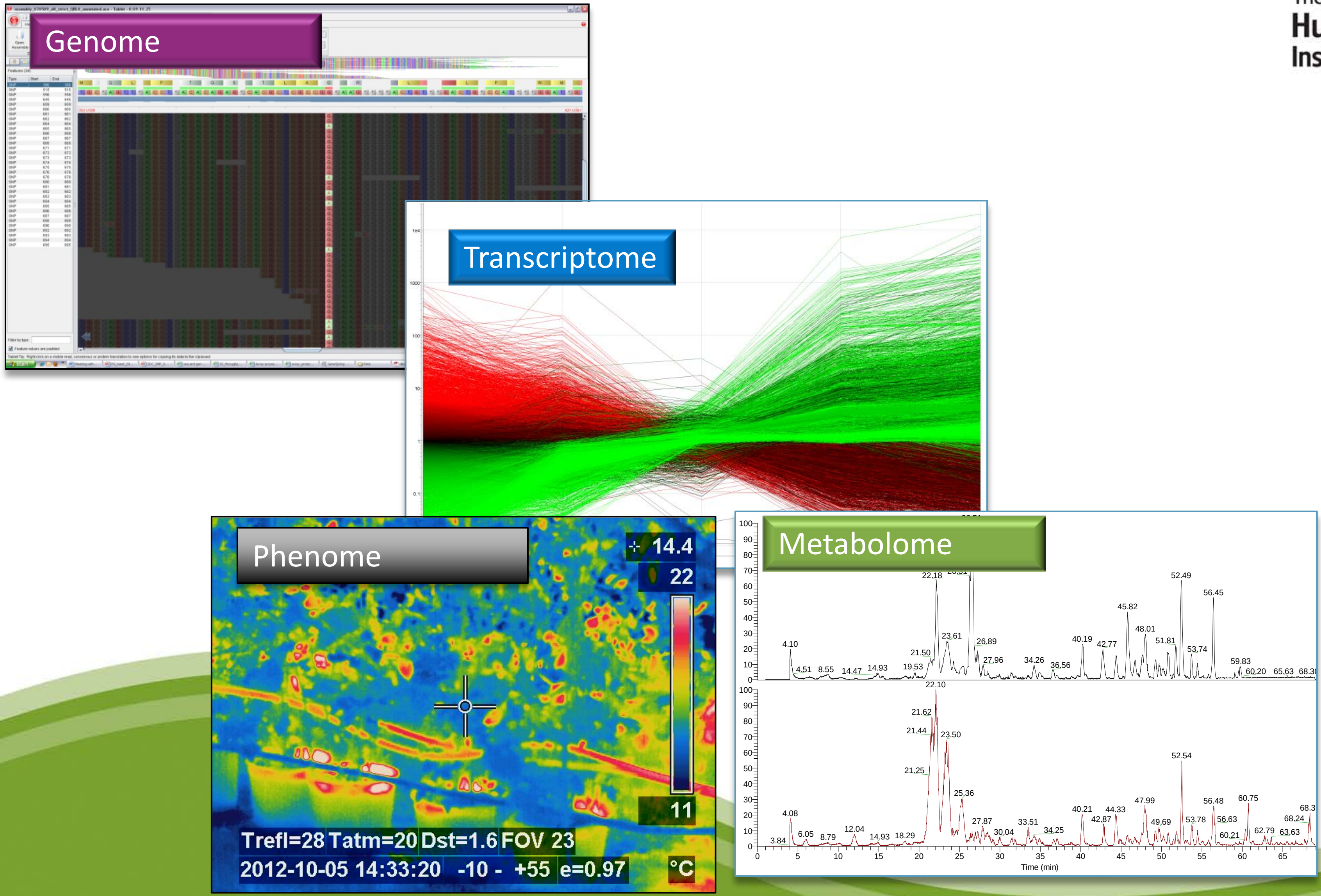
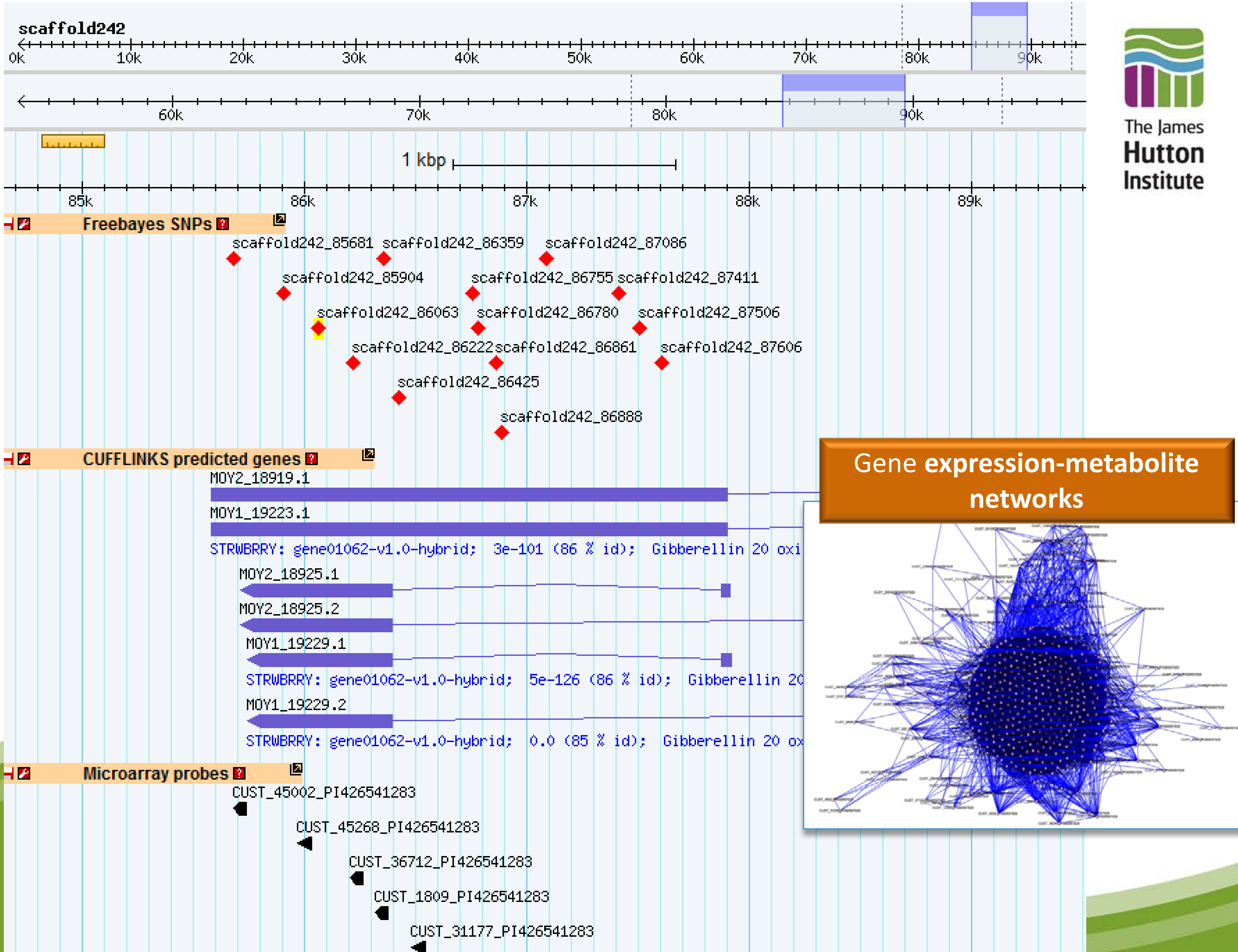


Gene **expression-metabolite networks**



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Knowledge and tools for breeding

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Kay Smith
Susan McCallum
Chris Hackett
Rob Hancock
Ankush Prashar
Ali Karley
Craig Simpson
Linda Milne
Pete Hedley
Runxuan Zhang
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Dominic Williams
Avril Britten
Carolyn Mitchell

Innovate UK
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