Keep or Cull:
Strategies for Replacement and Culling Decisions

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The Importance of Genetic Improvement

Genetic improvement is a long-term goal and solution.

Some advantages of focusing on genetic improvement:

- Industry and farm-level profitability and competitiveness
- Environmental implications
- Public perception
- Adapting for future market demands

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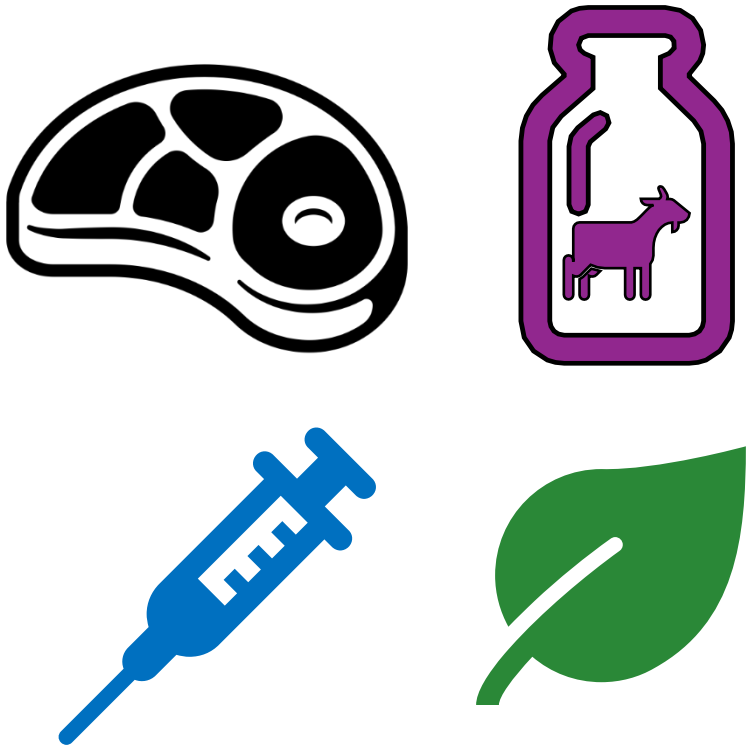
Preparing and adapting to future market demand

Genetic selection allows the industry to meet and prepare for future changes in the market



Product Quality

- Components in milk (i.e. casein protein composition)
- Meat tenderness / quality

Environmental / Societal Implications

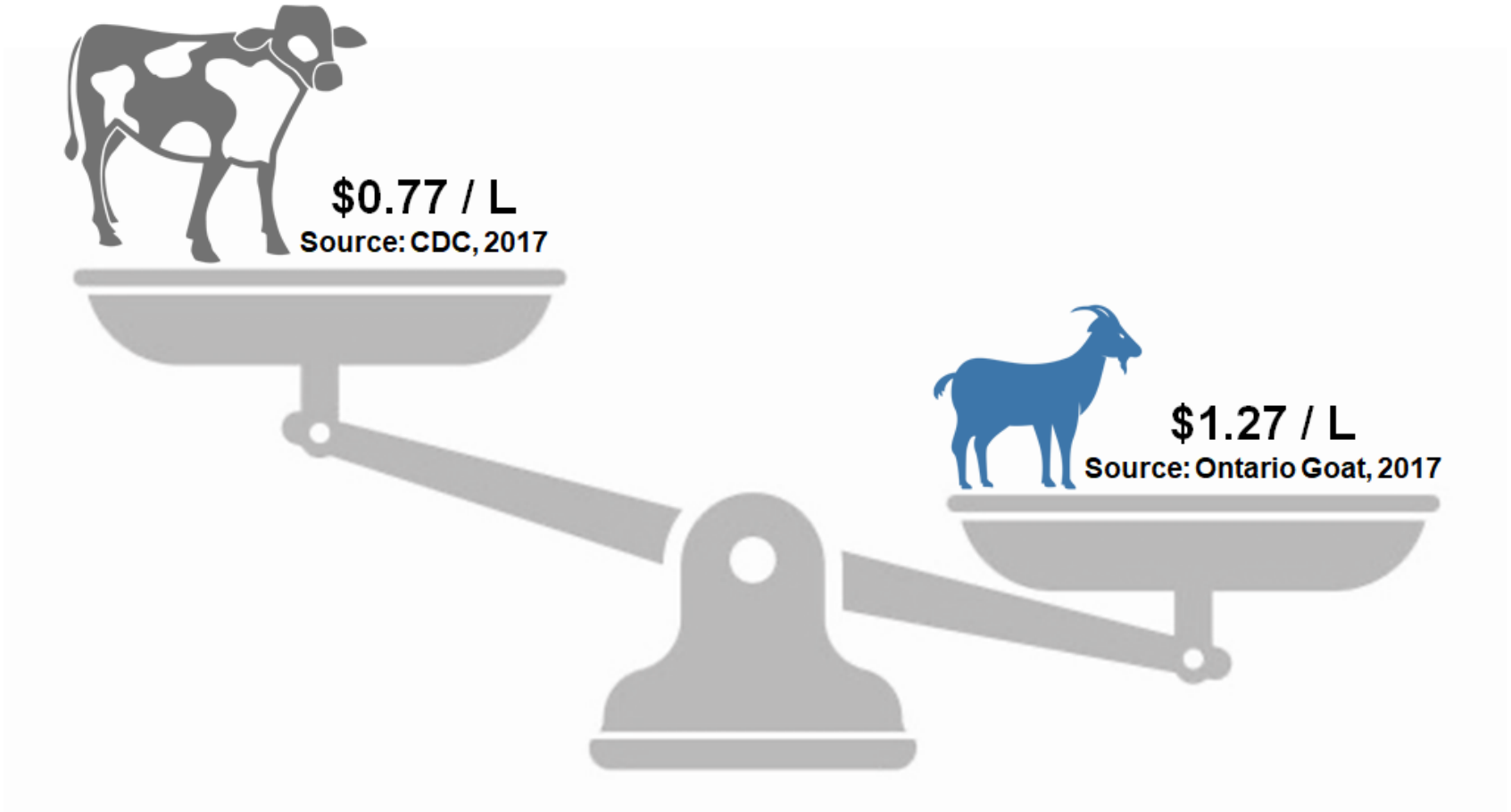
- Polled genetics to decrease disbudding
- Decreasing anti-microbial use
- Welfare traits (i.e., lameness)
- Methane emission and feed efficiency

Meat Icon: Created by Dmitry Mirolyubov from Noun Project

Improving Profitability and Sector Competitiveness

Example: Canadian Dairy Cows vs Goats

Cost of Production



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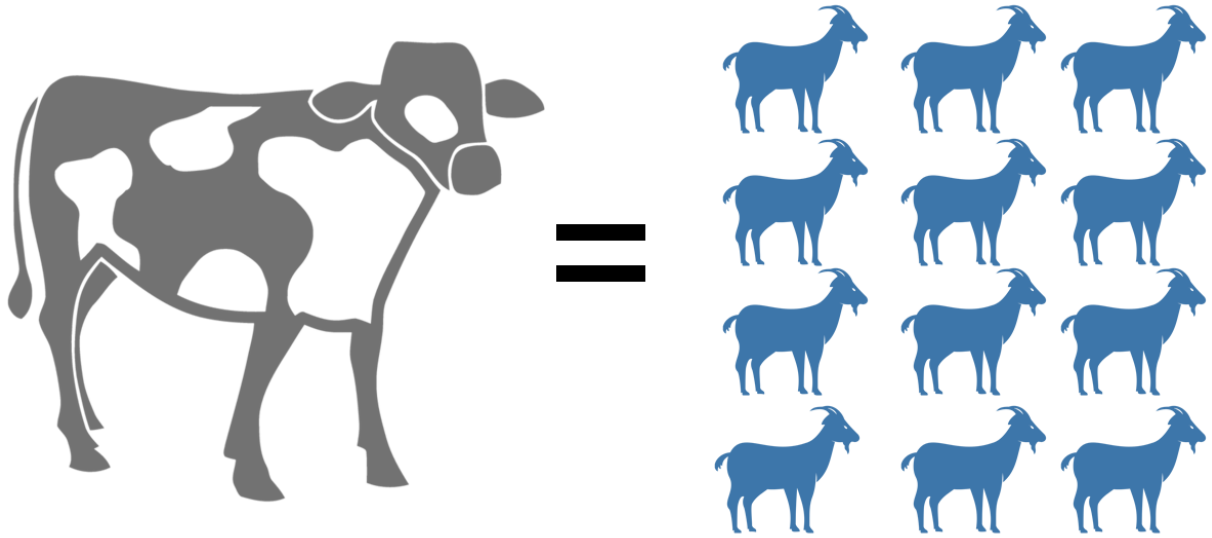
Improving Profitability and Sector Competitiveness

Example: Canadian Dairy Cows vs Goats

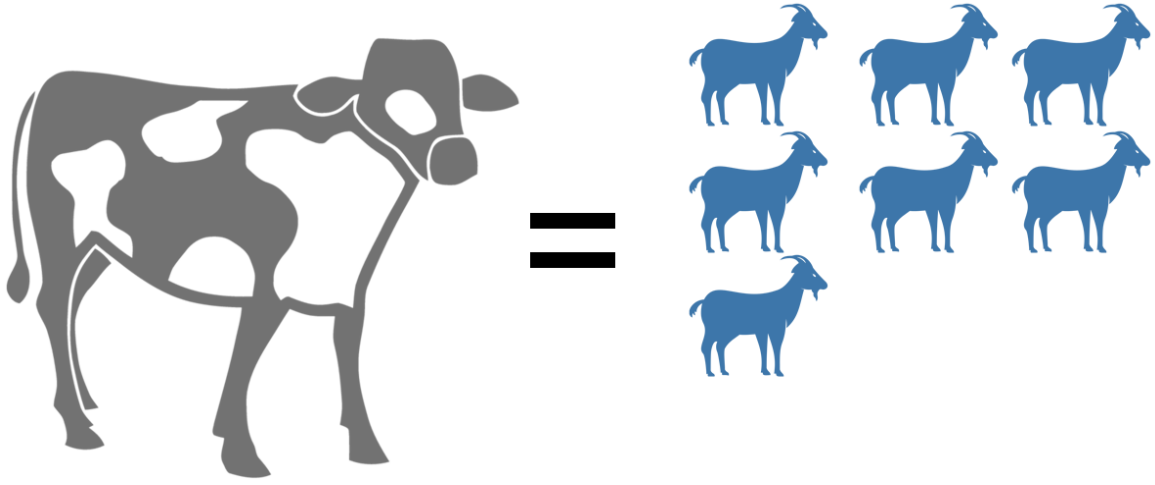
Production



10,909 kg / Cow
Source: CDIC, 2019

917 kg / Doe
Source: Ontario Goat, 2016

Expenses



Est. 1,276lb cow @ 3.5% DMI

Est. 135lb doe @ 5% DMI

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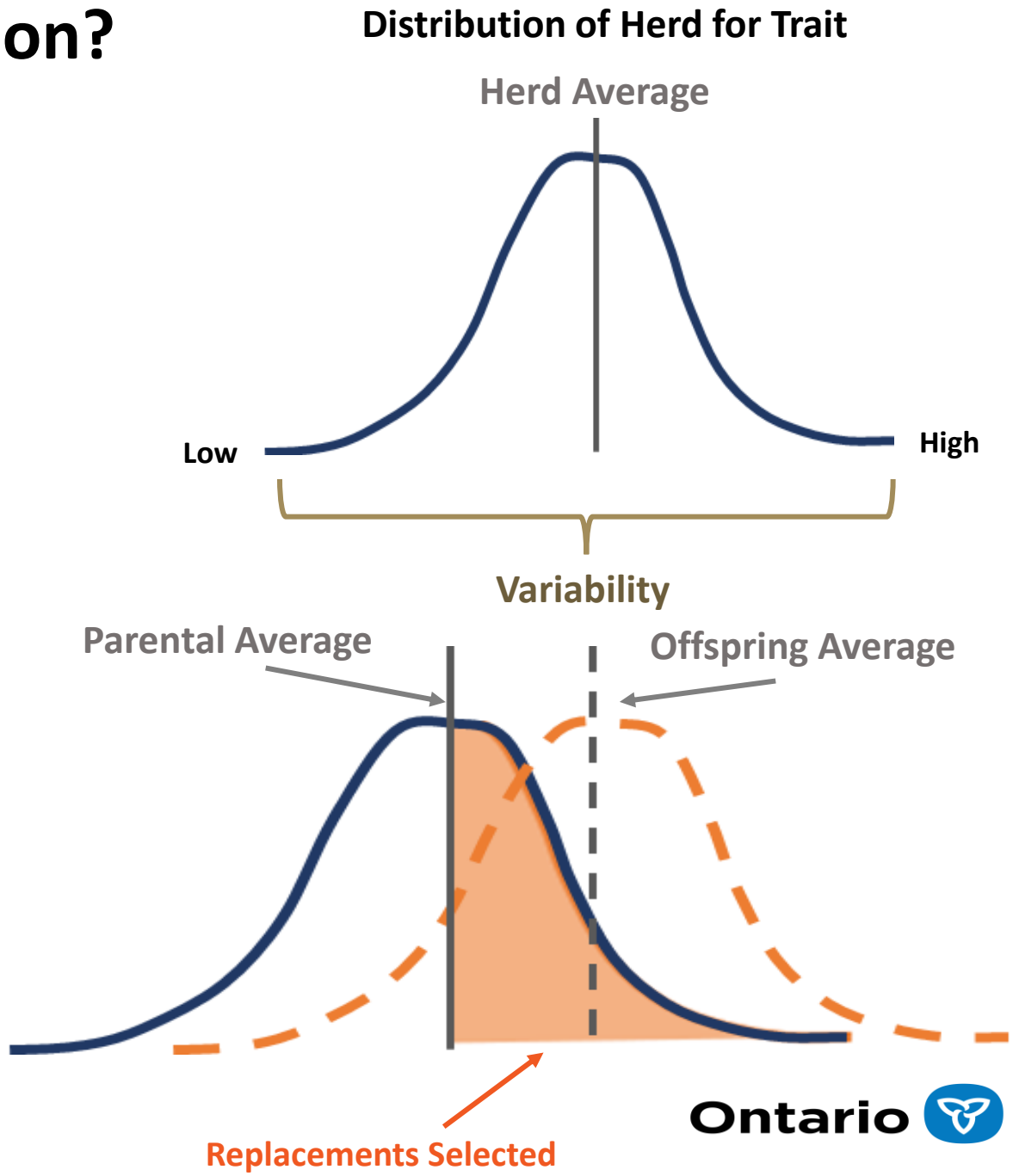
The Basics of Genetic Selection

What is the goal of genetic selection?

- In general, genetic selection at the commercial level aims to increase the production efficiency of the herd
  - Increase Production
  - Decrease Mortality
  - Increase Longevity

- Interested in change in the **population**. Selection and culling decisions are made in order to change **average performance** in the population.

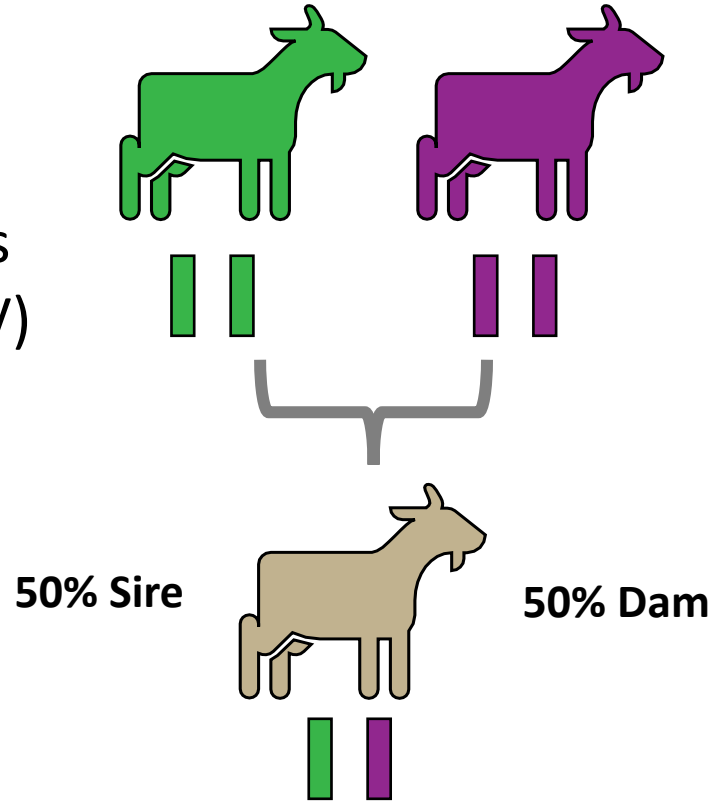


Selection – Both Sides Count!

- Genes come in pairs, one from the sire and one from the dam

- Expect offspring genetic merit to be the average of their parents
  - 50% Sire Genetic Merit (EBV) + 50% Dam Genetic Merit (EBV)
  - Genetic merit of full siblings is assumed to be the same

- Sires have a greater impact on the genetics of the whole herd, but the impact of dam genetics should not be ignored



Female Replacement Selection Rule of Thumb:

1. If sires are far superior to dams, keep more replacements

2. If sires are similar to dams, be pickier with which doelings to keep

Estimated Breeding Value (EBV) – A prediction of an animal's genetic merit based on the information available

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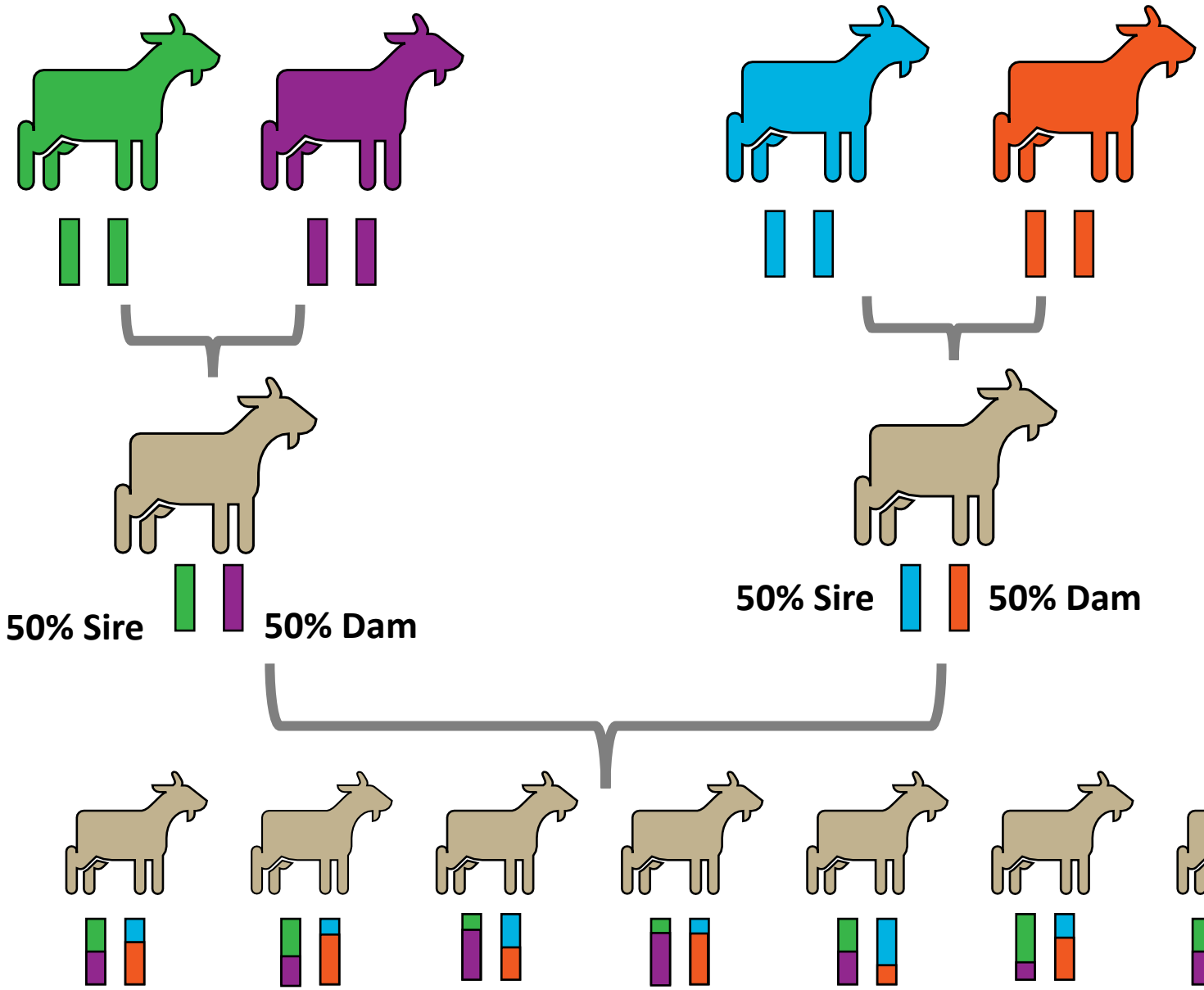
Genetics: It's Random



- **The copy of the gene received by individuals is random**
  - This is called **Mendelian Sampling**
  - Explains why full-sibling performance is variable
- **Crossing over**, random swapping of genetic material during egg and sperm formation, adds more variability

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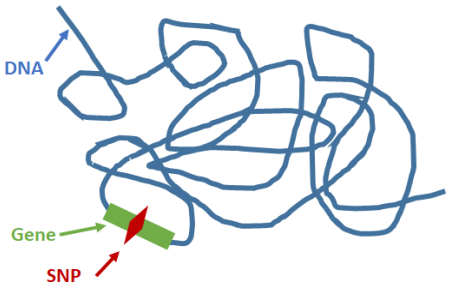
Types of Traits

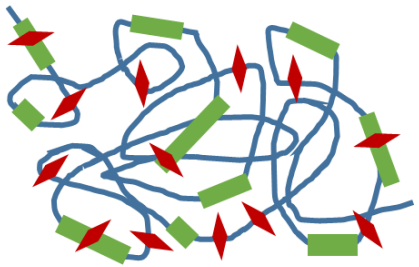
Simple Traits

- Affected by one or a few genes with a major influence on performance
- Observed characteristic is usually distinct categories
- Examples: coat colour, presence of horns



Complex Traits

- Affected by many genes, each with a small influence on performance
- Performance is often numeric and continuous
- Examples: height, weight, milk yield



Trait – An observable or measurable characteristic of an individual

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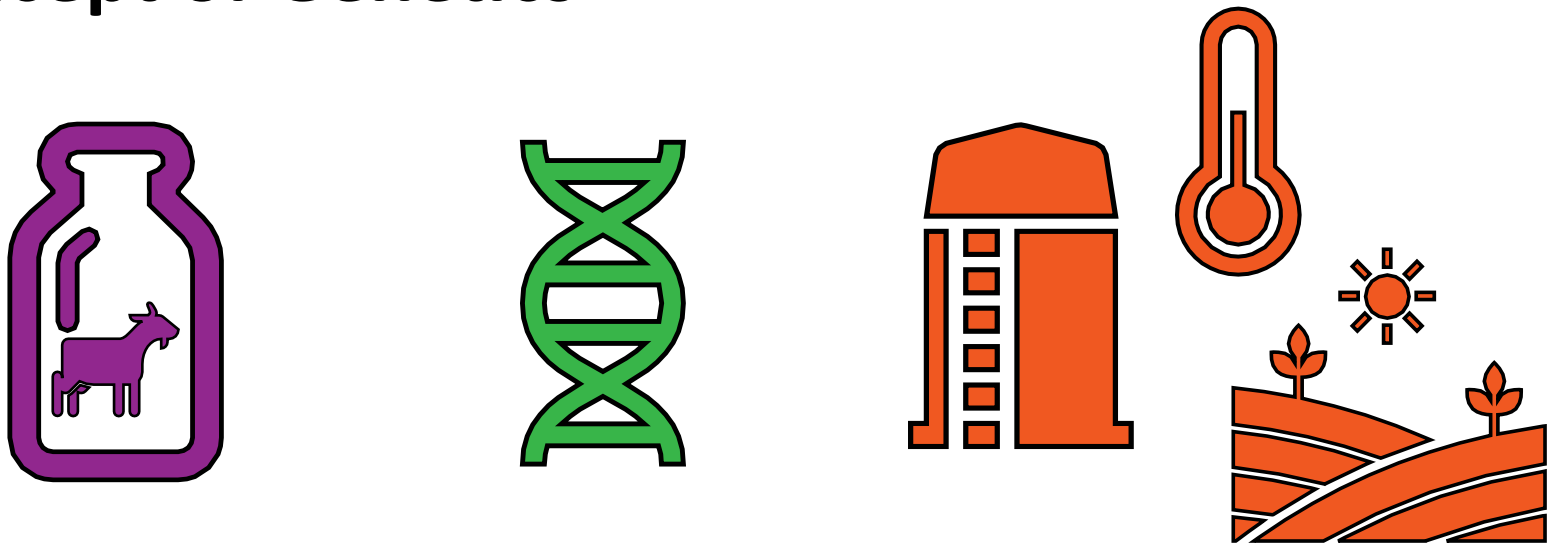
Image Sources: "Weighinggoats, Cobar NSW" by NSW DPI Schools program is licensed under CC BY-NC-SA 2.0 ; "supper time for the milking goats" by taratara69 is licensed under CC BY-NC 2.0

The Key Concept of Genetics



$$P = G + E$$

Phenotype – Performance of an animal for a given trait (e.g., milk yield, market weight, coat colour)

Genotype – The genetic makeup of an animal at a specific gene or across the genetic code

Environment – All the "non-genetic" factors that influence performance (e.g., climate, season, diet)

Heritability

- **Heritability (h^2)** – A measure of the proportion of observed (phenotypic) variation for a trait that is due to genetics and passed from parents to progeny

$$h^2 = \frac{G}{G + E}$$

High $h^2 = \frac{\quad}{\quad + \quad}$

High Heritability (>0.30)

Variability in performance more influenced by genetic merit of parents

Low $h^2 = \frac{\quad}{\quad + \quad}$

Low Heritability (<0.10)

Variability in performance more influenced by environment

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Heritability Estimates for Key Traits in Goats

Trait	Heritability
Milk Production	
Milk Yield	0.33
Protein Yield	0.40
Fat Yield	0.36
Protein Percentage	0.54
Fat Percentage	0.52
Productive Life	0.17 - 0.22
Health	
Somatic Cell Score	0.20 - 0.24
CAE Resistance	0.08
Conformation	
Udder	0.15 - 0.40
Teats	0.22 - 0.50
Feet & Legs	0.02 - 0.25

Trait	Heritability
Growth	
Birthweight	0.16
Weaning Weight	0.15 - 0.40
Market Weight	0.28 - 0.45
Yearling Weight	0.31
Pre-weaning Daily Gain	0.17
Post-weaning Daily Gain	0.28
Reproduction	
Litter Size	0.05
Age at First kidding	0.17
Gestation Length	0.10
Kid Pre-weaning Survival	0.09

(Jembere et al., 2017)

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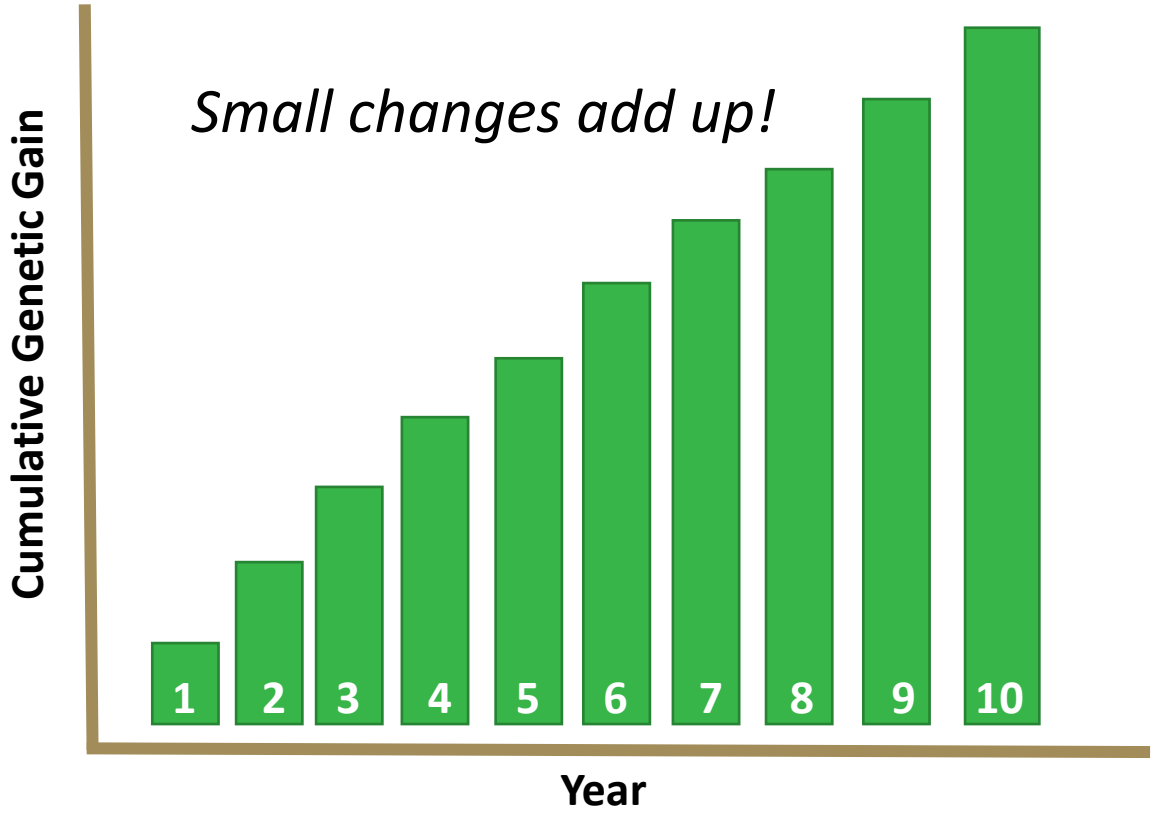
Change the Genetics or Change the Environment?

If the environment plays such a large role in most traits, why do we care about genetic selection?

Genetic selection produces cumulative and permanent changes in the population!

- Some environmental factors are out of our control (e.g., climate, disease)
- Improving the environment (e.g., diet) requires sustained input costs to maintain performance
- Genetic selection increases productivity without continuous input costs as the animals in herd become more efficient



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Genetic Diversity and Inbreeding

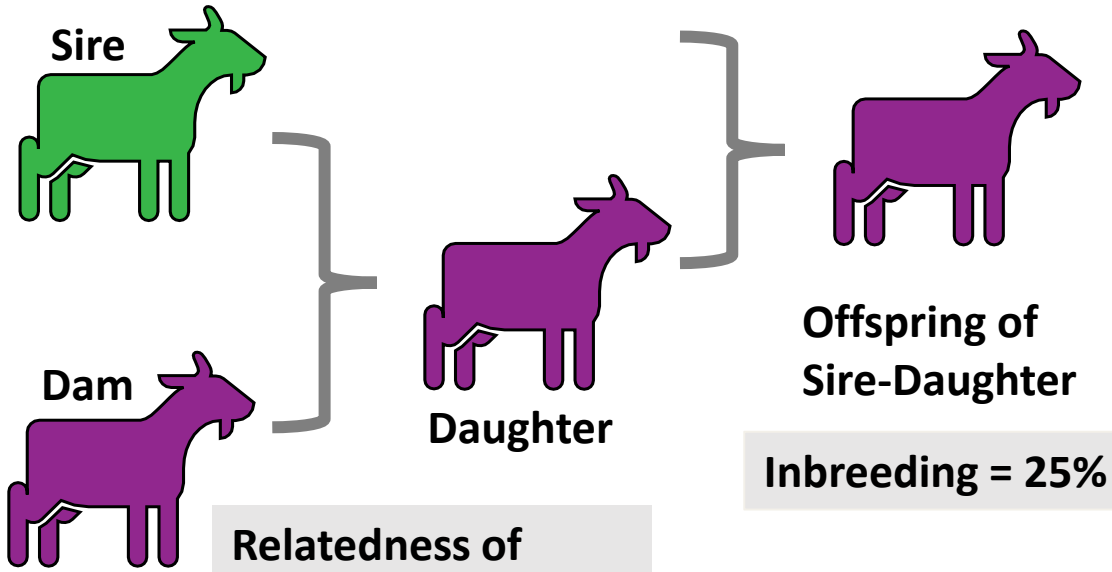
Genetic diversity refers to the presence of genetic differences within a population

- Driving force behind genetic improvement
- Increases adaptability for changes to breeding objectives
- Reduced by inbreeding and selection

Inbreeding – The mating of related individuals

- Recessive genetic conditions
- Inbreeding depression

Type of Mating	Relationship of Parents (%)	Inbreeding of Progeny (%)
Sire and Daughter, Dam and Son	50	25
Full-Siblings	50	25
Half-Siblings	25	12.5
Unrelated Inbred Individuals	0	0



How to Manage Genetic Diversity in the Herd

1. Maintain individual pedigree records and manage matings to avoid inbreeding
2. Purchase new buck/doe genetics
3. Avoid excessively selecting replacements from within specific families
4. Replace bucks every few years

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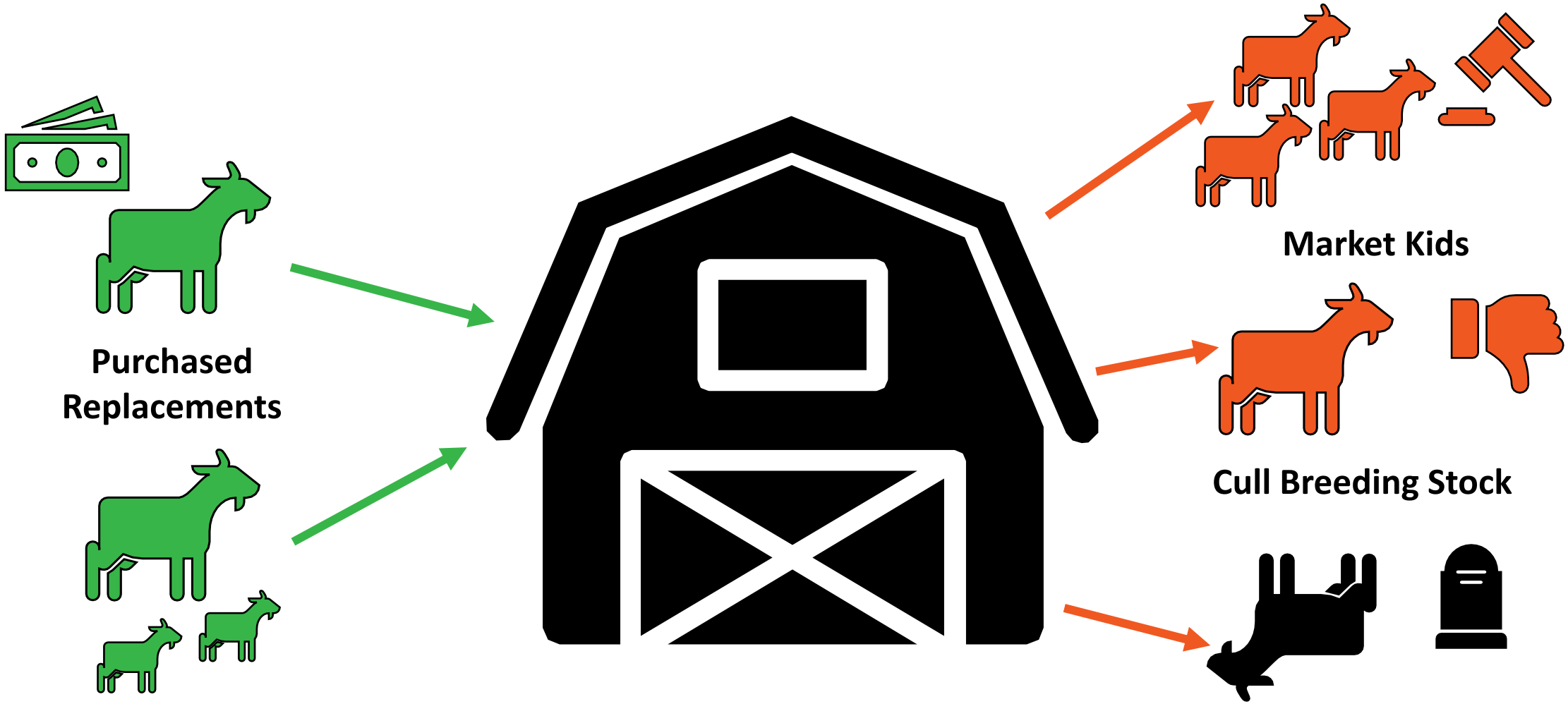
Factors Influencing Rate of Genetic Progress

1. **Selection Intensity**
   - How picky you are with selecting breeding candidates?
   - Higher selection intensity means faster progress
2. **Accuracy**
   - How correct were you at identifying the "best" animals?
   - Higher accuracy means faster progress
3. **Genetic Variation**
   - How much variability there for the trait?
   - More variability means more opportunity for selection
4. **Generation Interval**
   - How rapidly do offspring replace their parents in the breeding herd?
   - Shorter generation interval means faster progress
5. **Number of Traits**
   - As more traits are selected, progress for each trait decreases due to trade offs

Optimizing breeding programs requires a balancing act between the different factors affecting genetic progress

Herd Dynamics

How do animals enter and exit the herd?



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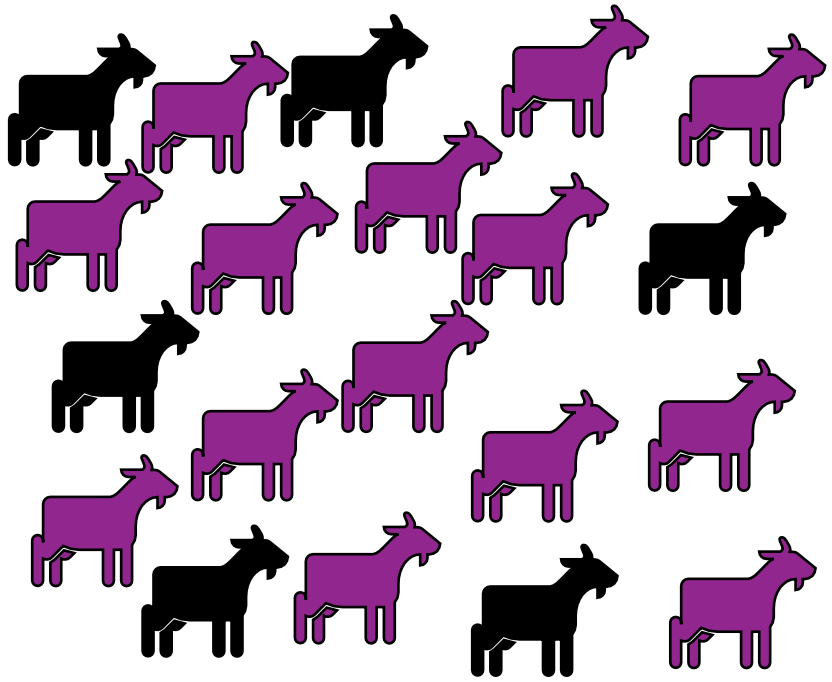
Exiting: Involuntary vs. Voluntary Culling

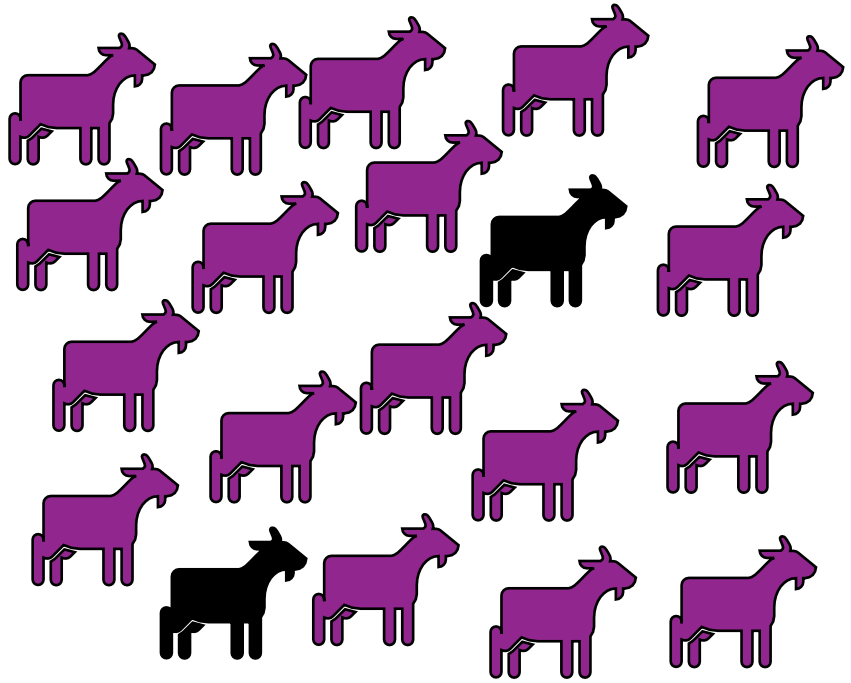
Involuntary Culling – The removal of breeding stock or potential replacements from the herd due to no productive future (e.g., illness, injury, infertility, CAE positive or death.)

Voluntary Culling – The removal of breeding stock or potential replacements because they do not meet an economic and breeding objective criteria (e.g., poor production, temperament).

Herd A
30% Kid Mortality



Herd B
5% Kid Mortality



Impact of Culling on Genetic Improvement

- High kid or adult mortality rates reduce selection intensity
- Genetic progress will be minimal if you can't make voluntary culling decisions based on performance.

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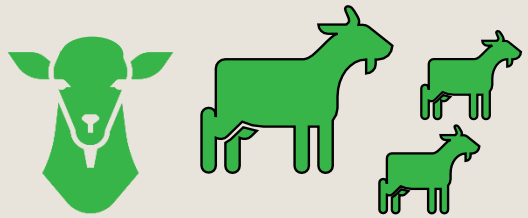
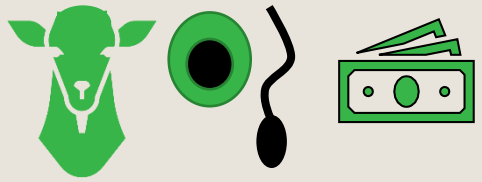
Entering the Herd: Buy or Raise Replacements

	Pros	Cons
Raising Replacement 	• No purchase cost • Closed herd, lower biosecurity risk	• Lower genetic diversity • Increased inbreeding • Limits genetic progress • Rearing costs and labour • Risk of mortality
Buying Replacement	• Increase genetic diversity • Purchase "better" genetics • No rearing costs or labour • Ready to breed	• Purchase costs • Open herd, higher biosecurity risk • Low availability of performance recorded bucks/does
Artificial Insemination & Embryo Transfer 	• Increases accuracy of genetic evaluations • Ability to get genetics that are unaffordable • Import unavailable genetics • No housing or rearing expenses • Lower biosecurity risk	• Lower conception rates • Experience breeder or training on AI breeding • Less choices of bucks at this time

Decision Making

How many replacements do you keep?

Herd turnover rate is dependant on the number of does voluntarily and involuntarily leaving the herd and average herd inventory

Records that you need to keep:

- ✓ Animal inventory
- ✓ # of does that die on farm including euthanized animals
- ✓ # of does that exit the herd for economic reasons

How do you determine the number of replacements:

- Calculate herd turnover for a specific period or group of animals
- Desired herd size (expanding, stable or decreasing)

Other considerations:

- ✓ Ability to produce and sell product
- ✓ Barn space
- ✓ Amount of feed
- ✓ Moderate vs. intense culling
- ✓ Kid mortality

(Fetrow et. al., 2006)

Defining SMART Breeding Goals

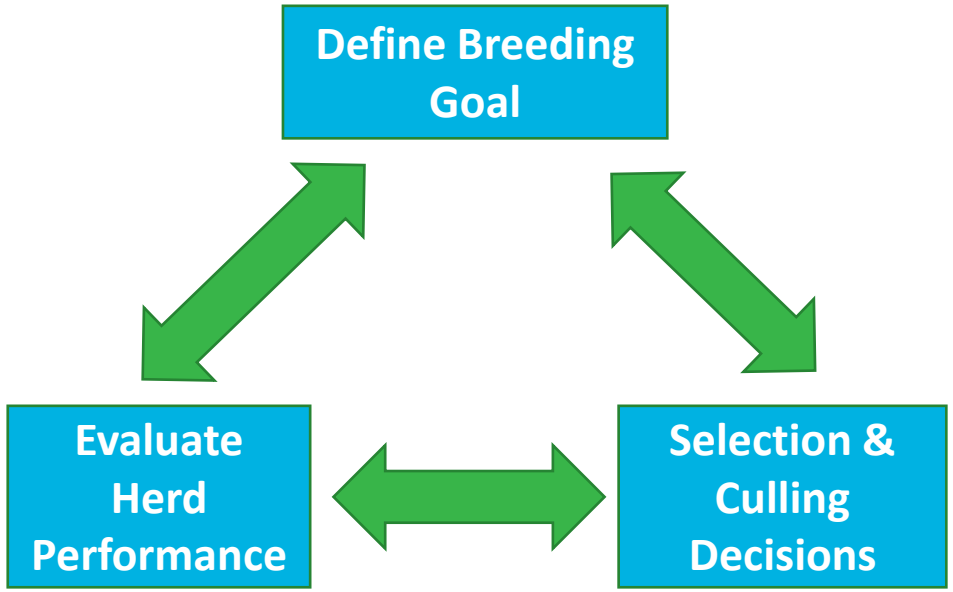
Specific – What are you trying to accomplish and why?

Measurable – Do you have the tools and management system to evaluate progress towards this goal?

Attainable – Are there other barriers that may make this goal unfeasible (e.g., high kid mortality, limited access to new genetics, lack of individual identification)?

Relevant – Is this breeding goal aligned with your broader objectives for your farm business and/or target market? Is the goal tied to profitability, sustainability or public perception?

Timely – When is your target to achieve this goal? Is this realistic given the heritability of the trait and your rate of genetic improvement?



Keep in mind that:

- **Breeding goals change over-time**
- **Genetic improvement is a long-term strategy (4 years per generation)**
- **Consistent, systematic selection and frequent evaluation are needed to see progress**

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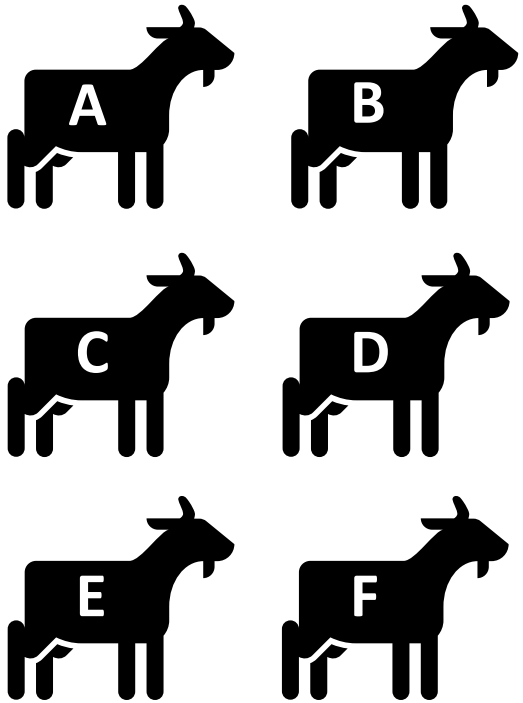
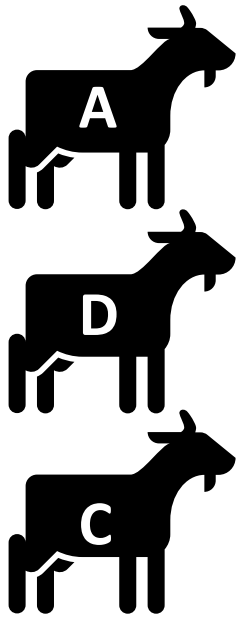
What animals should you keep?



No Breeding Goal

Breeding Goal

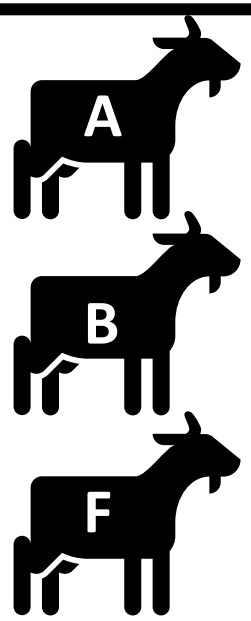
How do you decide which animals to keep?



Survived to breeding age

Bred back another year

“I feel this animal is good”



Performance

Conformation

Health

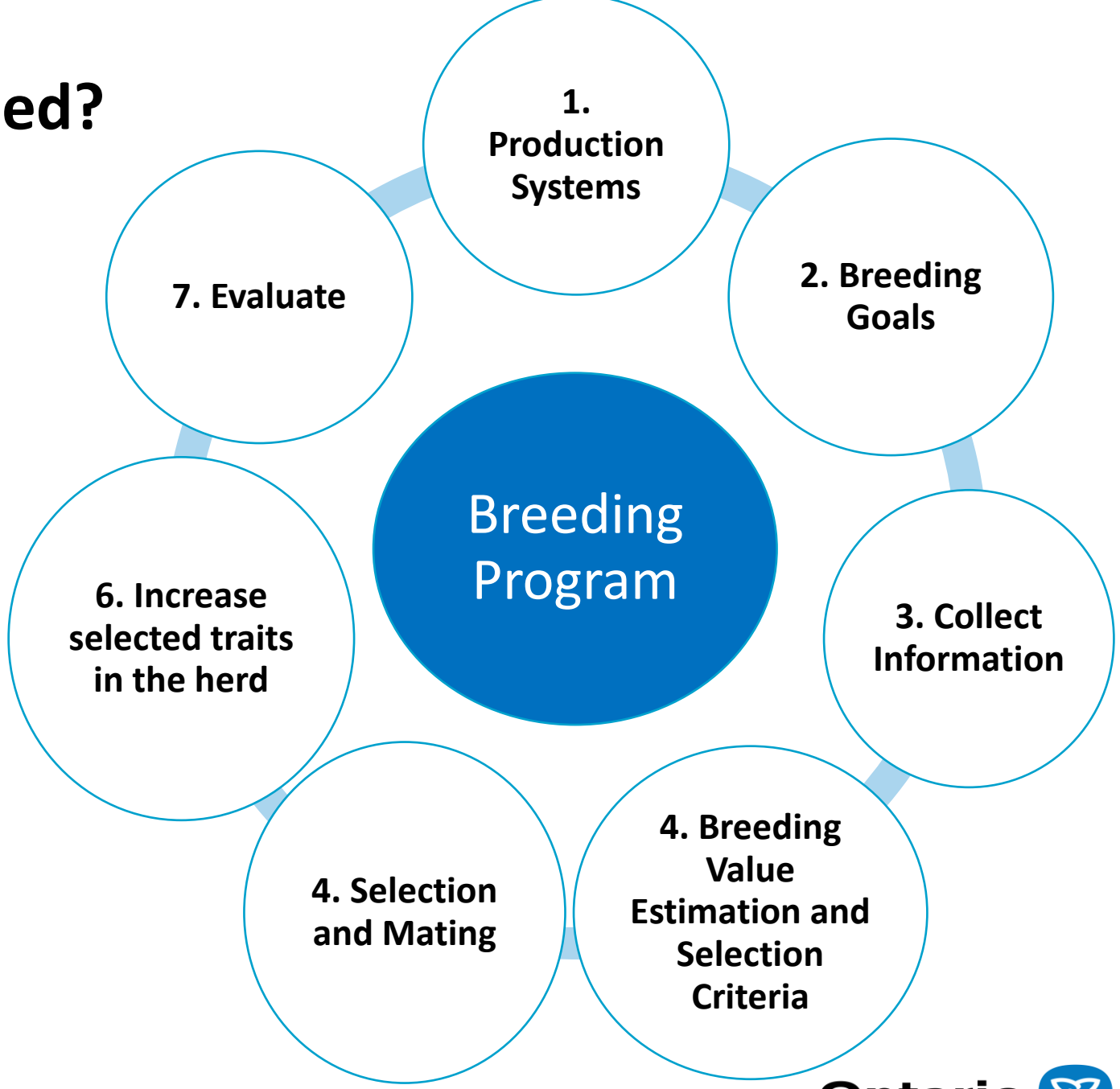
Reproduction

Temperament

What information do you need?

Three things you need to make informed decision:

1. Individual Animal ID
2. Data and Records
3. Data Analysis



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Thank you. Questions?

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References & Resources

Bourdon, R.M. 2014. Understanding Animal Breeding. Pearson Education Limited, Essex, United Kingdom.

Fetrow, J., Nordlund, K.V., and H.D. Norman. 2006. Invited Review: Culling: Nomenclature, Definitions, and Recommendations. J Dairy Sci. 89:1896-1905.

Jembere, T., Dessie, B. Rischkowsky, K. Kebede, A.M. Okeyo and A. Haile. 2017. Meta-analysis of average estimates of genetic parameters for growth, reproduction and milk production traits in goats. Small Ruminant Research. 153, 71-80. Doi: https://doi.org/10.1016/j.smallrumres.2017.04.024.

Van der Waaij, E.H., Lont, D.E., and H.A. Mulder. 2013. How to teach Animal Breeding and Genetics to undergraduate students: presentation of a thinking process. Proceedings 10th World Congress of Genetics Applied to Livestock Production. 2014.