

Potential impact of animal biotechnology on food and economic security in developing economies

Steve Kemp

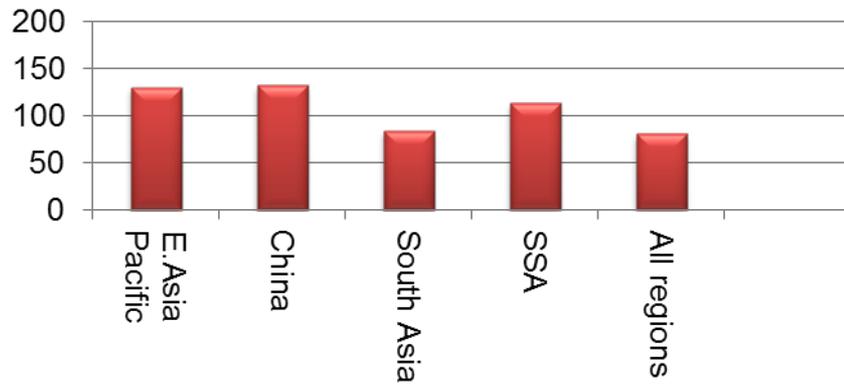
International Livestock Research Institute



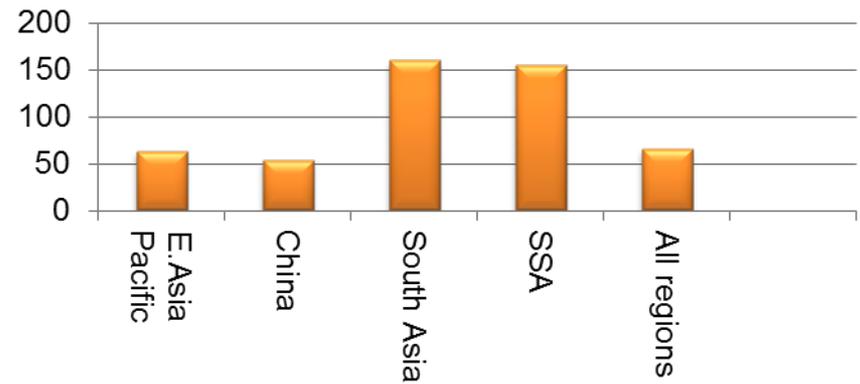
**Second International Workshop for Regulation of Animal Biotechnology:
Preparing Markets for New Animal Product Opportunities**
(August 18- 21, 2014 - Brasilia, Brazil)

% growth in demand for livestock products 2000 - 2030

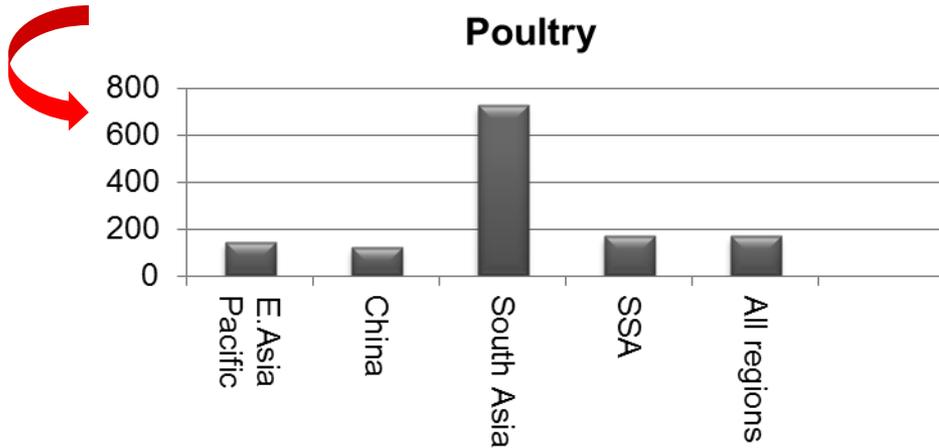
Beef



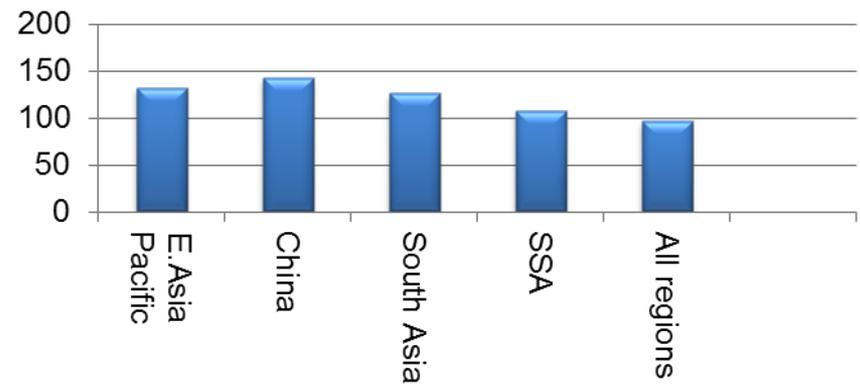
Pork



Poultry

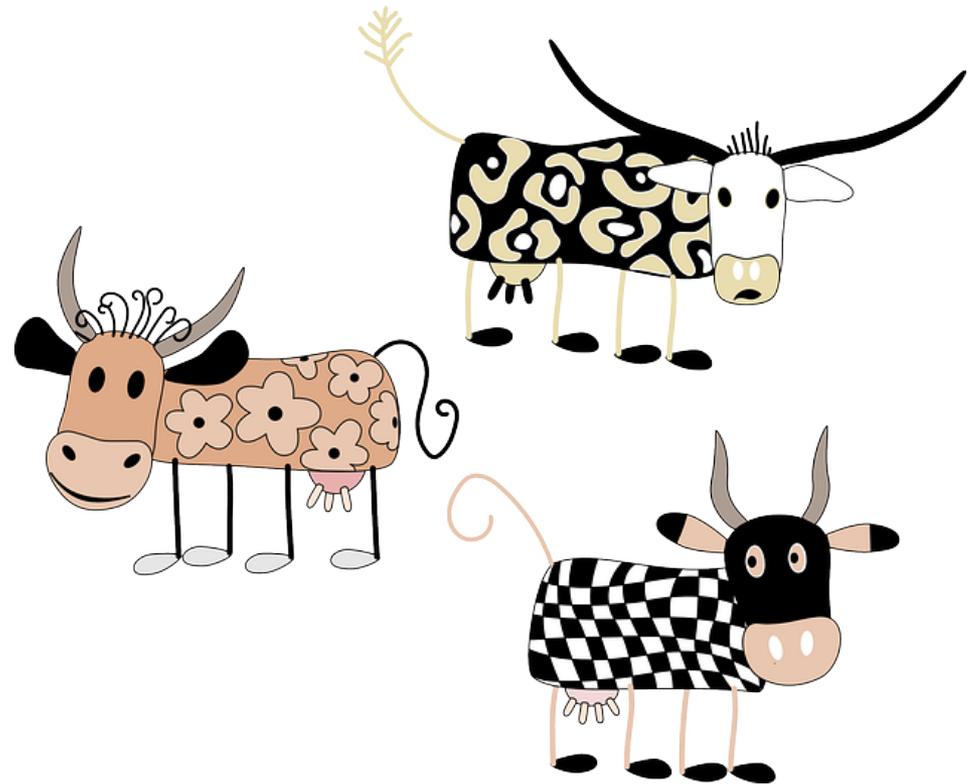


Milk

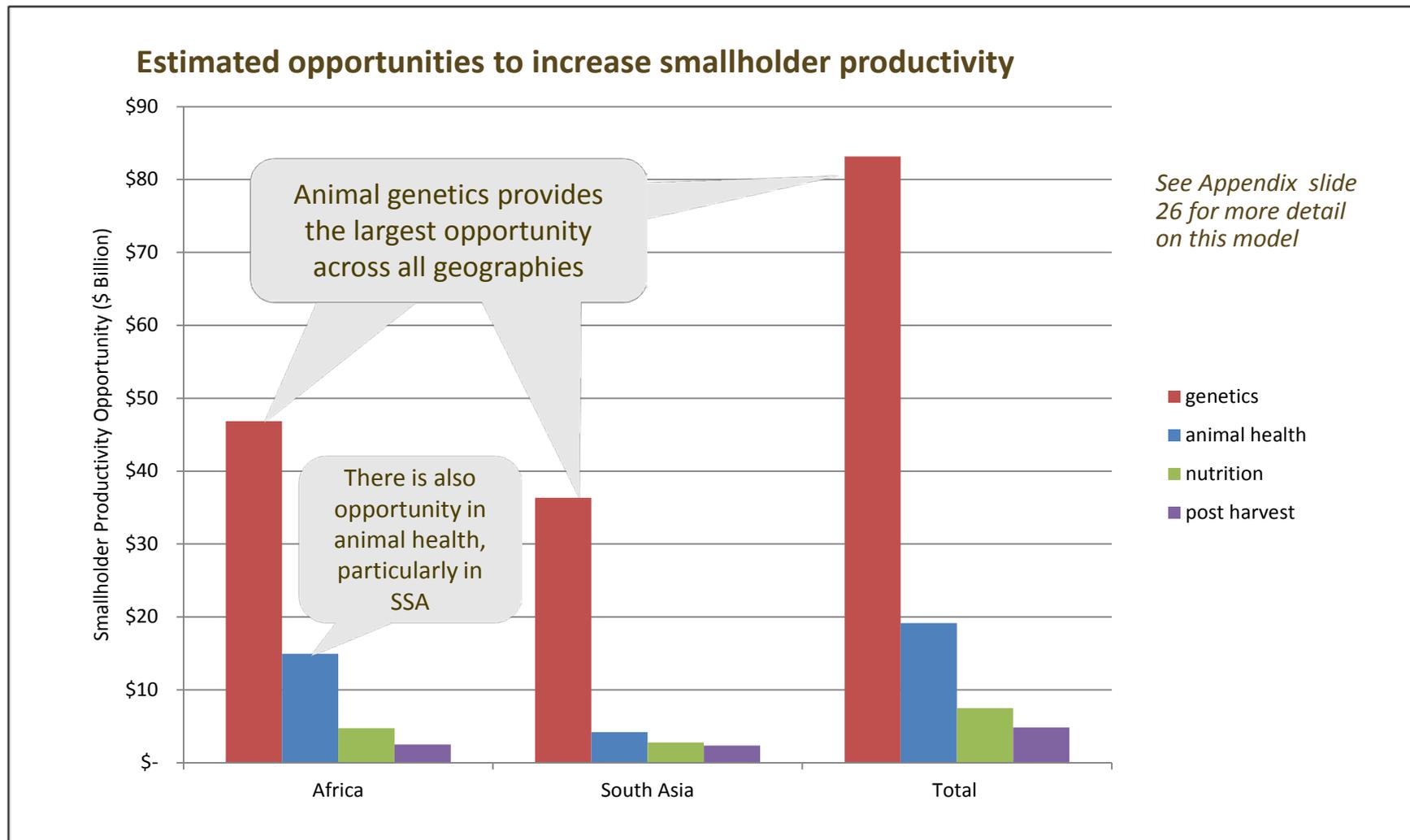


Livestock yield gaps are hard to measure - but significant

- Significant gaps exist
- Opportunities to address livestock yield gaps:
 - Technology:
Health, genetics, feed
 - Non-technical:
Market access, input delivery
- Need to target
 - By commodity
 - By system

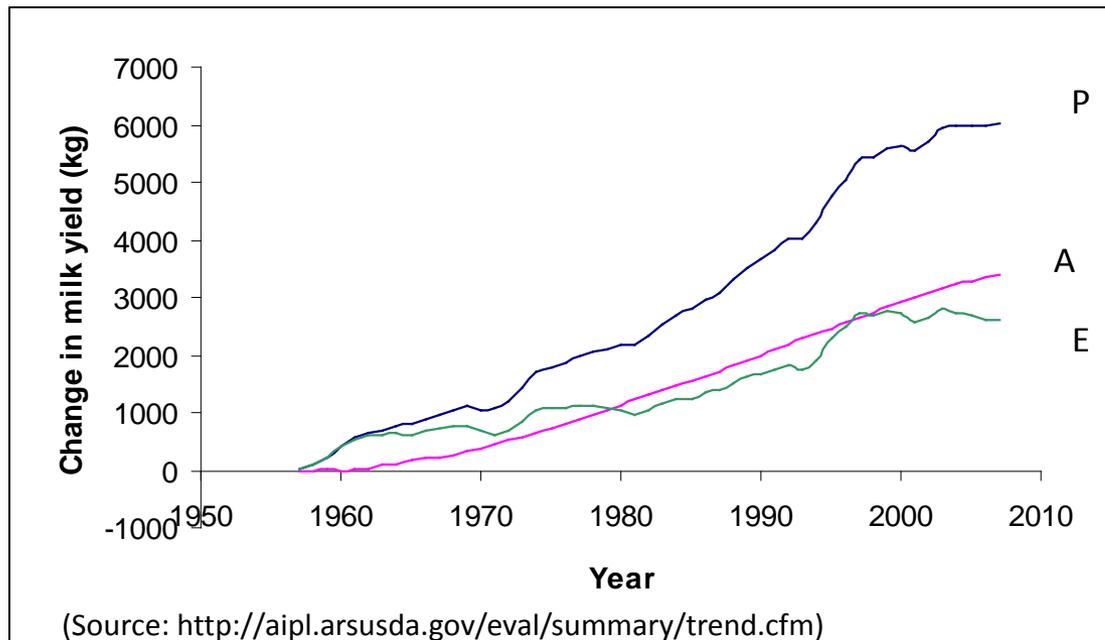


Health and genetics are the greatest opportunities to improve sustainable productivity for our target species



Sources: estimates based on BMGF analytical models referencing multiple data sources including: Oct 4-5 Livestock Landscape Analysis Expert Panel Workshop; Oct 27 Livestock Foundation Genetics Workshop; Expert Interviews; FAOSTAT; OIE Technical Disease Cards; the Center for Food Security and Public Health Animal Disease Information; OIE-WAHID database; Merck Veterinary Manual; 2011 Market Probe market research for Kenya, Ghana, Nigeria, Ethiopia

Genetic selection, interacting with environment, drives 'improvement'



Changes in milk yields of US Holstein cows

Mean phenotype (P), breeding value (A) and environmental effects ($E = A - P$).
Results relative to 1957 base (mean yield 5859kg).

In the industrial world genetics has driven dramatic improvements in productivity

- **Homogeneous environments** (systems, markets, health, regulations, policies.....)
- **Homogeneous genetics** (a handful of well defined breeds)
- **Superb data recording** driving selection schemes

Achieving genetic gain in developing countries – the same biological rules but different *environments*

We must take account of the realities of small-scale livestock producers.

Diversity of:

- Environment
- Climate
- Feeds available
- Endemic diseases
- Local market context
- Infrastructure
- Institutions



Achieving genetic gain in developing countries – the same biological rules but different *environments*

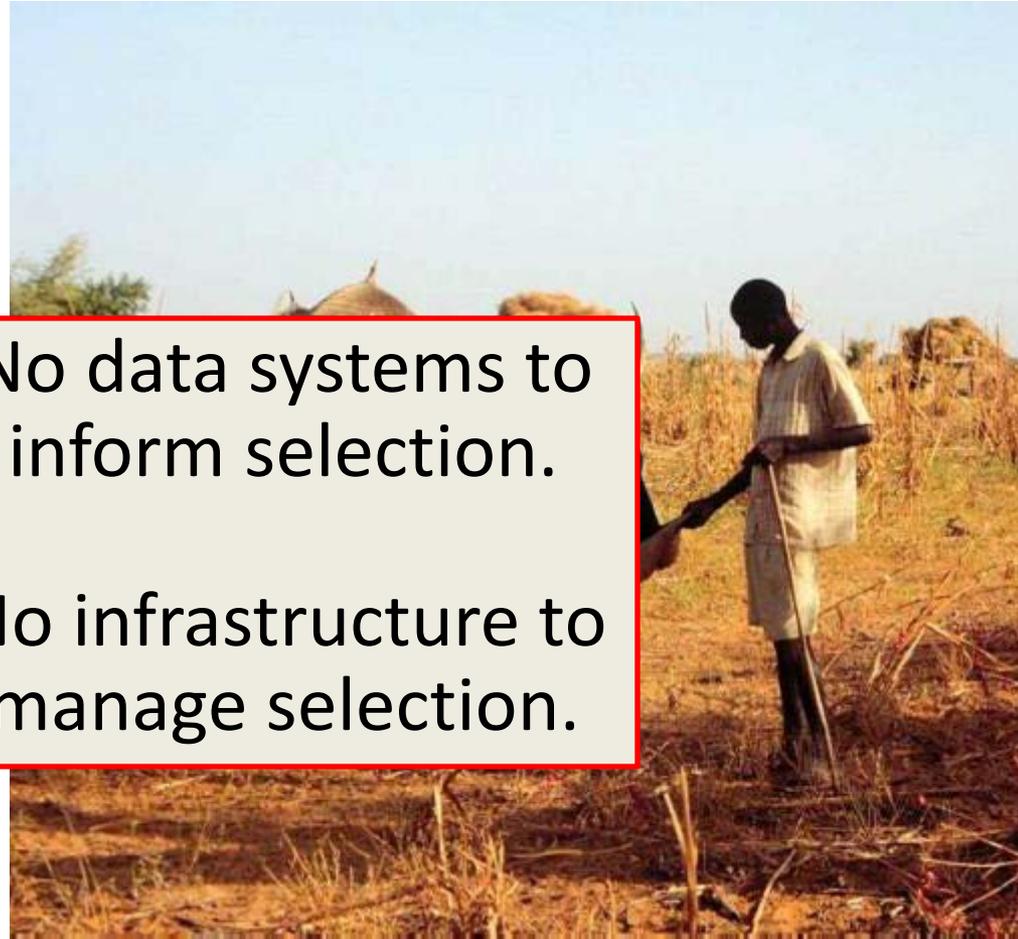
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Diversity of:

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No data systems to inform selection.

No infrastructure to manage selection.

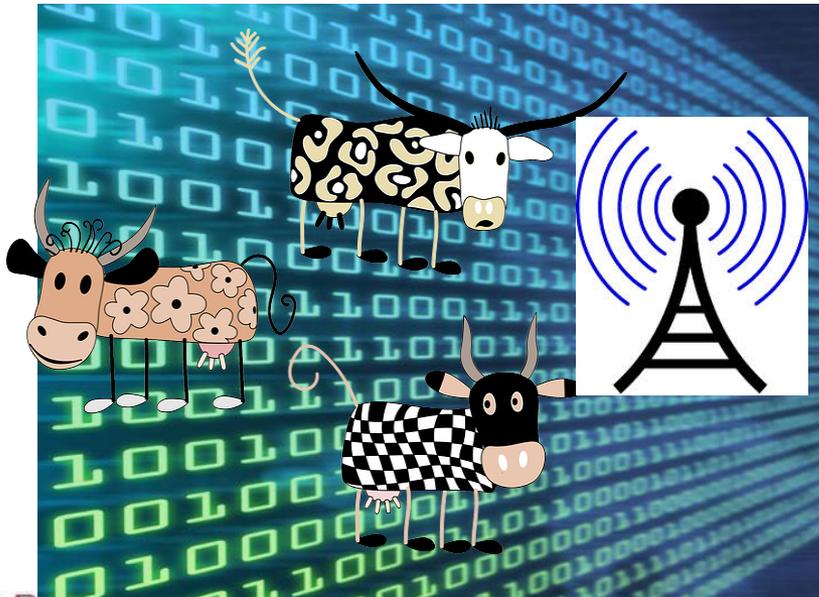


Genotype data is cheap and easy to obtain. Phenotype data remains a problem.



Can we skip a generation of technology?

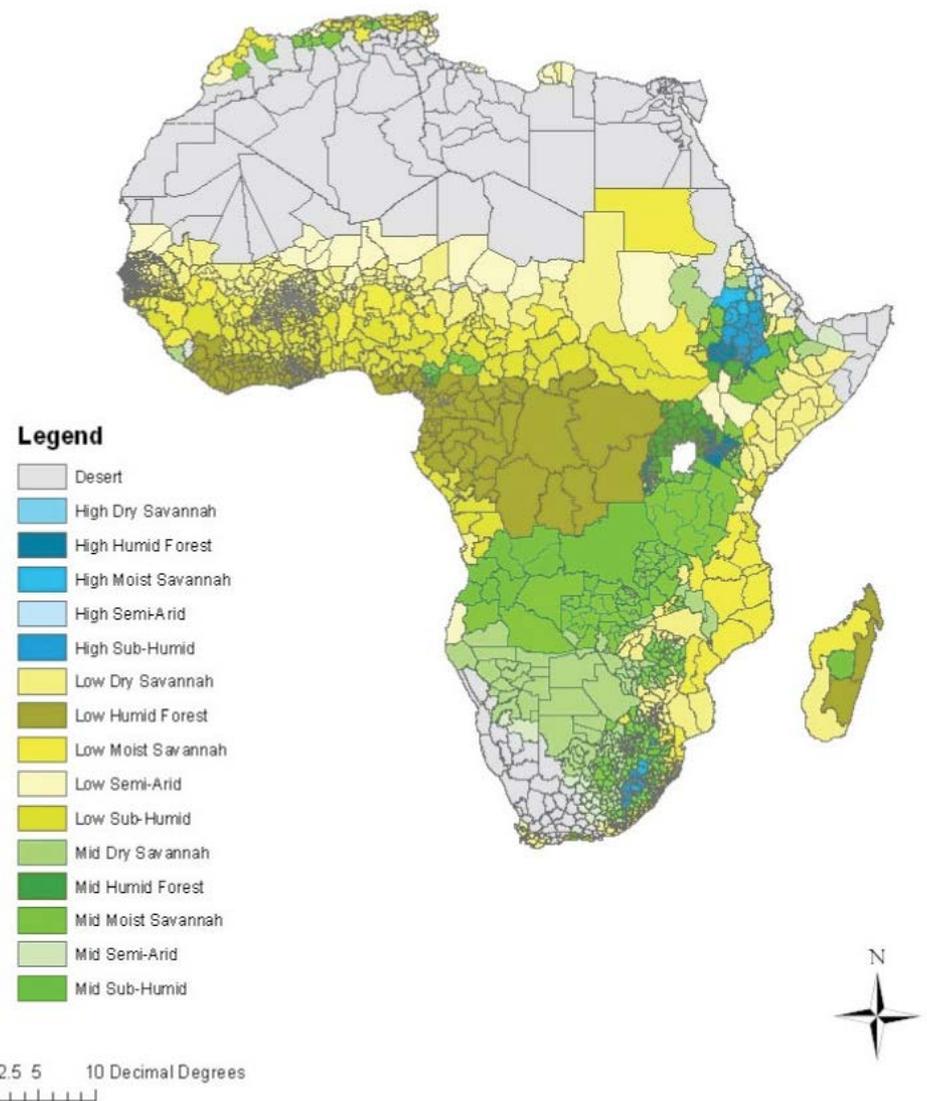
- Fast, light, cheap performance data harvesting.
 - Cheap sensors, mobile platforms, crowd sensing.....
 - Simultaneously providing management information to the farmer and performance data to the breeder.



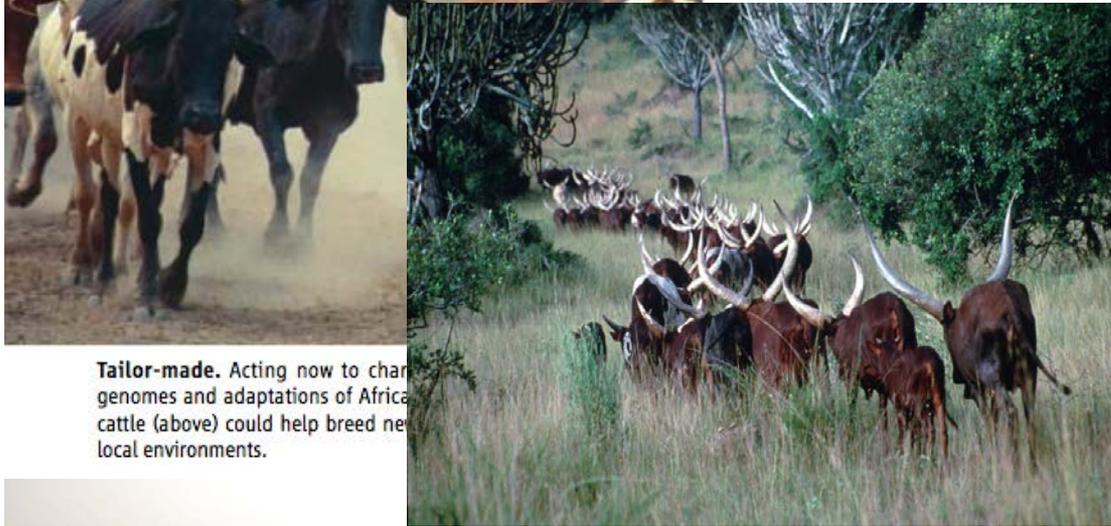
Diversity of *environments* has created diversity of genetics. Let's not discard it.



Tailor-made. Acting now to characterize and exploit the unique genomes and adaptations of Africa's livestock, such as the NAMEK cattle (above) could help breed new genotypes tailored to changing local environments.



Where are the most important, hardest to find, genetics?



Tailor-made. Acting now to characterize genomes and adaptations of African cattle (above) could help breed new local environments.



African Trypanosomiasis

African Trypanosomiasis

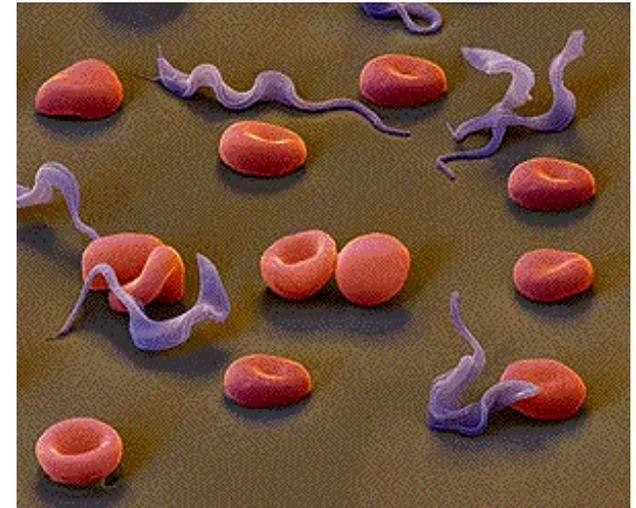
- Caused by extracellular protozoan parasites – *Trypanosoma*
- Transmitted between mammals by Tsetse flies (*Glossina* sp.)
- Prevalent in 36 countries of sub-Saharan Africa.

In cattle

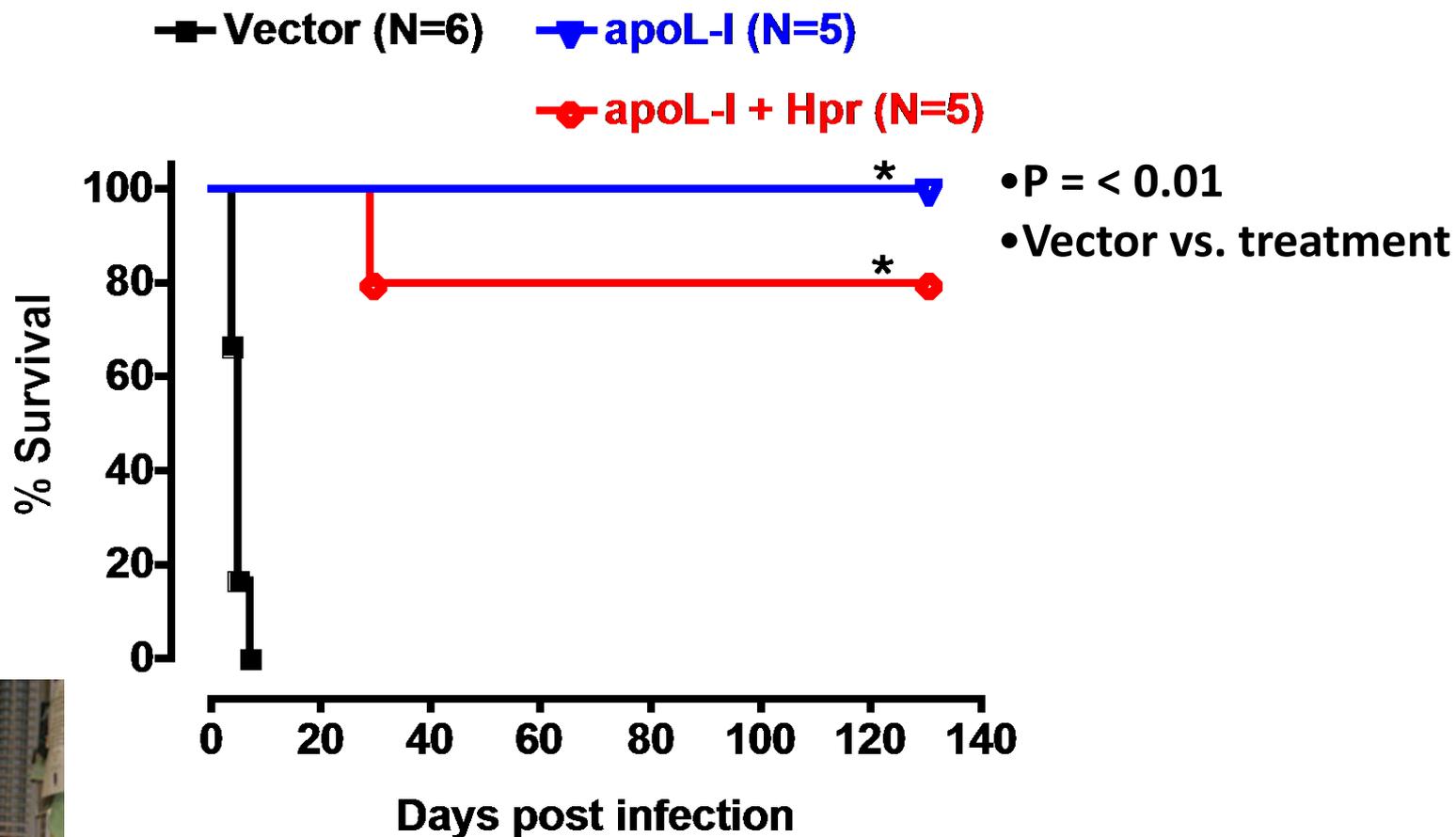
- A chronic debilitating and fatal disease.
- A major constraint on livestock and agricultural production in Africa.
- Costs US\$ 1 billion annually.

In human (Human Sleeping Sickness)

- Fatal
- 60,000 people die every year
- Both wild and domestic animals are the major reservoir of the parasites for human infection.



Complete protection from *Trypanosomes* by baboon ApoL-I in transiently transgenic mice





Tumaini

A cloned Kenya Boran calf
made by SCNT from a Boran
embryo fibroblast cell line

New tools allow us to look in new places for sources of variation – including wildlife

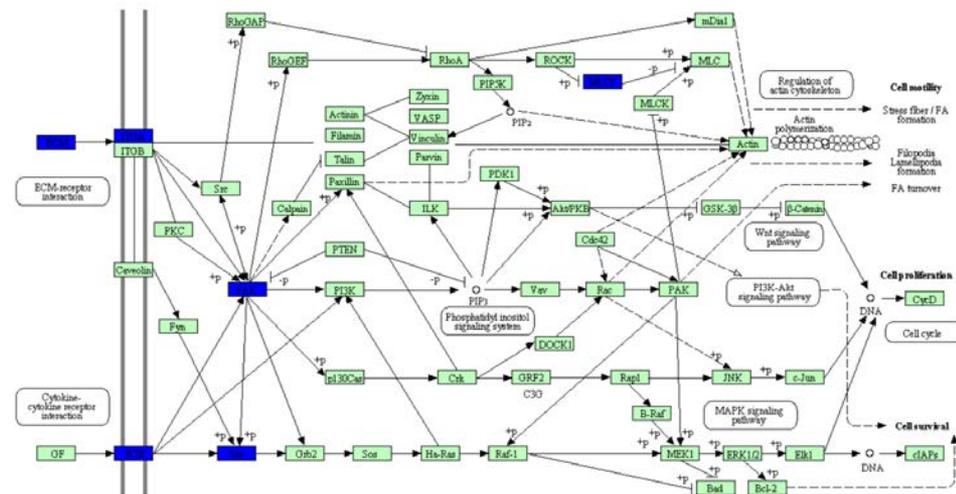


“traditional” linkage mapping requires crosses – so initial discovery is limited to variants within a species

Cow NDama	KFITRRPSLKTLQEKGLIKDQIFGSPHHTLCEREKSTVPRFVKQCI EAVEK
Cow Boran	KFITRRPSLKTLQEKGLIKDQIFGSHHTLCEREKSTVPRFVKQCI EAVEK
Human	KFISRRPSLKTLQEKGLIKDQIFGSHLHTVCEREHSTVPWFVKQCI EAVEK
Pig	KFITRRPSLKTLQEKGLIKDQIFGSHLHTVCERENSTVPRFVKQCI EAVEK
Chicken	KFISRRPSLKTLQEKGLIKDQIFGSHLHLVCEHENSTVPQFVRQCI KAVER
Salmon	KFISRRPSMKTLQEKGI IKDRVFGCHLLALCEREGTTVPKFVRQCV EAVEK



Comparative gene network and sequence analysis allows to ask new kinds of questions about genomes – eg “*what is different about this (group of) species compared to all other mammals*”

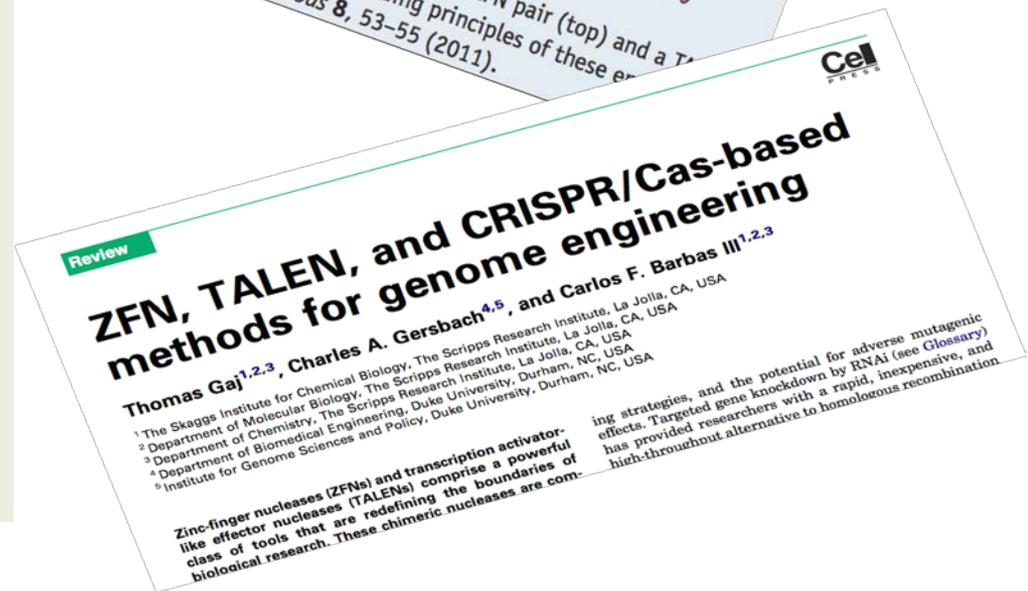
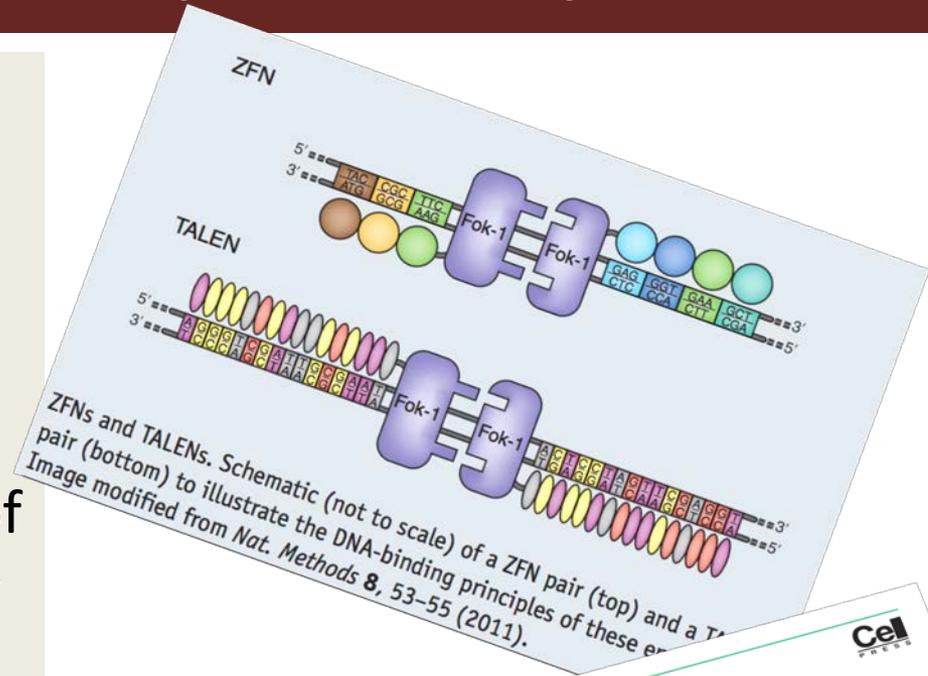


Time for a new search for variation underlying tropical adaptation and productivity

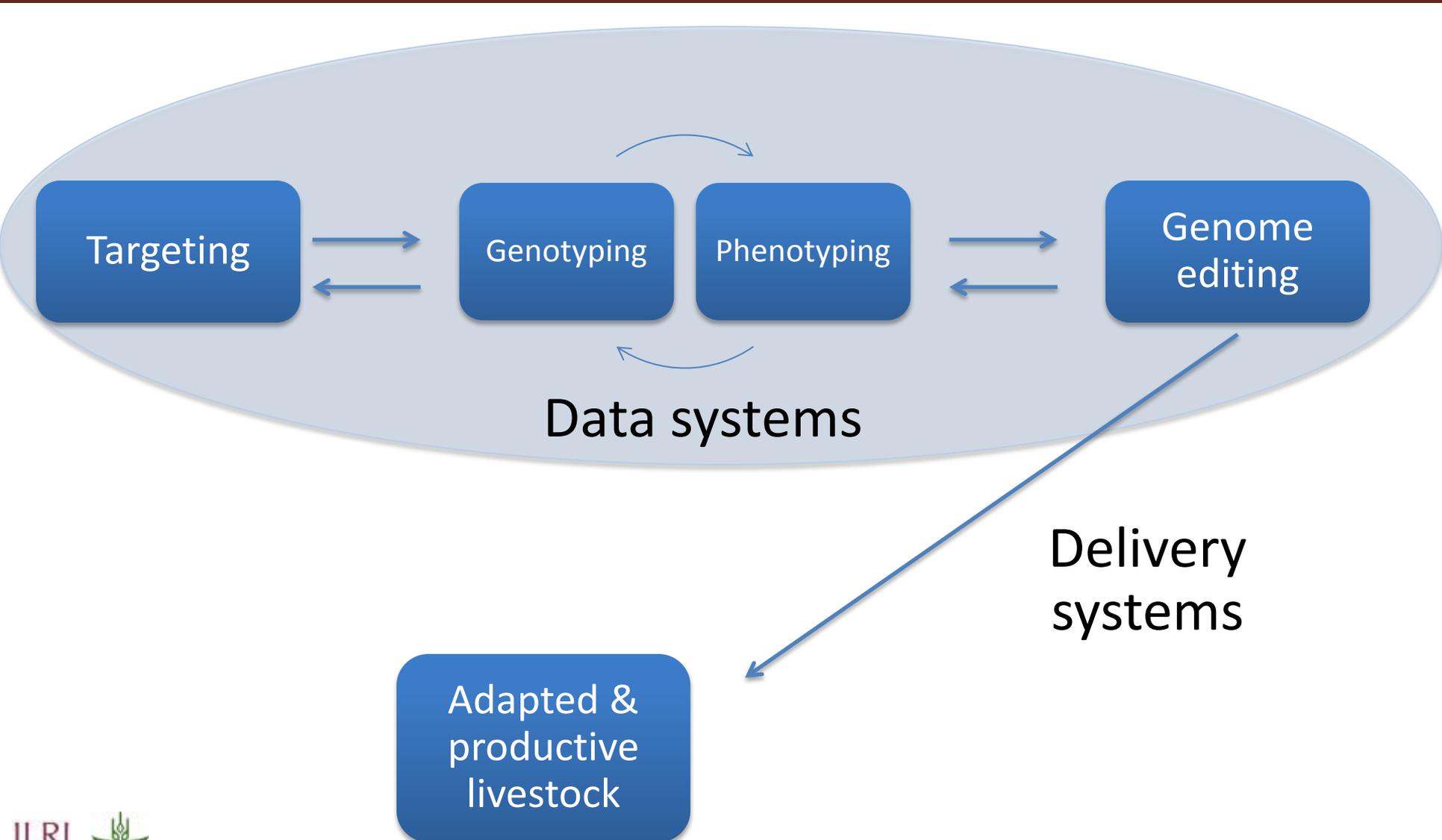
Identify and make use of the genetics underlying natural variation.

There has been no systematic search for the genomic basis of adaptation. Because until now we have had no validation tools and no delivery tools.

New Genome Editing tools change the landscape.

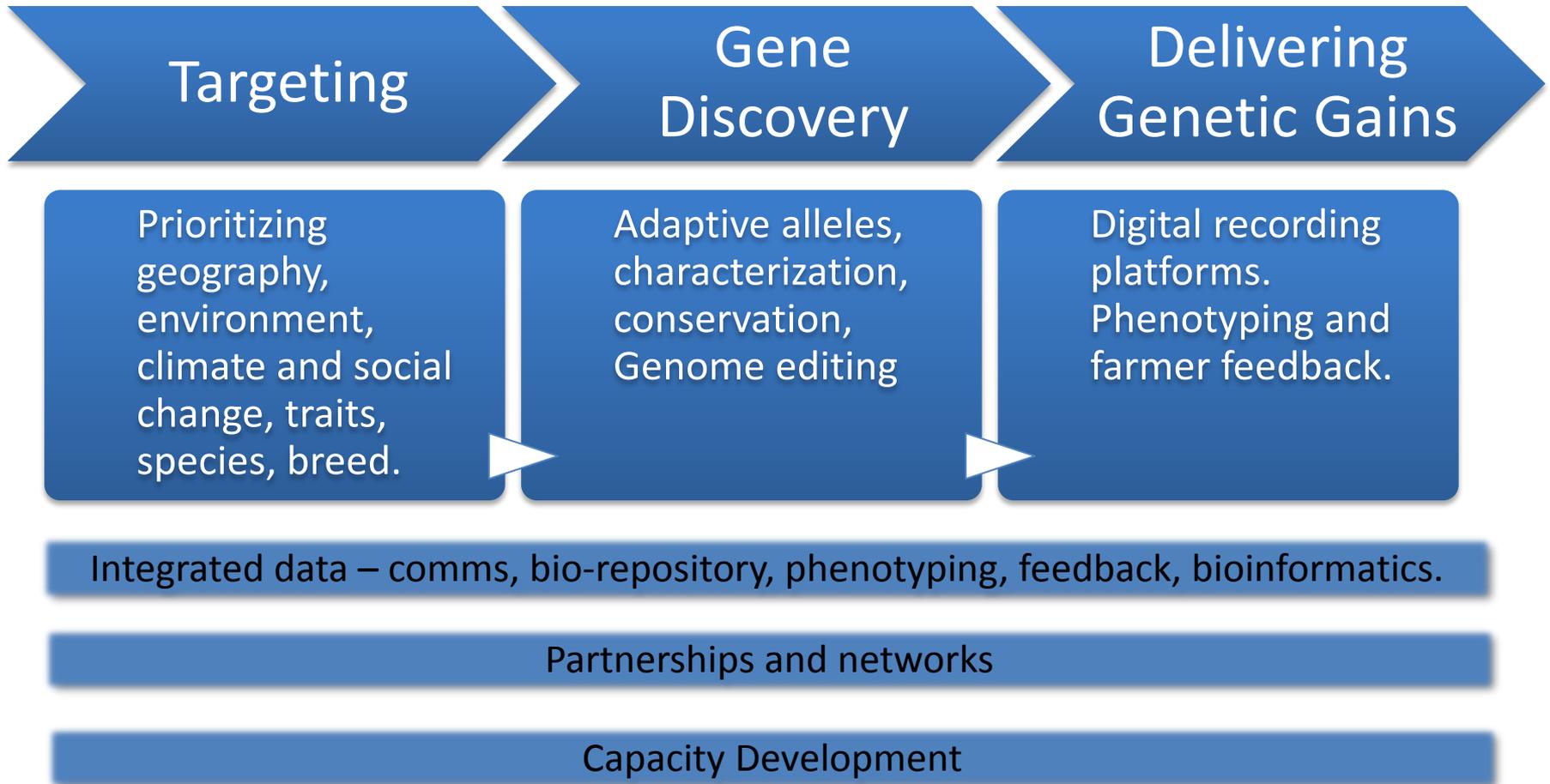


Identify and deliver variants associated with adaptation



LiveGene

Delivering improved genetics to the world's small-scale livestock keepers



Targeting

Gene
Discovery

Breeding &
Delivery

Integrated data – comms, bio-re

Informatics

otyping, feedback, bioinformatics.

Partnerships and networks

Capacity Development

Poultry Genetics Projects

Dairy Genetics Projects

Functional Genomics of Tropical adaptation and Gene Editing

Quantitative
Genetics

Quantitative
Genetics

Livestock
Geo-Wiki
plus

High
throughput
genotyping
platform

Livestock Genomics
Platform

Advanced phenotyping tools

LiveGene – examples of outcomes

- A choice of improved genetics for small/medium scale production systems characterized and made available
- NARS equipped to continually and sustainably improve and deliver their genetic resources
- An independent poultry testing and evaluation center for SSA
- A Livestock Genomics Platform for identifying and exploiting allelic variations associated with tropical adaptation which is integrated with breeding programs
- Including a reproductive technology platform developing and applying a range of technologies to improve delivery of appropriate genetics.
- IP ownership and policy models that facilitate access to improved genetics for African small holders
- An open data and sample exchange system acting as a hub for expertise on tropical livestock functional diversity: from targeting, to genome sequence to phenotype to farmer feedback

Why no silver bullets for Africa ?

Are we imposing a developed world view of benefits on people facing very different risks ?



We must be braver and clearer in making the case for biotechnology

Who should make the risk/benefit decisions?



Thank you

better lives through livestock

ilri.org

Video 'Developing disease-resistant cattle for Africa'

<http://vimeo.com/74942619> 11 minute version

<http://vimeo.com/74940697> 3 minute version

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better lives through livestock

ILRI is a member of the CGIAR Consortium

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Some breeds are resistant



A variant in N' Dama ARHGAP15 accounts for part of that resistance

H → P mutation at AA282

Cow NDama	KFITRRPSLKTLEKGLIKDQIFGSP	LHTLCEREKSTVPRFVKQCI	EAVEK
Cow Boran	KFITRRPSLKTLEKGLIKDQIFGSH	LHTLCEREKSTVPRFVKQCI	EAVEK
Human	KFISRRPSLKTLEKGLIKDQIFGSH	LHTVCEREHSTVPWFVKQCI	EAVEK
Pig	KFITRRPSLKTLEKGLIKDQIFGSH	LHTVCERENSTVPRFVKQCI	EAVEK
Chicken	KFISRRPSLKTLEKGLIKDQIFGSH	LHLVCEHENSTVPQFVRQCI	KAVER
Salmon	KFISRRPSMKTLEKGIKDRVFGCH	LLALCEREGTTVPKFVRQC	VEAVEK

Gene frequency

	N'Dama	Boran
282P-Allele	0.990	0.125
282H-Allele	0.010	0.875

Wild genomics

Eg Comparing giraffe and okapi with everything

