



**Asia-Pacific
Economic Cooperation**

2015/HLPDAB/006

Agenda Item: 14

**Animal Biotechnologies: Opportunities and
Challenges Recent Developments, Potential
Applications, Regulatory Considerations and
Challenges**

Submitted by: United States



APEC
PHILIPPINES
2 0 1 5

**High Level Policy Dialogue on Agricultural
Biotechnology
Iloilo, Philippines
30 September – 1 October 2015**

Animal Biotechnologies: Opportunities and Challenges

Recent Developments, Potential Applications,
Regulatory Considerations and Challenges



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Animal Biotechnologies in Context

Assisted Reproductive Technologies

- Artificial insemination (1890s - 1900s)
- Embryo transfer (1950s)
- *In vitro* fertilization (1980s)
- Sex selection
- Embryo splitting
- Somatic cell nuclear transfer (Cloning; 1990s)

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Genetic Modification

- Mass selection
- Pedigree selection
- Progeny selection
- Marker-assisted selection
- **Transgenics* (1980s)
(Genetic Engineering)**
- Genome-wide selection
- **Gene Editing* (2000s)**

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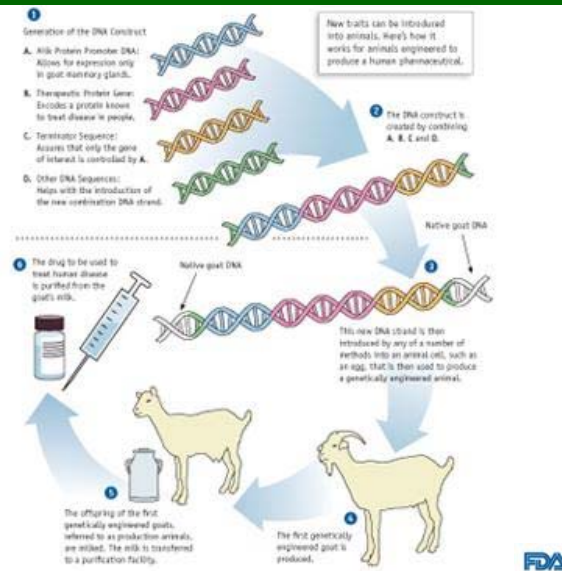
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Change Genetic Makeup

What are Genetically Engineered (GE) Animals?

Piece of DNA (rDNA construct) coded to express the desired trait - inserted into an animal's genome



Why Use Genetic Engineering instead of Conventional Breeding?

Gene insertion or deletion or modification

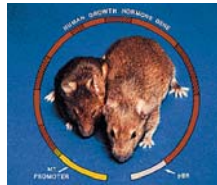
- Overcome otherwise low heritability
- Separate “linked” genes
- Increase precision and efficiency of introducing desirable traits (*conventional breeding is random*)
- Introduction of traits not available via conventional breeding





1980s: First Genetically Engineered Plants and Animals

First GE Mammal: Mouse (1982)



First GE Plant: Tobacco (1983)



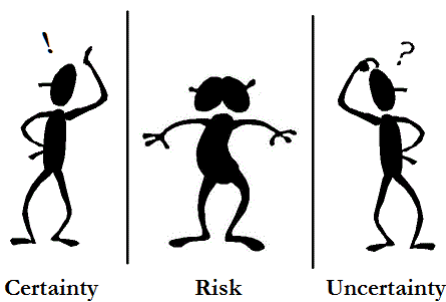
First GE Fish (1983)



First GE Livestock: Pig (1985)



* Genetically Engineered (GE)



Mid-1980's → expression of need for establishment of regulatory oversight...

Regulation of Biotechnology in the United States

- Based on **existing laws** for regulatory authority over products developed using modern biotechnology.
- In 1986, the U.S. government established the ***Coordinated Framework for the Regulation of Biotechnology***.
- Individual U.S. Agencies have issued regulations to implement their individual laws and guidances to help sponsors prepare their regulatory submissions.



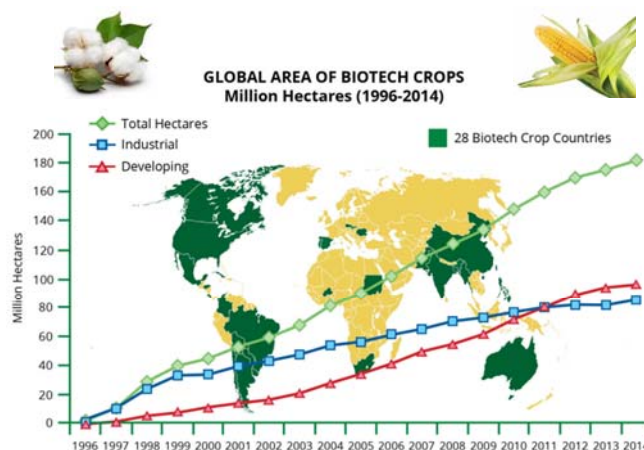
1990s: First Regulatory Approvals for Genetically Engineered Plants



**Flavr Savr Tomato
USA (1994)**



**Europe
(1996)**



A record 18 million farmers, in 28 countries, planted 181.5 million hectares (448 million acres) in 2014, a sustained increase of 3 to 4% or 6.3 million hectares (~16 million acres) over 2013.
Source: Clive James, 2014.

Genetically Engineered Animals under the Coordinated Framework

- In 2009, the Food and Drug Administration (FDA) issued Guidance: *Regulation of Genetically Engineered Animals Containing Heritable Recombinant DNA Constructs*
- The FDA regulates the recombinant DNA construct as a “new animal drug”, “**an article intended to alter the structure or function**” of the animal (**trigger**)
- New animal drug approval is based on a showing that the product is “safe” (for animals, humans, and the environment) and “effective” for the **intended use**



FDA Regulation of GE Animals for Food

- FDA/CVM regulates GE animals under the New Animal Drug Provisions of Federal Food, Drug, and Cosmetic Act
 - ✓ Mandatory premarket approval
 - ✓ Consideration of animal health, food safety, and requirement to address National Environmental Policy Act (NEPA)
- Food safety assessment consistent with Codex Guidelines
- Reviewed by on Case-by-Case basis
- Other requirements apply, including those of NEPA
- At this time, food from GE Animals will require additional labeling only in cases where the food is materially different from its traditional counterpart
- All animals in lineage covered (*offspring are GE*)

Commercialization of Animal Biotechnology



Research models
(mice, rats, zebrafish)



GloFish (2003)
[Enforcement Discretion]



Atrypa Goat
(2009, the USA)



Oxitec mosquito
(2014, Brazil)



Enviropig (Canada)



AquAdvantage
Salmon (the USA)

No GE animal for food has yet received regulatory approval

Progress to Market for Animal Biotechnologies has been Slow

- Developers of GE animals are:
 - Universities
 - Small companies
 - Government researchers
- No obvious path to market for food animals
- Human health applications moving forward
 - Seen as “life-saving” rather than “scary”
 - Pharmaceuticals and Xenotransplantation

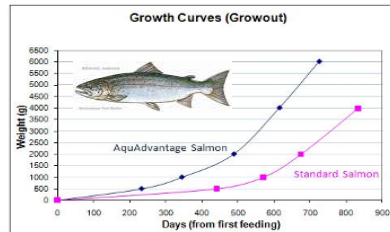
**No Big Animal
Biotech
Companies**

AquAdvantage Salmon: 1st GE Animal for Food?

- Express a Coho salmon Growth Hormone gene
- Grown in inland tanks

Preliminary FDA Findings:

- Safe to eat
- Meat is not different from other farmed Atlantic salmon
- No significant environmental impact (FONSI) under the conditions of application



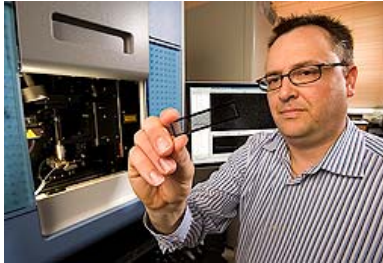
Genetically Engineered Goats Expressing Human Lysozyme (HLZ)

- Healthier goats
 - Reduction of mastitis in dairy goats
- Increased milk shelf life
- Drinking lysozyme milk beneficial to health*
 - Improved gut health
 - Reduced diarrhea



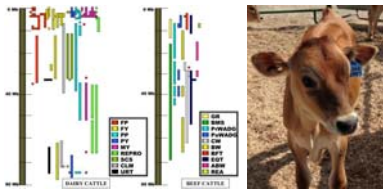
(* baby pig model; Brazil for clinical trials)

Animal Biotechnology Advances



Livestock Genomes Mapped

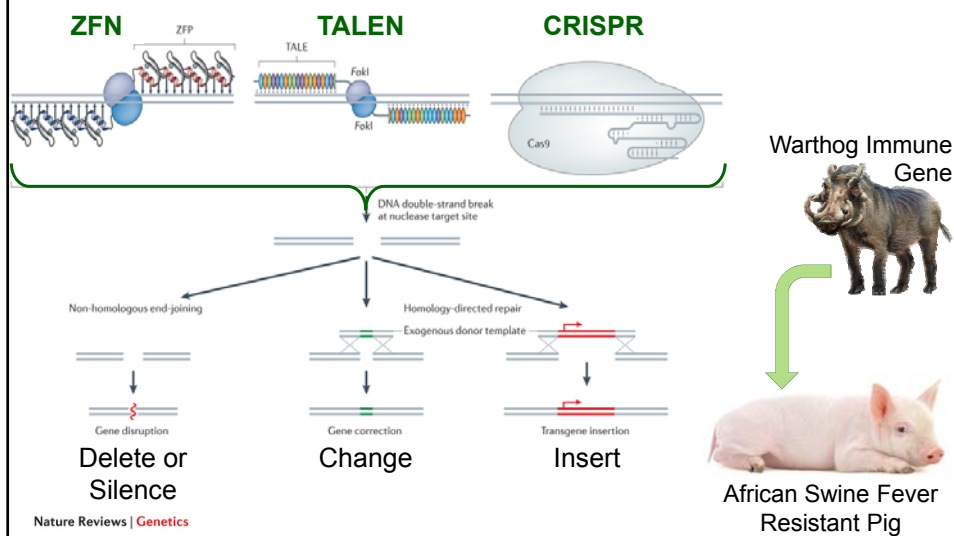
- Identify sequences associated with valued traits
- Genomic selection of sires
 - Combine with cloning and other biotechnologies to reduce generation time



Gene editing

- Easier, efficient and inexpensive
- Some animals not distinguishable from “natural” breeding

Gene Editing in Livestock



Animal Traits of Interest *

Food and Production

- Production traits - growth, milk, wool
- Healthier food products
- Reduce environmental impact

Disease and Pest Control

- Disease resistance – Avian influenza, BSE (prion-free), mastitis (antibiotic use reduction), TB, Foot and mouth disease, etc.
- GE insect releases – mosquitoes, plant and animal pests

Animal Welfare

- Polled dairy cattle, sex selection (laying hens), better health

Biomedical and Industrial

- Human health - xenotransplants, models of human disease
- Other products - spider silk in goat milk, GE silkworms

** Incomplete list*

Animal Traits Targeted to Specific Regions



Challenges and Barriers – New Animals via New Technologies

- Public acceptance a challenge:
 - Emotional connection to animals
 - Unfamiliarity with animal agriculture
 - Mis-information campaigns
- Focus on production processes, not product safety
- Political involvement (or pressure) in regulatory decisions
- Newest Technologies may be indistinguishable from nature



Reasons “Not Favorable” Toward Animal Biotech

- “Lack of information” and “not understanding the benefits” of animal biotechnology continue to be reasons consumers cite for being *not favorable* toward animal biotechnology.

Reasons Not Favorable	Total 2014 (A) n=547	Total 2012 (B) n=381	Total 2010 (C) n=382
I don't have enough information	55%	55%	54%
I don't understand the benefits of using biotechnology with animals	42%	42%	39%
I don't eat meat or dairy products	3%	5%	3%
Other	16%	16%	23%

In the U.S.,
education
an issue
and
solution?

U.S. survey

A/B/C indicate statistical significance between years
Q33. Why are you not favorable toward using biotechnology with animals that produce food products?



Customer Surveys in the United States: Food Products of Animal Biotechnology



Regulatory Goals

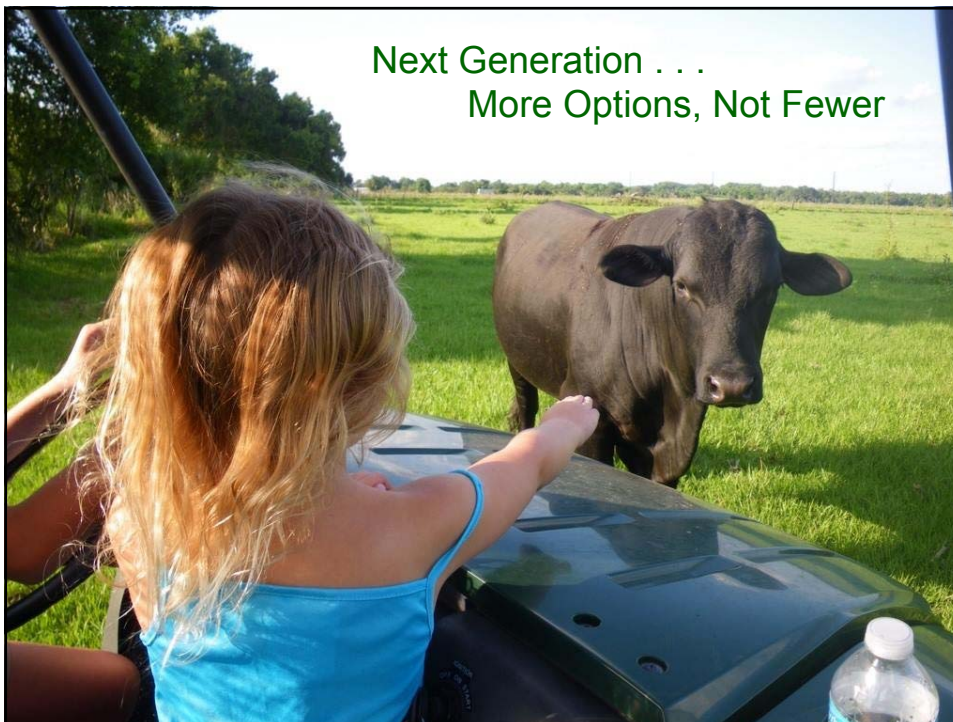
- Effective – i.e., protect public safety (human health, animal health, environment)
- Science-based, risk-based and defensible
- Transparent to all
- Timely and predictable (important for innovation)
- Credible to the public – whose concerns may reflect non-scientific, values-based issues



Ideally, regulations should enable safe new products to reach the market.

Encourage development of new ideas and innovations . . .

Provide opportunity to utilize and combine the most appropriate and targeted tools to meet the challenges of the future.



**Next Generation . . .
More Options, Not Fewer**



Extra slides

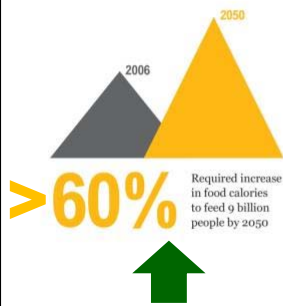
2050 Challenge: Feed the World (Sustainably)

THE GREAT BALANCING ACT

The world must achieve a "great balancing act" in order to sustainably feed 9 billion people by 2050. Three needs must be met at the same time.

Food*

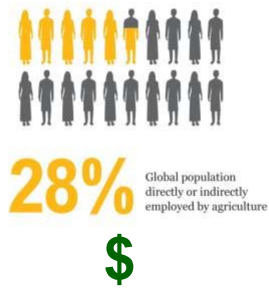
CLOSING
THE FOOD GAP



(* demand for animal protein)

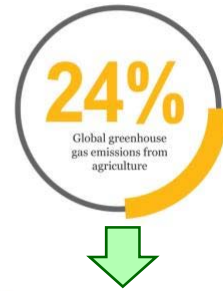
Economy

SUPPORTING
ECONOMIC DEVELOPMENT



Environment

REDUCING
ENVIRONMENTAL IMPACT



WORLD RESOURCES INSTITUTE