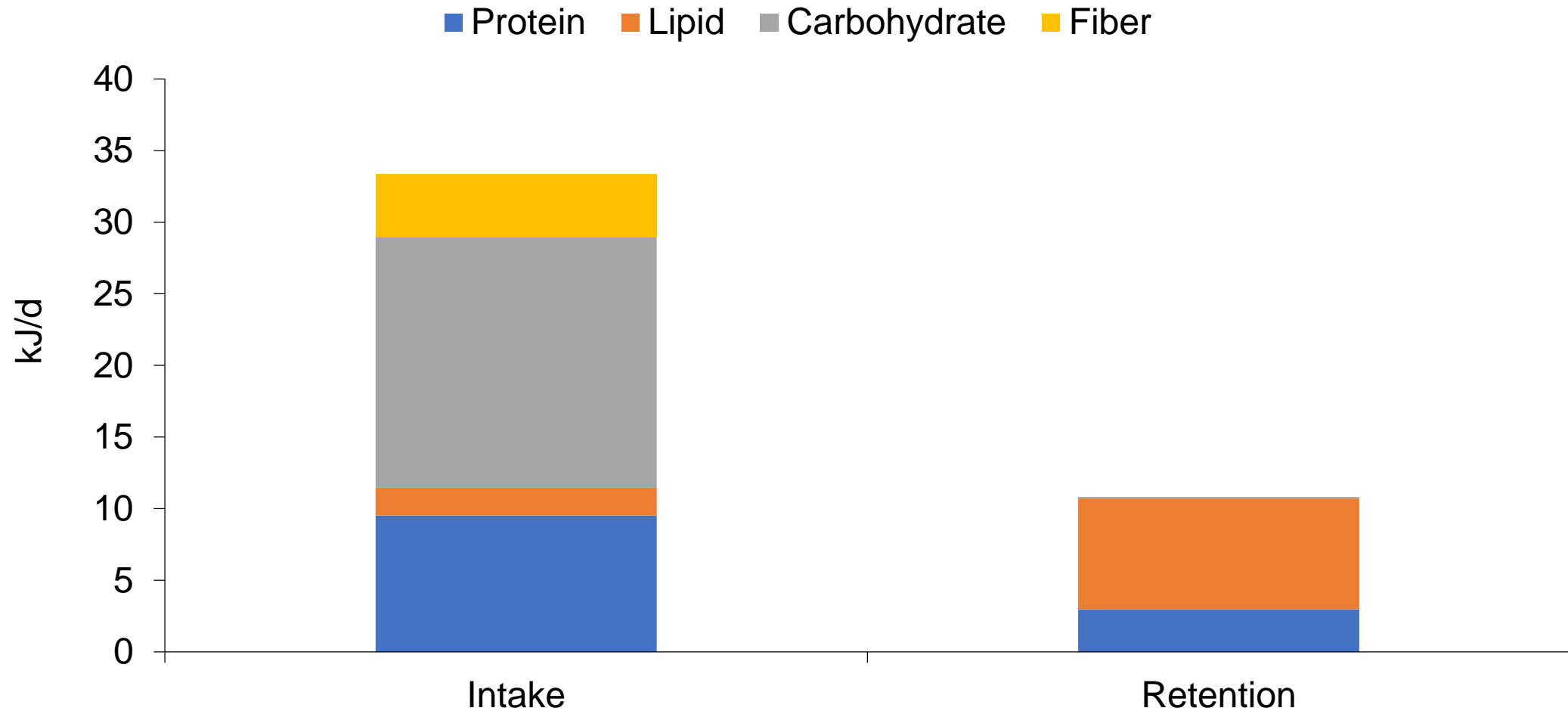




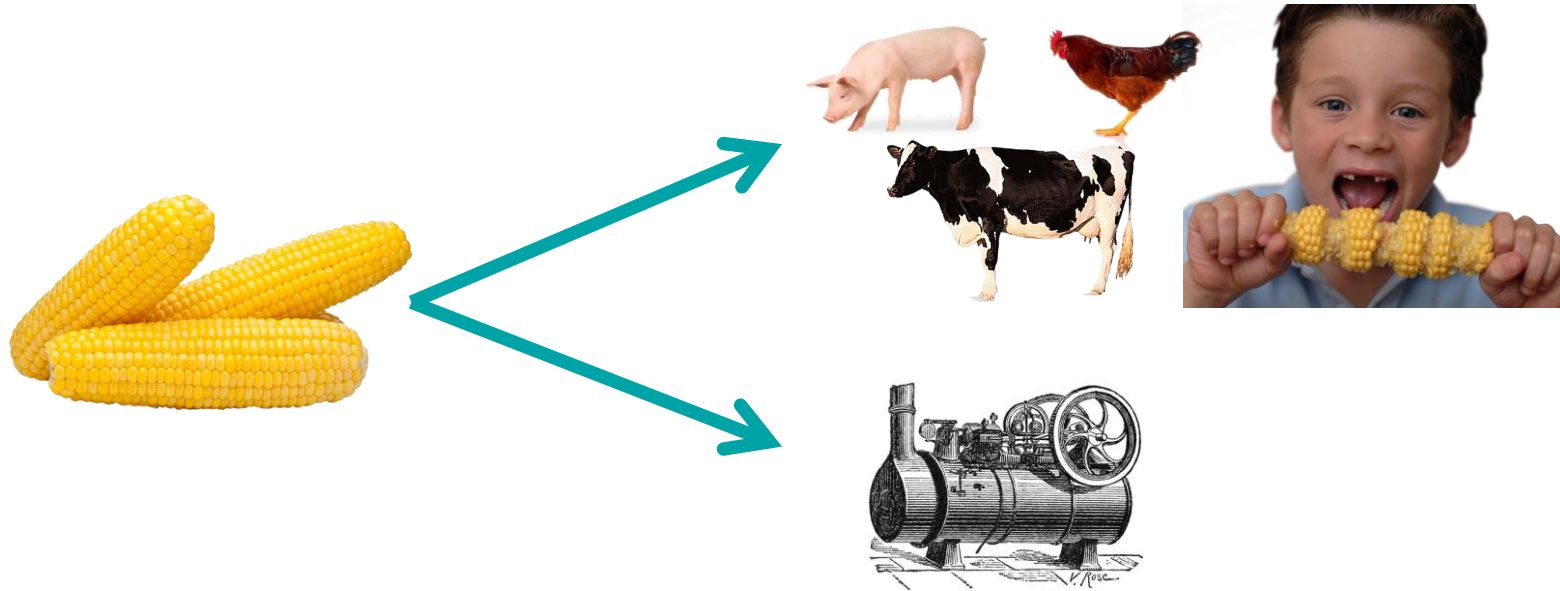
➤ Energy intake and metabolism:
incredibly complex but very well controlled

Jaap van Milgen

➤ The energy efficiency of a growing pig is not very high



➤ The issue of efficiency is not new



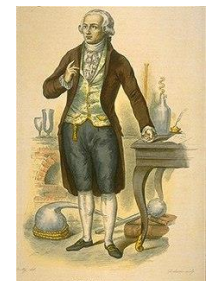
The Efficiency of the Animal Compared with the Steam Engine.

It is of interest in studying the efficiency of the animal as a converter of energy in work and food production to compare it with a mechanical energy converter such as the steam engine. We have recently been confronted with the phenomenon of the burning of corn for fuel in place of the usual use as a food for animals or man. The economy of this substitute conversion might help solve the question of the ethics of such a substitution. Van de Velde¹⁰ has presented some figures to show that

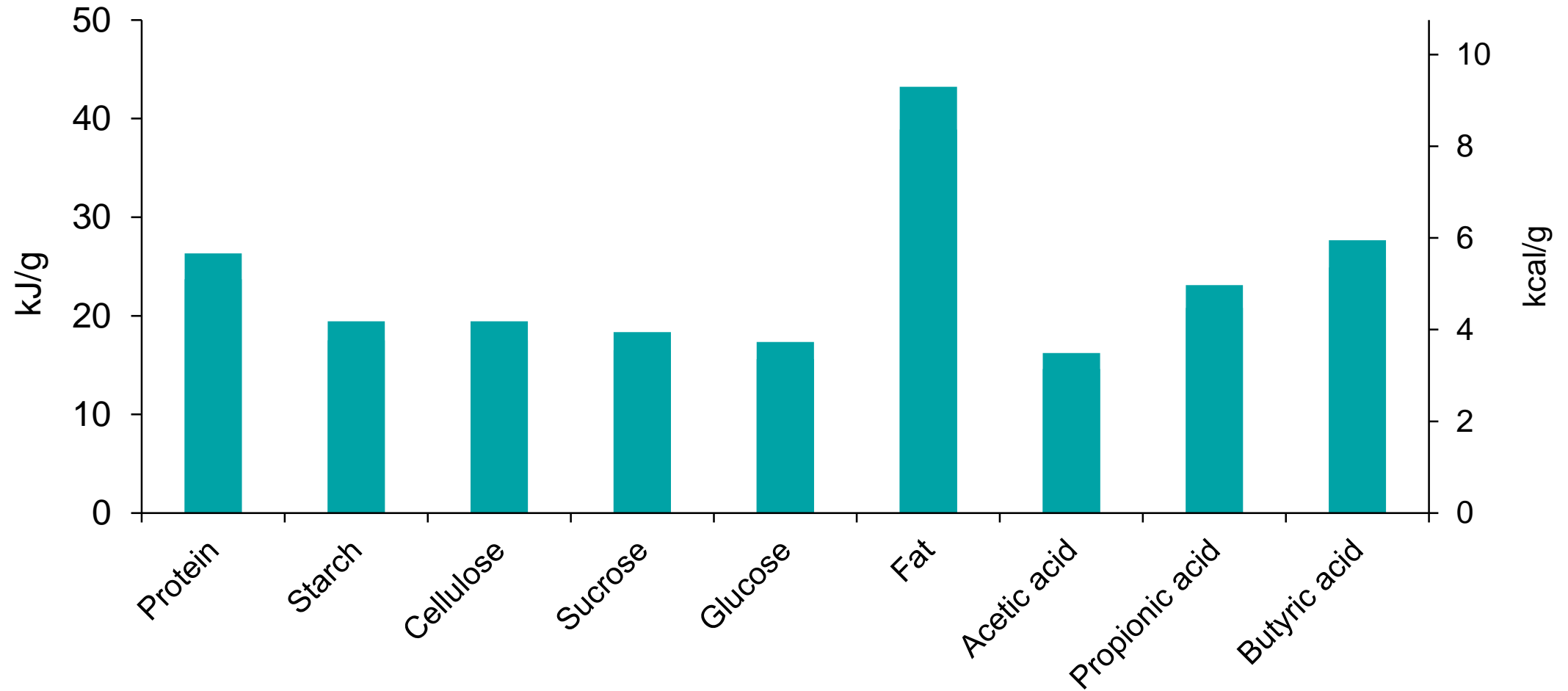
Armsby H.P. & Moulton C.R. (1925). The animal as a converter of matter and energy. A study of the role of livestock in food production. American Chemical Society, New York.

➤ What is energy?

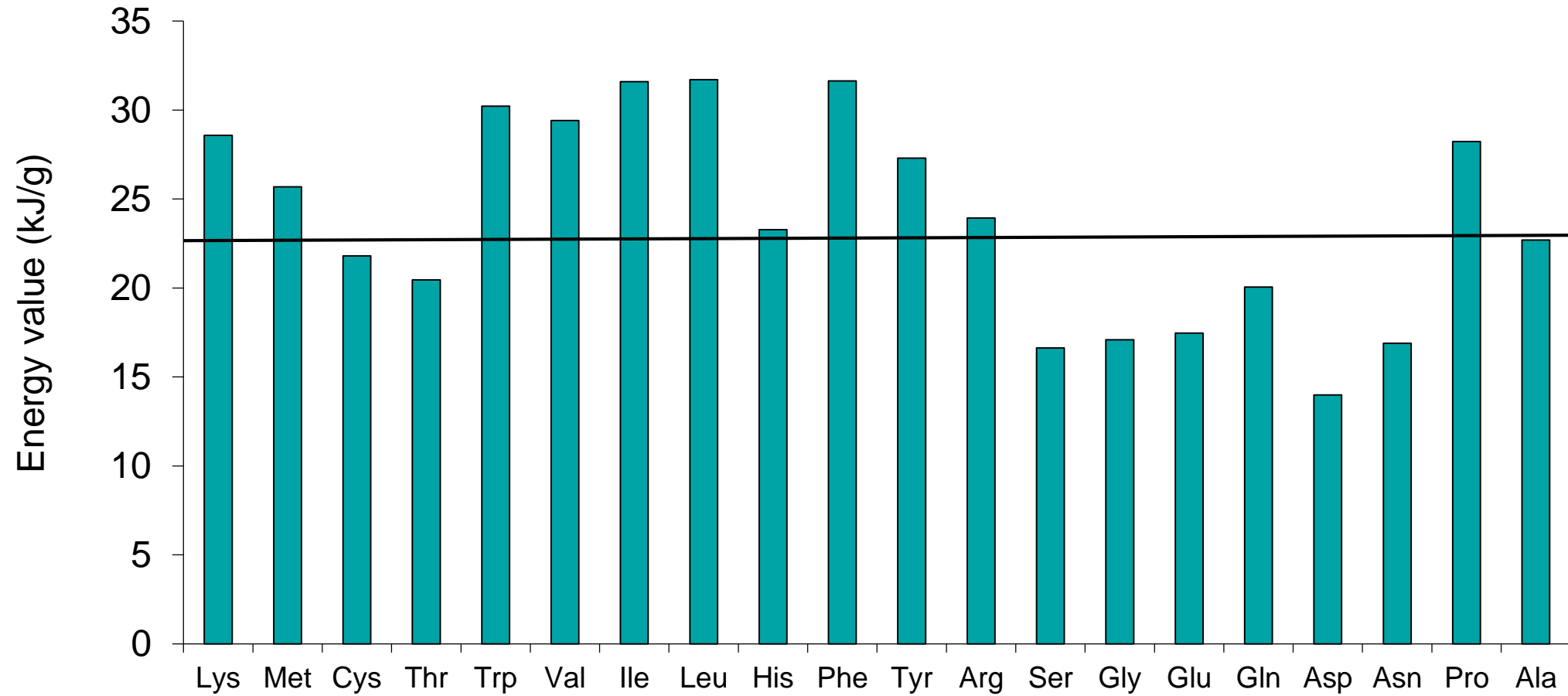
- Energy is not a nutrient
- Energy is a property of nutrients to “perform work”
- Energy exists in different forms, e.g.:
 - Chemical energy
 - Thermal energy
 - Kinetic energy
 - Radiant energy
- The chemical energy (heat of combustion) can be measured in a bomb calorimeter



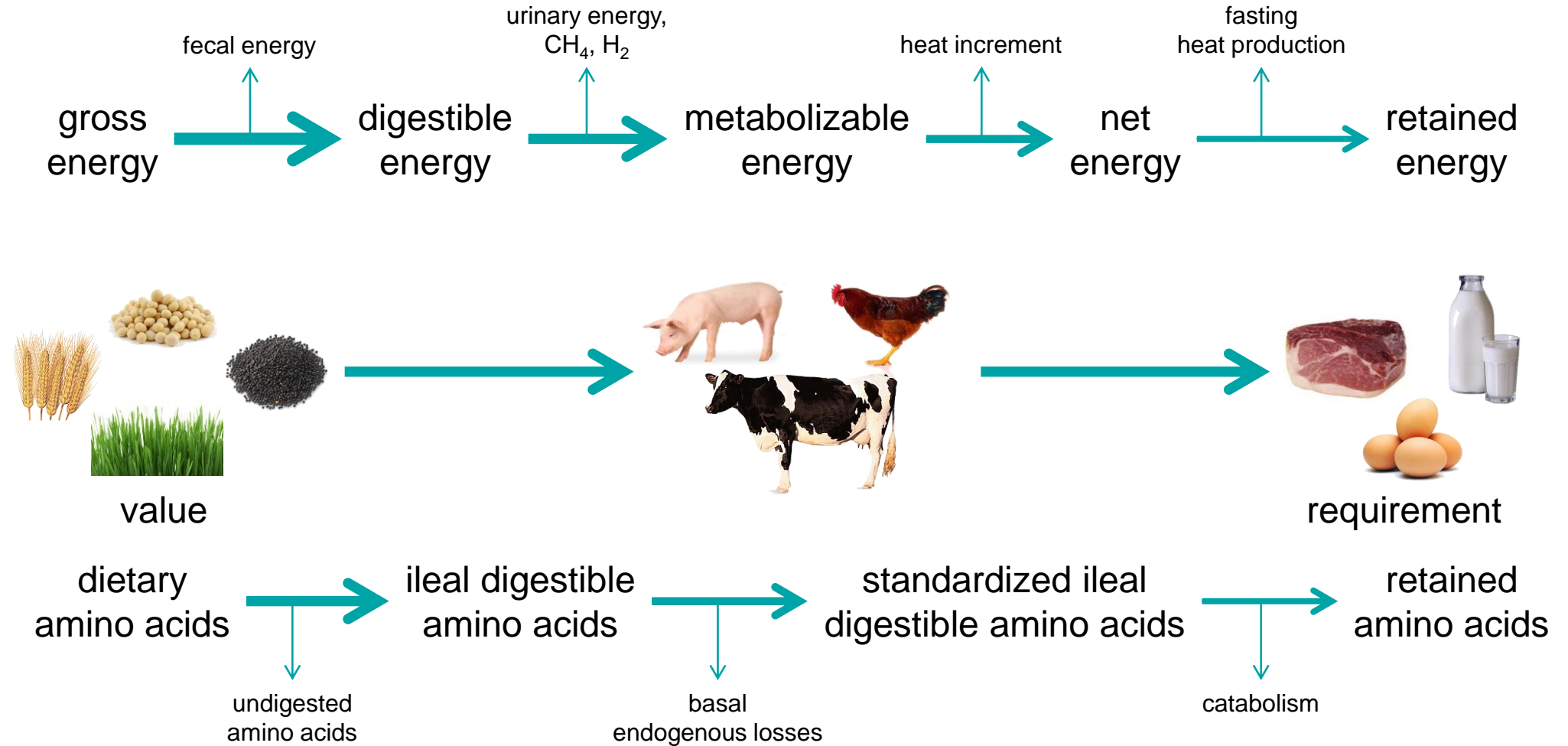
➤ Gross energy values of nutrients



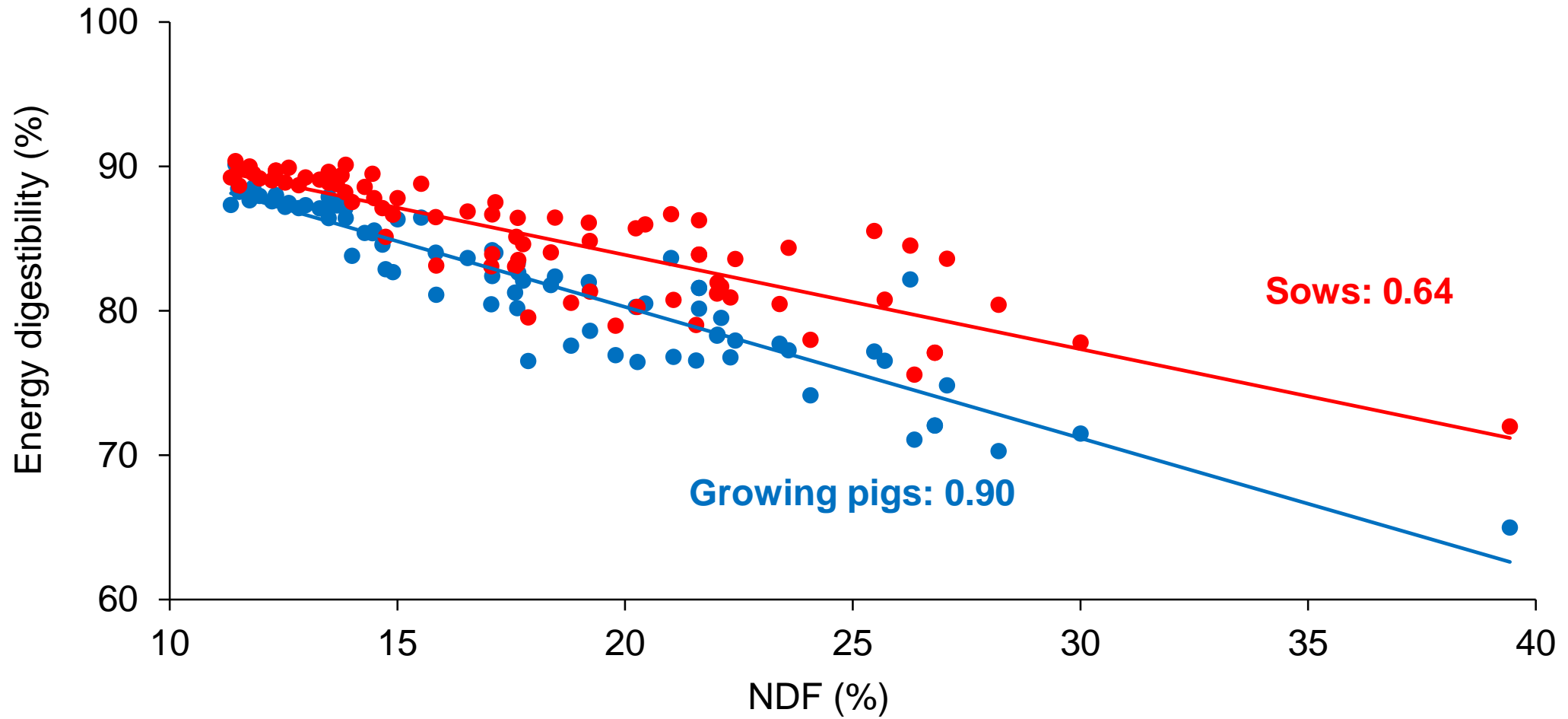
➤ Gross energy values of protein and amino acids



➤ Nutritional systems: a compromise between “value” and “requirement”

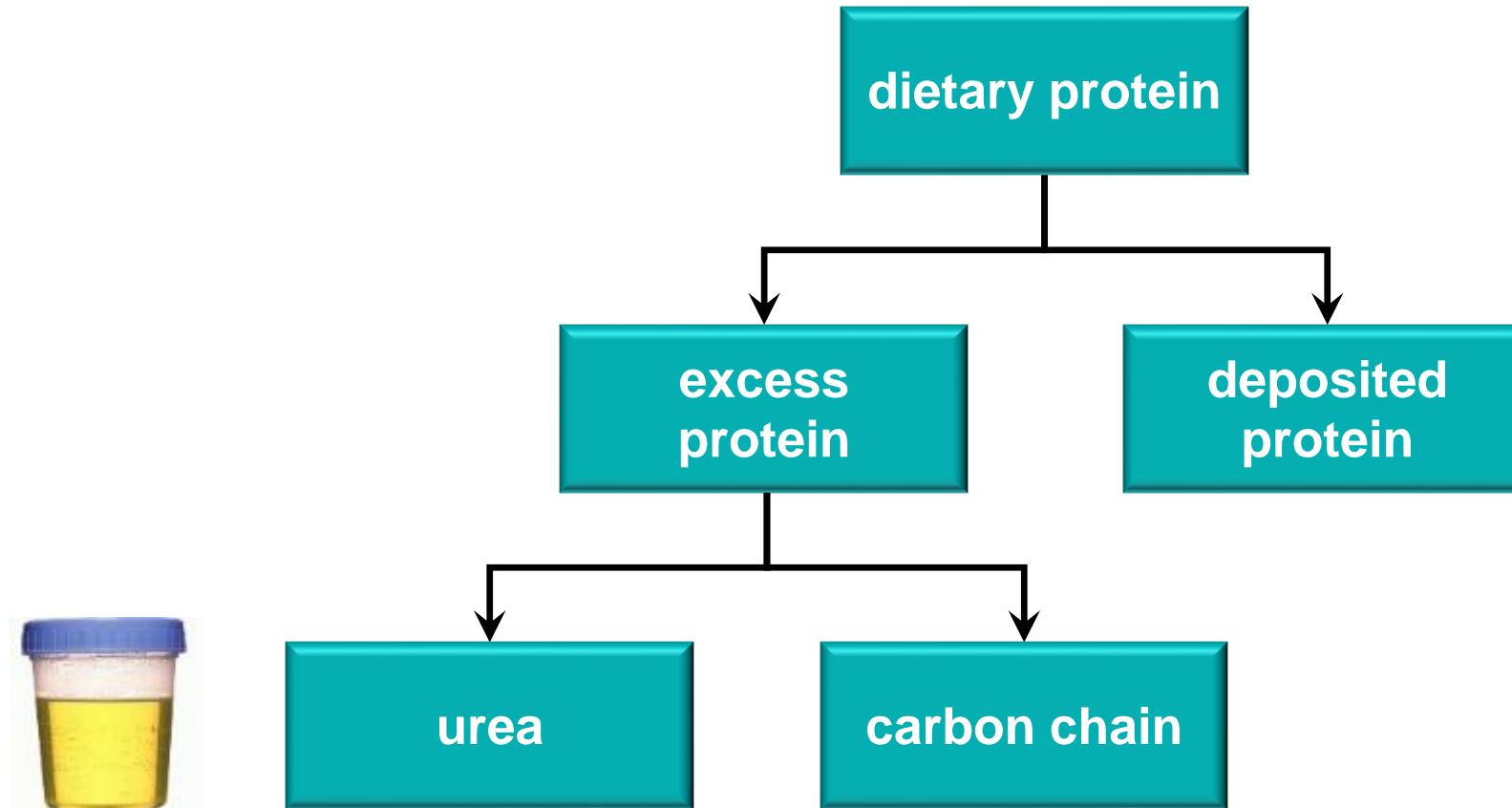


➤ Fecal energy losses

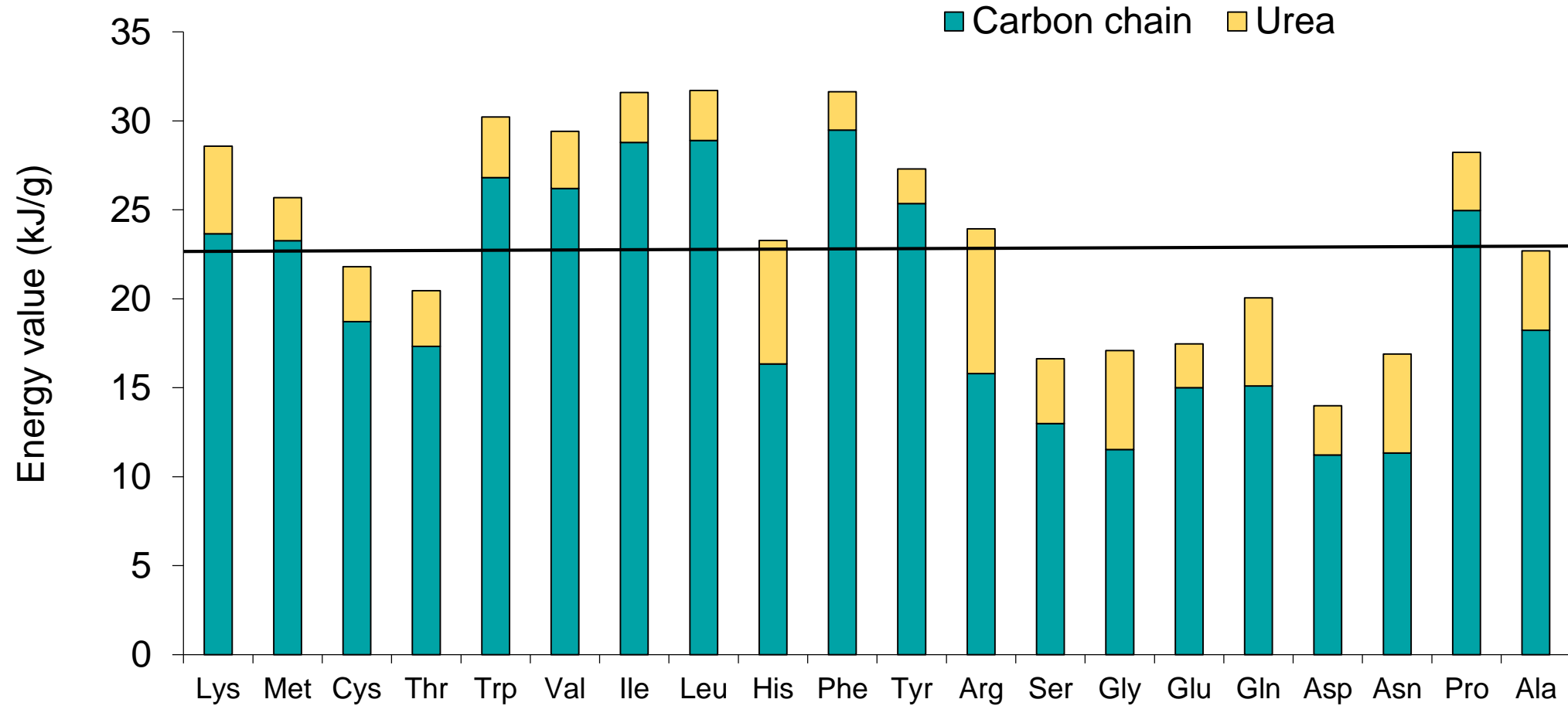


Sauvant *et al.* (2004)

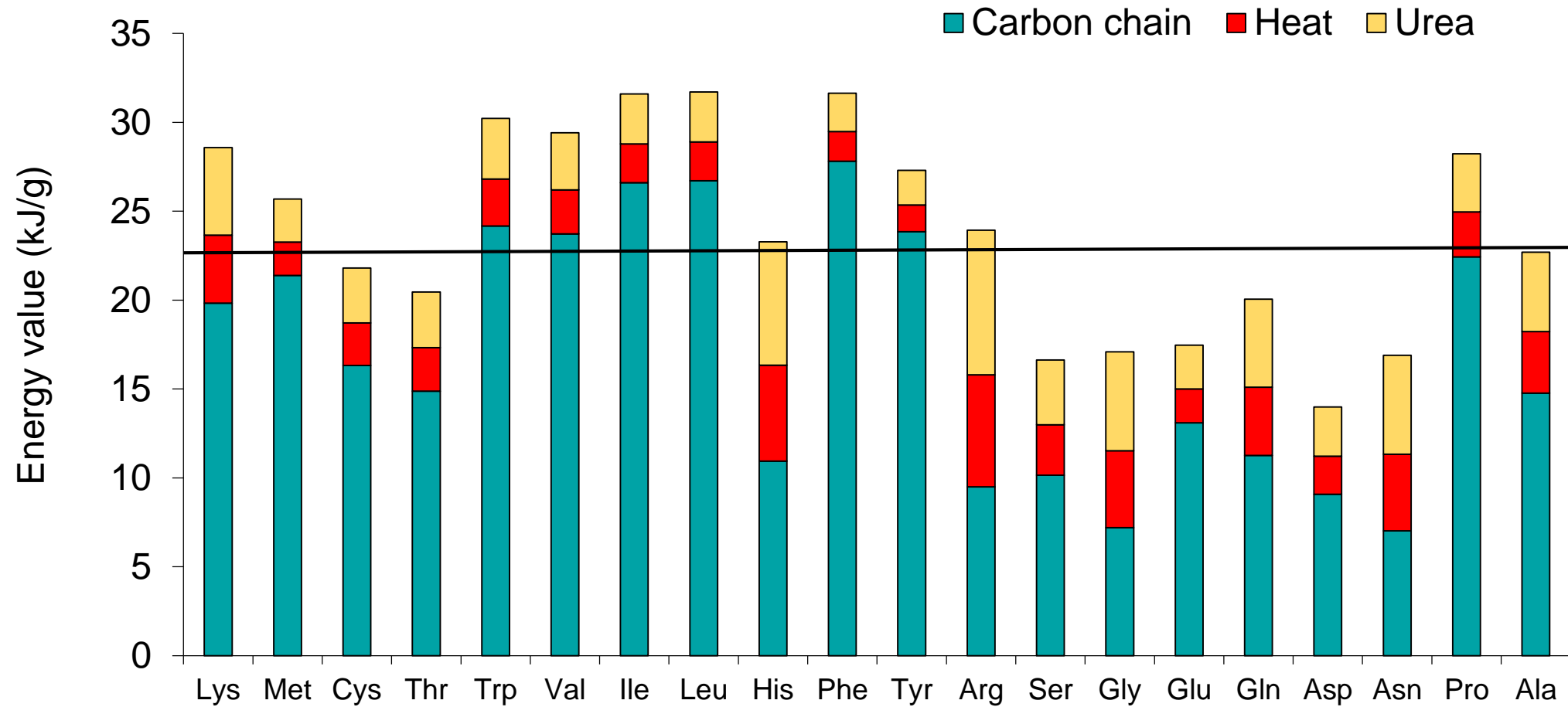
➤ The nitrogen of excess protein is excreted in the urine



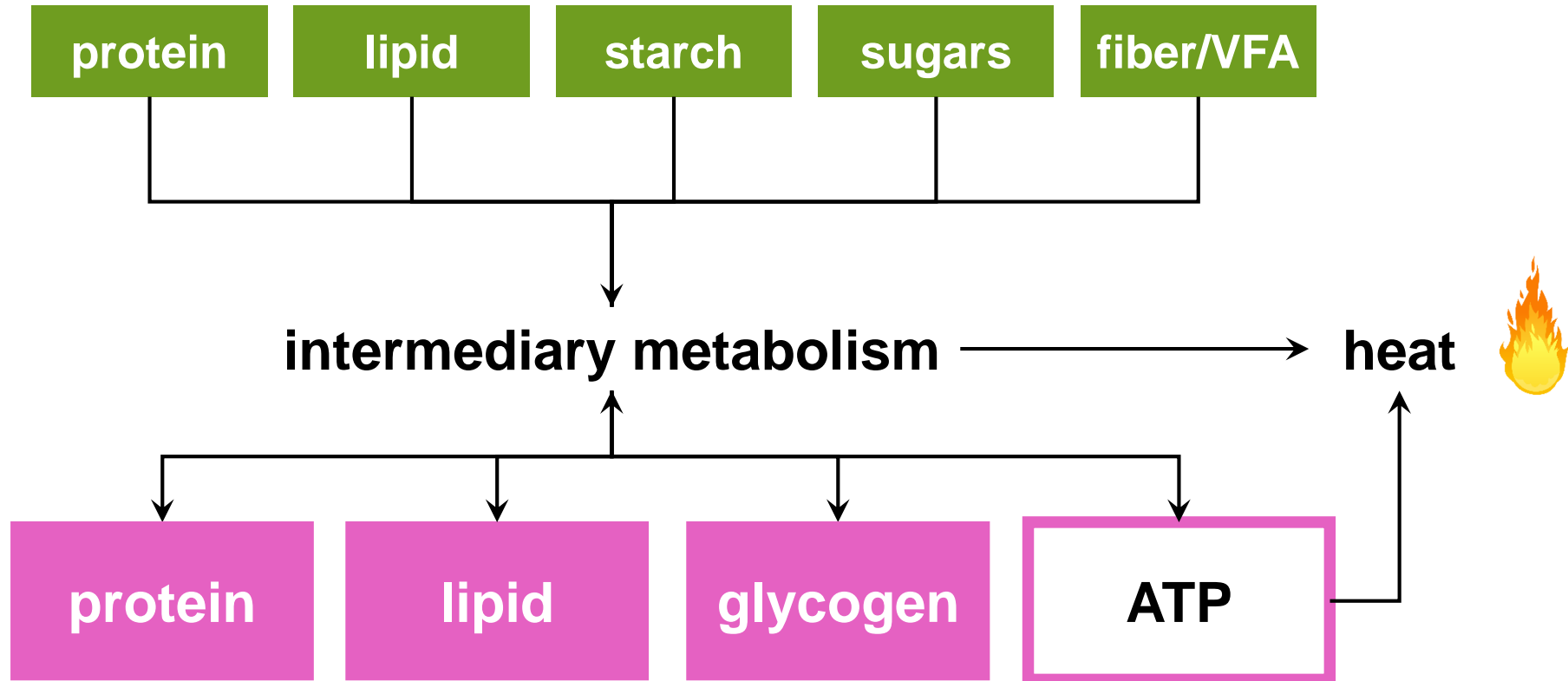
➤ Metabolizable energy values of excess amino acids



➤ Net energy values of excess amino acids



➤ From nutrient intake to nutrient utilization



➤ Spatial and temporal aspects of energy metabolism



Where is the energy of your lunch right now?

➤ Spatial and temporal aspects of energy metabolism



➤ Spatial and temporal aspects of energy metabolism

We have some control, ...



... are rather robust,
and able to self-repair.



We can convert
Regular into Premium, ...

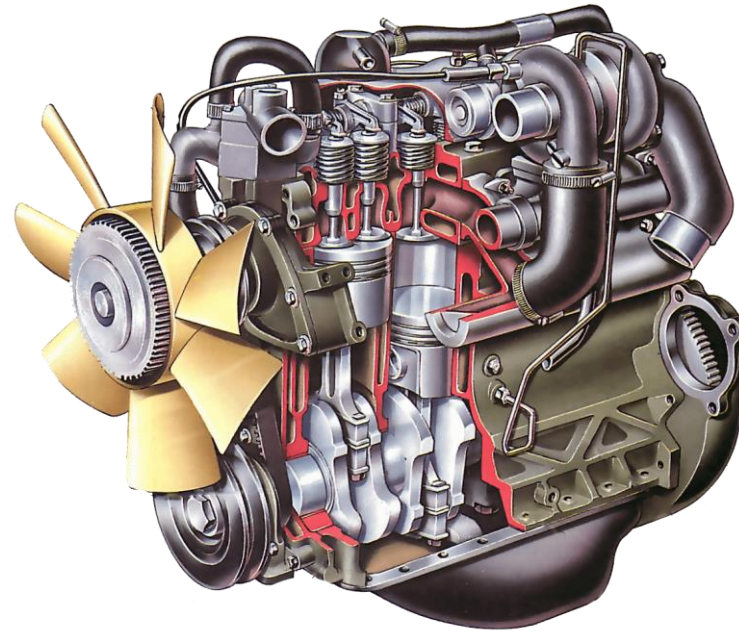


... and put 100 liter of fuel
in a 50 liter tank.



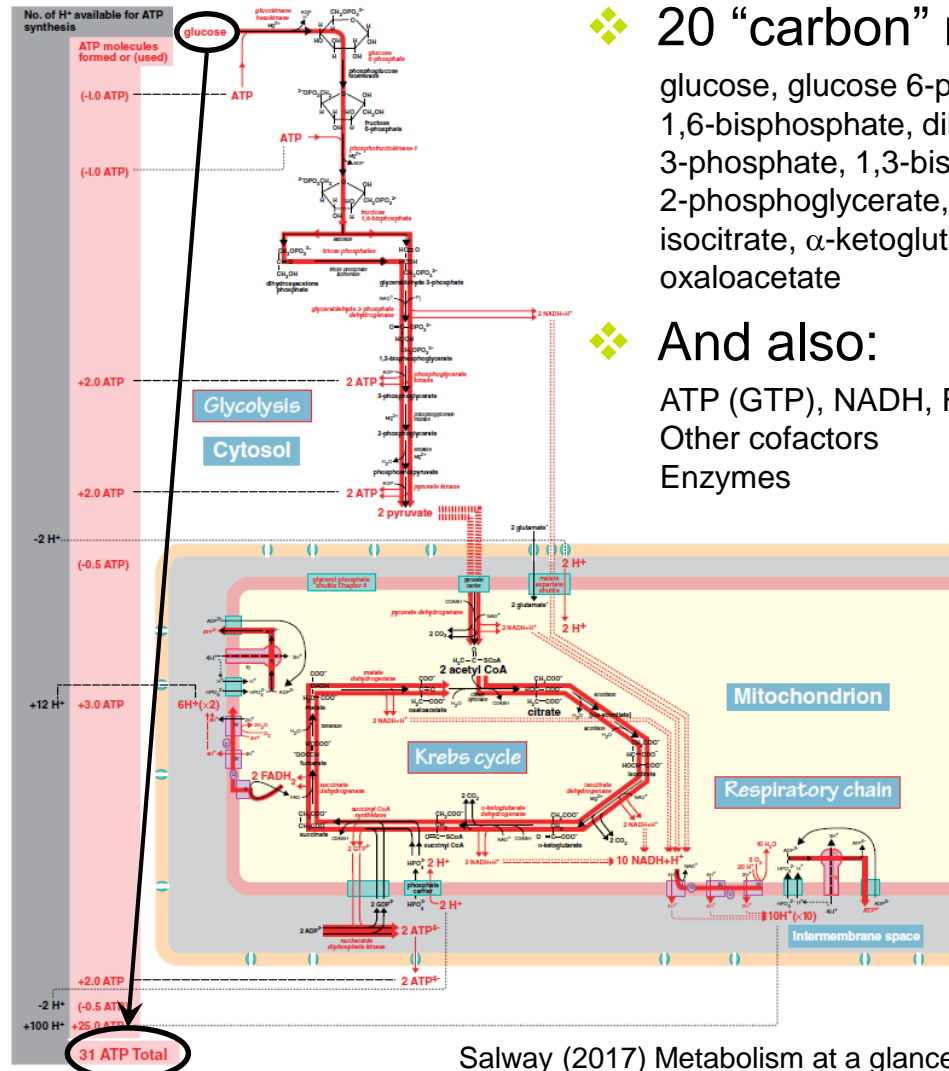
➤ Adenosine triphosphate (ATP)

Glucose and other fuels will go in ...



... but it is ATP that drives most of the mechanical, electrical, and chemical systems

➤ The catabolism of glucose (or: the synthesis of ATP from glucose)

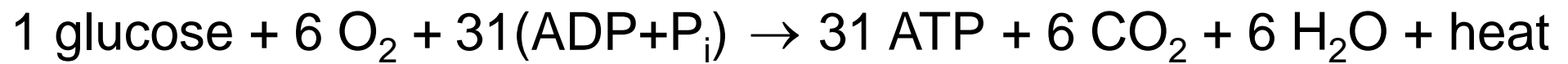


- ❖ 20 “carbon” metabolites involved:
 - glucose, glucose 6-phosphate, fructose 6-phosphate, fructose 1,6-bisphosphate, dihydroxyacetone phosphate, glyceraldehyde 3-phosphate, 1,3-bisphosphoglycerate, 3-phosphoglycerate, 2-phosphoglycerate, phosphoenolpyruvate, pyruvate, acetyl CoA, citrate, isocitrate, α-ketoglutarate, succinyl CoA, succinate, fumarate, malate, oxaloacetate
- ❖ And also:
 - ATP (GTP), NADH, FADH₂, H⁺ (proton motive force), O₂, CO₂
 - Other cofactors
 - Enzymes

Salway (2017) Metabolism at a glance



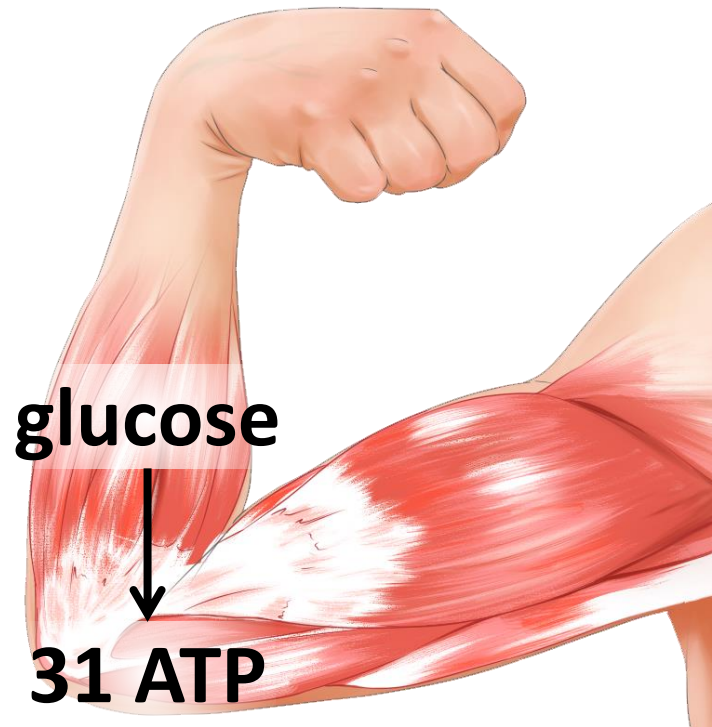
➤ The metabolism of glucose to ATP



↑
“work” (+ heat)



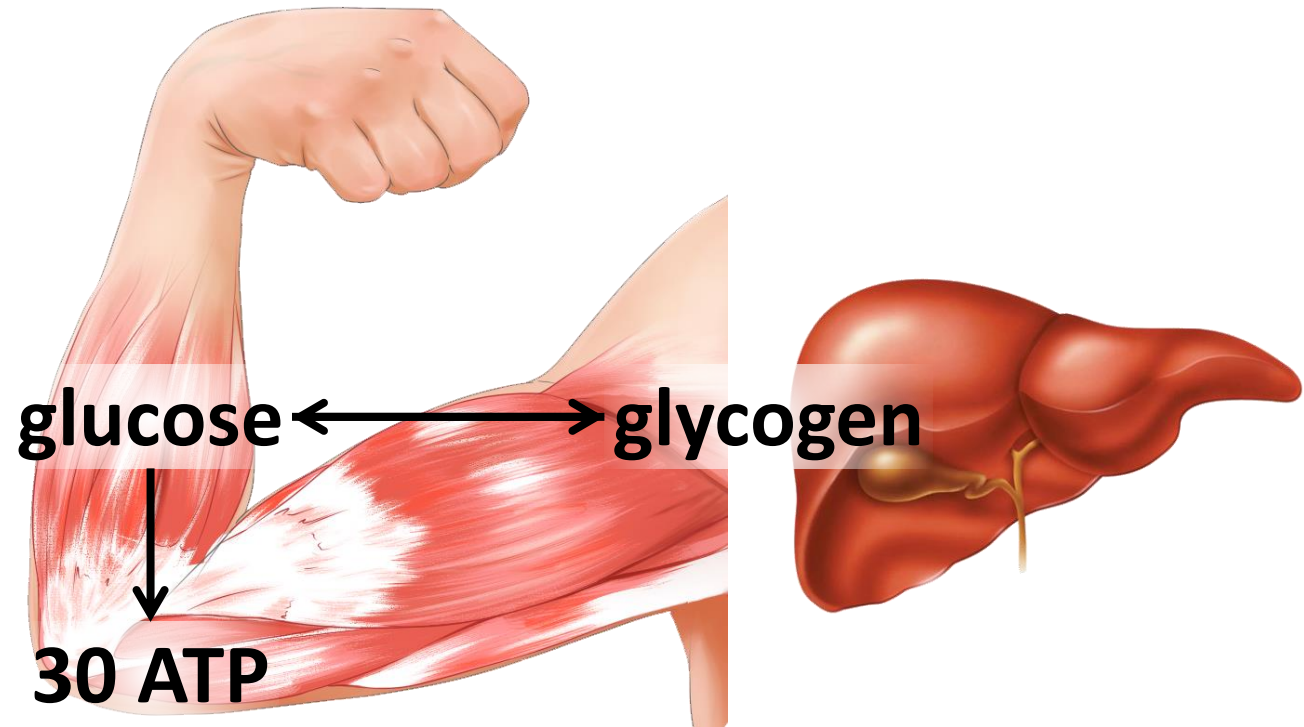
➤ The metabolism of glucose to ATP



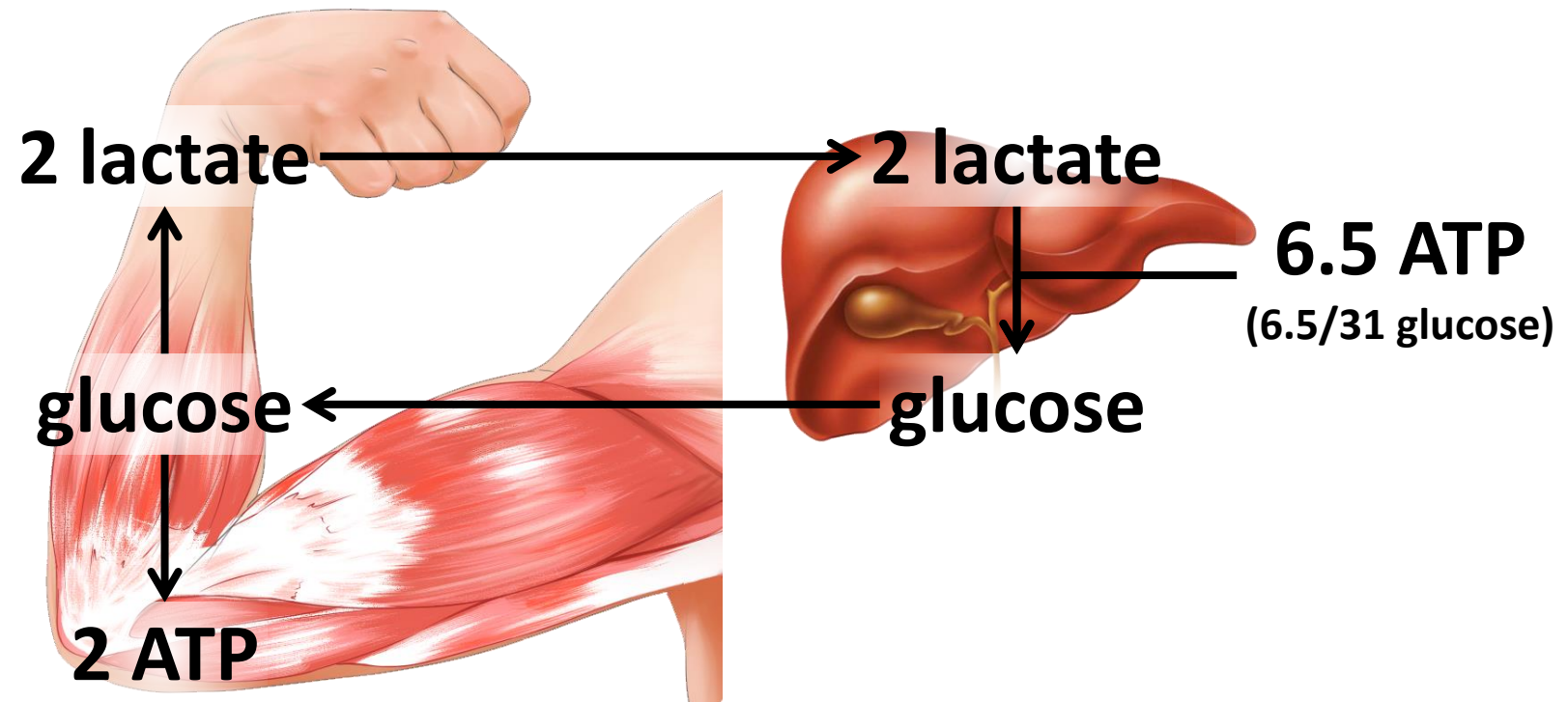
➤ The metabolism of glucose to ATP



A photograph of Beatrice Chepkirui, a Kenyan long-distance runner, celebrating her victory at the Tokyo 2020 Olympics. She is wearing a red and white Kenyan singlet with 'KENYA' and 'KIPCHOGE' on it, and a bib number '2020'. She is holding a white banner with the Olympic rings and '2020'.

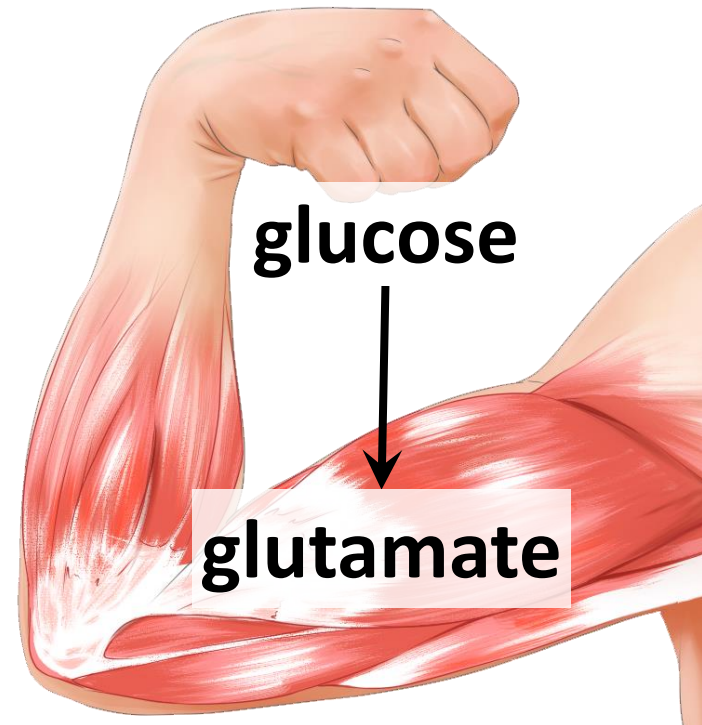
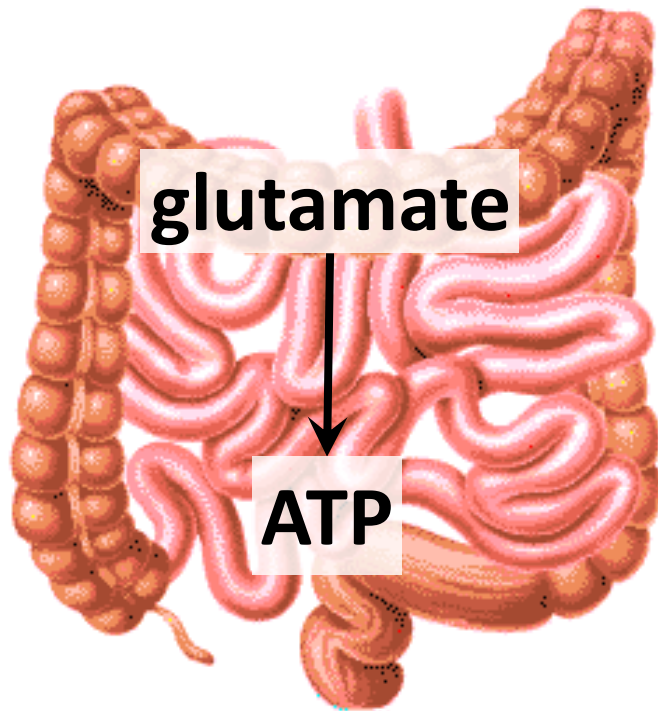


➤ The metabolism of glucose to ATP



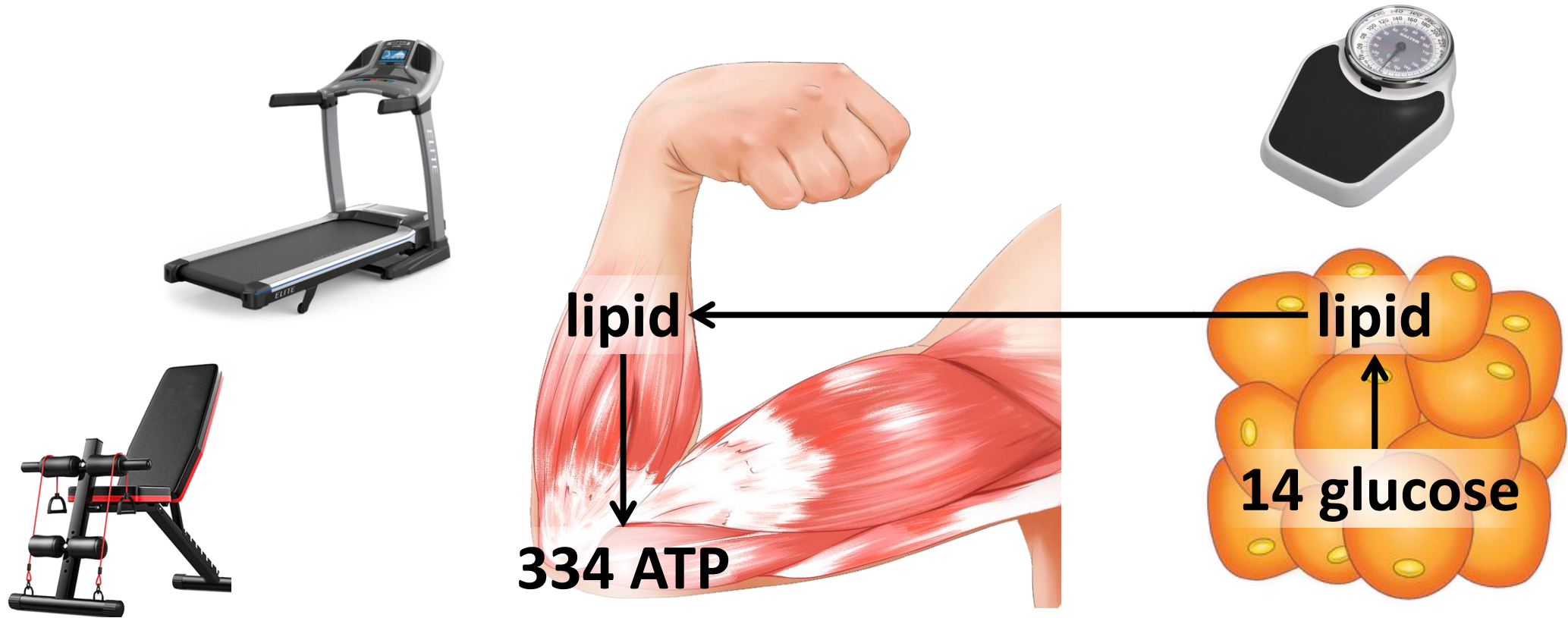
1 glucose → 9.6 ATP

➤ The metabolism of glucose to ATP



1 glucose → 30.25 ATP

➤ The metabolism of glucose to ATP



INRAE

Energy intake and metabolism: incredibly complex but very well controlled
May 12th, 2022 / Peter Theil's inauguration as full professor at Aarhus University / Jaap van Milgen

➤ The metabolism of glucose to ATP



Glucose → ATP	ATP	Efficiency
Direct	31	100%
Via glycogen (in muscle)	30	97%
Via lactate (Cori cycle)	9.6	31%
Via glutamate	30.25	98%
Via lipid	23.8	77%



➤ Control of your energy intake



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➤ Control of your energy balance

Both are well balanced,
but what about their energy balance?

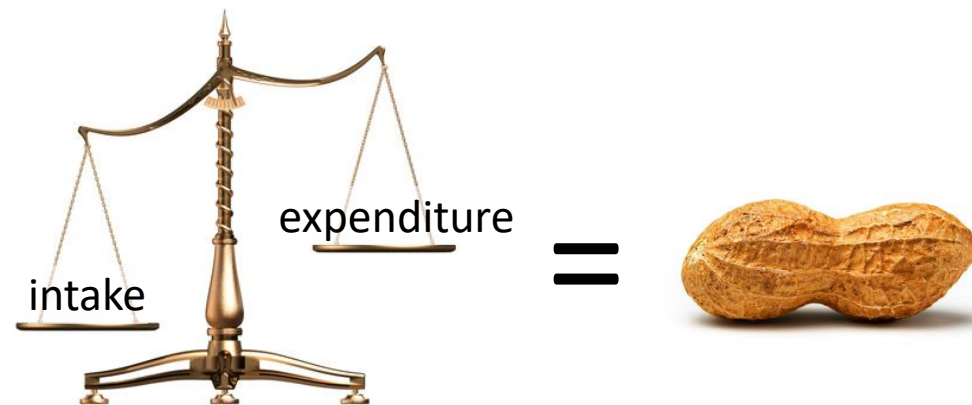
energy intake = energy expenditure



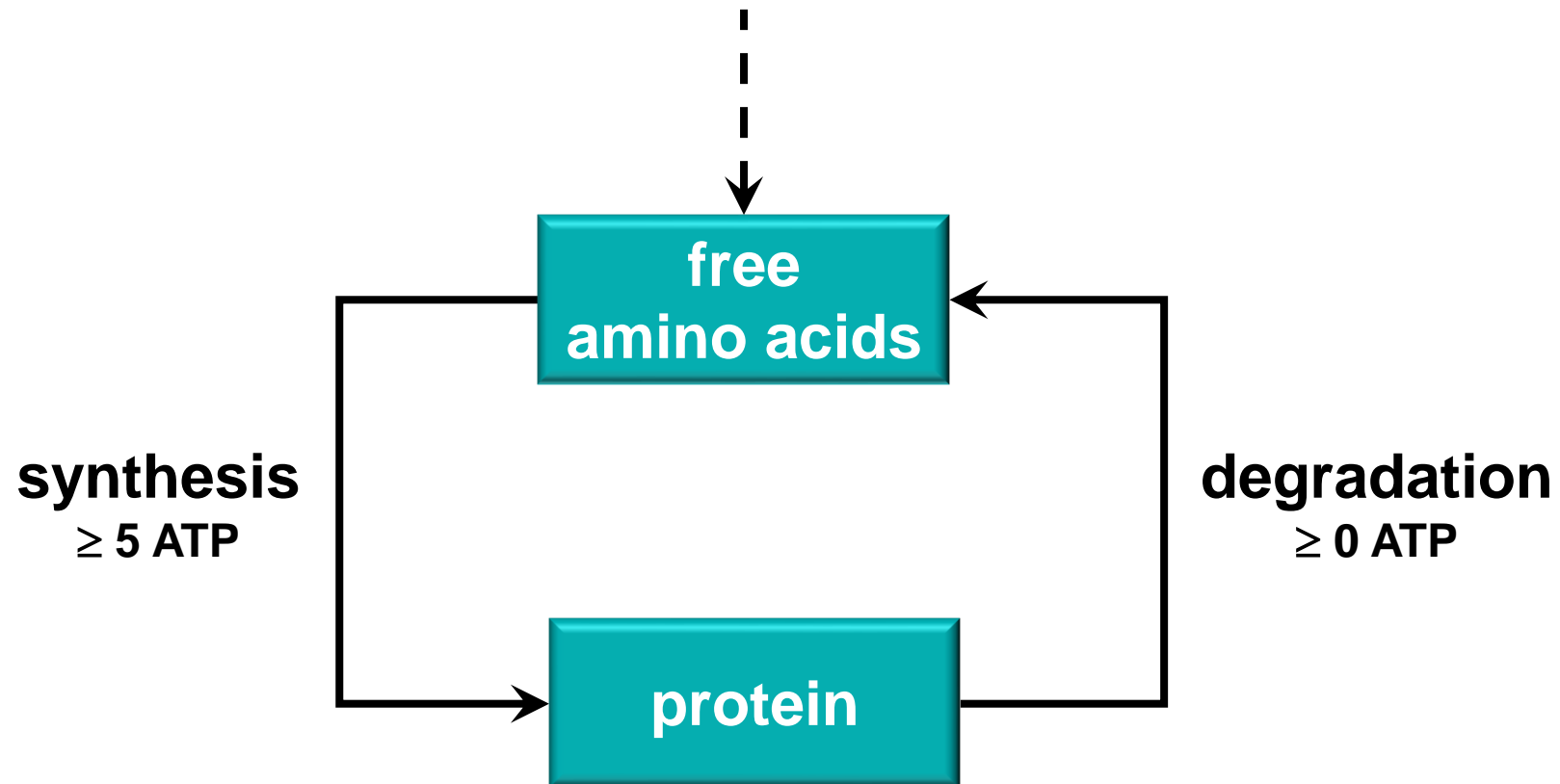
energy intake = 1.005 x energy expenditure

➤ Control of your energy balance

Item	Energy
Maintenance energy requirement	2580 kcal/d
0.5% imbalance	13 kcal/d
Deposited as lipid	1.3 g/d
Per year	481 g/yr
Between 20 and 60 years of age	19 kg of lipid



➤ Self-repair: the energy cost of protein synthesis and turnover



deposition = synthesis - degradation



➤ Self-repair: the energy cost of protein synthesis and turnover

Turnover (ATP requirement)	Gly	Lys	Protein
0 (5 ATP)	0.68	0.89	0.86
1 (10 ATP)	0.52	0.80	0.75
2 (15 ATP)	0.42	0.73	0.67
3 (20 ATP)	0.35	0.67	0.60

$$\text{Efficiency} = \frac{\text{energy value of amino acid}}{\text{energy value of amino acid} + \text{ATP cost}}$$

Glucose used as energy source (92.0 kJ/ATP)

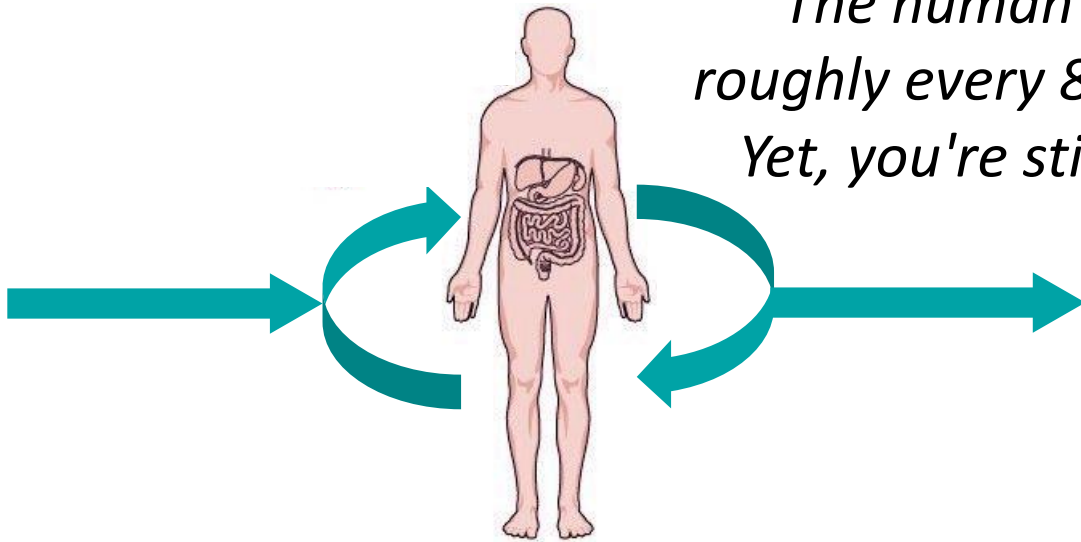
The fractional protein synthesis rates vary from 4%/day in muscle to more than 100%/day for splanchnic tissues

➤ Self-repair and robustness

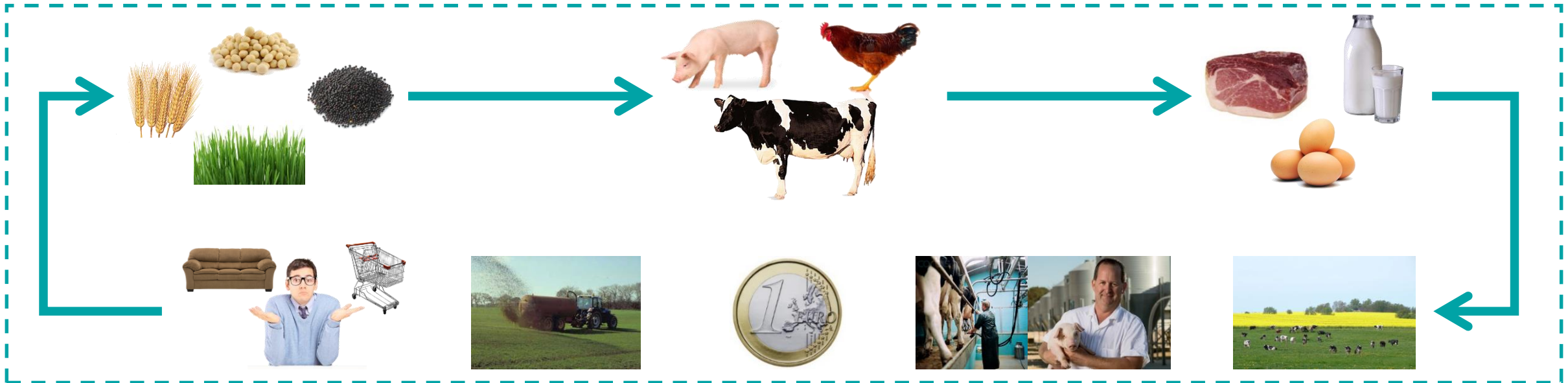
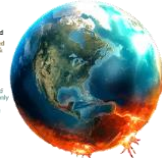
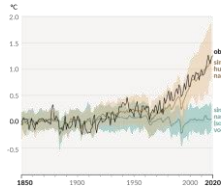
“If science insists on chasing particles, they will follow them right through an organism and miss the organism entirely”

“The human body completely changes the matter it is made of roughly every 8 weeks, through metabolism, replication and repair. Yet, you're still you, with all your memories, your personality ...”

(Robert Rosen)



➤ Conclusion



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