Transition Cow Diets and Phosphorus

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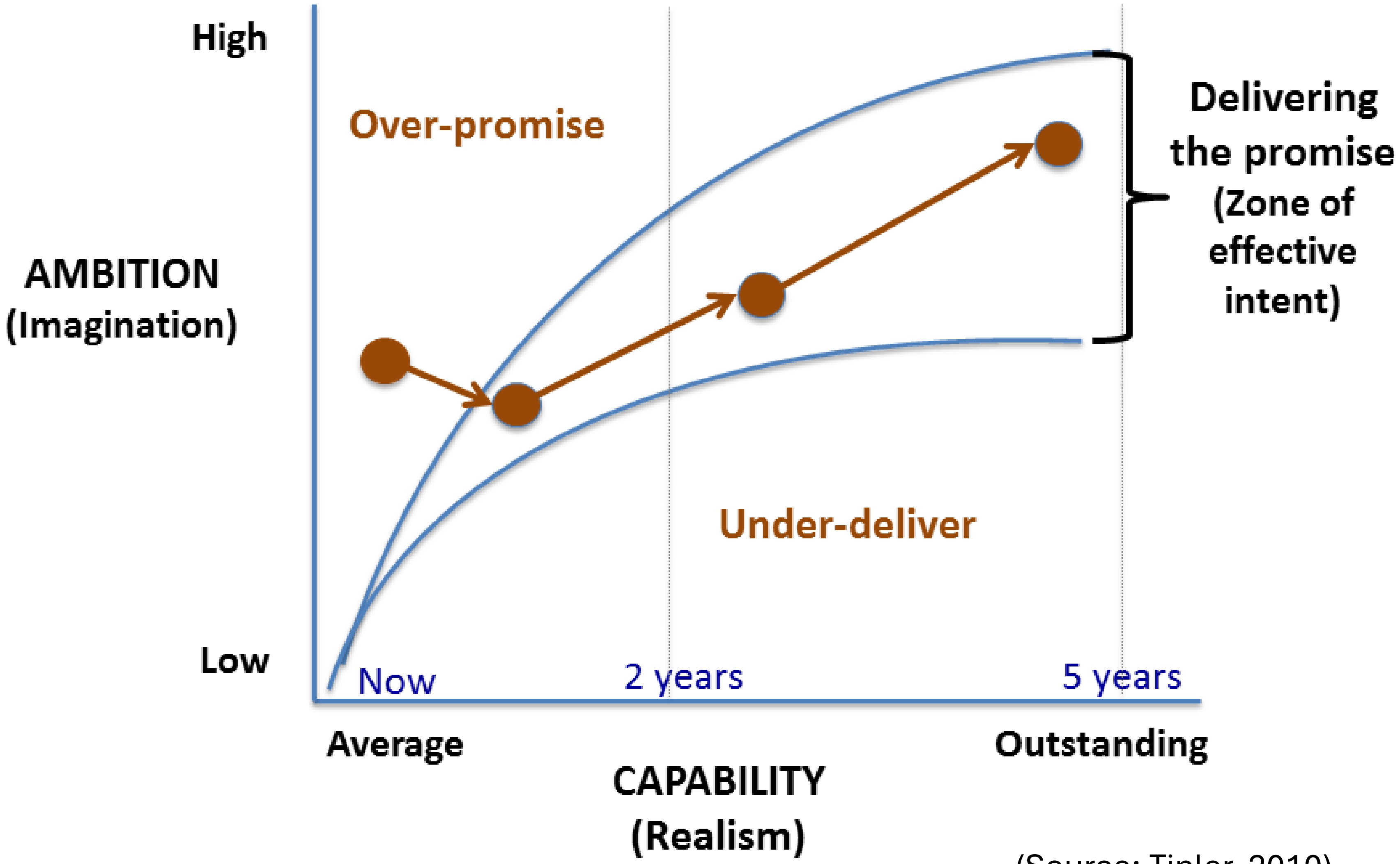
Data Overload, Decision Paralysis??

- Low Ca
- High Ca + 25-OH-D3
- High Mg
- Low DCAD
- Ca binders
- P binders
- MgO dusting
- $MgSO_4$ via water
- Include R2's?
- Do nothing…

The zone of effective intent

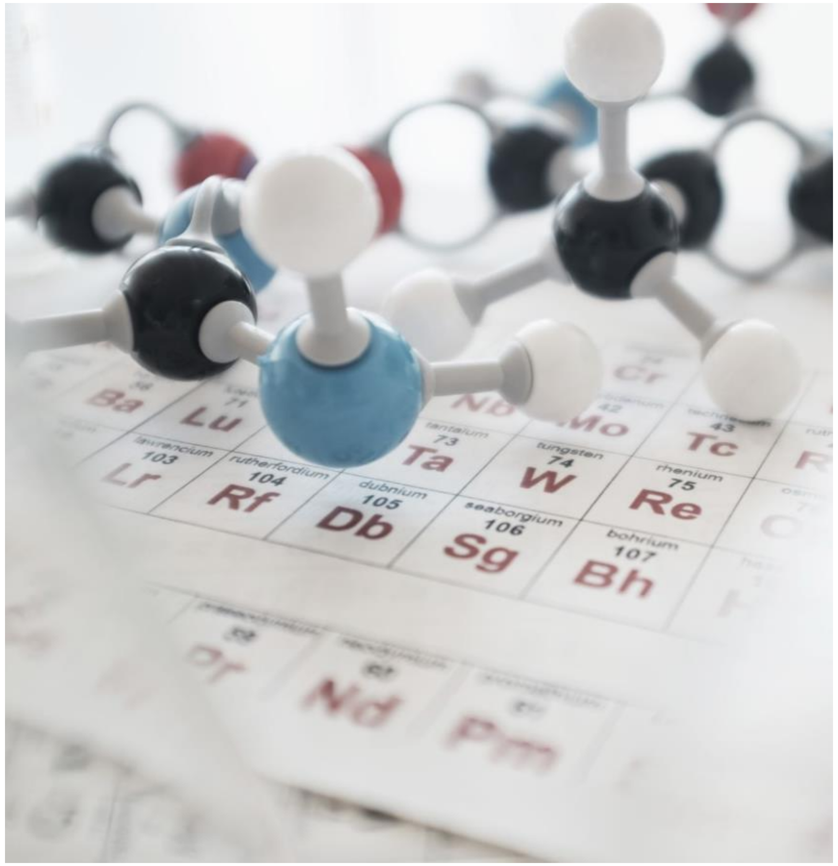


(Source: Tipler, 2010)

What Does Winning Look Like?

- Reduce the incidence of clinical and sub-clinical milk fever and the metabolic diseases often associated with it, target <1%
- Support optimum DMI through understanding HOT, ME and MP requirements, pro-actively managing BCS losses to be less than 0.6 of 1 BCS
- Reduce the number of days in milk (DIM) required to realise cows achieving 90% of peak milk solids production, creating longer peaks with reduced metabolic stress
- Increased milk protein yields
- Continued improvements to 6 week in calf rates (aiming for >75%) via managing BCS loss, rumen and immune dysfunction. Knock on effect is reduced empty rates <10% at 10 weeks within seasonal calving herds
- Environmental sustainability- ration balancing that reduces methane and urinary Nitrogen output per kg MS produced (intensity)

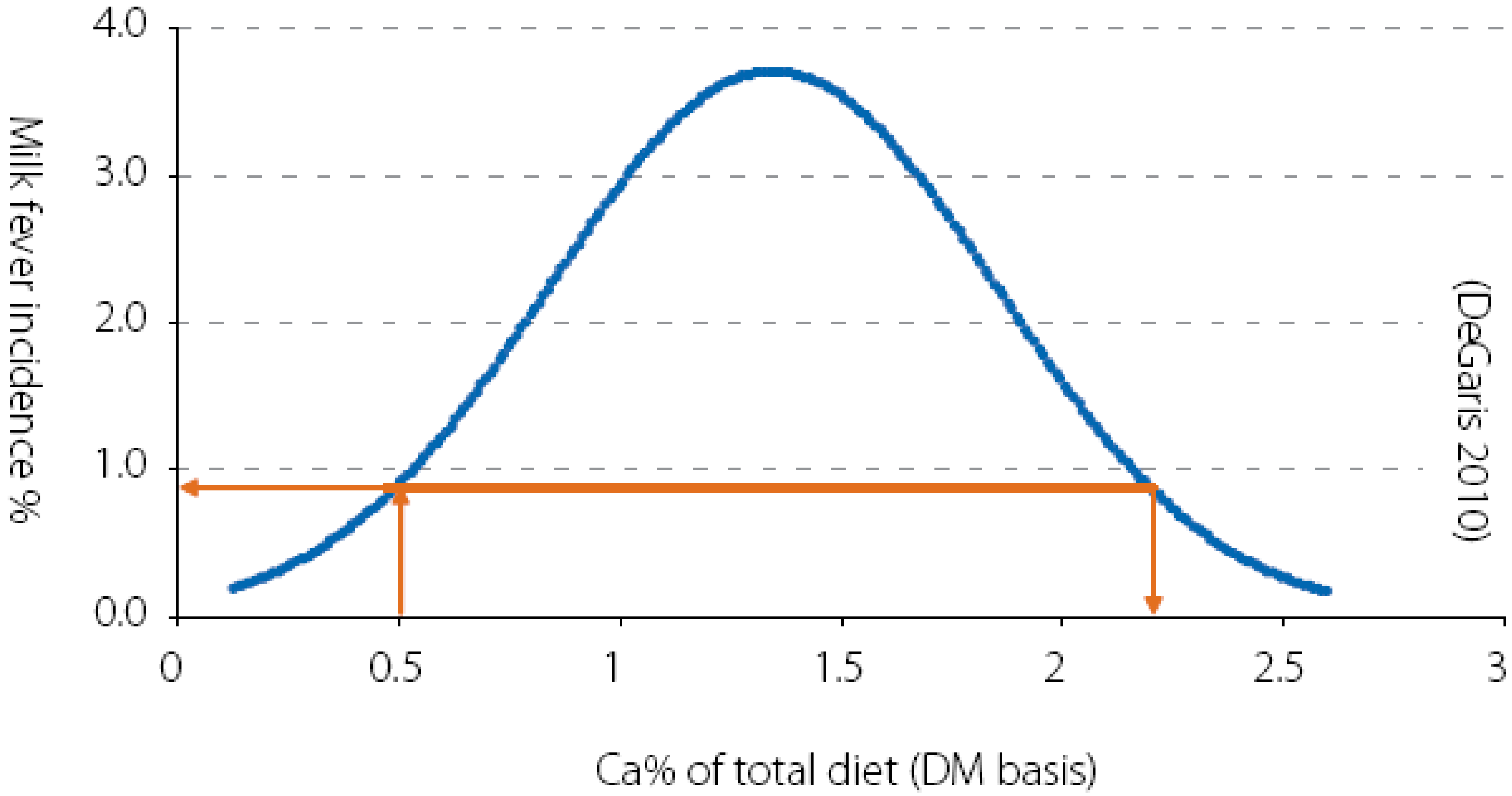
- Attain optimal operating profit for the production system (economic farm surplus before interest, principal, tax and personal drawings)



What do we mean by "establishing a successful lactation"?

- Live calf is delivered and 150g IgG is consumed in the first 2 hours of life
- Cow does not suffer ill-health, commonly experienced during and immediately following calving
- Cows steadily increase DMI and milk solids production to achieve early peak lactation targets with minimal BCS losses
- Cow fertile and cycling BEFORE mating start date

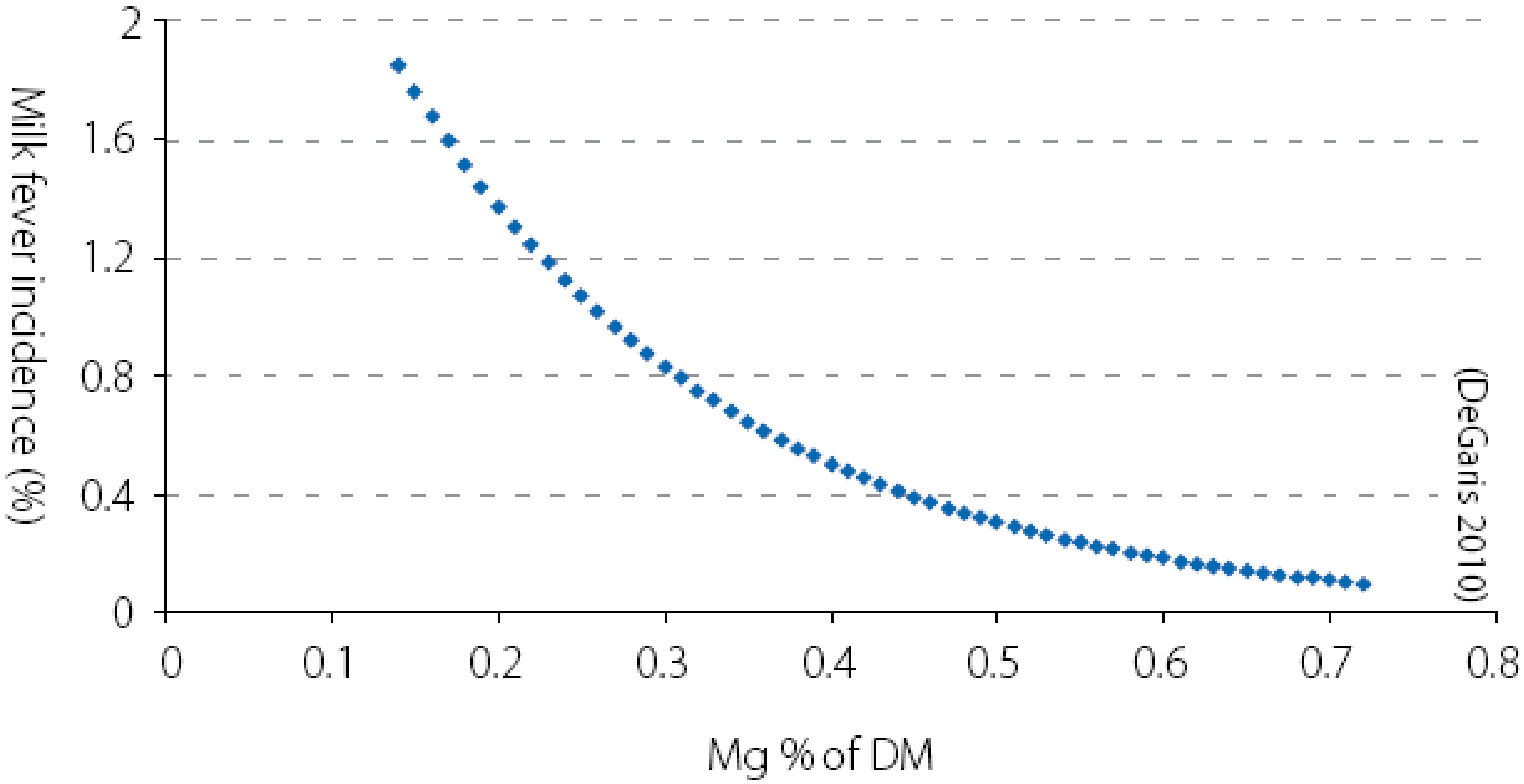
Effect of **Calcium** on milk fever risk



Recommendation for transition diet is
0.4 – 0.8% per kg DM

From “Transition Cow Management”, published by Dairy Australia, 2010

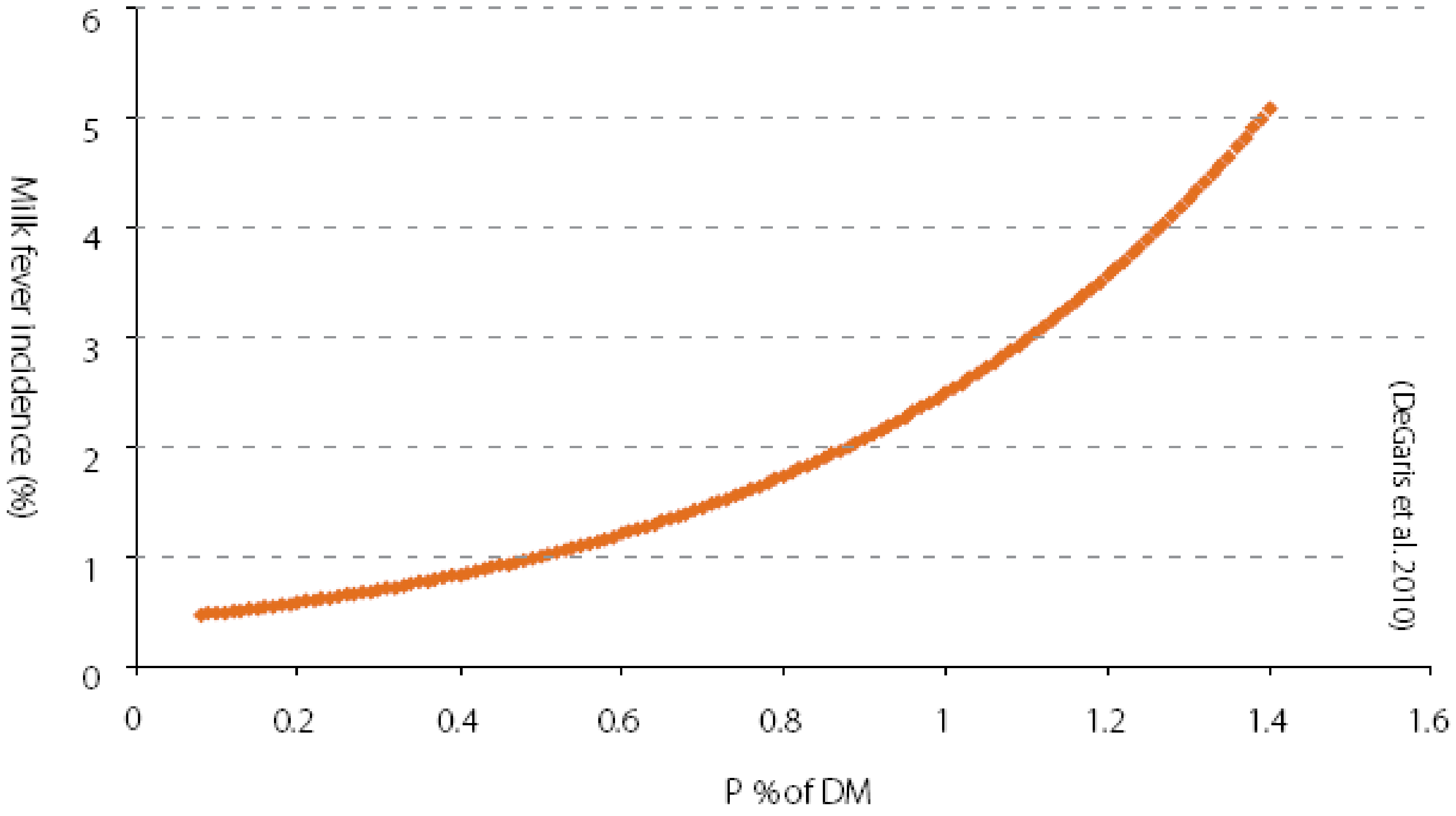
Effect of **Magnesium** on milk fever risk



Rec. for transition diet: > 0.45% Mg/kg DM

From "Transition Cow Management", published by Dairy Australia, 2010

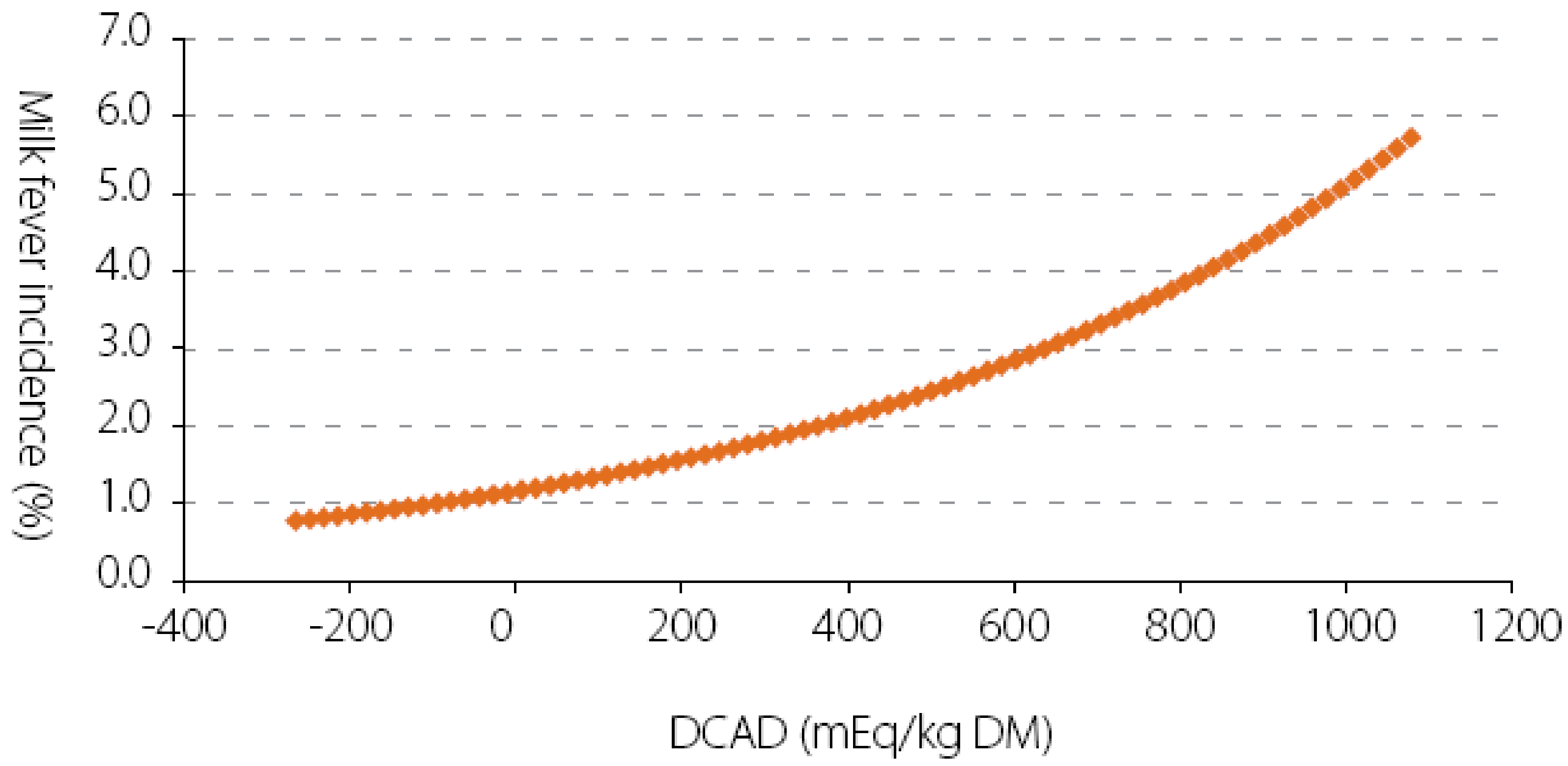
Effect of **Phosphorus** on milk fever risk



Rec. for transition diet: < 0.4% P/kg DM

From "Transition Cow Management", published by Dairy Australia, 2010

Effect of DCAD on milk fever risk

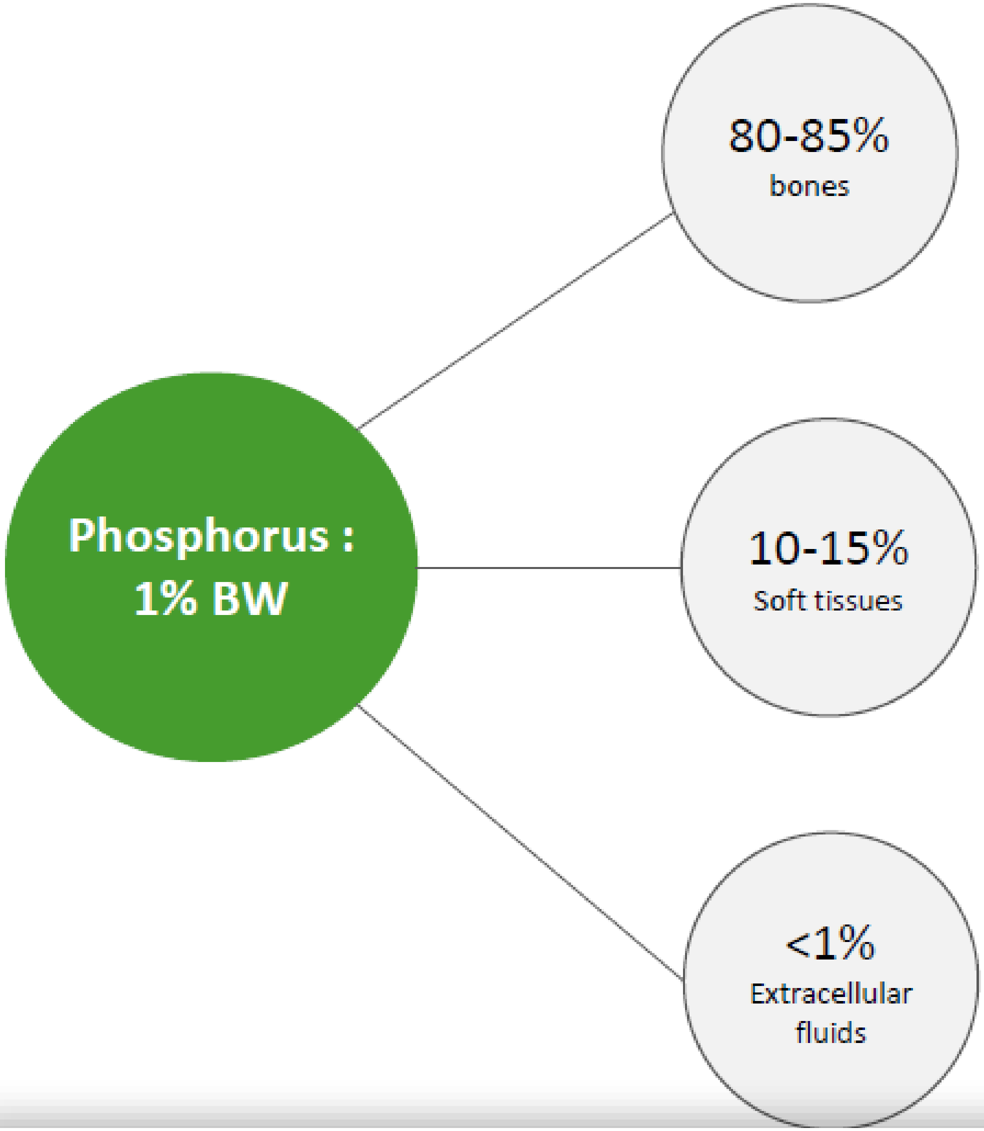


Any decrease in DCAD will reduce milk fever risk!!

From "Transition Cow Management", published by Dairy Australia, 2010

Phosphorus (P) essential for growth and health

- Phosphorus is important for;
- Bone growth/integrity
- CHO metabolism (insulin) and fueling cells (ATP)
- Fat/lipid production
- Cell membrane integrity
- Reproduction and fetal growth
- Milk Production
- Immune system
- PO_4 buffer systems (saliva, blood)



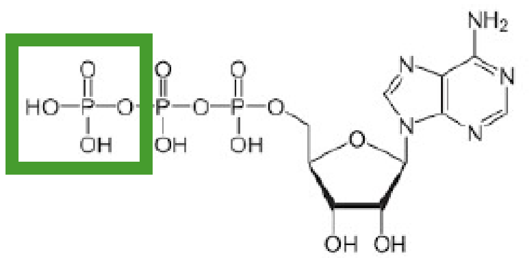
	P requirement
Maintenance	≈ 24 g / day
Lactation	0.9 g/kg milk produced / day

Phosphorus Stores

Phosphorus (P) for ruminants - background

Phosphorus is necessary for rumen bacteria

ATP

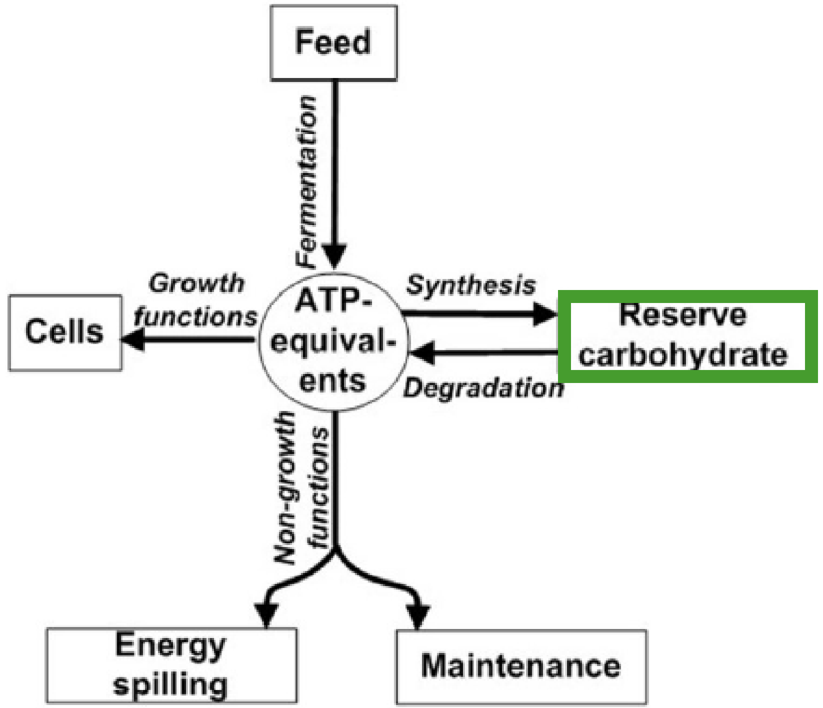


Rumen microbes need phosphorus :

- ✓ **70g P/day** for microbial growth (*Goselink et al., 2015*)
- ✓ **P is required to build ATP** (Adenosyl triphosphates) for microbes itself (Leng and Nolan, 1984)
  - ➢ Mobility
  - ➢ Osmoregulation and cellular component replacement
  - ➢ Extra cellular protein production
  - ➢ Active transport

Partitioning of ATP energy toward growth functions, non-growth functions, and synthesis of reserve carbohydrate

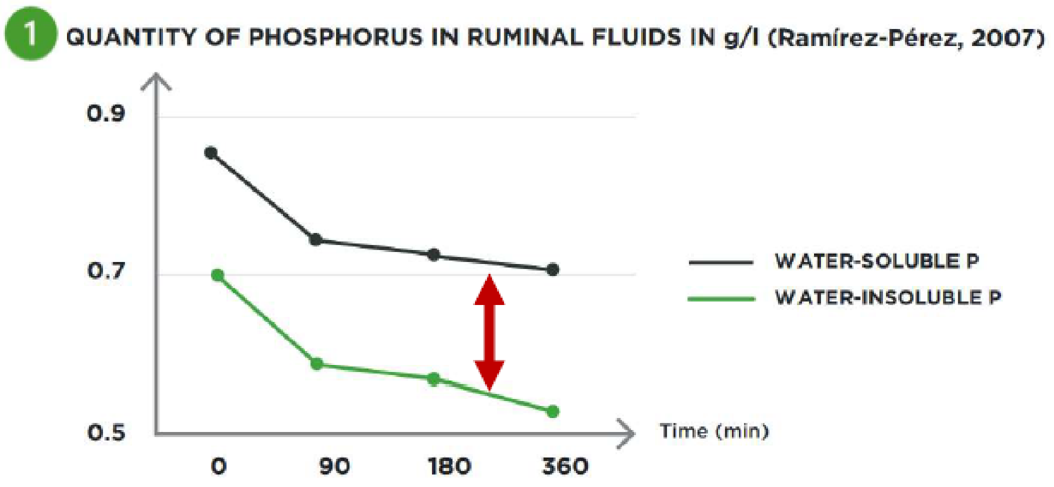
(Hackmann and Firkins, 2015)

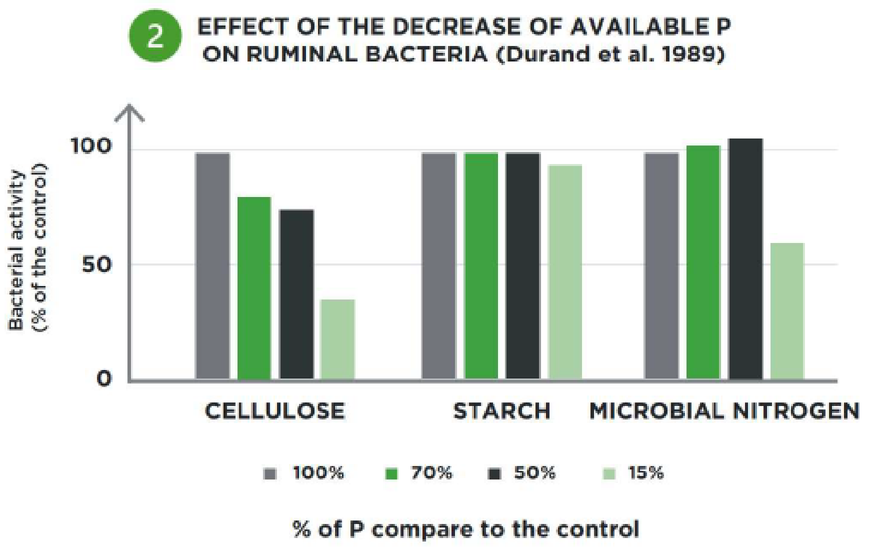


ATP-equivalents can include ATP or ATP-yielding carbon compound (e.g., glucose). Modified from Russell and Wallace (1997) and Russell (2007a).

Phosphorus (P) for ruminants - background

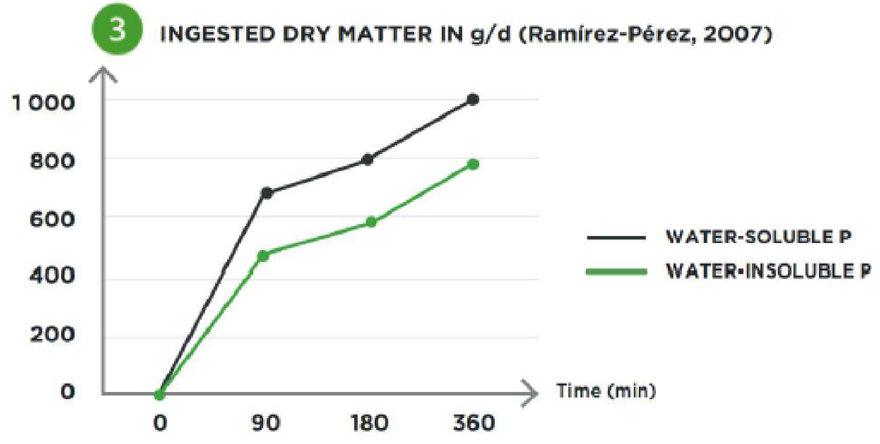
P water solubility to secure P intake for ruminal micro-organism





In case of SARA, P salivary recycling decreases…

- ✓ Less **water-soluble P** available
- ✓ **Cellulolytic bacteria** are first impacted and then, the microbial nitrogen synthesis is impacted
- ✓ A decrease of **voluntary feed intake** is observed



Sources: Cohen 1978 ; Witt and Owens 1983 ; Durand and Komisarczuk 1987 ; Karn 2000 ; Bravo et al. 2003 ; Satter et al. 2005 ; Goselink et al. 2015 ; Grünberg et al. 2019

Weaner Steers with ration P @ 0.9g/kg DM vs 2.4g/kg DM (5 months)

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

So, why all the interest in P during transition??

Acute and sub-acute deficiencies

P Deficient "Crawlers" – Why?

P soil application has reduced significantly, pasture P levels reducing from >5g/kg DM to 2.5 – 3.5g/kg DM + antagonists…

Low P forage crop (beet, maize silage etc.) and supplement (tapioca, soy hulls) usage has increased

1,25-OH_2-D_3 required for intestinal absorption of both Ca and P, can be limited during winter months…

P requirements high during late gestation, freshening and peak milk periods – do we meet the requirements of high producing cows in the herd??

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NZARN

AMTS

Min/Vit Report

AMTS Nutrition

Feed		kg/day (DM)
Ryegrass pasture Spring NZ	13.5	13.5
Palm Kernel Expeller NZ	1.305	1.305
Corn Grain Ground Coarse	0.880	0.880
Soybean Hulls Ground	0.455	0.455
Limestone Ground	0.1493	0.1493
Magnesium Ox	0.0398	0.0398
Salt White	0.0498	0.0498
Click to add...		
Total	16.3788	16.3788

Farm: NZARN
Cattle: Low Input
Barn/Lot: Grazing Low Pdn

FBW: 505 kg
BCS (1-5): 2.50
ADG: 0.053 kg/day

DIM: 45
Milk: 25.0 kg/day
Milk Fat: 4.50%
Milk Prt: 3.30% (True) / 3.55% (Crude)

Inputted DMI: 16.38 kg
Predicted DMI: 16.50 kg

Nutrient	Diet Concentration		Diet Intake	Added	Water Intake	Absorbed				%Rqd	Organic (% Total)
						Supplied	Rqd	Balance			
Ca	0.70	%DM	114.51	50.47	0.00	56.58	53.43	3.15	g/day	106	-
P	0.37	%DM	60.79	0.03	-	39.72	41.90	-2.18	g/day	95	-
Mg	0.32	%DM	51.85	24.57	-	20.03	5.57	14.45	g/day	359	-
K	2.84	%DM	465.27	0.18	0.00	418.74	159.50	259.24	g/day	263	-
S	0.28	%DM	45.62	0.06	0.00	45.62	32.76	12.86	g/day	139	-
Na	0.24	%DM	39.68	19.66	0.00	35.71	36.20	-0.49	g/day	99	-
Cl	0.93	%DM	153.08	30.24	0.00	137.78	42.32	95.45	g/day	326	-
Fe	157.17	ppm	2574.30	522.38	0.00	257.43	28.75	228.68	mg/day	895	0.00
Zn	36.27	ppm	594.05	0.00	0.00	89.11	131.55	-42.44	mg/day	68	0.00
Cu	7.15	ppm	117.09	0.00	0.00	4.68	7.68	-3.00	mg/day	61	0.00
Mn	66.38	ppm	1087.28	3.98	0.00	10.87	1.85	9.02	mg/day	586	0.00
Se	0.01	ppm	0.19	0.00	-	0.19	4.91	-4.73	mg/day	4	0.00
Co	0.01	ppm	0.11	0.00	-	0.11	1.80	-1.69	mg/day	6	0.00
I	0.00	ppm	0.06	0.00	-	0.05	7.58	-7.52	mg/day	1	-
Vit-A	0.00	KIU/kg	0.00	0.00	-	0.00	55.55	-55.55	KIU/day	0	-
Vit-D	0.00	KIU/kg	0.00	0.00	-	0.00	15.15	-15.15	KIU/day	0	-
Vit-E	0.00	IU/kg	0.00	0.00	-	0.00	404.00	-404.00	IU/day	0	-

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Feed		kg/day (DM)
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Milk Prt: 3.30% (True) / 3.55% (Crude)

Inputted DMI: 17.88 kg
Predicted DMI: 18.04 kg

Nutrient	Diet Concentration		Diet Intake	Added	Water Intake	Absorbed				%Rqd	Organic (% Total)
						Supplied	Rqd	Balance			
Ca	0.68	%DM	120.70	50.47	0.00	58.43	55.95	2.48	g/day	104	-
P	0.37	%DM	66.04	0.03	-	43.08	48.24	-5.16	g/day	89	-
Mg	0.30	%DM	54.13	24.57	-	20.39	6.38	14.01	g/day	320	-
K	2.88	%DM	514.78	0.18	0.00	463.30	176.71	286.59	g/day	262	-
S	0.28	%DM	50.14	0.06	0.00	50.14	35.76	14.38	g/day	140	-
Na	0.23	%DM	41.87	19.66	0.00	37.68	39.58	-1.91	g/day	95	-
Cl	0.93	%DM	166.30	30.24	0.00	149.67	48.51	101.16	g/day	309	-
Fe	149.71	ppm	2676.63	522.38	0.00	267.66	34.13	233.54	mg/day	784	0.00
Zn	36.34	ppm	649.65	0.00	0.00	97.45	153.05	-55.60	mg/day	64	0.00
Cu	6.99	ppm	125.02	0.00	0.00	5.00	8.49	-3.49	mg/day	59	0.00
Mn	64.61	ppm	1155.10	3.98	0.00	11.55	2.02	9.53	mg/day	573	0.00
Se	0.01	ppm	0.19	0.00	-	0.19	5.36	-5.18	mg/day	4	0.00
Co	0.01	ppm	0.11	0.00	-	0.11	1.97	-1.86	mg/day	5	0.00
I	0.00	ppm	0.06	0.00	-	0.05	7.58	-7.52	mg/day	1	-
Vit-A	0.00	KIU/kg	0.00	0.00	-	0.00	55.55	-55.55	KIU/day	0	-
Vit-D	0.00	KIU/kg	0.00	0.00	-	0.00	15.15	-15.15	KIU/day	0	-
Vit-E	0.00	IU/kg	0.00	0.00	-	0.00	404.00	-404.00	IU/day	0	-

Ingredient	Total P (%)	Digestible P PIG (%)	Digestible P Poultry (%)	Digestible P Ruminants (%)
Monosodium Phosphate	25.5	22.9 (90%)	22.7 (89%)	22.7 (89%)
Monocalcium Phosphate	22.7	20.3 (89%)	19.5 (86%)	19.5 (86%)
MonoDical Phosphate	21.3	16.6 (78%)	16.8 (78%)	16.8 (78%)
Dicalcium Phosphate	18.0	13.1 (73%)	14.1 (78%)	14.1 (78%)
Tricalcium Phosphate	18.0	10.0 (55%)	10.0 (55%)	10.0 (55%)
Wheat 12%	0.32	0.11 (34%)	0.12 (37%)	0.22 (70%*)
Sorghum	0.28	0.08 (29%)	0.08 (29%)	0.16 (58%*)
Barley 11%	0.30	0.10 (33%)	0.11 (37%)	0.21 (70%*)
Soybean 47%	0.75	0.25 (33%)	0.27 (36%)	0.52 (69%*)
Canola Meal 36%	0.93	0.28 (30%)	0.34 (37%)	0.56 (60%*)
Millmix/run	1.00	0.30 (30%)	0.37 (37%)	0.68 (68%*)
Field Peas	0.38	0.17 (45%)	0.16 (42%)	0.33 (87%*)
Lupins	0.30	0.14 (47%)	0.15 (50%)	0.29 (97%*)

* Assuming natural rumen phytase hydrolyses 50% of phytate and grains

Premier Atlas 2016

Organic P digestibility is related to rumen function!

Soluble P required…

RESEARCH ARTICLE

Relationship between true digestibility of dietary phosphorus and gastrointestinal bacteria of goats

Lizhi Wang[1,2☯]*, Ali Mujtaba Shah[1,2,3‡], Yuehui Liu[1,2☯], Lei Jin[1,2‡], Zhisheng Wang[1,2], Bai Xue[1,2], Quanhui Peng[1,2]

1 Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, Sichuan, China, **2** Key Laboratory of Animal Disease-Resistant Nutrition, Chengdu, Sichuan, China, **3** Department of Livestock Production, Shaheed Benazir Bhutto University of Veterinary and Animal Science, Sakrand, Sindh, Pakistan

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Abstract

The present research was conducted to evaluate the connection between the true digestibility of Phosphorus (TDP) in diet and bacterial community structure in the gastrointestinal tract (GIT) of goats. Twenty-eight Nubian goats were chosen and metabolic experiment was conducted to analyze TDP of research animals. Eight goats were grouped into the high digestibility of phosphorus (HP) phenotype, and another 8 were grouped into the low digestibility of phosphorus (LP) phenotype. And from the rumen, abomasum, jejunim, cecum and colon content of the goats, bacterial 16S rRNA gene amplicons were sequenced. In the rumen 239 genera belonging to 23 phyla, in abomasum 319 genera belonging to 30 phyla, in jejunum 248 genera belonging to 36 phyla, in colon 248 genera belonging to 25 phyla and in cecum 246 genera belonging to 23 phyla were noticed. In addition, there was a significant correlation between the TDP and the abundance of *Ruminococcaceae_UCG-010*, *Ruminococcus_2*, *Ruminococcaceae_UCG-014*, *Selenomonas_1* and *Prevotella* in the rumen, *Lachnospiraceae_ND3007_group*, *Saccharofermentans*, *Ruminococcus_1*, *Ruminococcaceae_UCG-014*, *Lachnospiraceae_XPB1014_group* and *Desulfovibrio* in the abomasum, *Prevotella*, *Clostridium_sensu_stricto_1*, *Fibrobacter*, *Desulfovibrio* and *Ruminococcus_2* in the jejunum, *Ruminococcaceae_UCG-014* in the colon, and *Desulfovibrio* in the cecum. Present research trial recommended that the community of gastrointestinal microbiota is a factor affecting TDP in goats.

Comparison of different Phosphorus sources (INRA, Premier Atlas 2016)

* Ileal Digestibility

Ingredient	Total P %	Amount of Digestible P %*	P Digestibility Pigs %	Citric Acid Solubility	P Solubility in water
Monosodium Phosphate (MSP)	**25.5**	**23.0**	**90**	>98%	**>95%**
Monocalcium Phosphate (MCP)	**22-22.7**	**20.3**	**75-89**	85-95%	**75-95%**
Mono Dicalcium Phosphate (MDCP)	**21.3**	**16.6**	**65-78**	80-95%	**50-85%**
Dicalcium Phosphate (DCP)	**18**	**13.1**	**55-72**	70-90%	**8-20%**
Tricalcium Phosphate (TCP) (70% of what's sold as DCP)	**(16)18**	**10.0**	**42-55**	40-80%	**<1%**

The Other Side of the Dice – Excess in Transition

Phosphorus Binders

- Sodium aluminum silicate when first introduced was thought to be a Ca binder… then this was published

2323W Effects of 3 different prepartum diets on dry matter intake, beta-hydroxybutyrate, and mineral concentrations in multiparous Holstein cows. W. Frizzarini*1, J. Diniz2, A. Vang1, P. Monteiro1, and L. Hernandez1, 1*University of Wisconsin, Madison,WI*, 2*Federal University of Minas Gerais, Belo Horizonte, MG, Brazil*.

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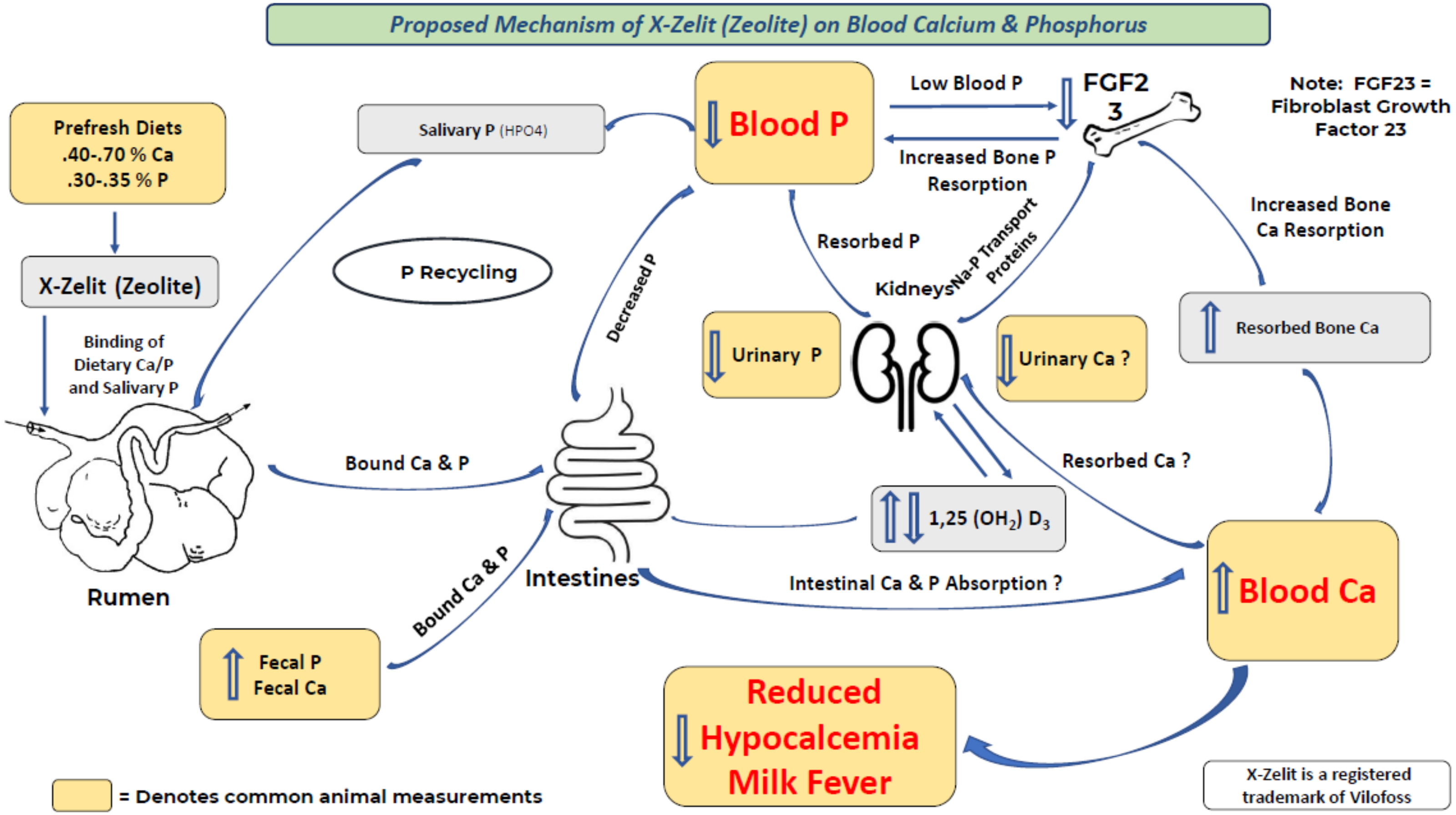
respectively). Ca was increased in cows fed XZ compared with CON during the prepartum ($P < 0.05$). On D0, cows fed XZ had the highest Ca concentrations, and cows fed DCAD had increased Ca compared with CON (2.18 ± 0.03, 1.95 ± 0.05, 1.86 ± 0.05, for XZ, DCAD, and CON respectively; $P < 0.01$). P concentrations were decreased in XZ cows compared with DCAD and CON cows in the prepartum period (2.67 ± 0.11, 5.22 ± 0.12, 5.08 ± 0.13, respectively; $P < 0.05$). On D0 CON had higher Mg (3.00 ± 0.10, 2.69 ± 0.10, 2.61 ± 0.10, for CON, DCAD, and XZ respectively; $P < 0.05$). In conclusion, XZ increased BHB and Ca concentrations and decreased DMI and P concentrations during the prepartum period.

Key Words: transition period, dairy cow

Hernandez *et al* 2022

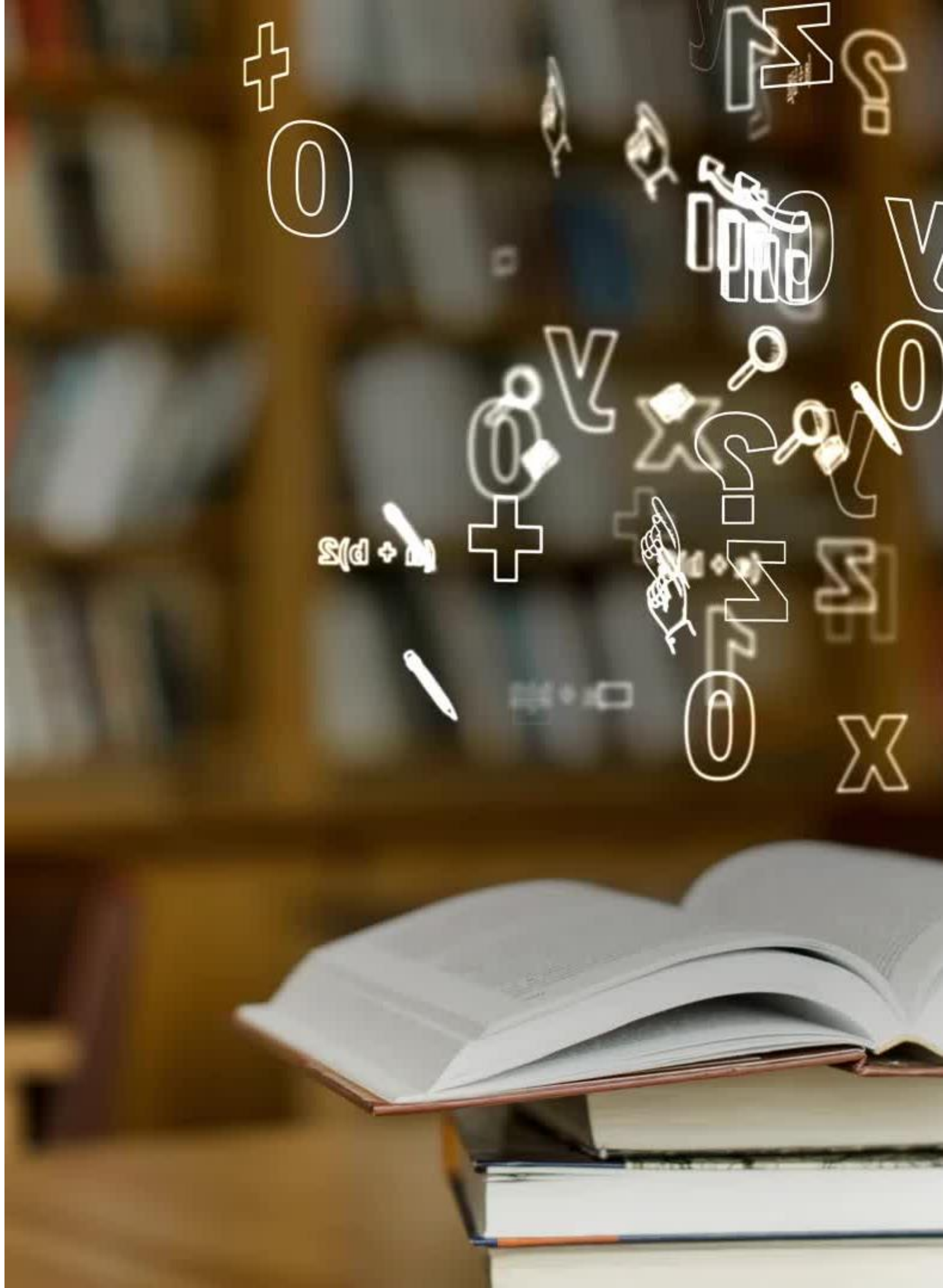
SAS Focus On FGF23 (peptide hormone, P↓, FGF23↓, 1-25 D↑)



From Hoffman and Martin

When To Apply?

- Start with knowing the level of P in the proposed pre-calving ration…
- If P > 2.5g/kg DM and DCAD strategies cannot be implemented, it may provide a suitable alternative (10g SAS/1g ration P)
- Be aware of some limitations, the Hernandez study showed decreased DMI and increased BHB… so you will want to address those via your fresh cow ration
- Min. blood P @ 0.30mmol/L - monitor



Don’t Forget Dr. Lance Baumgard…

Traditional Belief

Increased NEFA, Hyperketonemia, and Hypocalcemia…..CAUSE production and health problems

What if transition problems were caused by inflammation?

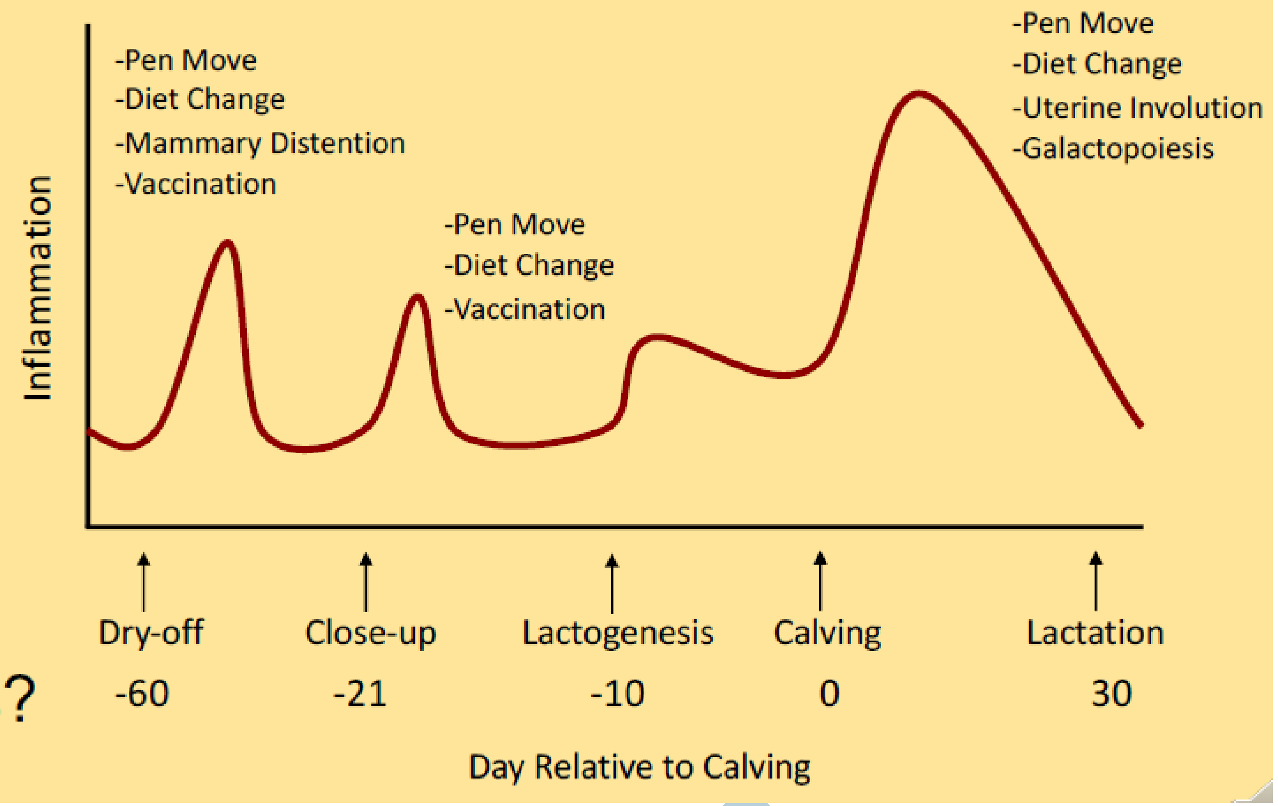
Inflammation in Transition Cows

- Observed in all cows

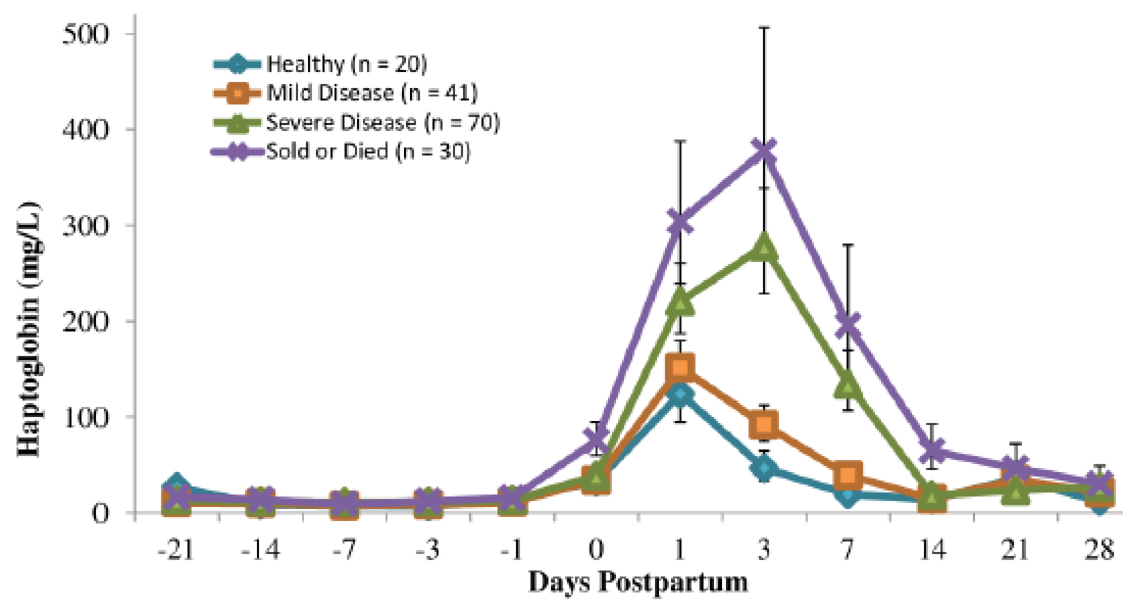
(Bertoni et al., 2008; Bradford et al., 2015; Trevisi and Minuti, 2018)

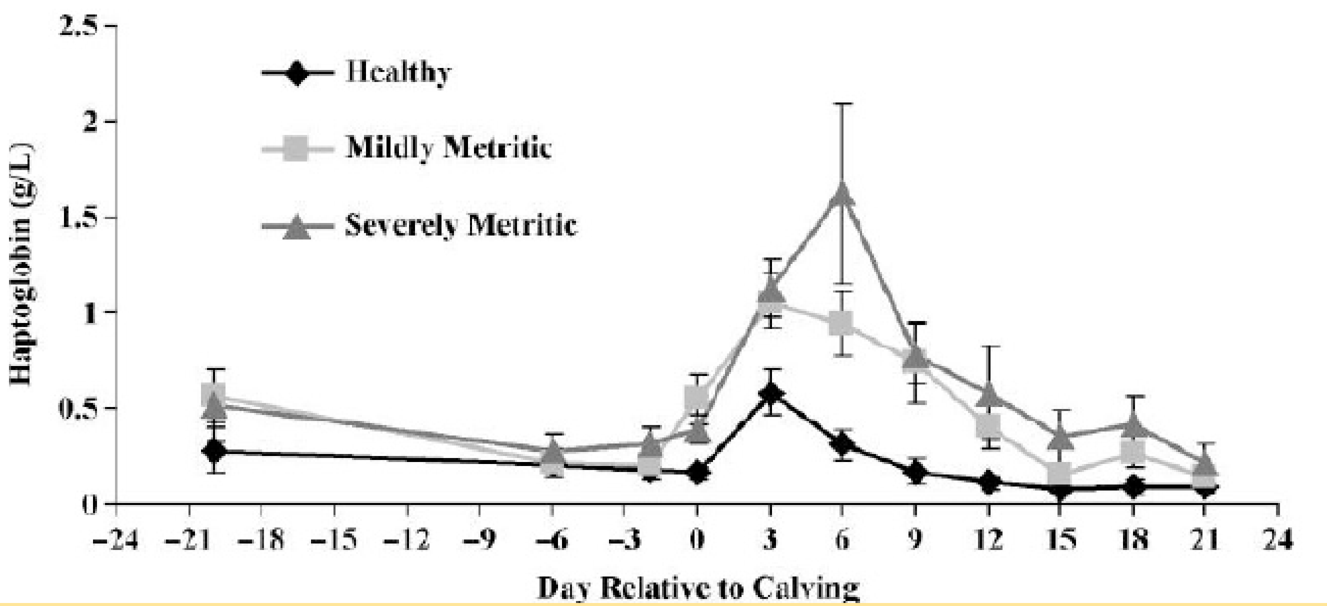
- What is the source?
  - Mammary Gland
  - Uterus
  - Gastrointestinal tract

- What are the consequences?



Immune Activation (Haptoglobin) Precedes Clinical Disease





Sebedra 2012

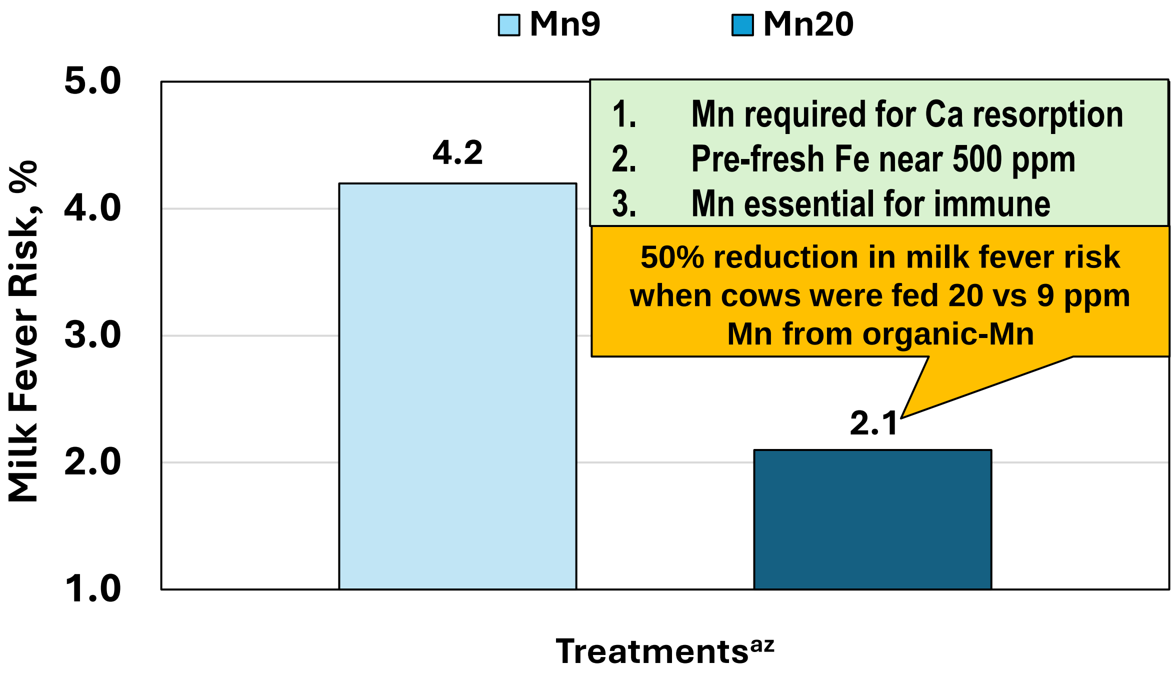
Huzzey et al., 2012

Immune activation acutely causes hypocalcaemia…

Moving from 9 – 20ppm Manganese (amino acid ligand) within 60ppm total

- 729 Cows stratified by previous lactation 305 d ME (multiparous only) and parity; randomly assigned to one of two treatments:
    - 51 ppm supplemental Mn from $MnSO_4$ plus 9 ppm supplemental Mn from organic Mn (n = 356)
    - 40 ppm supplemental Mn from $MnSO_4$ plus 20 ppm supplemental Mn from organic Mn (n = 373)
- Cows on treatment from -30 to 200 DIM

MILK FEVER RISK REDUCED



[a] 300 mg of Mn from $MnSO_4$ (Mn9; n = 356 cows) or manganese amino acid complex (Mn20; n = 373 cows) administered orally via mixing with 50 mL of molasses to achieve 9 ppm and 20 ppm Mn from organic-Mn for Mn9 and Mn20, respectively

[z] Treatment effect, $P = 0.09$

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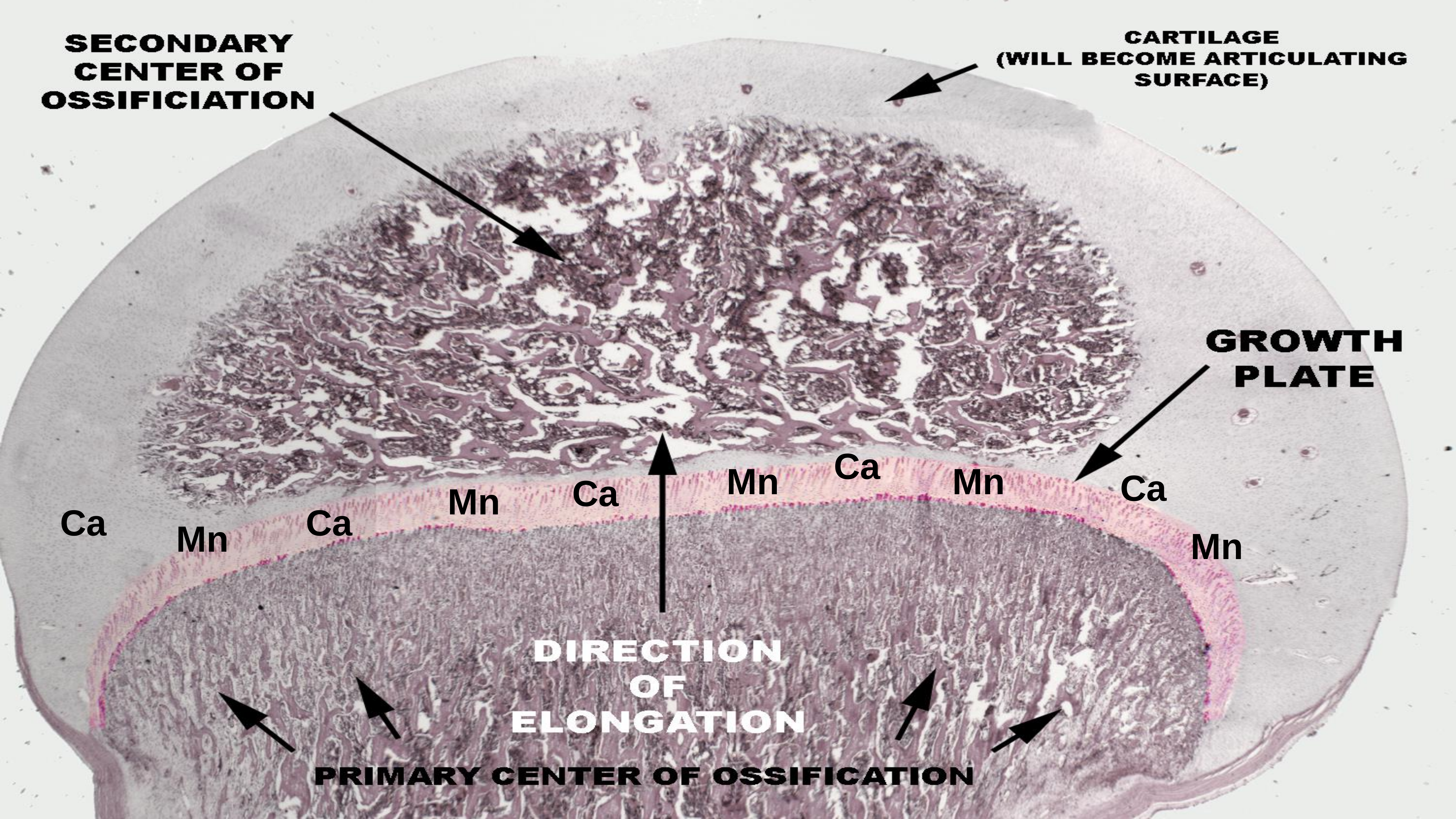
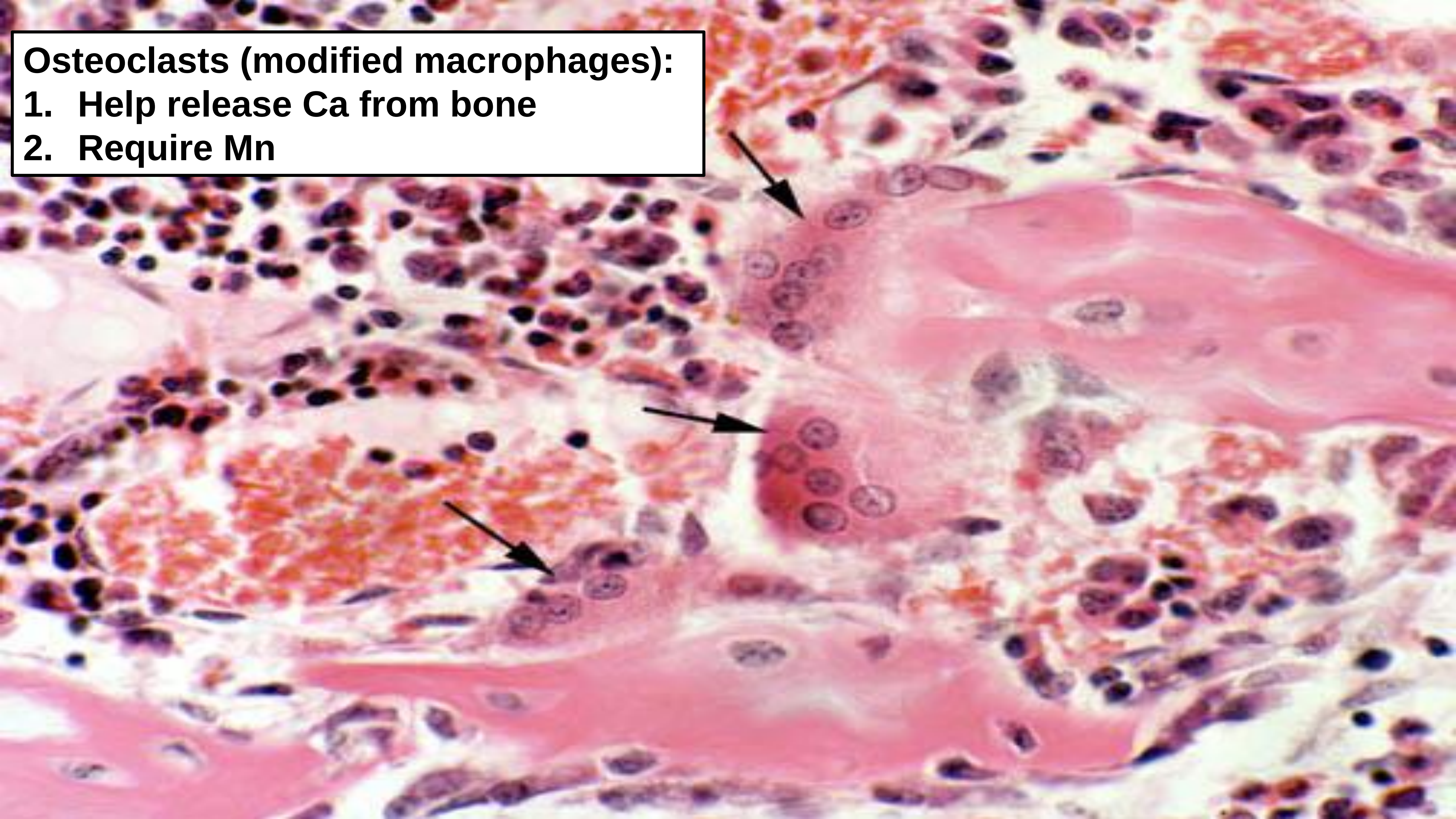

SECONDARY CENTER OF OSSIFICIATION
CARTILAGE (WILL BECOME ARTICULATING SURFACE)
GROWTH PLATE
Ca
Mn
Ca
Mn
Ca
Mn
Ca
Mn
Ca
Mn
DIRECTION OF ELONGATION
PRIMARY CENTER OF OSSIFICATION

Osteoclasts (modified macrophages):

1. **Help release Ca from bone**
2. **Require Mn**



Summary

Measure and monitor herd P status via blood/liver sampling and ration ingredient testing throughout the season

Correct for deficiencies during lactation and don't ignore the dry period, especially if utilising winter crops

Not all P supplements are the same, request water solubility data and consider the value of 25-OH-D_3 supplements to support homeostasis

SAS products provide an alternative when pre-calving ration P is higher, but it isn't possible to implement – DCAD strategies

Don't forget that all cows experience some level of inflammation during transition, the first line of defence is epithelial integrity - gut, uterus, mammary (Ca, Zn, Mn etc.) and moderating rumen pH to limit LPS generation… then be supportive of immune function