Nutrigenomics – a tool to meet the future demands for animal-derived foods

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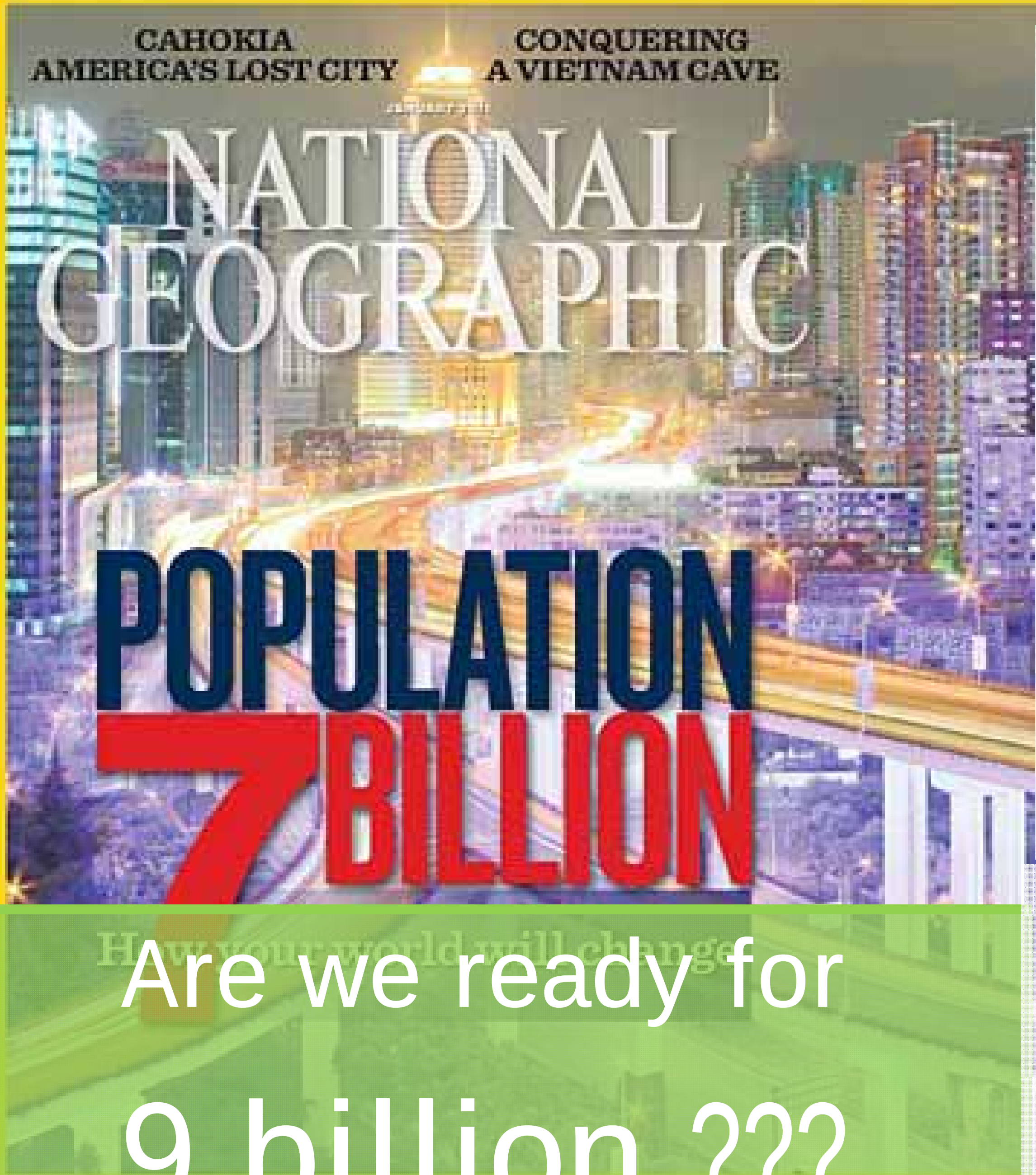
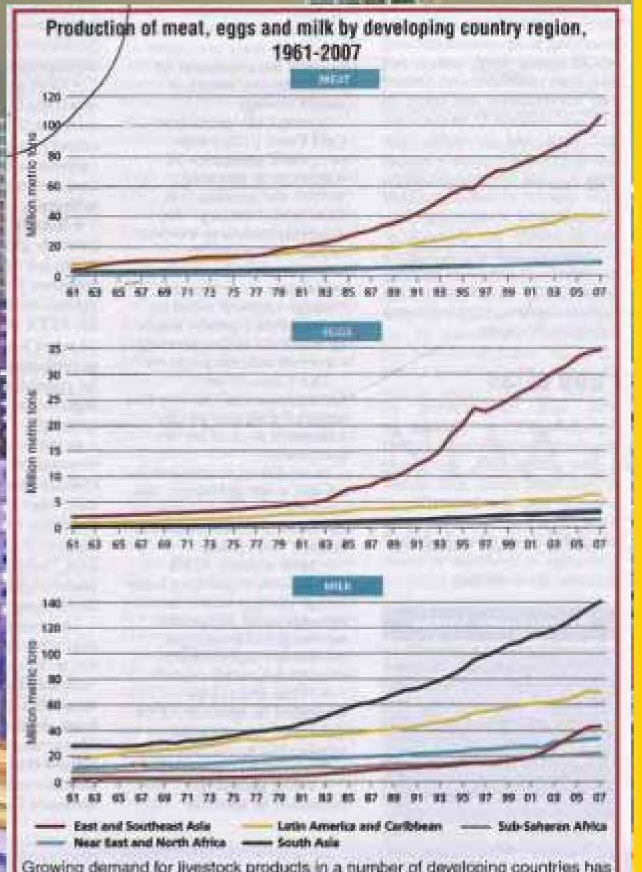
23rd June 2011





Growing demand for livestock products in a number of developing countries has been driven by economic growth, rising per capita incomes and urbanization.
Source: U.N. Food & Agriculture Organization, "State of Food & Agriculture."

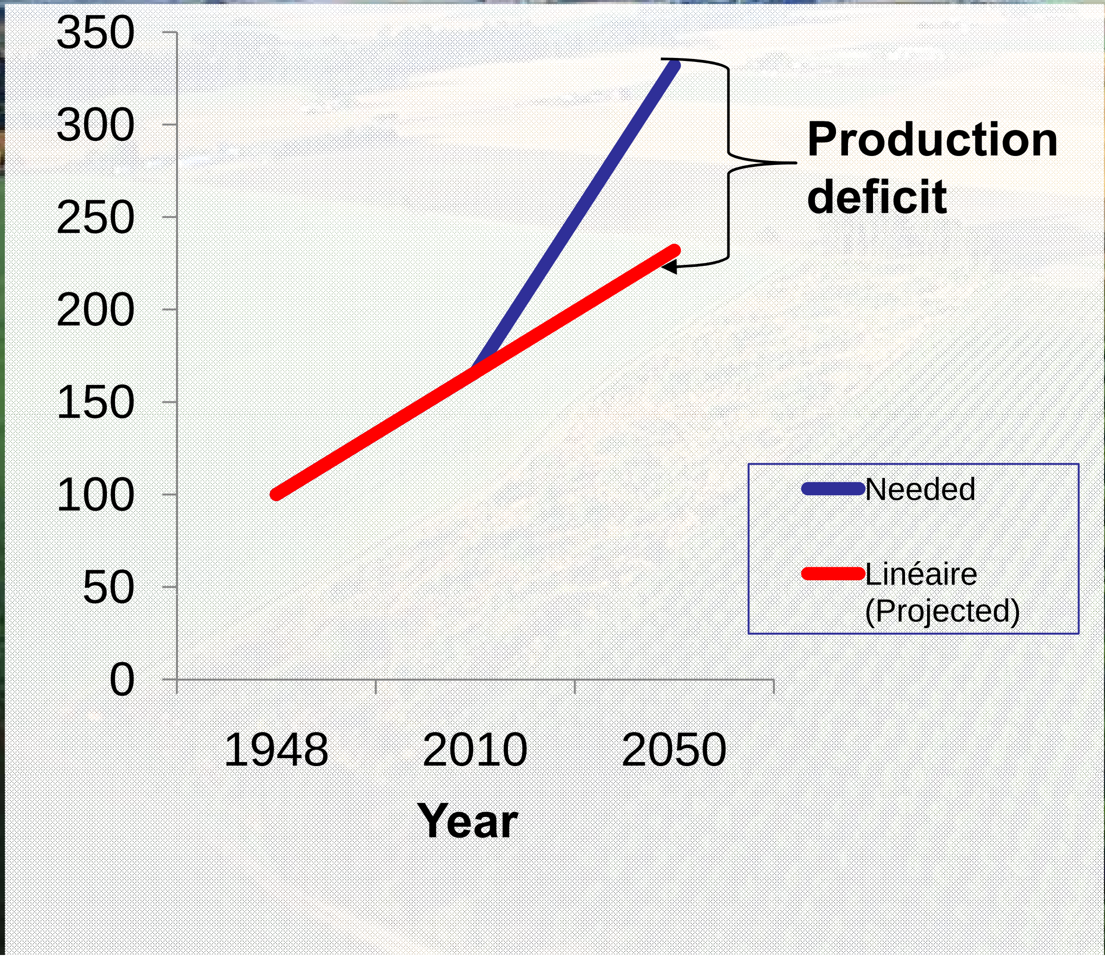
Are we ready for
9 billion ???

The World needs to double the meat production in the next 50 years

What are the **challenges?**

- **Changes in the world economy**
- **Changes in the environment**
- **Decreased availability of land and water**
- **Impact of the transportation of foods**
- **Food security: Food chain safety and traceability**
- **Food sufficiency: Efficiency of food production**
- **Demand for functional foods**
- **EU ban on AGPs**
- **Effective nutrient utilization**

The future and the deficit: *A CRISIS in the making*



- Continued increases in production at past rates will result in a deficit in overall food production

Small changes in food production efficiencies will not be sufficient

- It is time to make quantum leaps
  - Time to identify new resources
  - Time to develop new production technology
    - New tools and more efficient systems
    - Time for dramatic changes in management styles
  - Time to redefine nutritional strategies

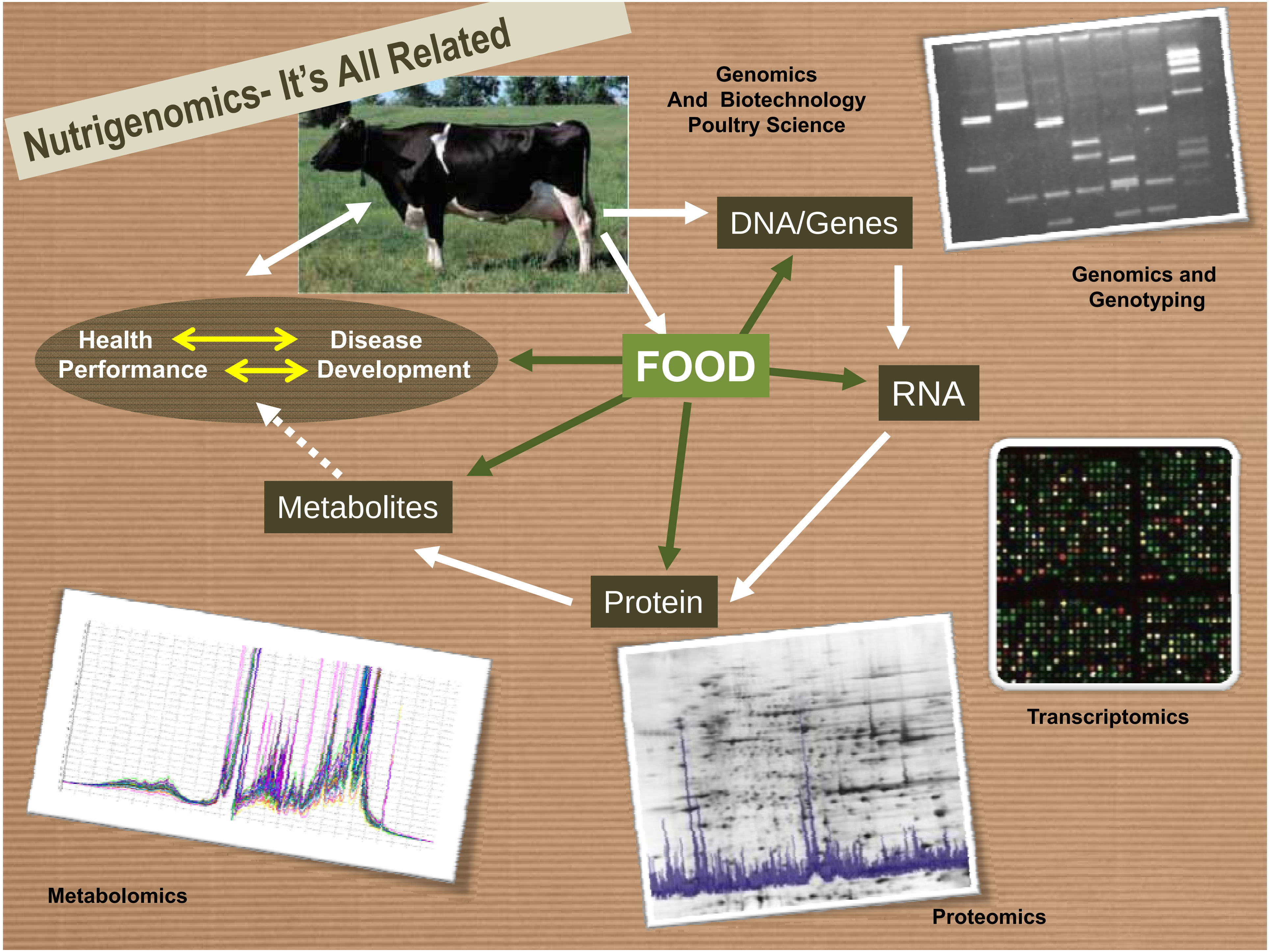
The new tool: Nutrigenomics

What can molecular tools tell us about nutritional programming strategies?

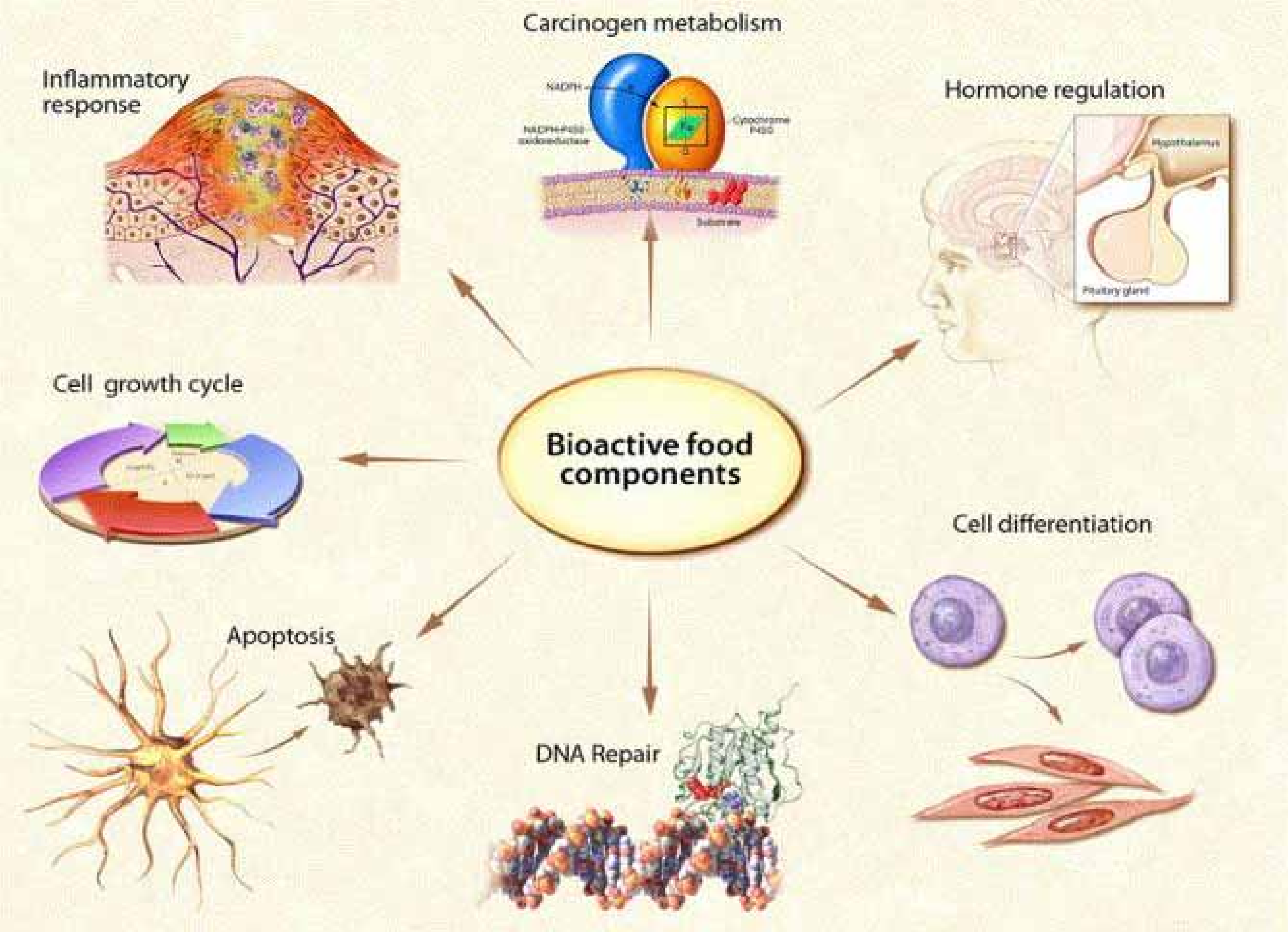
Nutrigenomics opens the gateway to a new paradigm

- How diet influences gene transcription, protein expression and metabolism.

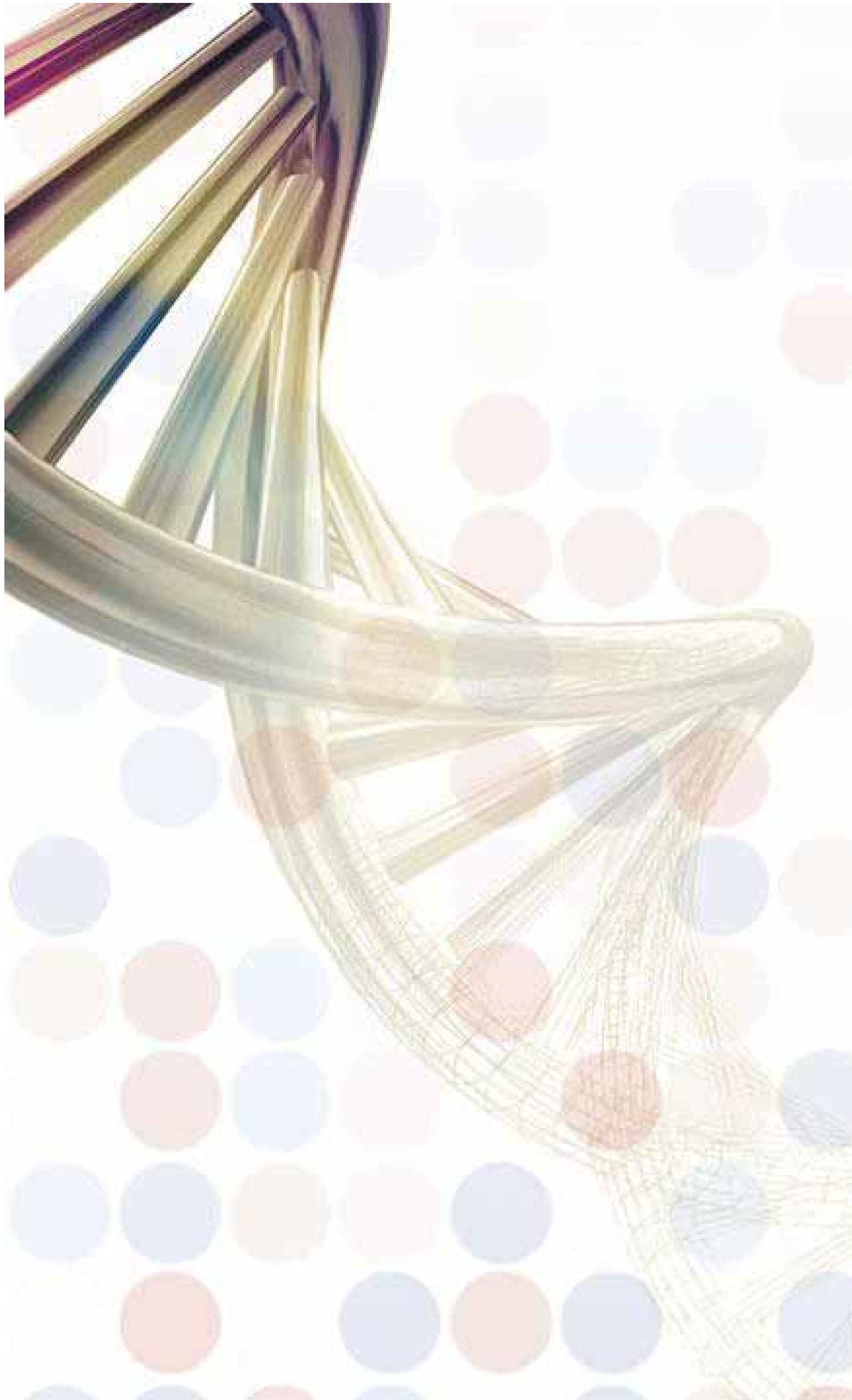
- Seeks to provide a molecular understanding for how common dietary chemicals affect health by altering gene expression


Nutrigenomics- It's All Related
Genomics
And Biotechnology
Poultry Science
DNA/Genes
Genomics and
Genotyping
Health
Performance
Disease
Development
FOOD
RNA
Metabolites
Protein
Transcriptomics
Metabolomics
Proteomics

Bioactive food components can influence gene expression and ultimately cellular function



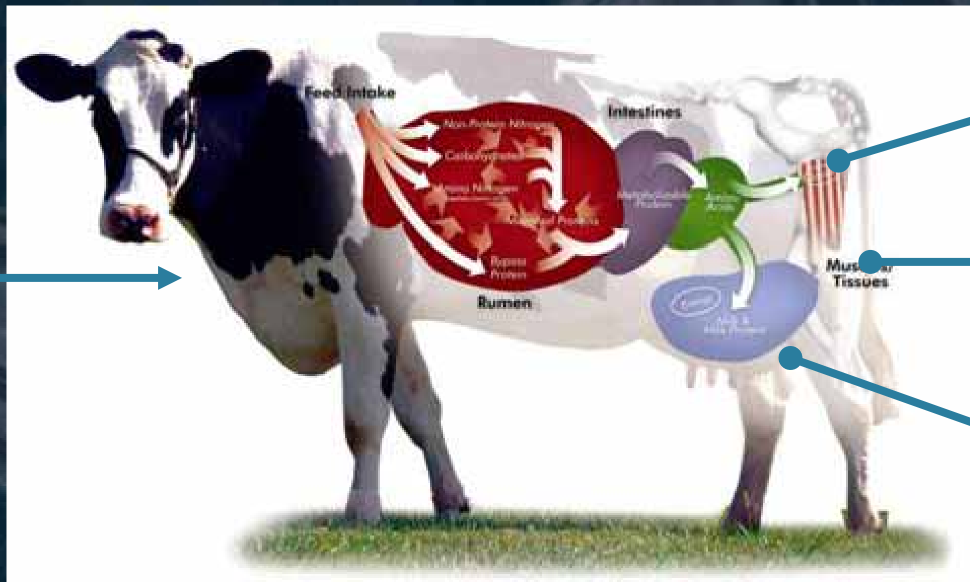
Trujillo et al., 2006



How can we best assess the effect of nutrition?

Traditional trial approach

Diet

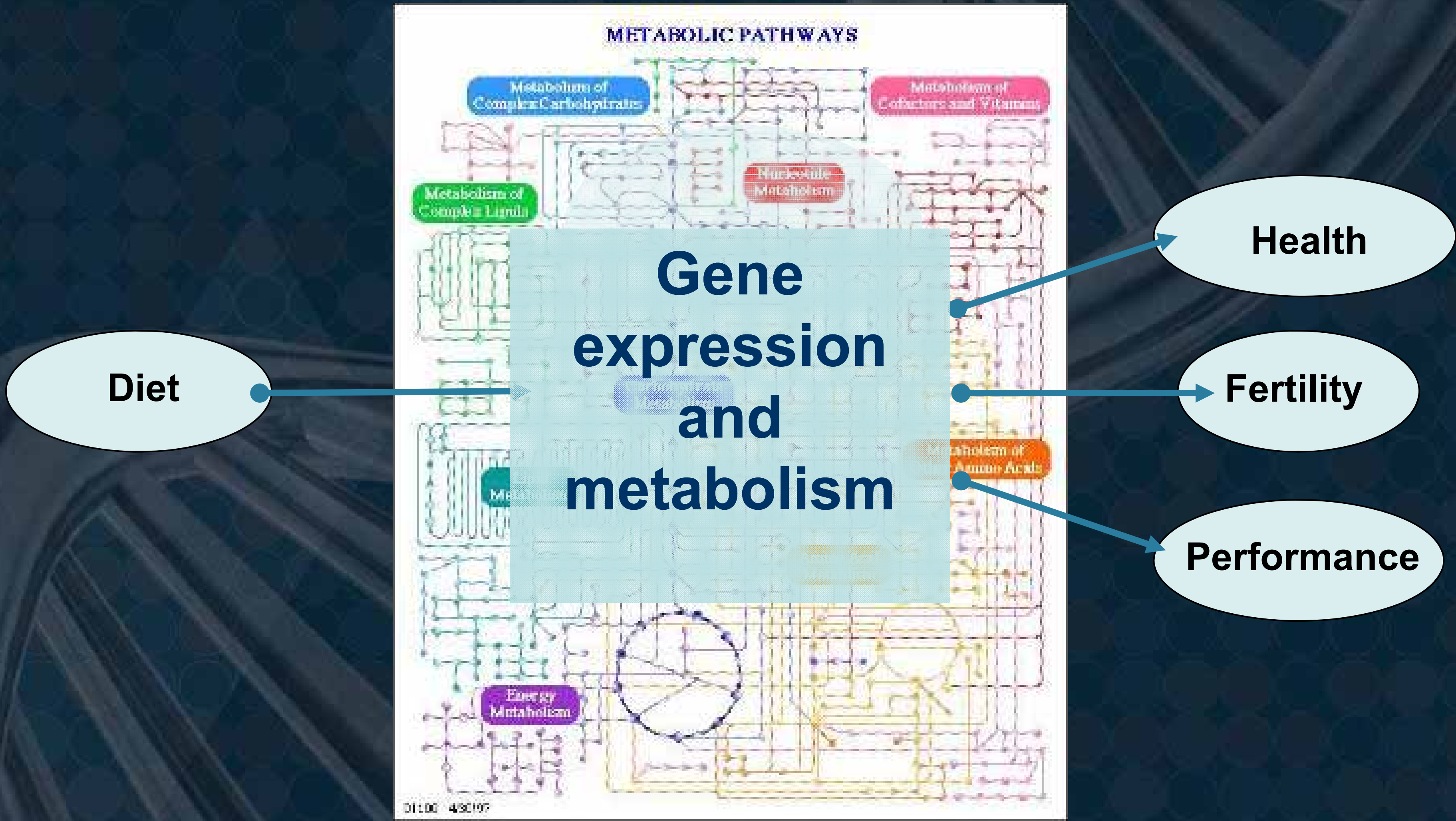


Health

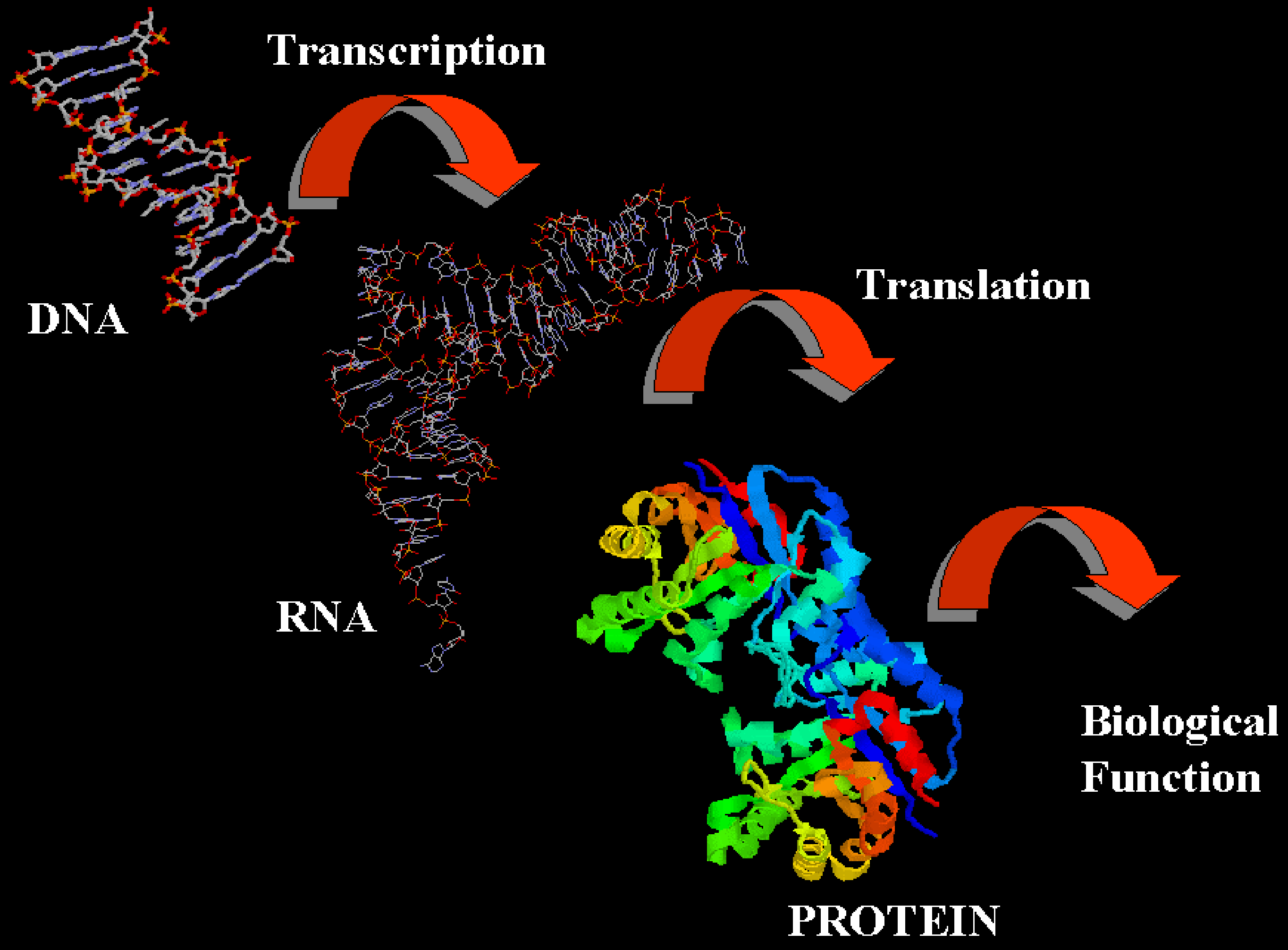
Fertility

Performance

Nutrigenomics approach



Ultimately genes control biological function



Altered Gene Expression = Altered Biological Function

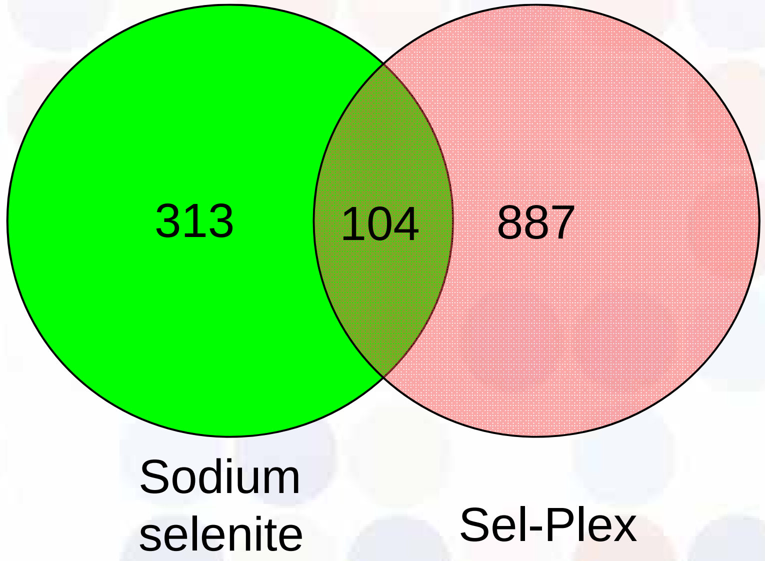
Potential issues

- Incomplete annotated genome sequences
- Gene transcription is only one step in the regulatory pathway
- Not always possible to correlate changes in mRNA levels with phenotypic or protein changes
- Transcriptomics still represents a major tool to elucidate key processes in metabolic regulation

Looking at practical examples – What can you learn?

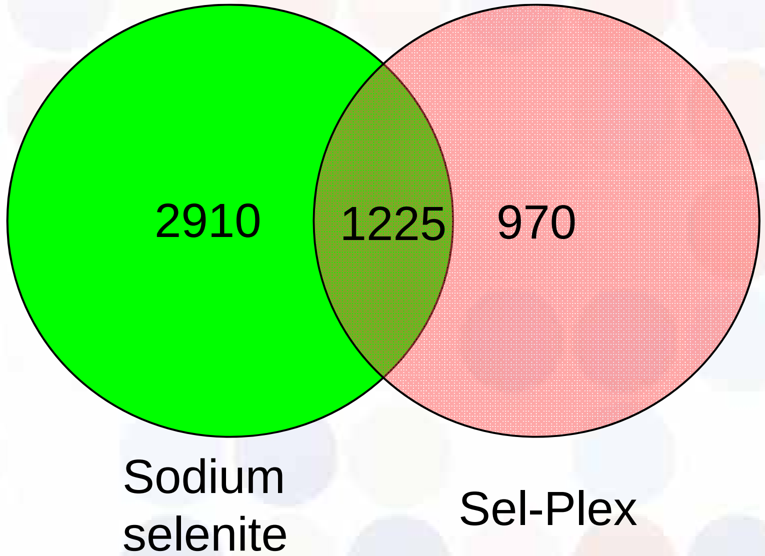
- Different tissues respond differently to the same nutrient
- Different forms of the same nutrient differently alter gene expression patterns
- Biomarkers relating gene expression to nutrition induced changes in physiology

Gene expression in intestinal tissue



- **1,304 transcripts were significantly affected by at least one selenium treatment in intestine ($P \leq 0.05$)**
- **Sel-Plex supplementation strategy altered 68%**
- **Sodium selenite group altered 24%**
- **Only (8%) were altered in the same way by both selenium supplementation strategies**

Gene expression in uterine tissue



- **5,105 transcripts were significantly affected by at least one selenium treatment in oviduct ($P \leq 0.01$)**
- **57% were influenced by sodium selenite supplementation**
- **19% influenced by Sel-Plex supplementation (19%)**
- **Both sodium selenite and Sel-Plex had similar effects on 24% of these genes.**

Observations

Nutrient type dictated which genes were altered

Different tissues were altered in different ways with the same supplementation strategy

Looking at practical examples – What can you learn?

- Different tissues respond differently to the same nutrient
- Different forms of the same nutrient differently alter gene expression patterns
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Cross-tissue analysis: GADD45β

Fold change data:

Selenomethionine				Sodium selenite				Sel-Plex			
ctx	int	liv	skm	ctx	int	liv	skm	ctx	int	liv	skm
-1.26	-1.07	1.24	1.02	-1.39	1.08	1.25	-2.42	-1.48	-1.39	-2.58	-2.16

Transcript abundance:

Growth arrest and DNA-damage-inducible 45 beta

Ctx Int Liv Skm

Most abundant → Least abundant

•GADD45β expression significantly decreased across all tissues tested by Sel-Plex® only

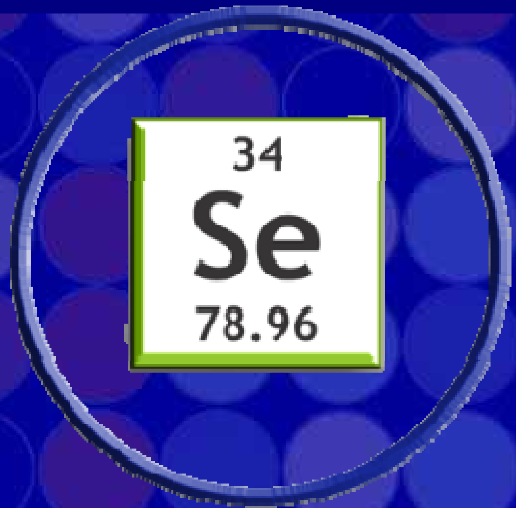
•Indicates lower endogenous oxidative stress and DNA damage throughout the entire animal

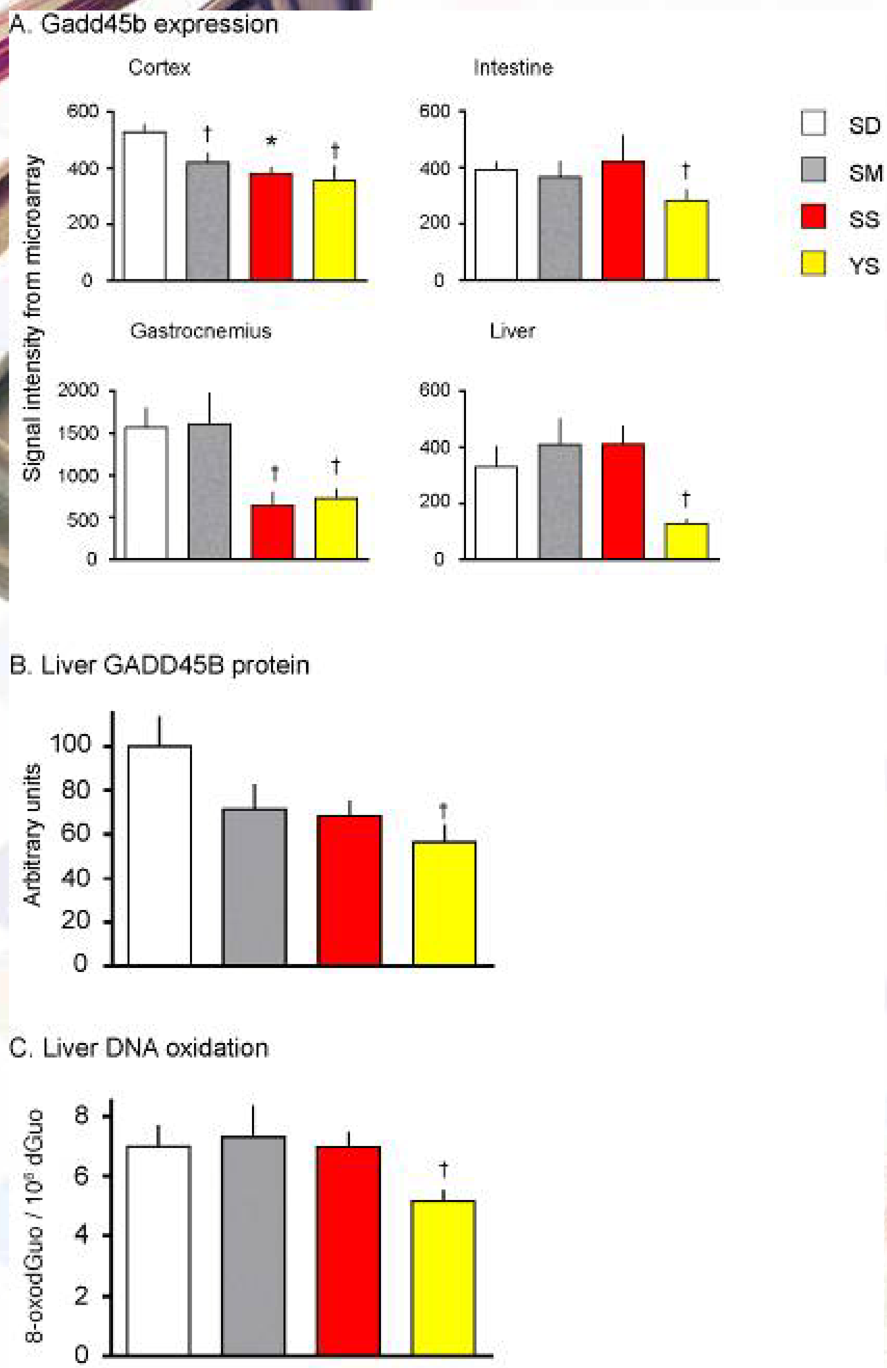
GADD45β: From youth to old age

Fold change data: Brain cortex

Young			Middle-aged			Old		
SM	SS	SP	SM	SS	SP	SM	SS	SP
-1.22	1.01	-1.48	-1.10	-1.44	-1.53	-1.18	-1.10	-1.42
Mouse age: 3 months			Mouse age: 15 months			Mouse age: 25 months		
Human equivalent: <10 years			Human equivalent: 45 years			Human equivalent: 75 years		

- **GADD45β expression significantly decreased across all age groups by Sel-Plex® only**



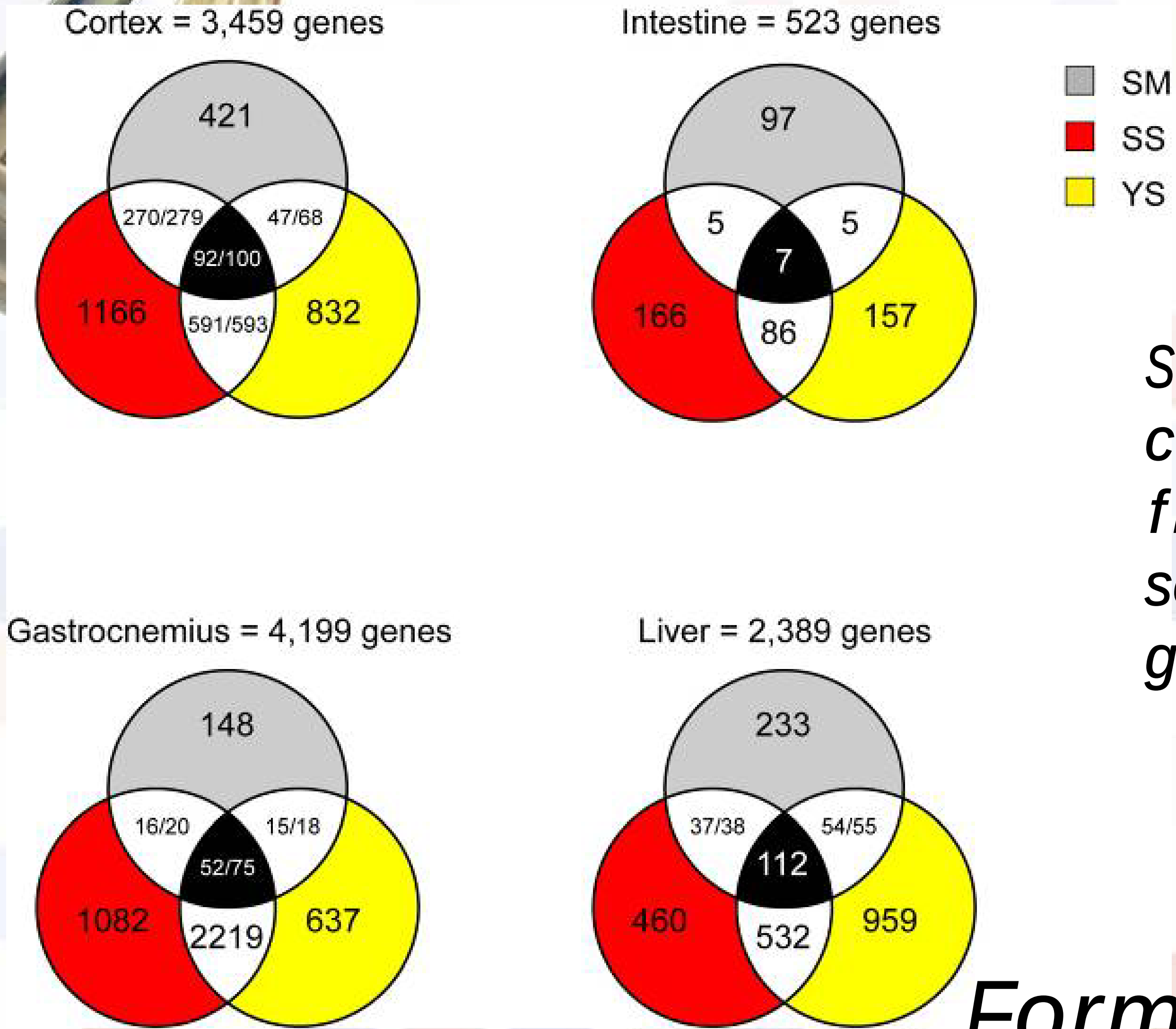


Physical measurement of GADD45 and DNA damage

(Barger et al., 2009)

Effect of selenium supplementation on the number of differentially-expressed genes in four tissues of mice

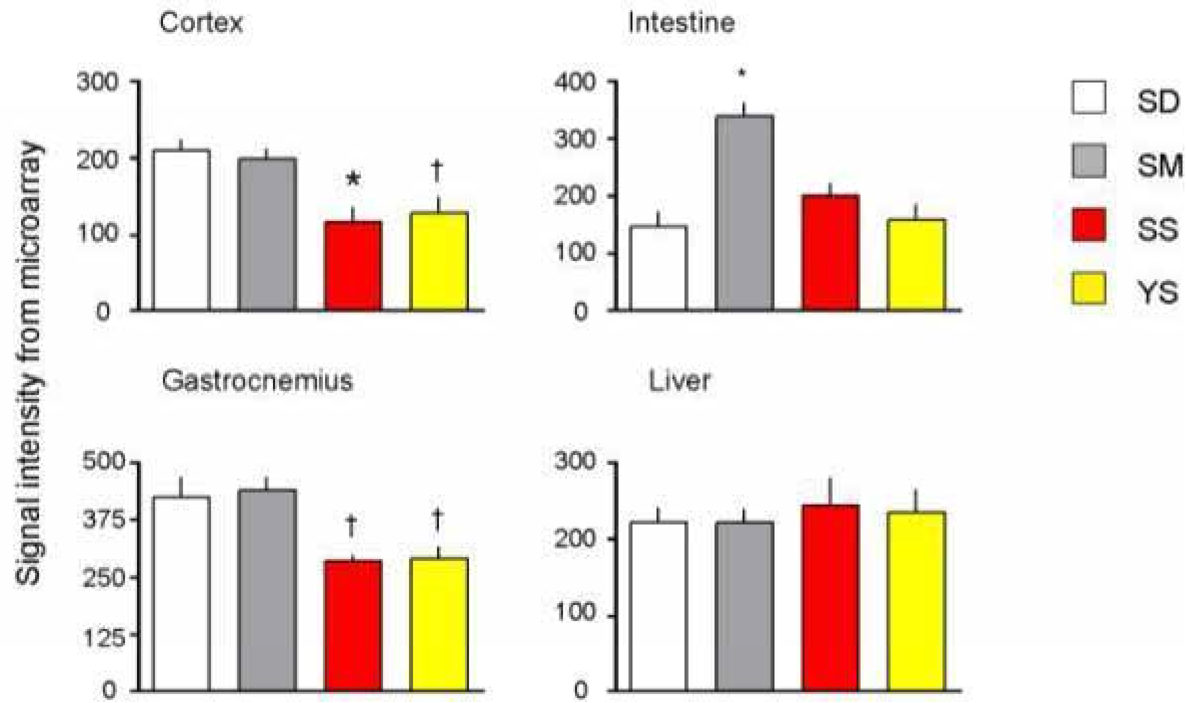
(Barger et al., 2009)



Selenomethionine can only elicit a fraction of the selenium-associated gene responses

Forms of selenium

Free L-selenomethionine induces the p53 tumor suppressor gene in intestine. Genotoxicity? **(Barger et al., 2009)**



- **Not all selenium sources are the same**

- **Care must be taken in selecting the form of specific nutrients**

Forms of selenium

Antioxidant Systems

"The cooperative interaction between antioxidants in the cell is vital for maximum protection from the deleterious effects of free radicals"

(Surai, 2001)

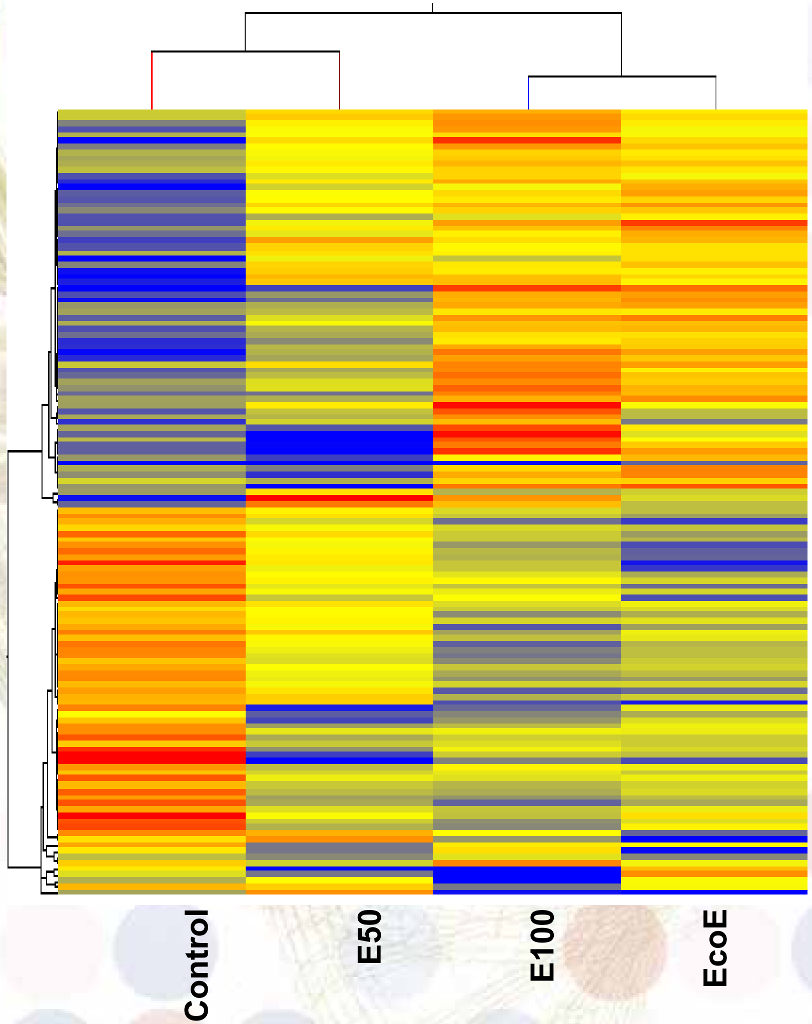
Economas

The challenge: measuring antioxidant effects

- **Antioxidants are required for optimal growth, immunity, and reproduction**
- **Historically added vitamin E at 5 to 10 times NRC requirements to meet a perceived need to maintain product quality**
- ***Alternative approaches have been proposed, <u>but have been difficult to evaluate</u>***
- **Gene expression to evaluate alternative strategies**

	ctx	int	liv	skm	ctx	int	liv	skm	ctx	int	liv	skm
Rpl12	-1.09	1.47	-1.11	1.07	1.24	-1.38	-1.34	1.46	1.14	-1.47	-1.21	1.39
Rpl13a	-1.06	1.17	-1.04	1.01	1.13	-1.31	-1.23	1.16	-1.08	-1.26	-1.27	1.18
Rpl37a	-1.08	-1.12	-1.02	1.02	1.16	-1.66	-1.18	1.27	1.02	-1.51	-1.10	1.27
Rps16	*-1.06*	*-1.00*	*-1.04*	*1.03*	*1.14*	*-1.68*	*-1.20*	*1.23*	*-1.08*	*-1.53*	*-1.16*	*1.22*
Rps2 /// L	*-1.00*	*1.23*	*1.02*	*1.16*	*1.24*	*-1.38*	*-1.09*	*1.23*	*1.18*	*-1.18*	*-1.06*	*1.19*
Rps5	-1.04	1.04	-1.04	1.20	1.22	-1.42	-1.10	1.23	1.06	-1.17	-1.07	1.27
Rps6kb1	1.07	1.06	-1.31	-1.05	1.17	1.47	-1.34	1.09	1.13	1.43	-1.31	1.27
Rps6ka4	-1.04	-1.03	-1.10	1.08	-1.23	1.22	1.76	-2.25	-1.48	1.20	1.54	-2.31
Mrpl9	-1.02	1.22	-1.07	1.04	-1.15	1.25	-1.19	-1.37	-1.20	1.13	-1.28	-1.28
Mrps34	-1.03	1.19	-1.02	-1.02	1.03	-1.28	-1.13	1.82	-1.26	-1.30	-1.11	1.81
Mrps9	1.01	-1.30	-1.04	-1.01	1.21	-1.41	-1.20	1.32	1.11	-1.12	-1.24	1.32

Hierarchy clustering of regulated intestinal genes in diets containing two levels of vitamin E and EconomasE

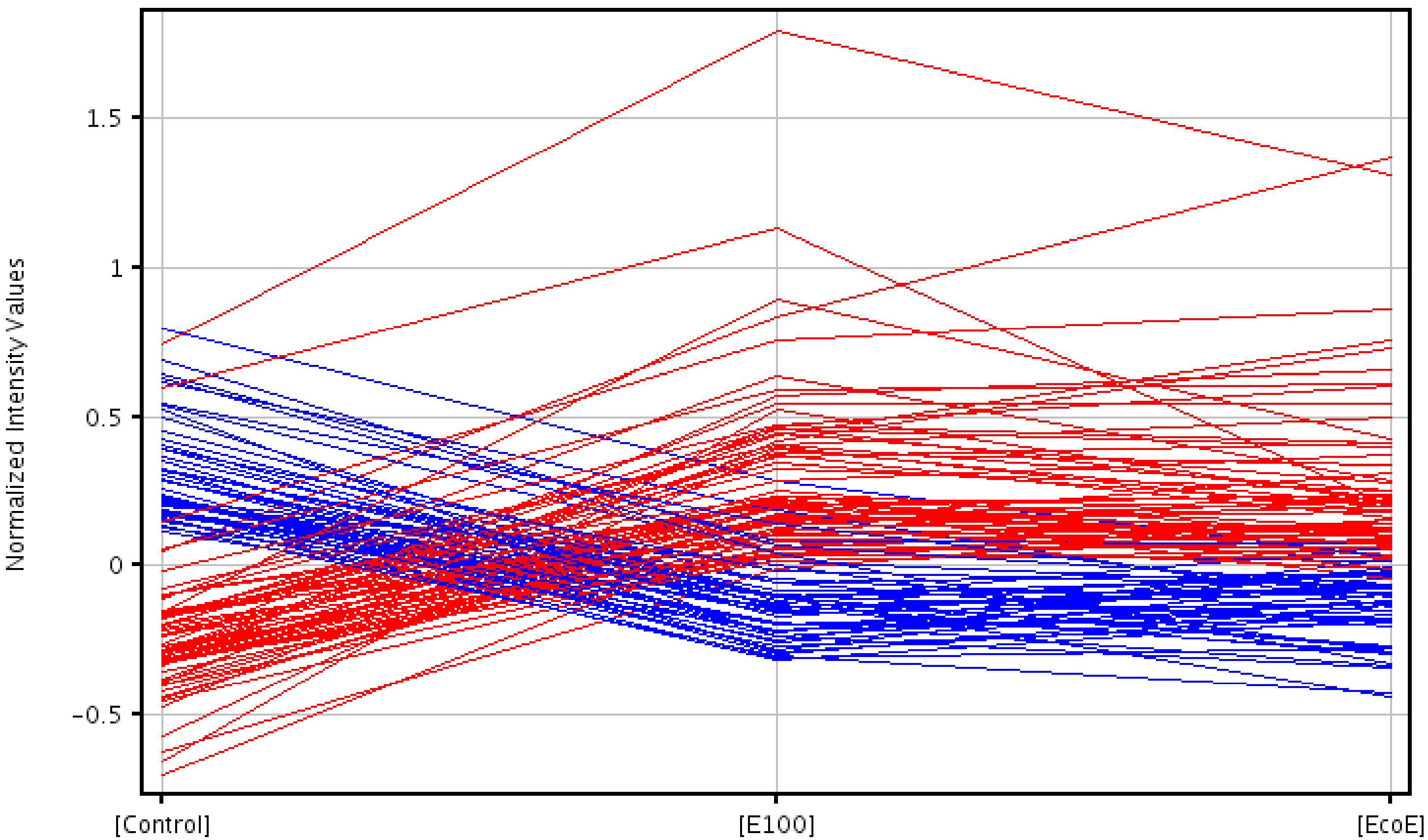


Genes included were significantly changed by EcoE and E100 (134 transcripts in total).

Expression level represented as higher (Red) or lower (Blue) than normalized median value of the corresponding genes.

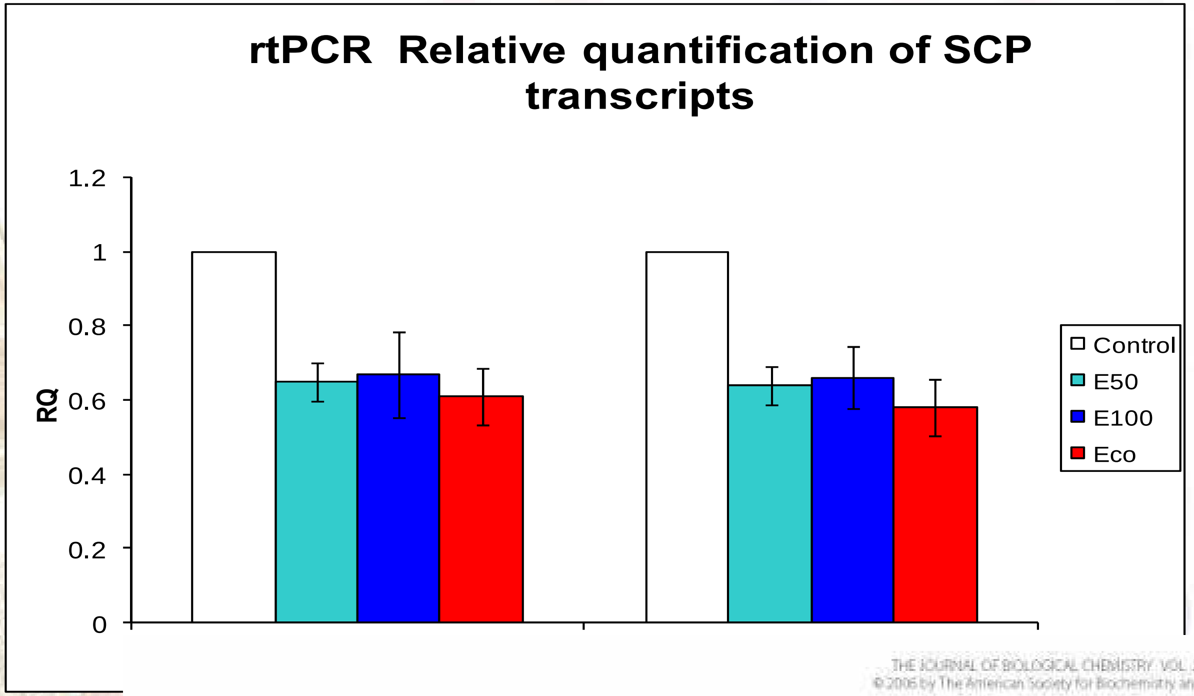
Results indicate that majority of genes are similarly changed by E100 and EcoE.

Genes changed unidirectionally by EconomasE and Vitamin E



* Genes included are those changed by both EcoE and E100

Effects of Vitamin E and EconomasE on expression of sterol carrier protein 2: Controlling tissue peroxidative stress and meat quality



* $p \leq 0.01$

THE JOURNAL OF BIOLOGICAL CHEMISTRY VOL. 281, NO. 33, pp. 23643–23651, August 18, 2006

Intracellular Dissemination of Peroxidative Stress

*INTERNALIZATION, TRANSPORT, AND LETHAL TARGETING OF A CHOLESTEROL HYDROPEROXIDE SPECIES BY STEROL CARRIER PROTEIN-2-OVEREXPRESSING HEPATOMA CELLS**

Received for publication, January 25, 2006, and in revised form, May 30, 2006 Published, JBC Papers in Press, June 12, 2006, DOI 10.1074/jbc.M600744200

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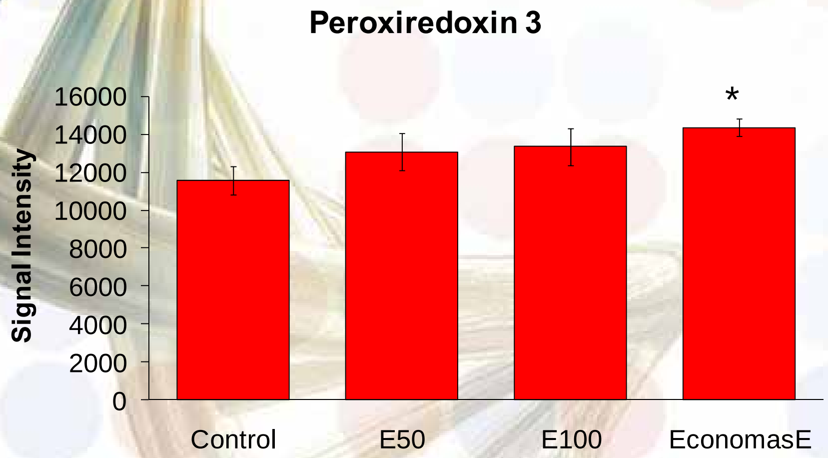
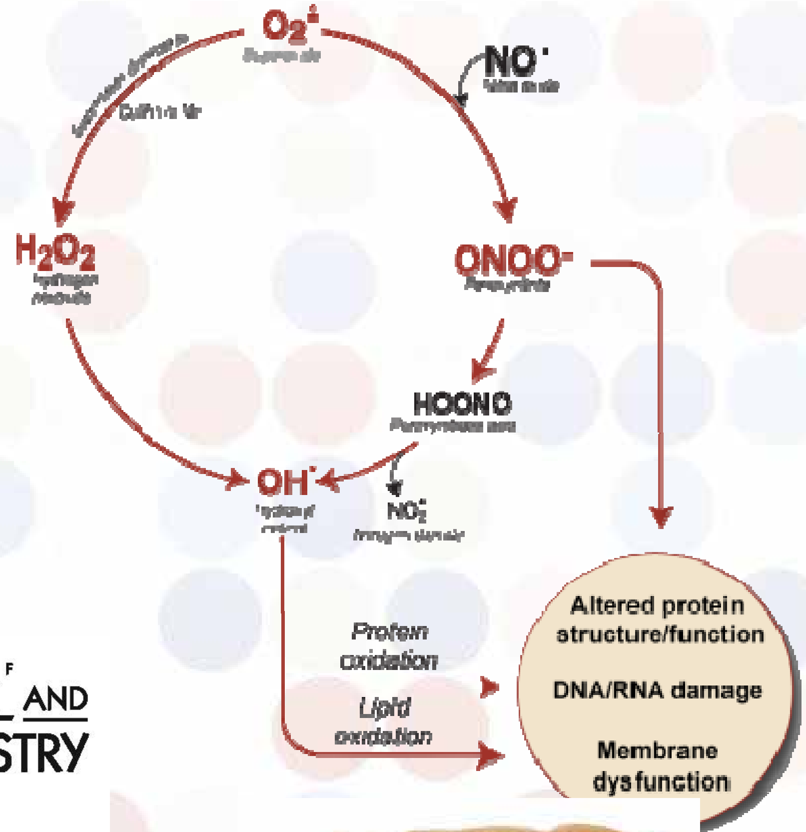
Effects of EconomasE on gene expression of proteins associated meat color



* $p \leq 0.01$



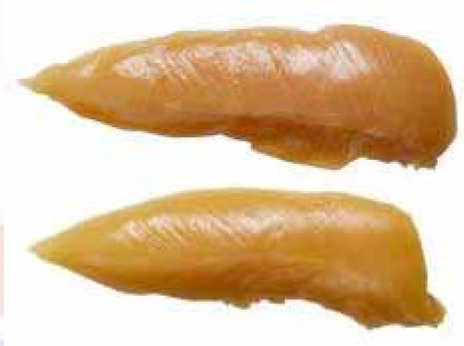
J. Agric. Food Chem. **2002**, *50*, 5220–5223

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

Potential of Peroxynitrite To Alter the Color of Myoglobin in Muscle Foods

Brian J. Connolly, Robert G. Brannan, and Eric A. Decker*

Department of Food Science, University of Massachusetts, Amherst, Massachusetts 01003



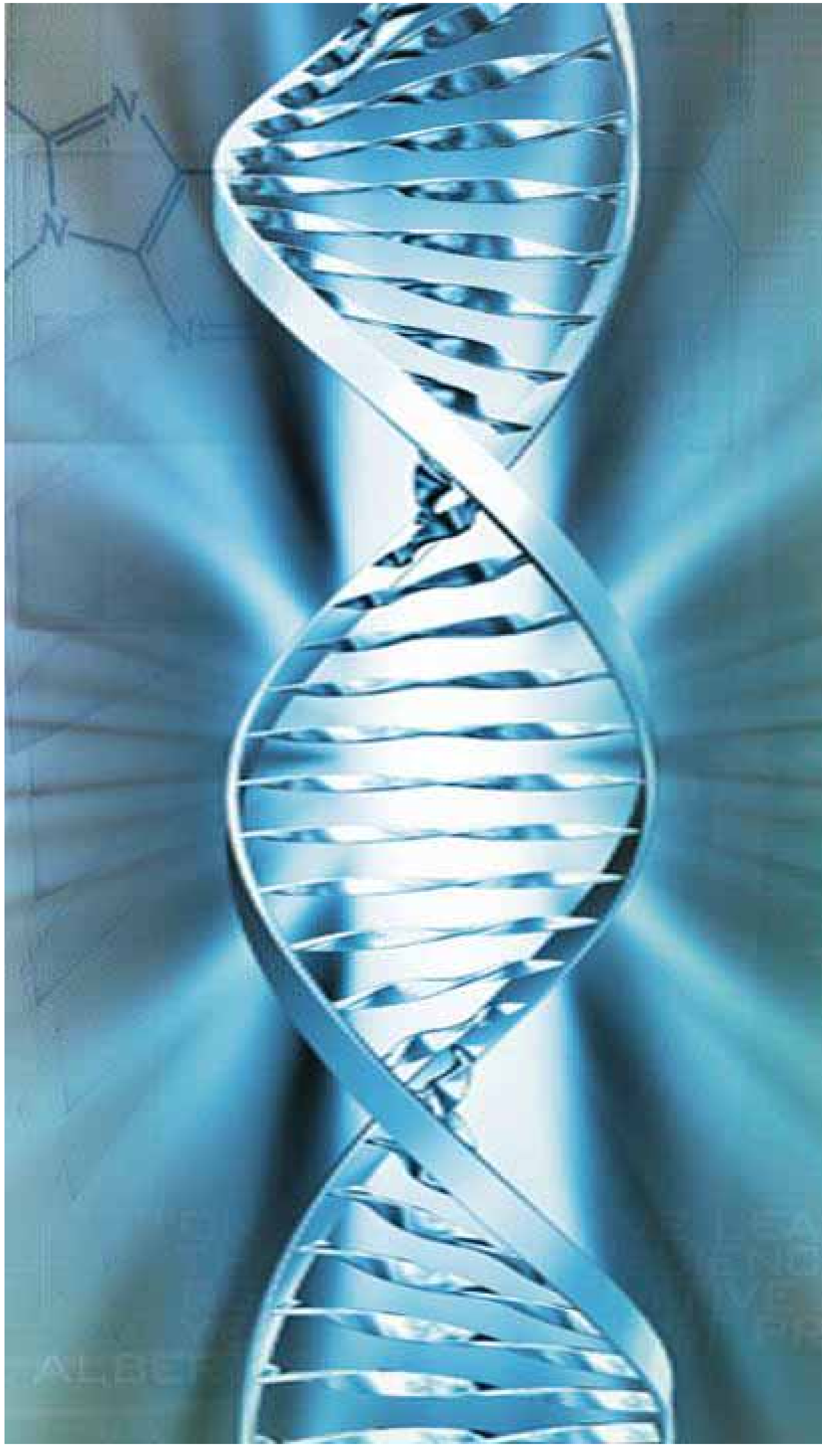
EconomasE and Vitamin E®
affect gene expression

- Influence of EconomasE® and vitamin E on gene expression is at the transcriptomic level

- Vitamin E and EconomasE® exert similar influences on gene expression

Adapted from Brennan et al., 2010; Xiao et al., 2010

Individual compounds will give a unique gene expression fingerprint



The revolution:

Lessons learned from Nutrigenomics work with minerals and antioxidants

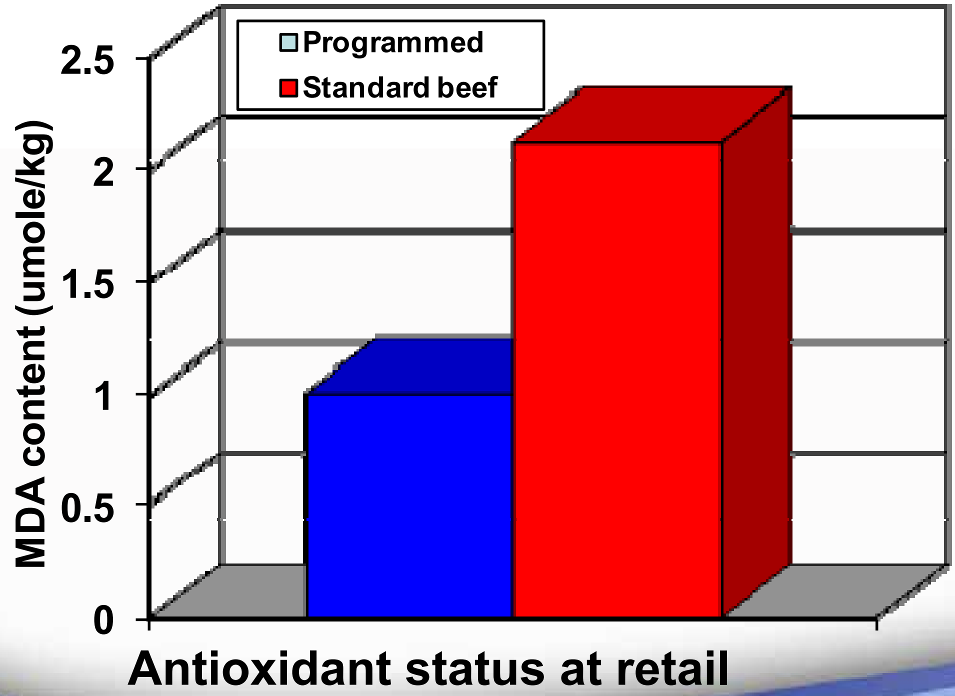
Simple changes in nutritional and supplementation strategies can have dramatic effects on biological functions

Strategic nutritional programming to improve the quality of beef

- Meat at the butcher

  - Lower pH
  - Lighter Color
  - Improved mineral status
  - Greater moisture content

Programming for improving performance of feedlot beef



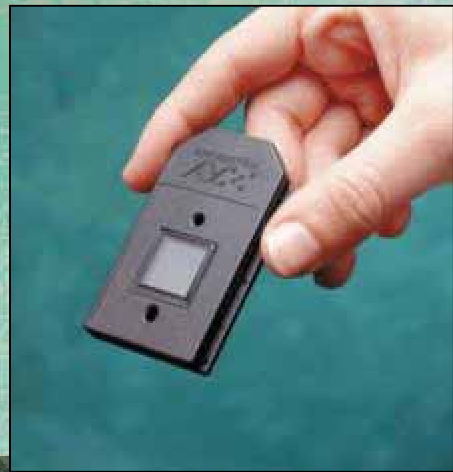
Bonus:

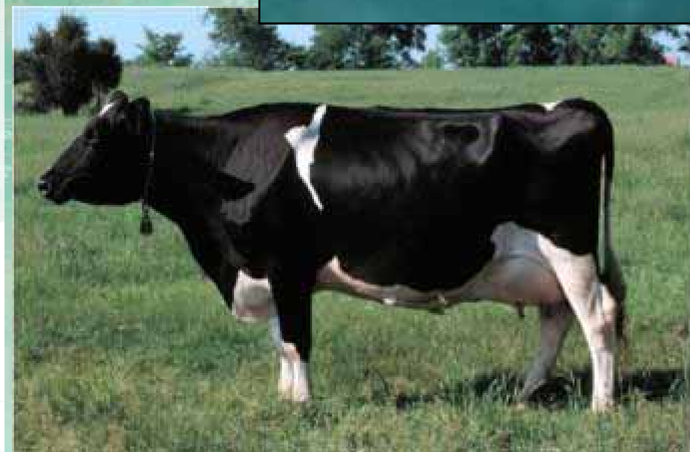
- -Average daily gain improved
- -Time to market weight decreased by 30 days

Where can the nutritional programming approach leading us?

- Strategic use of nutrients

- Developing programs to take advantage of our new understanding of physiological regulation





We have never had the tools to evaluate these approaches in the past

INTUITION IS THE SOURCE OF SCIENTIFIC KNOWLEDGE.
ARISTOTLE

The Key Points:

- **Rapid and effective evaluation of nutritional strategies is becoming a reality through molecular based technologies**

- **Thousands of data observations generated per experiment**

- **Provides a valuable and novel approach for improving the efficiency of animal production**

- **Programming strategies can be used to enhance performance, health and product quality**

- **It is the strategy that will drive advances in nutritional efficiency and not individual ingredients or supplements**

Nutrigenomics

Provides a molecular understanding for how common dietary chemicals (i.e., nutrition) affect health and performance by altering the gene expression patterns

It will be used to

Redefine Nutrition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You are here: Home > R&D > News > Nestlé partners with King's College London on food and gene research
Nestlé partners with King's College London on food and gene research
Our Vision
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June 10, 2011
The Nestlé Research Center in Switzerland will collaborate with King's College London on a joint research project into the relationship between food and genes.
Due to begin later this year, the six-month project will examine the interactions between genes and food ingredients, and how they can affect human health.
It will look at how our genes and their encoded proteins determine important bodily functions; including how efficiently we metabolise food, respond to the environment and detoxify our bodies from potentially harmful agents.
FEED MY GENES
PROTECT YOUR DNA AND OFFSET INHERITED AND AGE RELATED GENETIC DAMAGE
10.10.2010
UNILEVER STUDYING NUTRIGENOMICS
Unilever
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Lipton
Interestingly, Unilever announced on Oct 5 that they too have begun to collaborate and explore the links between diet and health. Such research has become a priority as modern, sedentary lifestyles and a fast food diet are fueling an epidemic in obesity, diabetes and heart disease. Conditions such as obesity, stroke, heart disease and type 2 diabetes are responsible for over 60% of deaths worldwide. It is widely recognized that specific dietary approaches can help prevent these disorders at an early stage. Emerging scientific evidence suggests that gut bacteria, interacting with diets, play an important role in this process. However, the underlying the need for new research. With the acquired insights, contribute to helping consumers maintain and improve llaboration which addresses a very important global and Health.
DANONE RESEARCH
RESEARCH AT DANONE
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Research words
Molecular nutrition (also known as nutrigenomics)
The science which studies the links between nutrients and variations in the expression of certain genes at a cellular level. Molecular nutrition is also called nutrigenomics.
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Bioscience Centres
Nutrigenomics Centre
Nutrigenomics is the interaction between diet and health as gene expression is directly influenced by nutrition.
Alltech has invested in this exciting domain, culminating in the creation of a dedicated Centre for Animal Nutrigenomics and Applied Animal Nutrition at its corporate headquarters in Kentucky.

Thank You