University of New England

Design of Breeding Programs

Decisions in breeding programs

Where to go? breeding objective (which traits)

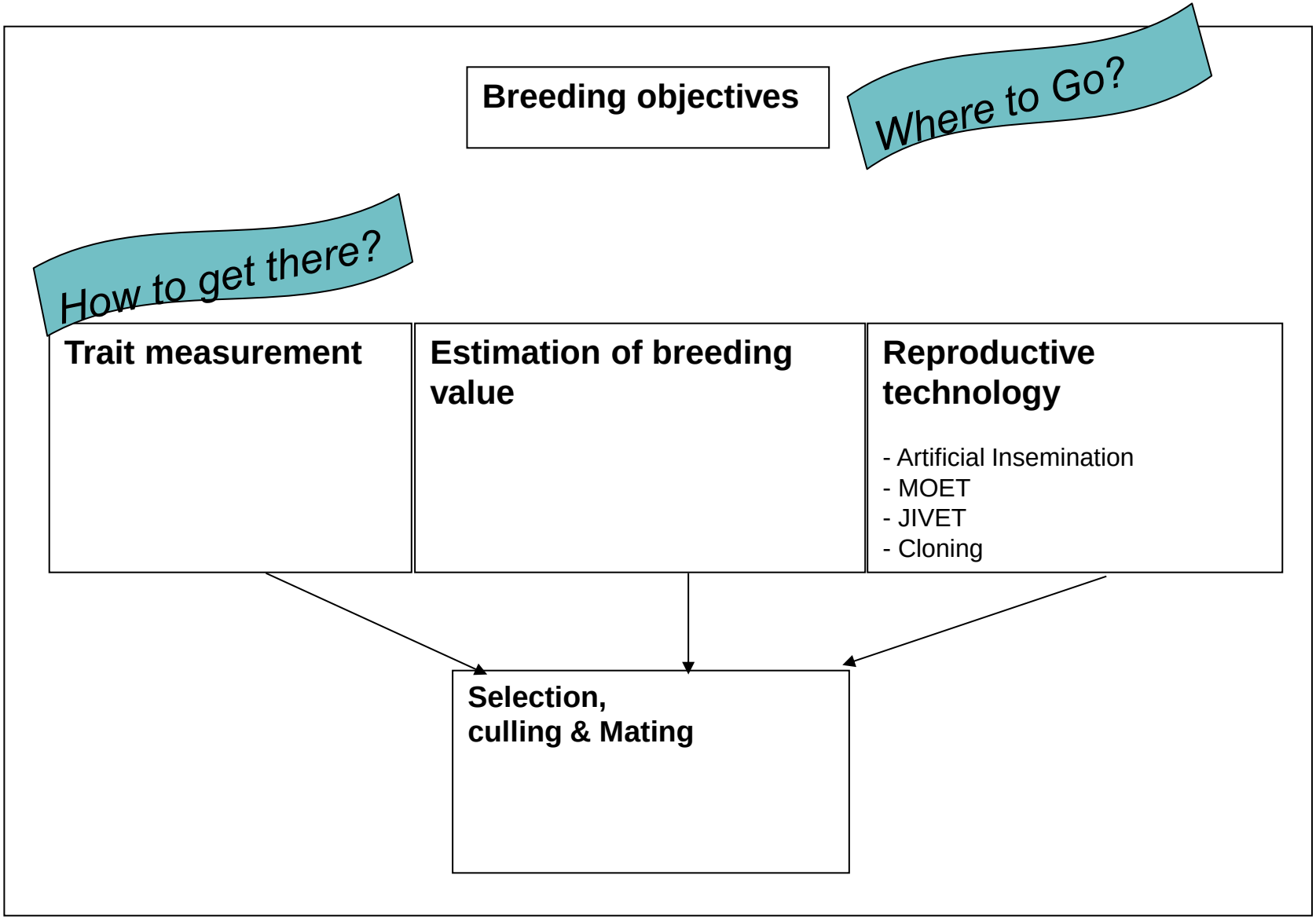
Who and what to measure? performance, DNA test

genetic evaluation

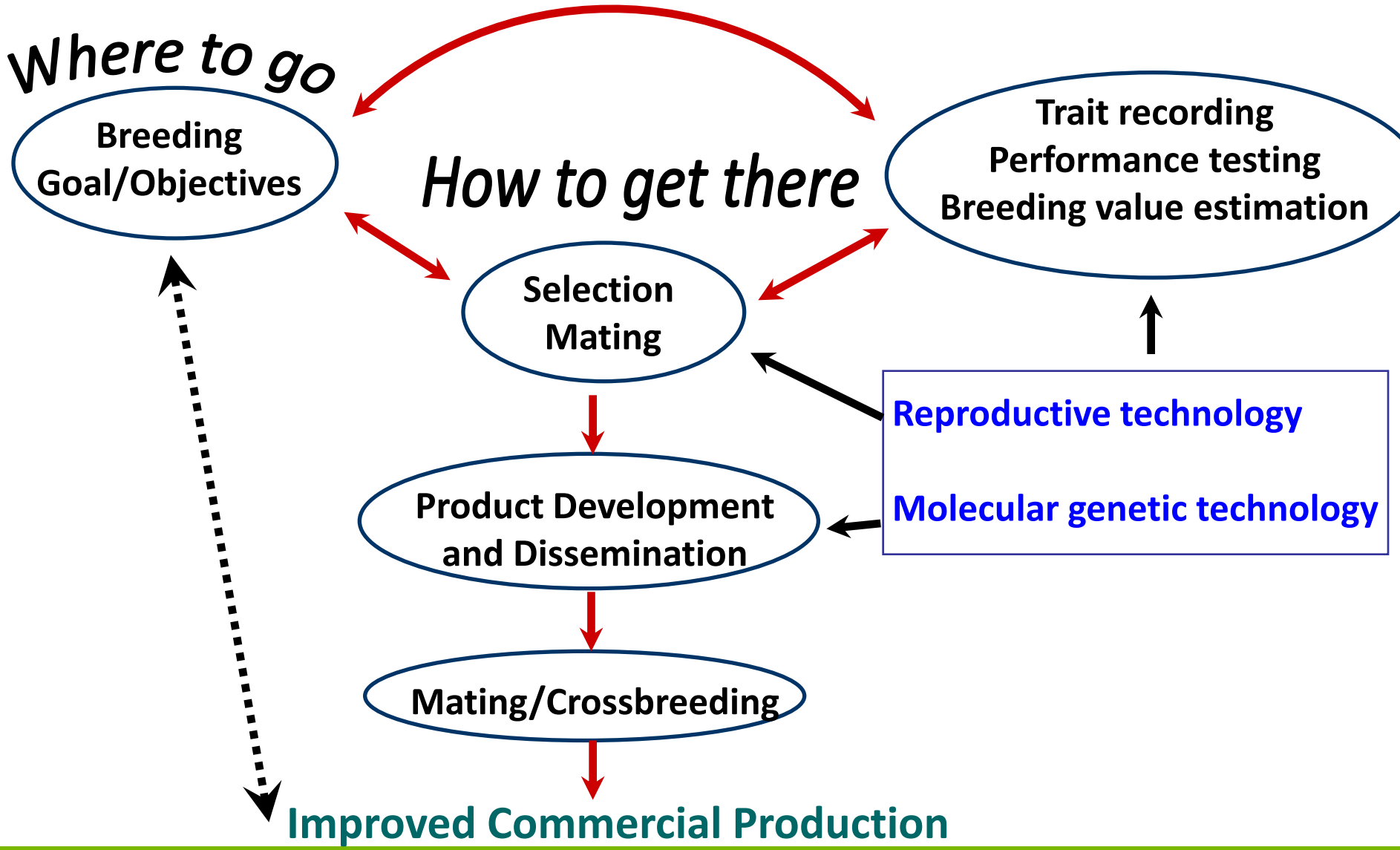
Who to select and mate? reproductive technol.

gains vs inbreeding

Animal Breeding in a nutshell



Basic Components of a Successful Breeding Program/Strategy



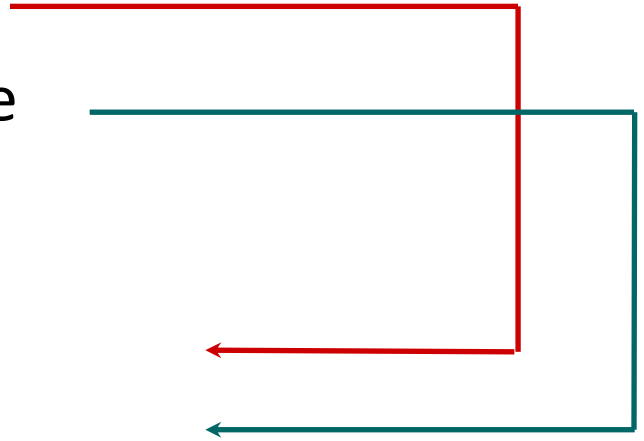
Why do we need a design?

- Genetic Improvement:
  - Which animals to measure?
  - Where to select them?
  - Mating strategy
  - Reproductive and Genomic Technologies?
- Dissemination of Genetic Superiority
- Inbreeding

Basic Principle of making genetic progress

Mate the “best” to the “best”

and do that as quickly as possible

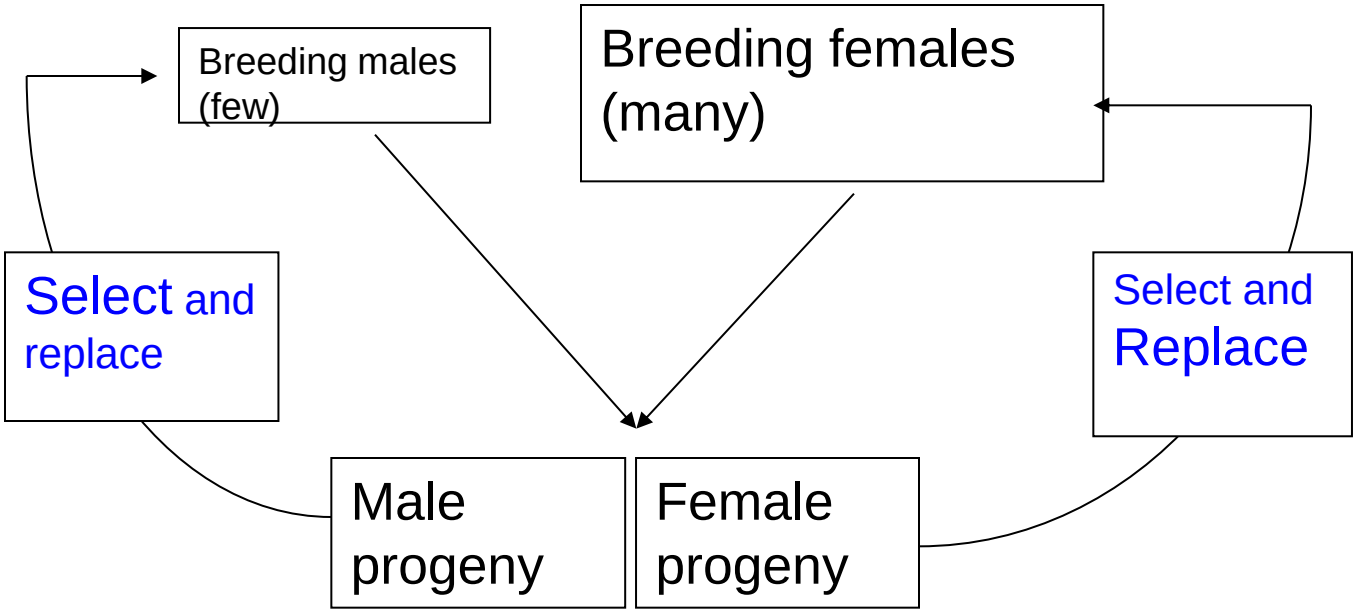


$$\text{Genetic Gain/yr} = \frac{\text{Genetic Superiority of parents}}{\text{Generation Interval}}$$

$$\text{Genetic Gain/yr} = \frac{\text{Sel Intensity x Accuracy X Genetic SD}}{\text{Generation Interval}}$$

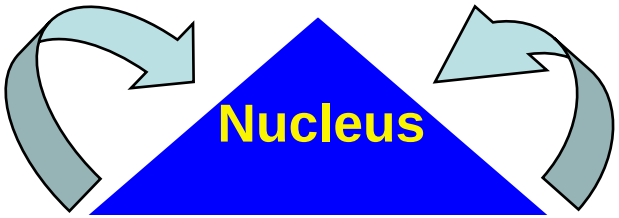
Design Examples

- One-tier breeding program



Design Examples

One-tier breeding program

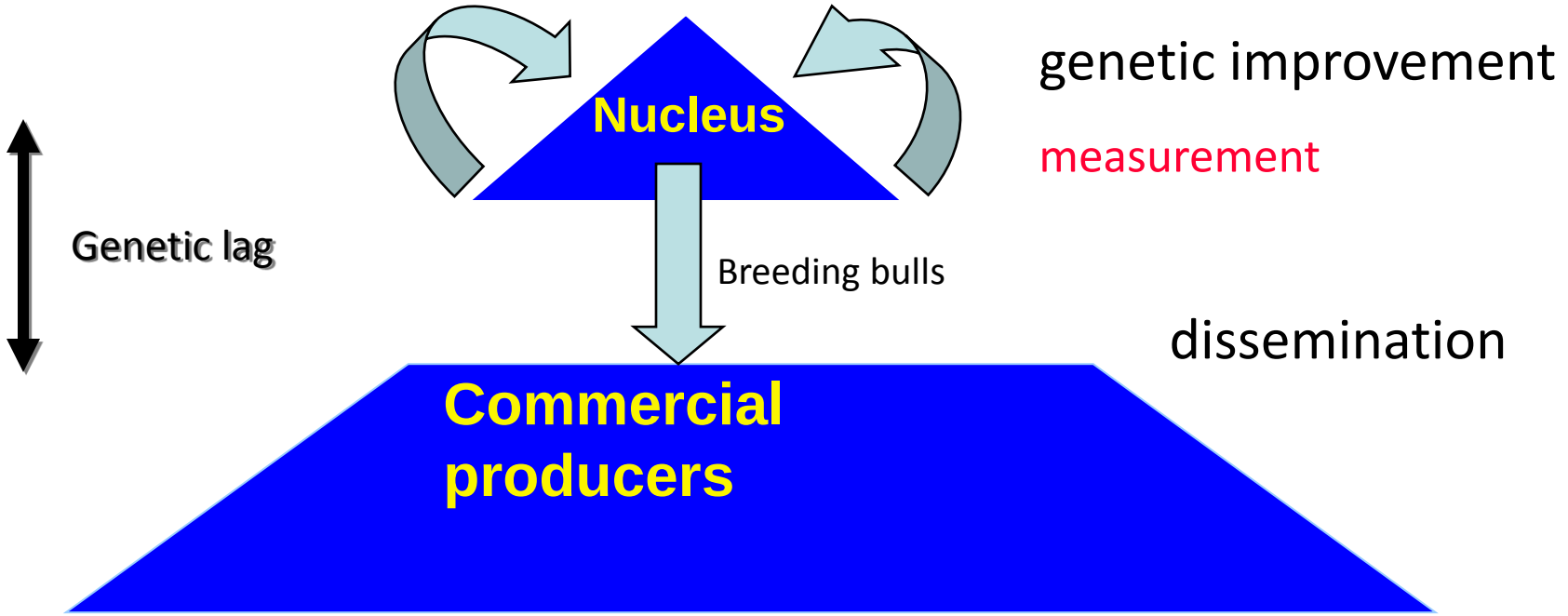


genetic improvement

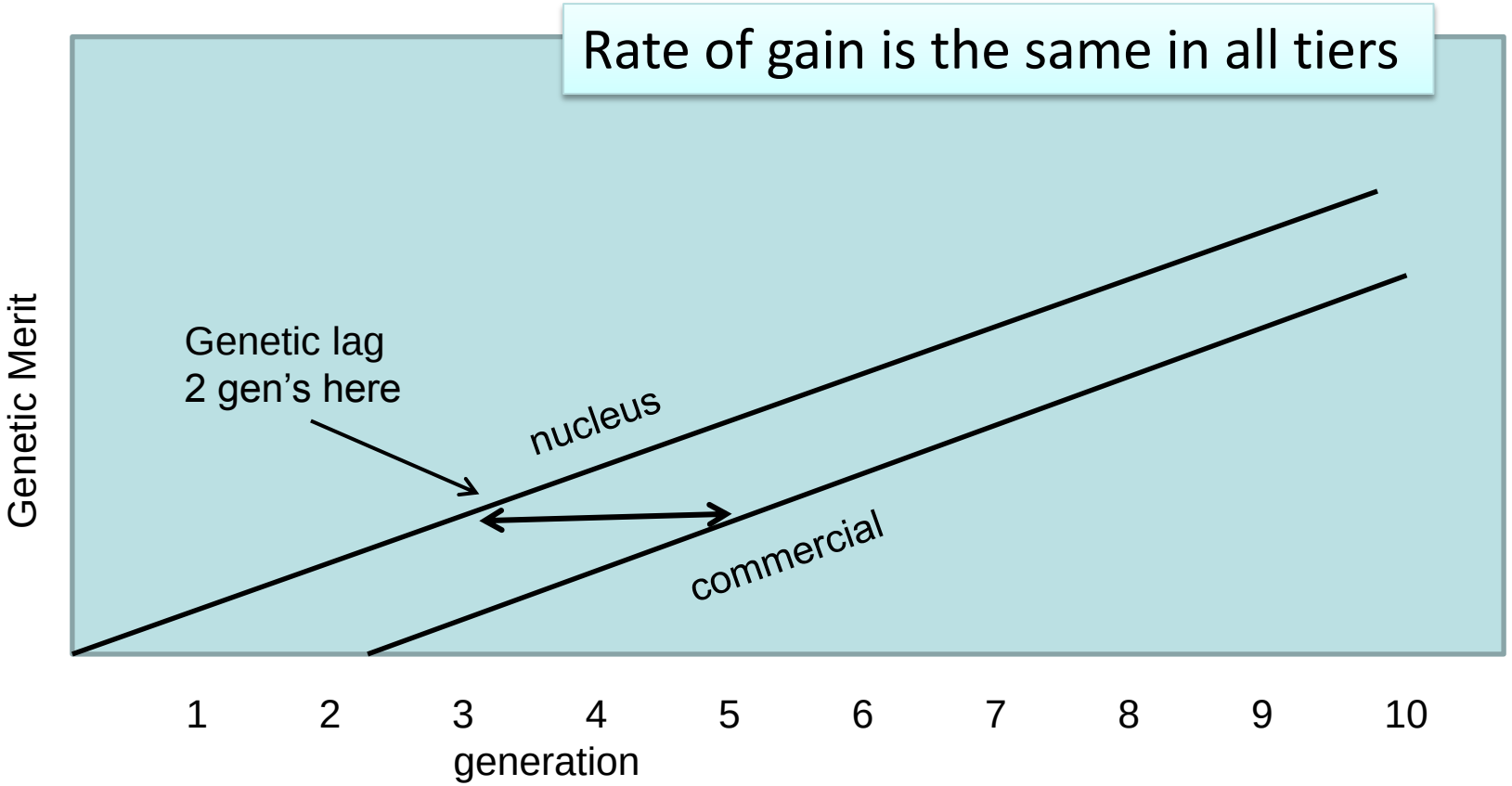
measurement

Design Examples

Two-tier breeding program

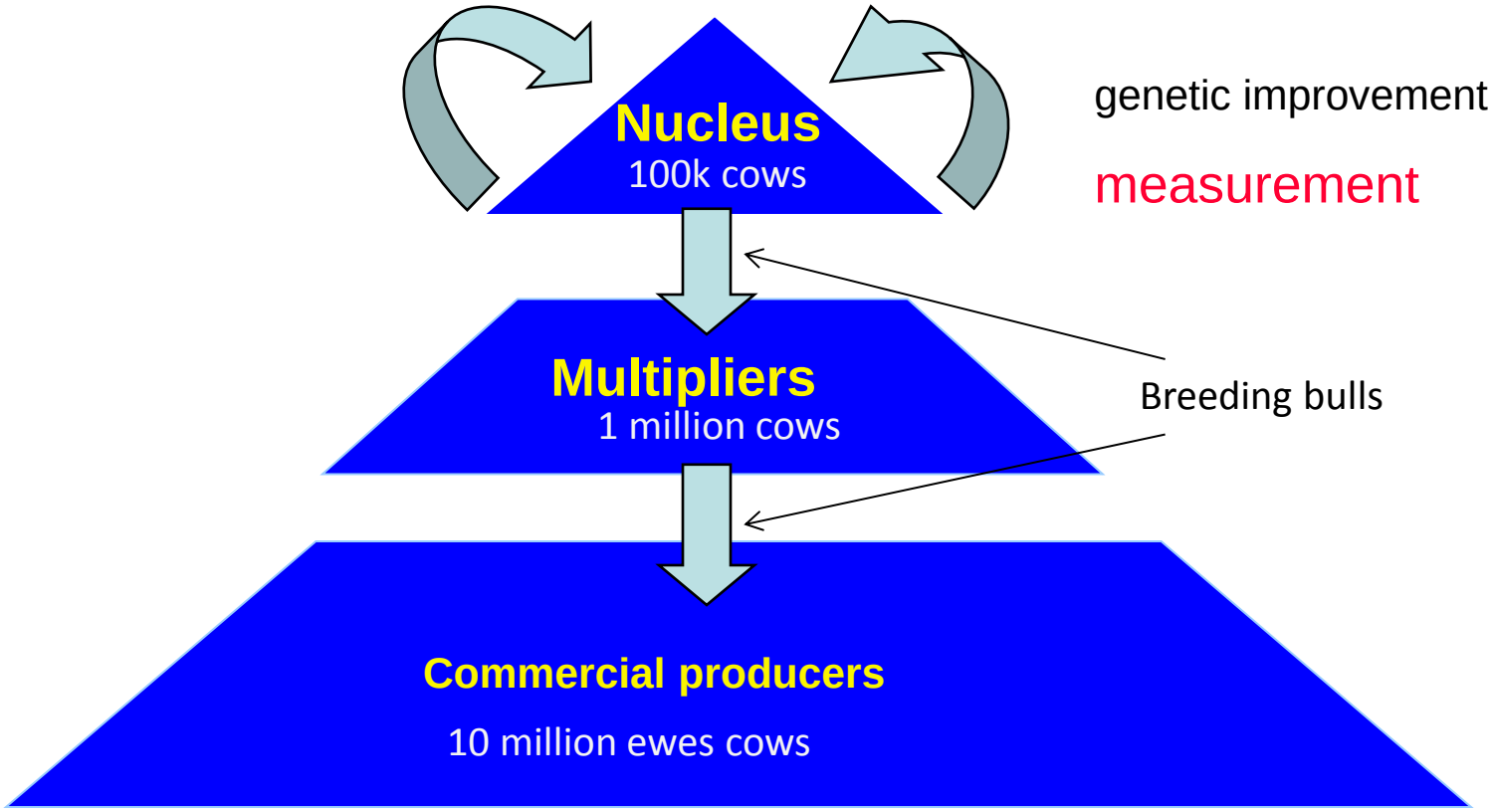


Genetic merit of Nucleus versus Commercial



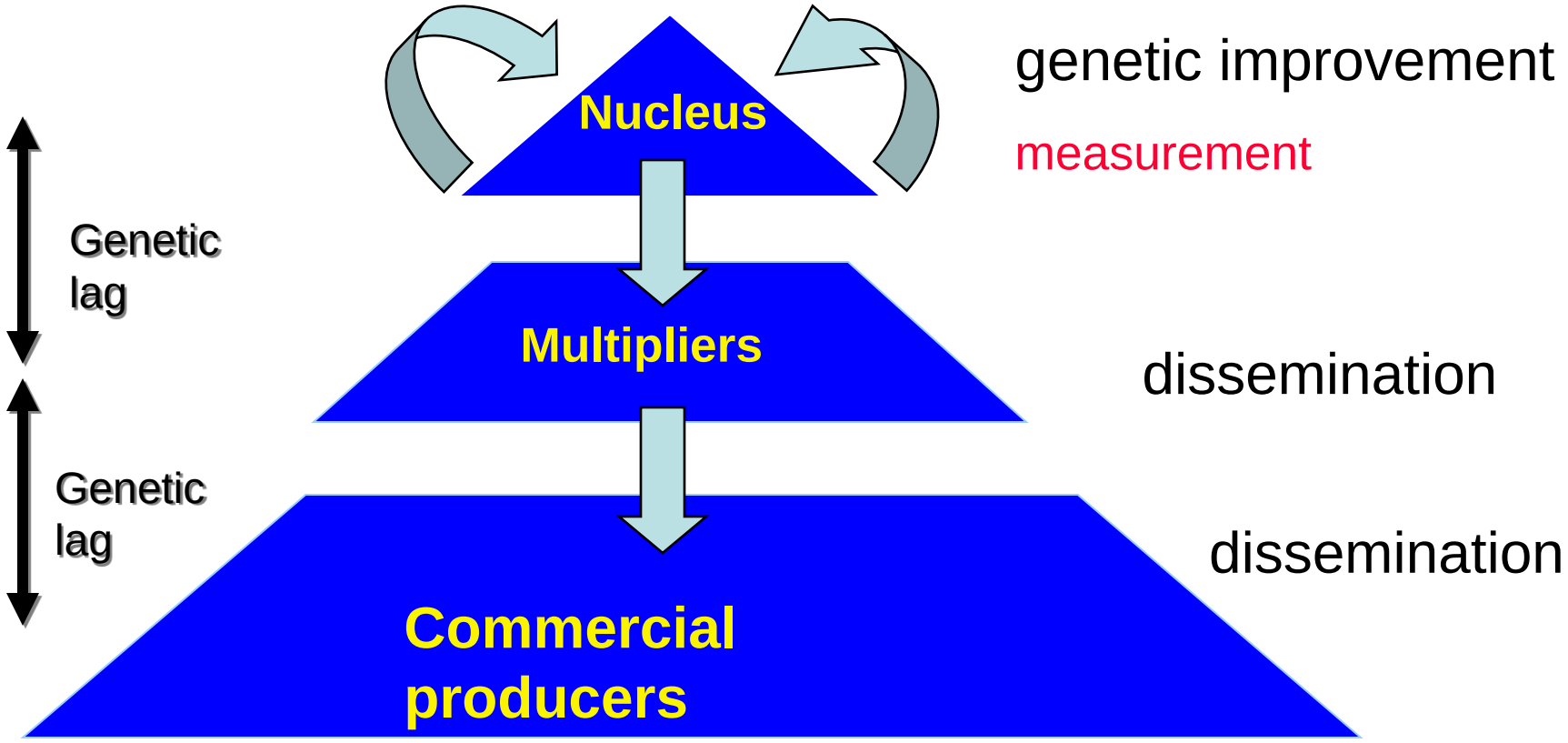
Design Examples

3-tier breeding program



Design Examples

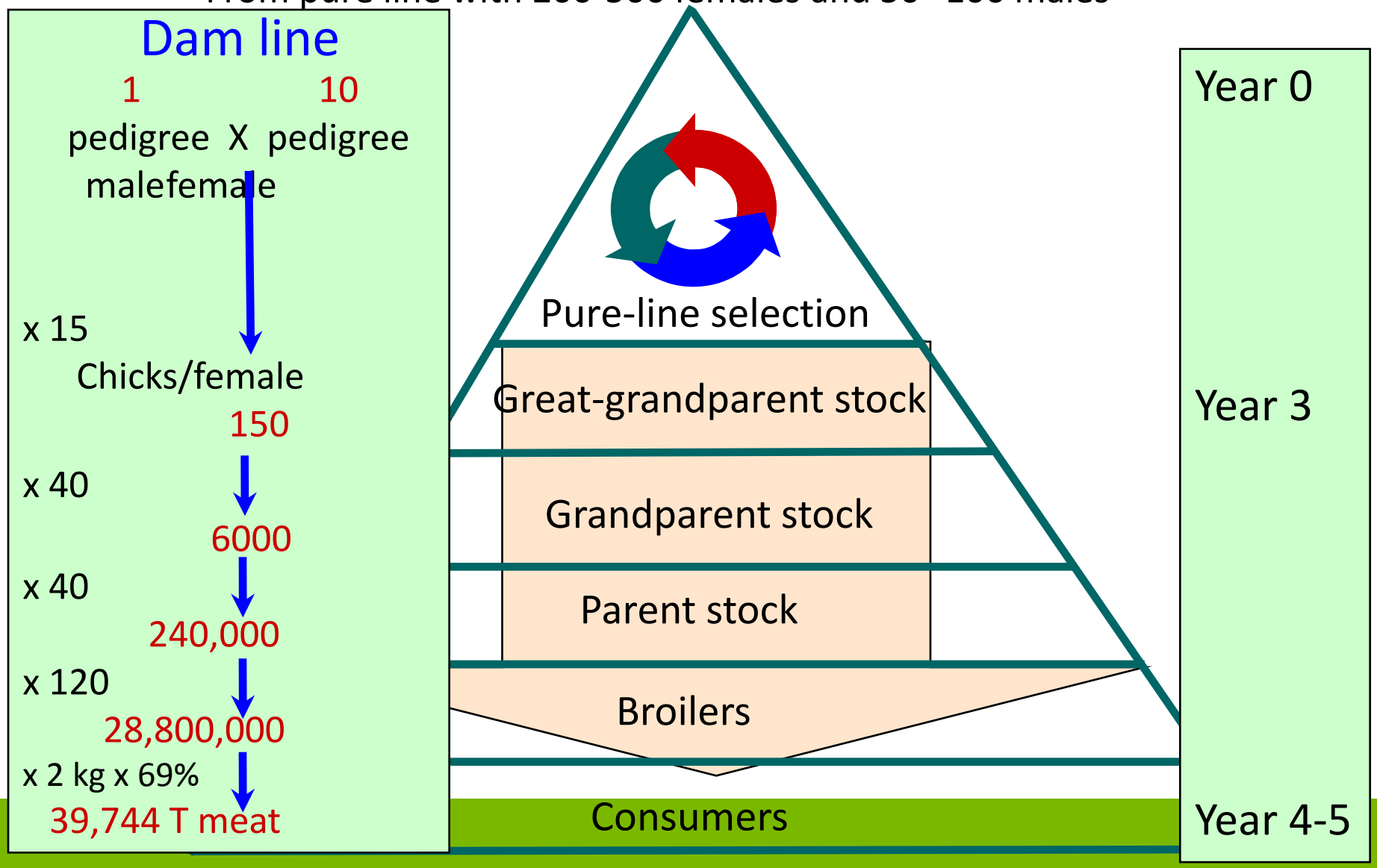
3-tier breeding program



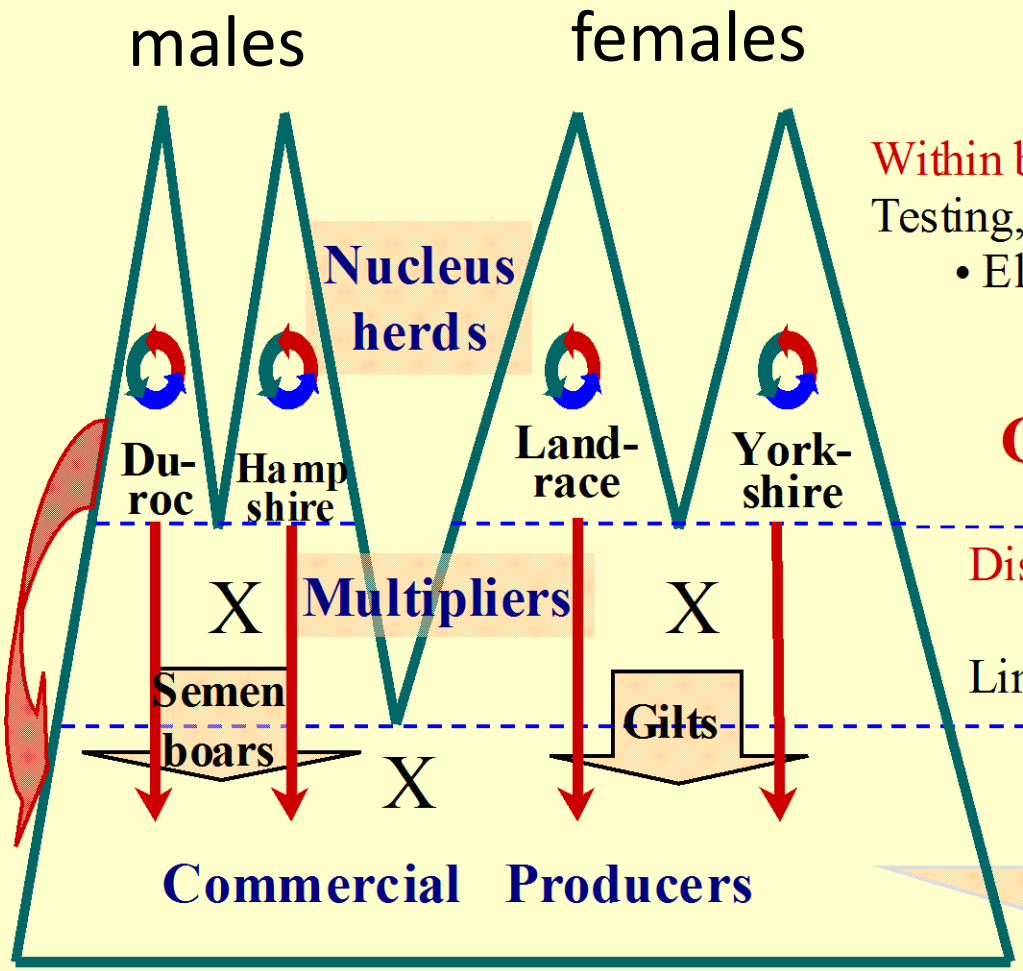
Multiplication in Broiler Breeding Programs

Adapted from: Poultry Breeding and Genetics, Crawford (ed). Elsevier, 1990

From pure line with 200-500 females and 50--100 males



Structure of Swine (Poultry) Breeding Programs



Within breed/line selection programs
Testing, evaluation, and selection
- Elite breeder herds or breeding company

Genetic Improvement ΔG

Dissemination - multiply superior genetics and provide to the commercial sector
Limited selection; some cross breeding

Production of market pigs
Limited selection
Extensive Crossbreeding

MARKET

Design Examples

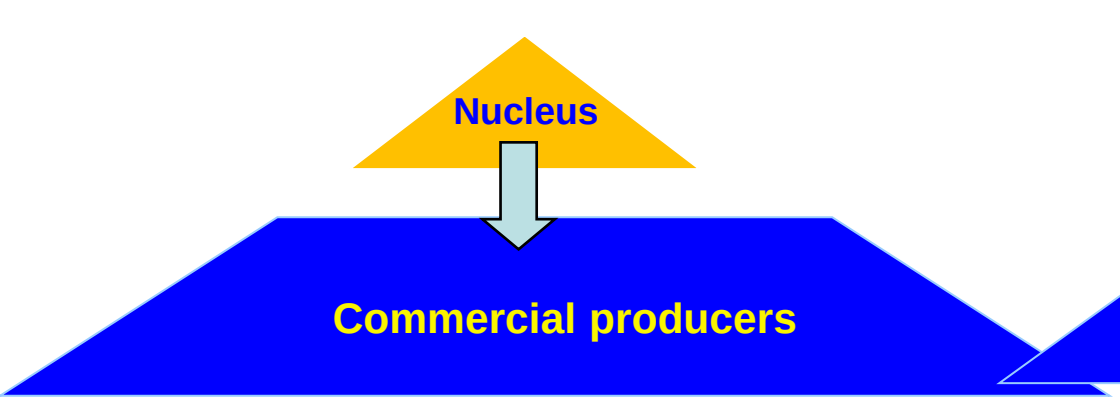
Two-tier breeding program

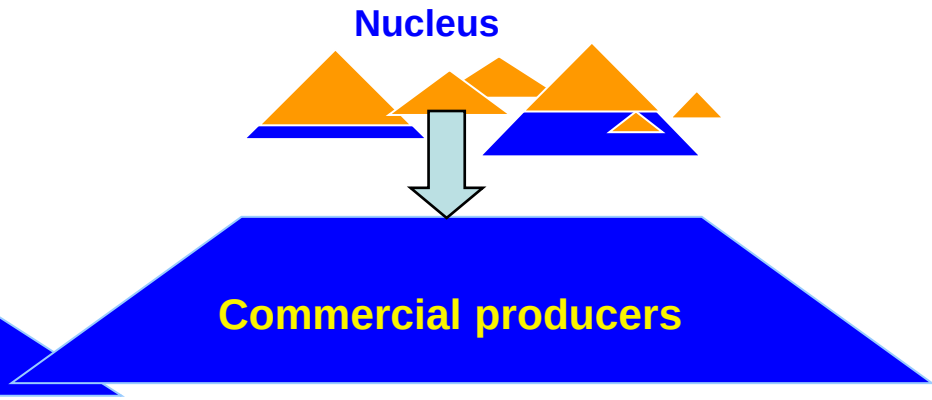
Central Nucleus

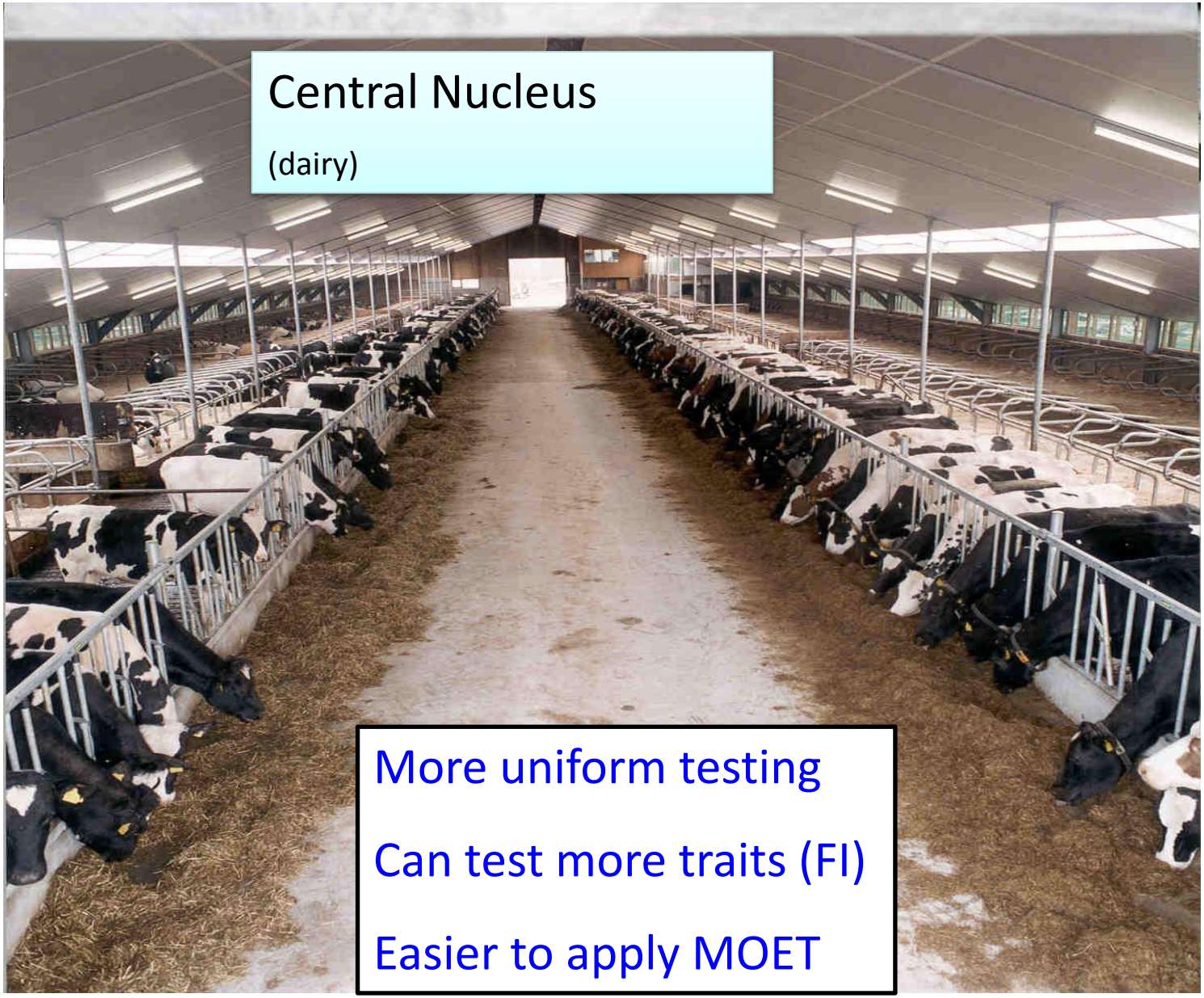
(pigs, poultry, some dairy)

or Dispersed

(sheep, cattle)



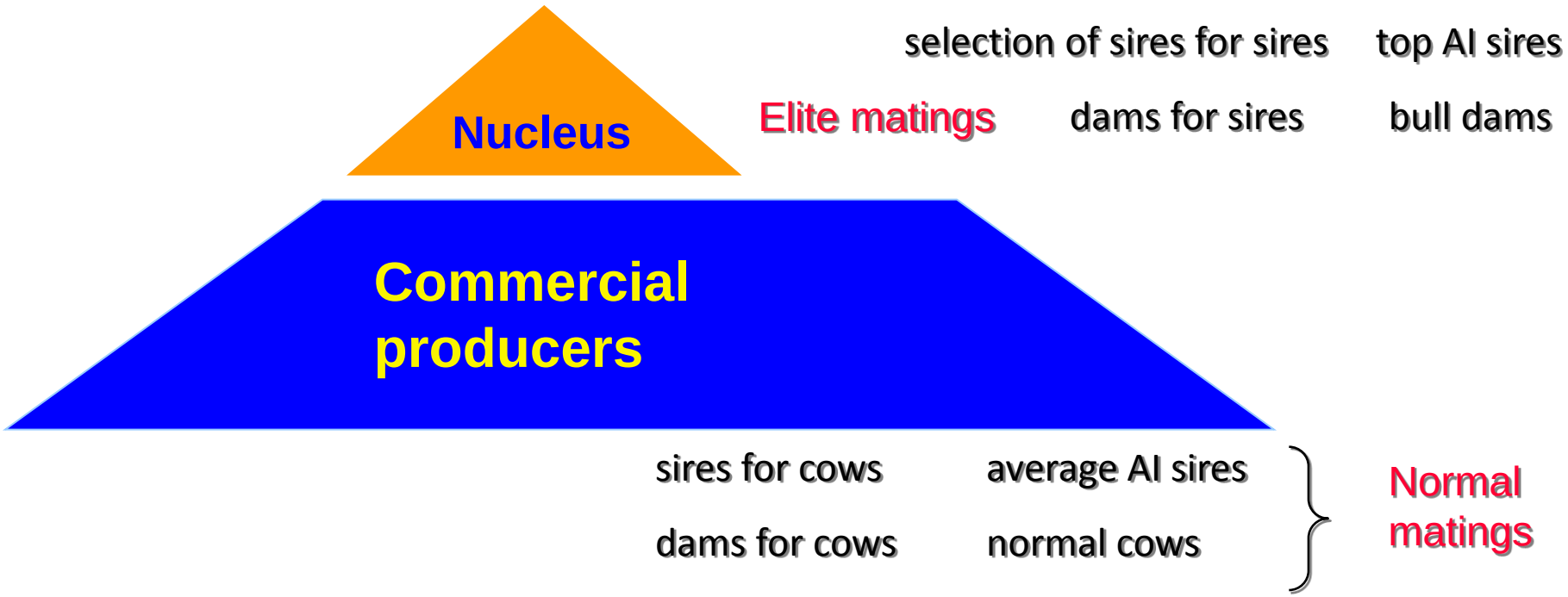



Central Nucleus
(dairy)
More uniform testing
Can test more traits (FI)
Easier to apply MOET

What defines the nucleus?

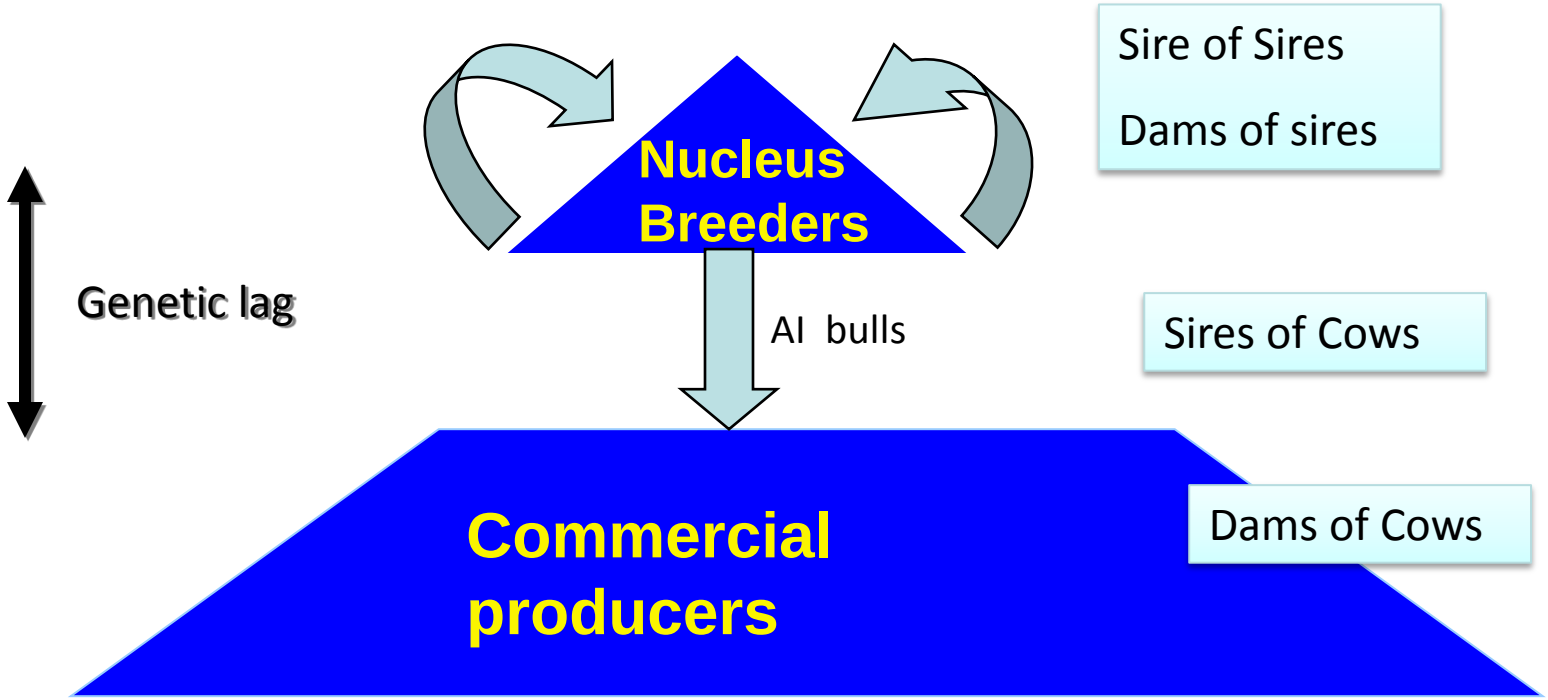
Nucleus: could be defined as

”the mothers and fathers of the future bulls”



Design Examples

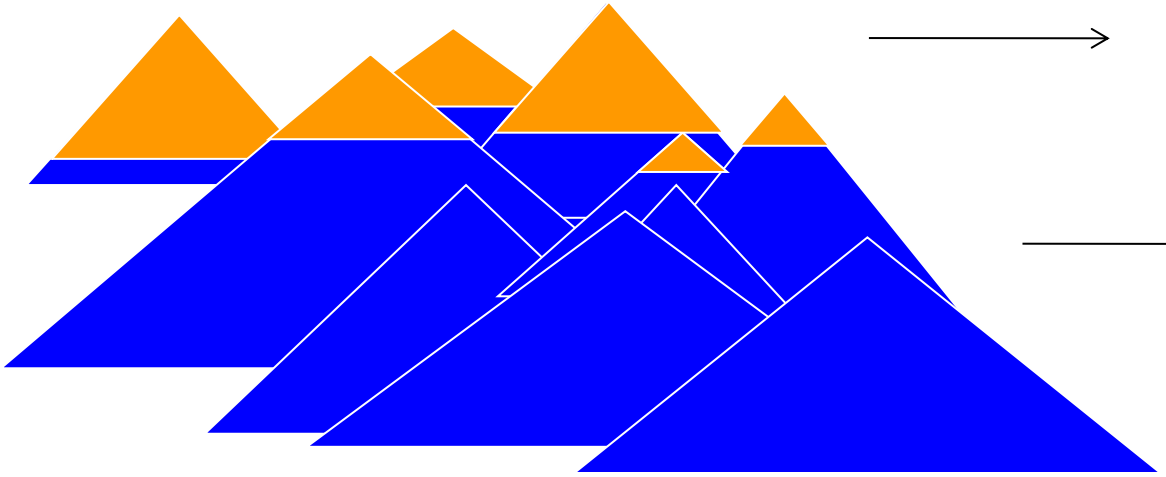
Two-tier breeding program (can compare with 4 pathways)



Dispersed Nucleus

Nucleus: could be defined as

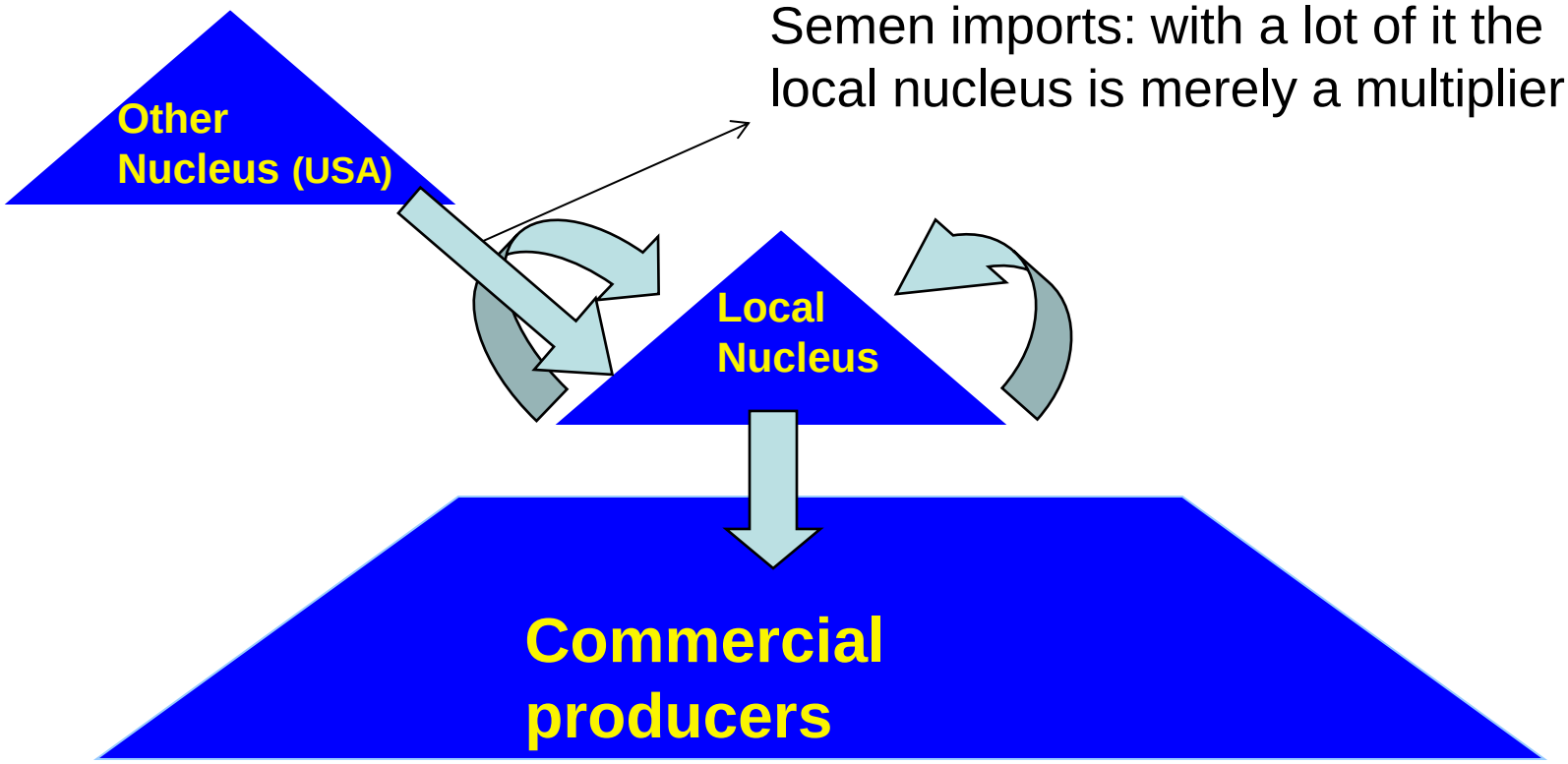
”the mothers and fathers of the future bulls”



Top studs
Delivering the genetics of the future bulls

Other studs
Acquire their genetic from top studs
Themselves being merely multipliers

Local ‘nucleus’ can in fact be multiplier



Examples: Angus Australia breeding program
Holstein Australia Breeding program

Nucleus Breeding Schemes

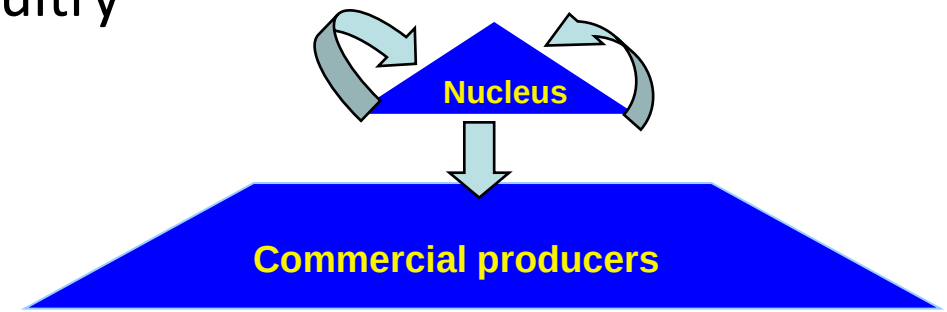
Closed Nucleus

Replacement animals for nucleus only from nucleus

Selection only permanently effective in nucleus.

Nucleus objectives impact on whole scheme.

Common in pigs and poultry



Nucleus Breeding Schemes

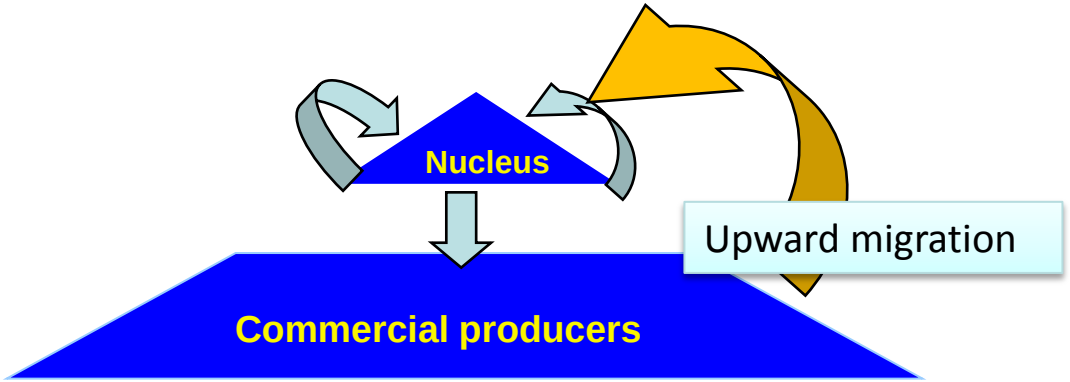
Open Nucleus

Replacement animals for nucleus but also some from base

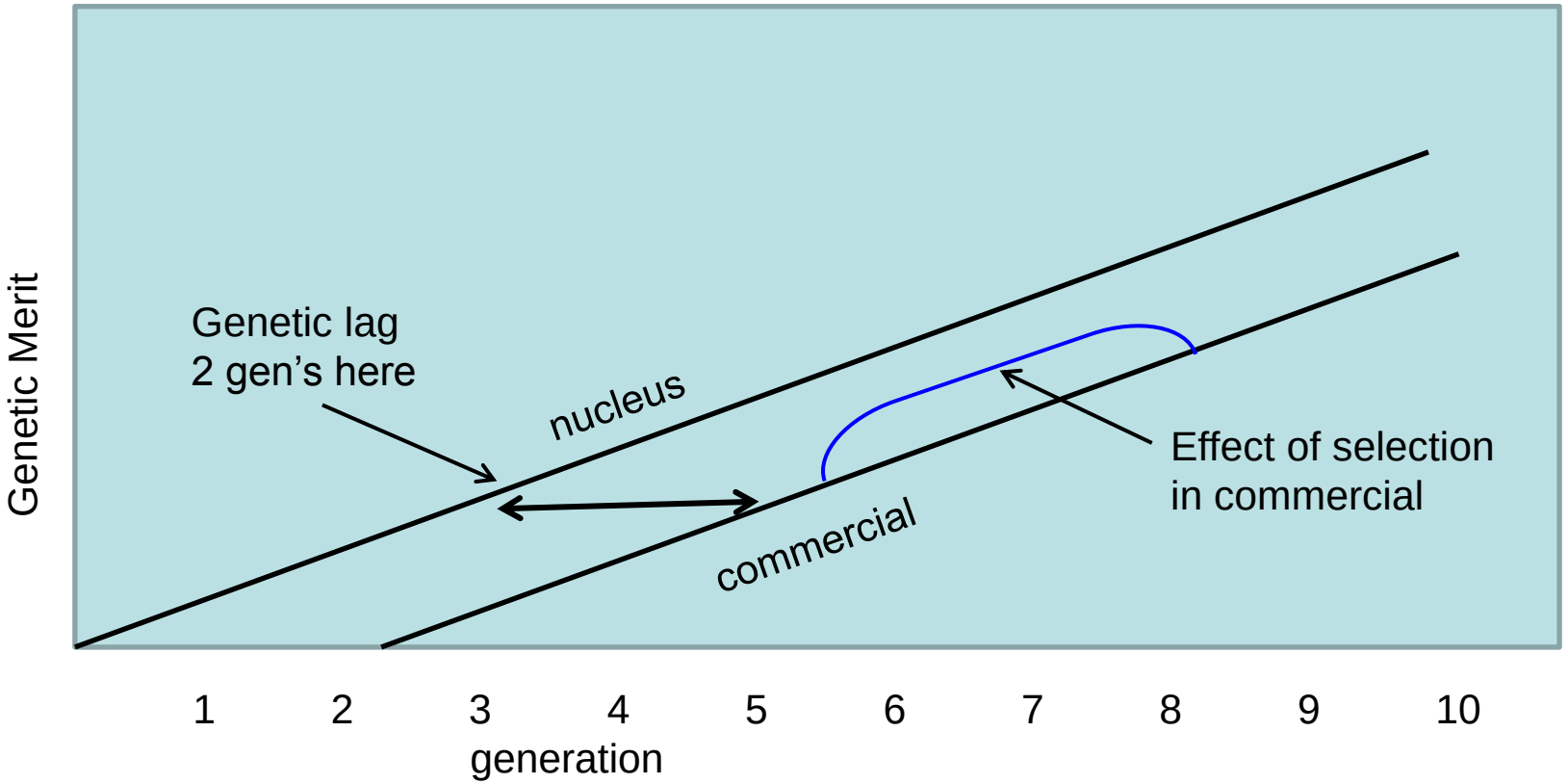
Selecting from base requires measurement in base

More genetic improvement than closed scheme (~15%)

Common in dairy

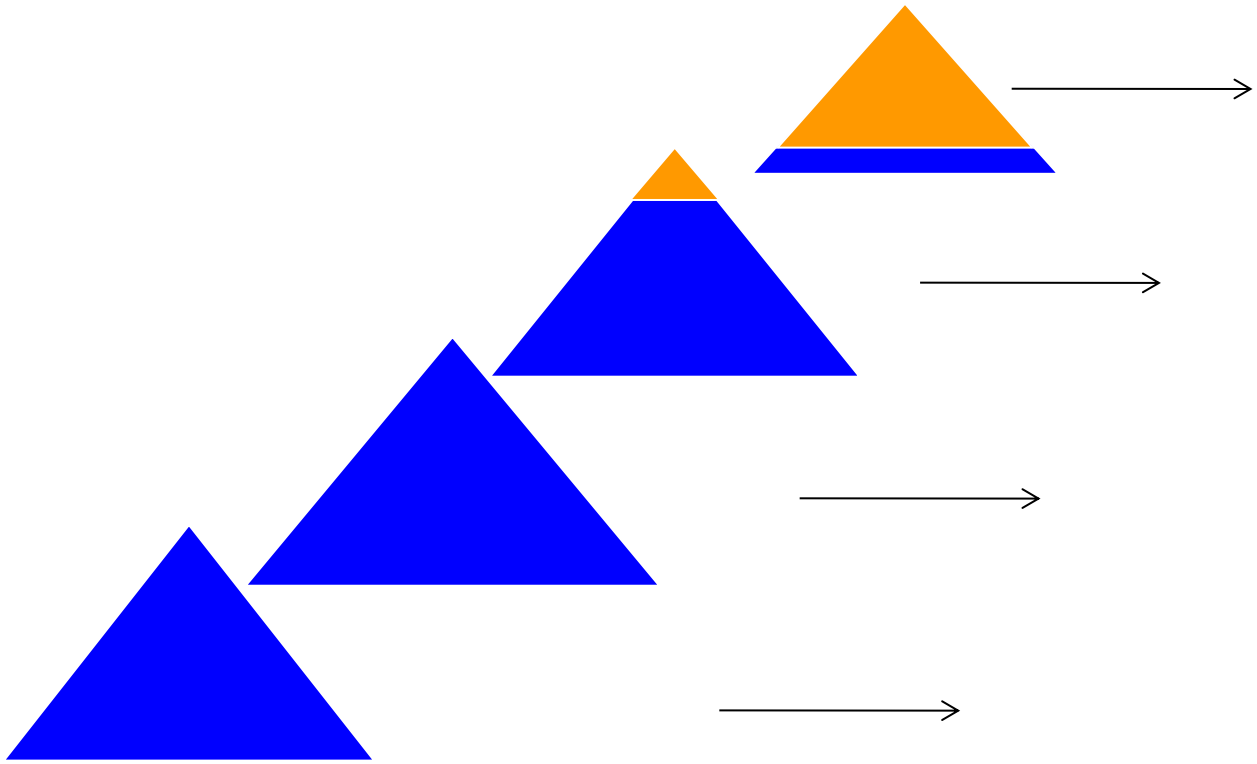


Genetic merit of Nucleus versus Commercial



In reality, tiers might be quite blurry

in beef, sheep (dairy)



Top studs
‘nucleus

Other studs
Buying bulls, select a bit

Commercial herds
Buying best bulls

Commercial herds
‘Buying average bulls

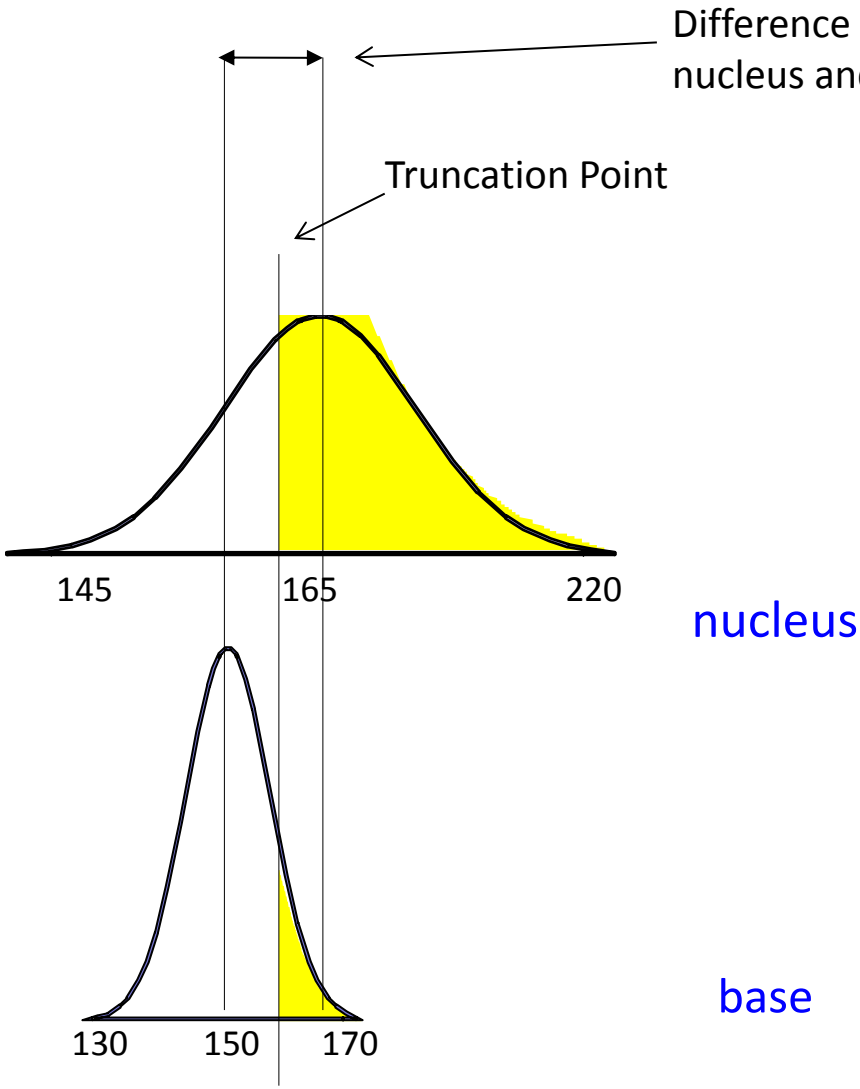
Open nucleus systems

- Select the best animals from lower tiers to compete for being nucleus parents

- degree of ‘openness depends on
  - difference between nucleus and commercial
  - spread of their breeding values

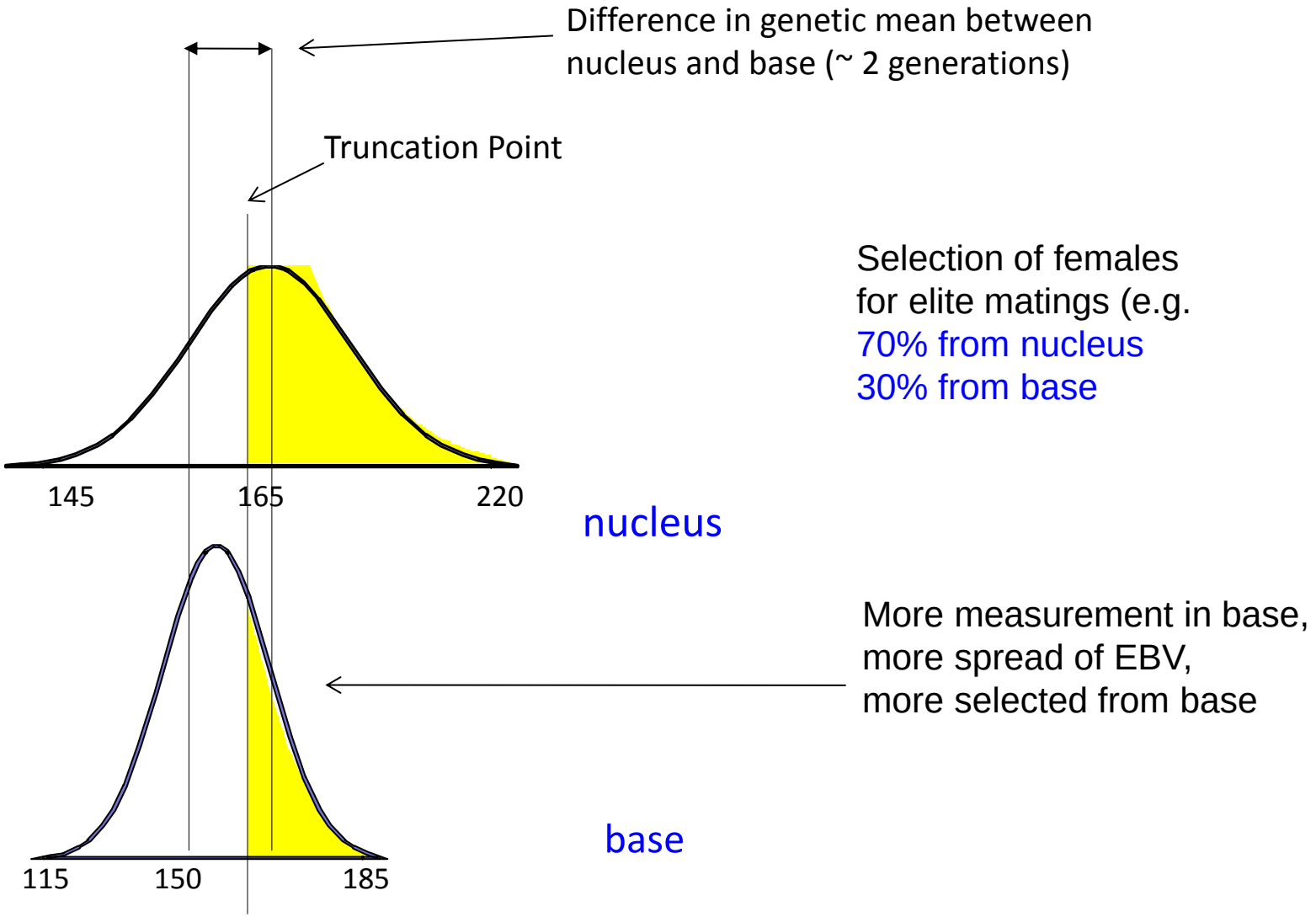
- Open to nuclei

Open Nucleus



Selection of females for elite matings (e.g.
80% from nucleus
20% from base

Open Nucleus: *effect of more information in base*



Selection of females for elite matings (e.g.
70% from nucleus
30% from base

More measurement in base, more spread of EBV, more selected from base

Contributions of pathways

2 pathways

	i	r
• Selection of sires	2	.5-.8
• Selection of dams	0.5-1	.5-.6

- → S_{sires} : S_{dams} at least vares from 2:1 to 5:1
- Sire selection contribute more than 70%-95% to dG

Contributions of pathways

4 pathways in dairy

	contribution to dG
• Selection of sires for sires	39%
• Selection of sires for cows	38%
• Selection of dams for sires	22%
• Selection of dams for dams	1%

Why need a design?

- Genetic improvement

Need decisions on

  - which animals to measure or genotype *nucleus males (females)*
  - where to select them *nucleus/base*
  - mating strategy *best to best* → elite matings

- Dissemination of genetic superiority
  - Often a challenge when setting up a new program, esp in developing countries.
  - How to sell/give improved seedstock to local farmers

- Inbreeding

Crossbreeding

Reasons

1. Sire-Dam complementation
   - Paternal: large, fast growth, good carcass
   - Maternal: small mature size, good fertility

   …….to increase the efficiency of the whole production system

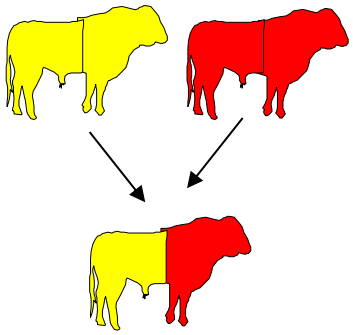
2. Heterosis
   - Direct heterosis
   - Maternal heterosis

3. Averaging of breed effects, Use of widest possible resources

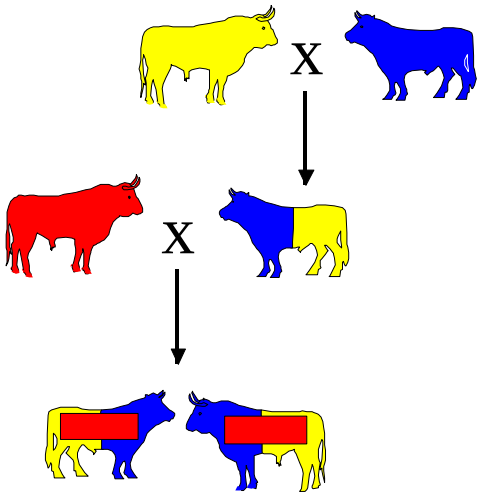
4. Other

Crossbreeding Examples

2-Breed Cross

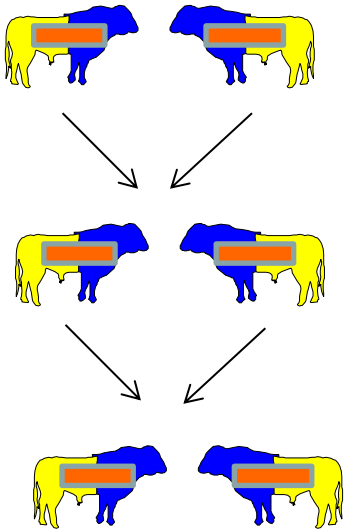


3-Breed Cross

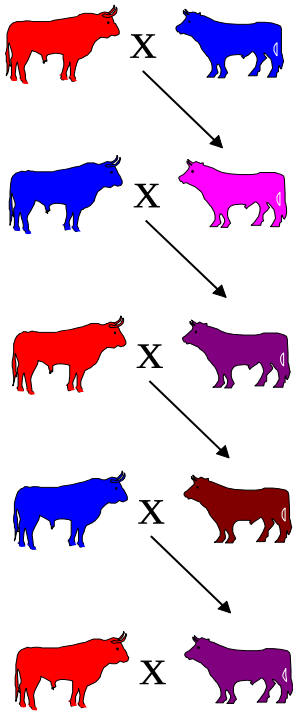


Terminal crosses

Composite/ hybrid



Rotational Cross



Patterns of use of crossbreeding

Industry	Fecundity	Typical crossing systems
Poultry	highest	4-breedcrosses
Pigs		3-breed crosses;back crosses
Meat sheep		3-breedcrosses
Wool Sheep		purebred*
Dairy		purebred*
Temperate Beef		rotations;composites
Tropical Beef	lowest	composites

***Wool sheep and dairy industries are exceptions due to availability of an outstanding pure breed in each.**

Crossbreeding:

Specialized lines and crossbreeding or dual purpose breeds?

			relative performance	
		price	meat breed	wool breed
wool		0.7	60	100
meat		1	100	60

Income from each system

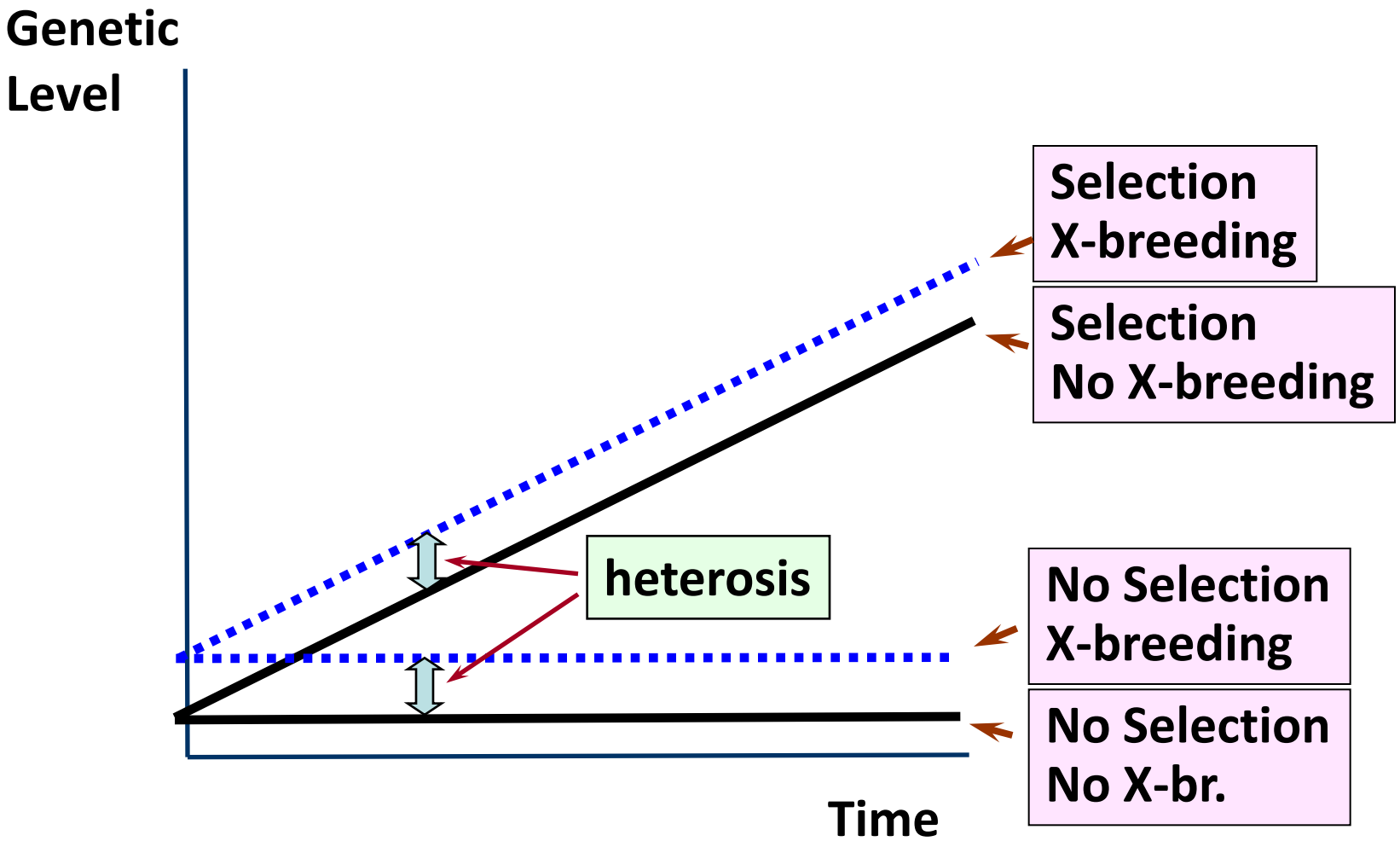
		rel nr.	meat breed	wool breed	X-ing system	dual purpose
wool income	females	1	42	70	70	56
meat income	males	0.5	100	60	80	80
		profit	92	100	110	96

A crossbreeding system is more profitable,
it exploits sire-line and dam-line complementation

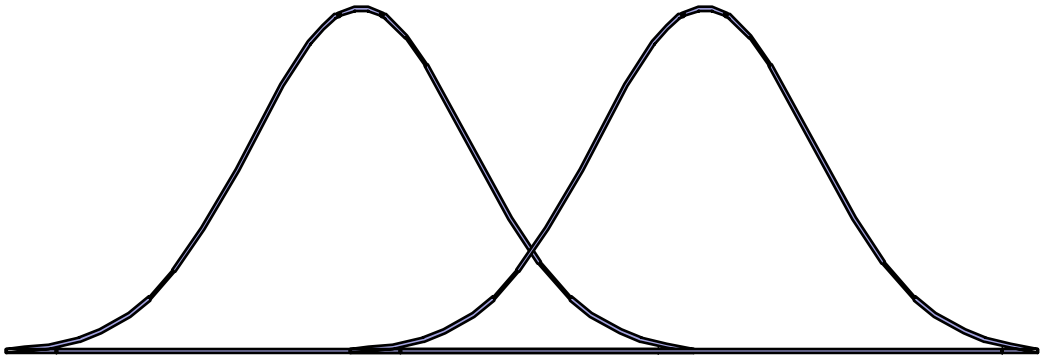
Predicting Crossbred Performance

- Additive direct breed effects
- Additive maternal breed effects
    - Proportional to breed proportion of animal / dam
- Direct heterosis
- Maternal heterosis
    - Proportional to heterozygosity of animal / dam

Importance of Selection vs. Mating/Crossbreeding



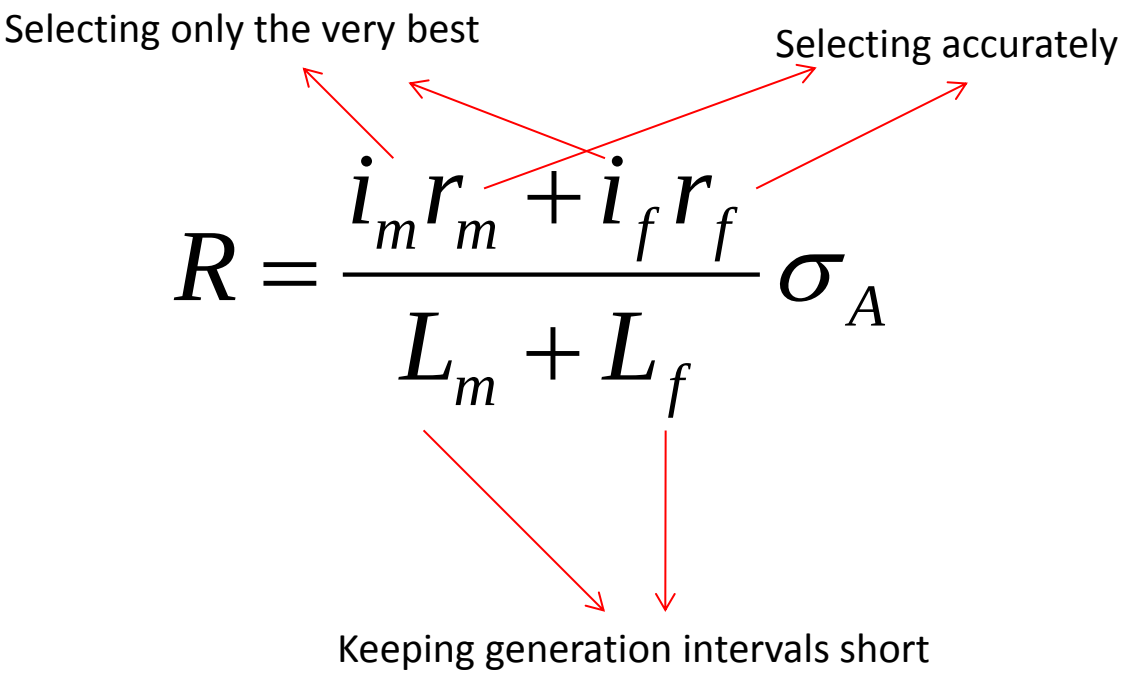
Importance of selection vs using between breed variation



Reproductive technologies

- Reproductive boosting
  - Artificial insemination, AI
  - Multiple Ovulation and Embryo Transfer, MOET
  - Oocyte Pickup
  - Juvenile In Vitro Embryo Transfer, JIVET
- Sexing of semen and embryos
- Cloning
- Whizzy Genetics - breeding in a test-tube

Making genetic progress is about

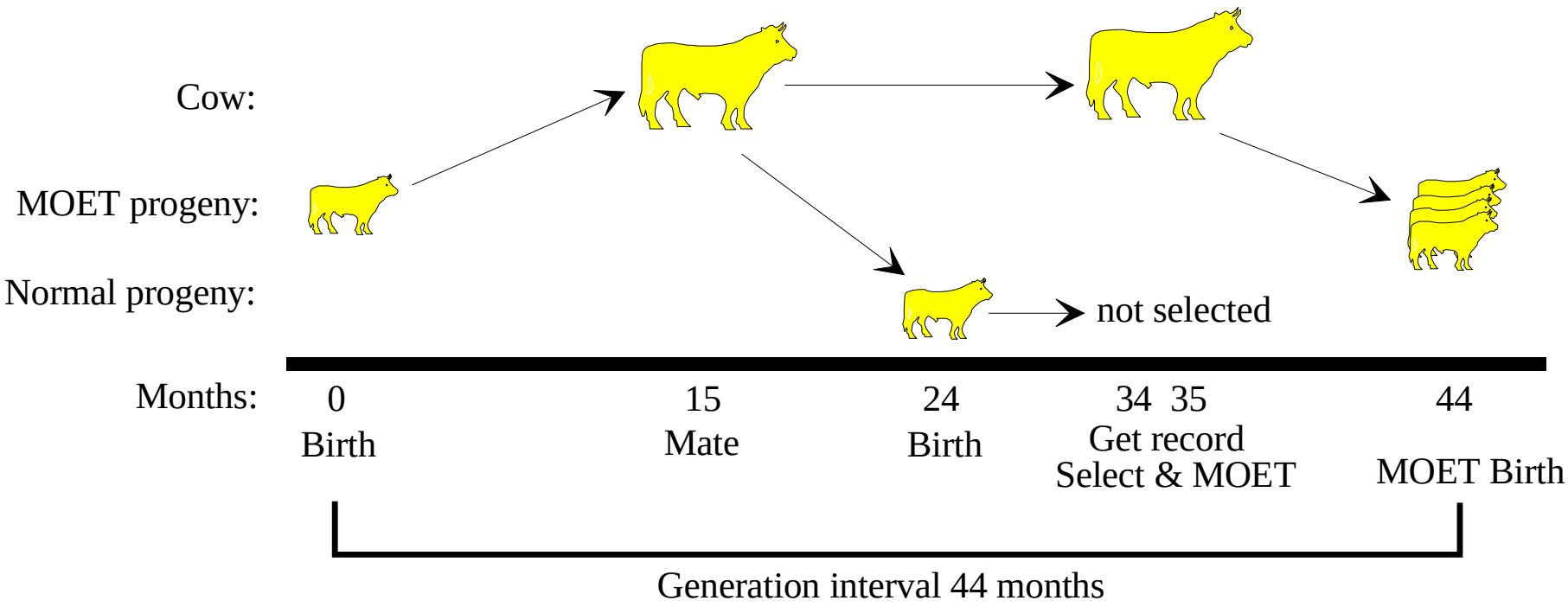


Reproductive rates affect all of the above!

Reproductive technologies

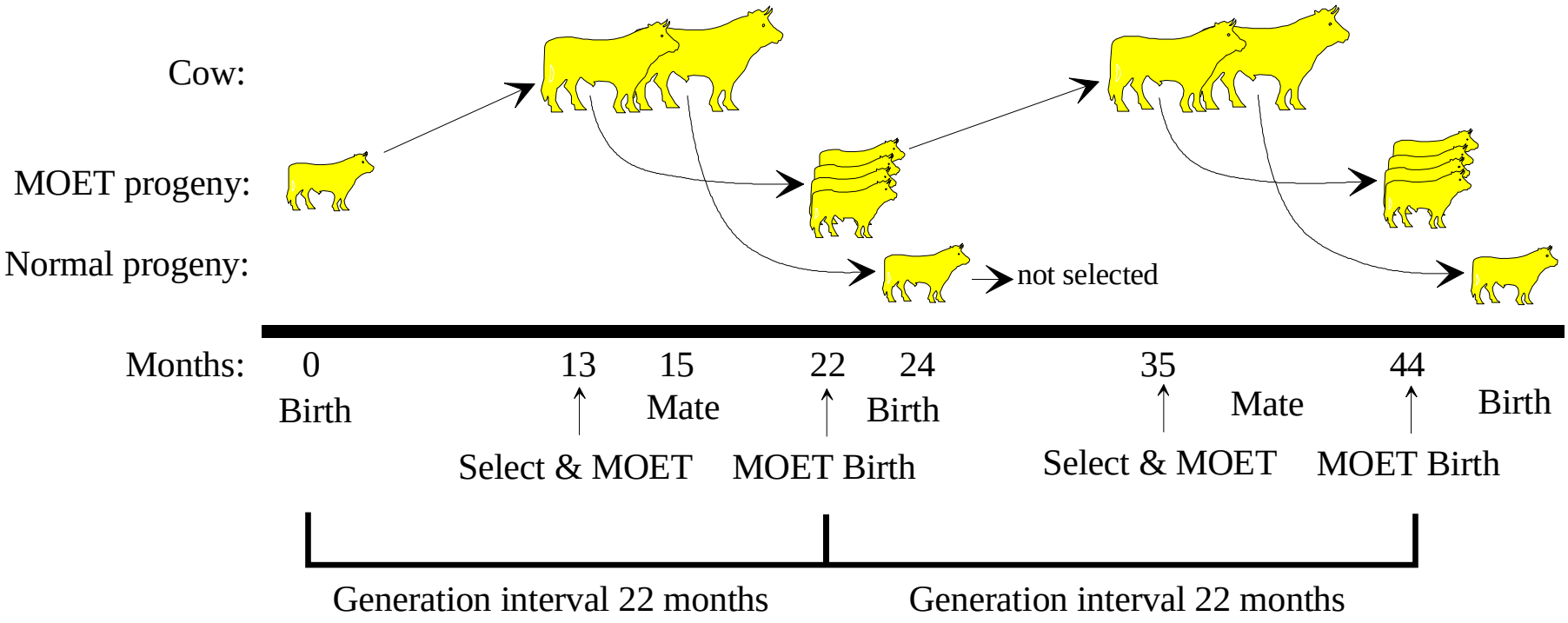
- Increases selection intensities
- Increases accuracy of EBVs
- Decreases generation intervals
- Increases inbreeding

Adult dairy MOET scheme



More offspring of top cow *after* testing it

Juvenile dairy MOET scheme



More offspring of top cow *before* testing it

Select base on parent average

Basic steps in the design of breeding programs

(Harris, 1984. Anim. Breeding Abstracts)

1) Describe the production system(s)
2) Formulate the objective of the system
3) Choose a breeding system and breeds
4) Estimate selection parameters and (discounted) economic values
5) Design an animal evaluation system
6) Develop selection criteria
7) Design matings for selected animals
8) Design a system for expansion - dissemination - of genetic superiority
9) Compare alternative programs

Developing and Optimizing Breeding Strategies

1 Identify the product and the product goal

- maximize genetic gain
- maximize profit from genetic improvement at farm level
  - supply high quality genetics at lowest cost
- maximize profit from sale of genetic material (dissemination)
  - appropriate with competitive market for breeding stock

2 Identify constraints

- test resources
- facilities
- market
- finances

Developing and Optimizing Breeding Strategies (cont'd)

3 Identify factors that affect the goal of the breeding program and which of those are under your control.

4 Determine how the factors that are under your control can be manipulated in order to maximize the goal.

Development of Breeding Strategies Summary

- Integration of the components of a breeding program into a structured system for genetic improvement, with the aim to maximize an overall objective (genetic gain, market share).

- Evaluate opportunities for improving upon current strategies.

- Evaluate the potential of new technologies.
  - How can they best be incorporated into current strategies?
  - Can their benefits best be capitalized on in a redesigned breeding structure?

Breeding Strategies - Summary

What tools are necessary to develop optimal strategies?

- Quantitative genetics theory
  - Predicting response to selection, selection index, inbreeding, etc.
- Systems analysis
  - Predicting and optimizing response in overall objective
- Common sense
- An open mind