

Assessing bioavailability of essential trace minerals in animal nutrition

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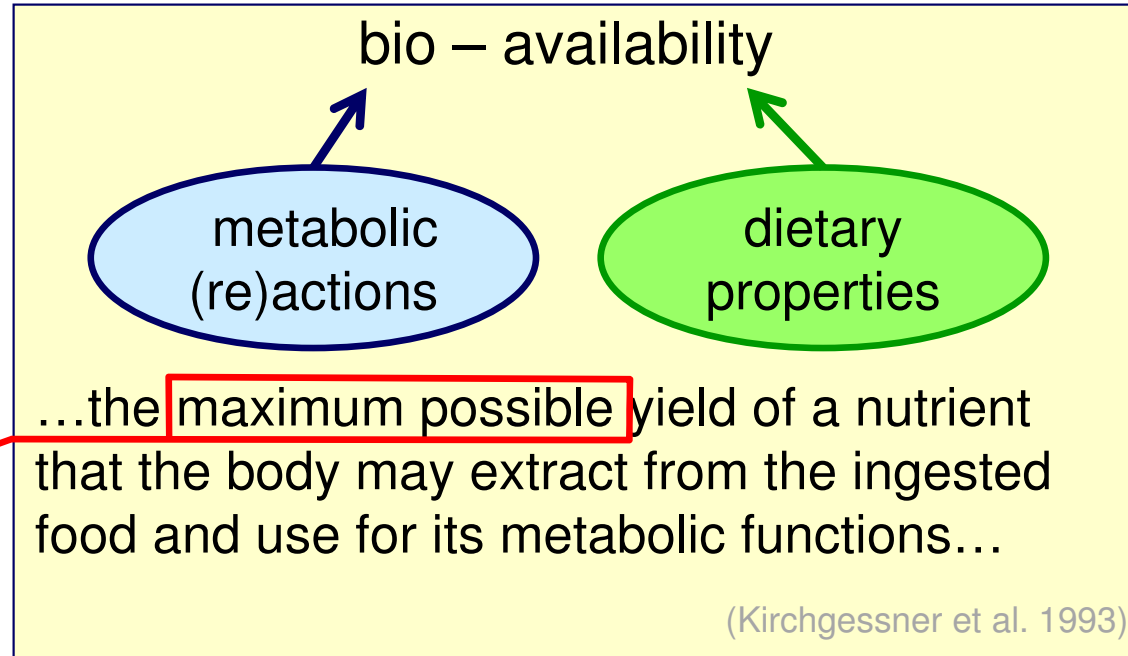


Hans-Eisenmann-Zentrum

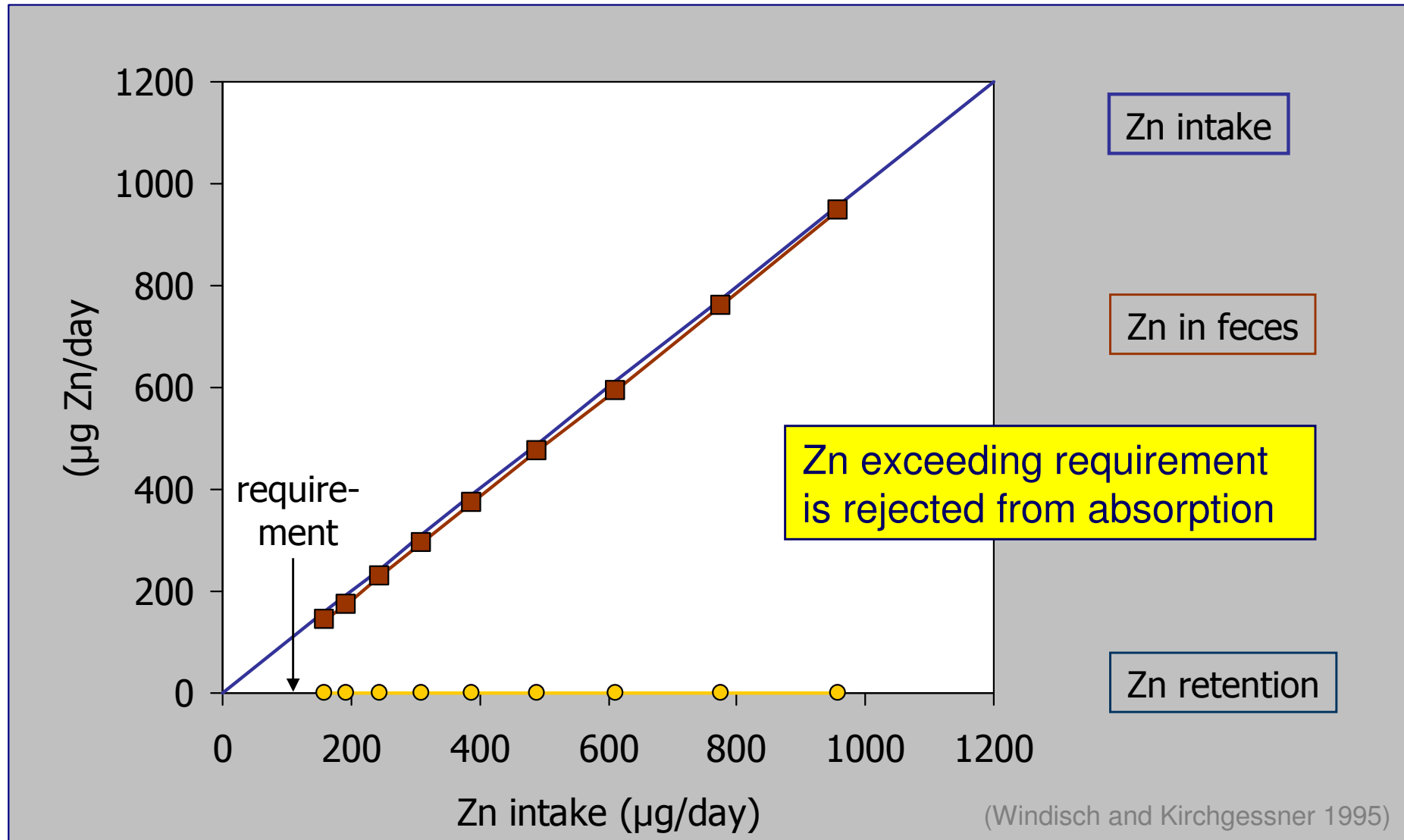
Bioavailability of essential trace minerals: restrictions resulting from general definition

In vitro studies
cannot fully
cover
bioavailability

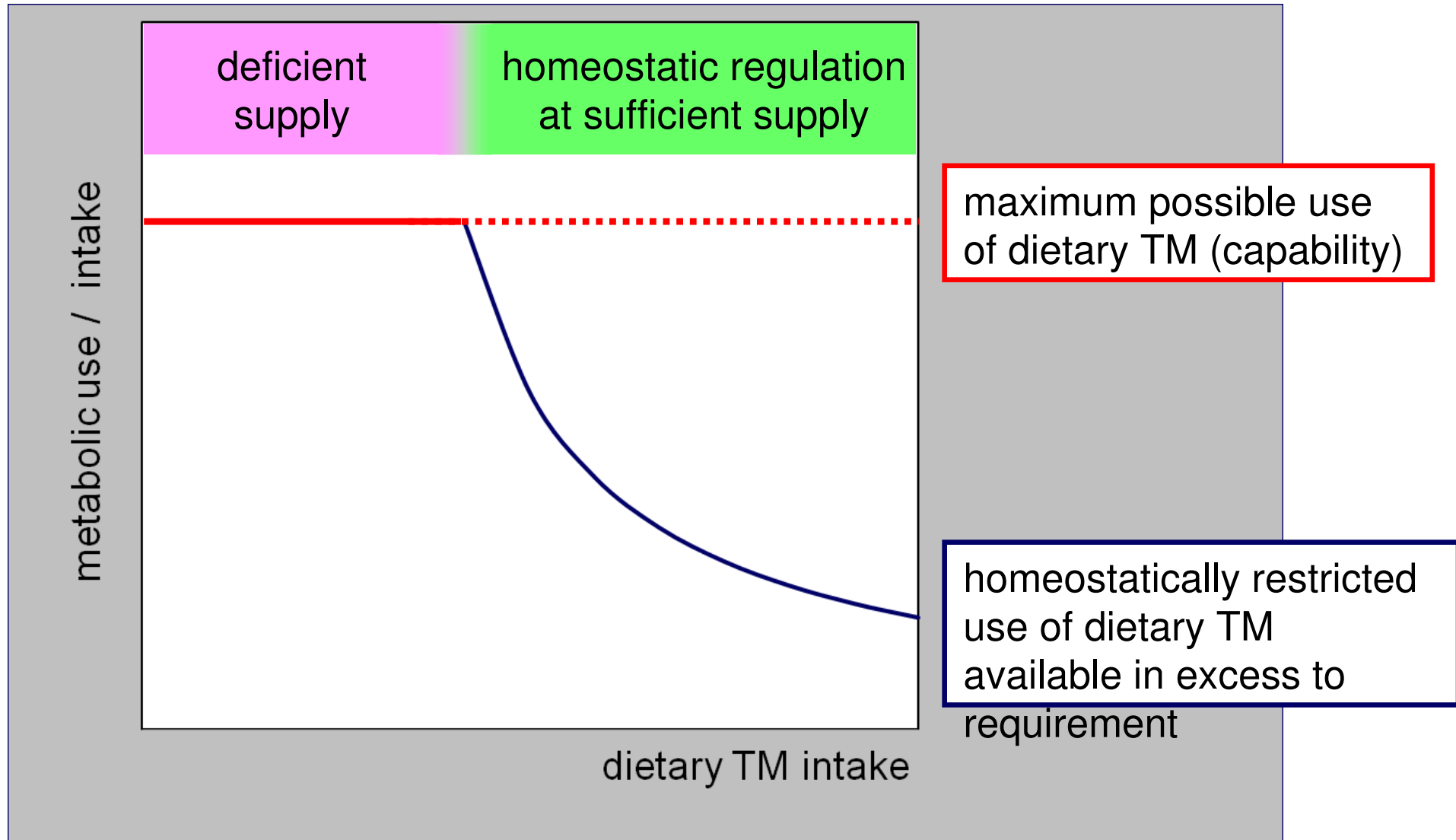
Bioavailability
= *capability*
of metabolic
use at the
absence of
homeostatic
regulation



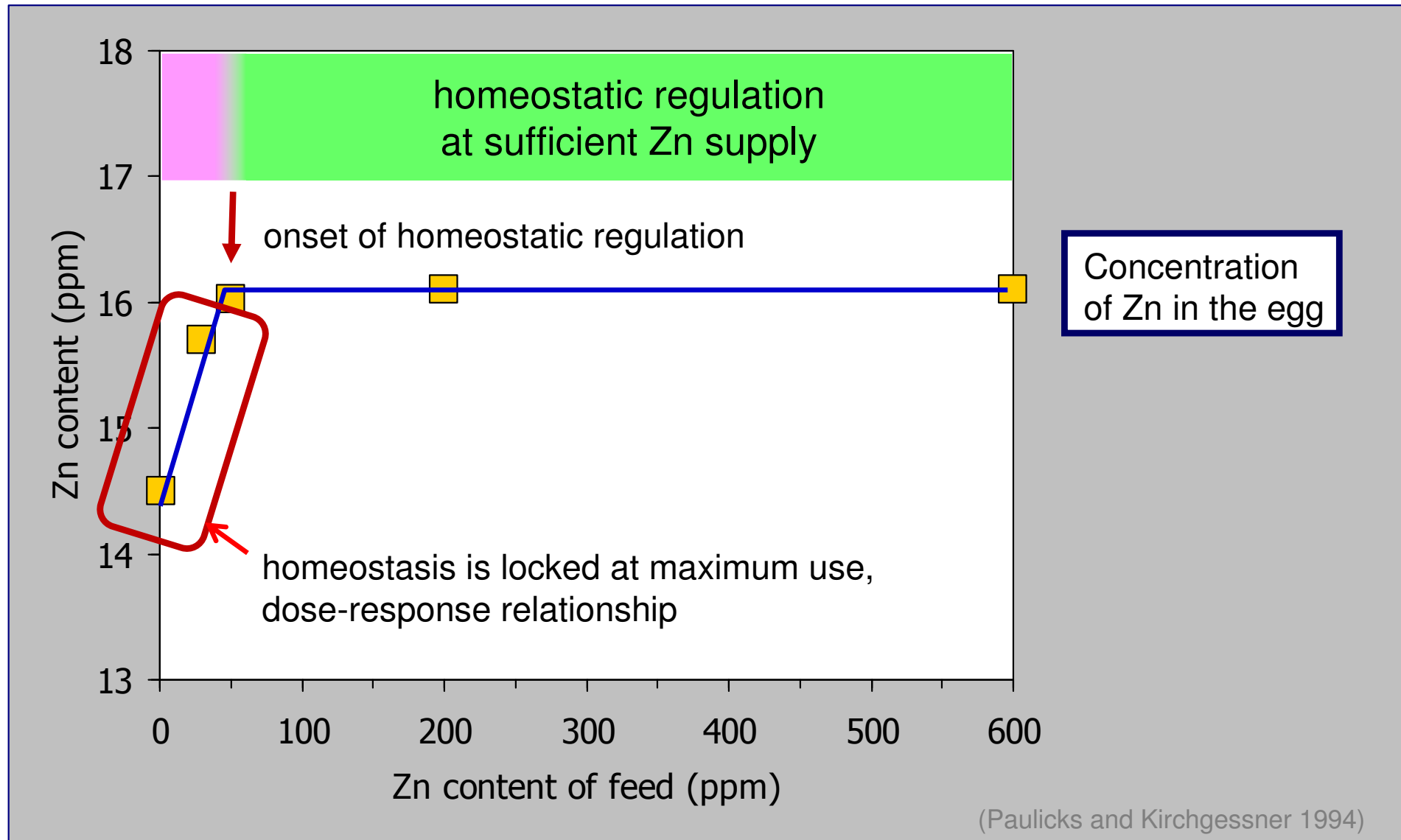
E.g. homeostatic regulation of Zn metabolism: Precise control of Zn uptake from intestinal tract



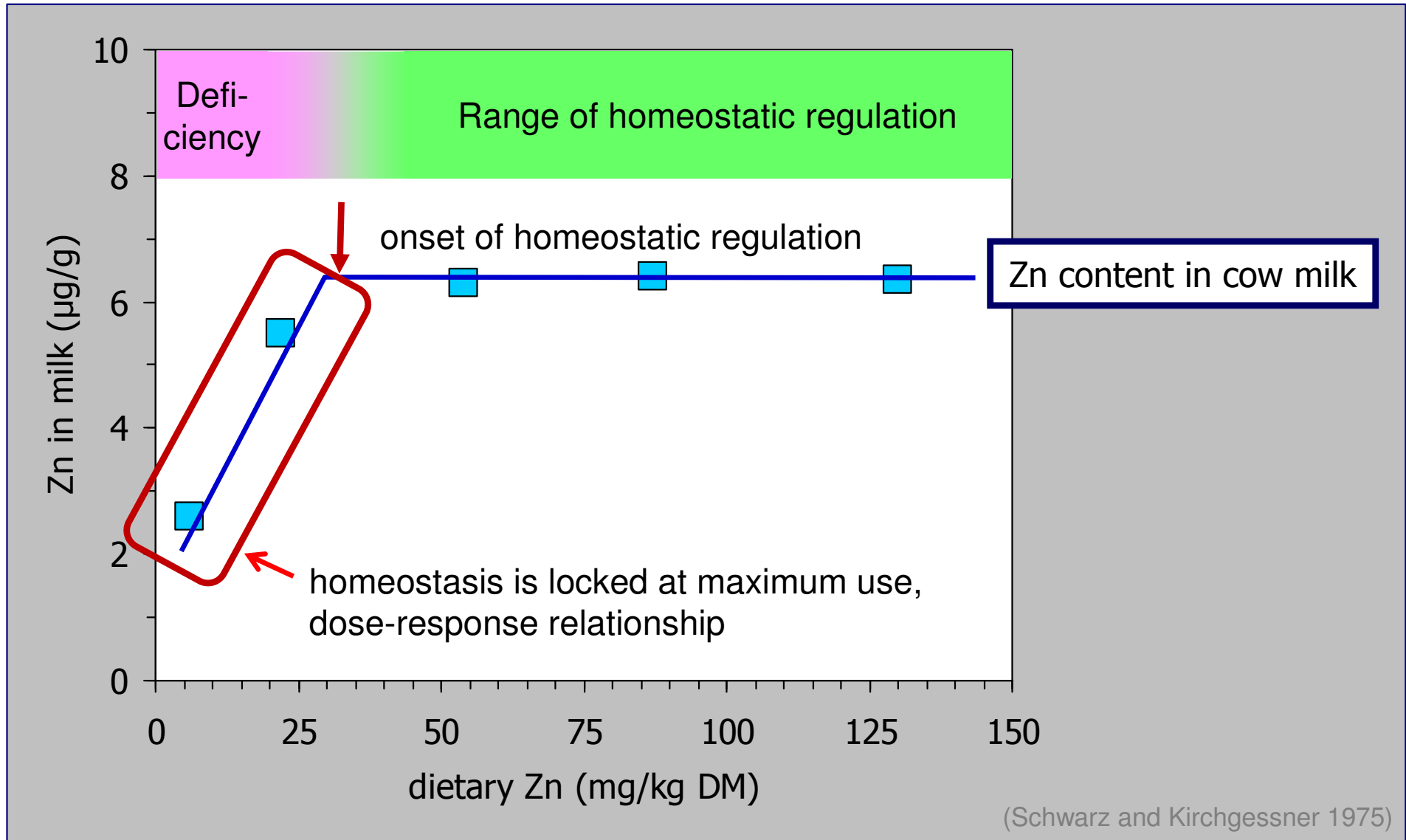
Metabolic use of dietary trace minerals in relation to homeostatic counter-regulation



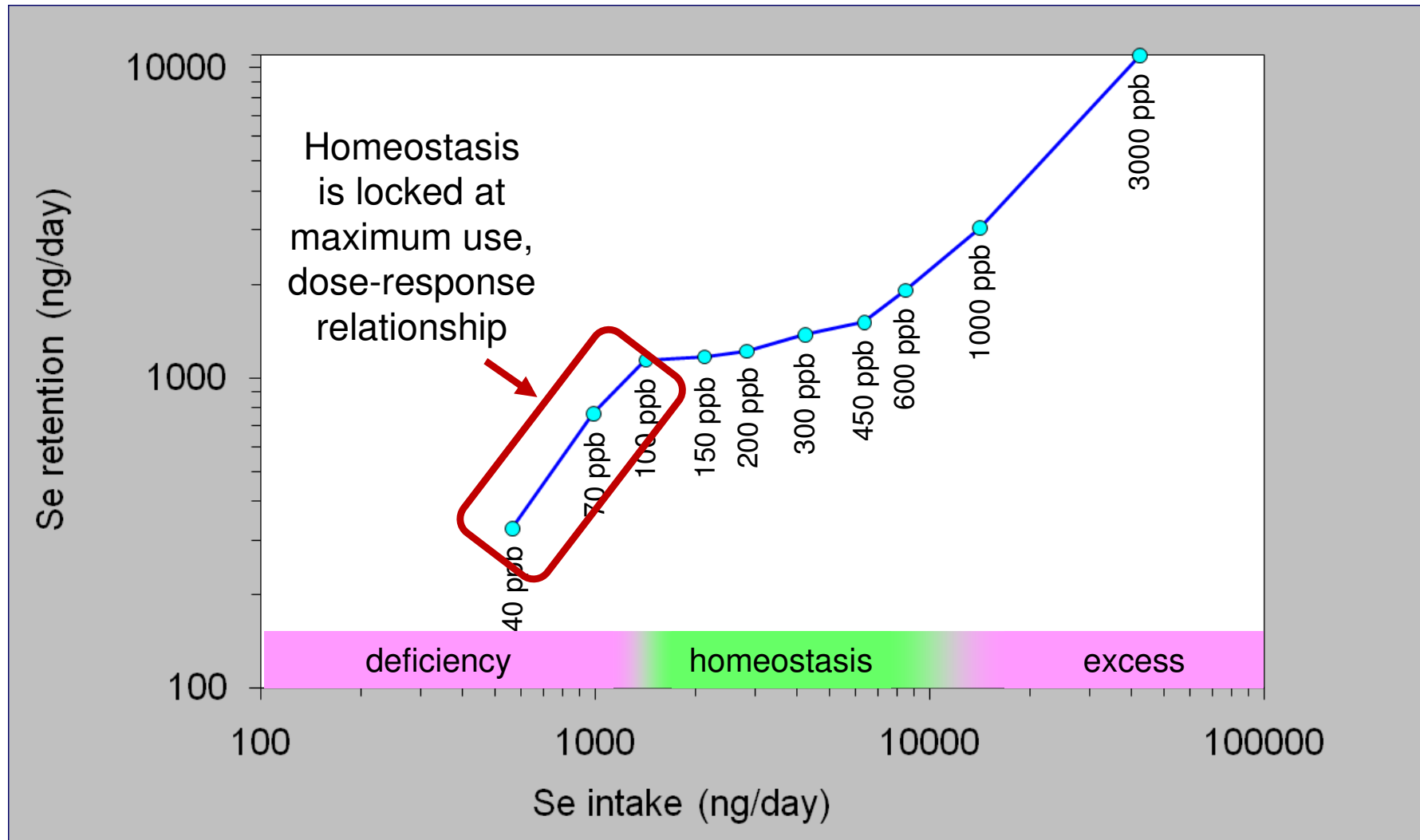
e.g. Zn homeostasis: Zn concentration in eggs



Example Zn homeostasis: Zn steady state in products (e.g. milk)

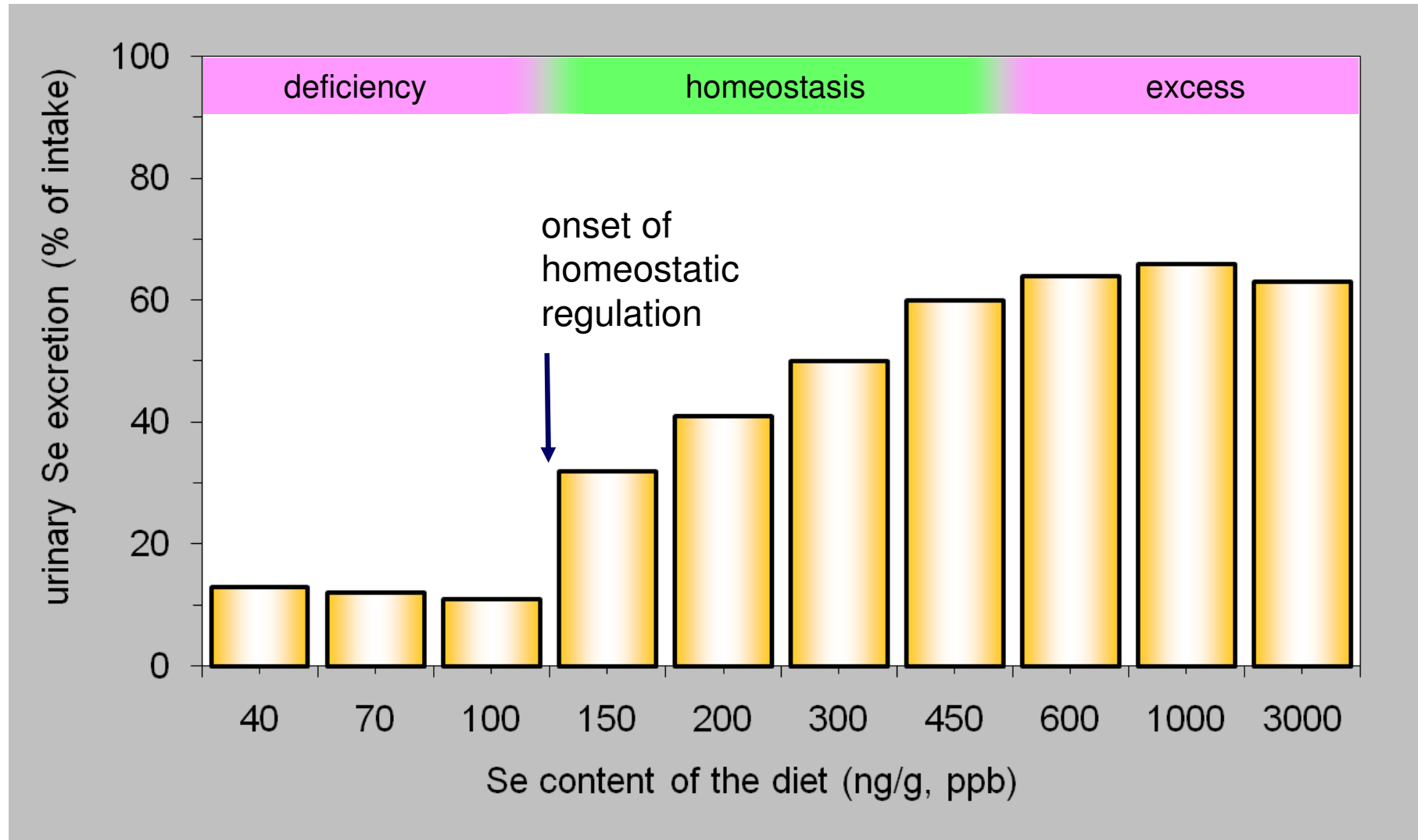


e.g. Se homeostasis: whole body Se retention



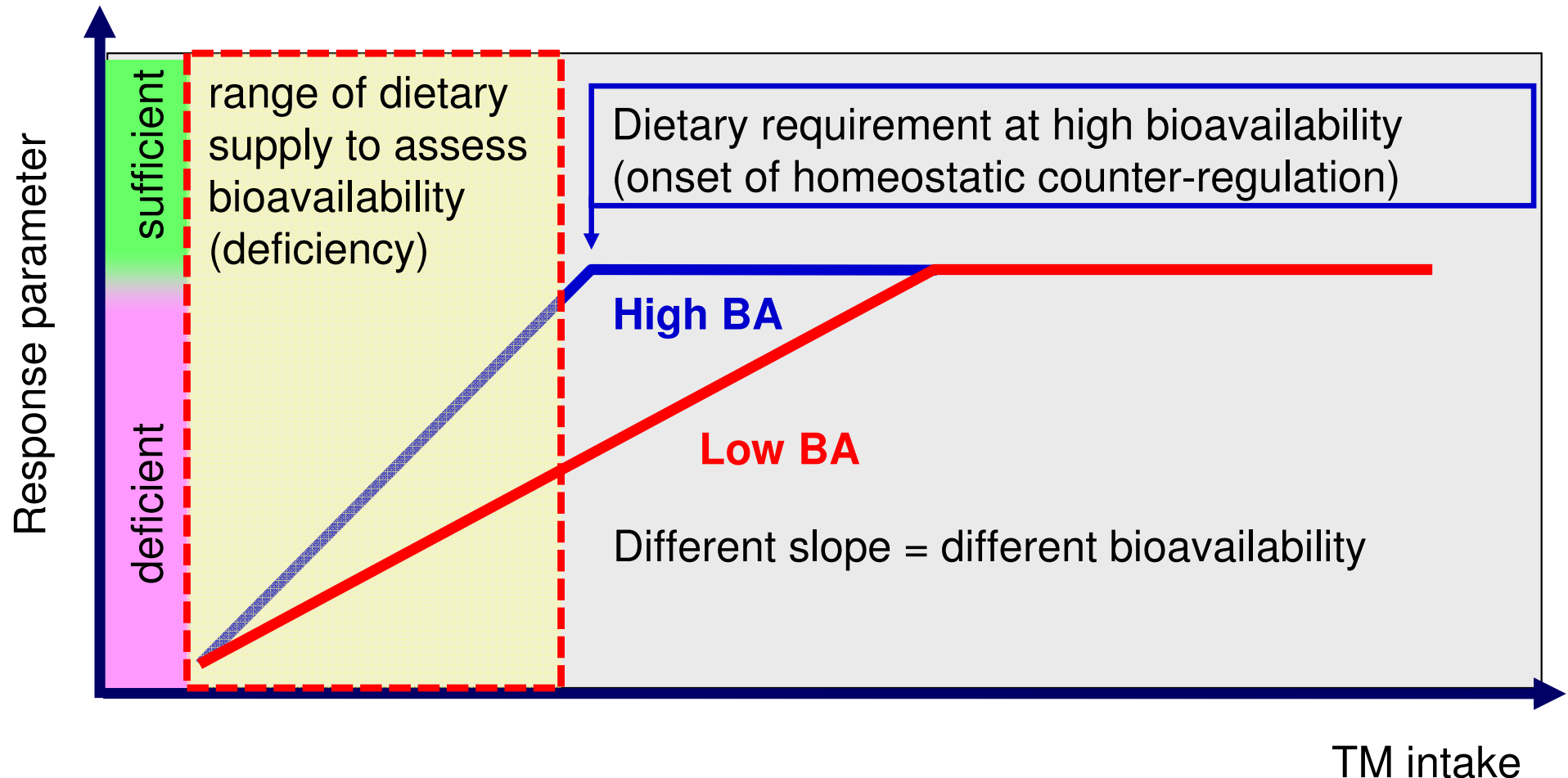
(Kirchgessner et al.1997)

e.g. Se homeostasis: urinary Se excretion

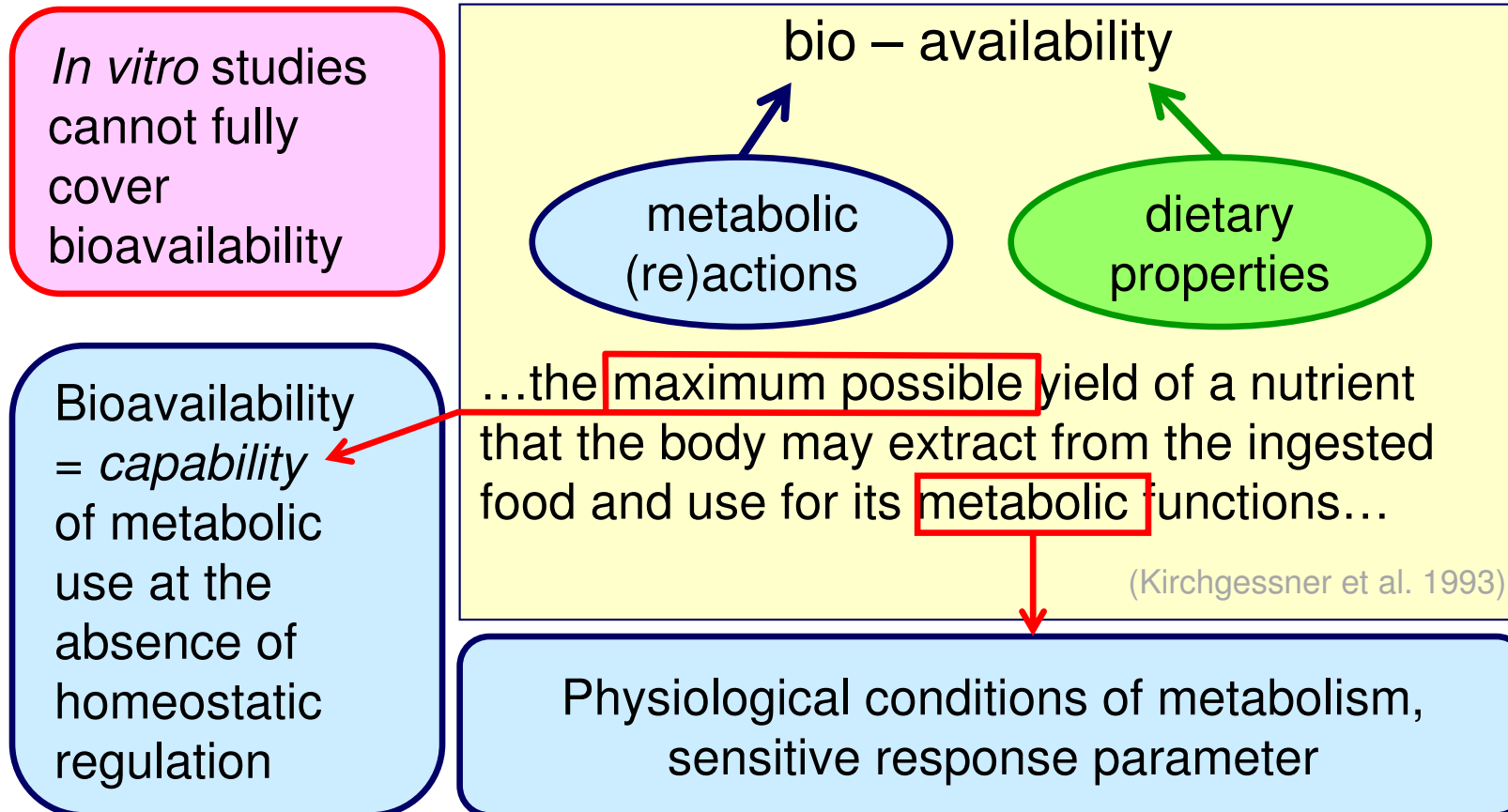


(Kirchgessner et al.1997)

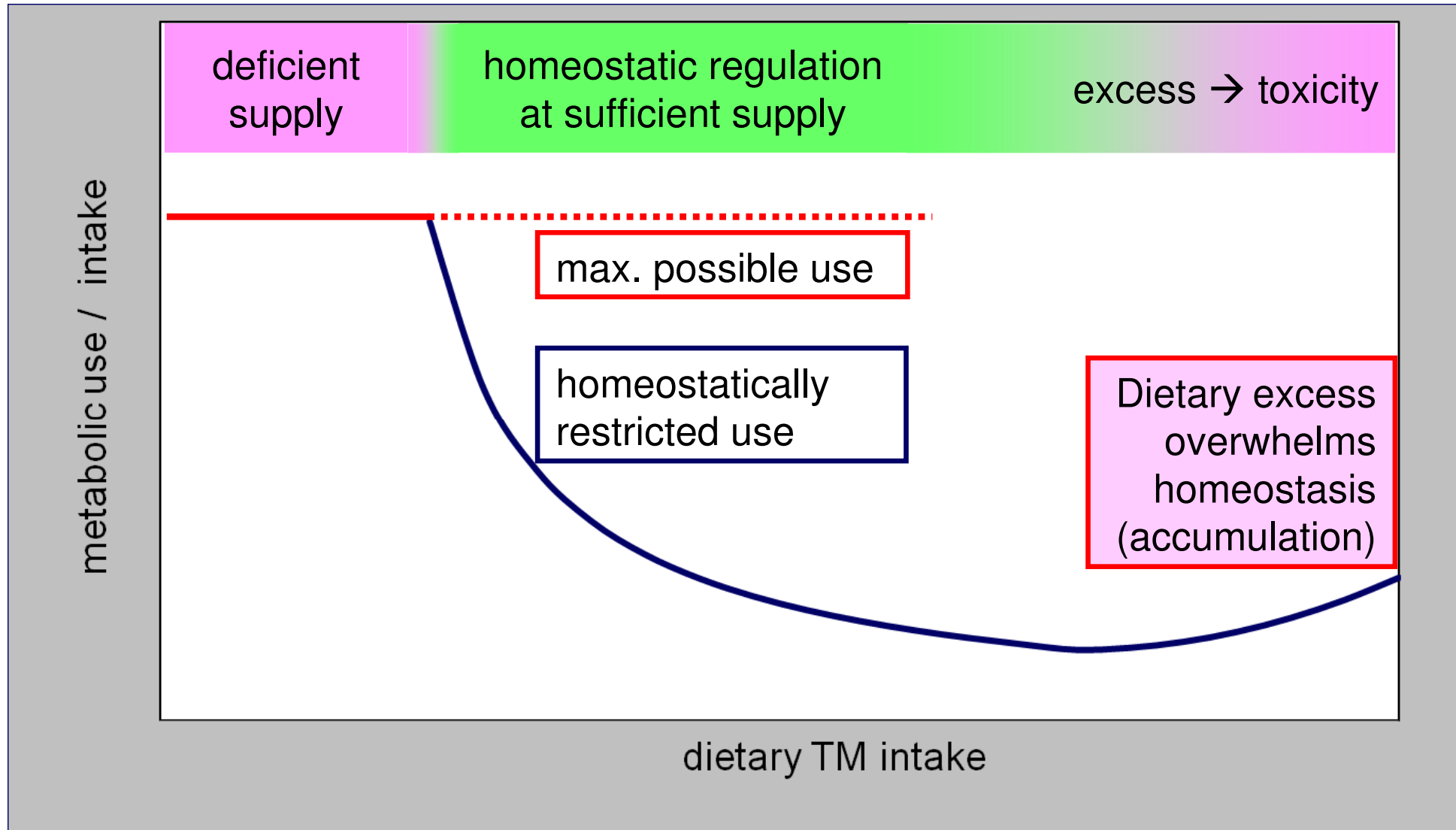
General principle to assess bioavailability of trace minerals



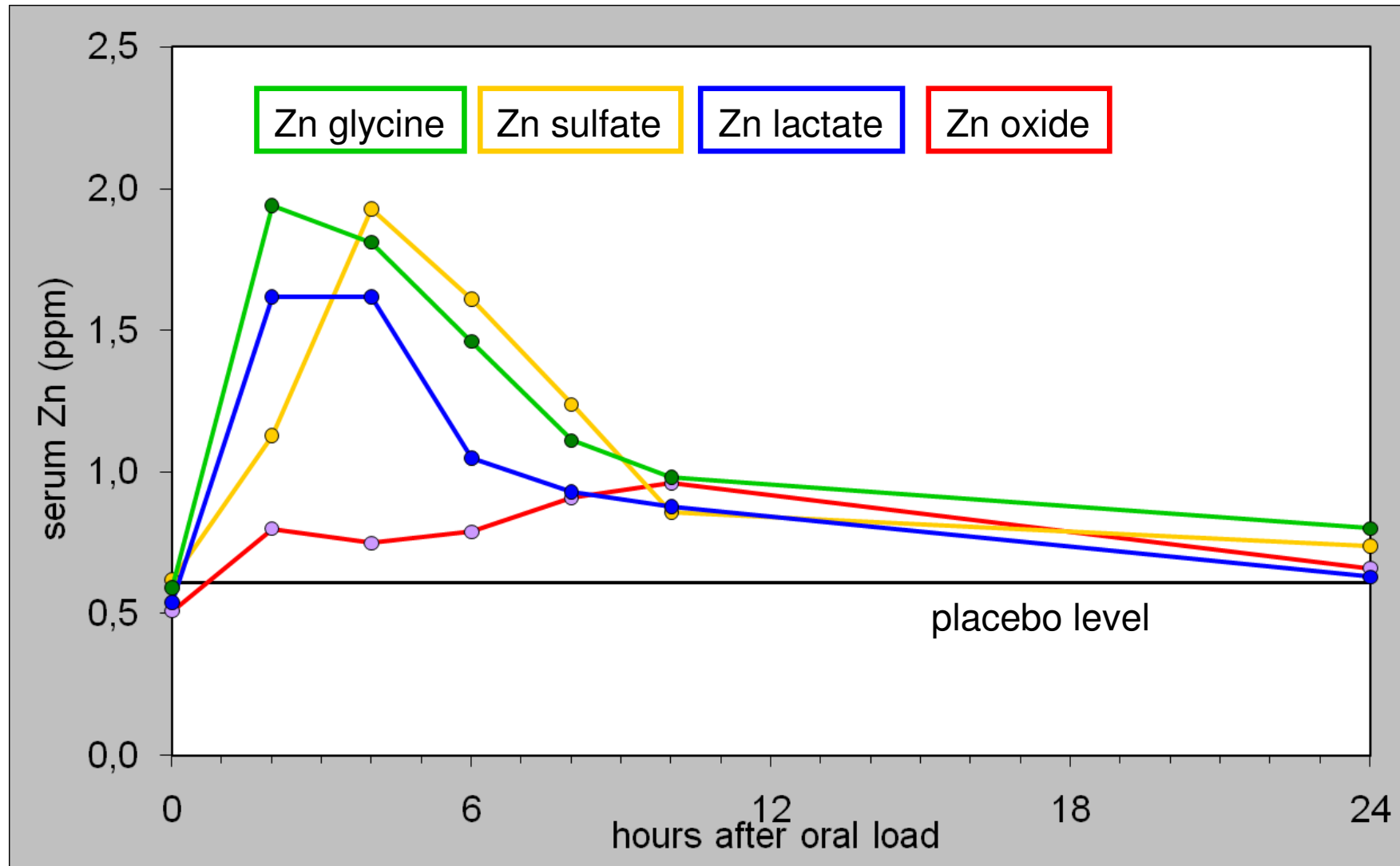
Bioavailability of essential trace minerals: restrictions resulting from general definition



Metabolic use of dietary trace minerals in relation to homeostatic counter-regulation

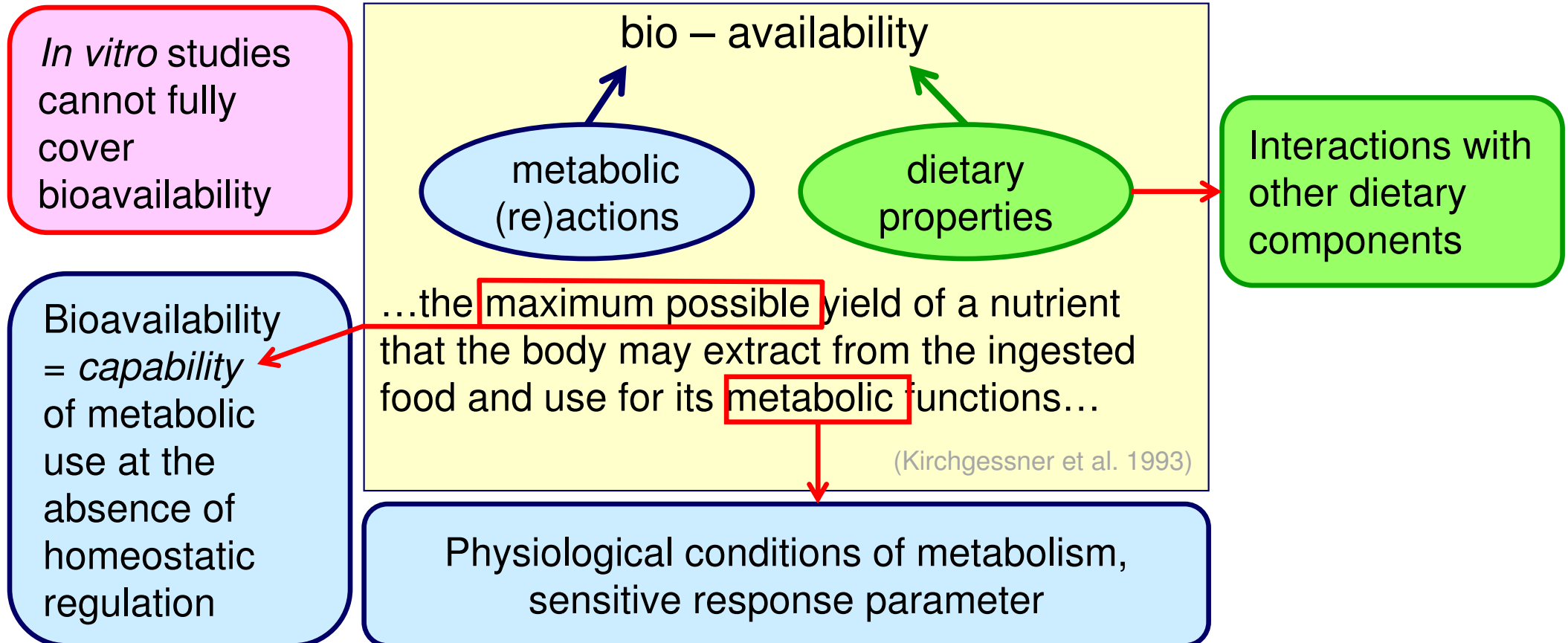


Short term oral excess demonstrates ability to overwhelm homeostatic counter-regulation (AUC-method)



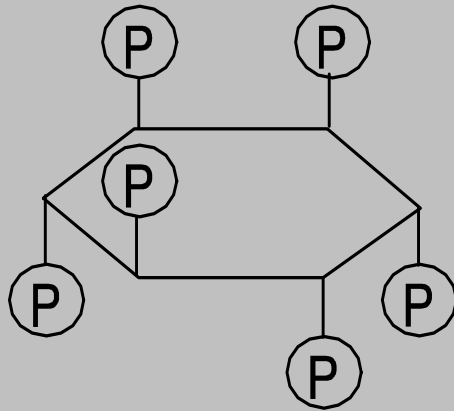
(Single oral Zn load in horses: Wichert et al. 2001)

Bioavailability of essential trace minerals: restrictions resulting from general definition

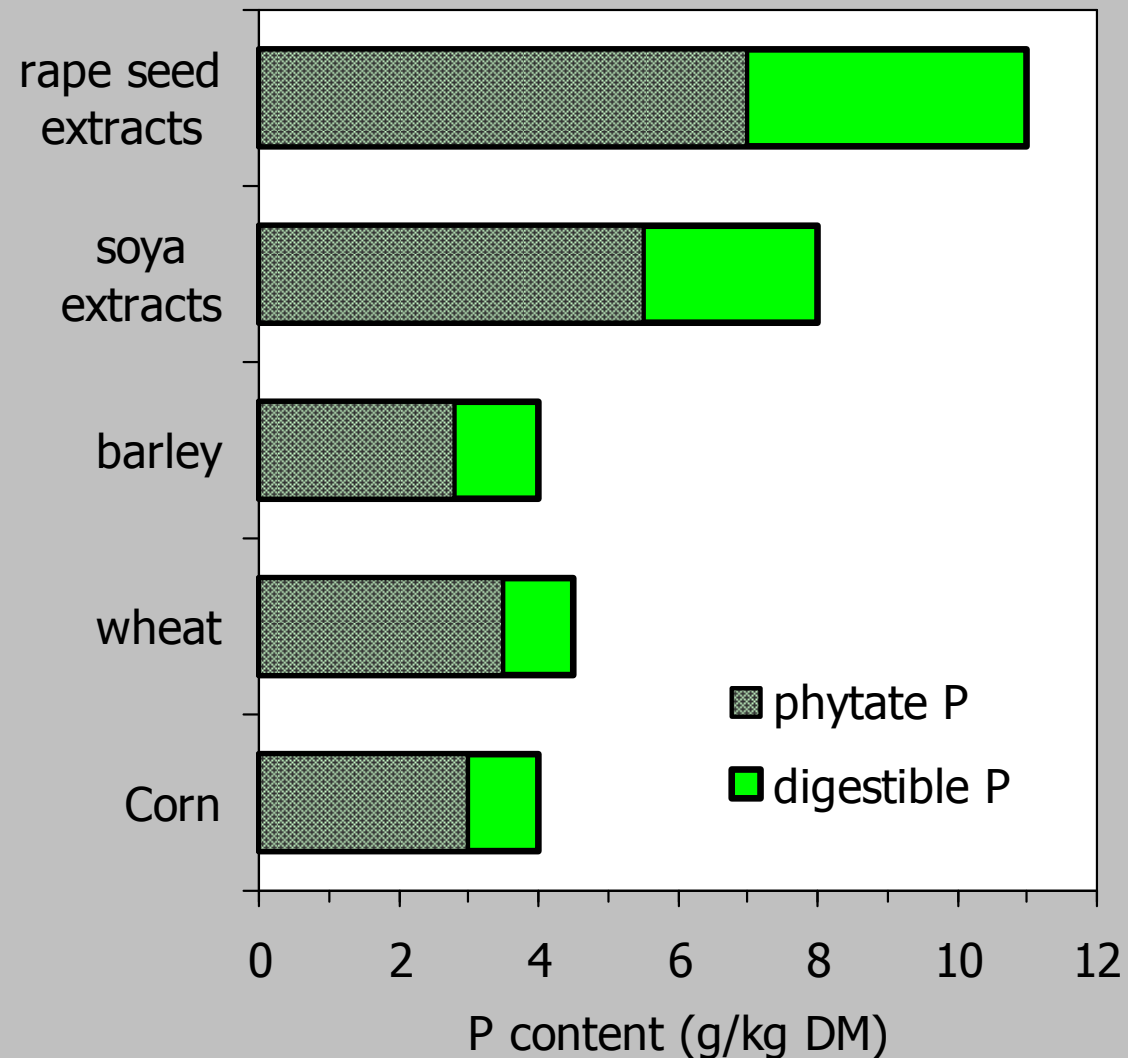


Phytic acid is a strong chelator to trace minerals

Phytic acid (phytate)

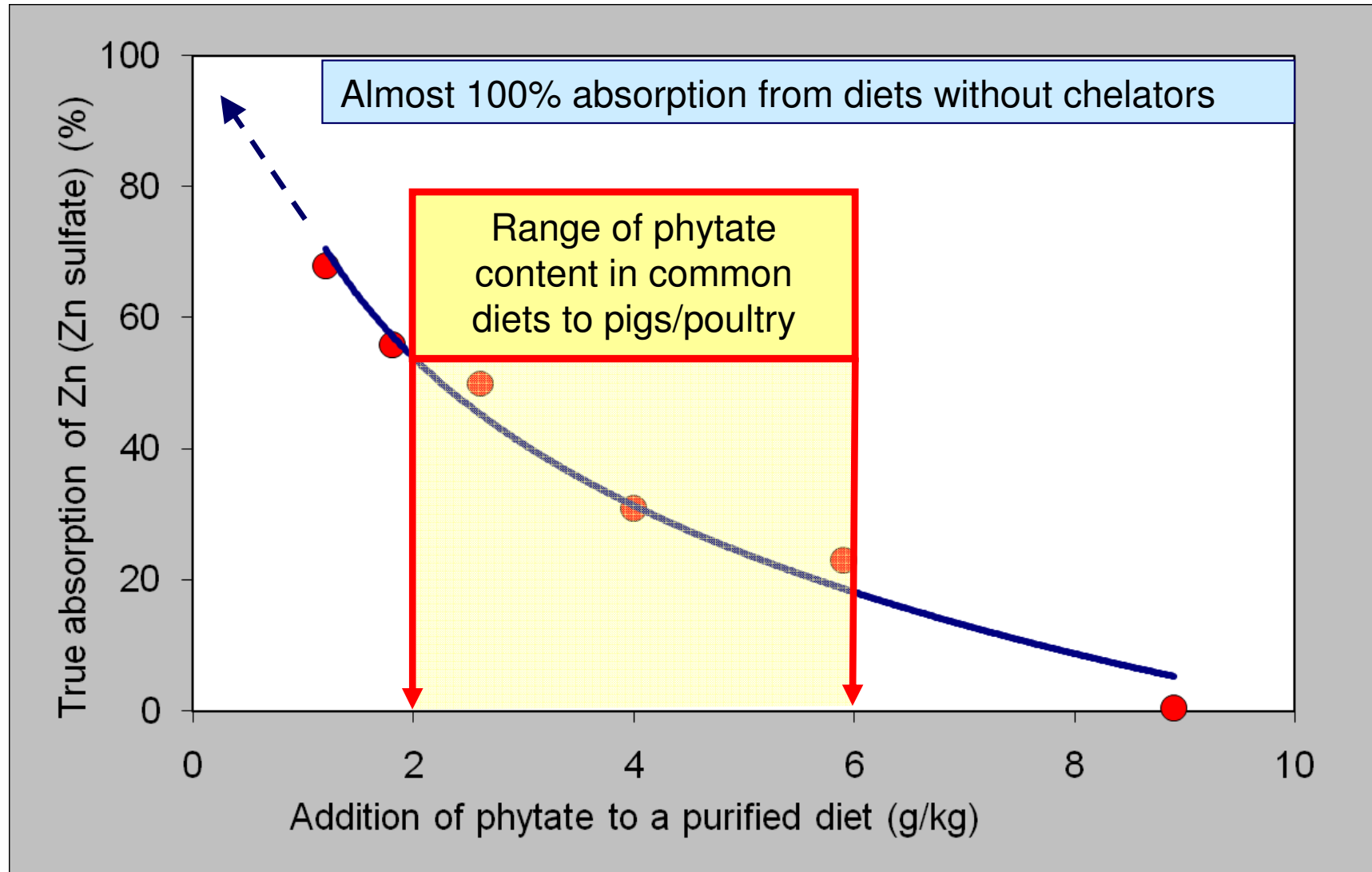


Inositol 1,2,3,4,5,6-Hexakis-
dihydrogenphosphat



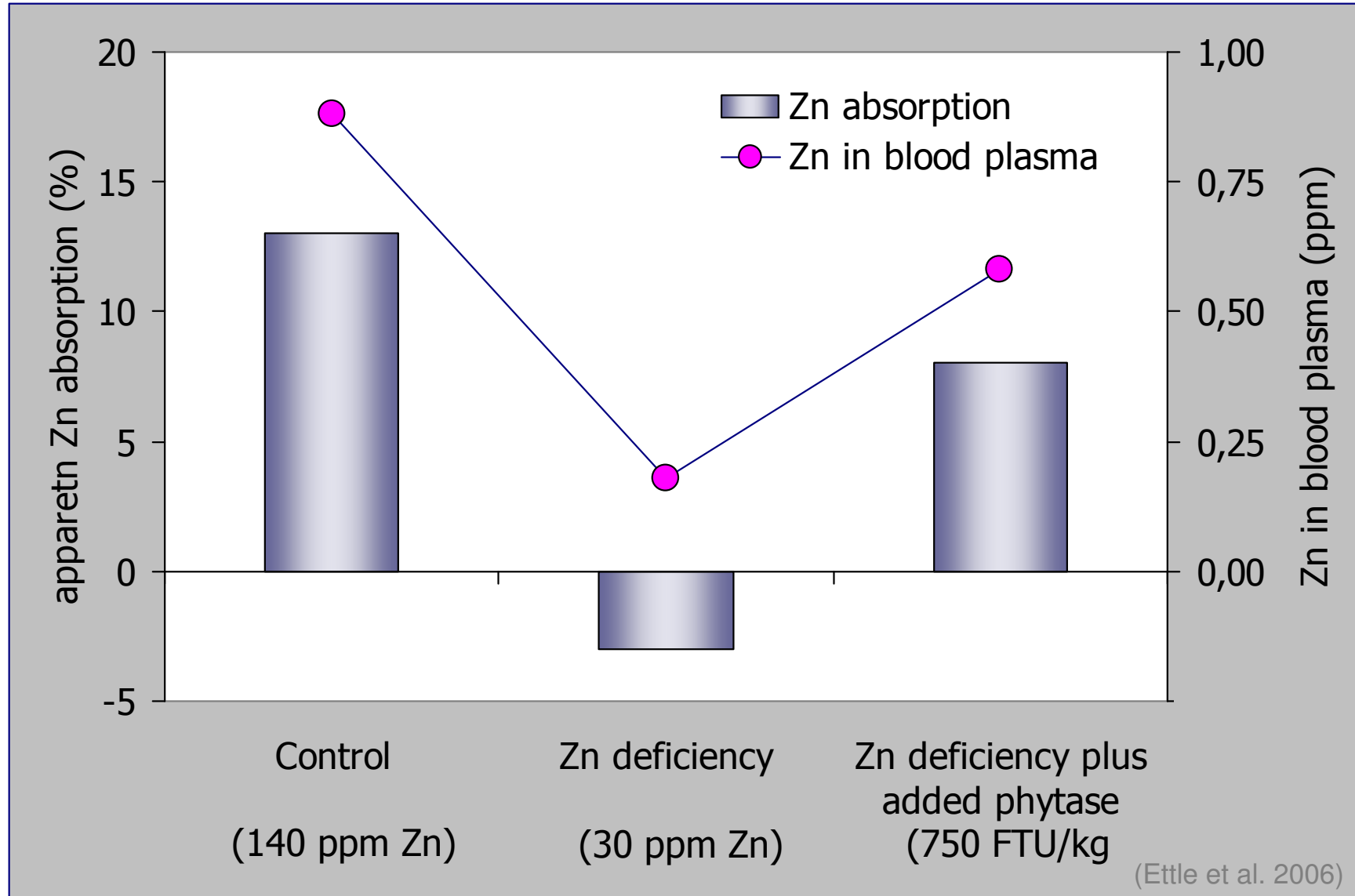
(Lantzsch 1990)

Dietary phytate may massively reduce maximum possible Zn absorption measured at Zn deficiency

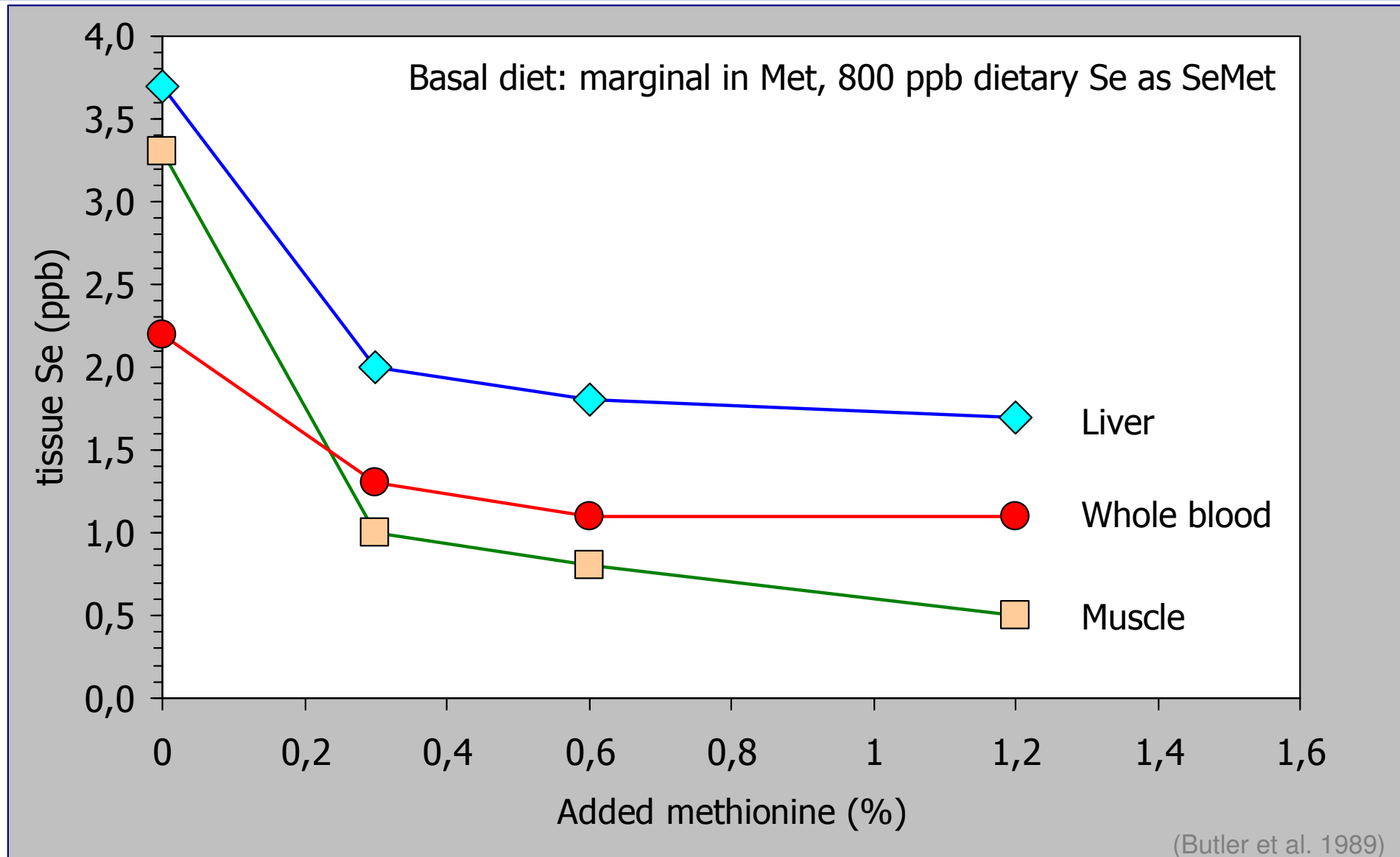


(Windisch and Kirchgessner 1999)

Added phytase may significantly improve Zn bioavailability (e.g. from inorganic sources, Zn sulfate)



Se retention from organic Se depends on supply status with methionine (growing rat model)



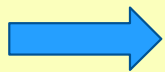
Assessing bioavailability of essential trace minerals in animal nutrition

In vitro methods do not fully cover bioavailability (BA).

BA = *capability* of metabolic trace mineral use
It is not fully realized at normal feeding conditions

Assessment of BA at deficient trace mineral supply
(no interference with homeostasis).

BA cannot be assessed independent from dietary composition.



Example to Zinc

Example: Quantifying Zn bioavailability with a radiotracer study

Bioavailability

=

**true absorption
of dietary Zn**

= influx of Zn from
diet into the
inside of the
organism

x

**metabolic utilization of
absorbed dietary Zn**

...for tissue retention,
endogenous faecal
and renal excretion,
surface losses, ...

measured in a radiotracer study
at Zn deficiency
using a purified diet added with Na₁₂phytate (8g/kg)

(Schlegel and Windisch 2006)

Example: Quantifying Zn bioavailability in a radiotracer study

(Schlegel and Windisch 2006)

| Treatment group: Added dietary Zn Zn status | positive control sulfate (52µg/g) sufficient Zn | negative control sulfate (12µg/g) deficient Zn | Test group Zn glycinate, (12µg/g) deficient Zn |
|---|--|---|---|
| Blood plasma Zn (µg/ml) | 1.35 ^a | 0.71 ^b | 0.76 ^b |
| <u>Zn flux (µg/day)</u> | | | |
| intake | 516 | 108 | 109 |
| truly absorbed from diet | 159 ^a | 48 ^b | 56 ^b |
| endogenous faecal excretion | 48 ^a | 18 ^b | 18 ^b |
| urine | 4 ^a | 3 ^b | 2 ^b |
| retention | 107 ^a | 27 ^b | 35 ^b |
| Max. absorption (%) | | 44.2 ^b | 50.8 ^a |
| Metabolic utilization (%) | | 94.7 | 95.7 |
| Bioavailabilitiy (%) | | 41.8 ^b | 48.6 ^a |

Experimental model to assess Zn bioavailability in practical pig feeding

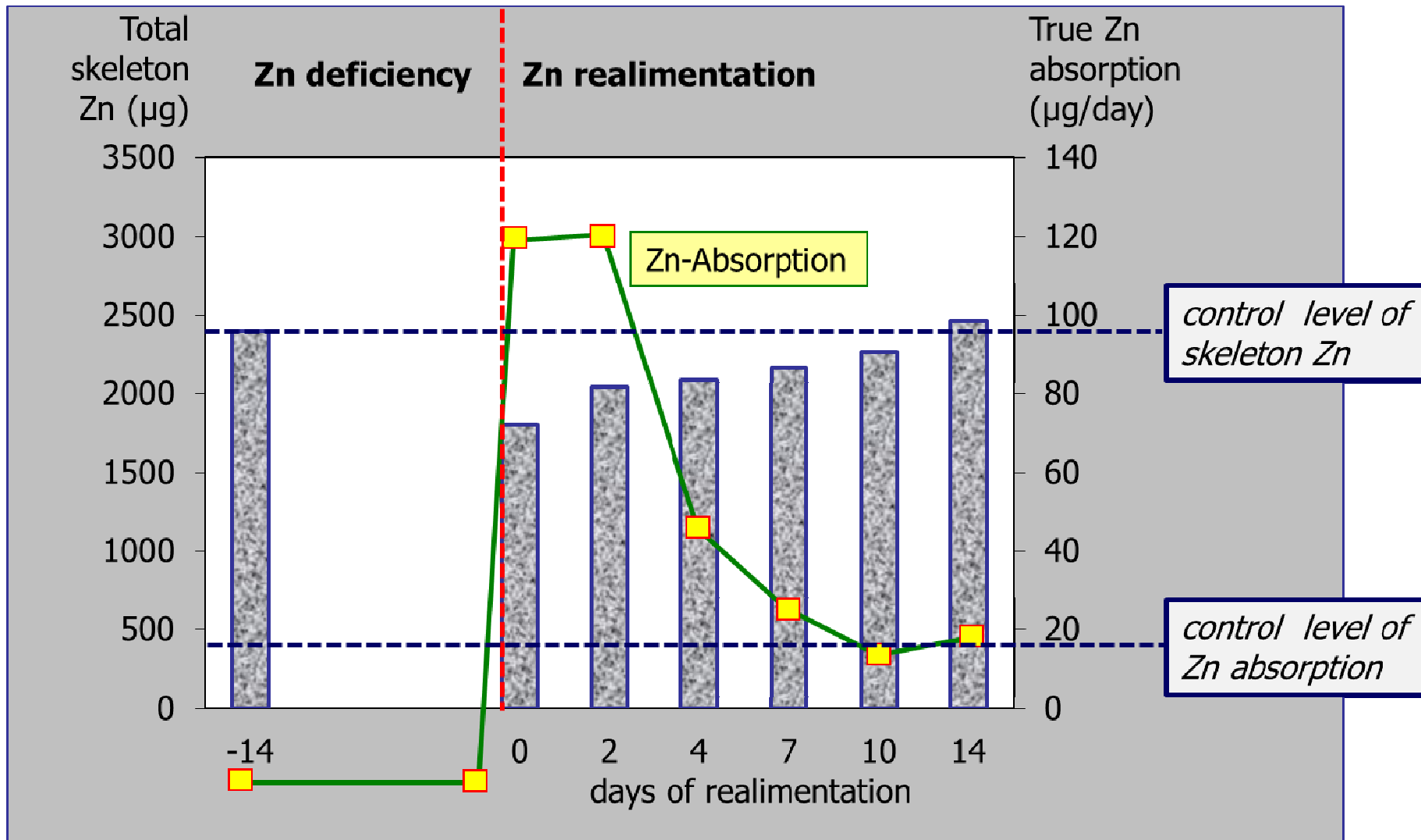
Diet?

“Worst case” diet (corn & soybean extracts): rich in phytate, low in native Zn, no phytase activity (pelleted with steam). Graded levels of added Zn (sulfate) from deficient to sufficient supply

Zn supply before the onset of study: depletion or adequate?

(Brugger et al. 2012)

Mobilization and refilling of mobilized bone Zn is highly regulated by homeostasis (rat model)



(Windisch 2001)

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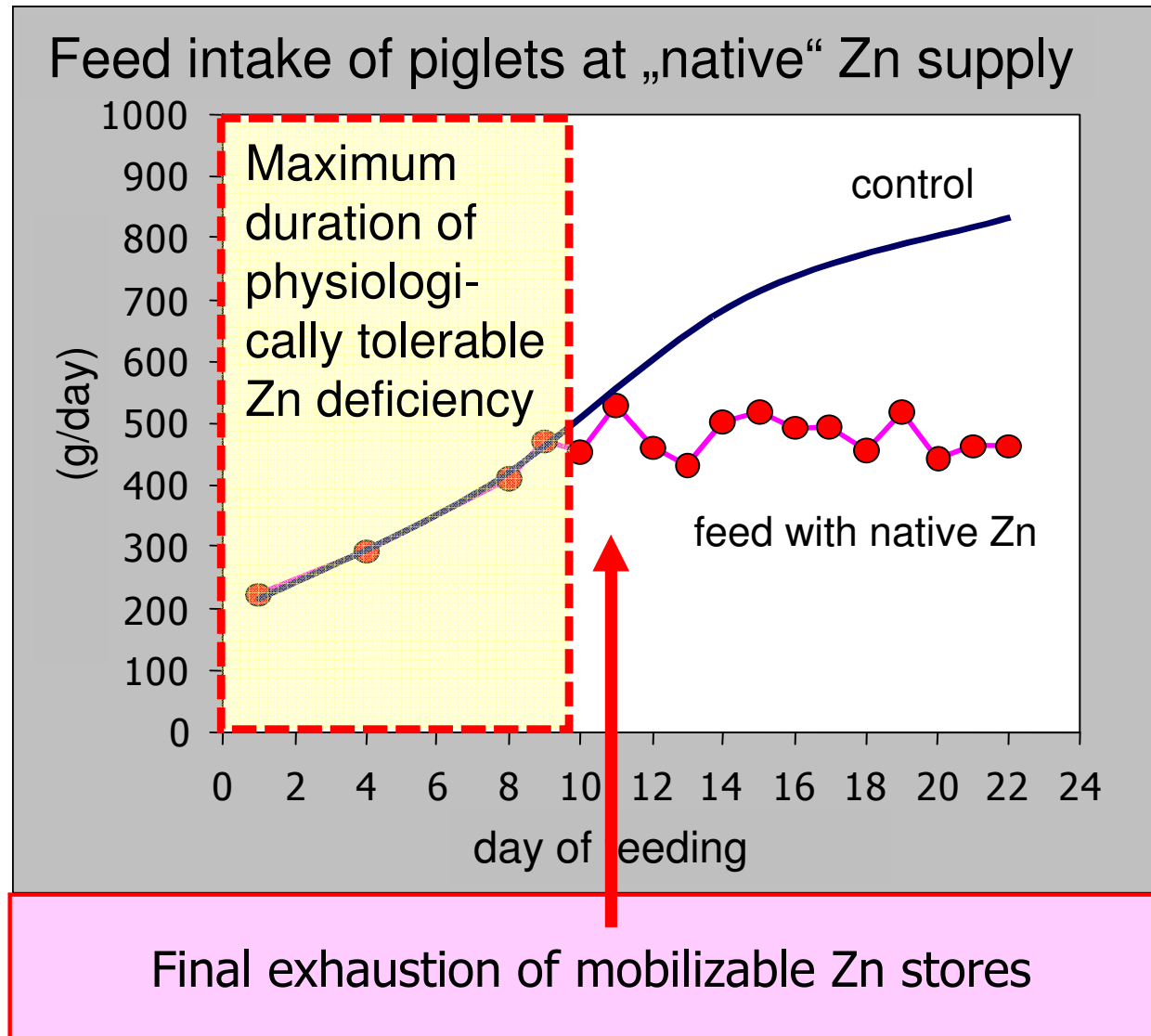
Zn supply before the onset of study: depletion or adequate?

Adequate Zn supply before the onset of study

Duration of Zn deficiency?
(no Zn deficiency symptoms)

(Brugger et al. 2012)

Symptoms of Zn deficiency in piglets fed a soya-corn-based diet without Zn supplementation



(Windisch et al. 2003)

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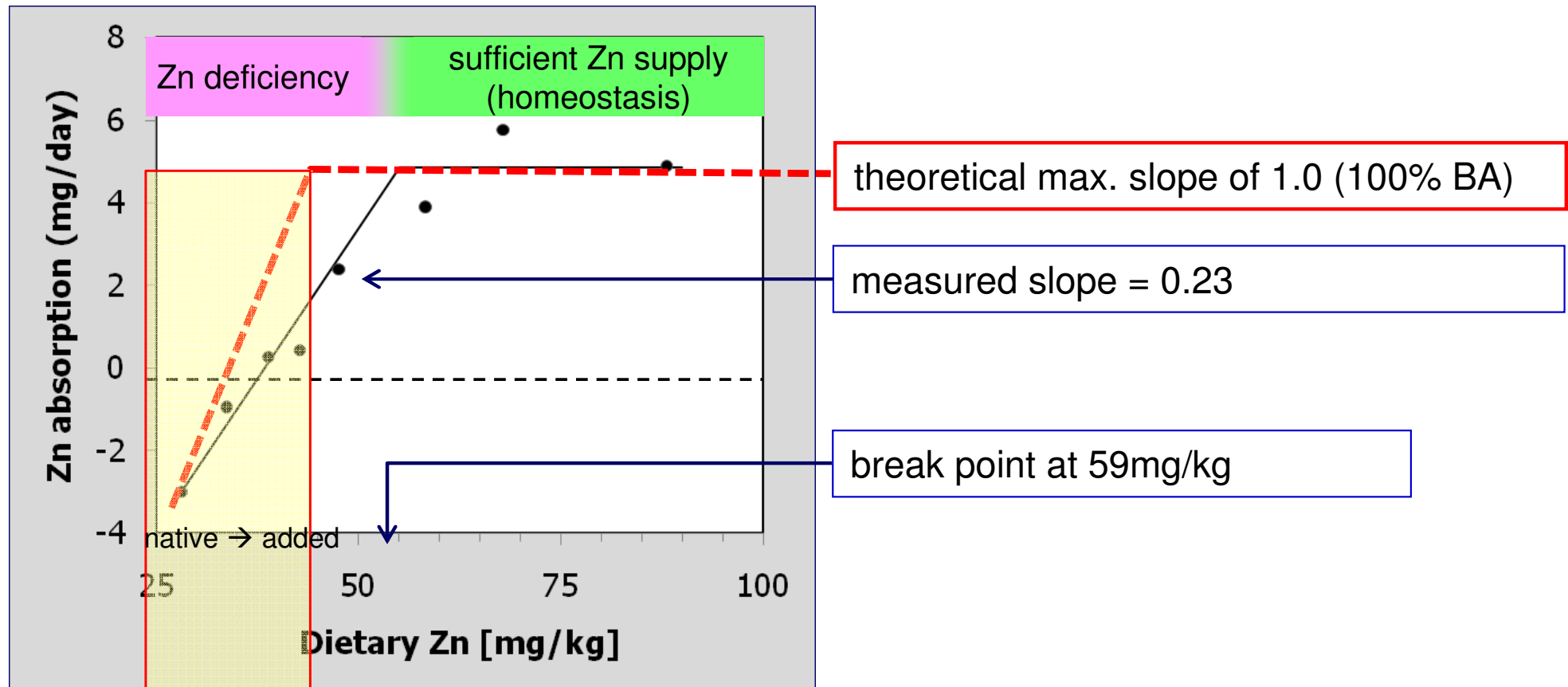
Maximum 8 days

Response parameter?

- Apparently absorbed dietary Zn (mg/day)
- Blood plasma: total Zn, AP activity
- Bone Zn
- mRNA of metallothioneine in intestinal tissues

(Brugger et al. 2012)

Reaction of apparently absorbed dietary Zn indicates absence/presence of homeostatic counter-regulation



Relevant range of dietary Zn to compare Zn sources of unknown bioavailability.

(Brugger et al. 2012)

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In vitro methods do not fully cover bioavailability (BA).

BA = *capability* of metabolic trace mineral use.

It is not fully realized at normal feeding conditions.

Assessment of BA at deficient trace mineral supply (no interference with homeostasis) and absence of deficiency disorders

BA cannot be assessed independent from dietary composition.

Comparison of dietary trace mineral sources for BA should be done on base of a well defined standard “worst case” diet.