Developing the right genetic stock for a different future

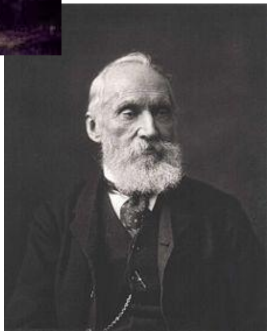
OXFORD FARMING CONFERENCE 2013

Genus

"Pioneering animal genetic improvement to help nourish the world"

Livestock agriculture – what are the right genetics for the future?

Robert Bakewell 1725 -1795



William Thomson, 1st Baron Kelvin, 1824-1907

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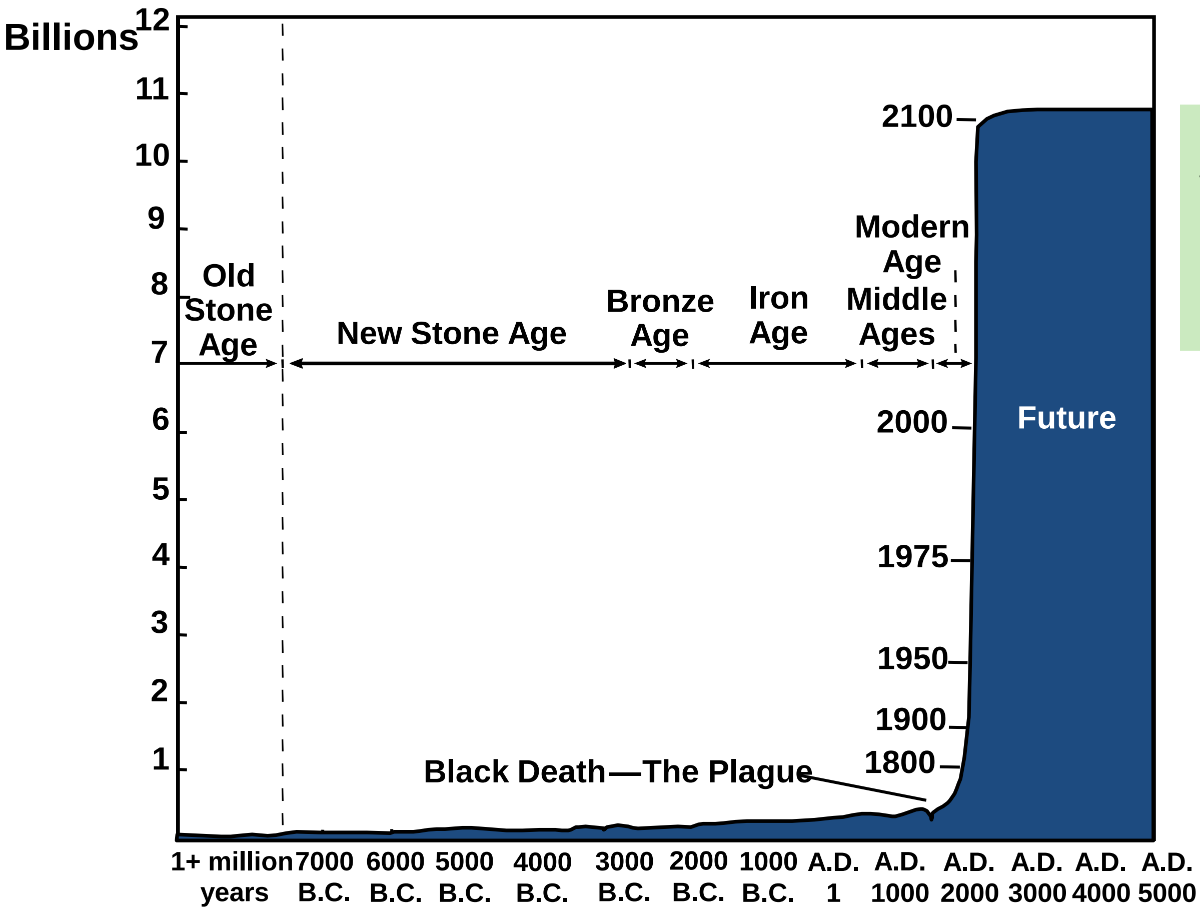
World Population Growth Through History



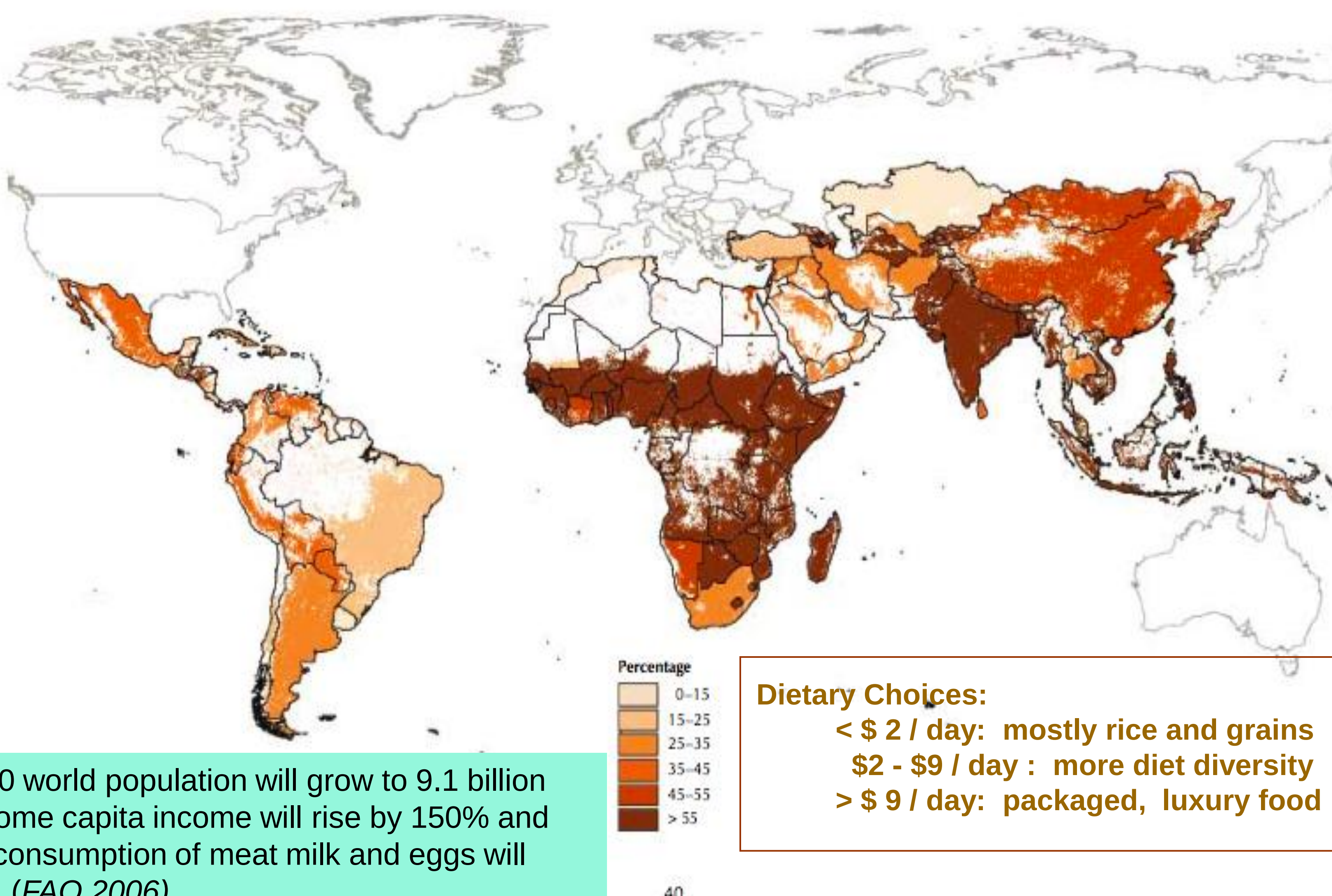
Its is predicted that by 2050 the worlds population will need 100% more food and according to the UN FAO 70% of it must come from efficiency enhancing technology

Source: Population Reference Bureau; and United Nations, *World Population Projections to 2100* (2009).

Will livestock Agriculture have a future?

V

Map 7d. Population below the poverty line (%): less than US$ 2 day[1]

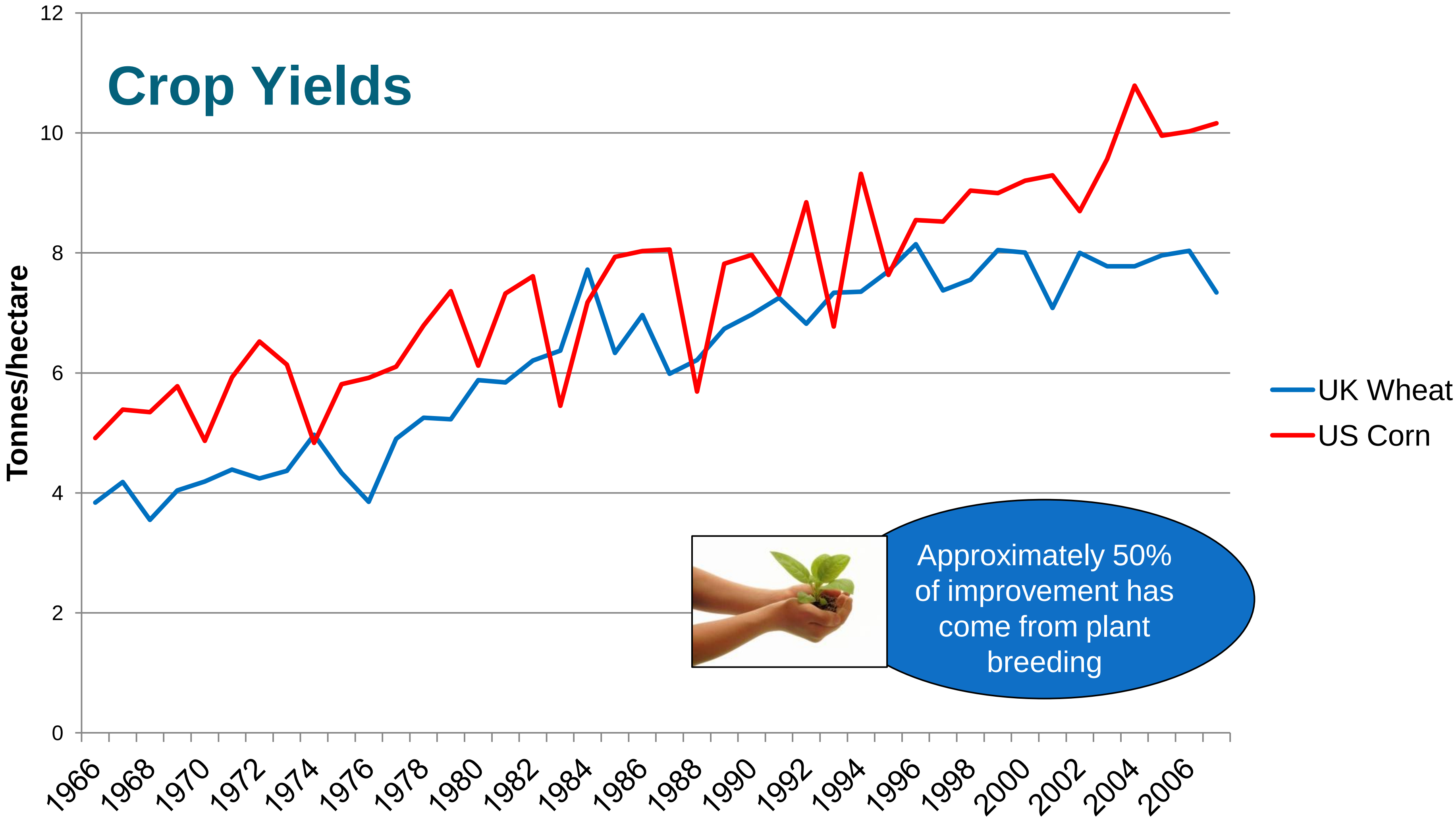


Dietary Choices:

- **< $ 2 / day: mostly rice and grains**
- **$2 - $9 / day : more diet diversity**
- **> $ 9 / day: packaged, luxury food**

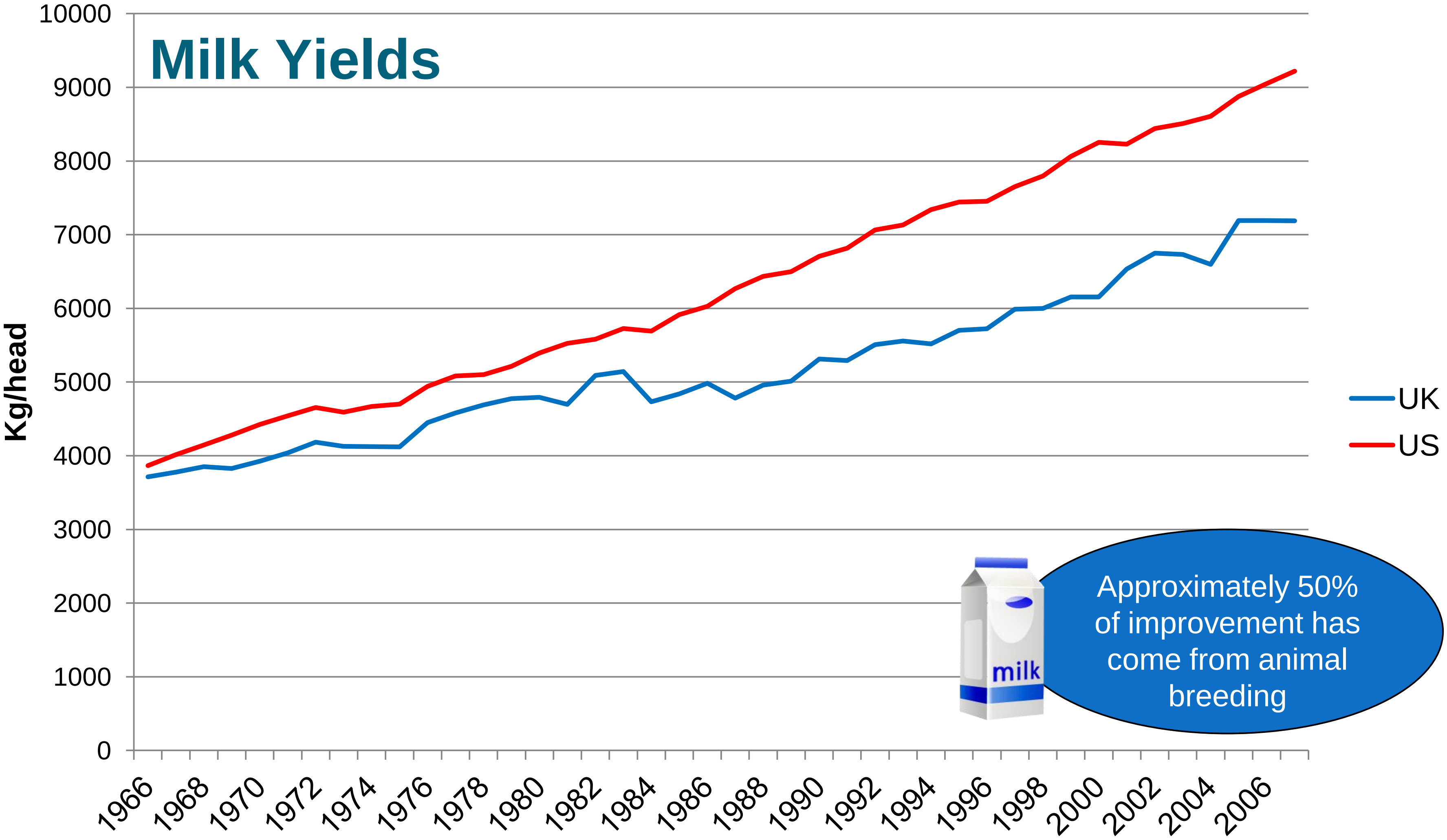
By 2050 world population will grow to 9.1 billion per income capita income will rise by 150% and global consumption of meat milk and eggs will double (*FAO 2006)*

How much can genetic improvement contribute?

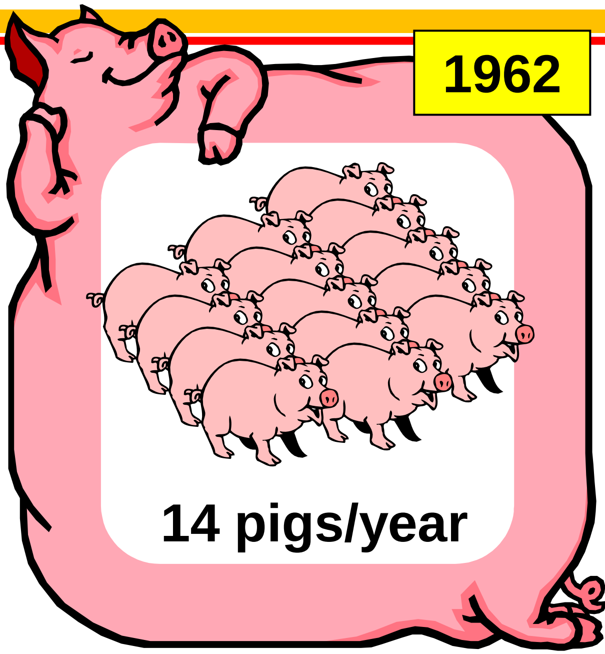


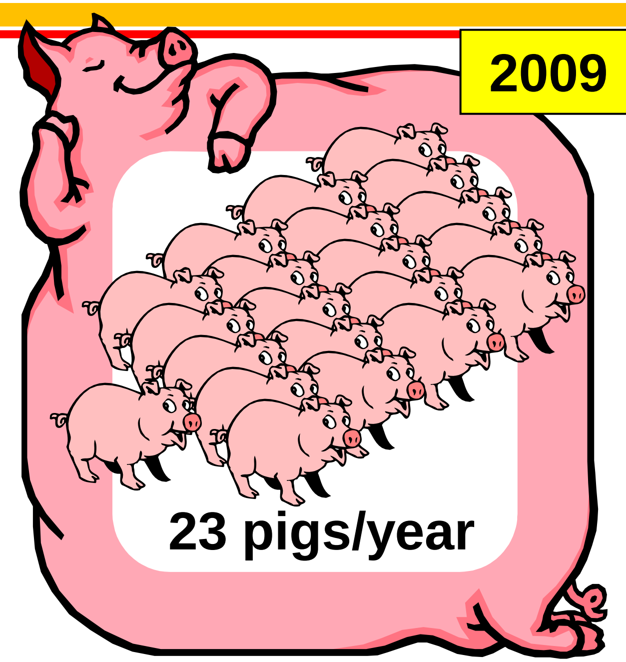
Approximately 50% of improvement has come from plant breeding

How much can genetic improvement contribute?



UK pig performance



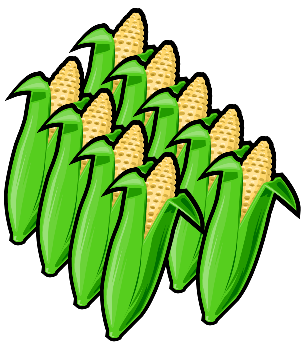


71% more pigs

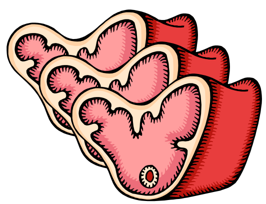
38% less feed

39% more lean

50% less manure per kg of lean

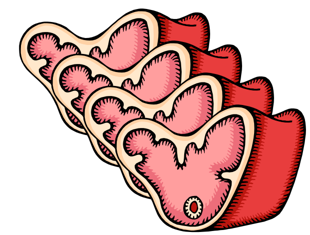


410 kg of feed each pig



34 kg of lean each pig

273 kg
feed
pi



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Approximately 60% of improvement has come from genetic improvement

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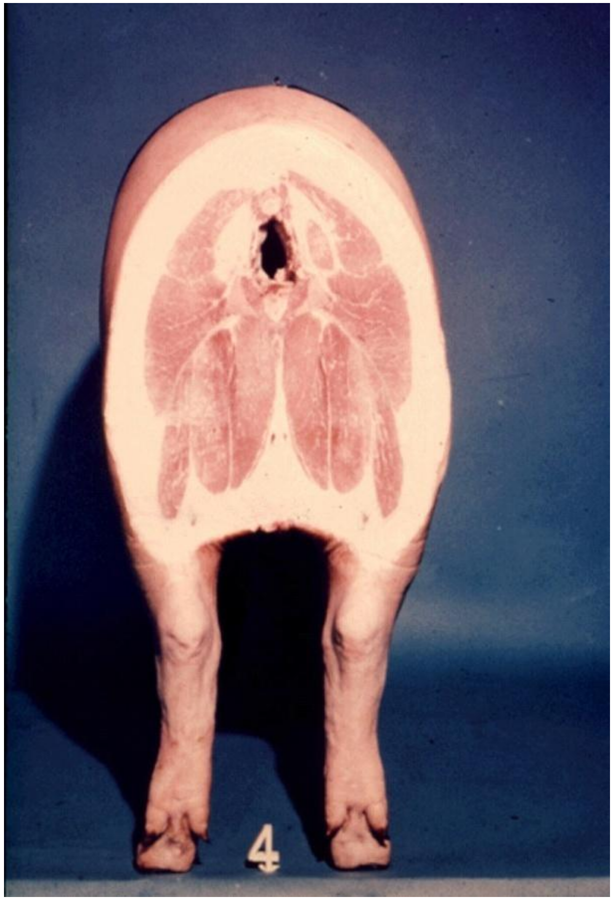
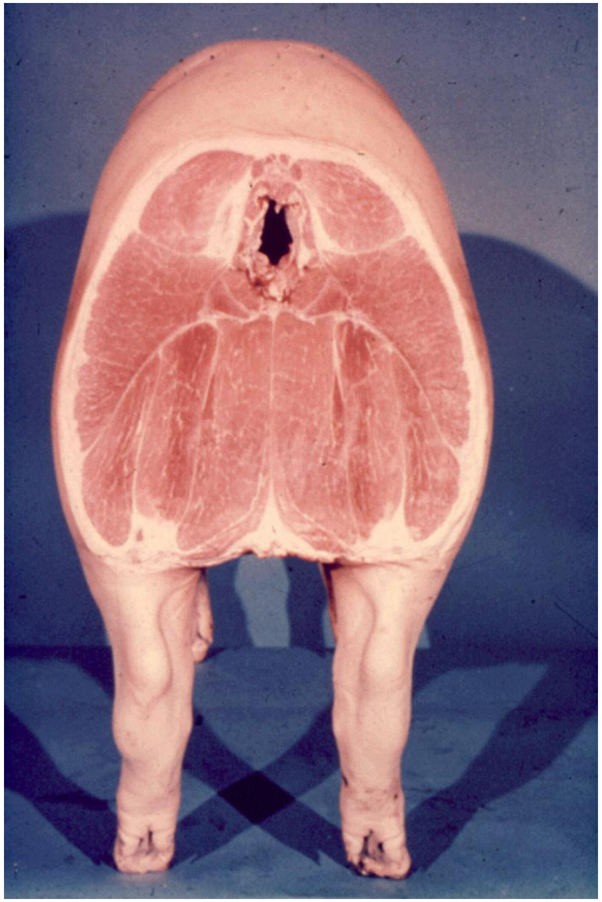


1962



2009

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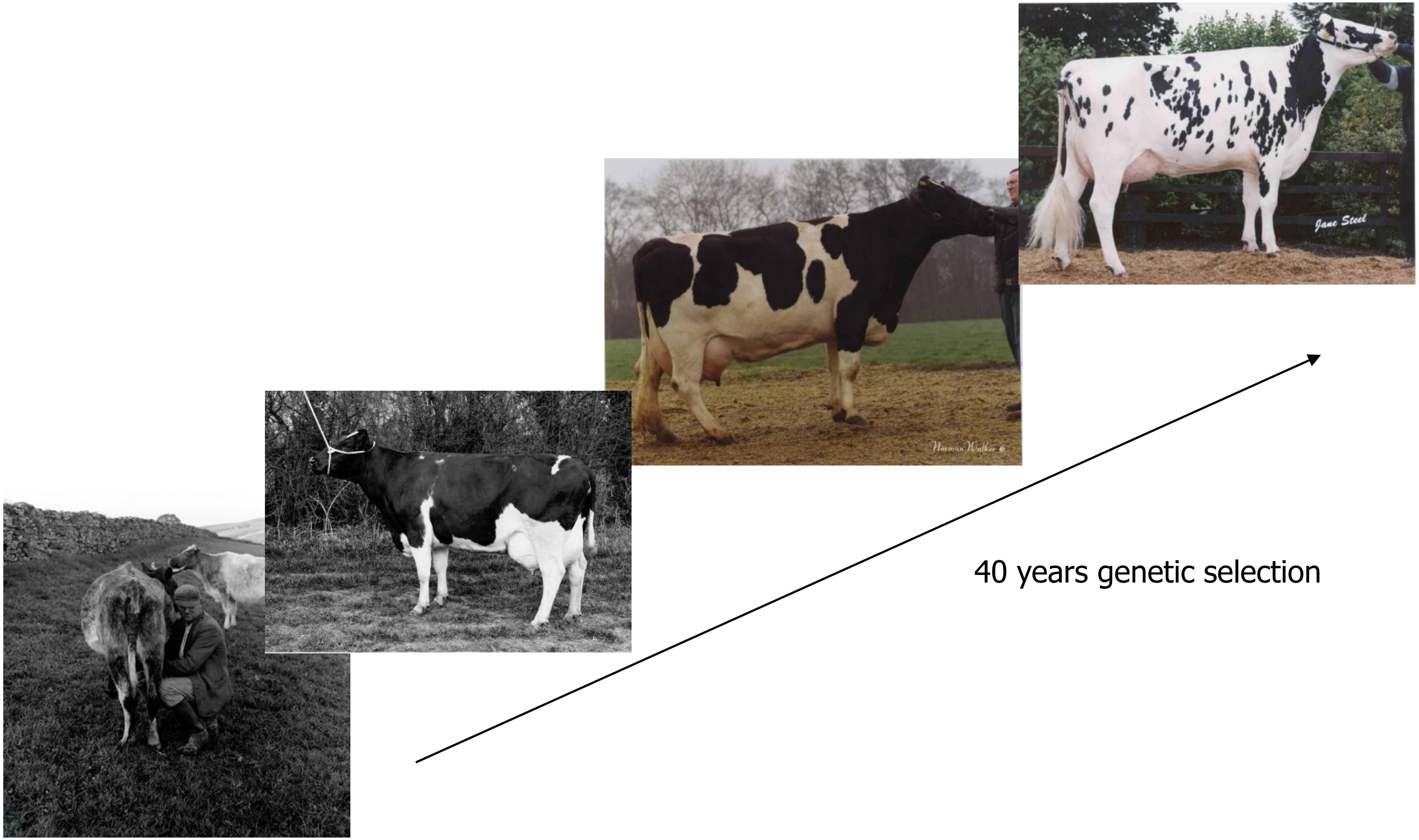


Genetic selection has become more sophisticated over time

1970's ICC's for Production **5 Traits**
Daughter averages for type

1980's PTA's for Production
PTA's For Type
16 Linear traits

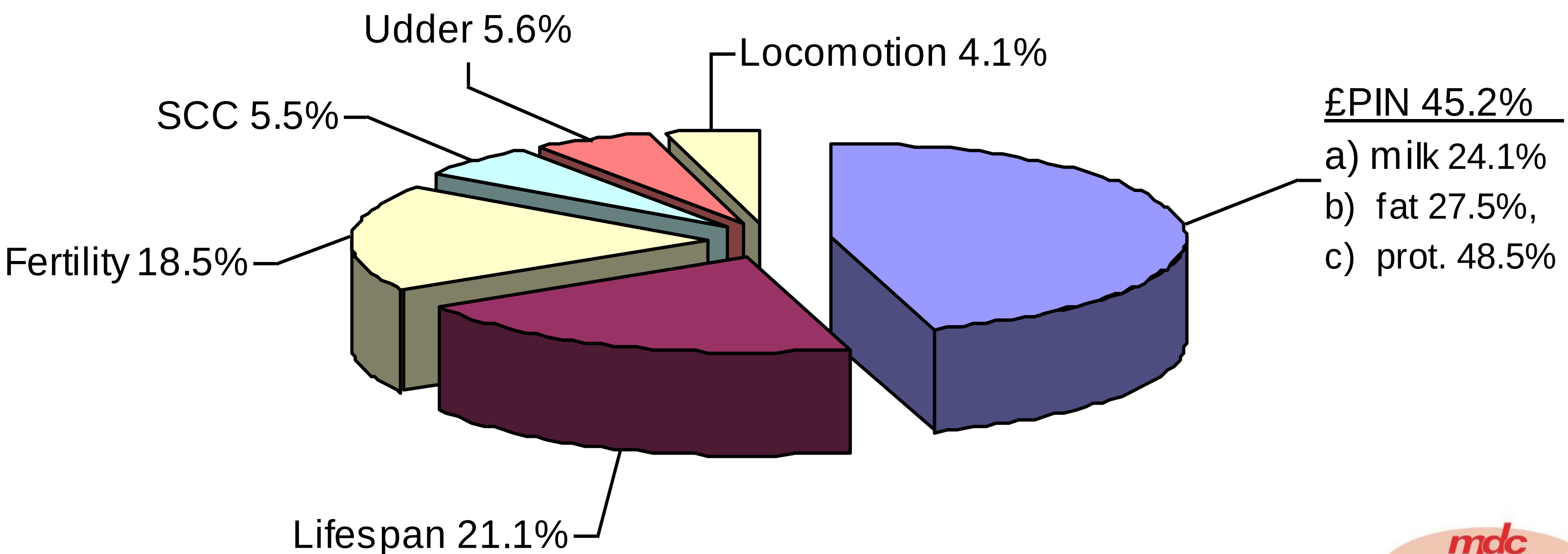
1990's PTA's for Production
PTA's For Type Type Merit plus four composites
16 Linear traits
Milking speed, Temperament, locomotion BCS
Lifespan SCC's

2000's PTA's for Production
PTA's For Type Type Merit plus four composites
16 Linear traits
Milking speed, Temperament, locomotion BCS
Fertility Index, Persistency Lifespan SCC's

36 Traits

Relative weights on selection have changed over time

Relative importance of traits in the Profitable Lifetime Index



What about the future ?

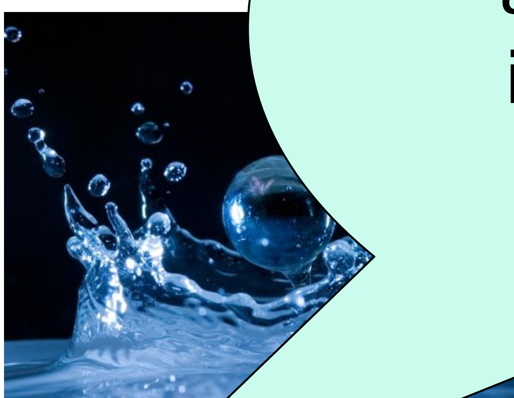
- Genetics have contributed approximately 50% of the phenotypic improvement we have seen over the last 50 years
- What will be required in the future

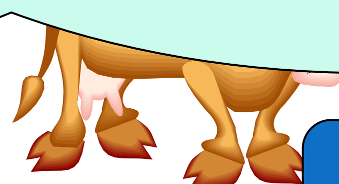
Changing environment

Less land available as
for livestock

Soaring energy and
protein feed costs

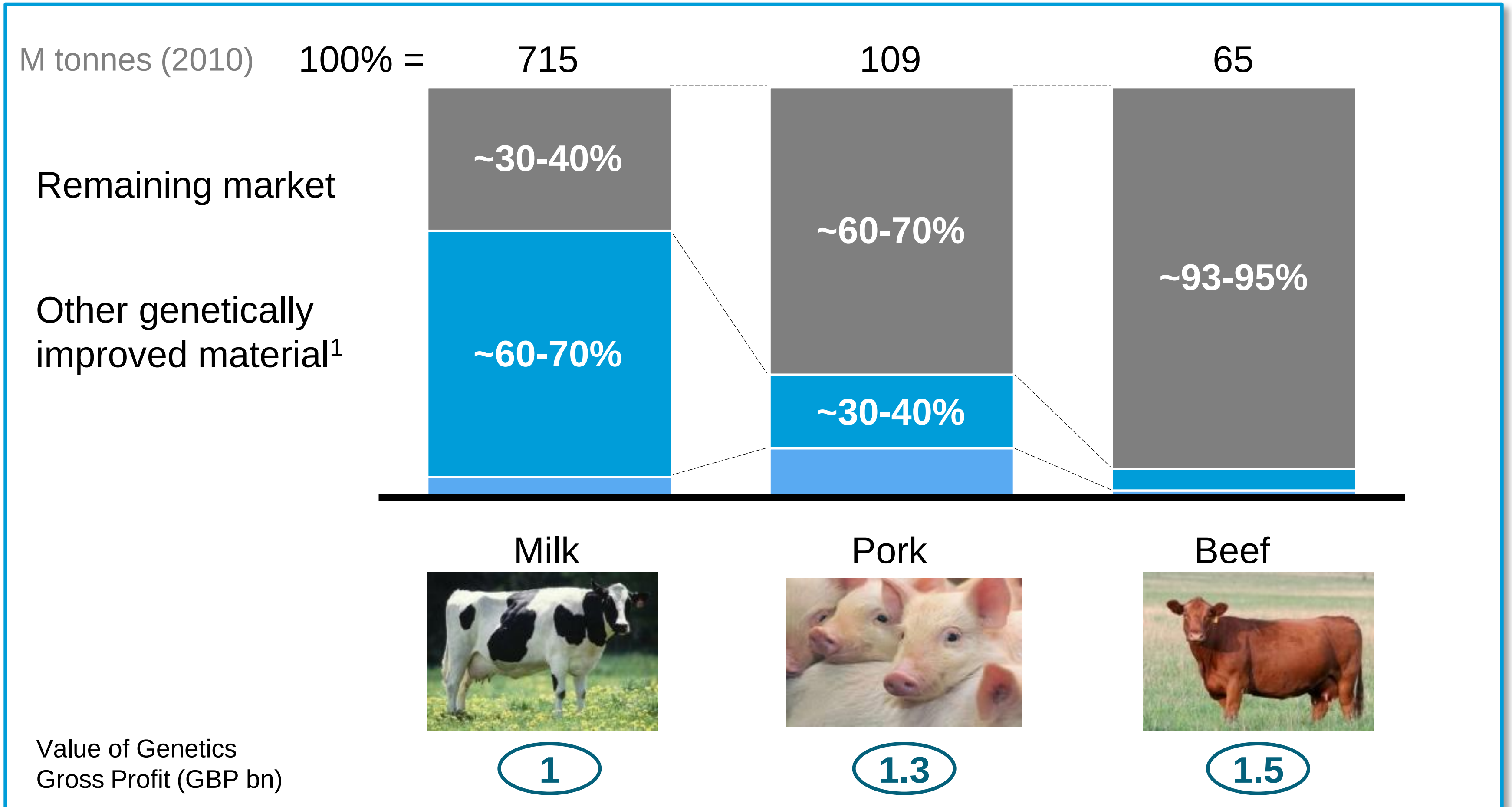
“basically we need to produce more from less and genetic improvement is going to be key to this”





Lower greenhouse
gas emissions

There is a big variation between species in use of improved genetics



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Opportunities in undeveloped species

Atlantic Salmon

Sea Trout

Pacific Salmon

Tilapia

Wild fish stocks are declining so over 50% of fish consumed is now farmed but less than 10% comes from genetically improved strains.

High reproductive rate in fish gives big potential for improved efficiency

Buffalos produce 20% of all the milk produced globally and 50% of all milk in India .

The average Indian buffalo produces 1000kg milk per year

Opportunities in <u>under</u> developed species

Sheep breeding has been limited genetic progress, most improvements to data have been through breed substitution and cross breeding

Lack of data and artificial breeding is limiting dissemination of better genetics

Beef breeding has made some progress, but nothing close to theoretical rates of gain.

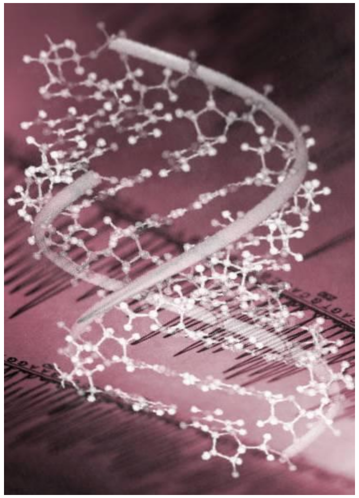
More data available but limited artificial breeding is limiting dissemination of better genetics

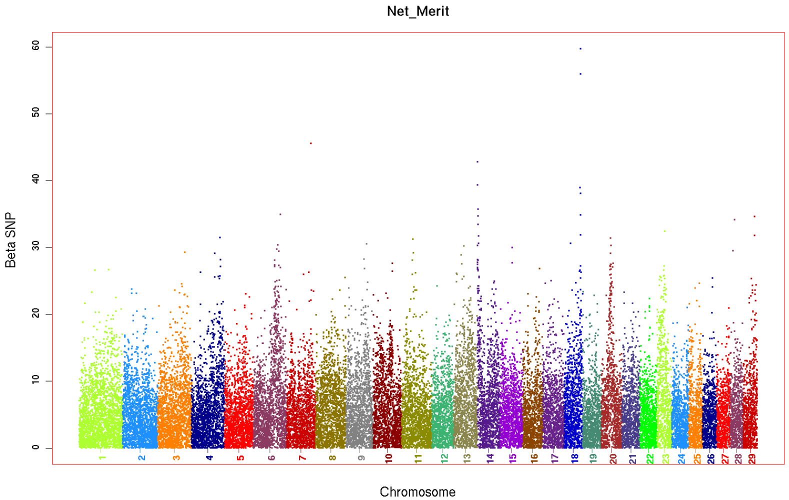
Genomic selection gives a big opportunity for the future genetic progress

- Cattle genome first sequenced in 2004
  - 30 chromosome pairs (including X,Y)
  - 3 billion letters from each parent

- Typically evaluate 3000 – 800K SNP's **(Single Nucleotide Polymorphism)**

- **DNA samples can be taken from very young animals and a genomic evaluation run based of an animals DNA rather than pedigree and performance data**





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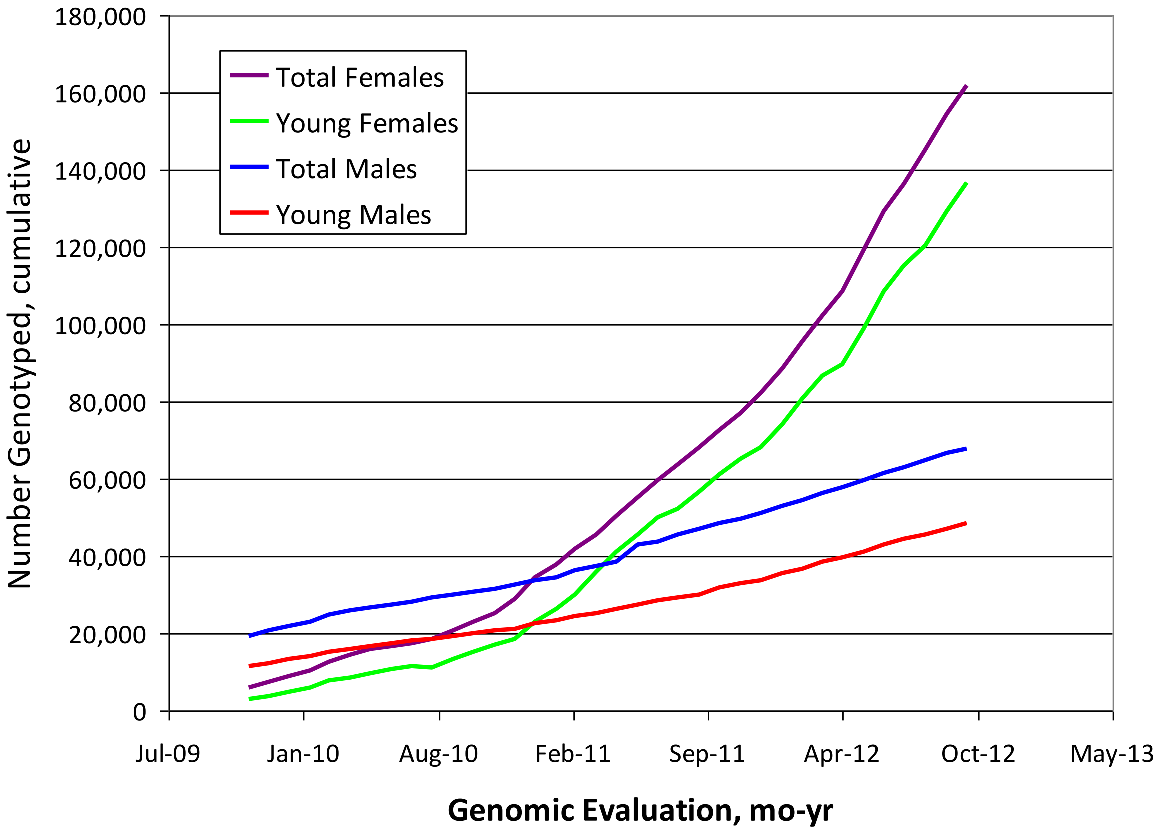
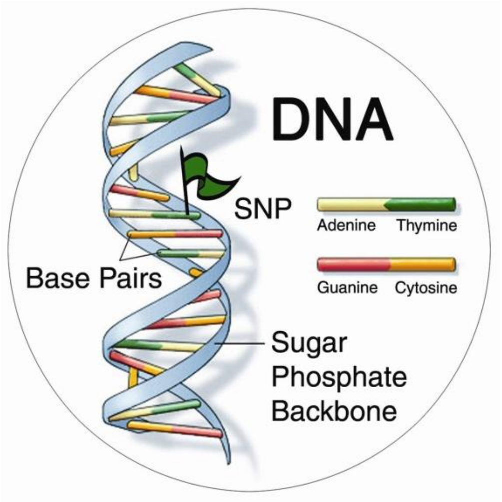
Dairy Genomic Evaluations in North America

- Released publicly in 2009
- Rapid adoption into breeding programs





USDA-AIPL, 2012

>68,000 males

>230,000 both sexes

Pursuit of Genetic Progress is changing as a result of genomic evaluations

Rate of genetic progress =

Genetic variation

x Intensity of selection

x Accuracy of selection

÷ Generation interval

→

Rate of genetic progress =

Genetic variation

x Intensity of selection

x Accuracy of selection

÷ Generation interval

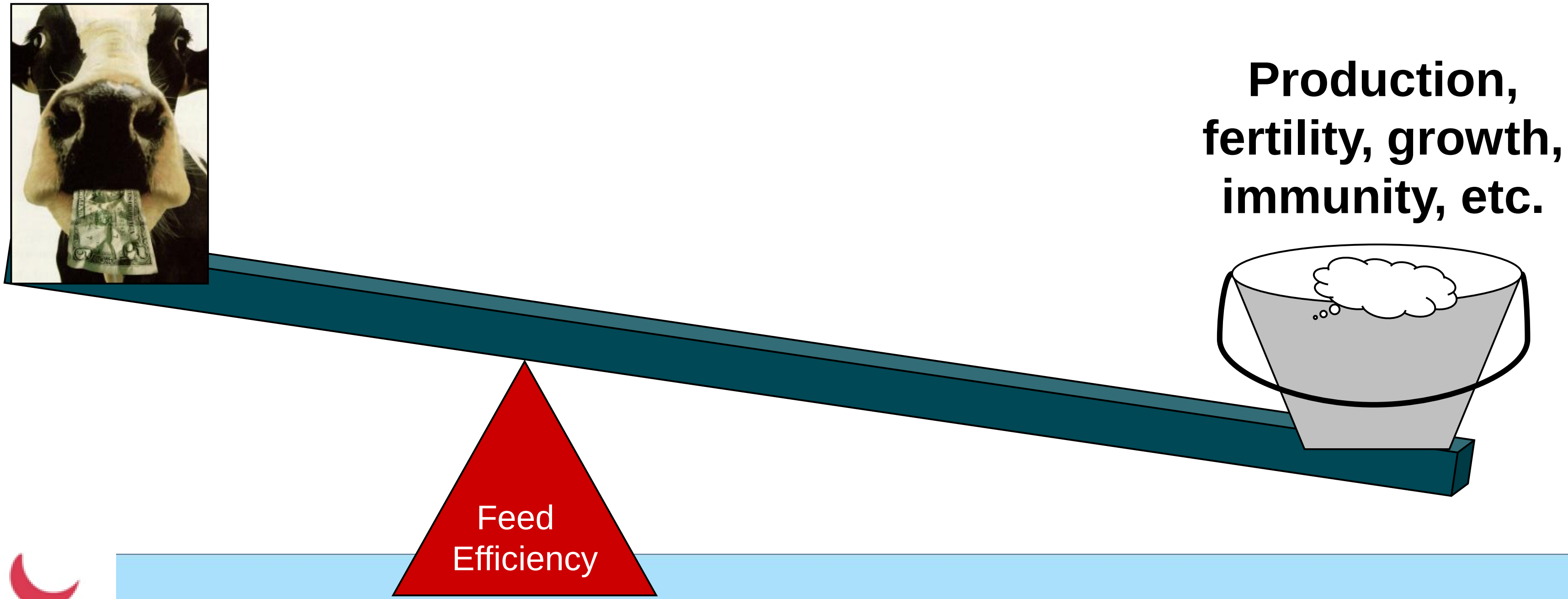
Trait	Traditional	Genomic	Genomic - Traditional*
Protein Yield	35	75	+40
Productive Life, mo.	26	72	+46
Somatic Cell Score	30	76	+45
Daughter Pregnancy Rate, %	26	71	+45
Type Final Score	32	75	+42
Calving Ease	33	57	+24

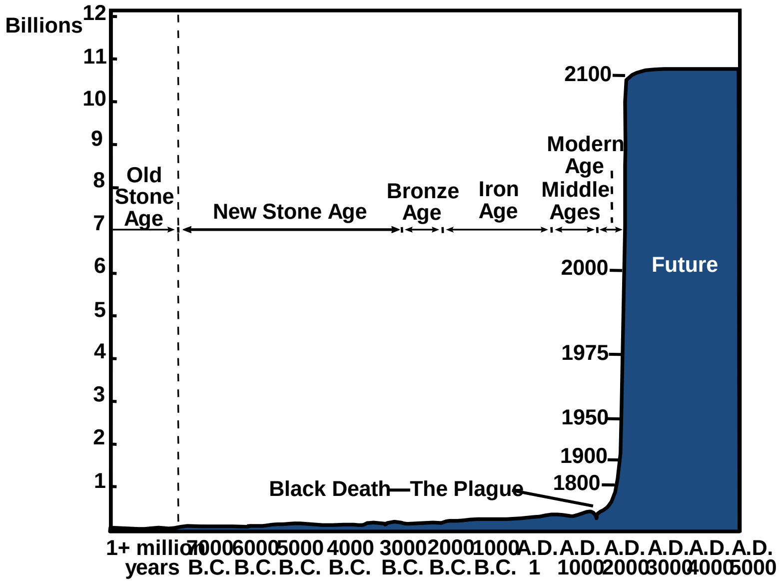
*Based on results from 44,950 Holstein young bulls

Reliability of PTA's increased significantly for young animals

Genomic evaluations will allow us to speed up genetic progress

- **Genomic selection is being applied to many species**
  - **Dairy Cattle, Beef, Pigs, Poultry**
- **Will accelerate genetic progress but still requires lots of phenotypic data to build and validate evaluations**
- **Will allow greater selection for lower heritability traits and evolution of new traits**

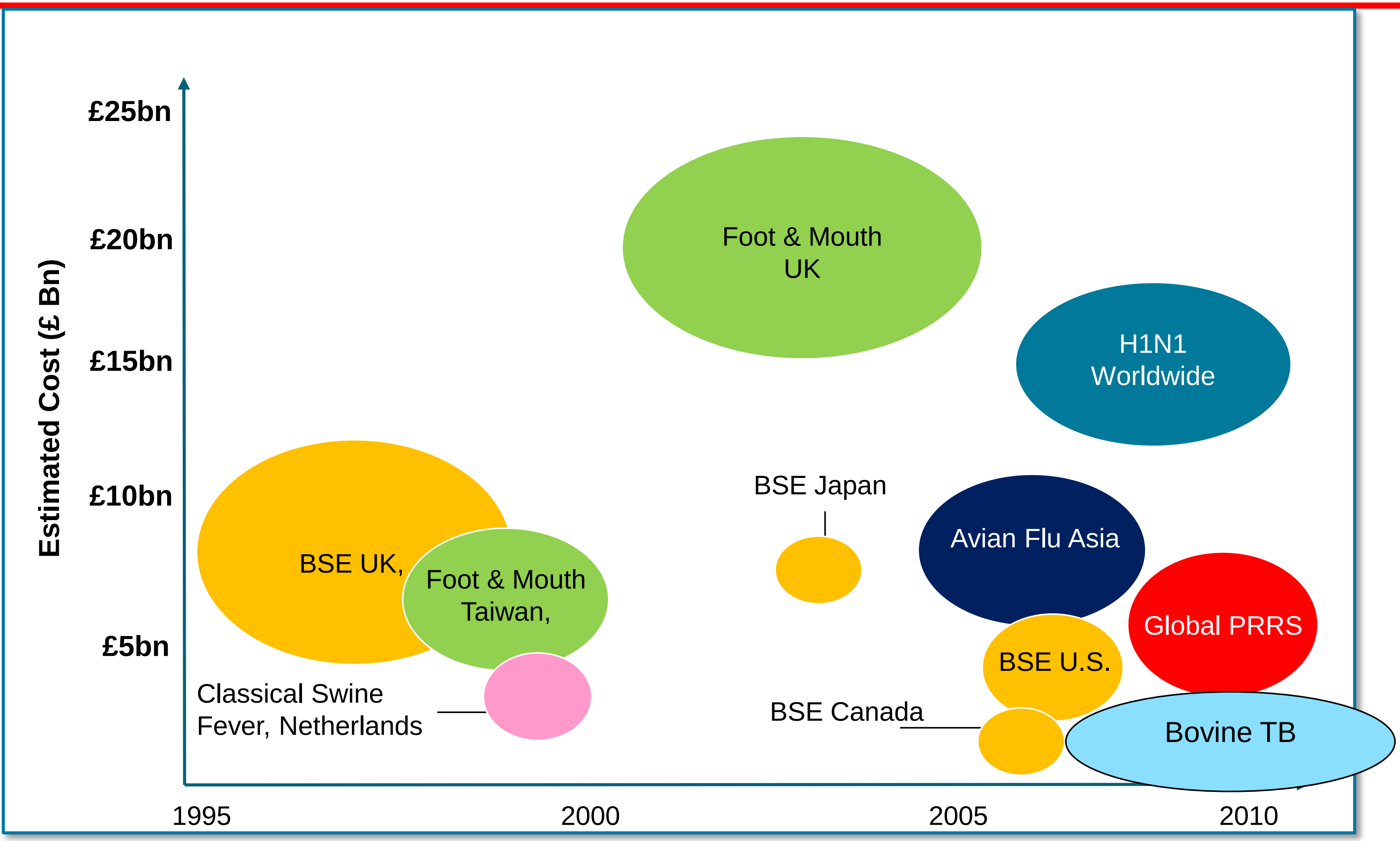




Source: Population Reference Bureau; and United Nations, *World Population Projections to 2100* (2009).

WILL IT BE ENOUGH, OR SHOULD WE ADOPT NEWER TECHNOLOGY?

Historical livestock disease events



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Developing Disease resistance/resilience

PRSS

Avian Flu

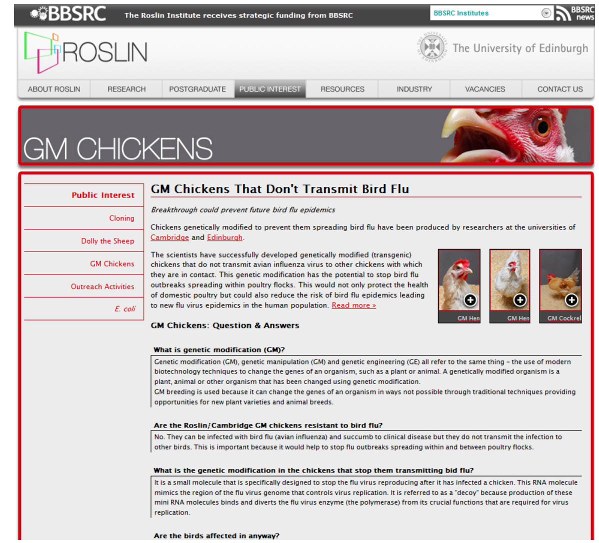
FMD

Bovine TB

Utilizing newer technology?

<table>
<tr><th>Technology</th><th>Note</th></tr>
<tr><td>Selective breeding as carried out for centuries</td><td>Has been established as safe over centuries</td></tr>
<tr><td>Cloning, where the genes of the offspring are identical to the parent; equivalent to twinning</td><td rowspan="3">Are not truly GMOs and do not introduce any gene material that is not already present and so there is no reason to believe that they will harm either the animal or man</td></tr>
<tr><td>Introduction of an additional normal gene already present in the animal</td></tr>
<tr><td>Gene deletion</td></tr>
<tr><td>Gene editing</td><td>Produces only minor changes and often will be introducing naturally occurring mutations so again should not be unsafe in any way</td></tr>
<tr><td>Introduction of another mammalian gene not normally found in that species</td><td>May be low risk particularly if the mammalian gene inserted is not normally eaten</td></tr>
<tr><td>Introduction of a non-mammalian or plant gene into that species</td><td rowspan="3">May have some risk that requires careful analysis</td></tr>
<tr><td>Introduction of a bacterial gene into the species</td></tr>
<tr><td>Introduction of a viral gene into the species</td></tr>
</table>

- Scientific breakthroughs in new genetic technologies could hold the key to step changes in livestock improvements
  - Disease resistance/resilience
  - Improved efficiency
  - Human health protection


BBSRC The Roslin Institute receives strategic funding from BBSRC

ROSLIN The University of Edinburgh

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GM CHICKENS

Public Interest | Cloning | Dolly the Sheep | GM Chickens | Outreach Activities | *E. coli*

GM Chickens That Don't Transmit Bird Flu

Breakthrough could prevent future bird flu epidemics

Chickens genetically modified to prevent them spreading bird flu have been produced by researchers at the universities of Cambridge and Edinburgh.

The scientists have successfully developed genetically modified (transgenic) chickens that do not transmit avian influenza virus to other chickens with which they are in contact. This genetic modification has the potential to stop bird flu outbreaks spreading within poultry flocks. This would not only protect the health of domestic poultry but could also reduce the risk of bird flu epidemics leading to new flu virus epidemics in the human population. Read more »

GM Hen | GM Hen | GM Cockrel

GM Chickens: Question & Answers

What is genetic modification (GM)?

Genetic modification (GM), genetic manipulation (GM) and genetic engineering (GE) all refer to the same thing – the use of modern biotechnology techniques to change the genes of an organism, such as a plant or animal. A genetically modified organism is a plant, animal or other organism that has been changed using genetic modification.
GM breeding is used because it can change the genes of an organism in ways not possible through traditional techniques providing opportunities for new plant varieties and animal breeds.

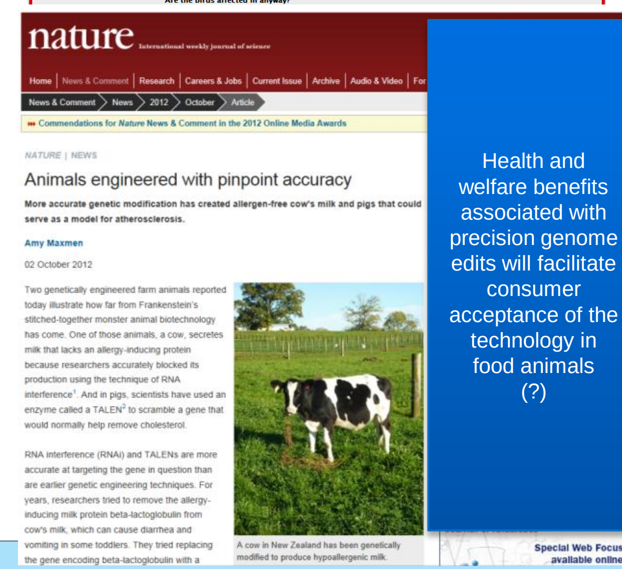
Are the Roslin/Cambridge GM chickens resistant to bird flu?

No. They can be infected with bird flu (avian influenza) and succumb to clinical disease but they do not transmit the infection to other birds. This is important because it would help to stop flu outbreaks spreading within and between poultry flocks.

What is the genetic modification in the chickens that stop them transmitting bid flu?

It is a small molecule that is specifically designed to stop the flu virus reproducing after it has infected a chicken. This RNA molecule mimics the region of the flu virus genome that controls virus replication. It is referred to as a "decoy" because production of these mini RNA molecules binds and diverts the flu virus enzyme (the polymerase) from its crucial functions that are required for virus replication.

Are the birds affected in anyway?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Animals engineered with pinpoint accuracy

More accurate genetic modification has created allergen-free cow's milk and pigs that could serve as a model for atherosclerosis.

Amy Maxmen

02 October 2012

Two genetically engineered farm animals reported today illustrate how far from Frankenstein's stitched-together monster animal biotechnology has come. One of those animals, a cow, secretes milk that lacks an allergy-inducing protein because researchers accurately blocked its production using the technique of RNA interference[1]. And in pigs, scientists have used an enzyme called a TALEN[2] to scramble a gene that would normally help remove cholesterol.

RNA interference (RNAi) and TALENs are more accurate at targeting the gene in question than are earlier genetic engineering techniques. For years, researchers tried to remove the allergy-inducing milk protein beta-lactoglobulin from cow's milk, which can cause diarrhea and vomiting in some toddlers. They tried replacing the gene encoding beta-lactoglobulin with a

A cow in New Zealand has been genetically modified to produce hypoallergenic milk.

Special Web Focus available online

Health and welfare benefits associated with precision genome edits will facilitate consumer acceptance of the technology in food animals (?)

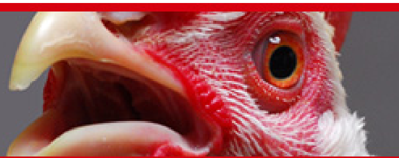
“Pioneering animal genetic improvement to help nourish the world”

Genus

Summary

- The world is a hungry place and will continue to require greater quantities of higher quality food
- Resources are finite and livestock agriculture will need to drive efficiency (more from less)
- Genetic improvement has played a major role in improving efficiency to date and will probably need to play an even greater role in the future
- Some species have greater opportunity than others.
- Selective breeding in conjunction with newer technology could hold the key to step changes in genetic improvement and deserve consideration

GM CHICKENS



Public Interest
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