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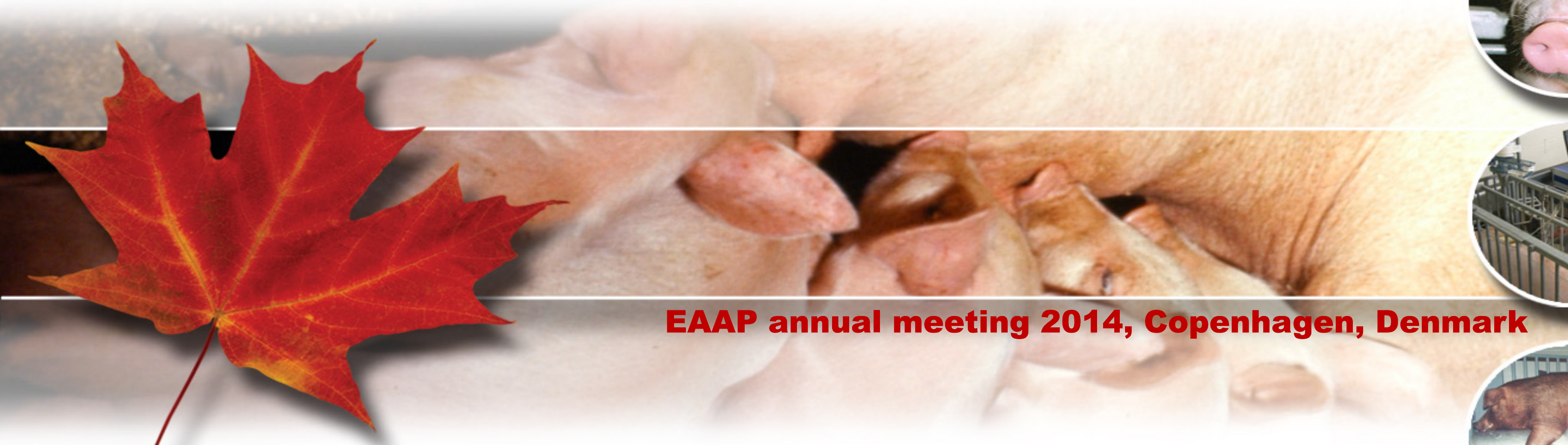

EAAP annual meeting 2014, Copenhagen, Denmark

Water-soluble vitamins and reproduction in sows: beyond prolificity

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Canada

Hyperprolificacy

- Depressed average birth weight and litter weight homogeneity:

  . consequences for ulterior growth performance

- Nutritional factors involved (micronutrients):

  . quality of ovulation

  . adequacy of micro-nutrients transfer from sows to embryos and fœtuses (B_9, B_{12} and immunology of reproduction) (Matte et al., 2006, CJAS 86:197-205)

  . adequacy of micro-nutrients transfer from sows to piglets

Hyperprolificacy

- **Depressed average birth weight and litter weight homogeneity:**

  . consequences for ulterior growth performance

- **Nutritional factors involved (micro-nutrients):**

  . quality of ovulation (vitamin B6 X selenium)

  . adequacy of micro-nutrients transfer from sows to piglets

Ovulation, embryo survival and prolificacy

	Parity = 1 1980	Parity = 1 "Hyper"	Parity > 1 1980	Parity > 1 "Hyper"
Ovulation rate	15	20	18	24
Fetal survival (%)	80	70[1] (40)[2]	72[1] (33)[2]	67[1] (44)[2]
Litter size (d 25)	12	14	13	16

[1] *overall*

[2] *supplementary embryos*

Oxidative stress and ovulation

From Fujii et al. (2005)

Reproductive Biology and Endocrinology 2005, 3:43

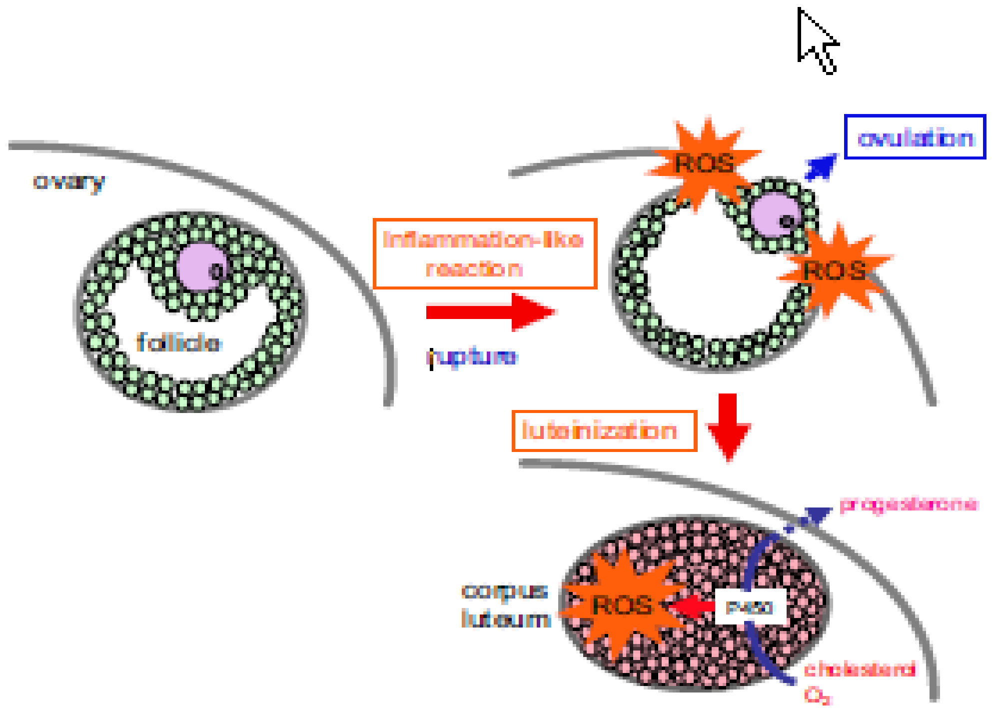


Figure 2
Generation of ROS during ovulation and sterodogenesis in corpus luteum. Ovulation appears to be an inflammation-like process. ROS is locally produced during follicular rupture and may be involved in the ovulation process. ROS is also generated by the corpus luteum via the monooxygenase reaction as a byproduct during steroid hormone synthesis.

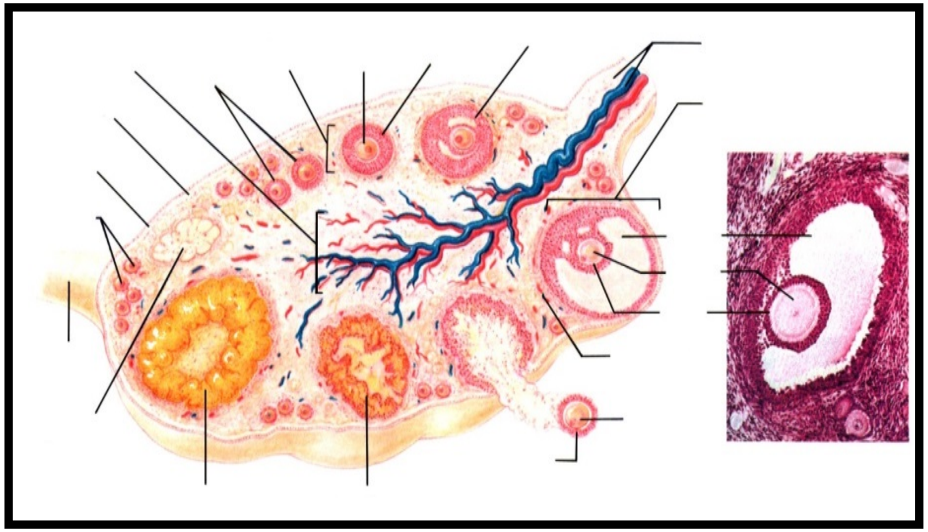
ROS must be timely neutralized with antioxydants to avoid

- damage (and apoptose) of oocytes,
- congenital defects of embryo
- and/or CL regression

Antioxidant and pig reproduction

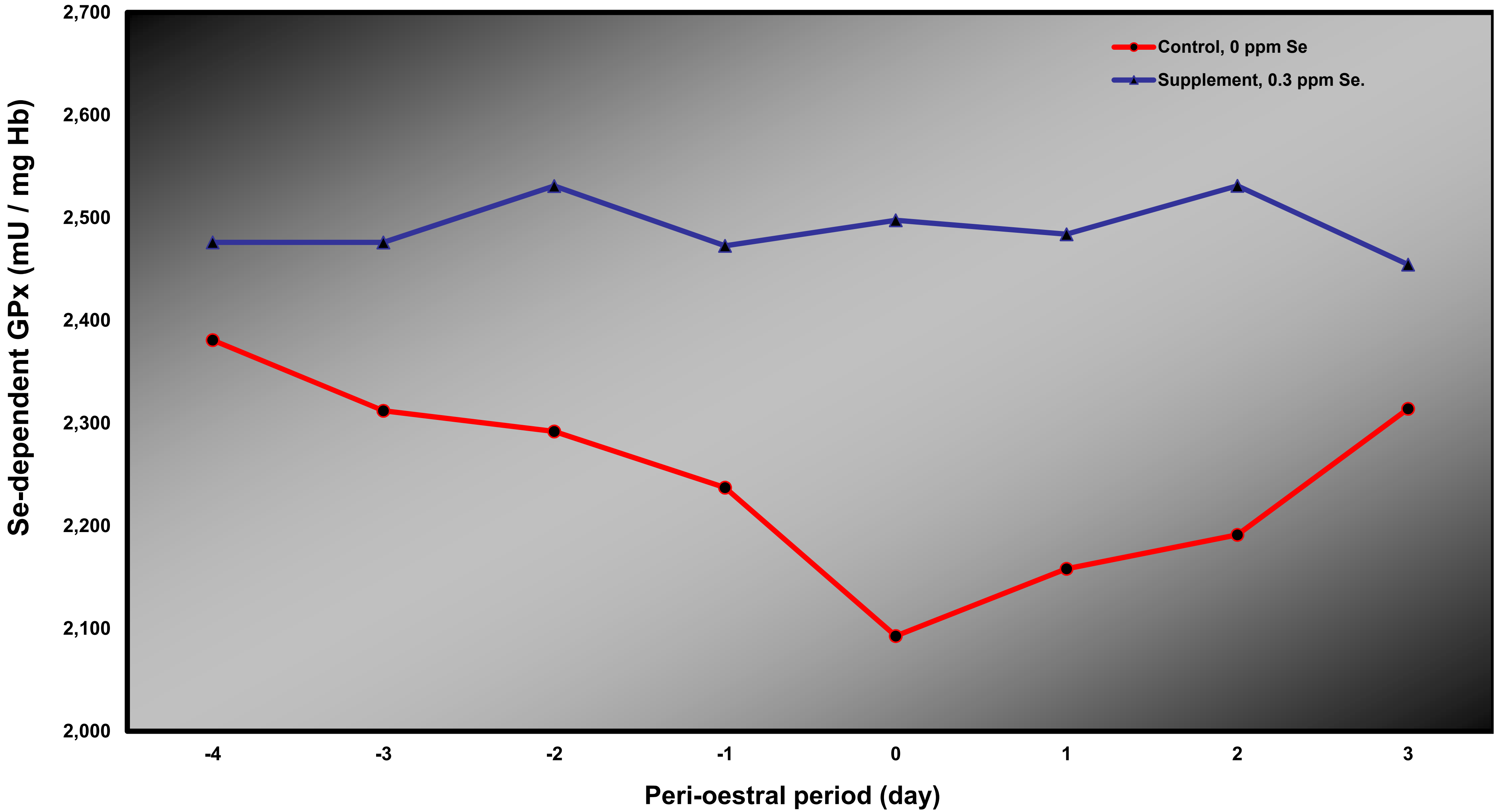
- Periods of maximal luteal and follicular activities are associated with increased concentrations of ascorbate within the tissue

- Considerable accumulation of vitamin C in the functional corpora lutea (100 X higher than in circulation)



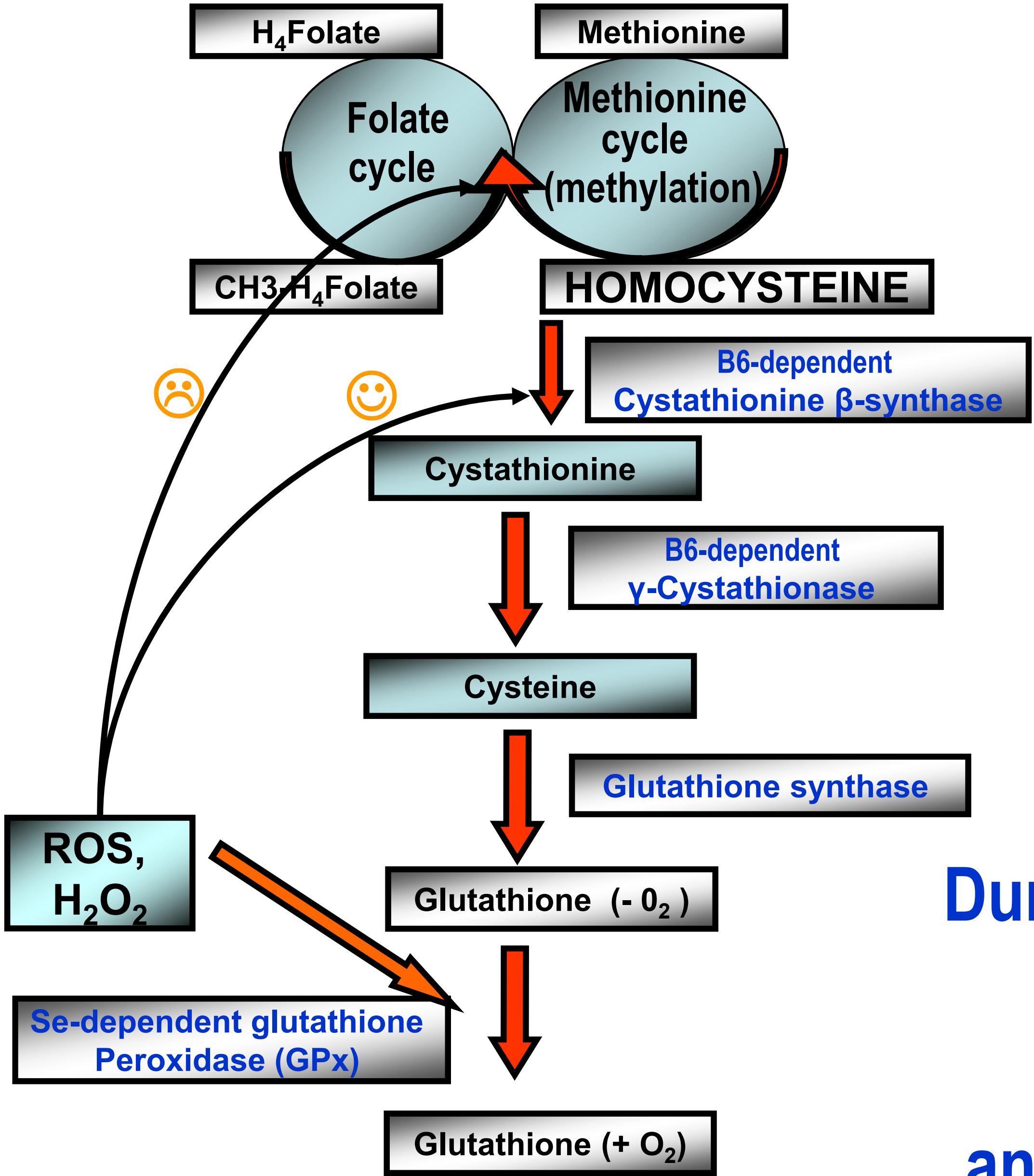
Adapted from Petroff et al., 1997;1998

Antioxidation, Se-dependent glutathione peroxidase (GPx) and ovulation



Adapted from Fortier et al. (2012)

S-methionine, S-cysteine and antioxidation



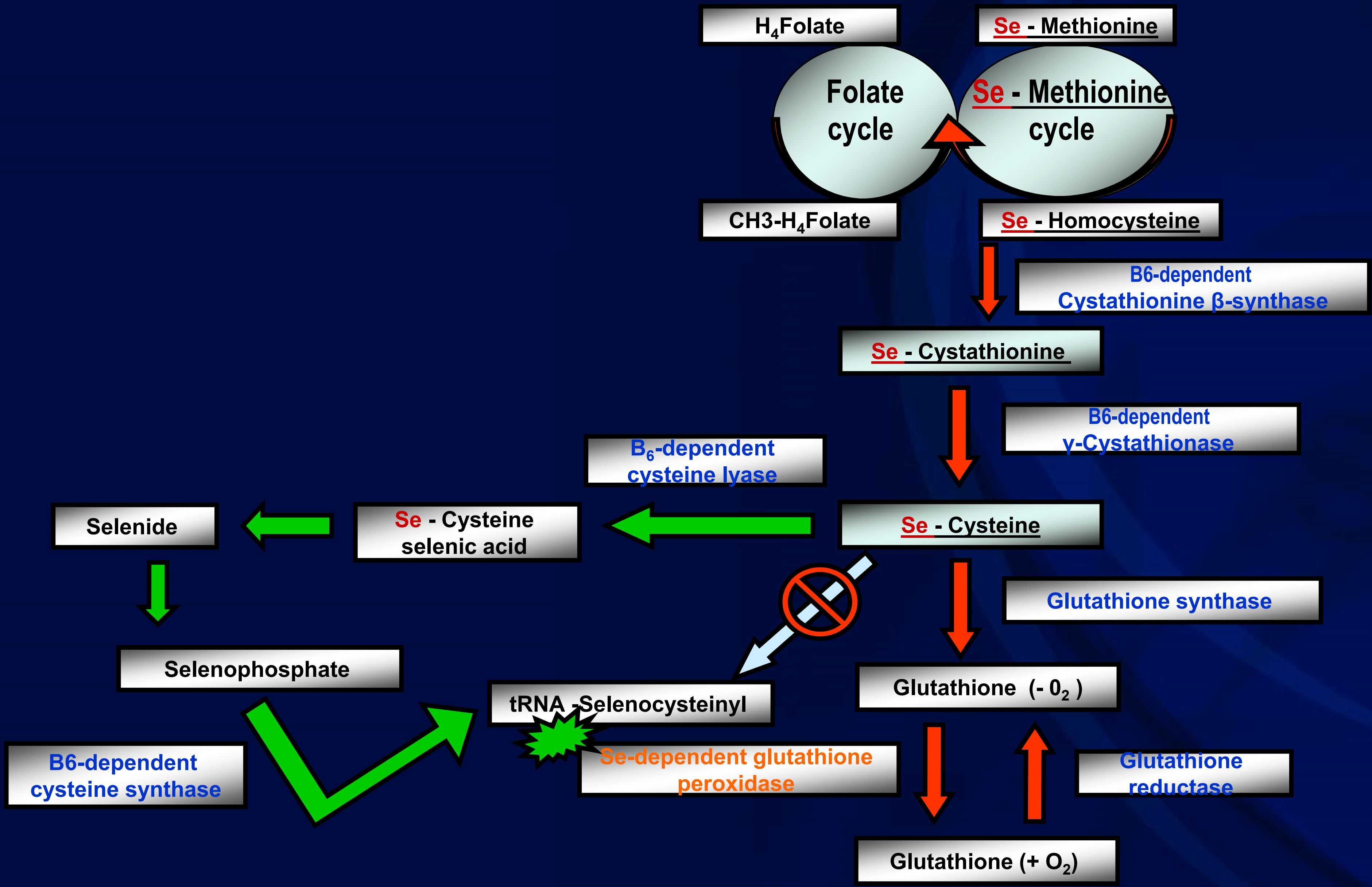
During an oxidative stress, pyridoxine is crucial for transsulfuration and glutathione synthesis

Antioxidation: glutathione and GPx vs vitamin B_6

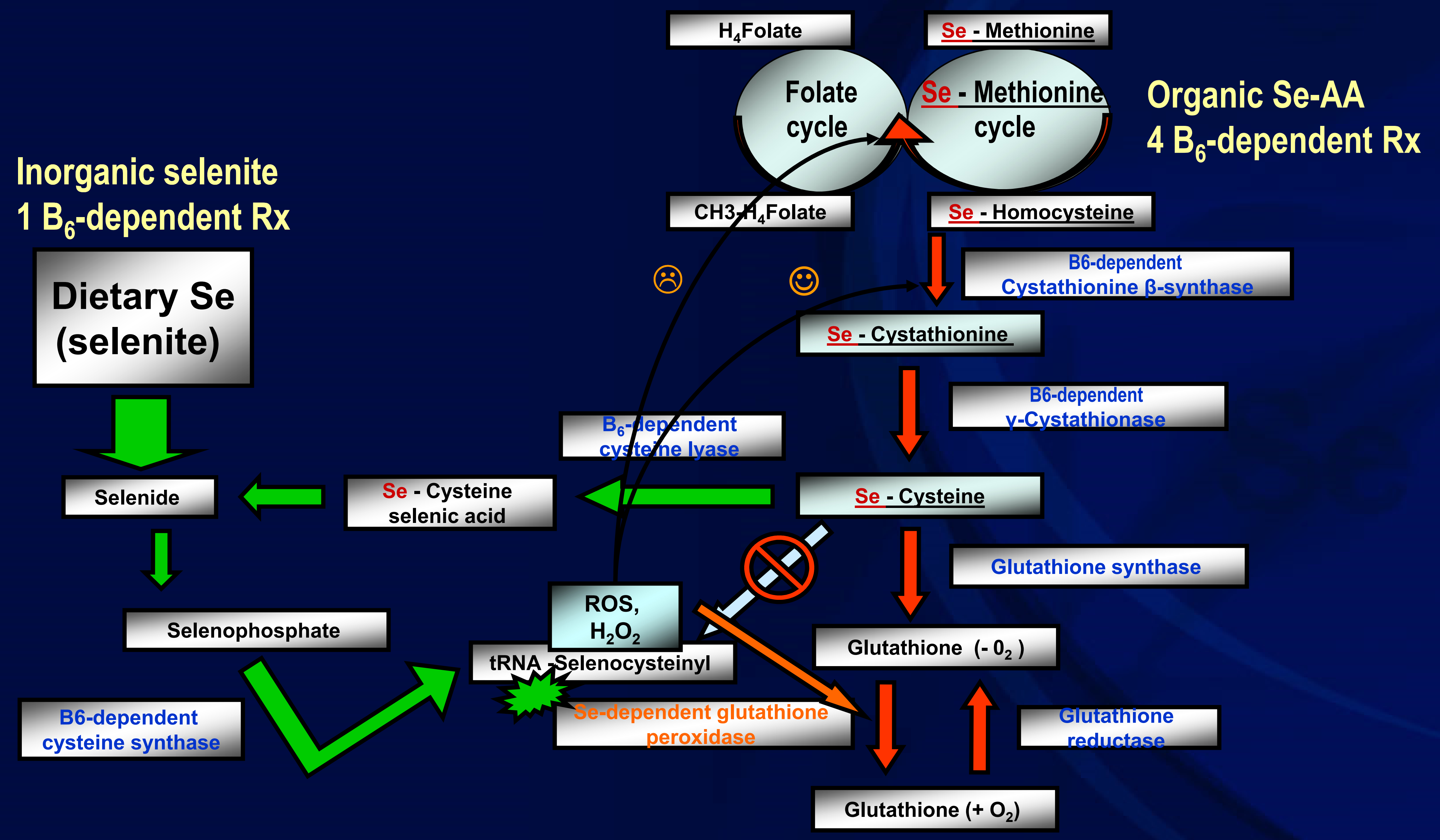
- Glutathione : synthesis is dependent of an adequate provision and availability of vitamin B_6 (pyridoxine)

- Se-GPx: metabolic route for activation of the enzyme is dependent of selenium but it differs according to the dietary source of selenium, inorganic vs organic (interaction with B_6)

Se-methionine, Se-cysteine and antioxidation



Se-methionine, Se-cysteine and antioxidation

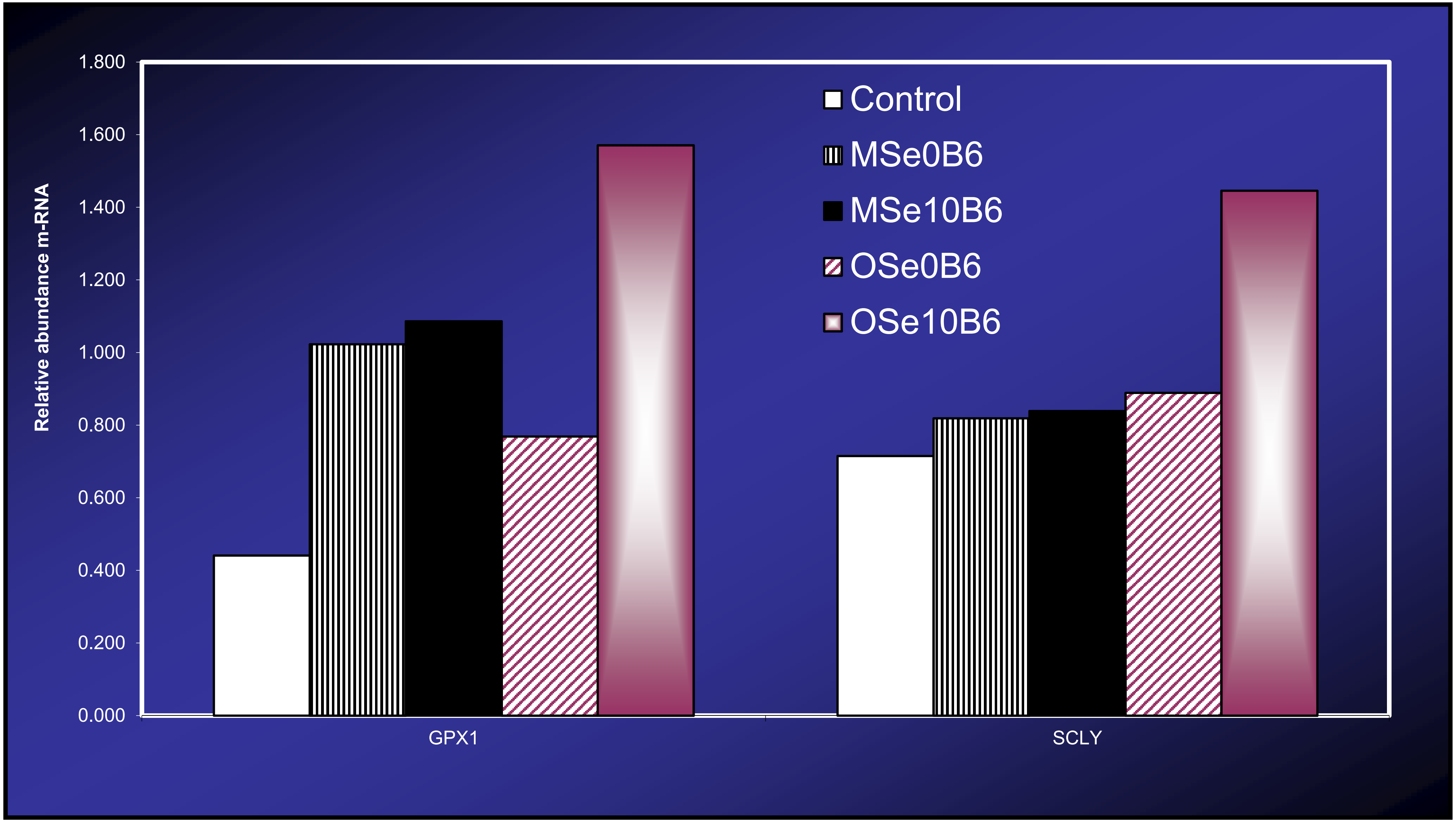


Objective

In gilts from puberty to the 4th post-pubertal oestrus

- dietary inorganic (selenite) or organic (Se-yeast) Se (0.3 mg/kg) with or without vitamin B6 (10 vs 0 mg/kg)
- on d 3 of the 4th post-pubertal oestrus (response to oxidative stress induced by oestrus)
  - gene expression of Se-cysteine lyase (SCLY) (liver)
  - gene expression of Se-GSH-Px (GPX1) (liver) tissues
  - ovulation

Gene expression in liver



Adapted from Roy et al. (2011)

Luteinizing hormone (LH) peak and corpora lutea (CL) (d 3 of 4th oestrus)

Treatment	LH peak (ng/mL)	Ovulation (# of CL)
Control	206.7	17.4
$MSe0B_6$	201.6	16.7
$MSe10B_6$	191.2	17.7
$OSe0B_6$	194.8	16.9
$OSe10B_6$	212.6	21.2

Average of 9 sows per treatment, adapted from Roy et al. (2011)

Conclusion

- Vitamin B_6 is critical for an adequate flow of selenomethionine and selenocysteine (organic selenium) towards the Se-GPx system. It could potentially enable metabolic and performance responses to dietary supplement of organic selenium

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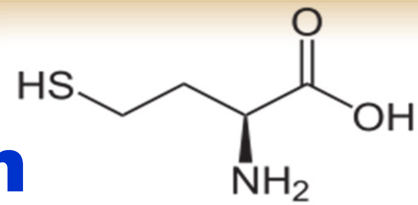
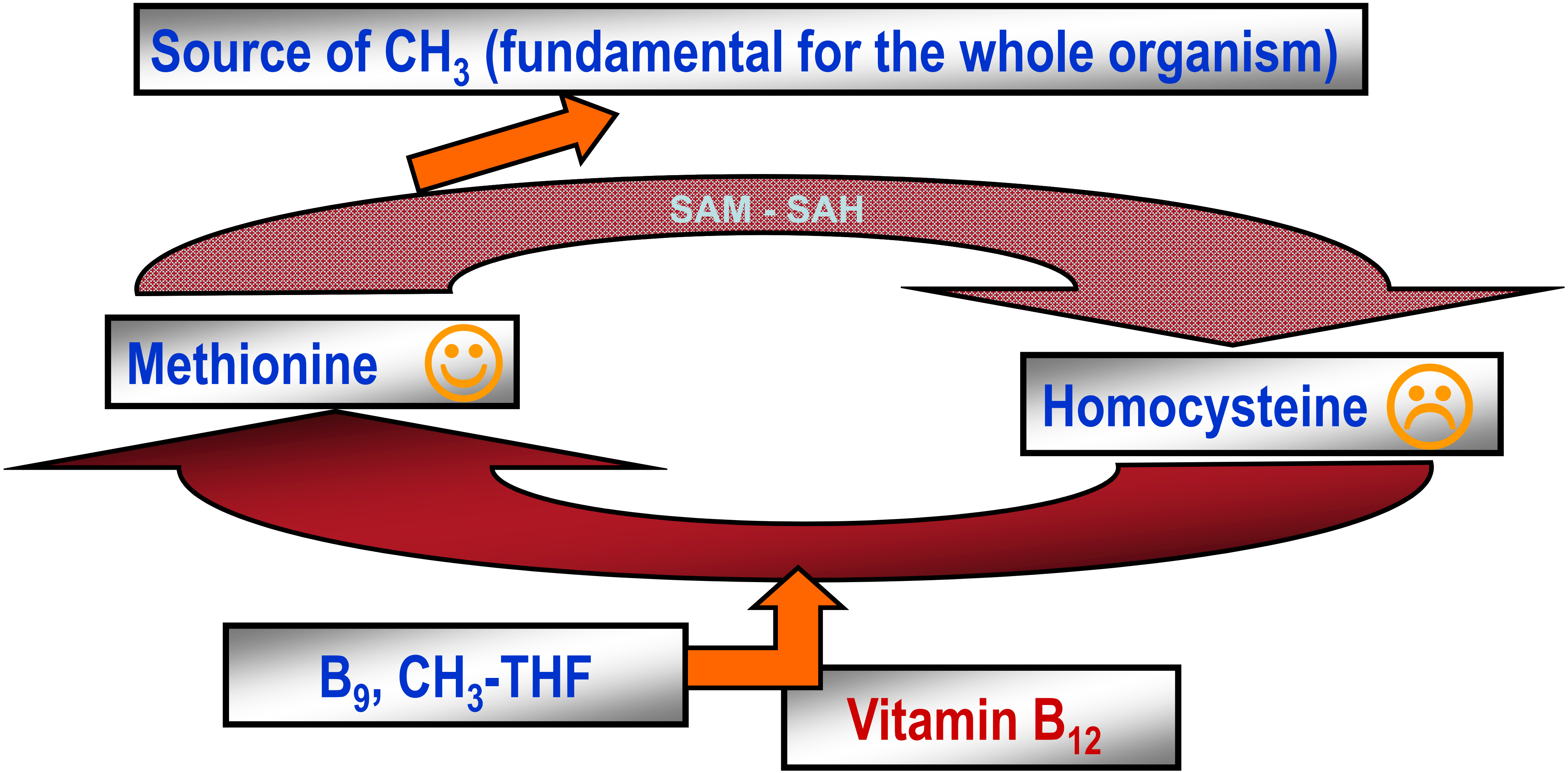
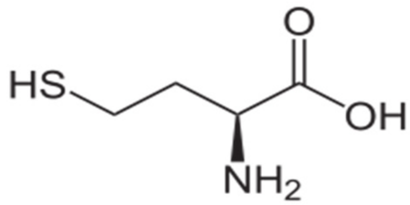
What is homocysteine?



Sulfur intermediary amino acid from methionine metabolism (cycle)



Why studying homocysteine in pigs?



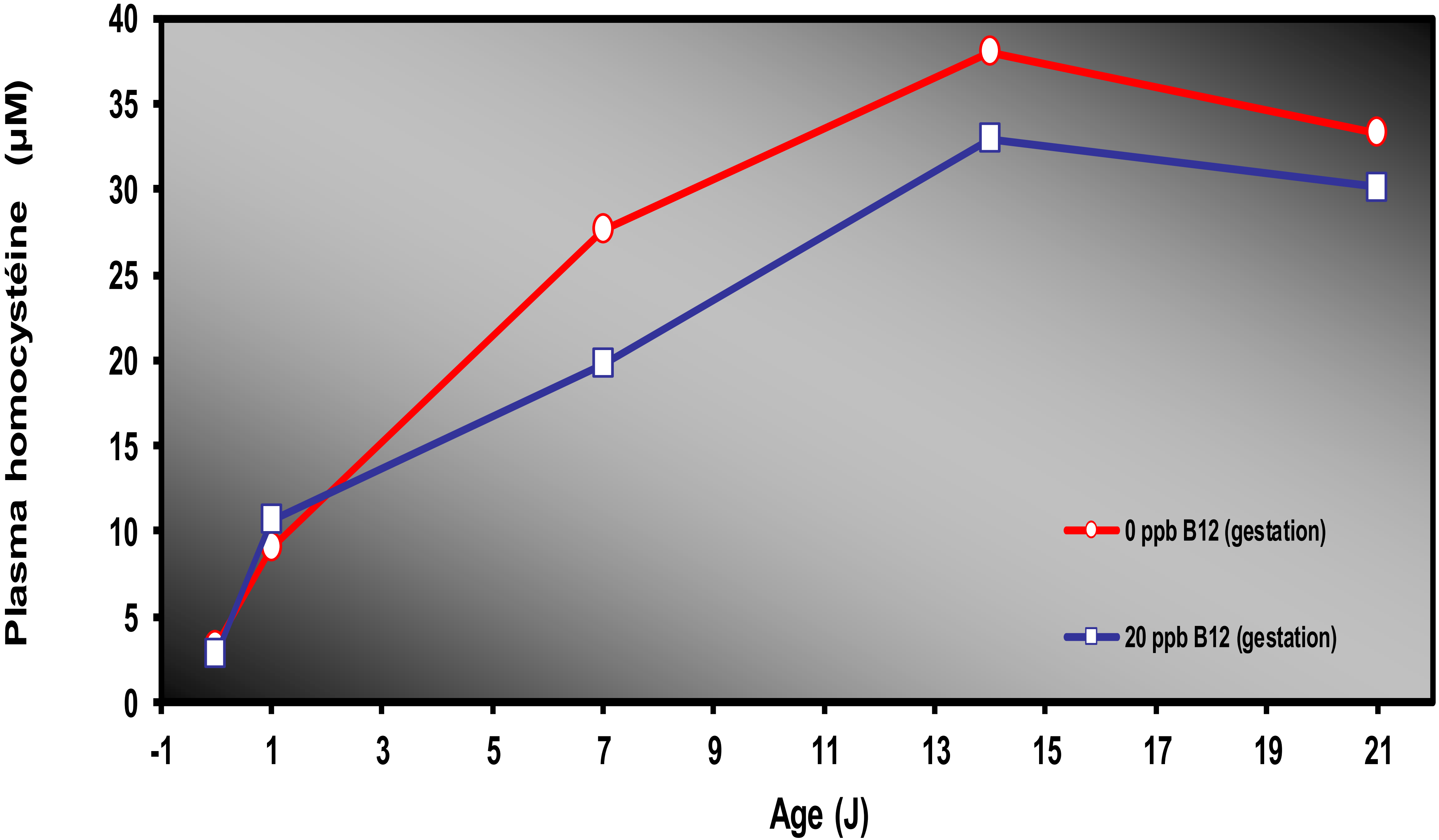
Sulfur amino acid from methionine metabolism

- **High levels in circulation are associated to several pathologies such as cardiovascular diseases, neurodegenerative diseases and osteoporosis**
- **Detrimental effects on embryo development, cell proliferation and immune response**

Why studying homocysteine in pigs?

Species	Plasma concentration (µM)
Mouse	2-3
Cow	2-7
Rat	6-8
Cat	3-4
Human (normal)	5-10
Human (high)	> 12
Poultry (laying hen)	< 14
Pig	15-25

Why studying homocysteine in piglets?



Adapted from Simard et al. (2007)

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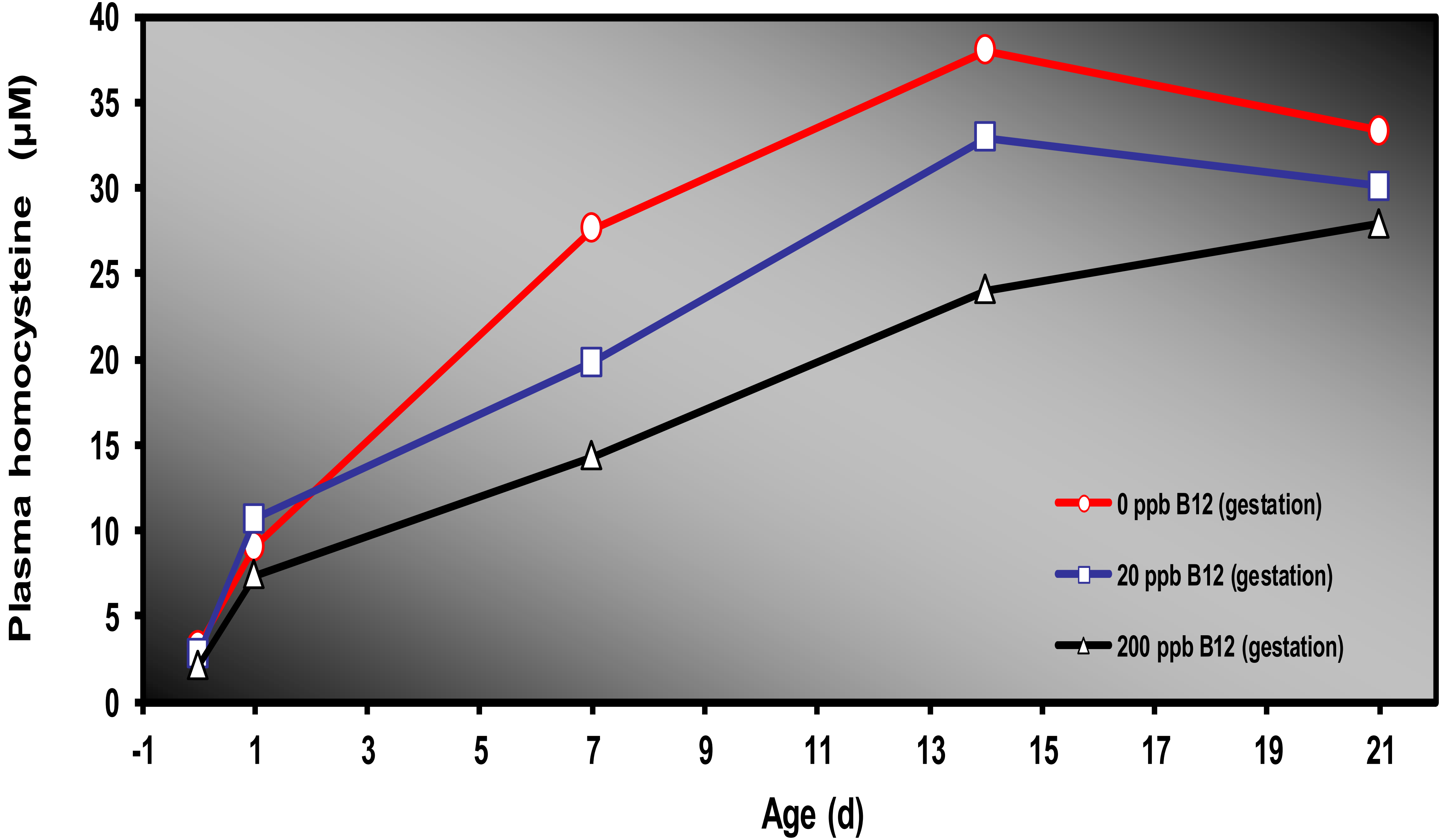

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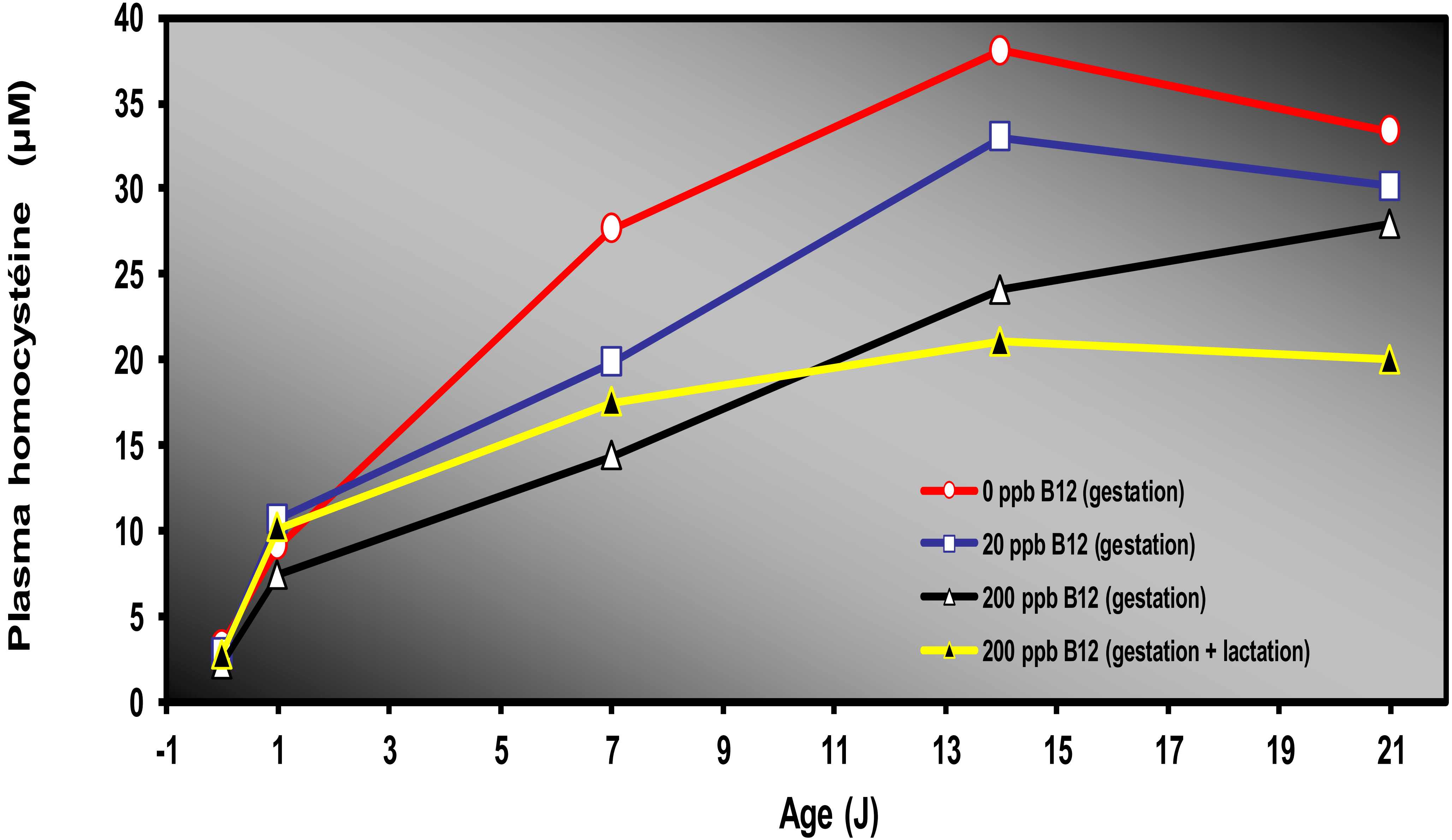


Adapted from Simard et al. (2007) & Côté-Robitaille et al. (2010)

Studied questions

- High levels of homocysteine detrimental for piglets?

- Substantial decrease beneficial for ulterior growth and immune competence during and after weaning?

- Approach using vitamins B_9 and B_{12} supplements as tools to modulate homocysteine.

Treatments

- **SOWS:** 31 multiparous

Sows S^- (n=15)

1 mg B_9 / kg feed
20 µg B_{12} / kg feed

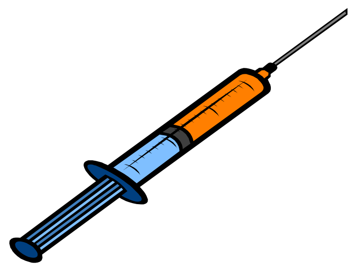
Sows S^+ (n=16)

10 mg B_9 / kg feed
200 µg B_{12} / kg feed

- **PIGLETS:** 12 per litter and injections on <u>d1 and d21</u>

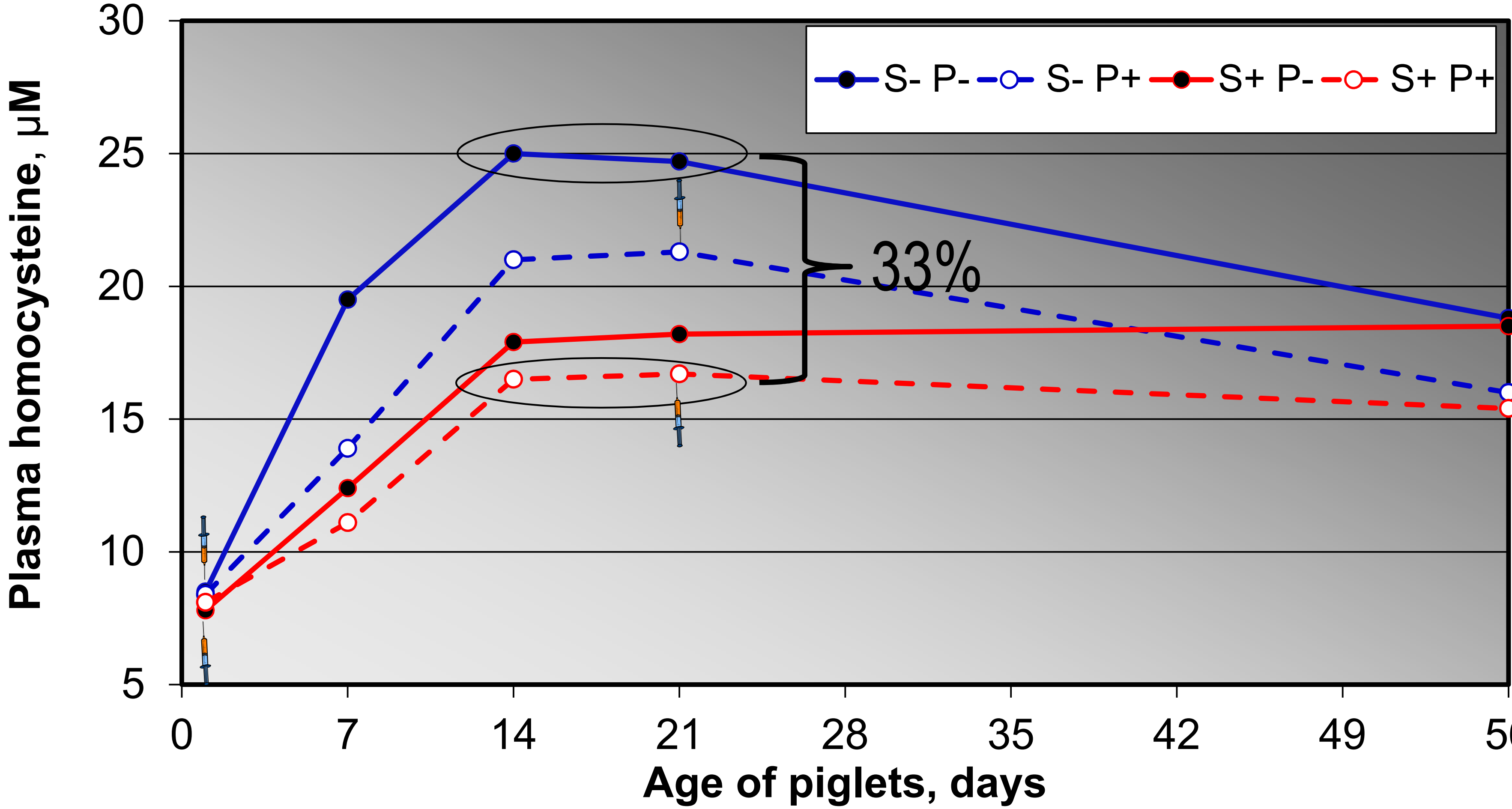
Piglets P^- (6 / litter): saline

Piglets P^+ (6 / litter): 150 µg of B_{12}



Audet et al., (2014), presented at JAM-ASAS annual meeting, Kansas City, MO, USA.

Plasma Hcy concentrations in piglets vs sow (S) and piglet (P) treatments



- The strategy of vitamin supplementation was successful in inducing large variations of Hcy among piglets

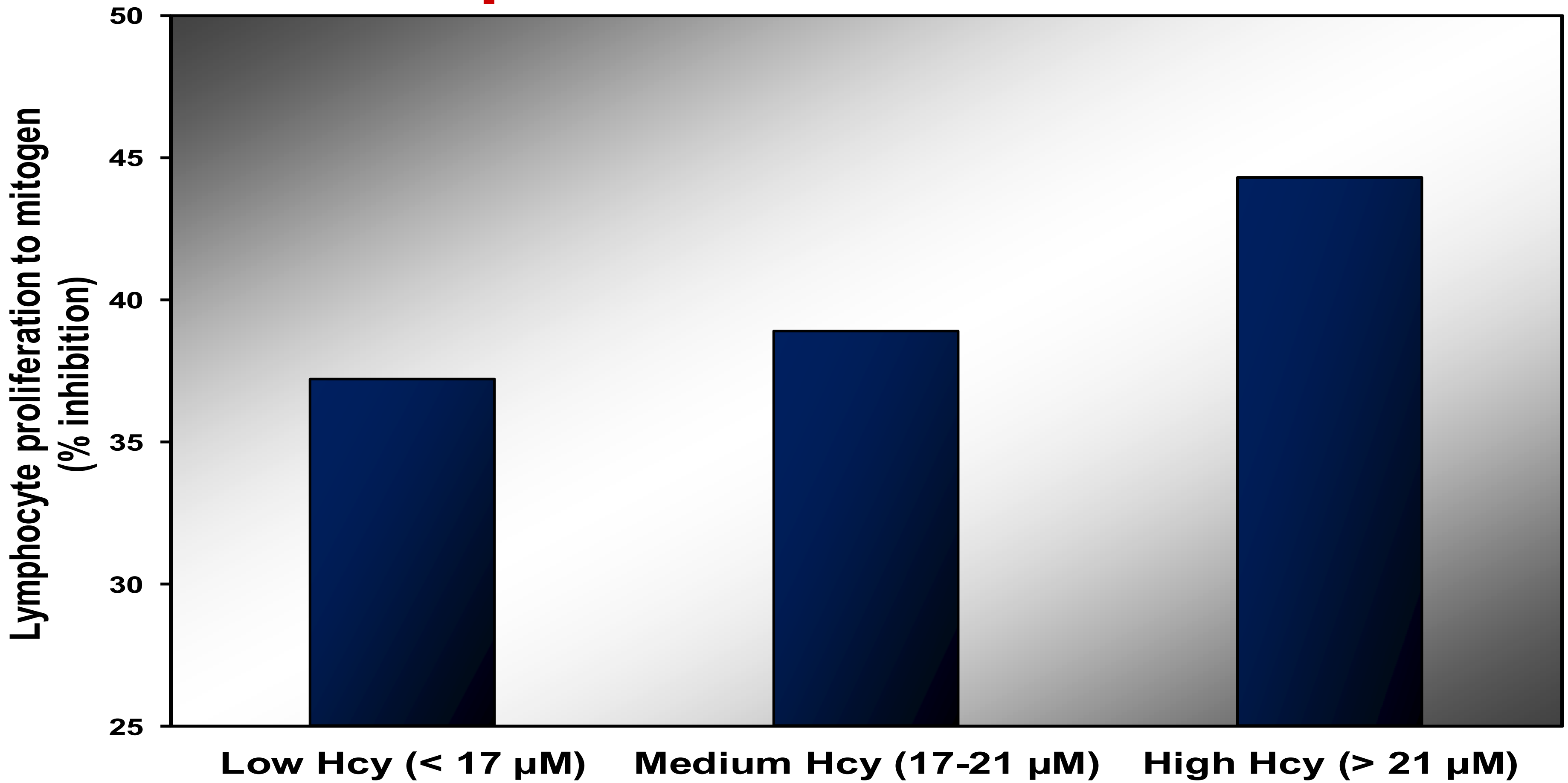
Results

- High homocysteinemia was not harmful for growth performance.

TREATMENTS:	S- P-	S- P+	S+ P-	S+ P+
ADG (lactation) g / day	276	271	270	283
ADG (post-weaning) g / day	412	392	378	404
ADFI (post-weaning) g / day / piglet	626	603	618	609
Feed efficiency ADG / ADFI	0.659	0.649	0.611	0.663

- In contrast, plasma values were positively correlated with some aspects of growth performance of piglets.

Inhibition of lymphocytes proliferation in response to Concavalin A



- Detrimental effects of high homocysteinemia on indicators of cell mediated immunity

Conclusion

- Although performance was not affected by vitamin treatments, it appears that the young “high performing” animals with high plasma homocysteine were immunologically more fragile.

Hyperprolificacy

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- Nutritional factors involved (micronutrients):

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  . adequacy of micro-nutrients transfer from sows to embryos and fœtuses (Matte et al., 2006, CJAS 86:197-205)

  . adequacy of micro-nutrients transfer from sows to piglets (2 aspects, case report related to B_{12} transfer vs neonatal Hcy + in general)

Why the transfer of micronutrients from sow to piglets?

- We rely a lot on "mother nature". In fact, the period of nutritional dependence of piglets to their mother (*in utero* + colostrum + milk), at ± 135 days, is equivalent to the whole post-weaning period (starter + grower + finisher).

- Is "mother nature" efficient enough in actual husbandry conditions?

Maternal transfer of micronutrients, “in utero” and /or colostral

- Not easy to estimate, few pertinent information available (approximately 20 molecules-elements)

- Which type of transfer is more important? For which micronutrient?

Maternal transfer of micronutrients, "in utero" and /or colostral

- A simple approach is needed to assess if there is a problem and to "screen" micronutrient(s)?

- Systemic (blood) vitamers in sows and piglets during the neonatal period (± 1 week)

Estimations of efficiency of "in utero" and colostral transfers of vitamins and minerals from dams to newborn piglets[1]

Vitamin	Ratio pre-colostral (piglets) : pre-farrowing (dam)	Relative importance of "in utero" transfer	Ratio post-colostral : pre-colostral (piglets)	Relative importance of colostral transfer
Retinol	0.26	– – –	2.7	+ +
Vitamin E	0.44	– –	4.7	+ + + +
Vitamin D	0.11	– – – – –	1.8	+
Vitamin C	2.9	+ + +	4.1	+ + + +
Folates	0.54	–	3.1	+ + +
Vitamin B_{12}	4.4	+ + + +	2.0	+ +

[1] Plasma concentrations: ratio

The importance of *in utero* vs post-natal transfer of some vitamins and minerals in pig.

Objective: For micronutrients where information is not available, generate data set on the efficiency of transfer from dams to piglets

- **samples collection on 20 litters**

Estimations of efficiency of "in utero" and colostral transfers of vitamins and minerals from dams to newborn piglets

Micro-nutrient	Ratio pre-colostral (piglets) : pre-farrowing (dam)	Relative importance of "in utero" transfer	Ratio post-colostral : pre-colostral (piglets)	Relative importance of colostral transfer
Vitamins				
Retinol	0.26	_ _ _	2.7	+ +
Vitamin E	0.44	_ _	4.7	+ + + +
Vitamin D	0.11	_ _ _ _ _	1.8	+
Vitamin C	2.9	+ + +	4.1	+ + + +
Folates	0.54	_	3.1	+ + +
Vitamin B_{12}	4.4	+ + + + +	2.0	+ +
Niacin[1]	1.0	=	4.0	+ + +
Pyridoxine[1]	5.1	+ + + + +	0.34	_ _ _
Riboflavin[1]	0.68	_	3.0	+ + +
Biotin[1]	7.9	+ + + + + + + +	0.23	_ _ _ _
Minerals				
Iron[1]	0.62	_	1.3	+
Zinc[1]	1.3	+	1.2	+
Copper[1]	0.30	_ _ _	1.6	+
Selenium[1]	0.36	_ _	1.4	+

[1] Values in red font, Swine Innovation Porc (Canadian Swine Cluster) 2009-13

Estimations of efficiency of "in utero" and colostral transfers of vitamins and minerals from dams to newborn piglets

Micro-Nutrient	Ratio pre-colostral (piglets) : pre-farrowing (dam)	Relative importance of "in utero" transfer	Ratio post-colostral : pre-colostral (piglets)	Relative importance of colostral transfer	Relative net balance ("in utero" + colostral) vs dams
Vitamins					
Retinol	0.26	_ _ _	2.7	+ +	–
Vitamin E	0.44	_ _	4.7	+ + + +	+ +
Vitamin D	0.11	_ _ _ _ _	1.8	+	– – – –
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[1] Values in red font, Swine Innovation Porc (Canadian Swine Cluster 2009-13

Why copper and vitamins A and D?

- In nature, this transfer was possibly not critical for evolution of the species because of abundance in the environment of newborn piglets of:
  - UV light (vitamin D)
  - plants rich in β-carotene
  - soil as source de trace minerals (idem Fe)

Implications: eventual strategies to maximise micronutrient transfer from sow to piglets

- **Apparent inadequacies for some micronutrients, amplified in a context of hyperprolificity?**
- **Should we think about targeted exogenous supplements of some micronutrients to piglets (not a new concept, ex. Fe)?**

Further considerations – perspectives

- Assessement of reproductive performance: prolificacy, yes, but also other aspects such as survival and disease resistance in piglets

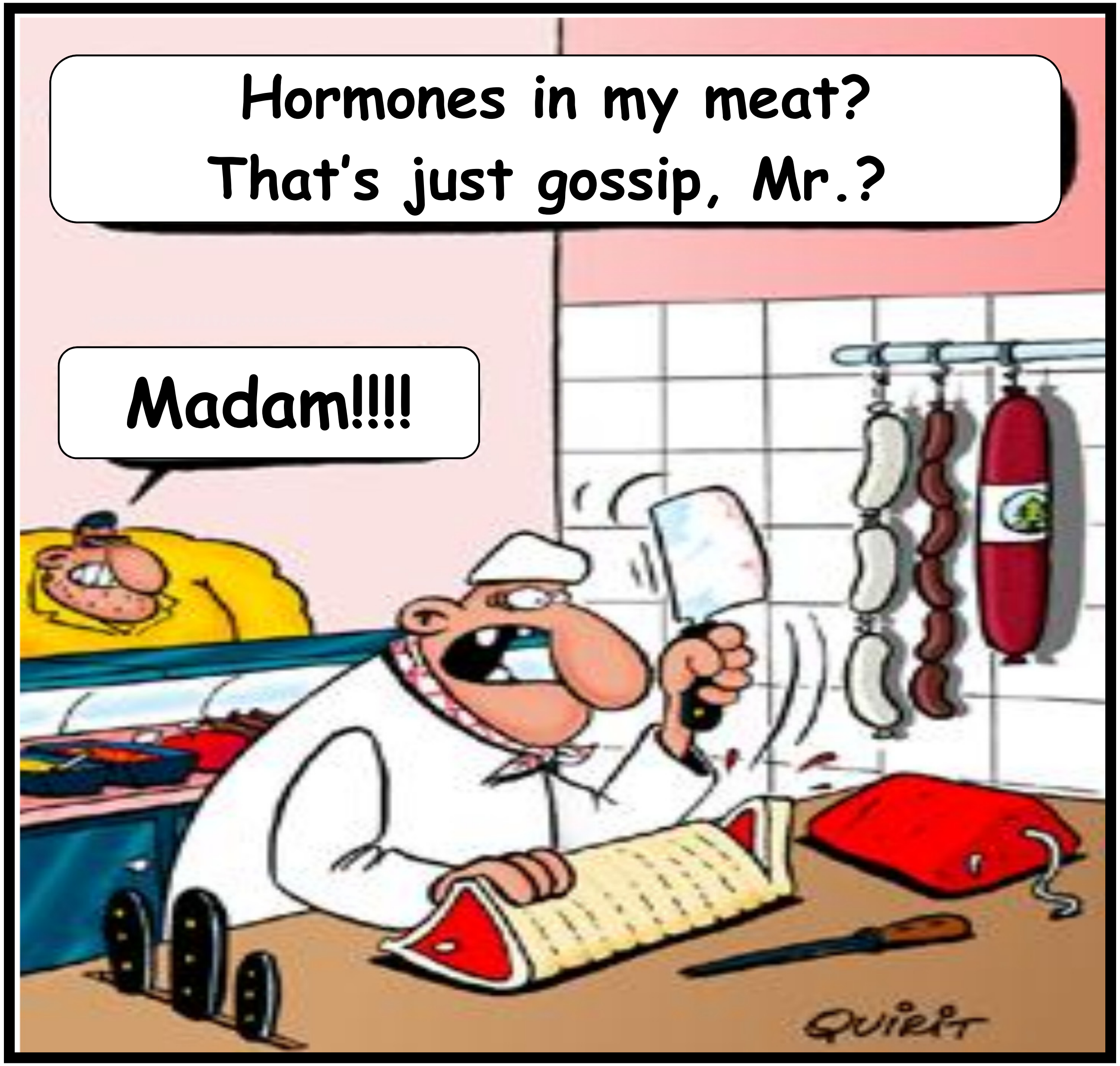
- Vitamins (water- and fat-solubles) are serious candidates for improvement of survival and disease resistance in piglets: besides growth performance, various roles in immunology and antioxidative capacity

☺

Micronutrients, pigs, updating and fine tuning

☹

Vitamins, the social aspect of feed additives



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Thank you !

For more information:

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