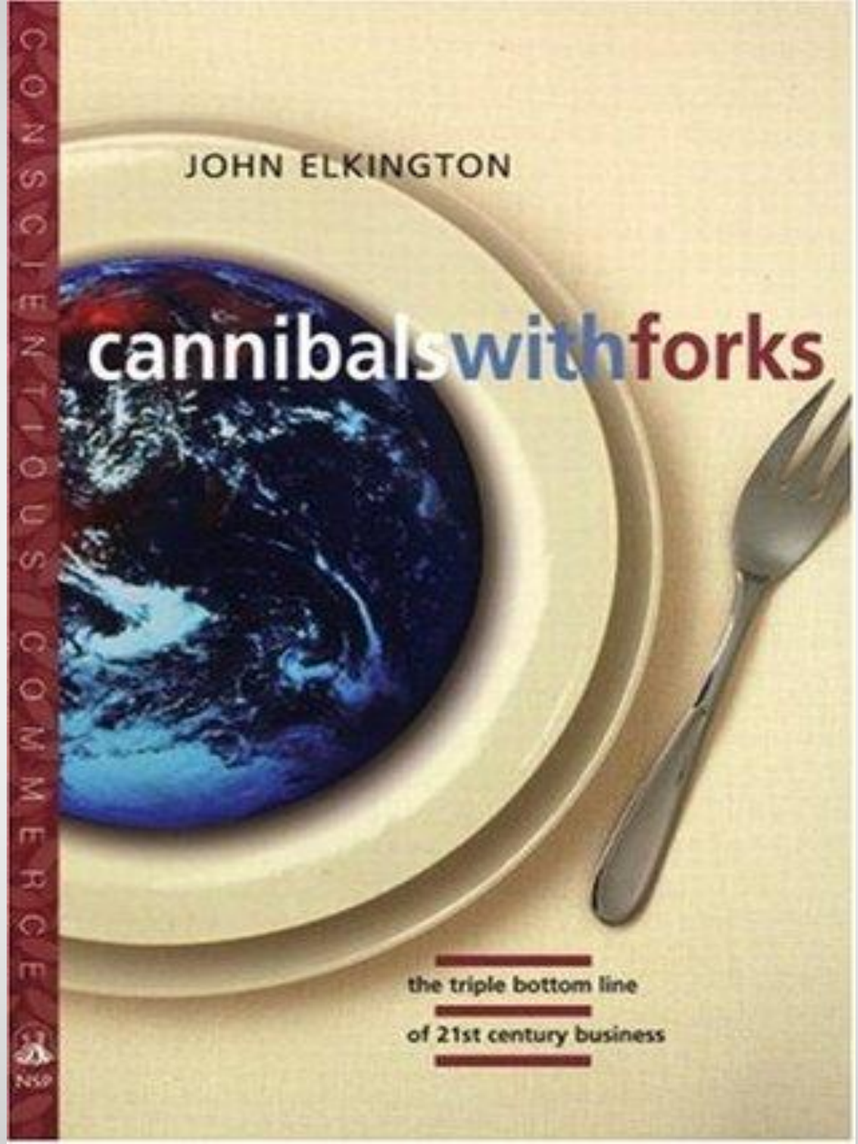
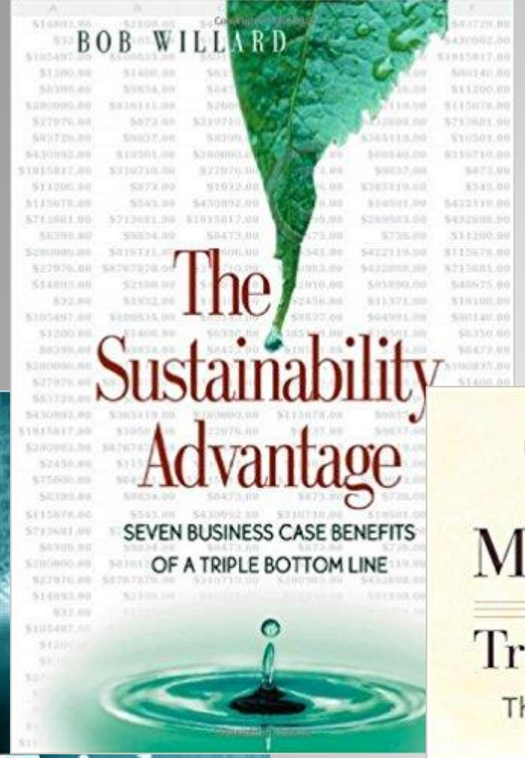
# How animal breeding can contribute to sustainable pig production

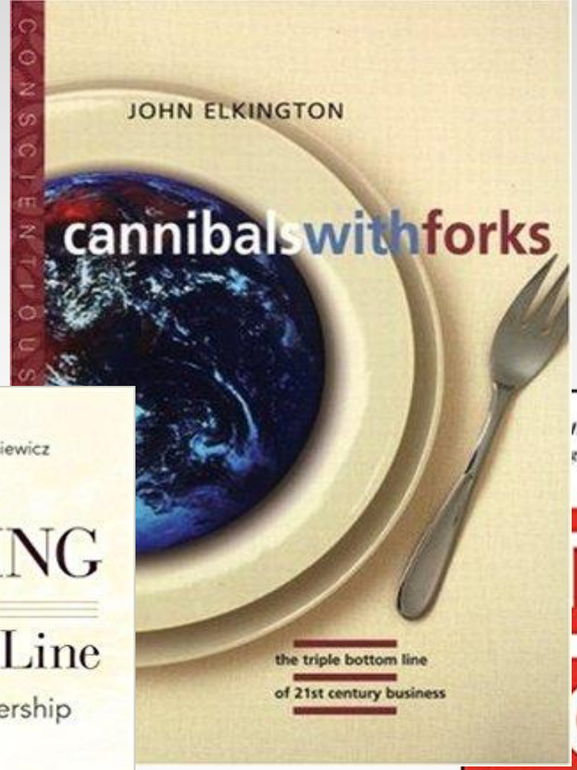
Pieter Knap

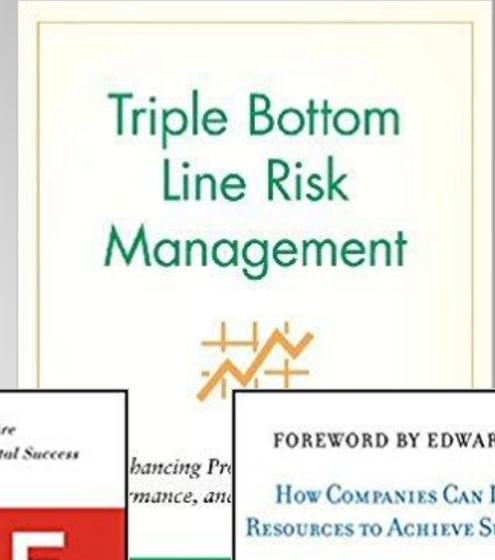
August 2018

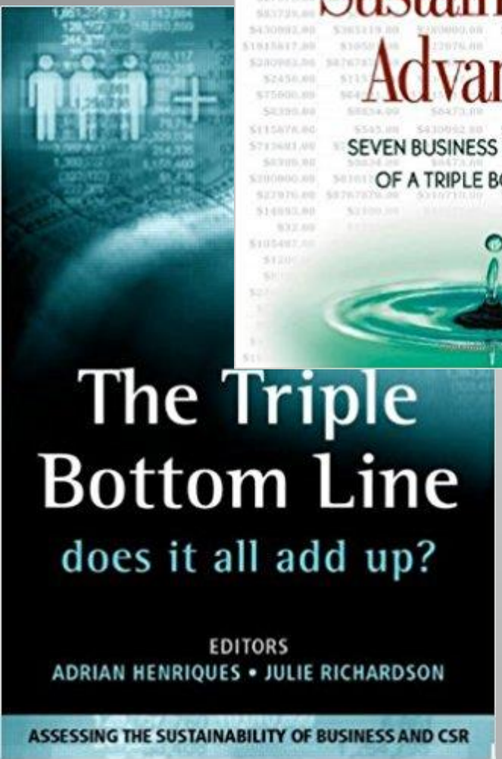


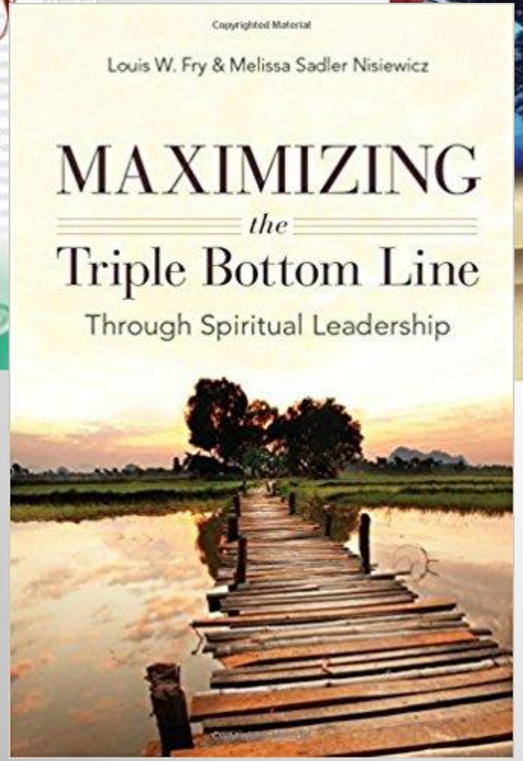

Elkington (1999)


BOB WILLARD
The Sustainability Advantage
SEVEN BUSINESS CASE BENEFITS OF A TRIPLE BOTTOM LINE


JOHN ELKINGTON
cannibalswithforks
the triple bottom line of 21st century business


Triple Bottom Line Risk Management


The Triple Bottom Line
does it all add up?
EDITORS
ADRIAN HENRIQUES • JULIE RICHARDSON
ASSESSING THE SUSTAINABILITY OF BUSINESS AND CSR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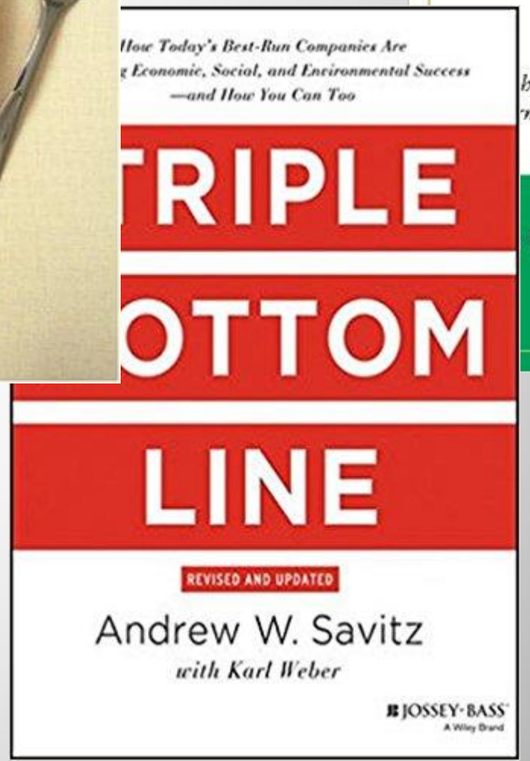
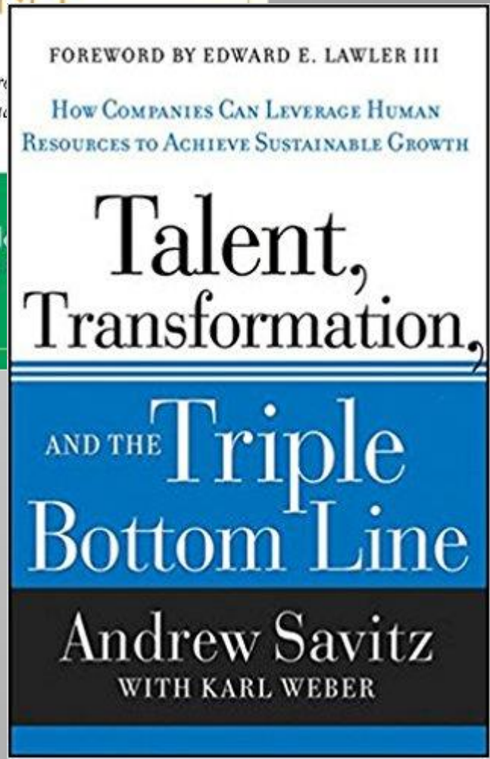
MAXIMIZING
the
Triple Bottom Line
Through Spiritual Leadership


—and How You Can Too
TRIPLE
BOTTOM
LINE
REVISED AND UPDATED
Andrew W. Savitz
with Karl Weber
JOSSEY-BASS


FOREWORD BY EDWARD E. LAWLER III
How Companies Can Leverage Human Resources to Achieve Sustainable Growth
Talent, Transformation,
AND THE Triple Bottom Line
Andrew Savitz
WITH KARL WEBER

# Sustainability in animal breeding

Van Arendonk

Session 19

**ble livestock p**

**Sustainability: triple bottom line**

**People – Planet – Profit**

**on: quadruple bottom line**

**People – Planet – Profit – PigsPoultryPuminantsPhish**

Sustainable production: favourable results for <u>all 3</u>

Sustainable production: favourable results for <u>all 4</u>

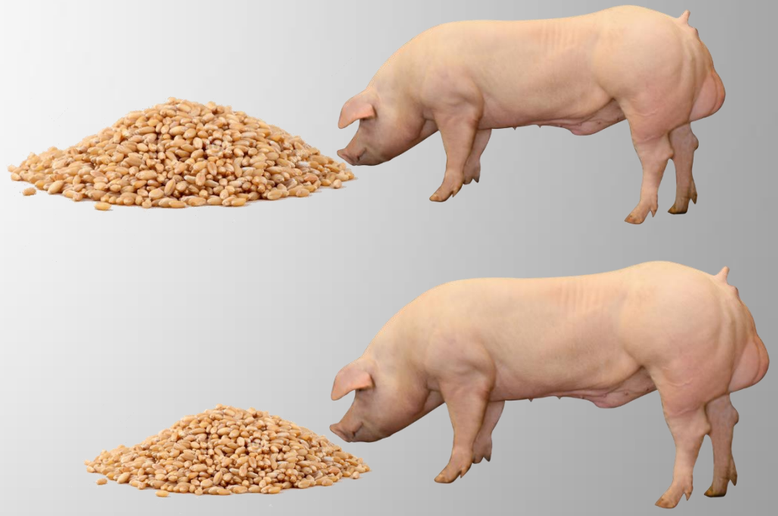
# People – Planet – Profit – PigsPoultryPuminants

**People:**

- **social justice** (e.g. biopiracy: Access & Benefit Sharing)
- **food safety** (e.g. cholesterol, PUFA; *Salmonella, Listeria* etc)

**Planet:**

- **resource efficiency**
- **environmental efficiency**
- **biodiversity** (e.g. AnGR management)



# People – Planet – Profit – PigsPoultryPuminants

People:

social justice (e.g. biopiracy: Access & Benefit Sharing)

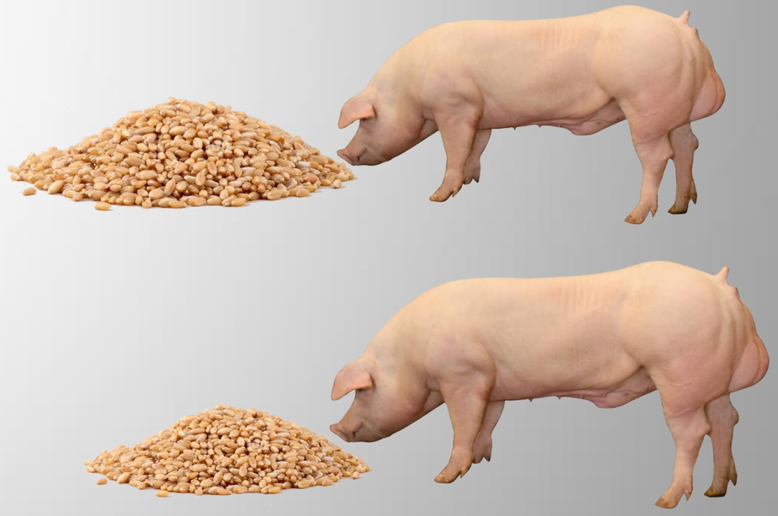
food safety (e.g. cholesterol, PUFA; *Salmonella, Listeria* etc)

**Planet:**

**resource efficiency**

**environmental efficiency**

biodiversity (e.g. AnGR management)

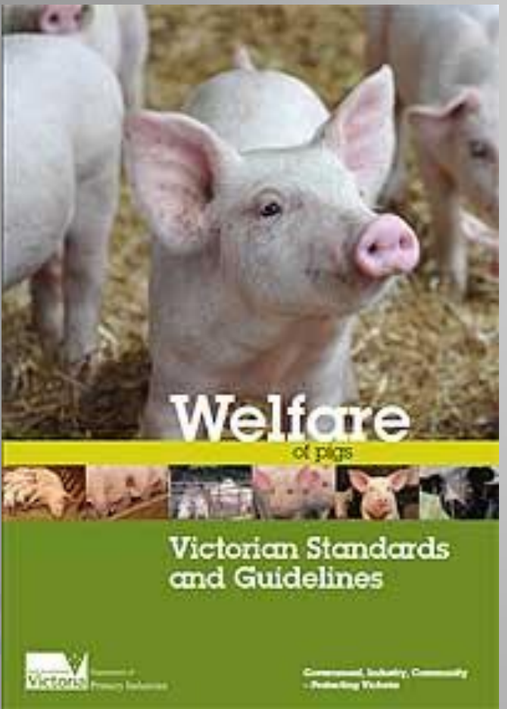


# People – Planet – Profit – PigsPoultryPuminants

**Profit:**

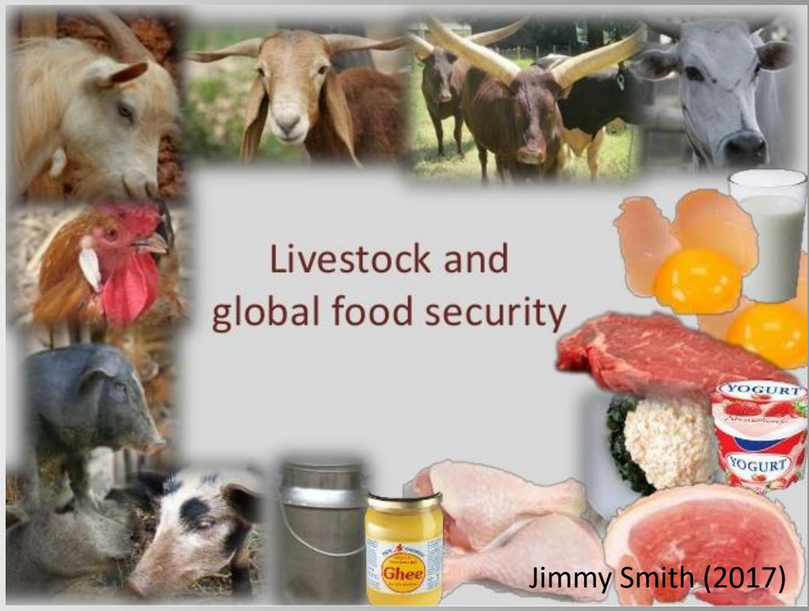
**productivity**

**food security: feed the globe**

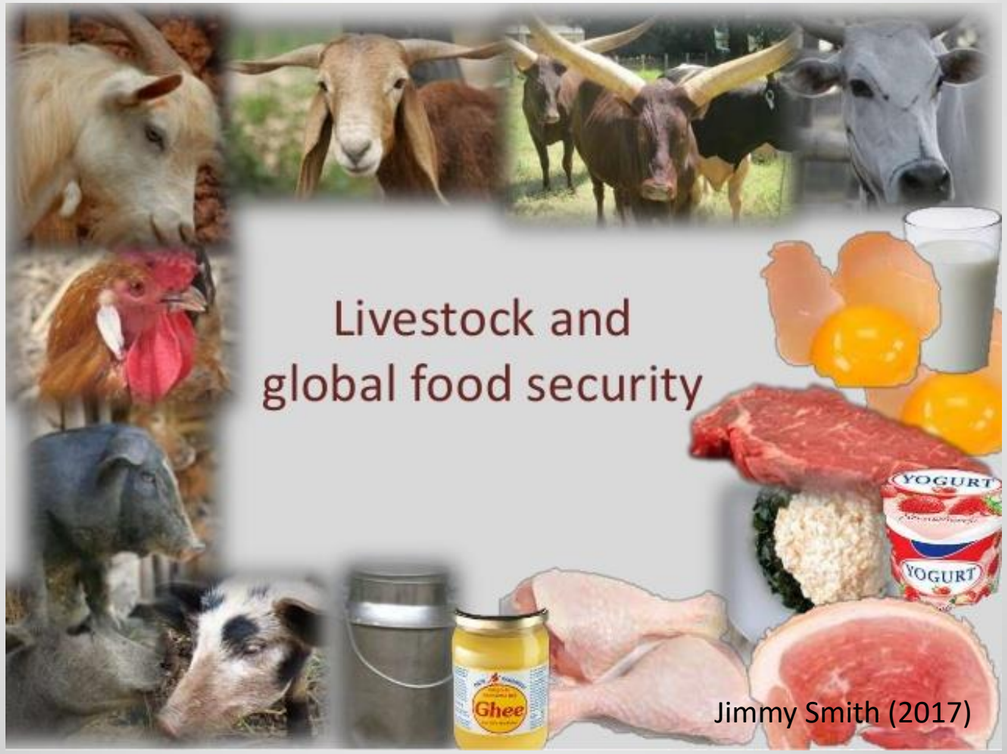



**PigsPoultryPuminantsPhish:**

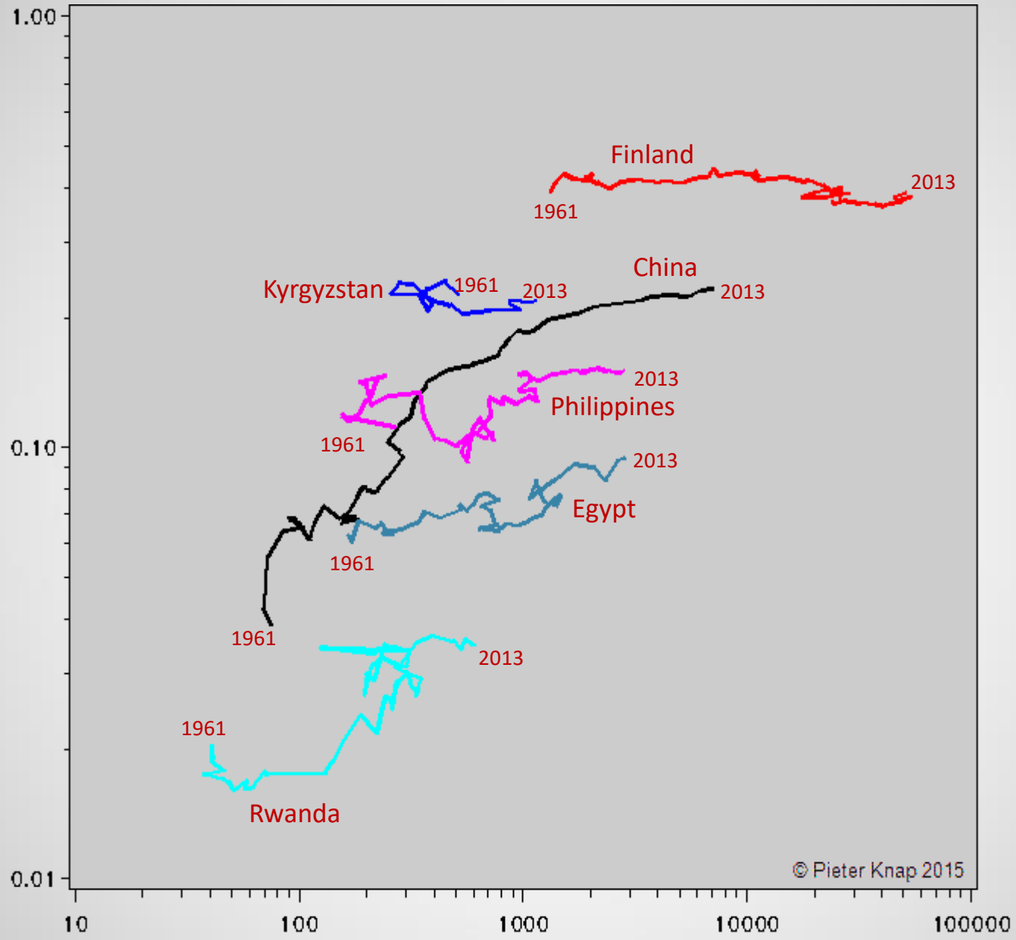
**animal welfare**



# Profit:
# productivity
# food security: feed the globe



proportion of calorie intake from animal products:  six countries, 1961 to 2013




GDP per capita (2013 USD per year)

data from FAOstat, OECD, WorldBank (2015)

proportion o

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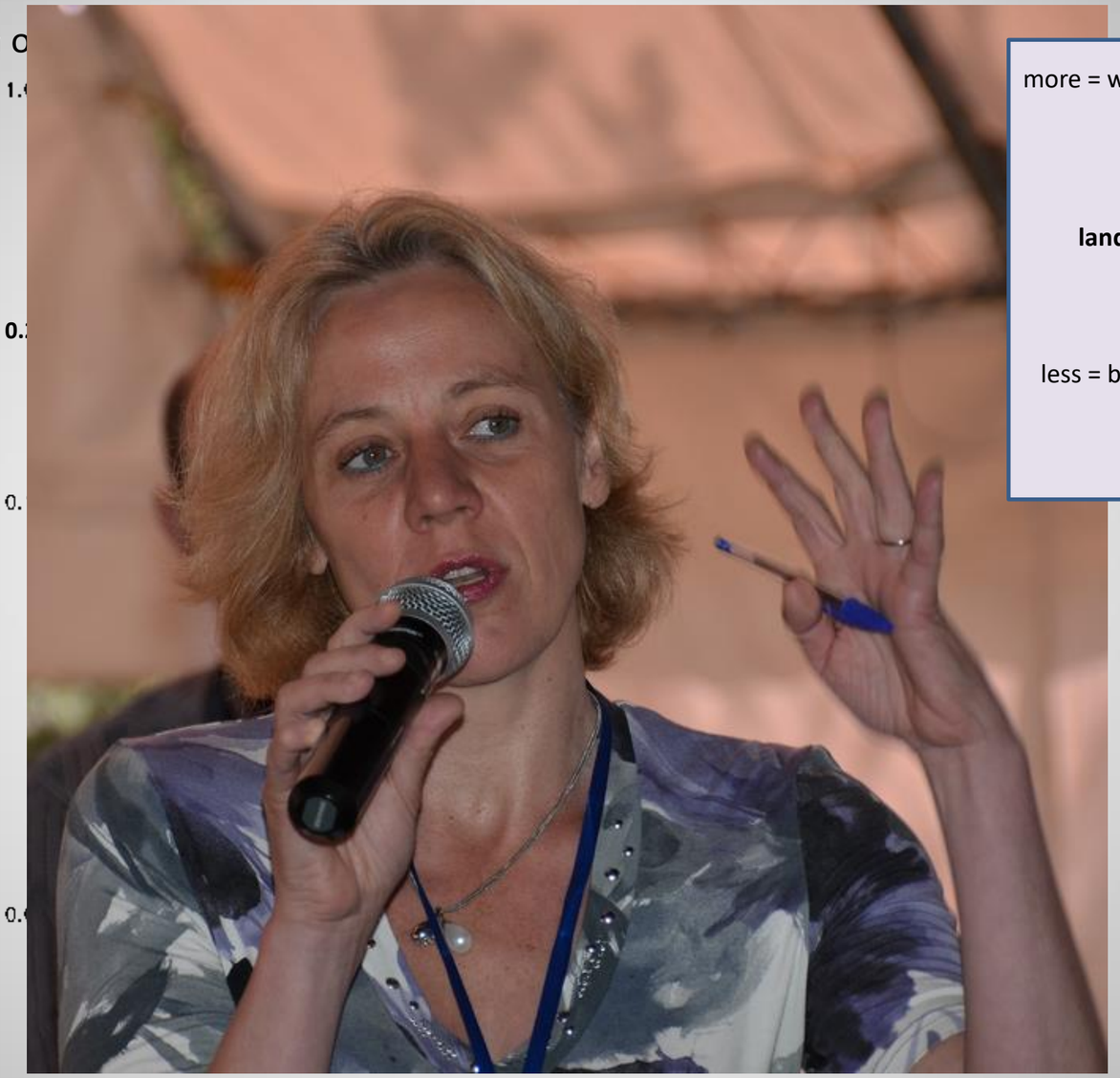
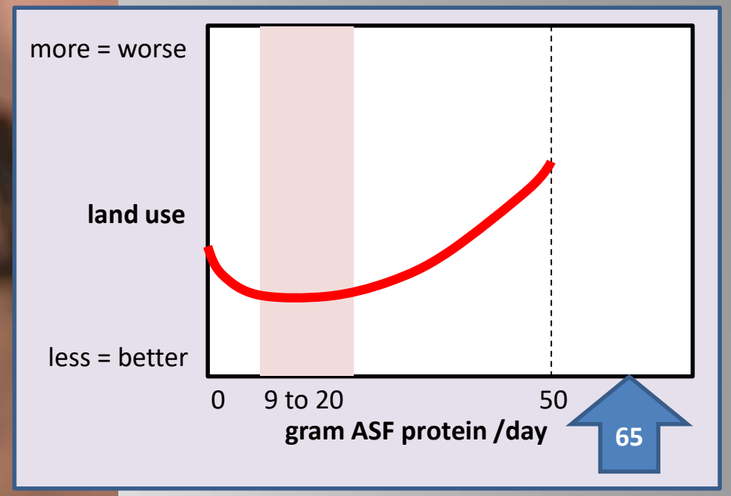
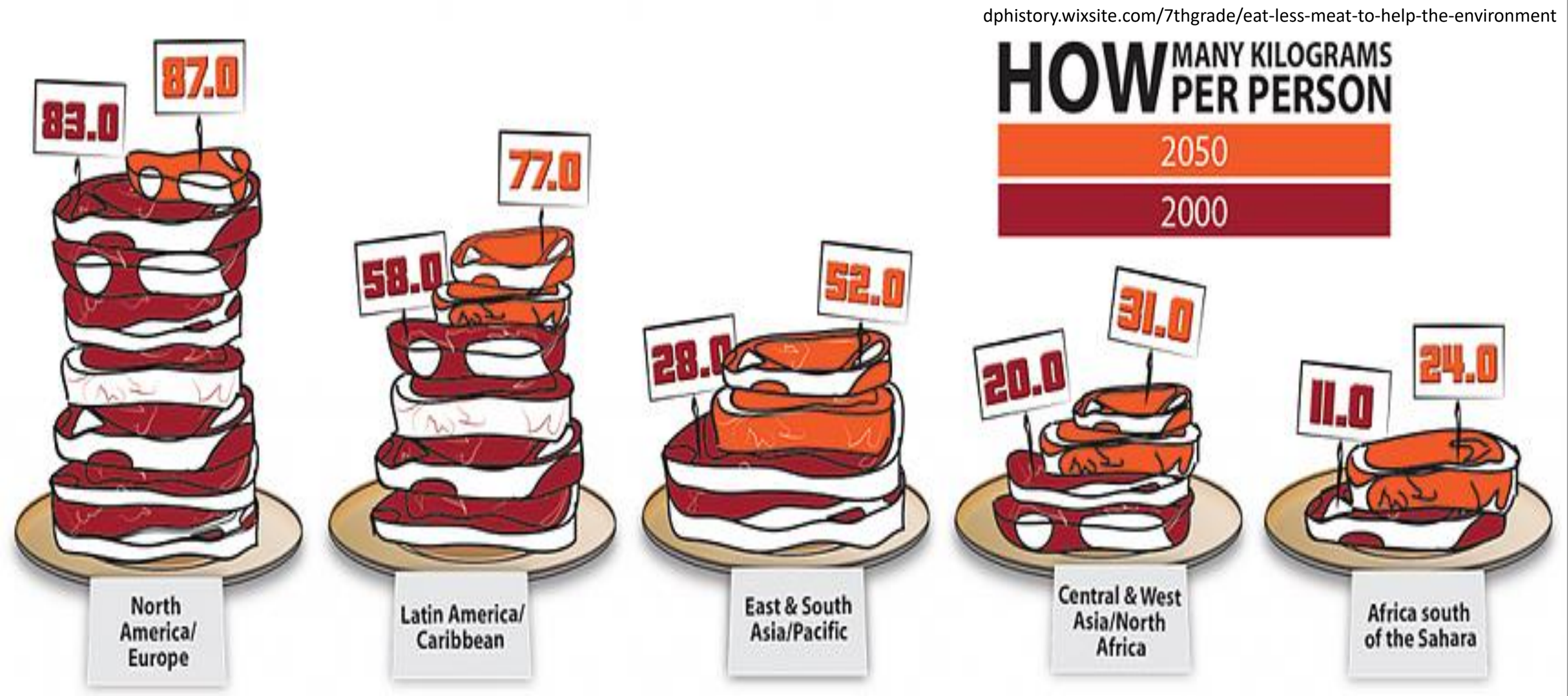


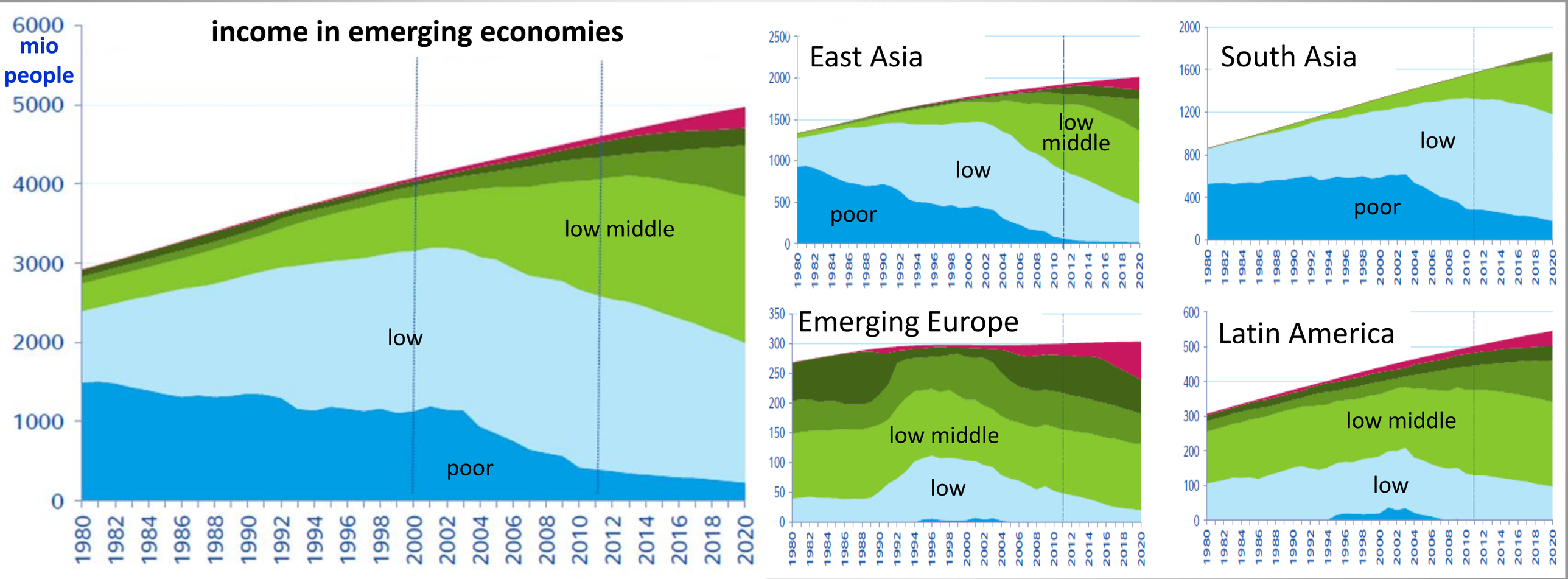



data from FAOstat, OECD, WorldBank (2015)

dphistory.wixsite.com/7thgrade/eat-less-meat-to-help-the-environment



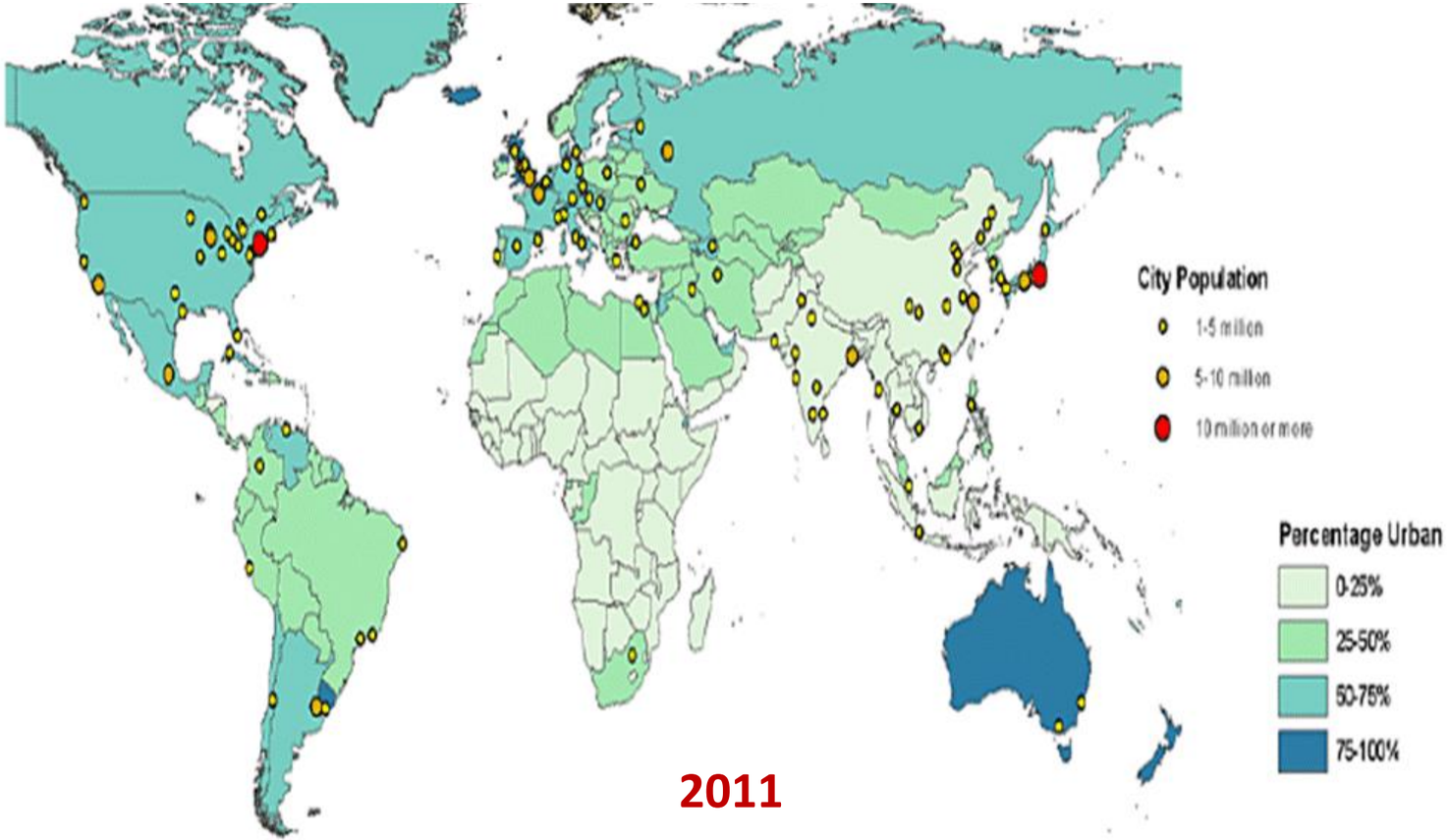
# Developing countries: the rising urban middle class






Ortiz Vidal-Abarca (2013) www.bbvaresearch.com/en/publicaciones/emerging-trends-in-developing-countries

# Urbanization



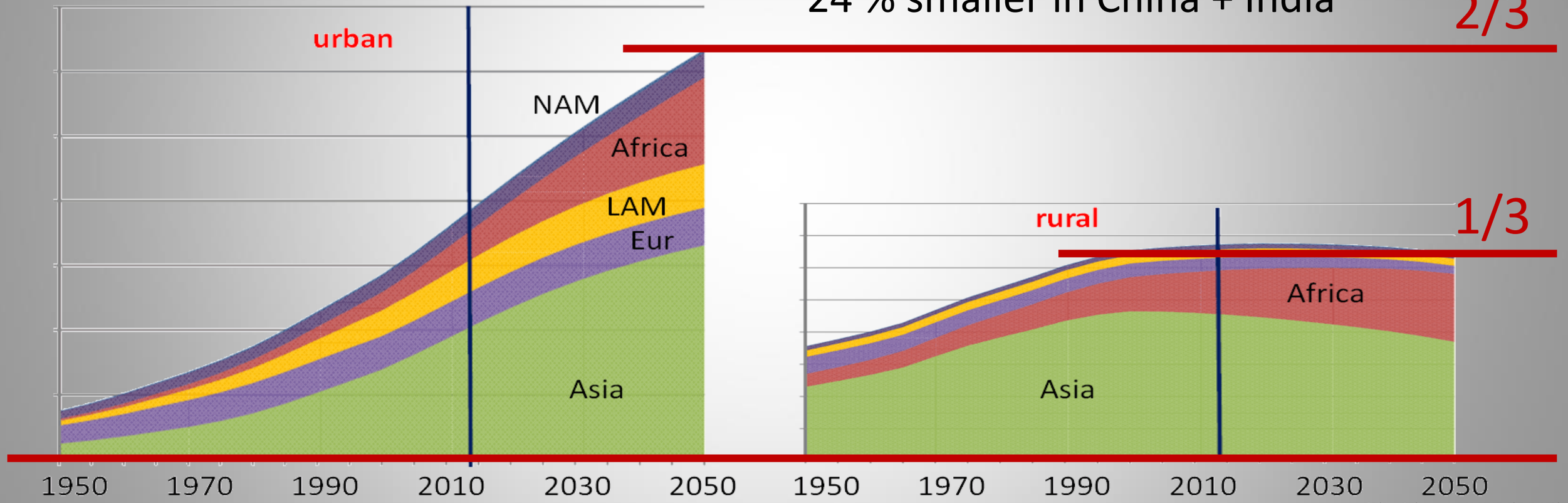

**2011**

Ortiz Vidal-Abarca (2013) www.bbvaresearch.com/en/publicaciones/emerging-trends-in-developing-countries

2050: 2/3 of the human world population lives in large cities

2050: the rural human population is 8% **smaller** than in 2010

24 % smaller in China + India



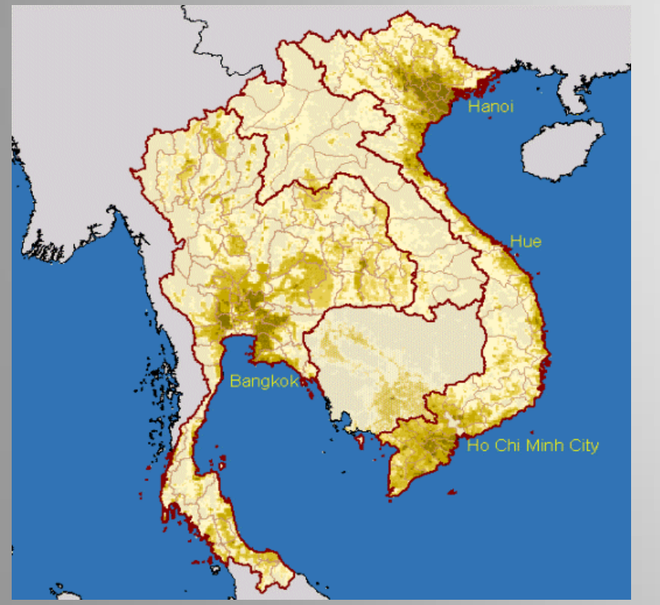

modified from UNDP (2014)

***Cities rarely contribute to the production of their food. Generally, they simply consume it.***

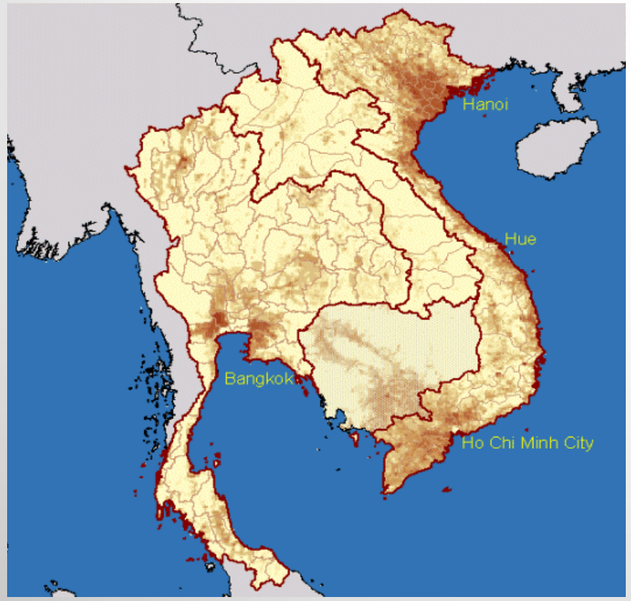
Mauro Ghirotti (1999)

## Urban and peri-Urban Concentration

**Poultry**



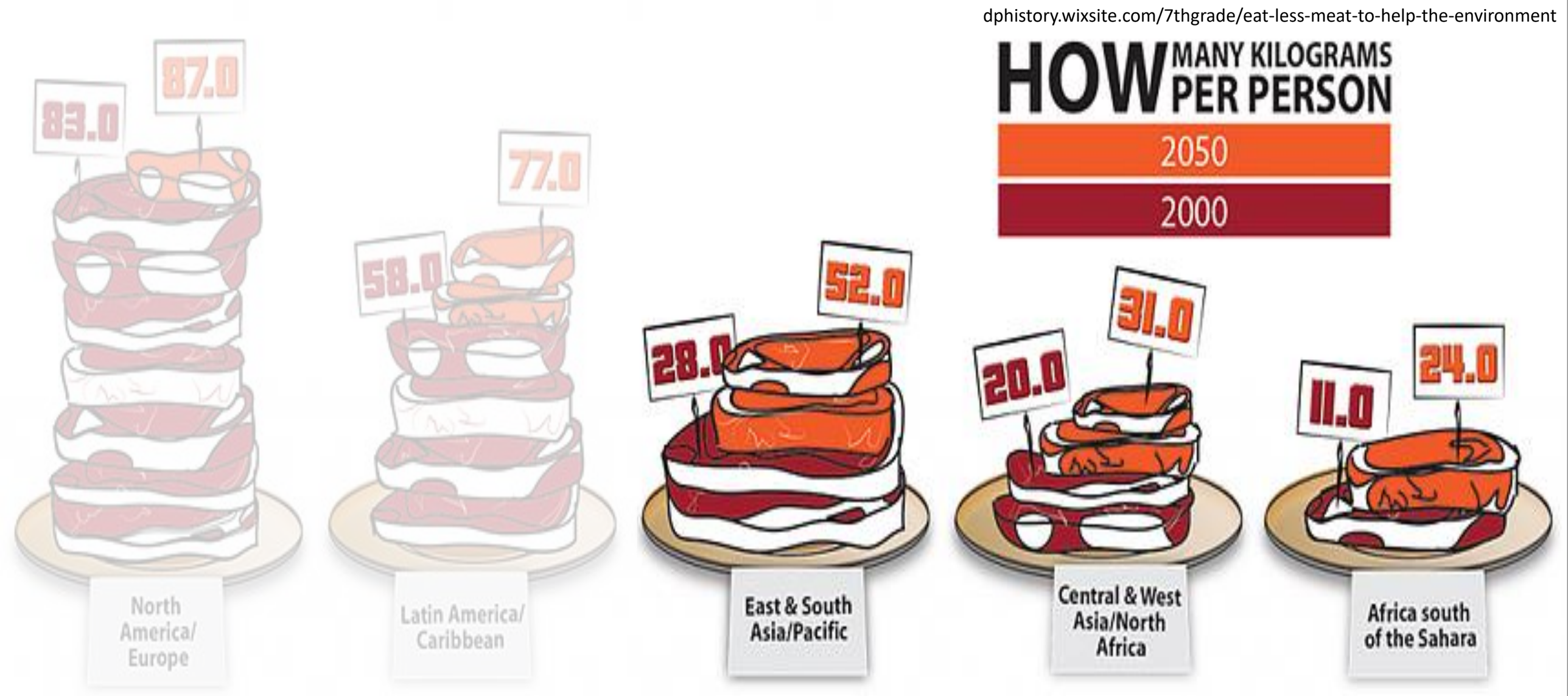

**Swine**




Jimmy Smith et al (2012); source: FAO/LEAD

- Productivity must increase
- Logistics of urban food supply
- **Intensive production close to cities**

dphistory.wixsite.com/7thgrade/eat-less-meat-to-help-the-environment



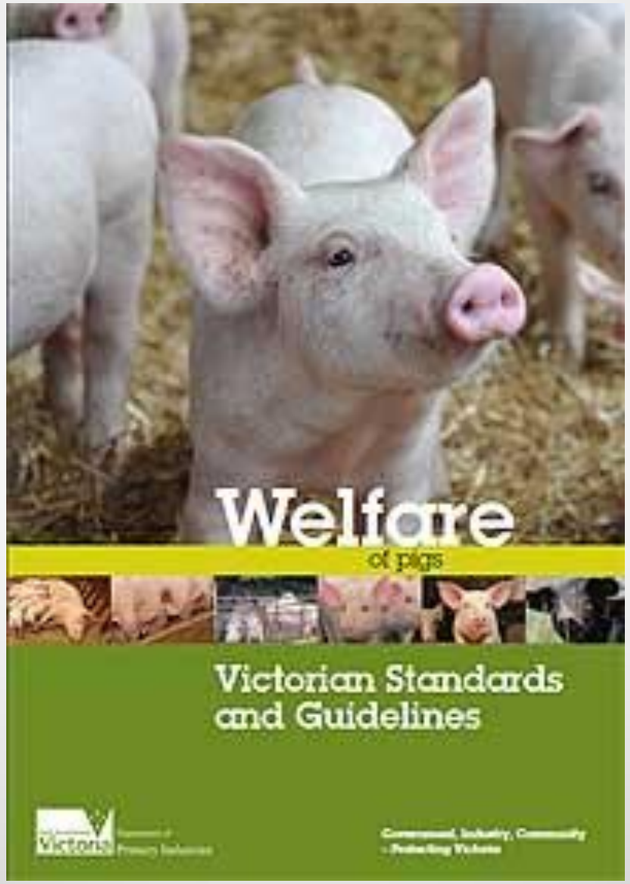
# What can animal breeding contribute to increasing productivity ?

- **A lot**
- **We knew that already & it will be very necessary**
- **Mainly to cater for the rising urban middle class,**

  **in cities all over the world**

Knowledge transfer to producers:
Olori, Van der Beek, Cleveland

# PigsPoultryPuminantsPhish:
# animal welfare



# What can animal breeding contribute to improving animal welfare?

**Animal welfare**

Invasive treatments

castration, tail docking, beak trimming, dehorning

Robustness; adaptability

disease resilience; aggressive behavior in group housing

Behavioural deprivation

# What can animal breeding contribute to improving animal welfare?

**Animal welfare**

Invasive treatments

castration, tail docking, beak trimming, dehorning

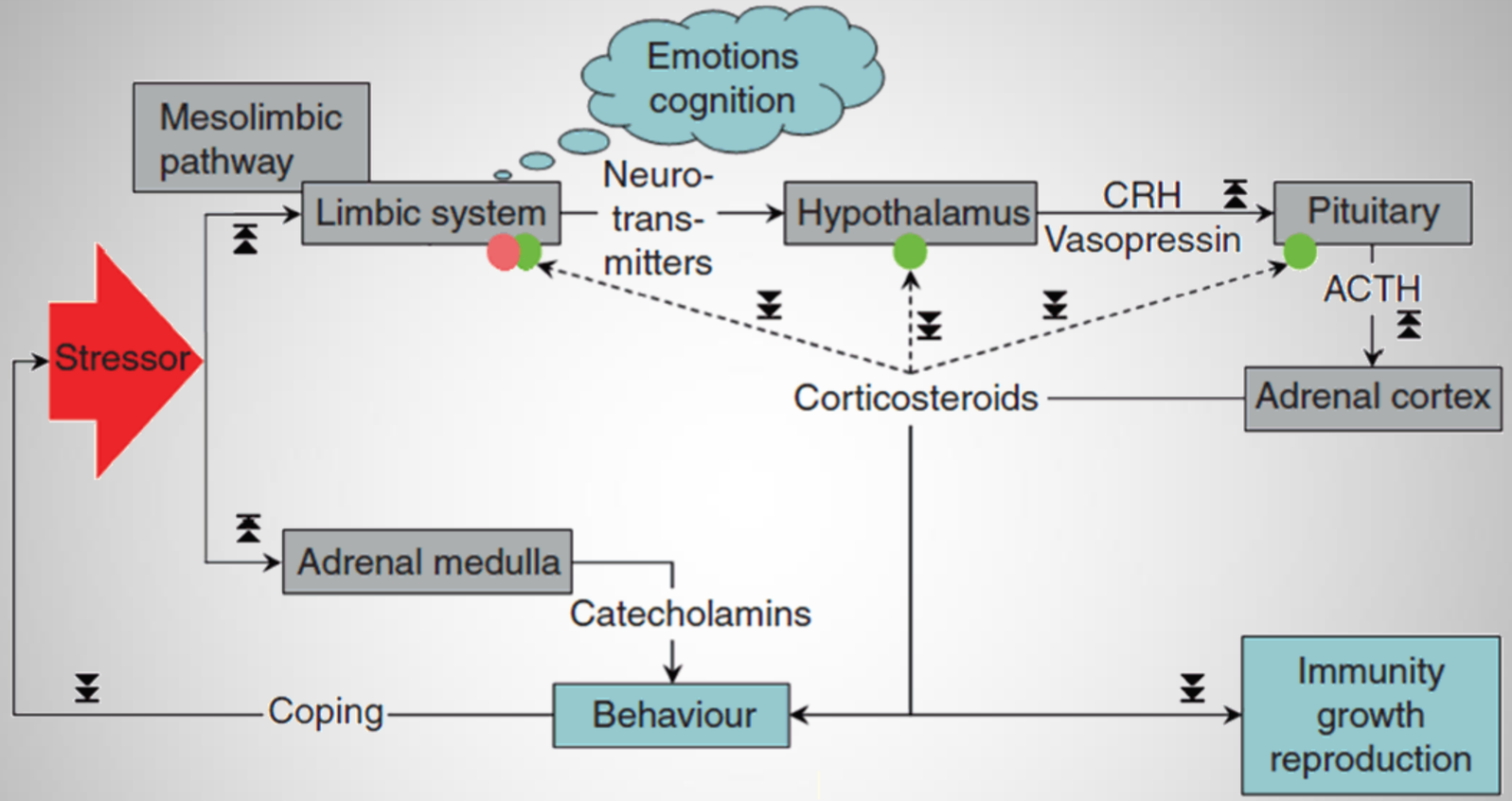
Robustness; adaptability

disease resilience; aggressive behavior in group housing

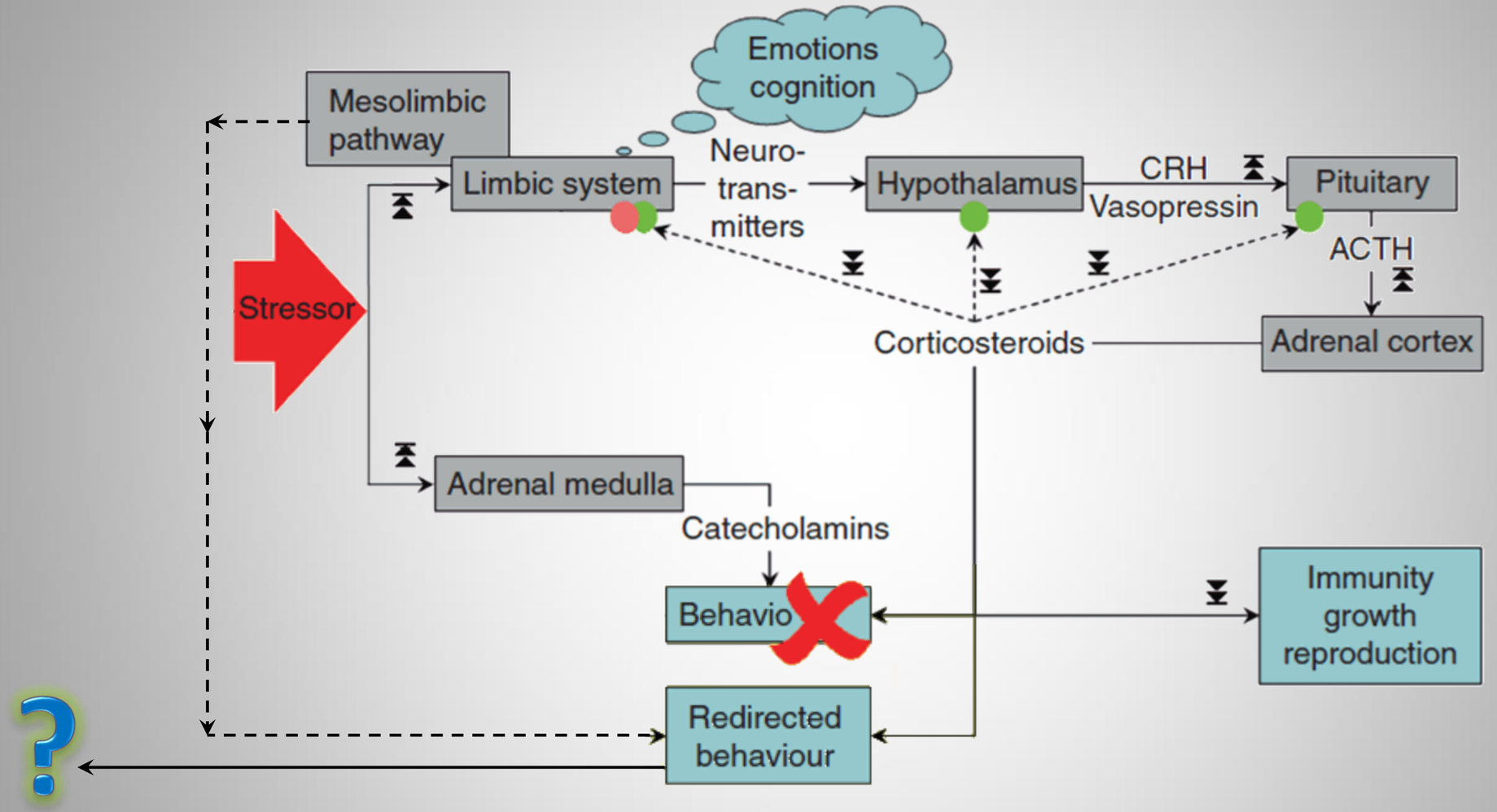
**Behavioural deprivation**

# Behavioural deprivation

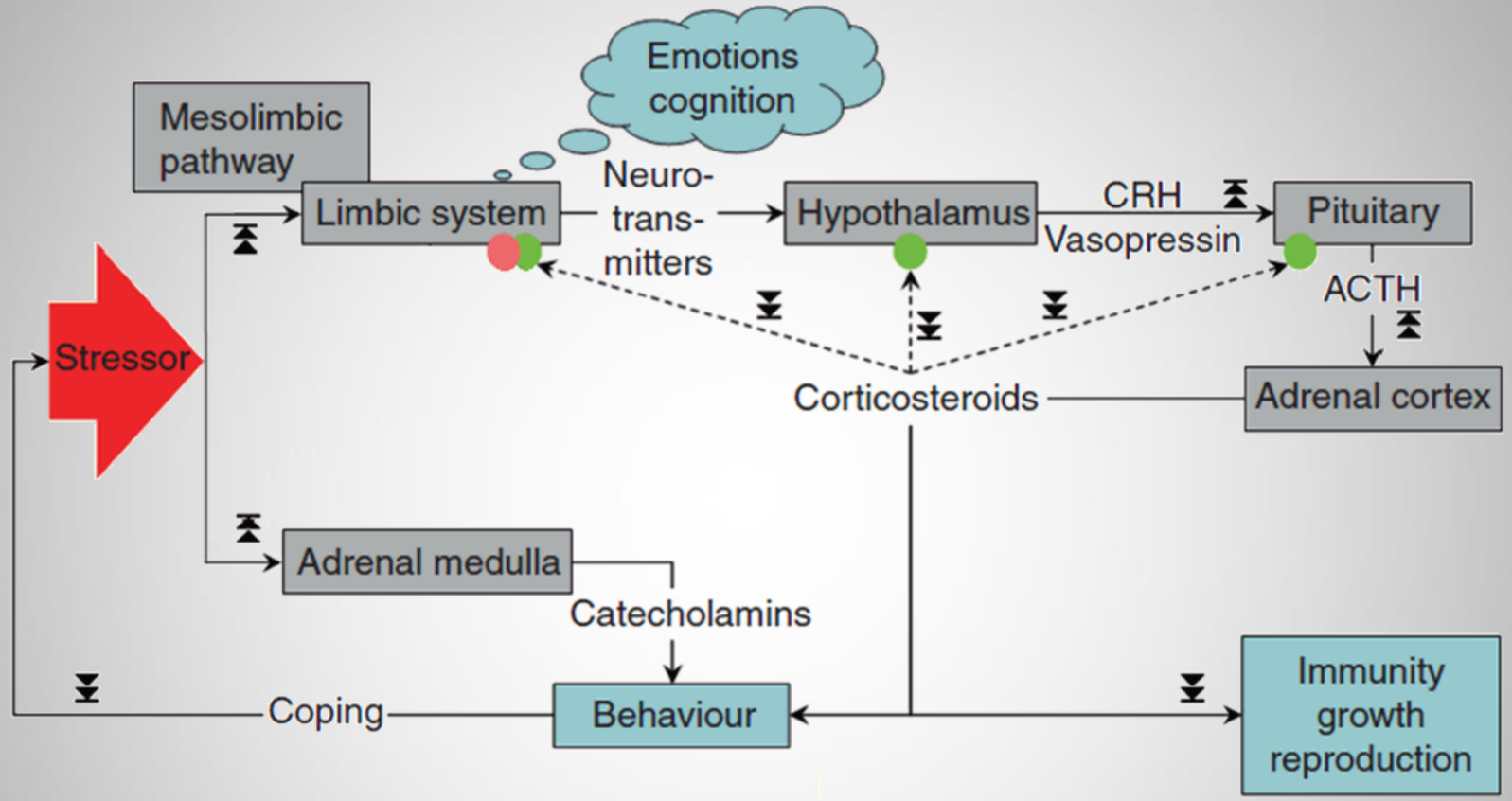
- instinct → motivations → coping behaviour patterns
- goal: remove a stressor, or remove its stressful effects
- intensive housing conditions may obstruct these patterns
  - by preventing the coping behaviour
    - e.g. the required substrate is not available: rooting material, nestbuilding material, other pigs
  - by keeping the stressor in place in spite of coping
    - e.g. tethered sows, pigs in an overcrowded pen


Emotions
cognition
Mesolimbic
pathway
Limbic system
Neuro-
trans-
mitters
Hypothalamus
CRH
Vasopressin
Pituitary
ACTH
Stressor
Corticosteroids
Adrenal cortex
Adrenal medulla
Catecholamins
Coping
Behaviour
Immunity
growth
reproduction

Knap (2012)




preventing the coping behaviour e.g. the required substrate is not available


Emotions
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Neuro-
trans-
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Pituitary
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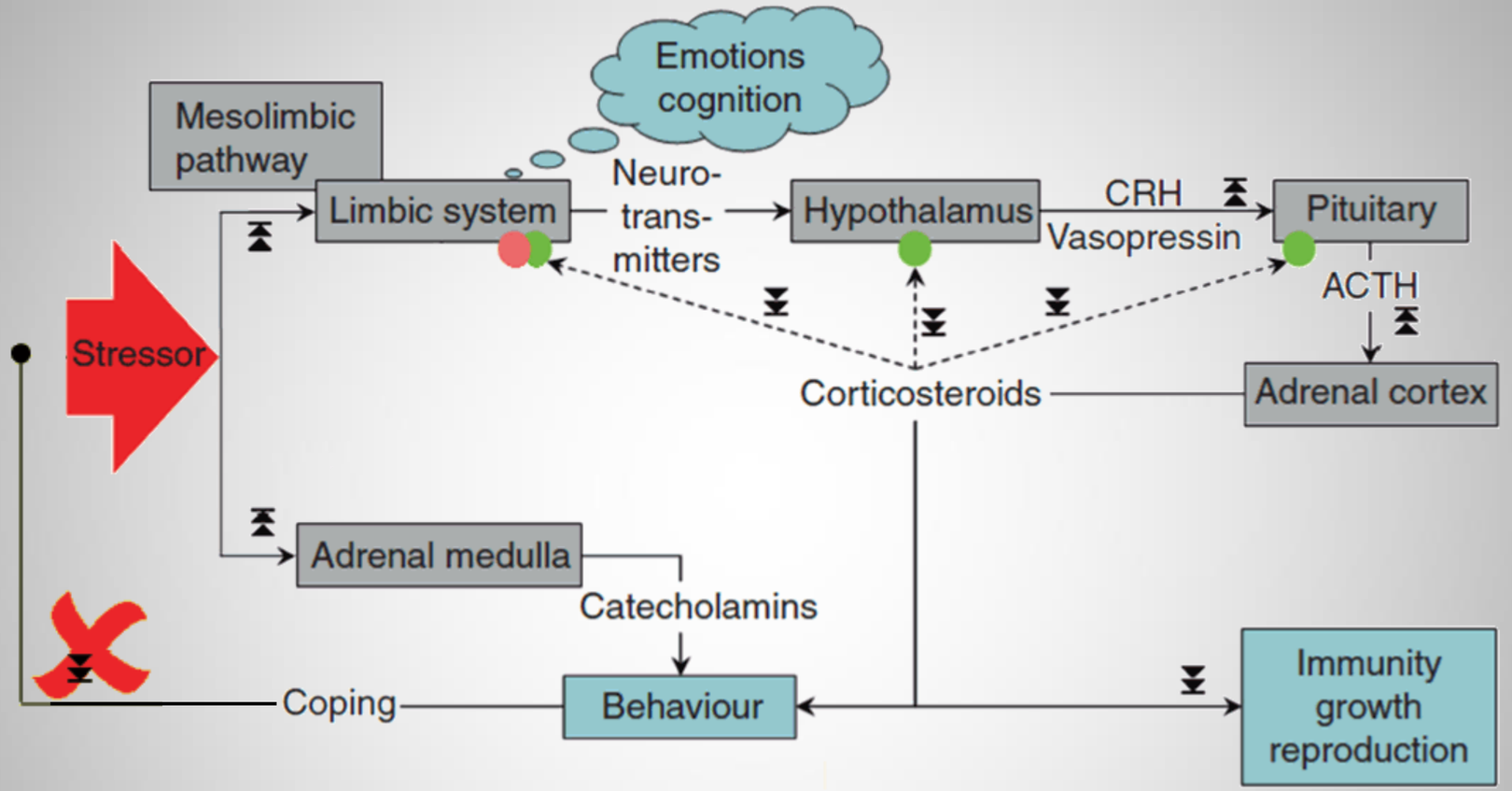
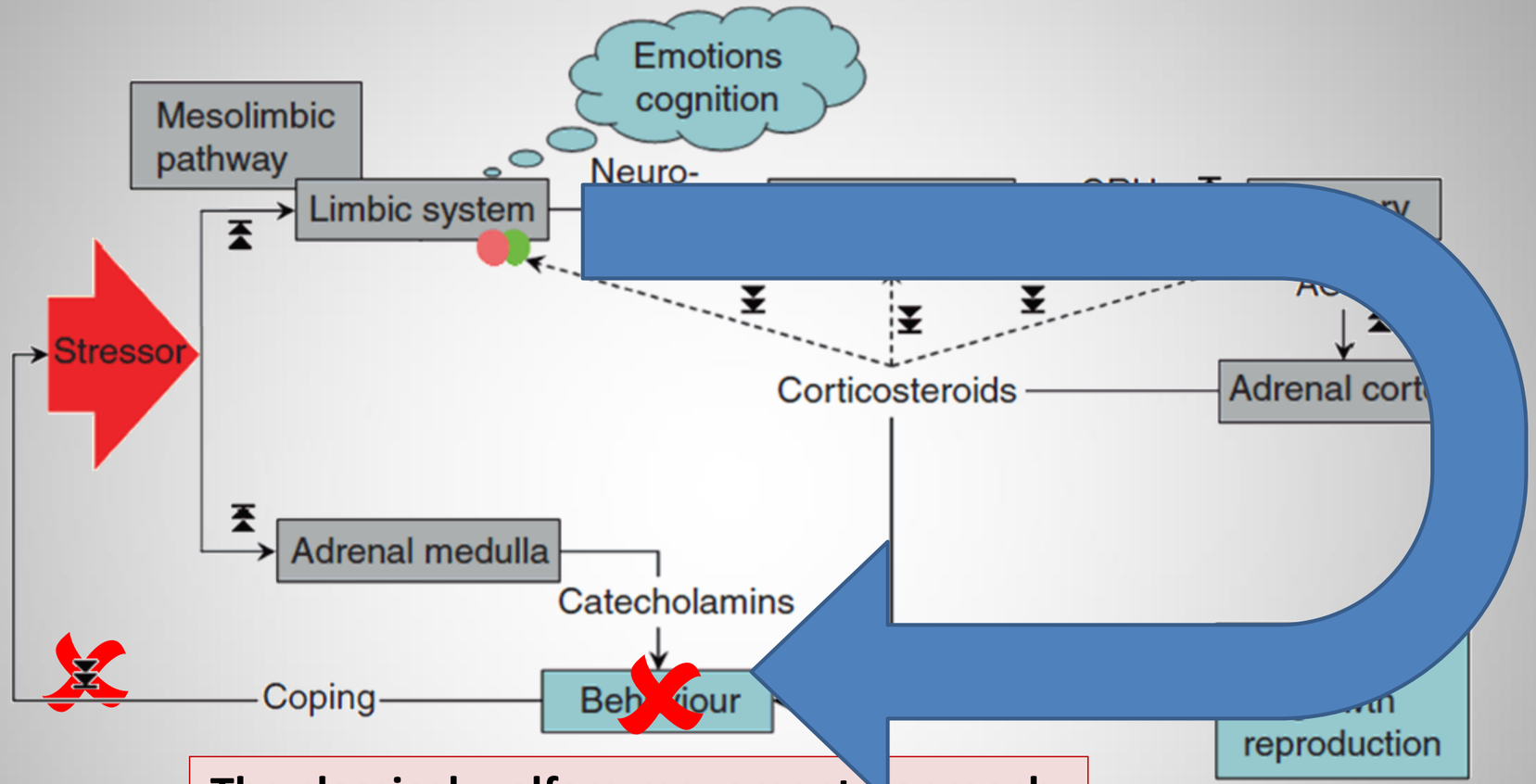
Corticosteroids
Adrenal cortex
Adrenal medulla
Catecholamins
Coping
Behaviour
Immunity
growth
reproduction

Knap (2012)




keeping the stressor in place in spite of coping

e.g. tethered sows, pigs in an overcrowded pen

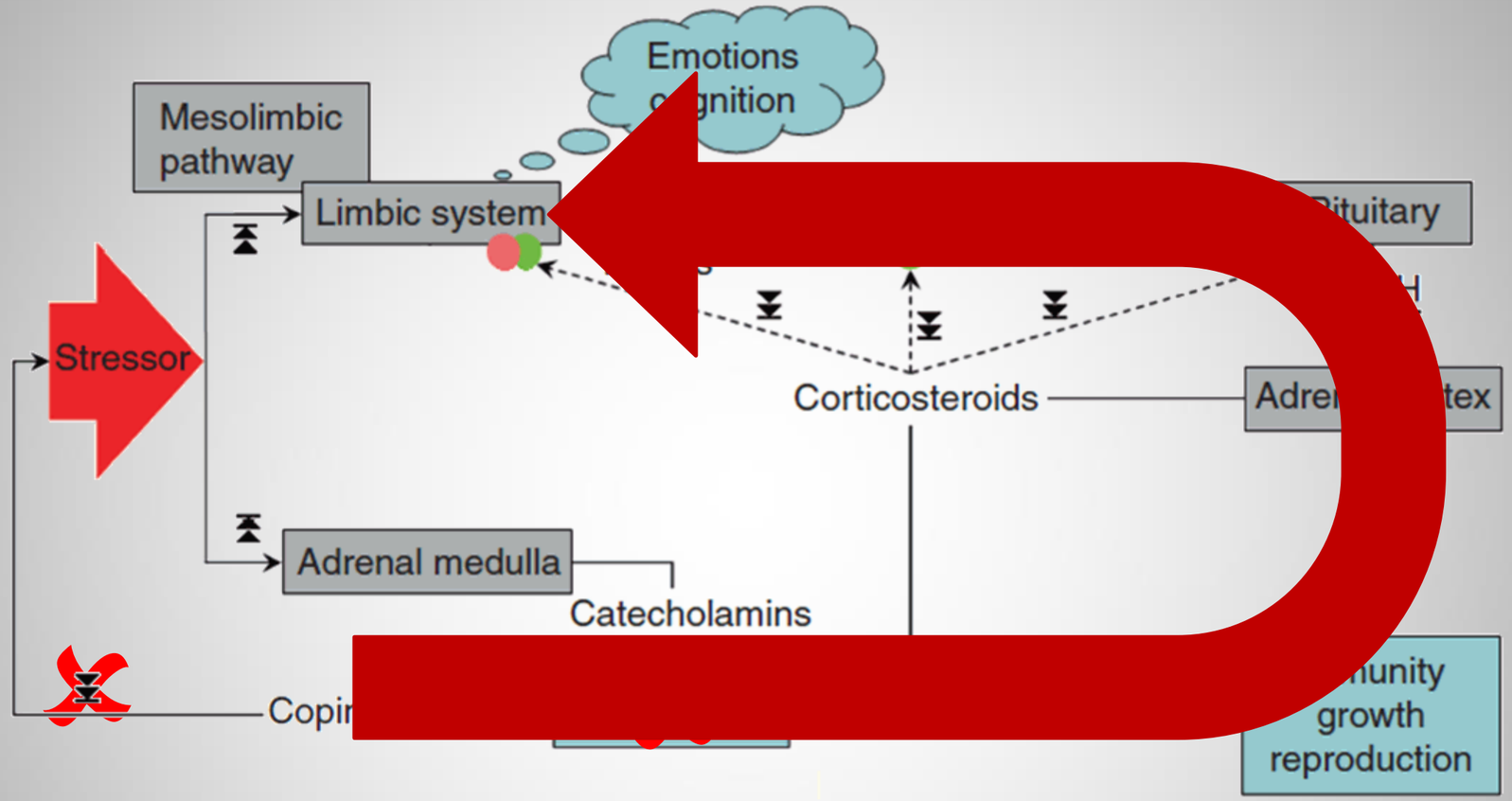



**The classical welfare movement approach:**

- **remove those blockades**
- **change the animal management system**

**= downstream control**

Knap (2012)

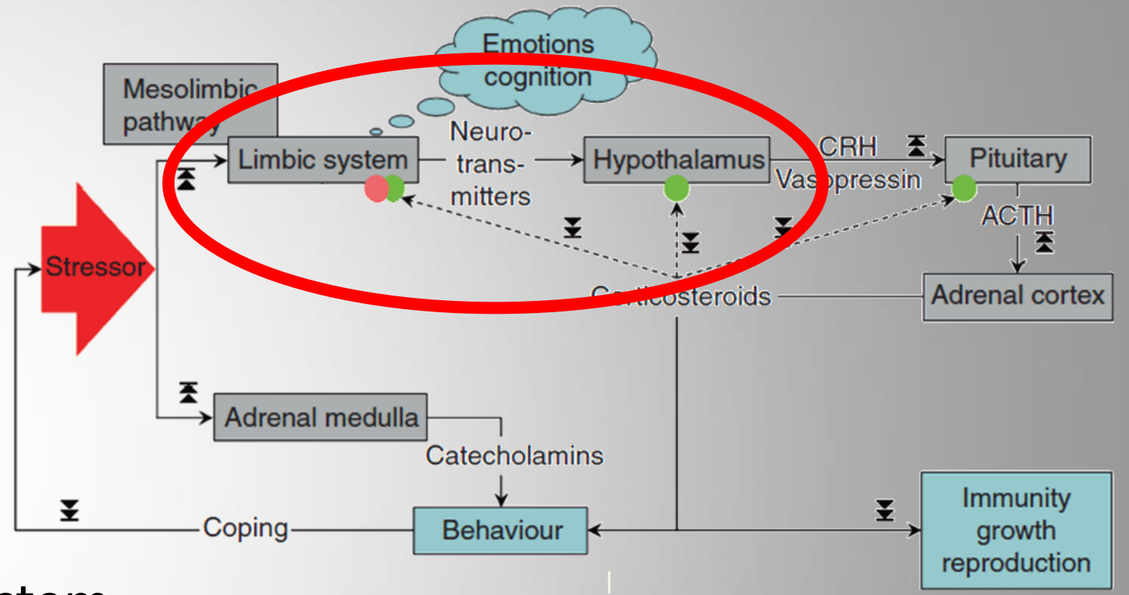



**But what about upstream control ?**

Knap (2012)

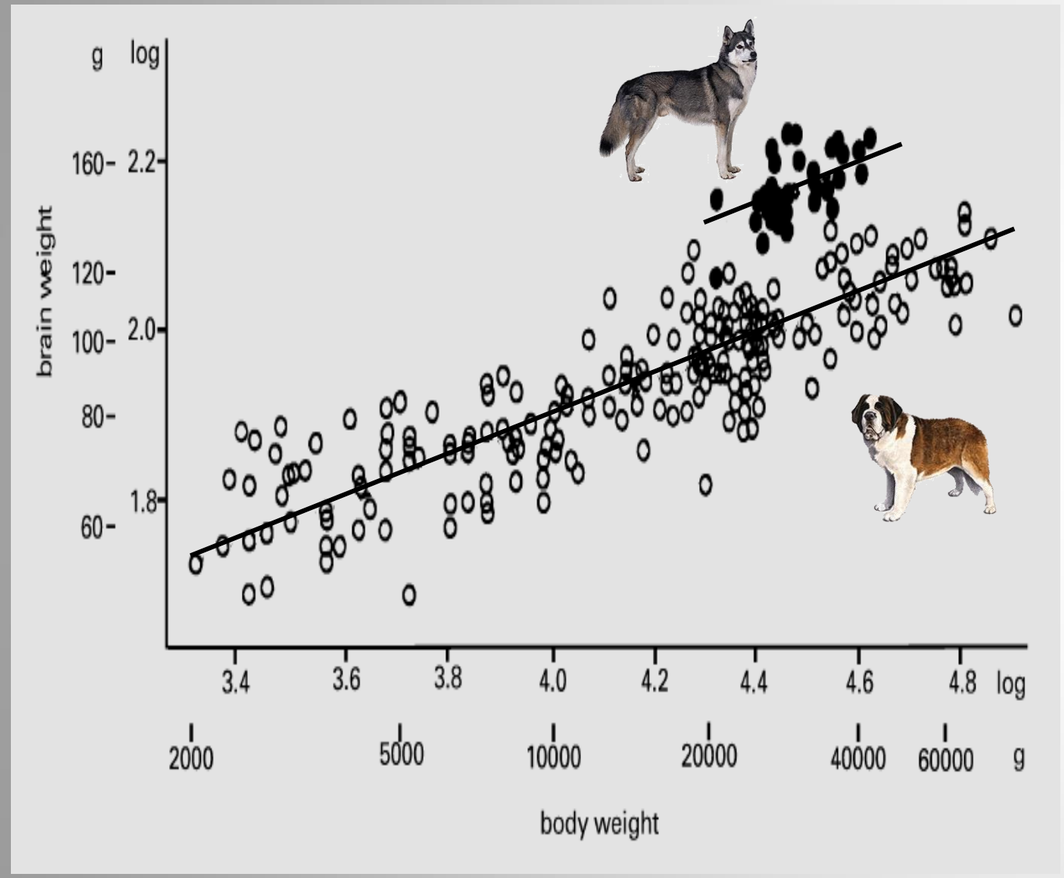
# Upstream control of animal adaptation issues

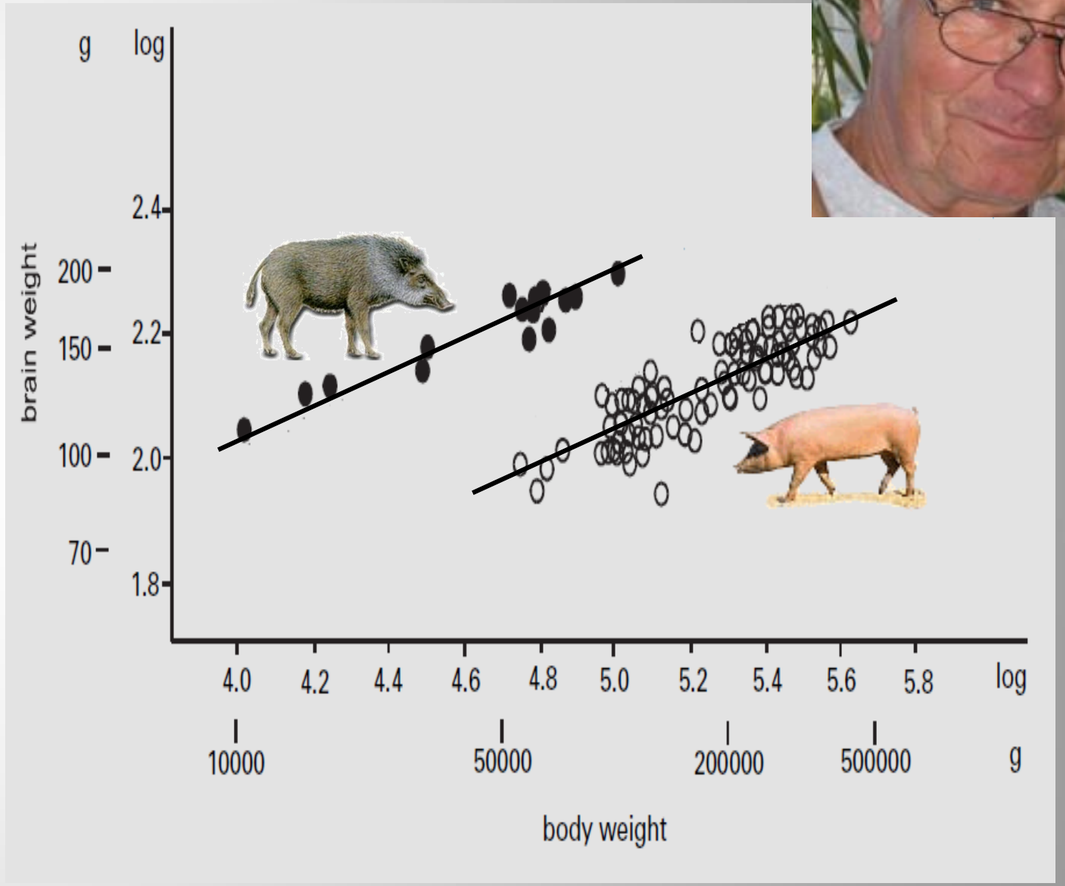
- Morris (2006): "the body simply has not evolved the capacity to **not** secrete corticosteroids during a crisis – in effect, evolution has only gotten so far…"
- evolution could be usefully **moved on** by targeting the regulator of the HPA axis: the limbic system
- modify instinctive patterns: reduce the motivation for behaviour that cannot be supported by the production system
- = change the intensity of behavioural responses = domestication (Grandin & Deesing 1998)
- adaptation of behaviour through selection = reduction of the drives for exploration, aggression etc: extension of 10,000 years of domestication
- so, what has happened during those 10,000 years ?



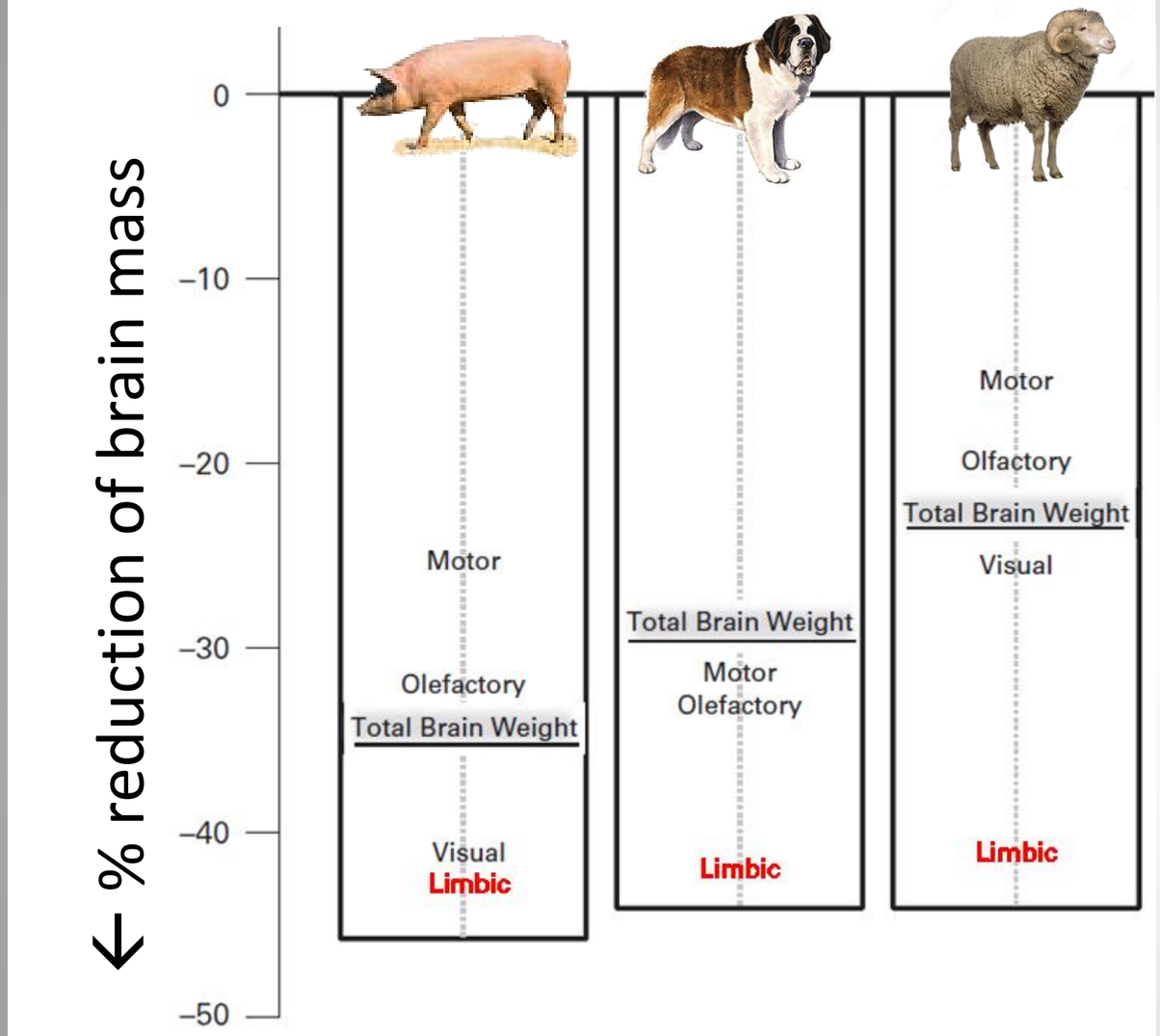

Knap (2012)

# Brain weight versus body weight

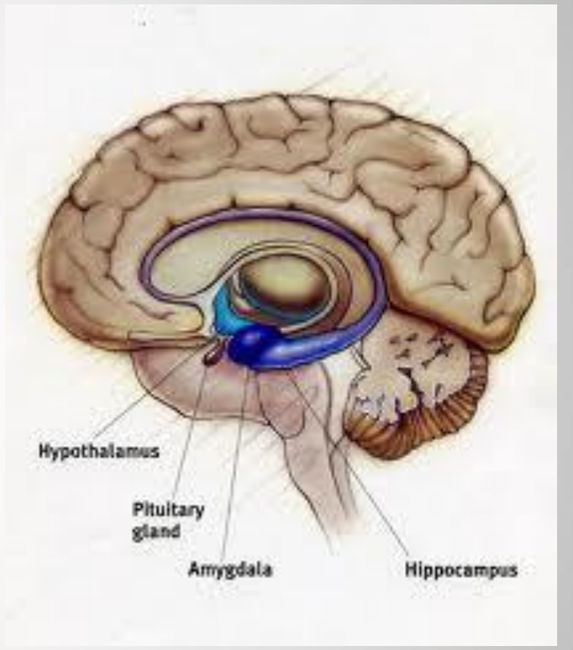



modified from Kruska (1970, 2003)




Kruska (1988); Zeder (2012)




Agrar- und Ernährungswissenschaftliche Fakultät

C|A|U

Christian-Albrechts-Universität zu Kiel

Institut für Tierzucht und Tierhaltung

# FeelGood: Erfassung positiver Emotionen beim Schwein


**Katja Krugmann, Farina Warnken, Irena Czycholl und Joachim Krieter**

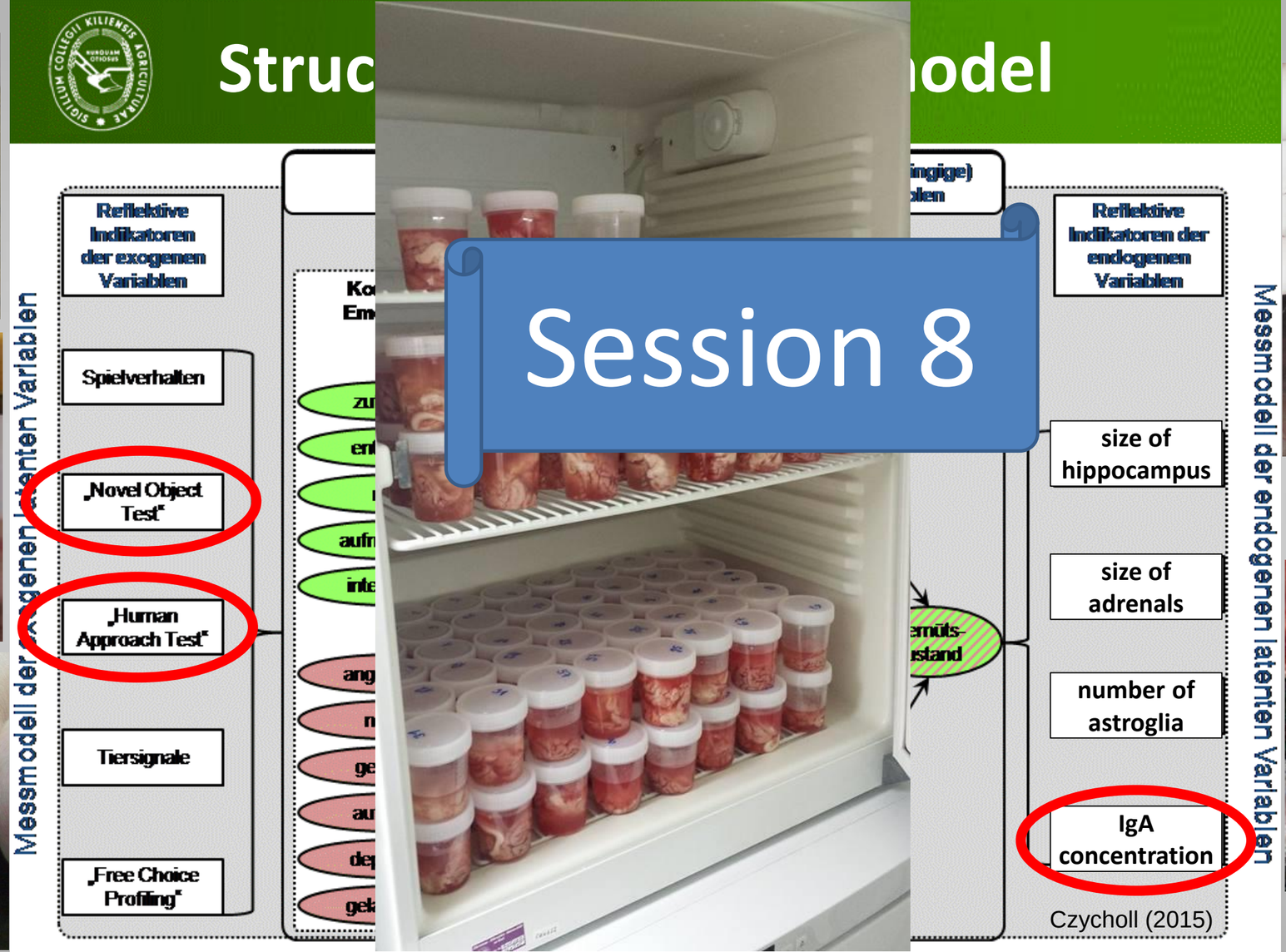
**Institut für Tierzucht und Tierhaltung**


**11. April 2017**


Gefördert durch:

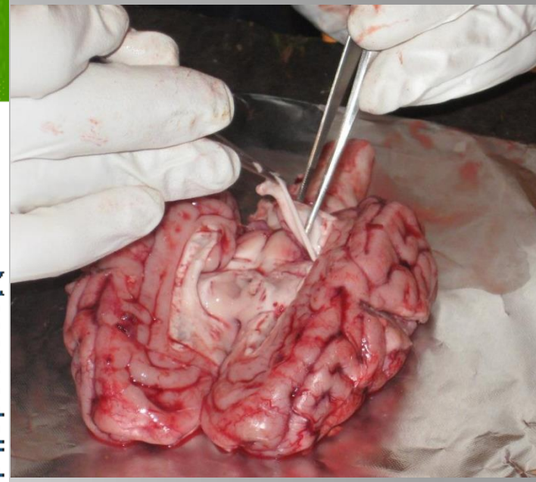
Bundesministerium für Ernährung und Landwirtschaft

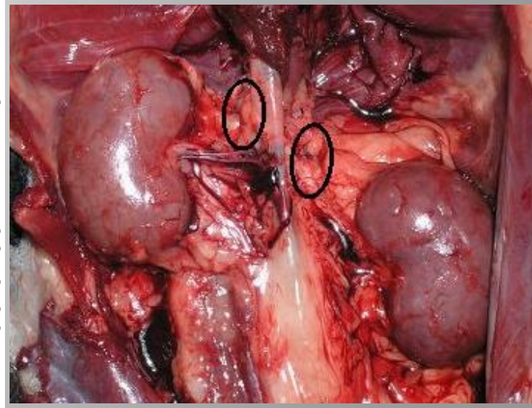
aufgrund eines Beschlusses des Deutschen Bundestages



Struc
odel
Reflektive Indikatoren der exogenen Variablen
Spielverhalten
„Novel Object Test"
„Human Approach Test"
Tiersignale
„Free Choice Profiling"
Messmodell der exogenen latenten Variablen
Reflektive Indikatoren der endogenen Variablen
size of hippocampus
size of adrenals
number of astroglia
IgA concentration
Messmodell der endogenen latenten Variablen
Czycholl (2015)



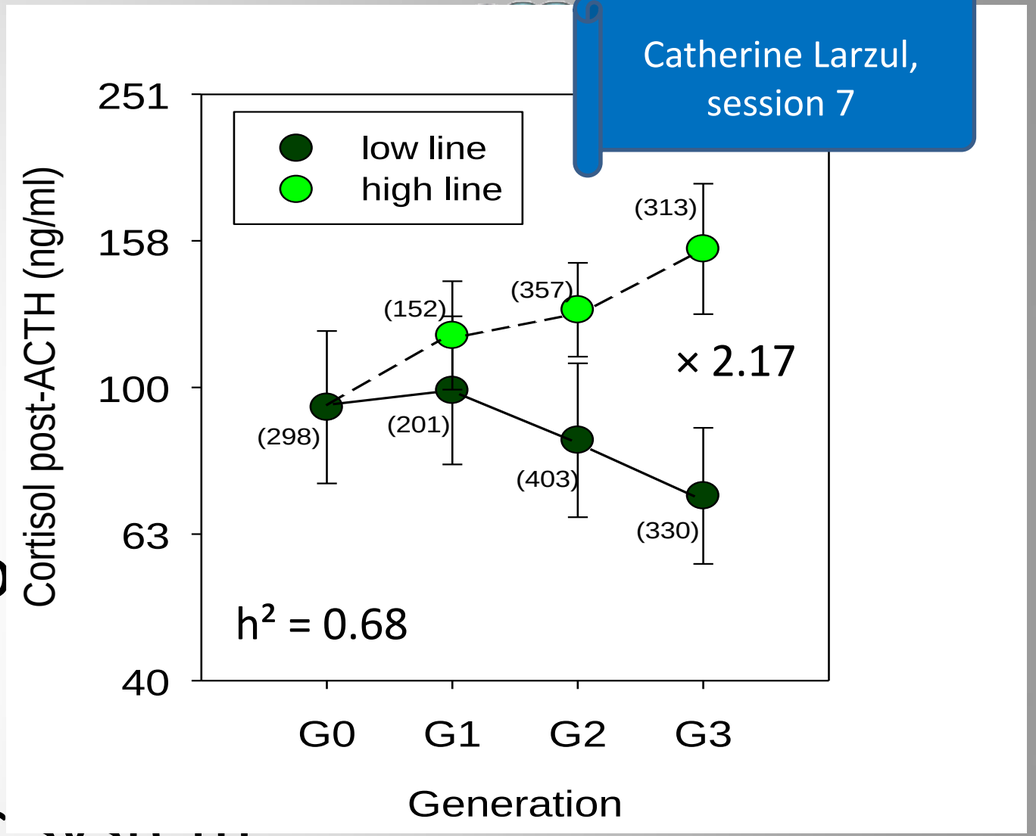
Session 8





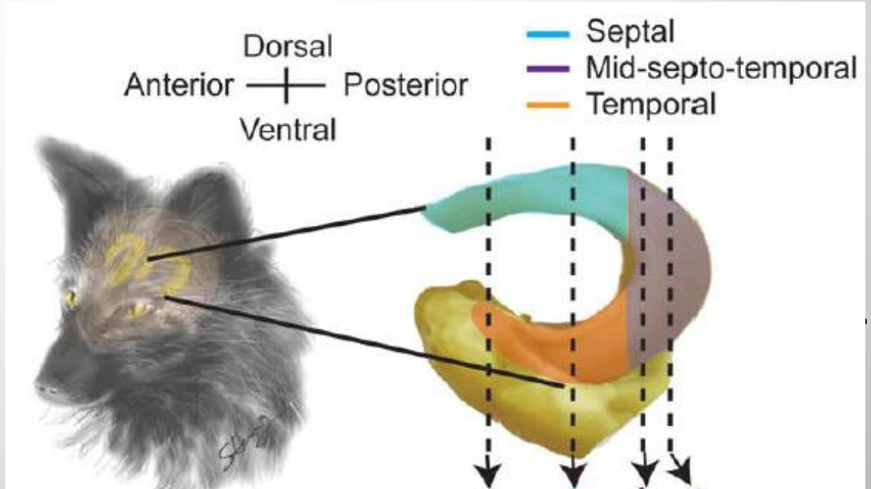
# Upstream control of animal adaptation issues

- Find the genes that control:
  - exploratory and aggressive motivatio
  - oversupply of corticosteroids
  - corticosteroid receptors in the limbic system
- Get them under control → speed up domestication & improve welfare



It is tempting to think that in the tame foxes we observe a prolongation of the phase in which young neurons possess their unique properties, as has been shown in rats.

In the tame foxes, this might be regulated by genes that are targeted during domestication and that are expressed heterogeneously along the septotemporal axis.

- Get them under control → 

improve welfare

Huang, Trut, Amrein et al (2015)

# What can animal breeding contribute to improved animal welfare?

- **Technically, a lot …**
- **… but in practice, it all depends on the breeding goals.**
- **Someone must be willing to pay for it.**
- **Needs incentives from market forces / legislation.**

# Planet:
# resource efficiency
# environmental efficiency

# What can animal breeding contribute to improving efficiency?

**Resource efficiency**

Feed efficiency

Losses

**Environmental efficiency**

# What can animal breeding contribute to improving efficiency?

## Resource efficiency

Feed efficiency

Losses

**Environmental efficiency**

Session 31

# Resource efficiency: the Food Feed Fuel trade-off

Session 30

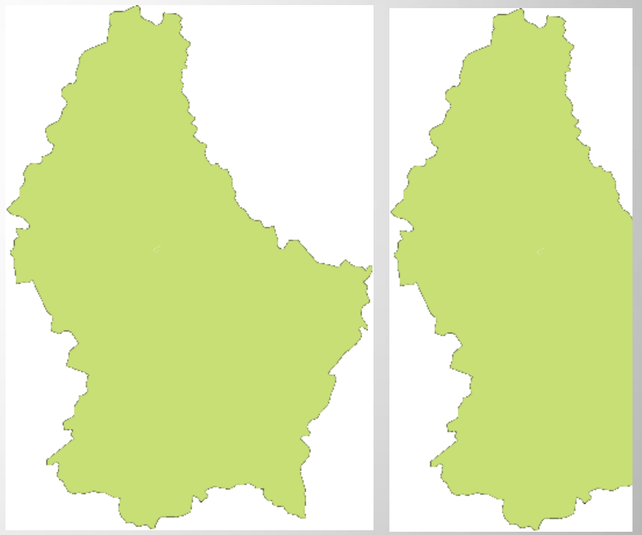
- b tion (2017, worldwide):

  149.3 mio ton liveweight

225 x Dubrovnik

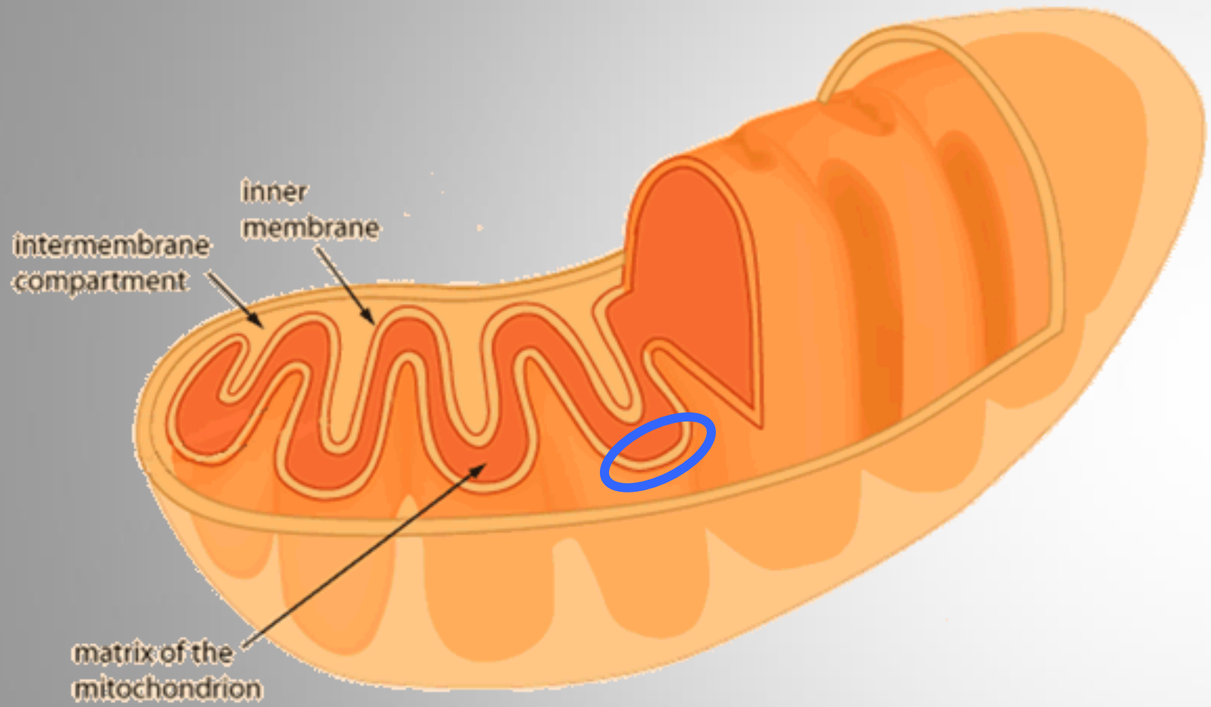
- ΔG(FCR) = –0.015 kg/kg per year
- this saves –0.015 × 149.3 mio

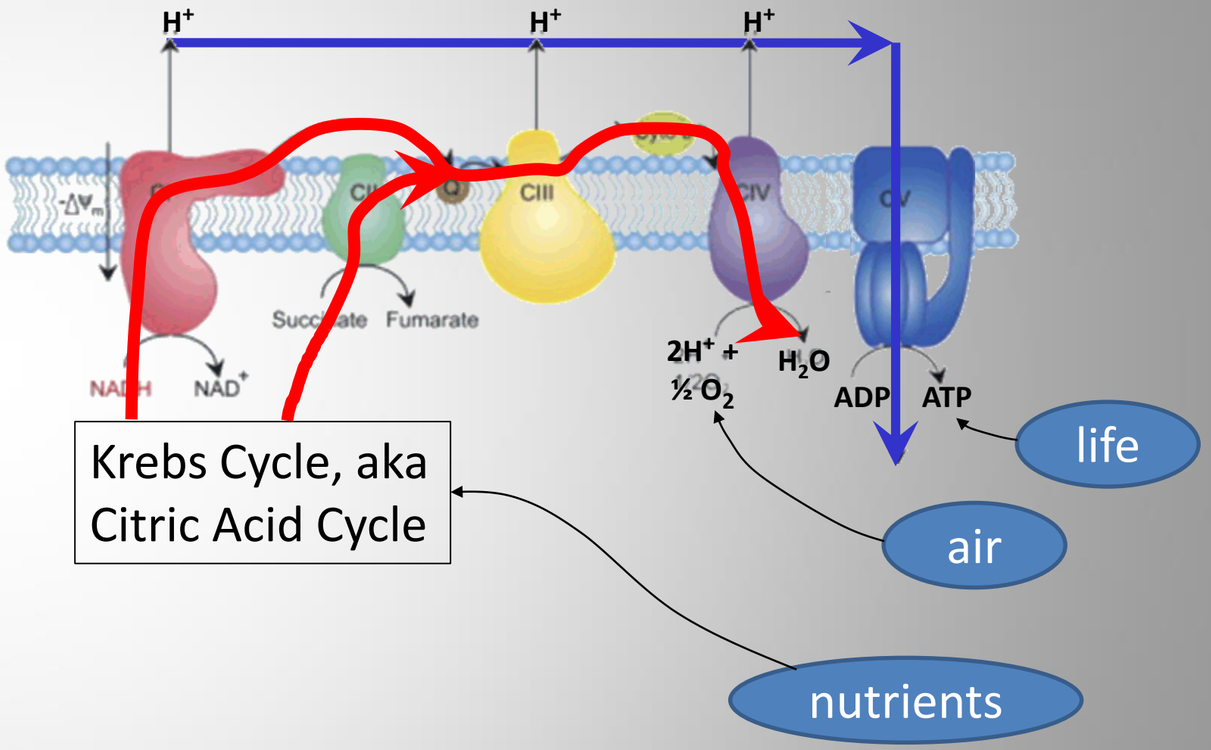
  = 2.24 mio ton feed



- 4800 km$^2$ arable land per year, cumulative: 1.8 × Luxembourg

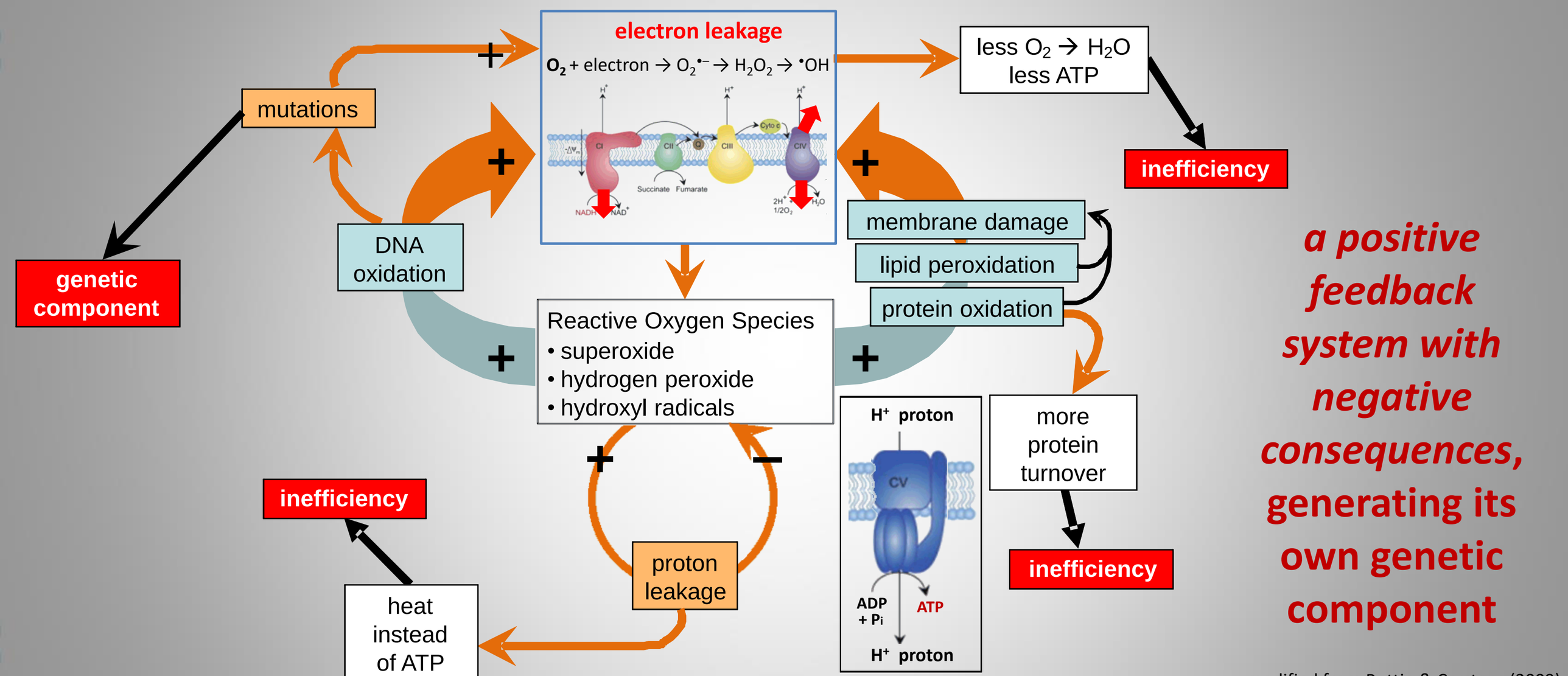
updated from Neeteson et al (2012)

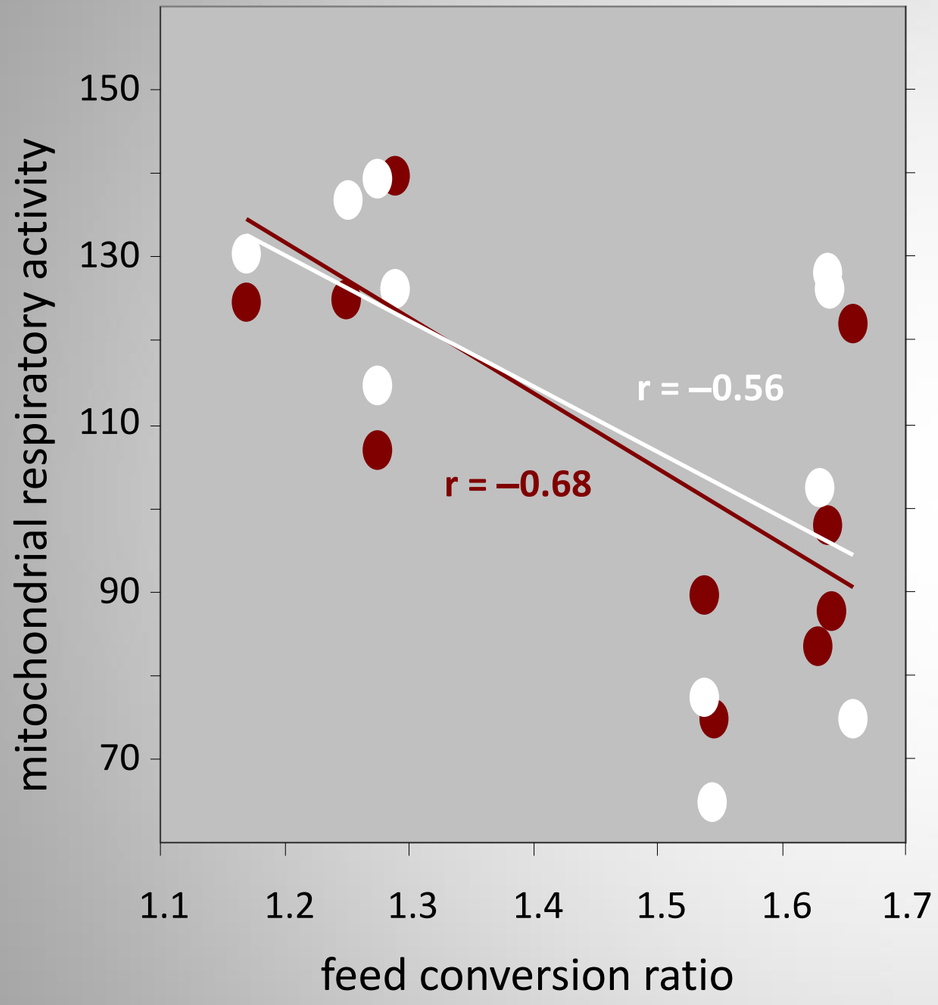


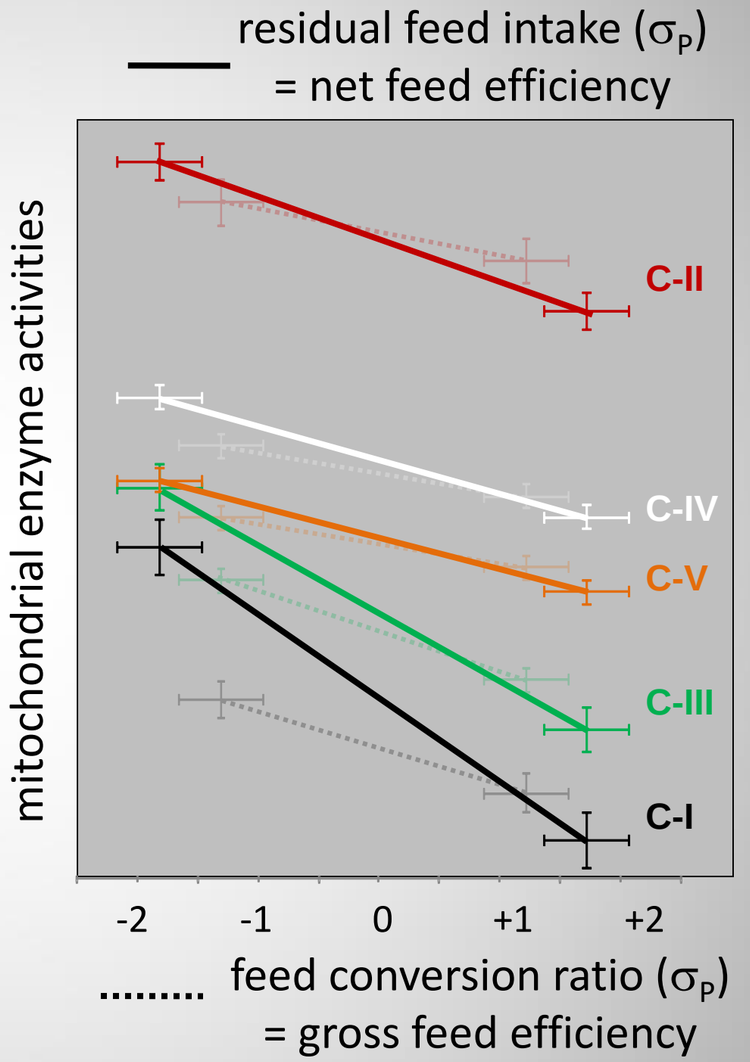




weightlossmma.com/muscle-burn-fat/

modified from Osellame et al (2012)


electron leakage
$O_2$ + electron → $O_2^{\bullet-}$ → $H_2O_2$ → $^{\bullet}OH$
less $O_2$ → $H_2O$
less ATP
inefficiency
mutations
genetic component
DNA oxidation
membrane damage
lipid peroxidation
protein oxidation
Reactive Oxygen Species
• superoxide
• hydrogen peroxide
• hydroxyl radicals
more protein turnover
inefficiency
H+ proton
CV
ADP + Pi
ATP
H+ proton
proton leakage
inefficiency
heat instead of ATP
a positive feedback system with negative consequences, generating its own genetic component
modified from Bottje & Carstens (2009)





modified from Bottje et al (2002)

data from Sharifabadi et al (2012)

SCIENTIFIC REPORTS

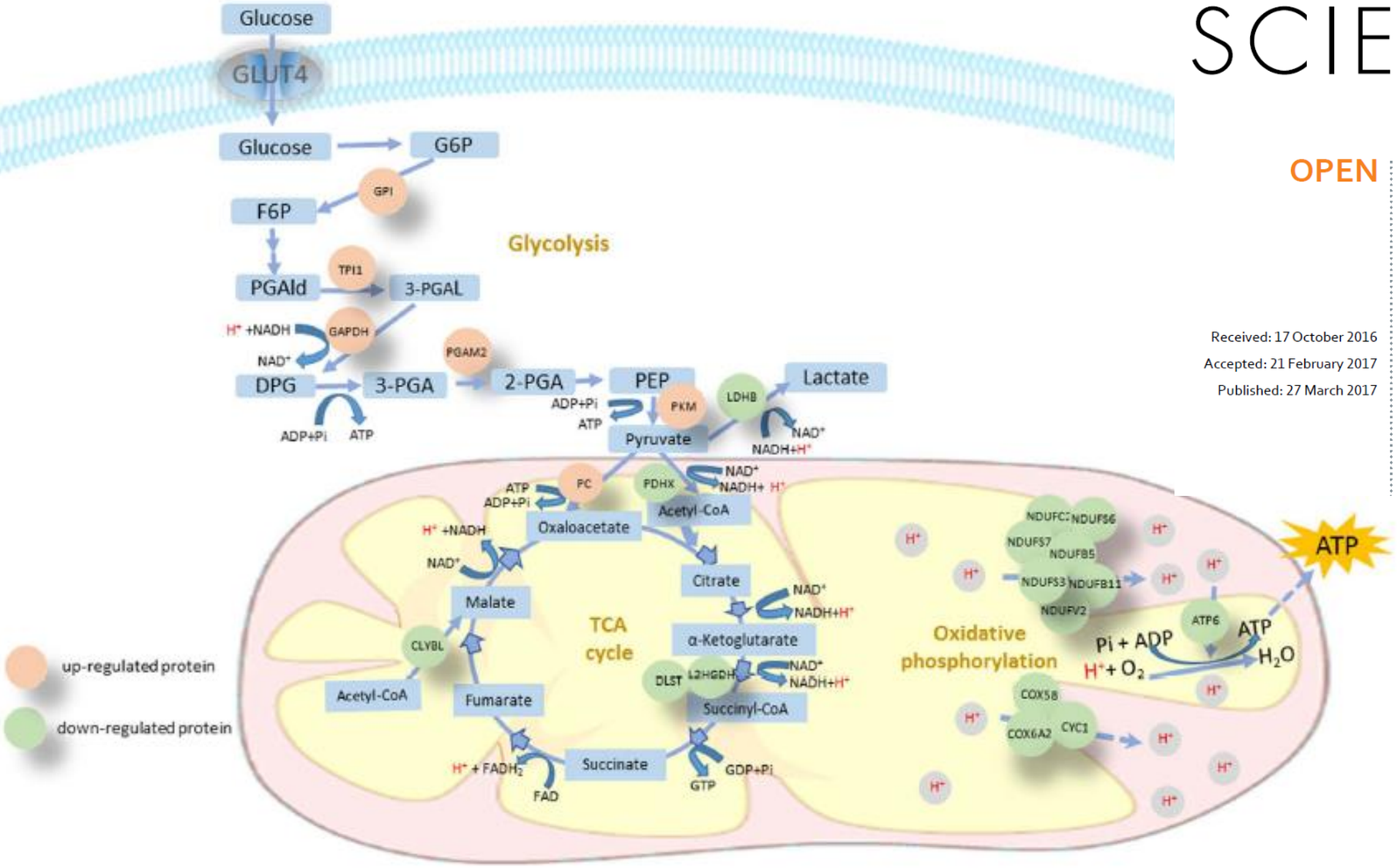



**Figure 5. Key signaling pathways represented by DEPs in skeletal muscle tissues between high- and low-FE pigs.** Pink represents up-regulated proteins and green represents down-regulated proteins in high-FE pigs.

OPEN

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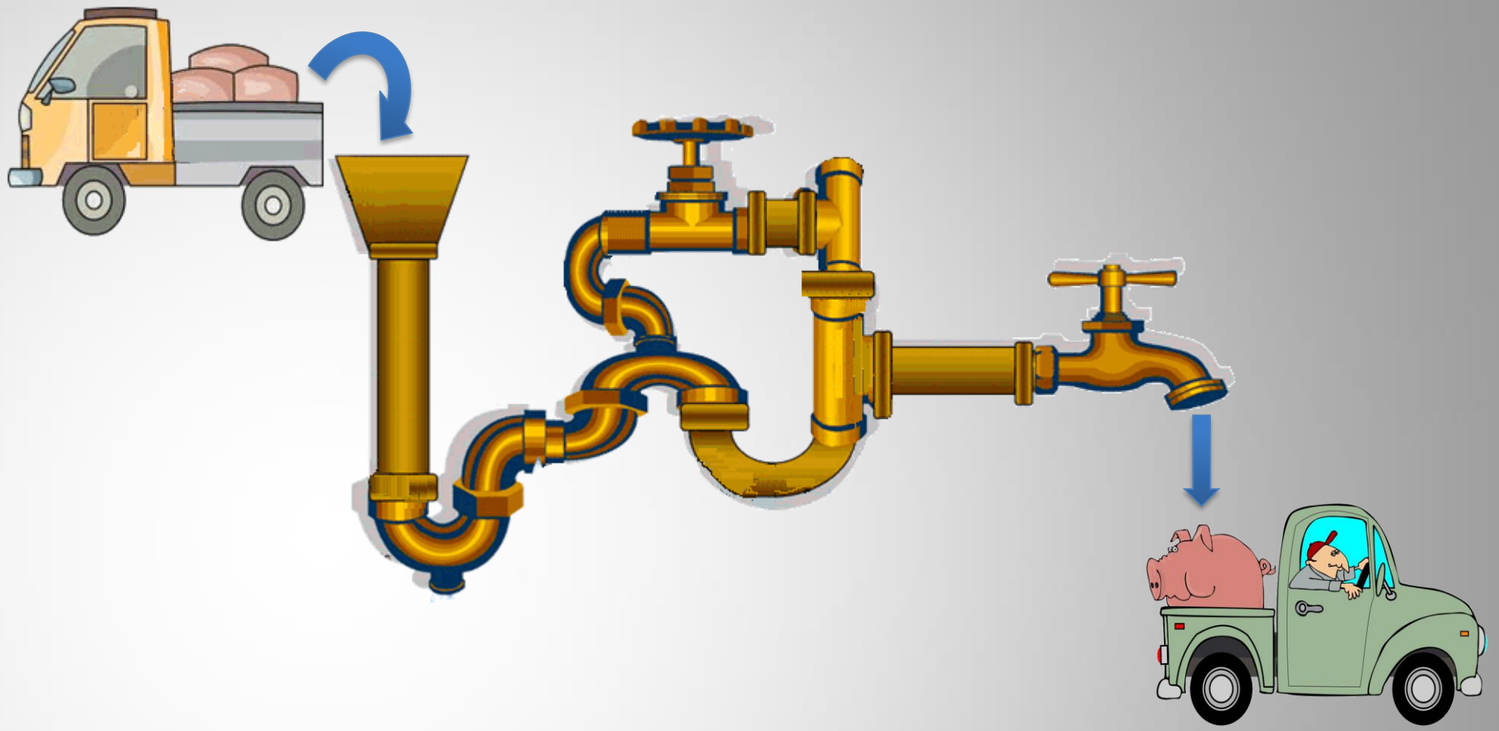
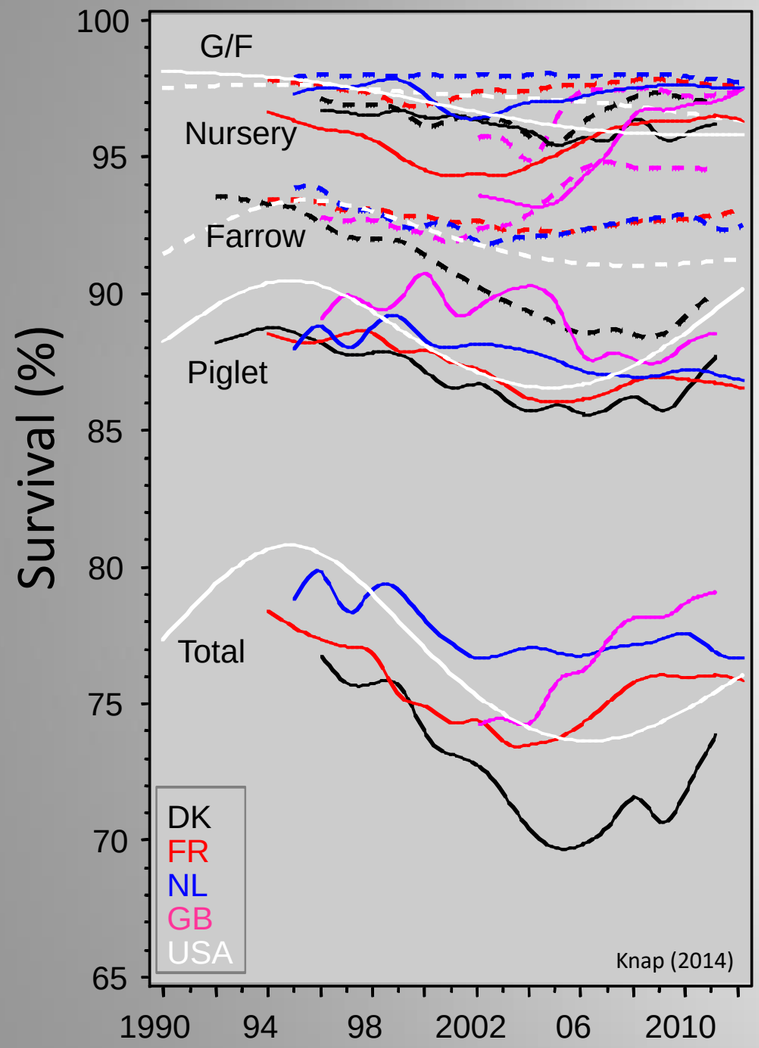
# Proteomic analysis indicates that mitochondrial energy metabolism in skeletal muscle tissue is negatively correlated with feed efficiency in pigs

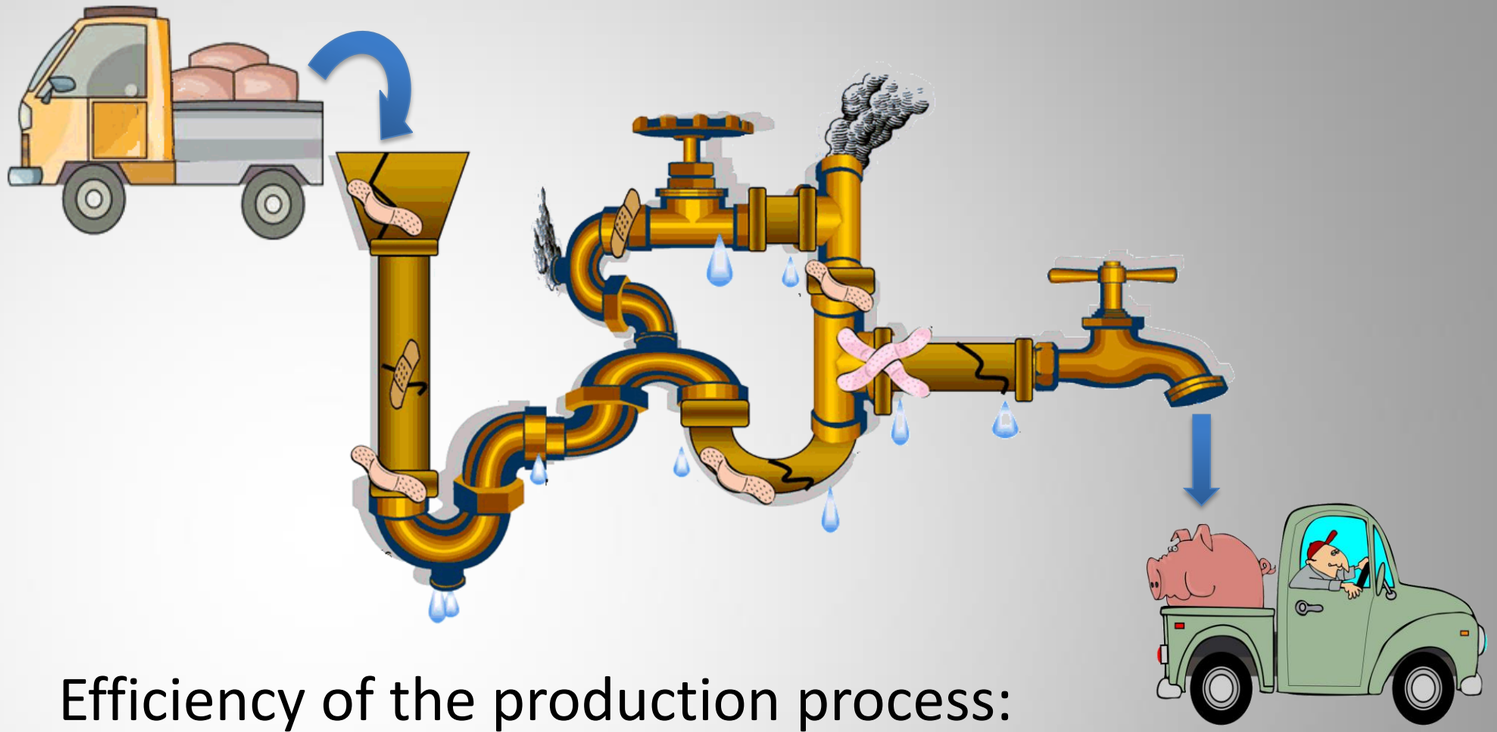
Liangliang Fu[1,2], Yueyuan Xu[1,2], Ye Hou[1,2], Xiaolong Qi[1,2], Lian Zhou[1,2], Huiying Liu[1,2], Yu Luan[1,2], Lu Jing[1,2], Yuanxin Miao[1,2], Shuhong Zhao[1,2], Huazhen Liu[1,2] & Xinyun Li[1,2]

- **Losses**
- **More efficient systems tend to be more sensitive to external disturbance**
- **Less idle capacity to fall back on, in times of trouble**



modified from Knol (2010); www.thebudgetwarrior.com/2010/06/how-value-of-your-benefits-can-leak.html

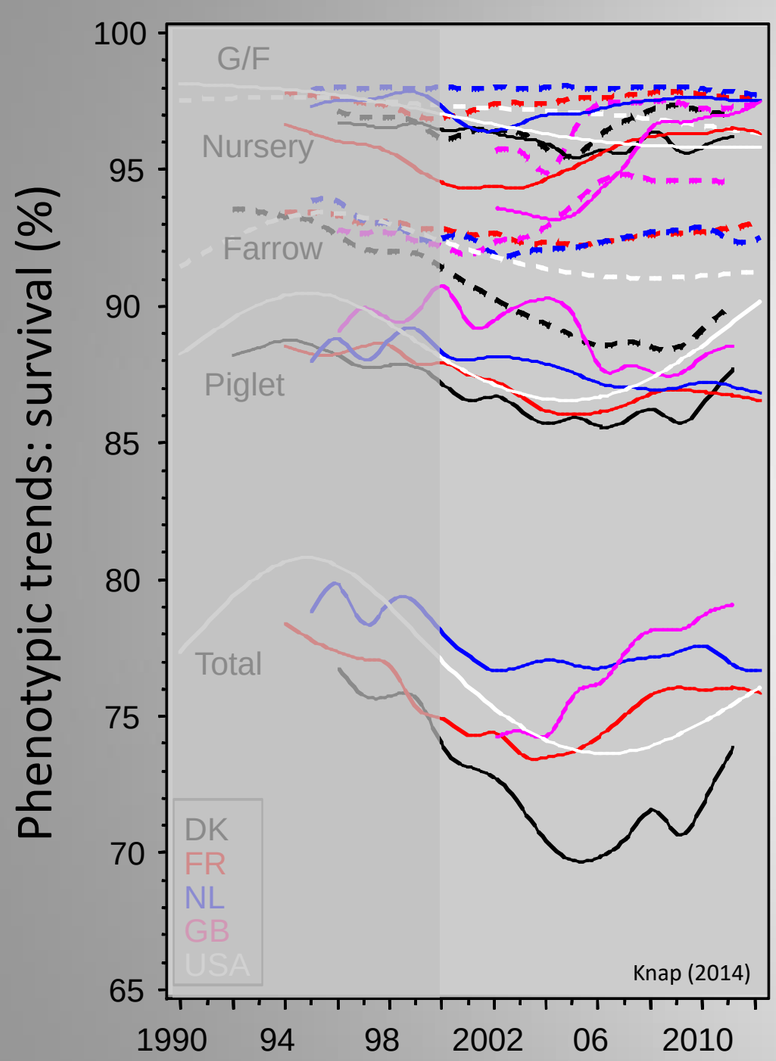


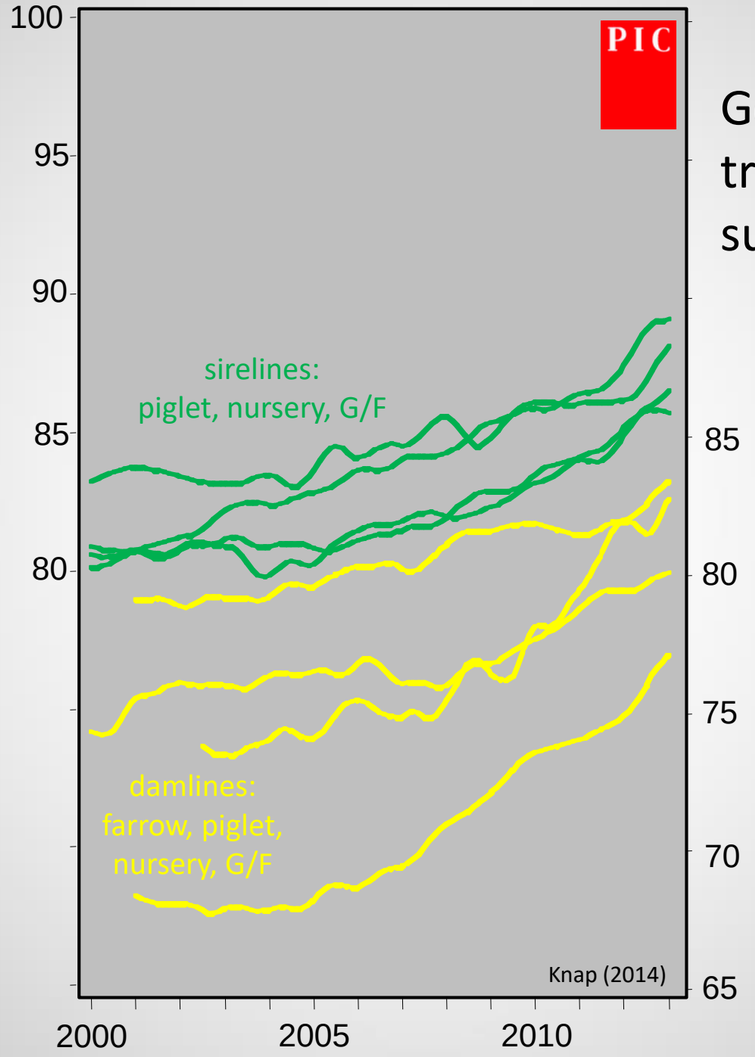



Efficiency of the production process:

- Losses

modified from Knol (2010); www.thebudgetwarrior.com/2010/06/how-value-of-your-benefits-can-leak.html




Genetic trends: survival (%)

# What can animal breeding contribute to improving efficiency?

**Resource efficiency**

Feed efficiency

Losses

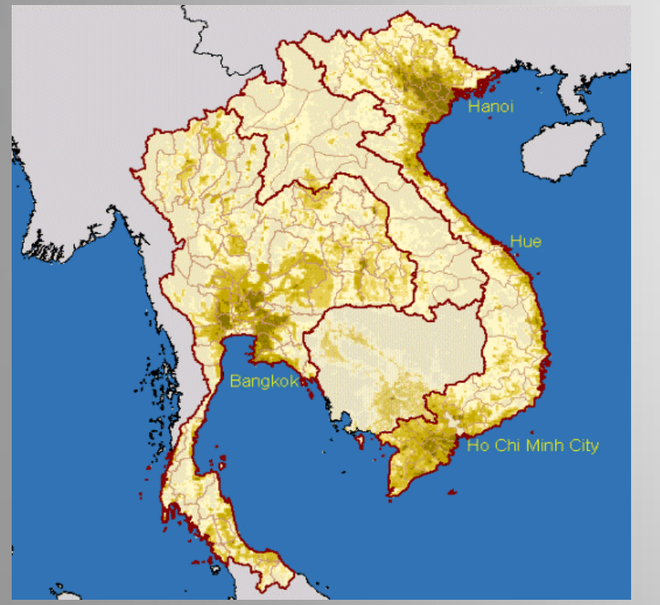
**Environmental efficiency**

***Cities rarely contribute to the production of their food. Generally, they simply consume it.***

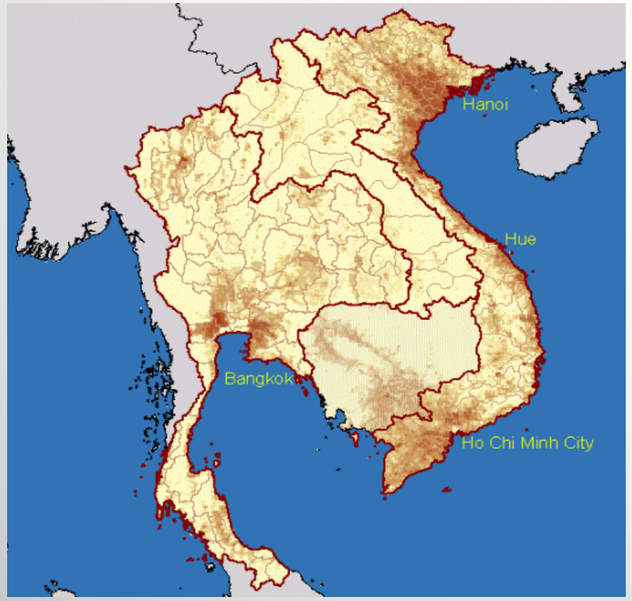
Mauro Ghirotti (1999)

## Urban and peri-Urban Concentration

**Poultry**




**Swine**




Jimmy Smith et al (2012); source: FAO/LEAD

- Productivity must increase
- Logistics of urban food supply
- Intensive production close to cities
- **Must be environmentally friendly**

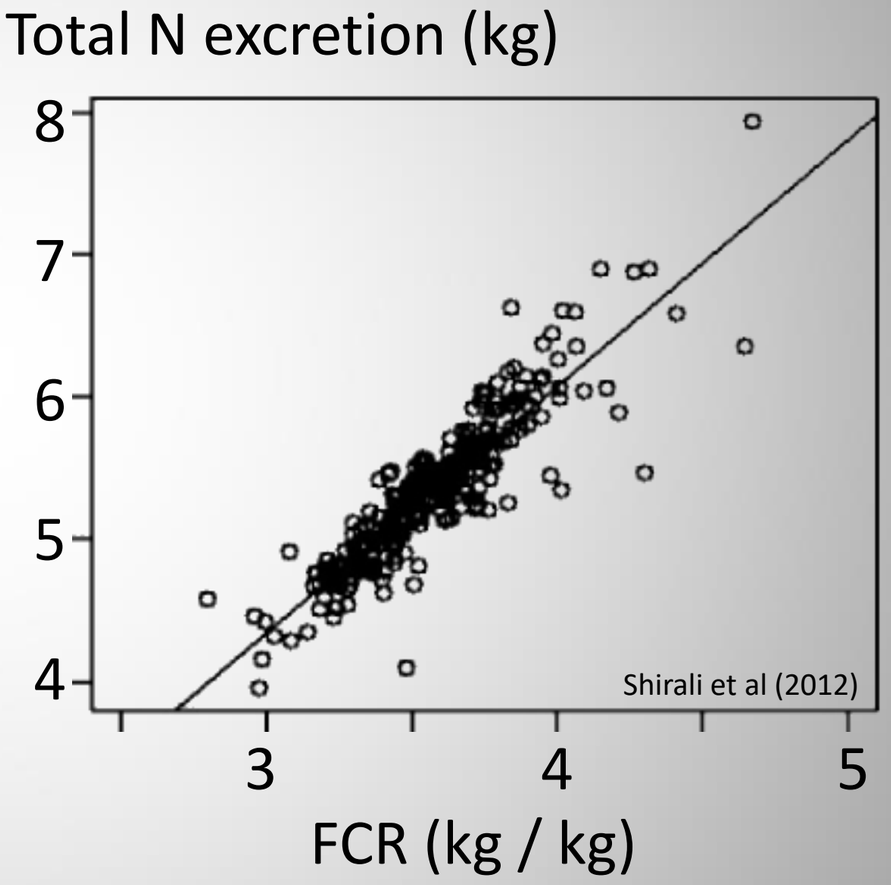
# What can animal breeding contribute to improving efficien

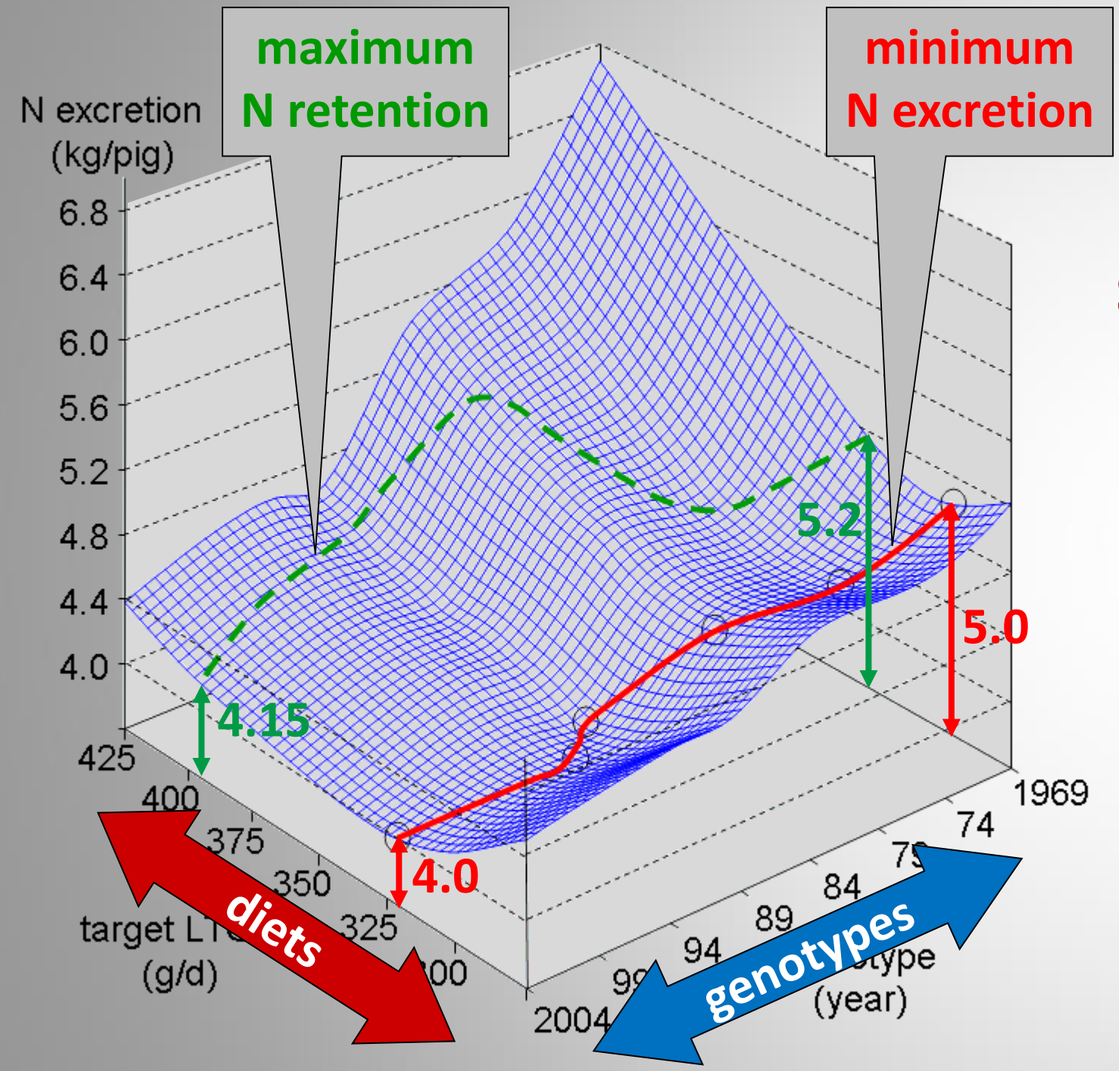
**Resource efficiency**

Feed efficiency

Losses

**Environmental efficiency**






# Genetic improvement reduces nitrogen excretion of pigs

**selection for lean tissue growth rate (= N retention) has reduced …**

- **… N excretion per 120-kg pig from 5.0 to 4.0 kg = by 20 % in 35 years**
- **… N excretion per kg N retention by 25 % in 35 years**

**… when fed to minimum excretion**

Knap (2012)

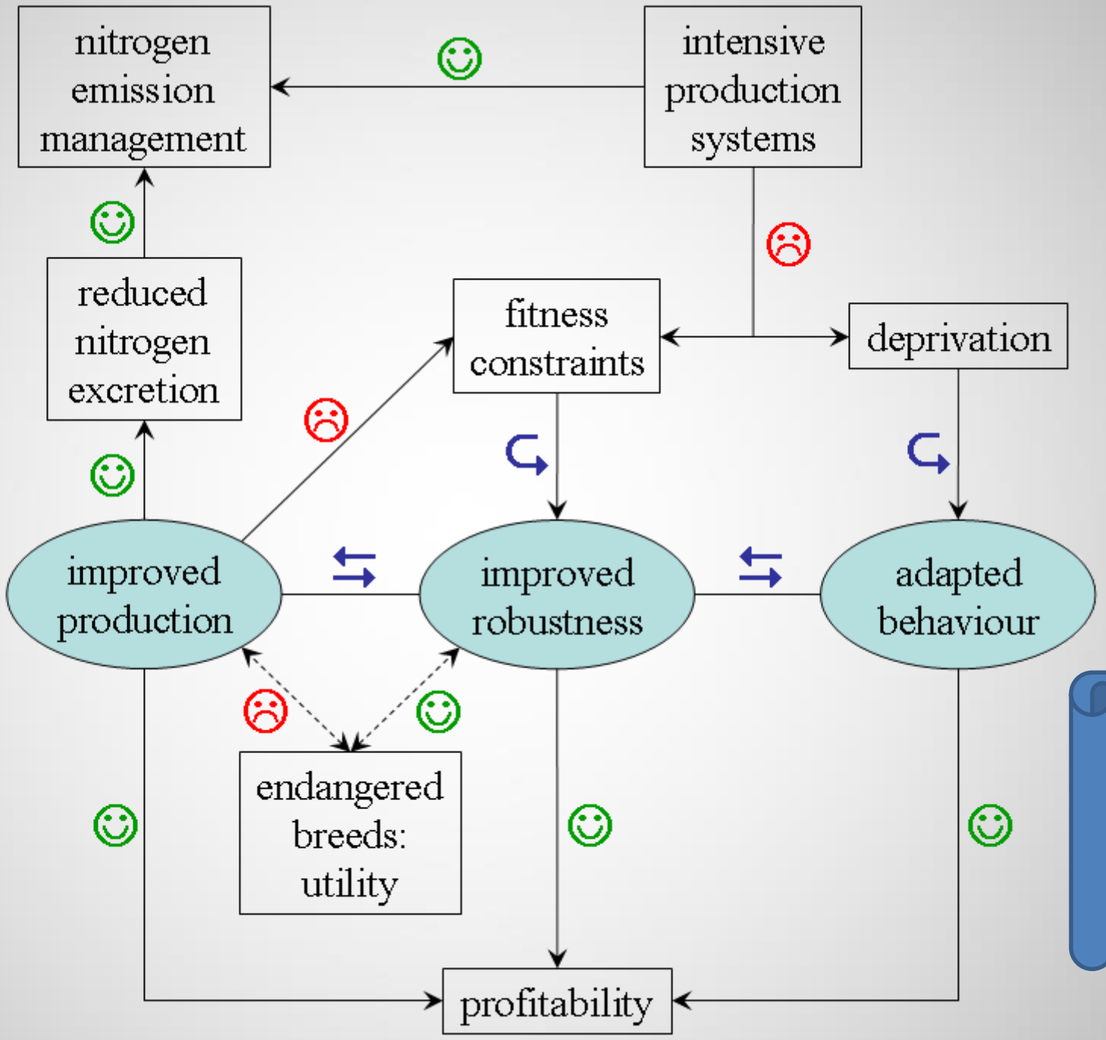
# What can animal breeding contribute to improving efficiency?

- A lot …
- … and much of the environmental efficiency improvement is happening as a side effect.
- Can be targeted more explicitly …
- … but that will require a clear economic value.
- Shadow prices of greenhouse gases.  Coming up now, in USA.

# improve sustainability

**Trade-offs between sustainability elements.**

# Trade-offs between sustainability elements.




Besbes

Knap (2012)

# How animal breeding can contribute to sustainable pig production

Pieter Knap

August 2018