July 14-16, 2014

103rd Annual Meeting of the Poultry Science Association

Corpus Christi, Texas

Sponsored by:

DUPONT®

"The Role of the Poultry Industry in Feeding the World in 2050" Symposium

Unlocking the Genetic Potential

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2050

100%

70%

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1928

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1948

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2012

Genetic Selection Criteria

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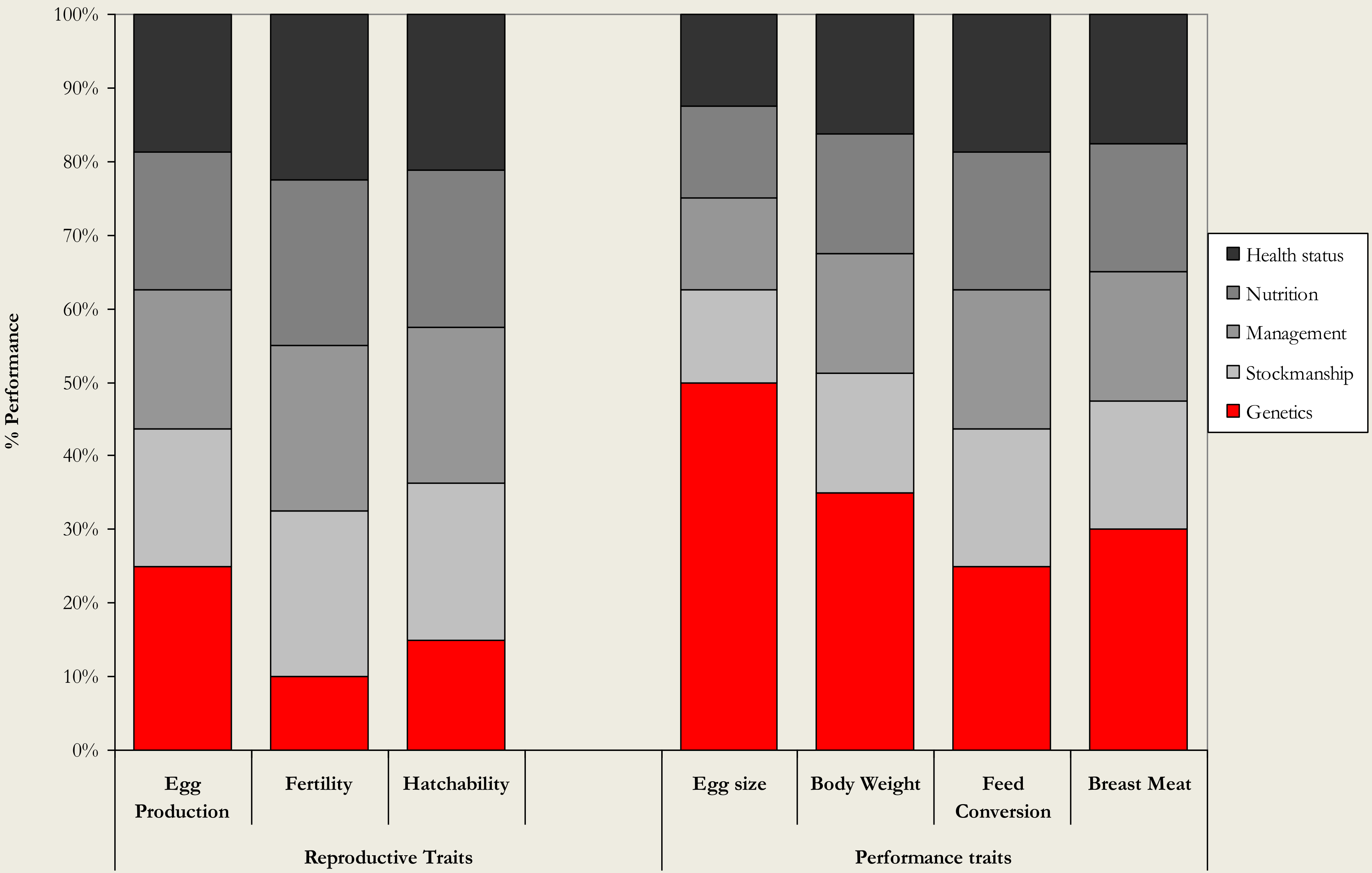
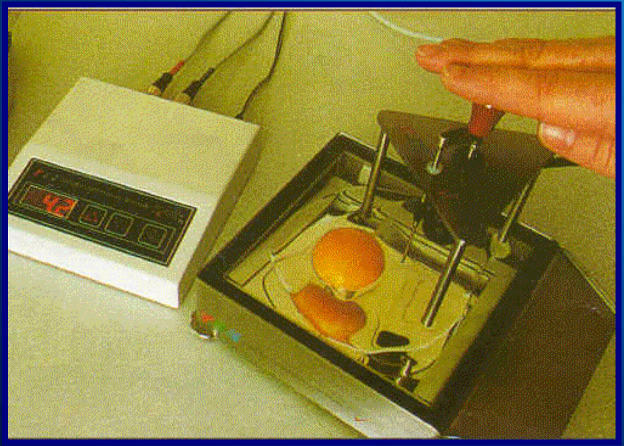
Influence of Genetics



Technology



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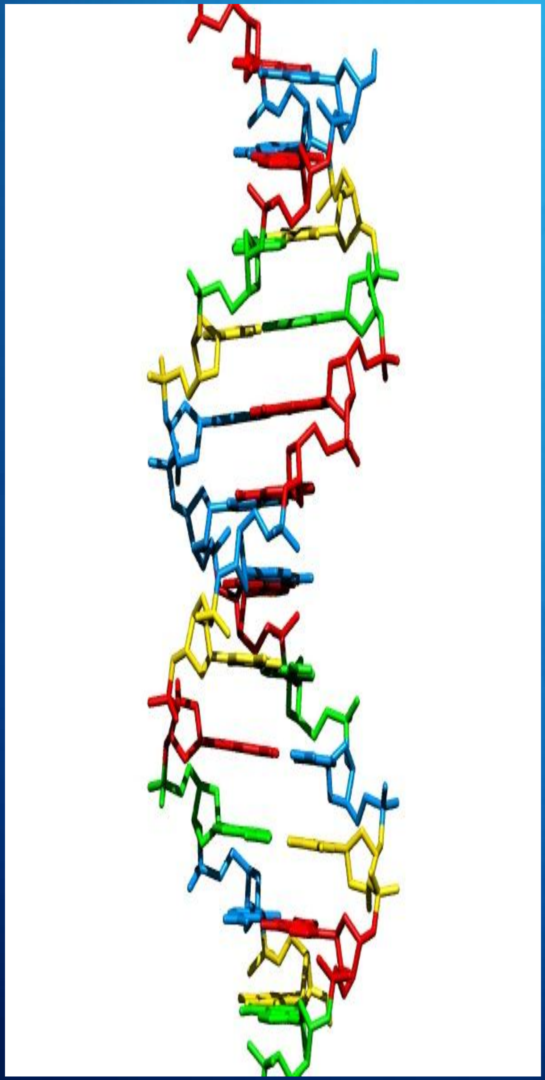
- December 2004, publication of the chicken genome (Int. Chicken Genome Sequencing Consortium, 2004)
  - Estimated to cover 90-95% of the genome
  - Approximately 18,000 identified genes
- 2.8 million single nucleotide polymorphisms (SNPs) became available (International Chicken Polymorphism Map Consortium, 2004)
- Genetic variation in chickens is 5 X higher than that observed in humans!
  - Good News for Genetics Companies and their customers!



- DNA is constantly changing, however slowly
- These nucletide changes are “mutations”
- Mutations can be positive, negative, or neutral
- If the change only involves a single nucleotide and is common in the population it is a SNP “snip”

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Nutritional Genomics

- Investigating the interaction among genes and factors in the environment
  - Sub-disciplines include:
    - Nutrigenetics – how do genetic changes in the individual influence the functioning of that individual in its environment
    - Nutritional Epigenomics – which genes are expressed in which cells at which time; also influenced by its environment
    - Nutrigenomics – concerned with the influence of environmental factors on gene expression

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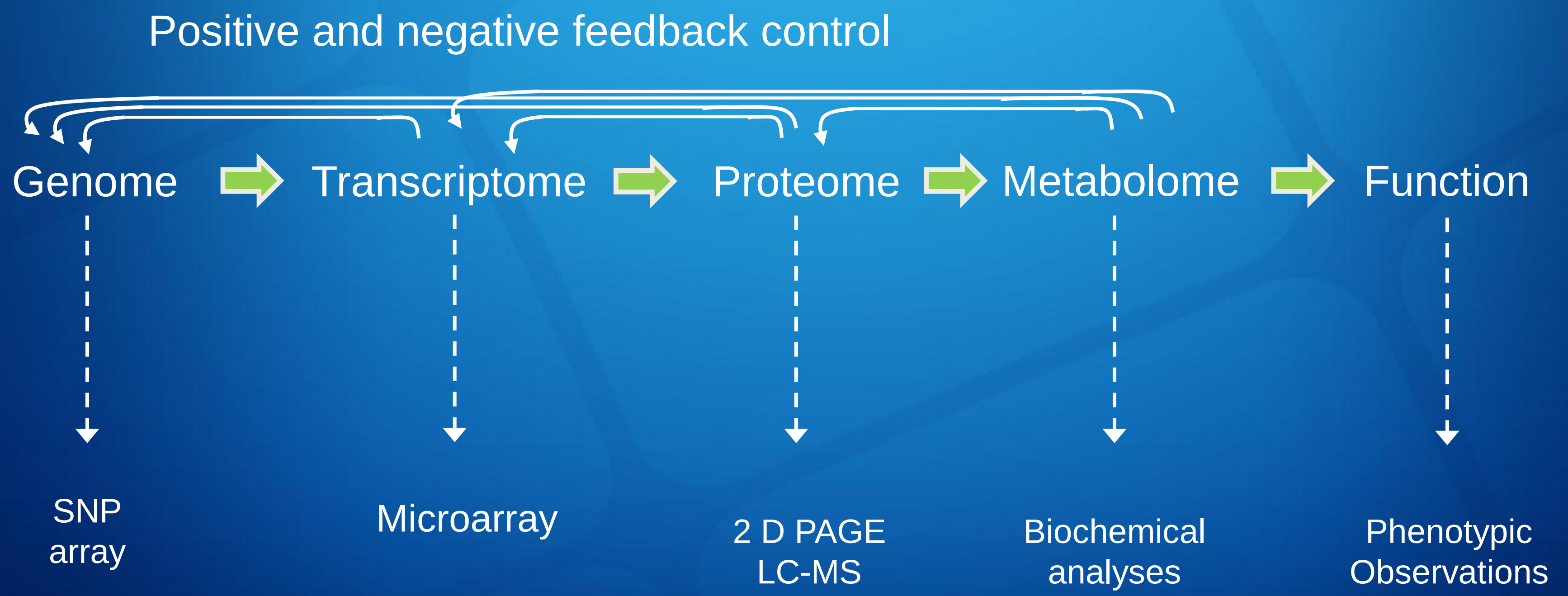
General schematic of the '-omic' organization where the flow of information is from genes to transcripts to proteins to metabolites to function (or phenotype)



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After: Goodacre, R., 2007

- Nutrigenetics
  - Gene changes in the animal can result in different response to environment
    - eg., a genetic mutation results in lack of response to a certain nutrient due to a failure of particular enzyme. Result is that the animal now requires either the enzyme or the nutrient to be added to the diet

- Nutritional Epigenomics
  - Gene expression is changed without a mutation in the nucleotide sequence
    - Chromatin remodeling
    - DNA methylation
    - Genomic imprinting
    - RNA interference
  - All result in reducing the mRNA available for translation into proteins

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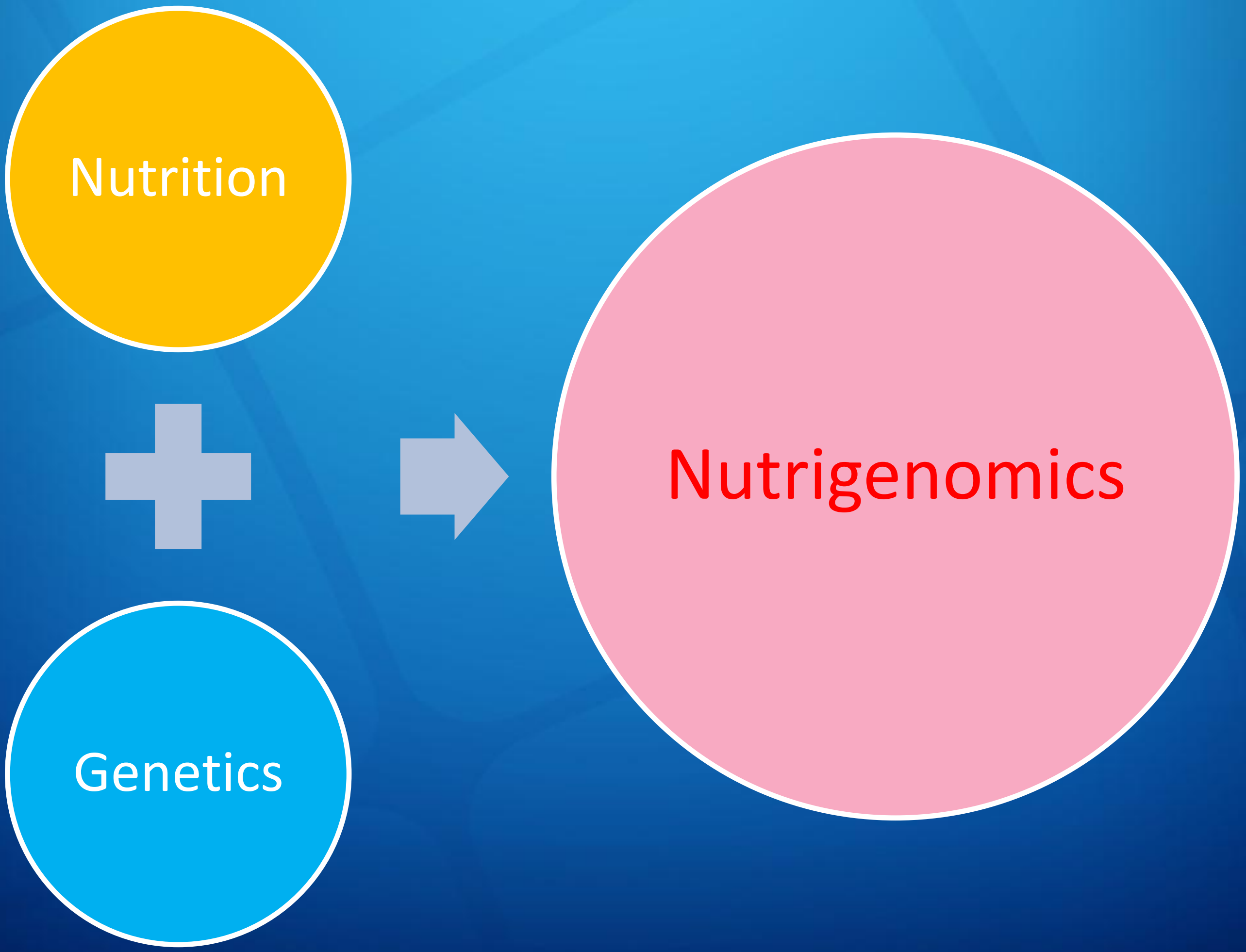

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Nutrigenomics

- Earliest studies in the 1940's
  - Beadle and Tatum were able to determine nutrient requirements for a single cell eucaryote using a series of mutations
  - Determined metabolic pathways and genes responsible for enzymatic conversions
- Gene x Environment or "G x E" interactions theorized in early 1960's
  - Jacob and Monod, 1961, deduced that nutrients were capable of turning gene expression on and off

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Nutrigenomics

- Synthesis of L-tryptophan by E. coli is a classic example
  - If tryptophan is present in the environment surrounding E. coli, the genes which are responsible for coding for the enzymes which synthesize tryptophan are turned off

Nutrigenomics

- How can we better model the avian system so that we can take advantage of these opportunities? **By using the products of gene expression as tools**
  - Metabolomics
    - Measure the end product metabolites
      - Mass Spectrometry for low abundance metabolites
      - Nuclear Magnetic Resonance (NMR) for high abundance
  - Proteomics
    - Study of proteins within a cell or organism
  - Transcriptomics

Metabolomics

- Study of the complete metabolite set of a given cell, tissue, organ or organism produced as a result of its environment (treatments!)
- Metabolites change due to environmental stimuli
- The scale of the metabolome is huge!
  - Estimated that human metabolome is ~2,500 primary metabolites and ~15,000 secondary metabolites

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- The Chicken is really a “Superorganism” composed of its genome as well as its microbiome (microflora)

- Acquistion of a healthy microflora has a profound effect on the overall health of the chicken
- When we feed the chicken we also feed the microbiome
- Metabolites in the serum and urine are affected by changes in the Superorganism

- It is estimated that the human intestinal microflora is composed of between 10^{13} and 10^{14} microorganisms (10 times the number of cells in a human body!)
- Over 1000 bacterial species
- This microbiome has at least 100 times the number of genes as our own genome!
- We can consider that this microbiome is another organ in the body
- This microflora plays an important role in maintaining health

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G x E

- Havenstein, et al., 1994 investigated G x E interaction using 1957 and 1991 genetics using feeds typical for both years.
  - Using 1991 diets, the 1957 broilers increased body wt. by 20 – 26% over the 1957 diets
  - The 1991 broilers were significantly heavier than the 1957 on either diet, indicating that the genetic component was highly significant
- This trial was repeated in 2001 with similar results
- Summary: 85–90% of the body wt. gain up to 56 days was due to genetic selection, 10-15% was due to better nutrition

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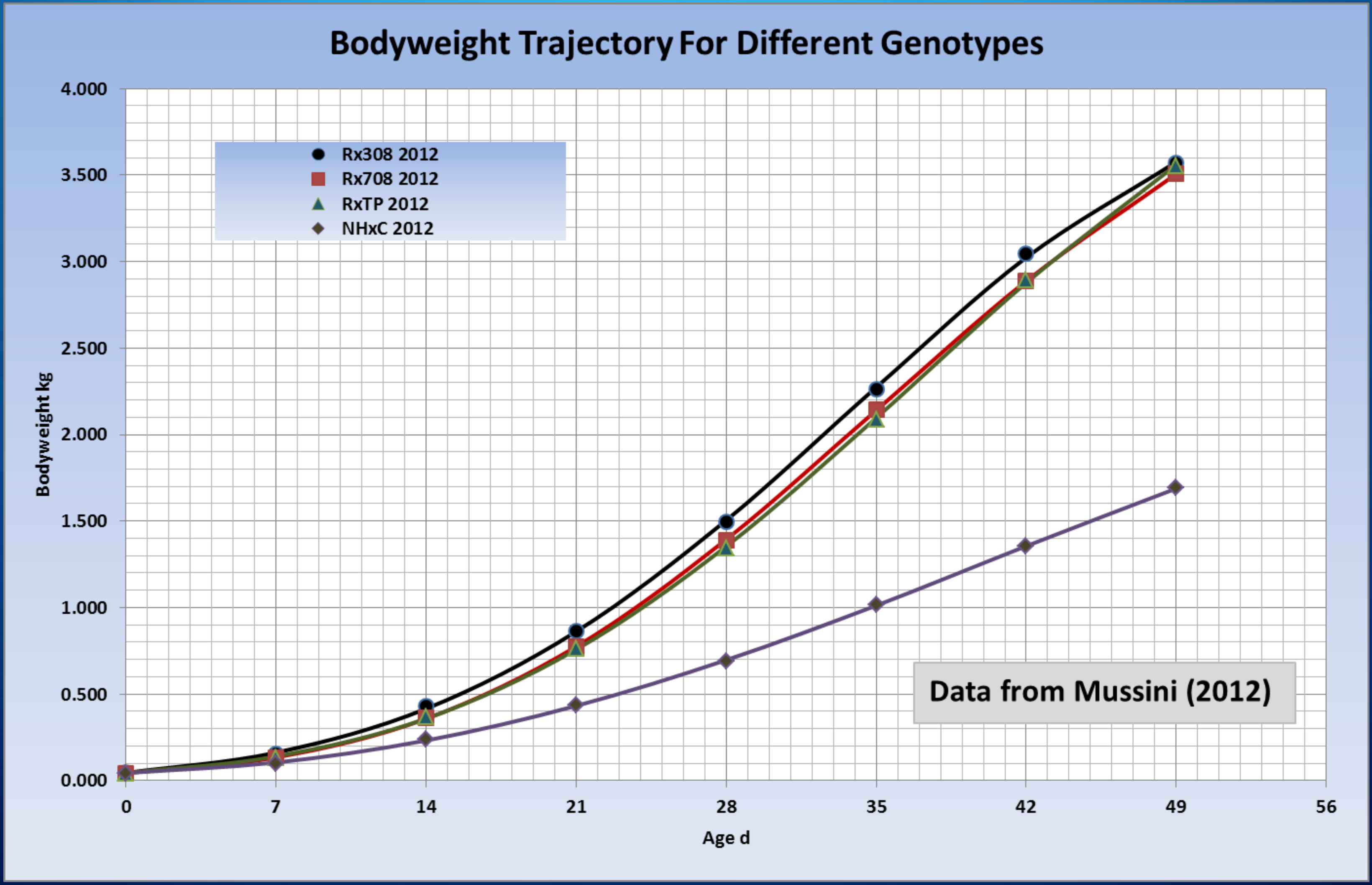
Broiler Genetic Progress



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Broiler Genetic Progress

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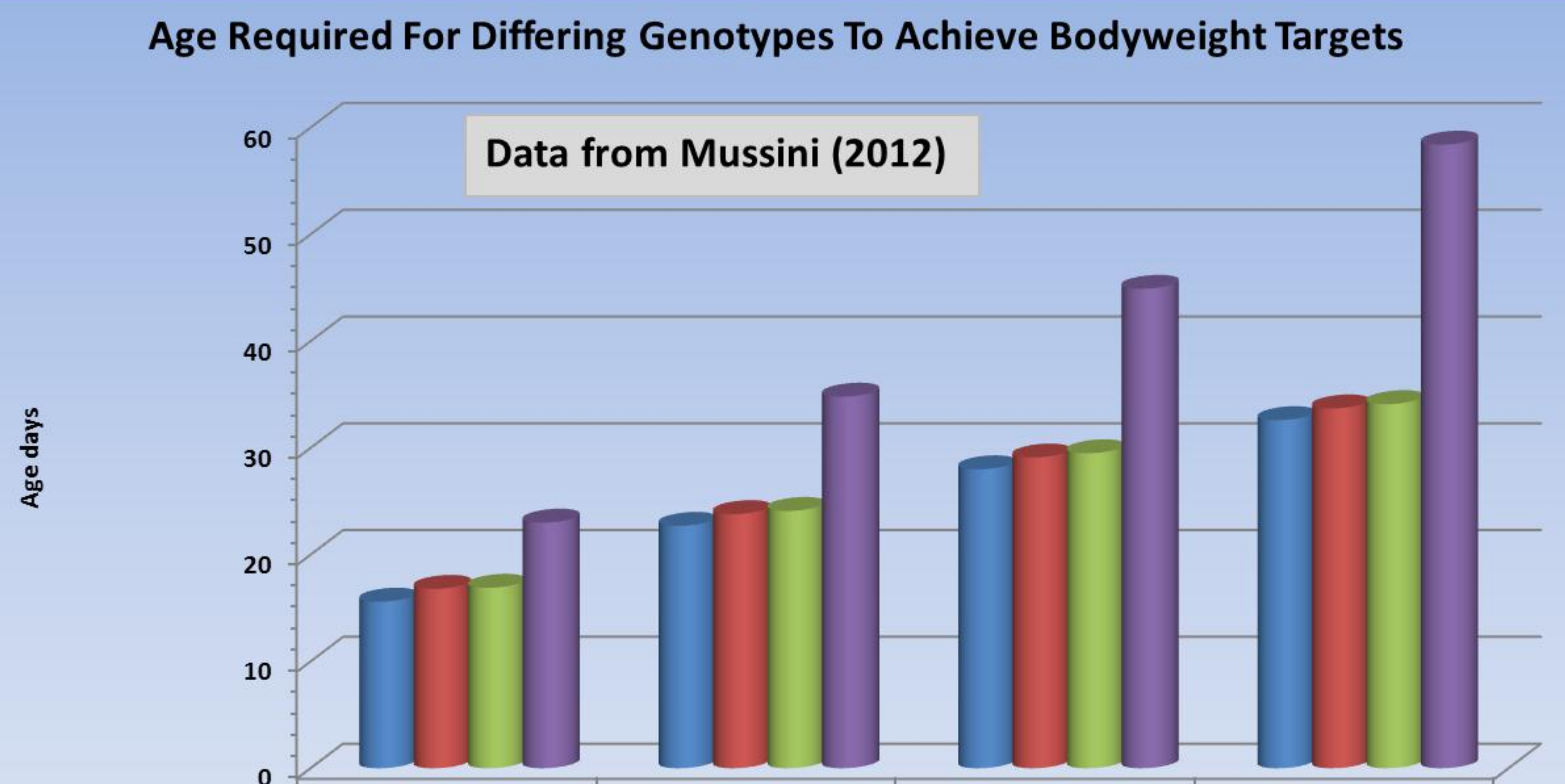
Broiler Genetic Progress



	Days to 500g	Days to 1000g	Days to 1500g	Days to 2000g
Rx308 2012	15.6	22.7	28.0	32.6
Rx708 2012	16.8	23.8	29.1	33.7
RxTP 2012	16.9	24.1	29.5	34.1
NHxColumbian 2012	23.0	34.8	44.9	58.4

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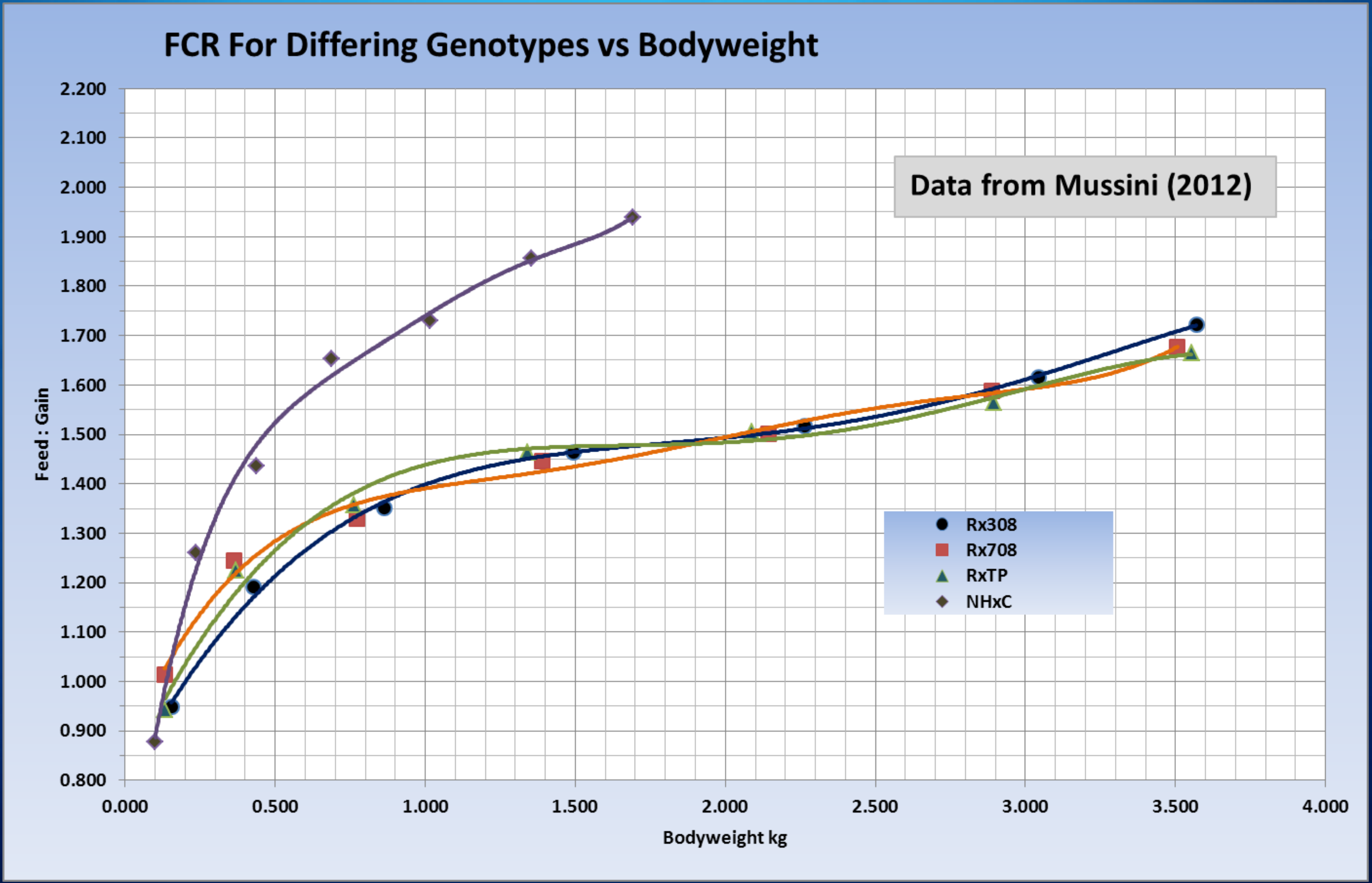
Mortality for all genotypes was very low

Broiler Genetic Progress



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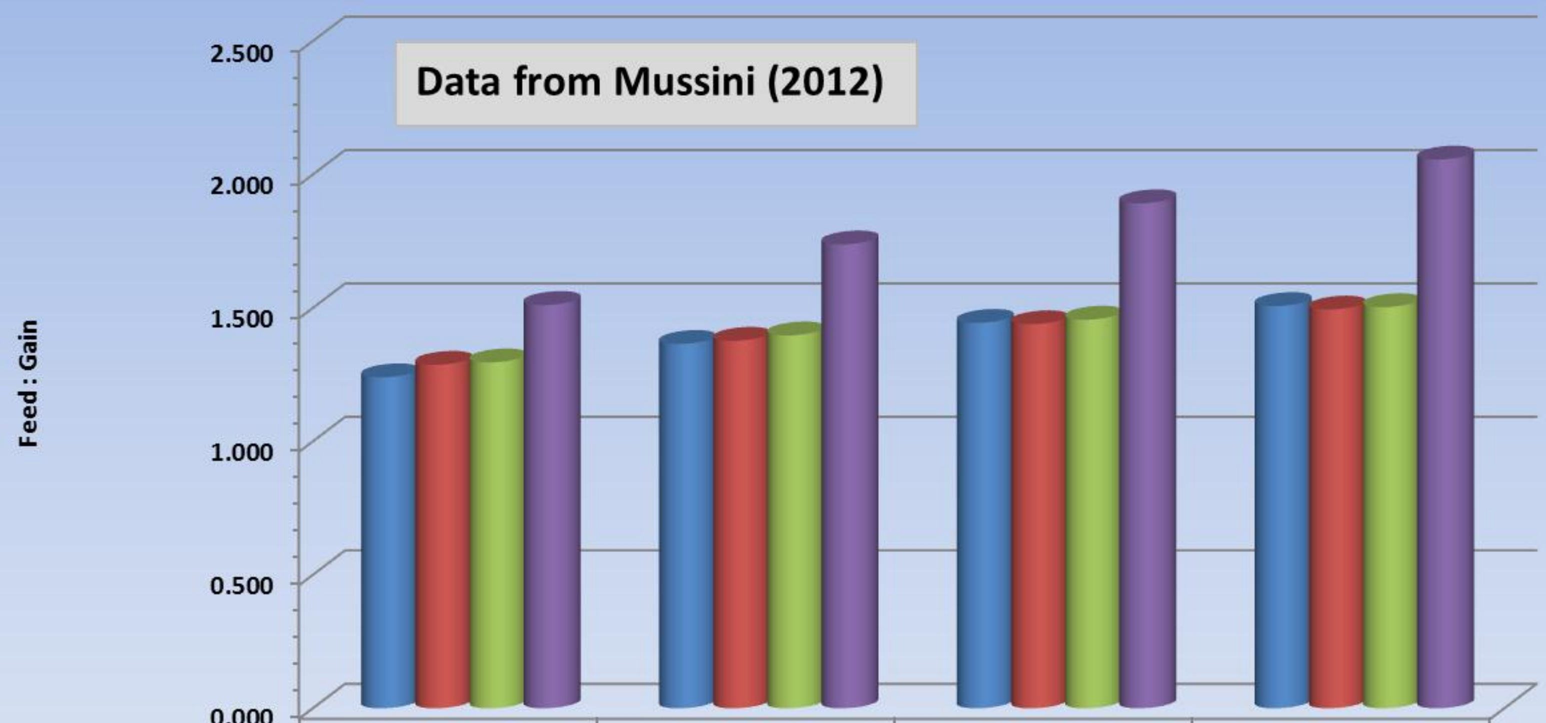
Broiler Genetic Progress

FCR For Differing Genotypes At Different Bodyweight Targets



	FCR @ 500g	FCR @ 1000g	FCR @ 1500g	FCR @ 2000g
Rx308 2012	1.240	1.365	1.444	1.507
Rx708 2012	1.287	1.377	1.439	1.494
RxTP 2012	1.296	1.397	1.456	1.503
NHxColumbian 2012	1.511	1.738	1.892	2.056
Pt. FCR/yr	0.4	0.6	0.7	0.9

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Effect of FCR Improvement

- In 2010, global broiler production was ~124 M mt, live weight
- If we only assume a -0.015 kg/kg improvement in FCR due to genetic selection
- -0.015 X 124 M mt = 1.85 M mt of feed
- 1.85 M mt feed/466 mt of wheat/km^2
- = 4000 km^2 of arable land per year!

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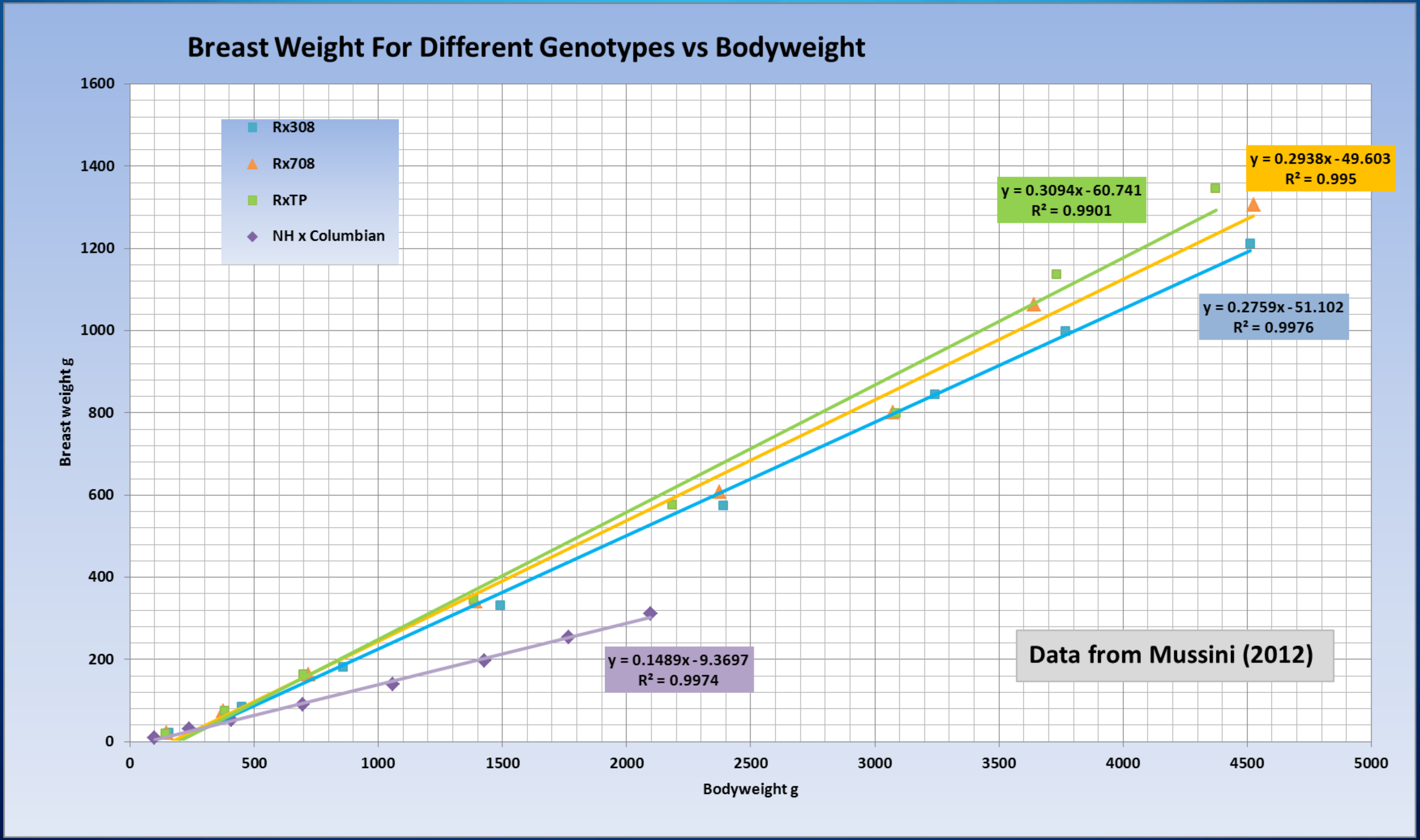
Broiler Genetic Progress – Processing



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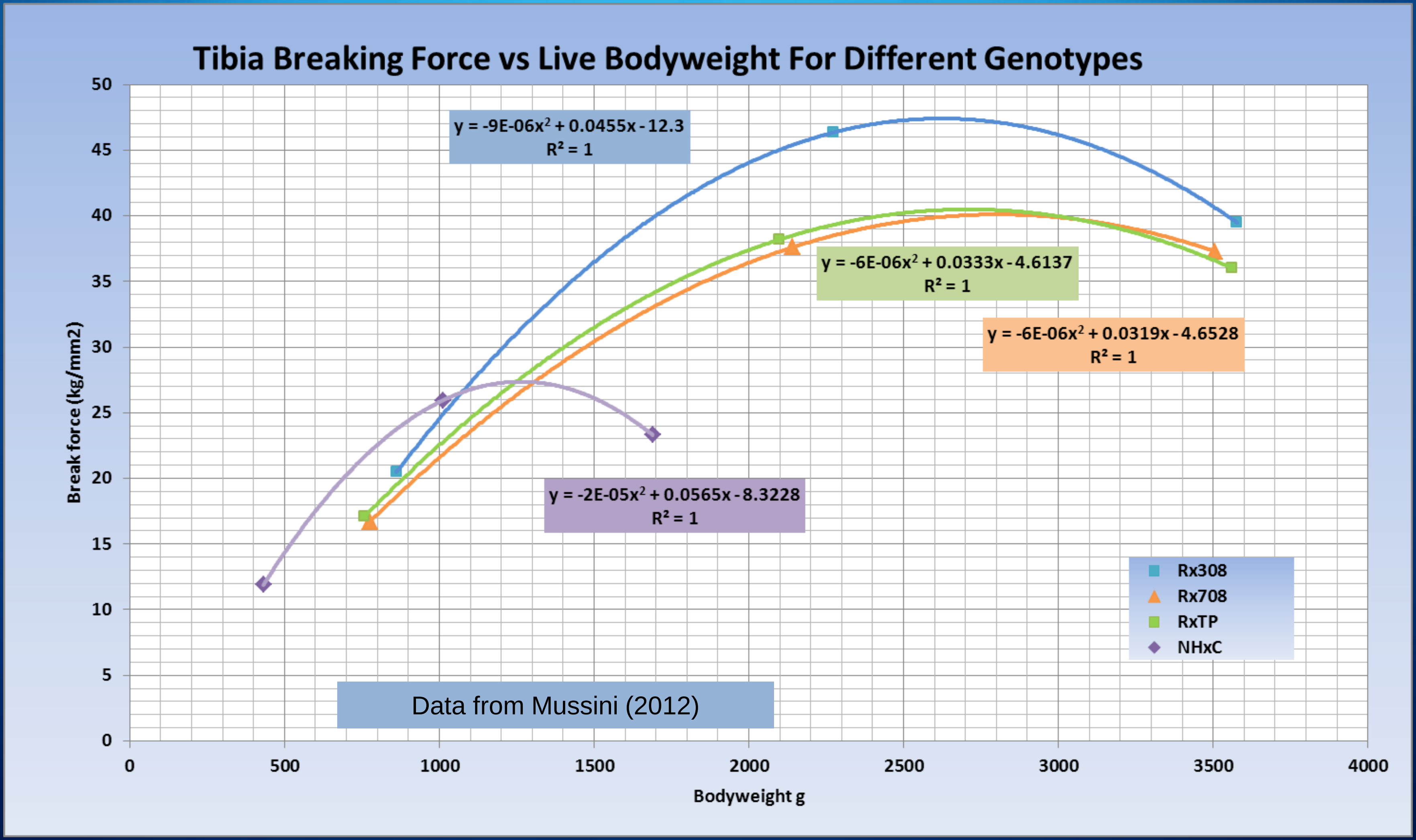
Broiler Genetic Progress – Skeletal



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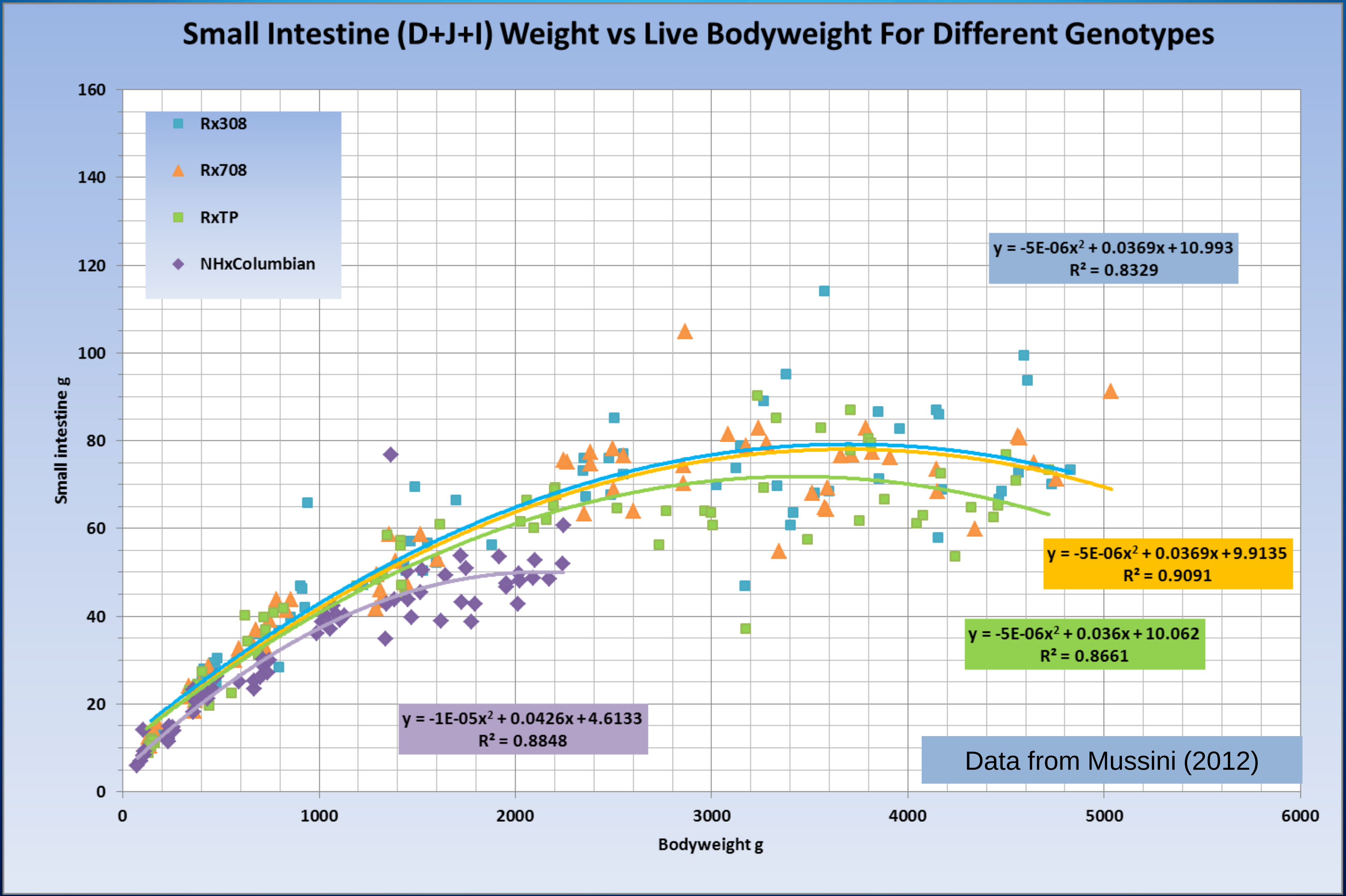
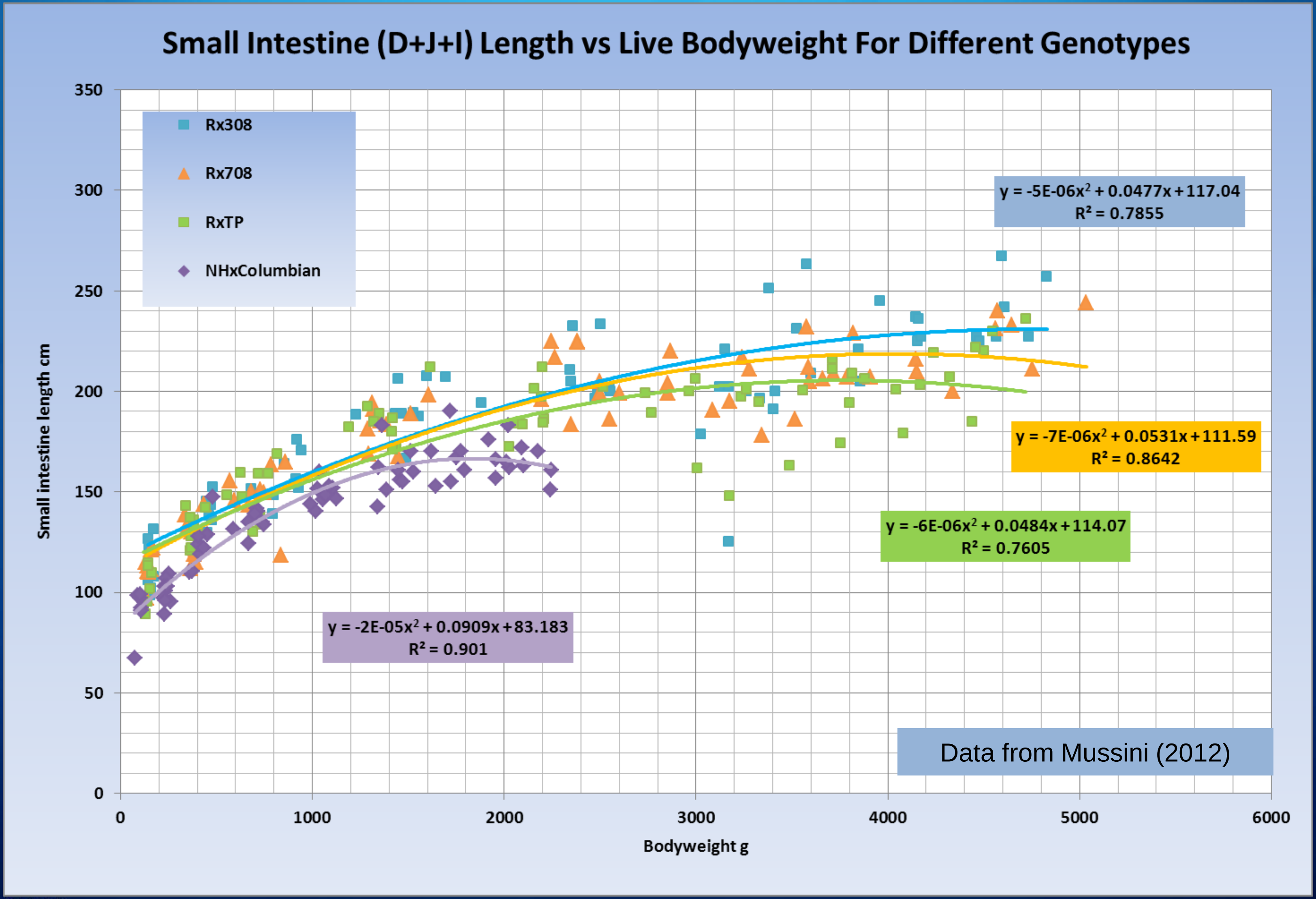
Anatomical Changes

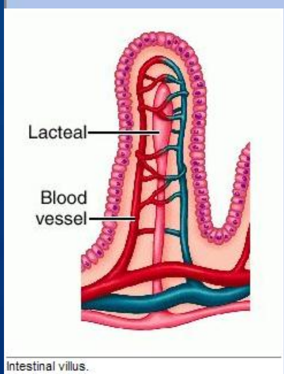


Anatomical Changes

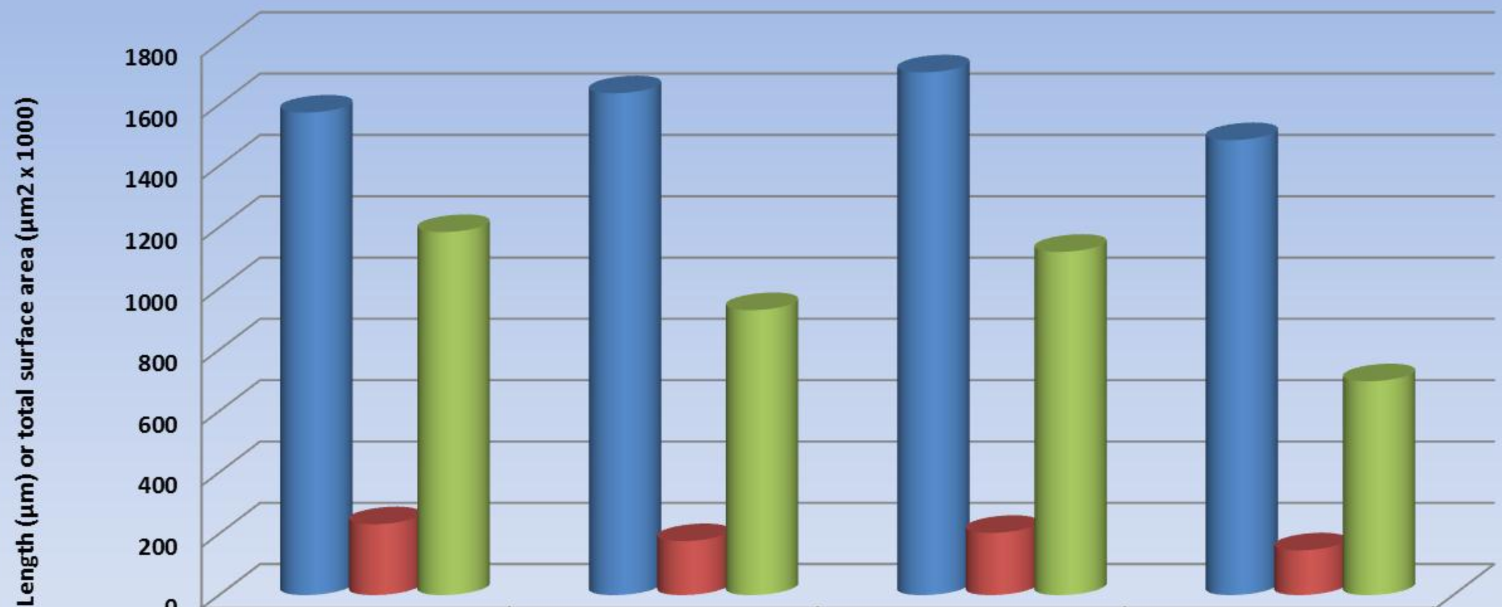


Broiler Digestive Capacity

Small Intestine Villus Morphometry (28 d) For Four Different Genotypes



Intestinal villus.



	Rx308	Rx708	RxTP	NHxC
SI villus length (µm)	1574	1637	1705	1484
SI villus width (µm)	231	176	203	146
Est. total surface area (mm2*1000)	1,184	929	1,120	697

On average – modern breeds have ~55% more surface area

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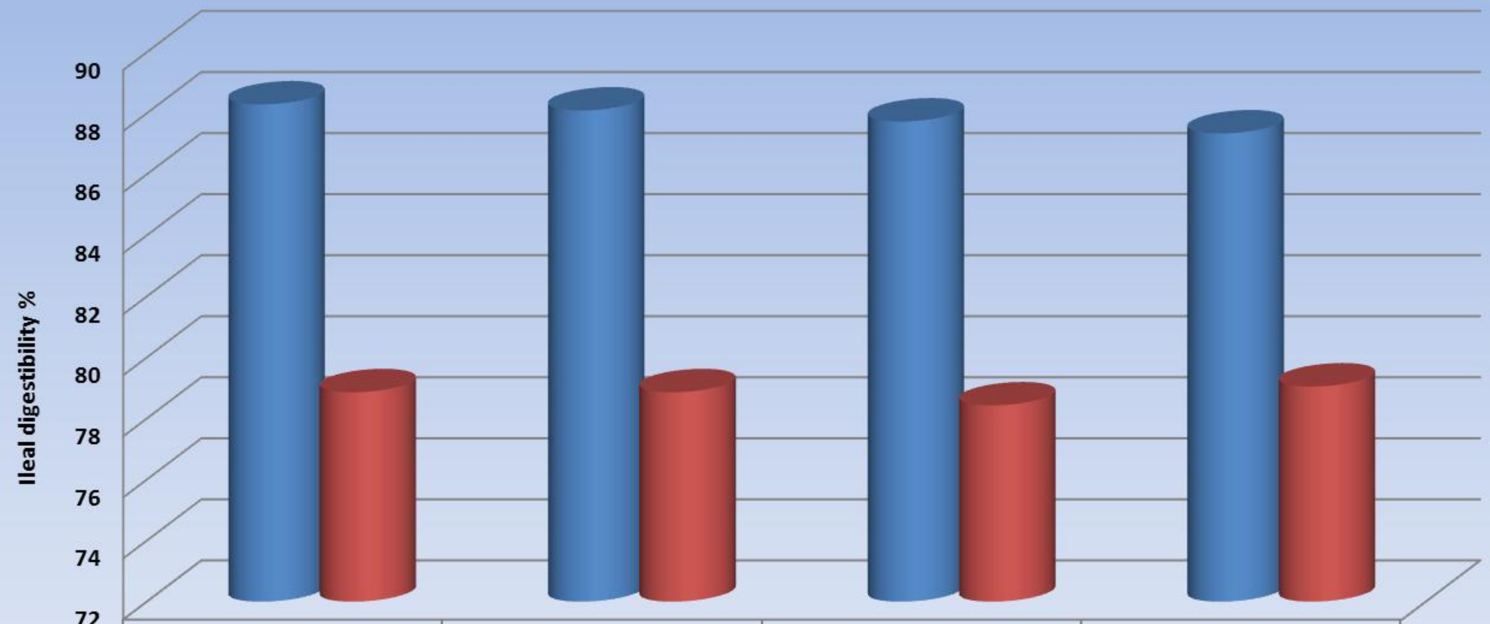
Data from Mussini (2012)

Nutrient Digestibility

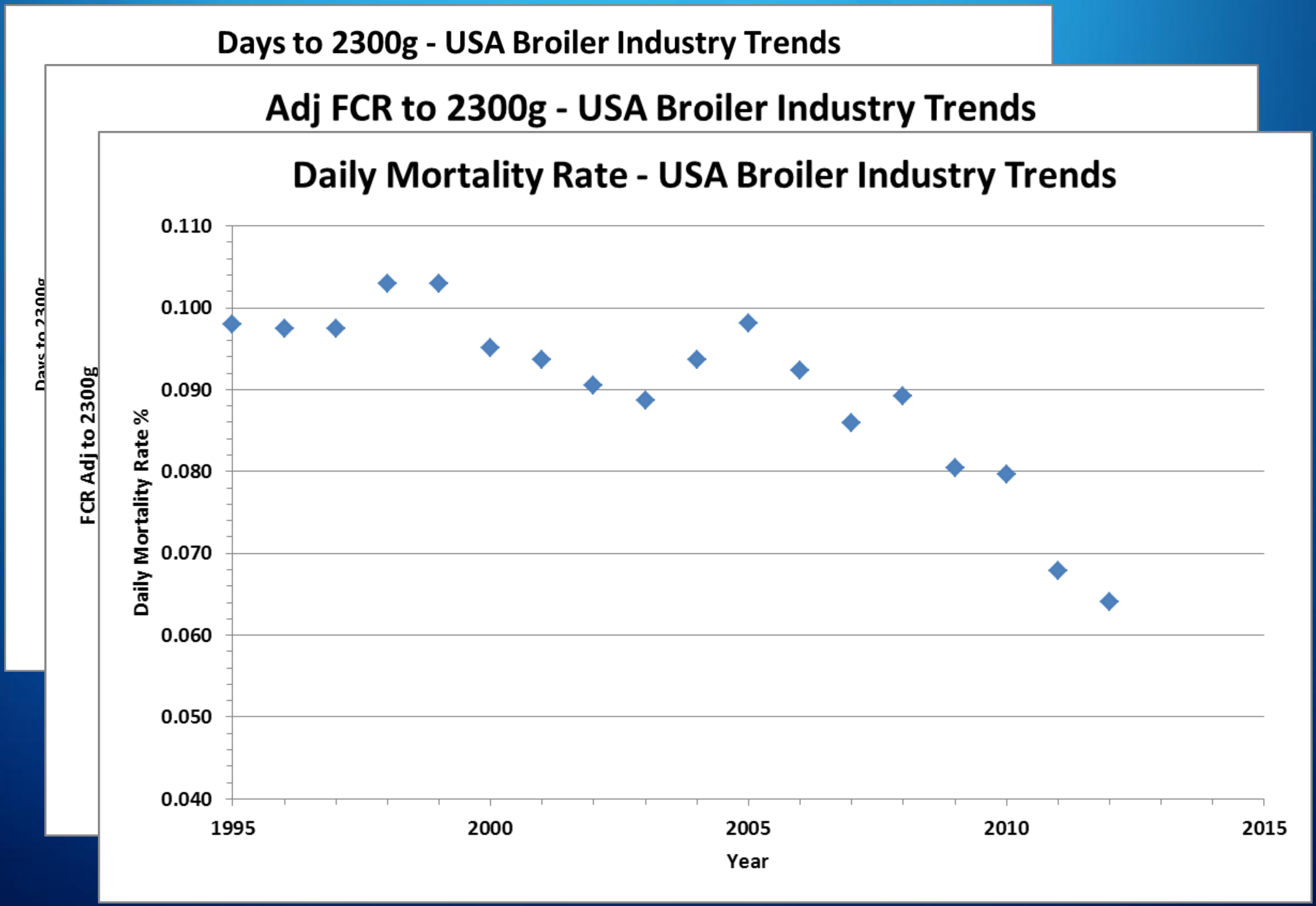
Nutrient Digestibility (Ileal at 27 d) For Four Different Genotypes



	Rx308	Rx708	RxTP	NHxC
Protein digestibility %	88.29	88.09	87.73	87.34
Energy digestibility %	78.86	78.86	78.43	79.05

Data from Mussini (2012)

Reflection on Past Ten Years in US



Conclusions

- Huge task ahead of us
- Poultry Genetics has made tremendous progress in the past 50-60 years
- New tools (technologies) are available to help move this even faster with more productive gains
- Not using available technology will result in failure to reach 2050 goals

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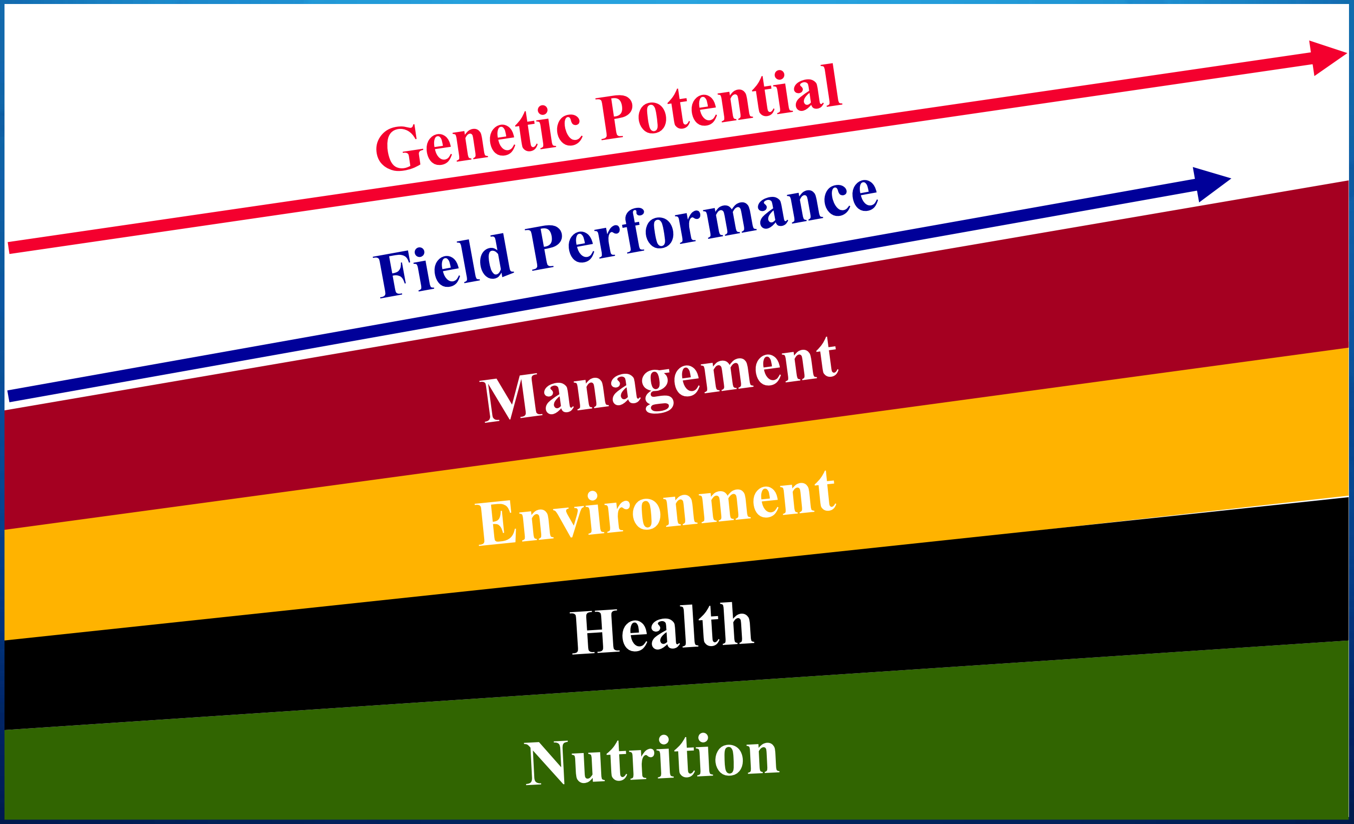
Translating Genetic Potential into Field Performance



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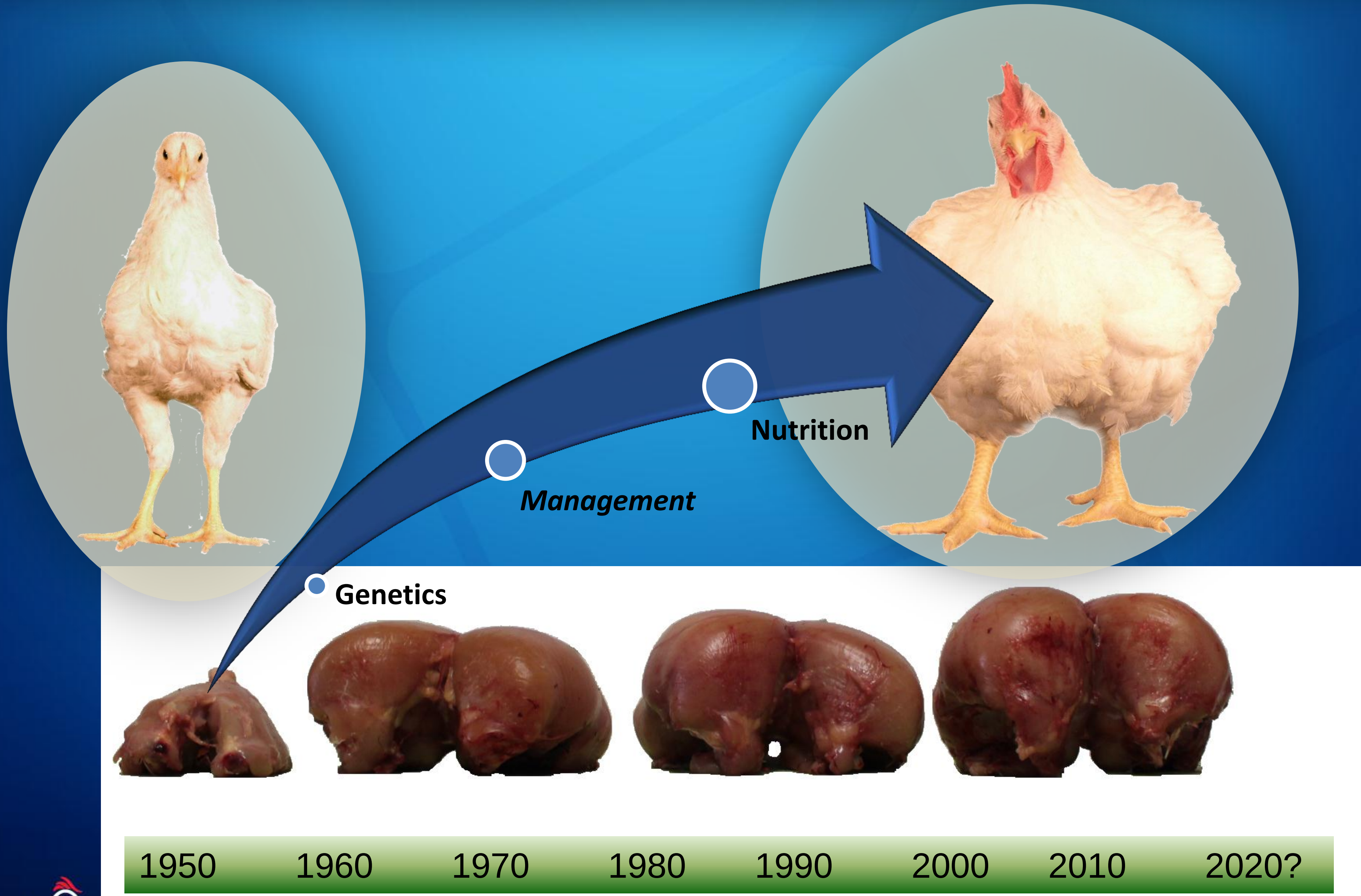
Nutrition
Management
Genetics
1950
1960
1970
1980
1990
2000
2010
2020?