Conscious choices in cross-breeding: Making money through the heterosis

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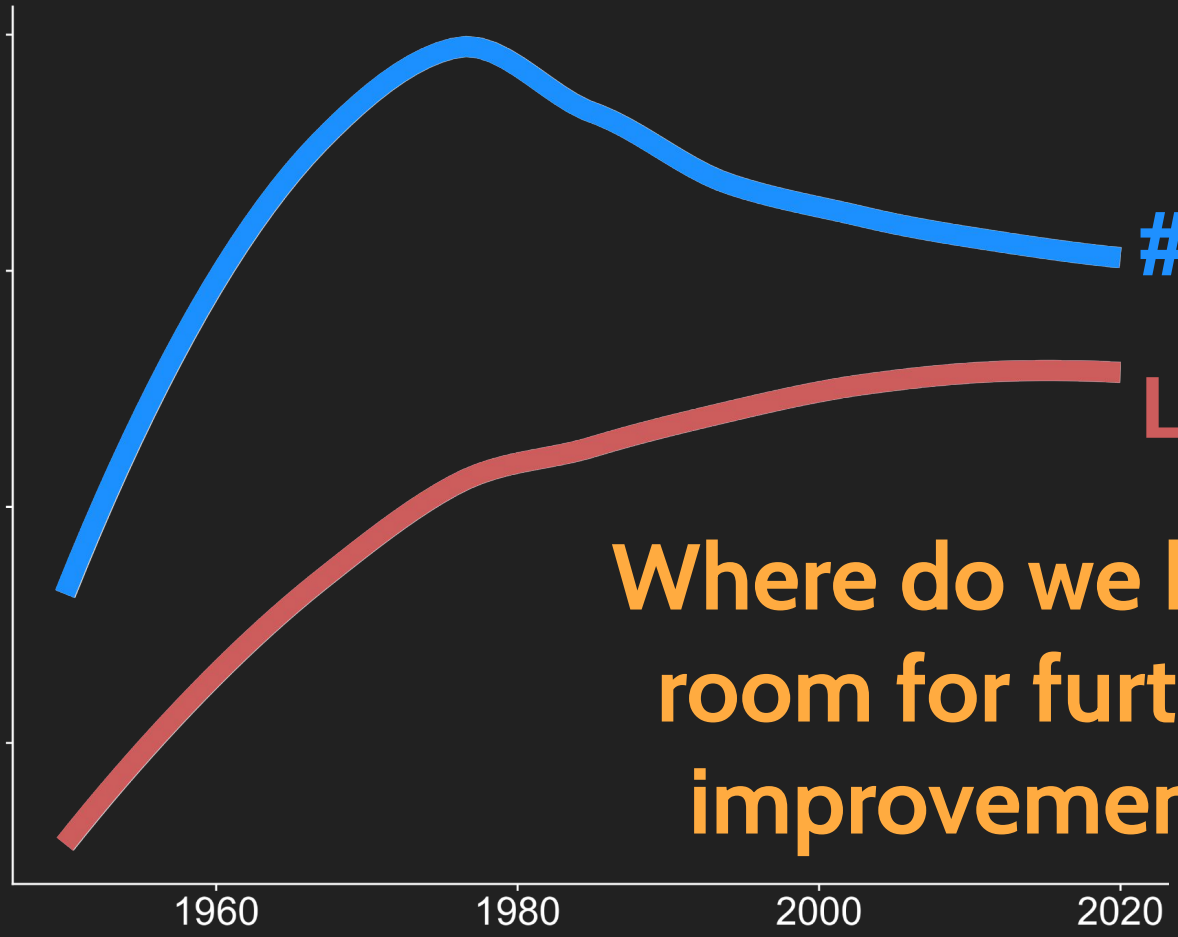
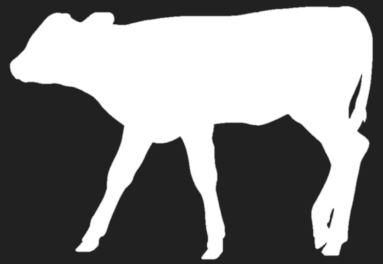

Cows
Lbs. Beef
Where do we have room for further improvement?
1960
1980
2000
2020

Which traits matter to our profitability?

“Revenue-generating” traits



Live calf

Weaned pounds

“Cost” (aka replacement female) traits

The easiest way to improve **all** economically important traits?:

CROSSBREED!

What keeps us from crossbreeding?

Buyers (& Feeders & Packers) demand uniformity

Mongrelized cattle = more variation in quality and performance

Challenges introducing multiple breeds in “one-bull” herds

Personal preferences?

Organized Crossbreeding vs. Mongrelization

Two-fold advantage of crossbreeding

1) Breed complementarity
   - Align multiple breed strengths
   - e.g. Charolais lean growth, Hereford fertility, etc.
   - *Bos indicus* environmental adaptation

Breed complementarity (USA) in terminal crossbreeding program

Table 1. Relative Breed Differences for US Beef Breeds

Breed*	Birth Wt. (lb)[1]	Weaning Wt. (lb)[1]	Yearling Wt. (lb)[1]	Mature Wt. (lb)[1,2]	Maternal Milk (lb)[1]	Marbling Score[3]	Ribeye Area (in^2)[4]	Fat (in)[5]	Carcass Wt.(lb)[1]	Lean to-fat[6]	BCS[7]	FE Index Steer[8]
Angus	★★	★★★★	★★★★★	★★★★	★★★★	★★★★★	★★	★★★★★	★★★★★	★	★★★★	★★
Beefmaster	★★★	★★★	★★★	★★	★★						★★★	★★★★★
Brahman	★★★★★	★★★★★	★★★	★★★★	★★★	★	★★	★★★	★★	★★★	★★★★	★★★
Brangus	★★★	★★★	★★★	★★★	★★★★						★★★	★★
Braunvieh	★★★	★★	★★	★	★★★★★	★★★	★★★★	★★	★★	★★★★	★	★★★
Charolais	★★★★	★★★★	★★★★	★★★★	★★★	★★★	★★★★	★★	★★★★	★★★★	★★★★	★★★
Chiangus	★★★	★★	★★	★★★	★★★	★★★	★★★	★★★	★★★	★★★	★★★	★★★★
Gelbvieh	★★★	★★★★	★★★★	★★	★★★★	★★★	★★★★	★★★	★★★★	★★★	★★	★★★
Hereford	★★★	★★★	★★★	★★★	★★	★★★	★★	★★★★	★★★	★★	★★★★	★★★
Limousin	★★	★★★	★★★	★★	★★★	★★★	★★★★	★★★	★★★★	★★★	★★	★★★★★
Maine-Anjou	★★★	★	★	★★★	★	★★	★★★★	★★	★★	★★★★	★★★	★★★★
Red Angus	★	★★★	★★★★	★★★	★★★★	★★★★★	★★	★★★★★	★★★★	★	★★★★	★★
Salers	★★	★★★	★★★	★★★★	★★★★	★★	★★★★	★★	★★	★★★★	★★★	★★★
Santa Gertrudis	★★★	★★★	★★★	★★★	★★★	★★	★	★★★★	★★★	★★	★★	★★★★
Shorthorn	★★★★	★★	★★	★★★	★★★	★★★	★★	★★★	★★★	★★★	★★	★★★
Simmental	★★★	★★★★	★★★★	★★★★	★★★	★★★	★★★★	★★★	★★★★	★★★	★★★	★★
South Devon	★★★	★★	★★		★★★	★★★	★★★	★★	★★	★★★		★
Tarentaise	★★	★★★	★★		★★							★★★

Breed Comparison• www.eBEEF.org • 2023-1

Crossbreeding plans MUST align with a herd's breeding goals!

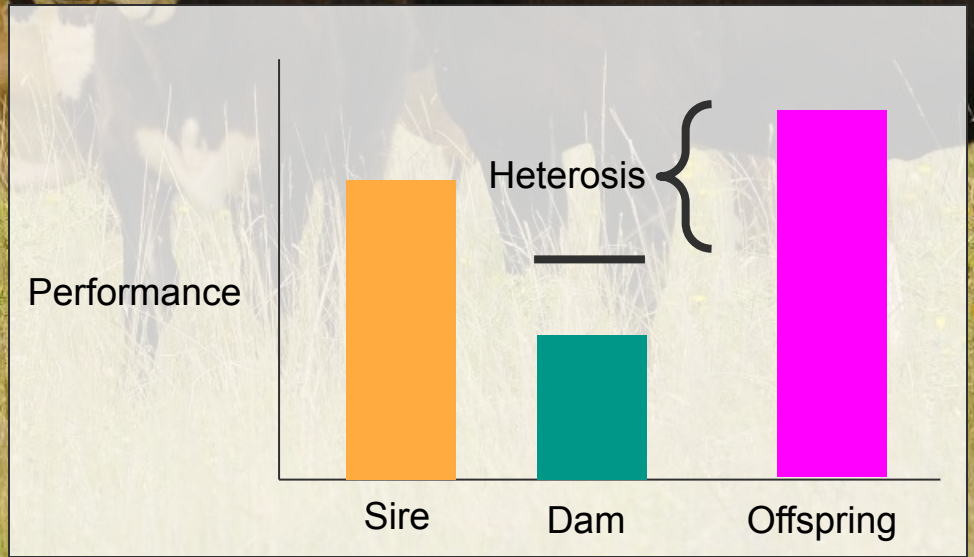
- Not appropriate to use a maternal bull when all calves are marketed as terminal
  - We lose out on carcass performance in this case!
- Keeping replacement females?
  - Two terminal breeds could decrease cow overall efficiency
- Are there premiums for a certain type of cattle?
  - In US, black-hided cattle have an associated premium
- Can I afford NOT to crossbreed?

Two-fold advantage of crossbreeding

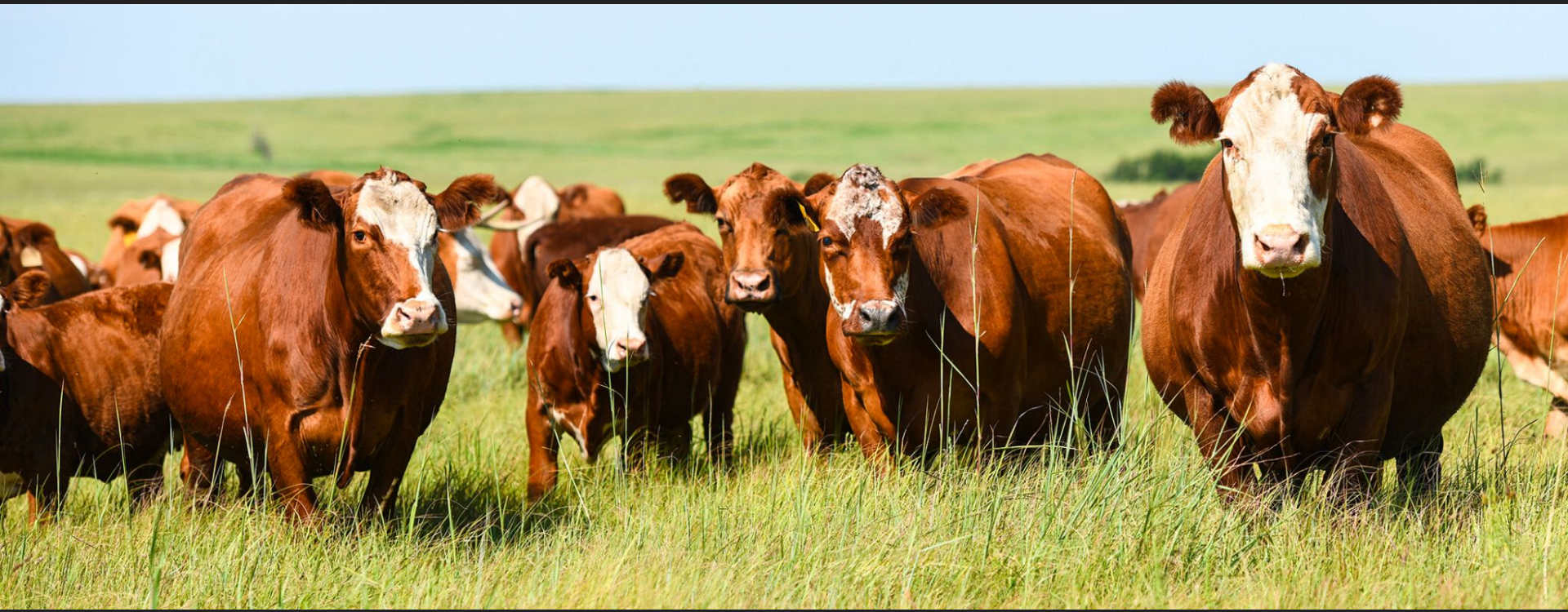
1) Breed complementarity
   - Align multiple breed strengths
   - e.g. Charolais lean growth, Hereford fertility, etc.
   - *Bos indicus* environmental adaptation

2) Heterosis
   - Superior performance of crossbred offspring compared with parent-average
   - Complex mechanism, clear results

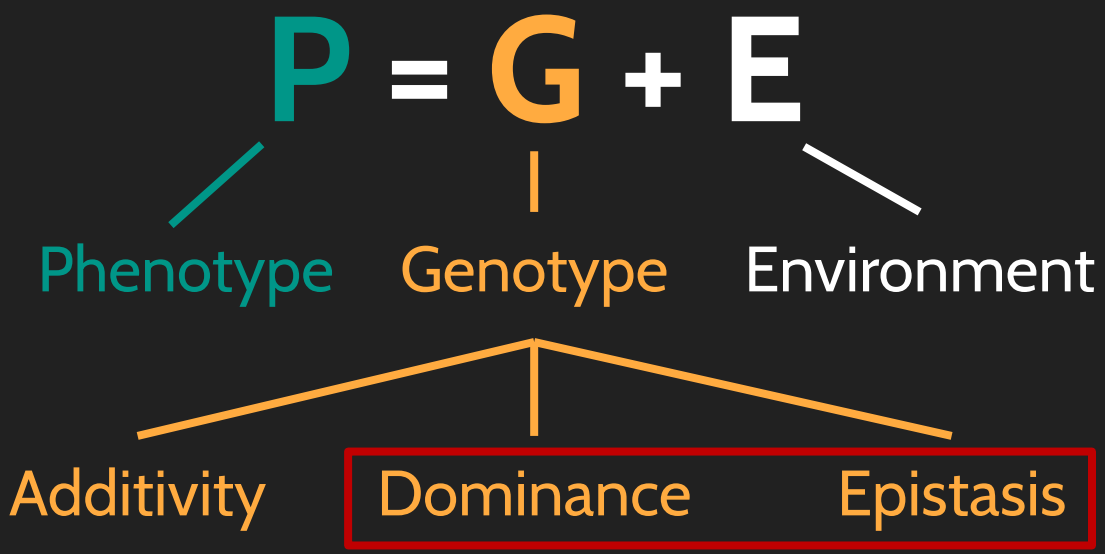
% Heterosis = [(crossbred avg. – straightbred avg.) ÷ straightbred avg.] x 100

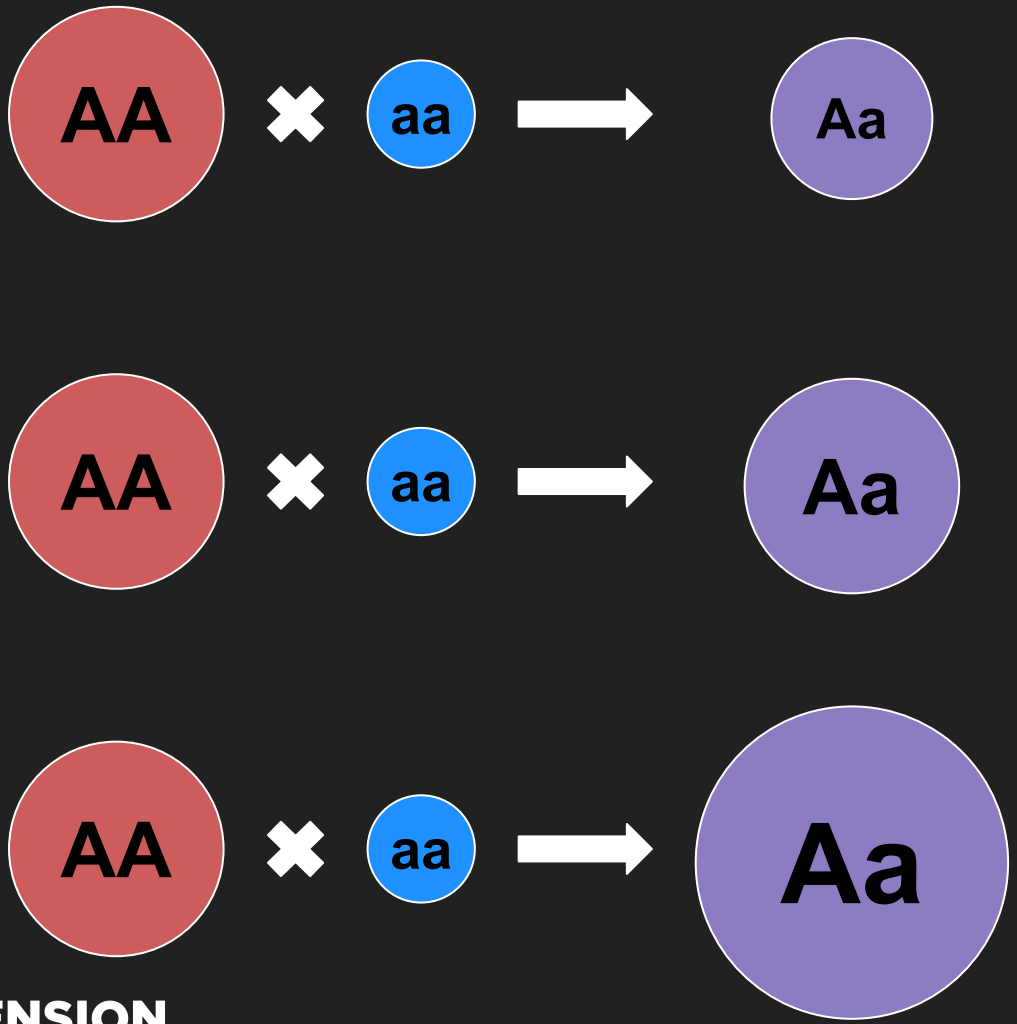


Crossbreeding reverses the effects of inbreeding



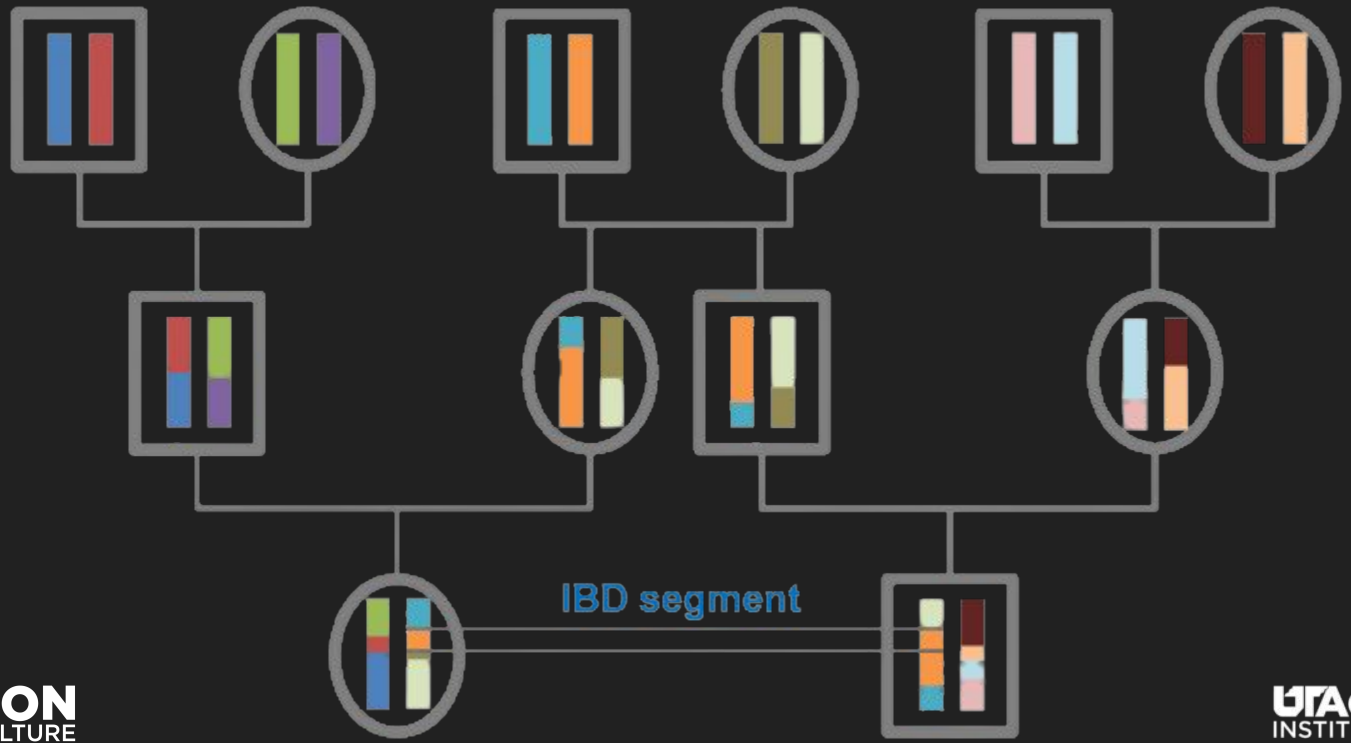
The nuts and bolts of heterosis




AA
aa
Aa
Additivity
AA
aa
Aa
Dominance
AA
aa
Aa
Overdominance

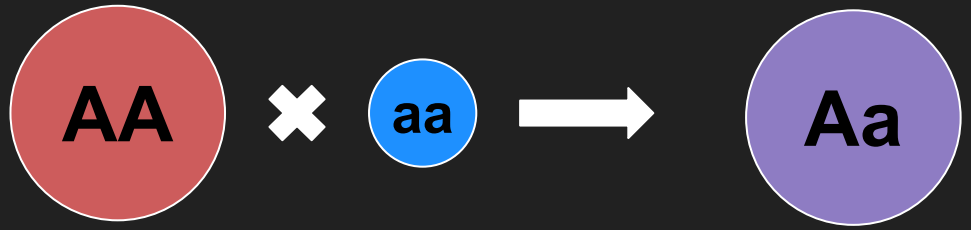
Purebred animals are more homozygous across DNA

"Identity-by-descent"

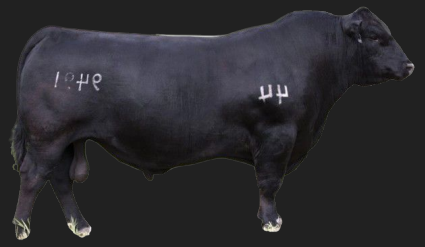


Angus x Angus

Hereford x Angus



Crossbreeding "Unlocks" genetic potential at non-additive loci



69 years

More divergence

=

More heterosis

~1 million years

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Heterosis is inversely related to heritability

Trait	Heritability	Level of Heterosis
Carcass/end product Skeletal Measurements Mature Weight	High (0.4-0.8)	Low (0 to 5%)

Adapted from: https://beef-cattle.extension.org/crossbreeding-for-the-commercial-beef-producer/

A crossbred calf is great...

Direct heterosis (estimated by Cundif & Gregory 1999)

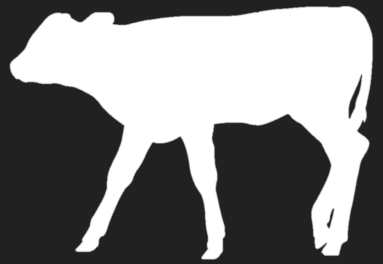
Trait	Observed Improvement	%Heterosis
Calving rate	3.2%	4.4
Survival to weaning	1.4%	1.9
Birth weight	0.77 kg	2.4
Weaning weight	7.4 kg	3.9
Average daily gain	0.03 kg/day	2.6
Yearling weight	13.2 kg	3.8

$40.75 per calf!

But crossbred females are the MOST Valuable

Which traits matter to our bottom line?

“Revenue-generating” traits



Live calf

Weaned pounds

“Cost” (aka replacement female) traits

Developing heifers is EXPENSIVE!

Cow-longevity is the most important component of efficiency, sustainability, and profitability!

Maternal heterosis (estimated by Cundif & Gregory 1999)

Trait	Observed Improvement	%Heterosis
Calving rate	3.5%	3.7
Survival to weaning	0.8%	1.5
Birth weight	0.72 kg	1.8
Weaning weight	8.2 kg	3.9
Longevity	1.36 years	16.2
Cow lifetime production		
Number of calves	0.97 calves	17.0
Cumulative weaning weight	272.2 kg	25.3

What does an extra calf per cow mean?

1) Cow has another calf after her payback period (profit)

2) One less heifer to develop in cow's place (cost savings)

3) One more animal to market as a feeder animal or a bred heifer (additional revenue)

Less than 50% of commercial herds in the USA crossbred!

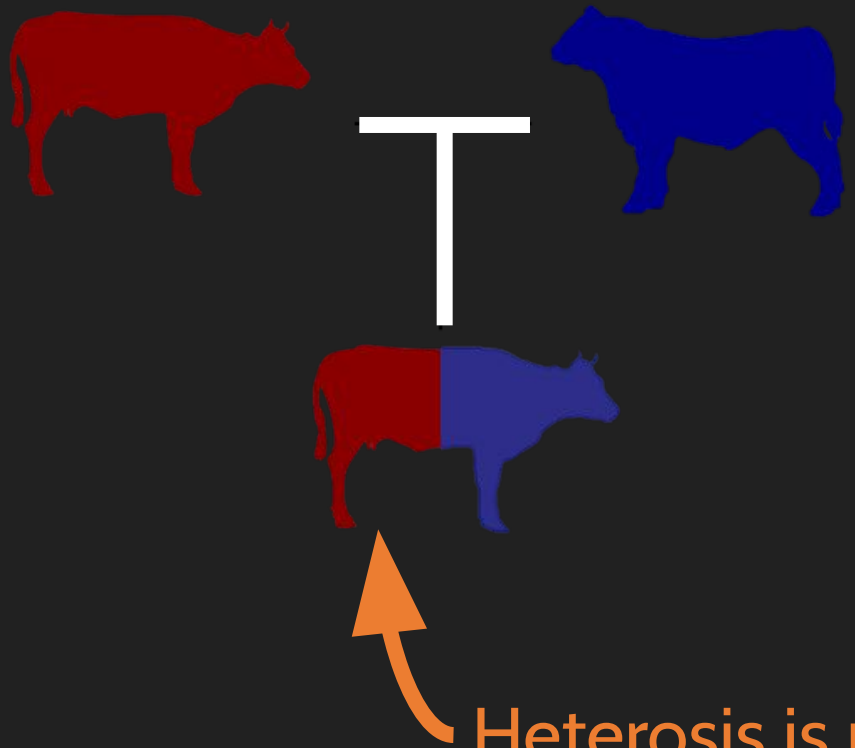
We are leaving $$ on the table!

Heterosis is maximized in the first generation cross

Subsequent generations of “re-crossing” will fail to realize maximum heterosis

Crossbreeding systems allow us to maximize the amount of heterosis that is “retained” from generation to generation and helps herds become more uniform.

Crossbreeding Systems: Two Breed Terminal Cross



Straight-bred bull crossed with straight-bred cow

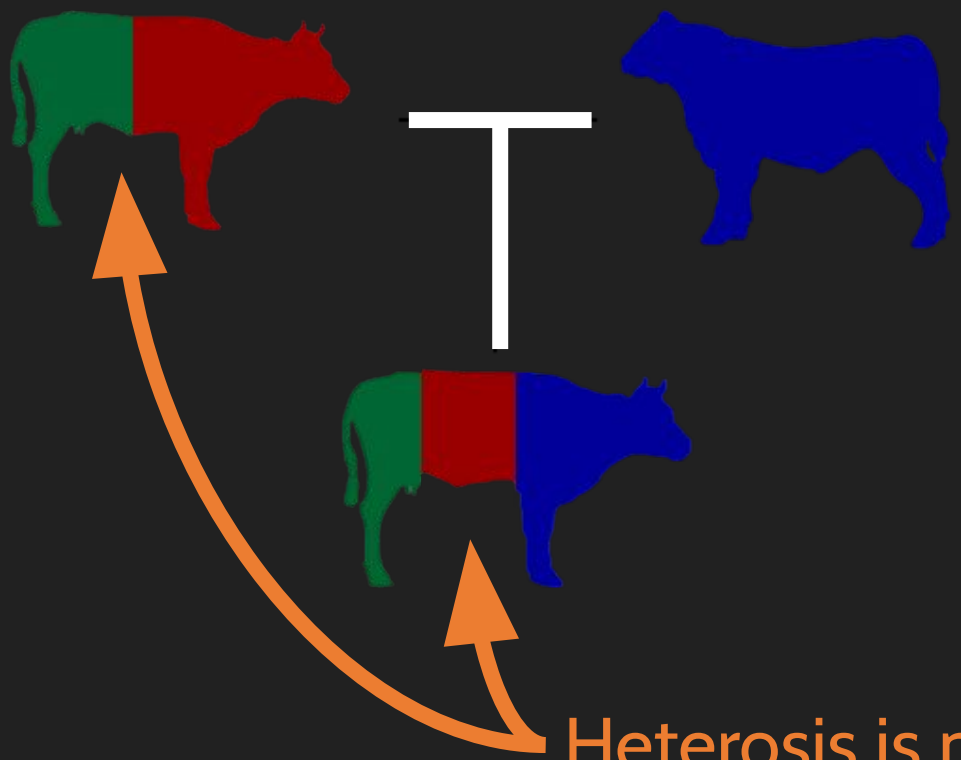
Terminal cross when stopped here

- Must purchase replacements
- All calves must be terminal (no maternal heterosis)
- No “retained heterosis in cow”
+ Simple to execute in small herds

Ex. Charolais Bull x Angus Cow

Heterosis is maximized in the “F1”

Crossbreeding Systems: Three breed terminal cross



Breeds F1 cow to straight-bred bull of a different breed

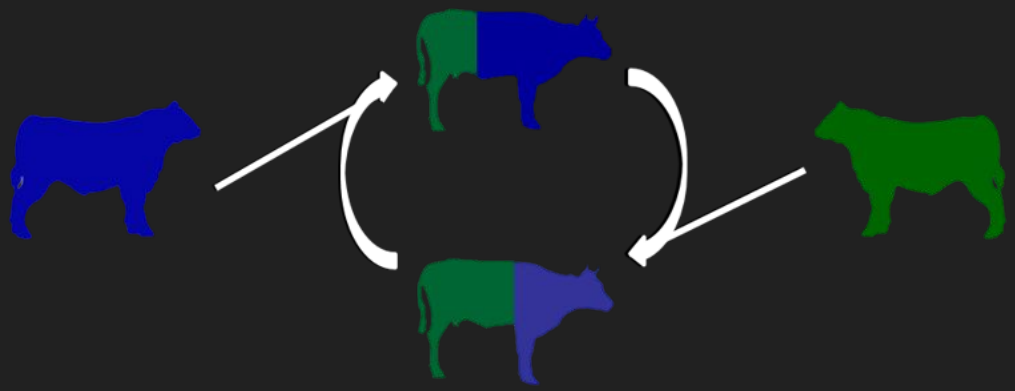
Results in terminal cross calf crop

- Must purchase replacements
  *Or have separate maternal rotation
+ Maximum heterosis in cow and calf
+ Simple to execute in small herds

Ex. PB Charolais Bull x Baldy Cow

Heterosis is maximized in the “F1”

Crossbreeding Systems: Two-breed rotation



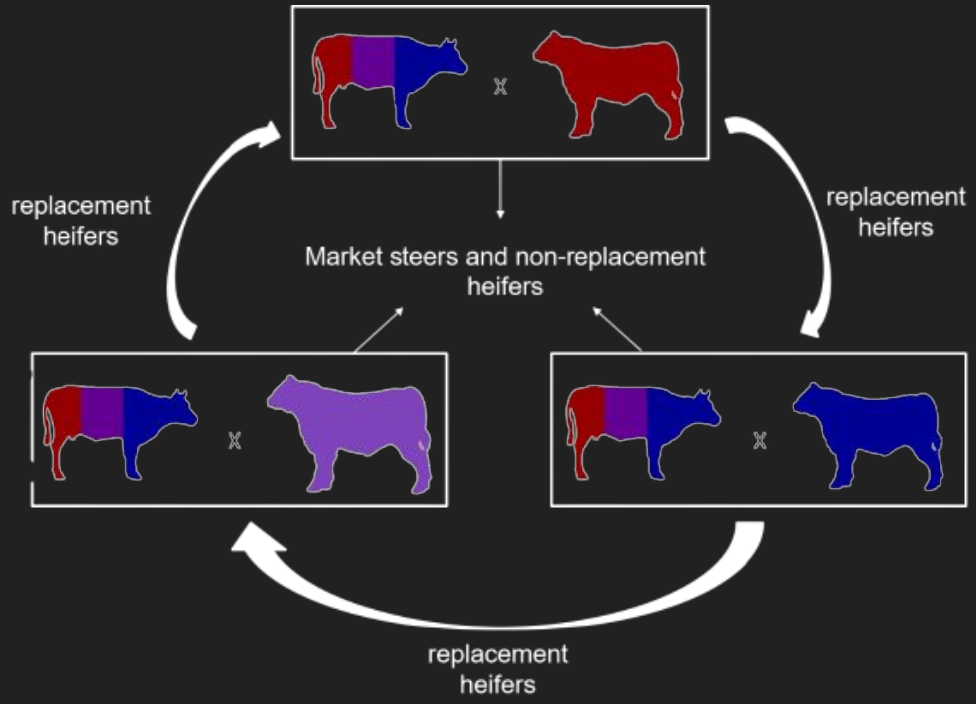
Breed replacement heifers to bull opposite breed of sire

Generates terminal and replacement animals

- More difficult to take advantage of breed complementarity
+ Crossbred females generated
+/- Requires two breeding pastures (herd size-dependent)

Ex. Angus x Hereford

Crossbreeding Systems: Three-breed rotation



Same as two-breed rotation, but with additional breed

More separation between replacements and bull in their pastures

+ Greater amounts of hybrid vigor
+ Retains more heterosis in cows
- Complex execution with minimum of three sire pastures

Type of System	% of Cow Herd	% of Marketed Calves	Advantage (%)[a]	Retained Heterosis (%)[b]	Minimum # of Breeding Pastures	Minimum Herd Size	# of Breeds
Two-breed Terminal Cross (Figure 1)							
T x (A)	100	100	**8.5**	0[c]	1	Any	2
Terminal Cross with Purchased F1 Females (Figure 2)							
T x (A*B)	100	100	**24**	100	1	Any	3
Composite Breeds (Figure 5)							
2-breed	100	100	**12**	50[d]	1	Any	2
3-breed	100	100	**15**	67	1	Any	3
4-breed	100	100	**17**	75	1	Any	4
Rotating Unrelated F1 Bulls							
A*B x A*B	100	100	**12**	50	1	Any	2
A*B x A*C	100	100	**16**	67	1	Any	3
A*B x C*D	100	100	**19**	83	1	Any	4

There is a trade off between crossbreeding scheme complexity and retained heterosis

From https://beef-cattle.extension.org/crossbreeding-for-the-commercial-beef-producer/

Crossbreeding in Small Herds

Small Herd Challenges

- Keeping replacements means bulls must cycle in and out of herd to avoid sire-daughter matings

- Multiple breeding pastures is not possible/feasible

- Not possible to capture full % of heterosis in traits due to replacement female turnover rate.

- GREAT Publication with more details: https://extension.missouri.edu/publications/g2040

Small Herd Solutions: Two Breed Rotation

Year	1	2	3	4	5	6	7	8	9	10
Bull	B1	B1	B2	B2	A1	A1	A2	A2	B3	B3

- Rotate two breeds: Same bull for 2 years, same breed for 4 years
- More heterosis by rotating breeds every two bulls than every bull
- 59% of maximum heterosis (47% maximum maternal heterosis)
  - Compared with 72% (direct) and 56% (maternal) in large herd 2-breed rotation

Lamb and Tess, 1989

Small Herd Solutions: Three Breed Rotation

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Bull	B1	B1	B2	B2	C1	C1	C2	C2	A1	A1	A2	A2	B3

- Rotate three breeds: Same bull for 2 years, same breed for 4 years
- 77% of maximum heterosis (60% maximum maternal heterosis)
- More heterosis (direct & maternal) than in optimal 2-breed rotation

Lamb and Tess, 1989

Crossbreeding is the easiest way to increase a herd's overall productivity

Magnitude of heterosis increases with lower heritabilities of trait & divergence of breeds

Crossbreeding systems pay! Both in calf pounds and improved replacement females

Crossbreeding systems can be implemented in any herd size!

Reach out with questions!

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