

Animal Biotechnology

David Harry, Biotechnology Outreach
April, 2008

- Part 1: Animal Breeding and Genomics
- Part 2: Animal Cloning & Other Issues

Animal Biotech, Parts 1 and 2

- Overall: Introduce biotechnology as used in animal agriculture
- Part 1 (Thursday, April 10th)
 - Breeding and genomics
 - Video (UCD Animal Biotech)
- Part 2 (Tuesday, April 15th)
 - Animal cloning
 - Genetic engineering
 - Biotech in animal husbandry
 - Social & ethical concerns

Part 1: Breeding & Genomics

Describe the breeding industry in animal agriculture

- Historical, technical and social context
- Approaches to breeding
- Highlight milestones
- Identify problems and challenges
- Are breeders responsive to social pressures?



Part 2: Cloning and Other Issues

- Assisted Reproductive Technologies (ART)
 - artificial insemination
 - in vitro fertilization / embryo transfer
- Animal cloning
 - what and how?
 - why controversial?
- Transgenic animals
- Tools in animal husbandry
 - feed additives
 - animal health
 - rBST & milk
- Ethics and animal agriculture



News Reports and Public Perceptions



Science, June 16, 2006



Clone: Ten years after Dolly's birth, scientists are learning that clones may not be such perfect copies after all

From the Magazine | Science

The Perils of Cloning

Ten years after Dolly's birth, scientists are learning that clones may not be such perfect copies after all

By ALICE PARK

TIME, July 10, 2006

Public concerns and animal welfare



Animal Cloning

- What's involved?
- How does it work?
- Is it safe?
- Is it ethical?
- How would it be used?

What are clones?

- Definition
 - different individuals who share identical genotypes
 - derived from somatic (asexual) processes
- Examples
 - many fruits are cloned, propagated through grafting
 - wine-grape varieties (Cabernet sauvignon etc)
 - many horticultural perennials
- Cloning and recombinant DNA
 - bacterial cells diluted single-cells
 - cloned DNA harvested from a cloned bacterial colony
- How about animal clones?
 - Common in some primitive animals (e.g. hydra)
 - Also in some insects (aphids) and crustaceans (copepods)

Identical twins are human clones!

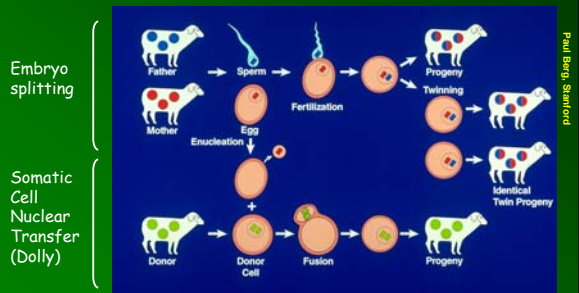


Cloning Vertebrates

- "Pre-Dolly"
 - Somatic cell nuclear transfer (frogs, 1977)
 - Embryo-splitting (cloned sheep, 1984)
 - Embryonic nuclear transfer (mid-1980's)
- Dolly
 - First vertebrate clone using somatic cell nuclear transfer with an adult donor cell
 - Technical advance involves nuclear "re-programming"
- Stem cells
 - retain ability to develop into many cell types
 - hot topic for research, with much more to learn
 - recent breakthroughs involve adult stem cells

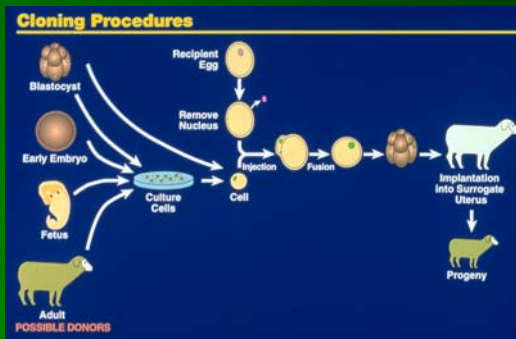


Cloning Pathways in Sheep



Paul Berg, Stanford

Alternative Donor Cells



Paul Berg, Stanford

Rainbow and her clone, Cc



Genetic Savings & Clone

Rainbow and Cc have identical nuclear genomes. Why do they appear so different?

Other mammalian clones

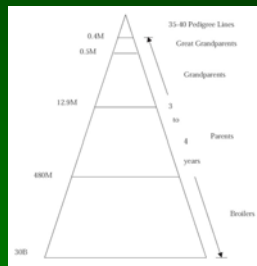


Immortal: Watson 10's genes can live on in his clones.

How would clones be utilized?

Breeders? →

Meat animals? →



Production pipeline for meat-type chickens ("broilers" are consumed)

Reiser et al. 2008

Concerns with animal cloning

- Food safety
 - Extensive testing with cloned animals
 - No differences in live animals or their products
 - FDA ruling (2008): meat and animal products are safe
- Animal health and welfare
 - Problems associated with cloning and "ART" are generally similar (embryo loss, neonatal issues (e.g. large offspring syndrome))
- But animal cloning is unnatural!
 - yes, and so are other ART procedures
 - diverse viewpoints influenced by cultural norms and religious beliefs, etc.

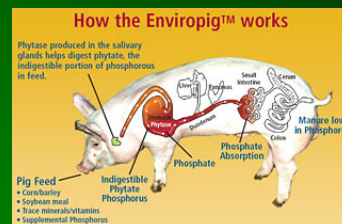


Transgenic Animals

- Genetic engineering of animals
 - in general, resembles process in plants
 - recombinant DNA produced in laboratory
 - inserted into animal cell (mechanism varies)
 - cell develops into whole organism
- Process is labor intensive and expensive
- Why bother to try?
 - pharmaceuticals
 - novel traits (e.g. cannot accomplish in any other way)



EnviroPig™: Opportunity?



Expression of phytase enzyme in salivary gland digests phytate in grain feeds, releasing phosphorus for absorption by pig and reducing P in manure

Atlantic Salmon with Growth Hormone



Photo Courtesy: For The New York Times
Even though these Atlantic salmon are roughly the same age, the big one was genetically engineered to grow at twice the rate of normal salmon.

Transgenic Animals: Medical Applications

- Therapeutic products
 - interferon in egg-whites
 - lysozyme in goats' milk (anti-bacterial)
 - human antibodies in cattle (harvested by processing blood)
- Xenotransplantation
 - using pigs as organ donors
 - GE to "humanize" pig organs (impart recognition signals to avoid rejection)

Transgenic Animals: Concerns

- Food safety
 - GE animals not approved for human consumption
 - co-mingling could be problematic
- Environmental issues
 - environmental release (escapes)
 - interbreeding with native species
 - disease transmission with xenotransplantation
- Ethical
 - animal welfare
 - un-natural process, and therefore wrong

Biotechnology & Animal Husbandry

- Feed additives
 - amino acid supplements produced through fermentation
 - metabolic modifiers
- Animal health
 - vaccines
 - will not discuss
- rBST & milk yield
 - technology
 - controversy
 - animal welfare

Feed Additives: Metabolic modifiers

- Metabolic modifiers re-allocate body mass
 - increase lean muscle
 - decrease fat tissue
- U.S. = Ractopamine (β -adrenergic agonists)
 - Paylean 9™ for swine
 - Optaflexx 45™ for beef cattle
- Concerns: mostly RE human health



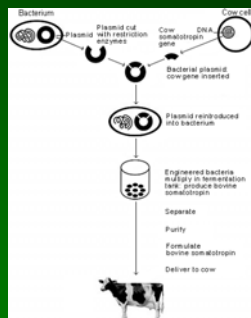
Biotechnology & Animal Husbandry

- rBST & milk yield
 - technology
 - controversy
 - animal welfare
- Why animal husbandry?
 - rBST is a GE product
 - does not involve GE animals
 - rBST is administered to cows through injections

rBST & Milk Yield

What is Bovine Growth Hormone?

Posilac® bovine somatotropin (BST) is also known as Recombinant Bovine Growth Hormone (rBGH). Recombinant means that its genes have been recombined (artificially manipulated), also known as genetically engineered or genetically modified.



rBST background

- Bovine somatotropin (BST) naturally produced in pituitary
- Sometimes called bovine growth hormone (BGH)
- Long known to stimulate milk production, but production capacity limited
- Recombinant DNA technology provided new production tool
- rBST (recombinant BST) produced in fermentation process
- BST (and rBST) is not active in humans
- BST (and rBST) stimulate IGF synthesis in cattle
- IGF stimulates milk production
- Bovine IGF is active in humans
- Increased IGF in milk is very small

Why is rBST controversial?

- First GE agricultural product (mid-1990's)
- Produced by Monsanto (consumer mistrust)
- Milk production already high
- Labeling was debated
 - "hormone free" label was blocked
 - rBST-free was an acceptable label
- Human health concerns
 - BST does not affect humans
 - BST increases IGF in milk
 - studies have found no link to human health
- Does rBST improve milk yield?
- Animal health effects?

rBST and milk yield

- rBST injected into individual cows
- Must be administered at proper time
 - early in production cycle, rBST will not increase yields
 - can prolong peak production period
- Treat cows require additional feed and water to produce more milk
- Used correctly, rBST does increase milk yield
 - overall increase of ~10-15 % through one lactation cycle (~300 days)

Animal health effects?

- Yes, cows treated with rBST have higher risks of health problems
- Mastitis (inflammation of mammary gland) risks are increased by ~25%
 - mastitis causes pain
 - increases somatic cell counts in milk (reduced quality)
- Increased risks also seen for leg and hoof problems
- rBST may reduce conception rates (and delay resumed lactation)

Ethics & Animal Agriculture

- Balancing needs of people vs. needs of animals
 - human sustenance
 - production costs
 - humane husbandry
 - humane slaughter
- What are our rights and responsibilities?



Market forces drive Animal Welfare

The screenshot shows the McDonald's website with a focus on the 'Animal Welfare Program' page. The page title is 'ANIMAL WELFARE PROGRAM' and it includes a sub-section for 'KFC Poultry Welfare Guidelines'. The text on the page states: 'KFC has had an animal welfare policy for a number of years. In 2005, KFC adopted specific, comprehensive animal care standards to establish the processing, handling and welfare of animals against those standards. As shown below, KFC's processing guidelines and welfare are designed to manage and reduce much of the stress to determine whether the birds supplied to KFC are handled humanely, and any welfare or animal care issues to improve the conditions of the birds. Any welfare or animal care issues that result in termination of the supplier's contract, KFC's policy for its suppliers apply to all chicken submitted to the unit by KFC. KFC's guidelines for its suppliers include: Processing Guidelines'.

Housing Conditions and Slaughter

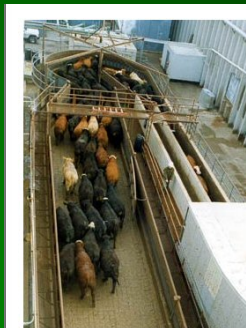


Dr. Temple Grandin's Web Page



Livestock Behaviour, Design of Facilities and Humane Slaughter

Mimic Natural Instincts of Animals



Stairway to Heaven
Grandin designed a new ramp that takes cattle to their final moments gently. She gave the ramp a nickname that people all over the industry use. Photo: @Rosalie Winard

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Ethics & Animal Agriculture

- Welfare
 - Genetic gains through conventional breeding have had unintended consequences on animal well-being
 - Animal husbandry (particularly on large farms)
 - Concentrated Animal Feeding Operations (CAFOs)
 - crowded housing (un-natural behaviors)
 - access to pasture
- Handling and slaughter
 - "Downer" cattle
 - Stress in transport to slaughterhouse
 - Humane killing
- Assertion: implications from genetics & breeding are small compared to these other issues

Thought Questions

- What does "animal biotechnology" encompass?
- Compare and contrast ethical concerns associated with animal cloning vs. traditional animal agriculture.
- How does animal breeding affect genetic diversity?
- How might genetic marker technology be used to enhance animal welfare, perhaps by breeding for disease resistance?
- What types of incentives induce animal breeders to pay attention to consumer attitudes?
- Genetic engineering and animal cloning are similar, and yet different. How so?
- GE salmon with enhanced growth and rBST both affect production traits. Compare and contrast these two different GE technologies.