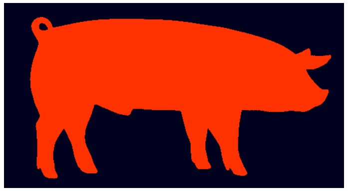
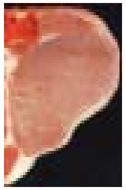


IFAFS project



Mapping and use of QTL for marker-assisted improvement of meat quality in pigs

Jack Dekkers, Max Rothschild, Rohan Fernando
Iowa State University

Sandra Rodrigues-saz, Jonathan Beever
University of Illinois - Urbana Champaign

Pork Quality

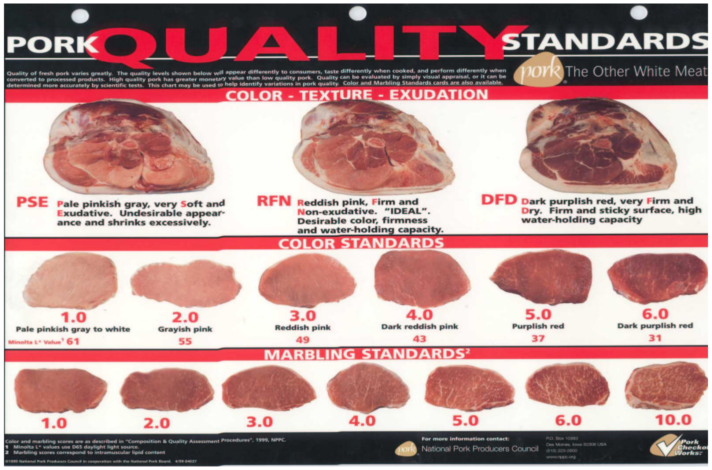
- Consumer demands pork that is:
  - reasonably priced
  - wholesome
  - palatable
  - attractive
- Pork quality has important genetic basis
- Difficult to improve by conventional selection
- Improvement possible if genes are known

Pork Quality

Wholesome, attractive, palatable

Carcass traits

- Marbling, color, firmness scores



PORK QUALITY STANDARDS

pork The Other White Meat®

Quality of fresh pork varies greatly. The quality levels shown below will appear differently to consumers, taste differently when cooked, and perform differently when converted to processed products. High quality pork has greater monetary value than low quality pork. Quality can be evaluated by simply visual appraisal, or it can be determined more accurately by scientific tests. This chart may be used to help identify variations in pork quality. Color and Marbling Standards cards are also available.

COLOR - TEXTURE - EXUDATION

PSE Pale pinkish gray, very Soft and Exudative. Undesirable appearance and shrinks excessively.

RFN Reddish pink, Firm and Non-exudative. "IDEAL". Desirable color, firmness and water-holding capacity.

DFD Dark purplish red, very Firm and Dry. Firm and sticky surface, high water-holding capacity

COLOR STANDARDS

	1.0	2.0	3.0	4.0	5.0	6.0
	Pale pinkish gray to white	Grayish pink	Reddish pink	Dark reddish pink	Purplish red	Dark purplish red
Minolta L* Value[1]	61	55	49	43	37	31

MARBLING STANDARDS[2]

1.0 2.0 3.0 4.0 5.0 6.0 10.0

Color and marbling scores are as described in "Composition & Quality Assessment Procedures", 1999, NPPC.

1 Minolta L* values use D65 daylight light source.

2 Marbling scores correspond to intramuscular lipid content

©1999 National Pork Producers Council in cooperation with the National Pork Board. 4/99-04037

For more information contact:

National Pork Producers Council

P.O. Box 10383
Des Moines, Iowa 50306 USA
(515) 223-2600
www.nppc.org

Pork Checkoff Works:

- Ultimate pH
- Light reflectance
- Water holding capacity
- Glycolytic potential
- Lipid and cholesterol content
- Fiber type

Sensory panel traits

- Tenderness
- Chewiness
- Juiciness
- Flavor
- Off flavor

Cooking traits

- Star probe tenderness
- % Cooking loss

Genome Scan for Meat Quality

F_0 2 Berkshire sires 9 Yorkshire dams

BB x YY

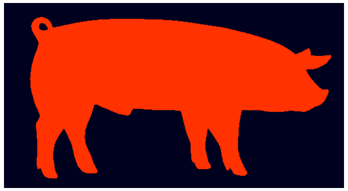
provided by National Swine Registry

F_1 8 sires BY x BY 26 dams

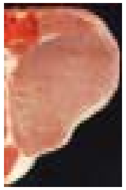
M_1 B N_1

M_2 Y N_2

F_2 527 BB BY YB YY



Traits measured



Growth traits

- Birth weight
- 16d weight
- ADG to 16 d.
- ADG to slaughter

Sensory panel traits

- Tenderness
- Chewiness
- Juiciness
- Flavor
- Off flavor

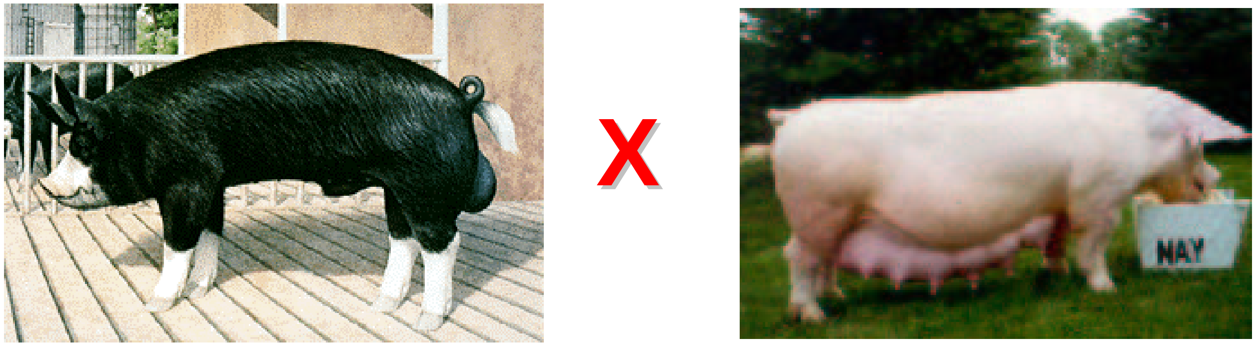
Carcass traits

- Carcass weight
- marbling, color, firmness scores
- Ultimate pH
- Minolta reflectance, Hunter L color
- Water holding capacity
- Drip loss (72 hrs)
- Lipid and cholesterol content
- Fiber type I (%) Fiber type Ia/Ib (%)

Cooking traits

- Star probe tenderness
- % Cooking loss

Second phase research



- Positional Candidate Gene analyses
- Further statistical analyses
- Use of QTL findings in selection programs

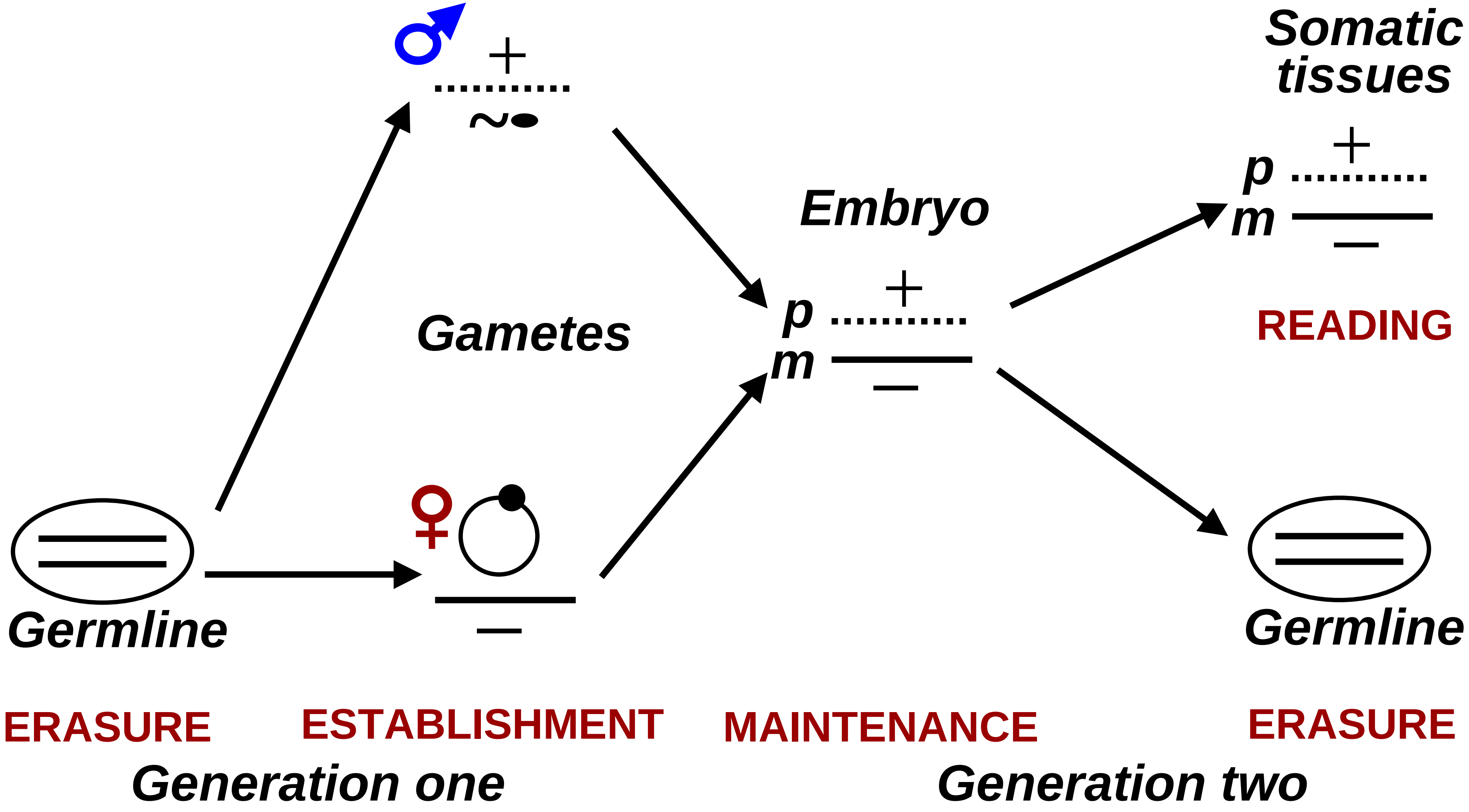
Outline

- QTL results with new markers in ISU population
- Detection of QTL with non-Mendelian expression
- Use of identified QTL in introgression programs

Gametic imprinting

DNA methylation

Constancia et al. Genome Research, 1998



Gametic imprinting

Gene expression depends on parental origin

- **Human**
- **Mouse**
- ***Swine IGF-2* region on SSC2**
  - **- muscle mass and fat deposition**

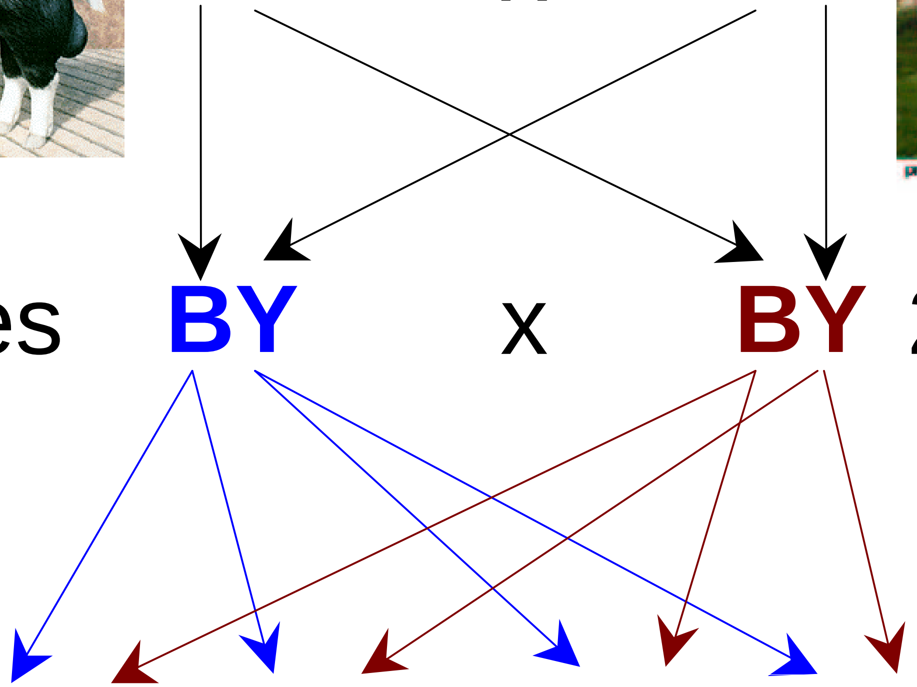
(Nezer *et al*., ‘99 and Jeon *et al*., ‘99)

Gametic imprinting

Gene expression depends on parental origin

F_0 2 Berkshire sires 9 Yorkshire dams

provided by National Swine Registry



BB x **YY**

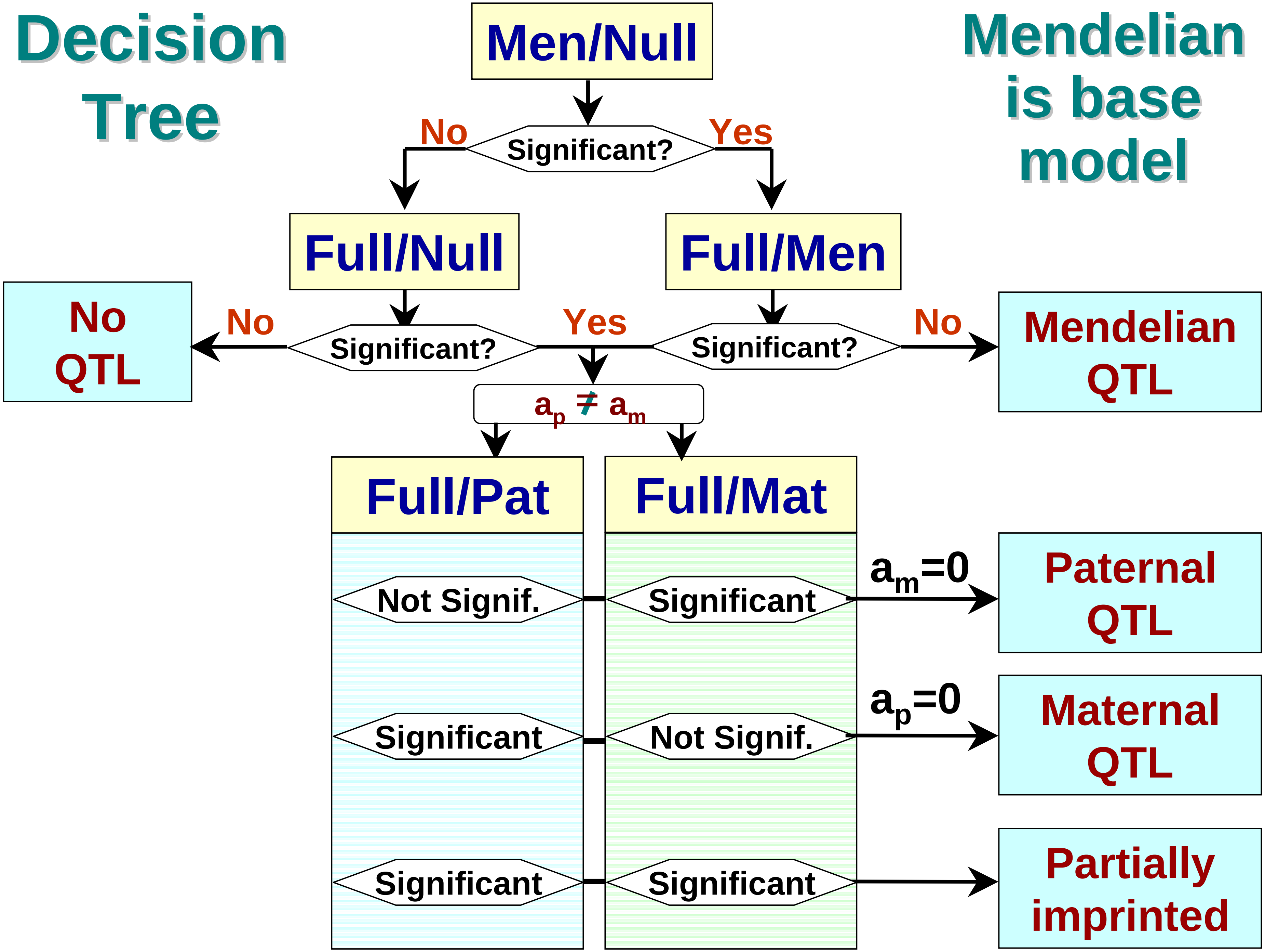
F_1 8 sires **BY** x **BY** 26 dams

F_2 527 **BB** **BY** **YB** **YY**

Maternal Imprinting

Decision Tree

Mendelian is base model



Men/Null

Significant?

No

Yes

Full/Null

Full/Men

Significant?

Significant?

No

Yes

No

No QTL

Mendelian QTL

$a_p \neq a_m$

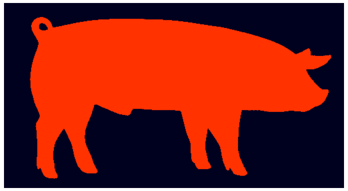
Full/Pat

Full/Mat

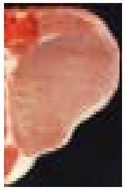
Not Signif. — Significant — $a_m=0$ → Paternal QTL

Significant — Not Signif. — $a_p=0$ → Maternal QTL

Significant — Significant → Partially imprinted



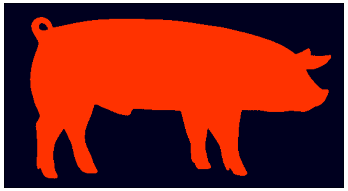
IFAFS project objectives



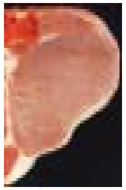
1) Develop and apply methods for combined analysis of the ISU and UIUC populations

- Complete phenotyping and genotyping of the UIUC F_2 population
- Fill gaps in the ISU population map by 30 additional markers
- Develop statistical methods for QTL detection for application to the individual and joint data
  - Multiple QTL models
  - Gametic imprinting models
  - Epistatic models
  - Between and within-breed segregation models
  - Multiple trait models
  - Categorical trait models
  - Non-parametric methods

Hypothesis testing procedures

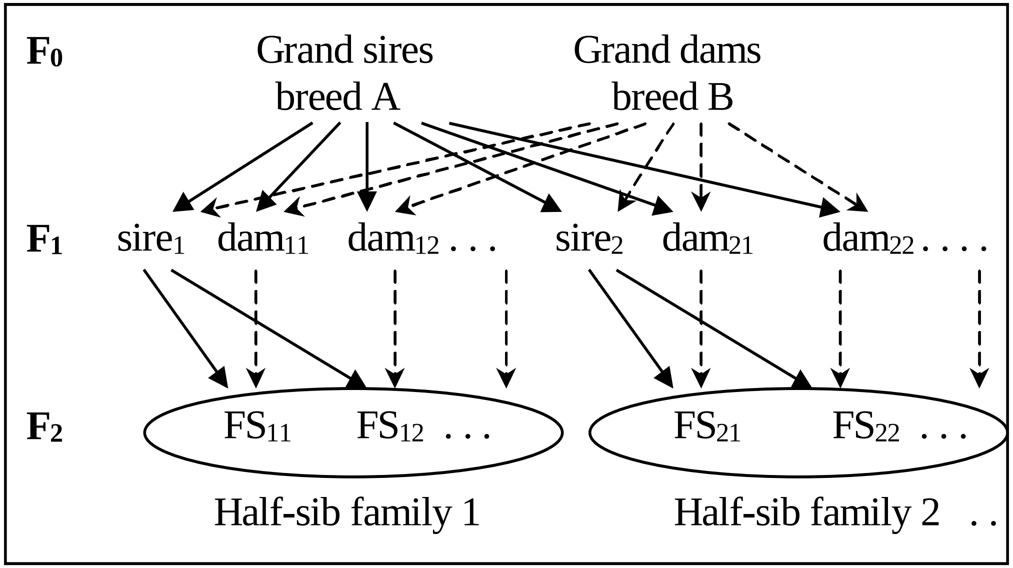


IFAFS project objectives



1) Develop and apply methods for combined analysis of the ISU and UIUC populations

Figure 1a. *Hierarchical structure of an F_2 resource population from outbred lines*[1)]



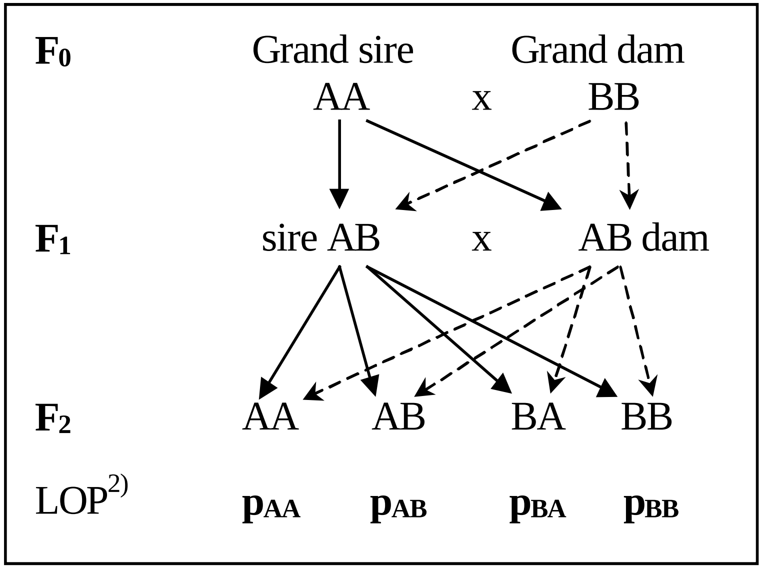
F_0 Grand sires breed A Grand dams breed B

F_1 sire_1 dam_{11} dam_{12} . . . sire_2 dam_{21} dam_{22} . . . .

F_2 FS_{11} FS_{12} . . . FS_{21} FS_{22} . . .

Half-sib family 1 Half-sib family 2 . .

1b. *Structure and line-of-origin probabilities (LOP) for a breed-cross analysis*[1)]



F_0 Grand sire AA x Grand dam BB

F_1 sire AB x AB dam

F_2 AA AB BA BB

LOP[2)] **p_{AA}** **p_{AB}** **p_{BA}** **p_{BB}**

[1)] Solid lines represent paternal transmission, dashed lines maternal transmission. FS represents full sib family.

[2)] p_{AB} is the probability that the paternal allele (1st index) originated from breed A and the maternal allele from B

IFAFS project objectives

2) Develop strategies for the use of QTL for meat quality in genetic improvement programs

provided by National Swine Registry

Both breeds had favorable alleles at alternate QTL

- Marker-assisted development of optimal synthetics
- Marker-assisted introgression of multiple QTL

IFAFS project objectives

Cont’d

3) Facilitate implementation of results by industry

- **Dissemination of information through**
  - **Scientific articles**
  - **Industry articles**
  - **Pig Genome Update Newletter**
  - **Direct contacts with breeders**
- **Industry workshop**