Transgenic Animals for Agriculture

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Since 1985 –

- **over 200 types of transgenic large animals produced (for review see Tan et al. 2012, Advs Genet)**
- **over 25 species of fish genetically engineered**
- **multiple constructs transferred into poultry**

Agriculture

Currently > 60 constructs

- **Modification of milk components**
  - **Increased nutrition**
  - **Functional foods**
  - **Increased production**
  - **remove allergens**

- **Modification of wool growth**

- **Improved growth**

Agriculture

- Improve digestion/nutrition
  - decrease pollution

- Disease resistance

- Improve health/welfare of animals
  - milk production in sows

Currently available transgenic animals

Source	Country	Gene	Species
Du et al. 1992	Canada	csGH	Salmon
Martinez et al. 1996	Cuba	tGH	Tilapia
Bleck et al. 1998	USA	bα-lac	Pig
Golovan et al. 2001	Canada	*E. coli* phytase	Pig
Van Berkel et al. 2002	Netherlands	hLactoferrin	Cattle
Brophy et al. 2003	New Zealand	bß-cas, bκ-cas	Cattle
Maga et al. 2006	USA	hLysozyme	Goat
Wall et al. 2005	USA	sLysostaphin	Cattle
Jabed et al. 2012	New Zealand	ß-lactoglobulin KO	Cattle

GE livestock for Agriculture - 2013

Some GE animals available today

1. the enviro-pig™
2. bovine alpha-lactalbumin pigs
3. human lysozyme goats

the EnviroPig

-Expresses *E. coli* phytase in salivary gland

-Can digest about 70% of plant phytate consumed

- No need for supplemental phosphorus

- 70% reduction in excreted phosphorus

- Should be a boon to the environmentalists

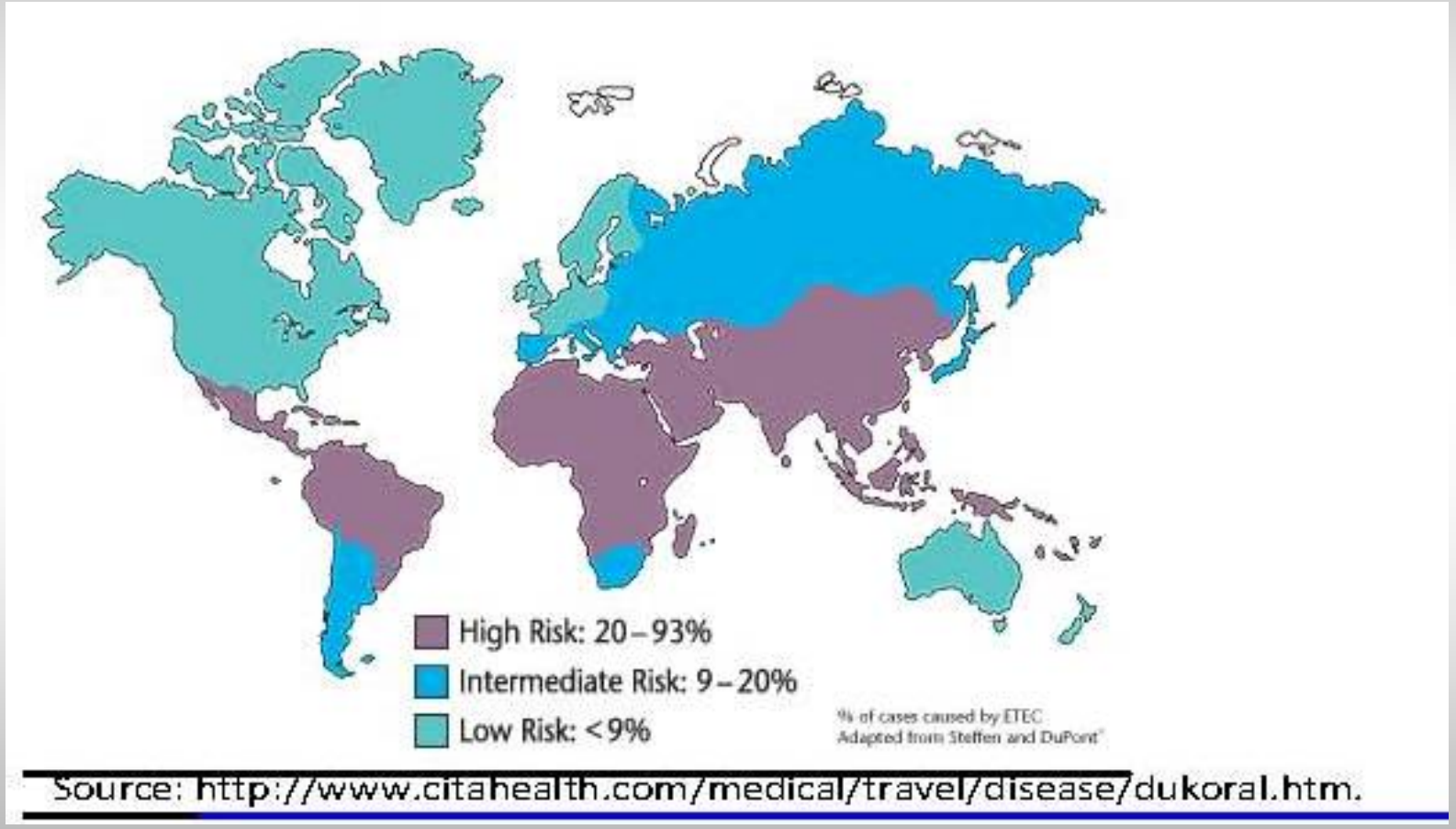
- Currently in frozen storage

Bovine α-lactalbumin pigs

- **Express TG only in lactating mammary gland**
- **Sows produce more milk**
- **Baby pigs grow faster, heavier at weaning**

Human lysozyme Transgenic goats

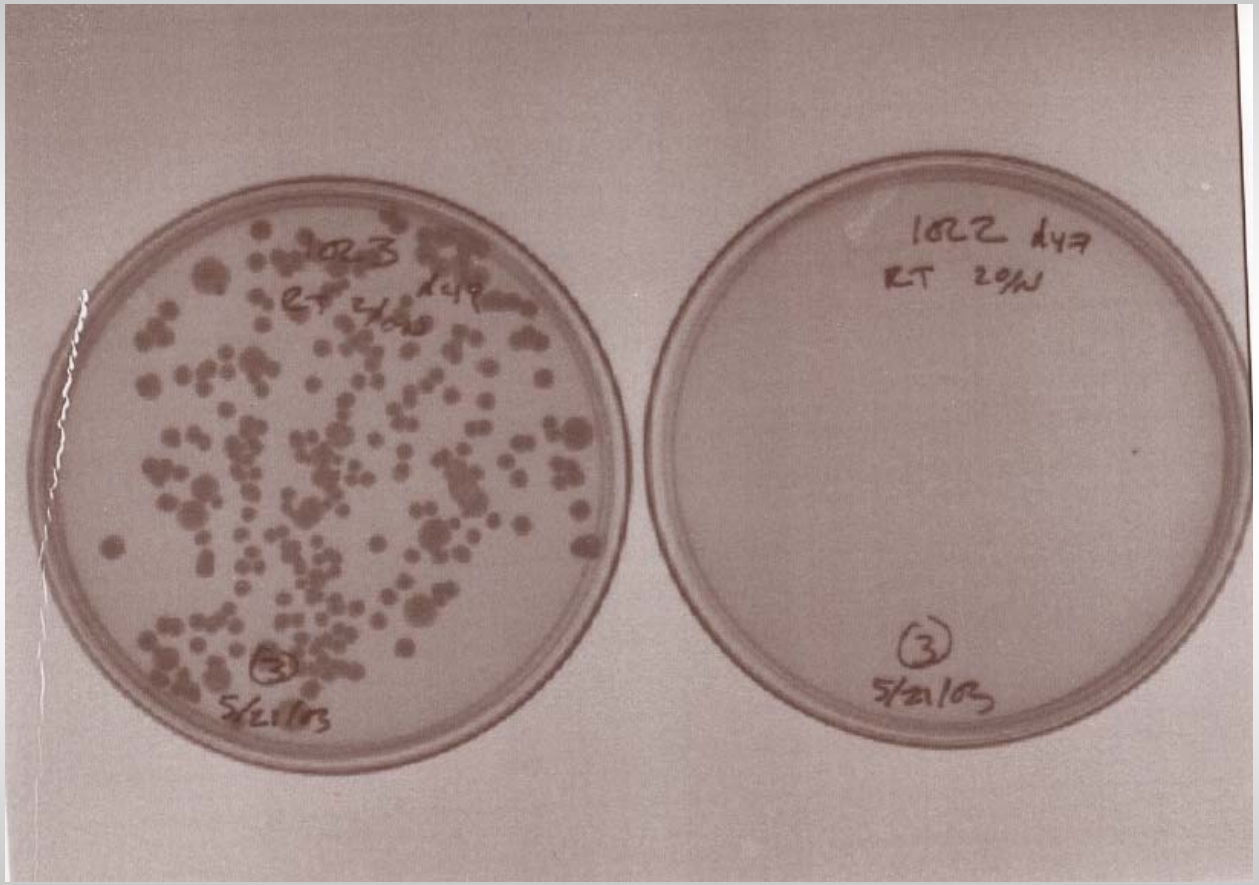
World diarrhea map – E. coli



hLZ transgenic goats at UC Davis

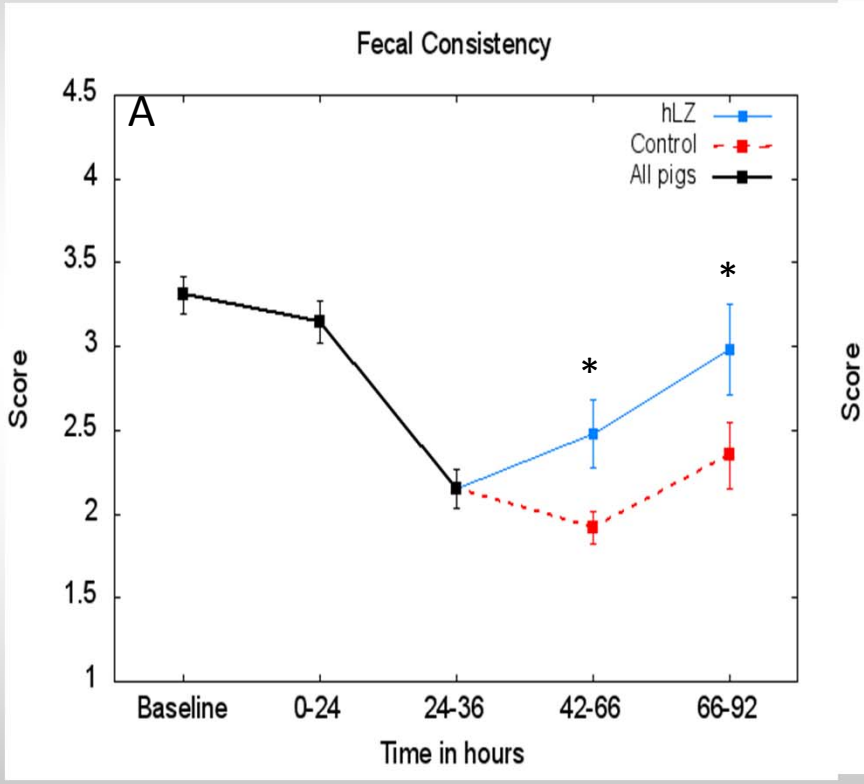
- Currently have 6th generation
- Most hemizygous; now have homozygous
- Express 270µg/ml hLZ (68% of human)
- Expresses only in mammary gland
- Demonstrated anti-microbial activity when fed to baby pigs

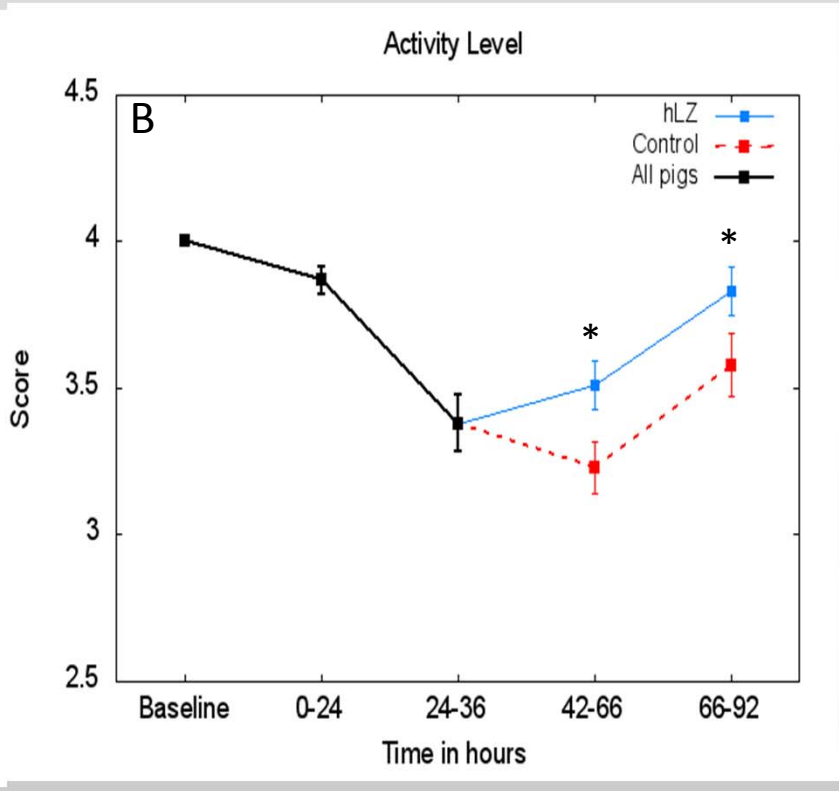
Anti-microbial activity



Control **Transgenic**

Clinical symptoms following E. coli infection






Conclusions:

Conclusions

GE livestock, poultry and fish will be necessary to feed the world in the future

Lines of animals are available today that may be useful in agriculture

Regulating: Process versus Product

Presence of TG DNA and protein in food product

	Meat	Meat	Milk	Milk
	TG-DNA	TG-Protein	TG-DNA	TG-Protein
Lactalbumin-pig	yes	no	yes	yes
EnviroPig	yes	no	yes	no
Lysozyme-goat	yes	no	yes	yes

Regulatory paradigm should reflect hazard and risk of harm balanced by potential benefit

- **In each of these three cases, protein is commonly consumed – phytase in GI tract bacteria, lactalbumin in dairy products, lysozyme in saliva**
- **Meat from all these animals does not contain transgene product – only transgene DNA**
- **Review process should reflect the product**

Limitations to the use of transgenic animals in agriculture

1) "Long" Regulatory timeframe
    a. regulatory issues are political

2) The absence of scientific or clinical data showing any harm

3) Opposition by activists

4) Food production is global and lack of harmonization impedes trade