Early-life programming effects on long-term productivity of dairy calves

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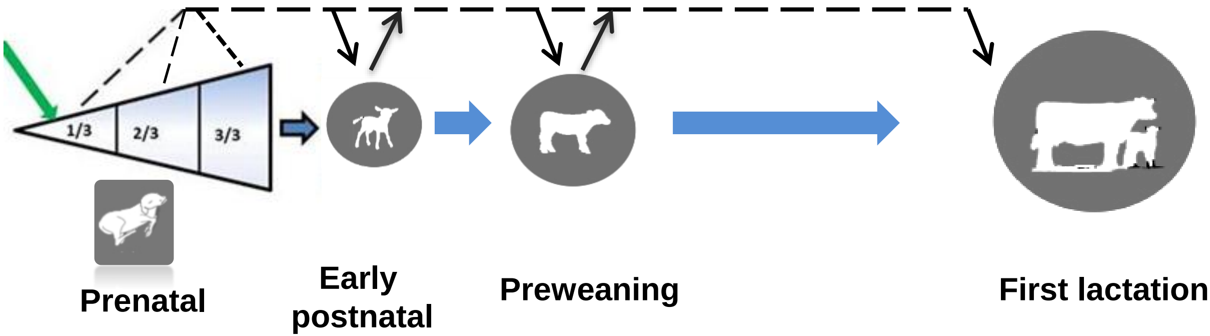
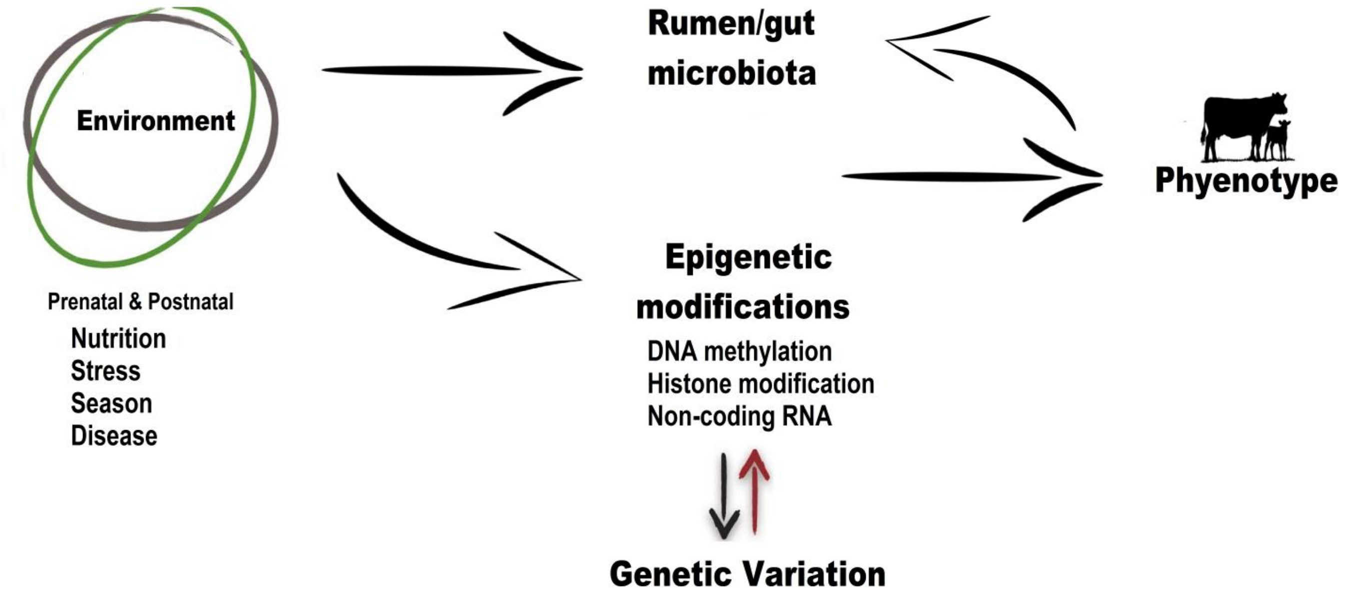
Developmental programming: The concept

- ❑ Developmental programming involves a critical time window in early life



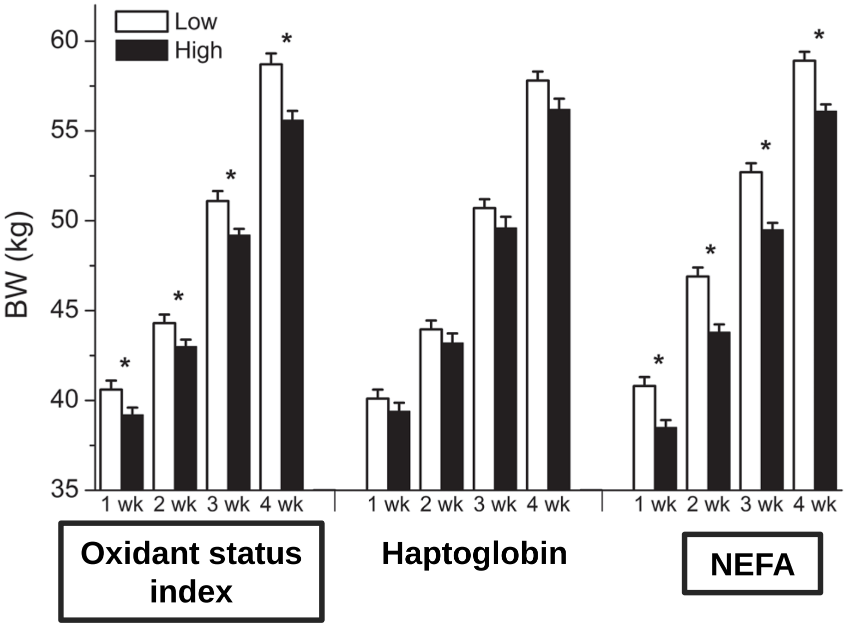
Factors involved in developmental programming?



❑ Maternal status

- **Prenatal exposure to maternal metabolic stress**

(Ling et al., JDS 2018)



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Maternal nutrition and postnatal life

Maternal Diet

Energy density	Rumen-protected methionine (RPM)	Organic trace minerals (ORG, Zn, Cu, Mn, and Co)
Low NEL = 5.25 MJ/kg of DM vs. High NEL = 6.48 MJ/kg of DM	Control vs. RPM	ORG vs. Sulfate sources
↓ Birth weight ↓ Body height ↓ Body length ↓ T lymphocytes ↓ Total antioxidant capacity (Gao et al, JDS 2012)	↑ Maturation of hepatic gluconeogenesis ↑ Growth rates ↑ Wither height ↑ Body weight ↑ Hip height (Jacometo et al, JDS 2017) (Xu et al, JDS 2018)	↓ Oxidative stress Status Down-regulation of inflammatory mRNA and miRNA (Jacometo et al, JDS 2015)

Postnatal

Role of Nutrition

❑ Lactocrine hypothesis

Bartol et al., 2008

- **Milk-borne bioactive factors (MbFs)**
  - **Immunoglobulin (Ig)**
  - **Bioactive peptide (Cytokines)**
  - **Lactoferrin**
  - **Hormones and growth factors, (IGF-I, EGF, TGF and relaxin)**
  - **Oligosaccharides**
  - **Immune-related miRNAs**

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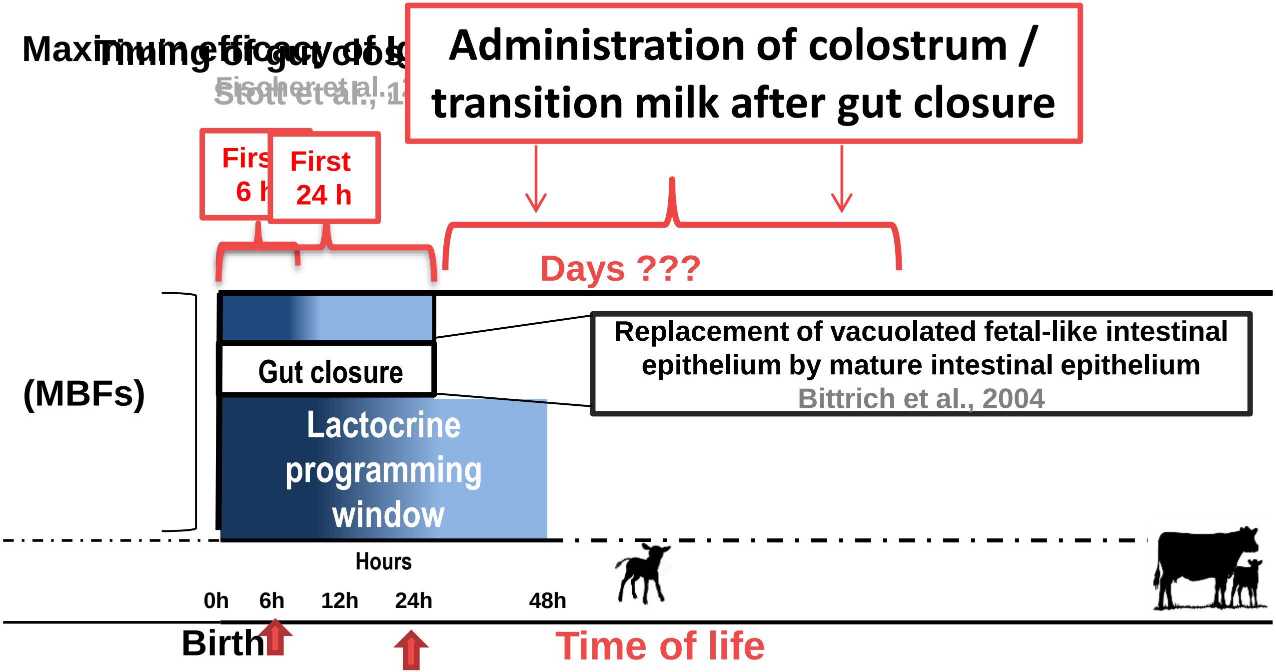
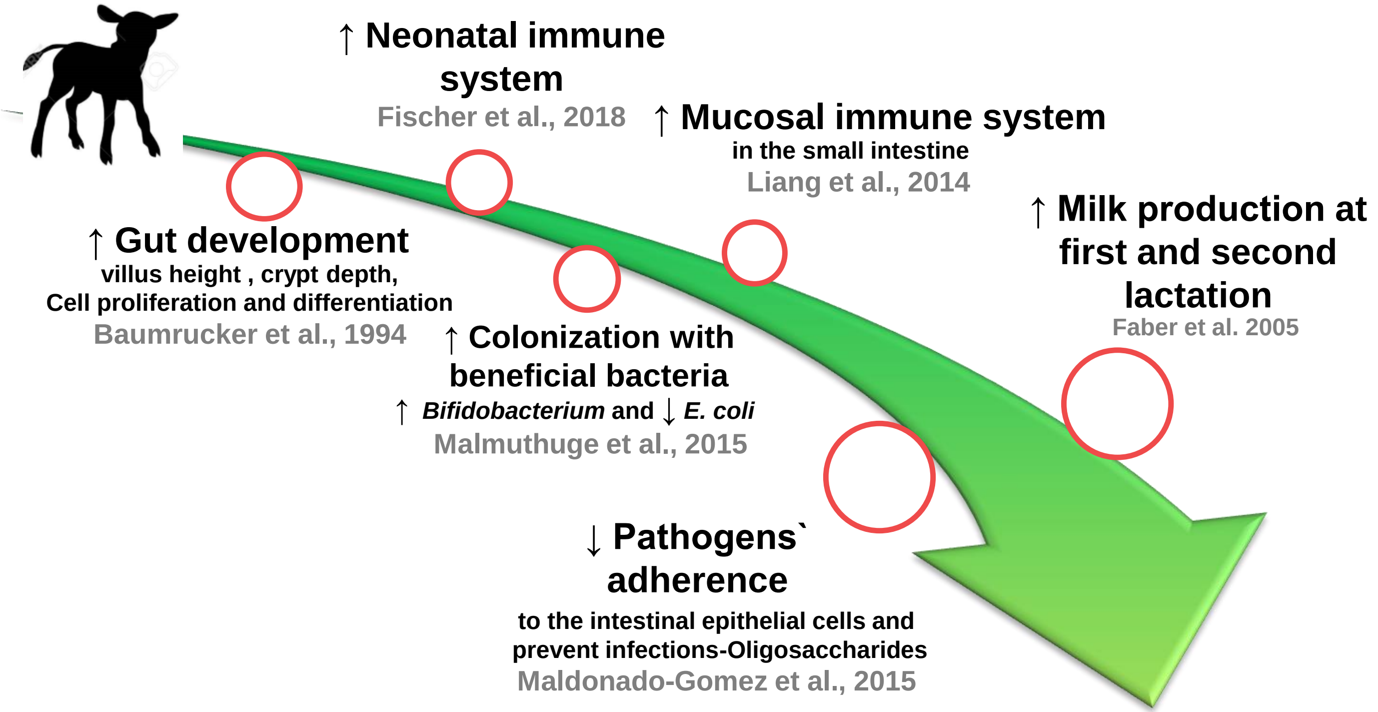
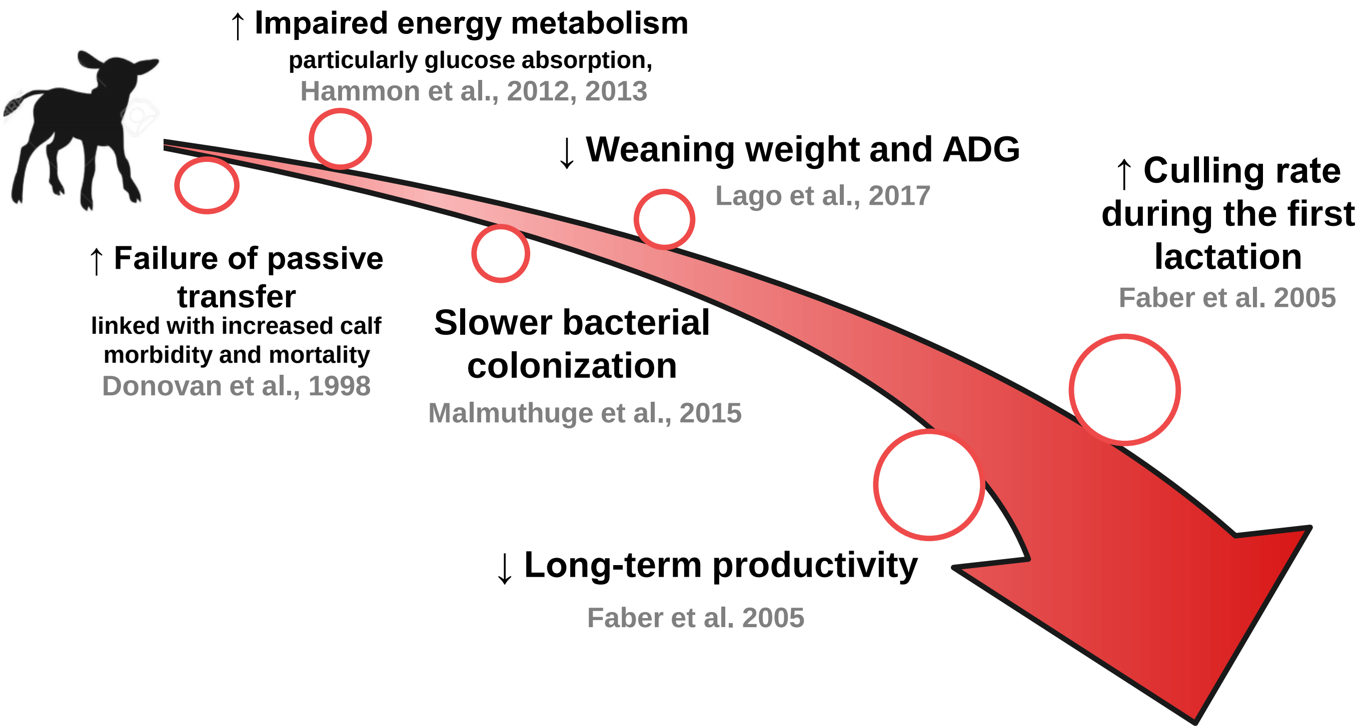
Lactocrine hypothesis



Success of lactocrine signaling



Disruption of lactocrine signaling



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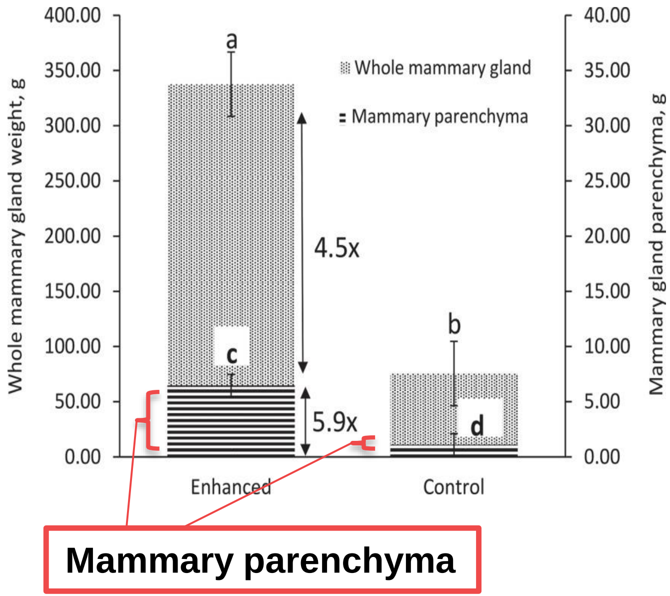
Early Life Nutrition & Future Milk

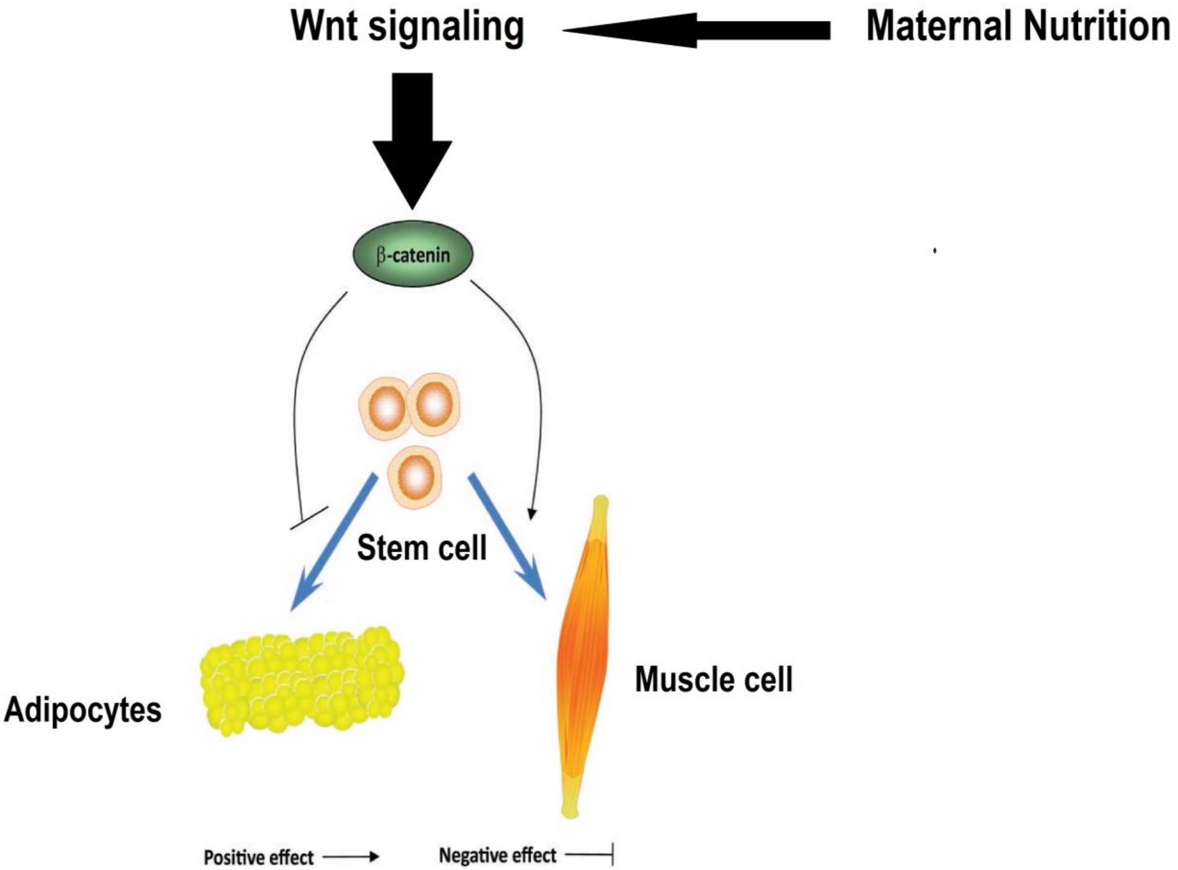
Study (high vs. low milk)	Response (milk production)	
Foldager et al., 1997	+ 572 kg	NS
Bar-Peled et al., 1997	+ 454 kg	(p = 0.08)
Ballard et al., 2005	+ 242 kg	NS
Shamay et al., 2005	+ 132 kg	NS
Pollard et al., 2007	+ 836 kg	NS
Aikman et al. 2007	---------	NS
Raeth-Knight, 2009	+ 718 kg	NS
Terré et al., 2009	+ 624 kg	NS
Morrison et al., 2009	– 91 kg	NS
Davis-Rincker et al., 2011	+ 416 kg	NS
Kiezebrink et al., 2015	– 25 kg	NS
Korst et al. 2017	+ 612 to + 725 kg	NS

Preweaning nutrient intake & mammary gland development



Item	Control	Enhanced	SE	P-value
Whole mammary gland, g	75.48	337.58	29.14	**<0.01**
Mammary gland as % of BW	0.12	0.41	0.03	**<0.01**
Mammary parenchyma, g	1.10	6.48	1.00	**<0.01**
Mammary parenchyma as % of BW	0.002	0.008	0.001	**<0.01**

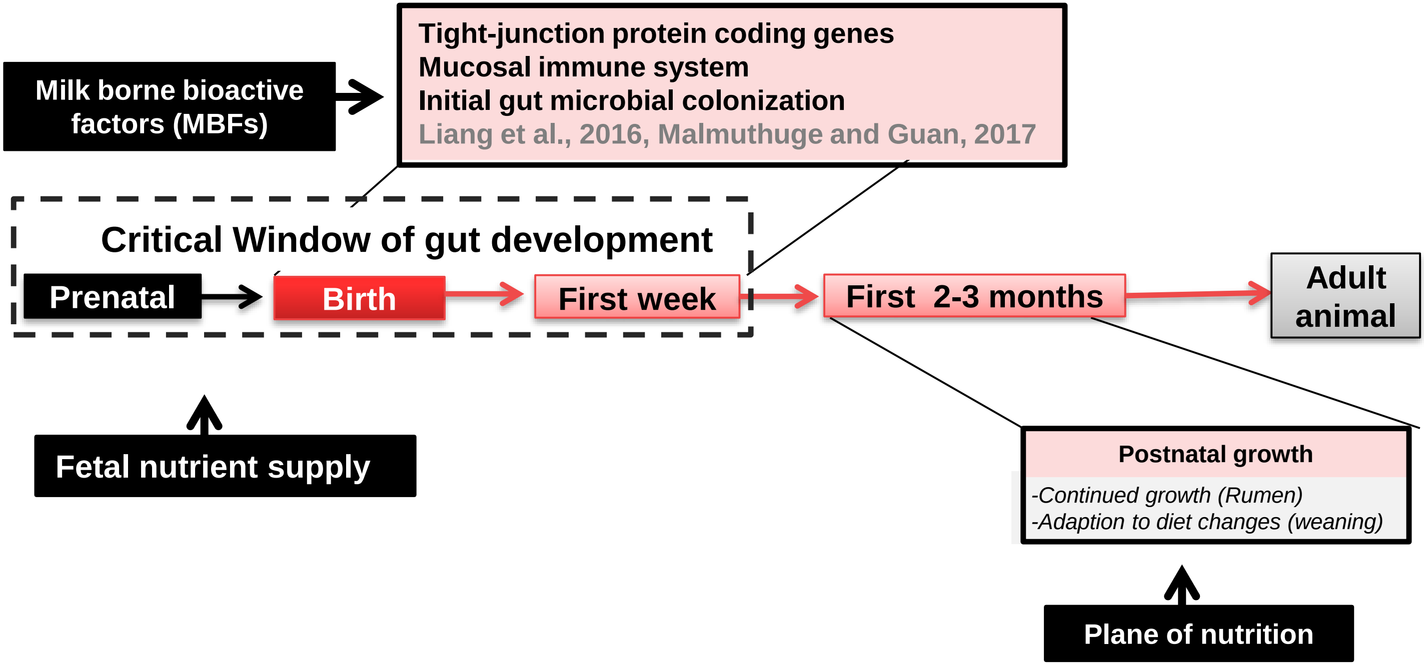
Adapted from Soberon and Van Amburgh, 2017 JDS



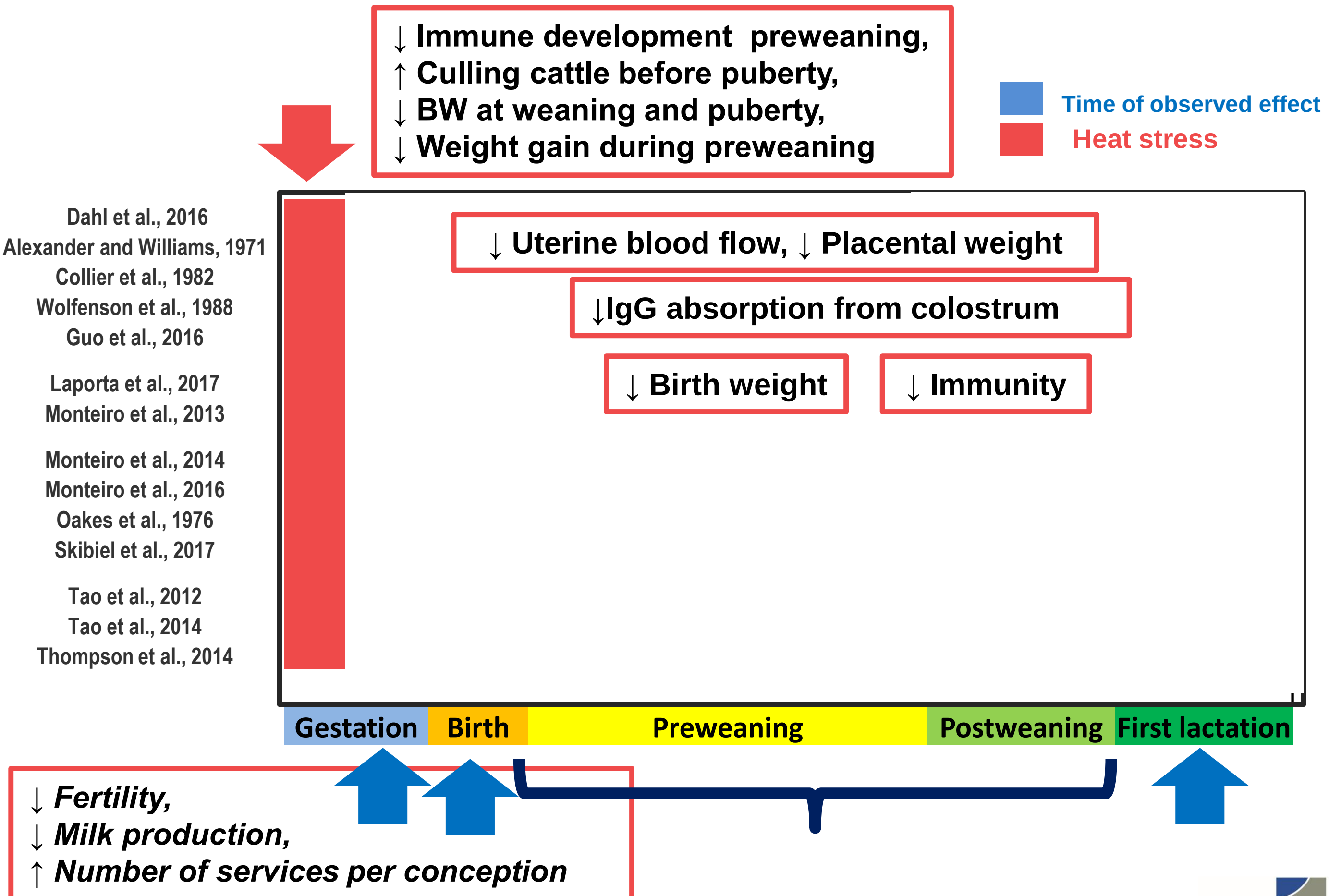
Fetal programming of muscle development

Adapted from Du et al., 2010 J Anim Sci.

Developmental programming of gut



Maternal heat stress and its long term effects



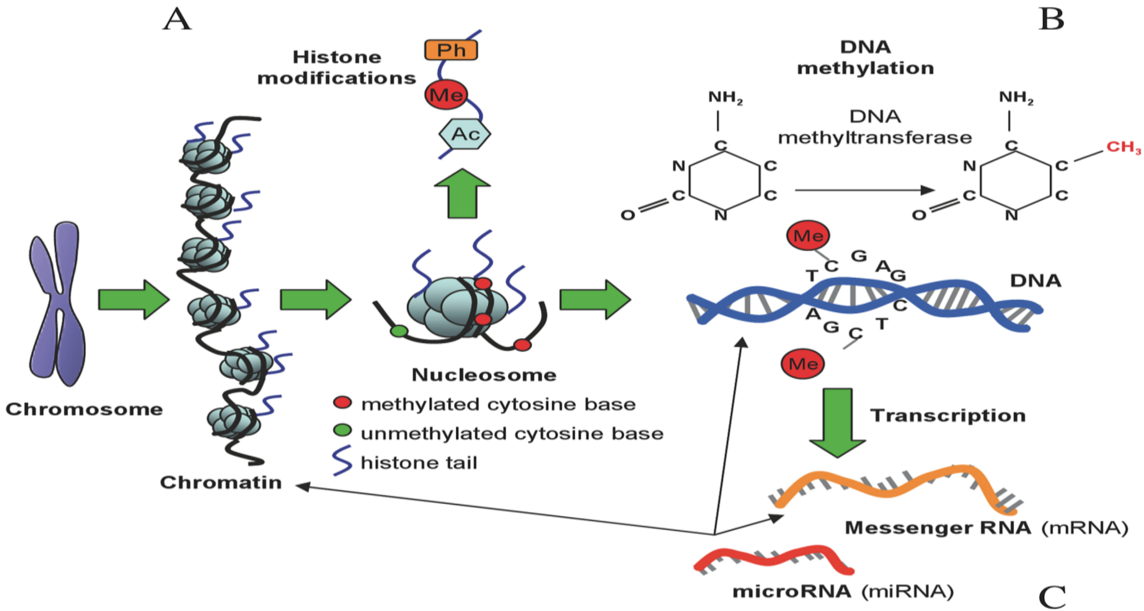
Take home messages

- ❑ Programming occurs in neonatal dairy calves and early life events have long-term effects on calf performance.
- ❑ Delivery of MBFs from cows to calves in early life plays a pivotal role in the programming of later life performance by affecting immune system maturation, and gut development
- ❑ Fetal gestation is a critical window of skeletal muscle development in ruminant and maternal under-nutrition would compromise postnatal birth weight and growth

Take home messages

- ❑ **Preweaning plane of nutrition may altered programming of mammary gland development in dairy calves and can shift it to an allometric phase of growth**
- ❑ **There are <u>multiple developmental windows</u> for the small intestine during perinatal, and neonatal periods in dairy calves and programming of this plastic tissue seems to play a critical role in later growth, health, and performance**
- ❑ **Maternal heat stress or maternal under-nutrition may impact immune function and metabolism of dairy calves as well as future lactational performance.**

Thank you for your attention



Types of epigenetic modifications

Gómez-Díaz et al., 2012. PLoS Pathog 8(11): e1003007.