

# Bio-Imaging for the International Mouse Phenotyping Consortium

5 June 2014

9<sup>th</sup> OME User's Meeting - Paris

Gautier Koscielny

MPI2 Consortium

EMBL-EBI

[www.mousephenotype.org](http://www.mousephenotype.org)



# Outline

- Goals of IMPC
- Informatics for the IMPC
- Preliminary results
- 2D Imaging modalities (2 use cases)
- Work in progress: 3D Imaging modalities (2 use cases)
- Dissemination on the IMPC portal
- Future directions



# IMPC

International Mouse Phenotyping Consortium



[www.mousephenotype.org](http://www.mousephenotype.org)

From Steve Brown, MRC Harwell

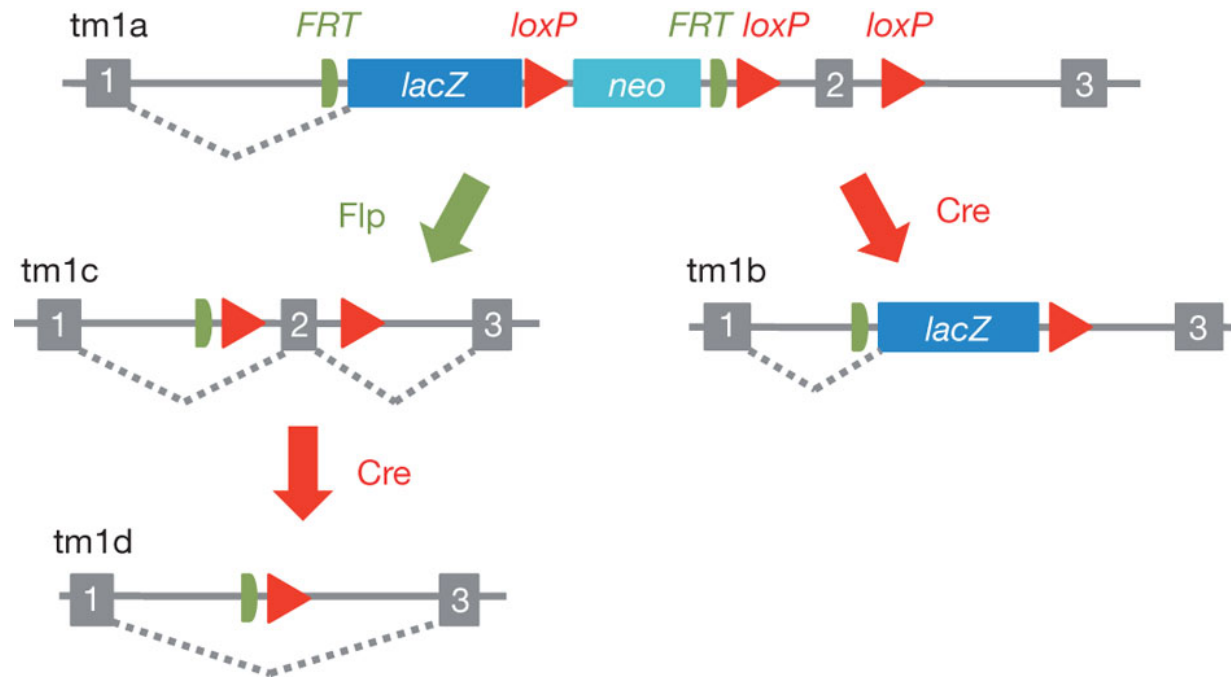
# IMPC Goals

- Encyclopedia of mammalian gene function
- Create and phenotype over 20,000 mutant mouse lines
- Build collaborative "networks" for more focused phenotyping efforts
- Industry outreach
- Provide a centralized data center and portal for free, unrestricted access to primary and secondary data



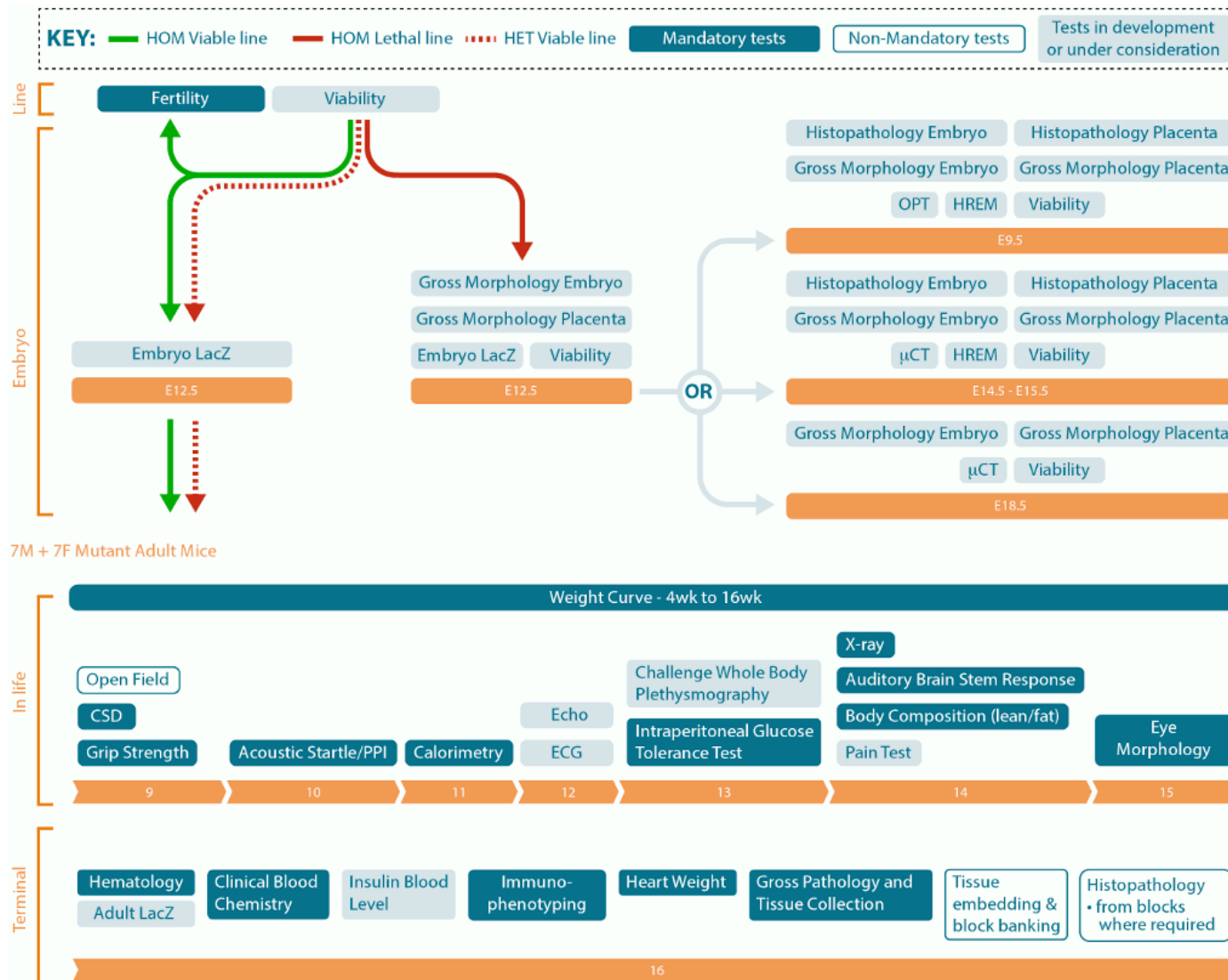
# Alleles most frequently used in IMPC

Schematic of the 'knockout-first' conditional allele.



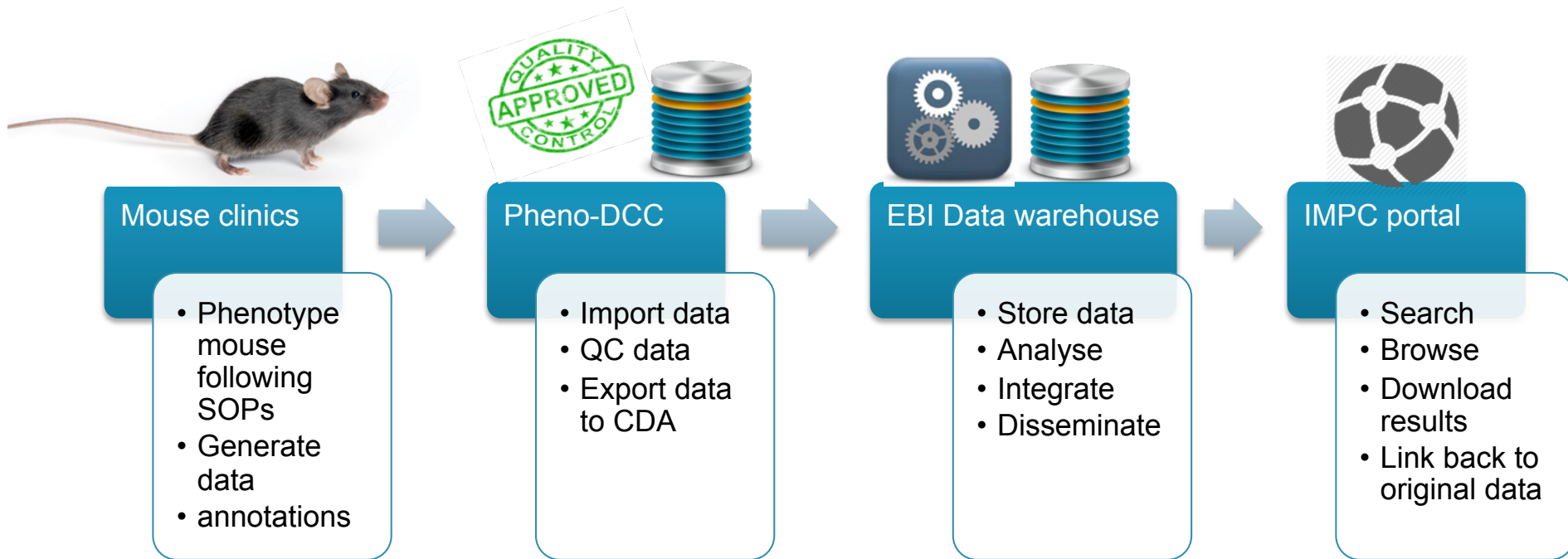
WC Skarnes *et al. Nature* **474**, 337-342 (2011) doi:10.1038/nature10163

# IMPC Core Phenotype Pipeline





# High Throughput Phenotyping Workflow

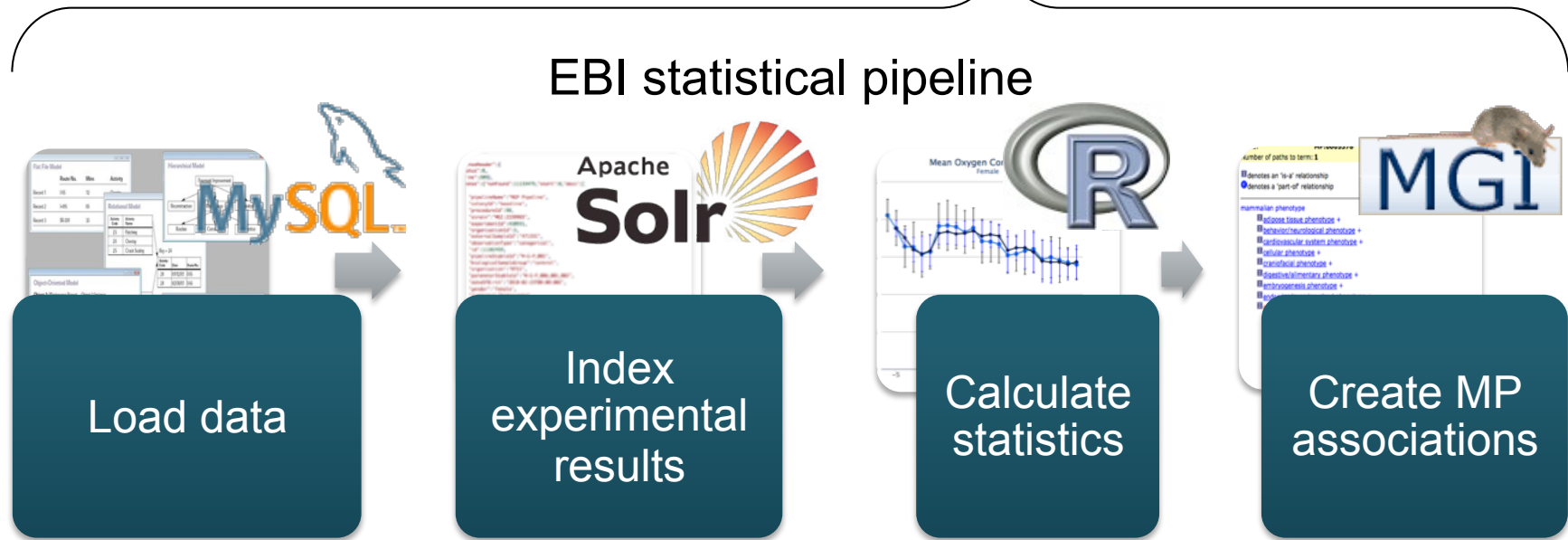
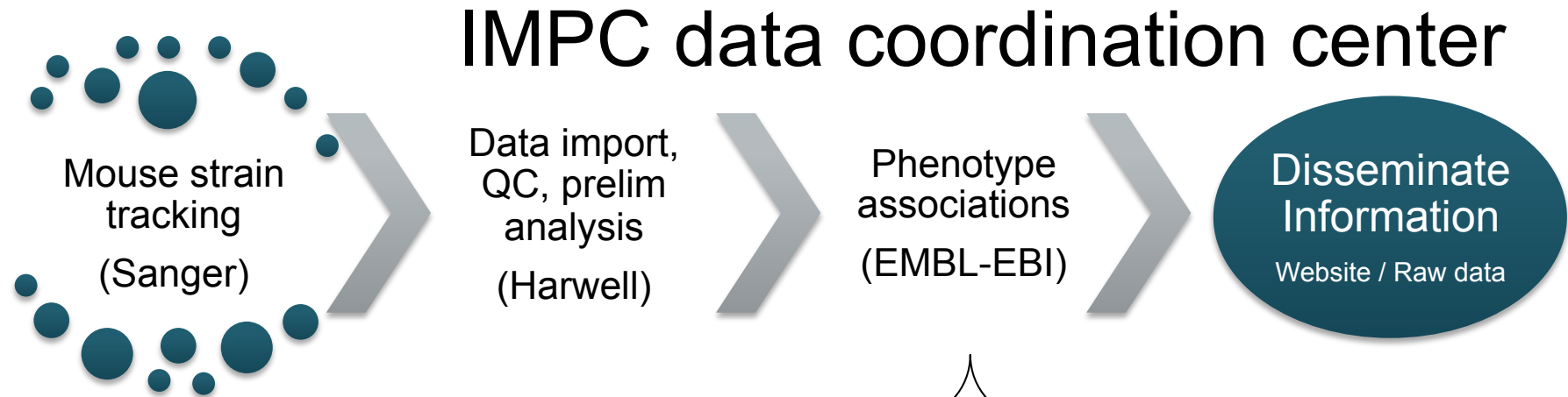




# Statistical Analysis Overview

- Goal: Associate Genotype to Phenotype via stats
- Statistical analysis depends on the experimental workflow
- Built statistical analysis platform on expected workflows
  - Fisher Exact Test
  - Linear regression- Mixed Model
- Improving analysis is active area of research
- Adjust to workflow at IMPC centers
- Versioning of statistical analysis
- Involvement of IMPC members

# High Throughput Phenotyping Workflow



# Procedure to Phenotypes

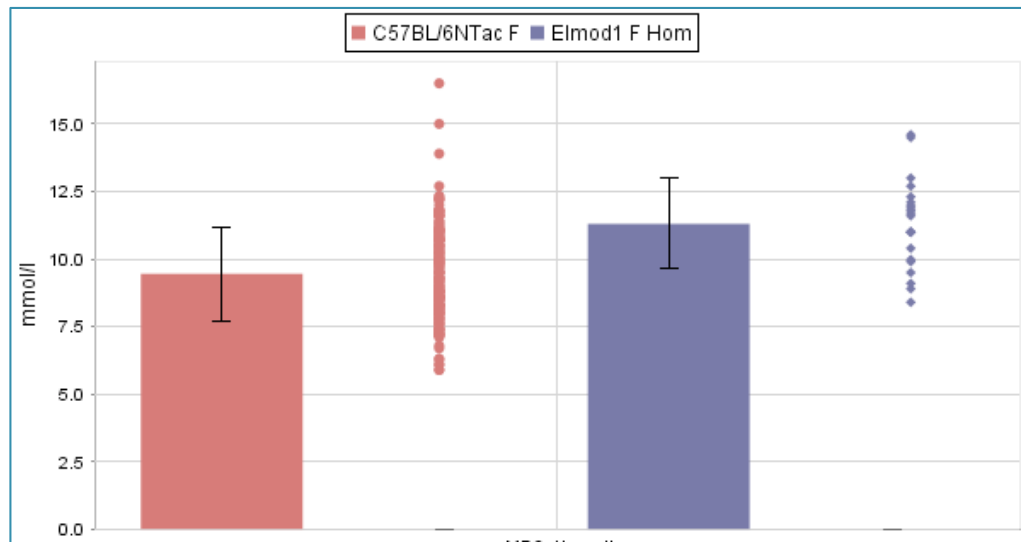
## Clinical Blood Chemistry Procedure

	Version	Type	Req. Upload	Req. Analysis	Annotation	Option	Unit	Data Type
Sodium	1	simpleParameter	x	x	x		mmol/L	FLOAT
Potassium	1	simpleParameter	x	x	x		mmol/L	FLOAT
Chloride	1	simpleParameter	x	x	x		mmol/L	FLOAT
Urea	1	simpleParameter	x	x	x		mmol/L	FLOAT



## Blood Urea Parameter

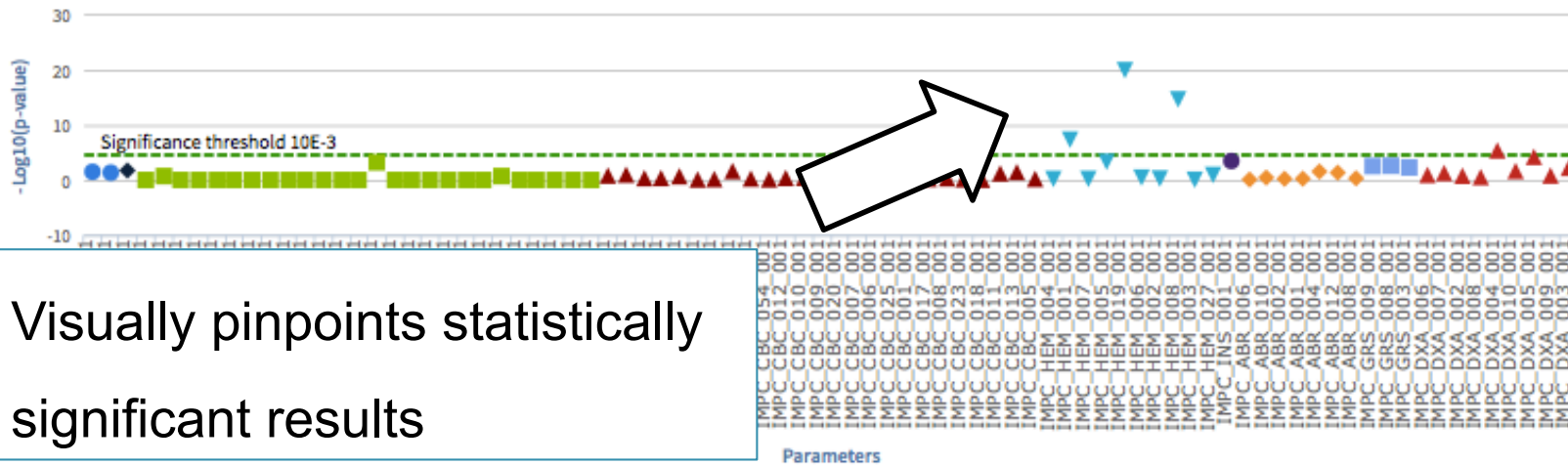
Parameter	Observation	Relative Value	MP Term	MP ID
Urea	mMol concentrations	<b>ABNORMAL</b>	abnormal blood urea nitrogen level	MP:0005265
Urea	mMol concentrations	<b>INCREASED</b>	increased blood urea nitrogen level	MP:0005565
Urea	mMol concentrations	<b>DECREASED</b>	decreased blood urea nitrogen level	MP:0005566



**MP:0005565**

**increased blood urea nitrogen level**

# Statistical Analysis Overview



Visually pinpoints statistically significant results

- Heart Weight    ◆ Intraperitoneal glucose tolerance test (IPGTT)    ■ Eye Morphology
- ◆ Auditory Brain Stem Response    ■ Grip Strength    ▲ Body Composition (DEXA)
- ▲ Clinical Blood Chemistry    ▼ Hematology    ● Insulin Blood Level

Total number of results: 94

Procedure	Parameter	Data type	Zygoty	P-value	Status	Graph
Hematology	Mean platelet volume	unidimensional	homozygote	0.0	Success	
Hematology	Platelet count	unidimensional	homozygote	2.10942E-15	Success	
Hematology	White blood cell count	unidimensional	homozygote	4.71196E-8	Success	
Body Composition (DEXA lean/fat)	Bone Mineral Density (excluding skull)	unidimensional	homozygote	4.17771E-6	Success	
Body Composition (DEXA lean/fat)	Bone Mineral Content (excluding skull)	unidimensional	homozygote	6.11604E-5	Success	
Insulin Blood Level	Insulin	unidimensional	homozygote	3.48163E-4	Success	



# Data Available on the IMPC Portal (June 2014)

- Preliminary results from statistical analysis available for **846** submitted knockout strains (QC in progress)
- **293** knockout strains QC'ed with complete data:
  - > **12M** data points measuring parameters from standardised operating procedures defined in IMPReSS
  - Normal fertility and viability
- > **98,000** images from the Wellcome Trust Mouse Genetics Program
- Number of line submitted will grow over time

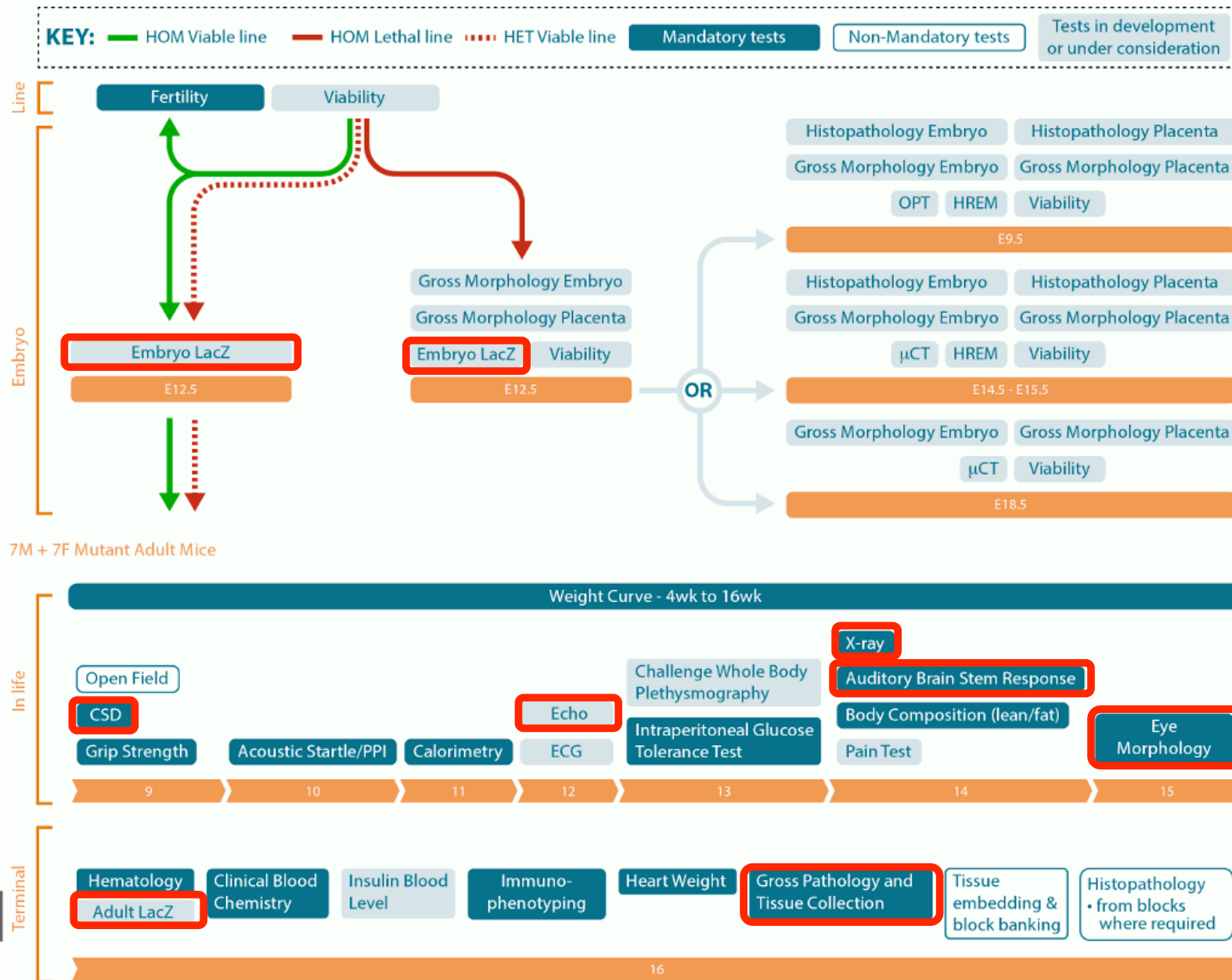
# IMPC and Imaging

- Understanding of in vivo gene function
- Identify novel genes
- Provide models of human disease
- Identification and highlight of unique anatomical structures expressing a targeted gene
- Detection and quantification of morphological and histological phenotypes (e.g. skeletal abnormalities)
- 30% of mutant strains are embryonic lethal, subviable
- Multiple modalities: HREM, OPT, micro-CT
- Images are linked to MP and MA ontology terms

# Use Cases

- Highlight morphological phenotypes in adult and embryo
- Visualise gene expression patterns (LacZ)
- Adult procedures (X-Ray, eye morphology, LacZ)
- Embryonic lethal mice: 3D imaging (HREM, OPT, micro-CT)
- Show images related to KO genes
- Retrieve images related to publication
- Compare mutants to baseline (wild-type images, Atlases)

# Current pipeline schematic: 2D images





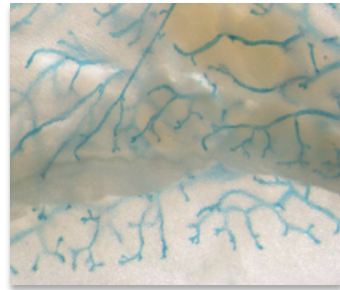
# Developing Use Cases for 2D images

- **Wellcome Trust Sanger Institute Mouse Genetics Program**
- Rich resource of high-throughput phenotype images
- Test imaging import infrastructure
- Test representation of the information on the web
- **> 98,000** images to date (June 2014)
- Mouse anatomy and Mammalian phenotype ontology annotations
- Control mouse images available

# Mouse Genetics Program Imaging



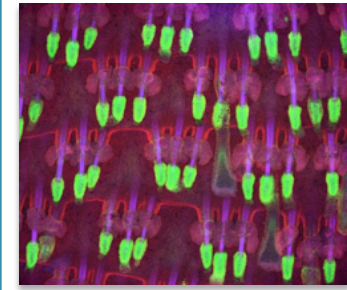
High-Throughput  
X-ray phenotyping



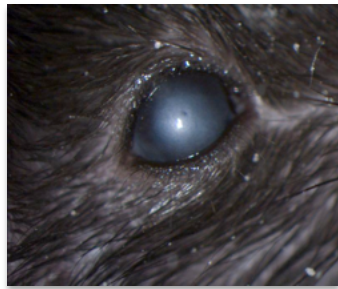
Wholemount  
expression



Histology slide



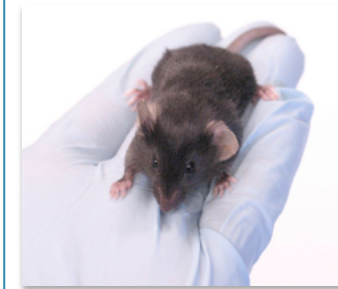
Tail epidermis  
wholemount



Eye morphology

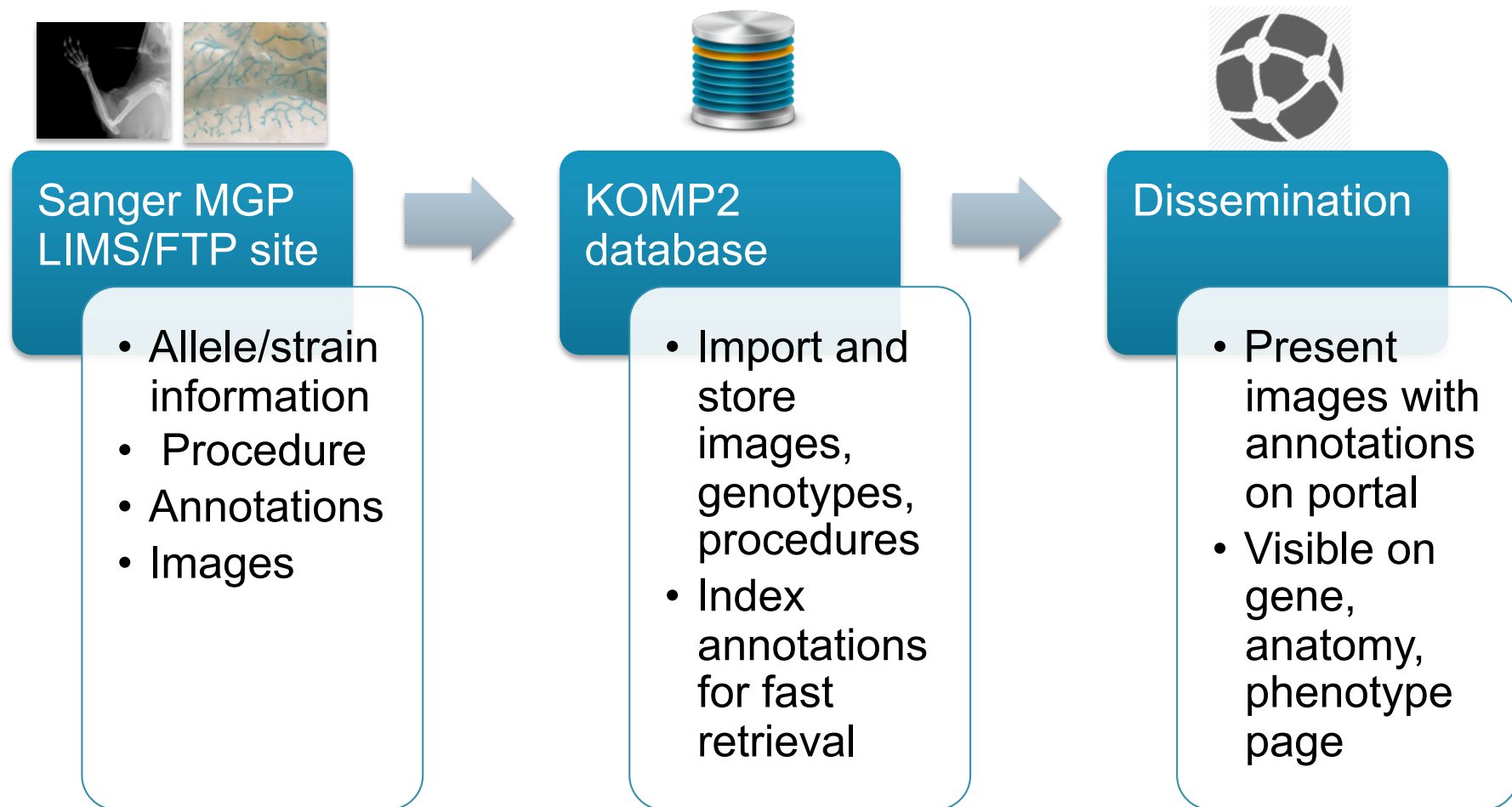


Embryo  
morphology



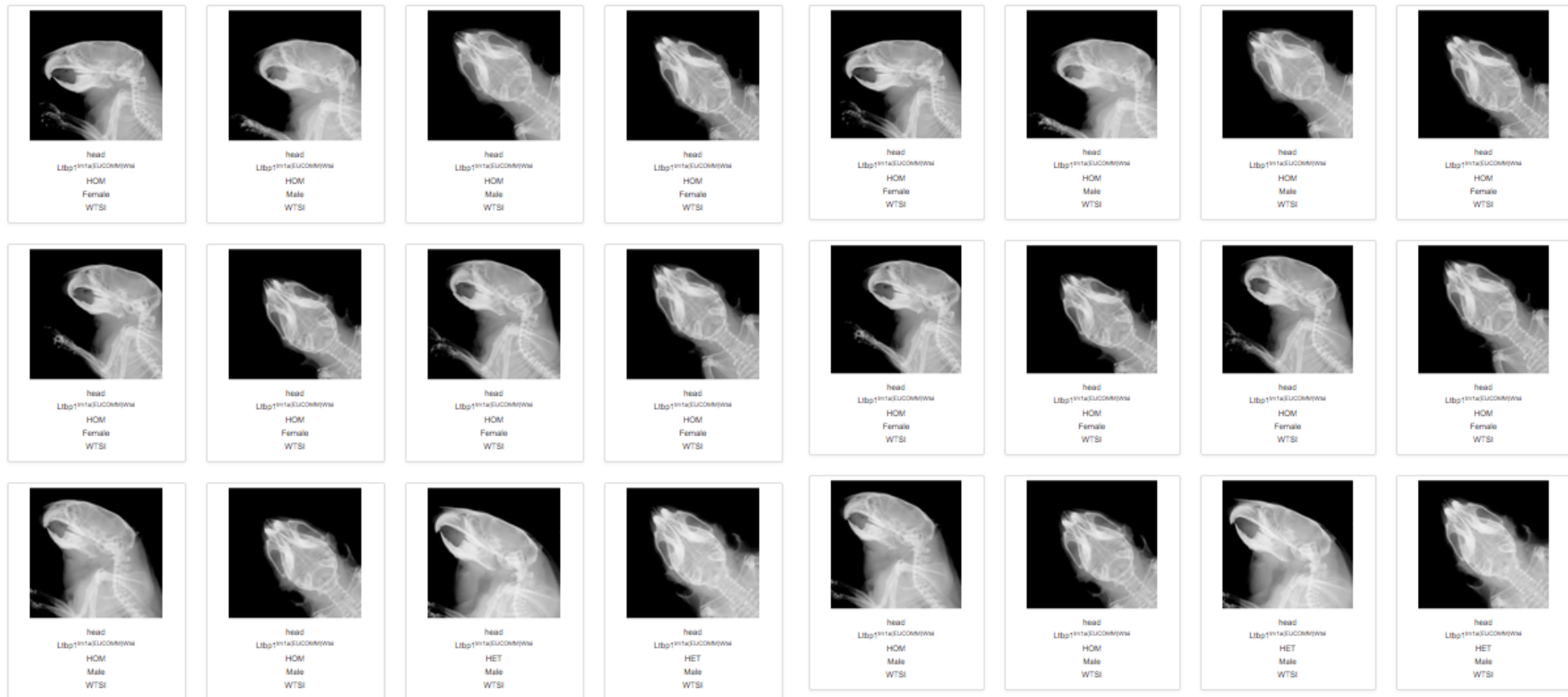
Dismorphology

# Use case: Wellcome Trust Sanger Institute



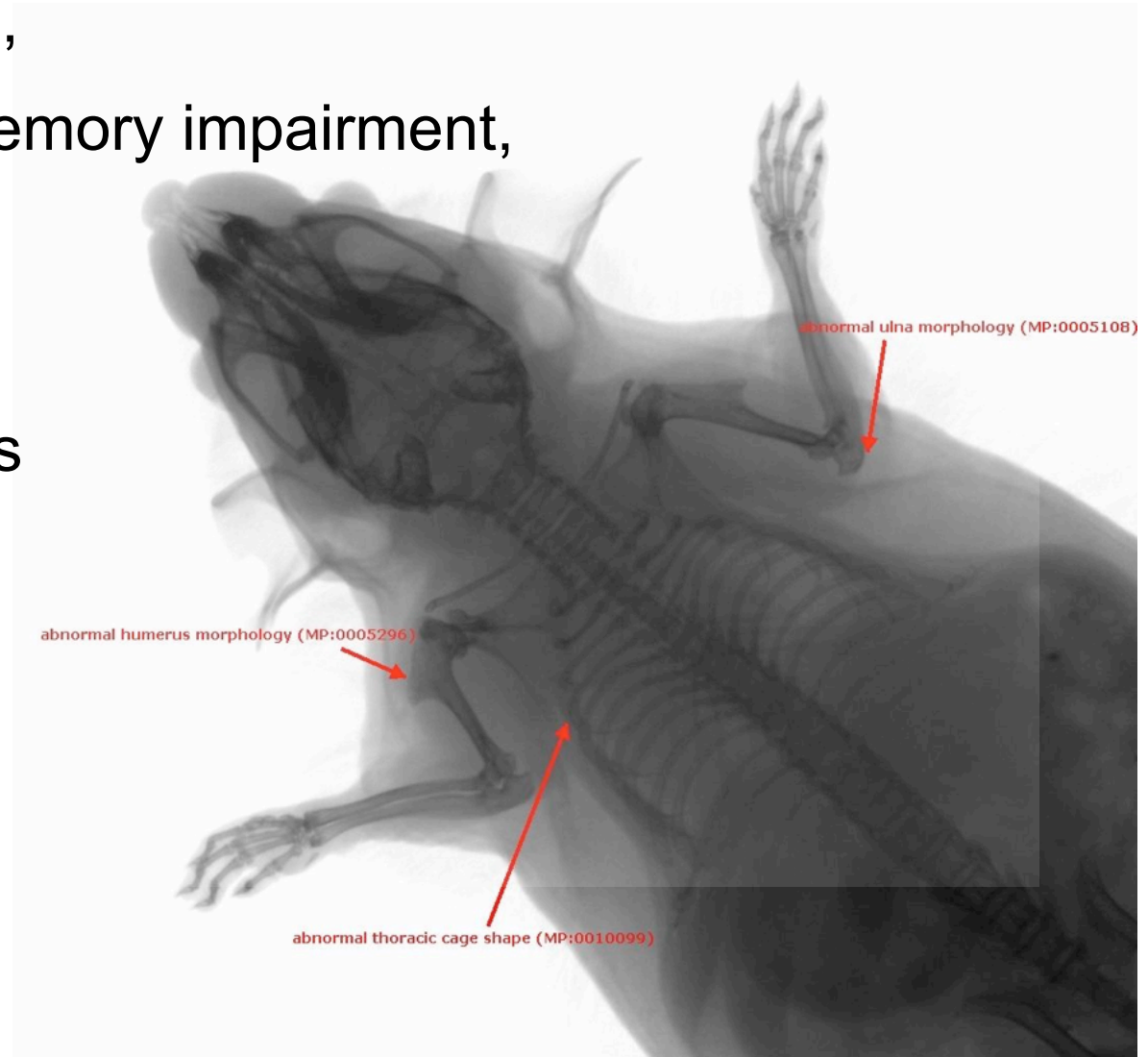
# High-Throughput X-ray Phenotyping

- Detecting Skeletal abnormalities (DEXA scan)
- E.g. *Ltbp1*, Camurati-Engelmann disease (CED)



# Cenpj<sup>-/-</sup> Phenotypes – Seckel Syndrome

- intrauterine dwarfism,
- microcephaly with memory impairment,
- ossification defects,
- ocular and
- skeletal abnormalities



Disruption of mouse Cenpj, a regulator of centriole biogenesis, phenocopies Seckel syndrome  
Rebecca McEntyre et al. PLoS Genet. 2012;8(11)

# Statistics

- Compare KO animal results to baseline/WT
- Phenotypers report abnormality (using SOPs)
- Data are QC'ed and passed to EMBL-EBI for analysis and dissemination
- Example: Abnormal Cranium Morphology
- Fisher-Exact Test (here 2x2 contingency table)
- <http://beta.mousephenotype.org/data/genes/MGI:2444584>

# Allele - Mysm1<sup>tm1a(KOMP)Wtsi</sup>

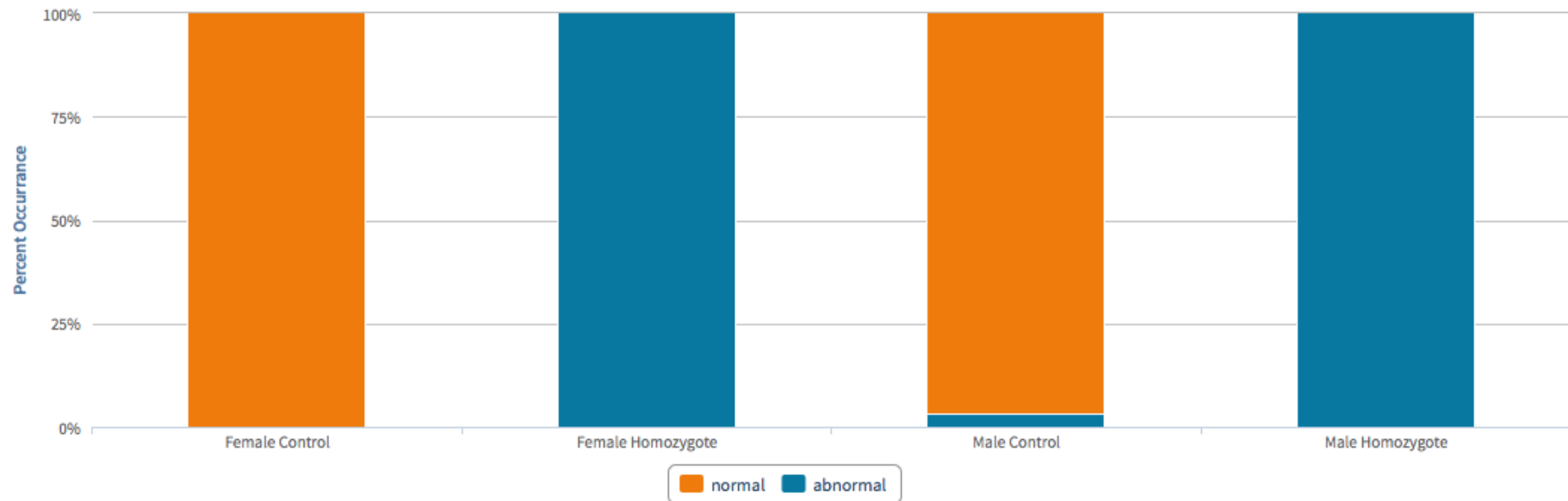


Background - involves: C57BL/6

Phenotyping Center - WTSI

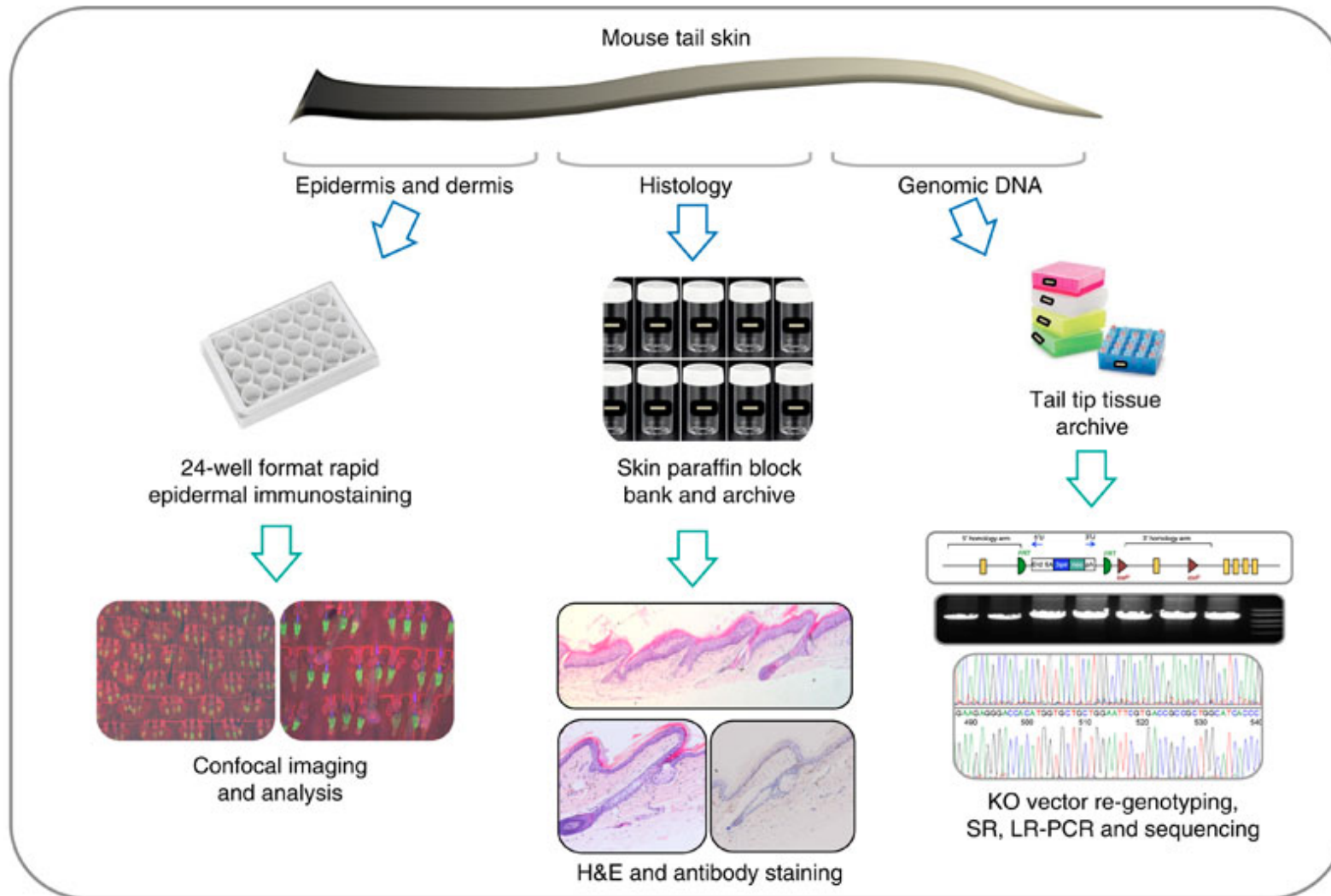
Pipeline - EUMODIC Pipeline 1

Skull Shape  
ESLIM\_006\_001\_019



Control/Hom/Het	normal	abnormal	P Value	Max Effect
Female Control	120	0		
Female Homozygote	0	5	4.26382E-9	1.0
Male Control	115	4		
Male Homozygote	0	8	3.69308E-10	0.97

# Krt76<sup>-/-</sup> Skin Phenotypes



Novel skin phenotypes revealed by a genome-wide mouse reverse genetic screen  
Nature Communications 5, Article number: 3540  
doi:10.1038/ncomms4540



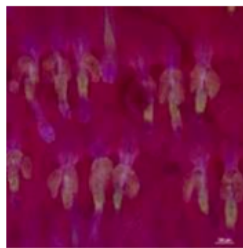
# Krt76<sup>-/-</sup> Skin Phenotypes

- Flaky tail skin
- *lacZ* reporter expression in footpad
- Confocal epidermal wholemount images of Krt76<sup>-/-</sup>



Krt76<sup>tm1a(KOMP)Wtsi</sup>

tail skin, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal sebaceous gland morphology, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal sebaceous gland morphology, HOM, Male, WTSI



Krt76<sup>tm1a(KOMP)Wtsi</sup>

tail skin, abnormal hair cycle, abnormal sebaceous gland morphology, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal sebaceous gland morphology, abnormal epidermis stratum basale morphology, HOM, Male, WTSI



Krt76<sup>tm1a(KOMP)Wtsi</sup>

tail skin, abnormal sebaceous gland morphology, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal sebaceous gland morphology, HOM, Male, WTSI



Krt76<sup>tm1a(KOMP)Wtsi</sup>

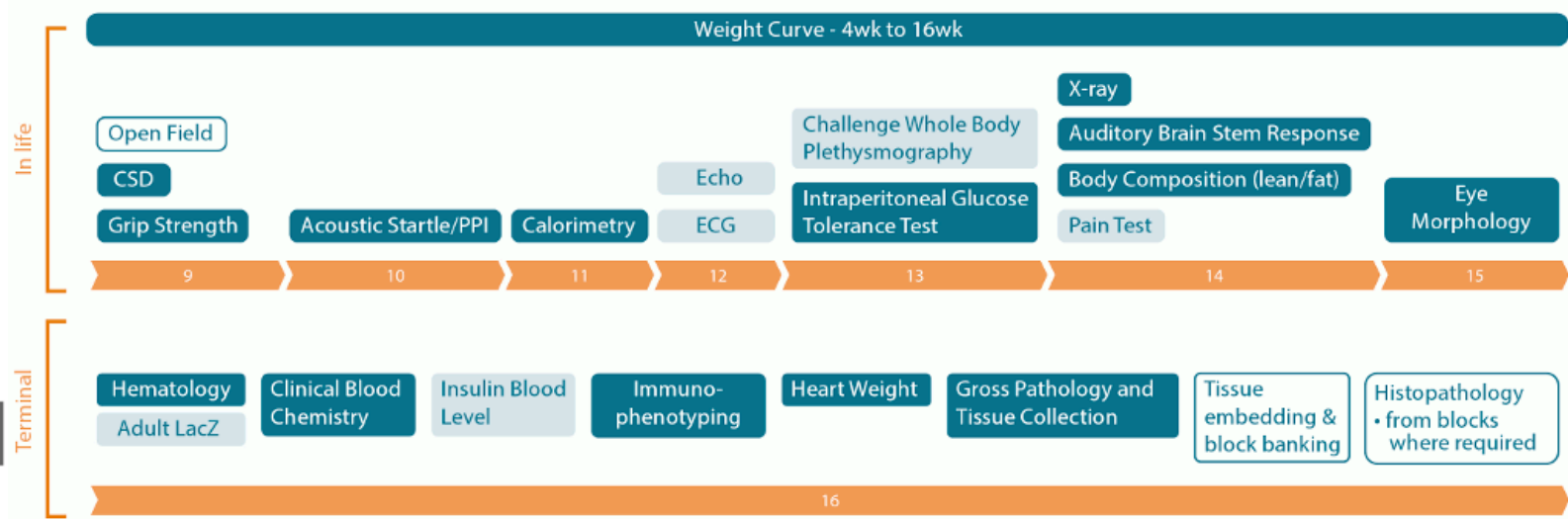
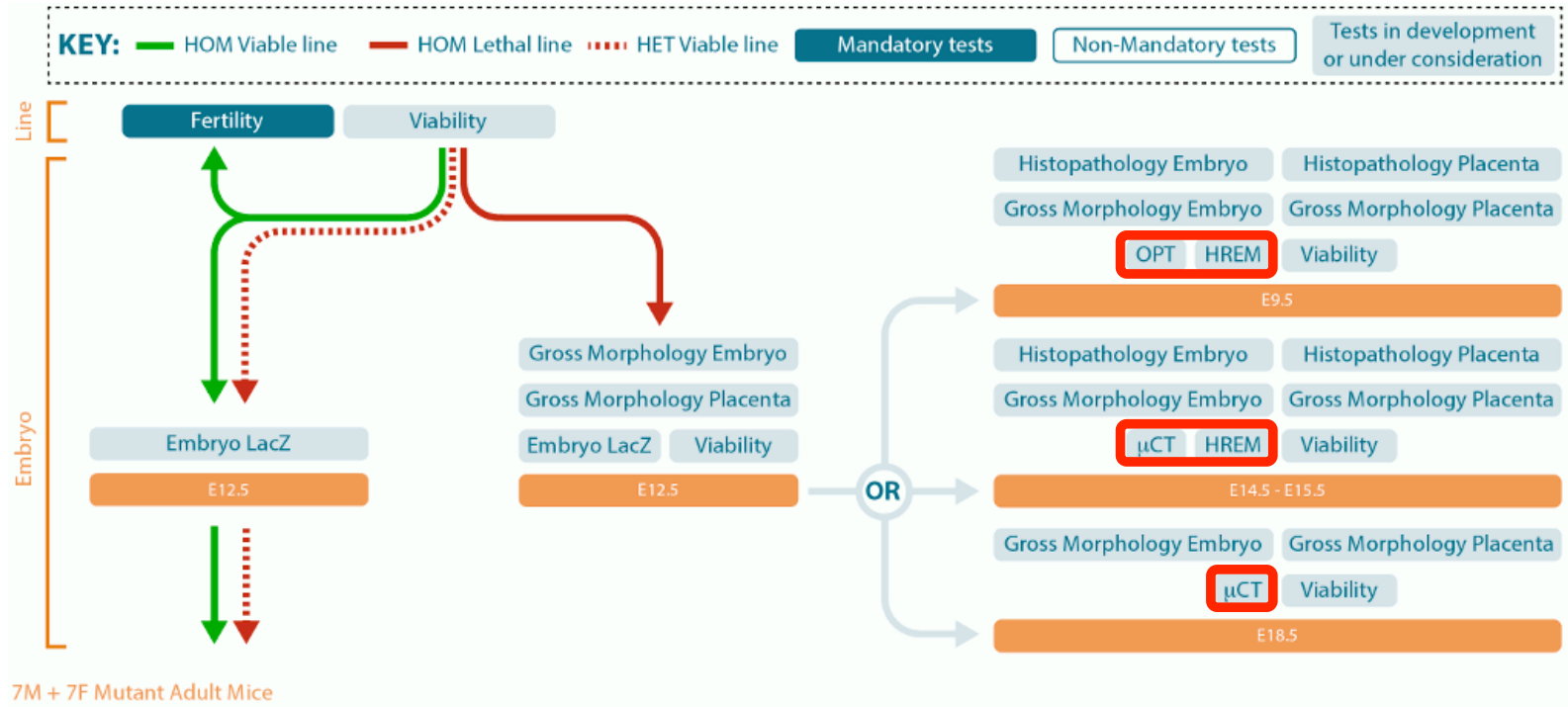
tail skin, abnormal epidermis stratum basale morphology, abnormal hair cycle, abnormal sebaceous gland morphology, abnormal epidermis stratum basale morphology, abnormal hair cycle, HOM, Male, WTSI



Krt76<sup>+/-</sup>

Novel skin phenotypes revealed by a genome-wide mouse reverse genetic screen  
 Nature Communications 5, Article number: 3540  
 doi:10.1038/ncomms4540

# Current pipeline schematic: 3D images



# Tests per center/consortium

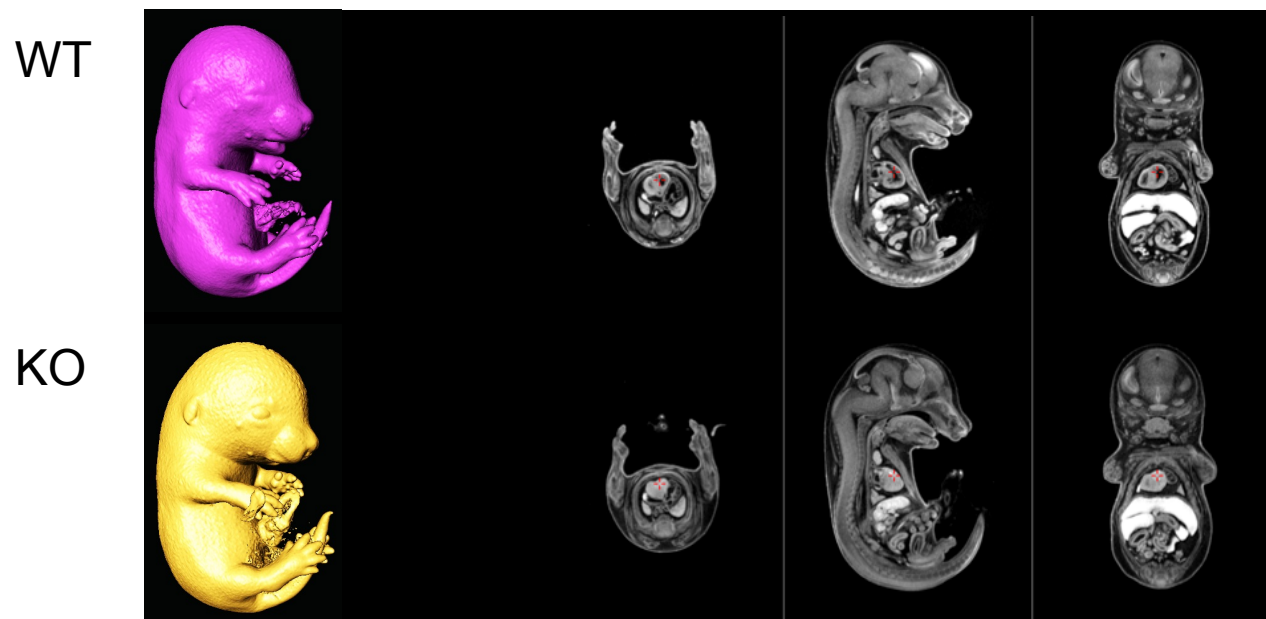
	JAX	DTCC	NorCOMM2 TCP	BasH BCM	WTSI/DMDD/ BasH	JMC	ICS	Harwell
<b>E18.5 and Older</b>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>P7 MRI Whole Brain</li> <li>P7 Whole Body Histopathology</li> </ul>			<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Neural development immunofluorescence screen</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Placenta</li> </ul>	
<b>E14.5/ E15.5</b>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>HREM</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>HREM</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>
<b>E12.5</b>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Embryo LacZ</li> </ul>
<b>E9.5 and Younger</b>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> <li>E8.5 4D OCT</li> <li>E7.5 Gastrulation Failure</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>HREM (TBC)</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>μCT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> <li>Histopathology Embryo</li> <li>Histopathology Placenta</li> </ul>	<ul style="list-style-type: none"> <li>Viability</li> <li>OPT</li> <li>Gross Morphology Embryo</li> <li>Gross Morphology Placenta</li> </ul>

**KEY:**

- Test in development or under consideration
- Mandatory test
- Additional test
- Non-Mandatory test
- Centre-specific test in development

# Three-dimensional (3D) Volumetric Imaging

- Whole embryo coverage
- Single gene mutations can cause multi-organ abnormalities that single tissue or two-dimensional (2D) sections can easily miss
- Resulting image comprises digital data that can be manipulated for optimal viewing



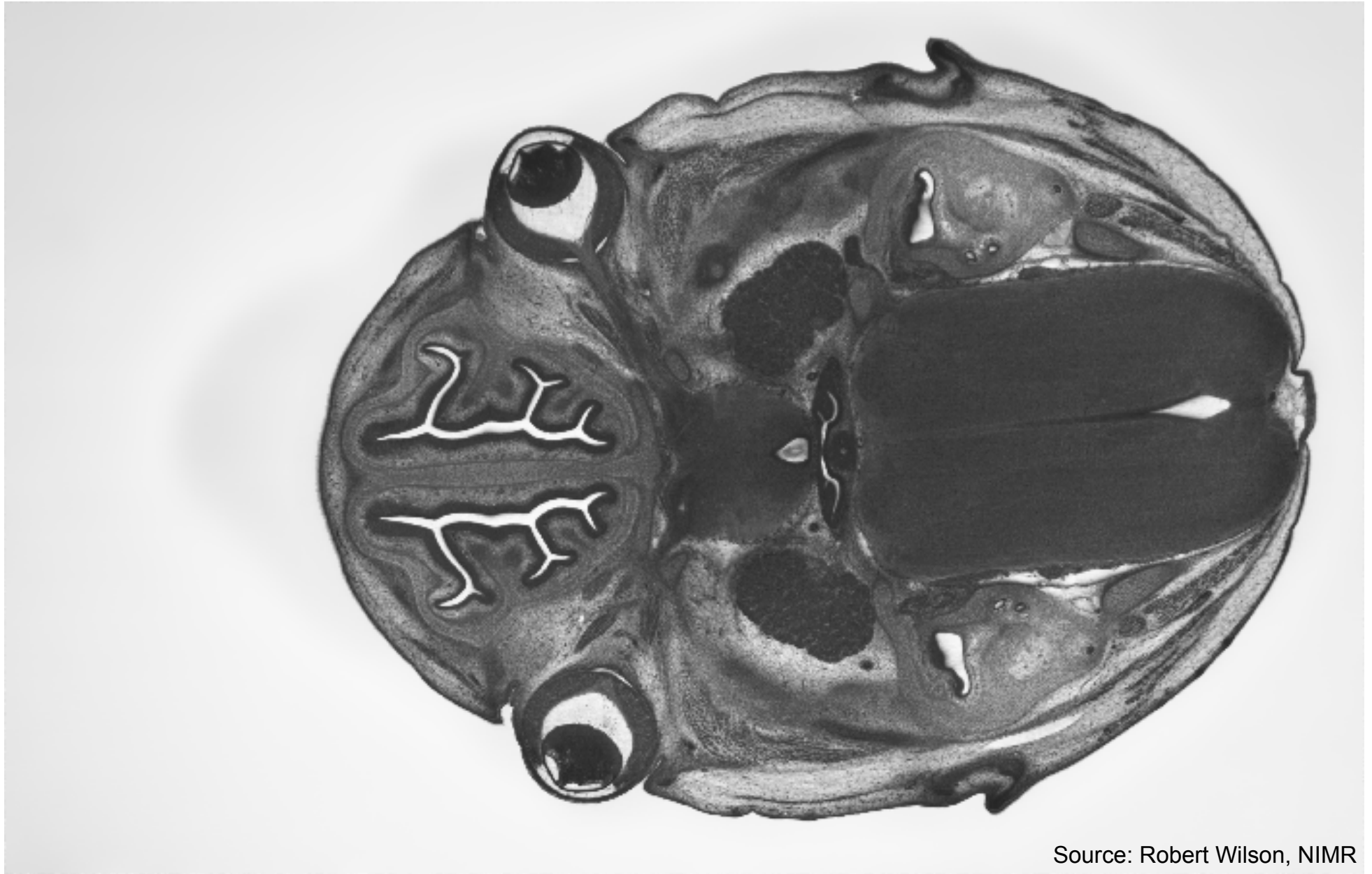
Source: Michael Wong, TCP

# DMDD



## Deciphering Mechanisms of Developmental Disorders

- Goals:
  - Advance understanding of embryo development
  - Identify models of developmental disease
  - Identify novel disease genes
- Systematic phenotyping of embryonic lethals (WTSI lines)
  - Imaging:  $\mu$ CT, HREM
  - **Manual** annotations
  - Dissemination: [embryoimaging.org](http://embryoimaging.org)



Source: Robert Wilson, NIMR

# HREM Embryo data sets



E14.5 wt

Wild-type: 93 embryos

7 stages

NIMR: Parkes and C57BL/6 genetic backgrounds

297,090 images



Psat1 -/-

Mutant lines: 91

- (383 embryos; 252 homozygous for a mutant allele)

E14.5 stage

7 genetic backgrounds

1,203,808 images

[Tim Mohun et al.](#)

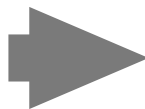
[Dis Model Mech.](#) 2013 May;6(3):562-6

# Pilot HREM embryo screen

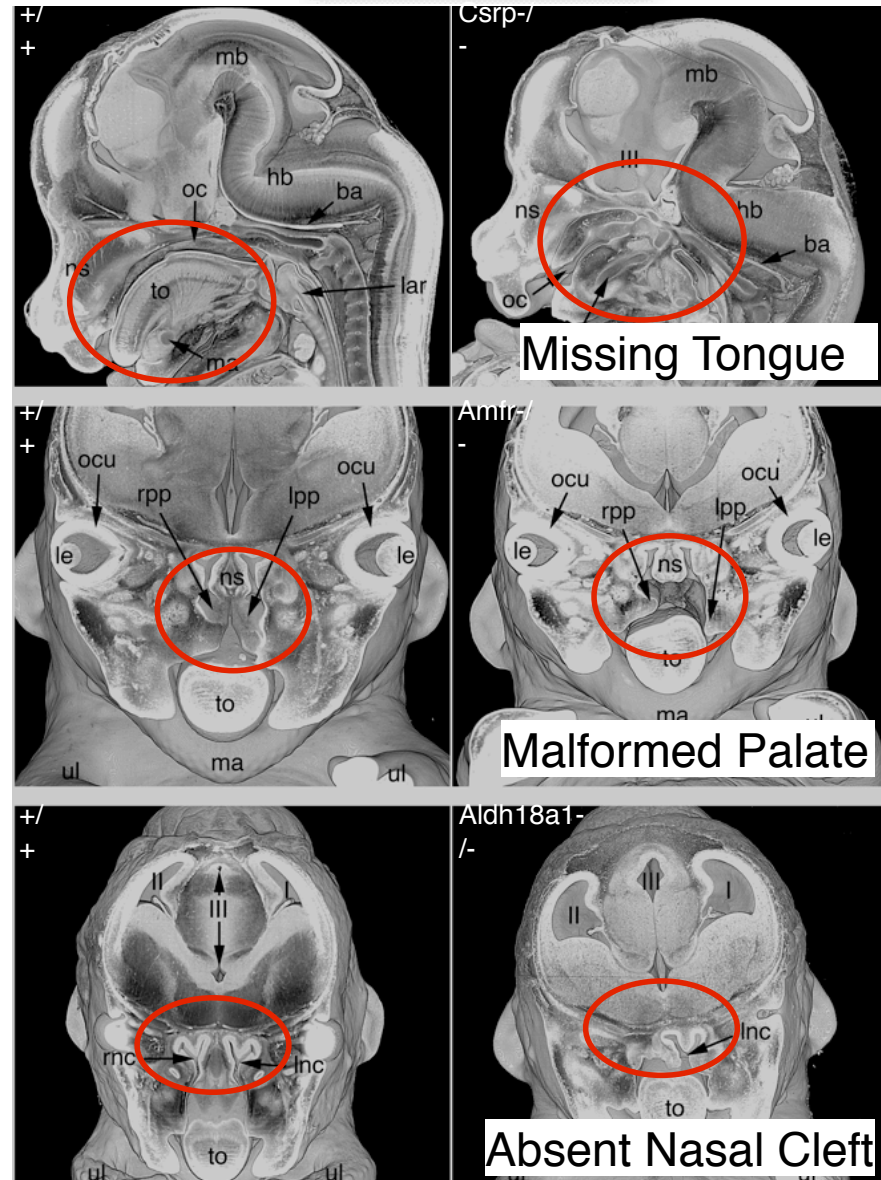


30 lines (122 embryos)  
**120** different defects

gross  
organ  
malformation



subtle  
vascular/nerve  
defect



Source: Robert Wilson, NIMR

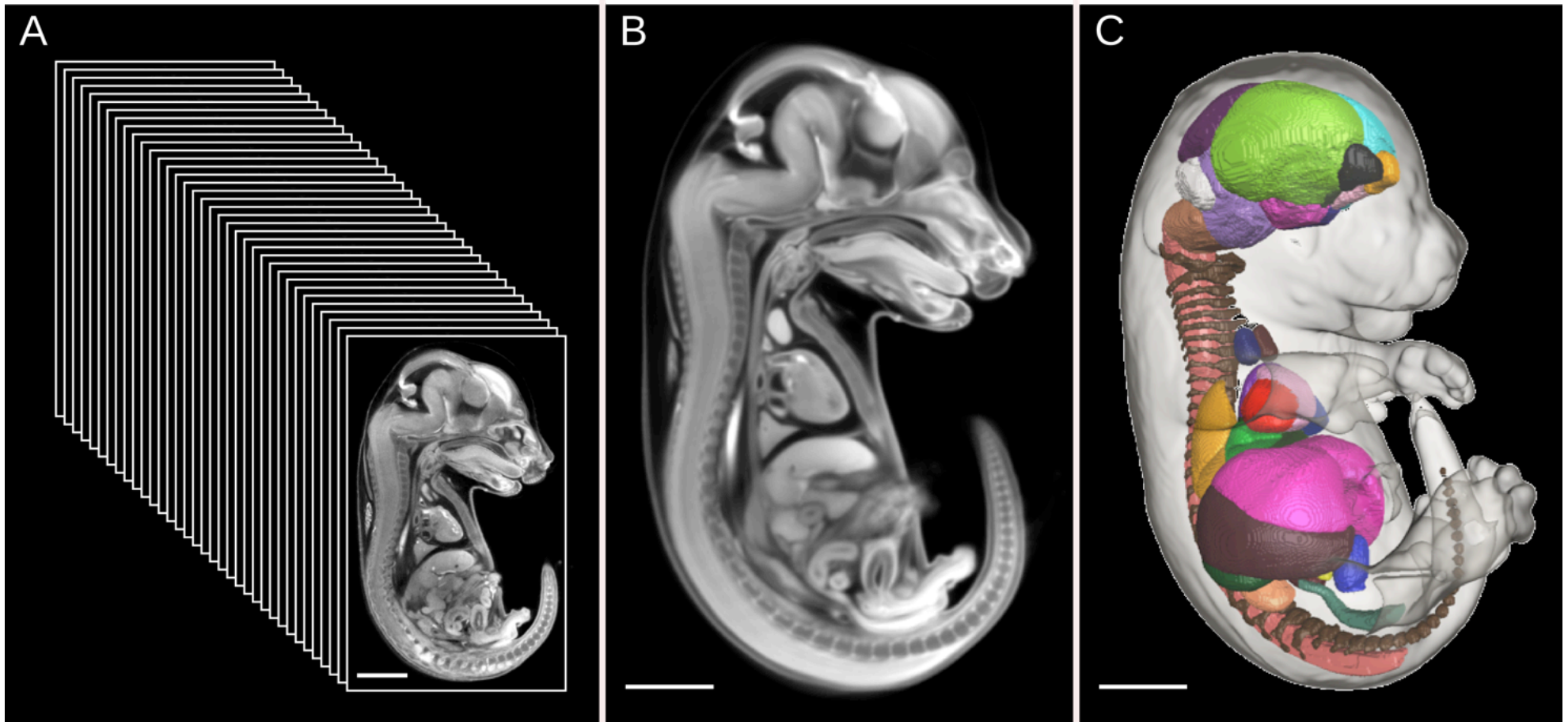


# Micro-CT Embryo data sets

- Mark Henkelman's group - TCP (University of Toronto)
- Automatically quantify morphological information of mouse embryos from 3D imaging
- Characterize the variability within the normal population
- 15.5 dpc C57BL/6J mouse embryo
- A reference 3D atlas has been developed of 48 structural volumes
- [http://www.mouseimaging.ca/technologies/mouse\\_embryo\\_atlas.html](http://www.mouseimaging.ca/technologies/mouse_embryo_atlas.html)

Wong, M. D., Dorr, A. E., Walls, J. R., Lerch, J. P. and Henkelman, R. M. (2012).  
A novel 3D mouse embryo atlas based on micro-CT. *Development* 139, 3248–3256.

# Building a 3D atlas of 48 structural volumes



Wong, M. D., Dorr, A. E., Walls, J. R., Lerch, J. P. and Henkelman, R. M. (2012).  
A novel 3D mouse embryo atlas based on micro-CT. *Development* 139, 3248–3256.

# Micro-CT Data Analysis

3 types analysis based on the results of the image registration:

## 1) Missing structures, gross differences

- Image intensity differences post registration

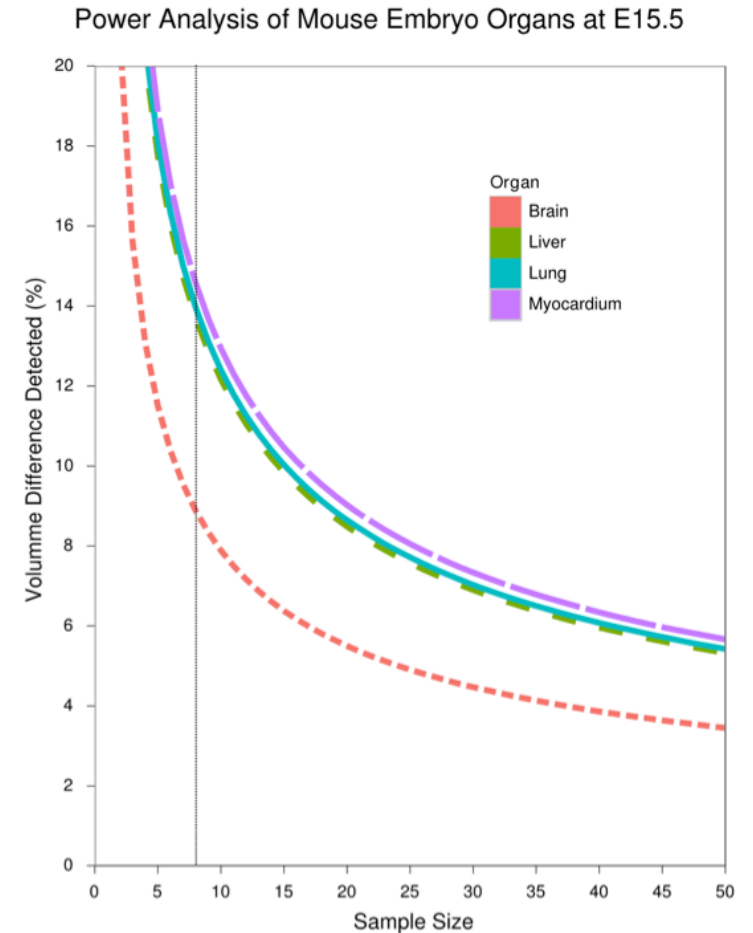
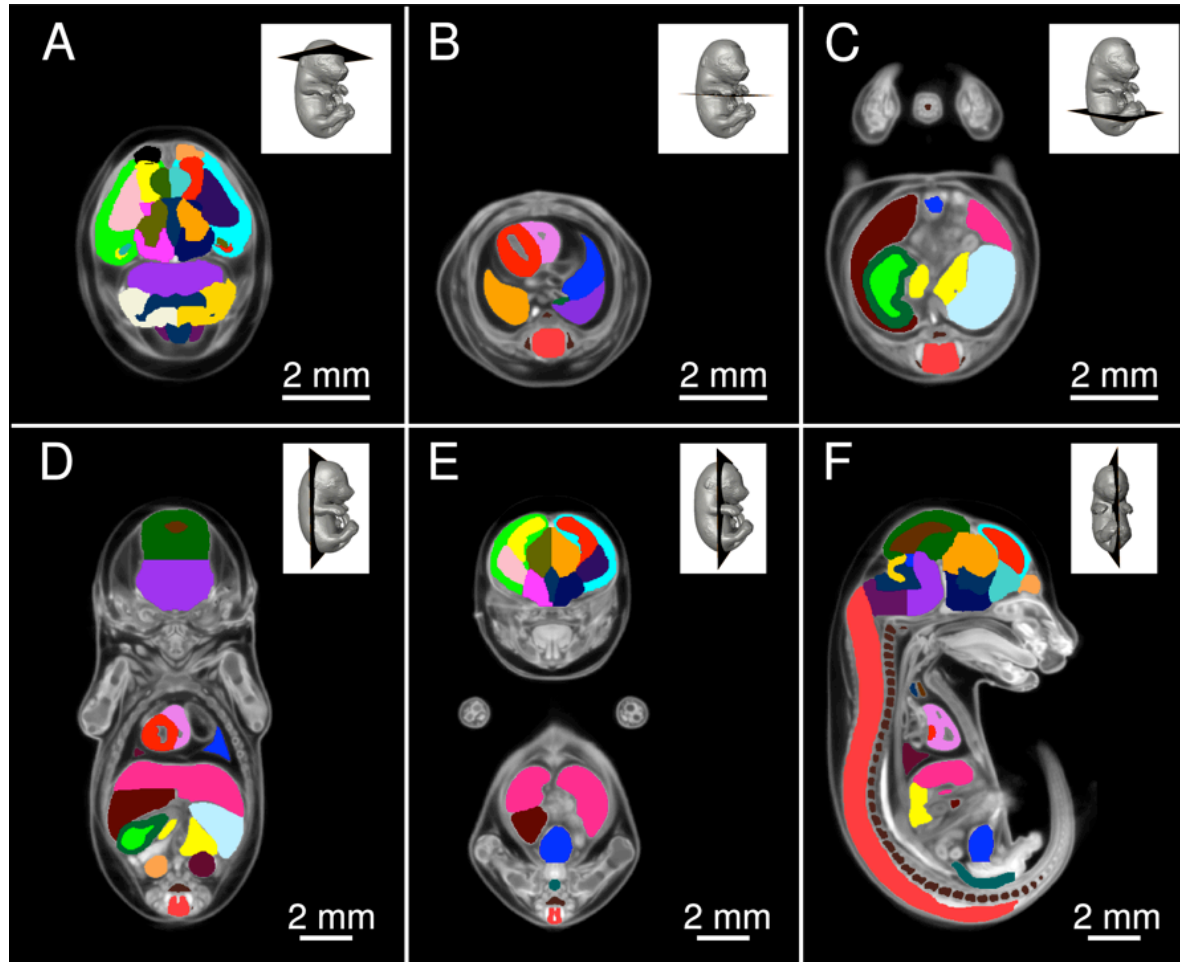
## 2) Local volume differences

- Differences in the amount of deformation to reach the average image

## 3) Whole structure volume differences

- Structure volumes from resampled segmented atlas

# Volume differences of 9-14% can be detected by sample sizes of n=8



Wong, M. D., Dorr, A. E., Walls, J. R., Lerch, J. P. and Henkelman, R. M. (2012).  
A novel 3D mouse embryo atlas based on micro-CT.  
Development 139, 3248–3256.

# New Web Portal – [beta.mousephenotype.org](http://beta.mousephenotype.org)


 **IMPC**  
International Mouse Phenotyping Consortium

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[Login](#) [Register](#)

We are building the first truly comprehensive, functional catalogue of a mammalian genome.

[Learn more](#)



### The Knockout Mouse

A powerful tool for precision medicine.

[Read why](#)

### Search IMPC database

Enter your favorite **gene**, **phenotype**, **anatomy** or **protocol** to find IMPC data important to your research.

Or browse

[new gene-phenotype associations](#)

### News and Events

March 18, 2014  
[Successful IMPC Phenotyping Meeting held in San Francisco](#)

March 5, 2014  
[IMPC members give two presentations at the RE\(ACT\) Rare Disease Meeting in Basel, Switzerland](#)

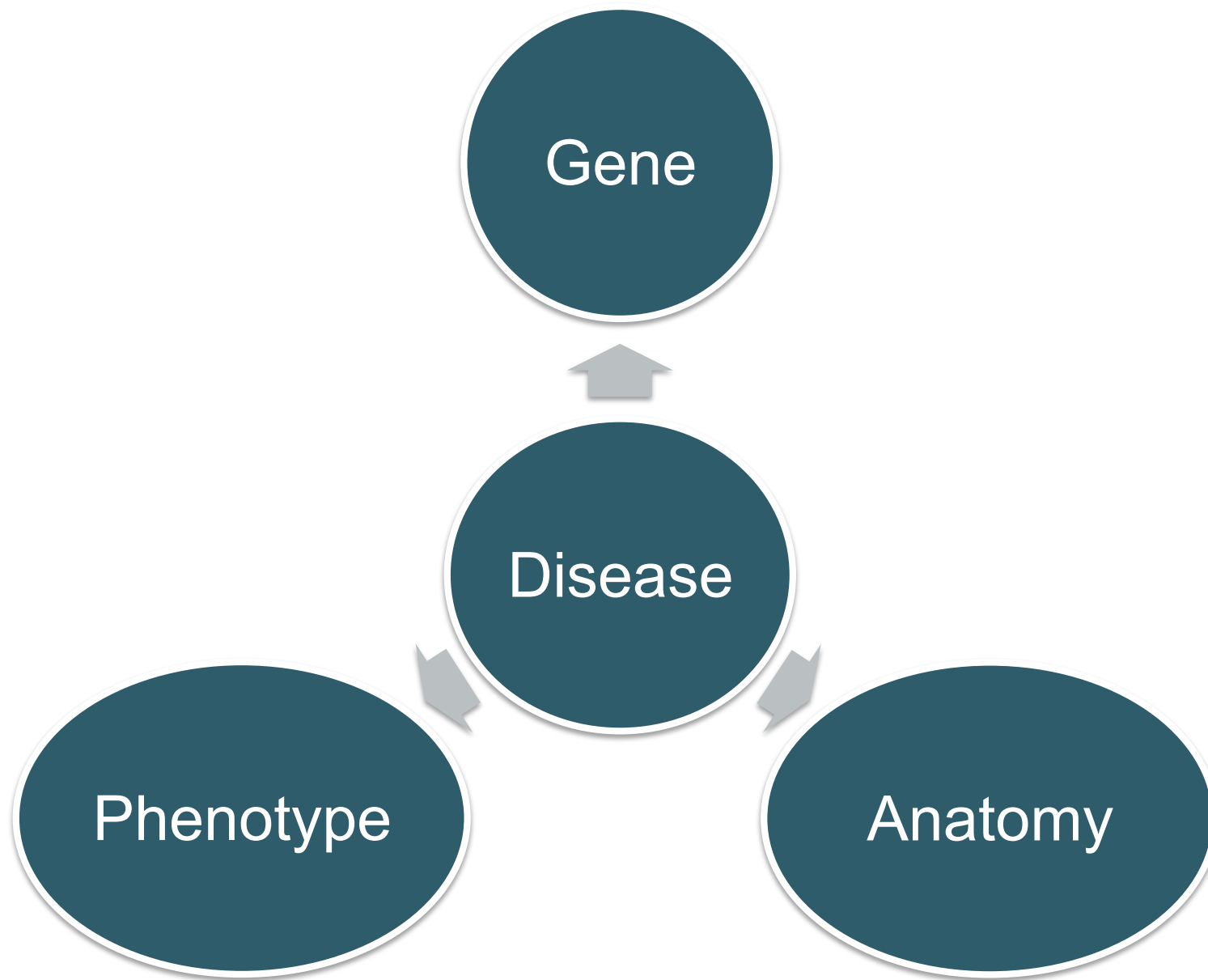
February 11, 2014

### Rare Disease Models

Find mouse models of rare disease by either shared gene or shared phenotype features.

[Visit Disease Models](#)

# Portal Search [beta.mousephenotype.org](https://beta.mousephenotype.org)



# Retrieving images on the portal

Group by attributes

Filter your search

- ▶ Genes 48282
- ▶ Phenotypes 689
- ▶ Diseases 7234
- ▶ Anatomy 249
- ▶ Procedures 3816
- ▼ **Images 97304**
- ▼ **Phenotype**
  - adipose tissue 7
  - behavior/neurological 42
  - cardiovascular system 1113
  - craniofacial 18194
  - embryogenesis 4
  - endocrine/exocrine gland 404
  - growth/size/body 11
  - hearing/vestibular/ear 18177
  - hematopoietic system 115
  - homeostasis/metabolism 7
  - immune system 115
  - integument 323
  - limbs/digits/tail 246
  - liver/biliary system 71
  - mortality/aging 4
  - nervous system 12
  - pigmentation 514
  - renal/urinary system 198
  - reproductive system 367
  - skeleton 198
  - vision/eye 1751
- ▶ Anatomy
- ▶ Procedure
- ▶ Gene

Search

[View example search](#)



Annotation View: groups images by annotation  
 Found 994 annotations / [97304 images](#)

Link to search documentation

Show Image View

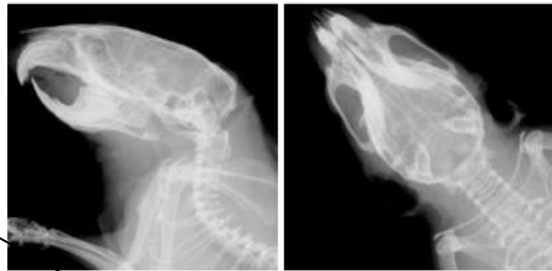
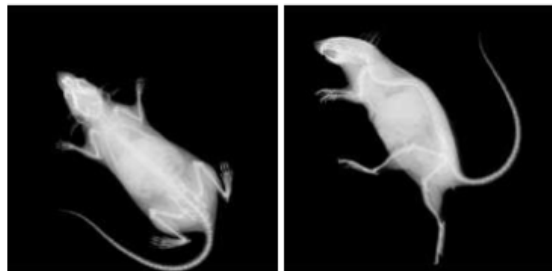
Link to image gallery

Download

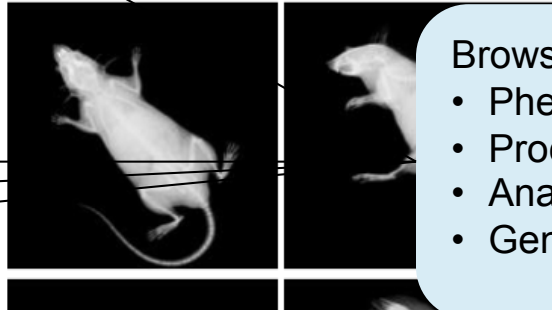
Export results

Name Example Images

Gene: [1110037F02Rik](#) (140 images)

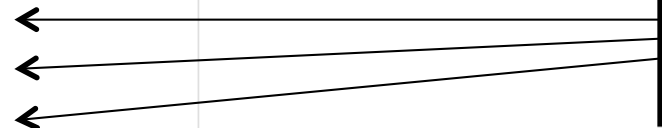


Gene: [1110059G10Rik](#) (70 images)



Browse and filter by:

- Phenotype
- Procedure
- Anatomy
- Gene



# Grouping Images: by gene attributes (Cenpj)

Filter your search

?

- ▶ Genes 1
- ▶ Phenotypes 64
- ▶ Diseases 3
- ▶ Anatomy 0
- ▶ Procedures 0
- ▼ Images 230
  - ▼ **Phenotype**
    - cardiovascular system 6
    - craniofacial 74
    - endocrine/exocrine gland 1
    - hearing/vestibular/ear 74
    - integument 1
    - limbs/digits/tail 16
    - pigmentation 1
    - renal/urinary system 1
    - reproductive system 6
    - skeleton 7
    - vision/eye 6
  - ▼ **Anatomy** 113
    - extremity 113
    - integumental system 1
    - nervous system 1

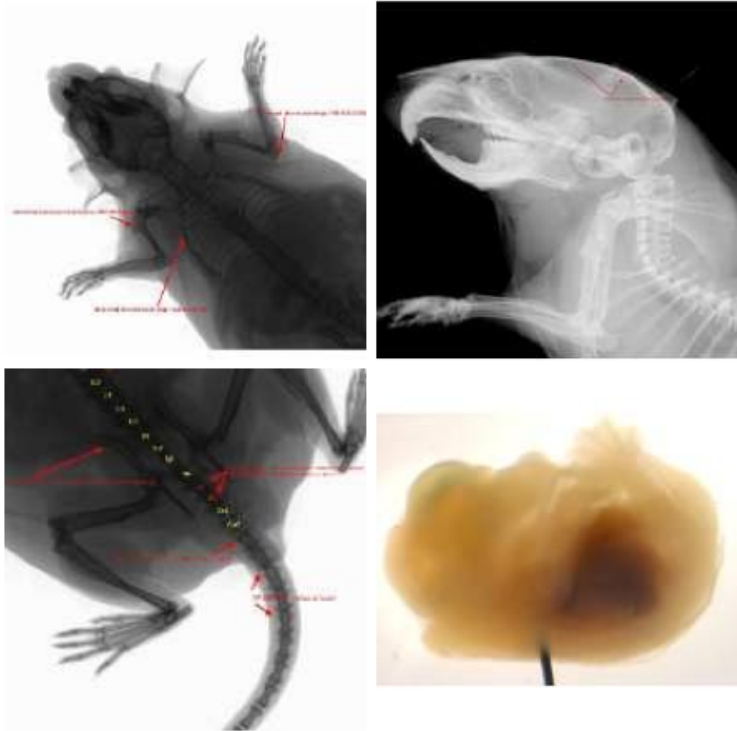
Q "cenpj"

[View example search](#)

Annotation View: groups images by annotation Show Image View

Found 27 annotations / [230 images](#)

[Download](#)

Name	Example Images
Gene: <a href="#">Cenpj</a> ( <a href="#">229 images</a> )	



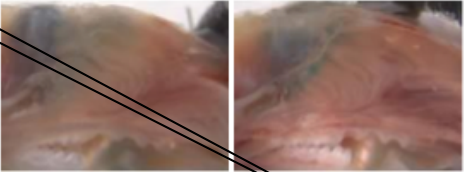
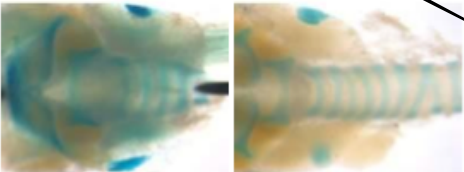
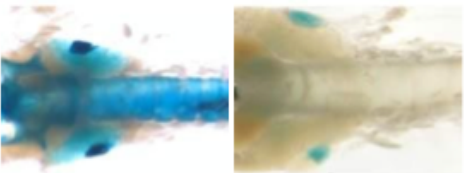
# Filtering: “Wholemound expression” and “respiratory system”

Filter your search

Search

Annotation View: groups images by annotation  
Found 204 annotations / 345 images

View example search  
Show Image View  
Download

Name	Example Images
MA: nasal cavity (2 images)	
MA: parathyroid gland (36 images)	
MA: thyroid gland (79 images)	

Filter results by

- Procedure and Anatomy

Filter your search sidebar:

- Images
  - Wholemound Expression
  - respiratory system
  - Remove all facet filters
- Genes: 0
- Phenotypes: 0
- Diseases: 0
- Anatomy: 0
- Procedures: 0
- Images: 345
  - Phenotype
    - adipose tissue: 0
    - behavior/neurological: 0
    - cardiovascular system: 1
    - craniofacial: 0
    - embryogenesis: 0
    - endocrine/exocrine gland: 0
    - growth/size/body: 0
    - hearing/vestibular/ear: 0
    - hematopoietic system: 0
    - homeostasis/metabolism: 0
    - immune system: 0
    - integument: 0
    - limbs/digits/tail: 0
    - liver/biliary system: 0
    - mortality/aging: 0
    - nervous system: 0
    - pigmentation: 0
    - renal/urinary system: 0
    - reproductive system: 0
    - skeleton: 0
    - vision/eye: 1
  - Anatomy
    - adipose tissue: 0
    - cardiovascular system: 1
    - digestive system: 0
    - endocrine system: 97
    - exocrine system: 0
    - extremity: 0
    - immune system: 0

# Filtering: “Akt2” and “X-ray” and “extremity”

Filter your search

Images

- Xray
- extremity

[Remove all facet filters](#)

?

- ▶ Genes 0
- ▶ Phenotypes 0
- ▶ Diseases 0
- ▶ Anatomy 0
- ▶ Procedures 0
- ▼ Images 32
- ▼ Phenotype
  - adipose tissue 0
  - cardiovascular system 0
  - craniofacial 24
  - growth/size/body 0
  - hearing/vestibular/ear 24
  - integument 0
  - renal/urinary system 0
  - skeleton 0
- ▶ Anatomy
- ▶ Procedure
- ▶ Gene

akt2

[View example search](#)

Show Image View

Annotation View: groups images by annotation

Found 4 annotations / [32 images](#)

[Download](#)

Name

Example Images

Image gallery

Gene: [Akt2 \(32 images\)](#)




Procedure: Xray ([32 images](#))



# Accessing images from the gene page

## Phenotype Associated Images

▼ Xray (135)



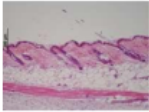
Ltbp1<sup>tm1a3UCOMHWSU</sup> head, HGM, Female, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> body, HGM, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> body, HGM, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> head, HGM, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> head, HGM, Male, WTSI

[▶ show all 135 images](#)

▶ Dysmorphology (7)

▶ Eye Morphology (1)

▼ Skin Histopathology (1)




Ltbp1<sup>tm1a3UCOMHWSU</sup> back skin, HGM, Female, WTSI

Phenotype images associated to the gene are presented test by test when available


## Expression

▼ Cardiovascular System (5)



Ltbp1<sup>tm1a3UCOMHWSU</sup> blood vessel, tail, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> heart, blood vessel, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> blood vessel, brain, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> blood vessel, brain, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> blood vessel, HET, Male, WTSI

▼ Digestive System (3)



Ltbp1<sup>tm1a3UCOMHWSU</sup> small intestine, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> gall bladder, HET, Male, WTSI  
Ltbp1<sup>tm1a3UCOMHWSU</sup> stomach, HET, Male, WTSI

Wholemount expression images available from gene page

# Abnormal Phenotype Page

http://beta.mousephenotype.org/data/phenotypes/MP:0001289

Home • Search • Phenotypes • persistence of hyaloid vascular system

## Phenotype: persistence of hyaloid vascular system

**Definition** failure of the degeneration of the transient vascular system of the eye during development, that normally nourishes the retina, immature lens and primary vitreous of the developing eye

**Synonyms** persistence of hyaloid capillary system

**Procedure**

- Eye Morphology (IMPC Pipeline)
- Eye Morphology (Harwell)
- Eye Morphology (JAX Pipeline)
- more procedures

**MGI MP browser** [MP:0001289](#)

### Summary

## Gene variants with persistence of hyaloid vascular system

Phenotype: All    Gene: All    Procedure: All    Analysis: All

Total number of results: 5

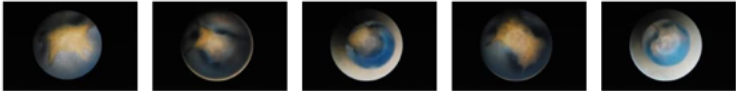
Gene	Allele	Zygoty	Sex	Phenotype	Procedure / Parameter	Phenotyping Center	Analysis	Graph
<a href="#">Cdkn2a</a>	<a href="#">Cdkn2a<sup>tm1a1EUCOMM/WSU</sup></a>	homozygote	♀	<a href="#">persistence of hyaloid vascular system</a>	Eye Morphology / Right eye Bergmeister's Papilla	WTSI	MGP	
<a href="#">Cdkn2a</a>	<a href="#">Cdkn2a<sup>tm1a1EUCOMM/WSU</sup></a>	homozygote	♂	<a href="#">persistence of hyaloid vascular system</a>	Eye Morphology / Left eye Bergmeister's Papilla	WTSI	MGP	
<a href="#">Prkcz</a>	<a href="#">Prkcz<sup>tm1a1EUCOMM/WSU</sup></a>	homozygote	♂	<a href="#">persistence of hyaloid vascular system</a>	Eye Morphology / Left eye Bergmeister's Papilla	WTSI	MGP	
<a href="#">Prkcz</a>	<a href="#">Prkcz<sup>tm1a1EUCOMM/WSU</sup></a>	homozygote	♂	<a href="#">persistence of hyaloid vascular system</a>	Eye Morphology / Right eye Bergmeister's Papilla	WTSI	MGP	
<a href="#">Slc25a30</a>	<a href="#">Slc25a30<sup>tm1a1EUCOMM/WSU</sup></a>	homozygote	♀	<a href="#">persistence of hyaloid vascular system</a>	Eye Morphology / Persistence of hyaloid vascular system	WTSI	IMPC	<a href="#">GA</a>

Export table as: [TSV](#) or [XLS](#)

### Mutant mouse strains

## Images

▼ Phenotype Associated Images



[Cdkn2a<sup>tm1a1EUCOMM/WSU</sup>](#)  
eye, abnormal retinal pigmentation, persistence of hyaloid vascular system, abnormal retinal pigmentation, persistence of hyaloid vascular system, HOM, Male, WTSI

[Cdkn2a<sup>tm1a1EUCOMM/WSU</sup>](#)  
eye, persistence of hyaloid vascular system, HOM, Male, WTSI

[Cdkn2a<sup>tm1a1EUCOMM/WSU</sup>](#)  
eye, persistence of hyaloid vascular system, HOM, Male, WTSI

[Cdkn2a<sup>tm1a1EUCOMM/WSU</sup>](#)  
eye, persistence of hyaloid vascular system, HOM, Male, WTSI

[Cdkn2a<sup>tm1a1EUCOMM/WSU</sup>](#)  
eye, persistence of hyaloid vascular system, abnormal retinal pigmentation, HOM, Male, WTSI

### Associated images

# Challenges and Future Directions

- Linking back to original image provider:
  - Unique identifier for each image linking to specific region (e.g. NDPI viewer)
- Managing images at EMBL-EBI: OMERO 5 platform pilot study
- Providing tools to annotate the images after their transfer to EMBL-EBI
- Planning with GXD to exchange data (LacZ images)
- Display volumetric phenotypes at different embryonic development stage:
  - 3D plugin (Woolz IIP)
- Implement a reference Atlas ([http://www.mouseimaging.ca/technologies/mouse\\_embryo\\_atlas.html](http://www.mouseimaging.ca/technologies/mouse_embryo_atlas.html))
- Exchange data with **PhenoImageShare**: federated resources to retrieve and annotate phenotype images from vertebrates and plants (BBSRC)

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