Design of Breeding Programs

Decisions in breeding programs

Where to go? — breeding objective (which traits)

Who and what to measure? — performance, DNA test

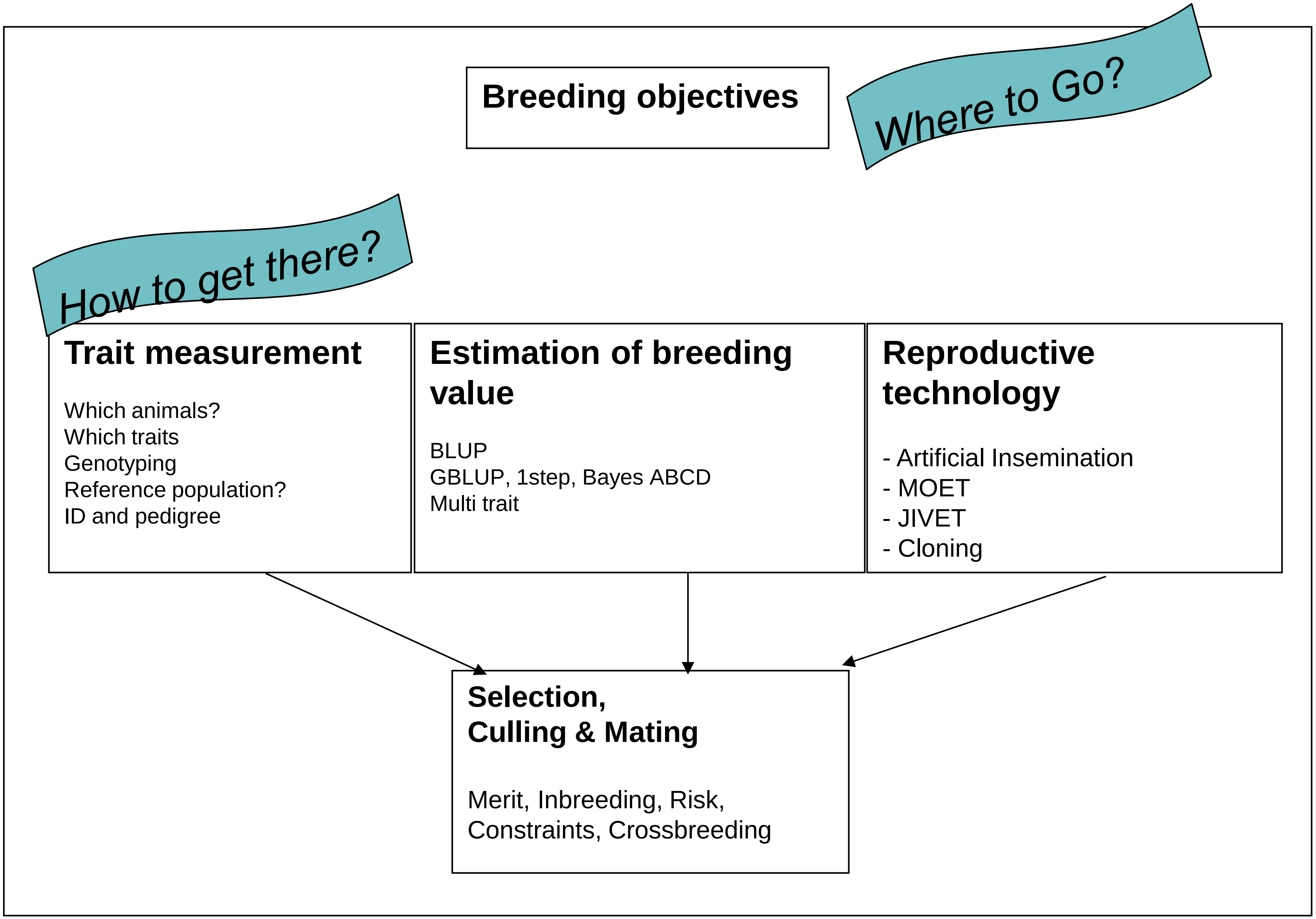
genetic evaluation

Who to select and mate? — reproductive technol.

gains vs inbreeding

une

Animal Breeding in a nutshell



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"

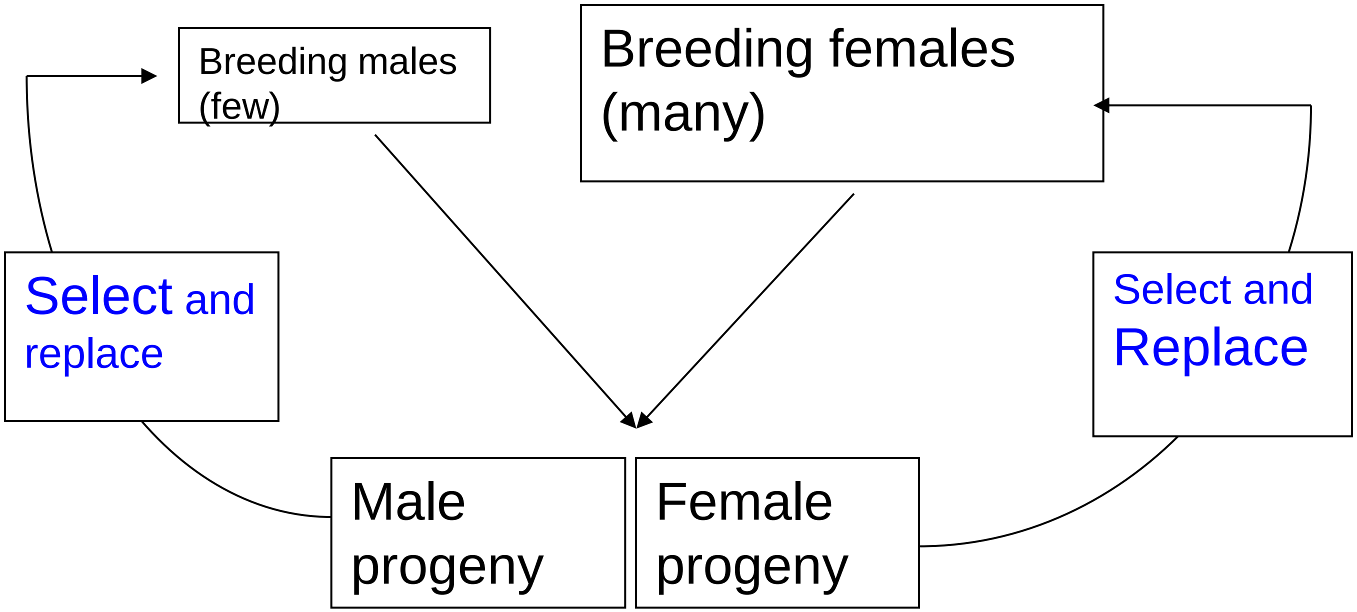
and do that as quickly as possible

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

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

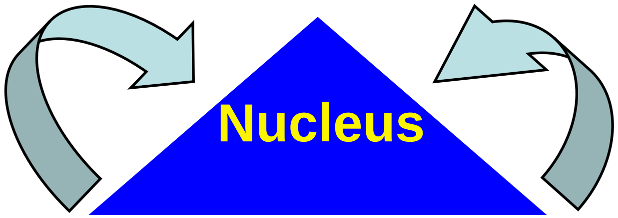
Design Examples

- One-tier breeding program



Design Examples

One-tier breeding program

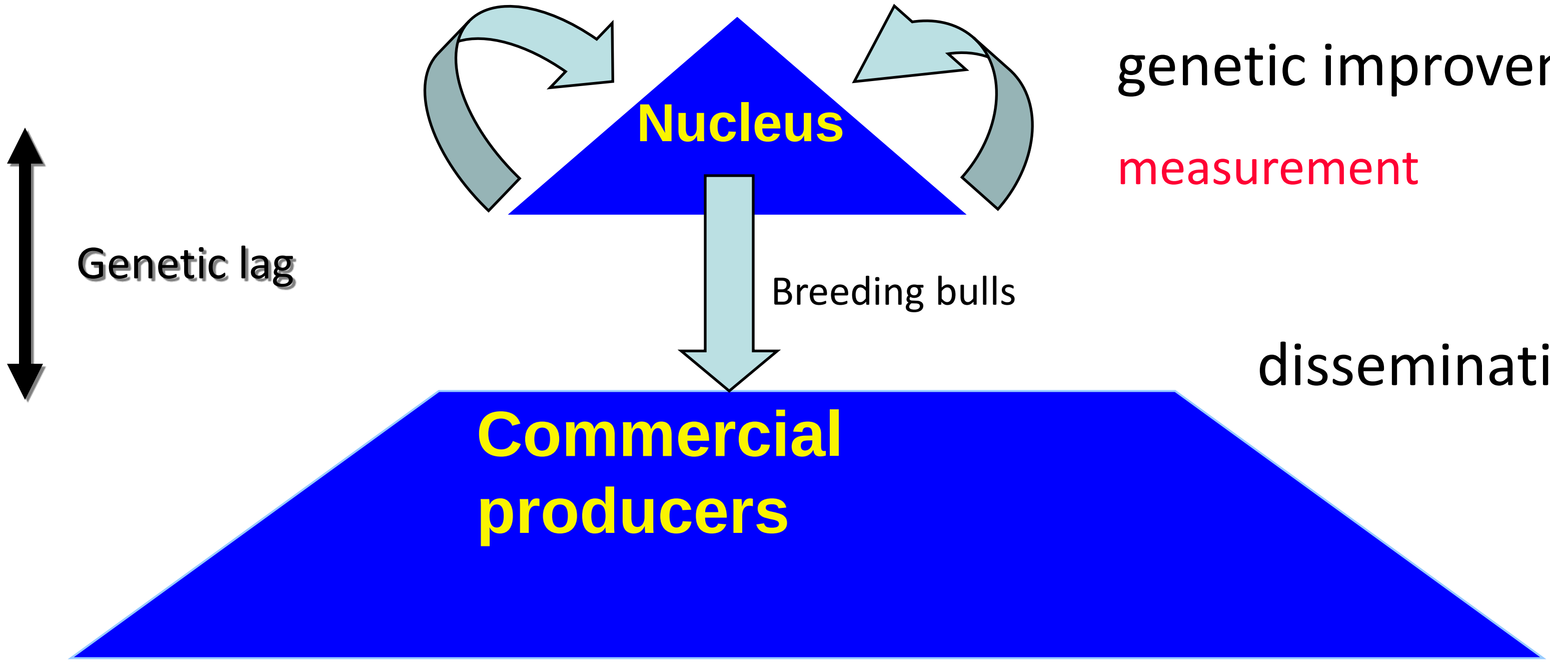


genetic improvement

measurement

Design Examples

Two-tier breeding program



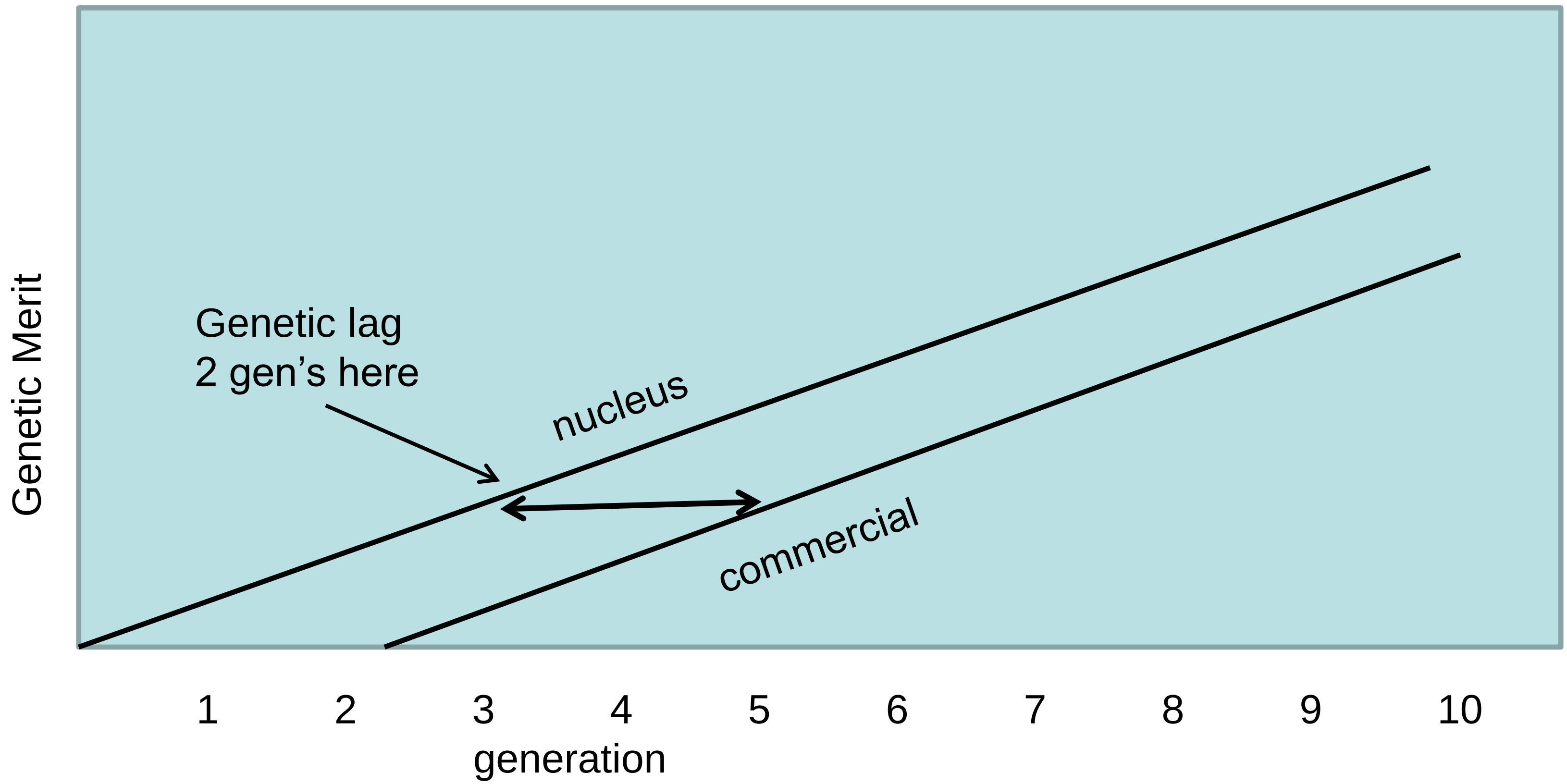
genetic improvement

measurement

dissemination

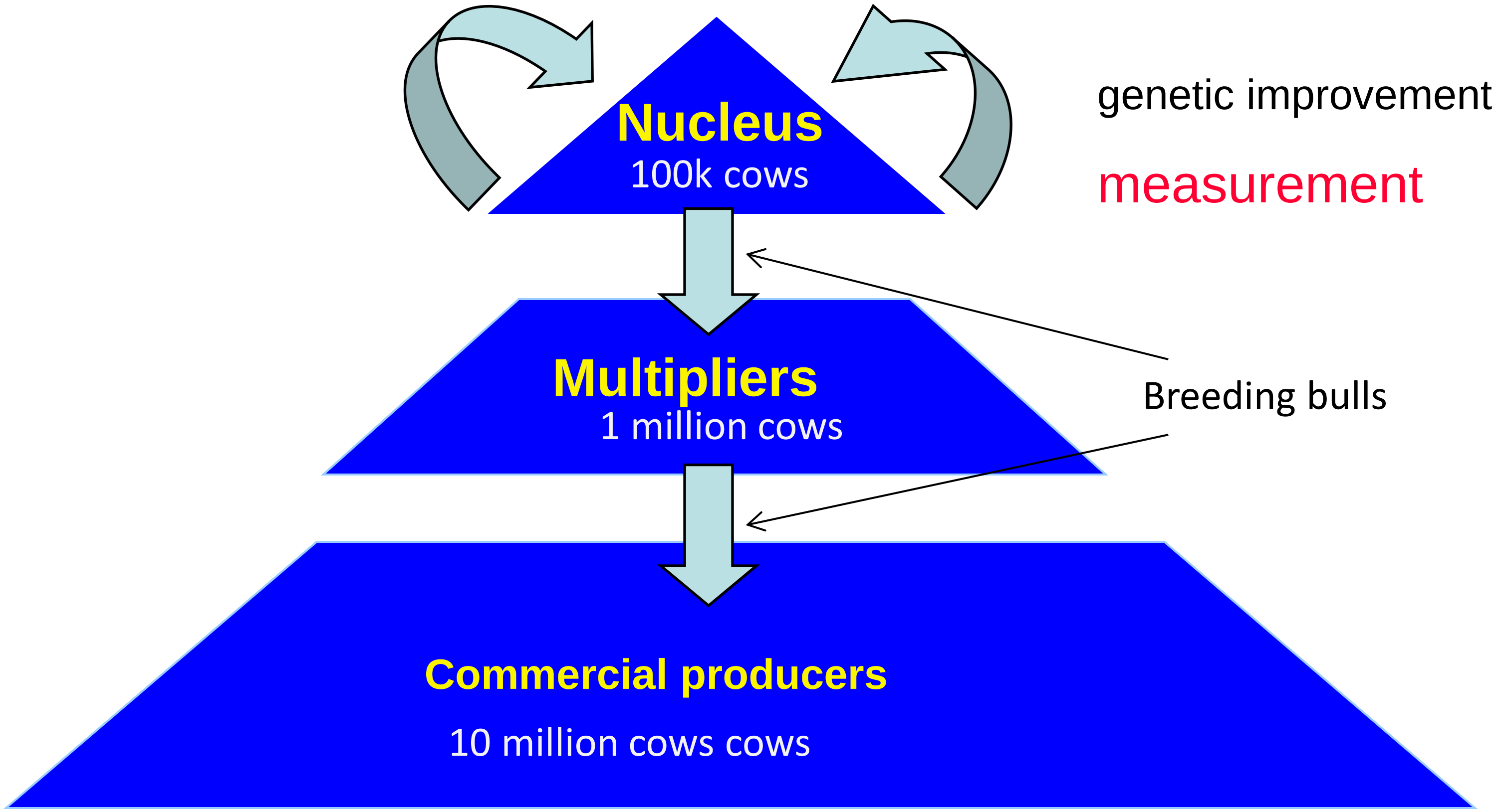
Genetic merit of Nucleus versus Commercial

Rate of gain is the same in all tiers



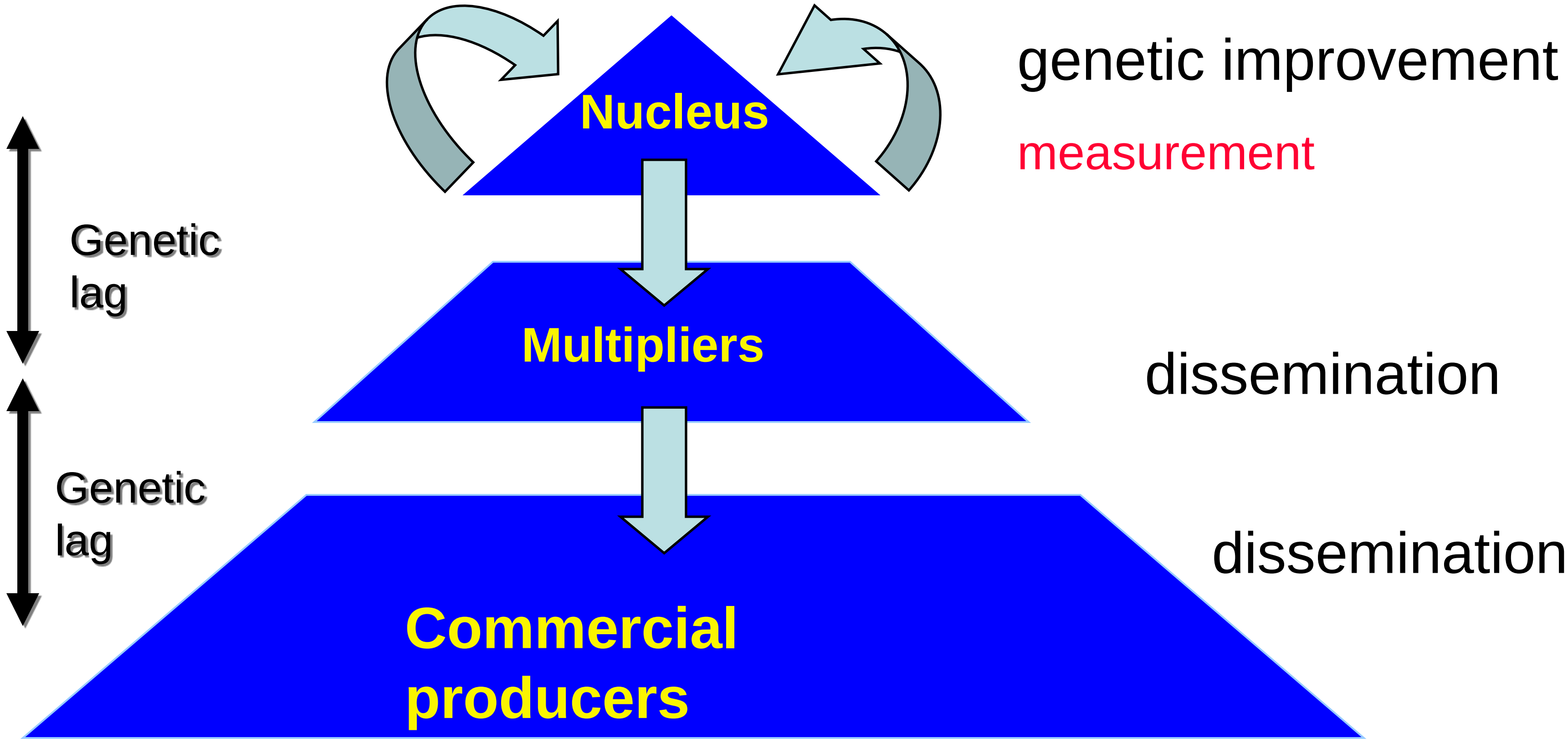
Design Examples

3-tier breeding program



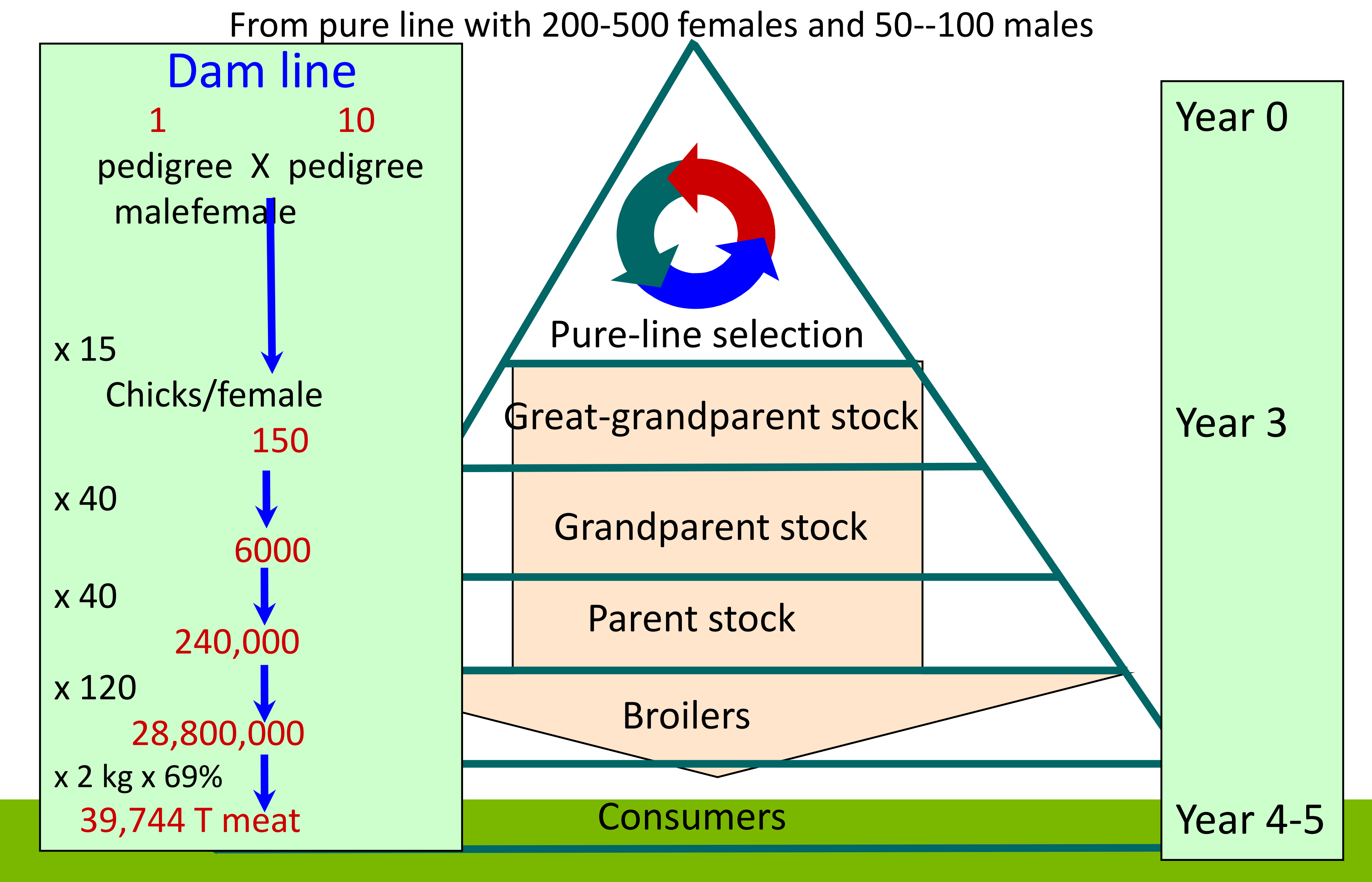
Design Examples

3-tier breeding program

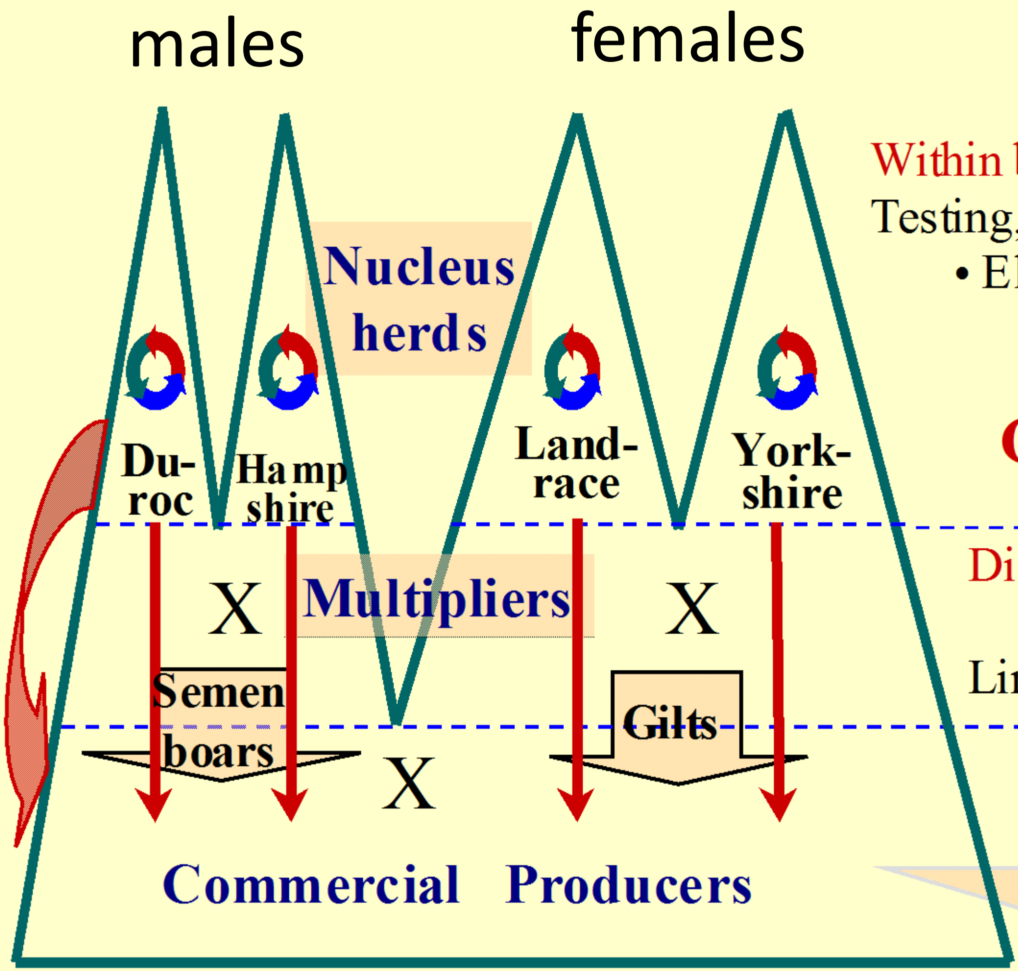


Multiplication in Broiler Breeding Programs

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



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

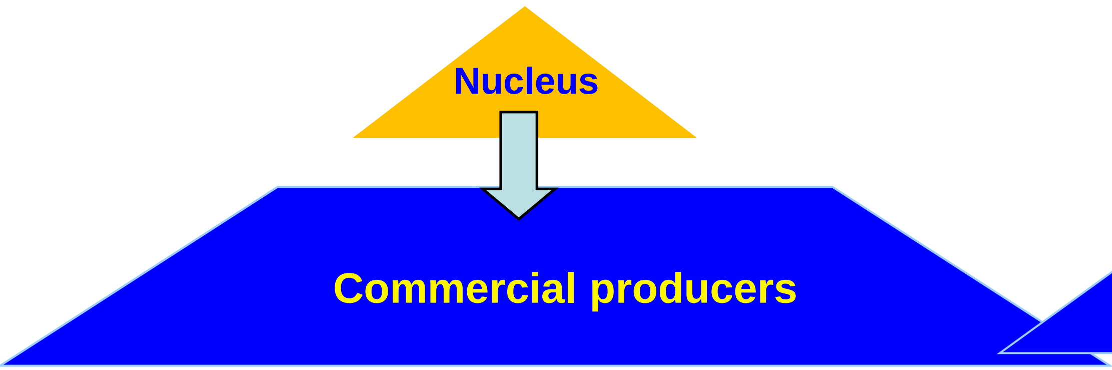
Two-tier breeding program

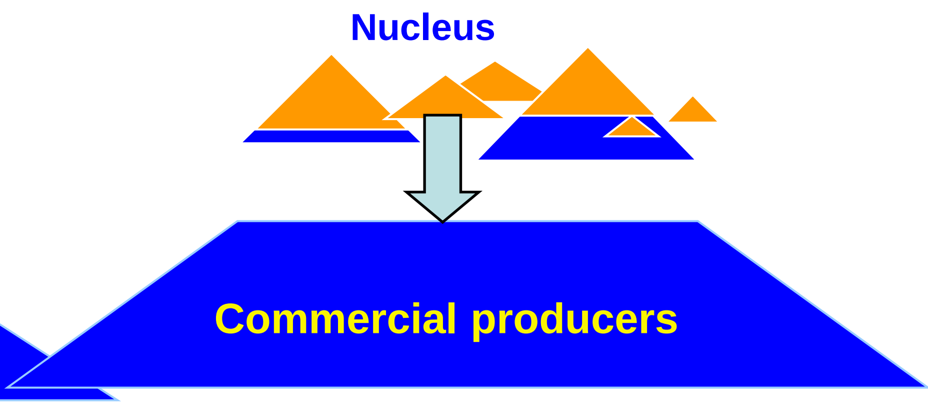
Central Nucleus

(pigs, poultry, some dairy)

or Dispersed

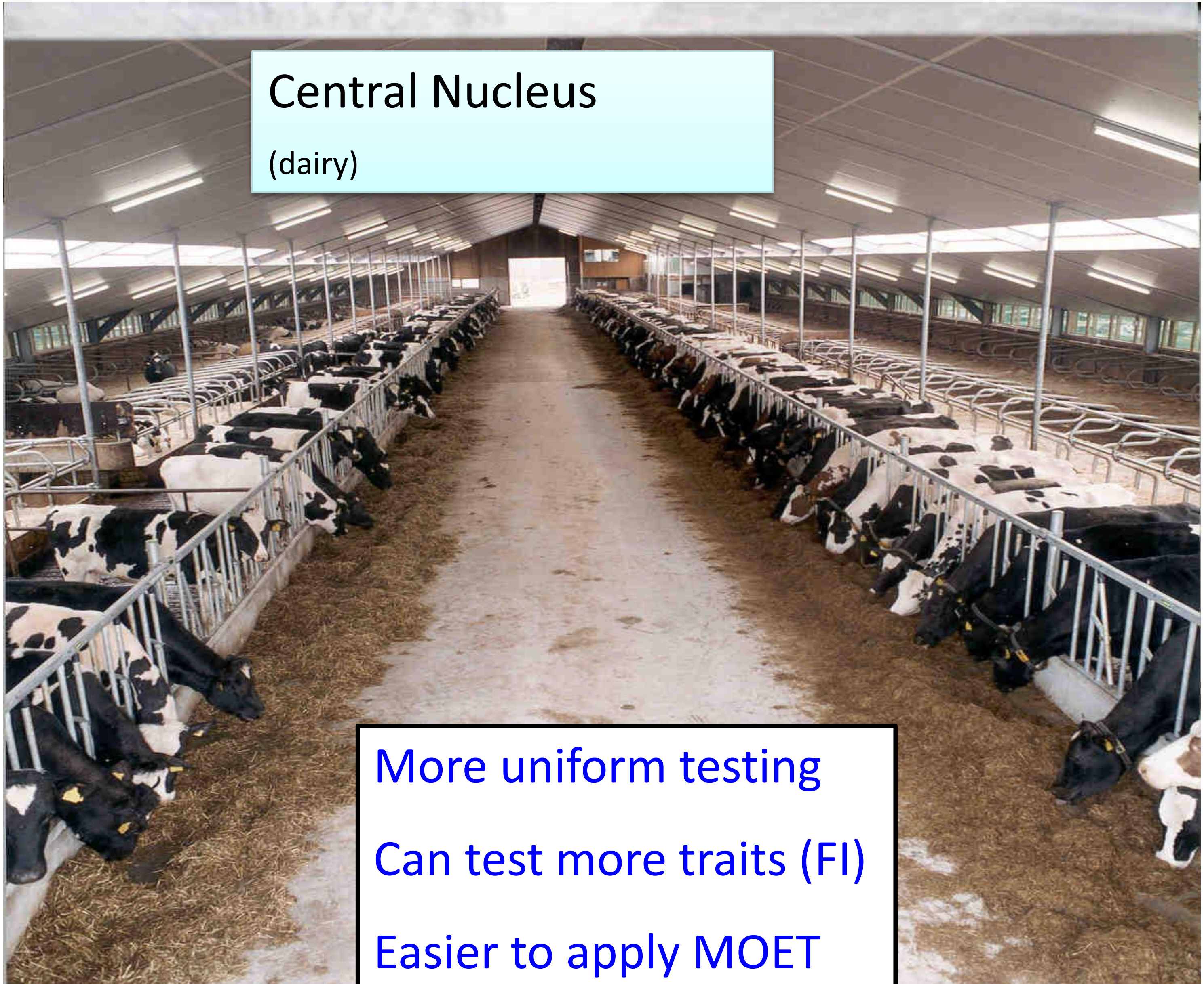
(sheep, cattle)





Central Nucleus

(dairy)



More uniform testing

Can test more traits (FI)

Easier to apply MOET

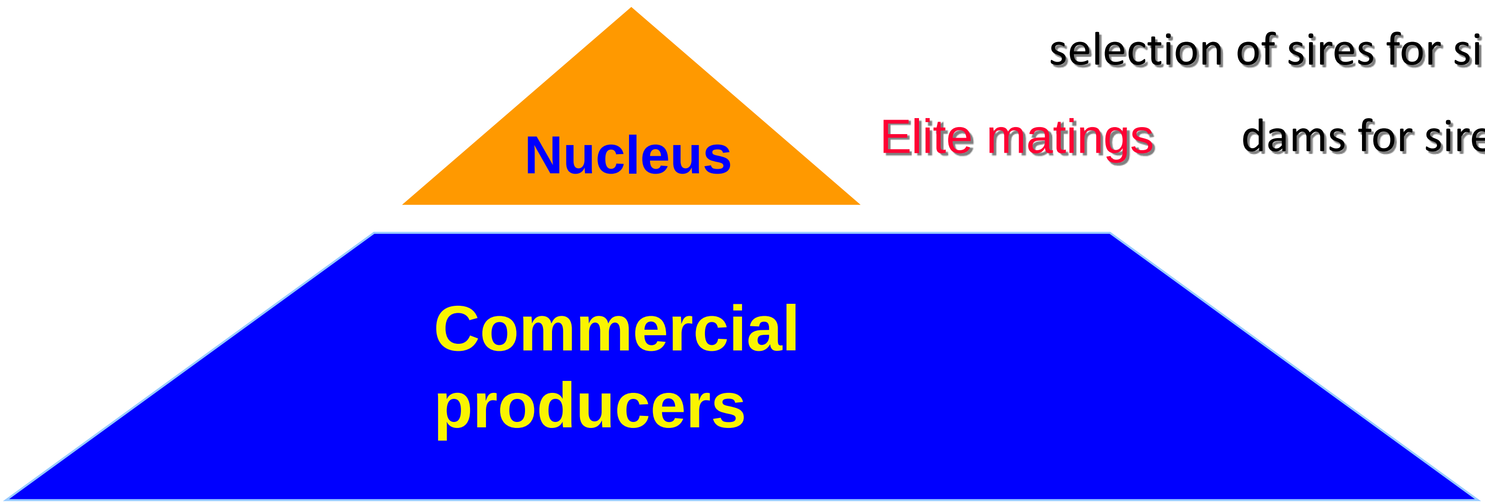
What defines the nucleus?

Nucleus: could be defined as

”the mothers and fathers of the future bulls”

4 pathways:	dairy
selection of sires for sires	top AI sires
dams for sires	bull dams

Elite matings

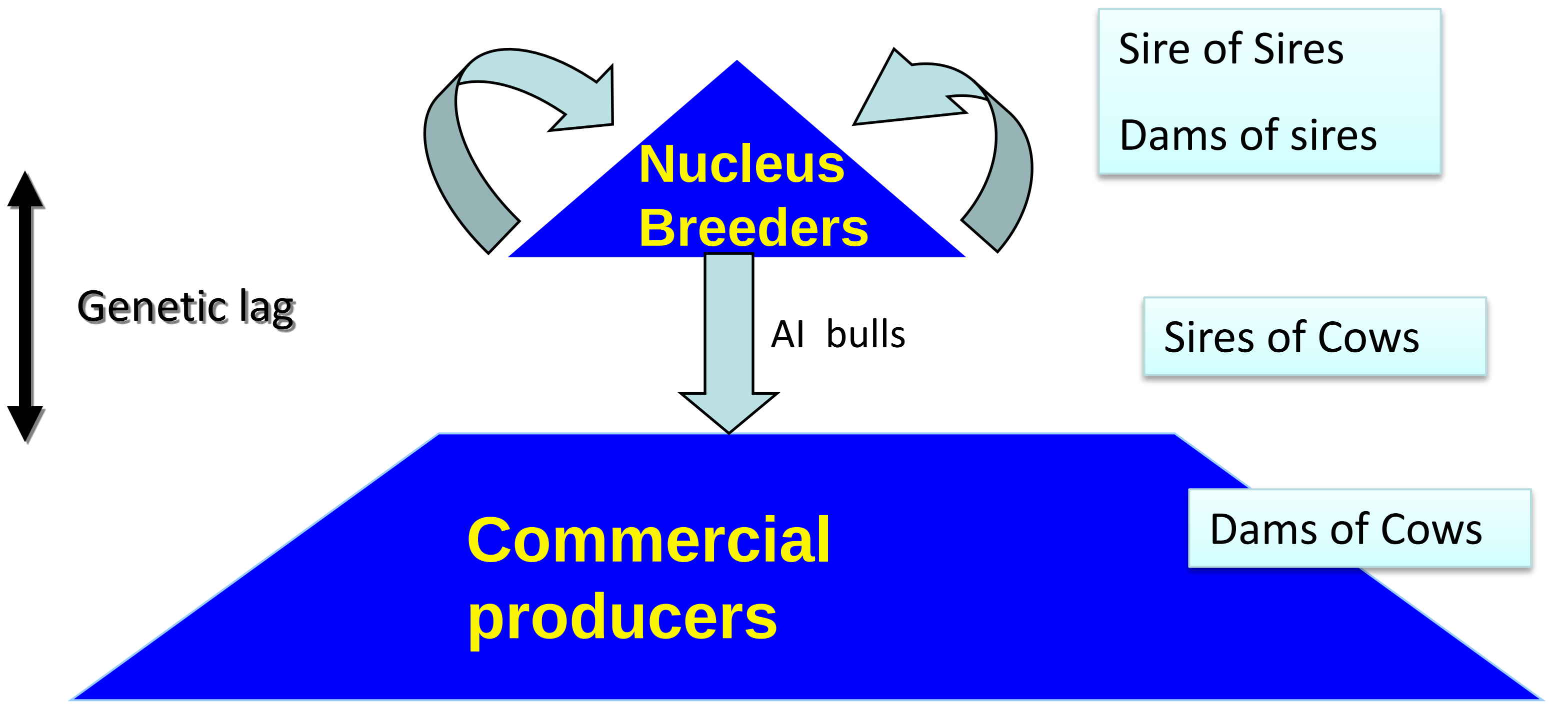


sires for cows	average AI sires
dams for cows	normal cows

Normal matings

Design Examples

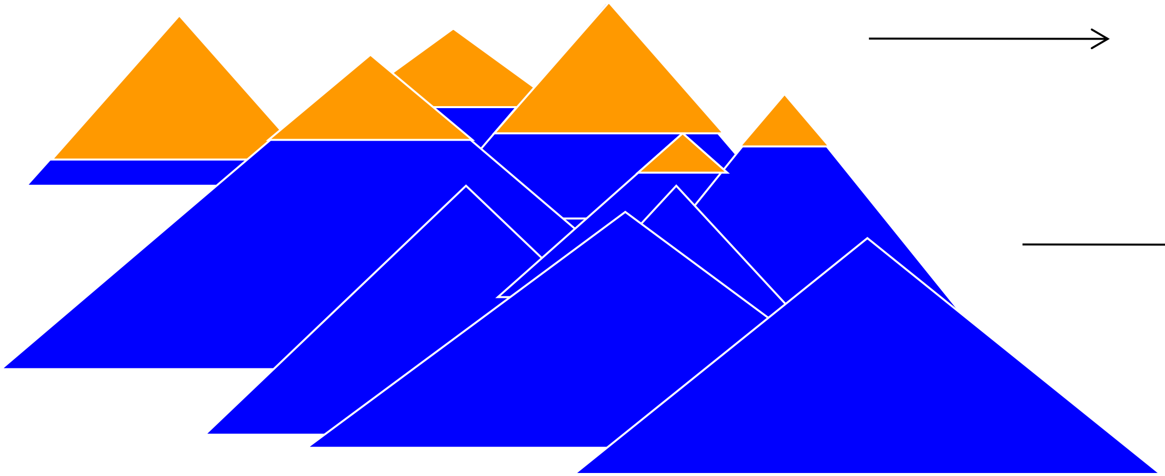
Two-tier breeding program (can compare with 4 pathways)



Dispersed Nucleus

Nucleus: could be defined as

”the mothers and fathers of the future bulls”

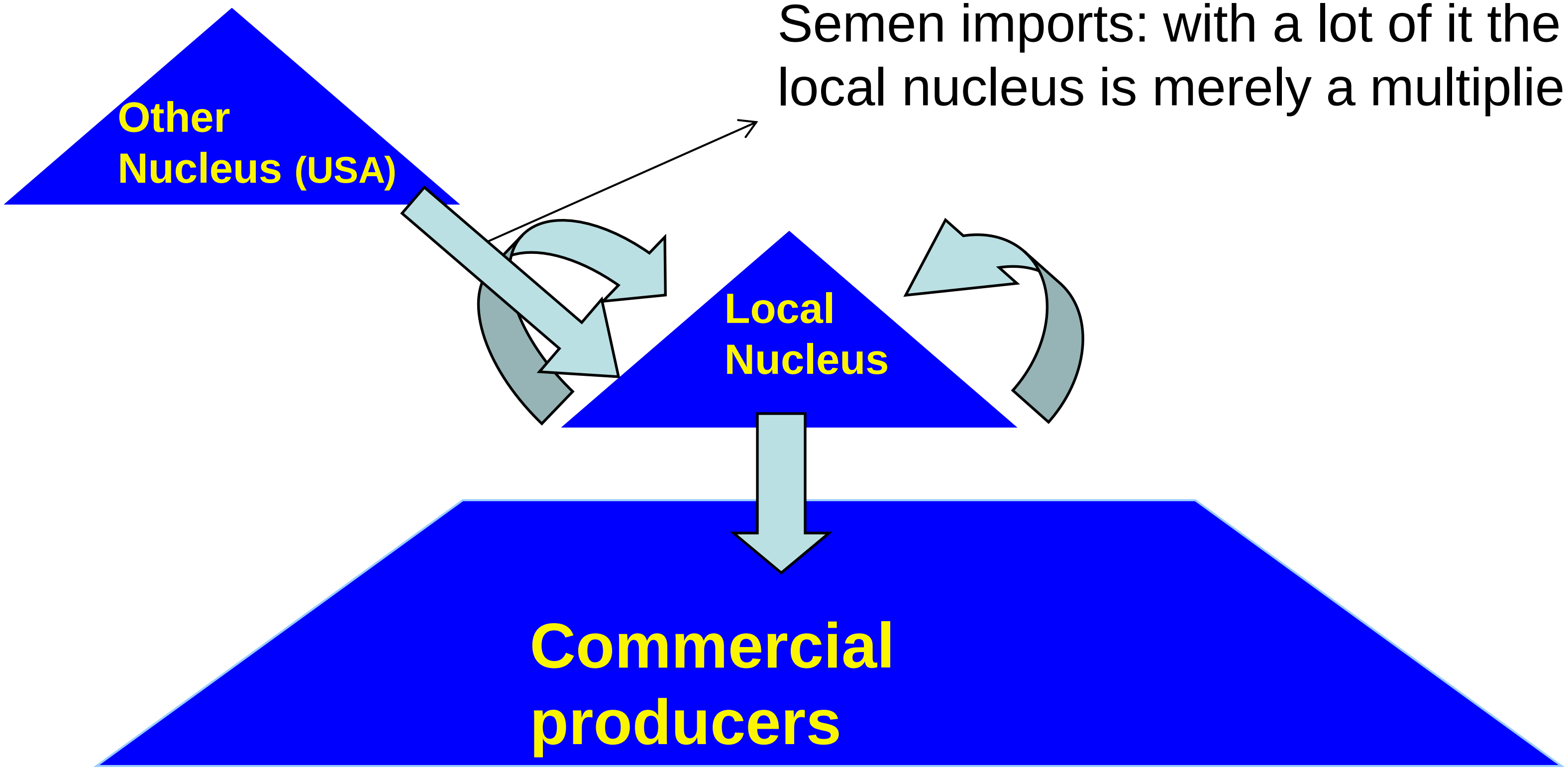


Top studs
Delivering the genetics of the future bulls

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

Local 'nucleus' can in fact be multiplier

Semen imports: with a lot of it the local nucleus is merely a multiplier



Examples: Angus Australia breeding program
Holstein Australia Breeding program

Nucleus Breeding Schemes

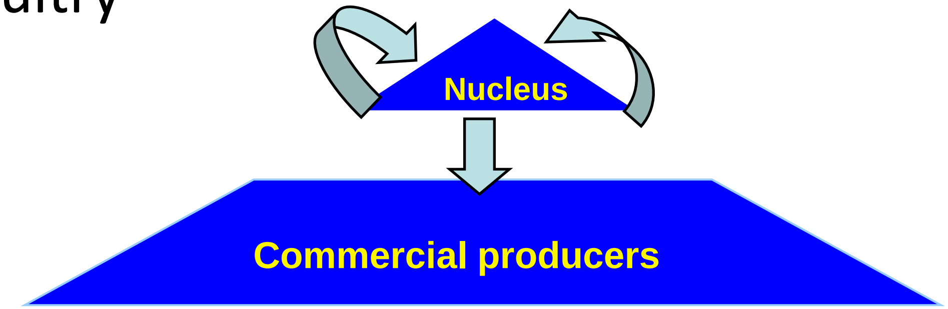
Closed Nucleus

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

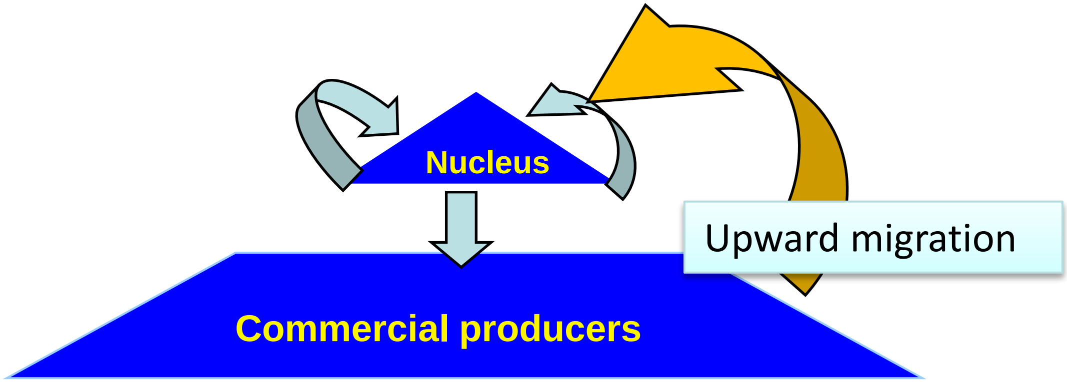
Open Nucleus

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



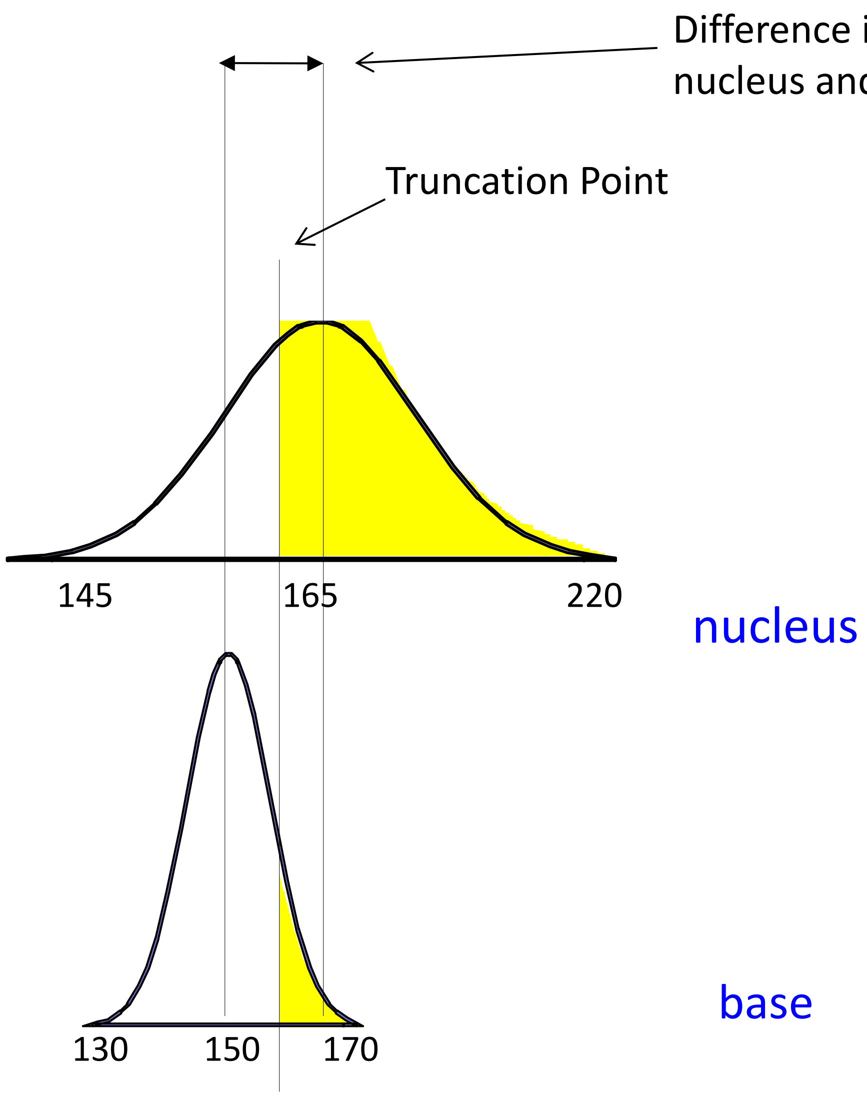
Open nucleus systems

- 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

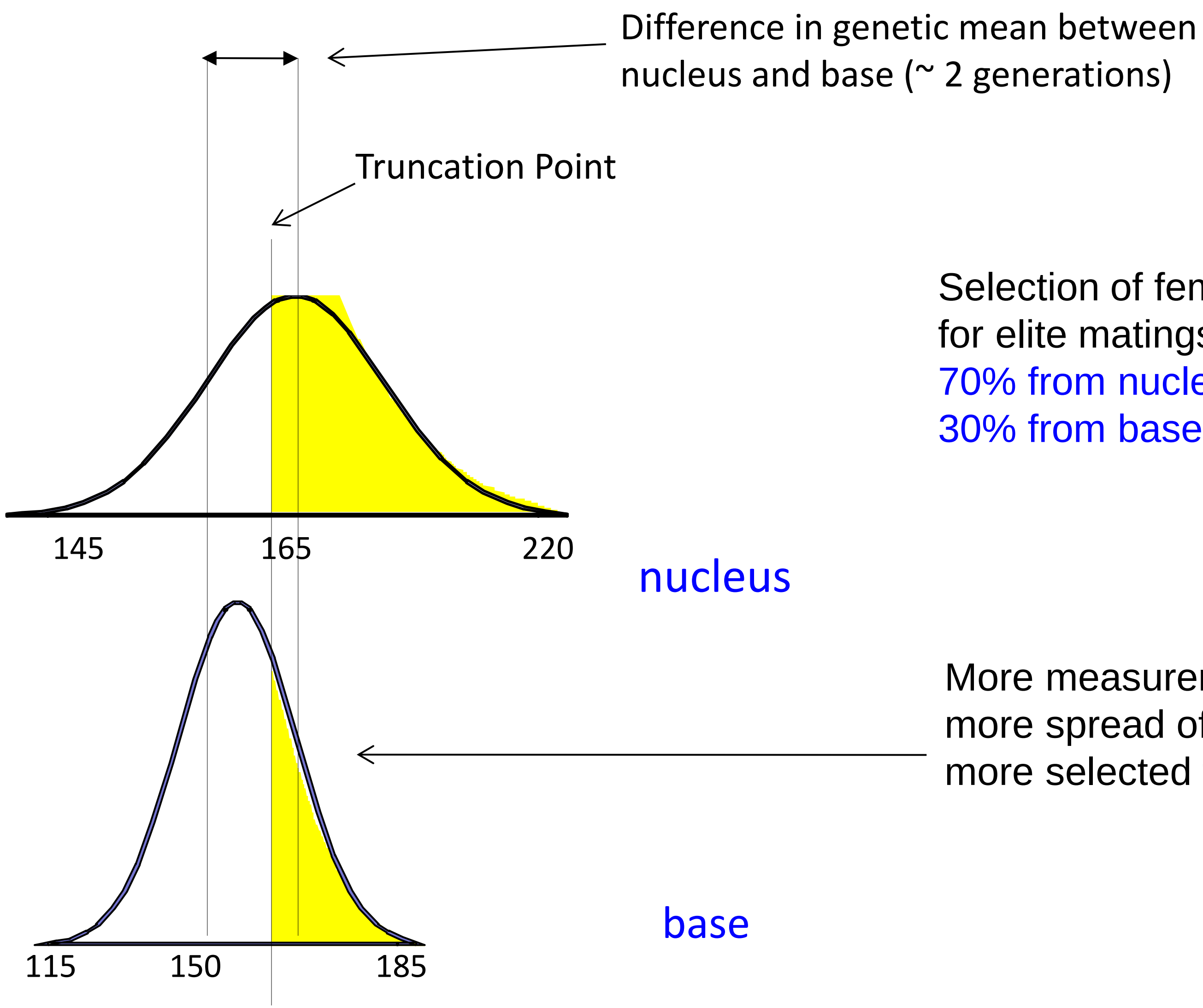
- Open to nuclei

Open Nucleus



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

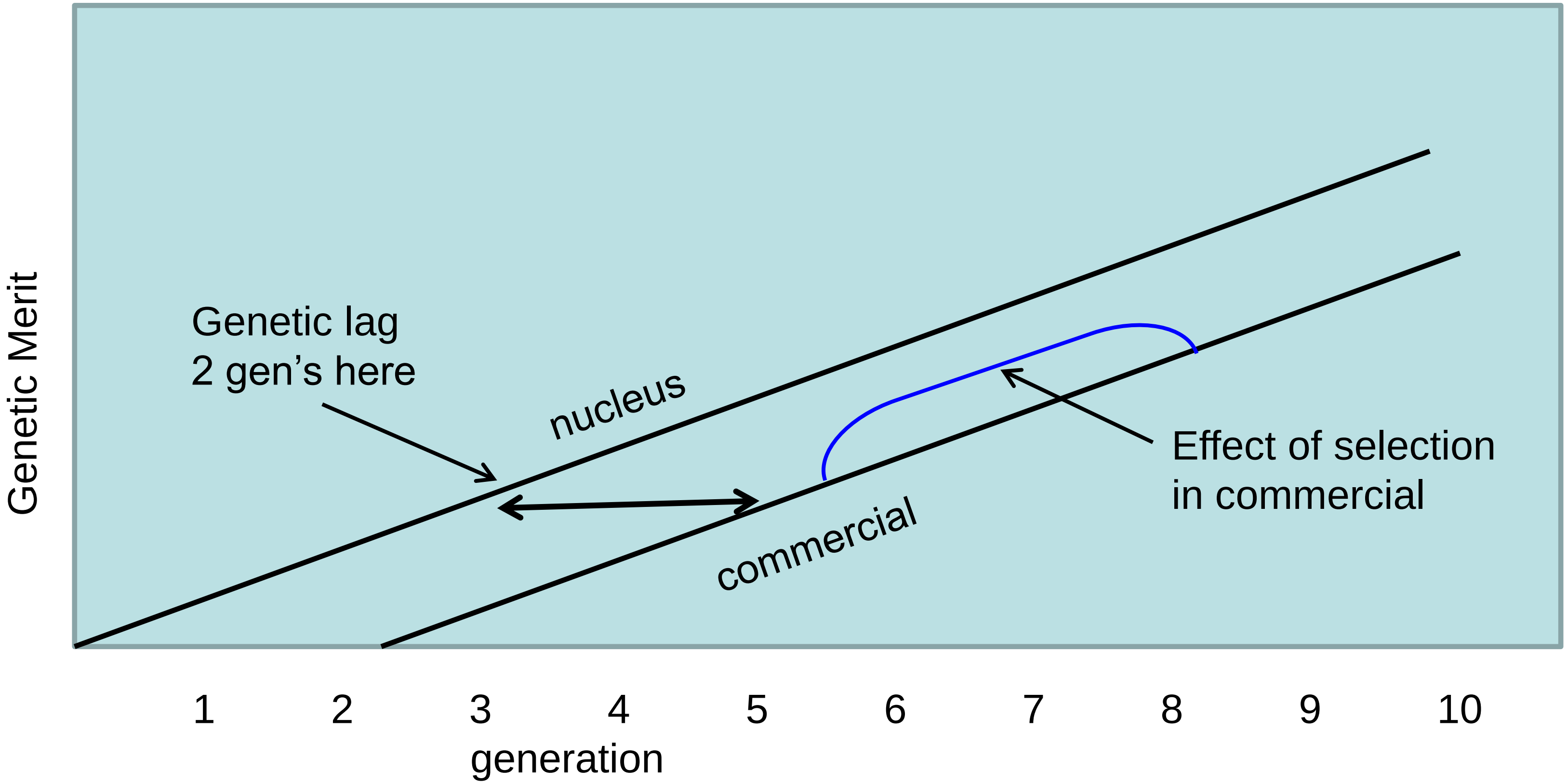
Open Nucleus: *effect of more information in base*



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

Benefit of selection in lower tier



Contributions of pathways

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

2 pathways

	sel.int	sel.accur
• Selection of sires	2	.5-.8
• Selection of dams	0.5-1	.5-.6

- → $S_{sires} : S_{dams}$ at least varies from 2:1 to 5:1
- Sire selection contribute more than 70%-90% to dG

une

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

Making genetic progress is about

Selecting only the very best

Selecting accurately

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

Keeping generation intervals short

Reproductive rates affect all of the above!

Reproductive technologies

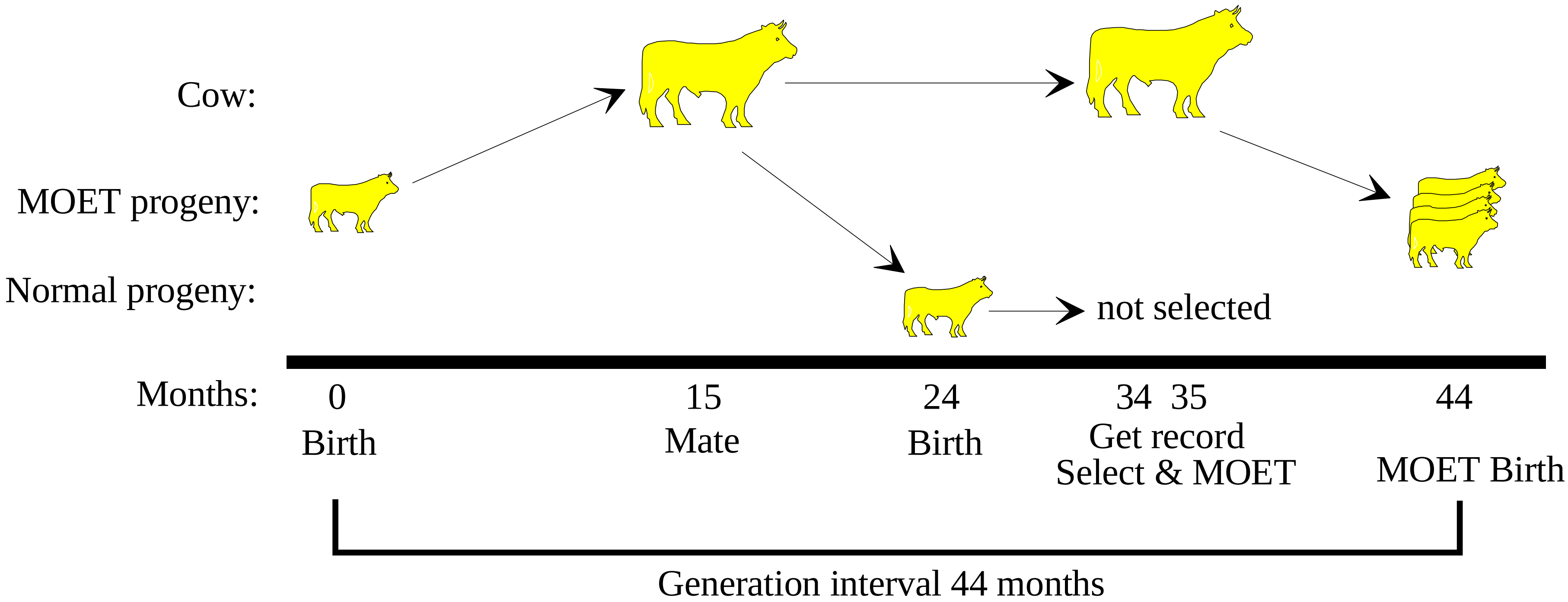
- Increases selection intensities

- Increases accuracy of EBVs

- Decreases generation intervals

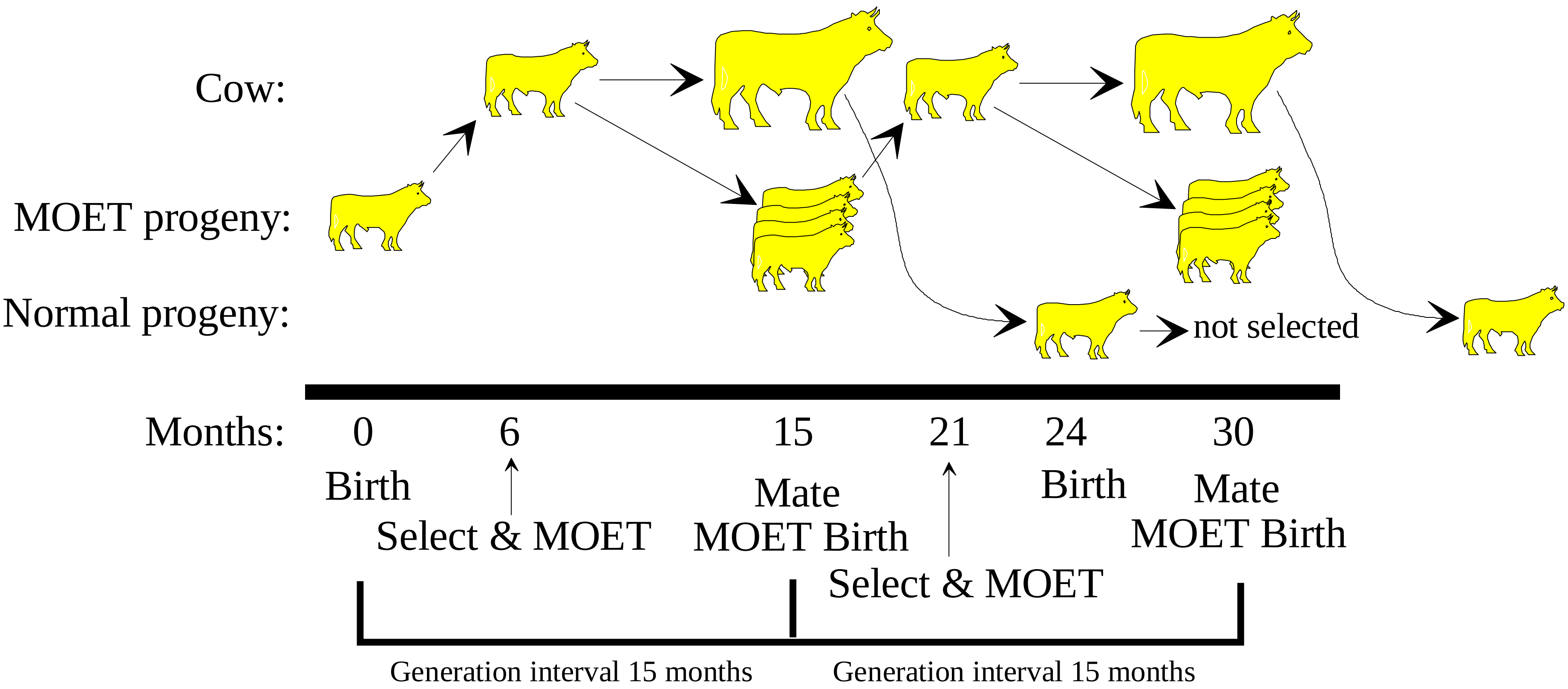
- Increases inbreeding

Adult dairy MOET scheme (1983)



More offspring of top cow *after* testing it

JIVET dairy scheme...



1998: Note that this is a bad design - EBV from <u>grand</u>parents!

2015: Maybe it isn't when we use genomics selection!

une

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