Teagasc Technology Foresight 2035

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Agriculture and Food Development Authority

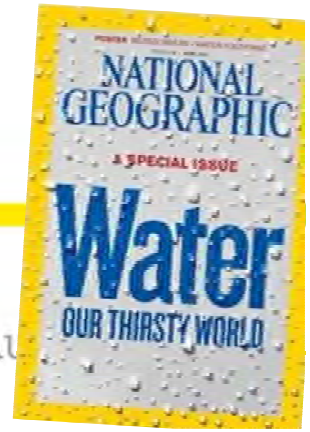
The Irish Agriculture and Food Development Authority

Presentation outline

- The global context for the Teagasc Foresight: global megatrends and drivers of change
- Needed transformations in global Agri-food sector
- Visions for five key technologies to transform Irish Agri-Food:
- Implementation of the Foresight vision

Global megatrends and drivers of change

- Food and nutrition security
  - Increasing population and income
- Climate change
- Pressure on natural resources
- More sustainable lifestyles and consumption patterns
- Growth of bioeconomy and circular economy



Needed transformations in global Agri-Food

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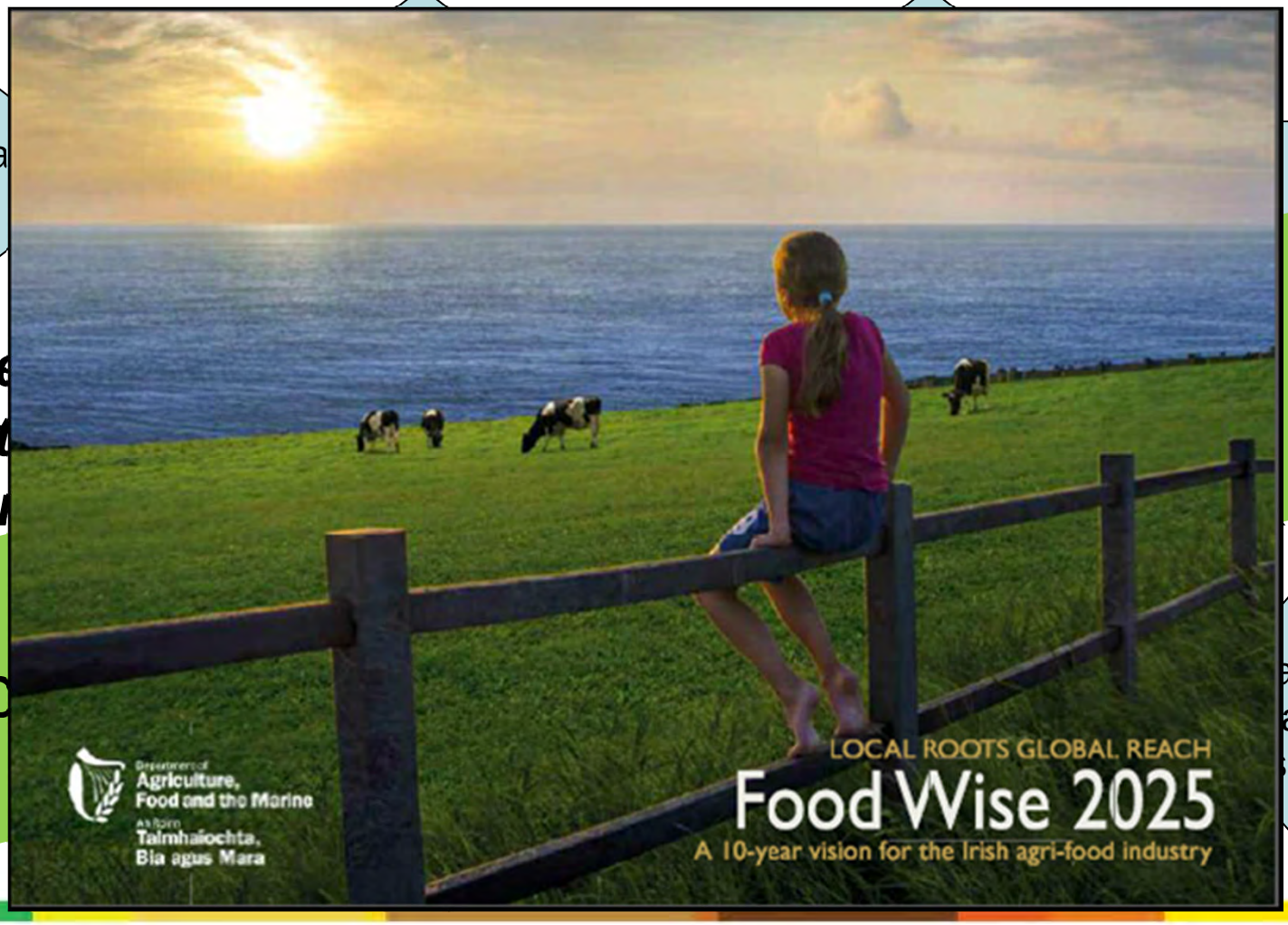
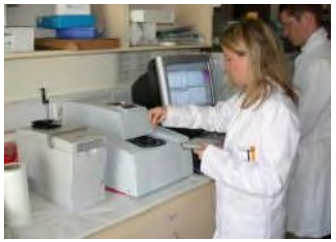


Science and technology critical



Key transformative technologies

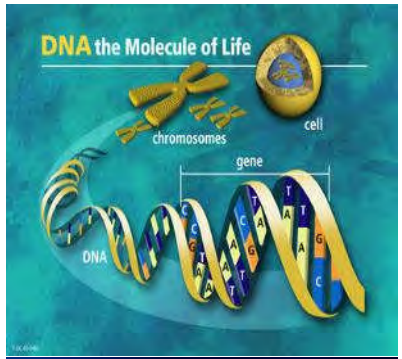
1. Plant and animal genomics and related technologies
2. Human, animal and soil microbiota
3. Digital technologies
4. New technologies for food processing
5. Transformation in the food value chain system

Linkages between these technologies obvious

1. Plant and Animal Genomics and Related Technologies

Low cost genotyping and sequencing has enabled this technology area to develop rapidly

Genomic selection in dairy cattle is one successful application



Current state of the art

- Cattle genotyping cost €275 (2008) → €22 (2015)
- 1 million animals * 50 m DNA variants (imputed) in 2017
- More accurate prediction of animal genetic merit – 50% increase in ΔG

- Crop genome sequencing technologies evolving rapidly
  - 2012 – '454 sequencing'
  - 2016 – Superseded by Illumina/PacBio systems
- DNA markers for nematode resistance used in Teagasc potato breeding programme – identify resistant varieties 2 years earlier

Future applications for livestock?

- **Beef genomic selection in 2016 – sheep possibly in 2017**
- **New traits**

  Animal health, meat and milk quality, feed intake, GHG emissions

  Phenotyping will be critical – link with Digital technologies
- **Huge growth in data**

  Dairy genomic selection: 1,000 bulls @ 56k SNPs

  Current BDGP: 1,000,000 cattle @ 50m SNPs (imputed)

  This is Big Data !
- **Applications will be in management as well as breeding**

  Individual animal genotypes will enable individualised animal management
- **Increased overall, balanced performance**

  (genetics + management)

Future applications for crops?

Currently, research underway to develop genomic selection in Teagasc grass breeding programme (DK, NZ)

Genome sequencing
Gene editing:
CRISPR/CAS, TALEN

- Speed-up breeding
- Novel traits such as disease resistance, NUE

2. The microbiota

The totality or community of microbes in a particular organism, place or environment

(human microbiota, gut microbiota, soil microbiota, etc)

Next generation DNA sequencing allows us to study the whole microbial community whereas traditional culturing only allowed a fraction to be grown and studied

Illumina - NextSeq

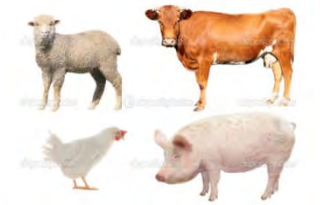
Current state of the art

- Rapidly expanding evidence that the human microbiota influences physical and mental health and development

- Human gut microbiota is influenced by food intake

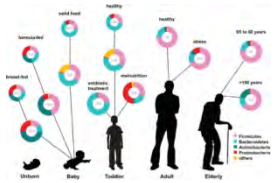
  ➔ opportunity for food industry

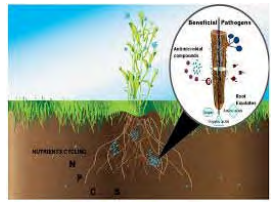
- Exciting potential to apply these techniques to animal, soil and plant microbiota



What future developments can be expected?

- NGS technology will continue to evolve
- Bioinformatics is limiting factor
- Over the next 15-20 years:
  - foods to promote health
  - enhanced agricultural efficiency,
  - reduced emissions,
  - Enhanced soil quality, etc





3. Digital technologies

Suite of technologies that involve the application of ICT, sensing, robotics, data analytics and other digital technologies to agriculture

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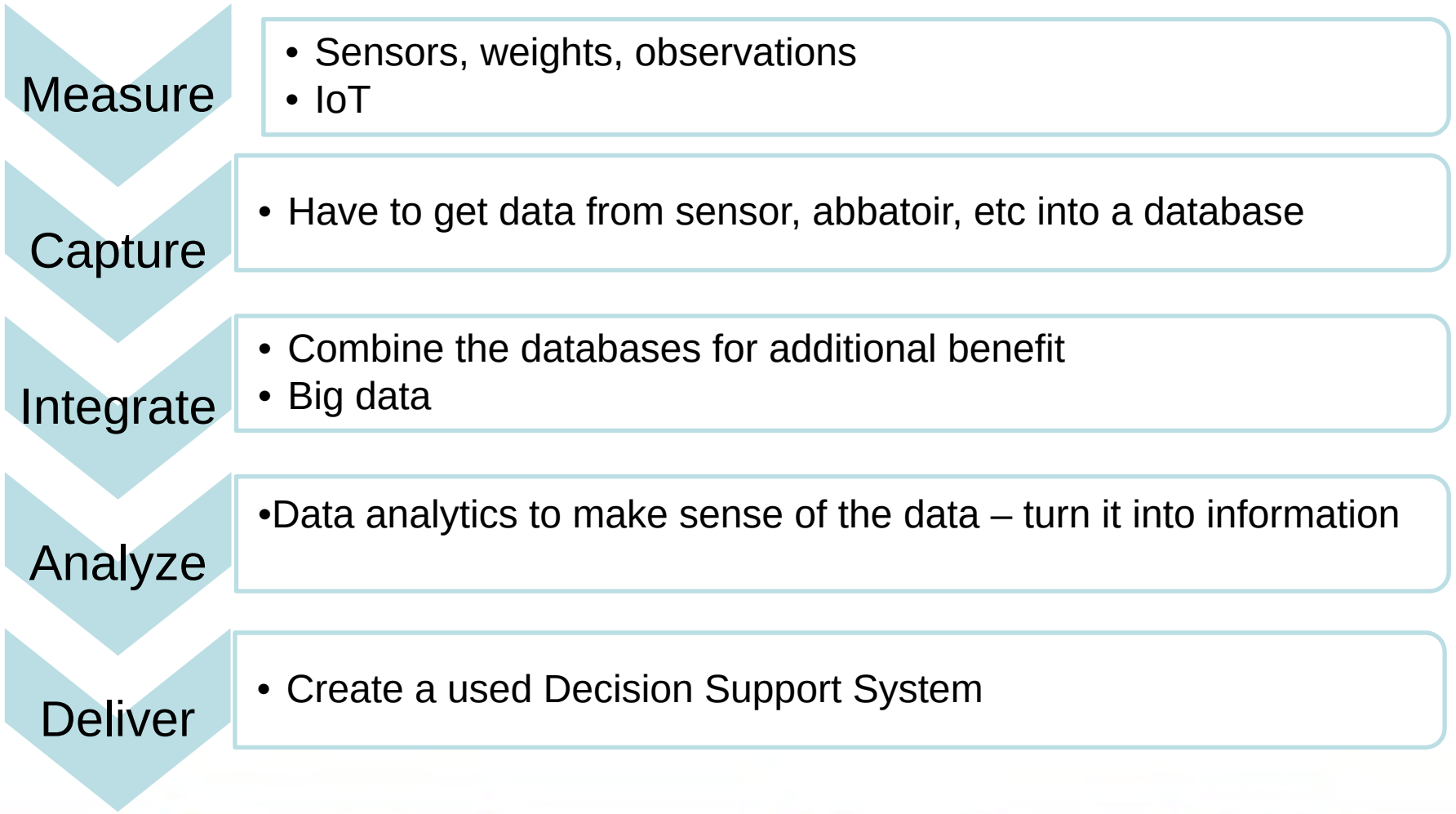
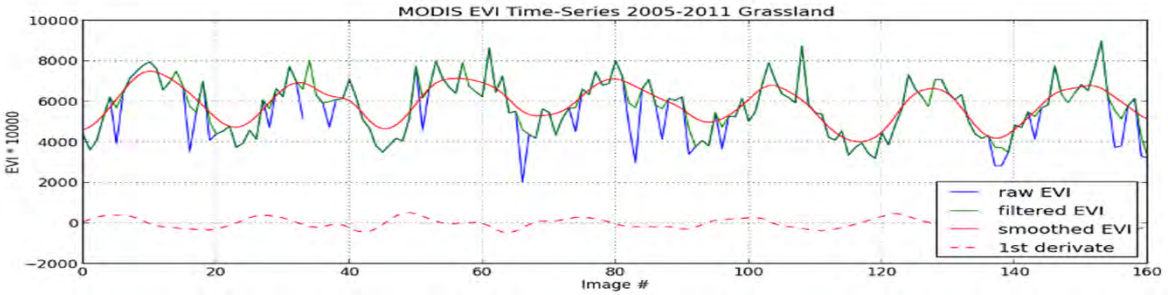
Conceptual framework for digital technologies



Sensors on satellites (remote sensing)

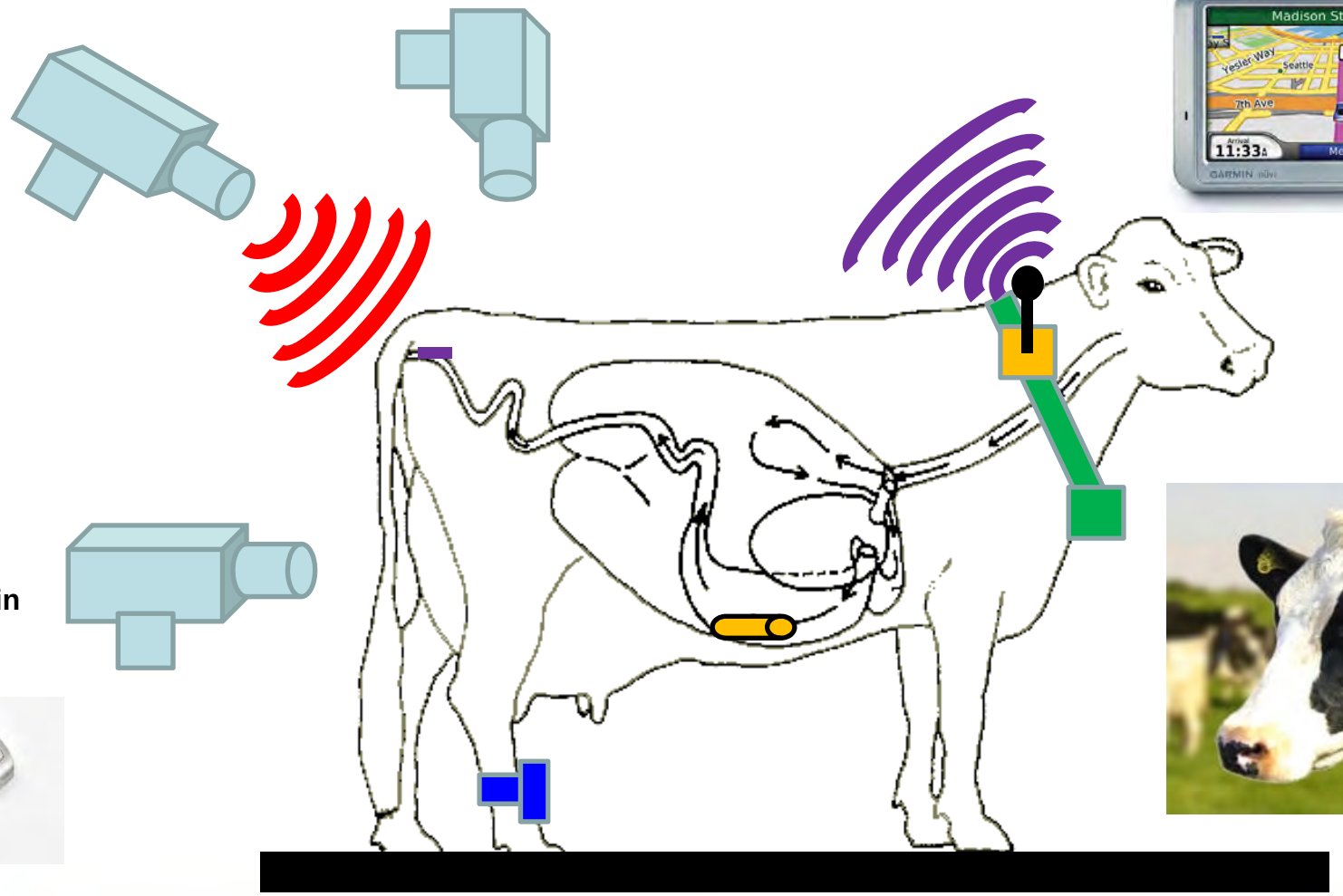


Currently using the NASA MODIS to estimate grass biomass at the field scale

Sentinel 2 satellite will improve our spatial resolution to 10's of meters not 100's.

MEASURE – CAPTURE – INTEGRATE - ANALYZE – DELIVER

Technology for animal monitoring

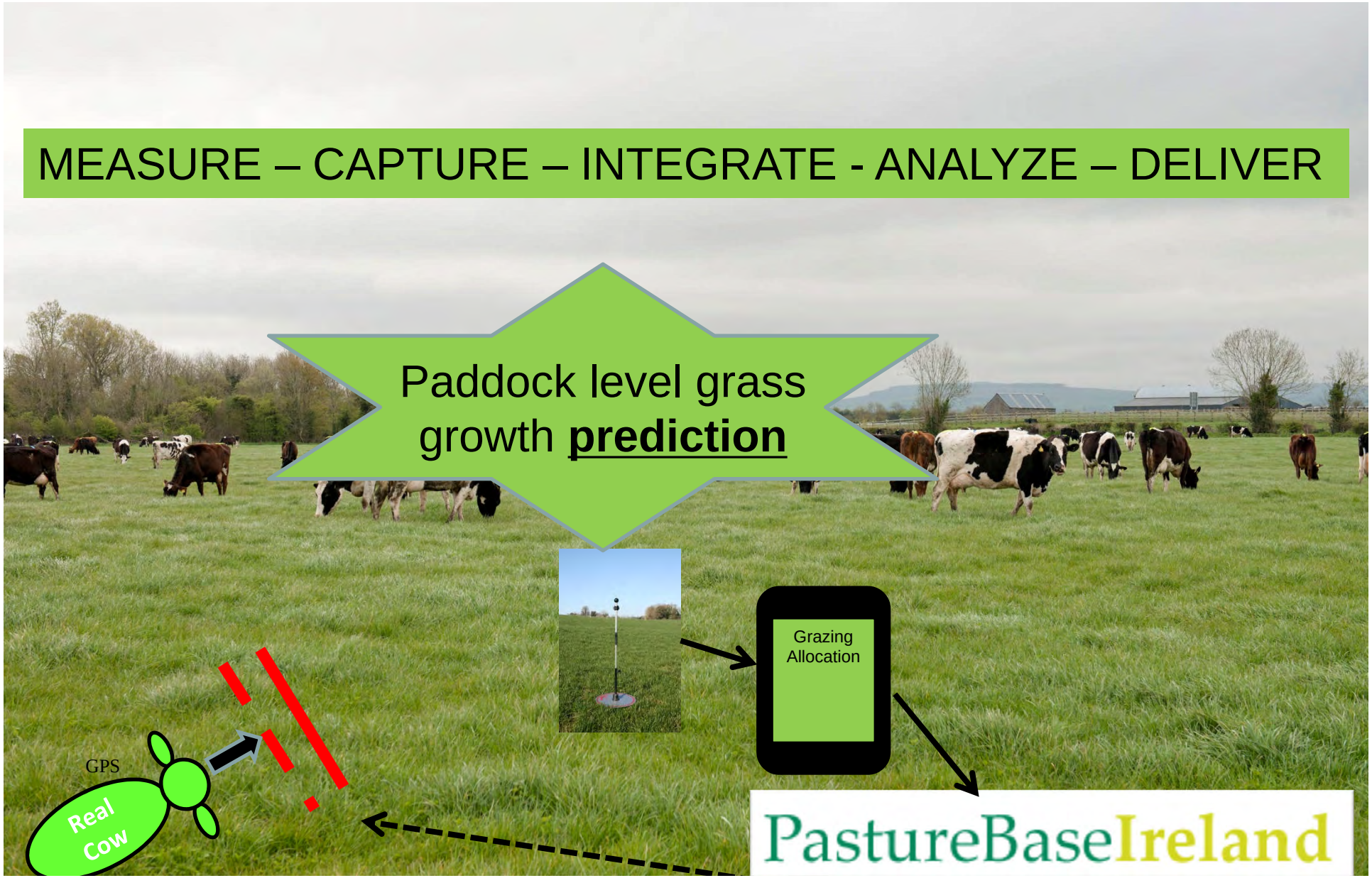


Biosensors in veterinary diagnostics

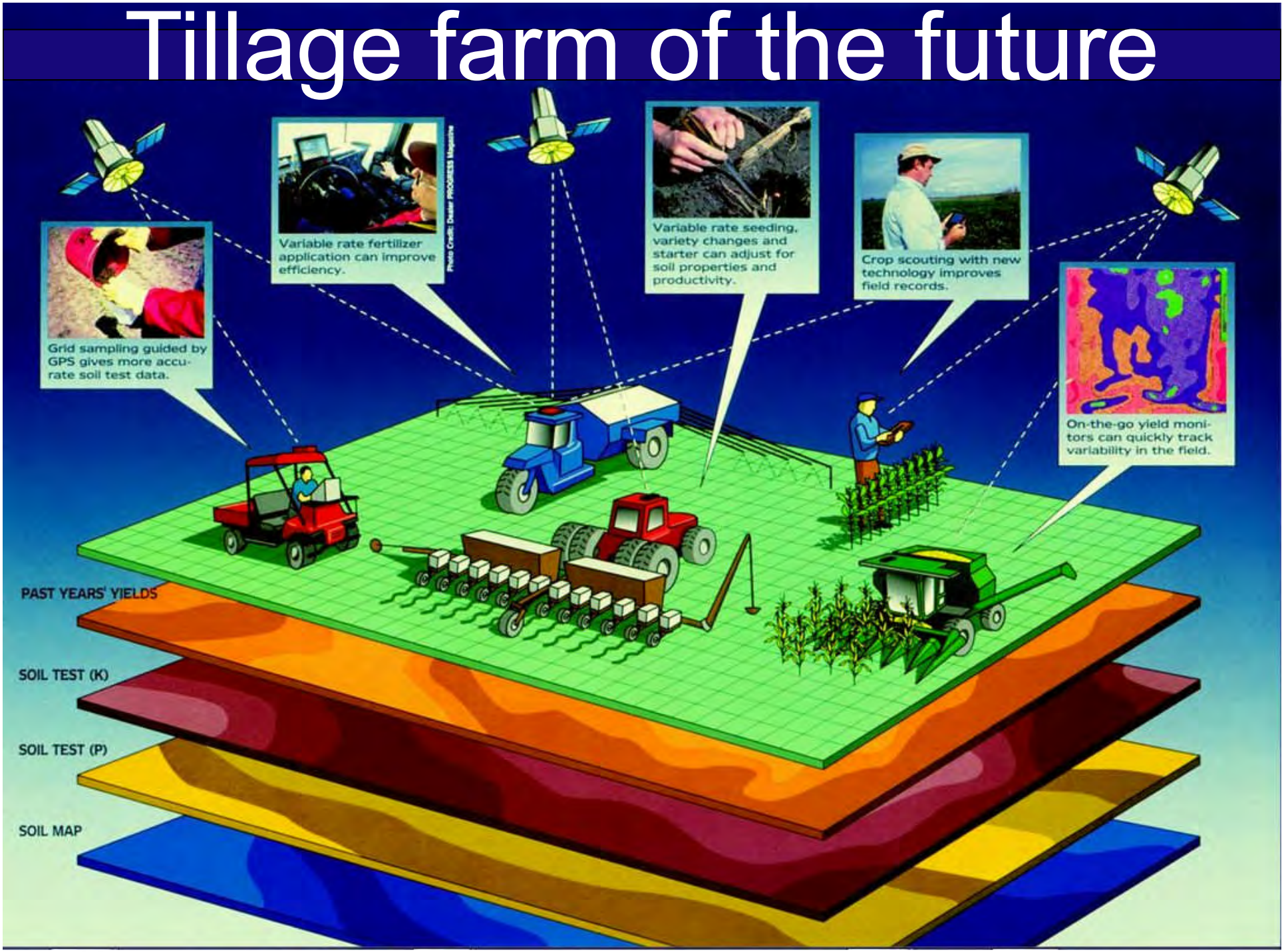
Wearable / internal / penside sensors, image analysis

MEASURE – CAPTURE – INTEGRATE - ANALYZE – DELIVER

How can digital technologies help this farm?



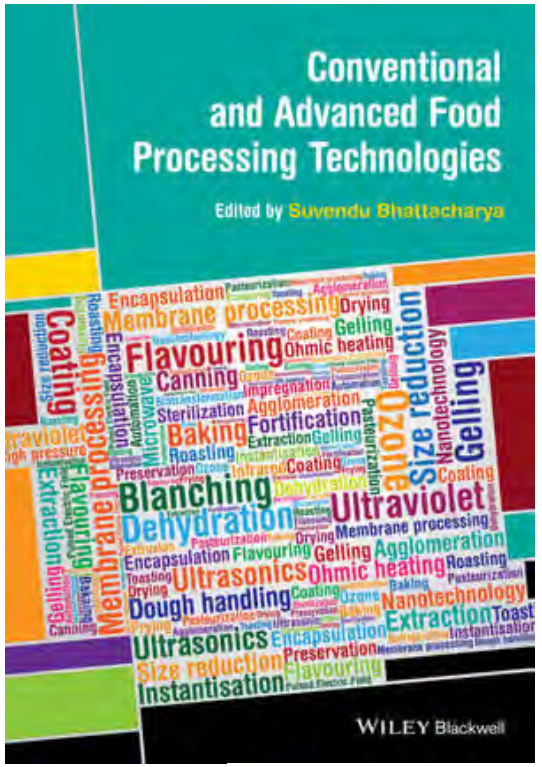
Tillage farm of the future



Future impacts of digital technology

- Decisions informed by information ➔ better decisions
- Greater control and precision
- Better use of labour
- Evidence for consumers, regulators

4. New Technologies for Food Processing



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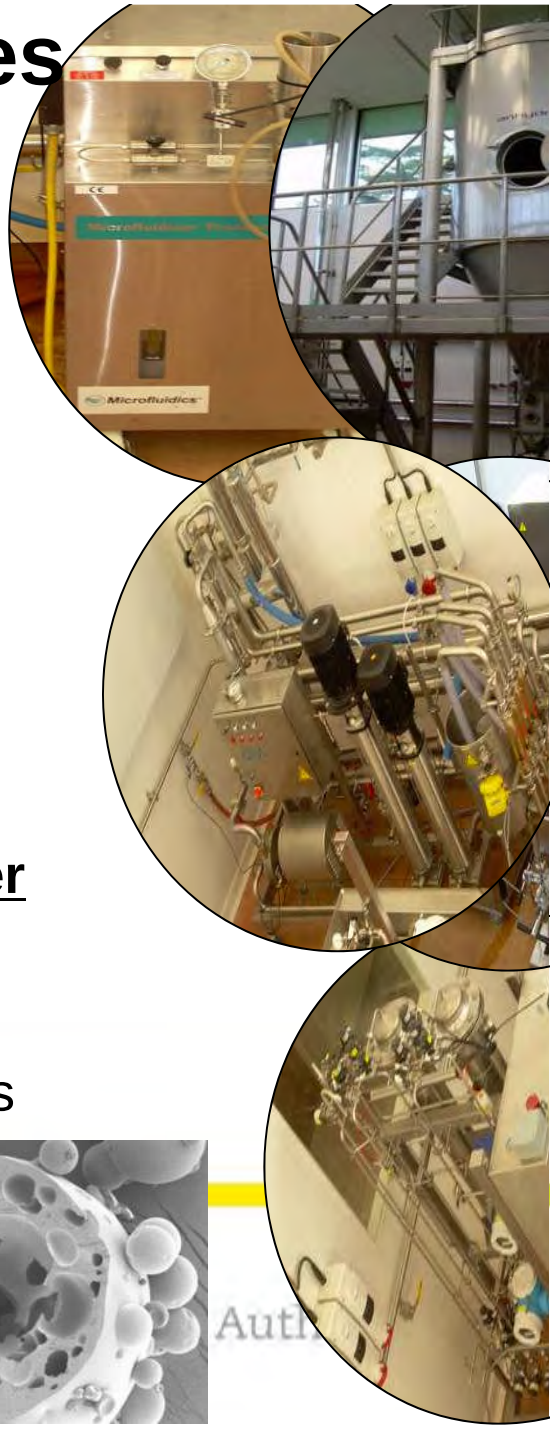
New food processing technologies

- Non thermal technologies like plasma and ultrasound
- Extraction technologies such as ultrasound, microwave assisted extraction, etc
- Biotransformation giving enhanced foods or ingredients
- Freezing technologies
- Biorefining
- Synthetic biology
- 3-D printing of food

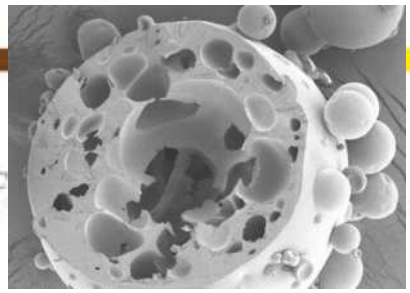


Developing trends

Moving from provider of food and beverage to **provider of nutrition and health**

Zero waste

Need to develop technologies with views of consumers in mind - “minimally processed”



Food for nutrition and health

Reducing salt, sugar and fat

Life stage (infant, expectant mother, elderly) and extreme (sports, cognitive function) nutrition

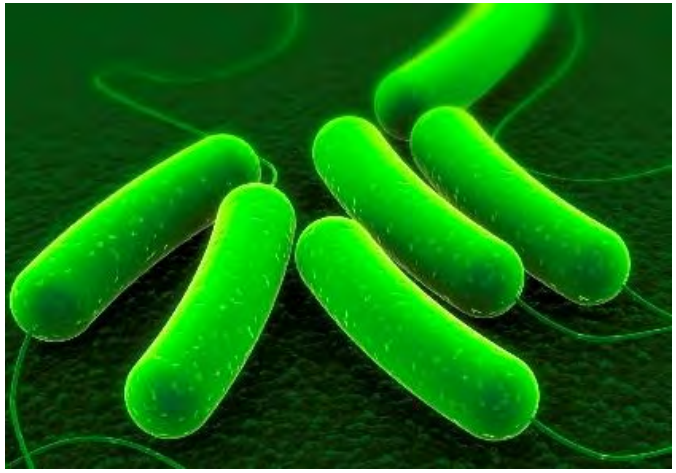
Sensiometrics will exploit the relationship between sensory, chemical and consumer science

Food quality and safety

Molecular fingerprinting for detection pathogens

Improved analytics will allow new regulations for residues and other contaminants

Advanced packaging will help food preservation, and give indication of spoilage



5. Transformation in the Food Value Chain System

Changes in scale, changes in specialisation or changes in the relationships between components of the value chain are key technological transformations.

Value Chain Transformation

Primary production

- Milk quota removal is a transformation
- Alternative models of land use and management
- Application of technology at farm level

Processing

- Continued change in dairy process mix
- Growth in scale of operation and/or scale of business?

Food service, distribution and retail

- Preferences of consumers will drive change right back to producers
- Personalised information will lead to personalised data driven services to consumers

Circular bioeconomy will spawn new value chains

1. Lignocellulosic feedstock, advanced biofuels, bio-based chemicals and biomaterials
2. Next generation forest-based value chains
3. Next generation agro-based value chains
4. New value chains from (organic) waste
5. Integrated energy, pulp and chemicals biorefineries

Outcomes

Improve production efficiency, protect natural capital, reduce wastage and meet changing consumer demand

Better tackle the challenge of climate change

Demonstrate compliance with legal obligations and reinforce position as a clean, green producer

New high value food ingredients and products

Ameliorate disease risk, allergies, food intolerance and delay the aging process

Combat anti-microbial resistance and loss of control agents against crop pests and diseases

Completion of a dynamic circular bioeconomy

Implementation – How Teagasc needs to lead

Build partnerships

Create Foresight Implementation Platforms

Ensure services are designed to be affordable and easily adopted

Establish a National Digital Farming TestBed

Implementation – How Teagasc needs to change

Establish Foresight Implementation Team

Embed these technology areas in our research and KT programmes

- augment rather than replace existing technologies

Invest in skills and training - review of education and training in 2016

Fill gaps in our staff and expertise – e.g. computational science, genomics, soil microbiota, digital agriculture, new food technologies

Conclusions

Huge opportunity to improve efficiency, profitability and sustainability

Ireland well positioned but others won't stand back

Aim to have ***the most technology-driven agri-food industry in the world***

Acknowledgements

Lance O’Brien, Project manager

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Go raibh maith agaibh!