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<u>You Decide:</u> Will the Meat/Pork Industry be a Dynamic Future Industry?

- Primary Observations
- Livestock/Pig Genetics: From the Past Into the Future
- Meat/Pork Industry: From the Past Into the Future
- Concluding Understanding

Meat Science & Technology Inspiration Symposium: *The power of meat – innovations and legacies paving the way for the future of meat. Wageningen, May 6, 2022.*
Andrzej Sosnicki, & Matt Culbertson, Genus-PIC

The Facts About the Future …"The Unknown Un-Knowns" …

…"There are known knowns — there are things we know we know"…
…"We also know there are known unknowns — that is to say, we know there are some things we do not know"…
…"But there are also *unknown* unknowns, the ones we don't know we don't know"…

Donald H. Rumsfeld, (former) US Secretary of Defense, February 2002

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The Facts About the Future …"The Unknown Un-Knowns" …

experienced supply chain disruptions. The war in Ukraine underscores the need for a European food system that is sufficiently resilient to shocks and is able to feed the world sustainably. At the same time, the consequences of the war call for short-term solutions to solve acute food insecurity. Some interventions may be at odds with the transition of our food system.

Responses to the Consequences of the War So Far

The question now is: considering these developments, will actors delay or accelerate the food system transition? Some argue that the food system transition will be put on the back burner for now to contribute to short-term food security. Others claim that the transition will be accelerated to reduce dependence on fossil fuels and improve resource efficiency to make the food system more resilient.

War in Ukraine Reveals the Pain Points in the European Food System's Transition.
Rabobank, April 21, 2022

… many 'futurists' think that a leading industry in *upcoming decades* will be – Agribusiness … so it will be … Livestock/Meat Industry…???

What are the forces pushing the Livestock/Meat Industry to change??

ONE SIMPLE FACT: Food and Nutrition are necessary for Life!
…it is in the interest of our existence to ***CONTINOUSLY*** improve:

- ***Availability***
- ***Cost/Affordability***
- ***Nutritional Value***

"Incentivizing Food system Transformation", World Economic Forum, Davos, January 2020)

What specific changes will we see in the Livestock/Meat Industry?

NO SIMPLE FACTS:

- Meat Industry must adapt, innovate, diversify and/or completely re-make itself, become dynamic-cutting-edge, attractive to new ideas for inputs to production means and for outputs ***leading to consumer-recognized value***

How will emerging changes in the Livestock/Meat Industry affect the Global Markets'?

NO SIMPLE FACTS:

- ***Meat affordability*** focused on global markets will endure; ***diversification is the key***
- ***'Natural & High-Tech' or 'Health-Claims & Low-Cost'*** meat products do NOT have to be, or perceived to be, mutually exclusive
- Cross-over between ***'Specialist-Channel Credibility' with 'Mass-Market Volume'*** will succeed
- Opportunities exist for the Meat, Fitness and Pharmaceutical industries to successfully introduce 'the better nutrition/diet' products
- *Etc. Etc. Etc.*

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… many "futurists" think that a leading industry in *upcoming decades* will be – Agribusiness … so it will be … Livestock/Meat Industry, being a very substantial part of Agribusiness ….

What specific changes will we see in the Agribusiness/Meat Industry?

NO SIMPLE FACTS **but 4 KEY PRIORITIES:**

1. **ESG (Environmental-Social-Governance) is a key driving force fostering the change**
   - **Environmental Compatibility**
     - *Livestock/Meat Agriculture must continue to reduce its tracks on environment*
   - **Social responsibility**:
     - *Livestock/Meat Agriculture must fully understand and address its impact on communities (real and perceived)*
       - ***The Importance of Animal Welfare***
     - *Livestock/Meat Agriculture must fully understand and address its consumer markets*
2. **Focus on Production Efficiency**
   - *Produce safe, abundant meat supply*
3. **Economic Viability**
   - *Livestock/Meat Industry are cornerstone for numerous national/regional and global economies (food security)*
4. **MACRO economic prosperity supports rising meat demand**
   - *World meat consumption rise 1-2% annually over long term with cyclical influences*

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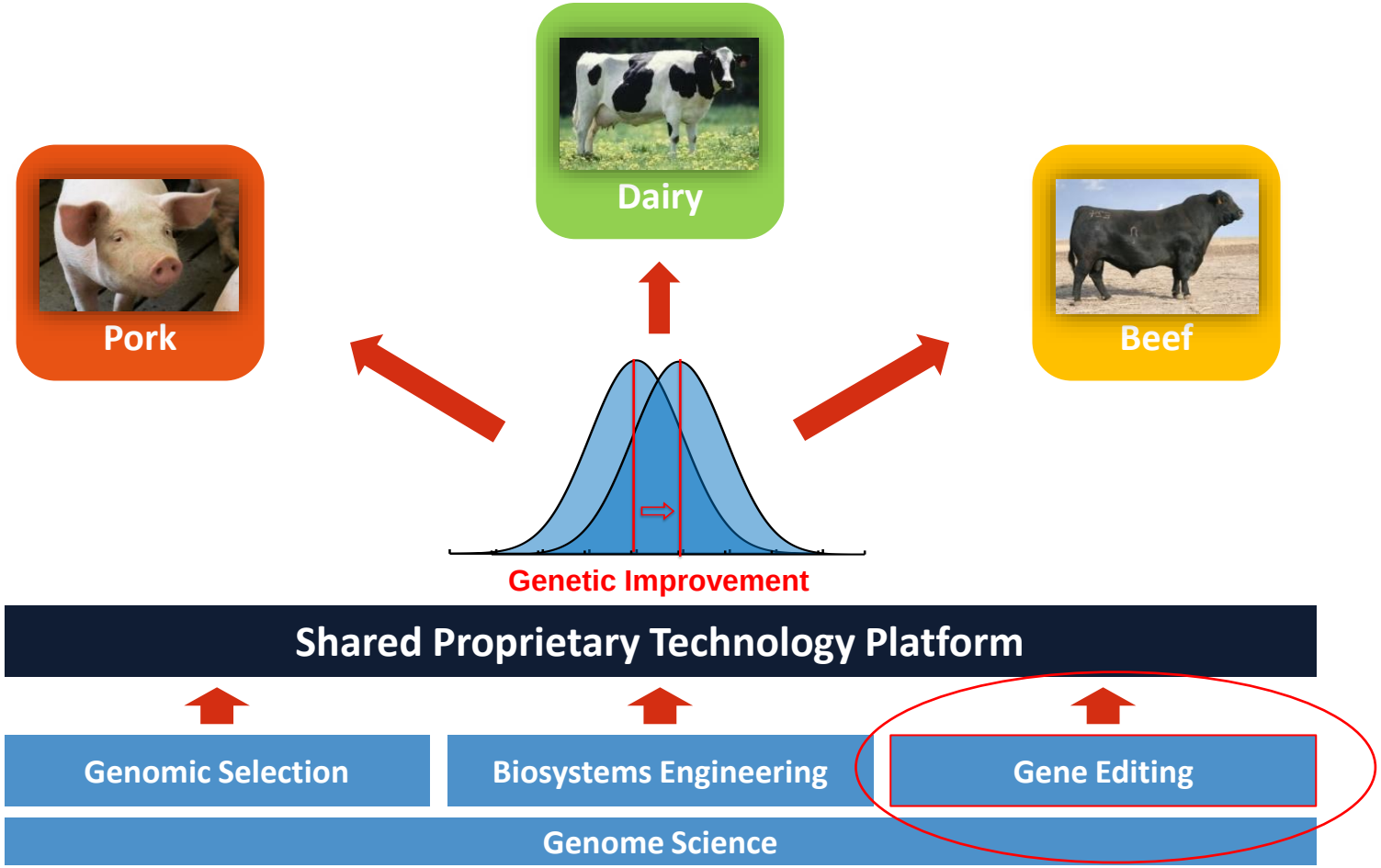
Genus' strategy: Drive Genetic Gain with Own Technology (*Internal 'Chain-Link' Model)*



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We Continue to Accelerate Genetic Gain with These FOUR Foundations

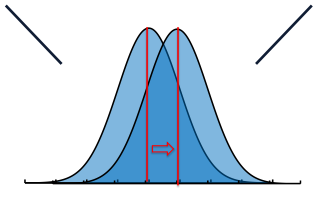
Investing in large, diverse populations, diverse phenotypic traits, and best selection tools… → ***…which results in accelerated genetic gain***

Selection intensity

Our elite populations doubled, and we select less boars / sow

Index deviation

We add differentiated germplasm, e.g., Møllevang



ΔG = Selection Intensity* Index Std * Accuracy / Generation Interval

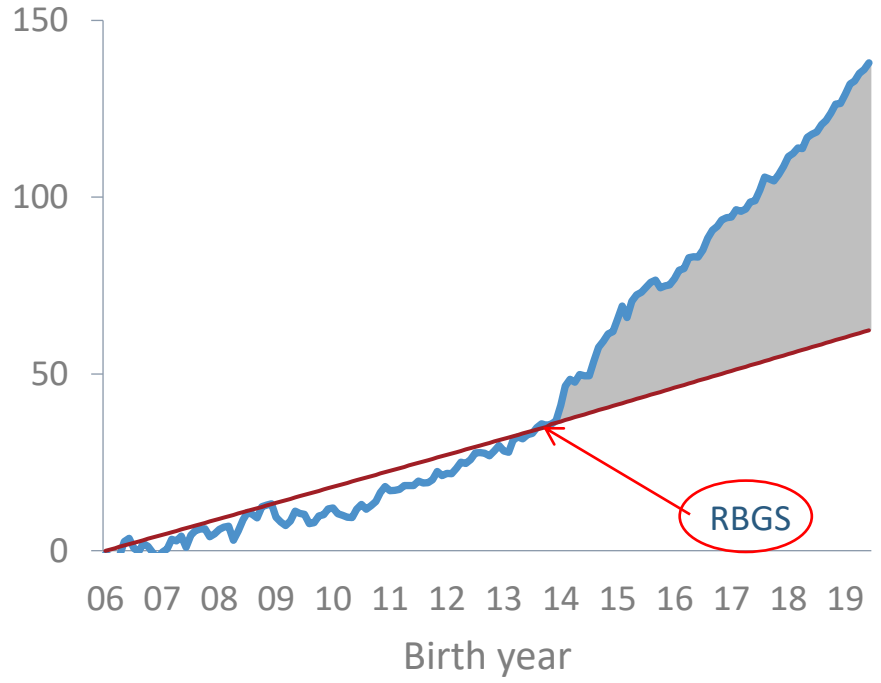
Generation interval:

We use higher replacement rates in sow farms and studs

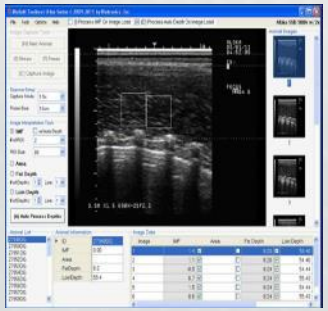
Selection accuracy:

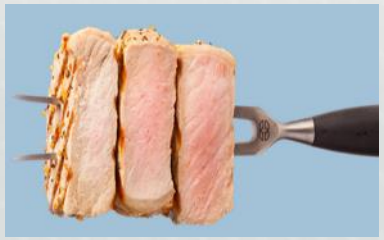
We combine extensive data capture of well established and new traits with the latest genomics technologies

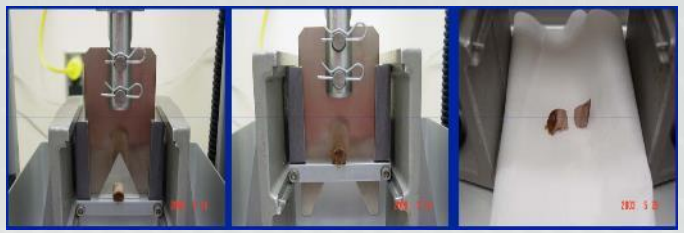
Commercial pig index trend



Breeding for Optimum Saleable Carcass Yield & Eating Experience







- **Saleable Lean Yield**
  - Bone-in primal contribution
  - Boneless primal contribution
- **Fresh Pork and Processing Quality**
  - Ultimate pH
  - Lean color
  - IMF
  - Physiological Fitness/Lactate Testing/MHC evaluations, etc.
- **Consumer Eating Satisfaction**
  - Warner-Bratzler Shear Force

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…The Future: Pork production ~2020-2030 (and beyond)

… 2020-2030 (and beyond) Pork Production
… *Will Increasingly Require*:

→

Faster & more accurate pork production improvement *TECHNOLOGIES*
better aligned with the needs of GLOBAL consumers' meat supply and value chains

- *High levels of disease resistance*
- *High levels of reproductive performance*
- *High levels of sow, piglet and growing pig survivability*
- *More efficient pig growth rate*
  - *Improved feed conversion rate*
- *Improved animal welfare standards*
- *Less impact on the environment*
- *Less use of energy*
- ***High carcass value, market-desirable meat quality (for pork product innovations)***

Contribution of genetic technologies to sustainability of meat production

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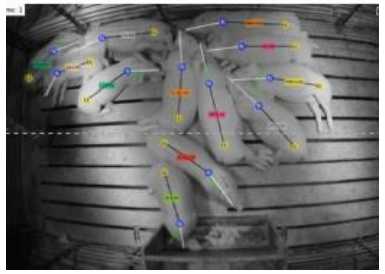
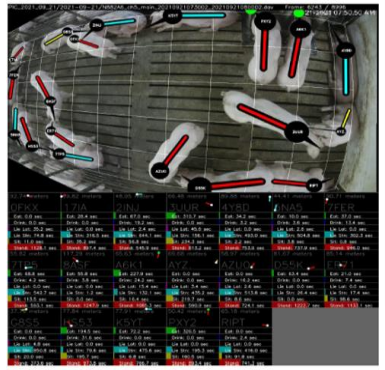
Emerging Traits to be Included in Genetic Selection:
Key Areas of Interest





- **Body dimensions**
  - *including weight, length, width, muscle composition & MHC microstructure*
- **Structural components**
  - *including feet and leg structure, kyphosis, hip and shoulder structure*
- **Behavior and social interactions, social competence**
  - *including pig activity, feeding and drinking behavior, and vices*
- **Traits we measure today that can…**
  - *Be Automated*
  - *Increase accuracy through serial measurements*
- **Reliable identification detection is key to these areas**

Can social competence be improved through pig management and breeding?

*..in collaboration with the **School of Biological Sciences at Queen's University Belfast and the Pig Improvement Company, (research)** will focus on pigs, which have complex social lives involving a range of positive and negative forms of social interaction…*

…News release, Scotland's Rural College (SRUC), 04/2022

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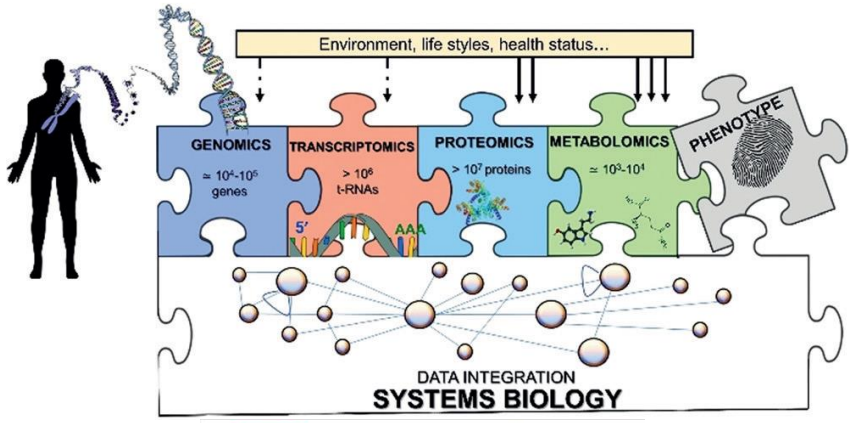
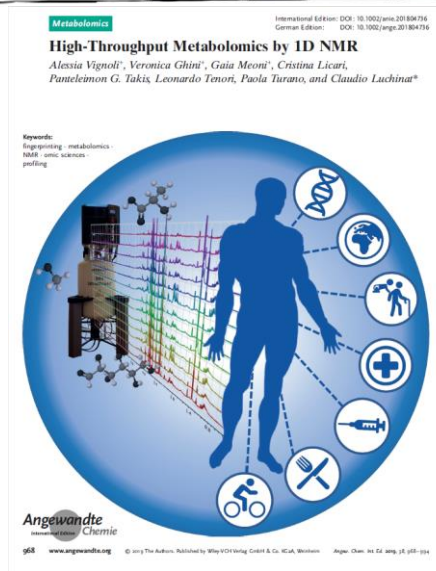
Emerging Research:




Metabolomics

High-Throughput Metabolomics by 1D NMR

Alessia Vignoli*, Veronica Ghini*, Gaia Meoni*, Cristina Licari, Panteleimon G. Takis, Leonardo Tenori, Paola Turano, and Claudio Luchinat*

Keywords: fingerprinting · metabolomics · NMR · omic sciences · profiling

Angewandte Chemie

- **Genomic sequencing**
- **Phenomics**
  - *Epigenetics*
  - *Microbiome*
  - *Metabolomics*

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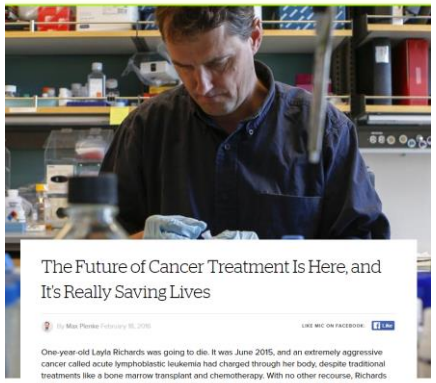
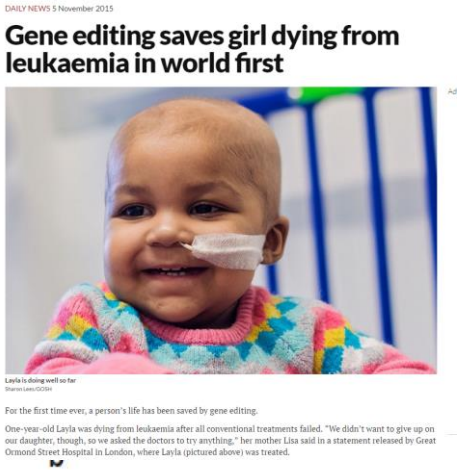
Genome Editing: The Next Frontier for Animal Health and Meat Production





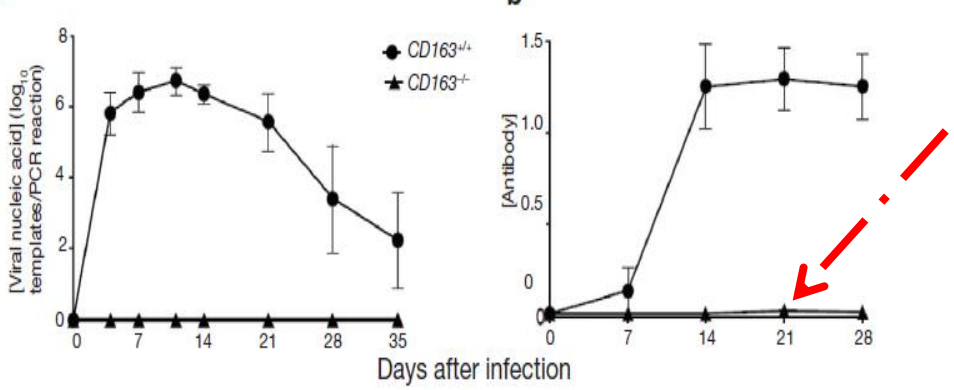


Figure 3 PRRSV-specific nucleic acid and antibody. (**a**,**b**) Mean and s.d. of PRRSV nucleic concentrations (**a**) and antibody (**b**) in serum from *CD163*$^{+/+}$ ($n = 7$) and *CD163*$^{-/-}$ ($n = 3$) pigs (one replication) are shown. Sample to positive ratio = the median fluorescent intensity (MFI) of the sample divided by the MFI of the positive control.

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AMERICAN SOCIETY FOR MICROBIOLOGY | Journal of Virology®

VIRUS-CELL INTERACTIONS

Pigs Lacking the Scavenger Receptor Cysteine-Rich Domain 5 of CD163 Are Resistant to Porcine Reproductive and Respiratory Syndrome Virus 1 Infection

Christine Burkard,[a] Tanja Opriessnig,[a,b] Alan J. Mileham,[c] Tomasz Stadejek,[d] Tahar Ait-Ali,[a] Simon G. Lillico,[a] C. Bruce A. Whitelaw,[a] Alan L. Archibald[a]

[a]The Roslyn Institute, Royal (Dick) School of Veterinary Studies, University of Edinburgh, Easter Bush, Midlothian, United Kingdom
[b]Department of Veterinary Diagnostic and Production Animal Medicine, College of Veterinary Medicine, Iowa State University, Ames, Iowa, USA
[c]Genus plc, DeForest, Wisconsin, USA
[d]Warsaw University of Life Sciences, Faculty of Veterinary Medicine, Department of Pathology and Veterinary Diagnostics, Warsaw, Poland

ABSTRACT Porcine reproductive and respiratory syndrome virus (PRRSV) has a narrow host cell tropism, limited to cells of the monocyte/macrophage lineage. CD163 protein is expressed at high levels on the surface of specific macrophage types, and a soluble form is circulating in blood. CD163 has been described as a

Genome Editing: The Next Frontier for Animal Health and Meat Production

Status

Technology	• University of Missouri discovery confirmed by academics in US, EU, China • Optimized the gene edit • Created founder populations in the US
Regulatory	• Engaged with FDA for US regulatory approval • Initiated contact with international regulators
Market/Consumer Acceptance	• Conducted consumer sentiment surveys in US and other countries • Engaged with key industry stakeholders
Market Implementation	• Developed genetic dissemination strategy

- **We believe this technology has the potential to eliminate a major disease in the swine industry which benefits the well-being of the animals, pork producer productivity, and consumers**
- **Genus and PIC are committed to responsible development of technology, adherence to regulatory standards, and responsible management of animals while we work through these developments**

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… Livestock/Meat Industry BUSINESS ENVIRONMENT…

…Meat industry is a competitive, high-volume, commodity-driven, *low-margin business*…

The global meat market is highly complex & can be segmented by:

- **Governance**
- **Species**
  - ***beef, pork, poultry***
- **Distribution channel**
  - ***retail, food service, commodity, international***
- **Type of processing**
  - ***slaughter, fresh meat, further processing***
- **Type of products**
  - ***bulk parts, retail packaged, raw meat, packed processed meats***
- **Geography**
  - ***country, continent, export, global***

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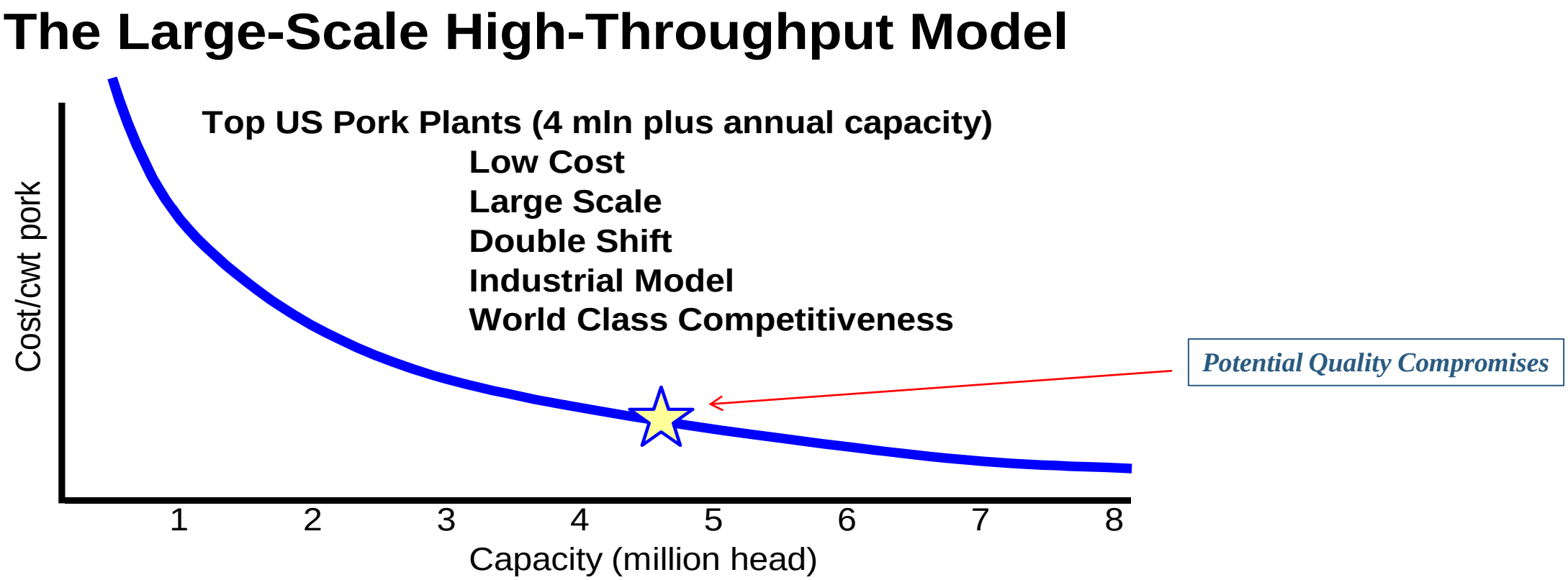
U.S. FSIS-Regulated Pig Slaughter Line Speed is 1,006 pigs/hour *(2021 YTD)*



Dr. Dennis DePietre, University of Missouri, 2000

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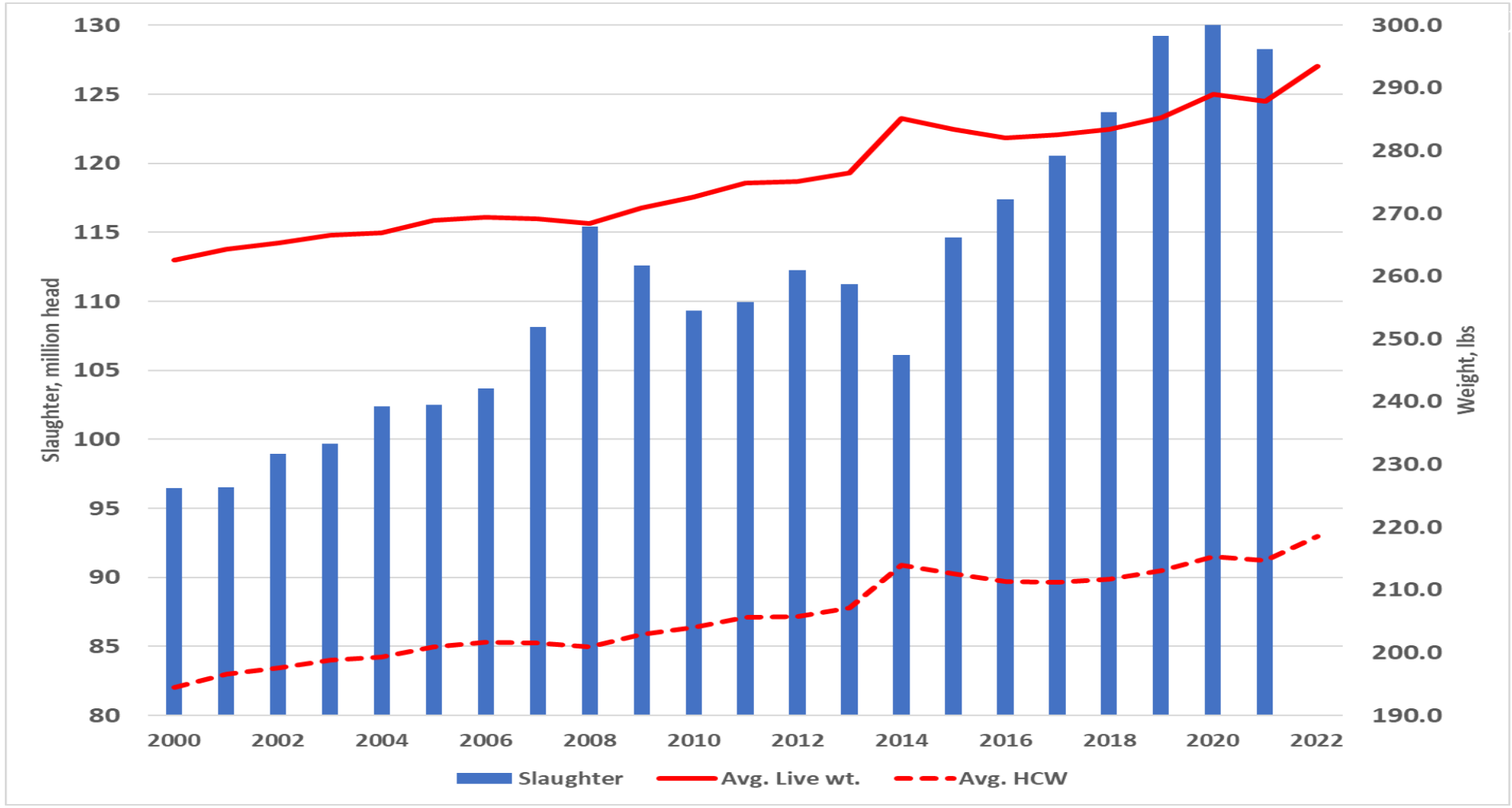
Throughput = Kg Pork Processed/Hour/Shift = *Carcass Weight & its Variation*

Commercial Pig Slaughter – United States



~136 Kg

Source: USDA-ARS, April 2022

… Livestock/Meat Industry BUSINESS ENVIRONMENT…2022 …Into the Future..

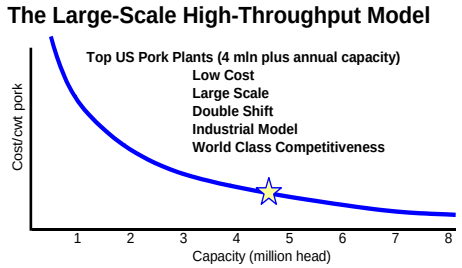
VALUE DEFINED

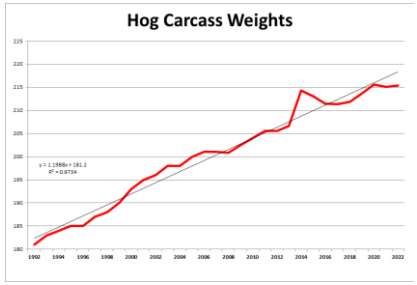
Quality + Service

COST

***NORTH & LATIN AMERICAN (and increasingly the EU)* Pork Industries are:**
Dominated by large multi-species Food enterprises

- *Focusing on long-term sustainable growth*
- *By developing value-added products & consumer brands*





COST

… 2022 …Into the Future
…Further Developing Meat Value Chains *vs. 'Traditional' Meat Supply Chains*

Meat Supply Chain
(1990's ~2010)

Meat Supply Chain management focuses mostly on increasing the efficiency of current operations

- *Its core focus is on reducing costs while retaining the systems and processes already in place*

Meat Value Chain
(~2010-YTD)

Meat Value Chain management is based on creating value from consumers' perspective

- *Its core focus is on developing the systems necessary to satisfy consumers' expectation*
- *Cost reduction is an outcome of this approach, as is superior quality and competitiveness through focusing resources on efficiently producing goods that offer superior consumer-recognized value*
- *A closely-aligned value chain often contains vertically and horizontally linked players such as genetics and genetic improvement program(s), livestock producer(s), processor(s), distributor(s), and retailer(s)*

Meat Value Chain
What Constitutes a Leading Firm with Great Overall Results Over time??

KEY Factors of High Performing Firms:

- *Core competencies: knowledge of the strong points … and weak points*
- *Value Chain Relationships: often contain vertically and horizontally linked players such as genetics and genetic improvement program(s), livestock producer(s), processor(s), distributor(s), and retailer(s)*
- *Technology Adoption: .. Willingness to invest in technology, people, systems, communication, .. to lead the industry*

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Alternative proteins

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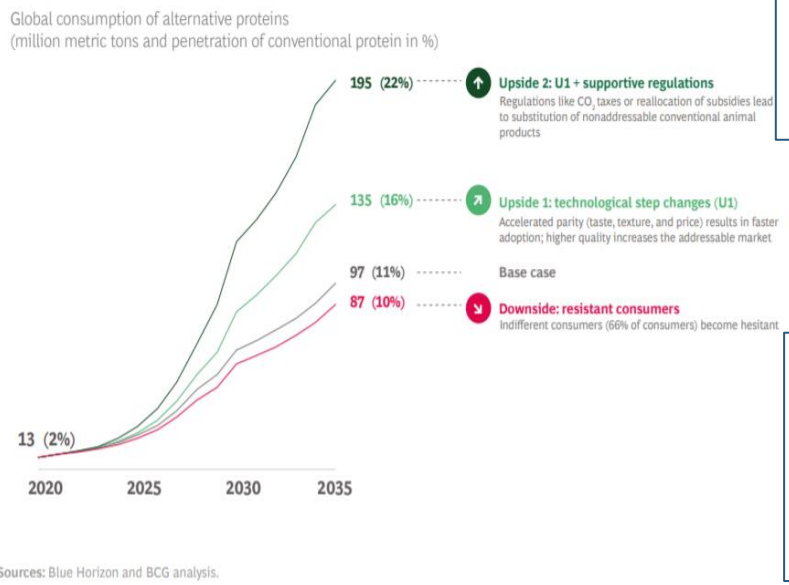
Exhibit 11 - Alternative Proteins Could Claim as Much as 22% of the Overall Protein Market by 2035



Source: Food for Thought, The Protein Transformation, BCG March 2021

…"Products like the Impossible Burger, with its 80-plus ingredients, are now in supermarkets and fast-food establishments worldwide"...

…"Lab-grown chicken has been on the market in Singapore since late 2020 and will likely soon be approved in the U.S.

"The IPES-Food report noted that the alternative protein sector has witnessed an influx of investment, with high-profile backers including Bill Gates, Sergey Brin, and Richard Branson. …It has also attracted support from US, Chinese and European governments.

But, if you follow the money, you find that the market has seen significant investments and acquisitions from the world's big meat processing companies, including JBS, Cargill, and Tyson"…

Compelling Value Proposition?

- ***Sustainability and carbon emissions***
- ***Social goals and food access***
- ***Health concerns around diet choices***
- ***Pressure on industrialized farming***

…Yet plant-based food companies may come with greater (ESG) risks for investors, at least if you consider the case of Tyson Foods (TSN) and Beyond Meat (BYND)…

.. Sustainalytics assigns Beyond Meat an even worse rating of Severe ESG Risk…

Morningstar….April 14, 2022. Data shows relative performance of BYND and TSN from March 31, 2021, through March 31, 2022

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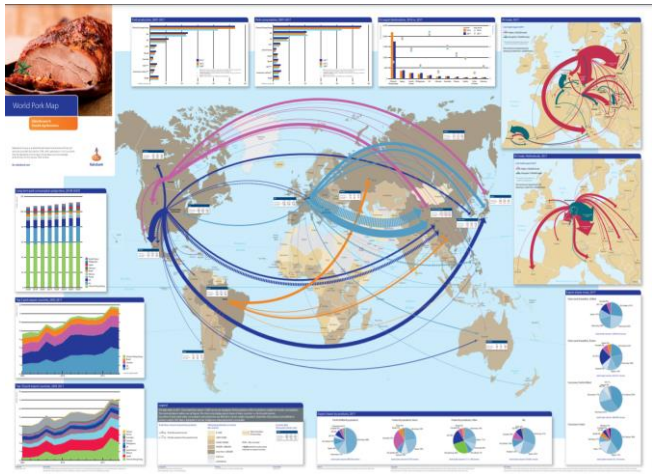
Realities of On-going Evolution of Global Meat Market



Source: Rabobank 2018 World Pork Map

- ESG rules in wealthy countries, although critical for the future success of Meat Industry, need to acknowledge the trade-offs
  - *Increasing realization of competing priorities leads to more technical innovations and definitions of trade-offs across food value chains*
  - *Consumer demands are the "compass"*
    - *Transparency and trust*
    - *Quality and familiarity*
- 'New' attitude must be fostered among Meat Industry professionals worldwide who share the same passion, commitment, persistence, and desire to service their customers – and ultimately consumers, globally
  - *Increase cross-functionality between basic and applied meat science & business development programs*
  - *Technical and business skills are most often NOT ENOUGH, success also depends on building relationships with all parties involved*
- Self-sufficiency is rarely an option
  - Diversification is the goal
  - The power of partnering is clearly a prerequisite for industry success
    - *New partnerships (i.e., forward contracts)*
    - *Dramatic changes in import/export (contracts)*
    - *Etc. Etc.*

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FINAL COMMENTS (for the SCIENTISTS):
Analytical Conundrum

Lots of Data and Many Questions

- *Are these independent or dependent variables?*
- *Are these causative, responsive, or associative?*
- *Are our existing biological explanations plausible?*
- *Are there simple analytical solutions?*
- *Does machine learning, neural networks, provide the best analytical solution?*

What is the final objective?

- *Is it a route to greater understanding of the animal that leads to better husbandry, better welfare, better (meat) quality, and sustainable improvements in animal proteins production*

Further reading…

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