The PEGaSus project:
Phosphorus efficiency in Gallus gallus and Sus scrofa

C. Gerlinger, M. Oster, H. Reyer, E. Magowan, E. Ball, D. Fornara, H.D. Poulsen, K.U. Sørensen, A. Rosemarin, K. Andersson, D. Ddiba, P. Sckokai, L. Arata, P. Wolf, K. Wimmers

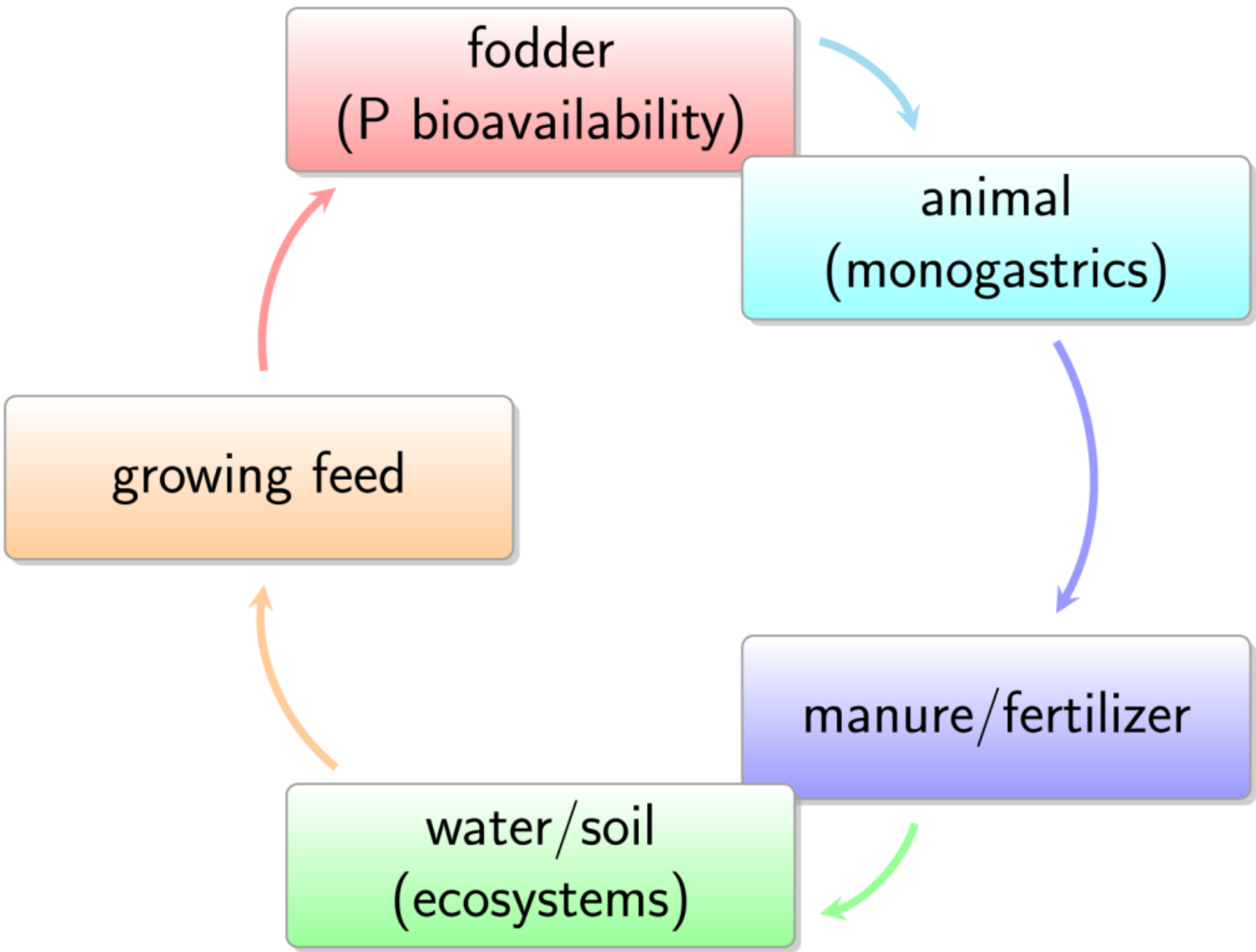
ERA-NET SUSAN

SCIENCE CAMPUS
PHOSPHORUS RESEARCH
ROSTOCK

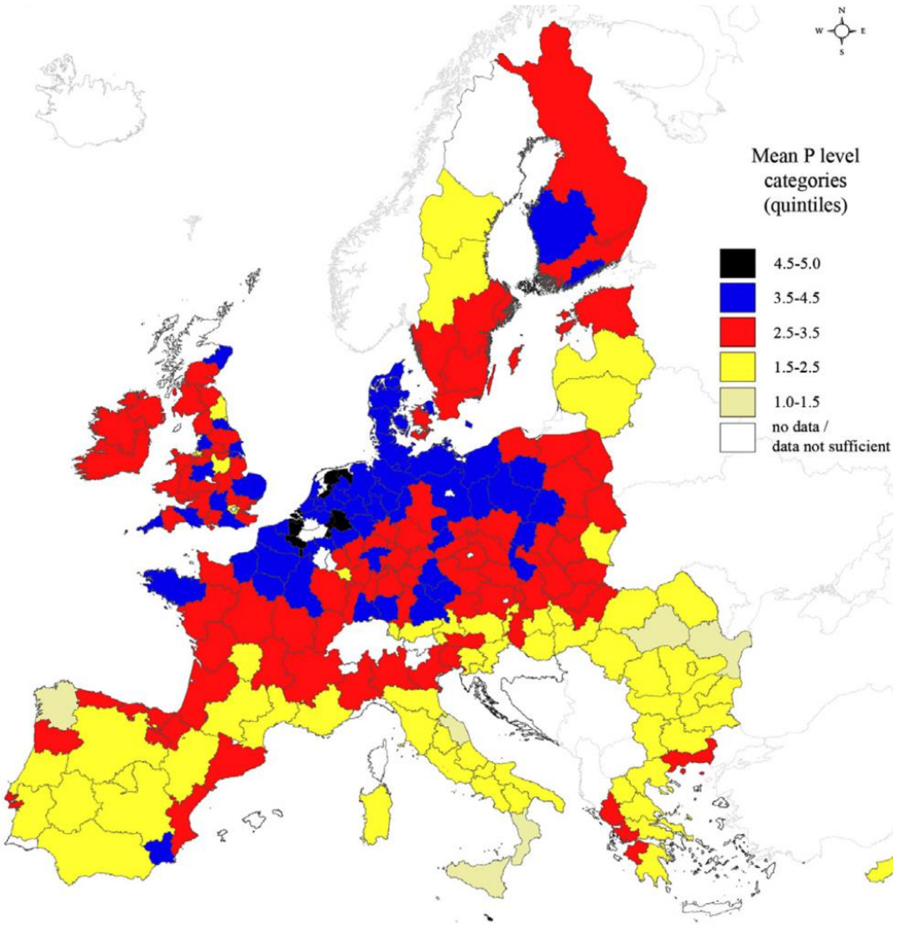
Phosphorus in animal production

- Phosphorus (P) is essential for all organisms
  (e.g. bone, nucleic acids, P proteins, P lipids, ATP, buffer)
- High environmental P load
- Global resources are limited

Bridging the gaps in the agricultural P cycle



Phosphorus concentration of cropland soils (EU)



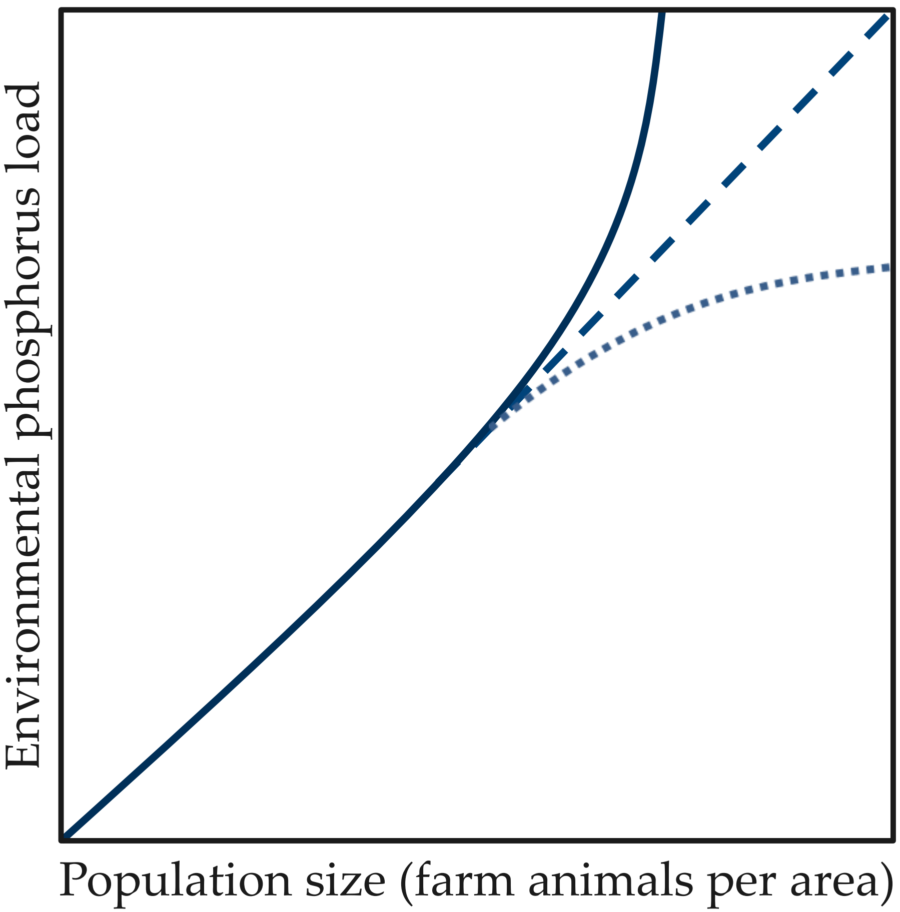
Tóth, G., Guicharnaud, R. A., Tóth, B., & Hermann, T. (2014). Phosphorus levels in croplands of the European Union with implications for P fertilizer use. *European Journal of Agronomy*, *55*, 42-52.

Scenarios illustrating the relationship between the population size of farm animals per area and environmental P load

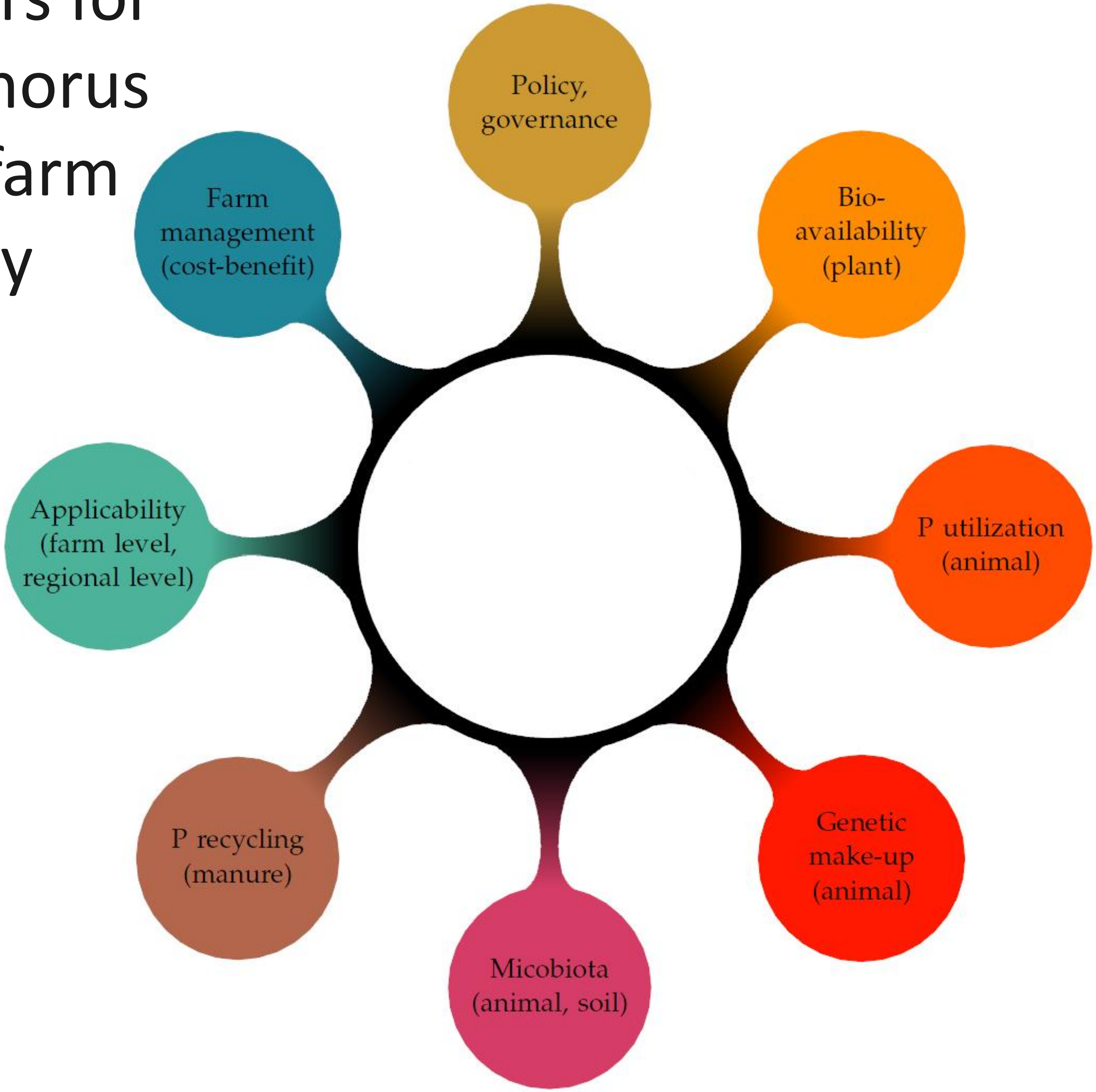
Solid line – P surplus areas due to P over-application.

Dashed line – in balance.

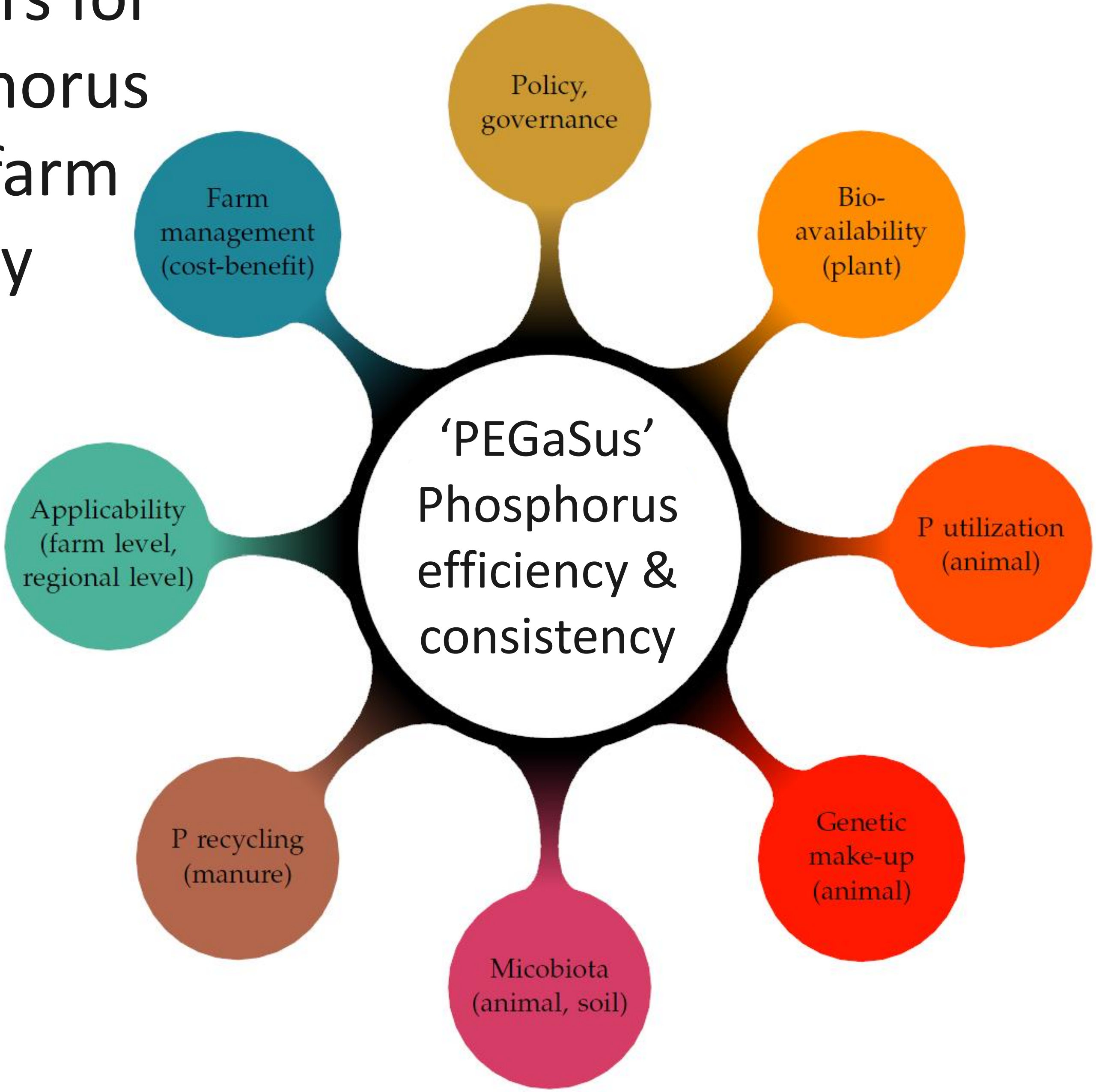
Dotted line – reduced impact using animal physiology, ecology, economy, recycling, policy & governance.



Dependent factors for achieving phosphorus sustainability in farm animal husbandry



Dependent factors for achieving phosphorus sustainability in farm animal husbandry



BASIC DATA

Funding:

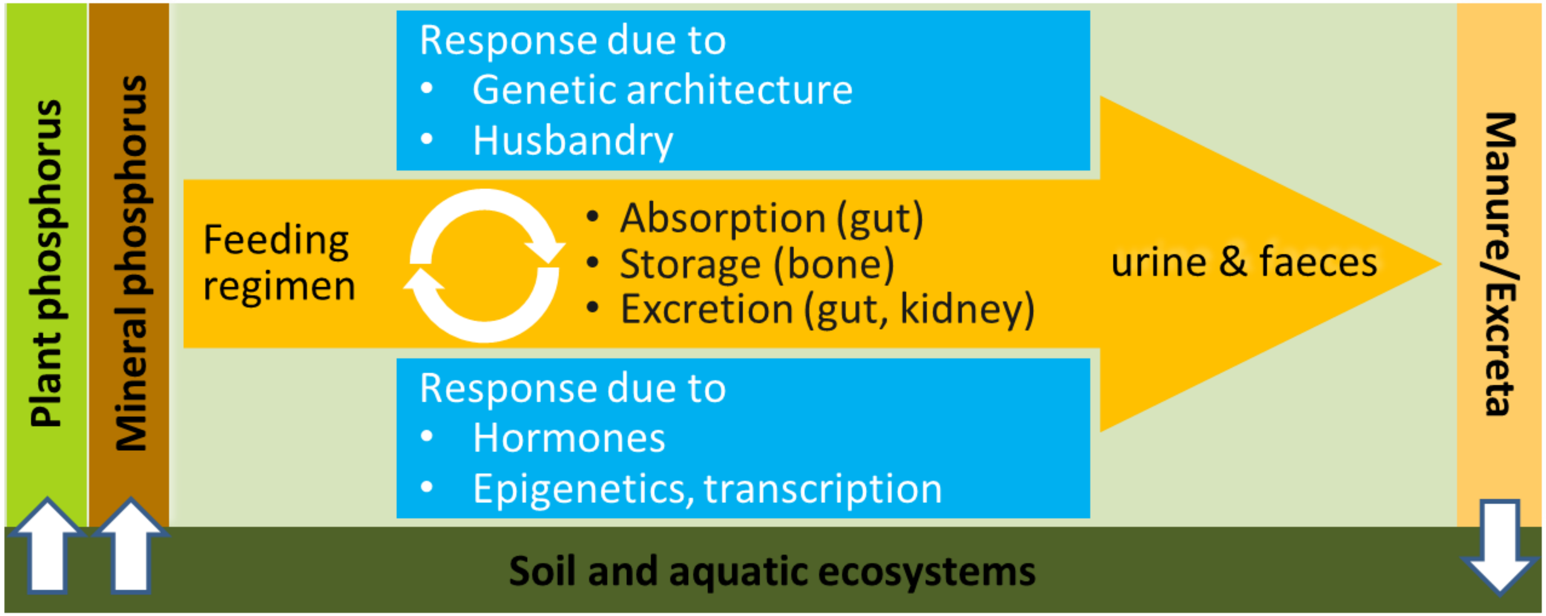
ERA-NET SUSAN

Coordination:
Leibniz-FBN

Duration:
2017-2020

5 European partners

Animal-centered model of the agricultural P cycle



- Feed stuff (bio-availability)
- Genetics (retention, excretion)
- Recycling (manure)
- Bio-economic potential (modelling)
- Phosphorus governance and policy aspects

Research components in summary

Animal husbandry

- Feeding strategies
  (e.g. P-conditioning, phytase, pre-digestion)
- Alternative feed sources
  (e.g. comfrey, low-phytate cereals)
- Genetics and gut microbiota affecting the efficiency of P digestion
- Methods of manure handling

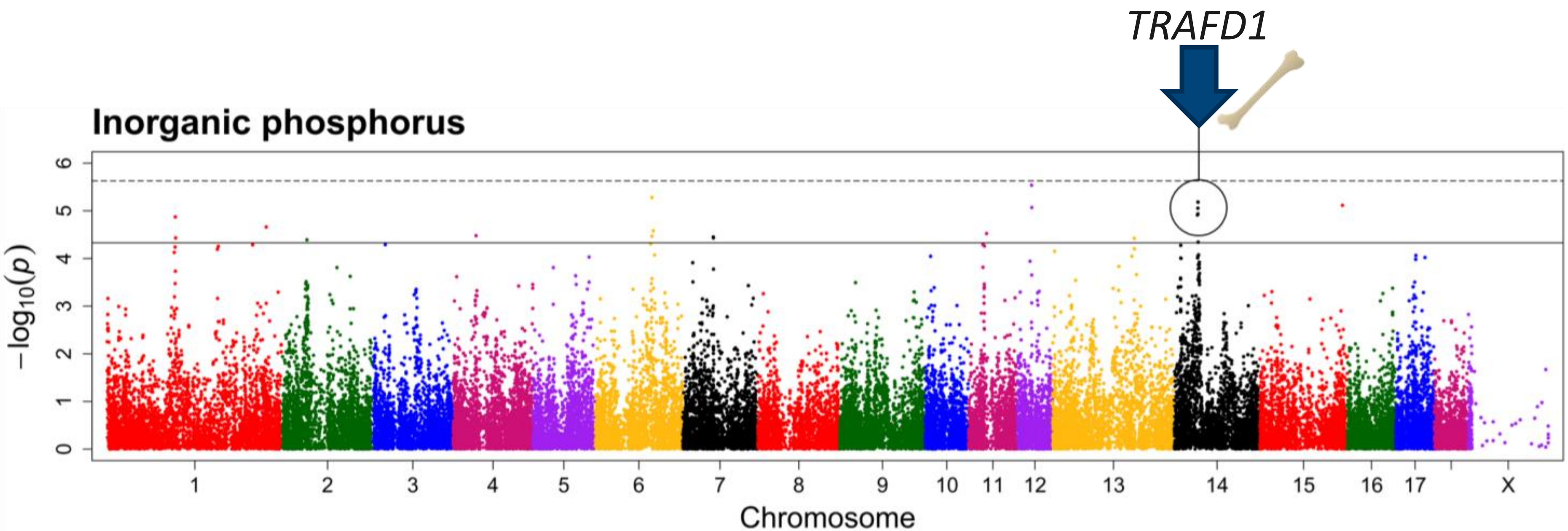
Soil systems/mesocosm – characterizing feeding plants & slurry

Reuse options – providing incentives to close the loop

Bio-economy model – looking at the financial losses and gains

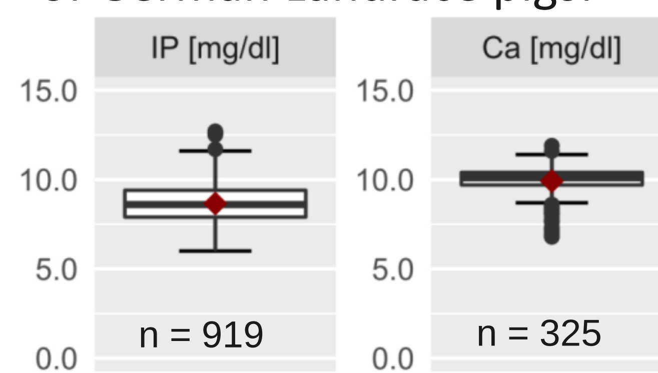
Governance and policy

Genetic architecture of serum P levels in pigs

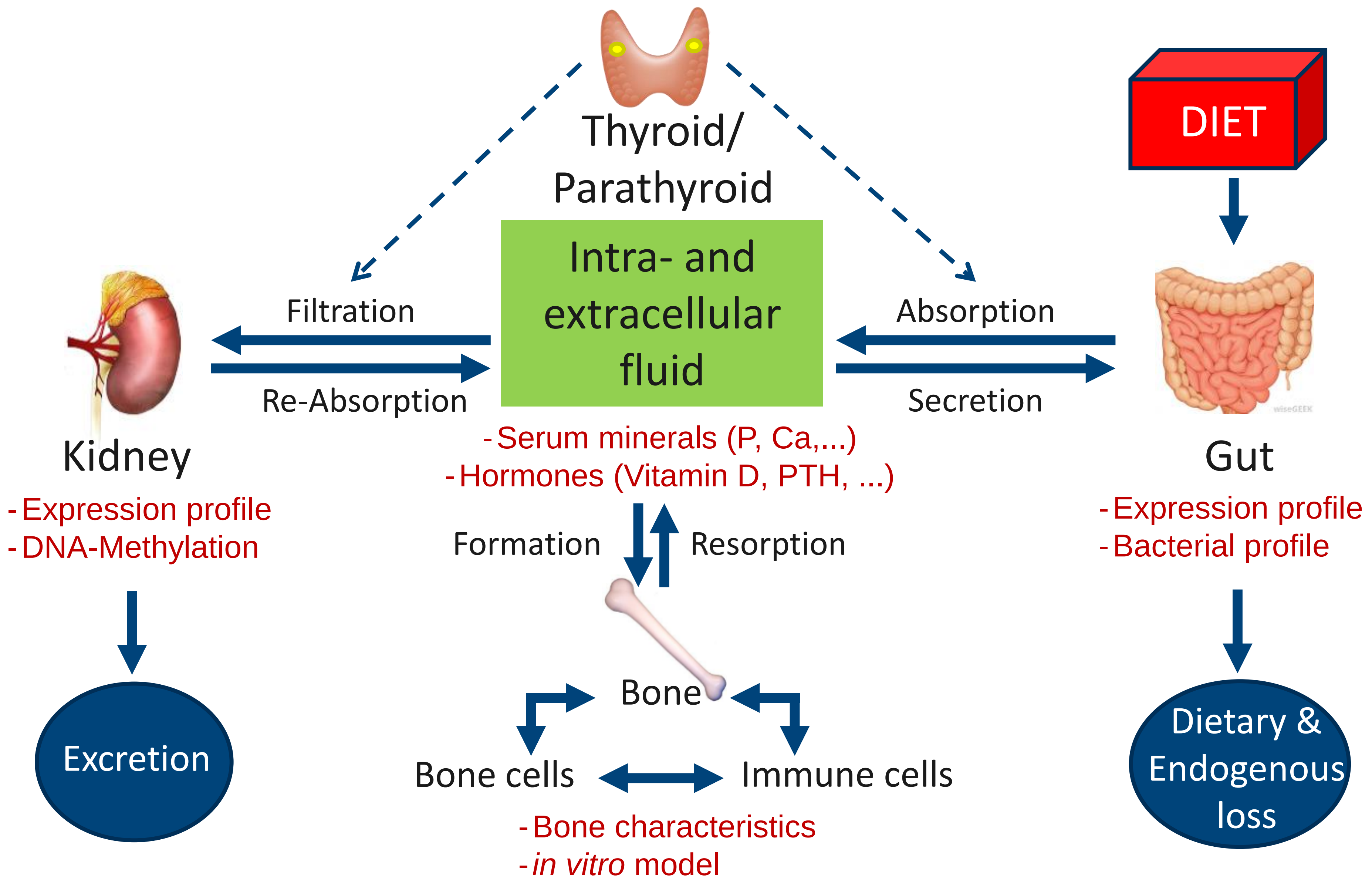


- New candidate genes for improved P efficiency, e.g. *TRAFD1*
- Heritability (genetic contribution to variation) = 0.43

Variable serum P and Ca levels of German Landrace pigs:

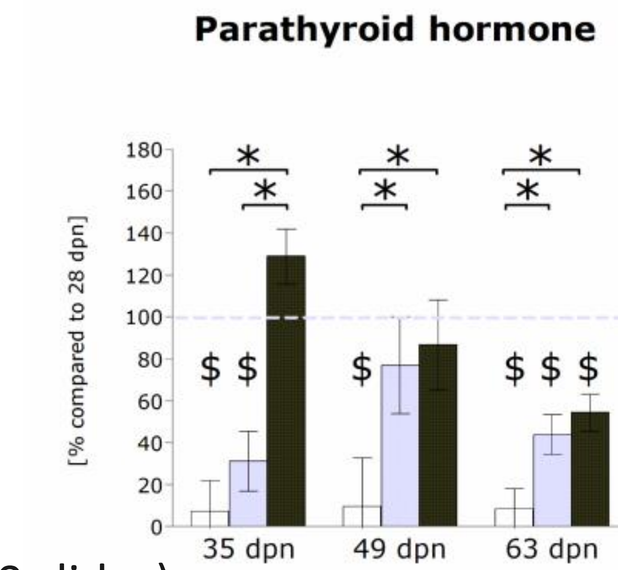


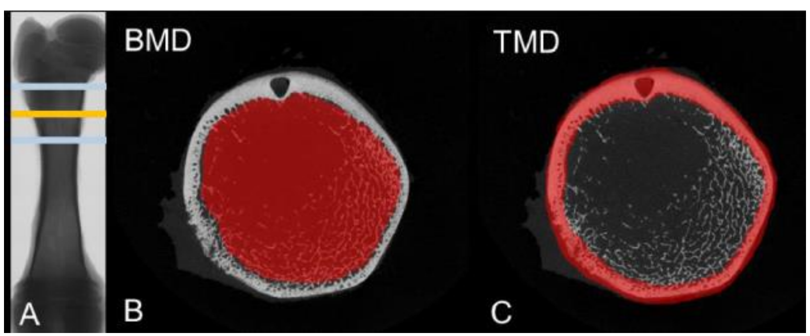
Map of the phosphorus homeostasis

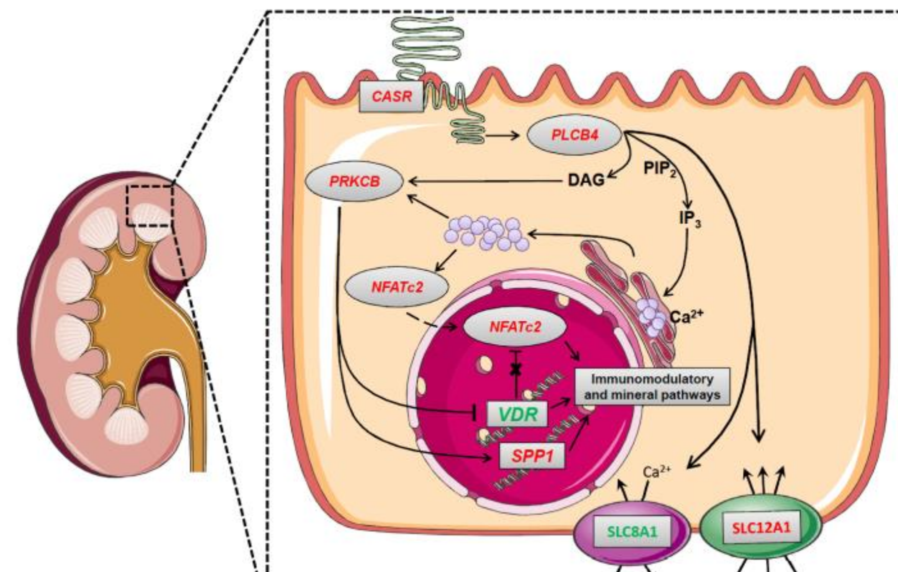


Impact of diets with variable mineral P content

- Analysis of endocrine parameters
  - P, Ca, PTH, Vitamin D, ALP, RANKL…
  - Regulation towards compensation/maintenance of plasma levels
- Analysis of gene expression
  - Expression profiles of blood, gut, kidney
  - Pathways of P homoeostasis, immune response
- Measurement by microCT analysis
  - 3d reconstruction of the bones at defined area (800 slides)
  - Trabecular structure affected by diet

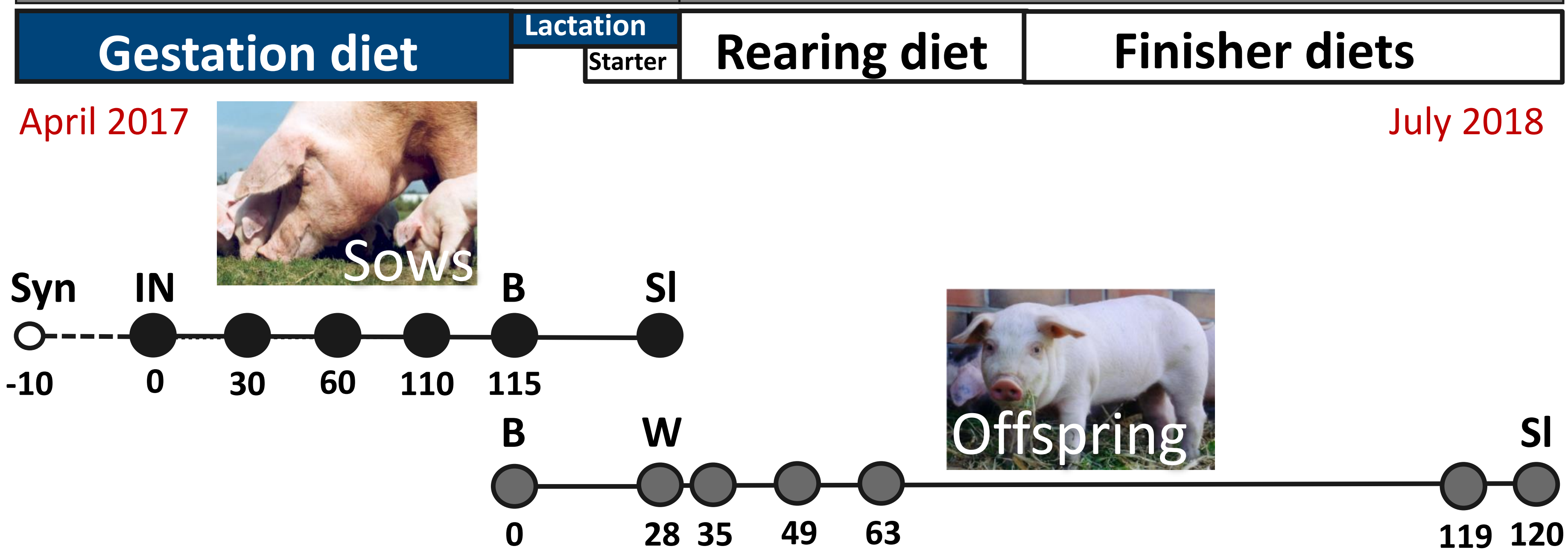






Mineral phosphorus in pigs – Experimental design

Gestation diet / Lactation	Starter / Rearing diet / Finisher diets	
L = low-P diet (n=5)	L = low-P diet	(n=10)
	M = medium-P diet	(n=9)
	H = high-P diet	(n=10)
M = medium-P diet (n=4)	L = low-P diet	(n=7)
	M = medium-P diet	(n=8)
	H = high-P diet	(n=8)
H = high-P diet (n=5)	L = low-P diet	(n=10)
	M = medium-P diet	(n=10)
	H = high-P diet	(n=10)



Syn = Synchronisation IN = Insemination B = Birth W = Weaning Sl = Sampling

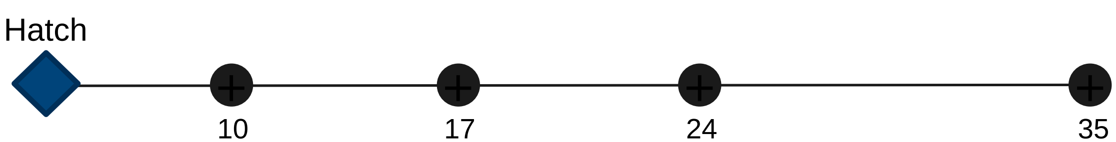
Plant phosphorus – Experimental designs

Item	g/kg of DM
Crude protein	352
Crude fibre	126
Ca	10.8
P	6.9
Ca/P ratio	1.57

- Comfrey trial in pigs (German Landrace): 20 % of DM

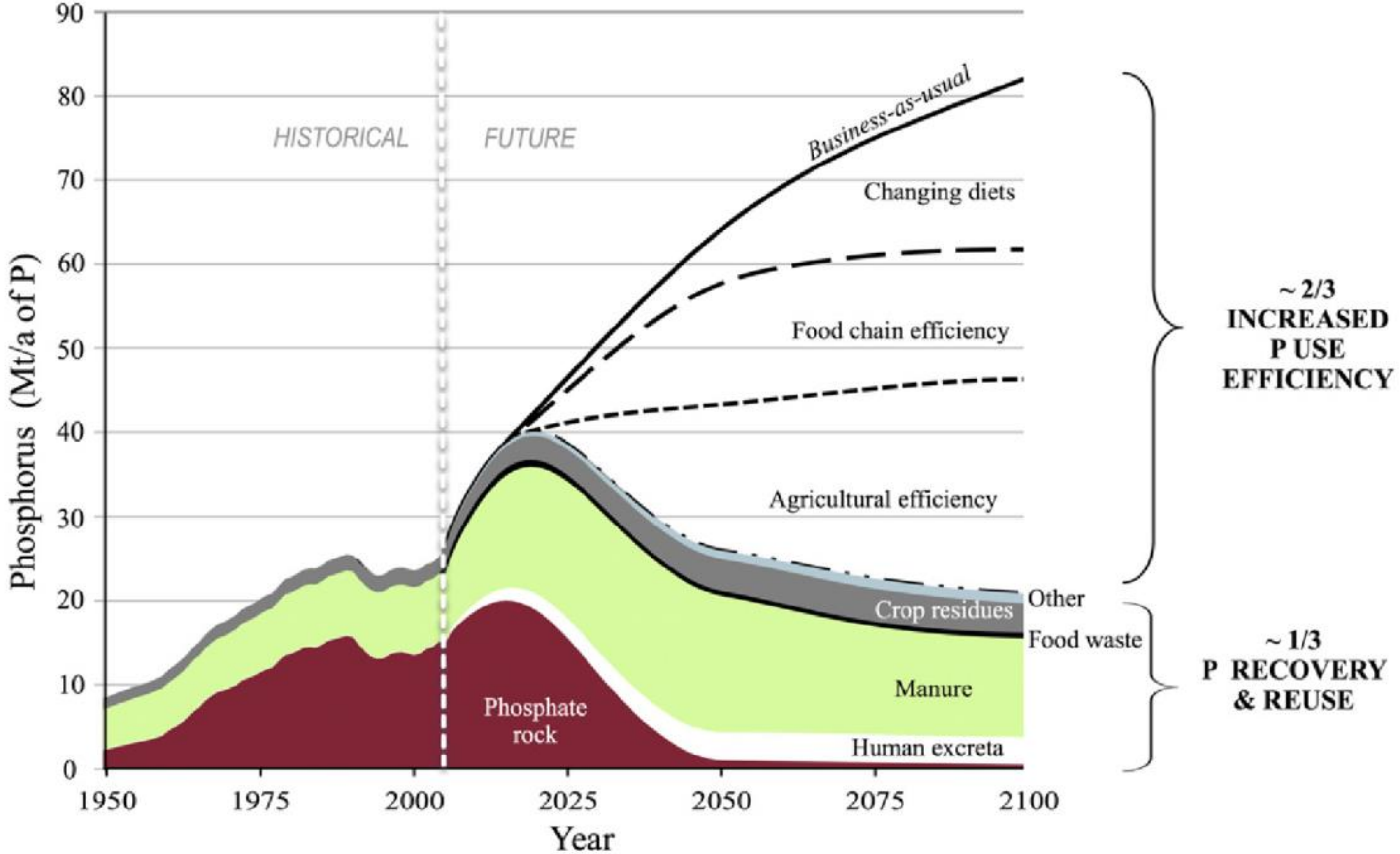
→ serum, leucocytes, kidney, jejunum, liver, excreta

- Comfrey trial in poultry (Cobb 500): 4 % of DM



→ serum, leucocytes, kidney, jejunum, liver, excreta

Models and scenarios



Cordell D, Rosemarin A, Schröder JJ, Smit AL. Towards global phosphorus security: a systems framework for phosphorus recovery and reuse options. Chemosphere. 2011; 84(6):747-58.

Partners | **Funders**

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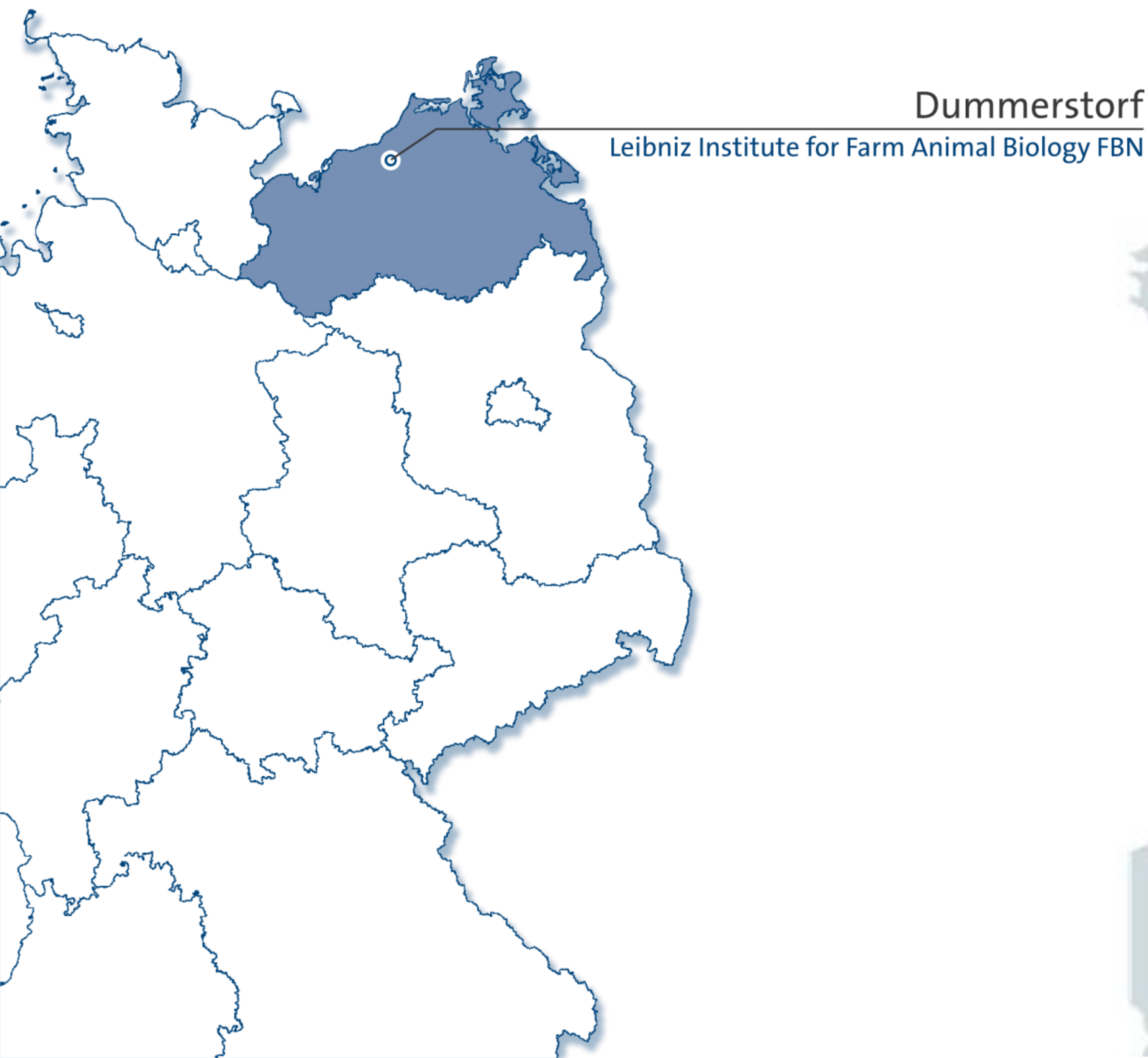
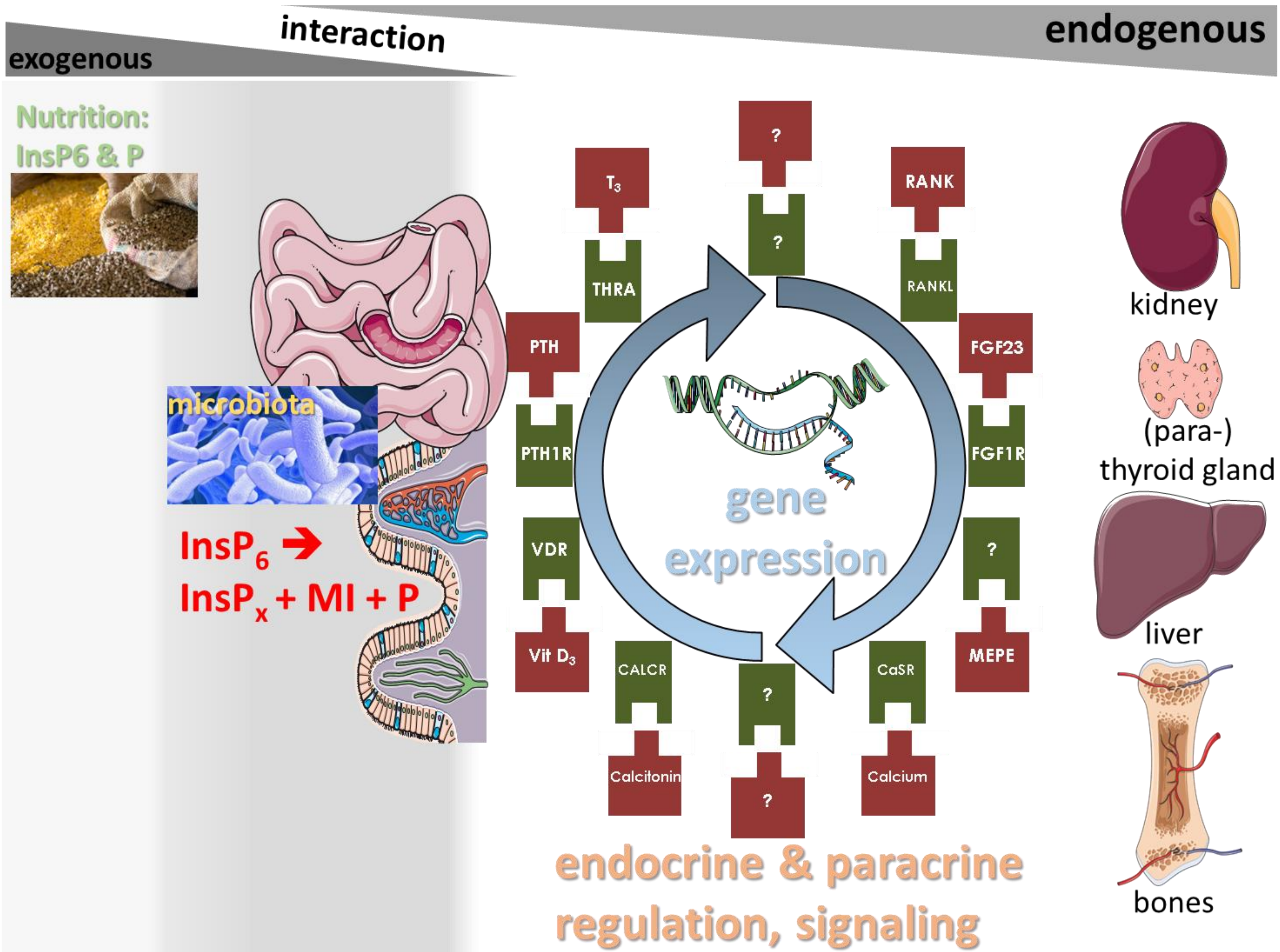
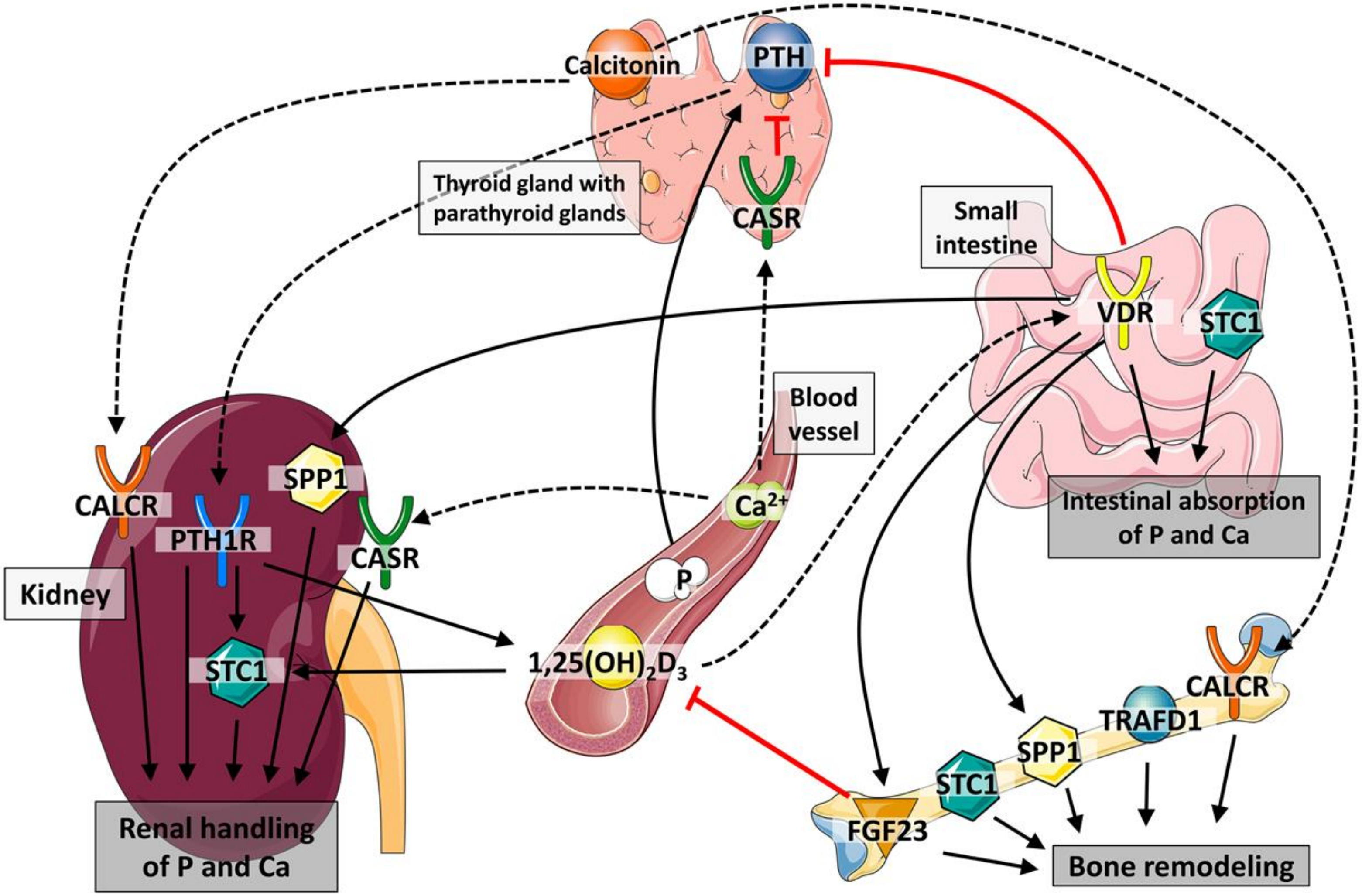




exogenous
interaction
endogenous
Nutrition:
InsP6 & P
microbiota
InsP6 →
InsPx + MI + P
?
?
T3
THRA
RANK
RANKL
PTH
PTH1R
FGF23
FGF1R
VDR
Vit D3
?
MEPE
CALCR
Calcitonin
?
?
CaSR
Calcium
gene
expression
endocrine & paracrine
regulation, signaling
kidney
(para-)
thyroid gland
liver
bones


Calcitonin
PTH
Thyroid gland with
parathyroid glands
CASR
Small
intestine
VDR
STC1
Blood
vessel
Intestinal absorption
of P and Ca
CALCR
PTH1R
SPP1
CASR
Ca2+
Kidney
P
1,25(OH)2D3
STC1
CALCR
TRAFD1
SPP1
STC1
FGF23
Bone remodeling
Renal handling
of P and Ca

Diets

Item		Unit	Low	Medium	High
Wheat		%	30	30	30
Barley		%	27.37	26.85	26.3
Barley flakes		%	12	12	12
Soy bean meal		%	21	21	21
Soybean oil		%	0.6	0.6	0.6
Premix[1]		%	7.4	7.4	7.4
Monocalcium phosphate		%	0.5	1.4	2.3
Calcium carbonate		%	1.13	0.75	0.38
Calculated value					
	Metabolisable energy	MJ ME/kg	13.5	13.4	13.4
	Crude protein	%	18.74	18.68	18.6
	sid lysine	%	1.02	1.02	1.02
	Phosphorus	%	0.5	0.7	0.9
	Digestible Phosphorus	%	0.33	0.51	0.74
	Calcium	%	1.05	1.05	1.05
Analysed composition					
	Dry matter	%	88.2	88.3	88.4
	Crude protein	% of DM	20.5	20.3	20.1
	Crude fat	% of DM	3.2	3.1	2.9
	Crude fibre	% of DM	6.6	6.3	6.5
	Crude ash	% of DM	5.9	6.3	6.9
	Starch	% of DM	47.4	46.3	45.3
	Sugar	% of DM	6.7	6.8	6.7
	Phosphorus	% of DM	0.6	0.9	1.1
	Calcium	% of DM	1.3	1.3	1.3
Calcium: phosphorus ratio			2.2:1	1.4:1	1.2:1
Metabolisable energy		MJ ME/kg	12.5	12.5	12.3