Dolly, BST, and transgenic animals: Cloning around with animals and genes

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Introduction

• Growing use and demand for agricultural animal biotechnology

• Biomedical purposes
  – Genetic selection
  – Gene therapy
  – e.g., for humans & companion animals
  – Disease management
Areas of ethical concern about animal biotechnology

• Safety/risk
  – What are the long/short-term effects?
  – Environmental impact

• Distributive justice
  – Who benefits?

• Animal welfare
  – Is the animal harmed?
rBST (bovine somatotropin)
rBST

- Naturally occurring protein
- Produced and secreted from anterior pituitary
- Regulates growth, stimulates milk production, improves productive efficiency

- Banned in European Union nations
- Synthesized using recombinant DNA techniques
  - bovine somatotropin (rbst) Kunkel, 2000
rBST (Bovine Somatotropin)
Applications

• Approved by the FDA in 1993
• Currently used by over 30% US dairy farmers
• Marketed as Posilac® by Monsanto
• Primary objectives:
  – Improve milk production in cows
    • up to 10-15 %
  – Increase production efficiency (yield/unit feed)
Ethical questions arising from use of rBST

• Health risks to humans?
  – Is rBST milk safe for human consumption?
  – Is there increased risk for developing allergies?
  – Should rBST milk be labeled?

• Animal welfare
  – Are cows injected with bST harmed?
    • Reports of increased mastitis, decreased conception rates, inflammation from repeated injections, arthritis, lameness
Ethical questions arising from use of growth promotants

- Distributive justice
  - Idea that small dairies would be even more disadvantaged than large commercial dairies
  - Potential for biotech to contribute to demise of small farms
    - Loss of choices in products offered
Transgenic animals
Transgenic animals

- Transgenic animals carry and express genetic information not normally found in that species (Singleton, 1999)
- “Frankenfoods”; “Pharm animals”; “Manimals”
Transgenic animals

• First transgenic mouse produced in 1981
  – Human growth hormone inserted into a mouse (Singleton, 1999)
  – Used to produce monoclonal antibodies and anti-inflammatory agents ⇒ useful for disease and infection treatment
Transgenic mouse compared to normal littermate. The transgenic mouse has had human growth hormone gene inserted into its genome.
Uses of Transgenic Animals

• Applications
  – Basic science: tools for fundamental research in agriculture, biology and medicine
  – Model development and progression of human disease e.g., CF
  – Facilitate xenotransplantation (animal-human organ transfer)

Singleton, 1999
Uses of Transgenic Animals

- Commercial use of farm animals to express highly desirable products
  - sheep modified to produce biologically active tissue plasminogen activator (TPA--therapeutic agent for human clotting disorders)
  - Factor VIII and Factor IX used to treat clotting disorders (hemophilia)
  - lactoferrin in milk; lactoferrin is an antibacterial protein used to treat immunosuppressed patients; (could be incorporated into infant formula)

Pew Initiative, 2001
Other benefits of transgenic technology in farm animals

- Alter milk composition
  - Reduced beta-lactoglobulin → reduce allergies
  - Reduced lactose → aid lactose intolerance
  - Increased antimicrobial proteins
    - Could prolong shelf-life of milk
    - Could reduce gastrointestinal problems

Pew Initiative, 2001
Other benefits of transgenic technology in farm animals

- Production of new materials
  - E.g., transgenic goats have been bred to produce milk with proteins from spider genes
  - Result: create very strong material similar to spider silk, which can’t be commercially produced

Pew Initiative, 2001
Transgenics in aquaculture

• Some species researchers are working with
  – catfish, carp, tilapia, striped bass, clams, oysters, shrimp, and abalone

• Traits under investigation in transgenic fish
  • Faster growth rates (3-11 times faster) & more efficient feed utilization
  • Increased tolerance to cold water
  • Improved disease resistance
Animal cloning

“The Dolly era”
Cloning: a very brief history

- 1997: Dolly--first successful cloning of adult animal
- 1997: Rhesus monkeys cloned
- 1998: Cloned calves reported
- 2001: Cloned pigs reported
- 2001: Cloned gaur--first endangered species
- 2001: First reported human embryo cloning
- 2002: First cloned pet (cat)
Cloning methods
(overview of nuclear transfer)

• Nuclei extracted from cultured cells (embryo, fetus or adult)
• Nuclei inserted into egg cells which have their original nucleus removed (nuclear transfer)
• Egg cells with the transplanted nuclei then implanted into a foster mother for development
Cloning in an Eggshell...
Cloning Applications

- Produce superior livestock
- Facilitate “pharm” animal production
  - Human therapeutic proteins
- Facilitate xenotransplantation
  - Safer source of organ and tissue transplants
- Provide defense against bio-terrorism
  - Hematech and the Dynport Vaccine Corporation developing cloned cows to produce antibodies to botulinum toxin in milk
Other Cloning Applications

• Model human cloning techniques
• Save/recover endangered species
• “Resurrect” treasured pets
  – (e.g. Genetic Savings and Clone)
  http://www.savingsandclone.com
Transgenics and cloning

• The reality:
  – Very expensive technology
  – Technologies still need to be refined
    • large numbers of repetitions required to produce viable offspring in animals
  – Applications currently very limited--predominantly used for biomedical purposes
Ethical issues associated with transgenics and cloning

- Technology isn’t perfected yet
  - Very low success rate
  - High mortality rates
Ethical issues associated with transgenics and cloning

- Safety/risk of consumption
  - According to the U.S. Food and Drug Administration
    - Cloned animals probably safe to raise and eat
    - Transgenic ones may not be safe to consume
Ethical issues associated with transgenics and cloning

• Animal welfare
  – ↑ birth weights, longer gestation, difficult births in clones
  – Poor survival rate of fetuses using some techniques
  – Anatomical, physiological, behavioral abnormalities
Ethical issues related to transgenics and cloning

- Suffering of transgenic animals
  - Case of Beltsville pigs (human GH introduced)
    - High mortality, arthritis, gastric ulcers, degenerative joint disease, infection, lethargy
- Cloned animals
  - Shortened life spans, health problems
- What happens to animals born without transgene?
Additional concerns regarding transgenics and cloning

- Implications for application of technologies to humans
- Moral concerns: “are we playing God?”
- Impact on ecosystems and genetic diversity
  - What if GE organisms escape reproduce?
  - What might be the impact of limited gene pools on livestock faced with new (deadly) pathogens?
  - Potential for GE animals to move into areas previously unused for agriculture $\Rightarrow$ disrupt fragile ecosystems
    - habitat preservation issues for wild animals
Additional concerns regarding transgenics and cloning

• Time factor
  – mistakes can occur more rapidly with GE than conventional methods of animal selection (e.g. selective breeding)
  – loss of incremental steps ⇒ lose ability to evaluate results at each step
    • e.g. traditional breeding allows time for evaluation, correction, reversal

• Ownership and legislation
Additional concerns regarding transgenics and cloning

- Lack of controls to prevent GE animals from entering the food chain (e.g., cows that produce drugs in their milk)
  - One reported instance of meat from GE animals used in a food product

NAS, 2002
Animal biotechnology and law

• “Any food system practice that does not allow individuals who do not want to consume meat or milk from clones to act upon their values at a reasonable cost is ethically unacceptable and ought to be illegal.” (Thompson, 1997)
Responsibility to the public: education

- Need for public education to facilitate understanding & discussion of biotech
- Need for informed consent
- Foisting of technology is wrong, not technology itself (Thompson, 1997)
Conflicts of Interest
(Hodges, 2000)

• “Politicians do not like probabilities
• “Scientists do not like ethics”
• “Consumers and users do not like risk”
• “Business does not like waiting”
References & additional reading

• Fraser, V. 2001. What’s the moral of the GM food story? Ag & Env. Ethics. 14 (2) 147-159.
Questions

• Should farm animals be bioengineered for food production systems?
• Is it ethically responsible to clone animals given the potential harms? (Another way to look at this question: Do the benefits of animal cloning and transgenics outweigh the harms?)
• Should some types of scientific investigations (e.g., cloning) be banned?
• Are scientists responsible for how their research is used?