

Animal Biotechnology

David Harry
April, 2009

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

Biotechnology in the News

Common Sense NEWSCENTER
Put Away the Flag
Wednesday, July 10, 2008
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Beyond GM Food: New Cutting Edge MAS Technology Makes GM Food Obsolete
by Jeremy Rifkin

NEWS OF THE WEEK
AGRICULTURE
A Kinder, Gentler Jeremy Rifkin Endorses Biotech, or Does He?

The venerable activist Jeremy Rifkin was the latest recipient of a Common Sense NewsCenter award for his latest book, *The Zero Marginal Cost Society*. In it, Rifkin argues that the rise of digital technologies and the Internet will lead to a new era of abundance, where the marginal cost of producing goods and services approaches zero. This, he argues, will lead to a new era of abundance, where the marginal cost of producing goods and services approaches zero. This, he argues, will lead to a new era of abundance, where the marginal cost of producing goods and services approaches zero.

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

Animal Biotech, Parts 1 and 2

- Overall: Introduce biotechnology as used in animal agriculture
- Part 1 (Tuesday, April 7th)
 - Breeding and genomics
 - Video (UCD Animal Biotech)
- Part 2 (Thursday, April 9th)
 - Genetic engineering
 - Animal cloning
 - 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?



Consumer & Market Forces



Monday, June 19, 2006

[Print this page](#)

Coughlan urged to back EU directive on chicken welfare

IRELAND - Animal welfare campaigners are calling on the Minister for Agriculture to ensure the EU issues a directive aimed at improving the welfare of broiler chickens.

The European Agriculture Council is meeting in Luxembourg today to decide on minimum rules for the protection of chickens.

Social and market forces are pressuring animal industries to re-examine their practices.

Impacts on Animal Welfare



Major food service and retail providers have implemented guidelines that have made significant changes in the husbandry and treatment of food animals.

Such changes are non-trivial!

Modern animal agriculture: times have changed



Similar types of changes have occurred throughout animal agriculture



New Technologies: Poultry Examples

Technique	Introduced
Trap nesting	1930
Hybridization	1940
Pedigree Control	1940
Artificial Insemination	1960
Index selection/evaluation	1960
Feed Efficiency Testing	1970
Electronic Data Collection	1980
BLUP selection/evaluation	1990
DNA Markers	1990
Individual feed efficiency	2000
Sequence, SNPs	2000

← White feathers. Why?

Modified from Arthur & Albers, 2003

Phenotype encompasses
Genotype and Environment



Phenotype encompasses
Genotype and Environment



$$P = G + E$$

Phenotype encompasses
Genotype and Environment



$$P = G + E$$
$$V_P = V_G + V_E$$

Phenotype encompasses
Genotype and Environment

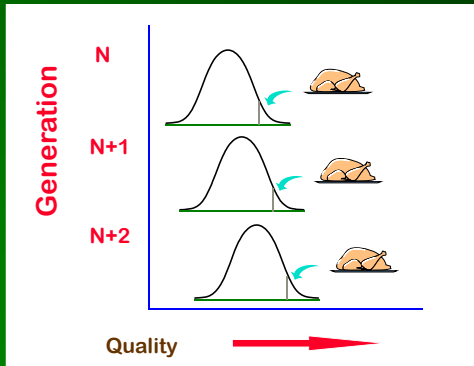


$$P = G + E$$
$$V_P = V_G + V_E$$

heritability (h^2): V_G / V_P

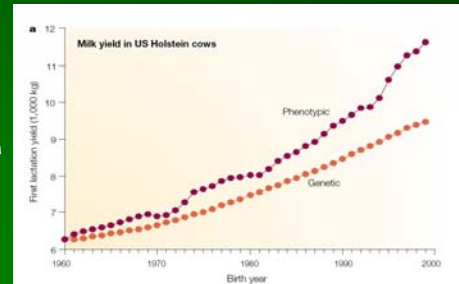
h^2 ranges from 0 to 1 (like a correlation) and
measures the relative degree of genetic vs.
environmental influence (nature & nurture)

Traditional Breeding: Select Best Individuals & Families



Milk Production in Holstein Cows

- Total milk production has doubled in 40 years
- Overall gains reflect improvements in both husbandry and breeding
- Genetic improvement is substantial!
How has it been accomplished?



Dekkers & Hospital, 2002

Meat Yield in "Broiler" Chickens

1957 Males



2001 Males



Day 43

Day 57

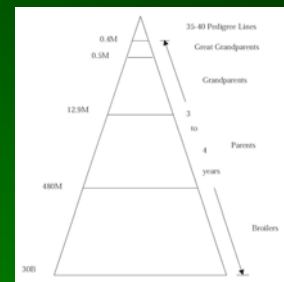
Day 71

Day 85

Hevenstein & Qureshi, 2004

Structure of Chicken Breeding Industry

- Separate programs for egg layers vs. meat-type (broilers)
- A few multinational firms, compete for market share
- Highly specialized to accomplish breeding goals
 - excellent growth & production
 - hardy and healthy
 - free of contagious diseases
- Sell breeding stock (parents & grandparents)



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

Rice et al. 2003

Dairy and swine breeding following a similar path (less so for beef, fish)

ABS Global : Dairy

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Dairy

- Online Directory
- Synchronization Systems
- Progeny Test - ABS Cornerstone™
- GMSB
- Featured Sires**
- Dairy Resources
- Dairy Links
- Dairy Sales Directory
- ABS Sexaton™
- Udder Care Products

Sire Summary Feature Bulls

- 29HO10124 BOLIVER
- 29HO11111 BOLTON
- 29HO11338 DETECTIVE
- 29HO10276 DUNDEE
- 29HO10944 GARRISON
- 29HO11109 GRAYSON
- 29HO11193 HOMESTEAD
- 29E3301 JATOLA
- 29HO10463 JAMMER
- 29HO10722 JET
- STREAM
- 29E3314 LEXINGTON
- 29HO10611 MANGO
- 29HO11013 SETON
- 29E3307 SHOWTIME
- 29HO0023 ROY
- 29HO12209 SHUTTLE

Headquartered in Delorest, Wisconsin, **ABS Global** is the world-leading provider of bovine genetics, reproduction services, technologies and additive products. Marketing in more than 70 countries around the globe, ABS has been at the forefront of animal genetics and technology since its founding in 1941. ABS Global is part of Genus Breeding, a division of Genus Inc.

Early efforts: Mapped DNA markers



- Maps & markers, mid-1990's
- Consensus maps, 2000
- Specific DNA tests
 - fast-feathering
 - MHC & blood groups
 - pigments
 - others...
- Breeding companies explored pilot-scale projects, and are now ramping up

Sequenced Animal Genomes



Pig sequence is also underway



Genome Sequence & SNP Markers (Single Nucleotide Polymorphisms)



December 9, 2004

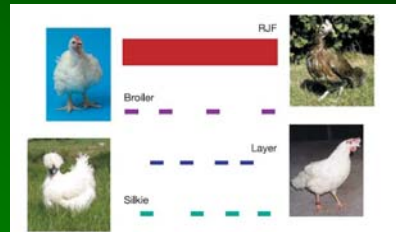
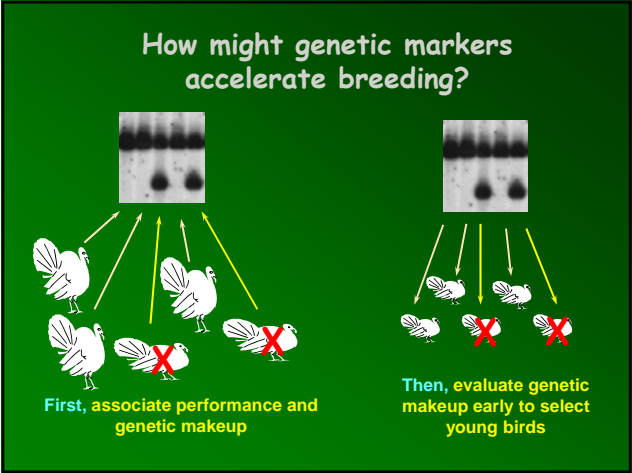
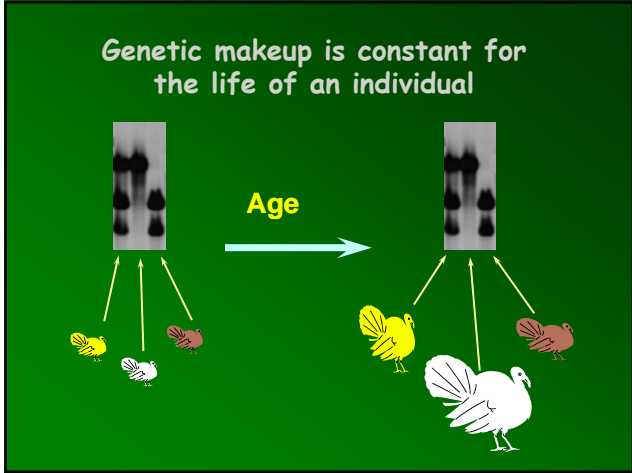
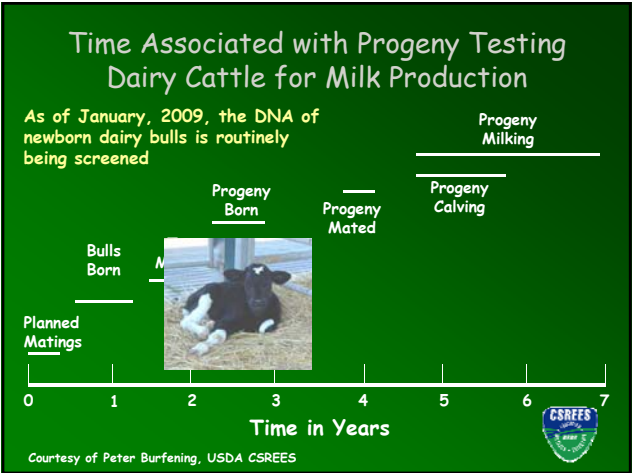


Figure 1 SNP discovery experiment. We sampled three domestic chickens at one-quarter coverage each and compared the resultant sequence to the 6.6x draft genome of red jungle fowl (RJF). Chicken photographs are provided by B. Payne (red jungle fowl), P. M. Hocking (broiler), L. Andersson (layer) and N. Yang (silkie).



- ### DNA tests are available for several traits & species
- Halothane and ryanodine receptor gene (Ryr)
 - porcine stress syndrome
 - defective allele discovered by comparing to known human condition
 - used with great success in industry
 - MHC tests (predicts disease resistance) in chicken
 - Meat quality in beef



Implications of enhanced genetic gain

- Are there trade-offs?
 - Highly specialized (i.e. single-purpose) breeds
 - chickens: meat vs. eggs
 - cattle: beef vs. dairy
- "Commercial" breeds provide the bulk of food animal products
- Genetic diversity remains a primary breeding goal, and yet, what are the risks?
- Strong selection on one or a few traits can lead to problems in other traits

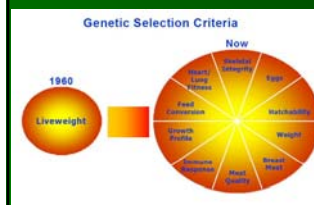
Trade-offs: Poultry Examples

- Chickens
 - Evaluating commercial traits based on individuals can inadvertently lead to aggressive behavior (best-fed individuals tend to have desirable traits)
 - Increased egg production can reduce calcium reserves in older layers (bone degeneration)
 - Rapid growth in broilers can cause locomotor (leg) problems
 - Increased crowding can increase stress thereby reduce immune function
 - Growth rate and fertility (egg production) are inversely correlated
 - US vs. European diets (corn vs. wheat)

Trade-offs: Cattle Examples

- Dairy
 - Increases in milk yield (per lactation) can lead to reduced fertility (conception rate). Only cows that give birth produce milk!
 - Excessive milk production can lead to udder irritation (mastitis)
 - Artificial insemination
 - pedigree control (e.g. to avoid inbreeding)
 - overall relatedness within Holsteins is increasing
 - 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 were initially developed in UK, and do not thrive in hot-humid environments
 - Solution: "Brangus" (~5/8 Angus and ~3/8 Brahman)

"Balancing" multiple traits



Tibial dyschondroplasia is a problem of bone development in legs related to rapid growth of meat-type chickens (an animal welfare issue). Once recognized, selection has reduced incidence.



Video: Animal Biotechnology

- Animal biotechnology
 - Broadly defined
 - Recently aligned with genetic engineering and cloning
- Genetic engineering
- Cloning
- Listen to some of the world's leaders!
- Reminder: Part 2 will emphasize these & other technologies

Thought Questions

What types of activities are included under the umbrella of "animal biotechnology."

If large-scale animal agriculture leads to problems, why do farmers continue using these practices?

How can animal breeding be managed to minimize long-term reductions in genetic diversity?

Genetic marker technology could be used to enhance breeding for disease resistance. How might this affect animal welfare?

Why might breeders pay attention to consumer attitudes? Genetic engineering and animal cloning are similar, and yet different. How so?