

Global protein scarcity – is meat a part of the solution?



VetAgro Sup

HOCQUETTE Jean-François

Thanks to

PEYRAUD Jean-Louis

MOLLIER Pascale

BONNY Sarah

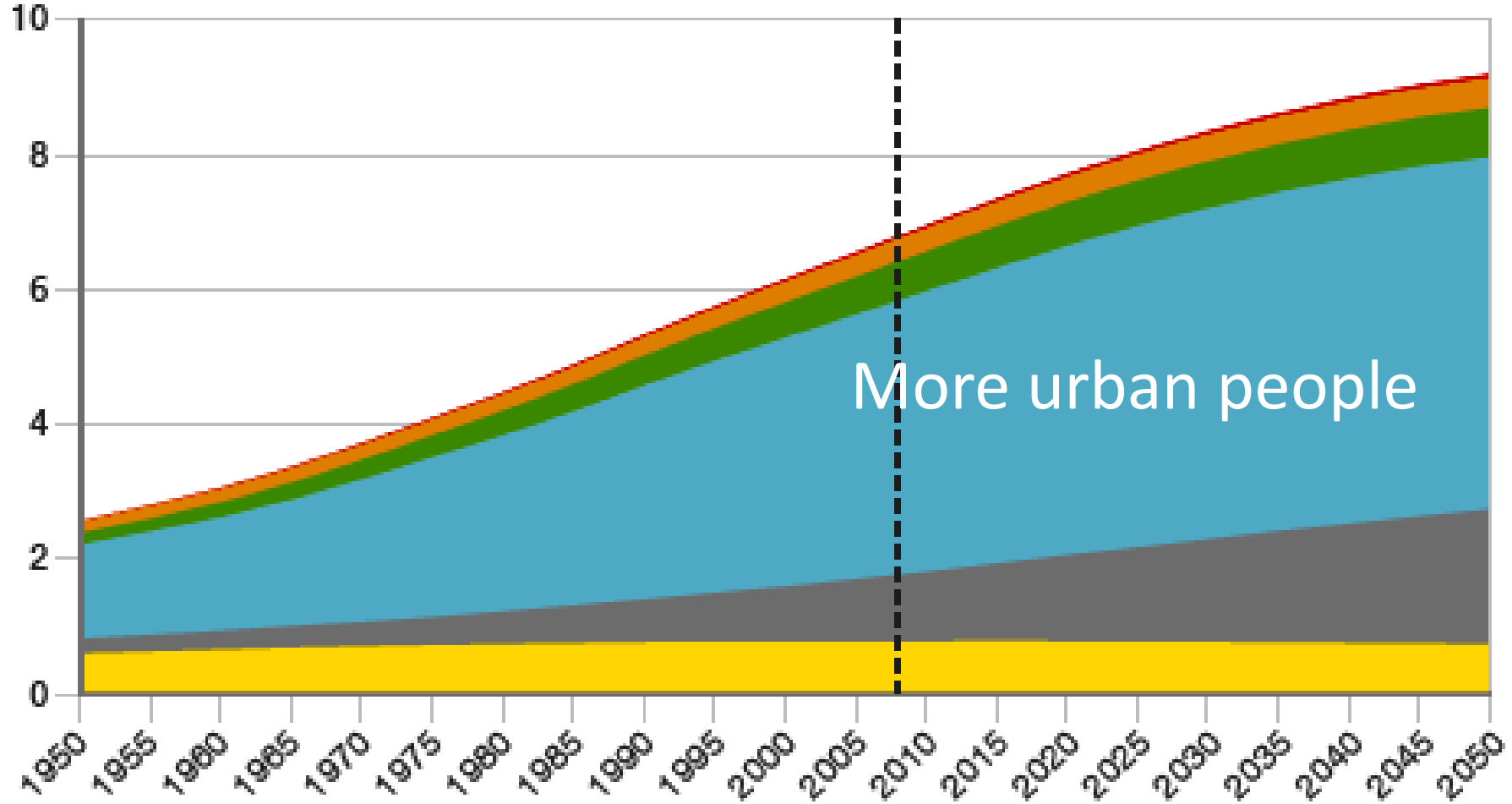


**Inra, UMR Herbivores, 63122 Theix, France,
jean-francois.hocquette@inra.fr**

The world's rising population, 1950-2050

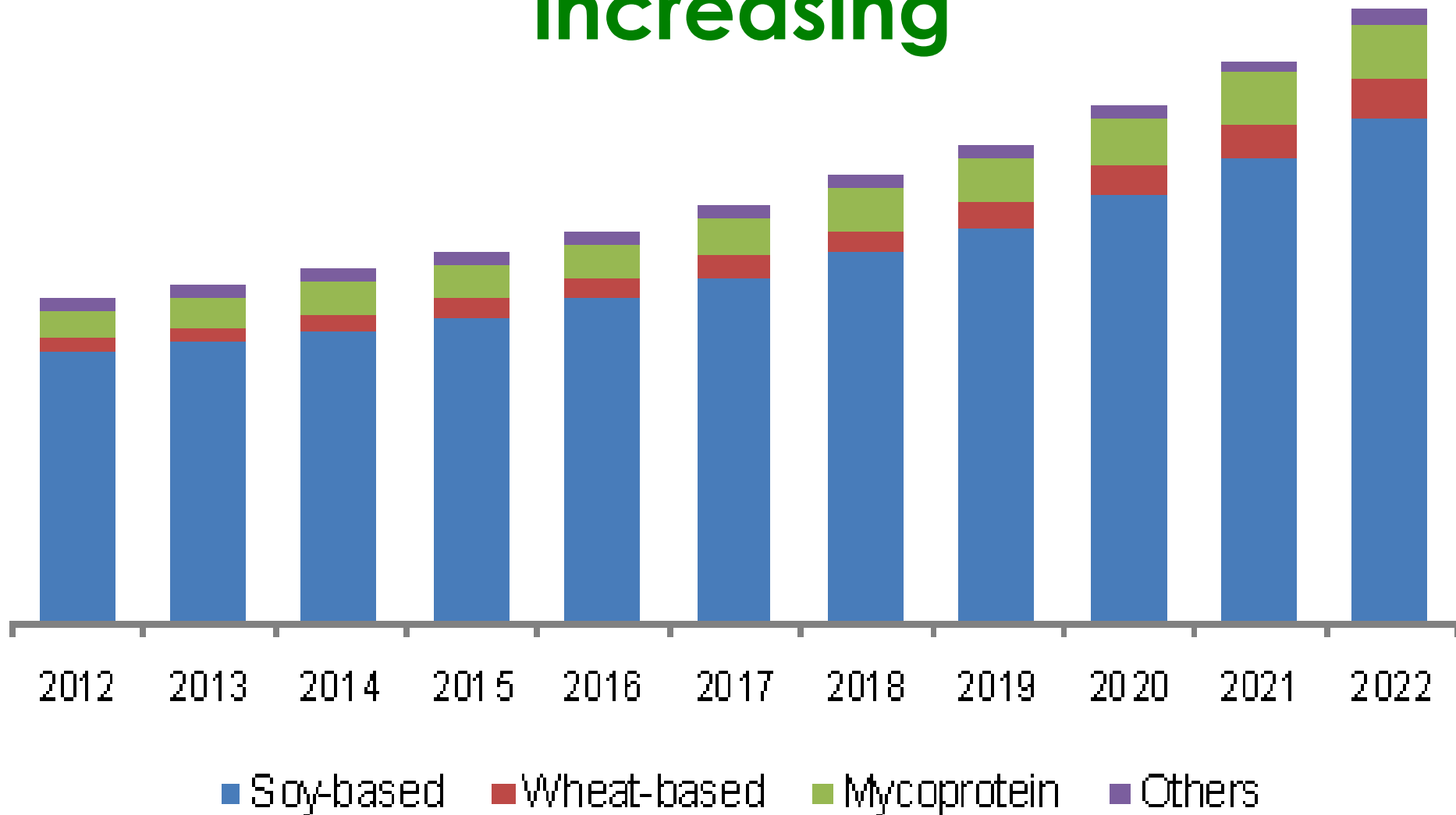


Billion



SOURCE: UN

The meat substitutes market is increasing



The problem to solve

Nowadays, the livestock and meat sectors are facing new and important challenges:

- their **environmental impact** and role in global climate change;
- balancing the need for **increased production** of animal products (to satisfy the increasing human population) coupled with a lower footprint,
- and addressing societal needs in terms of **animal welfare** and **product quality** for the consumer

The meat of the future? Cultured meat

HOW THE BURGERS ARE GROWN

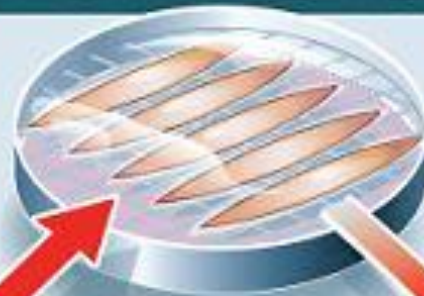
1 Tissue is taken from cow



2 Stem cells are extracted from the tissue



3 Stem cells are then grown into muscle fibres in the lab in six weeks



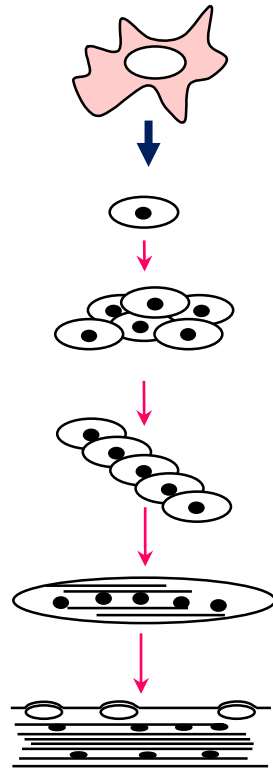
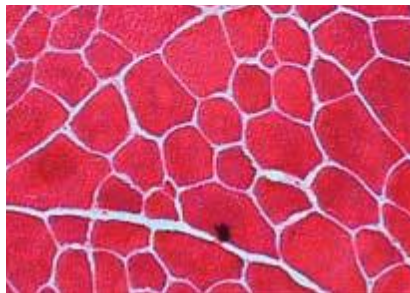
4 20,000 muscle fibres are then coloured, minced, mixed with fats and shaped into burgers



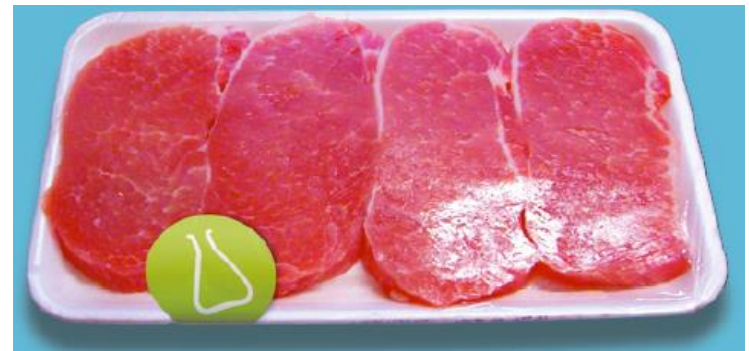
The meat of the future?

Cultured meat

Stem cells are cells with a large capacity for multiplication to produce muscle



MUSCLE FIBRE



Source: Post, 2012

The first artificial steak

Mark Post: « In seven years, you'll eat in vitro meat. »



On August 5, 2013, Prof Mark Post of Maastricht University presented a burger made from Cultured Beef in front of an invited audience in London. This was acknowledged by the World Technology Network when M Post received the World Technology Award for Environment on 15 Nov 2013. This burger costed €250,000. It was paid at least in part by Google co-founder Sergey Brin.

Bill Gates and Richard Branson Embark on the Business with Artificial Meat (August 30, 2017). They chose to invest capital in the new Memphis Meat Company.

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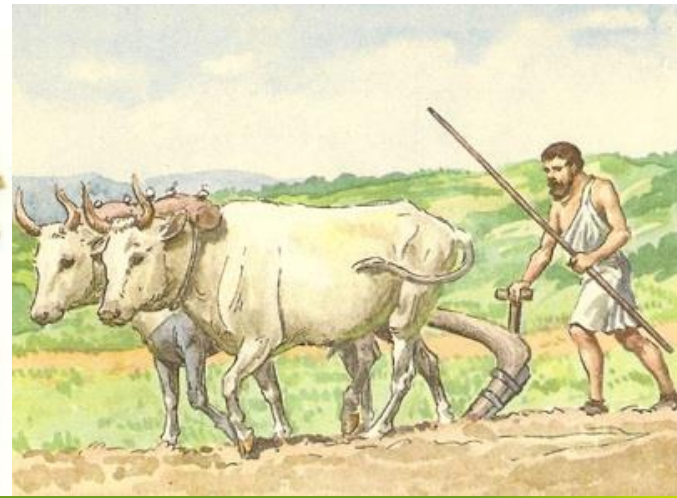
Meat consumption in human history

Human beings are omnivores

Human beings were eating meat as early as 1.5 million years ago. The main problem was to ensure enough food (energy and proteins).

A vast majority of human beings (> 90%) eat meat

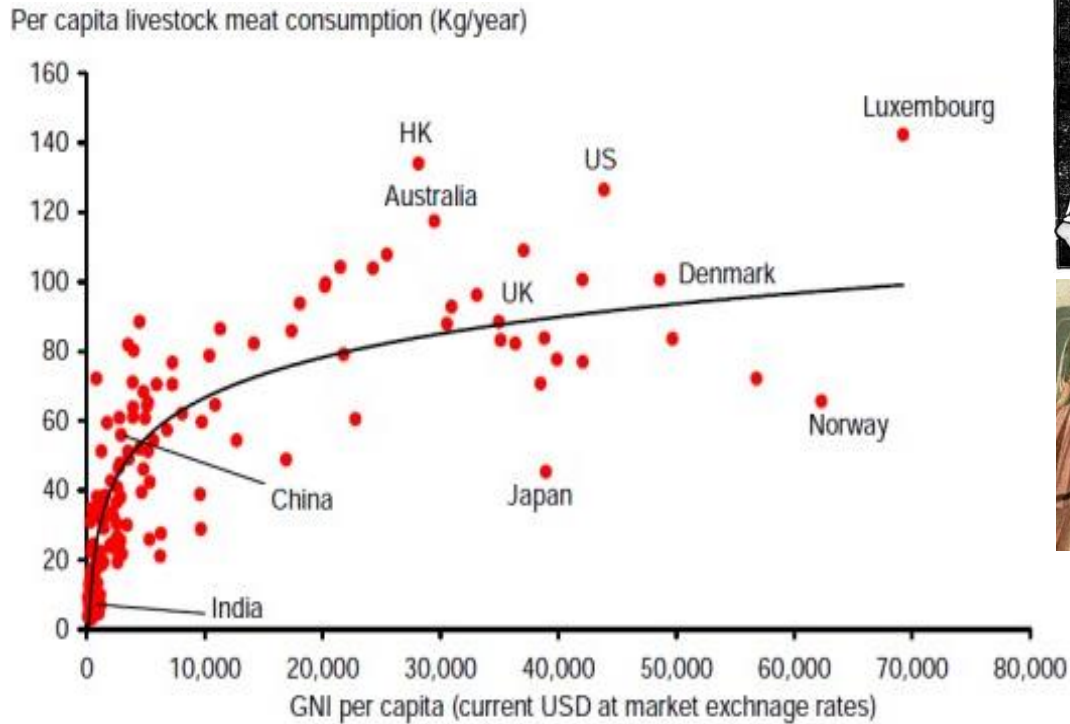
Farm animals are today well adapted to life with humans, and cannot simply return to the wild world without suffering



Drivers of meat consumption

The meat drivers are incomes and prices.

Meat consumption, as language, beliefs, religion, lifestyle (etc) is an element of culture and identity of social groups

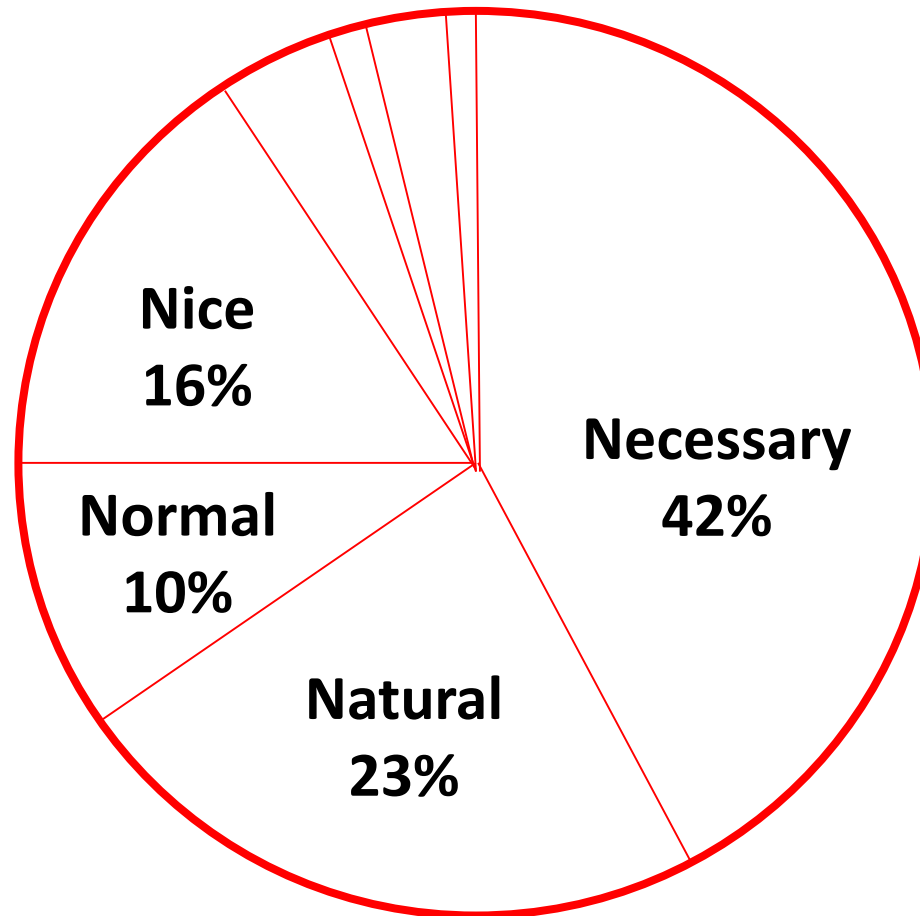


We eat meat because it is necessary, natural, normal and nice (4Ns)

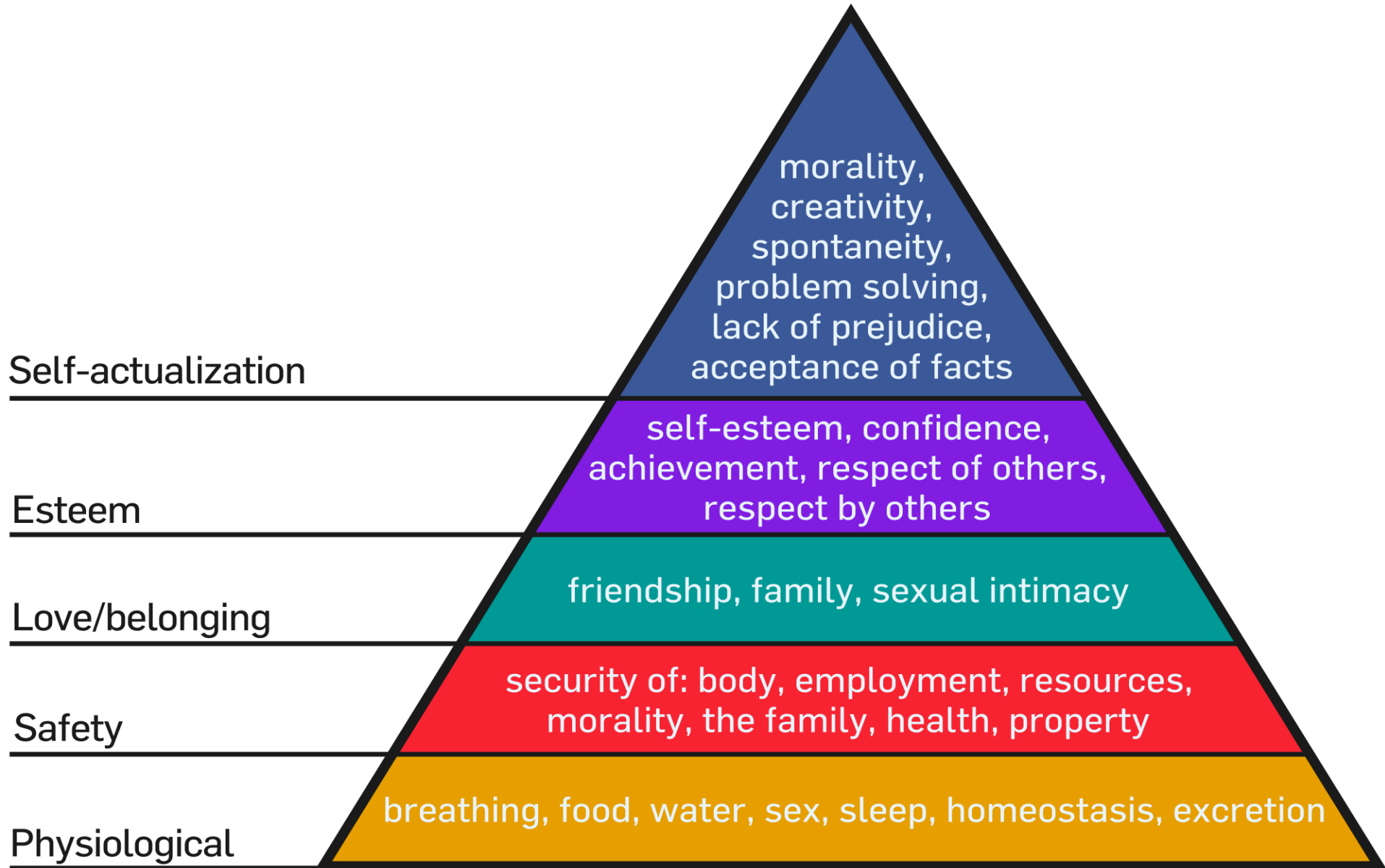
Eating meat is a pleasure

Humans have been eating meat for a long time

Meat provides proteins

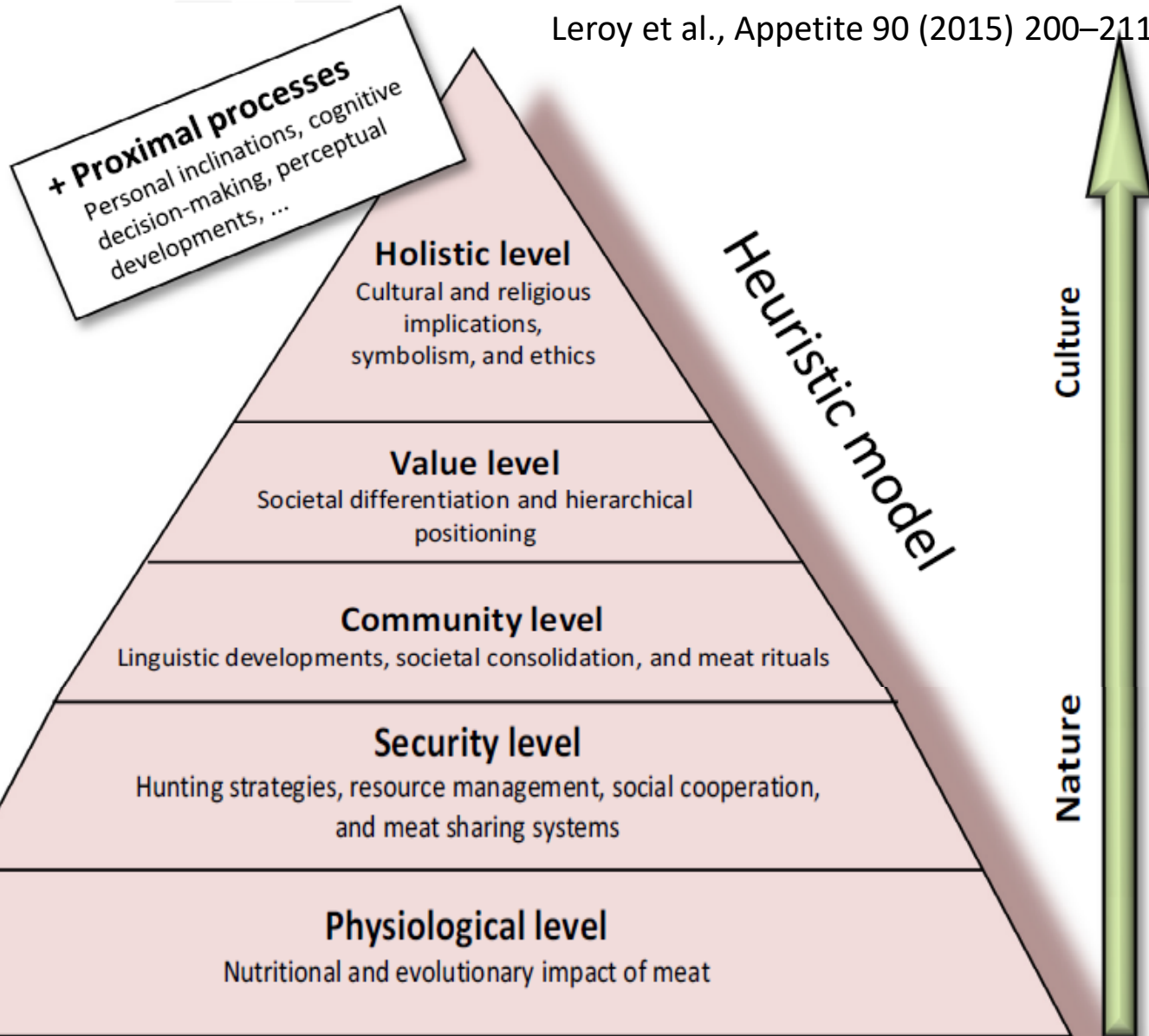


Maslow's hierarchy of needs



Meat traditions: the co-evolutions of humans and meats (based on Maslow's hierarchy of needs)

Leroy et al., Appetite 90 (2015) 200–211



The co-evolutions of humans and meats

Leroy et al., 2017, ICoMST

Reciprocity

Hunter-gatherers

- Collective hunting
- Meat is needed for sustainability
- Hunting and sharing rituals are key
- Animals as “subjects”

Ritualism

Domestication

- Frequent human-animal interactions
- Meat-eating is a rare trait
- Celebrative and sacrificial character
- Animals as “subjected”

Dissimulation

Postdomestic societies

- Production is outsourced and hidden
- Abundant meat-eating
- Removal of references to the animal
- Animals as “objects”

Confrontation

Impact and trends

- Animal welfarism
- Story meat (happy meat, metier, and crowd butchering)
- Hobby farming, home slaughter
- Neo-animalism, ritualism
- Cultured meat, pain-free meat, and entomophagy
- ‘Meatless meat’, meat avoidance

Confrontation

Disgust



Global protein scarcity – is meat a part of the solution?



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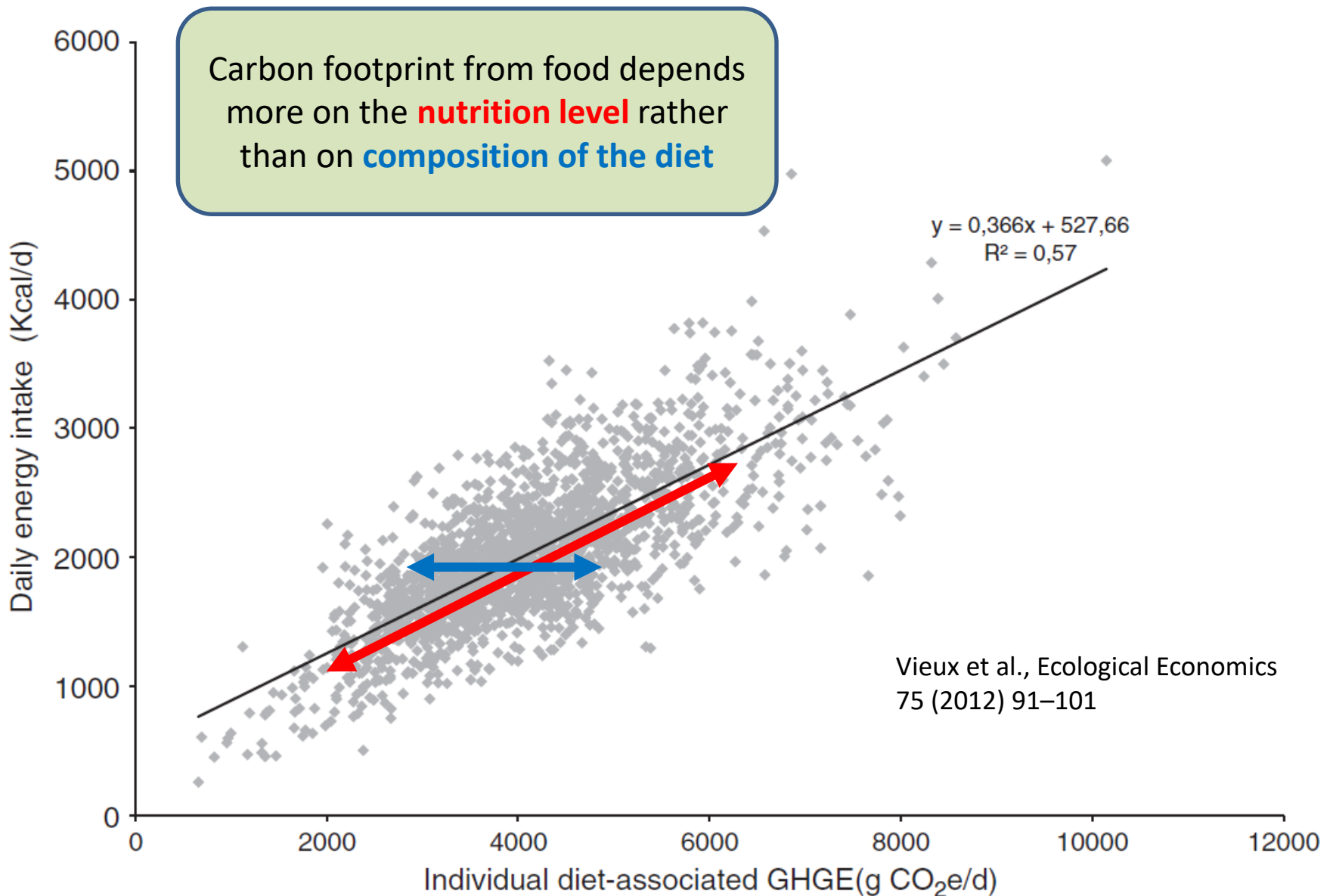


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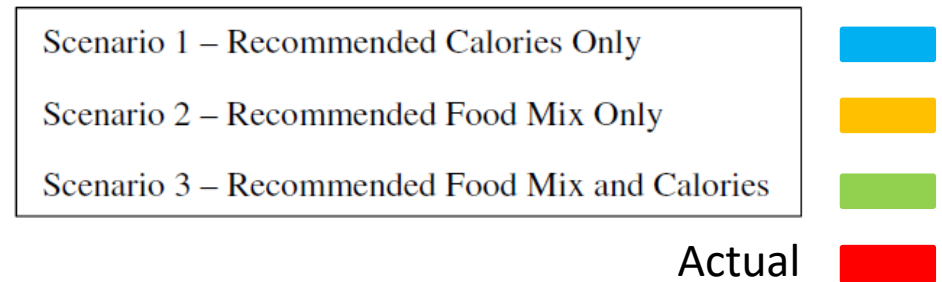
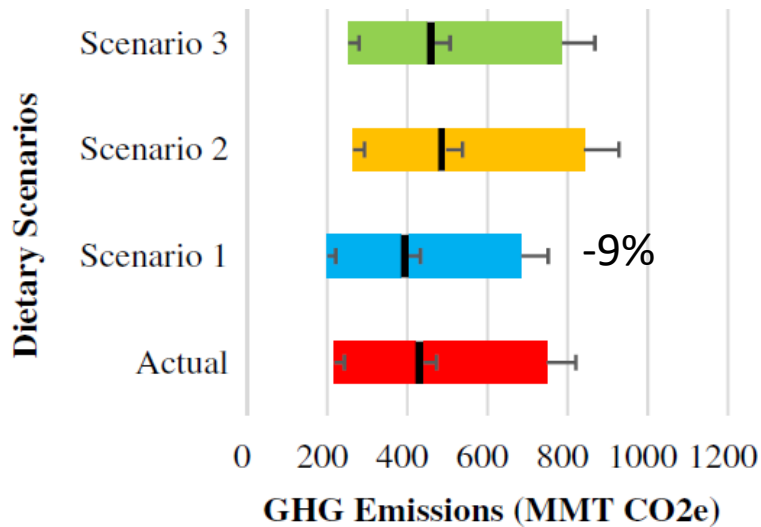
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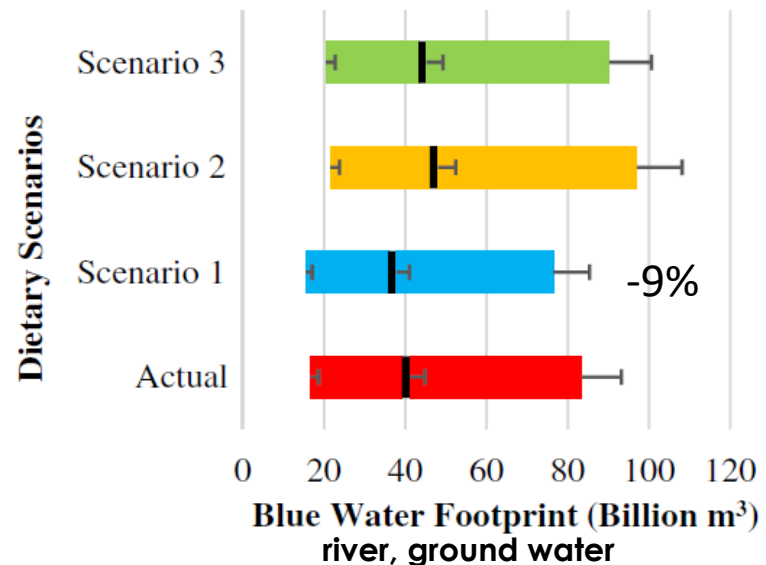
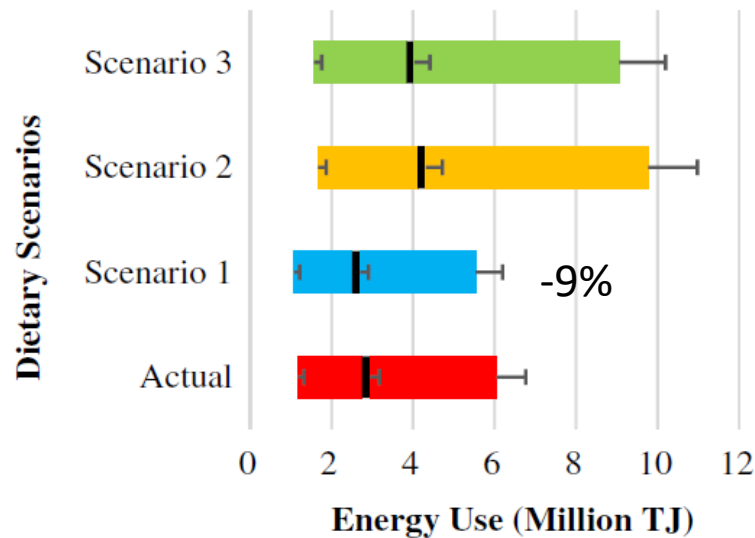
Human diet and carbon footprint



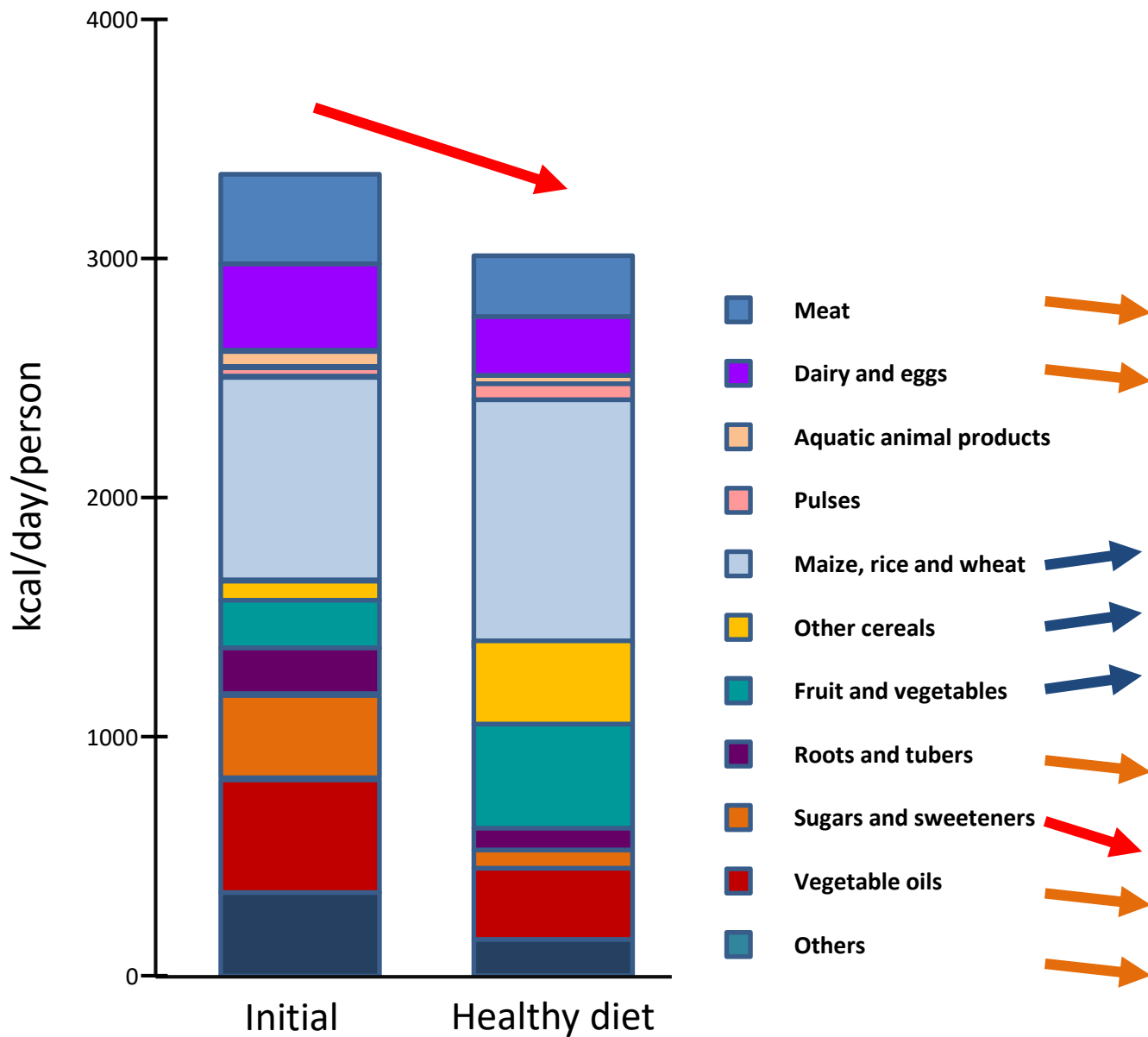
What happens if we follow dietary guidelines ?



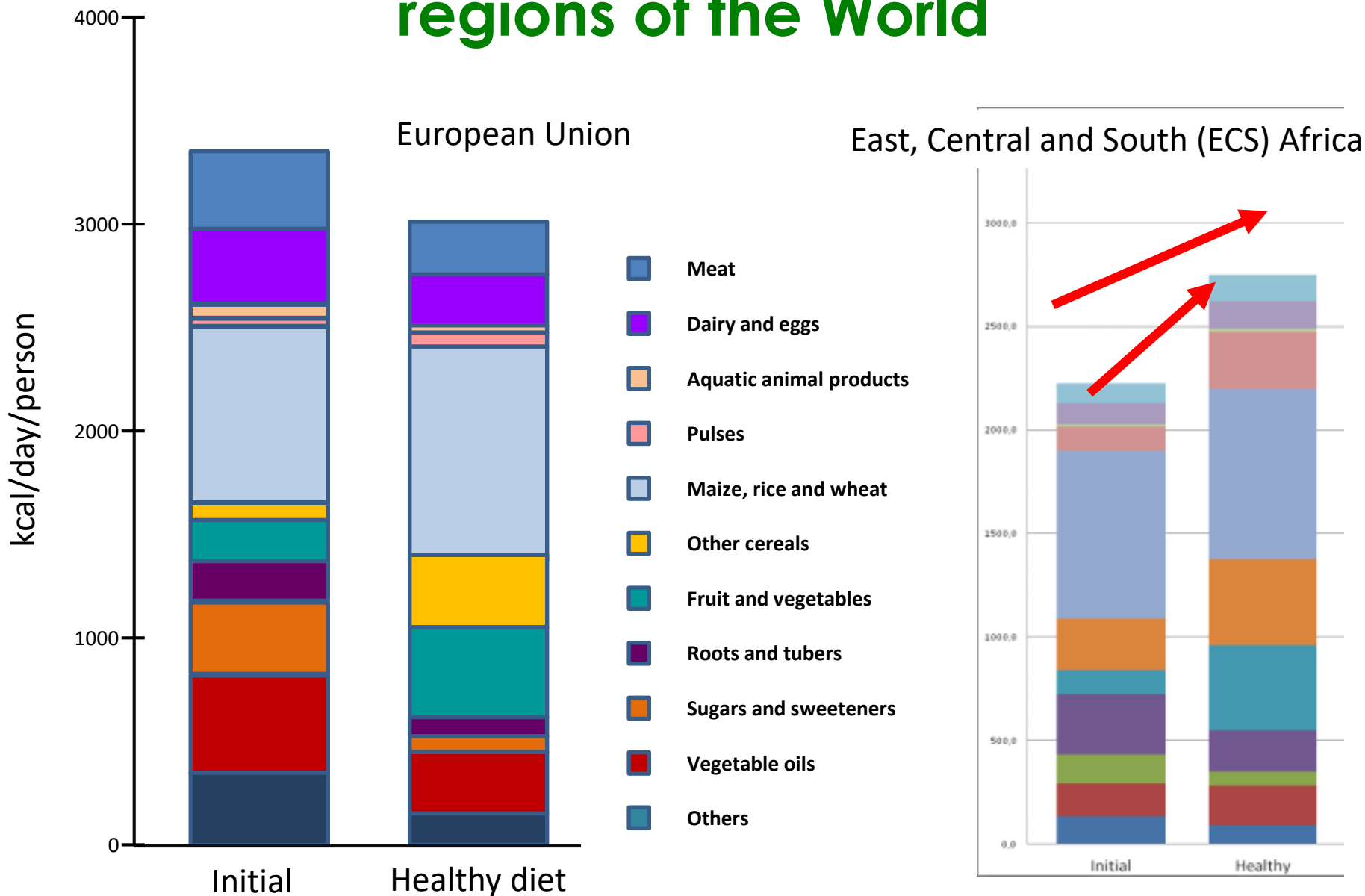
Tom, et al (2016). Environment Systems and Decisions, 36, pp 92–103



The recommended healthy diet in Europe



The recommendations vary according the regions of the World



Please consider the overall eating pattern, not one part of the diet, and eat a reasonable amount a variety of foods

How to Choose Healthy

Don't Eat This!

White Bread

White Rice

Fried Fish Sticks

Spare Ribs

Sausage

Double Cheeseburger

Pepperoni Pizza

Low in Fiber

Oily!

Lots of Fat

Full of Sugar!

Soda

Juice

Eat This!

Green Beans

Spinach

Water

Orange

Banana

Apple

Carrots

1/2 vegetable

Full of Vitamins

Fat-Free Milk

Calcium for Your Bones

Helps You Grow

1/4 protein

Full of Fiber

1/4 starch

Oatmeal

Whole Wheat Bread

Low-fat Yogurt

Low-fat or Natural Peanut Butter

Cheese

Egg

Yams

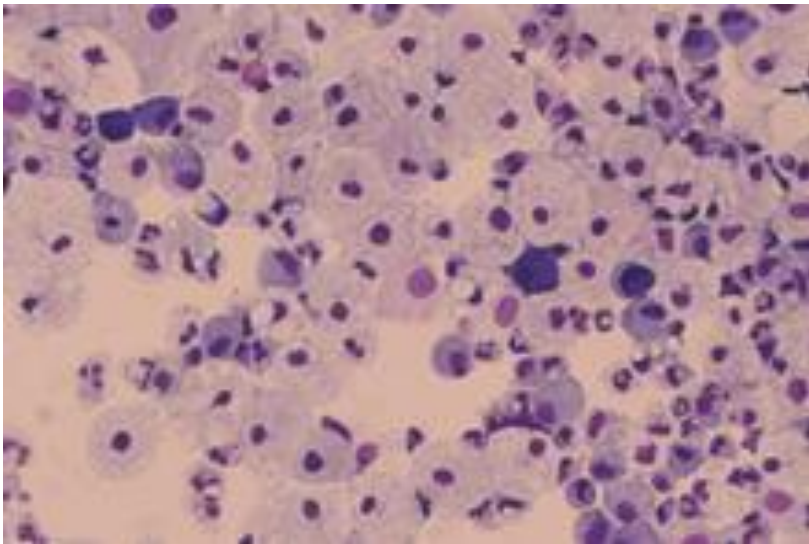
Corn

Whole Wheat Veggie Pizza

Beans

Nutritional issues with stem cells

Stem cells are the basis for artificial meat production



There is concern about **genetic instability** of cells due to the high number of proliferations **(i.e. cancer cells)**

The co-culture of muscle, adipose and other cells **to reproduce muscle tissue in its complexity remains a major technological challenge** to be overcome

Nutritional issues with cell culture



Numerous nutrients (carbohydrates, amino acids, lipids, vitamins...), growth factors (TGF β , FGF, IGF) **and hormones** (insulin, thyroid hormones and/or growth hormone) **are necessary** to culture the cells and to allow them to proliferate and differentiate.

All these compounds will have to be prepared by the chemical industry, **which raises nutritional issues.**

Currently, **stem cells are conventionally cultured in a medium containing antibiotics and fungicides for safety** as well as **fetal bovine or newborn calf serum**. The precise nature of the composition of these serums is unknown.

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How many kg of plant proteins to produce one kg of meat: calculation with total proteins

adapté de Bradford et al., 1999 par Peyraud, 2016

	Pork		Chicken		Beef	
	Total proteins		Total proteins		Total proteins	
Argentina	14		3,3		50	
Egypt	10		4,2		50	
South Korea	6,3		2,9		17	
USA	5,3		3,2		12,5	

Conclusions from these figures: it is better :

- 1) to eat plant proteins (it is more efficient) than animal proteins
- 2) to avoid beef

as said by vegetarians, vegans and proponents of artificial meat.

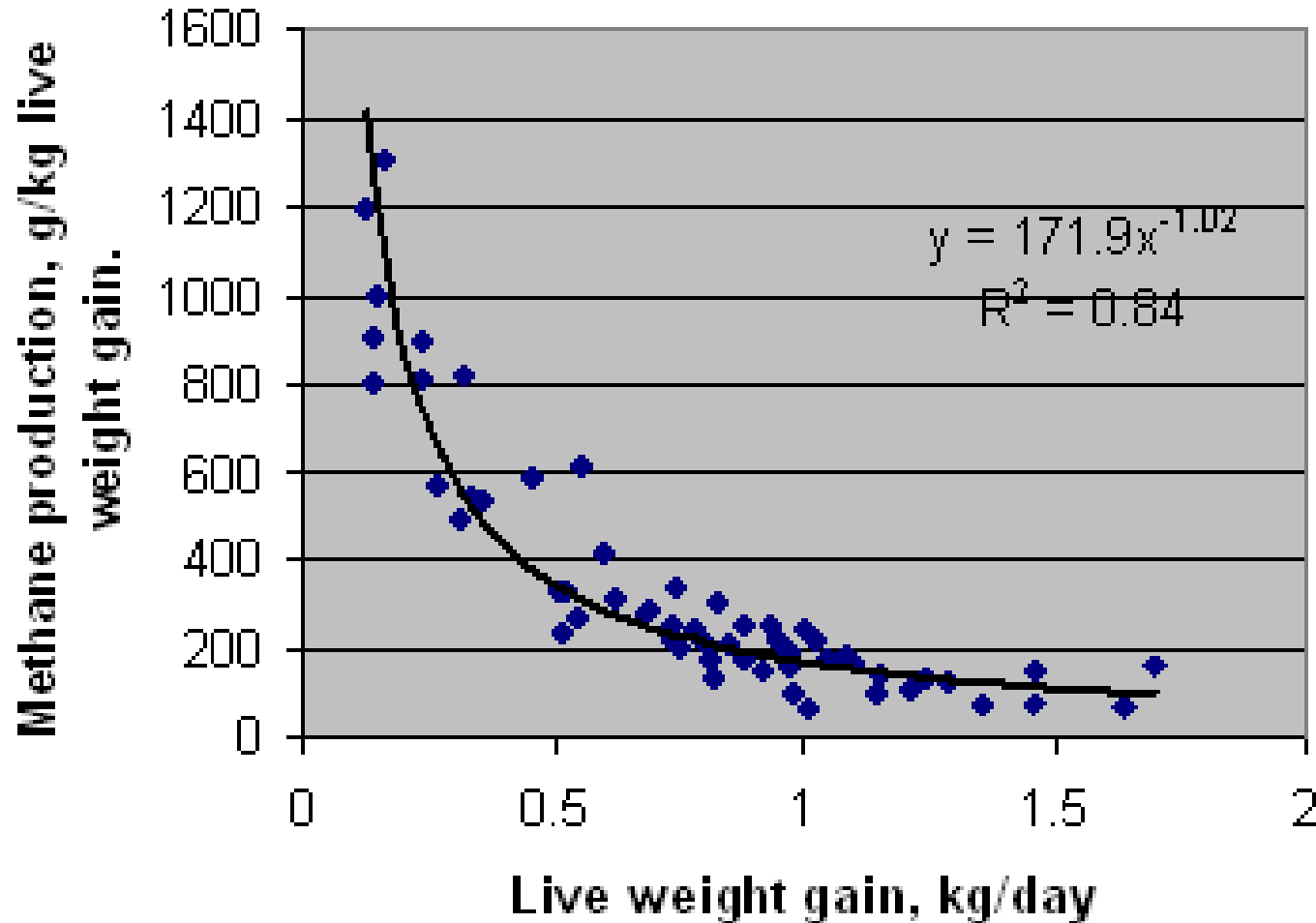
Adapté de Peyraud, 2016. <http://www.viandesetproduitscarnes.fr/index.php/fr/775-l-elevage-contribue-a-la-production-durable-de-proteines>

How many kg of plant proteins to produce one kg of meat: calculation with edible proteins

	Pork		Chicken		Beef	
	Total proteins	Edible proteins	Total proteins	Edible proteins	Total proteins	Edible proteins
Argentina	14	9	3,3	1,4	50	0,16
Egypt	10	2,3	4,2	0,6	50	Tends to zero
South Korea	6,3	2	2,9	0,96	17	0,15
USA	5,3	3,4	3,2	1,6	12,5	0,8

Conclusions from these figures: Ruminants are efficient to convert plant proteins into animal proteins: 80% of food consumed by cattle is not consumable by humans. Therefore, you may consider that **it is better to eat beef.**

Beef cattle with the highest growth rates produced less methane per kg of meat



Reduction of food waste and losses is an important issue



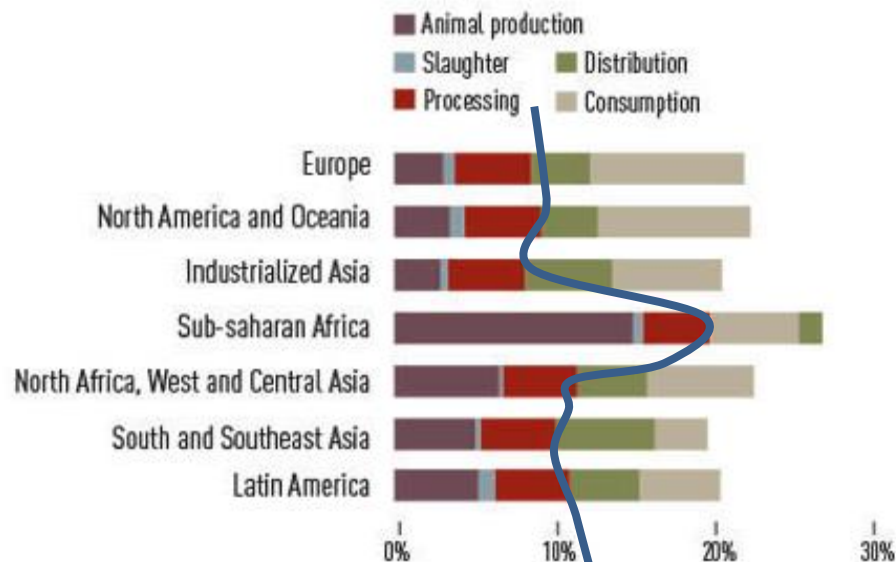
**20%
MEAT
FOOD LOSSES**

Of the 263 million tonnes of meat produced globally, over 20% is lost or wasted.



This is equivalent to 75 million cows.

Almost 4 times the French herd



Production

Distribution and consumption

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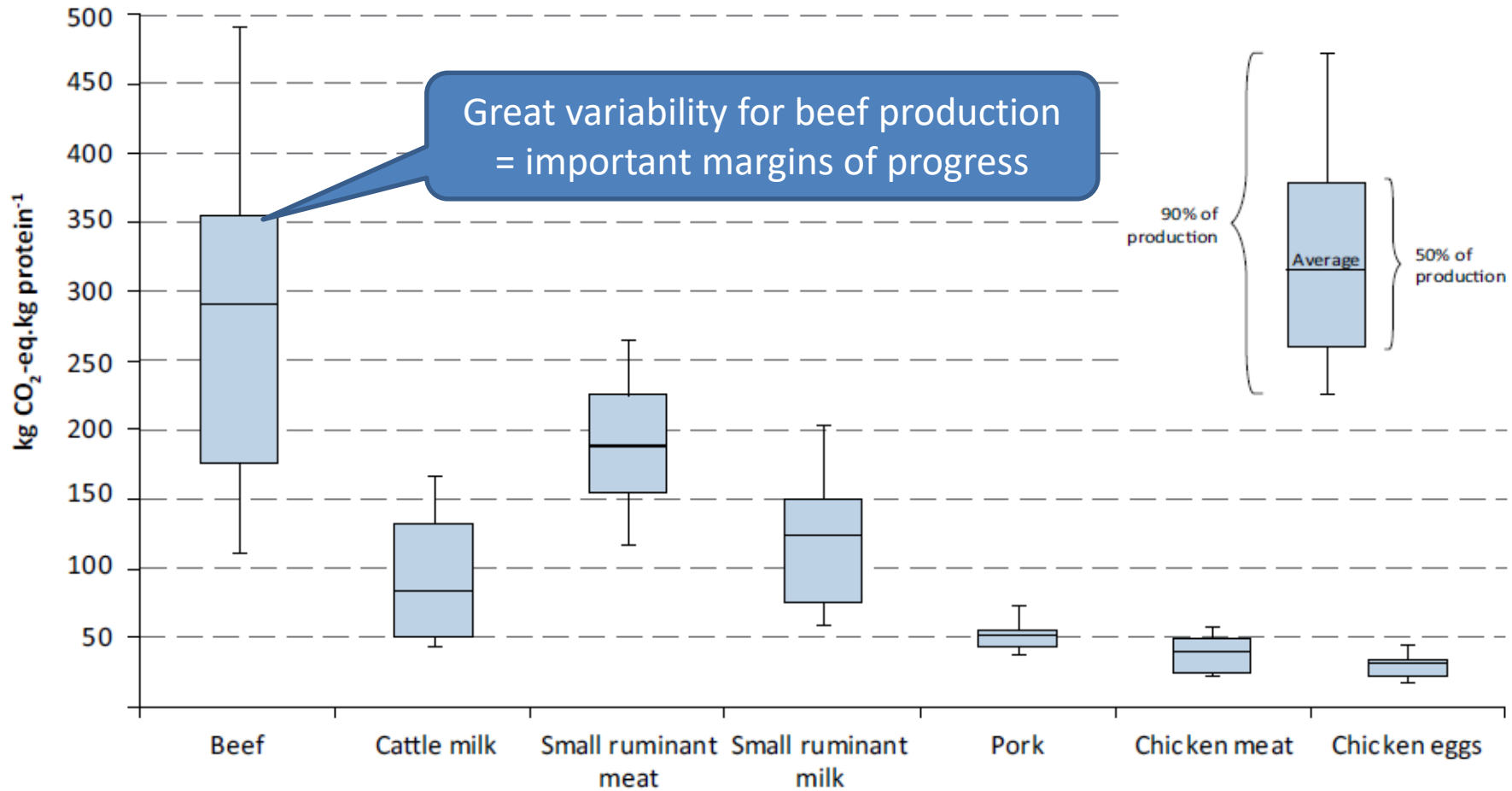


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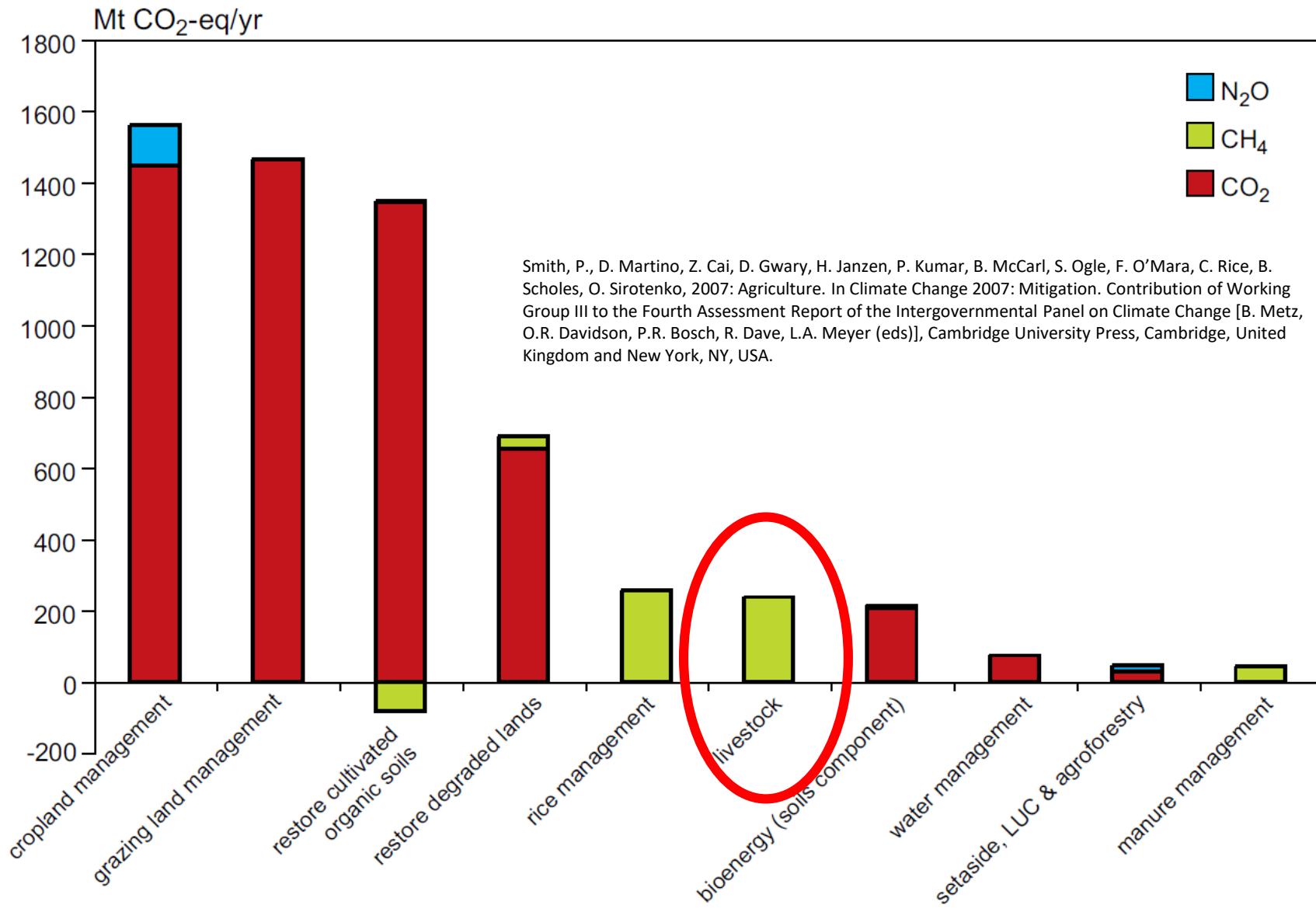


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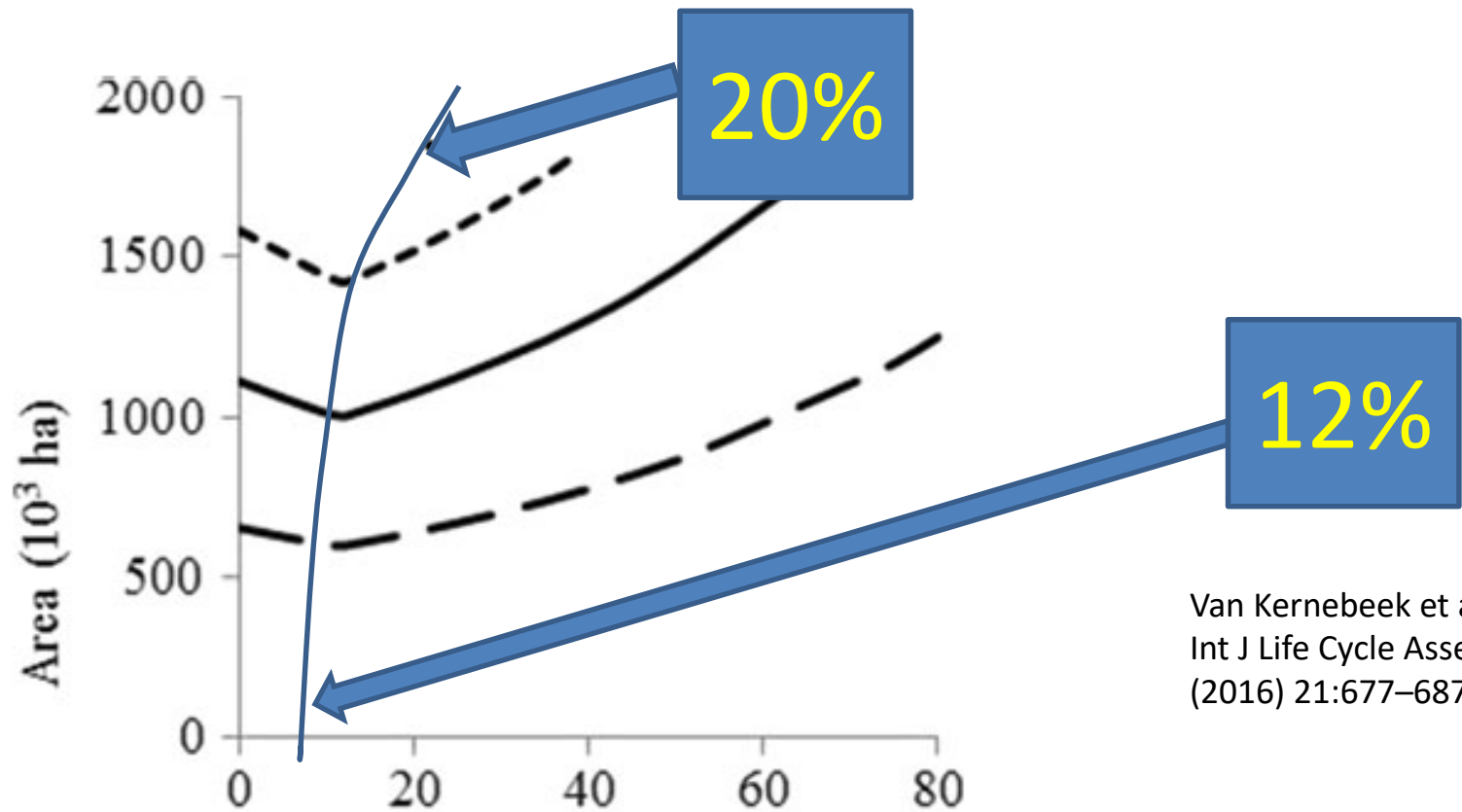
Yes, livestock supply chains are a contributor to GHG emissions



Where are margins of progress to reduce GHG emissions ?



Minimum land (10^3 ha) needed for feeding the total Dutch population with diets varying in % of dietary protein from animals

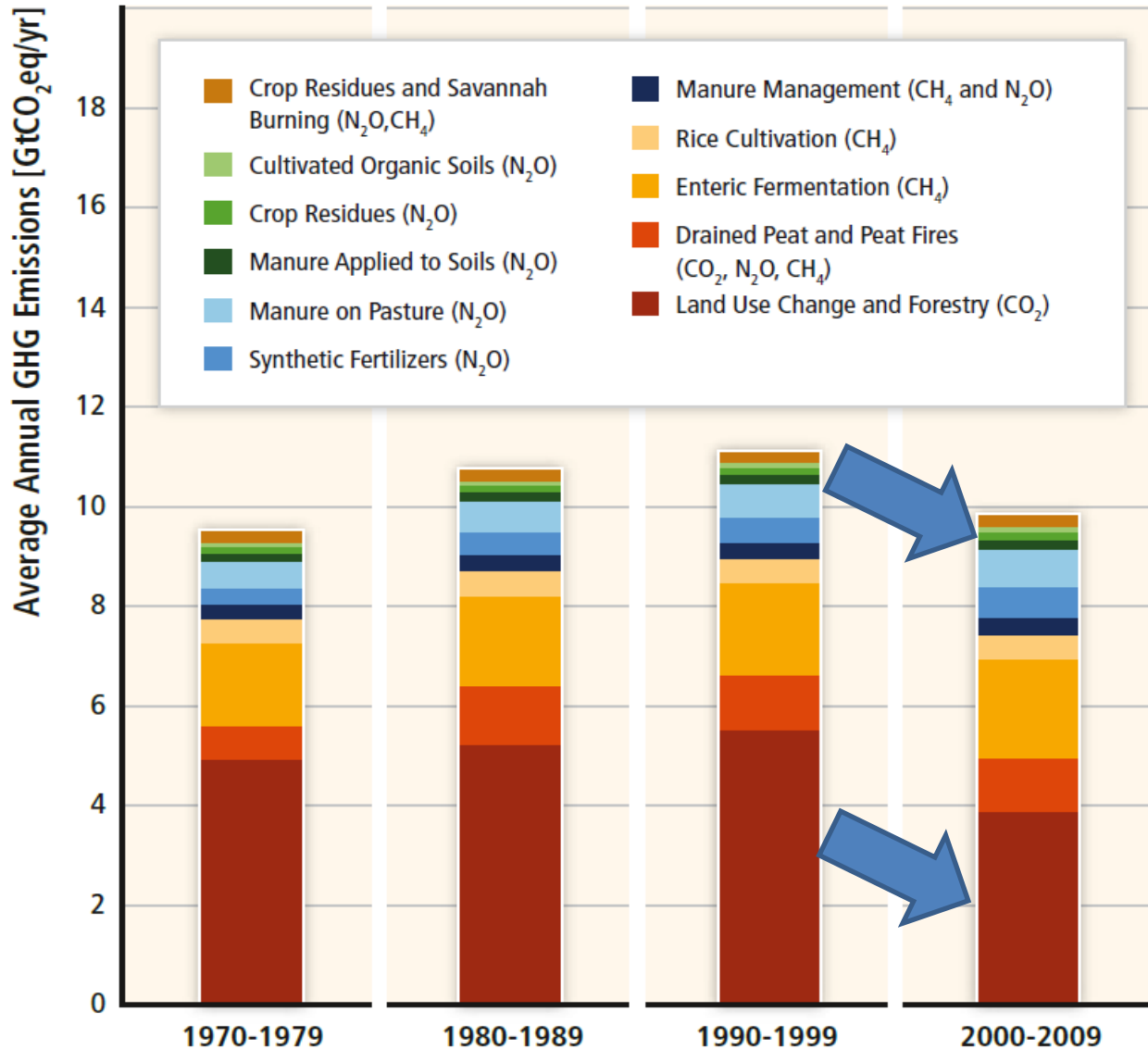


Van Kernebeek et al.,
Int J Life Cycle Assess
(2016) 21:677–687

% of animal proteins in human diet (dairy and meat)

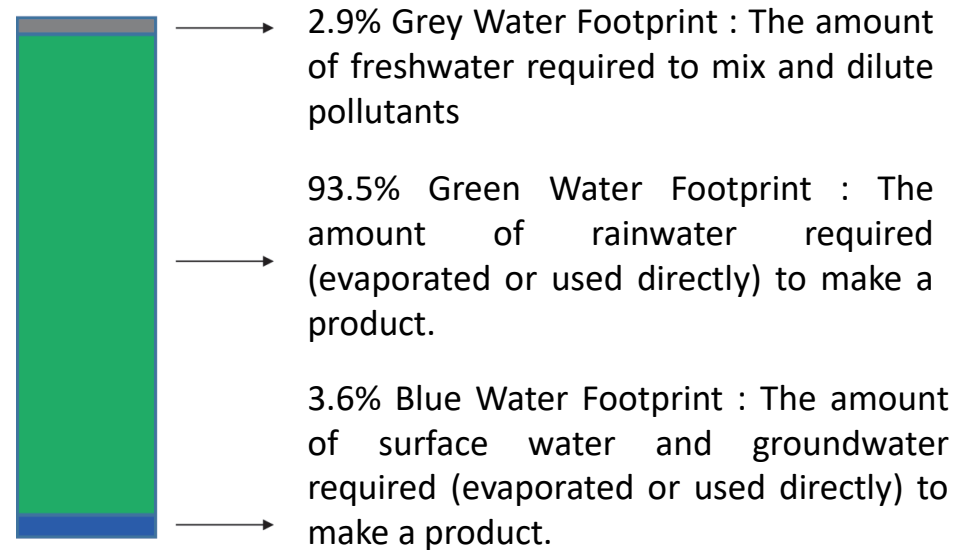
- 15 Mill.
- 25 Mill.
- - - 30 Mill.
- 41,3 Mill.

Improvements in conventional meat production in terms of GHG emission



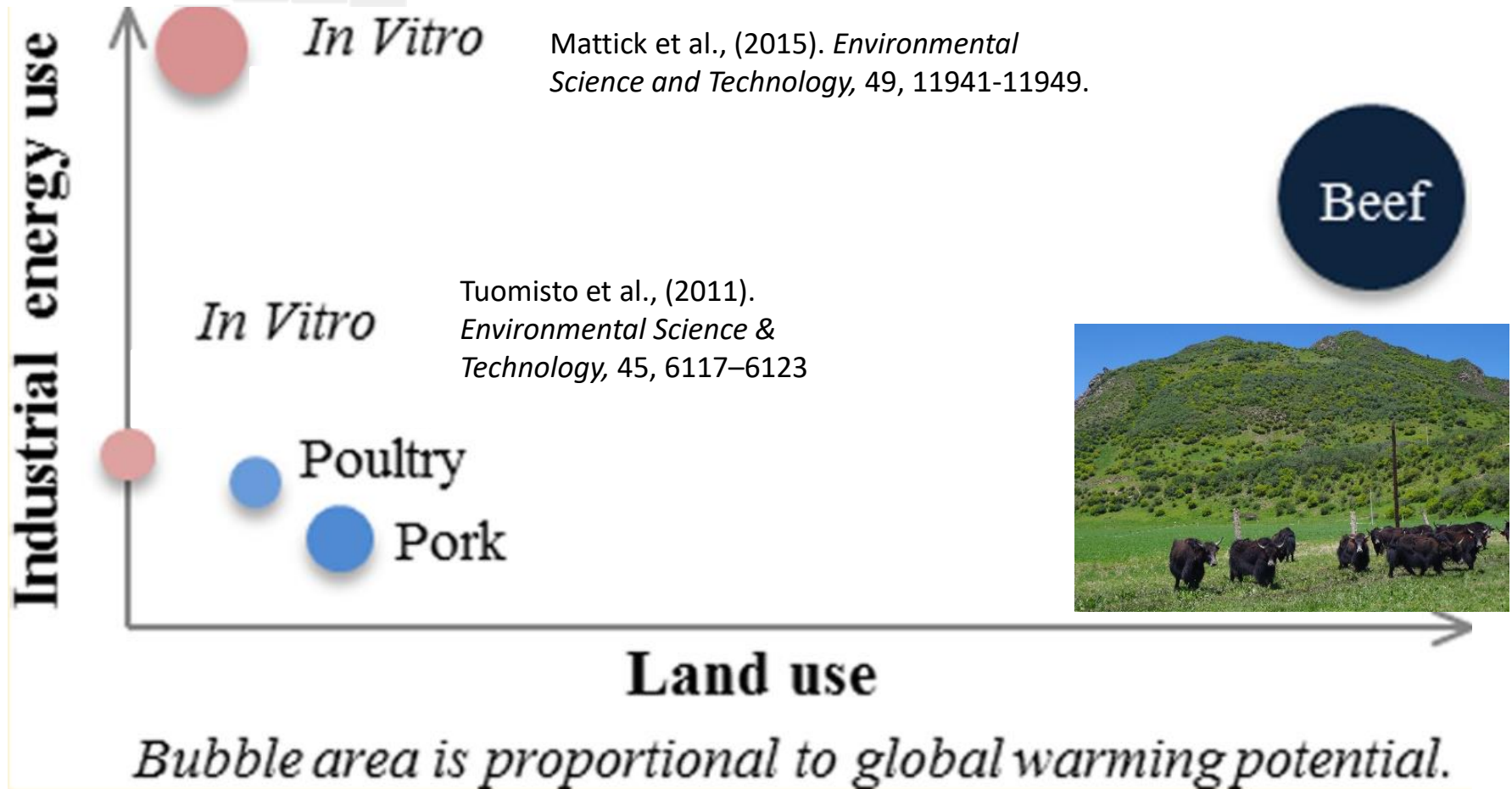
Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E. A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N. H. Ravindranath, C. W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Water consumption



Kg water/ Kg	Green water	Blue water
Beef	14 400	150 - 550
Cereals	1600	200
Pig	4 907	450
Poultry	3 545	313
Milk	860	10 - 200

Is artificial meat better? (not sure)



Artificial meat production is likely to use a lot of energy

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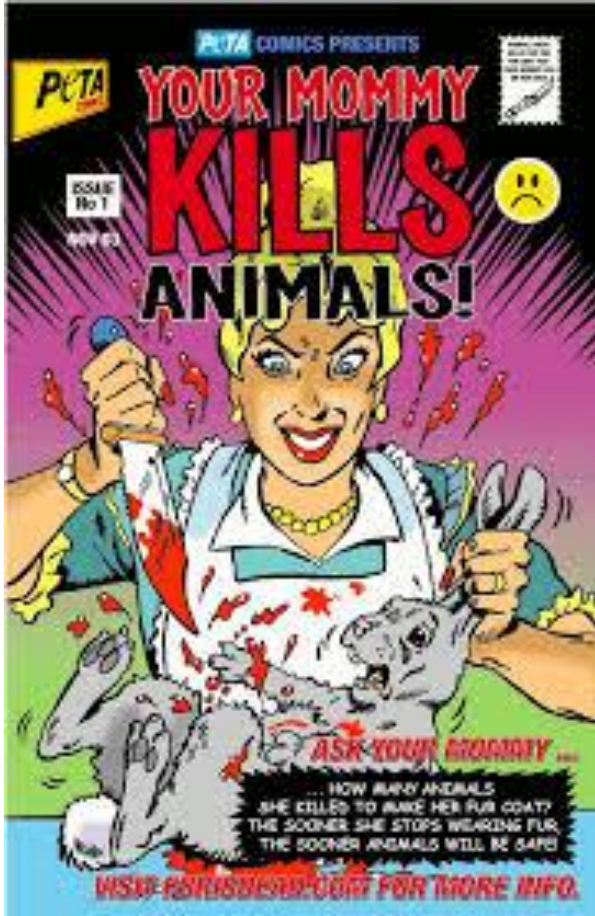


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Meat: a social issue?

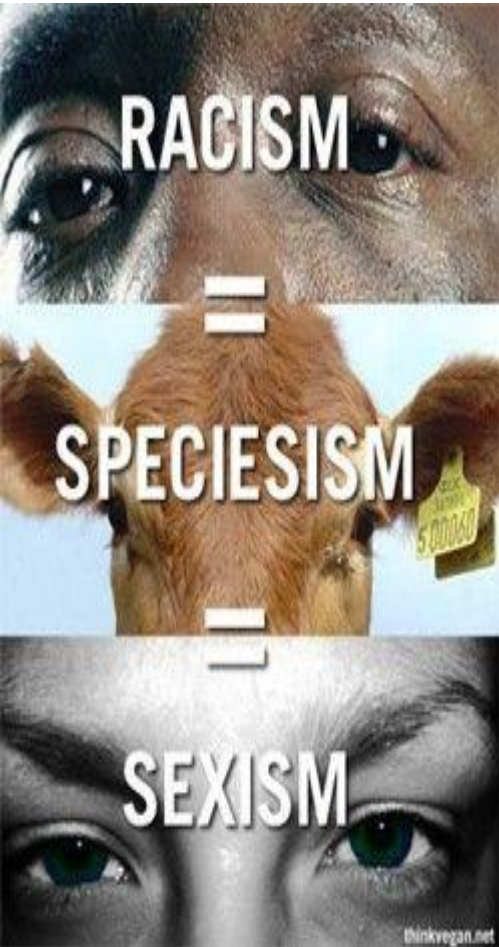


Pamela Anderson



Should we still eat animals?

Do we have the right to kill animals to eat them?



The philosophy from Lestel (2011) considers that anti-speciesism has a major contradiction:

- **it claims equality for all animal species**, including human beings
- **but it denies the right to predation only to one species**, “human beings”, whereas it recognizes this right to all other species.

We have to revise the relationships between animals and humans (Francis Wolf)

Human beings have a diversity of relationships with the diversity of living organisms in the animal kingdom (from flea to dog).

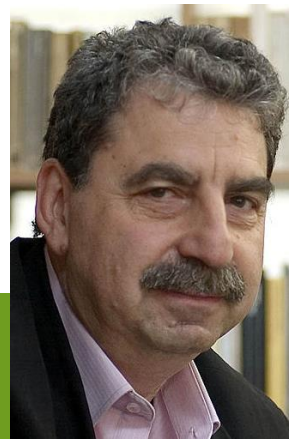
Thus, man's duties toward animals depend on the nature of these relations.

The status of the animal cannot be unique.



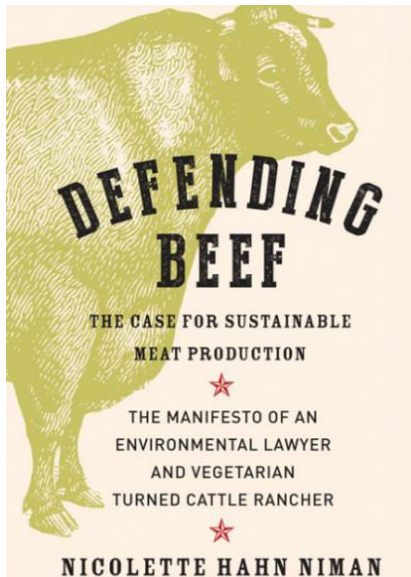
“Modern animalism”, which assigns a unique value to all animals, considered as a unique being (called), contains several contradictions: first, man is sometimes included, sometimes excluded from animal kingdom; then, dogs and their fleas cannot be handle in the same way.

The main cause of the complex relationships between humans and animals is the man consciousness loss of his human specificity

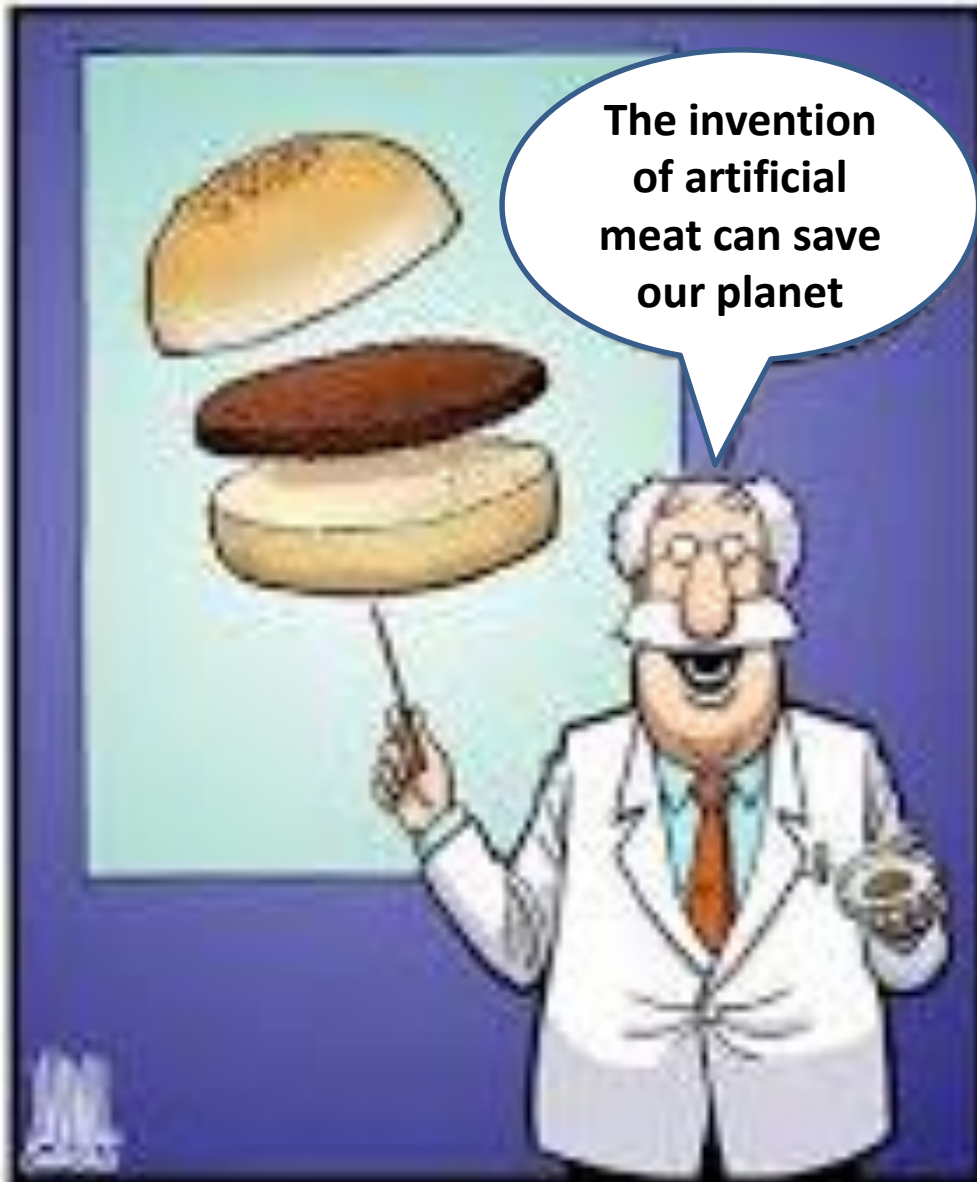


Meat: a social issue?

Do not be afraid to say
« I love meat »



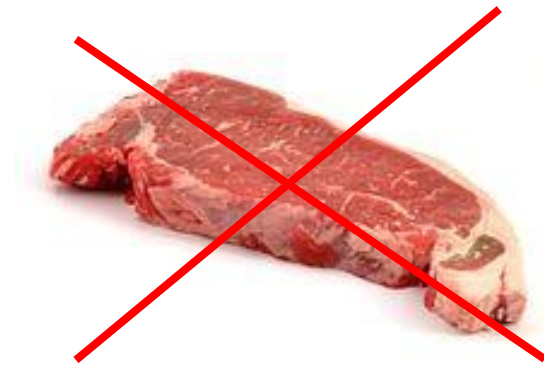
Meat: a social issue?



Consumers do not know any more what meat is

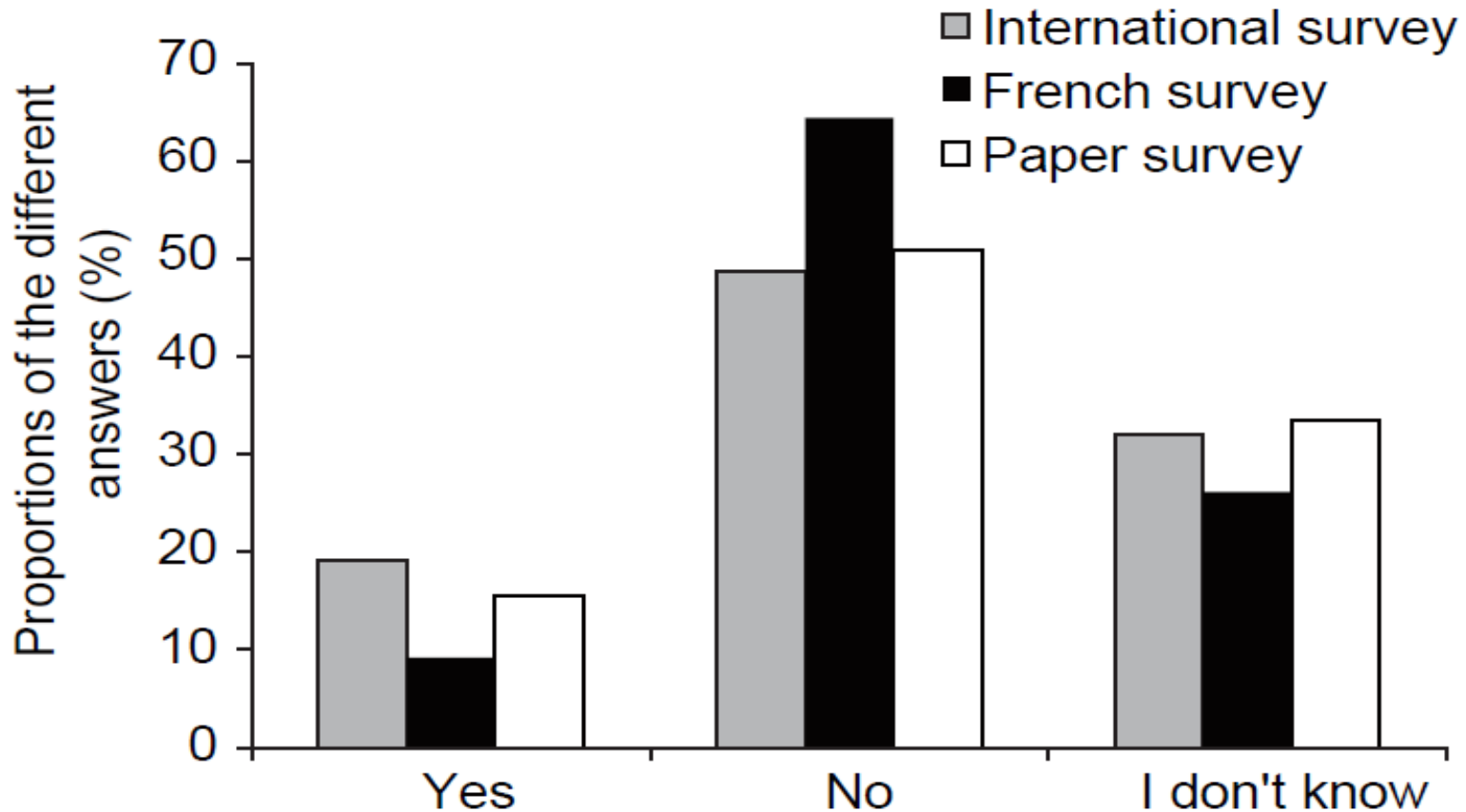
The first *in vitro* steak produced resembled a hamburger and **not real meat**, which is logical as it is much easier to produce a hamburger (ground beef) *in vitro* than a real steak.

Also, the hamburger has become progressively the international standard for meat (thanks to different fast-food chains) and has replaced rib steaks, flank steaks, pork chops or chicken legs.



Will consumers accept artificial meat?

According to your perception, will *in vitro* meat be well accepted by consumers? Will consumers buy it?



Consumers do not know what we can do

Do you have any favourite singer?

Do you have any favourite sportsman?

Do you have any favourite politician?

Now, you can eat meat from muscle samples taken from your celebrity



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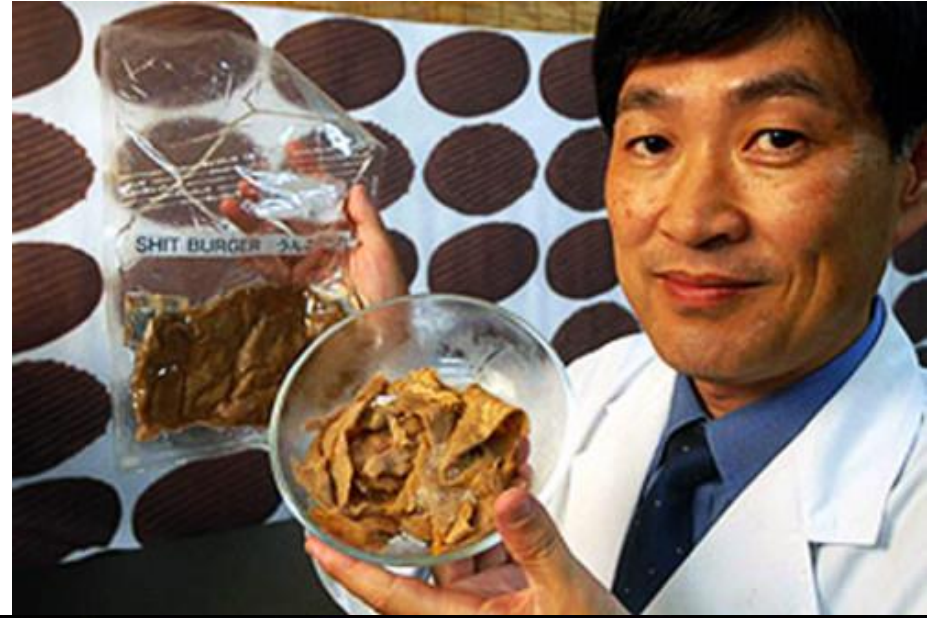


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The protein of the future?

Japanese scientist Mitsuyuki Ikeda has developed a “burger” made from soya, steak sauce essence, and **protein extracted from human feces present in sewage sludge of Tokyo.**

This process is very cheap, ready-to-use and therefore, likely to be very sustainable (?)

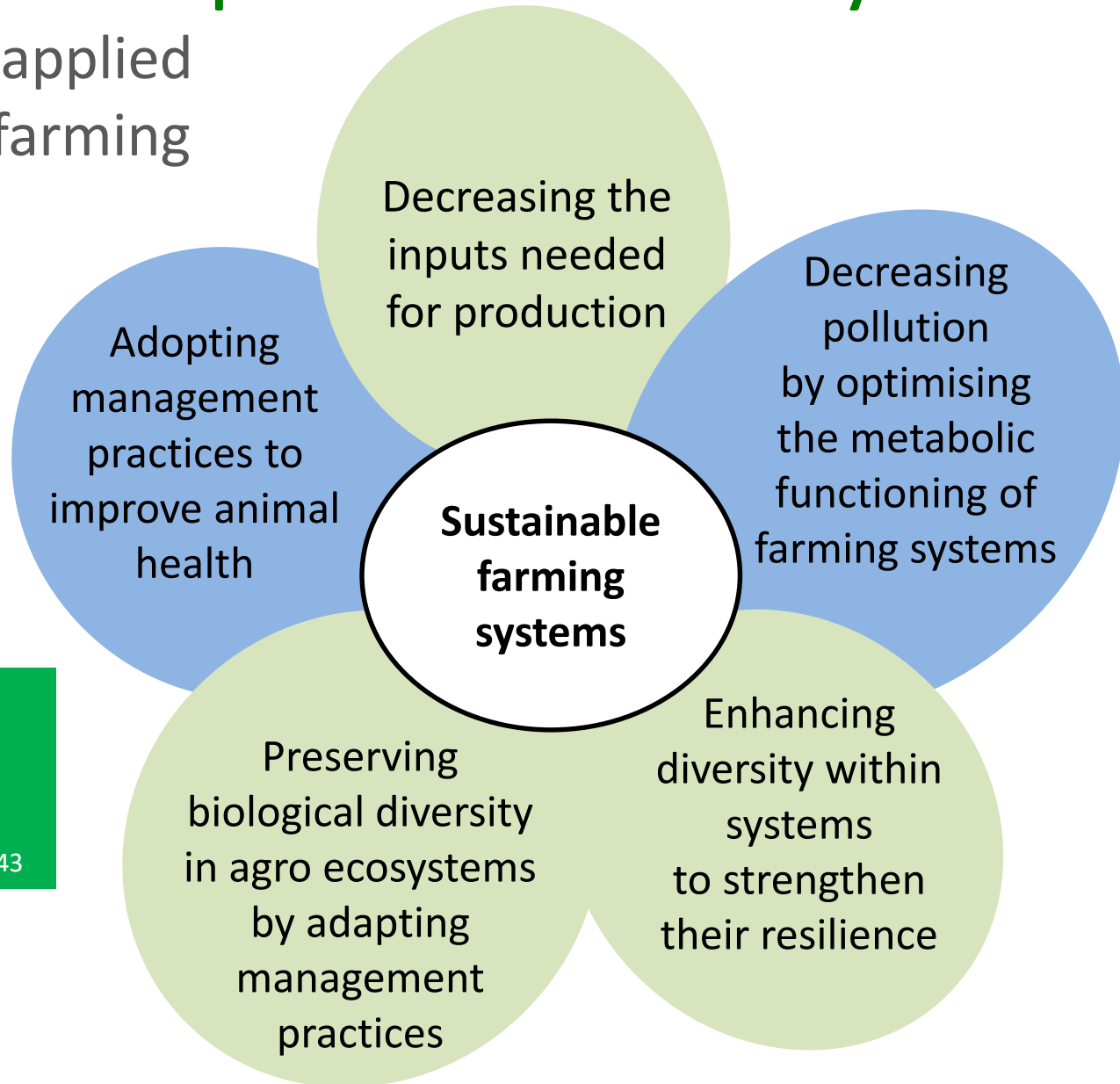


Eating proteins from mushrooms or insects



Agroecology: To take benefit of natural processes to improve farm sustainability

5 principles applied to livestock farming



Dumont et al.,
Prospects from agroecology
and industrial ecology
for animal production
in the 21st century
Animal (2013), 7:6, 1028–1043

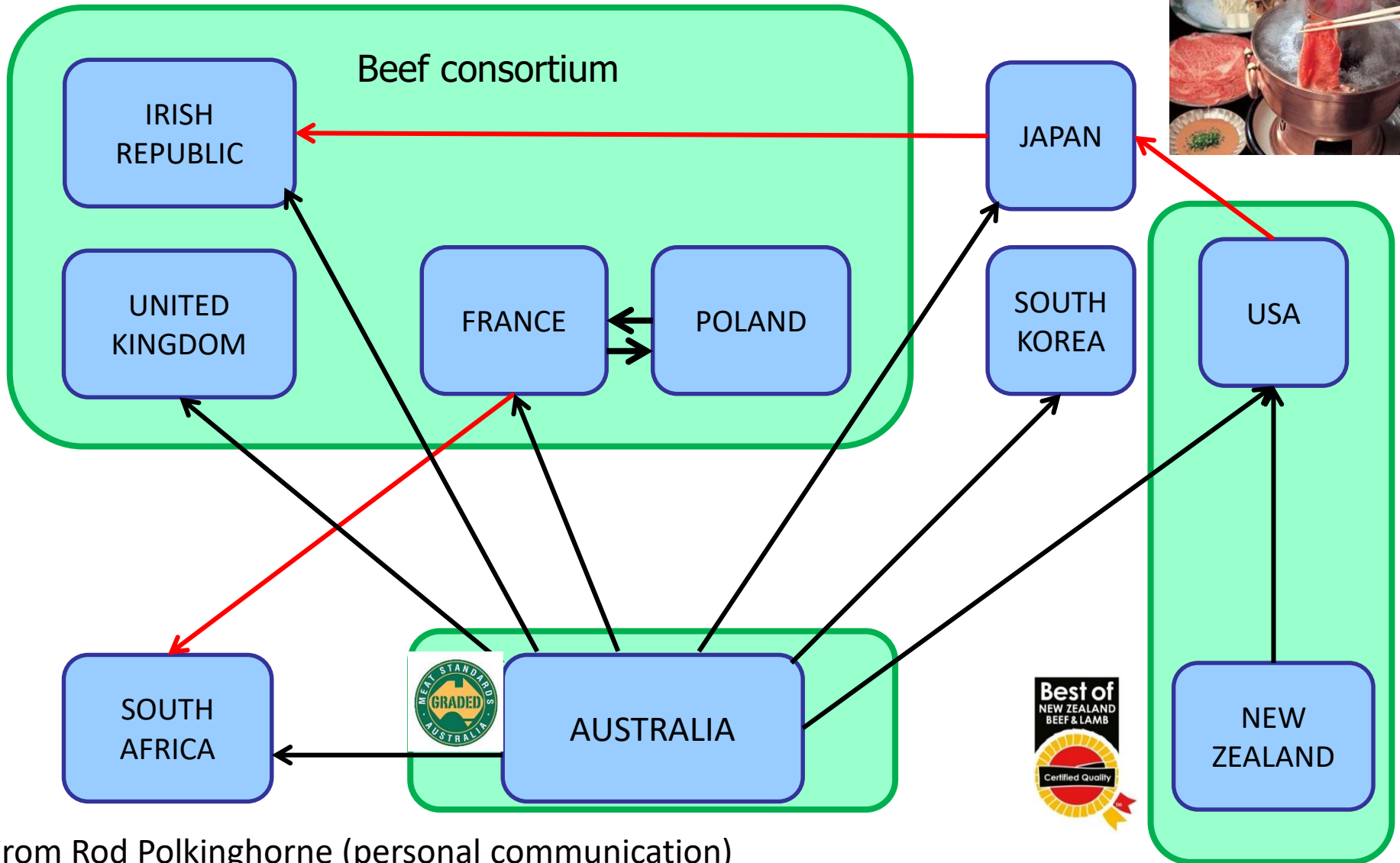
Eating quality: Towards an international model to predict eating quality in the plate

MSA2000model®

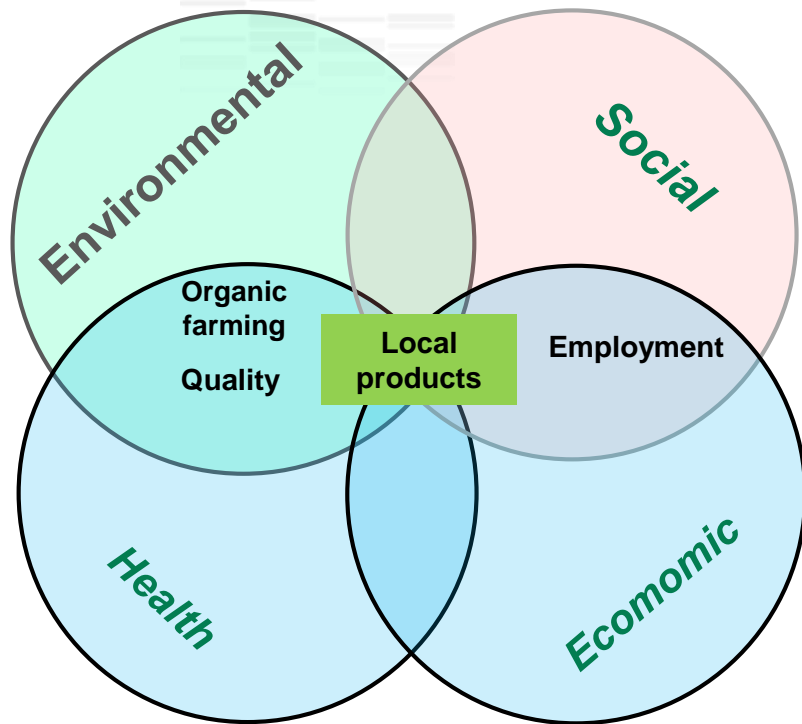
Hang (AT/TC/TS/TX)	AT
Sex (M, F)	m
Est.% Bos Indicus	0
Hump Height cms	0
Hot Std Carc Weight	250
USDA Ossification	140
Milk Fed Vealer Y/N	N
USDA Marbling	300
Days Aged (min 5)	5
Quarter Point Ribfat	12
Ultimate pH	5.50
AUSMEAT Meat Col.	2
Saleyard? (Y, N)	n
Wght/App.Maturity	0.86

Cut Description	Muscle Reference	Days Aged	Grilled Steak	Roast Beef	Stir Fry	Thin Slice	Cass-erole	Corne d Beef
Tenderloin	TDR062		5	5	5			
Cube Roll	CUB045		4	4	4	4		
Striploin	STR045		3	3	3	3		
Oyster Blade	OYS036		4	4	4	4		
Bolar Blade	BLD096		3	3	3	4	3	
Chuck Tender	CTR085			3	3	3	3	
Rump	RMP131		3	3	3	3		
Point End Rump	RMP231		3	4	4	4		
Knuckle	KNU099		x	3	3	3	3	
Outside Flat	OUT005			x	3	3	3	3
Eye Round	EYE075		x	3	3	3	3	x
Topside	TOP073		x	3	3	3	3	
Chuck	CHK078			3	3	3	4	
Thin Flank	TFL051				3		3	
Rib Blade	RIB041				3			
Brisket	BRI056				x	3	3	x
Shin	FQshin						3	

Eating quality: Towards an international model to predict eating quality in the plate



Towards sustainable meat production



Fouquery-Mérel, Paré, Fosse, DGAL, 2014

Role in bio-economy (those parts of the economy that use renewable biological resources) :

- 1) Recycling of raw materials that can not be consumed (pulp, grains, sounds, forages, ...),
- 2) Production of organic fertilizer,
- 3) Irreplaceable role for sustainable agriculture through polyculture and rotations

Feeding humans cannot be sustainable without animals and without animal products. But it is necessary to **change intensive production systems in competition with human needs**. This implies the use of **more ruminants** and to have diets with **no more than 30%-40% of dietary proteins from animal sources**.

Ensuring safety and quality in the production of beef

Volume 1: Safety

Edited by Professor Gary Acuff, Texas A&M University, USA
Professor James Dickson, Iowa State University, USA



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Ensuring safety and quality in the production of beef

Volume 2: Quality

Edited by Emeritus Professor Michael Dikeman
Kansas State University, USA



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