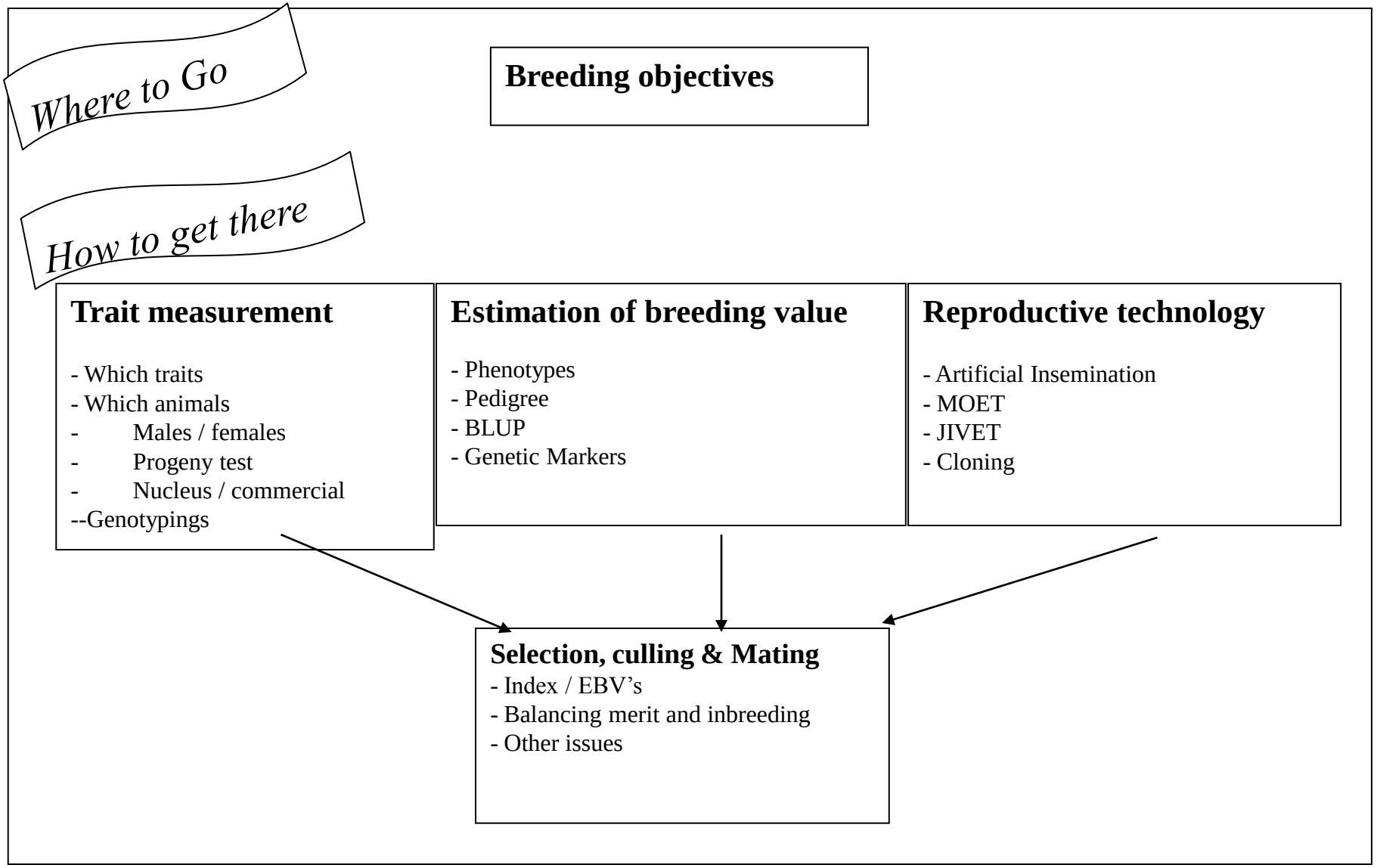
GENE 422/522

Genetic Evaluation and Breeding Program Designs

Genetic Evaluation and Breeding Program Designs

- A unit to integrate theoretical aspects with practical implementation
  - What is a breeding program?
  - What is a good breeding program? *(and for who)*
  - What are the technical/scientific issues
- Role of new technology fit in a breeding program?
  - Will it be useful, and will it be used?
  - Is it cost effective (e.g. genomic selection)
- Be aware of social economic context (can breeders afford the investment)
- Compare scenarios, asses the outcomes, compare benefits

Animal Breeding in a nutshell



Breeding objectives

- Define the clearly: Define Traits and their Value
- Include all traits, e.g. production, quality, health, longevity, welfare
- Economic Values
- “Other traits”

- risk of overemphasizing
  - genotypic information, how much of total variation does it account for?
  - certain traits, e.g. ‘type traits’…what is their real value?

Making genetic improvement

- Select only the very best
- Select based on *accurate* breeding values
- Select animals *early* in life

Example: Comparing current rates with potential rates of genetic improvement in sheep

Genetic progress in Sheep	Annual response ($ per ewe)		
	Potential	Realised *Since 2000*	Ratio (%)
Border (Maternal breed)	2.0	1.7	85
Merino	2.3	0.7	30
Terminals	1.8	2.0	111

Put think in perspective – what part are we working on?

Response

=

intensity …….i

accuracy…….r

genetic SD…….σ

/

generation interval…….L

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_G$$

It is important to know in a breeding program where the big gains are

About making genetic improvement

Progress is restricted due to need to balance

- ... between *early* and *accurate* selection
- ... multiple traits, limited information on some traits

→ Emphasis usually on traits that are easiest to improve

Genomic information:

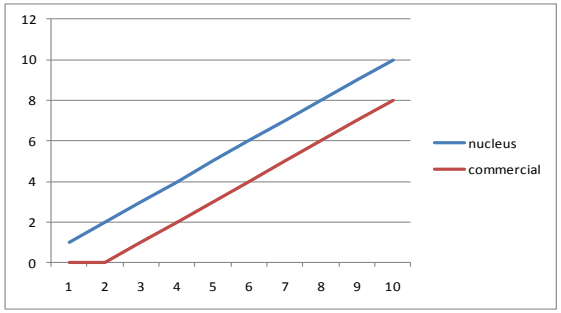
- Will increase selection accuracy
- Is early information
  → favours traits that are *hard to measure or late in life*: *HTML*
- Shifts the balance towards more emphasis on *HTML traits*

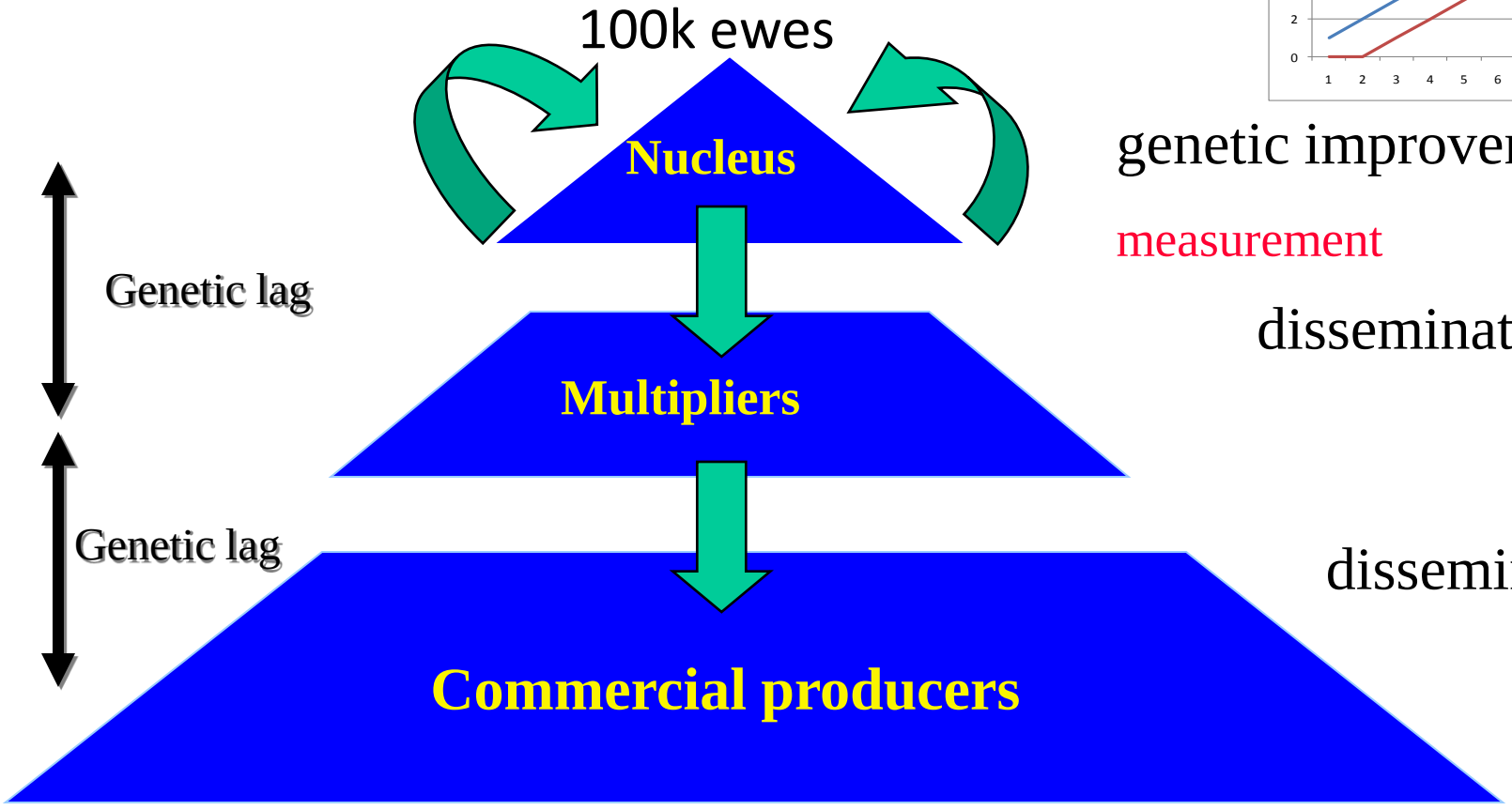
(Trait) measurement (= investment in breeding program)

- Which Phenotypes to measure? BrObj Traits? Correlated Traits?
- On which animals
  - Selection candidates or/and Relatives, Progeny, Crossbred progeny
  - Males, females, Nucleus, Commercial
- In which environment?
- Genotypes? On which animals

Structure of breeding programs

- *3-tier breeding program*





genetic improvement

measurement

dissemination

dissemination

Reproductive technologies

More offspring of the best breeding animals (AI, MOET)

- **Increased selection intensities**
- **Increased accuracies**
- **Decreased generation interval**

- **Increased Inbreeding**

Genetic Evaluation

- Predicting animals' breeding value
  - Aim for highest accuracy, and no bias
    - Need to account for non-genetic effects > Linear Model
    - Use of relative's information >> BLUP
      - requires pedigree recording

- BLUP/ Mixed Model is a comprehensive framework to adjust phenotypes for fixed effects, to include relative's info, to account for genetic trend, mating and selection

- BLUP can be extended to accommodate Maternal effects, Multiple Traits, Genetic Markers

- Need estimated of Genetic Parameter (heritabilities., Correlations)

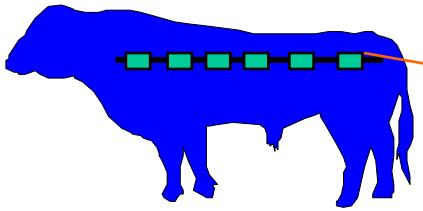
What we see, and the underlying model

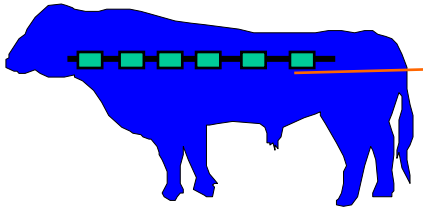
Phenotype

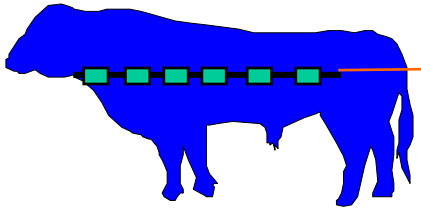
306Kg: +6 Animal 1

314 Kg: +14 Animal 2

310 Kg +10 Animal 3







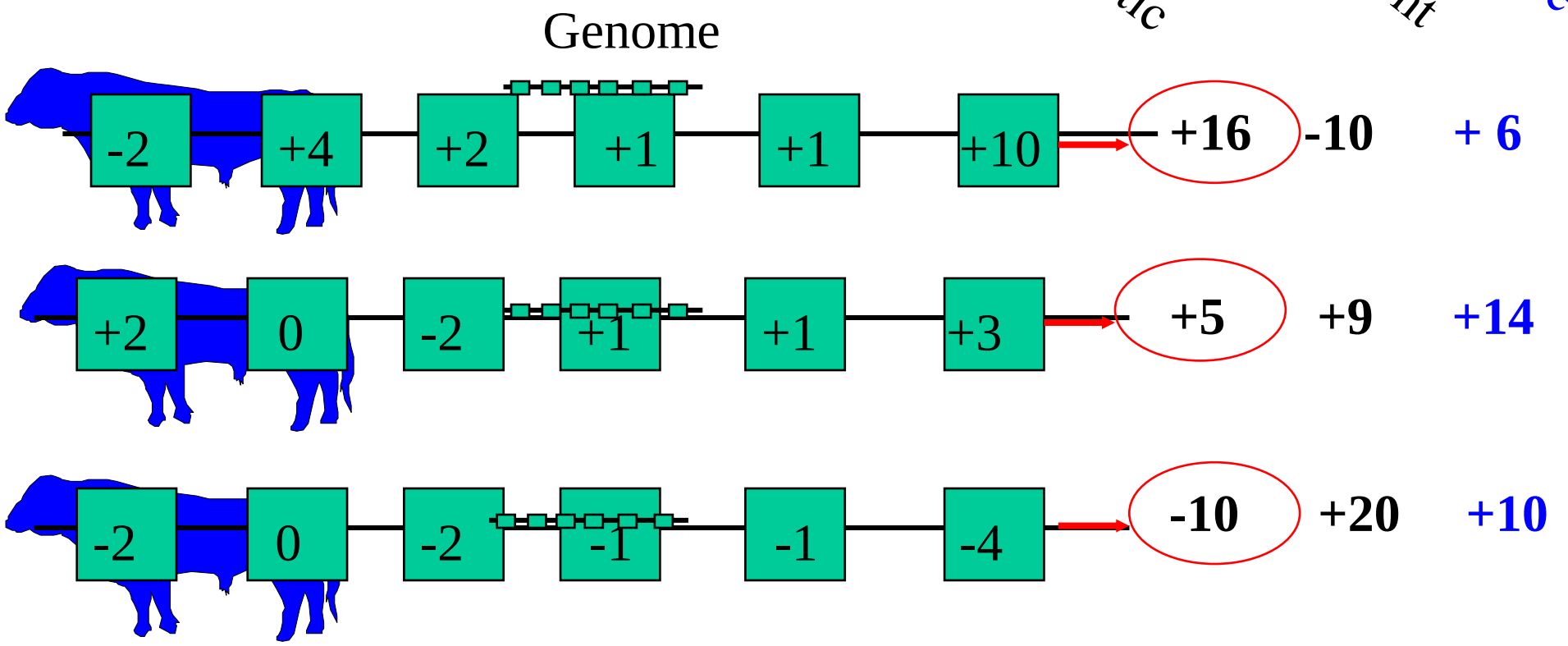
Genotype Environment

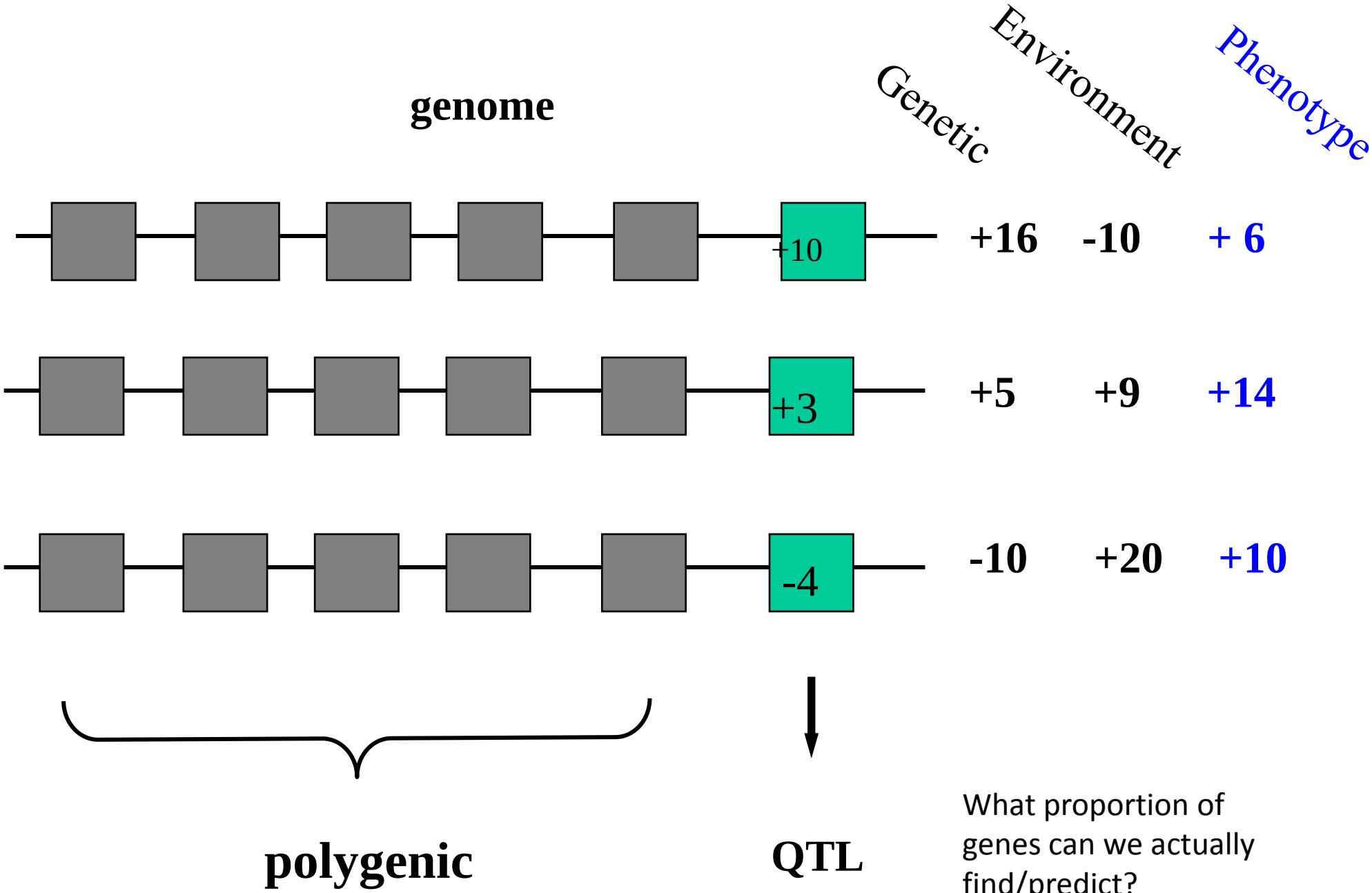
+16 **-10**

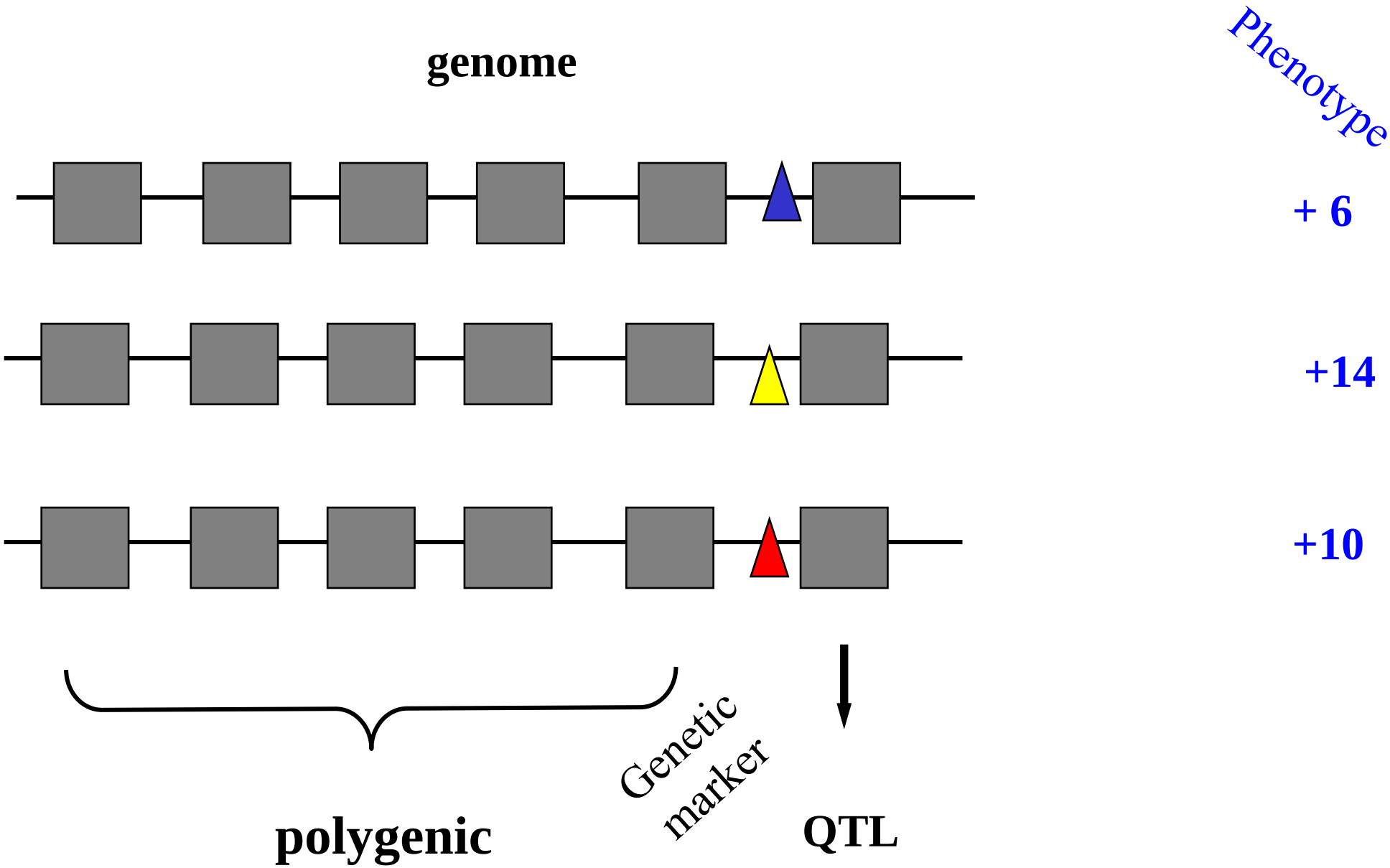
+5 **+9**

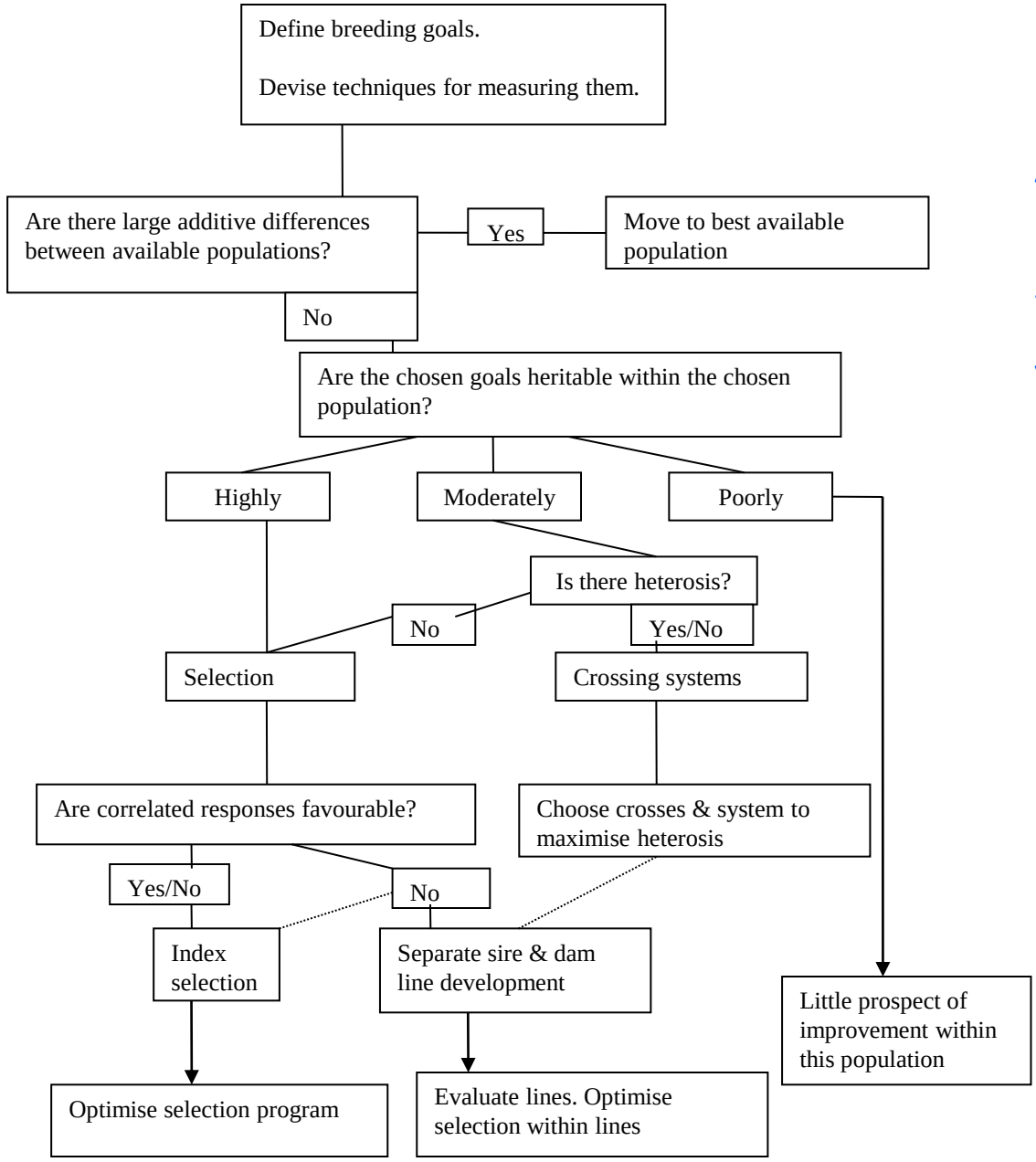
-10 **+20**

The ‘*real*’ values




genome
Genetic
Environment
Phenotype
+10
+16
-10
+ 6
+3
+5
+9
+14
-4
-10
+20
+10
polygenic
QTL
What proportion of genes can we actually find/predict?


genome
Phenotype
+ 6
+14
+10
Genetic marker
polygenic
QTL

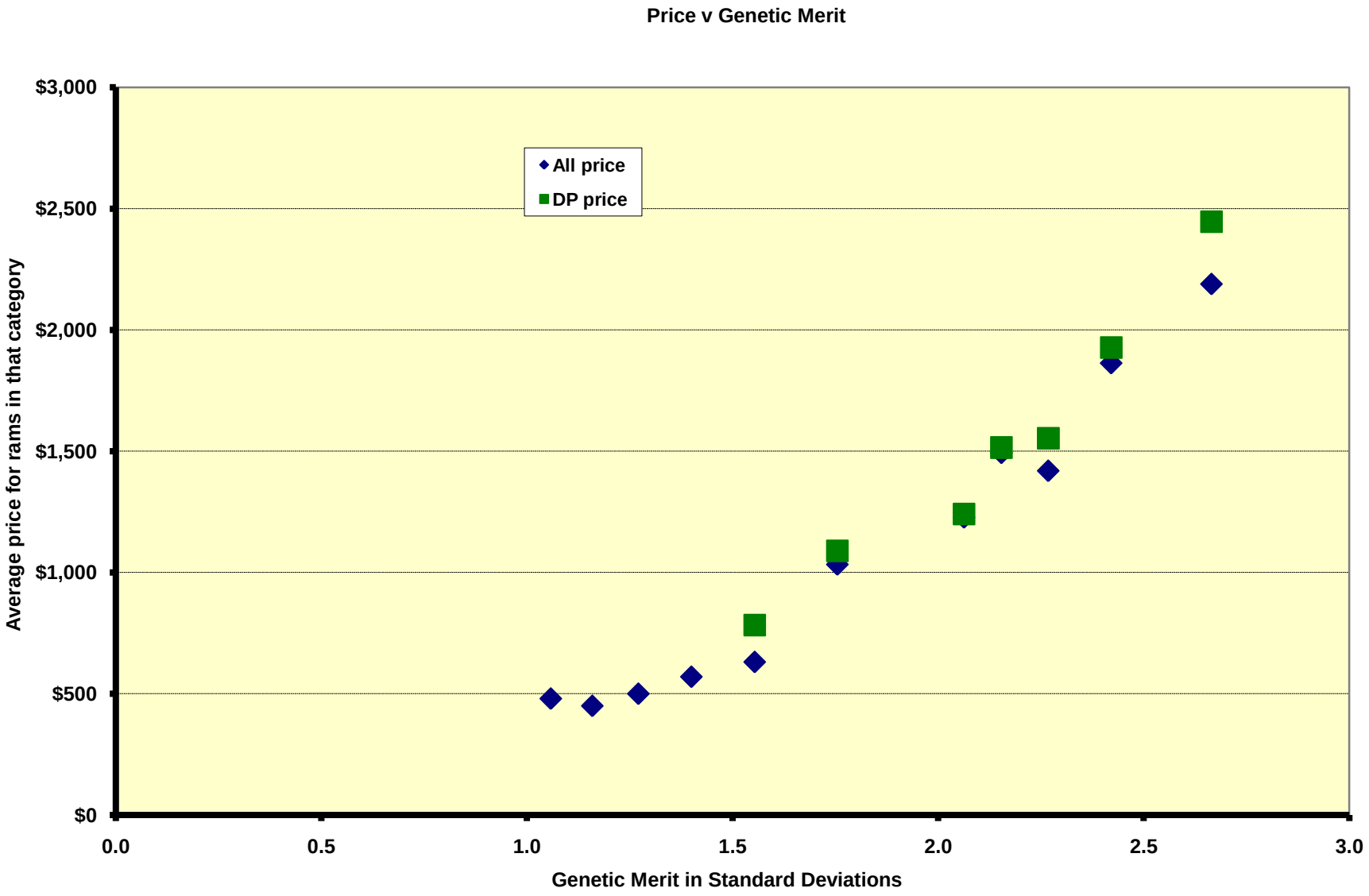


An old but useful model to decide where to start if you want to improve a production system (see notes)

Table. 1: Industry Production Systems

	Beef	Dairy	Sheep		Pigs/Poultry
			Meat	Wool	
Product:					
Primary	Meat	milk	meat	wool	meat/eggs
Secondary	Hides	meat	skins	meat	
Component products:					
	# progeny Wt/progeny Lean/wt	Yield/litre protein Fat	#progeny wt/progeny lean/wt	Kg/head Micron Weight	# progeny Wt/head lean/wt
Number of owners:					
Breeding	Large	small	Large	Moderate	Small
Production	Large	large	large	Large	Moderate/few
Degree of vertical integration:					
(i) Via ownership					
Breeding & production	Low	low	low	Low	Moderate/high
Whole chain	Low	low	low	Low	Moderate/high
(ii) Via price signals					
Breeding & production	Low/moderate	high	Low	Low	High
Whole chain	Low/moderate	high	Low	High	High
Ability to control the environment:					
Feed	Low/moderate	moderate	Low/moderate	Low/moderate	High
Biophysical	Low	Low/moderate	low	Low	Moderate/high
Market homogeneity:	Low/moderate	Moderate/high	Low/moderate	High (within FiD)	High
Degree of market influence:	Low	low	low	Low	Moderate
Offspring/female lifetime:	5 to 10	5 to 10	5 to 10	5 to 10	10’s to 100’s

Does a higher breeding value result in a higher revenue for the breeder?



Different industries respond differently to breeding challenges

Breeding Objectives

	Beef	Dairy	Sheep		Pigs/Poultry
			Meat	Wool	
Consistency of objectives over time:					
"Real"	mod/high	mod/high	mod/high	high	High
"Perceived"	moderate	moderate	moderate	mod/high	high
Importance of type traits in the objective:					
	mod/high	mod/low	moderate	high	low
Number of traits in the objective:					
"Real"	small	small	small	small	small
"Perceived"	high	high/few	small	high	small
Acceptance of "scientific" objectives					
	low/mod	mod/high	mod/high	low	high
Uniformity of objective across industry:					
	low/mod	high	mod/high	moderate	high
Variation between stud and commercial objectives:					
	mod/high	mod/low	mod/low	mod/high	low/0
Inclusion of feed efficiency in objective:					
	low	low/mod	moderate	low/mod	high

Making genetic improvement: Realized vs Potential

- Select only the very best
- Select based on *accurate* breeding values
- Select animals *early* in life

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Who benefits from investment in breeding?

Investment Perspectives

Perspective	Improvement in the national interest	Commercial breeding firm or breeder
Investment	Improvement of national breeding stocks	Improvement of own breeding stock
Time scale of investment (and return)	Long	Short
Returns to the investor	Large	Small
Reasons for investment:		
	(1) Value of improvement in national commercial production	(1) Returns from extra breeding stock sold
	(2) Permanent value of improvement over time	(2) Temporary value of competitive advantage
	(3) Value of successive improvements accumulates	(3) Successive improvements needed to maintain competitive position
	(4) Low risk of no returns	(4) High risk of no returns
Investment justified	Large	Small

Conclusion

- Animal breeding is a mix of technical and scientific issues

  (economic, statistical, genetic, biological)

- It is about decision making in a social economic context

Main Topics within the unit

- Genetic evaluation (EBV's)
- Genetic markers and molecular genetics
- Breeding objectives and multiple traits
- Breeding program design
- Applications