



**Animal
Biotechnology:
Myths, Lessons,
and Possibilities**

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What is Animal Biotechnology?

- Assisted Reproductive Technologies
 - Help distribute genetics beyond natural matings
 - AI, semen sexing, *in vitro* fertilization, embryo transfer, embryo splitting
 - 1300s-present



What is Animal Biotechnology?

- Cloning
 - More rapid distribution of naturally occurring desirable traits in breeding stock
 - 1990s-present

What is Animal Biotechnology?

- Genetic Engineering
 - Introduces/modifies genes not naturally occurring to introduce new traits
 - 1980s-present

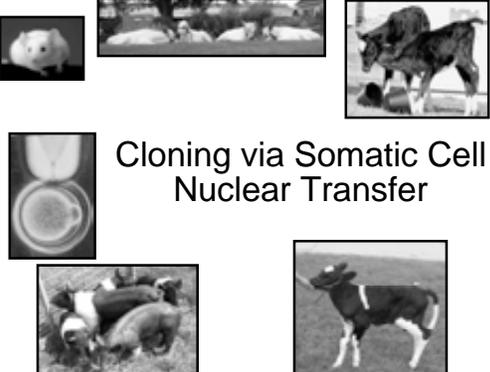
ARTs in Animal Agriculture

- ARTs developed to improve reproductive efficiency
 - Genetic Diversity
 - No longer limited to “nearby” genetics
 - Practical/economic issues
 - Mating is dangerous to males and females



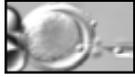
ARTs in Animal Agriculture

- Keeping herds of bulls/boars is costly and can be dangerous
- Maximize distribution of genetics
- Better livestock → increased profitability



Cloning via Somatic Cell Nuclear Transfer

Definitions



Somatic Cell Nuclear Transfer
= the fusion of the nuclei (or entirety) of diploid donor cells with unfertilized, enucleated oocytes.

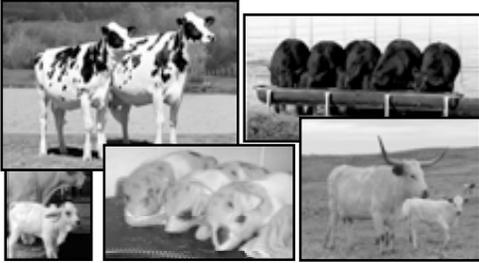
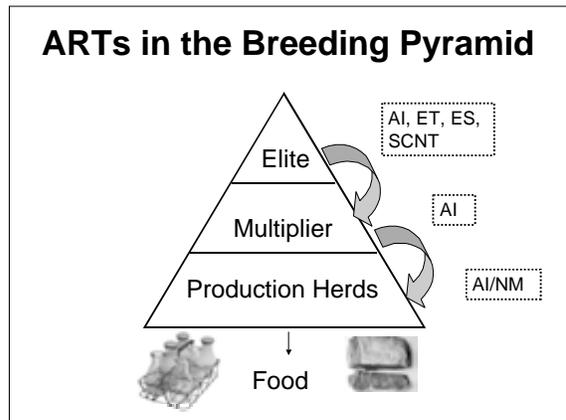


Clone = Animal resulting directly from SCNT (AC= Animal Clone)



Clone Progeny = Any animal derived from sexual reproduction that has a clone as at least one parent. Specifically excludes clones of clones.

Expansion of Elite Breeding Stock (clones are for breeding, not eating)

FDA Risk Assessment

- Food safety
- Animal health
- Weight of evidence evaluation



RA Conclusions: Risks to Animals

- Most adverse outcomes early in life
- No unique risks; Increased frequency
- LOS seen in cattle and sheep
 - Surrogate dams
 - Clones
- No apparent health risks after 50 days of age




RA Conclusions: Food Consumption Risks

- Clones: Food from cattle, swine, and goat clones that meet federal and state requirements is *as safe as* food from conventional animals that meets the same requirements
- Clone Progeny: Food from clone offspring poses no additional risk compared with food from other animals



"As safe as food
we eat every day"



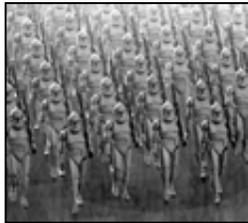
Current Status

- Final release January 15, 2008 → USG has no further scientific concerns
- USDA begins "smooth and orderly market transition"
- Legislative proposals
 - Additional review
 - Labeling
- International Efforts
 - NZ
 - EFSA
 - Japan



Cloning Myths

- Herds of Clones will Roam the Earth (or at least the US)
 - Elite breeders; expense



Cloning Myths

- Cloning is a New Technology
 - Not so; widely used in plants (bananas, potatoes, Grandma's geraniums)
- Clones Have a Specific Animal's DNA Grafted on to a "Body Blank"
 - Oh, please



Cloning Myths

- Can Cure Diseases in Animals
 - No, but it can propagate disease-resistant animals (see also GE animals)



Cloning Myths

- Weakens the Immune System
 - No evidence for increased disease rate or adverse changes in immune cell types
- Offspring of clones are clones, and get weaker with each generation
 - Sexually-reproduced offspring are NOT clones; they're animals (like any other)

Lessons from Cloning

- It's just another tool in the toolbox
- Stakeholder alignment
- Regulatory alignment
- Asymmetrical international decision-making



Cloning Possibilities

- Rapid deployment of desirable traits
- Rescue genetics of non-viable animals
- Rescue rare genetics
- Research tool for reproduction
- Tool for propagating GE animals



What About GE Animals?

Why are we doing this?
Can't regular breeding accomplish the same thing?



Possibly:
-Production traits
-Disease resistance



Not likely:
-Pharma animals
-Xenotransplants
-Unique production traits

GE Animals: Definitions



Genetic Engineering: introduction of new genes via rDNA technology. New genes usually found on an rDNA **construct**. Constructs may be heritable or non-heritable (e.g., gene therapy)



GE Animal: Animal produced via genetic engineering (contrast w Genetically Modified Organism: one modified via breeding, not limited to genetic engineering)

Why GE Animals?

- Allows for introduction of traits NOT possible via conventional breeding
- Alternative to antibiotics and steroid hormones in feed, implants, etc.

Why GE Animals?

- Agricultural and medical applications in many species
- Production matrix is known and safe



GE Animal: Products (1)

- Enhanced Food Quality/Agronomic Traits/Environmental Benefits
 - Cows Producing Milk with Long Shelf Life/Digestibility
 - Growth Enhanced Atlantic Salmon
 - Enviropig
 - Omega-3 Fatty Acid Pork
 - Milk for Cheese Making

GE Animal: Products (1)

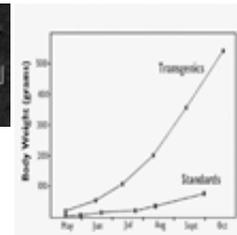
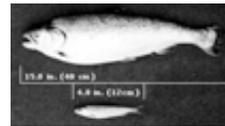
- Animal Health
 - Mastitis-Resistant Dairy Cows
 - BSE-Resistant Cattle
 - Other disease resistance



Fish Consumption

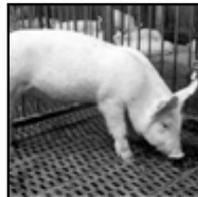
- Current annual US fish consumption: 15 lbs/person
- To meet 2025 projected fish consumption → 1 Billion lb deficit
- Growth enhanced fish can help meet the demand
 - Faster growth
 - Smaller environmental footprint
 - Decrease stress on wild populations

Growth Hormone-Enhanced Atlantic Salmon



These salmon are the same age, yet one grew spectacularly, thanks to a gene transplant

Enviropig



Environmental Issue

- Problem
 - Most plant-derived phosphate not bioavailable
 - Supplementation required
 - Phosphates excreted in manure; run-off



Environmental Issue

- Enviropig as part of solution
 - Pig produces enzymes in saliva to make plant phosphorus bioavailable
 - No need for supplementation; excretion ~ intake; less phosphate in manure



GE Animal:Products (2)

- Products for Human Therapeutic Use
 - Chickens/Cattle/Goats for pharmaceutical production
 - Swine as Xenotransplantation Sources
 - Cattle/Goats producing anti-biowarfare agents

GE Animal:Products (2)

- Mixed-Use High-Value Products
 - Goats producing spider silk
 - Cows producing highly specific antibody: functional molecule products



BioPharming

- Manufacturing capacity shortage
- Biological similarities make animals excellent choice as “bioreactors”
 - Non-toxic matrix



BioPharming

- Cheaper, less disease risk than isolating products from human cadavers
- Significant experience with vaccine development



GE Animals Making Antibodies to Biowarfare Agents (Hematech)

- Need for large-scale reliable sources of therapeutic agents for biowarfare agents (e.g., anthrax, viruses)
- Cattle as excellent sources of polyclonal antibodies



GE Animals Making Antibodies to Biowarfare Agents (Hematech)

- Introduce human antibody genes, remove bovine antibody genes
- Plasmaphoresis to isolate



GE Animal: Chemical Defense Agents (Pharmathene)

- Organophosphorus agents (modern nerve gas) block acetylcholinesterase



GE Animal: Chemical Defense Agents (Pharmathene)

- GE Goats produce human butylcholinesterase, pretreatment to guard against acute effects, or post-treatment to protect against long-term effects



Spider-Silk Goats (UWyoming)

- Orb-spinning spider silk remarkably strong, flexible
- Difficult to produce artificially
- Can be produced in milk of GE goats

Spider-Silk Goats (UWyoming)

- Uses:
 - Personal protection (Kevlar-type vests)
 - Parachutes
 - Medical sutures



GE Animals: (3)

- Companion Animals
 - Hypoallergenic cat
 - GloFish



Where is the Technology Today?

- Most early in development, and growing
- Proof of concept growing rapidly
- Some in regulatory review process
- One in commercial sales (GloFish)

Where is the Technology Today?

- Most tech providers small, entrepreneurial, VC-driven operations
- Public reaction likely wary



Animal Biotech Challenges

- Need formalized regulatory program
- Need reliable funding sources
- Products with clear benefits
- Realistic communications; no overpromising
- Public acceptance



Implications for Biosecurity

- Clones
 - Rapid introduction of disease-resistant animals
 - Ability to rescue valuable genetics if attack
 - Improper use limits diversity



Implications for Biosecurity

- GE Animals
 - Reliable, high volume sources of means to combat biological or chemical agents
 - Rapid replenishment of food sources
 - No products yet available



Thanks for Your Attention!

