A new and prospective vision of energy and protein metabolism research in the present socio-economical context

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ISEP, 2007, Vichy, France

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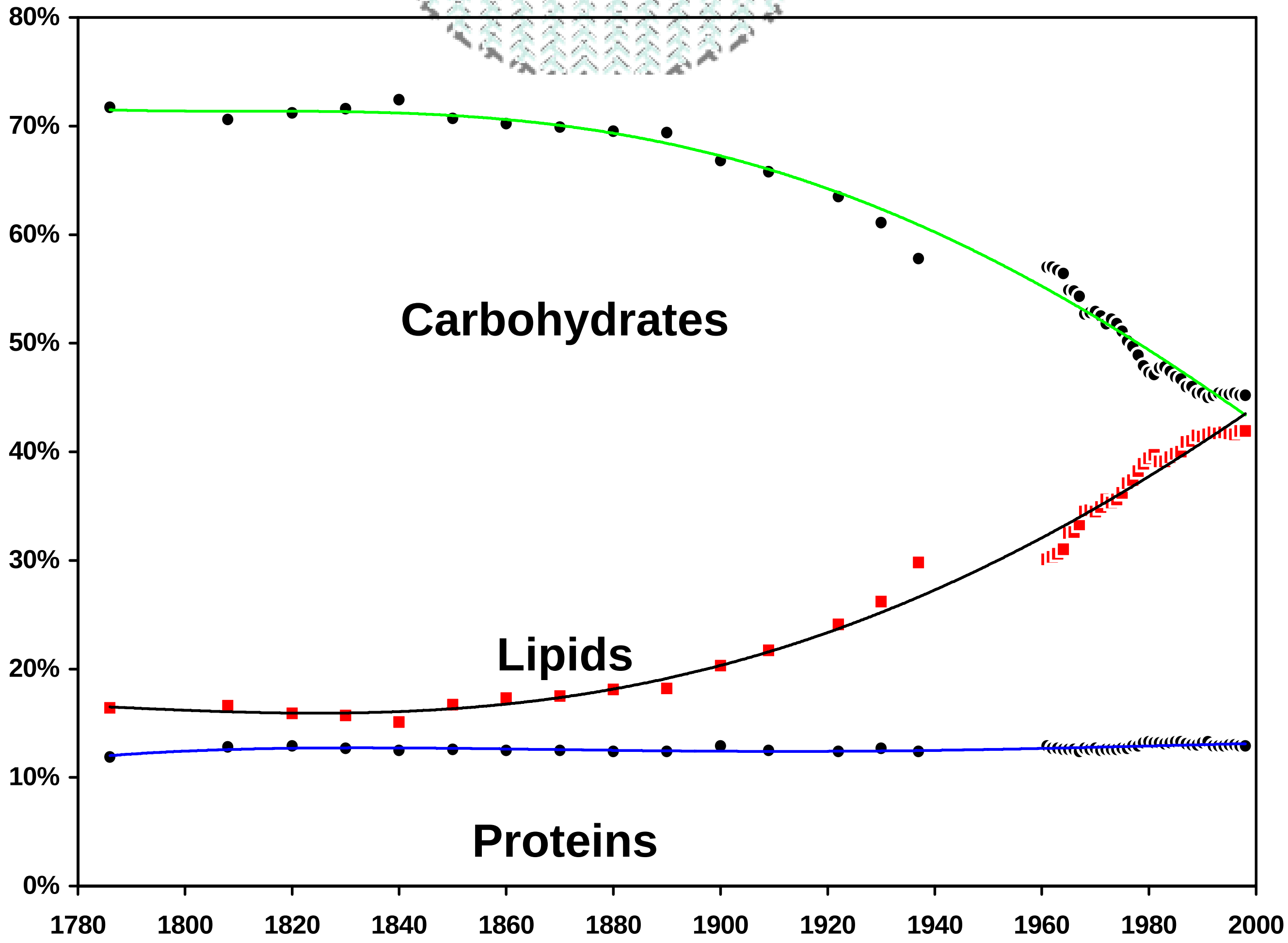
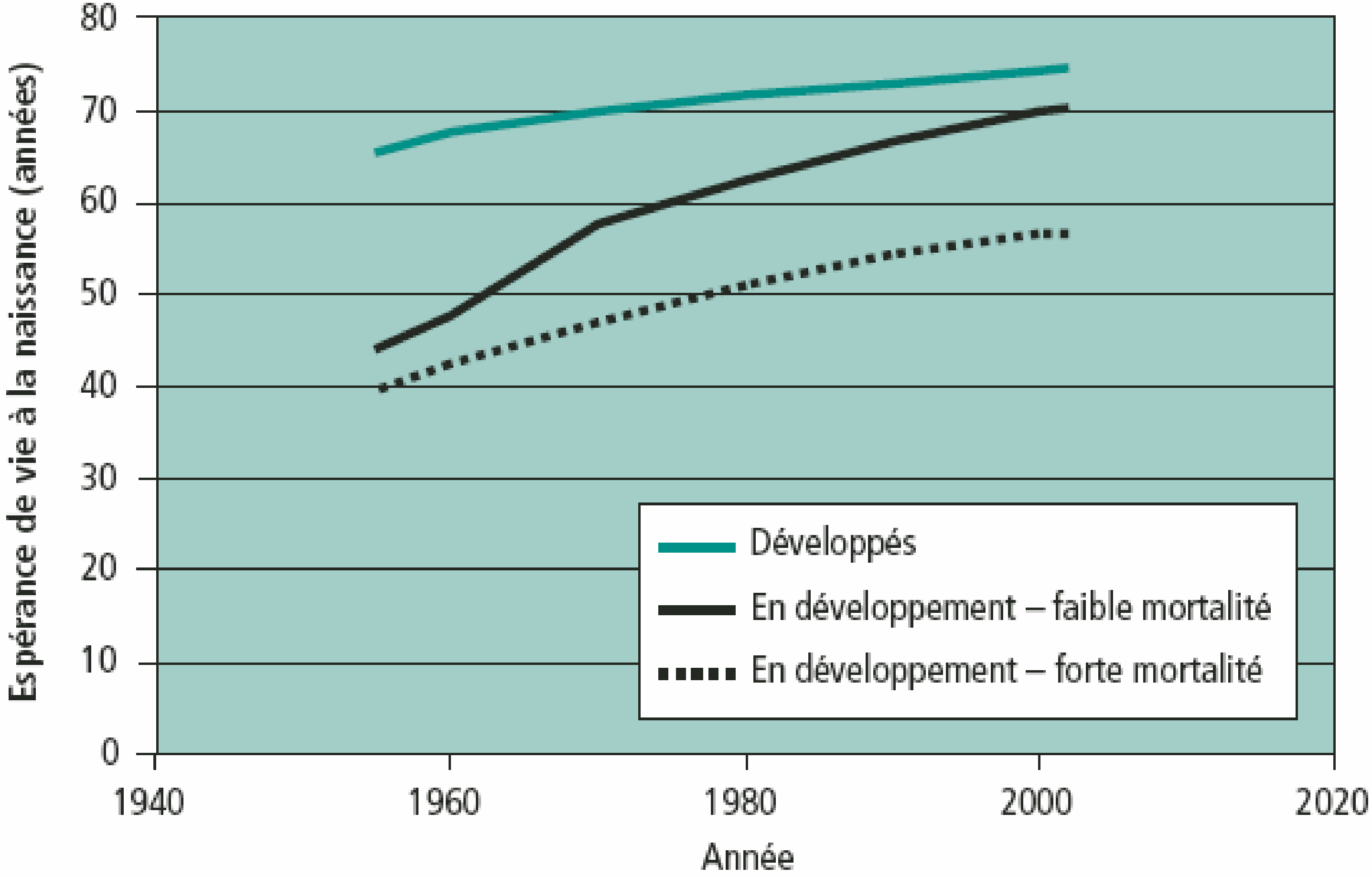
Nutritional Transition in France



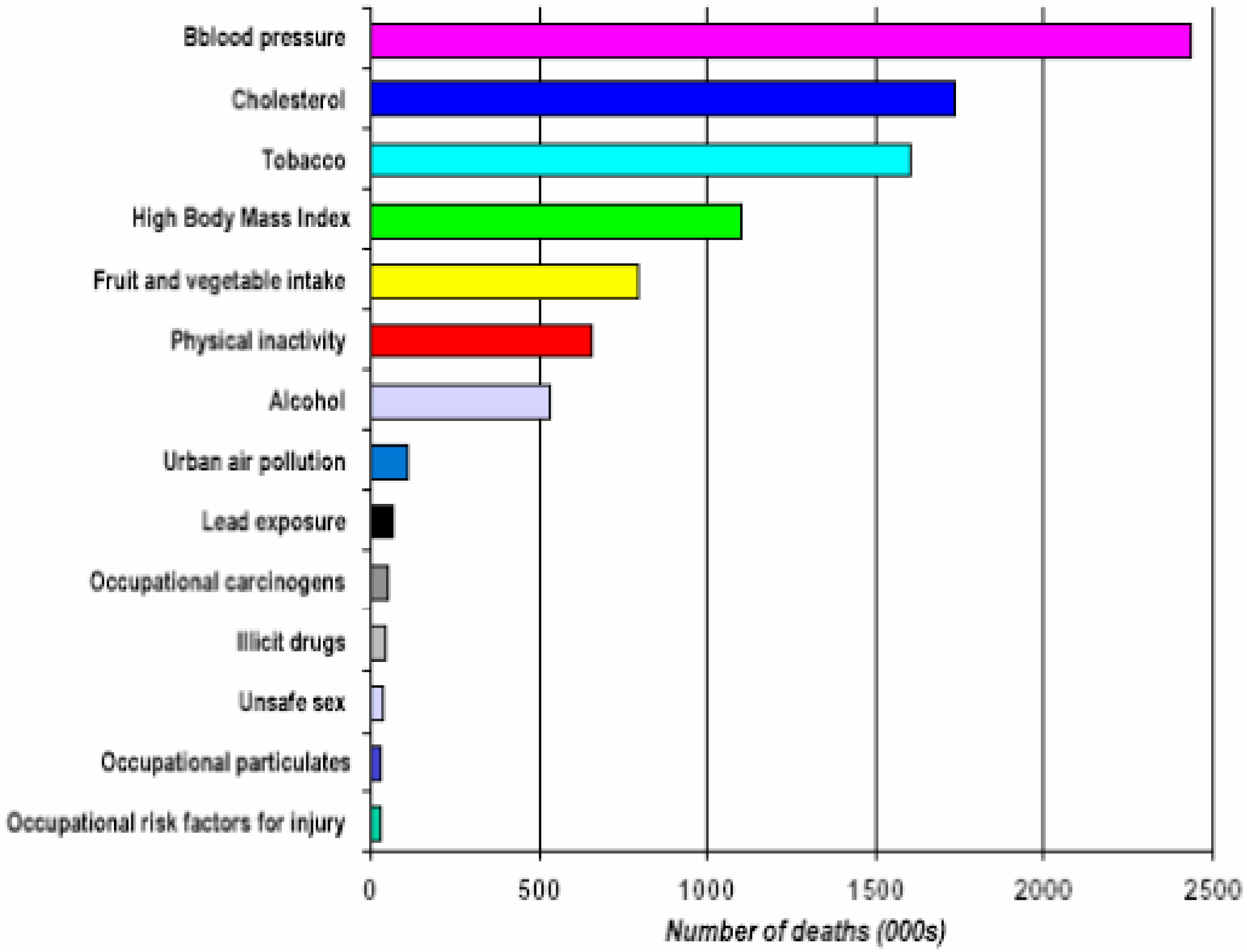
From : J.C. Toutain, FAO Stat

Figure 1.1 Espérance de vie à la naissance : pays développés et en développement, 1955-2002



Note : Les pays développés sont l'Australie, le Canada, les Etats-Unis, le Japon, la Nouvelle-Zélande, les pays européens et les pays de l'ancienne Union soviétique. Les pays en développement à forte mortalité sont les pays de l'Afrique subsaharienne ainsi que les pays d'Asie, d'Amérique centrale, d'Amérique du Sud et de la Méditerranée orientale où la mortalité des enfants et des adultes est élevée. Les autres pays en développement constituent les pays en développement à faible mortalité.

Fig. 3 Deaths in 2000 in Europe attributable to selected leading risk factors



Source: WHR 2002

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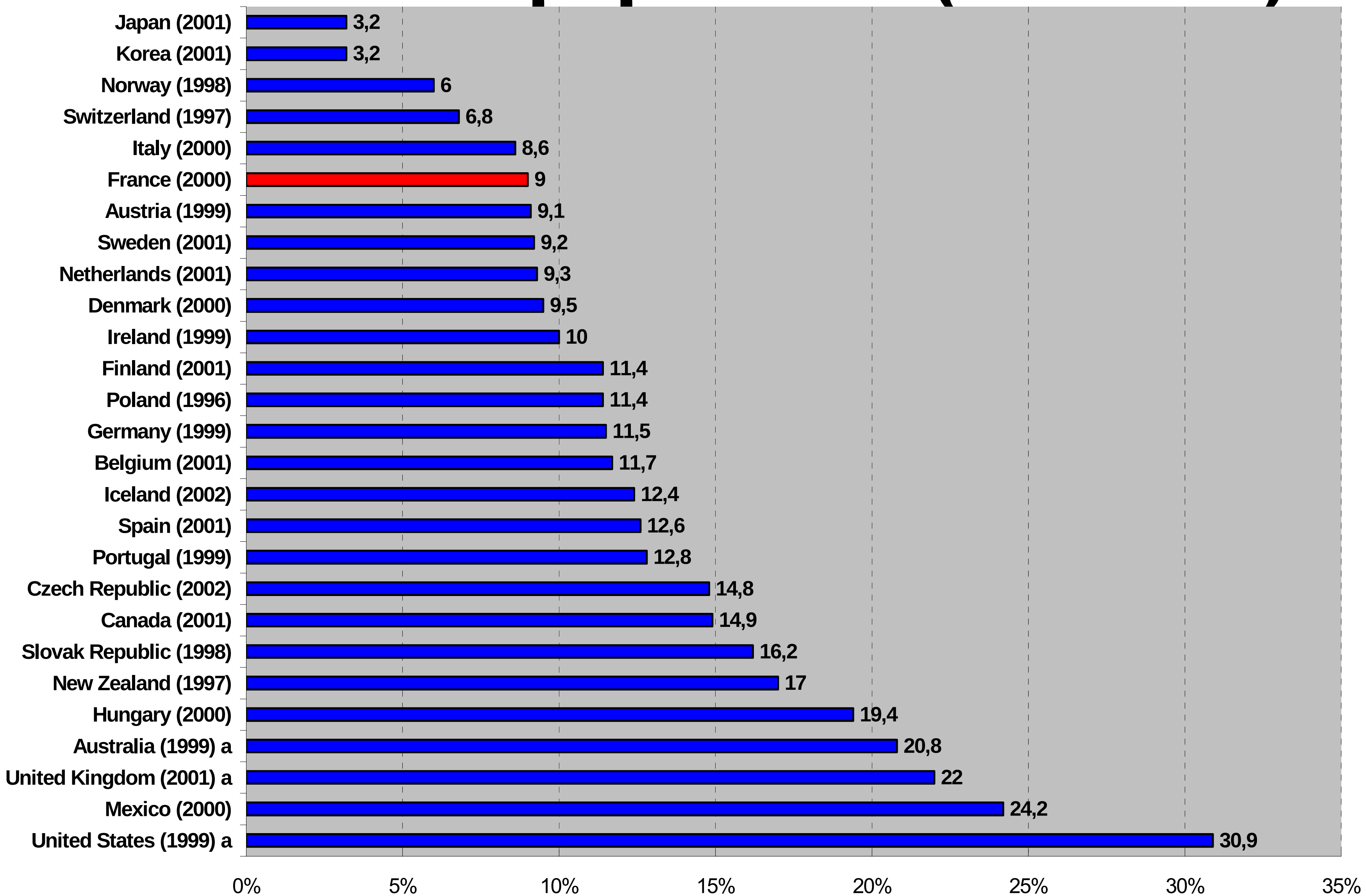
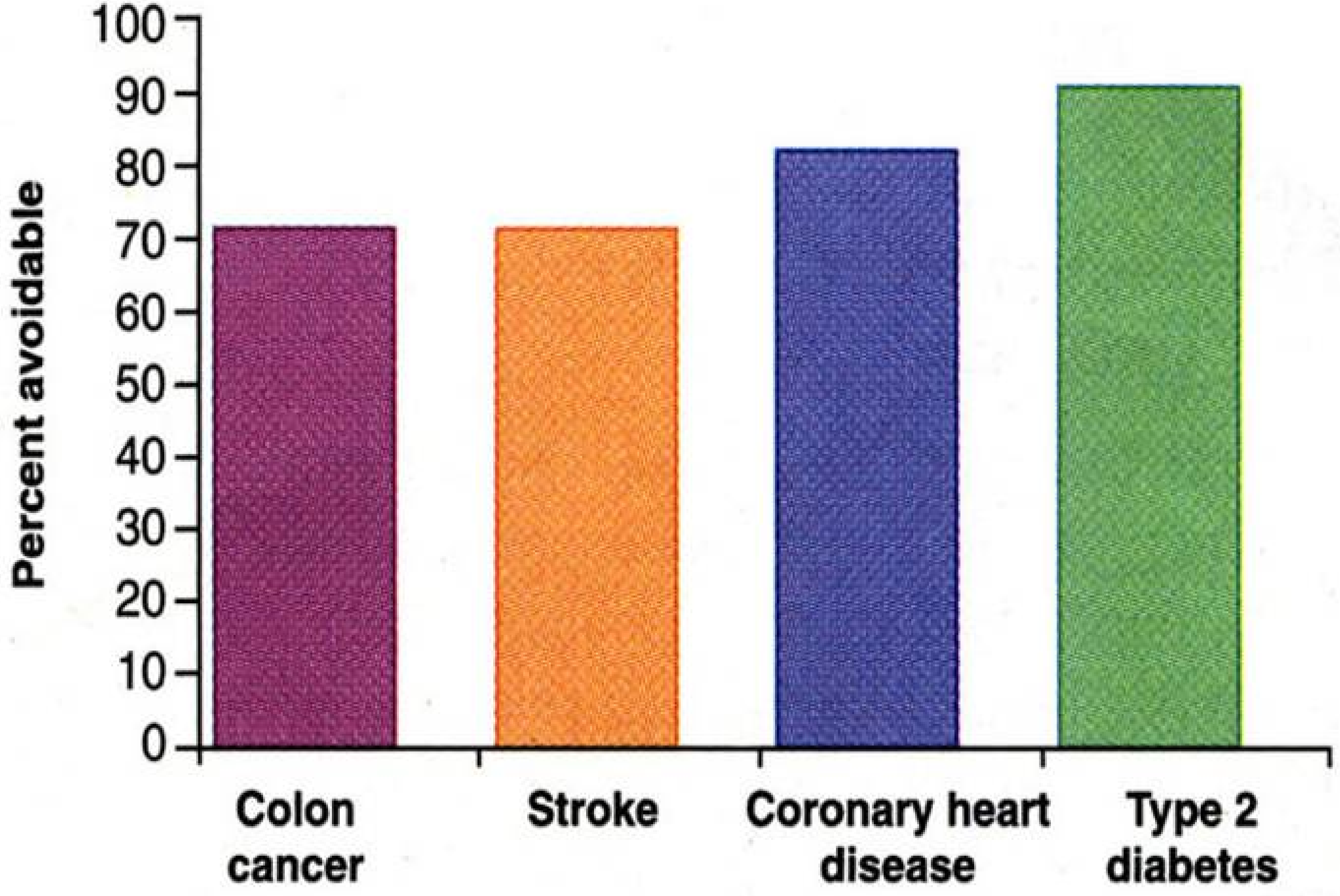
Adult obese population (BMI>30)



Source : OCDE 2003

Colon Cancer, Stroke, Coronary Heart Disease, and Type II Diabetes Potentially Preventable by Life-Style



1. From: Willett, WC. *Science* 296:696, 2002.

Animal nutrition and the Environment

- Feeding the world while considering human health and environment preservation.
- FAO report: "*Livestock's long shadow*" on environment interactions
- livestock sector is
  - of great economic and social importance,
  - a major determinant of nutrition and human health,
  - the largest land user of the world,
  - the major driver of pollution, gaseous emissions and climate change.

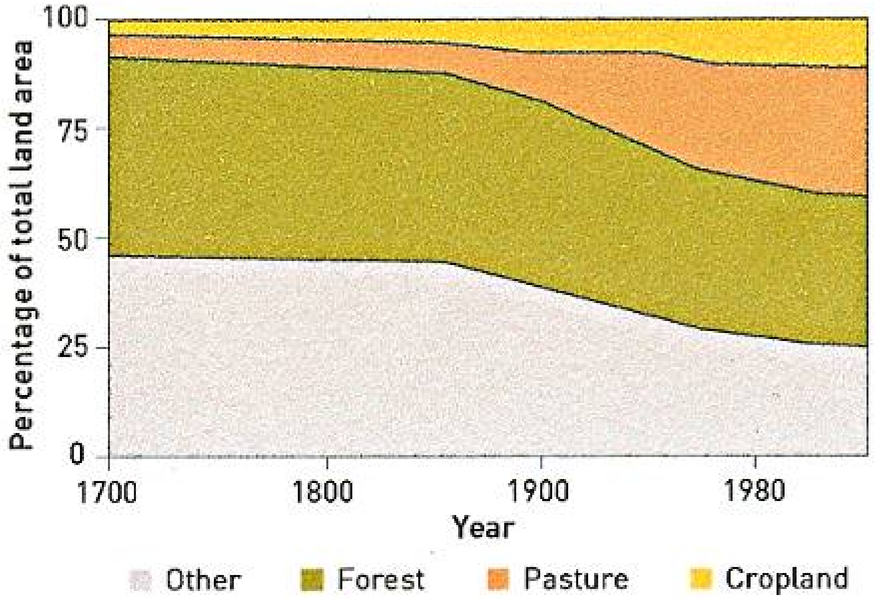
Animal nutrition and the Environment

- Inter-disciplinary and integrative approaches,
  - feeding system,
  - animal genetic and health,
  - breeding system
  - waste management

Animal nutrition and the Environment

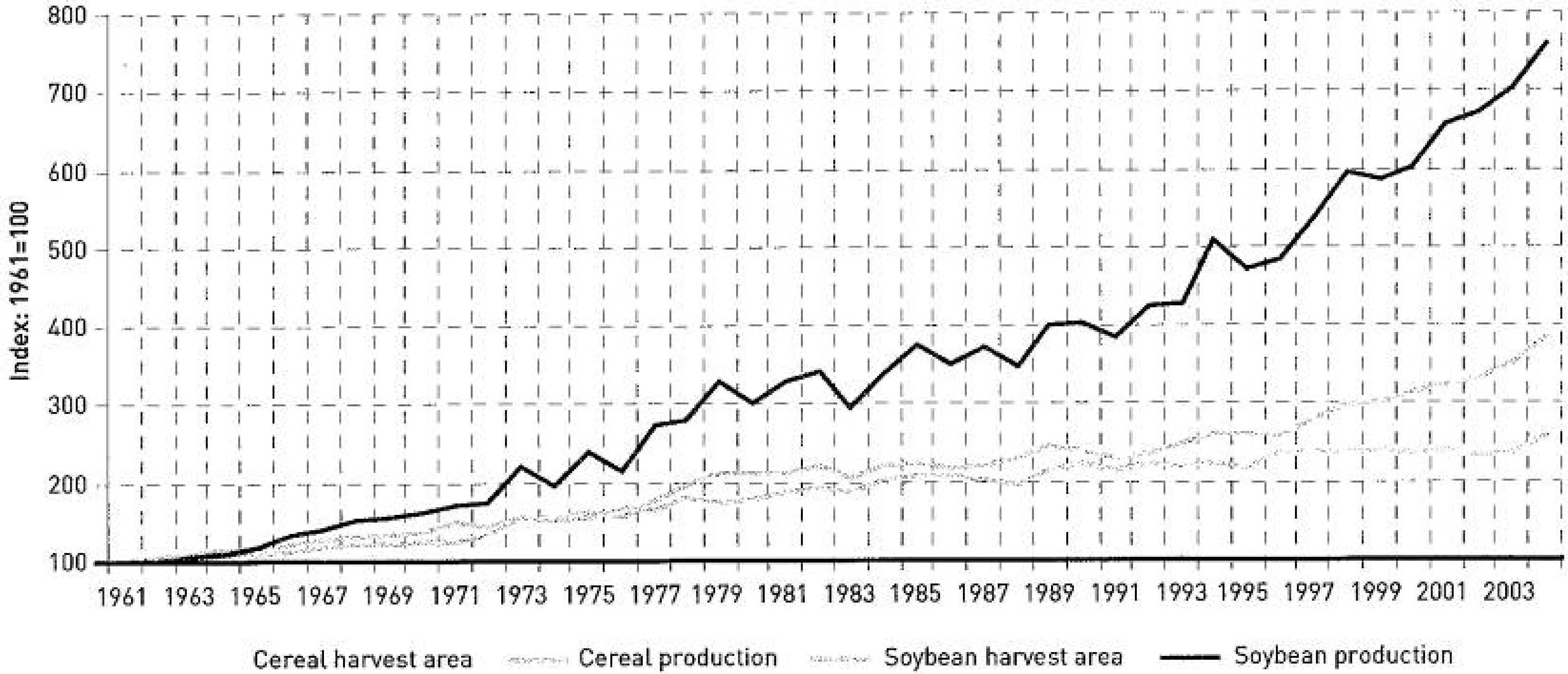
- Agrofuel production is growing in competition with animal production
  - Utilization of biofuel by-products to feed the animals (pig, poultry as well as ruminants) ?
  - nutritive value,
  - consequences on animal metabolism,
  - health and product quality
  - contribution of the whole system to greenhouse gas emission reductions.

Figure 2.1 **Estimated changes in land use from 1700 to 1995**



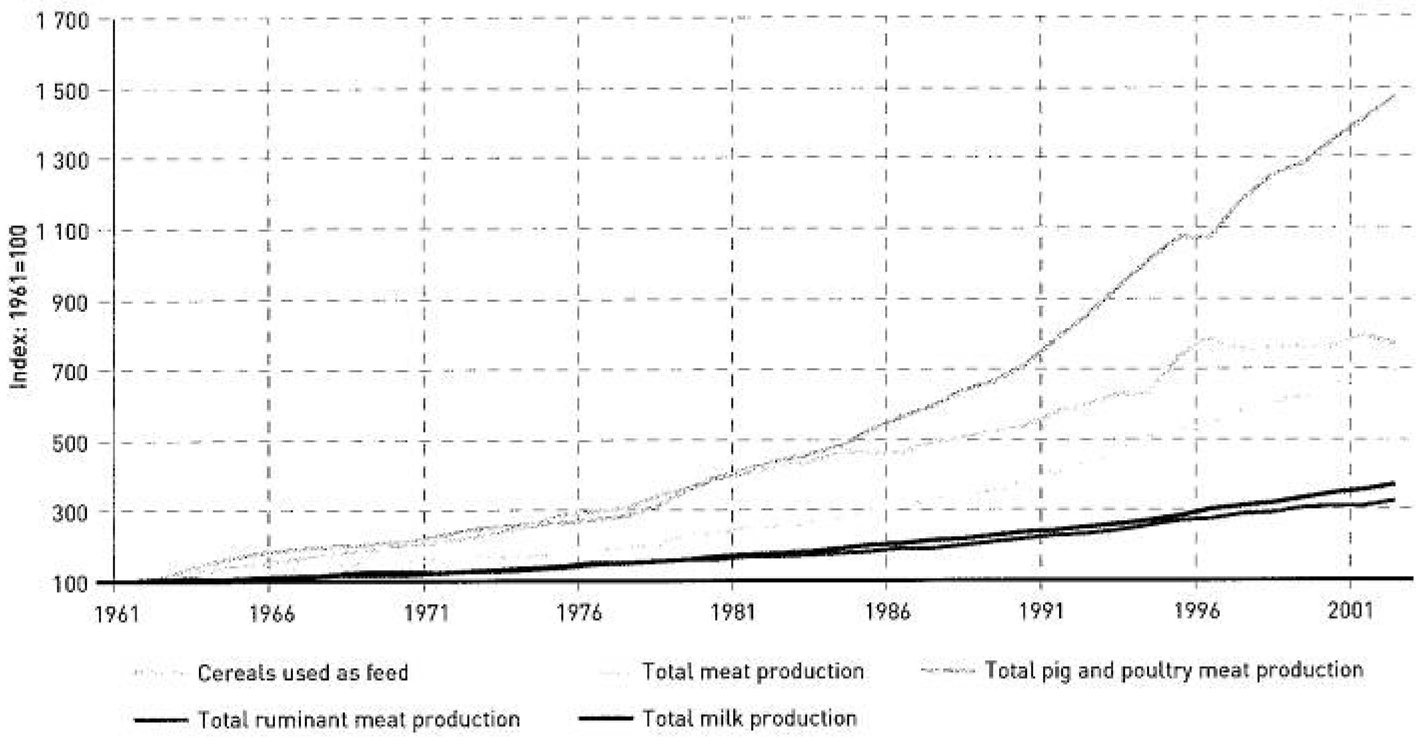
Source: Goldewijk and Battjes (1997).

Figure 2.2 **Total harvested area and total production for cereals and soybeans**



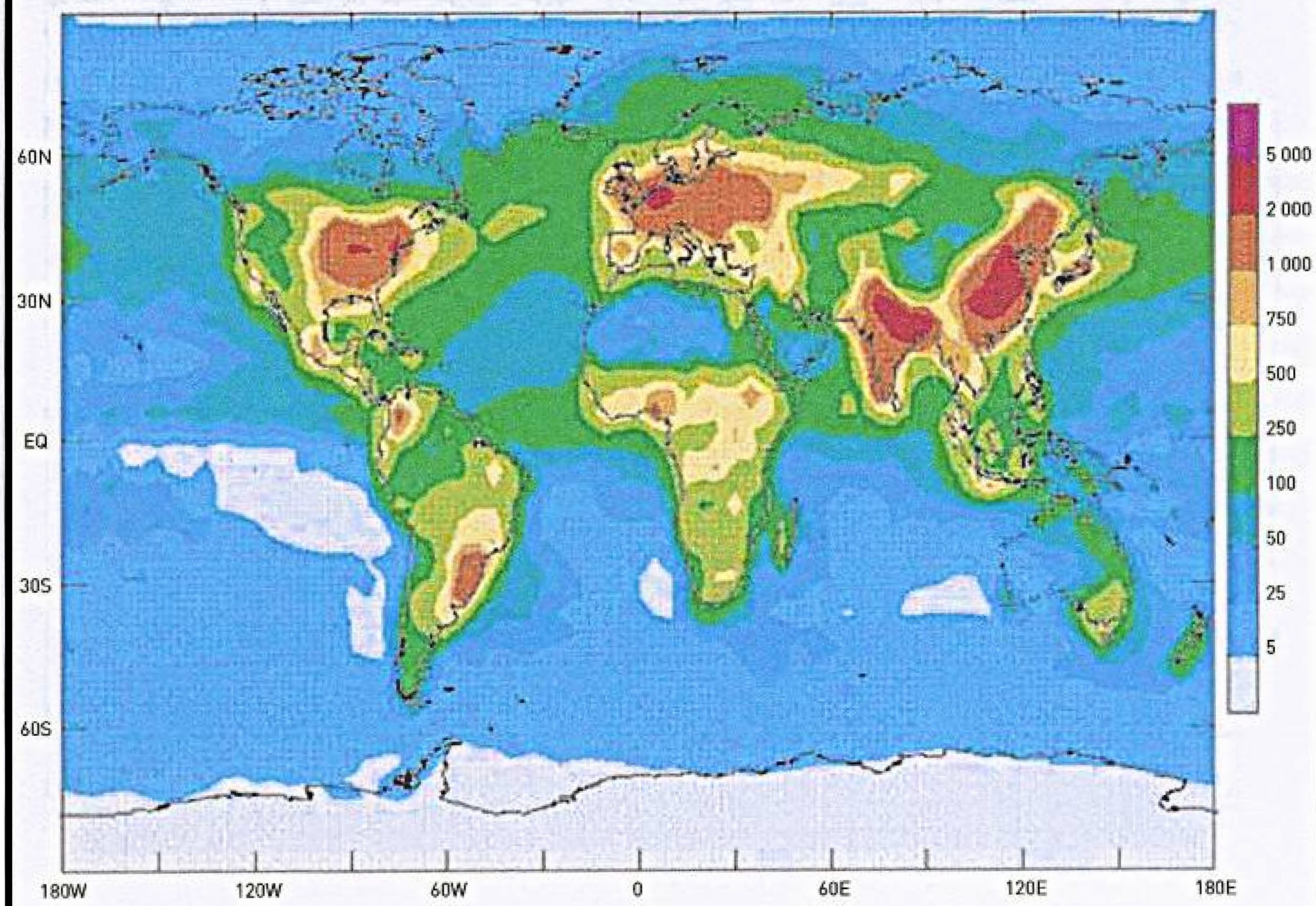
Source: FAO (2006b).

Figure 2.3 **Comparative growth rates for production of selected animal products and feed grain use in developing countries**



Source: FAO (2006b).

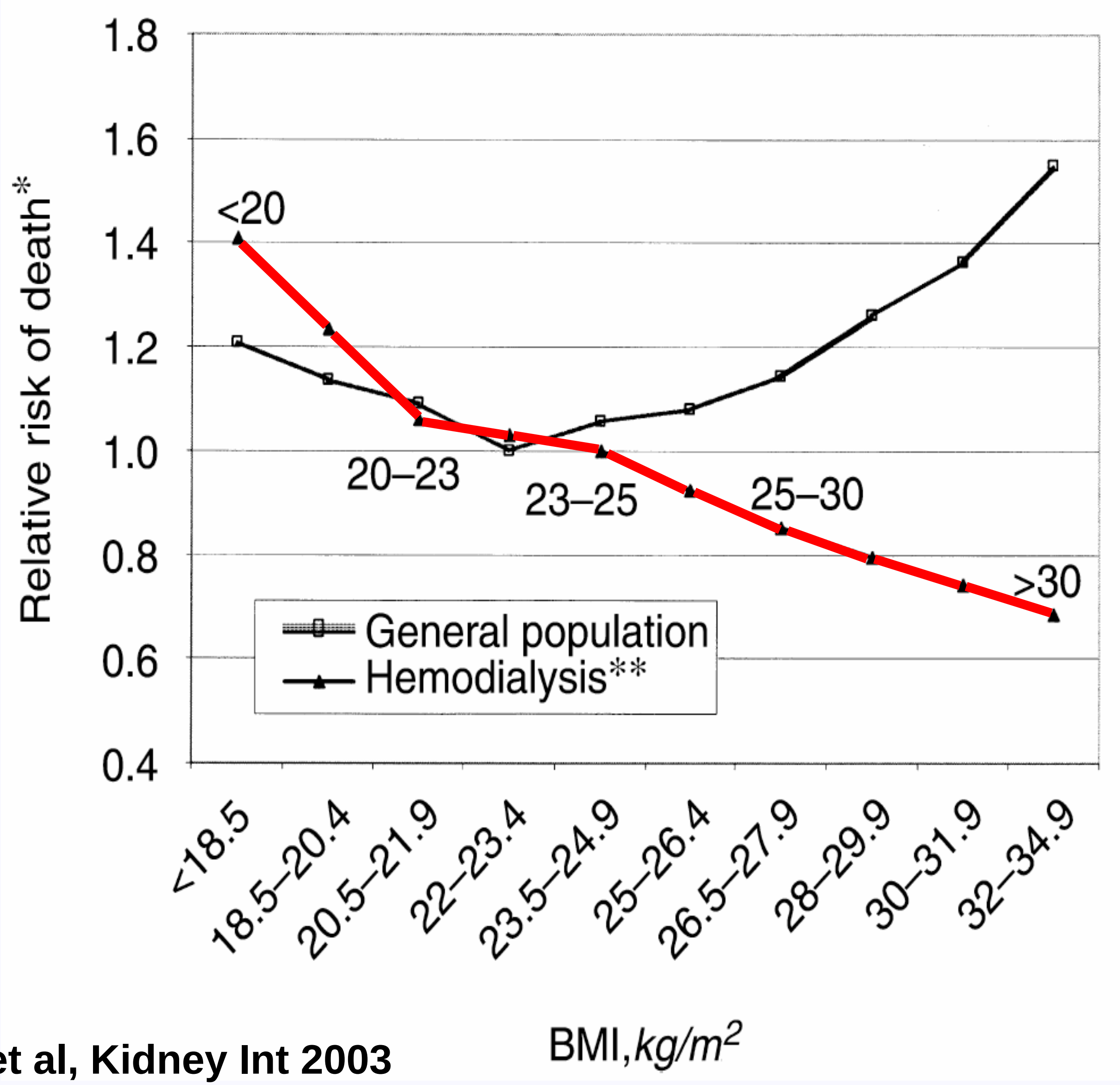
Nitrogen deposition



Note: Units – mg N per square metre per year.
Source: Galloway *et al.*, (2004).

Health and nutrition

- Human studies in health and diseases
- Laboratory animals: models for human nutrition research.
- Animal nutrition as specific topics.
  - Specific requirements in inflammatory states
  - Impact of diseases: inflammation and stress response
    - utilization of specific nutrients (immunonutrition): amino acids (cystein, glutamine, arginine, leucine, tryptophan, etc..), fatty acids, nucleotides, etc.
  - Preventive nutrition and nutritional programming or imprinting
    - identification of different fractions of colostrum and milk on gene expression
    - plasticity of milk composition and specific nutrient supplies.
    - nutritional programming and disease occurrence (obesity, type II diabetes, cardiovascular disease or metabolic syndrome): The “Thrifty Phenotype” hypothesis involving potentially epigenetic events, such as DNA methylation or histone modifications.

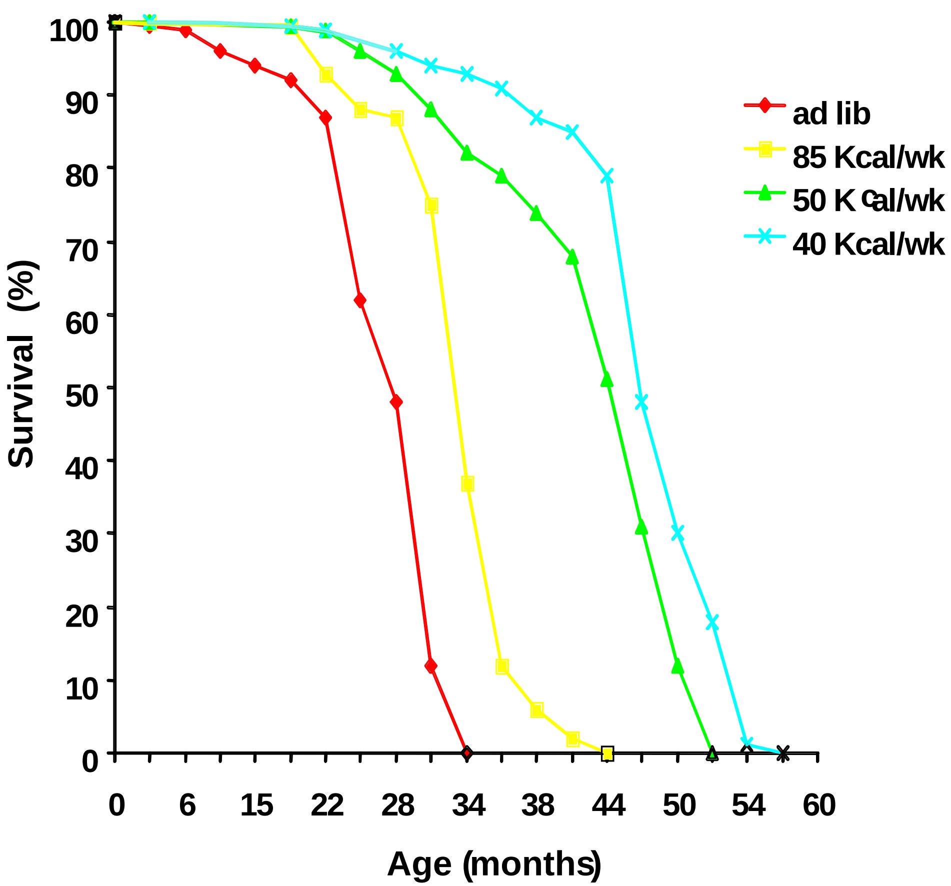


Kalantar-Zadey et al, Kidney Int 2003

Général population: Calle et al, N Engl J Med 1991

Hémodialysis data: Leavey et al, Nephrol Dial Transplant 2001

Effect of caloric restriction on life span in mice



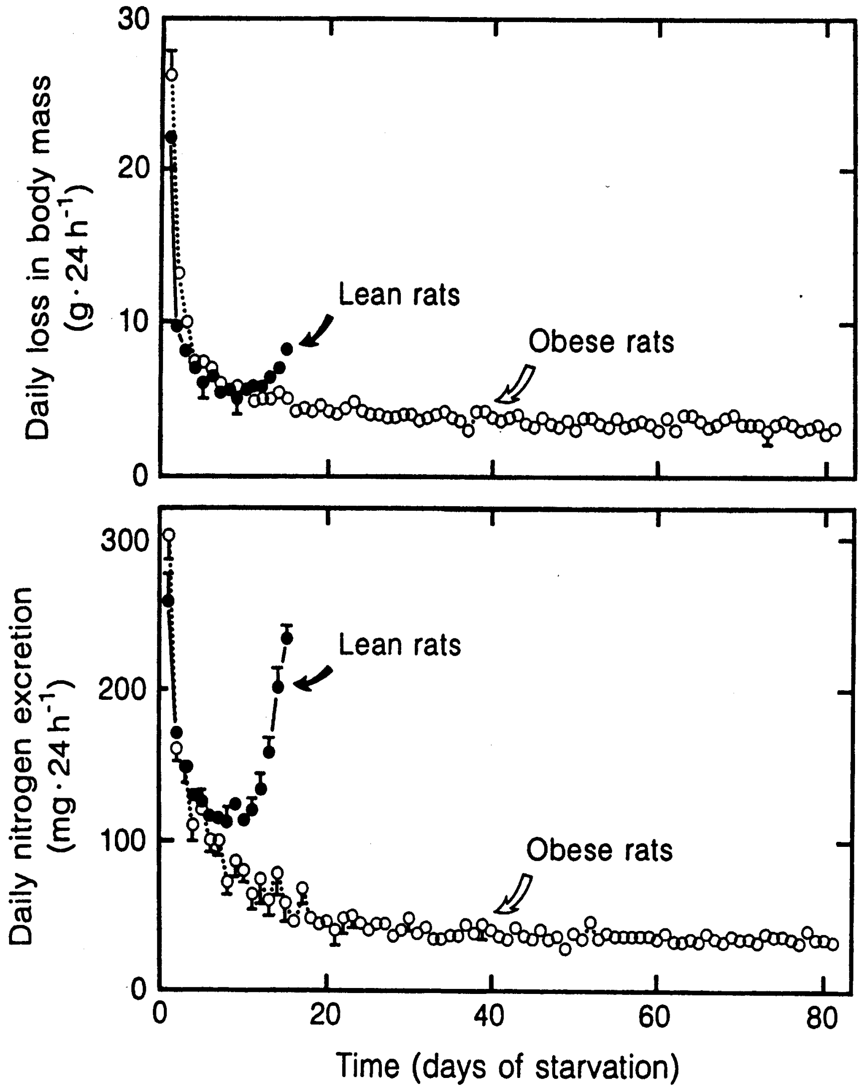


Fig. 1. Effect of fasting on daily body mass loss and daily nitrogen excretion in lean and obese female Zucker rats. Values are means ± SE with seven rats in each group

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Additive effect of training and High Fat diet on energy metabolism during exercise

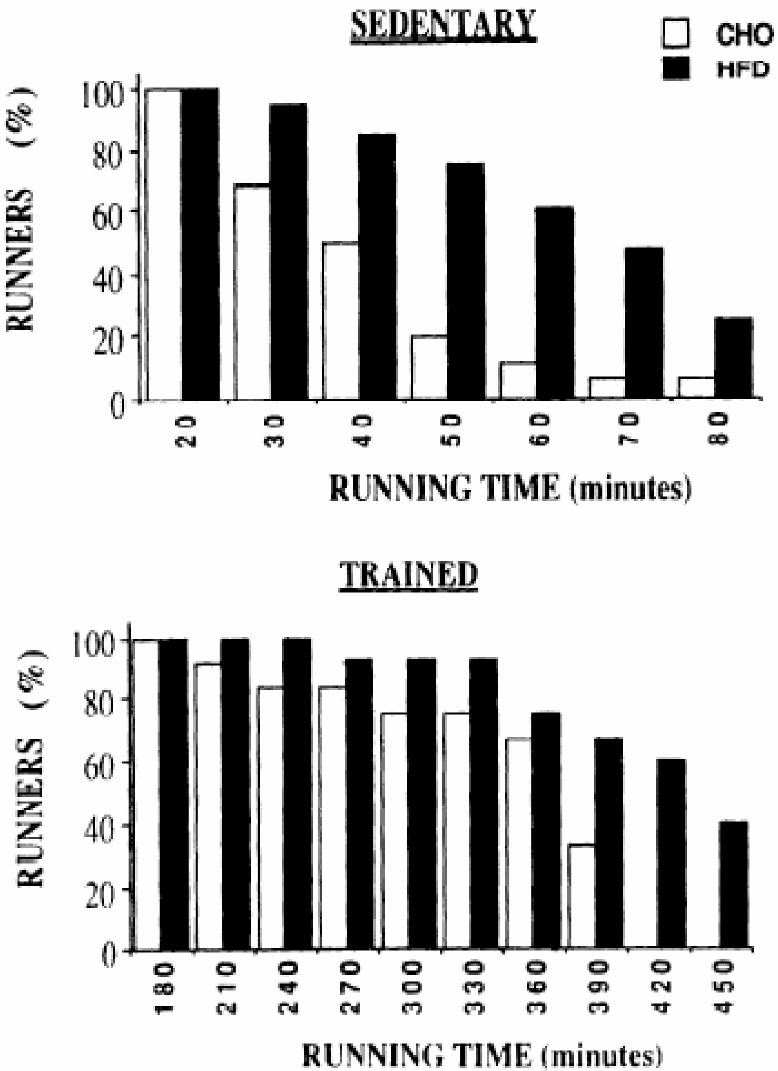

FIG. 1. Submaximal running endurance. Values are means ± SE for 12–15 values per group: Treadmill test was set at 30 m/min with 10% slope. Proportion of 100% runners for a group corresponds to totality of starting animals running on treadmill. After 5 h (300 min) trained rats have 1-min sprint at 50 m/min every 10 min.

TABLE 1. *Composition of the diets*

	CHO diet, g/100 g dry wt	HFD, g/100 g dry wt
Cornstarch	62	0
Casein	22.7	30
Vegetable oils	4.5	5
Lard	0	48
Minerals-vitamins	6.25	7.0
Cellulose	4.5	10.0
Energy value, kcal/100 g	379	597

CHO, carbohydrate; HFD, high-fat diet.

TABLE 2. *Body mass and* $\dot{V}O_{2\,max}$

	CHO		HFD	
	Sedentary	Trained	Sedentary	Trained
Body mass, g	375±9	371±9	373±8	359±7
$\dot{V}O_{2\,max}$, $ml \cdot min^{-1} \cdot kg^{-1}$	90.3±3.3	109.0±2.1*	101.7±2.1†	122.7±2.7*†

Values are means ± SE for 14–19 values per group. $\dot{V}O_{2\,max}$, maximal uptake. * Significantly different ($P < 0.05$) from sedentary on the same diet. † Significantly different ($P < 0.05$) from corresponding CHO group.

Favier, et al, J Appl Physiol, 1991

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Rimbert et al, FASEB J, 2004

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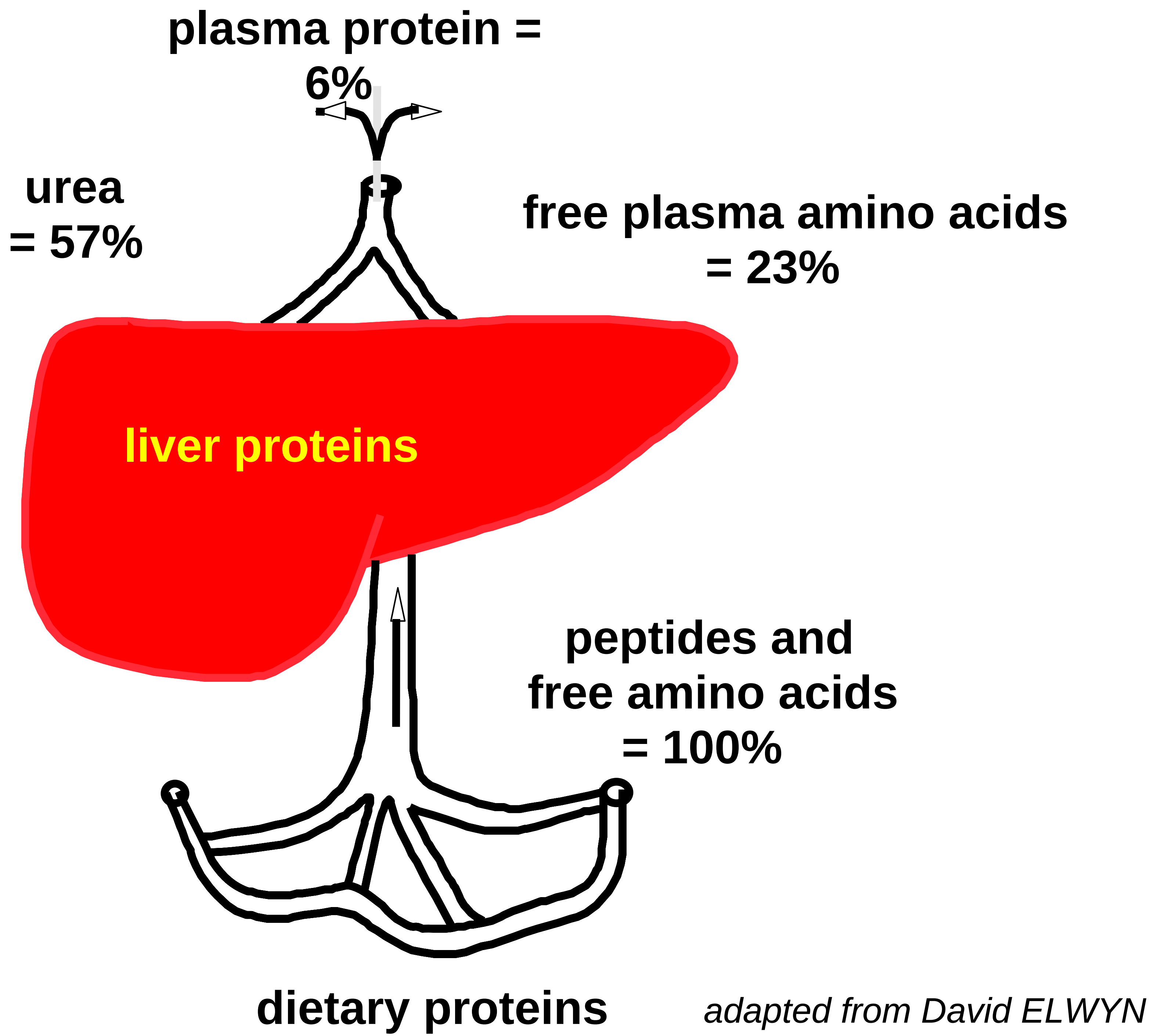
plasma protein =
6%
urea
= 57%
free plasma amino acids
= 23%
liver proteins
peptides and
free amino acids
= 100%
dietary proteins
adapted from David ELWYN

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Leucine supplementation improves muscle protein synthesis in elderly men independently of hyperaminoacidaemia

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Rieu et al, J Physiol, 2006

A leucine-supplemented diet restores the defective postprandial inhibition of proteasome-dependent proteolysis in aged rat skeletal muscle

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Combaret et al, J Physiol, 2006

Immuno nutrients

- Glutamine
- L arginine
- Omega-3 fatty acids
- Nucleotides
  - In cow or human milk:
    - 30% of nitrogen is nonprotein
    - 5% consist of nucleotide
  - several observations in children support the view of a beneficial effect of nucleoside
    - Growth and maturation
    - Neurological development
    - Fewer gastro-intestinal infections

Iwasa, Nutrition, 2000, Yu, Singapore Med J, 1998, Carver, Acta Peadiatr, 1999

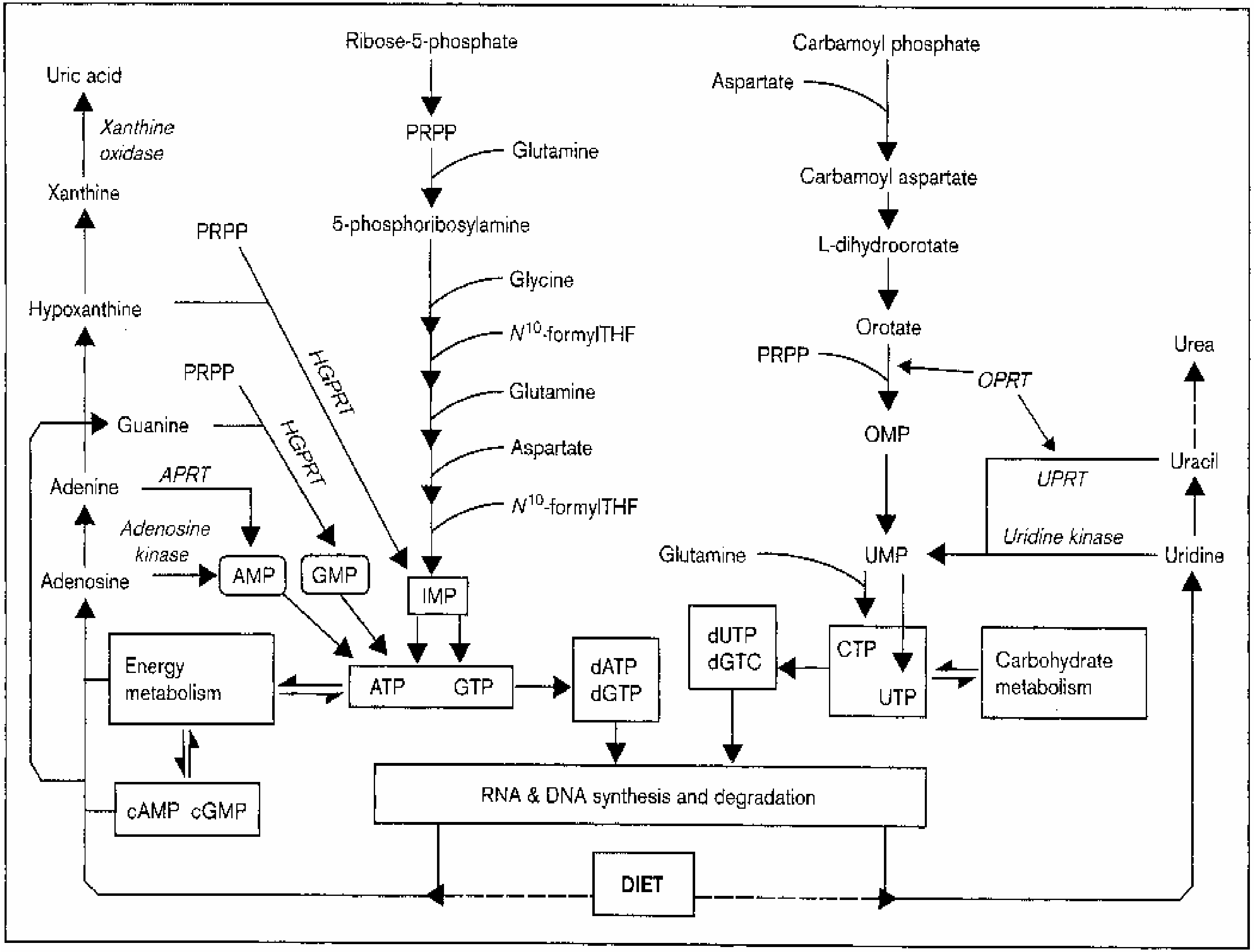
dietary nucleotides

- ∨ protein synthesis

- ∨ immune response

- ∨ survival rate in animal model with septic challenge

Fanslow WC et al. JPEN J Parenter Enteral Nutr 1988; 12 : 49-52
Heyland DK et al. Crit Care Med 1995; 22 : 1192-1202



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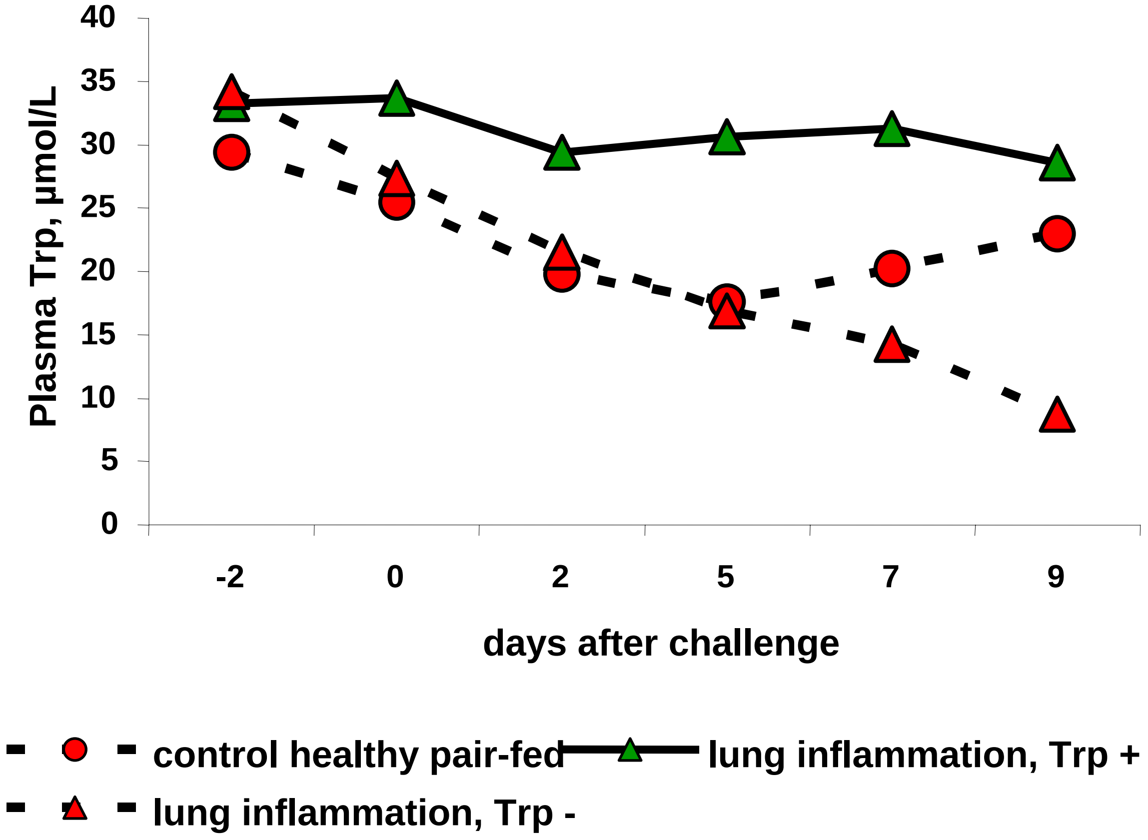
Plasma tryptophan, according to dietary tryptophan supply following non-infectious challenge in piglets



Melchior et al 2004

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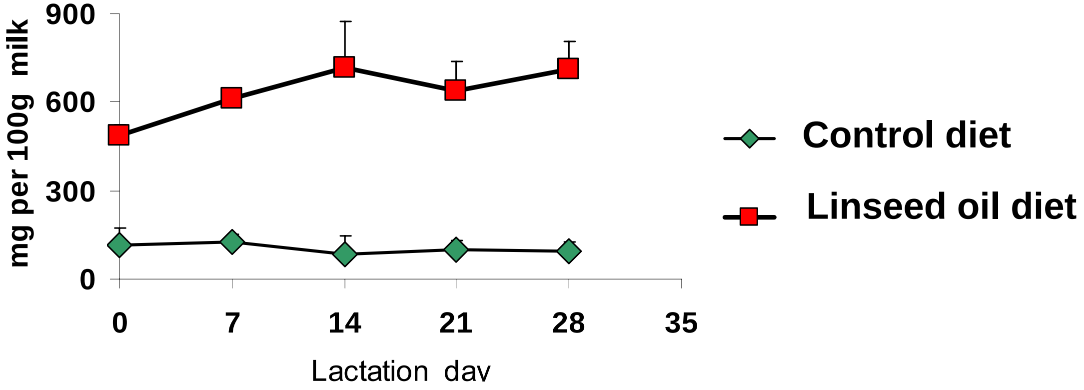
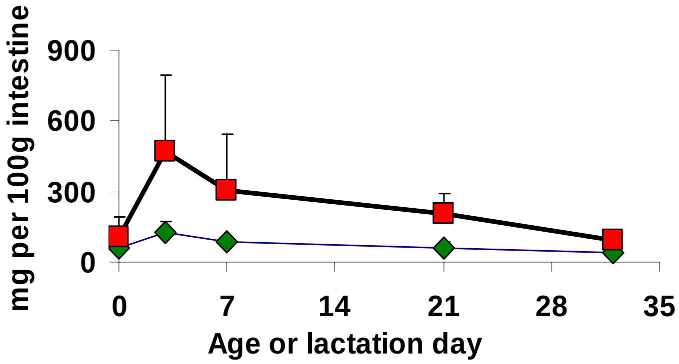
Relationship between animal nutrition and food quality

- Objective: taking into account the food-chain as a whole process
- Human nutrition — Heath –Food — Functional nutrients
- Specific vegetal constituents — efficacy of animal transfer
- Specific animal metabolism

Incorporation of linseed oil in sow's diet: enrichment of milk and piglet intestinal tissue in (n-3)PUFA

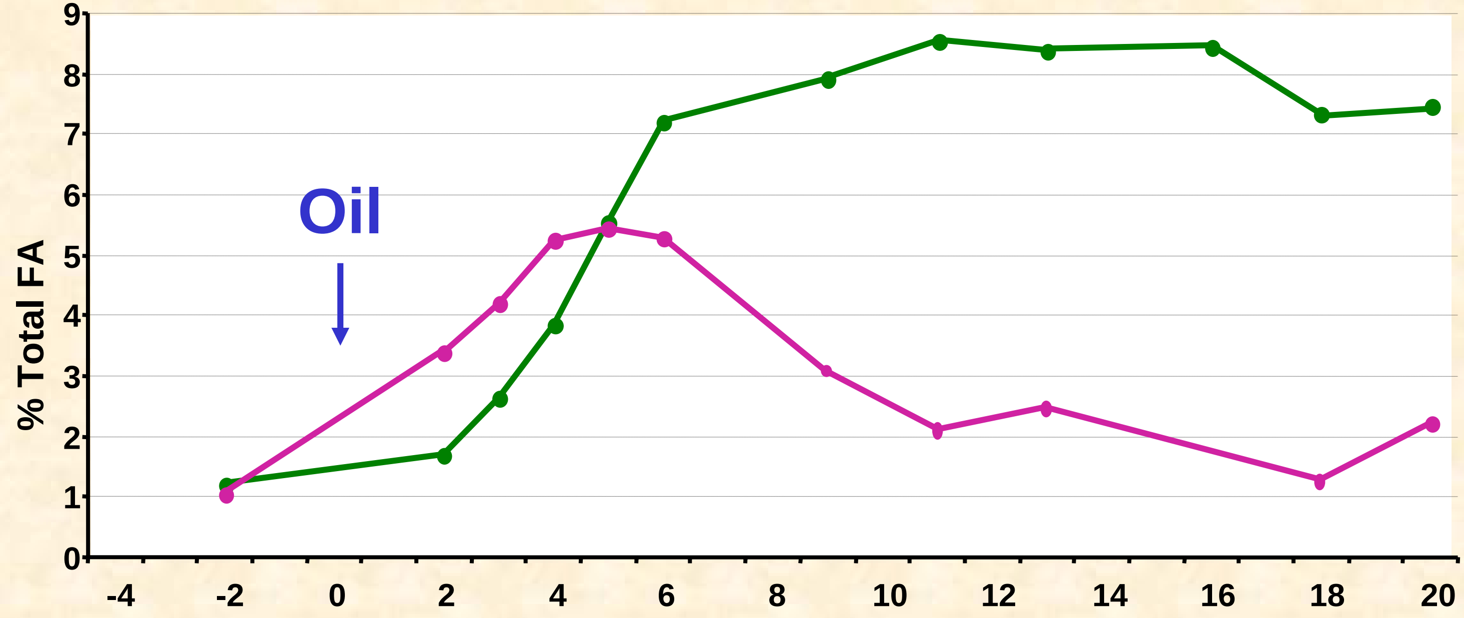


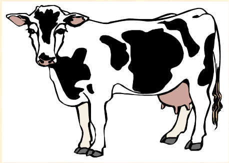


F. de Quelen, G. Boudry, J. Mourot, unpublished data

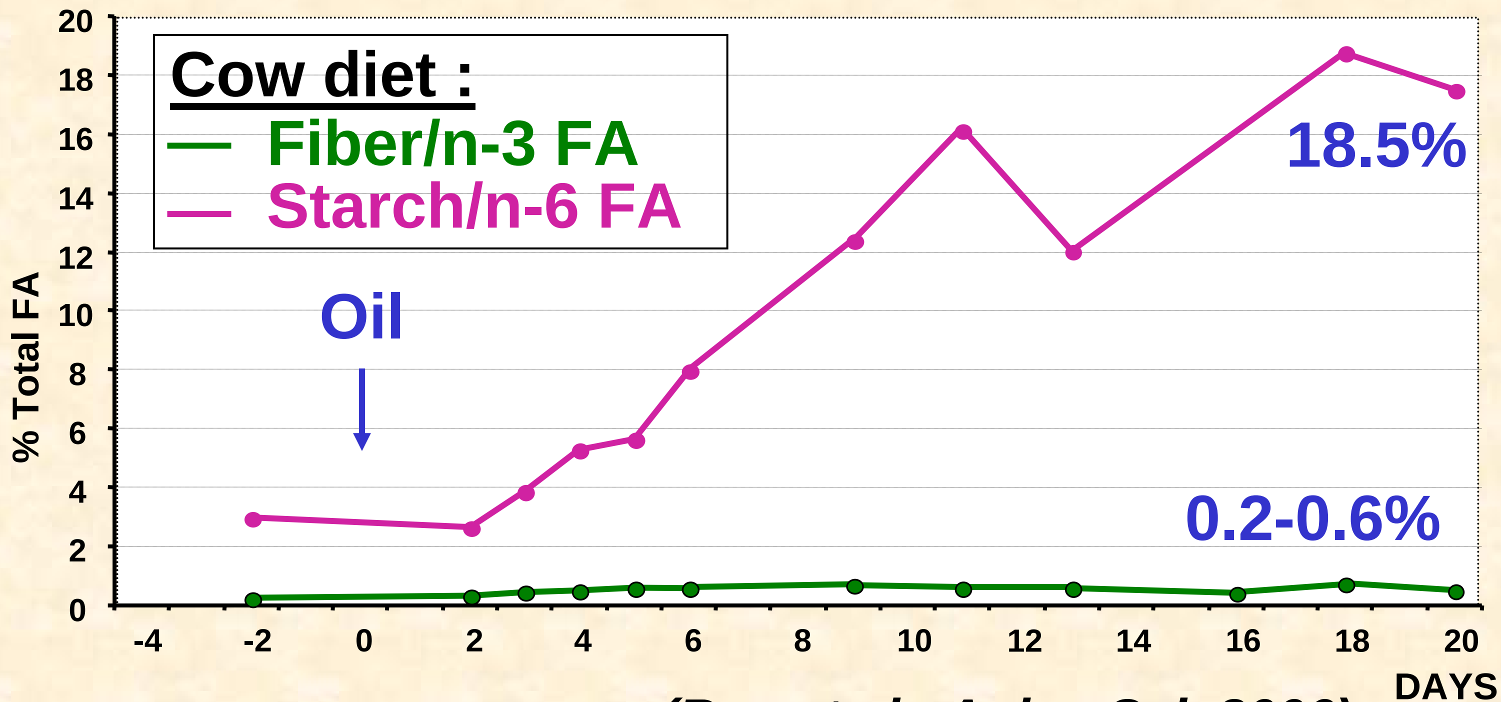
Milk FA :

*trans*11-18:1





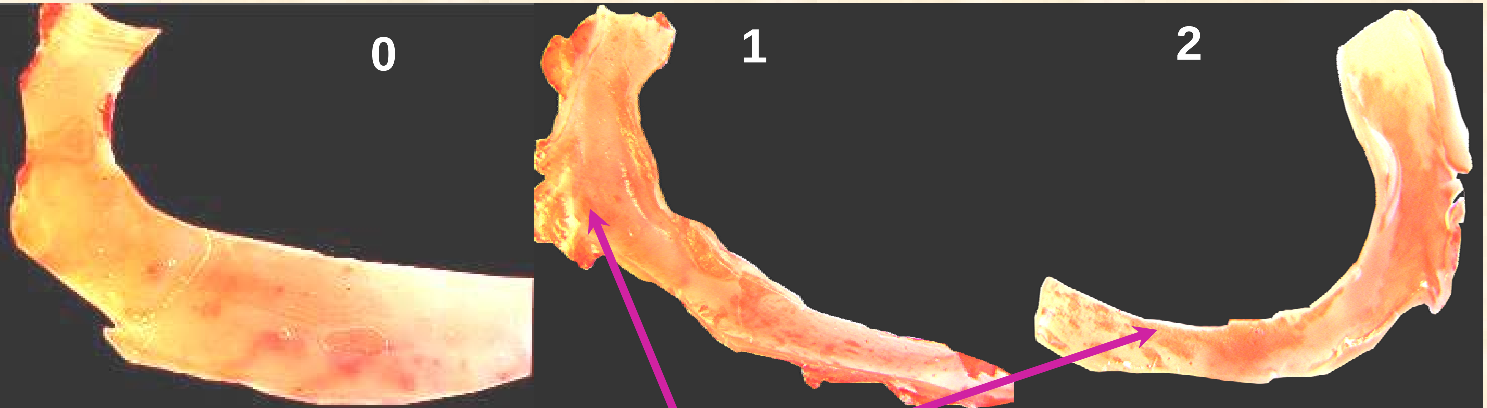
*trans*10-18:1

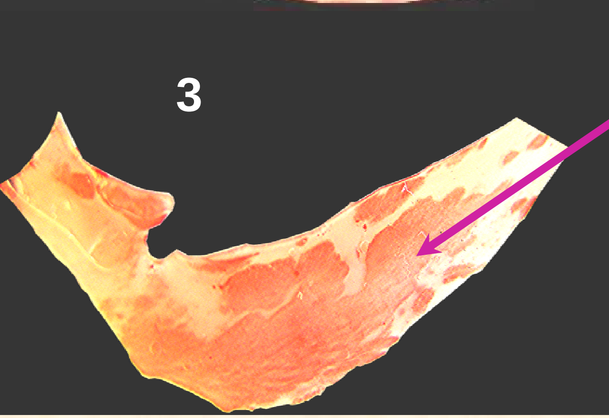


(Roy et al., Anim. Sci. 2006)

Effect of cow diet on butter FA profile and aorta lipid infiltration in rabbits fed 0.2% cholesterol

(Roy et al., Animal Sci. 2006 & Animal 2007)



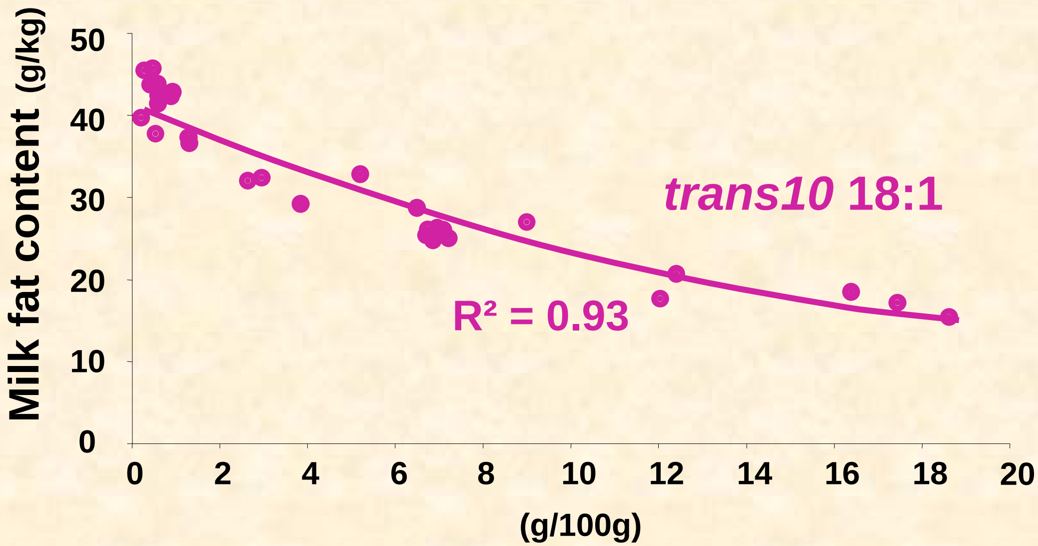


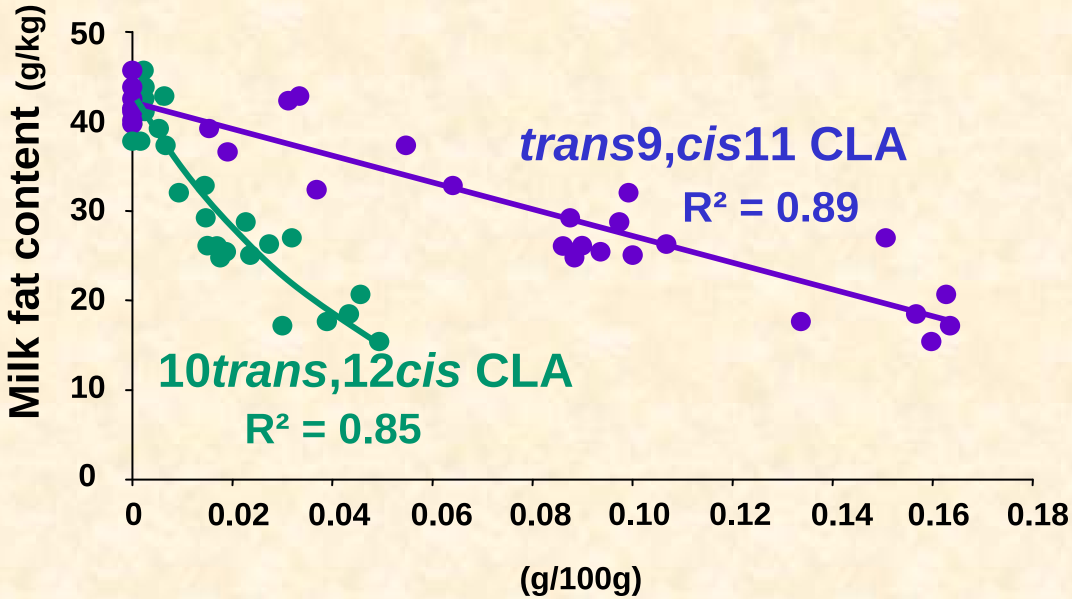
Lipid depositions

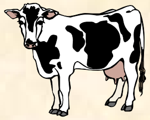
Cow diet	Butter	Aorta infiltration
starch + n-6 FA	trans10-rich	5/5[b]
mixed diet	saturated FA	5/6[ab]
fiber + n-3 FA	trans11-rich	2/6[a]

INRA

Trans-fatty acids and bovine mammary lipogenesis







Milk fat depression

Response sensitivity :

***trans*10,*cis*12 CLA**

>

***trans*9,*cis*11 CLA**

>

***trans10* 18:1**

(Roy et al., Anim. Sci. 2006)

INRA

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Nutrigenomics & Nutrigenetics

- Nutrigenomics
  - Determines the influence of dietary ingredients on the genome
  - Relates the resulting phenotypes to cellular and/or genetic response of the biological system.

  How a nutritional stimulus affects metabolic pathways and homeostatic control.

- Nutrigenetics,
  - Aims to understand how the genetic makeup of an individual
  - Coordinates their response to diet considering underlying genetic polymorphisms.

  How the genetic makeup of an individual coordinates the response to diet

Genes, nutrition and diseases

- Nearly 1000 genes associated with human disease
  97% result in monogenic diseases.
  - Dietary compounds can prevent some monogenic diseases (*i.e.*galactosemia and phenylketonuria).

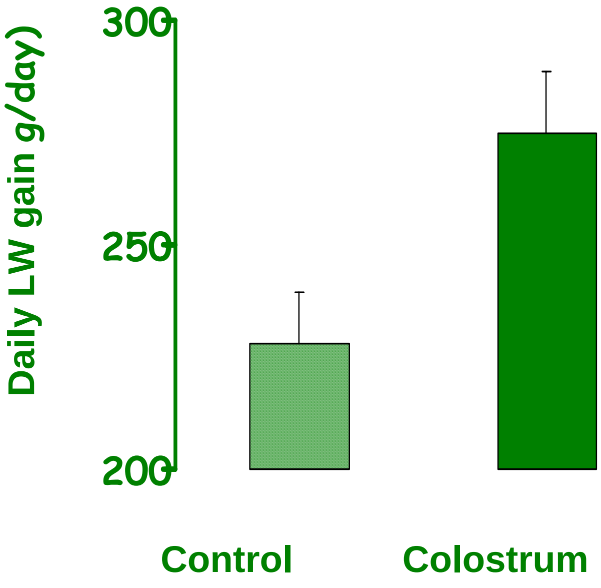
    Galactose-free and phenylalanine-restricted tyrosine-supplemented diets are the nutritional treatment of these diseases, respectively.

- Degenerative diseases (cancer, obesity, diabetes and cardiovascular disease) are the consequence of biological network dysfunctions (polygenic diseases).

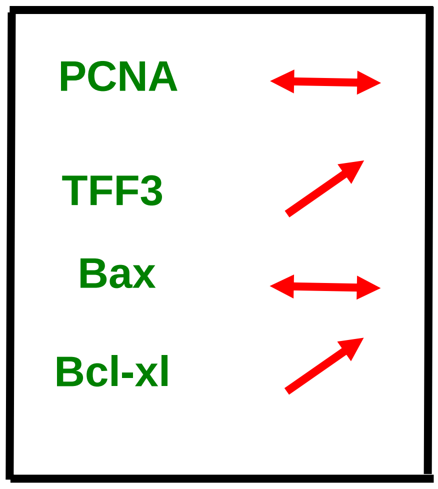
    A meta-analysis of 2000 microarray studies spanning 22 different tumor types evidenced no single common gene mutation but shared functional modules (Segal et al).

Colostrum addition to piglet diet:
Expression of genes associated with mucosal trophicity

Growth rate



Expression of intestinal genes



Le Huërou-Luron et al, 2004

Live long? Die young? Answer isn't just in genes

By Gina Kolata The New York Times

Published: August 31, 2006

"How tall your parents are compared to the average height explains 80 to 90 percent of how tall you are compared to the average person, but only 3 percent of how long you live compared to the average person can be explained by how long your parents lived.

You really learn very little about your own life span from your parents' life spans. Even twins, identical twins, die at different times: on average, more than 10-15 years apart."

From James Vaupel, director of the Laboratory of Survival and Longevity at the Max Planck Institute for Demographic Research in Rostock, Germany

1 MARCH 2002 VOL 295 SCIENCE www.sciencemag.org

REVIEW

Reverse Engineering of Biological Complexity

Marie E. Csete[1] and John C. Doyle[2*]

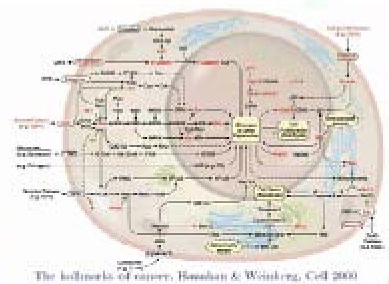
Advanced technologies and biology have extremely different physical implementations, but they are far more alike in systems-level organization than is widely appreciated. Convergent evolution in both domains produces modular architectures that are composed of elaborate hierarchies of protocols and layers of feedback regulation, are driven by demand for robustness to uncertain environments, and use often imprecise components. This complexity may be largely hidden in idealized laboratory settings and in normal operation, becoming conspicuous only when contributing to rare cascading failures. These puzzling and paradoxical features are neither accidental nor artificial, but derive from a deep and necessary interplay between complexity and robustness, modularity, feedback, and fragility. This review describes insights from engineering theory and practice that can shed some light on biological complexity.

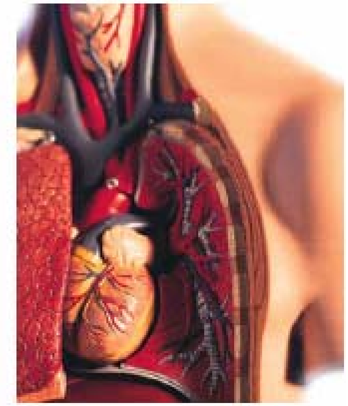
Cell, Vol. 118, 675–685, September 17, 2004, Copyright ©2004 by Cell Press

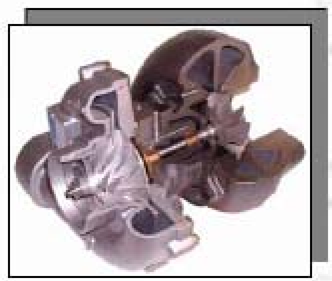
Robustness of Cellular Functions

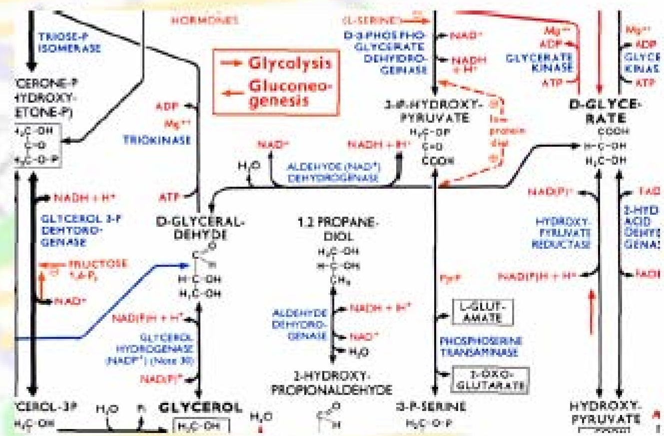
Robustness, the ability to maintain performance in the face of perturbations and uncertainty, is a long-recognized key property of living systems. Owing to intimate links to cellular complexity, however, its molecular and cellular basis has only recently begun to be understood. Theoretical approaches to complex engineered systems can provide guidelines for investigating cellular robustness because biology and engineering employ a common set of basic mechanisms in different combinations. Robustness may be a key to understanding cellular complexity, elucidating design principles, and fostering closer interactions between experimentation and theory.

Complex systems are the same in principle









Tools for understanding complex engineering systems can be applied in biomedicine

AIAA 1st Intelligent Systems Technical Conference
20 - 22 September 2004, Chicago, Illinois

AIAA 2004-6461

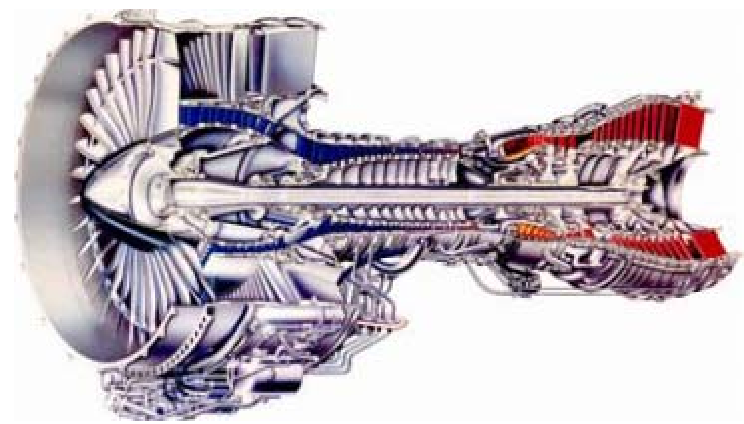
Development of an Information Fusion System for Engine Diagnostics and Health Management

Allan J Volponi
Pratt & Whitney, East Hartford, CT 06108

Tom Brotherton
Intelligent Automation Corp., Poway, CA 92064

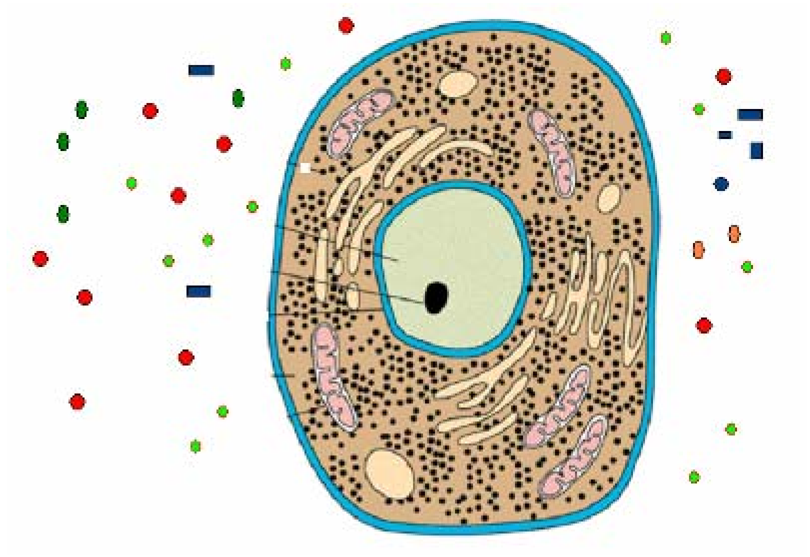
Robert Luppold
Luppold & Associates, West Newton, PA 15089

Figure 1 C-17 Globemaster



Vibration, Noise, Gas etc.

System-level features of a cell



- Secretome-extracellular proteins
- Metabonome-extracellular metabolites

Vibration Noise Gas

Cellular reverse engineering

- Clustering of cells based on their secretome and metabonome
- Differences of profiles of extracellular proteins and metabolites between cancer and normal cells
- Cellular Biomarker discovery based on secretome and metabonome

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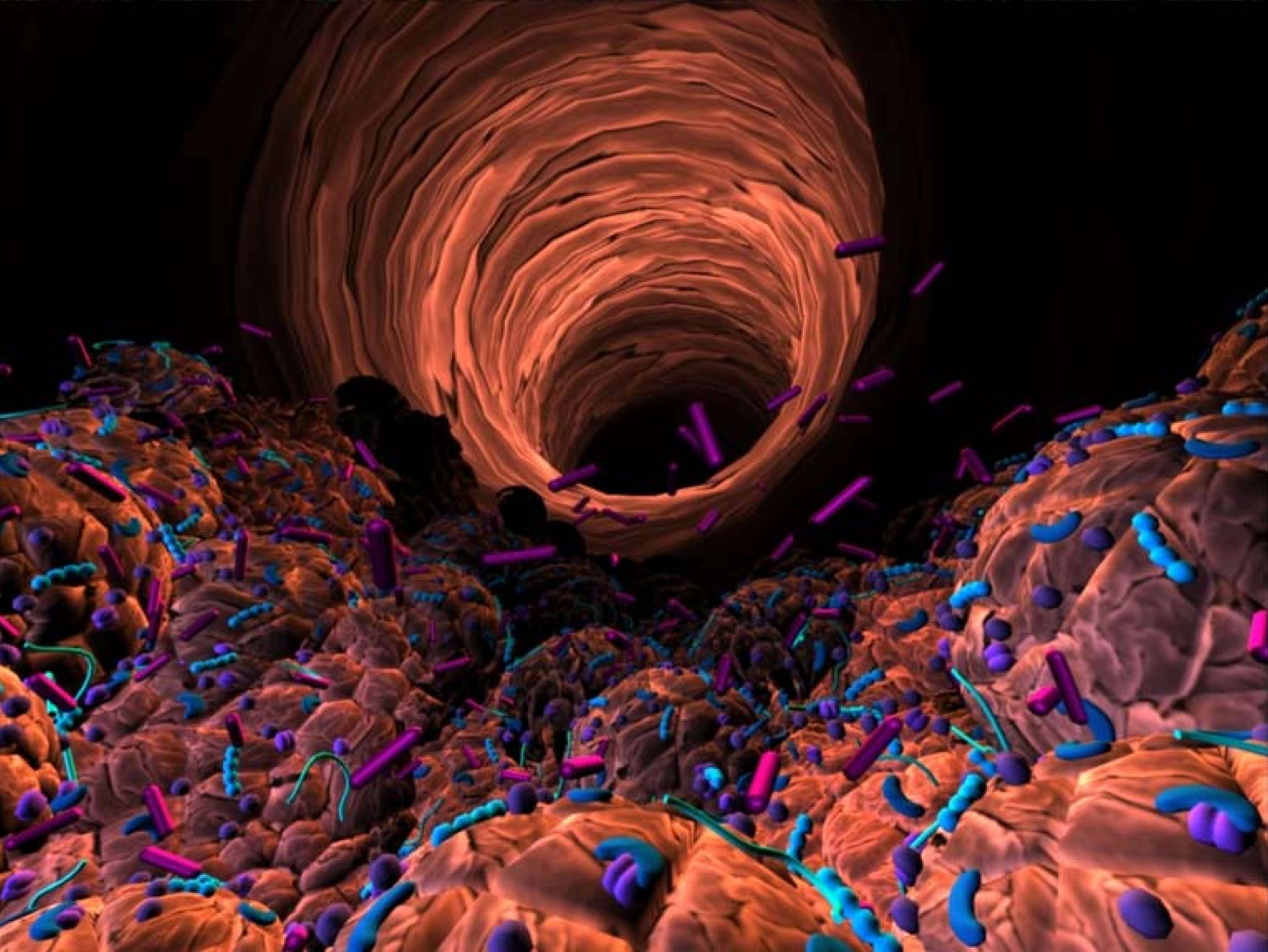
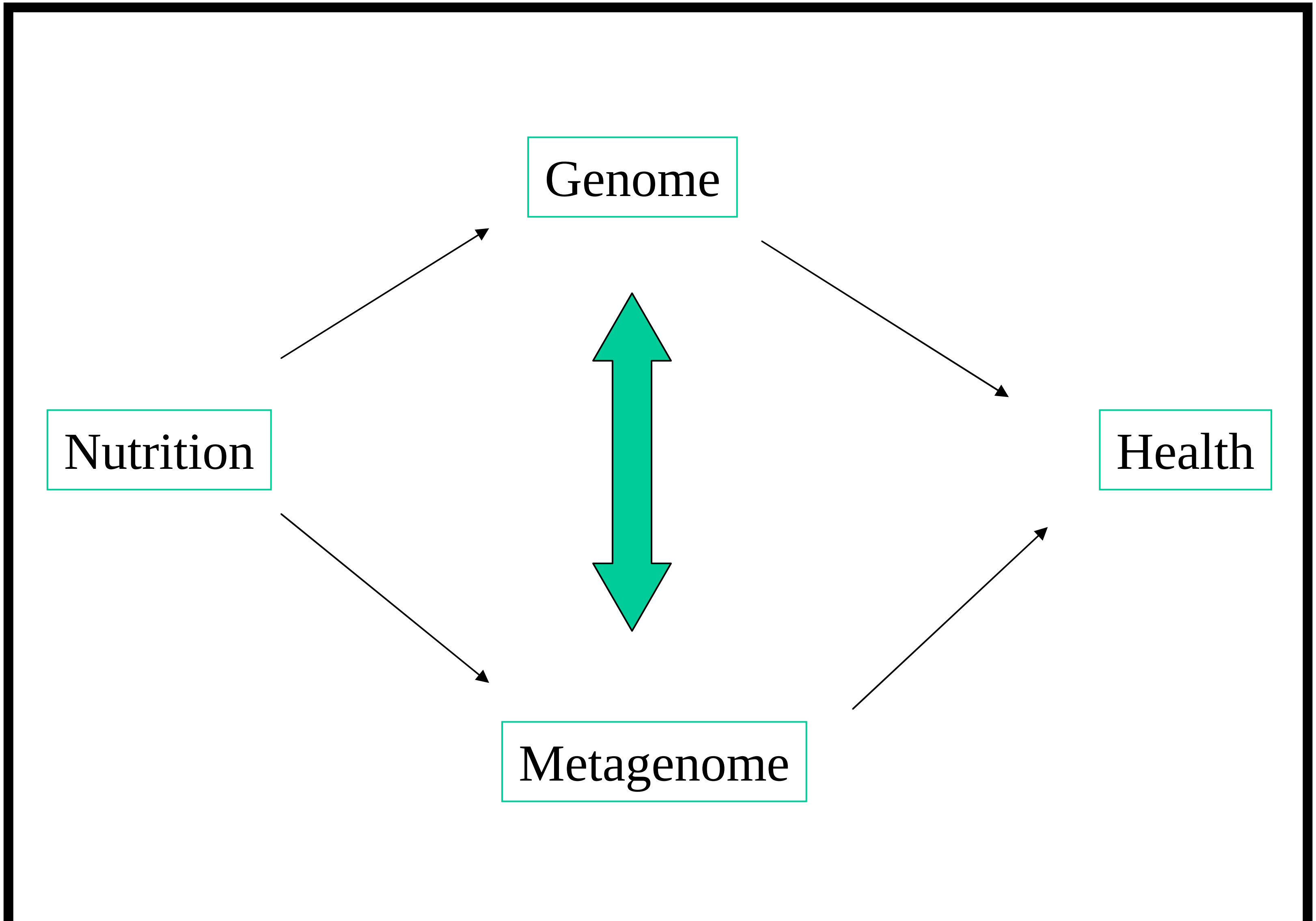
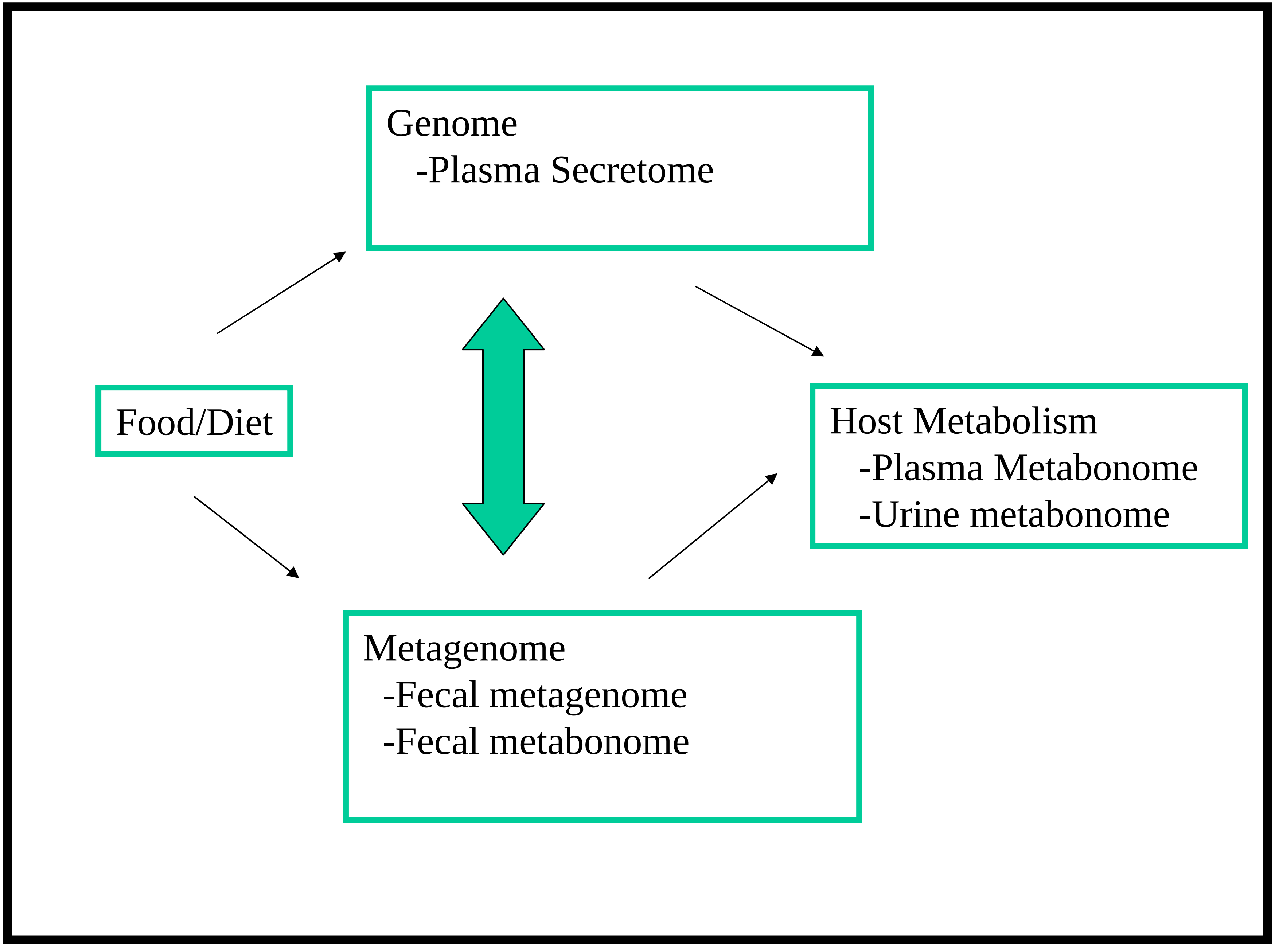


Animal nutrition and the Environment

- Controlling rumen fermentation is an interesting challenge (volatile fatty acid and protein synthesis). => Energy (methane) and protein (ammonia) inefficiencies
  - => Release of pollutants to the environment.
  - => alternatives to antibiotics in controlling specific microbial populations
  - => specific nutrients administration: essential oils and plant extracts (see C. Martin et al, at ISEP07), alternative protein sources (proteaginous) or natural additives (tannins, essential oils)



Environments

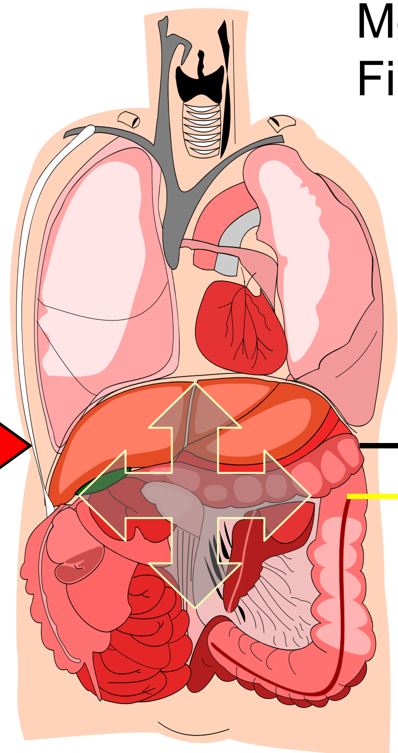


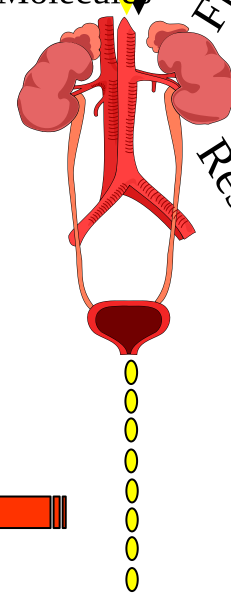
Environments

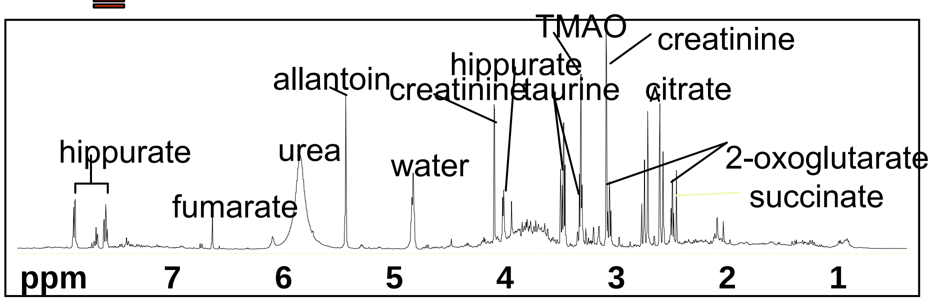
Organism reverse engineering

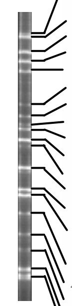
Metabonomic Fingerprint

Metagenomic Fingerprint









Band	Representa -tive clone	Nearest species	Similarity (%)	Richness (library) %
1	Clept 15	*Faecalibacterium prausnitzii* L2-6	98.8	2
	Clept 58	*Ruminococcus flavefaciens* ATCC 49949	92.3	1
2	Clept 1	*Faecalibacterium prausnitzii* L2-6	98.8	9
3	Clept 20	*Faecalibacterium prausnitzii* L2-6	99.2	7
4	Clept 6	*Ruminococcus flavefaciens* ATCC 49949	92.5	13
5	Clept 26	*Faecalibacterium prausnitzii* A2-165	98.4	3
6#	Clept 6-5	*Faecalibacterium prausnitzii* L2-6	91.7	\
7	Clept 24	*Faecalibacterium prausnitzii* A2-165	99.1	1
8	Clept 9	*Faecalibacterium prausnitzii* A2-165	98.6	1
9	Clept 2	Faecalibacterium prausnitzii; A2-165	99.2	6
10	Clept 34	*Faecalibacterium prausnitzii* L2-6	99.2	5
11	Clept 11	*Faecalibacterium prausnitz* L2-6	98.4	2
12	Clept 10	butyrate-producing bacterium M21/2 [c]	99.1	9
13	Clept 7	*Faecalibacterium prausnitzii* A2-165	98.4	4
14	Clept 18	*Subdoligranulum variabile*	98.9	2
	Clept 51	*Subdoligranulum variabile*	99.5	3
15	Clept 12	*Faecalibacterium prausnitzii* A2-165	99.6	3
16#	Clept 17-4	butyrate-producing bacterium M21/2 [c]	95.3	\
17	Clept 4	*Subdoligranulum variabile*	98.6	1
18	Clept 14	butyrate-producing bacterium M21/2 [c]	99	6
19	Clept 25	butyrate-producing bacterium M21/2 [c]	99.3	3
OL1	Clept 5	butyrate-producing bacterium A2-207 [c]	98.6	1
OL 2	Clept 8	butyrate-producing bacterium M21/2 [c]	98.7	1
OL 3	Clept 35	butyrate-producing bacterium A2-207 [c]	99	1
OL 4	Clept 87	*Faecalibacterium prausnitzii* A2-165	97.3	1
OL 5	Clept 99	*Faecalibacterium prausnitzii* L2-6	98.6	1
N 1	Clept 28	Lactobacillales bacterium HY-36-1	95.1	2
N 2	Clept 93	Lactobacillales bacterium HY-36-1	91.1	2
N 3	Clept 48	Lactobacillales bacterium HY-36-1	94.3	2
N 4	Clept 59	Lachnospiraceae bacterium 19gly4	92.4	1
N 5	Clept 13	Lactobacillales bacterium HY-36-1	95	4

QuickTime™ et un
décompresseur TIFF (non compressé)
sont requis pour visionner cette image.