

# Animal Biotechnology

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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 (Tuesday, April 7<sup>th</sup>)
  - Breeding and genomics
  - Video (UCD Animal Biotech)
- Part 2 (Thursday, April 9<sup>th</sup>)
  - 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



## 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 plants
- 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

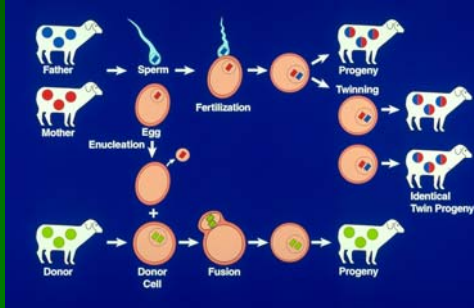
- "Pre-Dolly"
  - Somatic cell nuclear transfer (frogs, 1977)
  - Embryo-splitting (cloned sheep, 1984)
  - Embryonic nuclear transfer (mid-1980's)
- Dolly
  - First vertebrate clone using somatic cell nuclear transfer with an adult donor cell
  - Technical advance involves nuclear "re-programming"
- 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

Embryo splitting

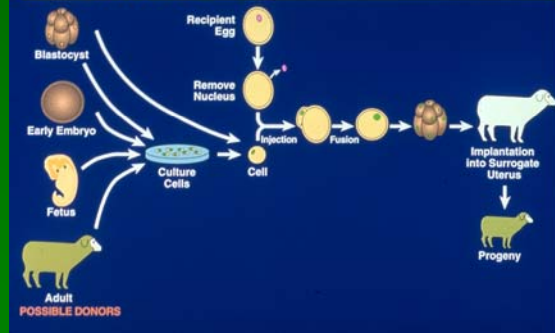
Somatic Cell Nuclear Transfer (Dolly)



Paul Berg, Stanford

## Alternative Donor Cells

### Cloning Procedures



Paul Berg, Stanford

## Rainbow and her clone, Cc



Genetic Services & Clones

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

## Other mammalian clones

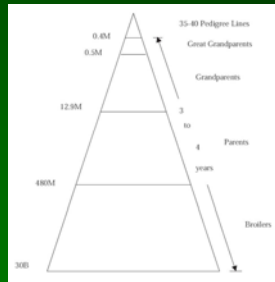


Immortal: Watson 10's genes can live on in his clones.

## How would clones be utilized?

Breeders? →

Meat animals? →



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

## 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.

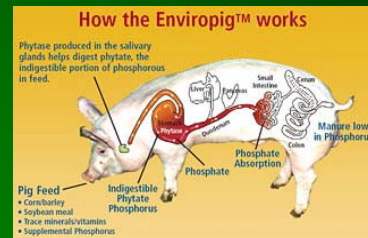


## Transgenic Animals

- 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



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 are produced using rDNA technology
  - 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 ( $\beta$ -adrenergic agonists)
  - Paylean 9™ for swine
  - Optaflexx 45™ for beef cattle
- Primary concern
  - human consumption and long-term health effects
  - guidelines restrict the timing of use



## 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

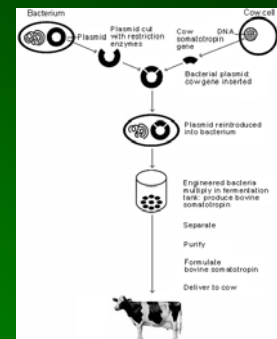
## rBST background

- Bovine somatotropin (BST) naturally produced in pituitary (also called bovine growth hormone (BGH))
- Pituitary extracts had long been 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

## 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.



## 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 deemed 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?



## From Part 1: Trade-offs in Animal Breeding?!

- Examples
  - Highly specialized (i.e. single-purpose) breeds
  - chickens: meat vs. eggs
  - cattle: beef vs. dairy
- Over-emphasizing some traits can lead to problems in others

## Trade-offs: Poultry

- Chickens
  - Aggressive behavior (selecting individuals for large size)
  - Reduced calcium reserves in older layers (& resulting bone degeneration)
  - Locomotor (leg) problems in rapidly grown broilers
  - Crowding increases stress & reduces immune function
  - Growth rate and fertility (egg production) are inversely correlated

## Trade-offs: Cattle

- Dairy
  - Increases in milk yield & reduced fertility
  - Excessive milk production can lead to udder irritation (mastitis)
  - Holsteins are superior for
    - grain-based diets
    - milk with reduced butterfat
    - what if the market changes?
- Beef
  - Angus breed has superior carcass traits
  - "Certified angus" DNA tests now available
  - Angus do not thrive in hot-humid environments
  - "Brangus" (~5/8 Angus and ~3/8 Brahman)

## Market forces drive Animal Welfare

The image shows two screenshots of corporate websites. The top screenshot is from McDonald's, featuring a 'Responsible Purchasing' section with a sub-section for 'Animal Welfare'. It includes a quote from Dr. Tamara Grandin, Director of Animal Science at Colorado State University, stating: 'There's a pre-McDonald's era and a post-McDonald's era. When I began working with the company on improving animal welfare audits, there was huge push change. These massive buying power have the most influence of the meat industry.' The bottom screenshot is from KFC, showing the 'ANIMAL WELFARE PROGRAM' and 'KFC Poultry Welfare Guidelines'. It states: 'KFC has had an animal welfare policy for a number of years. In 2008, KFC adopted specific, comprehensive welfare performance standards for processing chickens and audits are designed to manage and monitor each step of the process to determine whether the birds supplied by KFC are handled humanely and are suffering in transport. KFC audits its suppliers for compliance, and non-compliance could result in termination of the supplier's contract. KFC's policies for the suppliers apply to all flocks intended to be sold to KFC. KFC's guidelines for its suppliers include: Processing Guidelines'.

## Demanding progress in "Welfare traits"

**tech notes**

The Ross Broiler – First for Performance, Quality and Welfare

**Fast Food Embracing Animal Welfare**

WELLSVILLE, Pa., Nov. 5, 2013

It's not the eggs that come first here. It's the chickens.

Quickly, both McDonald's and Burger King have become leaders in animal welfare. Humane improvements for the hens that lay the fast-food egg and new standards for cattle and hogs destined to become sandwiches.

The hens, raised in crowded cages, must now have room to flap their wings, and at the slaughterhouse, chickens can't be frozen around the neck.

## Housing Conditions and Slaughter



### Dr. Temple Grandin's Web Page



### Livestock Behaviour, Design of Facilities and Humane Slaughter

Animal welfare specialists are brought in to evaluate husbandry and animal handling. They are being asked to design and implement changes.

## 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.