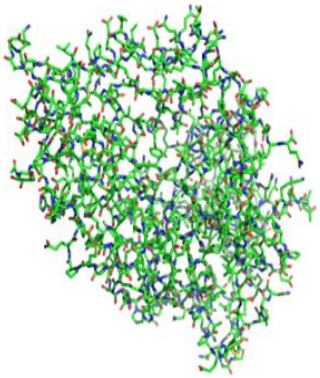

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Phytase – A Mature Or Immature Technology?

Dr. Peter H. Selle, Adjunct Associate Professor in the Poultry Research Foundation within The University of Sydney, Australia

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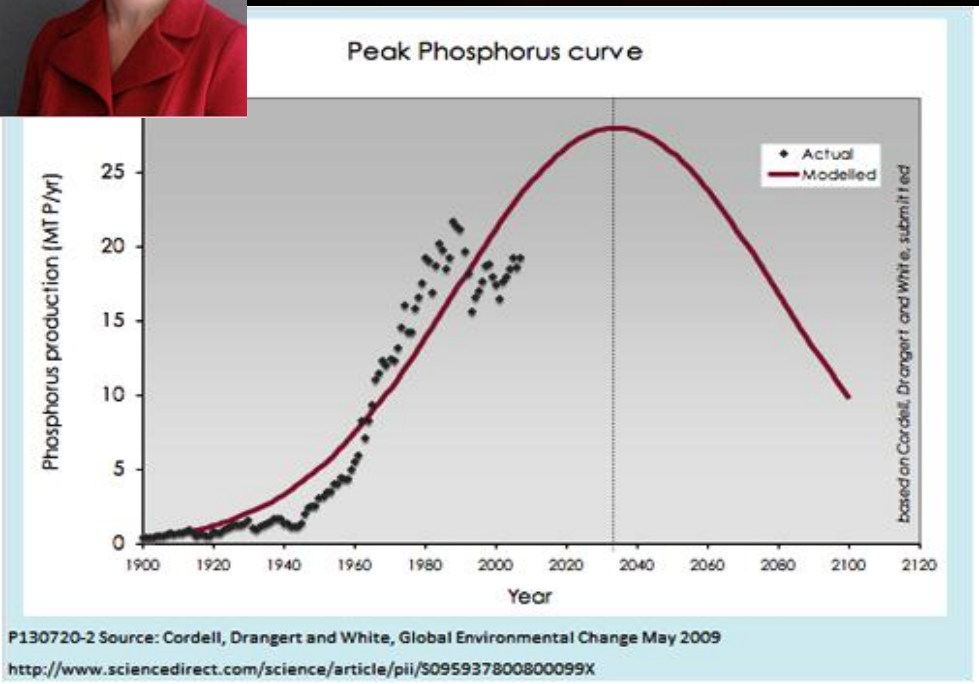
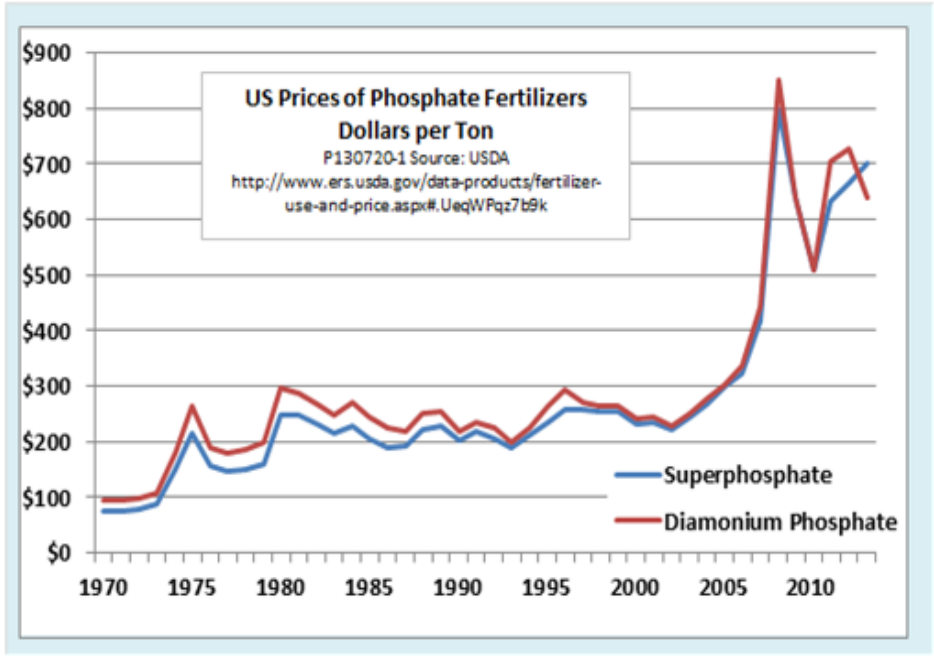
Will peak phosphate get us before global warming?

Ed Dolan 22/07/2013. *Oilprice*



P130720-2 Source: Cordell, Drangert and White, Global Environmental Change May 2009
http://www.sciencedirect.com/science/article/pii/S095937800800099X



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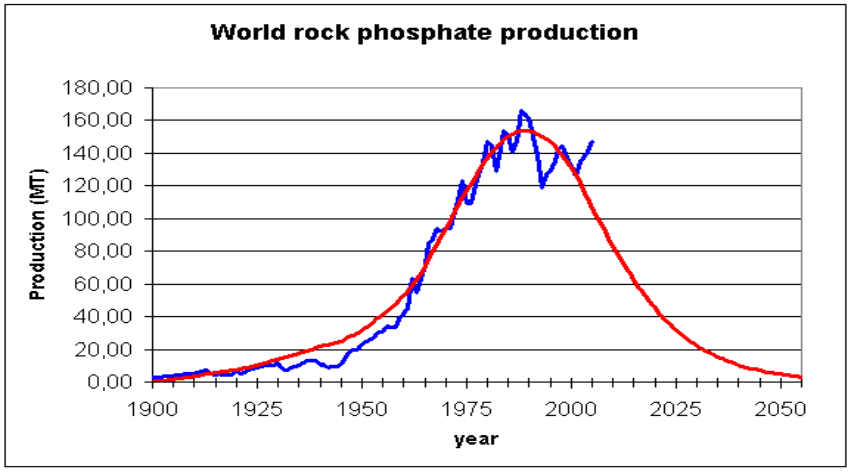
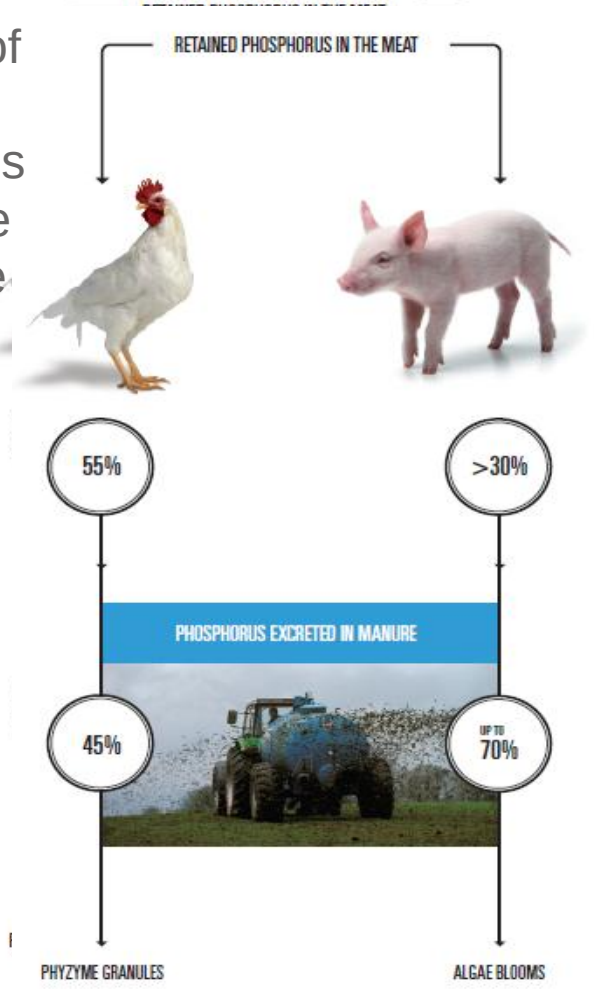
Phosphorus - One Of Nature's Paradoxes And A Challenge For The Emerging And Emerged Markets

- Excreted phosphorus is not only an issue because of the rarity and scarcity of inorganic phosphorus…it causes eutrophication and pollution, e.g. algae blooms
- The Netherlands/EU was the 1st country to introduce phosphorus tax. Iowa has been battling with the issue for decades.
- China, Brazil and Ukraine are emerging phosphorus hot spots





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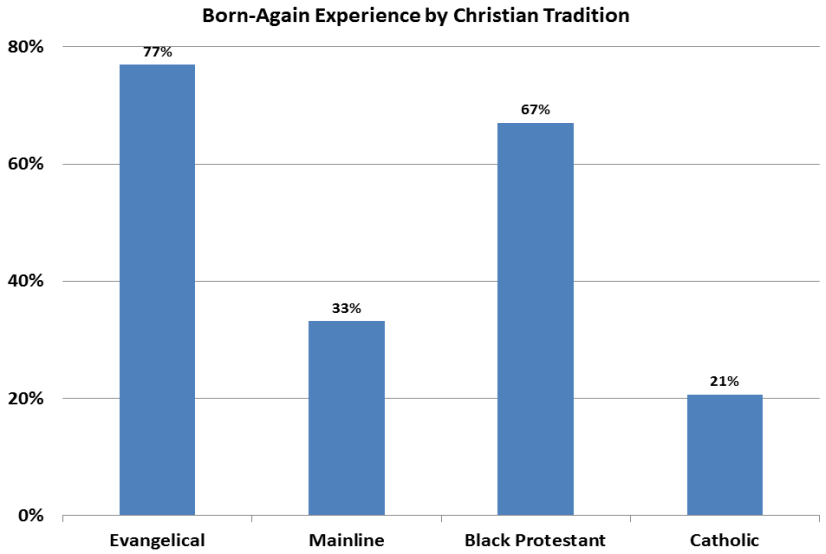
DOOMSDAY



Phosphorus Availability in Pigs Phosphorus studies in pigs
3. Effect of phytase supplementation on the digestibility and availability of phosphorus in soya-bean meal for grower pigs
P. P. Ketaren, E. S. Batterham, E. Belinda Dettmann and D. J. Farrell
British Journal of Nutrition
Volume 70 / Issue 01 / July 1993, pp 289-311

Has phytase a proteolytic effect in diets for weaner pigs?
Barnett BJ, Clarke WA, Batterham ES (1993)
APSA Proceedings IV, 227

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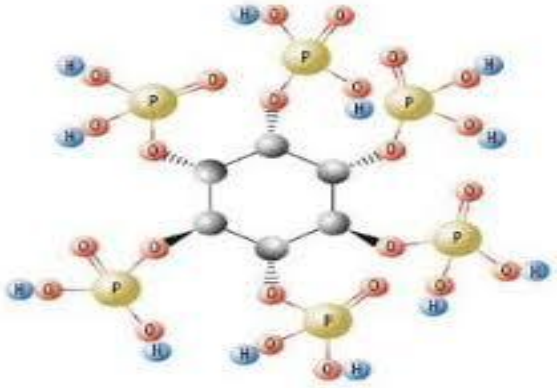

natuphos®
THE ORIGINAL PHYTASE

PHYTATE (*myo*-inositol hexaphosphate; IP_6)

Hartig T (1855) Uber das Klebermehl. *Botanische Zeitung* **13**, 881–885.

Pfeffer W (1872) Untersuchungen uber die Proteinkorner und die Bedeutung des Asparagins bei Kiemen der Samen. *Jahrbuch Wissenschaftlicher Botanik* **8**, 429–437.

PHYTASE

Suzucki U, Yoshimura K, Takaishi M (1907) Uber ein Enzym “Phytase” das Anhydro-oxy-methylen-diphosposaure spaltet. *College Agricultural Bulletin, Tokyo Imperial University* **7**, 503–505.

NATUPHOS® Phytase

Simons PCM, Versteegh HAJ, Jongbloed AW, Kemme PA, Slump P, Bos KD, Wolters MGE, Beudeker RF, Verschoor GJ (1990) Improvement of phosphorus availability by microbial phytase in broilers and pigs. *British Journal of Nutrition* **64,** 525–540.

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The Immaturity of Phytate and Phytase

Maturity emphasizes a clear comprehension of purpose

On that basis, phytate and phytase are still puppies

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The Role Of Microbial Phytases In Poultry And Pig Nutrition

Selle PH, Ravindran V, Cadogan DJ, Walker AR, Bryden WL (1996) Proceedings, Tenth Australian Poultry and Feed Convention pp 219-224. Australian Chicken Meat Federation. Australian Stock Feed Manufacturers' Association. World's Poultry Science Association. Australian Branch. Melbourne Vic

The acceptance of phytase will be determined by the following factors:

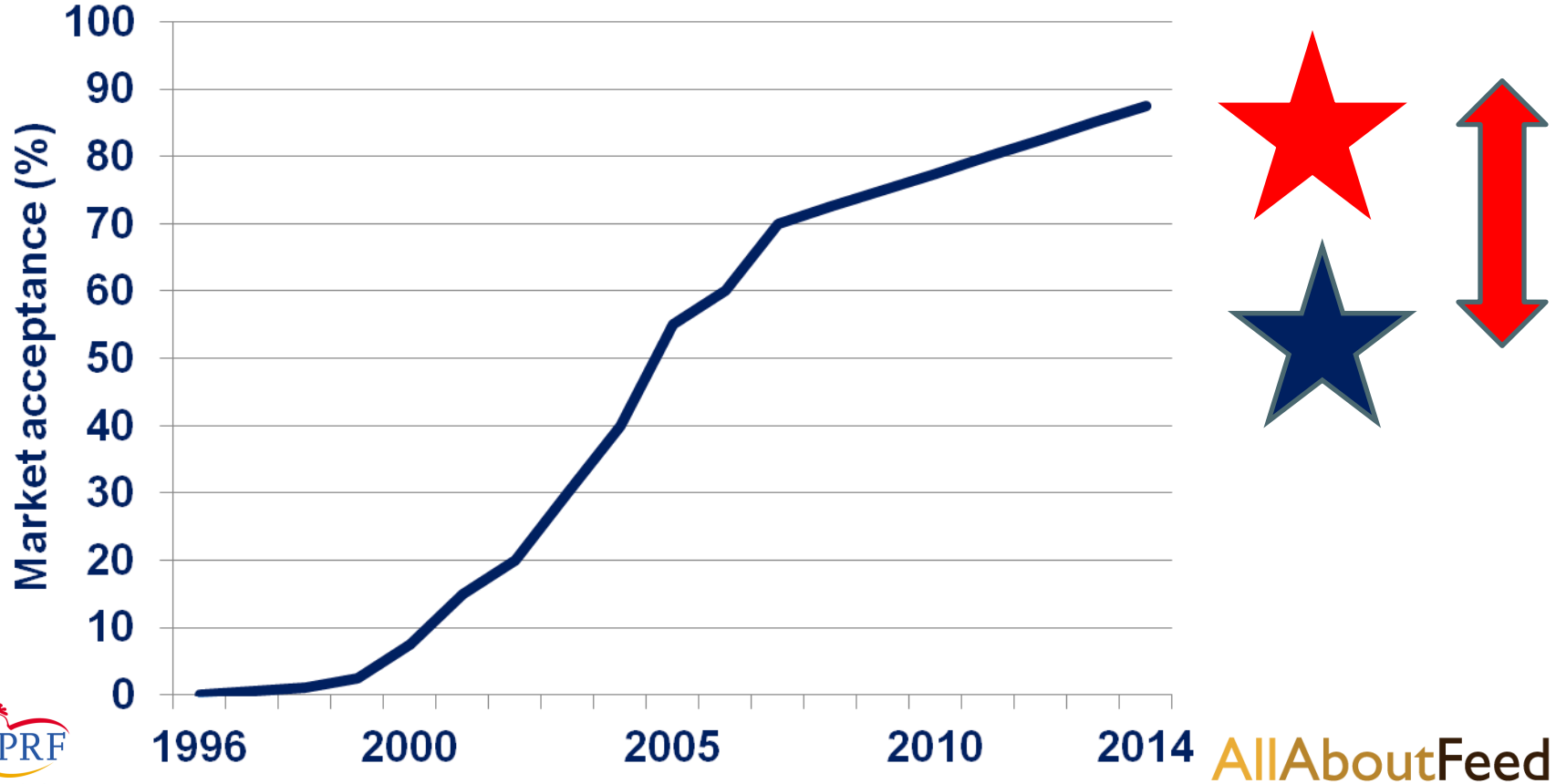
(i)Magnitude of response in terms of P released
(ii) Cost of phytase ⇓
(iii) Cost of inorganic P ⇑
(iv) Cost of P disposal
(v)The possible 'extra-phosphoric' benefits of phytase -especially in terms of improved protein utilization
(The possible 'extra-phosphoric' benefits of phytase about in terms of improved starch/energy utilization)

Approximate Market Acceptance Of Phytase Feed Enzymes At 500 Ftu/Kg In Australian Pigs And Poultry From 1996 To 2014. From Zip To 87.5%

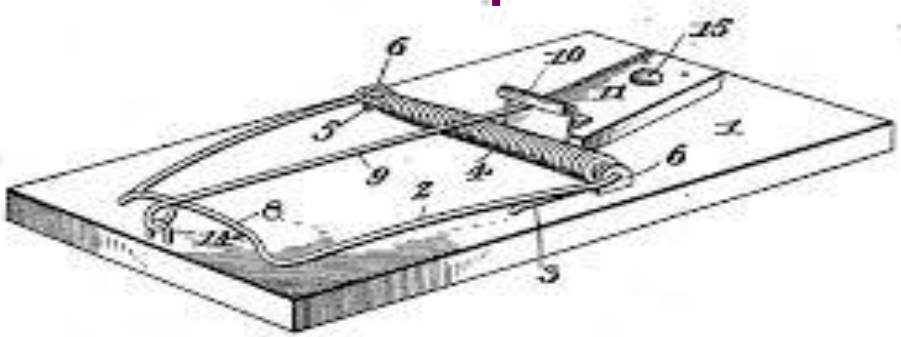
Allowance for "super-dosing"

Effective market acceptance 87.5 ⇒ 112.5%

4.605 mio t ⇔ 5.250 mio t ⇔ 5.930 mio t



Better Mouse-traps…

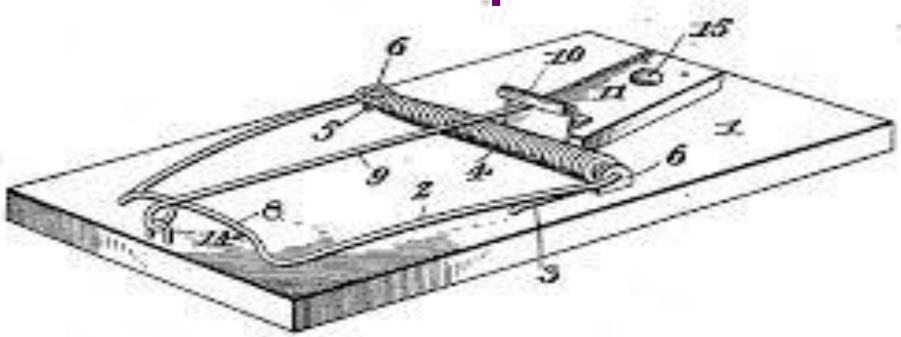


1996 Fungal phytases $4.50/t inclusion $280 per tonne diets (1.61%)

2014 Bacterial phytases $1.50/t inclusion $450 per tonne diets (0.33%)

= An 80% improvement in "affordability"

Better Mouse-traps…



Unpublished **Poultry Research Foundation** data established that a recently released bacterial phytase significantly outperformed the original fungal phytase

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Magnitude Of Response In Terms Of P Released

- Entirely dependent upon dietary level of phytate/phytate-P
- Extent of degradation of IP_6 phytate by phytase

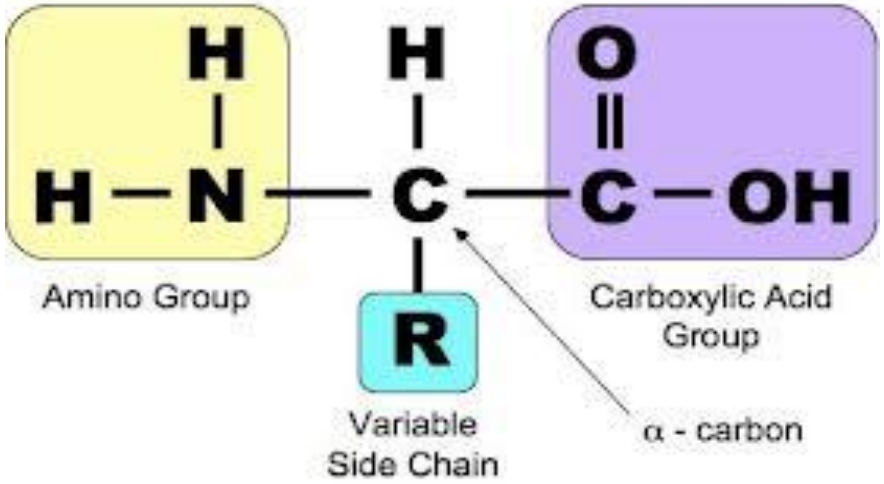
Nine P equivalency studies (Selle and Ravindran, 2007)
Alternatively: 10 g/kg phytate or 2.82 g/kg phytate-P x 0.452 ⇒ 1.27 g/kg

Phytase supplementation of maize-, sorghum- and wheat-based diets
Mean dietary level of 2.38 g/kg phytate-P or 8.43 g/kg phytate
Digestibility of IP_6 phytate by phytase at terminal ileum
0.238 ⇒ 0.631
Net increase of 0.393 or 39.3% degradation
Phytate-P released: 2.38 x 0.393 ⇒ 0.94 g/kg

Alternatively: 10 g/kg phytate or 2.82 g/kg phytate-P x 0.393 ⇒ 1.11 g/kg

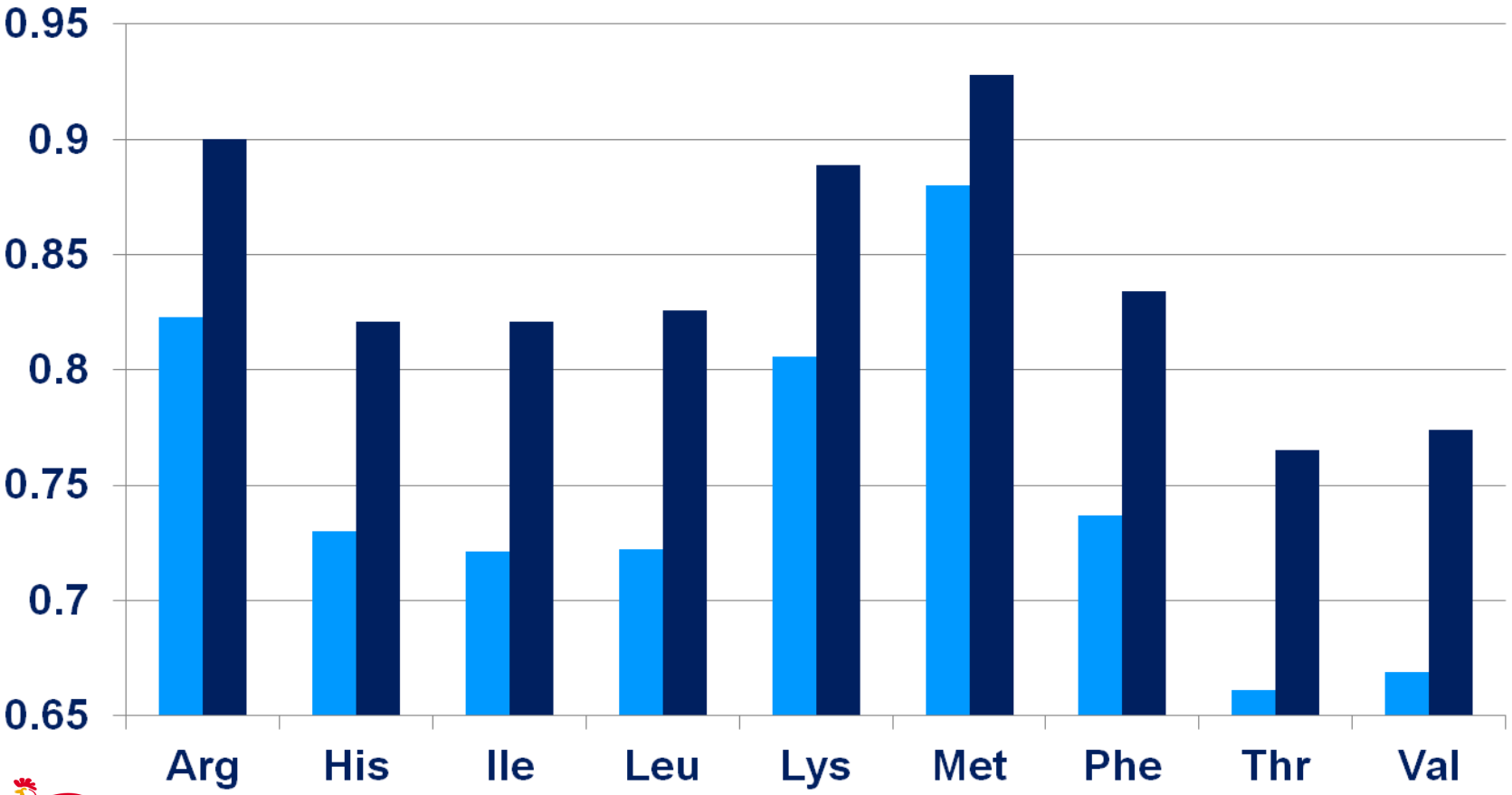
Inherent problem:
Studies to determine phytate digestibility coefficients with dietary markers (AIA, TiO_2, Cr_2O_3) almost certainly understate the case

The ‘Protein Effect’ Of Phytase



Adeola O, Sands JS (2003)
Does supplementary microbial phytase improve amino acid utilization?
A perspective that it does not.
Journal of Animal Science **81**, (E. Suppl. 2):E78-E85.

Inclusion Of 1000 FTU/Kg Phytase In Maize-based Broiler Diets Increased Average AID Coefficients Of Essential Amino Acids By 11.99% From 0.750 ⇒ 0.840 (Amerah *Et Al.* 2014)



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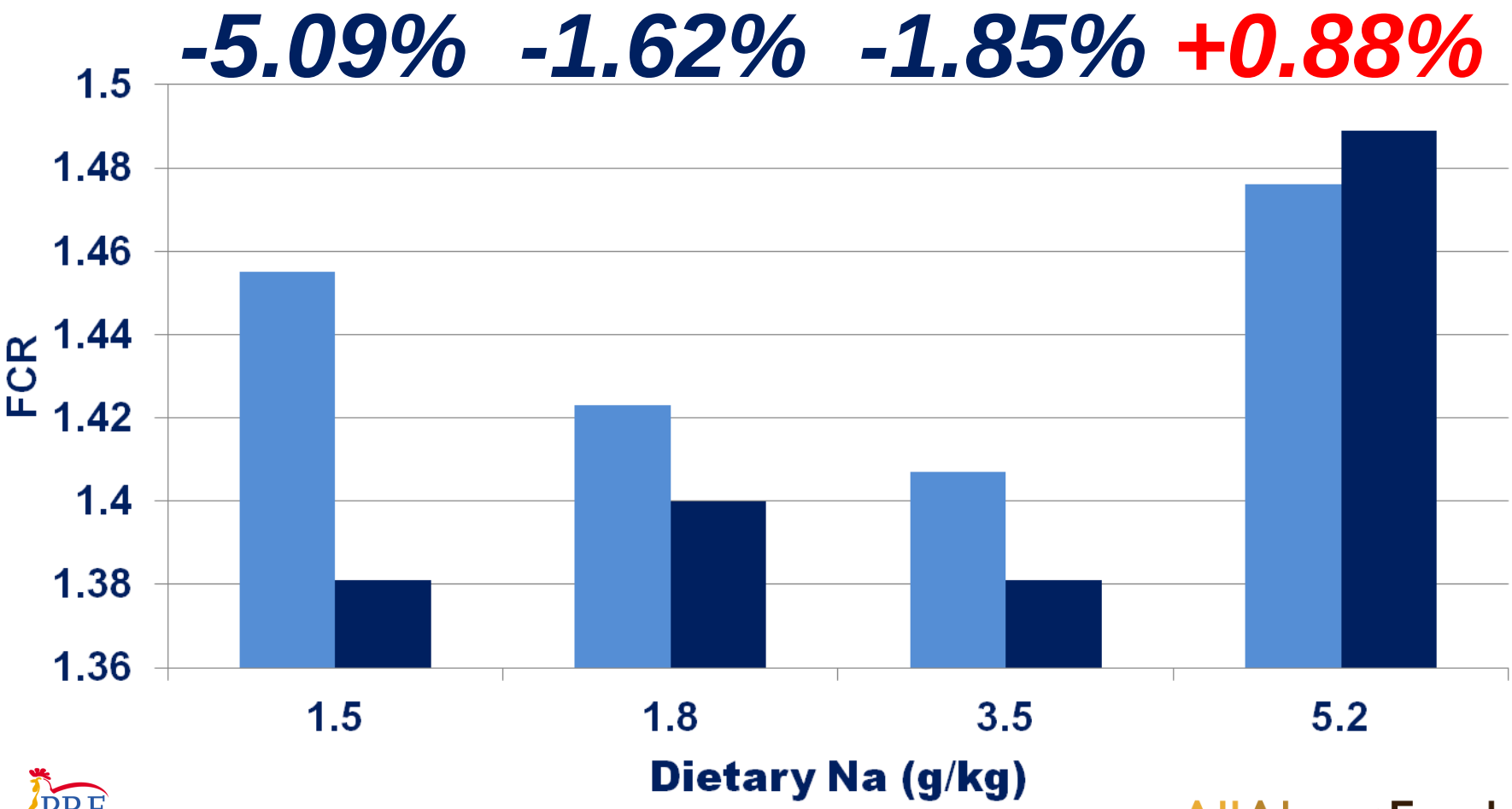
Phytase Responses Are A Function Of Dietary Substrate Levels And Nutrient Specifications

Calcium Ca^{2+}
Calcium levels should be at a 'respectable minimum' anyway, but *especially* in phytase-supplemented diets

Inositol [$IP_6 \Rightarrow$ inositol + 6iP]
Lower phytate esters may be completely degraded to inositol and inorganic P in the jejunal mucosa

Sodium Na^{+}
Dietary sodium levels are inversely related to the magnitude of phytase responses

FCR Responses To Exogenous Phytase Are Influenced By Dietary Na Levels Where 1.8 G/Kg Is Standard (Ravindran *et al.* 2009)



Serendipity? Sure!

However, in this study ***analyzed*** dietary Na levels appear crucial to the magnitude of phytase responses in maize, sorghum and wheat-based broiler diets

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Liu SY, Cadogan DJ, Peron A, Truong HH, Selle PH (2014)
Effects of phytase supplementation on growth performance, nutrient utilization and digestive dynamics of starch and protein in broiler chickens offered maize, sorghum and wheat-based diets
Animal Feed Science and Technology (article in press)

Truong HH, Yu S, Peron A, Cadogan DJ, Khoddami A, Roberts TH, Liu SY, Selle PH (2015)
Phytase supplementation of maize, sorghum and wheat-based broiler diets, with identified starch pasting properties, influences jejunal and ileal digestibilities of phytate (IP6) and sodium
Animal Feed Science and Technology (submitted for publication)

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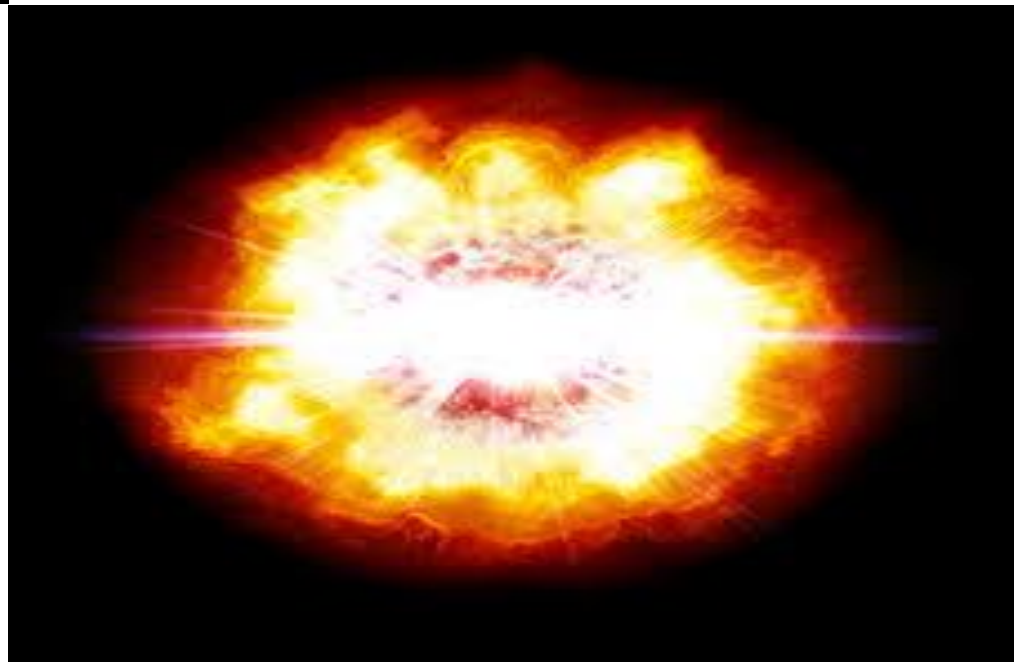
The ‘energy effect’ of phytase

In 12 studies phytase increased AME/AMEn by 0.37 MJ
13.27 ⇒ 13.64 MJ/kg
(Selle & Ravindran, 2007)



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Effect Of 500 FTU/Kg Phytase On Apparent Starch Digestibility Coefficients In Four Small Intestinal Segments In Finisher Broilers Offered Wheat- Or Maize-based Diets (Truong et al. 2015a)

Item	PJ	DJ	PI	DI
Wheat	**0.822**	**0.858**	**0.905**	**0.906**
Maize	**0.610**	**0.849**	**0.916**	**0.947**
Phytase 0	**0.658**	**0.833**	**0.890**	**0.915**
500 FTU/kg	**0.774**	**0.873**	**0.932**	**0.938**
Significance (P =)				
Grain	**< 0.001**	**0.664**	**0.609**	**0.015**
Phytase	**0.002**	**0.062**	**0.062**	**0.155**
Phytase response	***17.6%***	***4.80%***	***4.72%***	***2.51%***

Effect Of 500 FTU/Kg Phytase On Apparent Starch Disappearance Rates (G/Bird/Day) In Four Small Intestinal Segments In Finisher Broilers Offered Wheat- Or Maize-based Diets (Truong *et al.* 2015a)

Item	PJ	DJ	PI	DI
Wheat	67.5	70.3	74.2	74.2
Maize	50.7	70.4	76.1	78.6
Phytase 0	52.8	67.0	71.6	73.5
500 FTU/kg	65.3	73.8	78.7	79.3
Significance (P =)				
Grain	< 0.001	0.963	0.434	0.038
Phytase	<0.001	0.008	0.007	0.008
Phytase response	*23.7%*	*10.1%*	*9.92%*	*7.89%*

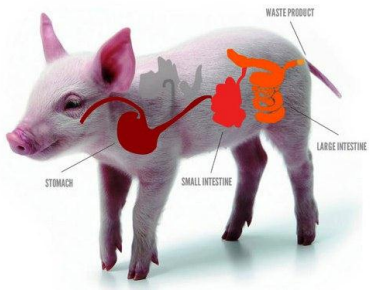
The Co-absorption Of Na And Glucose From The Gut Lumen Into Enterocytes Via SGLT-1 Transport Systems Is Driven By The Electrochemical Gradient Maintained By The Sodium Pump (Na^+,k^+-atpase)

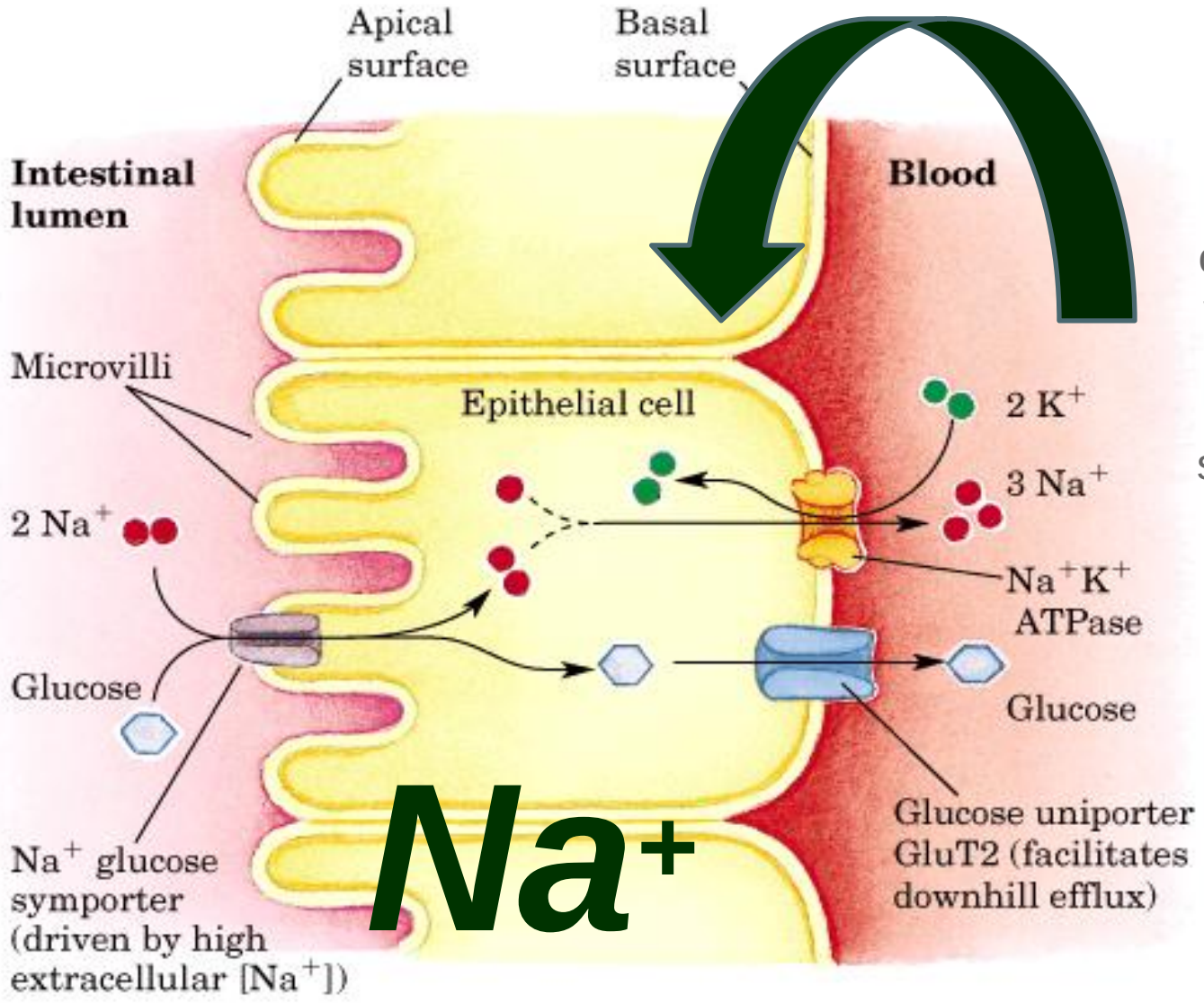
However, phytate has been shown to depress sodium pump activity in rats (Dilworth *et al.* 2005) and phytase has been shown to increase sodium pump activity in broiler chickens (Liu *et al.* 2008)

Does Phytate Impede Starch Digestion In The Gut Lumen And/Or Glucose Absorption Into Small Intestinal Enterocytes?

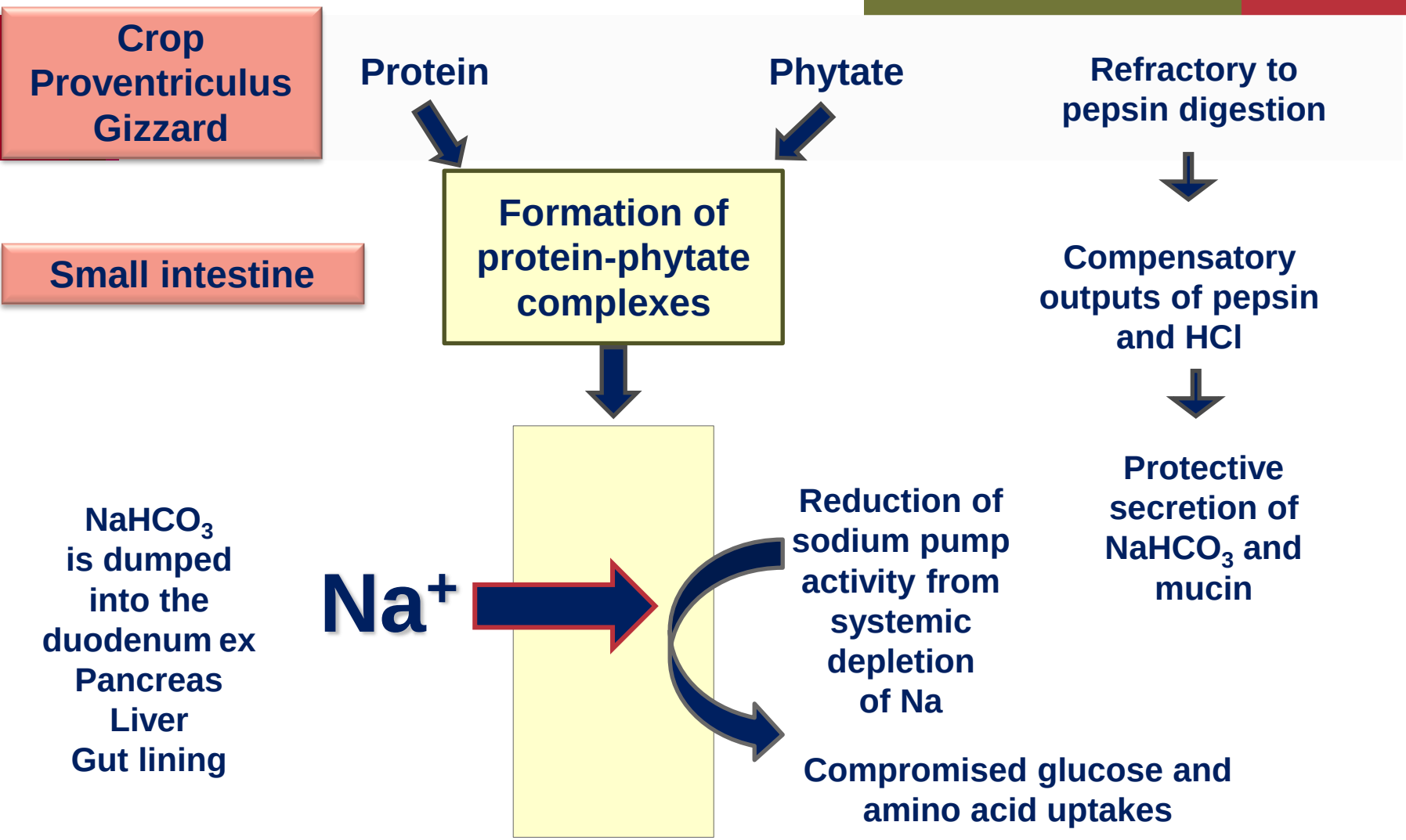
Phytate binding starch direct/indirectly [SGAP?]
Phytate inhibiting amylase activity [Ca?]

Phytate depressing intestinal glucose uptakes by restricting sodium pump (Na^+,K^+-ATPase) activity [Demjen and Thompson, 1991]



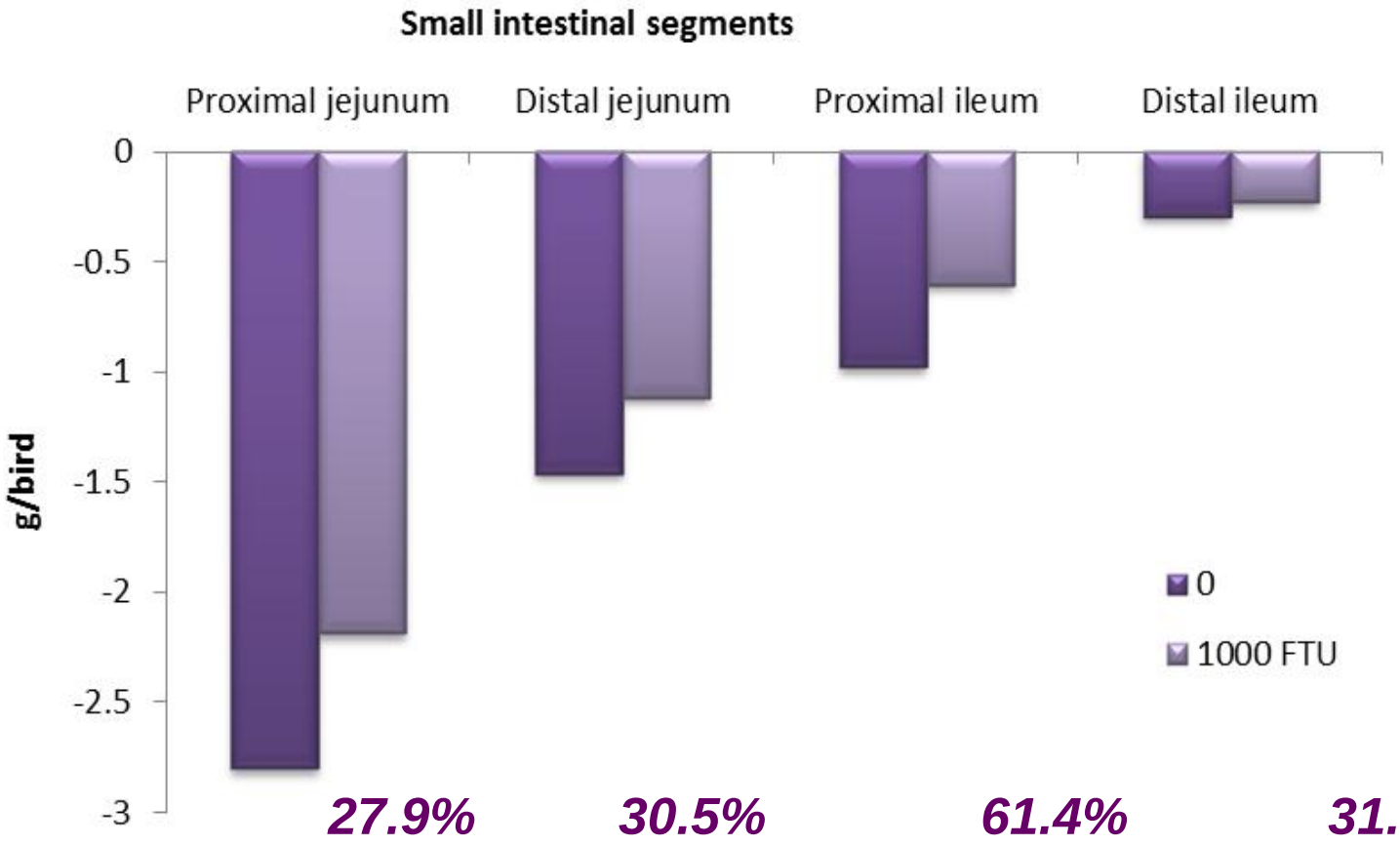


The cytoplasmic concentration of Na+ within enterocytes is the most important determinant of sodium pump activity (Therein & Blostein, 2000)



Systemic depletion of Na as $NaHCO_3$ is hyper-secreted into the duodenum to buffer excess HCl + pepsin secretion triggered by the presence of binary protein-phytate complexes that are refractory to pepsin digestion

Phytase Increased Na Recovery Along The Small Intestine Which Could Well Be Indicative Of Better Sodium Pump Function And Increased Intestinal Uptakes Of Glucose And Amino Acids (Truong *et al.* 2015b)

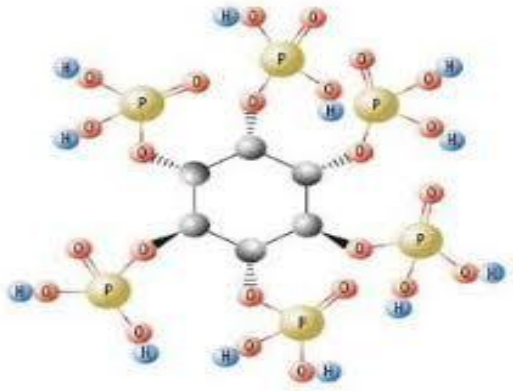


Phytate: A good or bad food component?
Barbara F Harland & Eugene R Morris (1995)
Nutrition Research 15, 733-754

Phytate reduces blood glycaemic indices in humans
Lilian U. Thompson Ph.D. Professor Emeritus
University of Toronto

The incidence of diabetes in the developed world has reached epidemic proportions From 1989/90 to 2011/12, the prevalence of diabetes more than doubled, from 1.5% to 4.2% of the human population. Emerging markets India and China are knows as the diabetes capitals of the world.

(sources Australian Institute of Health and Welfare; WHO)



Phytate:
A dietary means to control blood glucose levels in diabetic patients ????

Johnson and Tate (1969):

'Two attempts to isolate inositol penta- or hexaphosphtaes by a similar procedure from the blood of a female Murray River short-necked tortoise (Emydura macquarii) were unsuccessful.'

Phytate and Phytase

Chronologically mature but our comprehension remains naive and immature