

# QTL mapping 4: multivariate phenotypes

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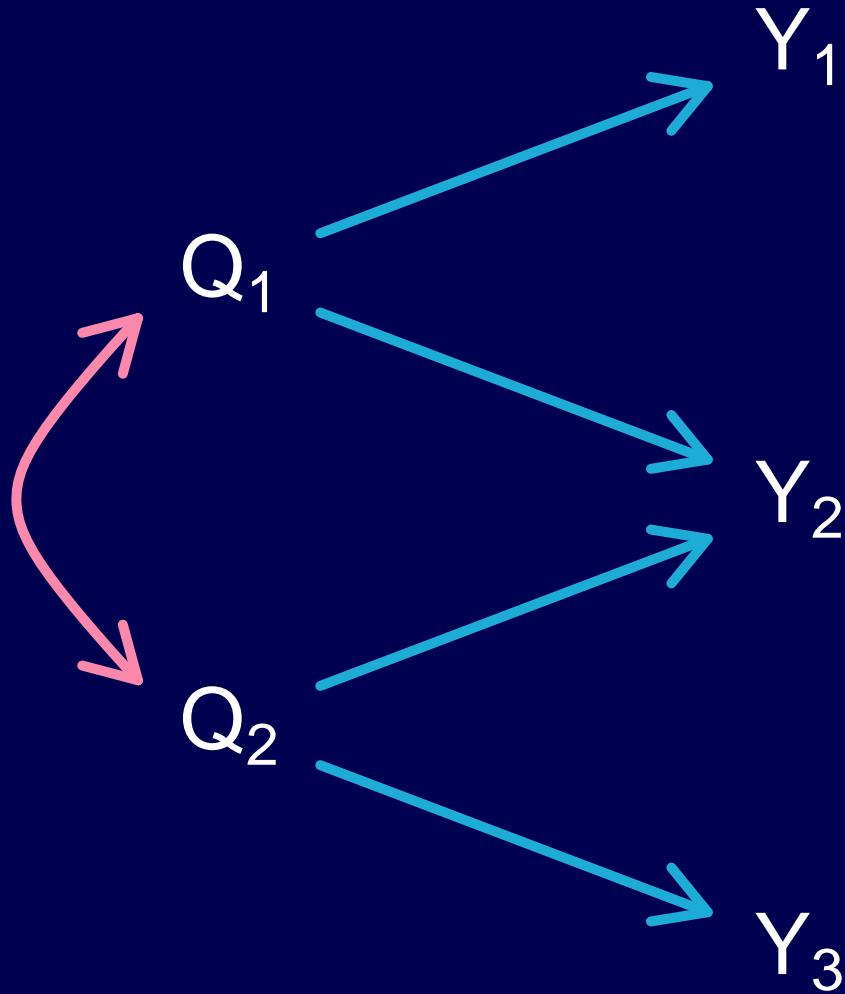
# Why multiple phenotypes?

- Might as well measure a bunch of stuff
- Not quite sure what to measure
- Interested in several related features
- Trying to get at intermediate biochemical processes
- What happens over time?
- Reduced measurement error → greater power

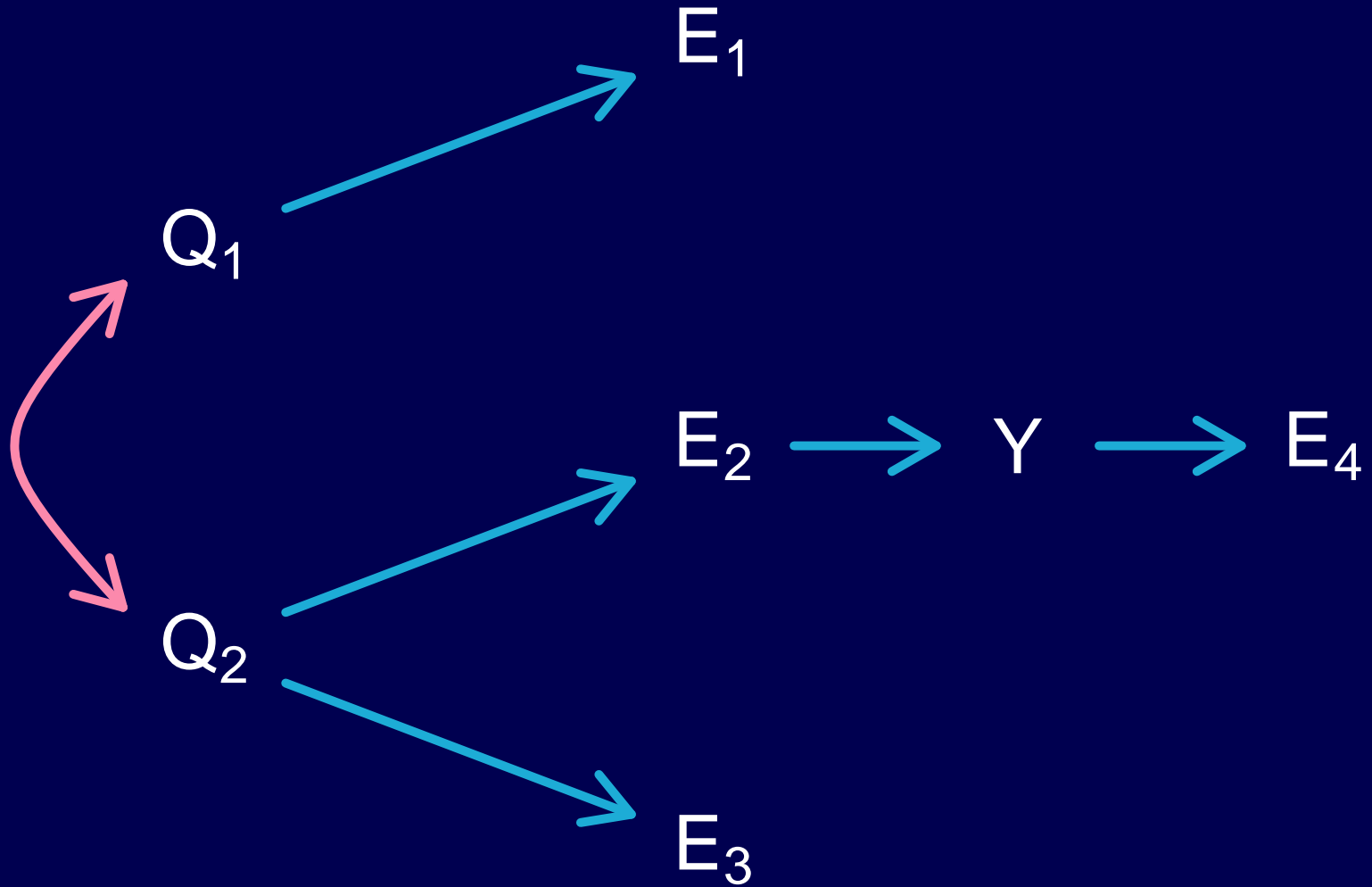
# Goals

- Use multiple phenotypes to improve QTL detection
- Do traits share QTL (pleiotropy)?
- Causal relationships among traits?
- Effects of QTL across time

# Pleiotropy?



# Causal?



# Basic model

One trait:

$$y = X\beta + \epsilon, \quad \epsilon \sim \mathbf{N}(0, \sigma^2)$$

Multiple traits:

$$Y = X\beta + \epsilon, \quad \epsilon \sim \mathbf{MVN}(0, \Sigma)$$

# Basic model

One trait:

$$y = X\beta + \epsilon, \quad \epsilon \sim \mathbf{N}(0, \sigma^2)$$

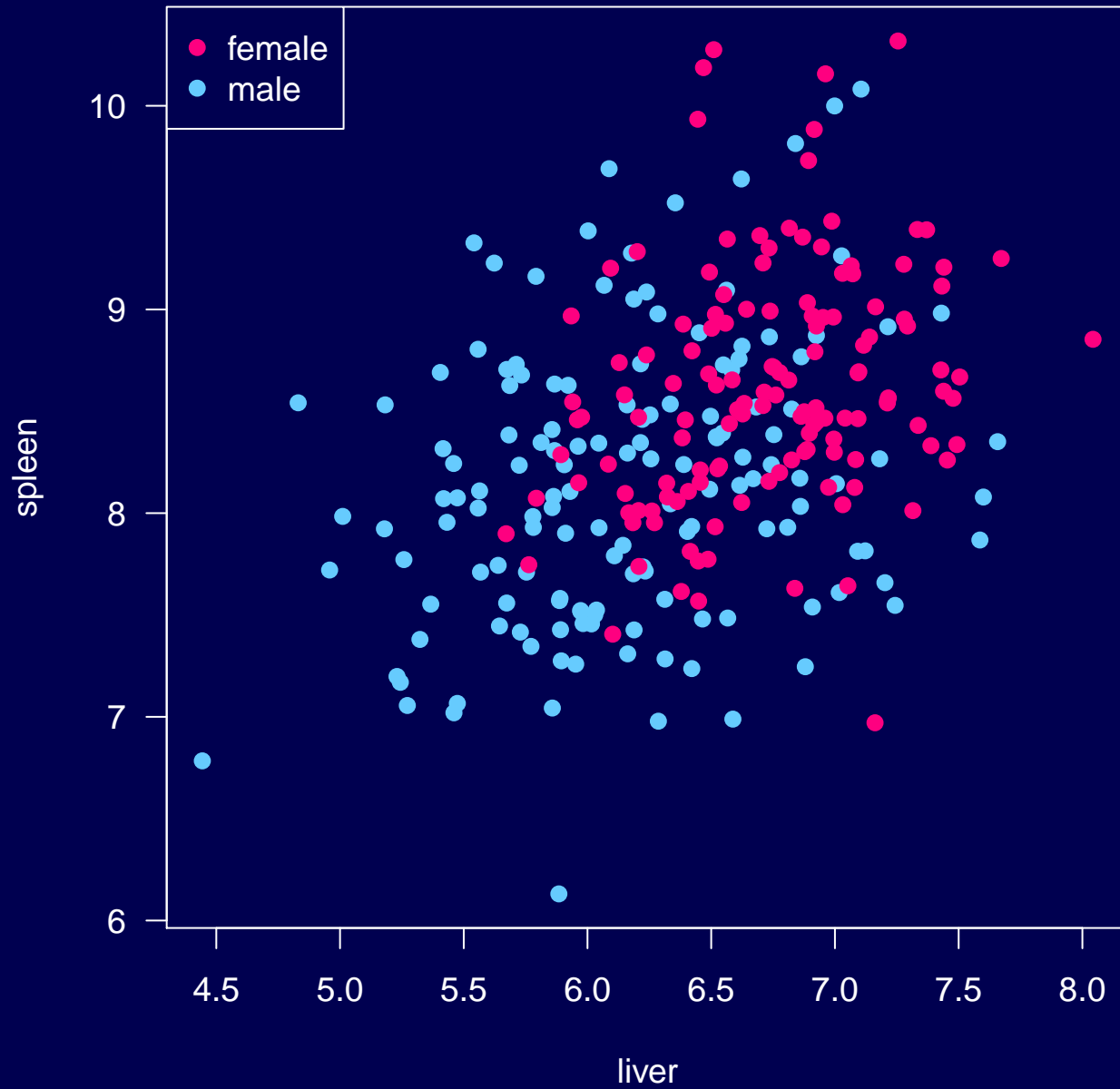
$$\text{LOD} = (n/2) \log_{10}(\text{RSS}_0/\text{RSS}_1)$$

Multiple traits:

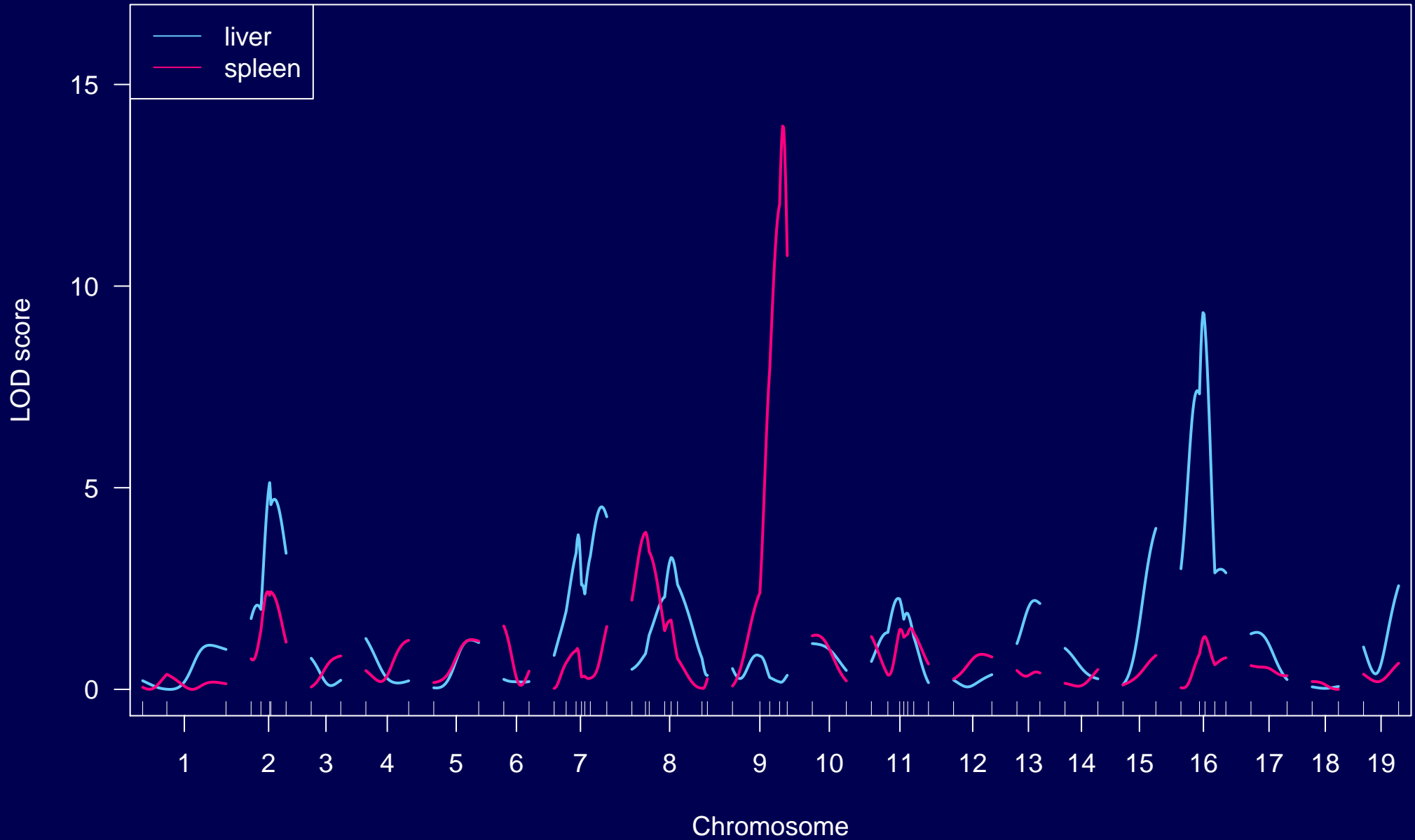
$$Y = X\beta + \epsilon, \quad \epsilon \sim \text{MVN}(0, \Sigma)$$

$$\text{LOD} = (n/2) \log_{10}(|\hat{\Sigma}_0|/|\hat{\Sigma}_1|)$$

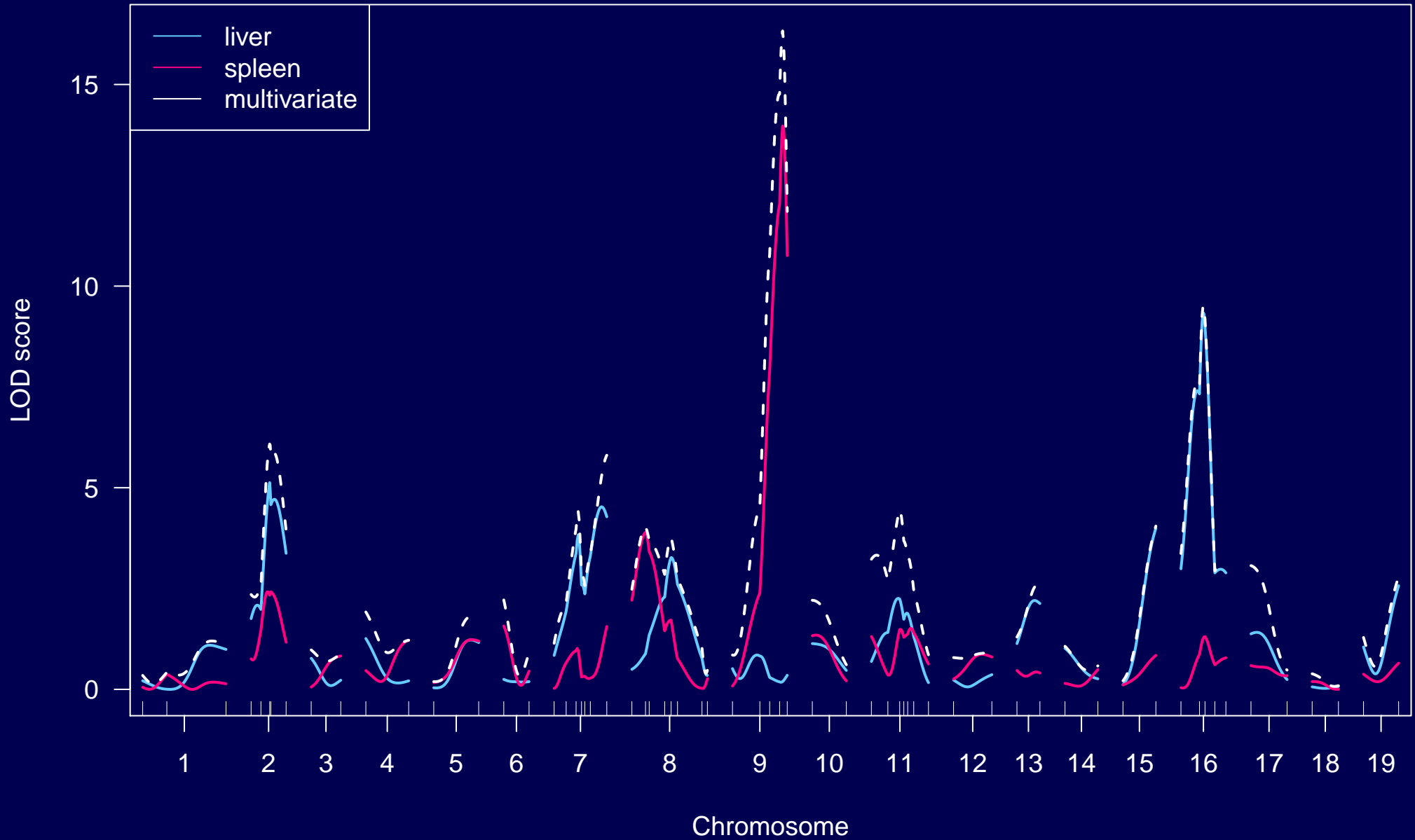
# Iron levels



# QTL scan



# QTL scan



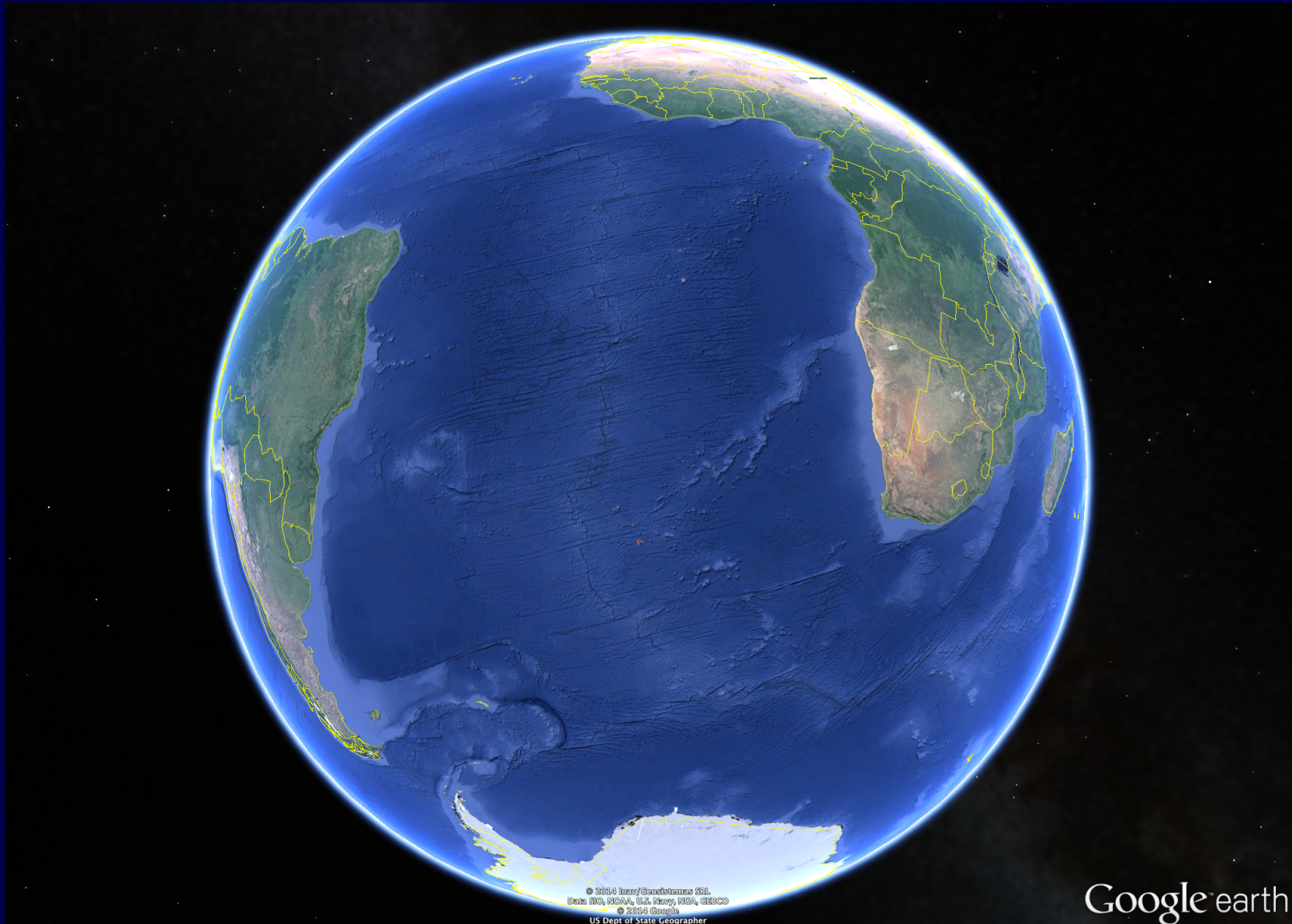
# Pleiotropy?

- Consider two traits
- Assume each affected by a single QTL
- Scan chromosome for single QTL, assuming it affects both
- Two-dimensional scan over chromosome, one QTL affecting one trait and other affecting the other trait
- Significance?
  - Parametric bootstrap using fitted single-QTL model
  - Stratified permutation test, permuting within strata defined by genotype at estimated single QTL

# Traits over time

- Fit model to each curve; use parameters as phenotypes
- Full QTL model of curves, where parameters depend on QTL genotypes
- Dimension reduction → standard multivariate QTL analysis
- Treat each time point individually, and then combine LOD scores

# Gough Island



# Gough Island



# Gough Island



# Big rodents



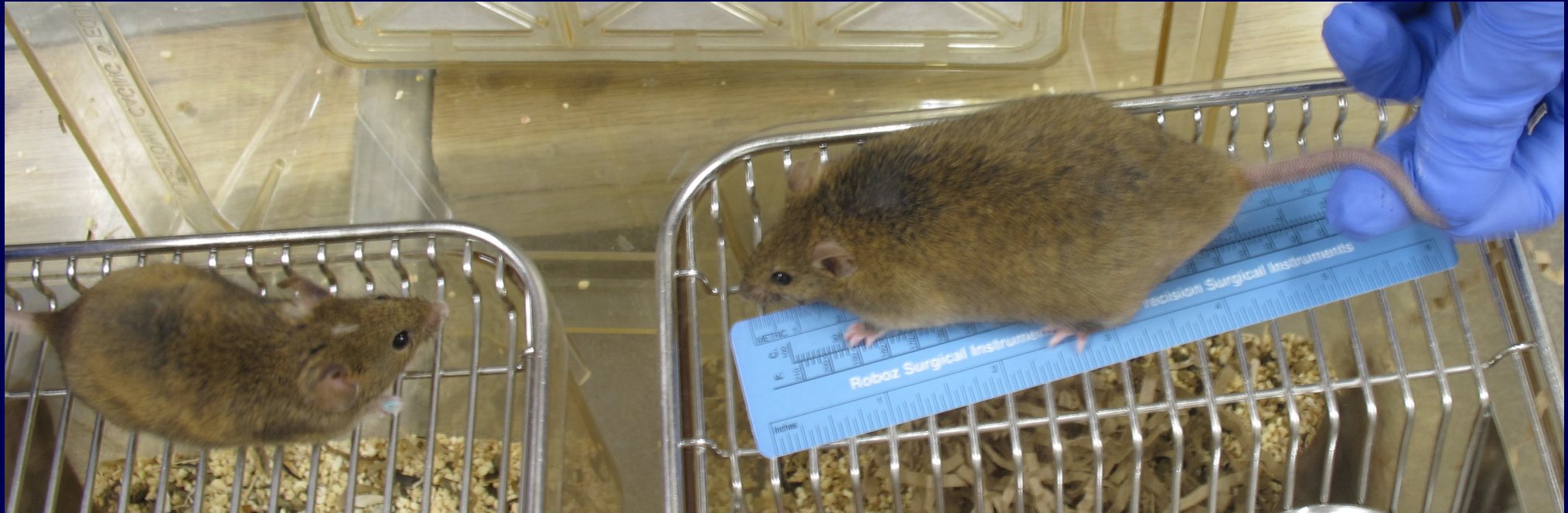
# Big rodents



# Big rodents

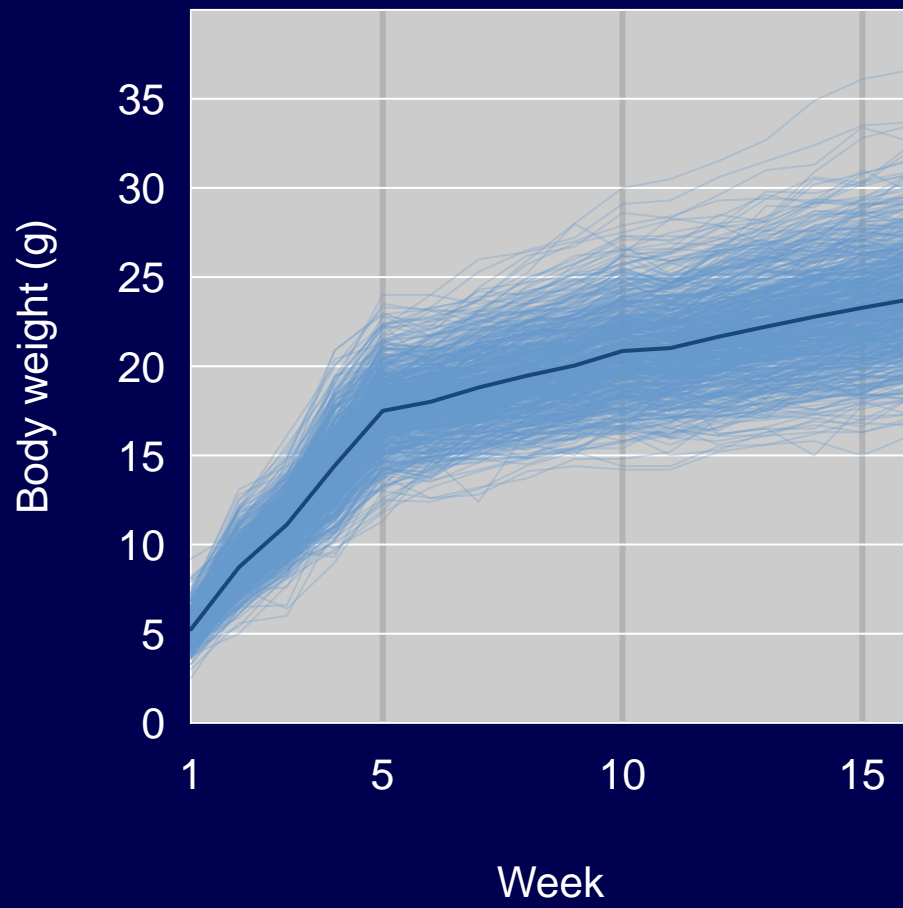


# WSB and Gough mice

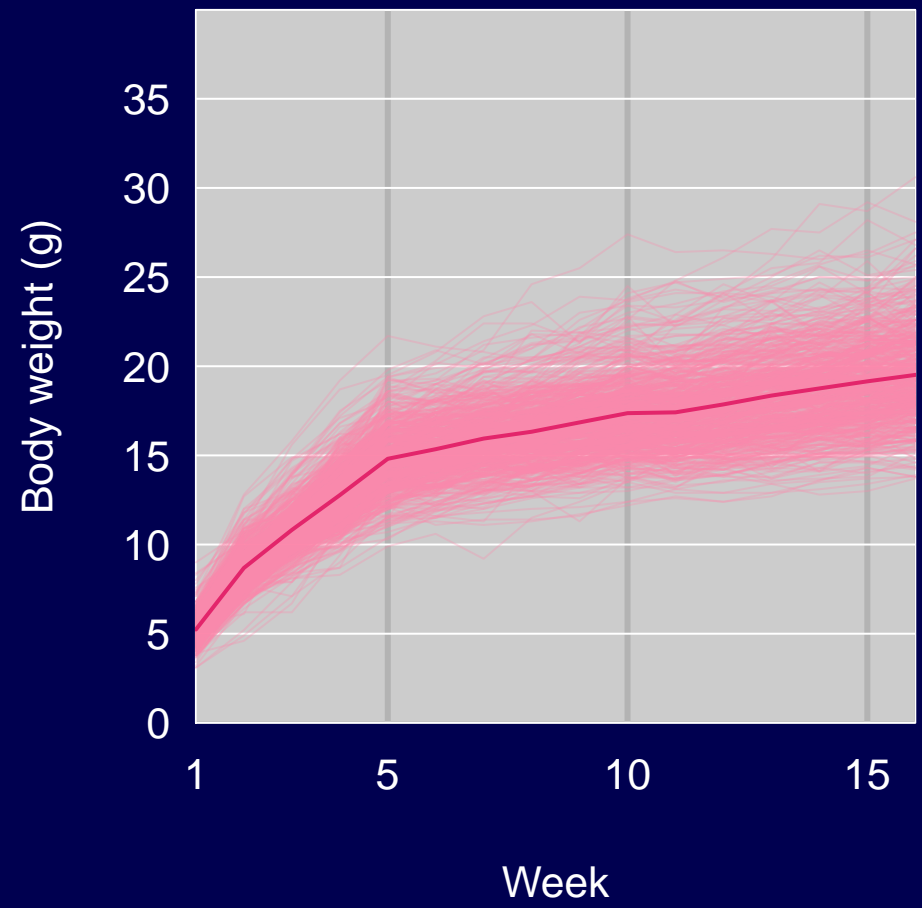


# Growth curves

## Males

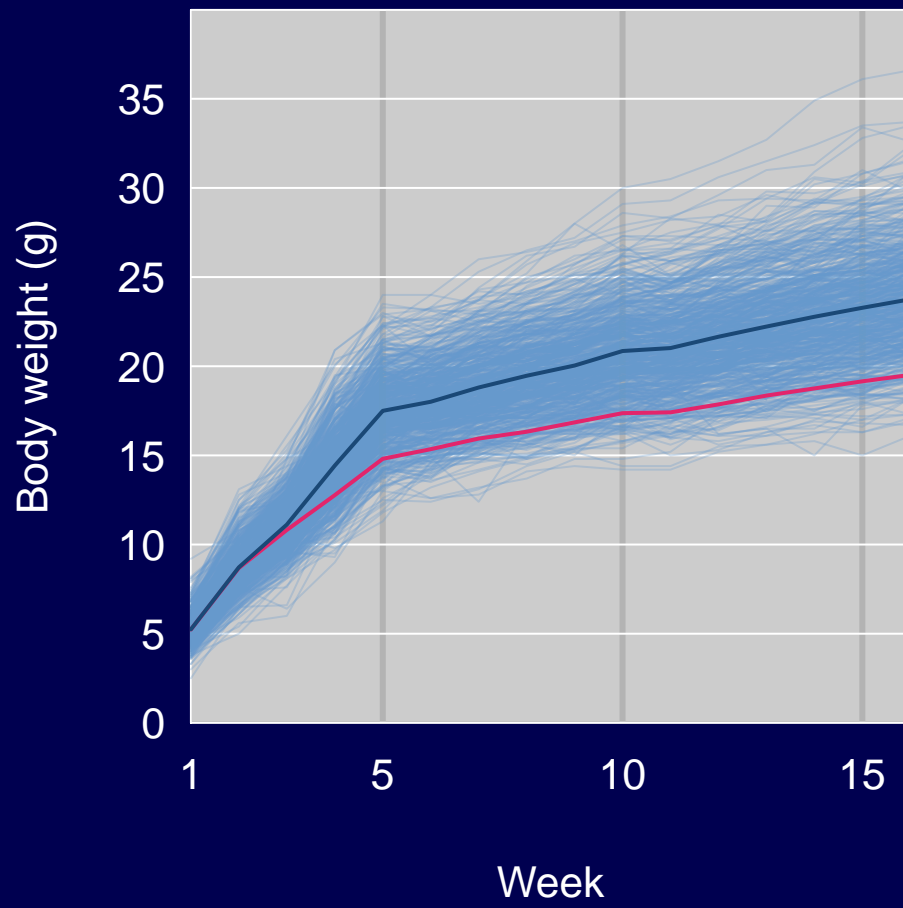


## Females

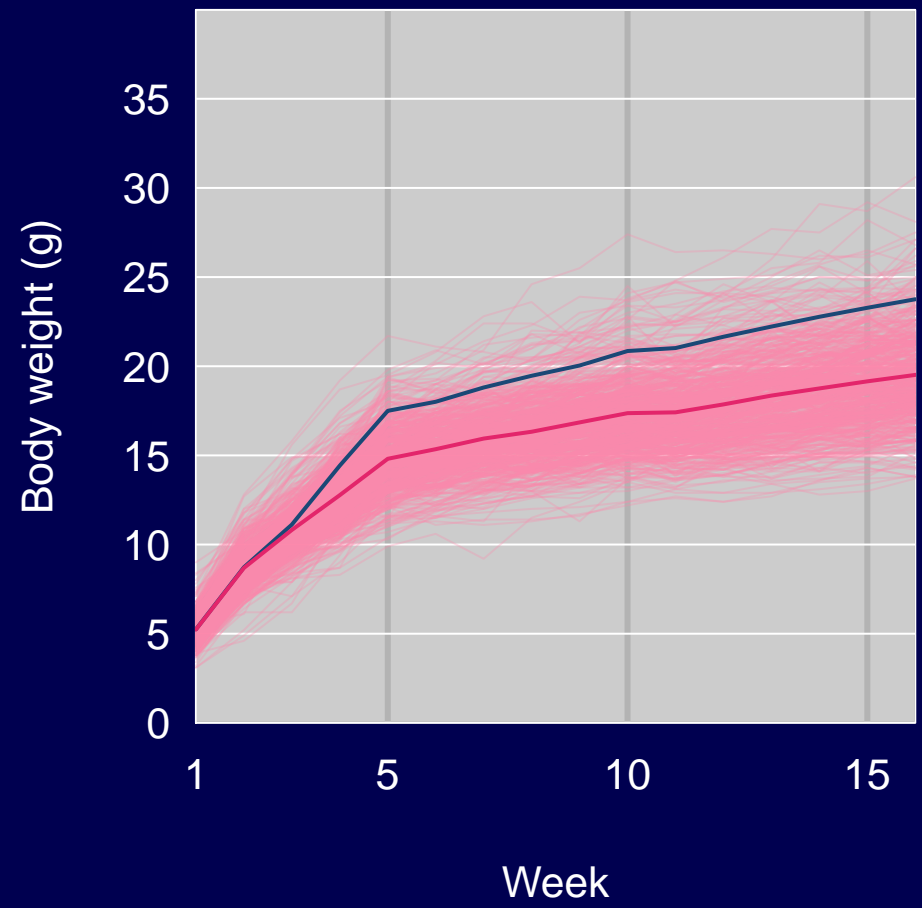


# Growth curves

## Males

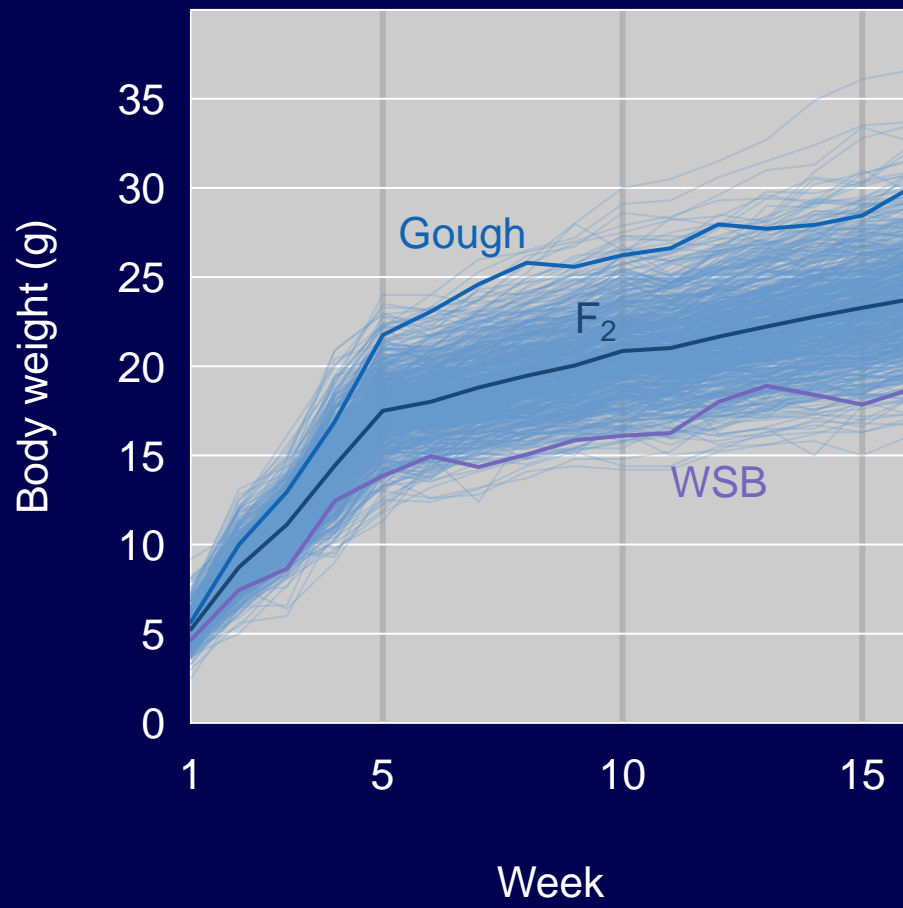


## Females

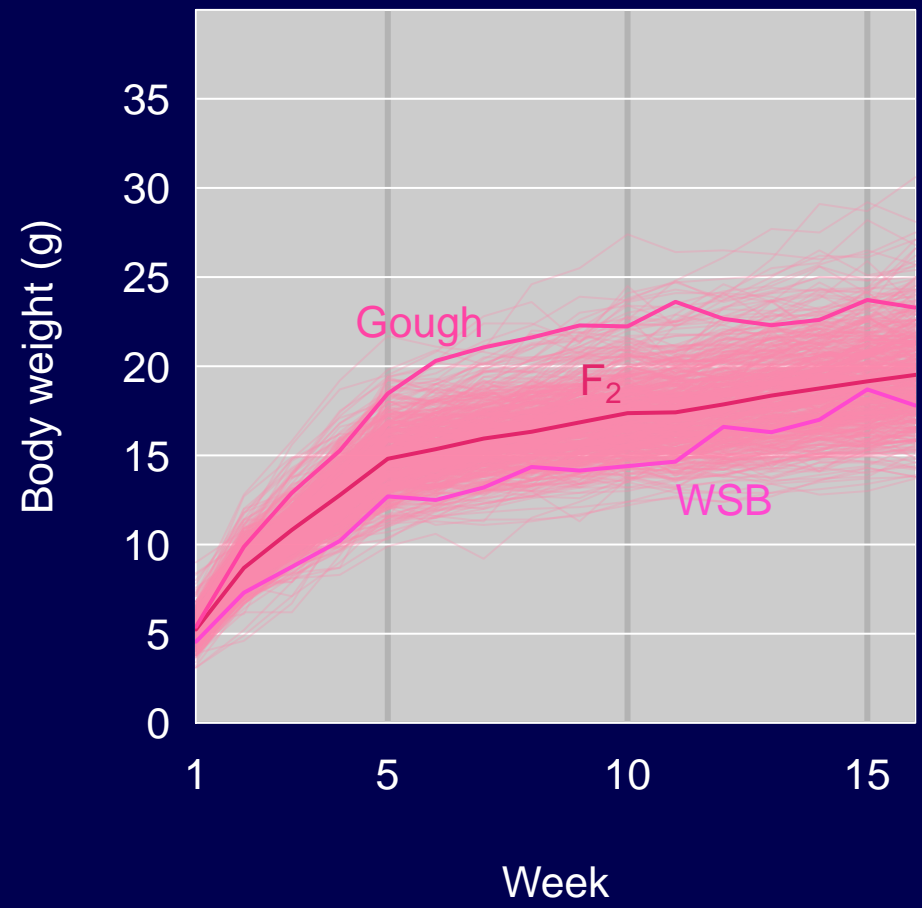


# Growth curves

## Males

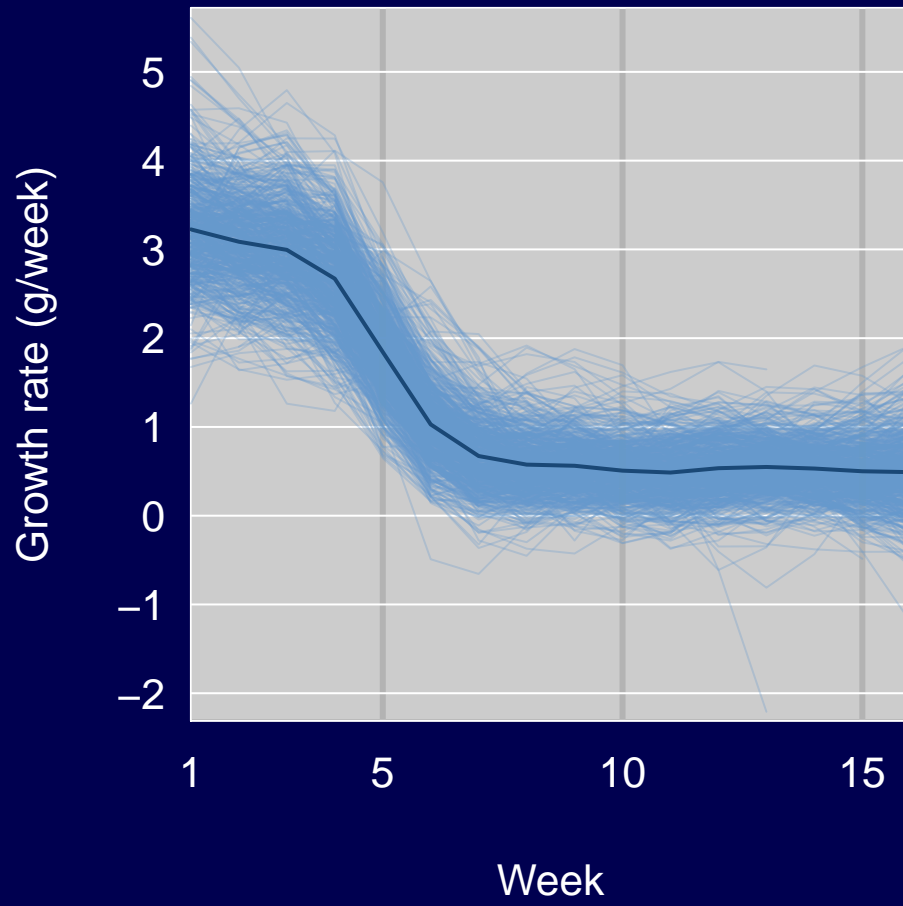


## Females

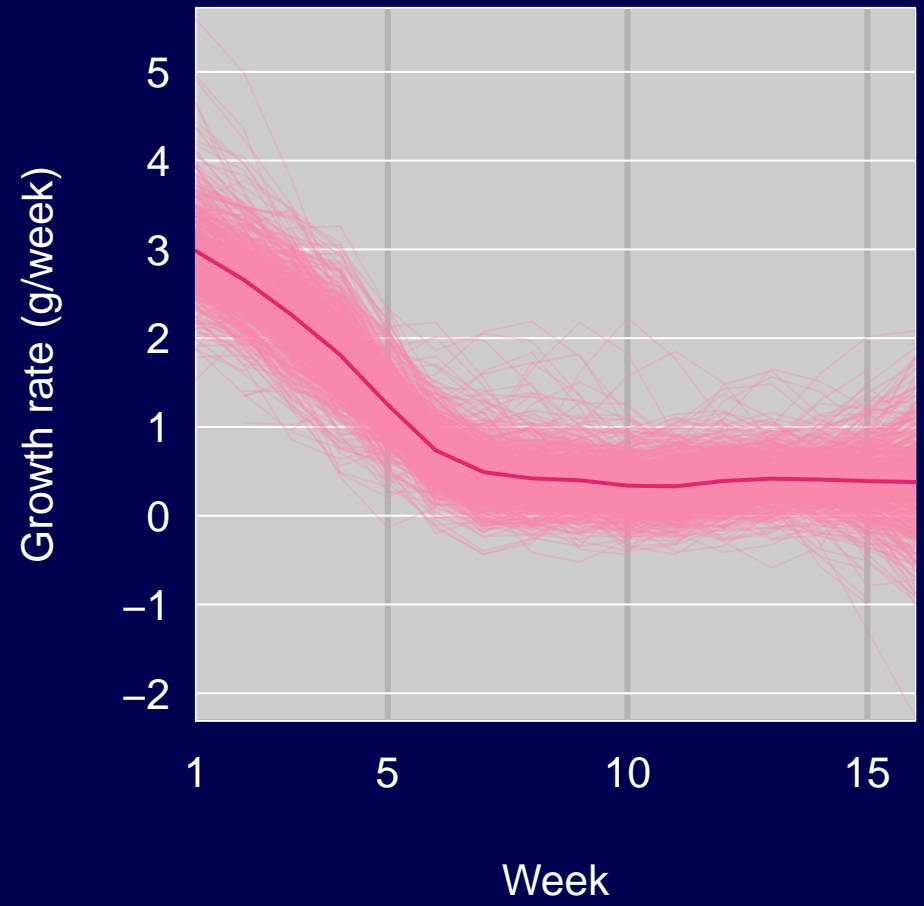


# Growth rate

## Males

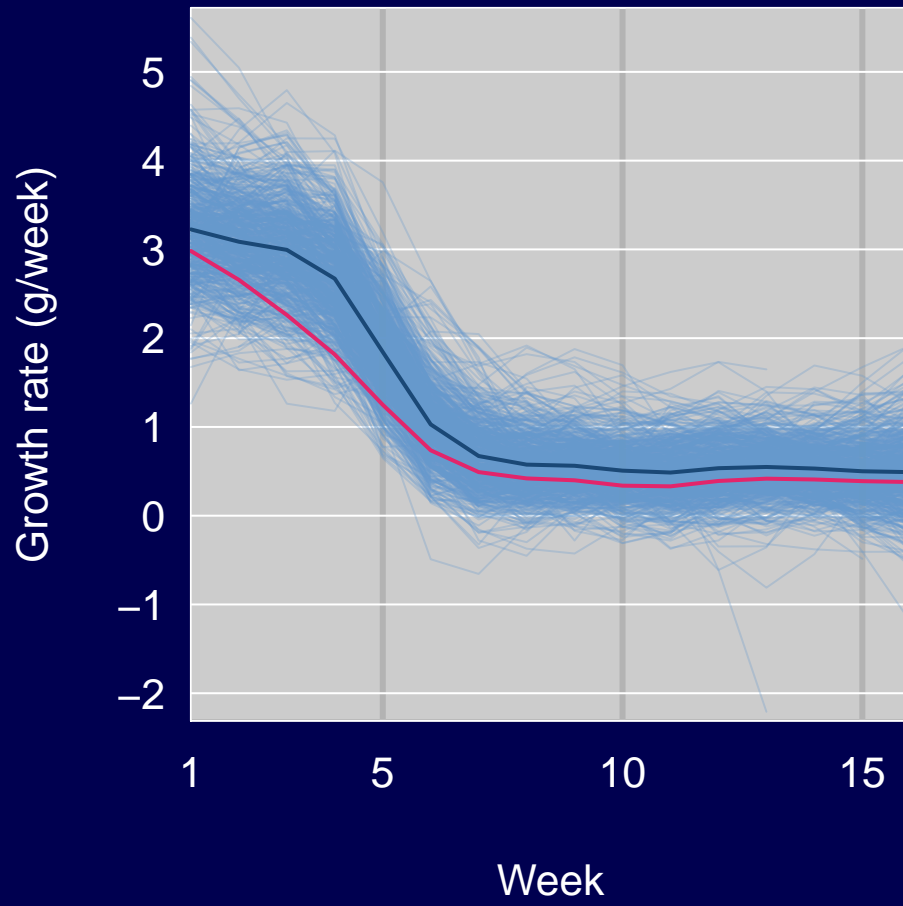


## Females

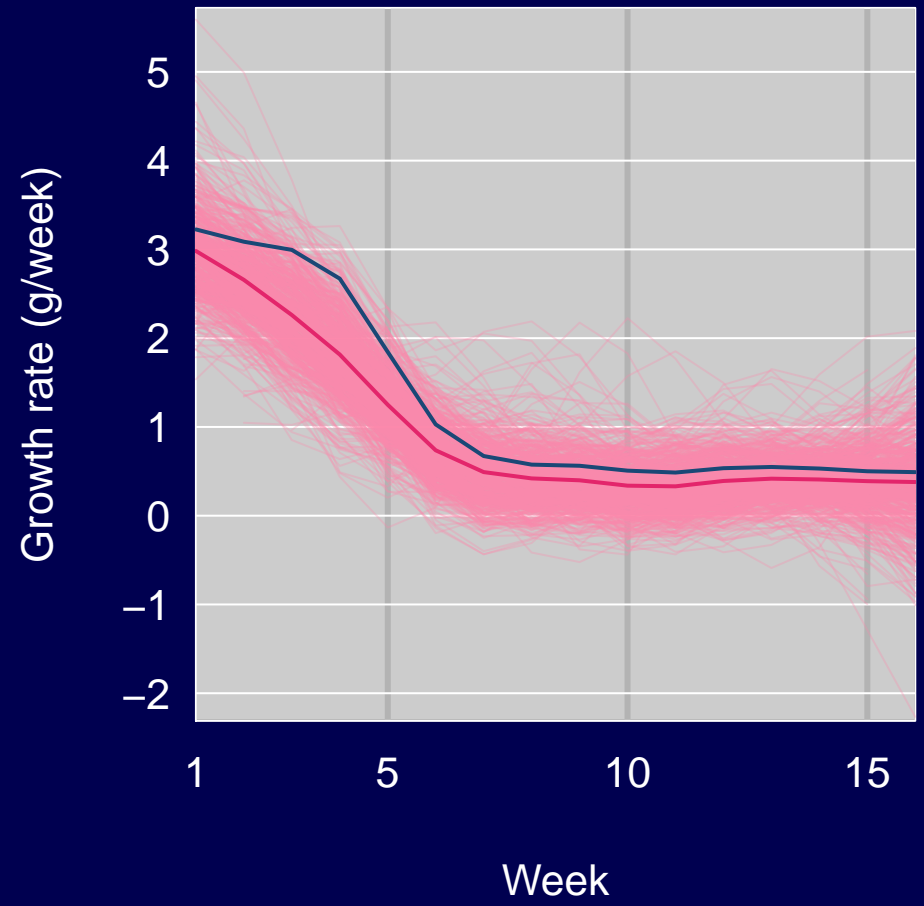


# Growth rate

## Males

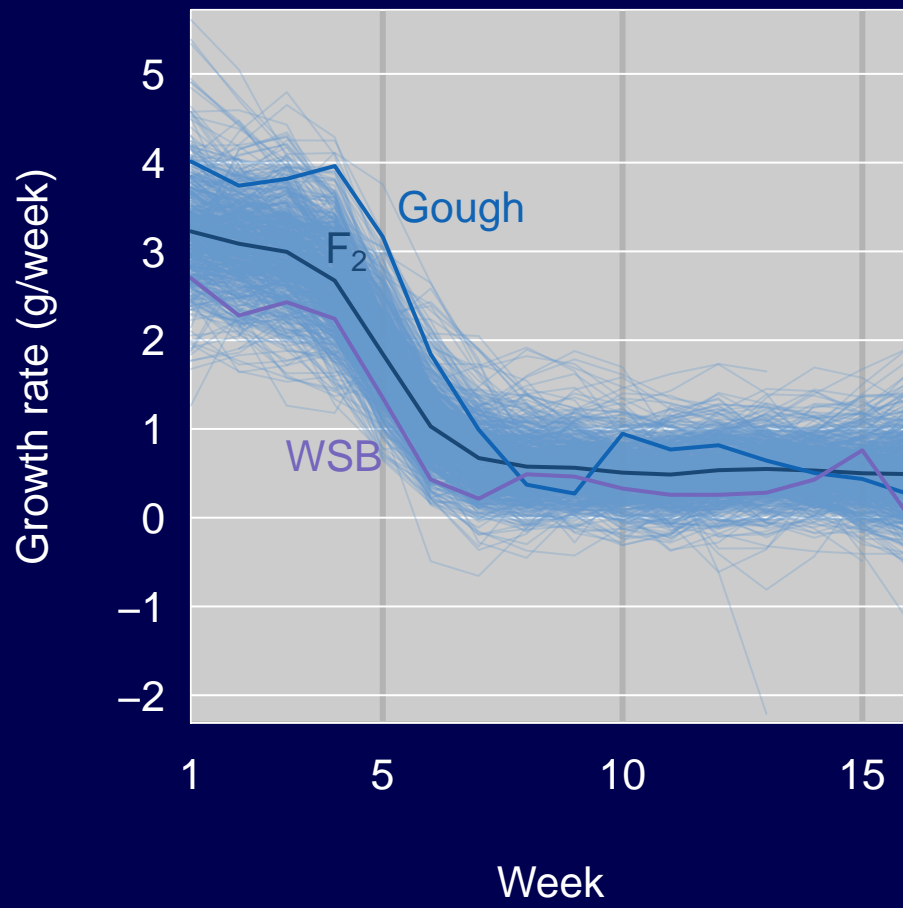


## Females

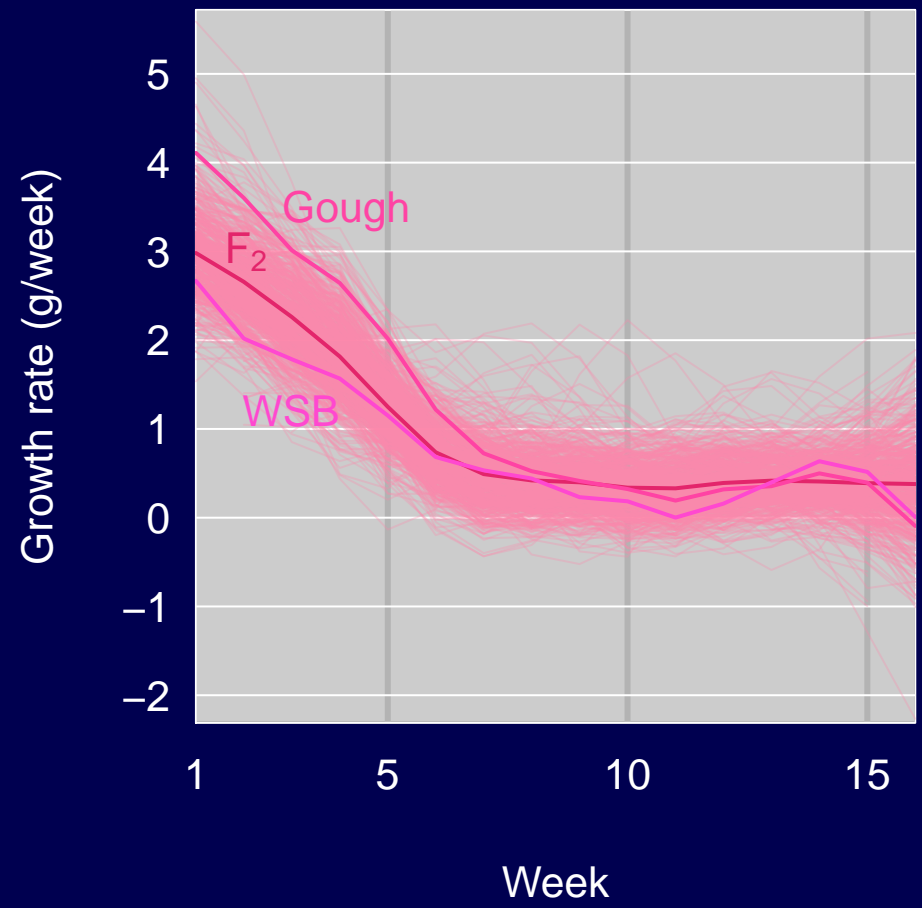


# Growth rate

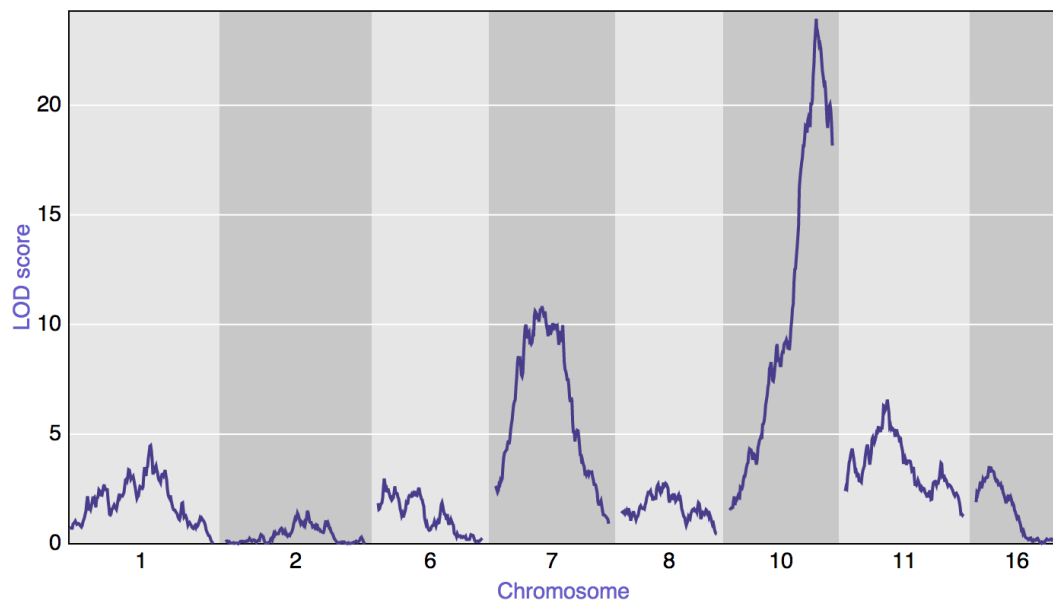
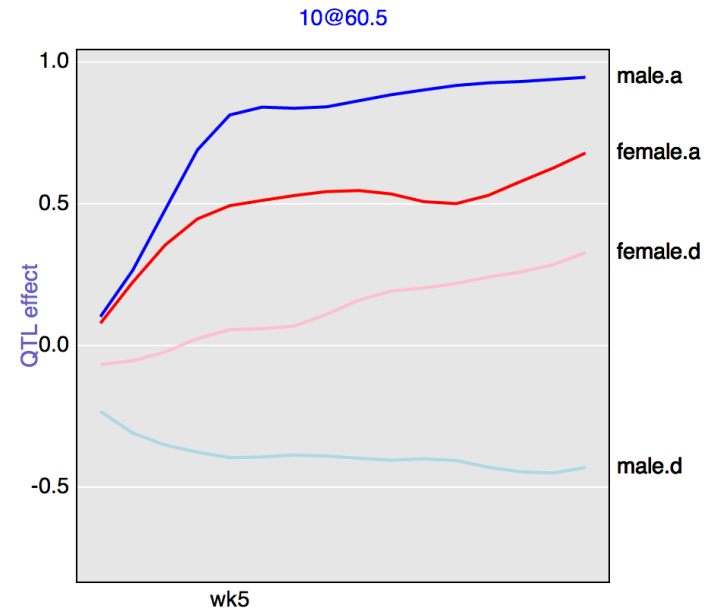
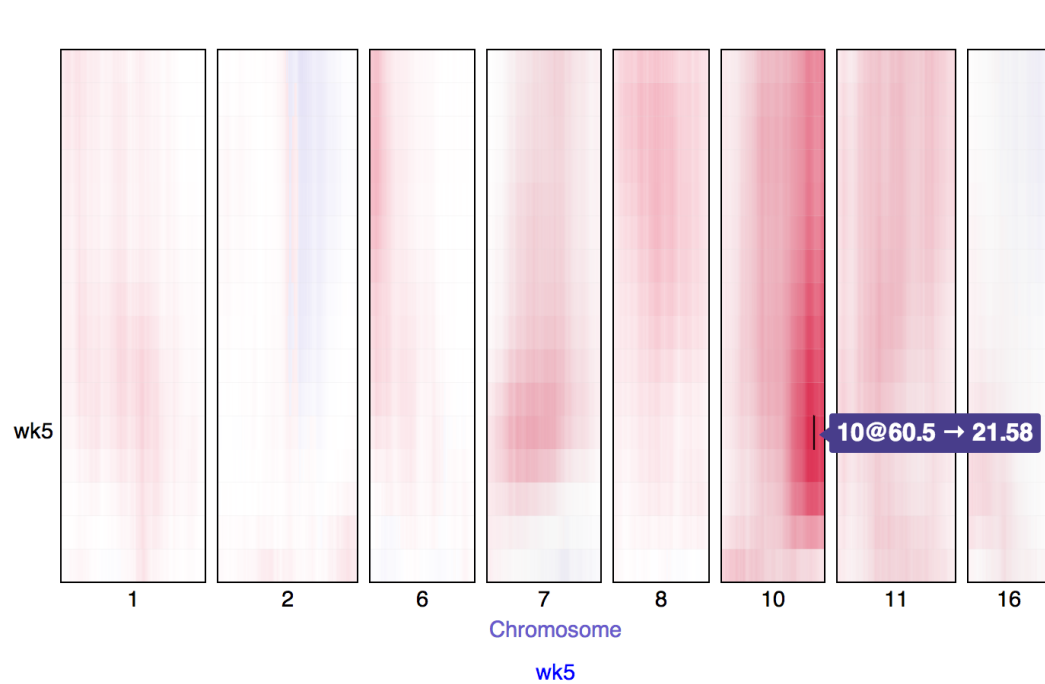
## Males



## Females



# QTL scan for body weight



# QTL scan for growth rate

