21st Century Genetic Technology and its Impact on Animal Welfare

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THE HUMANE SOCIETY
OF THE UNITED STATES

An HSUS Report: Welfare Issues with Genetic Engineering and Cloning of Farm Animals

Abstract

Developments in biotechnology have raised new concerns about animal welfare, as farm animals now have their genomes modified (genetically engineered) or copied (cloned) to propagate certain traits useful to agribusiness, such as meat yield or feed conversion. These animals have been found to suffer from unusually high rates of birth defects, disabilities, and premature death. In the United States, there is significant public opposition to the introduction of meat and milk from cloned animals and their progeny into the food supply and currently no regulations exist to protect the welfare of farm animals during cloning or genetic engineering agricultural research.

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THE BLOG

Frankenfish Wins FDA Approval

01/04/2016 05:59 pm ET | **Updated** Jan 04, 2016

Like 65

Joseph A. Palermo
Professor, historian, author

ASSOCIATED PRESS

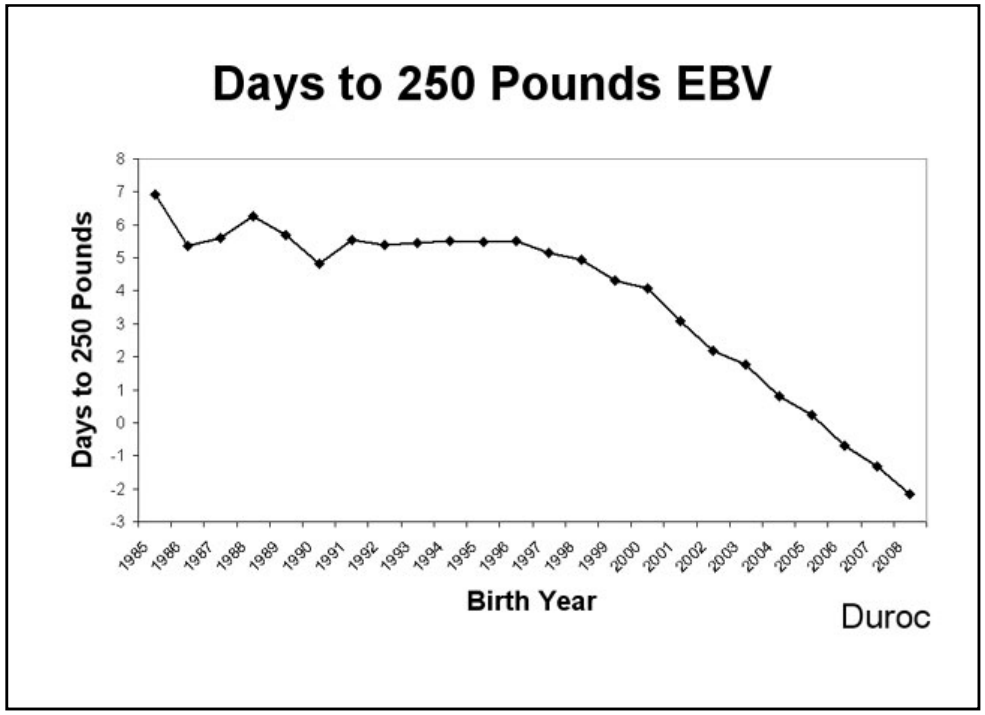
After a decade of intense lobbying from a Maynard, Massachusetts-based salmon production corporation the Food and Drug Administration for the first time has given its seal of approval to a genetically modified animal.

Retrieved from *The Huffington Post,* 10/04/16

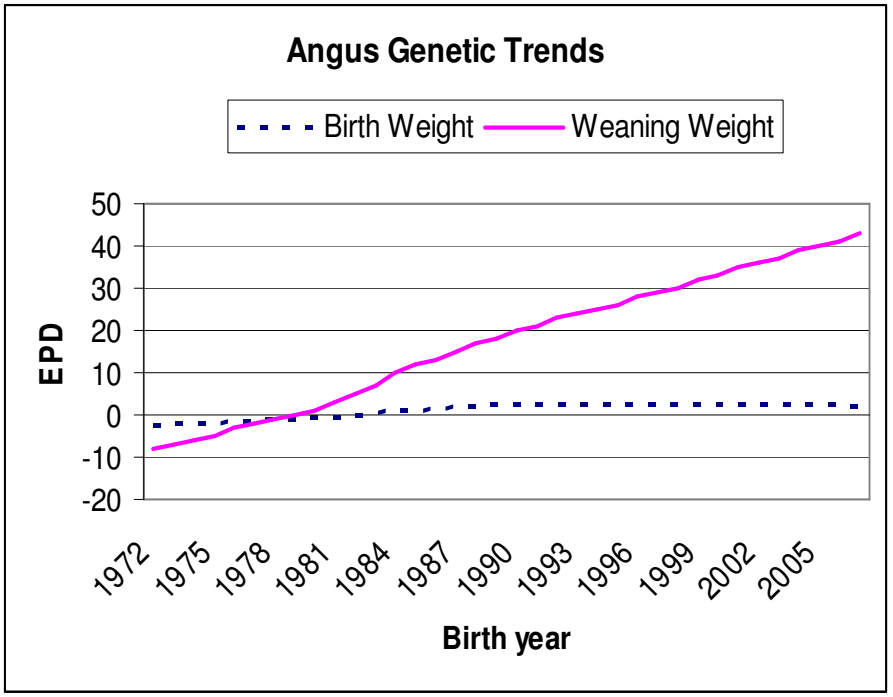
"What's to stop Colonel Sanders from creating a new genetically modified species of monster chickens that are market ready in a quarter of the time and possess six legs, ten wings and five breasts?"

Joseph Palermo, *The Huffington Post*, January 4, 2016

Brief History of Genetic Selection

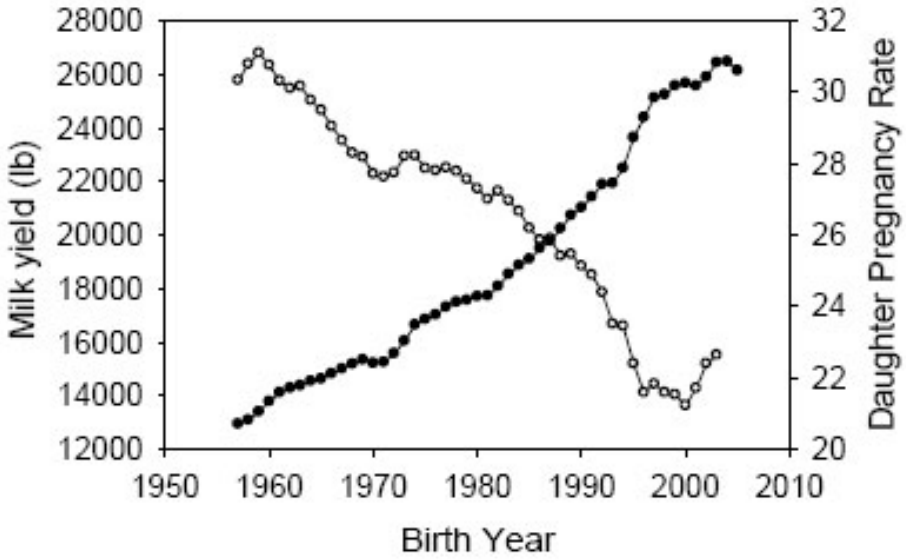


Genetic trend in the Duroc breed for days to 250 lbs. (1985-2008)



Genetic trend in the Angus breed for weaning and birth weights (1972-2008)

Brief History of Genetic Selection



P.J. Hansen, *Improving Dairy Cow Fertility Through Genetics,* 2008

poultryhub.org

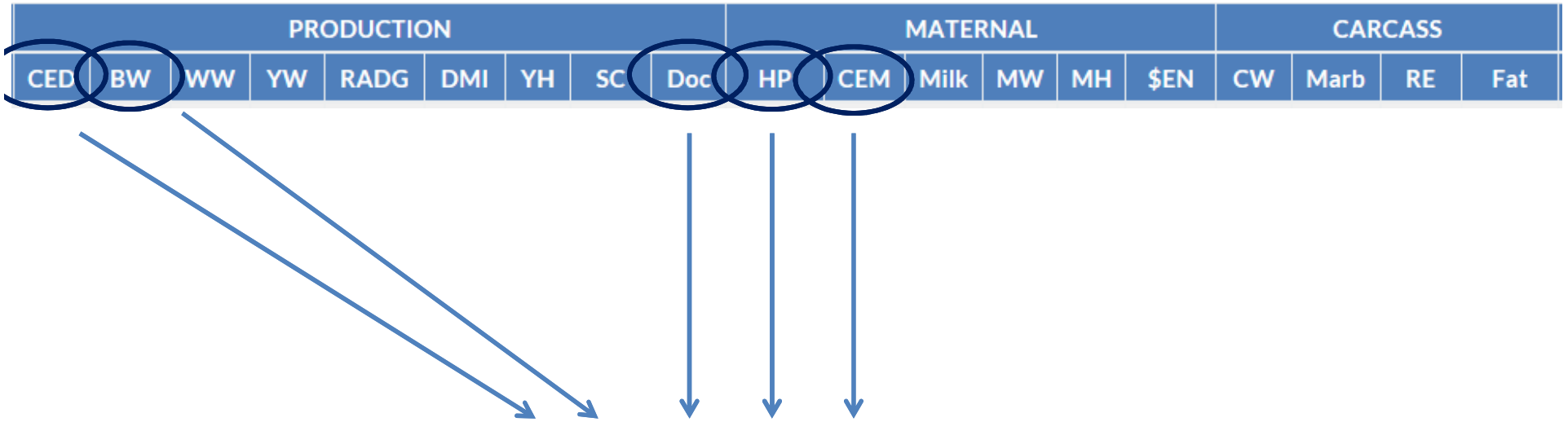
$Net Merit Values, AIPL, USDA

Trait	NM$ (2014)	Rel. % (2014)
Protein	4.14	20
Fat	3.22	22
Milk	-0.006	-1
PL	29	19
SCS	-122	-7
Udder	31	8
Feet/Legs	10	3
Body size	-16	-5
DPR	11	7
HCR	2.3	2
CCR	2.2	1
CA$	1	5

Traits included	USDA economic index (and year introduced)						
	PD$ (1971)	MFP$ (1976)	CY$ (1984)	NM$ (1994)	NM$ (2000)	NM$ (2003)	NM$ (2006)
Milk	52%	27%	-2%	6%	5%	...	5%
Fat	48%	46%	45%	25%	21%	22%	23%
Protein	...	27%	53%	43%	36%	33%	20%
Productive life	...	...	...	20%	14%	11%	20%
Somatic cell score	...	...	...	-6%	-9%	-9%	-8%
Udder composite	...	...	...	...	7%	7%	6%
Feet/leg composite	...	...	...	...	4%	4%	3%
Size composite	...	...	...	...	-4%	-3%	-3%
Daughter pregnancy rate	...	...	...	...	...	7%	7%
Calving ability	...	...	...	...	...	4%	5%

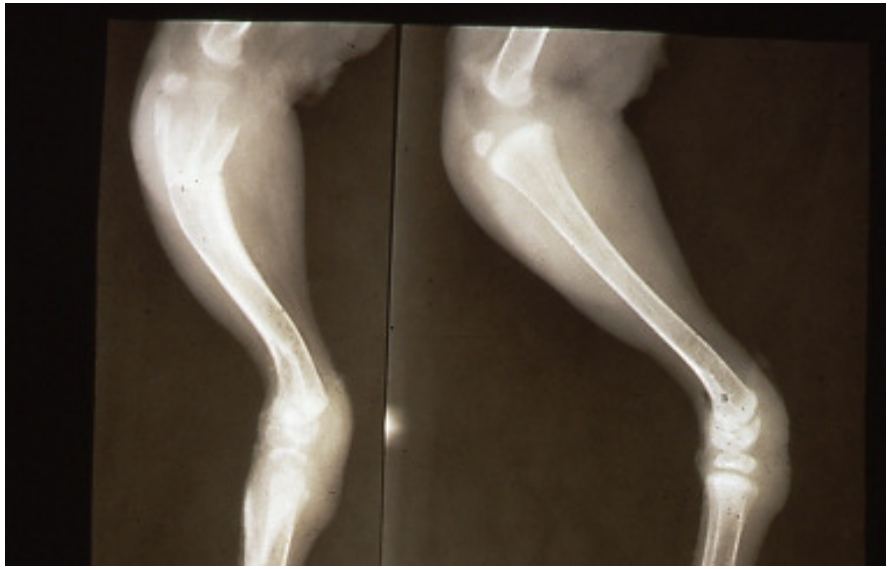
K.A. Weigel, *Net Merit and its Use in Genetic Improvement Programs,* 2010

American Angus Association EPDs, 10/2016

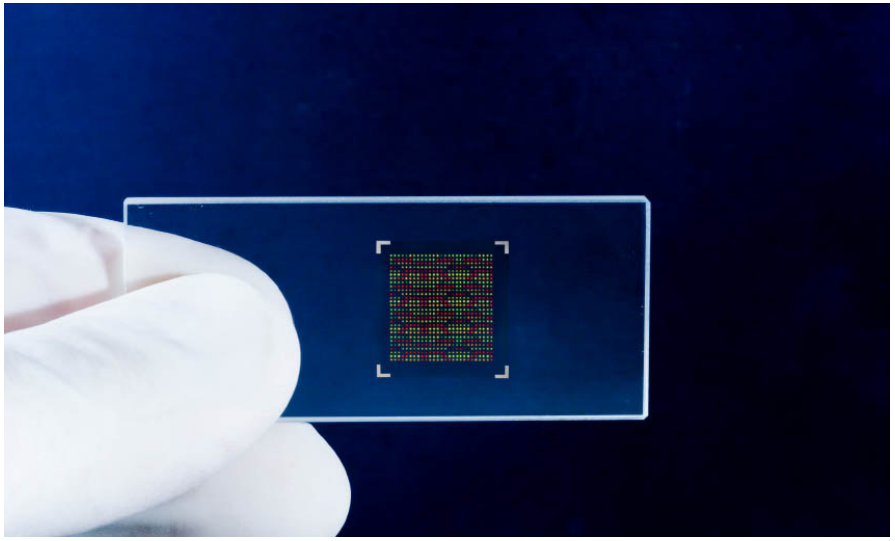


EPDs related to animal welfare (i.e., ability to cope with environment)

New Technologies Helping Animal Welfare



Australasian Veterinary Poultry Association, 2011



http://aspergillusblog.blogspot.com

GMO Livestock?

Gene Engineering and Biotechnology News, 2016

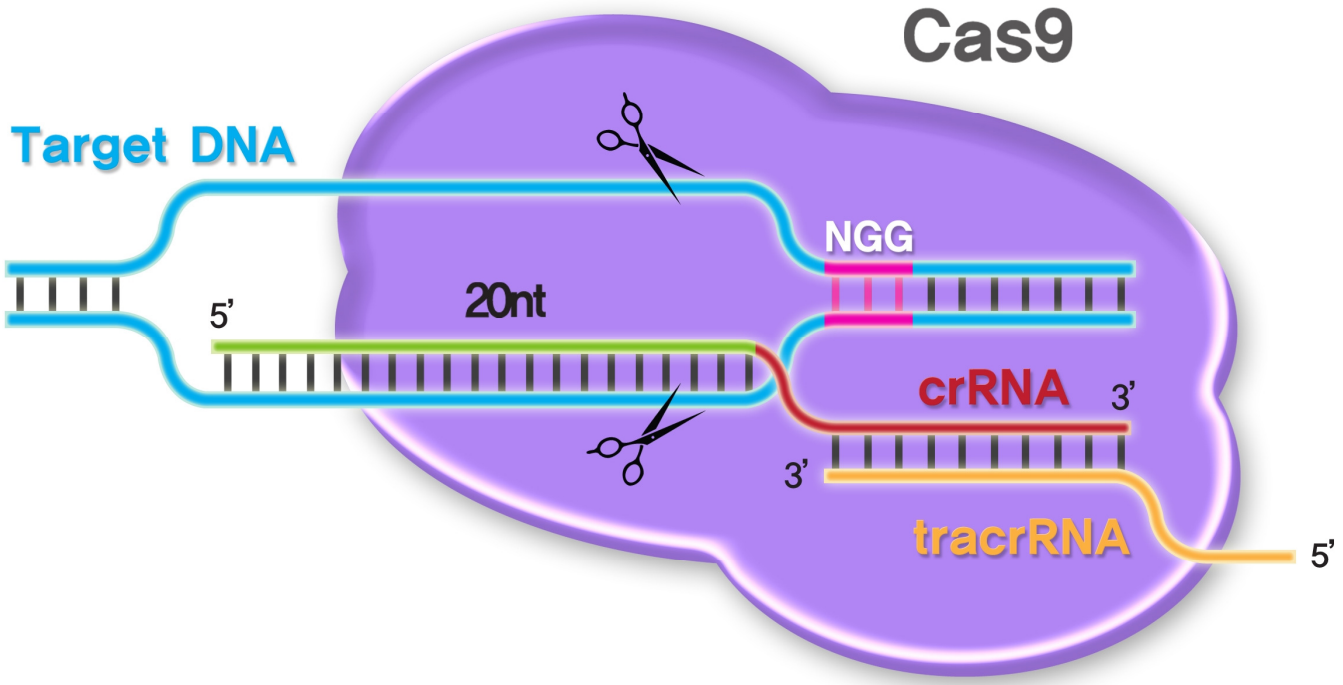
GMO Livestock

- Genetically Modified Organism – Changing the genome of an organism

- Does NOT imply “genetic engineering”

http://ruralrouteramblings.com
http://unitedcountry.com

CRISPR/Cas9 Gene Editing

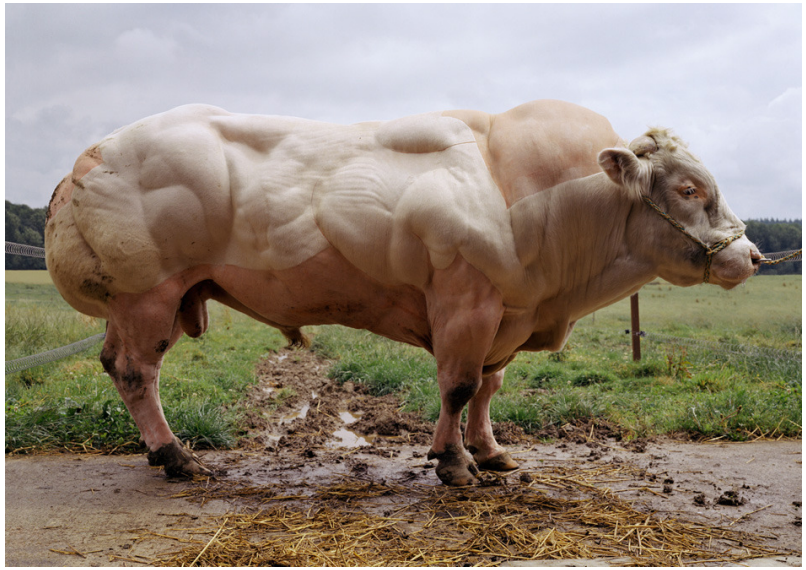


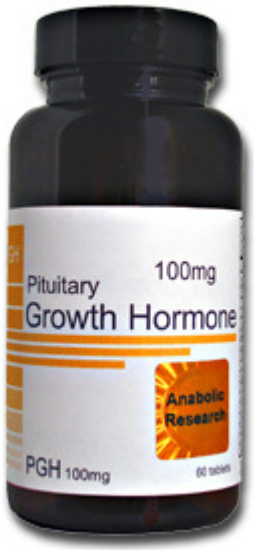
Benefits of GMO Livestock

- Modify phenotype faster than through traditional genetic selection
  - Sometimes in ways not possible through traditional genetic selection strategies

- Potential to improve
  - Agricultural productivity & composition
  - Environment ("sustainability")
  - **Disease resistance and animal welfare**

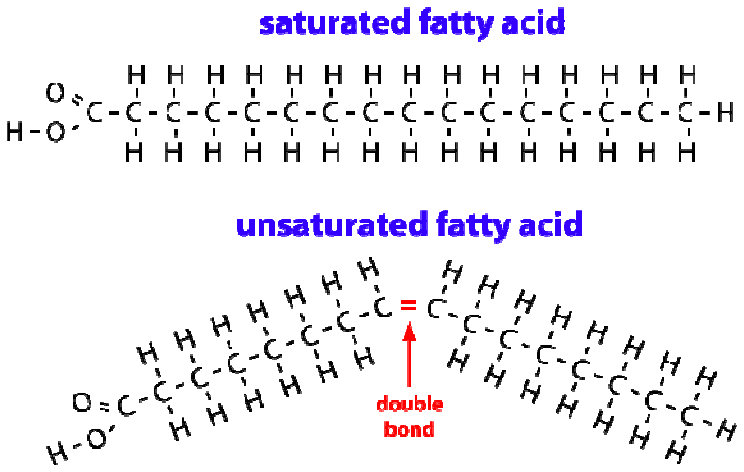
Improving productivity

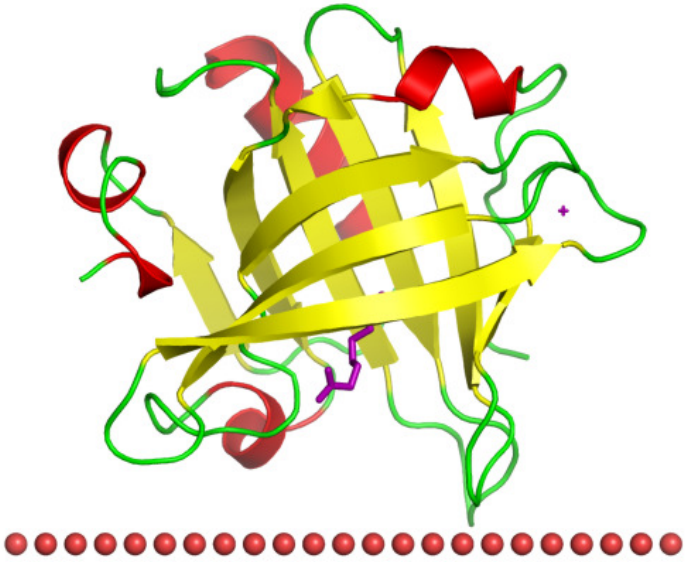




http://imgarcade.com
http://steroid.com

Improving food composition

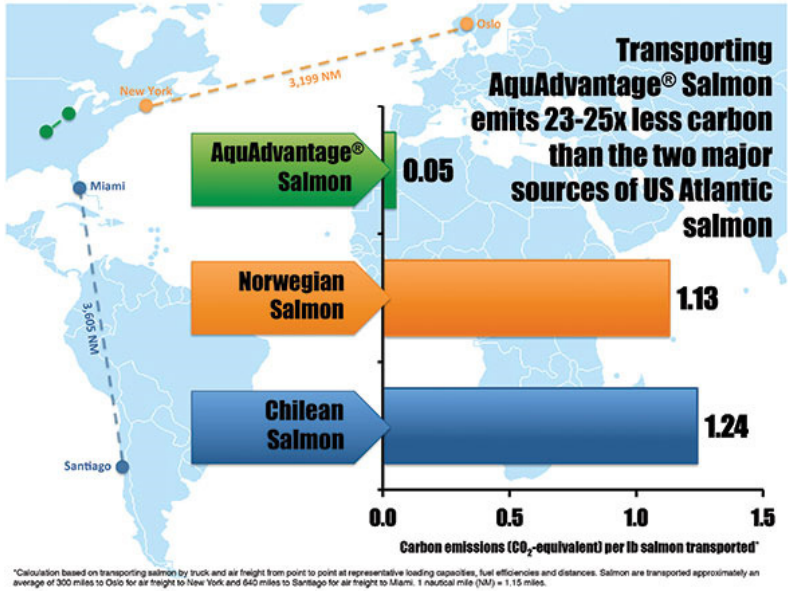




http://opm.phar.umich.edu
http://courses.washington.edu

Aqua Advantage Atlantic Salmon

- Introduced Chinook Salmon growth hormone gene into Atlantic Salmon
- Growth rate of salmon doubled, improving time to market and feed efficiency
- Approved by the FDA, 2015



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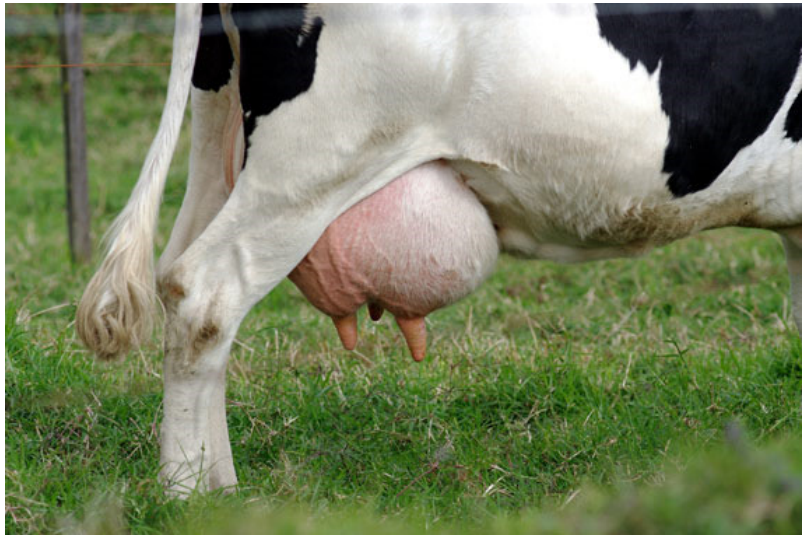
AquaBounty Technologies Inc., 2016

Critiques of GMO Salmon

- Effects of accidental release of GMO salmon into the environment
  - Will GMO Salmon out-compete wild-type?
  - Commercial fish are all female and sterile

- Public perception
  - AquaBounty would prefer product is not labeled as GMO

Disease Resistance



http://therural.co.nz
http://telegraph.co.uk

- Gene editing application in pigs
- Deletes CD163 gene
- This gene required by PRRS virus for entry into host.

PRRS-resistant hogs?

Virus discovery at University of Missouri could save swine industry millions of pigs, dollars

December 27, 2015
University of Missouri

Save | Post a comment |

COLUMBIA, Mo. (University of Missouri) - Porcine Reproductive and Respiratory Syndrome virus was first detected in the U.S. in 1987. Pigs that contract the disease have extreme difficulty reproducing, don't gain weight and have a high mortality rate.

To date, no vaccine has been effective, and the disease costs North American farmers more than $660 million annually.

Now, a team of researchers from the University of Missouri, Kansas State University, and Genus plc have bred pigs that are not harmed by the disease.

Article Photos

Nature Biotechnology **25**, 132 - 138 (2007)
Published online: 31 December 2006 | doi:10.1038/nbt1271

Production of cattle lacking prion protein

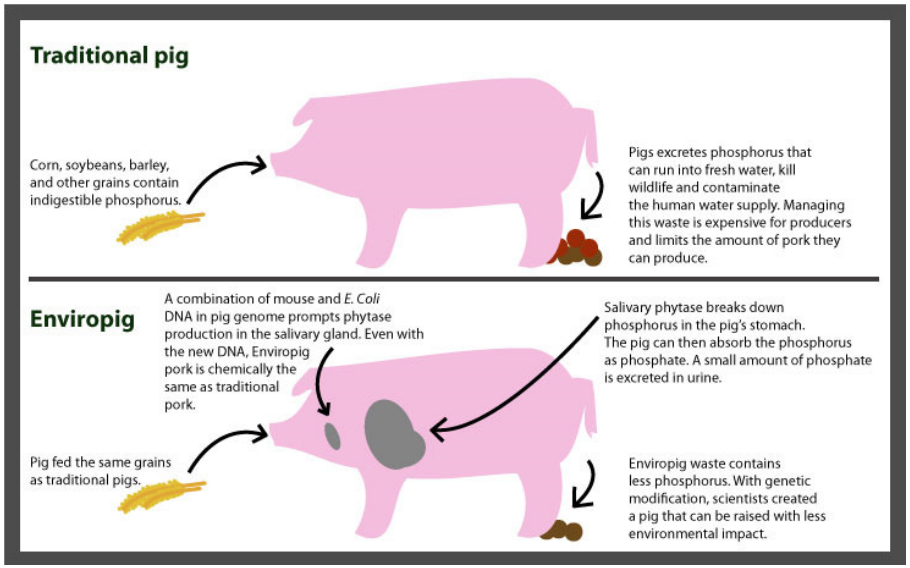
Jürgen A Richt[1,6], Poothappillai Kasinathan[2], Amir N Hamir[1], Joaquin Castilla[3], Thillai Sathiyaseelan[2], Francisco Vargas[1], Janaki Sathiyaseelan[2], Hua Wu[2], Hiroaki Matsushita[2], Julie Koster[2], Shinichiro Kato[4,5], Isao Ishida[4], Claudio Soto[3], James M Robl[2] & Yoshimi Kuroiwa[4,5,6]

Prion diseases are caused by propagation of misfolded forms of the normal cellular prion protein PrP^{C}, such as PrP^{BSE} in bovine spongiform encephalopathy (BSE) in cattle and PrP^{CJD} in Creutzfeldt-Jakob disease (CJD) in humans[1]. Disruption of PrP^{C} expression in mice, a species that does not naturally contract prion diseases, results in no apparent developmental abnormalities[2, 3, 4, 5]. However, the impact of ablating PrP^{C} function in natural host species of prion diseases is unknown. Here we report the generation and characterization of PrP^{C}-deficient cattle produced by a sequential gene-targeting system[6]. At over 20 months of age, the cattle are clinically, physiologically, histopathologically, immunologically and reproductively normal. Brain tissue homogenates are resistant to prion propagation *in vitro* as assessed by protein misfolding cyclic amplification[7]. PrP^{C}-deficient cattle may be a useful model for prion research and could provide industrial bovine products free of prion proteins.

Holsteins without horns?

- http://www.recombinetics.com/leading-gene-editing/for-livestock-farming/

Environmental sustainability



http://enr.state.nc.us
http://snipview.com

Animal welfare concerns

- Unintended consequences?
  - Insertion of GH gene in pigs
  - Affects on survival and welfare

- Public perception

Consumer Perceptions of Food Technology, 2012

- 69% of consumers stated it was important that foods are produced sustainably

- 67-71% of consumers stated it was somewhat likely or very likely that they would purchase GE meat, dairy, or fish

Garas et al., 2015

Consumer Perceptions of Food Technology, 2012

- 58% of consumers had a favorable or neutral impression of animal biotechnology
  - 16% of consumers did not know how to answer.
  - 26% of consumers had an unfavorable view of animal biotechnology
  - **42% of these consumers did not understand the benefits of animal biotechnology**

Garas et al., 2015

Take Home Messages

- Need for consistent regulations/approval processes for livestock GMOs
- Consumers are not, by default, against animal biotechnology
  - Especially if used to benefit animal welfare
- Education and transparency are key

Acknowledgements

- South Dakota State University
- Agricultural Experiment Station of South Dakota
- Dr. Elizabeth Maga and colleagues
- Heidi Carroll