# Production Consequences of Low Birth Weight Pigs

*A comprehensive approach by the*

**K-State Swine Reproductive Physiology,**

**Muscle Biology, and**

**Swine Nutrition & Management labs**

K-State Swine Day - November 19, 2015

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# Research Progression

# Collaboration at K-State

- Our goal is to further the development of management strategies and technologies to improve piglet survivability and ultimate value.

## Large Litters – A Problem?
## Commercial Data – Purdue University

| Total Born | Survival, % | Number Weaned | Margin |
|---|---|---|---|
| 11 | 86.0 | 9.46 | |
| 12 | 83.5 | 10.02 | .56 |
| 13 | 81.0 | 10.53 | .51 |
| 14 | 78.5 | 10.99 | .46 |
| 15 | 76.0 | 11.40 | .41 |

# The Problem of Extreme Litter-size

## Statement of Fact –

Increasing Litter-size (LS) has long been a goal of Pig Breeders and Producers, because it (a) dilutes weaned pig cost and (b) increases number pigs to MKT.

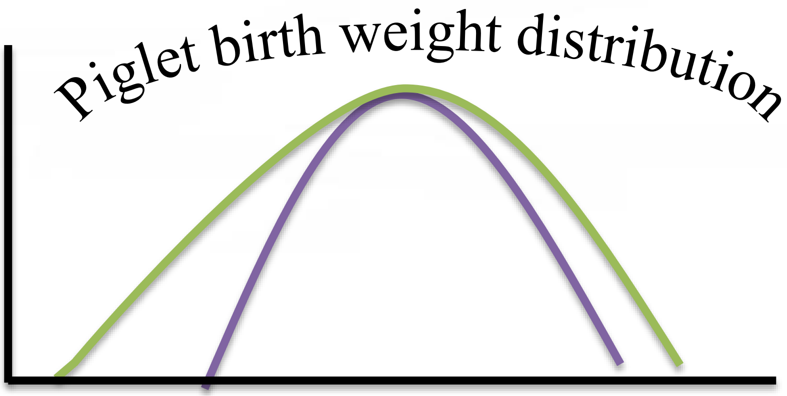
Rapid increases in LS is occurring because of Hyper-prolific sow subsets and a variety of gene markers. It is also clear (and predictable) that more piglets are born with low birth weight. Litter mortality is increasing in parallel to the Increase in Litter-size.

- This has Welfare implications (inadequate access to milk ➔ starvation)
- The Financial benefit is not clear (long-term effects not entirely clear)
- Is Phenomenon same for all Genetics ? (NO. Biological Implications Aware)

# Birth Weight and Mortality

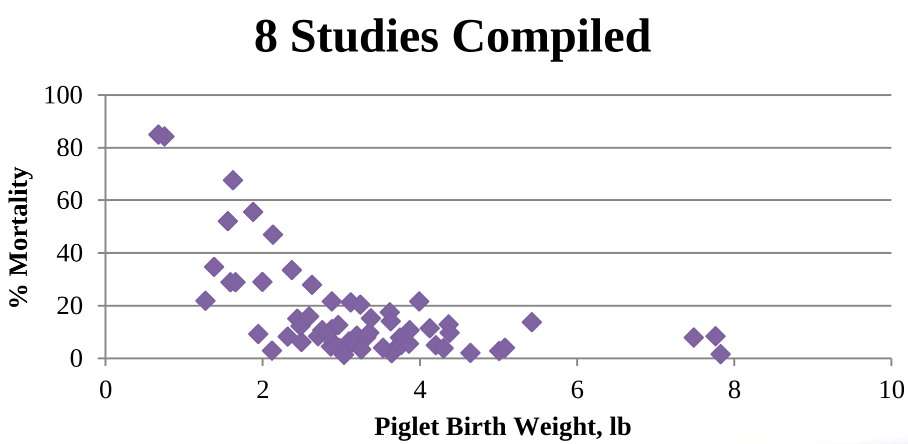
- Large litter sizes =

  Tyler et al., 1990
  Milligan et al., 2002




- Birth weight (BtW) & preweaning mortality:

  Quiniou et al., 2002
  Casellas et al., 2005
  Smith et al., 2007
  Bergstrom, 2011
  Da Silva, 2012
  Panzardi et al., 2013
  Ferrari et al., 2014
  Kohler and Bierman, 2014



# Birth Weight & Lifetime Performance

- Poor lifetime growth rate
  - Linear improvement with ↑ BtW up to 4.00 lb
  - Increased days to market
    - 2.2 vs. 4.4 BtW → 230 lb BW **= + 14 d**
    - 1.8-2.4 vs. 3.9-4.5 lb BtW → 225 lb BW **= + 12 d**
  - ↓ IGF-1 and fewer, larger muscle fiber numbers

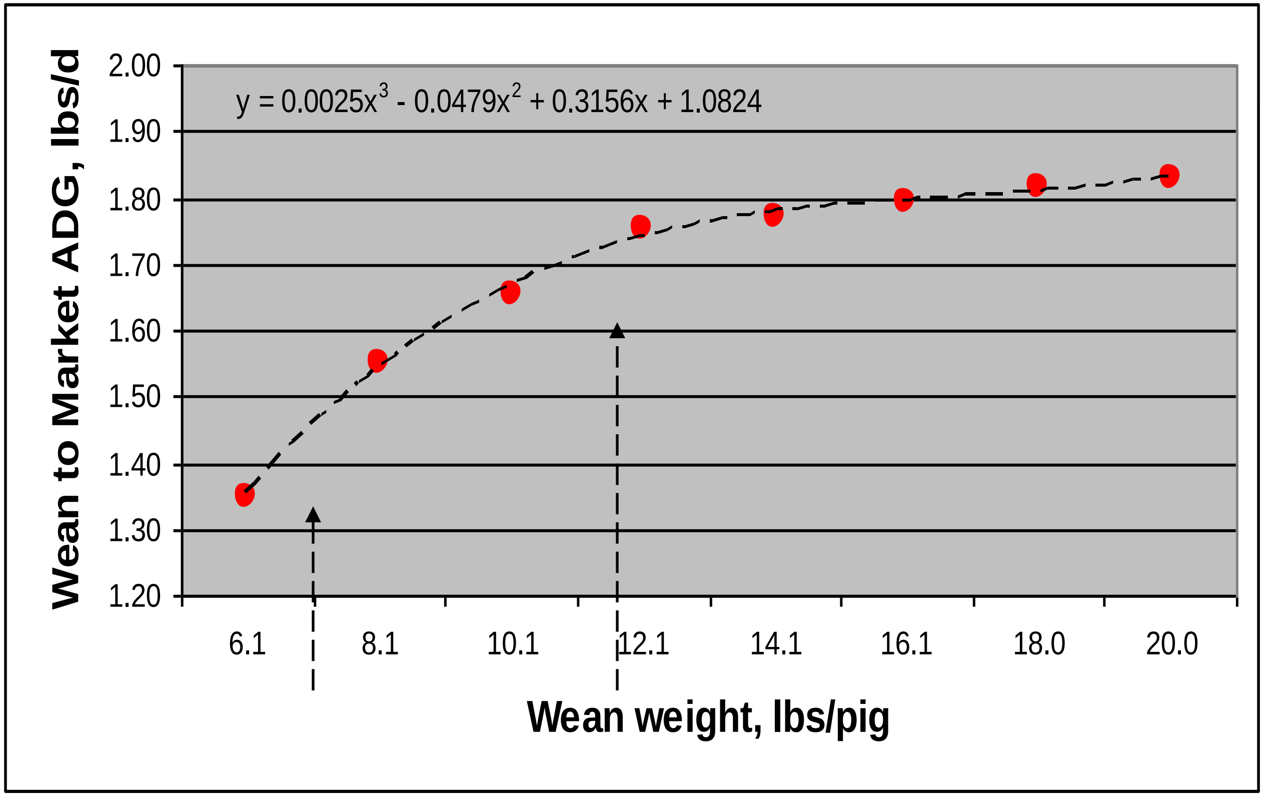
- Poor reproductive performance
  - Small litters, lighter BtW, more BtW variation

Quiniou et al., 2002; Gondret et al., 2005; Peterson, 2008; Corson et al., 2009; Beaulieu et al., 2010; Bergstrom, 2011; Douglas et al., 2013

# The Problem of Extreme Litter-size

Small Birth WT Pigs tend to have LO Wean WT.

How does Wean WT relate to W-F Growth Rate ?




<u>IF Facility Time = 160 W-F days</u>:

<u>7.0</u> lb Weaned Pig, 223 lbs b.w. vs <u>12.0</u> lb Pig, 289 lbs

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R. Dean Boyd, 2015

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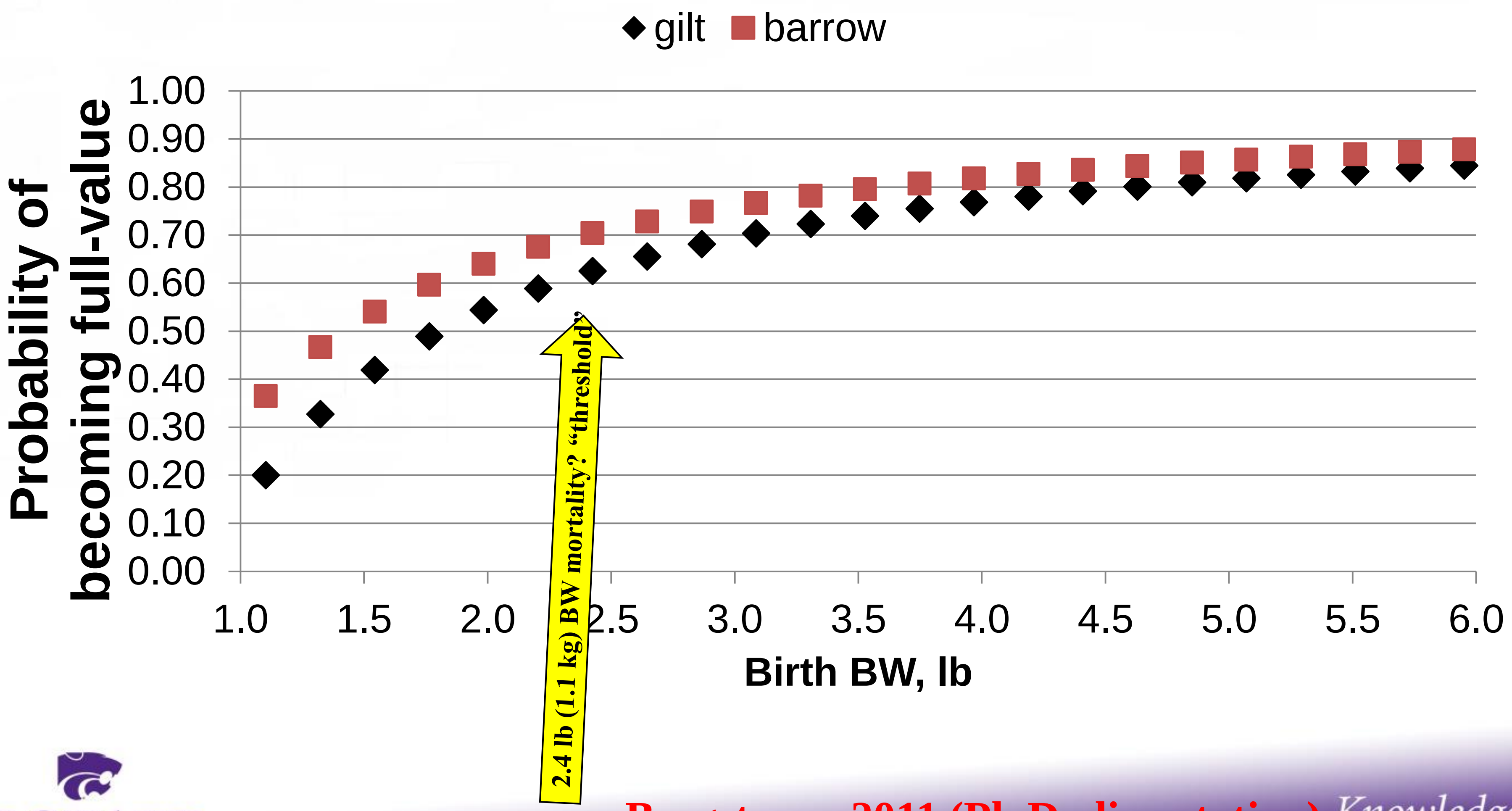
# Effects of piglet birth weight and gender on the probability of surviving pigs achieving full-value (>220 lb BW) at 180-d of age




**Bergstrom, 2011 (Ph.D. dissertation)**

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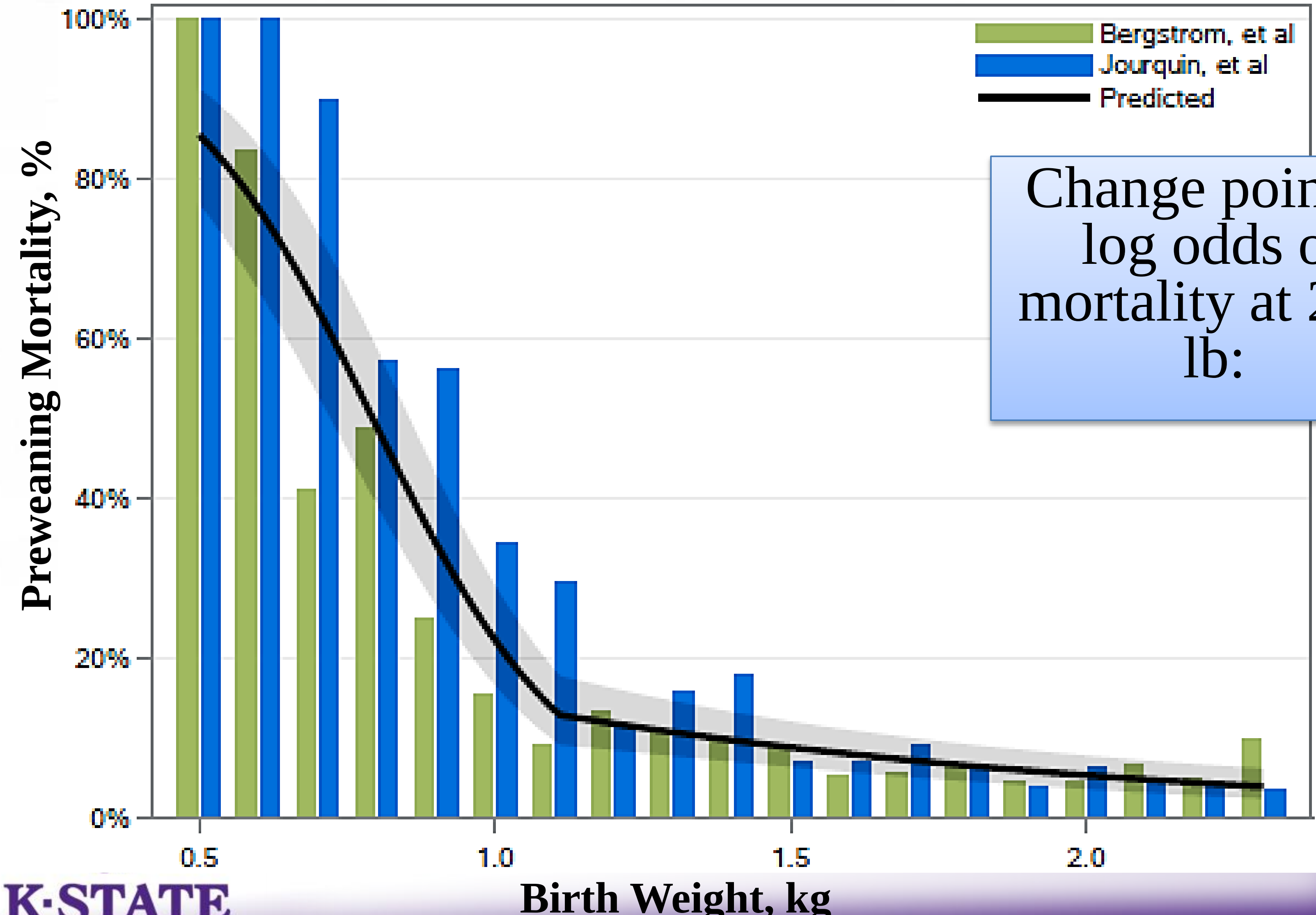
# Identifying “At-Risk”’ Birth Weight Pigs


- Is there a BtW threshold for survival across different animal and farm specific influences on mortality?

- Meta-Analysis
  - 4 different farms from 2 different studies
  - 4,068 records of BtW and preweaning survival outcomes

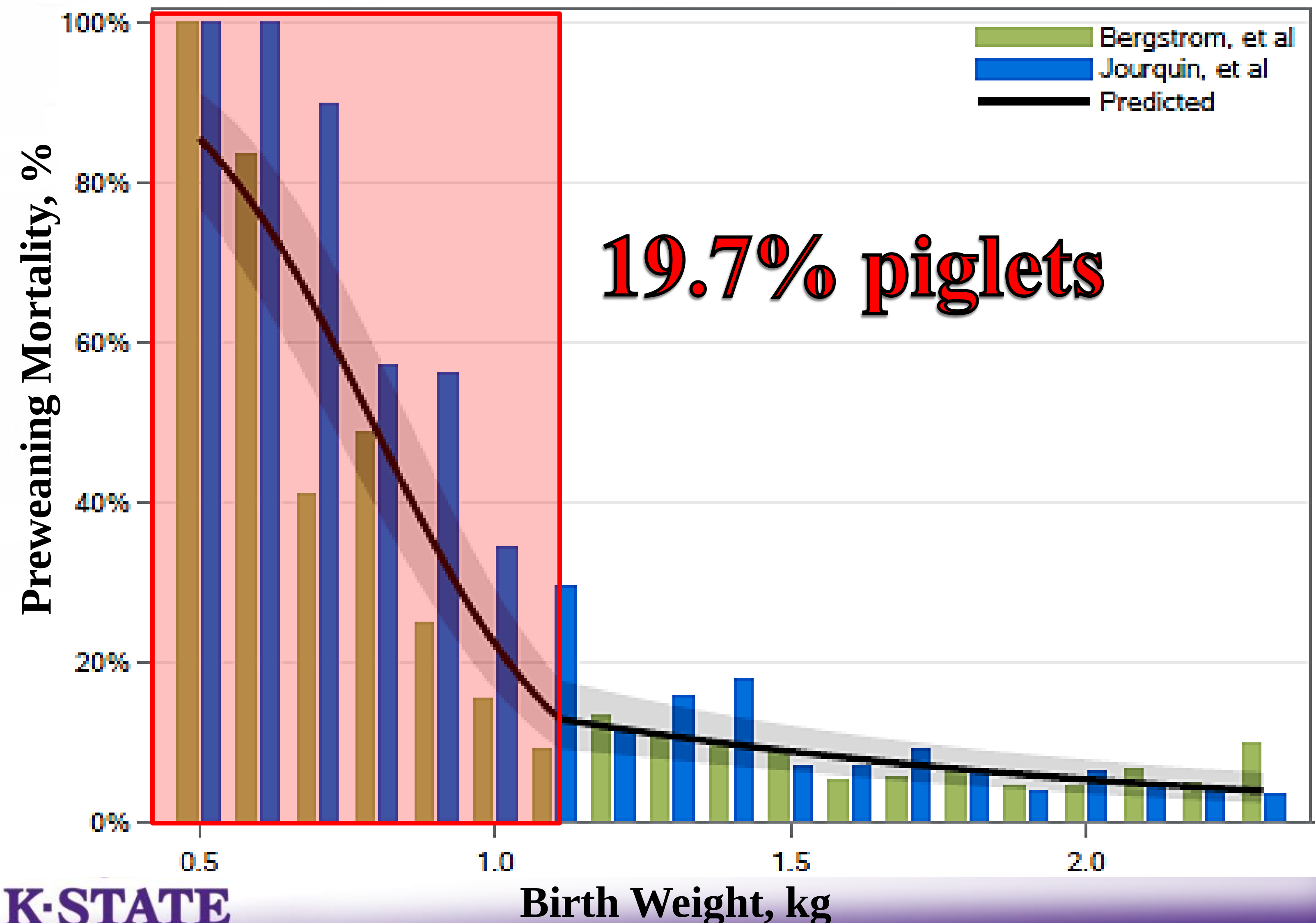
- Mixed effects logistic regression model
  - Random effect of study
  - Piece-wise linear predictor
  - Change point of model determined by comparing model fit for BtW ranging from .7 lb to 5.5 lb based on maximizing the likelihood

# Predicted Preweaning Mortality by BtW




Change point in log odds of mortality at 2.45 lb:

# Predicted Preweaning Mortality by BtW



# Conclusion

- Individual BtW is strongly associated with risk of preweaning mortality and relationship is non-linear.
- < 2.45 lb BtW pigs determined to be “at risk” pigs using logistic regression analysis
- Successful interventions may take the form of strategic postnatal intensive care or prenatal efforts to improve musculoskeletal development and BtW
- However, the latter approach of improving BtW not only can improve piglet survivability outcomes, but also contribute to greater lifetime growth and productivity of the pig and profitability to the swine producer.

# Fetal Muscle Development

- Muscle Mass Equation

Ultimate Muscle Mass = Muscle Cell Number + Cell Enlargement

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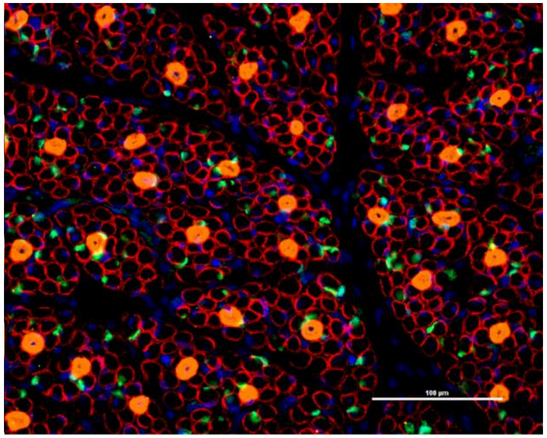
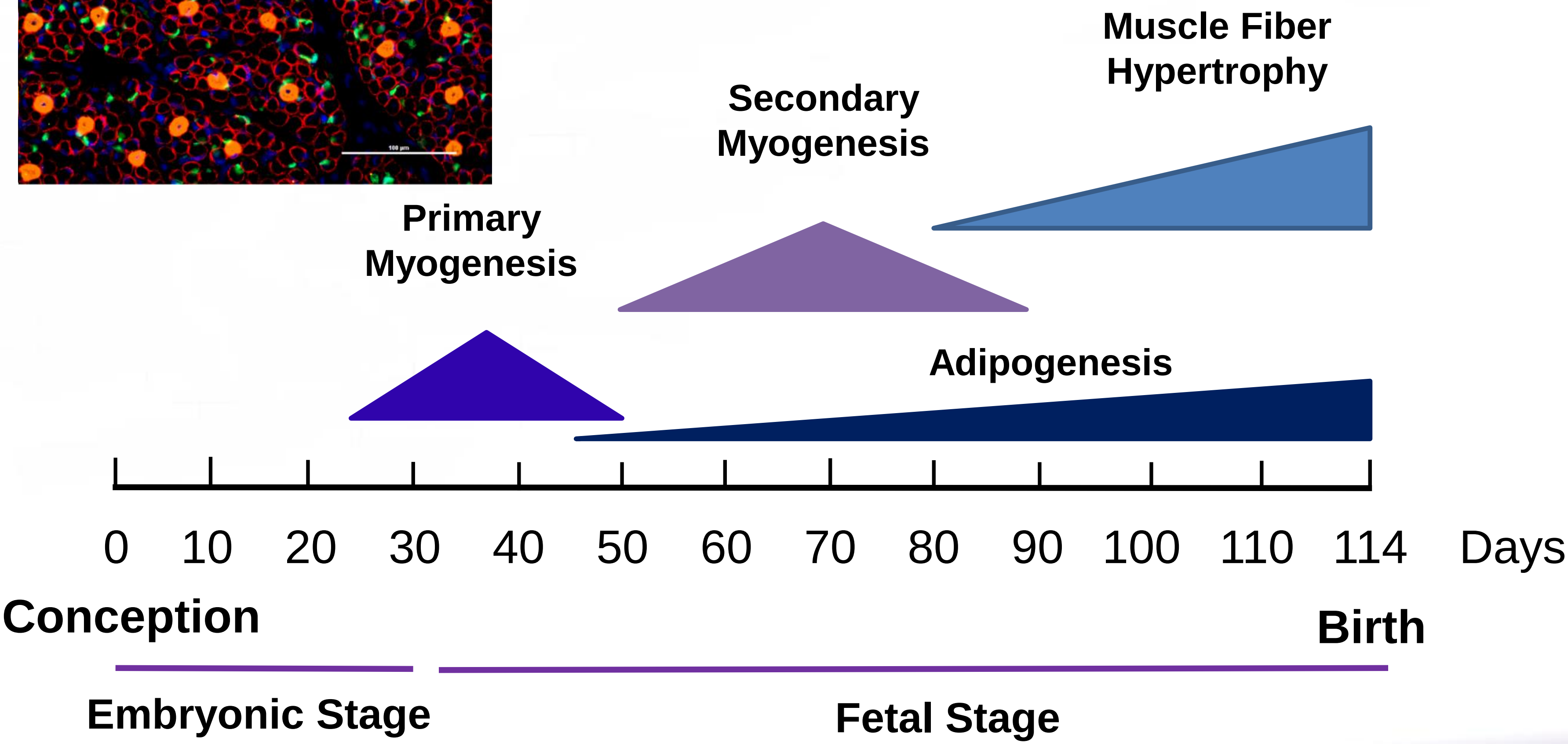
# Fetal Muscle Development



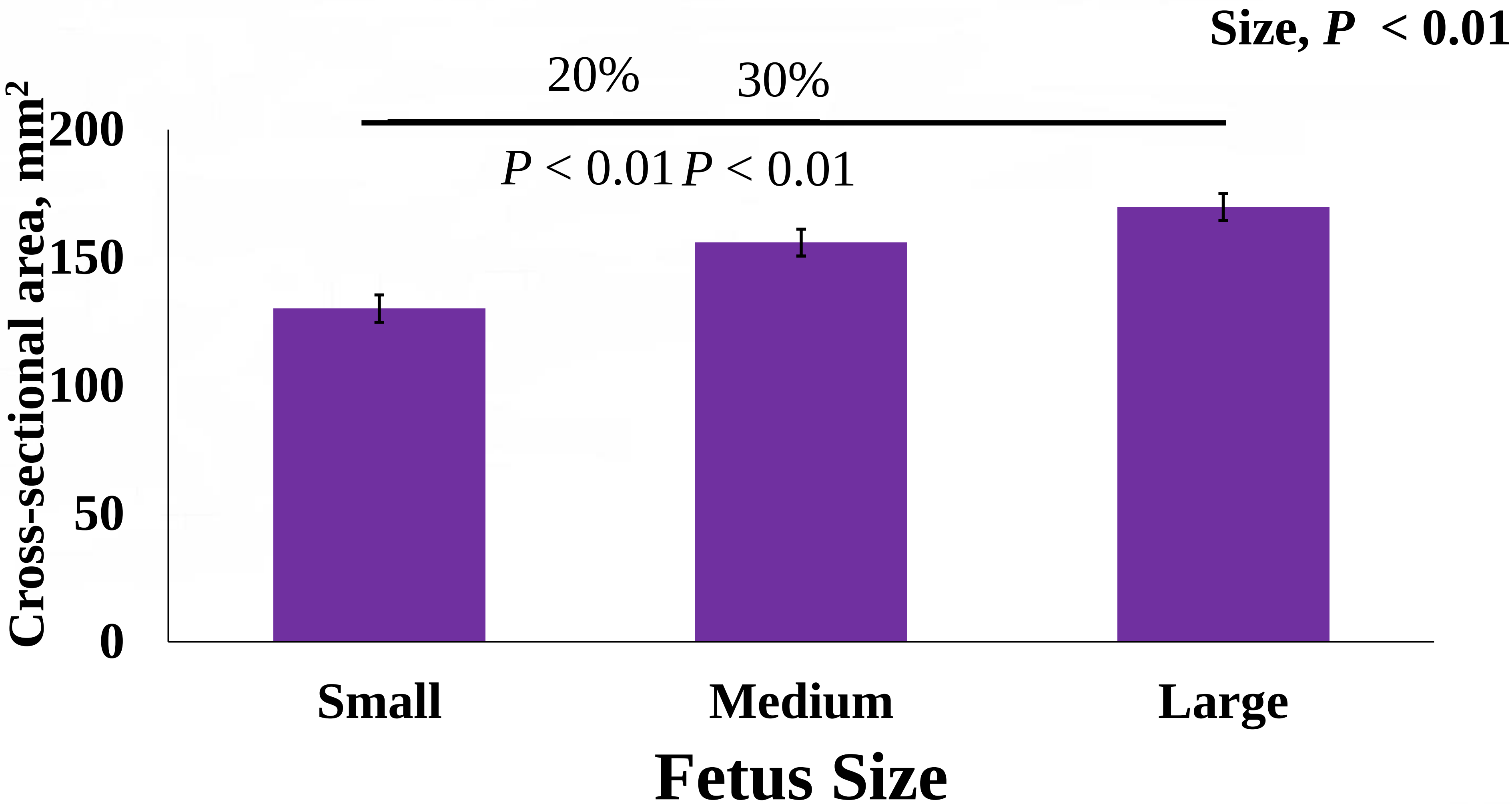


# 60-d Fetus Muscle Area Differences

| | Fetus size[1] | | |
|---|---|---|---|
| | Medium | Large | *P* - value |
| Whole muscle area, $mm^2$ | 13% | 21% | < 0.01 |
| Primary fiber number | 12% | 13% | 0.03 |
| Primary fiber area, $\mu m^2$ | No difference | No difference | 0.11 |
| Secondary per primary | No difference | 14% | <0.01 |

[1]Percent differences compared to small fetus.

# 90-d Fetus Muscle Area

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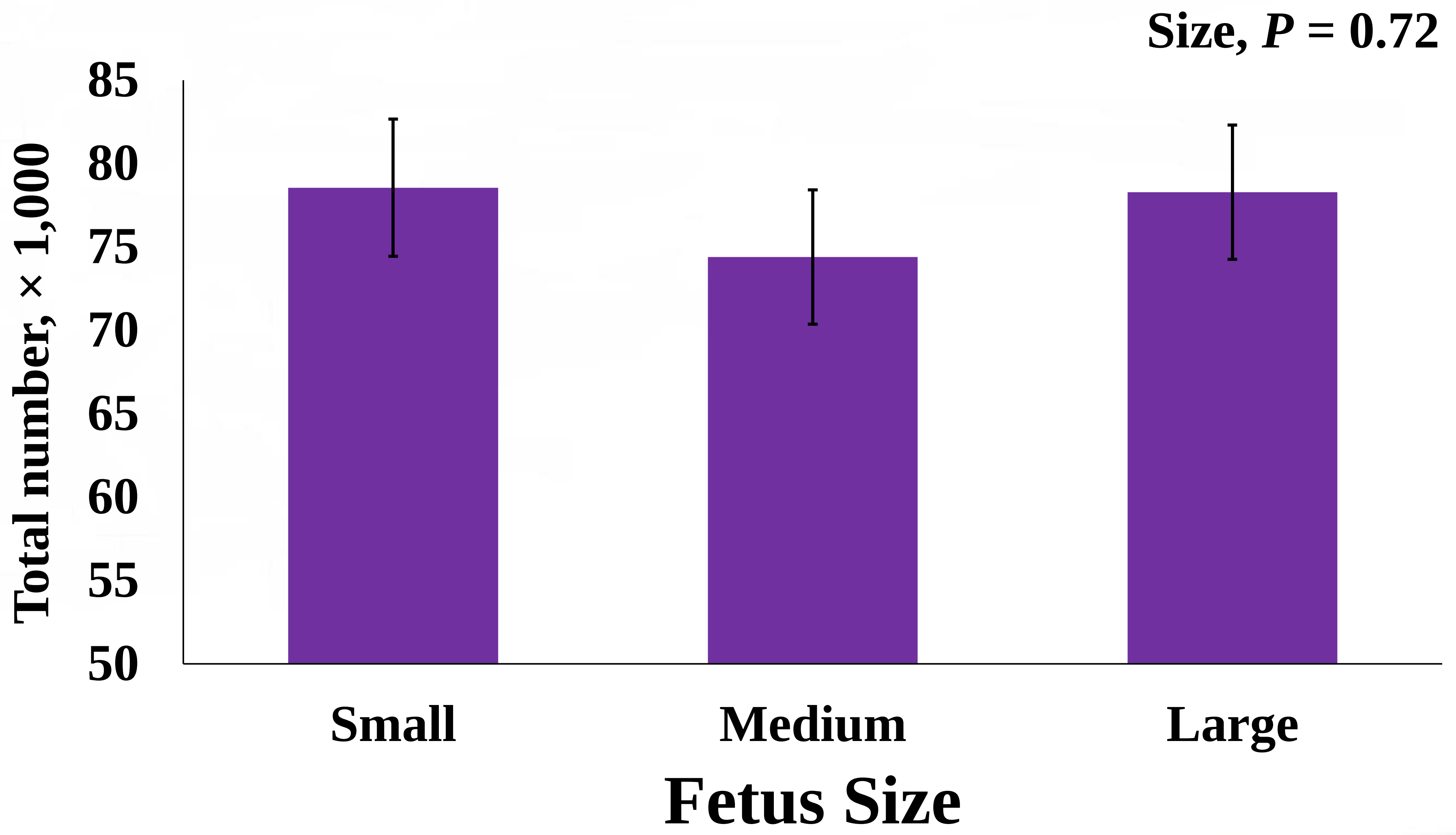
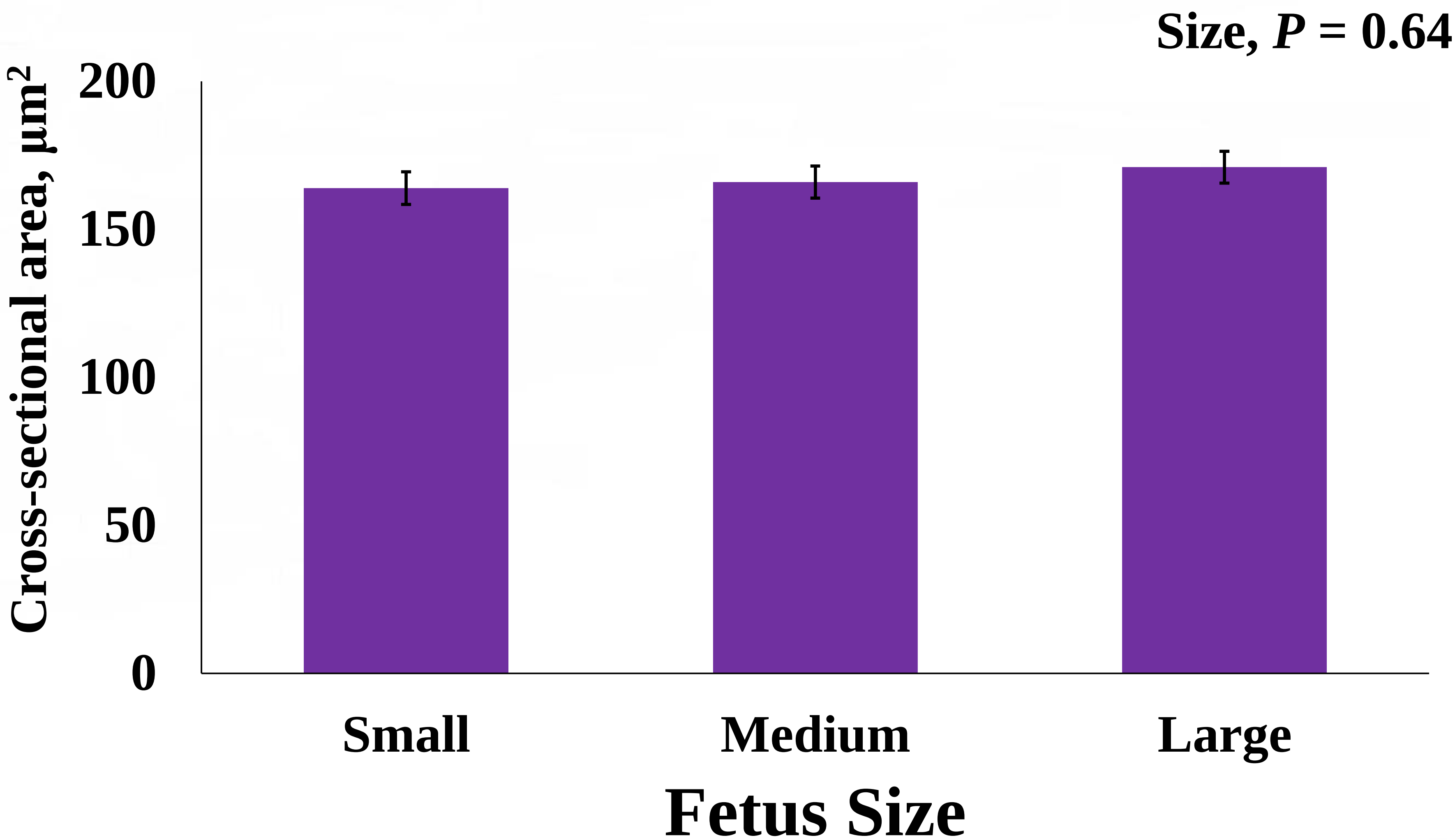
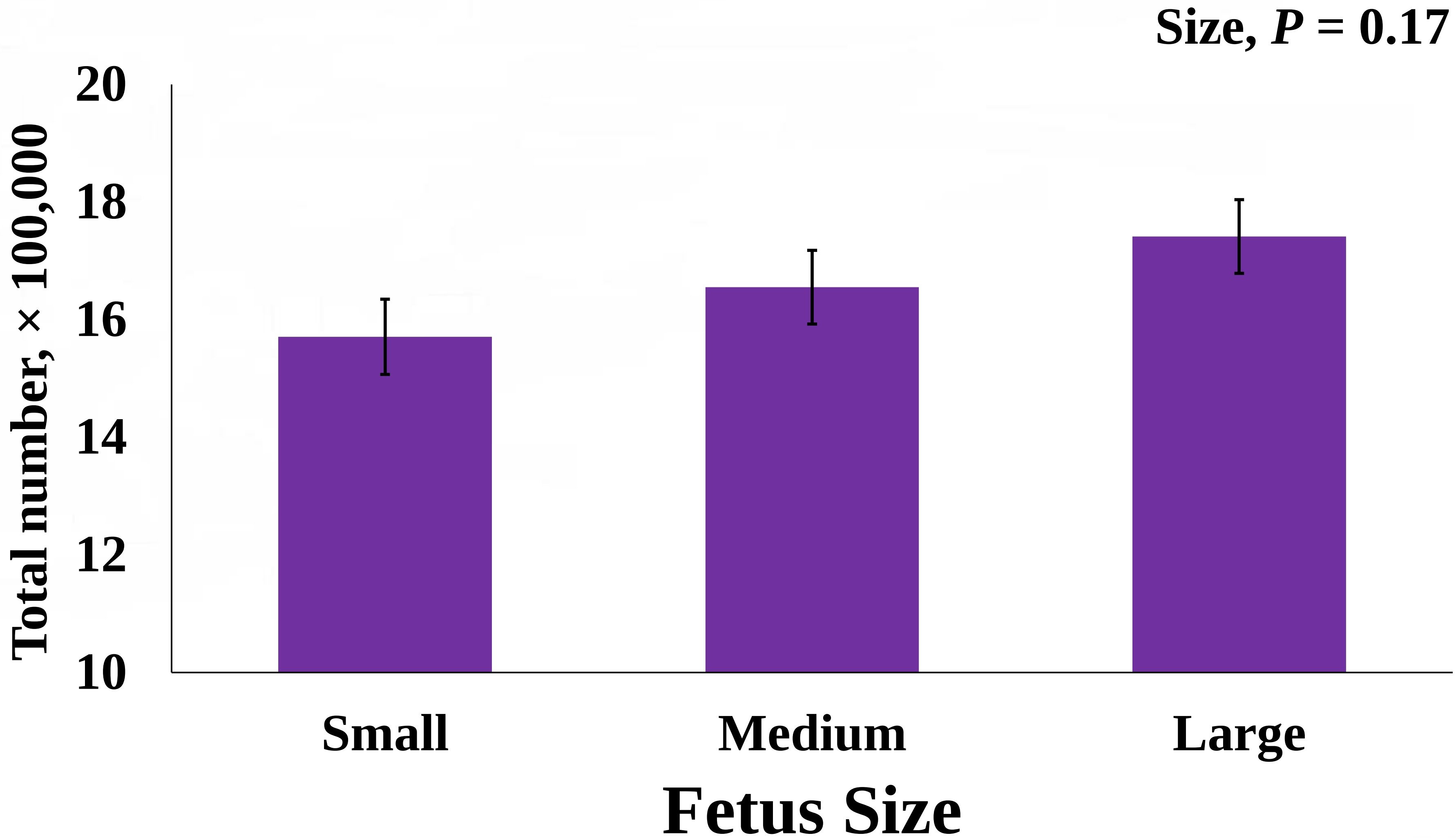
# Primary Fiber Number



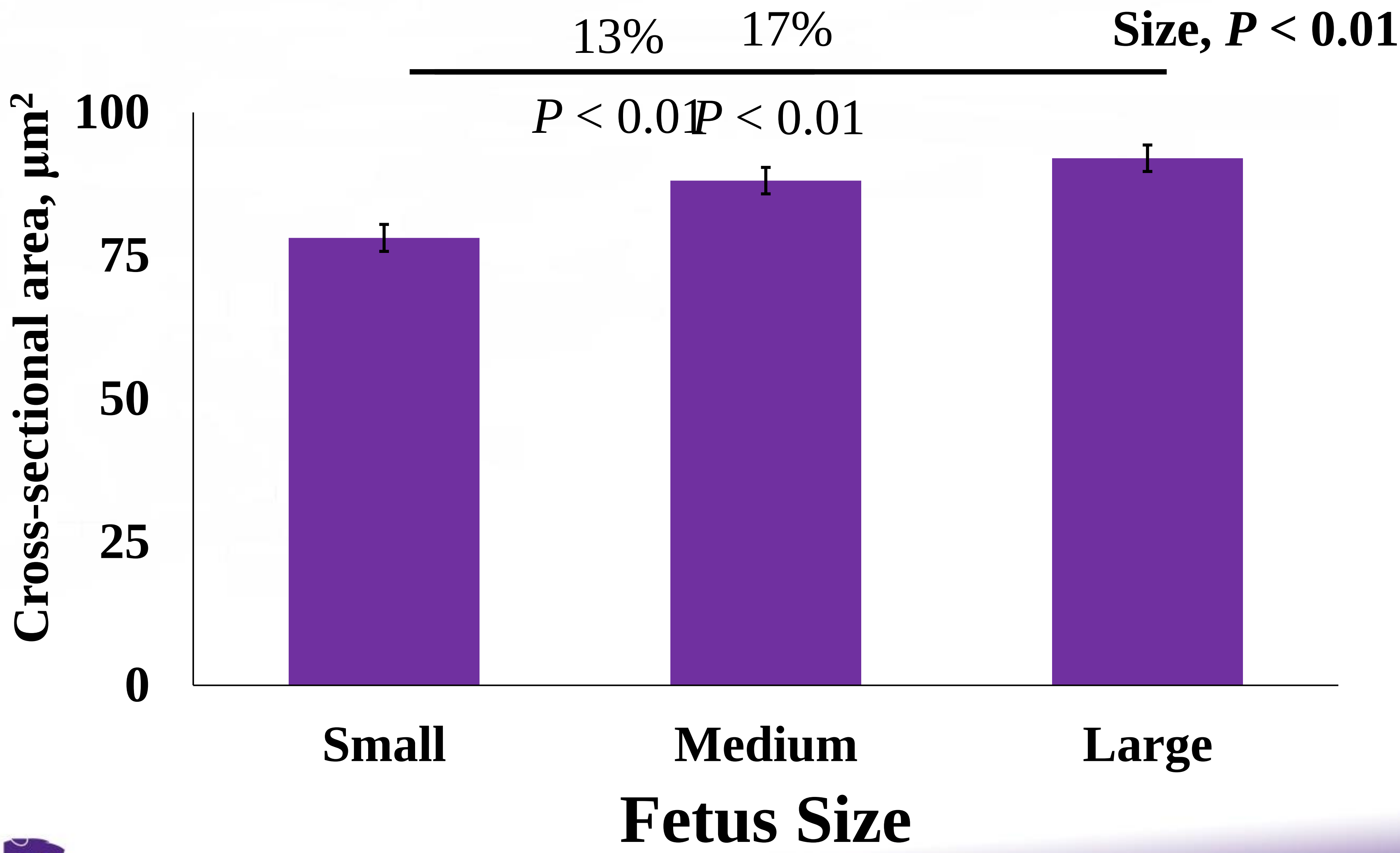
# Primary Fiber Area



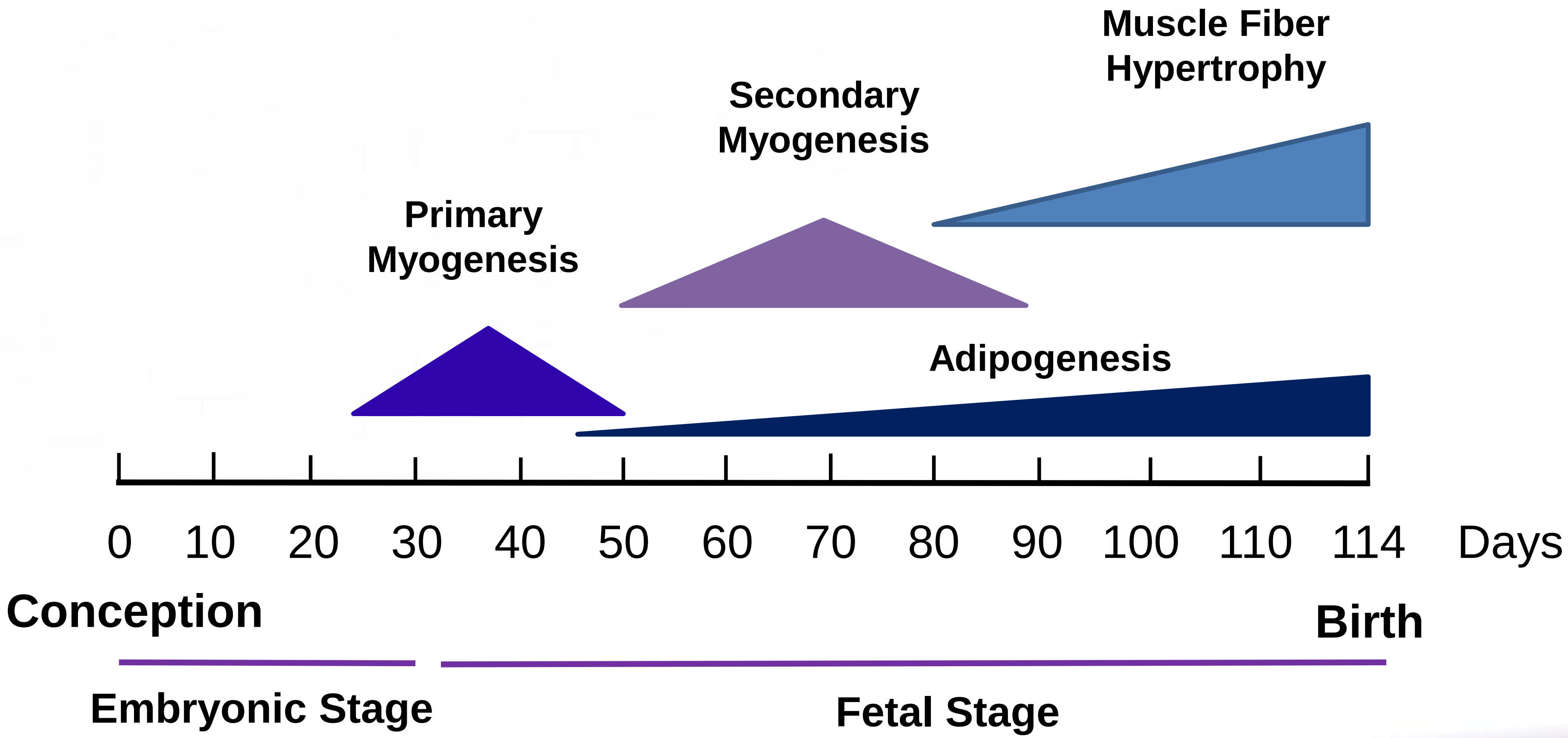
# Secondary Fiber Number



# Secondary Fiber Area



# Small Fetus Muscle Development



# 90-d Fetal Muscle Development

- Secondary fiber hypertrophy responsible for whole muscle differences.

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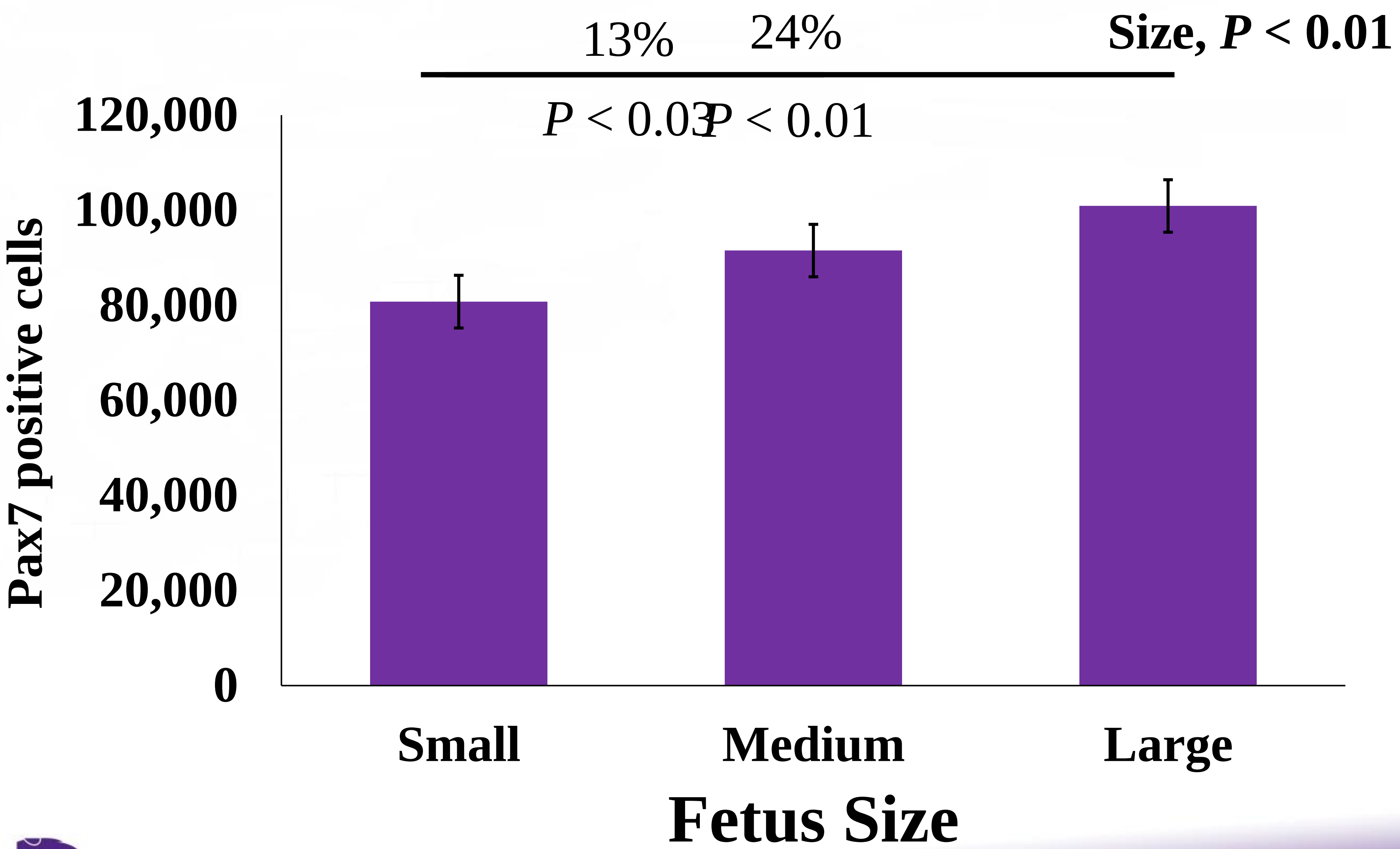
# Satellite Cell Number

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Prenatal growth restriction, altered fetal development, low birth weight, reduced colostrum intake, increased death losses, and fewer full-value pigs


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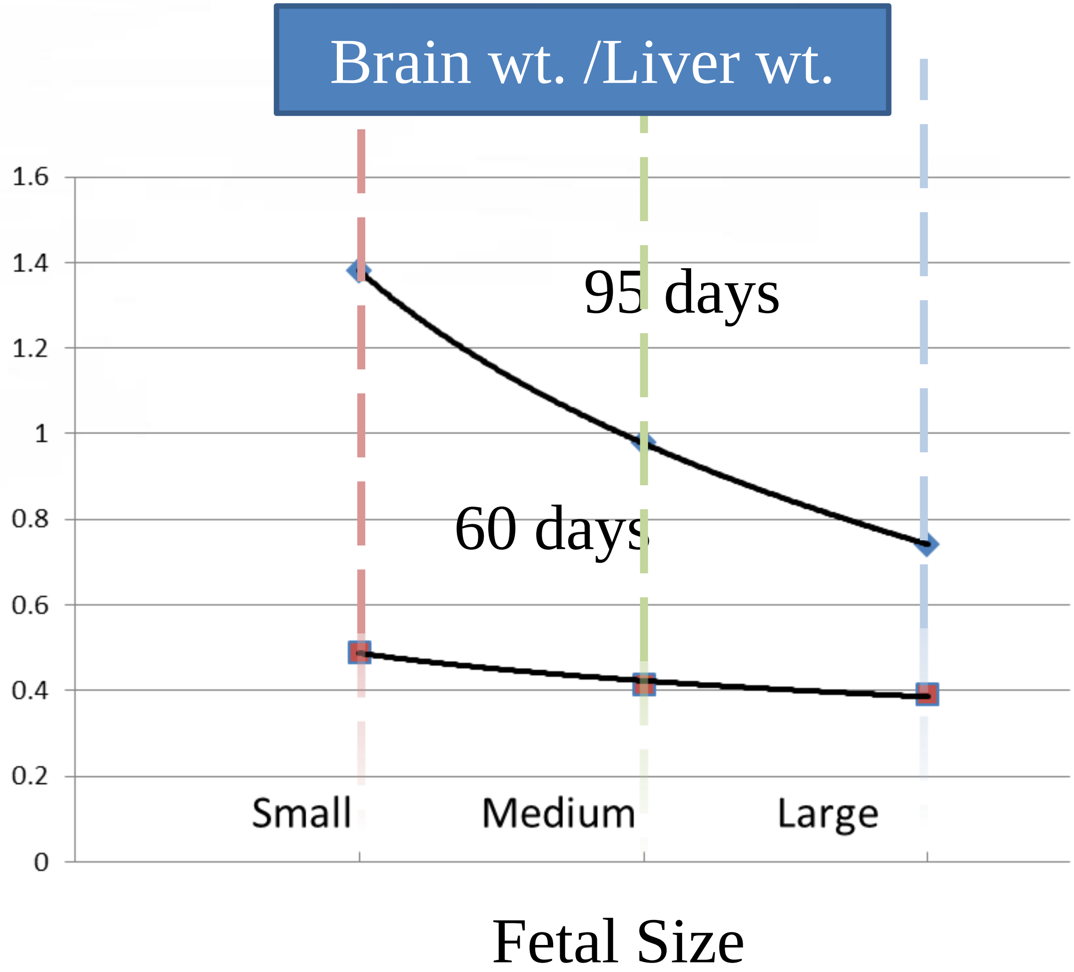
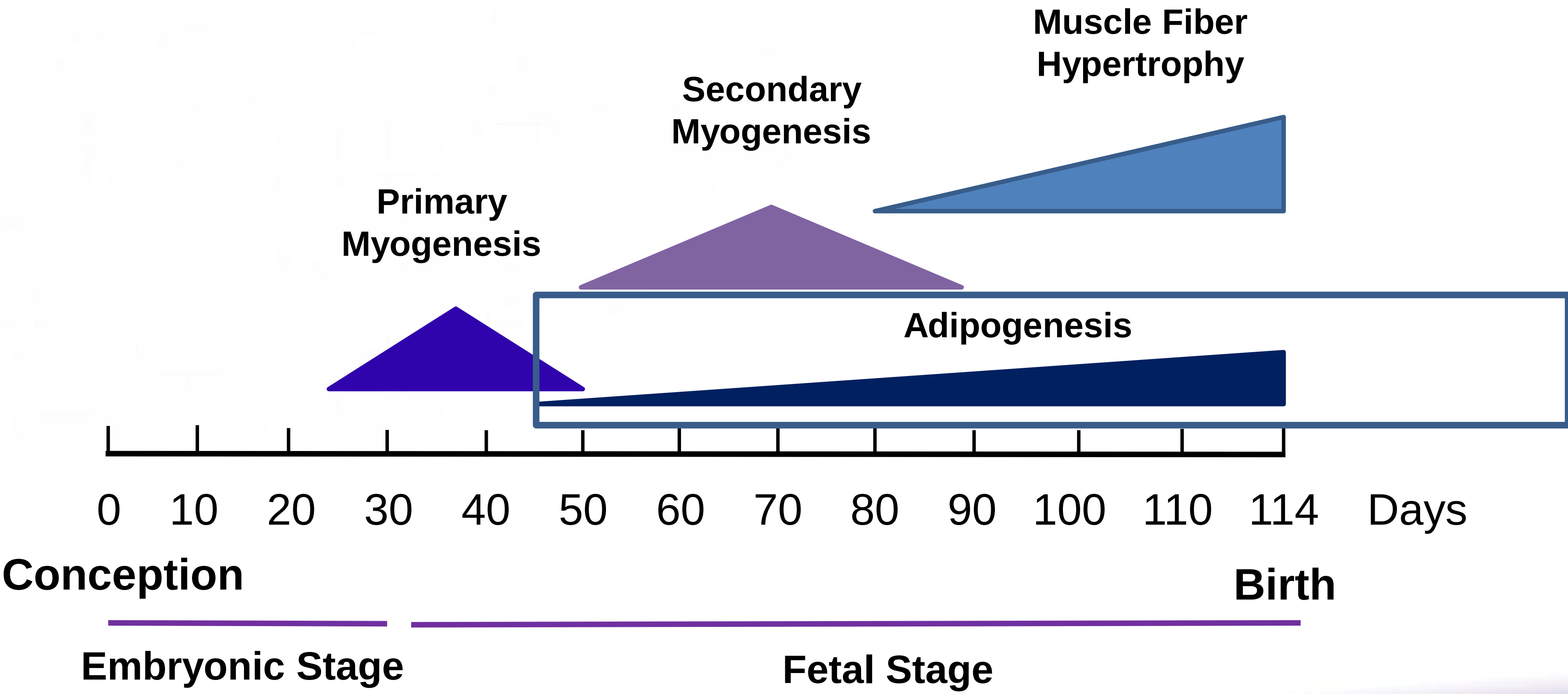
# Day 60 and 95 Allocation of Nutrients

# Fetal Muscle Development

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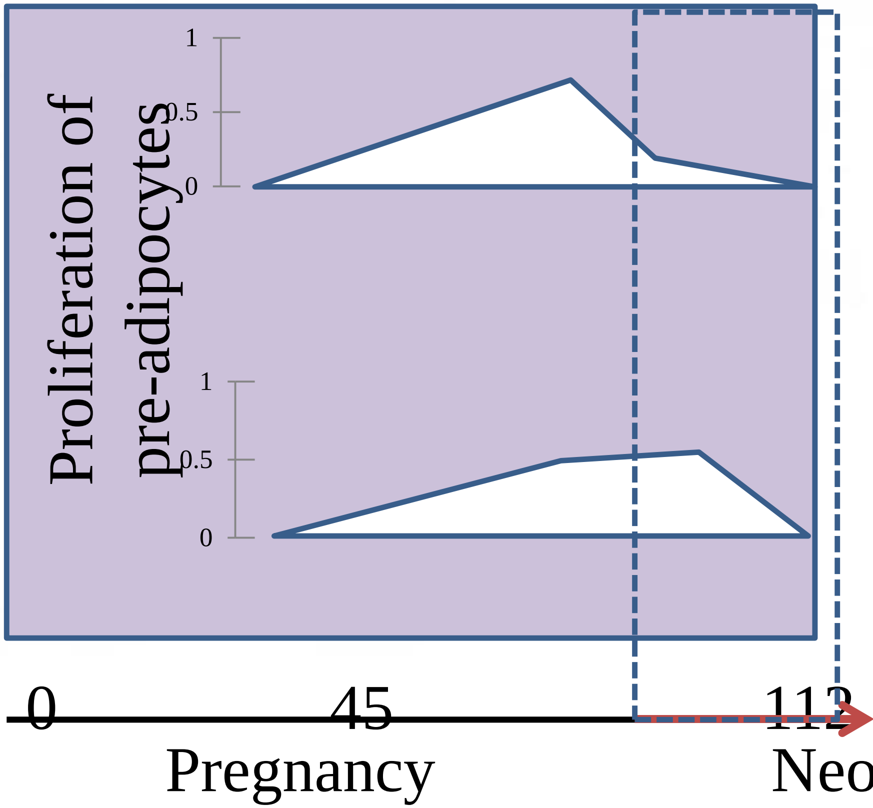
# Adaptations of Adipose Tissues

Development of adipose tissue





Drawn from information in the published literature including:
Hausman and Kauffman, 1986; Gondret et al., 2013

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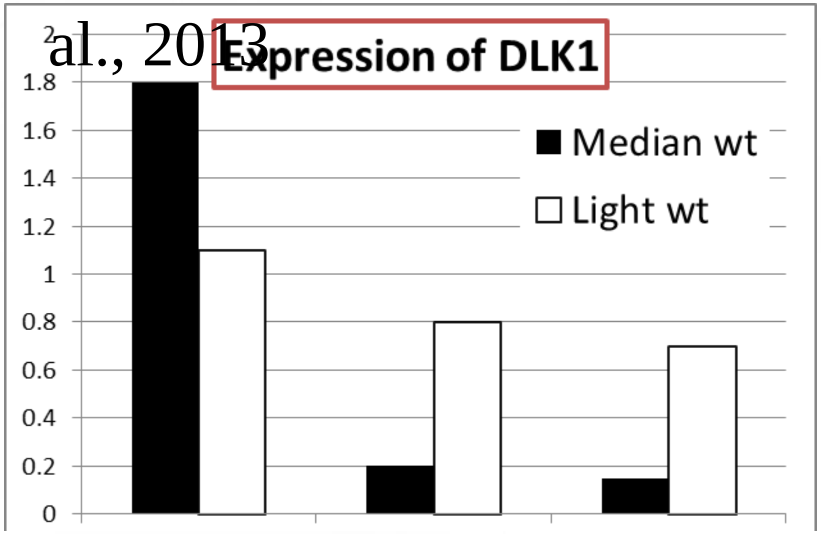
# Adaptations of Adipose Tissues

Re-drawn from Gondret et al., 2013





71 days 112 days

2 days

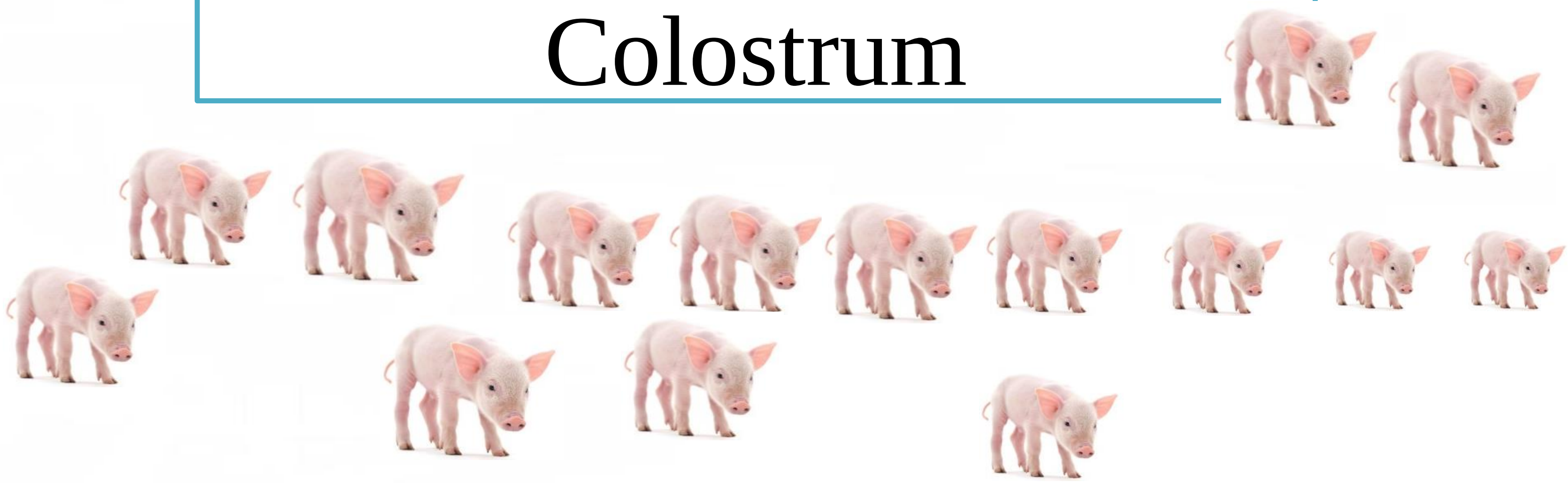
Pregnancy Neonatal

# One of the rules of Life:

**Those who have get more, those with less get less**

**Colostrum Consumption**

# Birth Weight and Colostrum



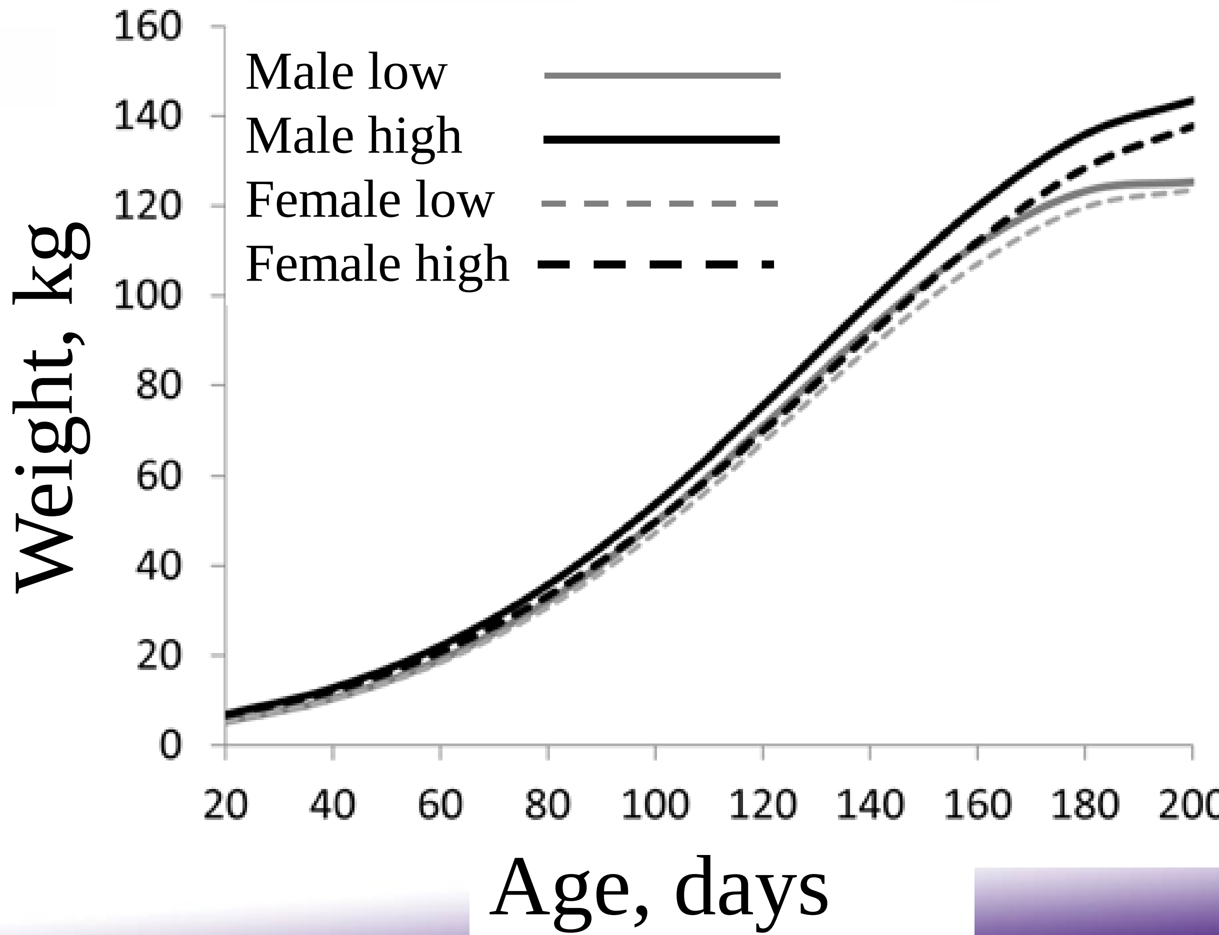
**<u>Bigger pigs get more colostrum</u>**

- A 3 lb pig needs 36 g more colostrum than a 2.5 lb pig
- A 3 lb pig (on average) consumes 68 g more colostrum

# Immunocrit values and performance traits

## Vallet et al., 2015

Postnatal growth sorted on immunocrit status

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# Immunocrit values and performance traits

## Reproduction and immunocrit

- More immunoglobulins
- Earlier age at puberty
- ↑ litter size
- ↑ pre-weaning growth

| Inter-related Indicators |
| --- |
| • Birth wt<br>• Brain/liver wt ratio<br>• Colostrum consumed<br>• Blood immunoglobulins (immunocrit) |

Vallet et al., 2015

# Gestation programming affects

→Neonatal period → Growth to market wt →Carcass


**DAMAGED PIGS**

Correctable?/Adaptable?

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