Feeding the World
... on a crowded planet

KA Jacques
Director of Nutrition
Alltech Inc.
1900 – 2000: 4X in 100 years

Population in billions

- 1 billion
- 1.6 billion
- 6.1 billion

- Latin America & Caribbean
- Asia & Oceania*
- Africa
- North America, Australia, Japan, and New Zealand
- Europe
For all the best reasons...

• **Agriculture**
  – Mechanization, crop varieties, transport, refrigeration....

• **Medicine**
  – Vaccines, antibiotics

• **Public health**
  – Sanitation, ‘germ theory’
Challenge 2050:
9.3 Billion coming to dinner
Today, 50% of us live in towns and cities.

In 2050, urbanites will make up ~70% (85+% in developed countries).

Arrival of the Urban Millennium

<table>
<thead>
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<th>% of Population Living in Urban Areas</th>
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<td>World</td>
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RISING INCOME IN THE DEVELOPING WORLD
Dynamics of Daily Income and Food Demand

As income rises, the amounts, types and reasons we buy specific foods changes.

- Ethical issues, Sustainability
  As consumers become more affluent, ethical issues and sustainability, the ultimate quality distinction, are reflected in purchasing decisions.

- Convenience, Food Safety
  As income increases, other product features affect food selection: added nutritional value, convenience and excitement become important. Confidence in food safety looms larger as globally sourced and processed foods form more our diet.

- Variety, Nutrition
  Between $2 and $10 per day, diet increases in variety and nutritional value with meat and dairy protein, edible oils, fruits and vegetables, more processed foods.

- More Meat Purchased
  As income rises above $2 a day, more meat is purchased, some processed goods (flour instead of grains).

- Demand for meat, dairy and fish is increasing as more people rise above the hunger threshold

HUNGER THRESHOLD
At $2 a day most calorie needs are met but more protein is needed.

MALNUTRITION & HUNGER
Below $2 a day, diets consist of locally available commodities with little meat.

In 2009, 48% of the world lived on < $2 per day versus 60% in 1981

~ 17% of the world lives on < $1 per day

Availability and Affordability

Sources: Population Reference Bureau; National 2008; The World Beyond Money
What and why we eat certain foods

Variety, Nutrition

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CHANGING DYNAMICS OF THE GLOBAL SUPERMARKET

THERE ARE MORE OF US.

WE LIVE IN TOWNS AND CITIES.

WE'RE CHANGING HOW WE MAKE FOOD PURCHASE DECISIONS.
How will we produce more food?
Opportunities for Agriculture

According to a recent OECD-FAO presentation the 3 billion new people, mostly urban dwellers, will require 1 billion tons of cereals and 200 million tons of meat.
In late 2011, Alltech used its global resources to conduct a feed survey.

Doubling feed production?
Global Feed Tonnage

873 Million
Global Poultry Feed Tonnage

379 Million

Poultry feed represents 44% of world feed reflecting cost, health and religious preferences.
Increase in feed prices
What's your plan?
“We in agriculture must think differently from how we have in the past, by adopting new technology at a faster pace and communicating in a way we never have before. We must find the balance for sustainable food production and protection of resources while satisfying consumer demands.”

–T.P. Lyons
Environmental impact
• Nutritional programming
• C/N/P focus

Animal health
• Gut health
• Immunity

Maximize raw material use
• Enzymes
• Algae

Food/feed safety
• Mycotoxins
• Dioxins/PCBs

Food quality
• Meat/milk/egg composition
• Carcass yield
• Shelf life
Gene chip: Breakthrough to Nutrigenomics

the study of the relationships between diet and gene expression
Alltech Center for Nutrigenomics
Nutrition has not kept pace with genetics

The time has come to close the gap

Meeting nutrient requirements ≠ Meeting genetic potential
Genetics changed the playing field...

...but expression of genetic potential is what drives performance and profits

Peter Ferket – Alltech Symposium 2011
How to focus on gene expression?
Seeking solutions at the cellular level

Using the Genechip®: a DNA Microarray

IS a collection of all the genes for an organism. Each gene represented by DNA fragments (probes). Each chip or microarray can have MANY (10s of thousands) probes.

Used to:
- Measure gene expression
- Detect SNPs
- Genotype/screen

GAME-CHANGER BECAUSE:
Very large # of genes at once
+ Very small size
= HUGE AMOUNTS OF DATA
Why measure gene expression?

Genes are DNA sequences that code for proteins, which are responsible for biological functions.

Gene expression is the transcription of DNA to form messenger RNA followed by translation of mRNA to make proteins.

DNA $\xrightarrow{\text{transcription}}$ mRNA $\xrightarrow{\text{translation}}$ Proteins

All cells have a complete set of chromosomes with identical genes, but only a fraction are expressed. In microarray experiments, we measure types and amounts of mRNA in response to specific nutrient regimens.

...to see what proteins cells are making.
**Gene Chip: DNA Microarray - What Can We Learn?**

What we learn -

**Changes How We Think of Nutrients & Reqs**

Not just building blocks and co-factors - nutrients are 'gene switches' that up/down regulate bio-functions.

**Discoveries & Solutions at the Interface**

Use interactions to build synergies, remove barriers.

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DNA → transcription → mRNA → translation → PROTEINS

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ANIMAL SCIENCE GAMECHANGER

- REDUCE animal testing
- ASK HARDER questions
- ASK more questions
GENE CHIP: DNA MICROARRAY - WHAT CAN WE LEARN?

- INTERACTIONS - eg. How does disease affect antioxidant demand and how does that affect energy flow?

\[ f_{CHO} \times [Zn] \times \text{Age@weaning} = X \]

DISCOVERIES & SOLUTIONS AT THE INTERFACE

Use interactions to build synergies, remove barriers
How are we using Nutrigenomic studies?

• Understand nutrient responses
• Understand product responses
• Target gene patterns – product development
Nutritional programming
‘Programming’ Nutrition

- Pre-natal nutrition
  - ‘Fetal programming’ – setting the stage for lifetime performance

- Post-natal diets
  - Selection of ingredients that target specific gene expression patterns
It is not just what we feed but when we feed it
Maternal nutrition: Early-life programming and human disease

Exposure to an adverse stimuli during critical periods of development can permanently reprogram normal physiological responses.
Exposure to an adverse stimuli during critical periods of development can permanently reprogram normal physiological responses. Early-life programming can turn on “thrifty” genes.
Dutch Hunger Winter – Famine of 1944

• Late WWII in western Netherlands
• 4.5 million people affected
  • Caloric intake dropped from 2000 to 5-700
Impact on children exposed to famine *in utero*

- Low birth weight
- Higher incidence of obesity, diabetes, CVD
- 2\textsuperscript{nd} and 3\textsuperscript{rd} generations
‘Epigenetic’ effects of nutrition

Heritable changes in gene expression without changing DNA structure

Phenotype = Genotype + epigenetic factors + environmental influences
Nutritional Imprinting

Imprint for the desired trait when they are young
Technology
Naturally programme young animals to use nutrients more efficiently

The conditioned birds have totally different physiological baseline.
In Ovo Feeding
The First Meal Makes the Difference

How do we feed the embryo in the egg?

"Deliver a suspension of nutrients and enteric modulators into the amnion of the late-term embryo"

Photo from World Poultry
Timing of In Ovo Feeding

Synchronize in-ovo feeding when the embryo begins to imbibe amniotic fluid

Volume of amniotic fluid (ml)

Optimum IOF Window
- E17-E18 for Broilers
- E23-24 for Turkeys

(“The Avian Embryo”, Romanoff 1960)
In ovo Feeding Timed to Boost 2\textsuperscript{nd} and 3\textsuperscript{rd} wave of satellite cell development
In OVO Feeding

• Administration of highly digestible nutrients into the amnion of embryos

• Benefits:
  – Improved chick quality
  – Increased glycogen reserves
  – Advanced gut development
  – Improved skeletal health
  – Advanced muscle growth
  – Increased body weight gain 2 – 5%
  – Improved Feed conversion ~2%
  – Enhanced immune function

Nutritional programming & food animal nutrition

Digestive efficiency

Reproductive function

Morbidity & mortality

Product quality
Conclusions

• Genetic progress gives us better birds, but gene expression drives performance and profits.

• Nutrigenomics approach is key to narrowing the genetics/nutrition gap.
  – Redefine not just nutrient requirements but the nature of requirements

• We have much to learn; but let’s use what we know! – Gamechanger in animal production
Thank you!