

Genetic Improvement of Beef Cattle

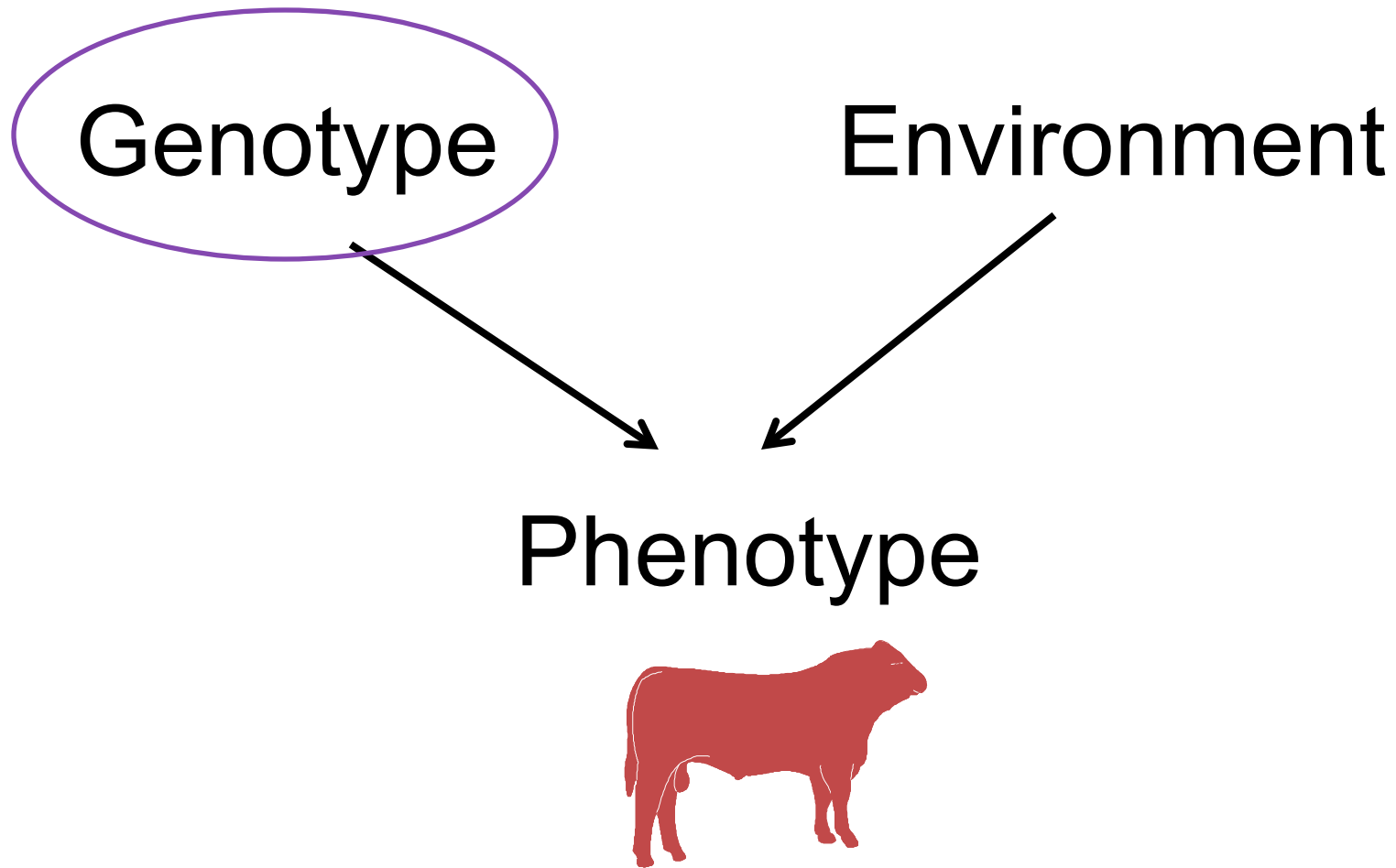
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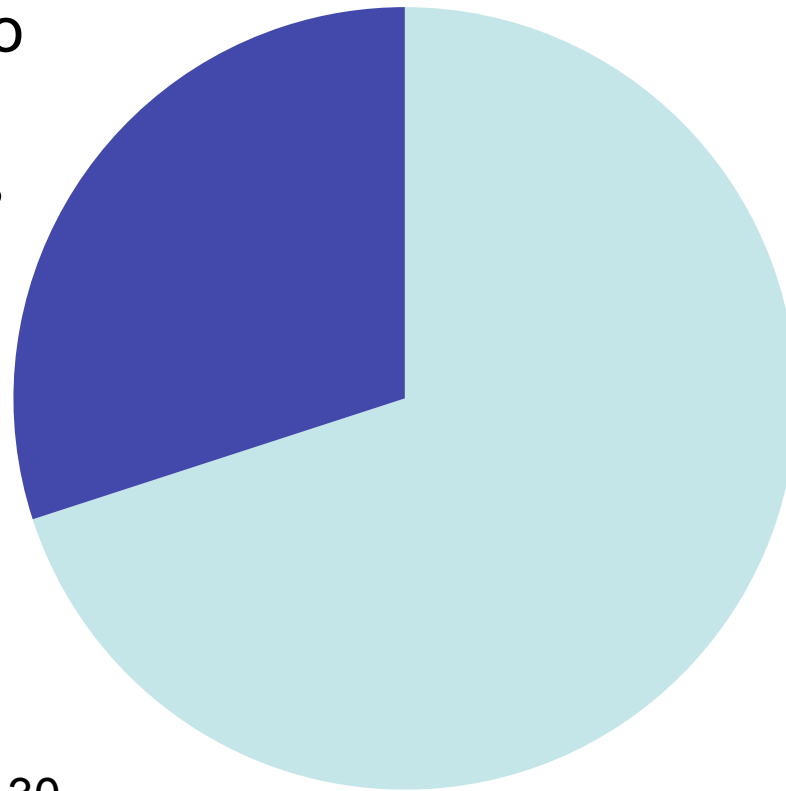
BEEF *Profit* **ALLIANCE**
Connecting in Kansas - Red Angus & Simmental





Genotype is the only part passed on to offspring, so it's the only part we care about as breeders.

Phenotype



$$h^2 = 0.30$$



Genotype

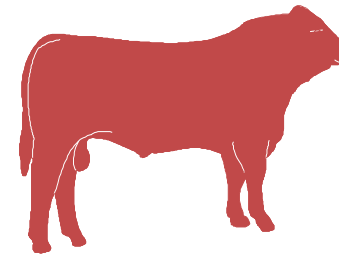
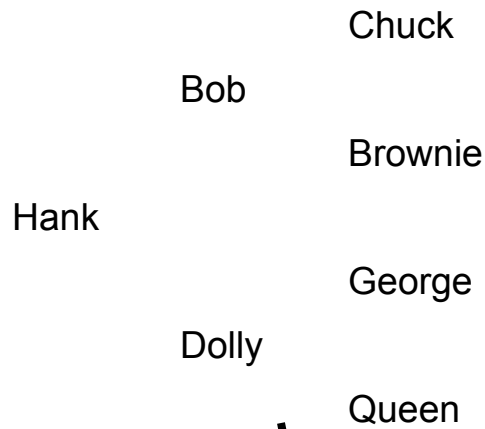
Basic problem: Genotype is unknown

Goal: Predict genotype



Pedigree

Phenotype



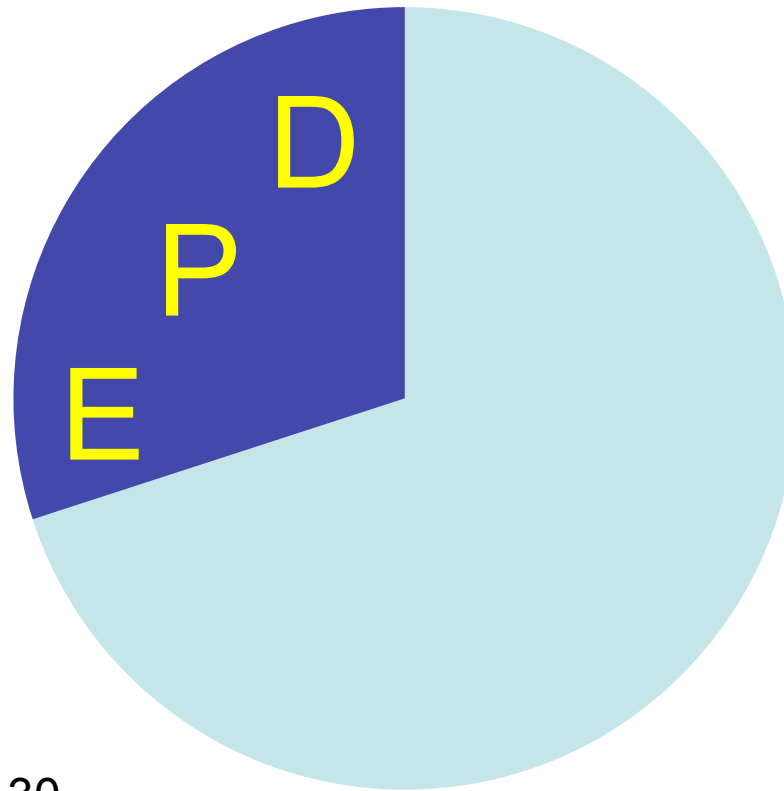
$$\begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + \lambda A^{-1} \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$

EPD



EPD is our best prediction of the genotype of an animal.

Phenotype



- Environment
- Genotype

$h^2 = 0.30$



History of Genetic Evaluation

- Simmental published the first beef sire summary in 1971
 - Eleven bulls
 - Weaning weight (direct only) and yearling weight



History of Genetic Evaluation

- Four universities took the lead in conducting National Cattle Evaluations:
 - Colorado State: Jim Brinks, Bruce Golden and Rick Bourdon
 - Cornell: Dick Quaas and John Pollak
 - Georgia: Larry Benyshek and Keith Bertrand
 - Iowa State: Richard Willham, Doyle Wilson and Gene Rouse



History of Genetic Evaluation

- NCE expanded to more traits, and every breed developed a system of data collection and reporting of genetic evaluation results
- Live animal ultrasound allowed evaluation of carcass traits earlier in the animals life, with less expense than progeny testing



Million Dollar Question

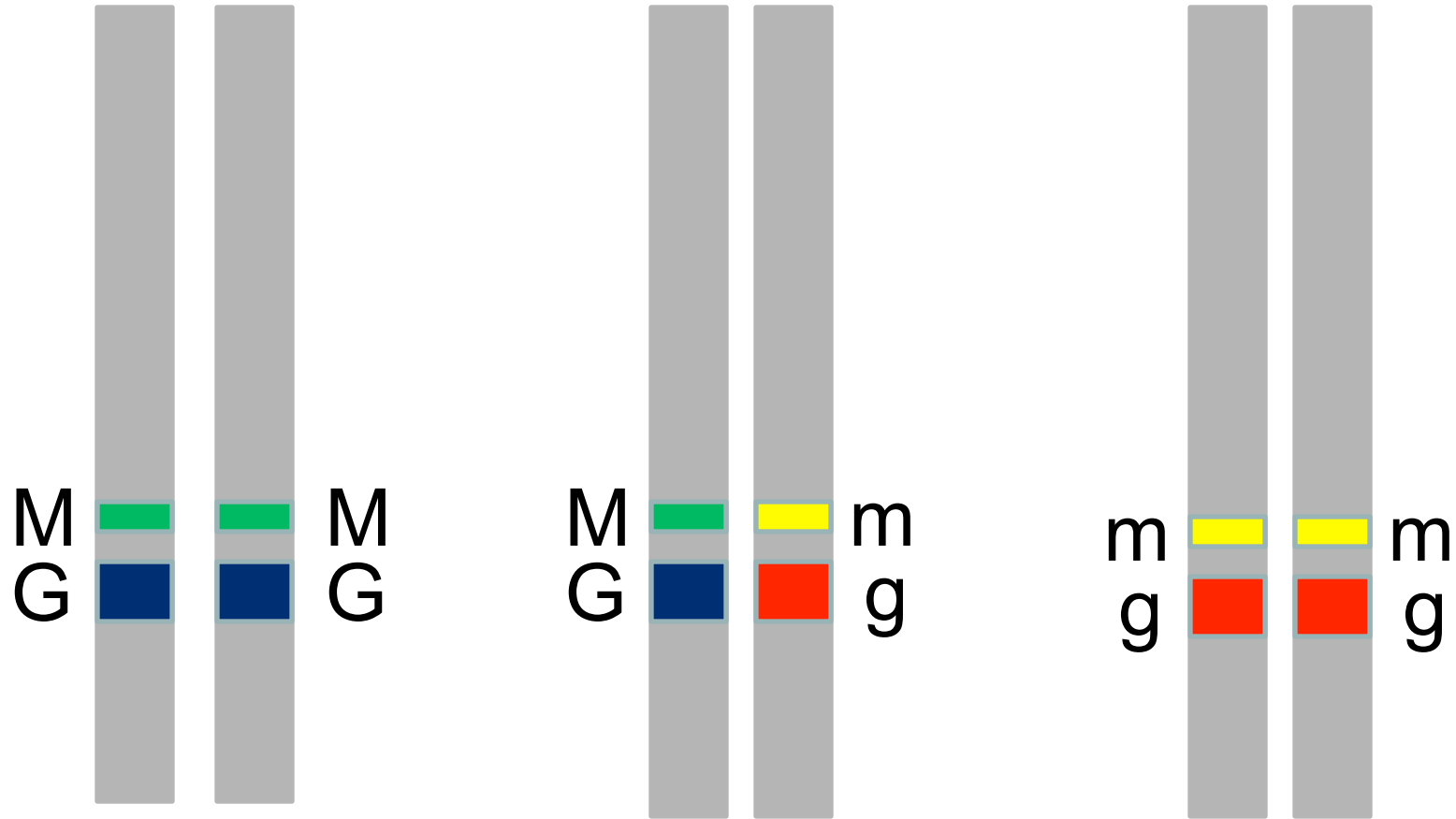
- Can we bypass the time and expense of collecting a lot of data and go directly to the DNA?



History

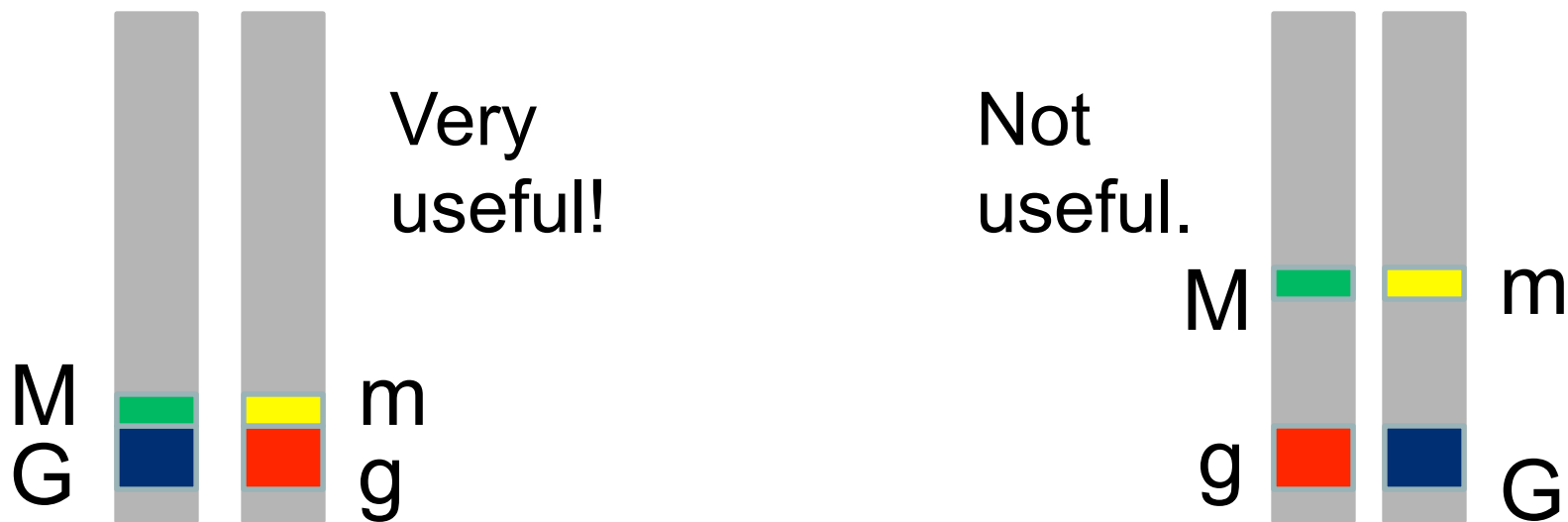
- Work in molecular genetics of beef cattle began in the late 1980's.
- Early efforts focused on true *marker-assisted selection*.
 - Selection on a few markers that were believed to be linked to “major genes”.





Sometimes the marker is very near the gene, in which case there is very little recombination between them.

Sometimes the marker is far away from the gene, so there is often recombination between them.



Progress?

- In beef cattle, marker assisted selection was largely unsuccessful.
 - Difficult to find good markers
 - Recombination
 - Didn't fit the structure of our seedstock industry



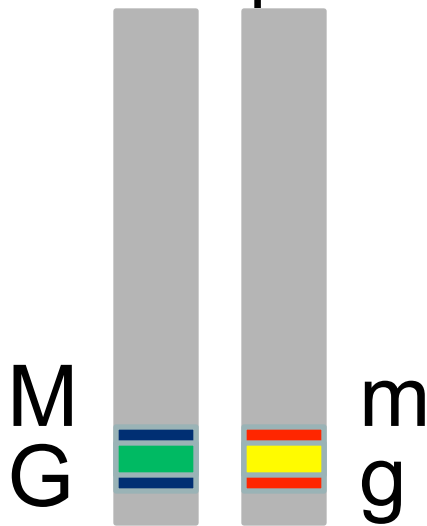
GeneSTAR Marbling

- The GeneSTAR marbling DNA test was announced at the 2000 BIF meeting in Wichita.
 - First commercial DNA test for a quantitative trait
 - Developed by CSIRO Australia, marketed by Genetic Solutions Ltd., later Bovigen Solutions, Inc.



GeneSTAR Marbling

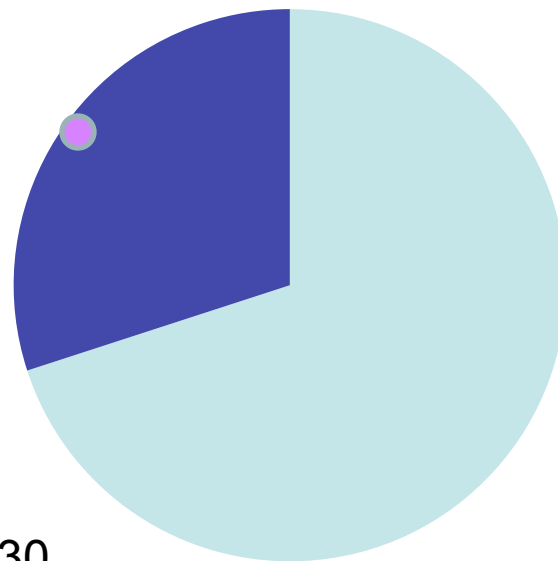
- Changed producer expectations for genomic testing
 - Easy to use, works on all animals (supposedly)
 - Simple result (**, *, or 0)



- Two other marbling markers were later added, creating the first quantitative trait “panel”.



Phenotype



- Environment
- Genotype
- Single or a few gene(s) or marker(s)

$h^2 = 0.30$



New Partners

- Pharmaceutical companies entered the genomics business in the early 2000's.
 - Merial created IGENITY, a subsidiary to develop and market genomic tests in beef and dairy, then acquired Frontier Beef Systems.
 - Pfizer acquired Bovigen Solutions (US) and Genetic Solutions/Catapult Genetics (AUS) to form Pfizer Animal Genetics.



New Products

- “Big Pharma” - R&D investment, marketing efforts, raises the profile of the business.
- Both companies upgrade and diversify their product offerings.
 - IGENITY - Profile[®], scores (1-10) on many different traits
 - Pfizer - MVPs for marbling, tenderness and feed intake
- Genetic defect testing (revenue and exposure)



Selection Dilemmas

Some animals have a genomic prediction from chip data as well as a traditional EPD.

Genomic
value



EPD



Selection Dilemmas

- At this point, DNA test results were not incorporated into National Cattle Evaluation.
- Bulls were marketed with EPDs, DNA test results, or both.
- The optimum weighting of those two types of information was generally unknown.



Breakthrough #1

- The academic community has long agreed that the optimum selection criteria is an EPD combining data, pedigrees, and DNA information.
- American Simmental Association incorporated calpain SNPs into its tenderness evaluation in 2004.



- American Angus Association incorporated Igenity Profile test results into its carcass evaluation in 2009.
 - Other traits, Pfizer tests added later
- American Hereford Association just released EPDs incorporating 50K SNP genotypes
- More breeds will soon follow suit



Pedigree

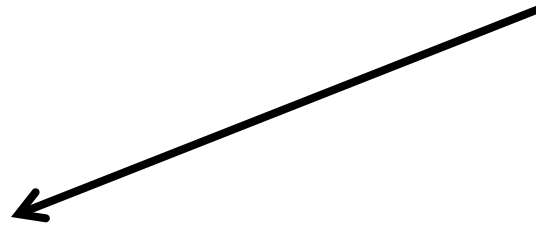
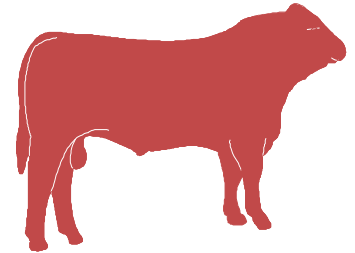
Chuck
Bob
Brownie
Hank
George
Dolly
Queen



Genomic Information



Phenotype



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EPD



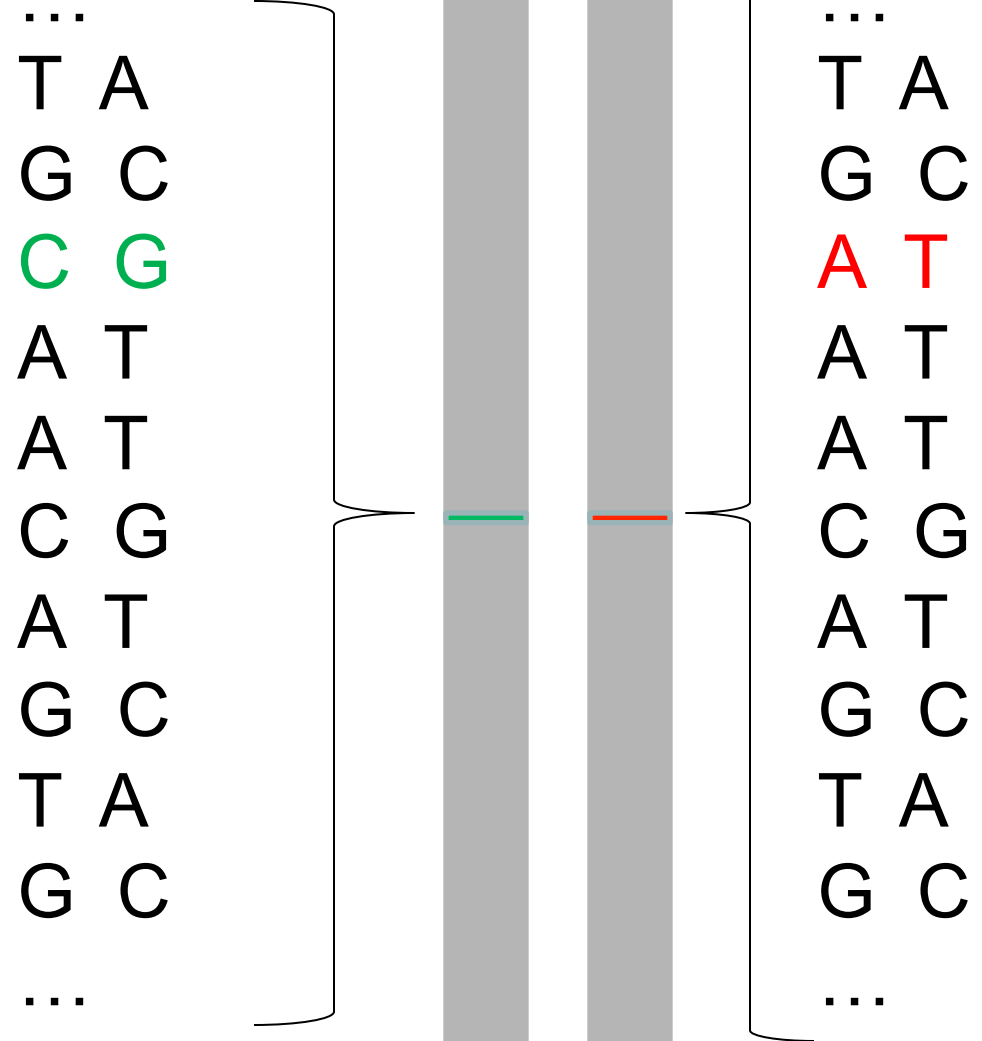
Breakthrough #2

- High density chips that test for over 50,000 SNPs were developed by 2008.
- Larger chips (770K) are now in use.
- We are beginning to ***sequence*** important animals.



SNP – Single Nucleotide Polymorphism

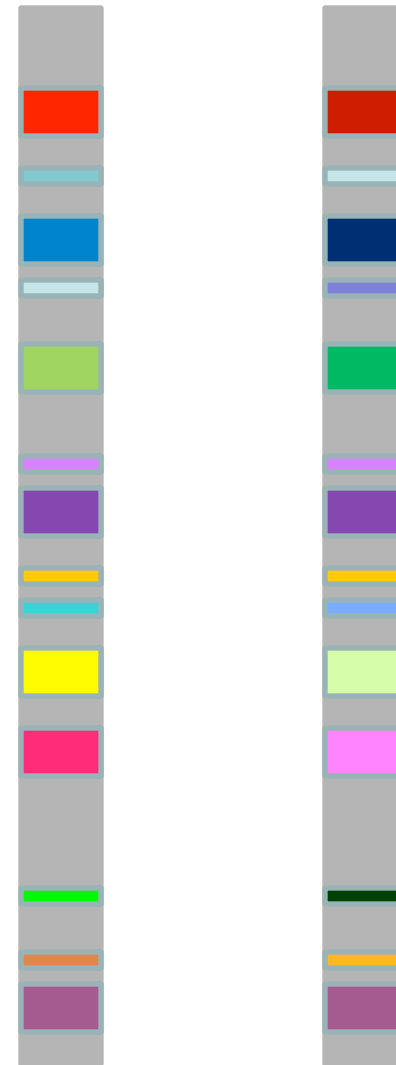
A single base pair that is different between individuals.



SNP Chip

Select SNPs evenly spaced across the genome

Genotype large reference populations for all SNPs



SNP Chip

- Use data from the reference population to determine which SNPs are associated with which traits.
- Can select the ‘best’ SNPs from the larger chip to make a smaller, more economical chip.
- Future animals are genotyped (with the full or reduced chip) and a prediction of genetic merit is calculated from the result.



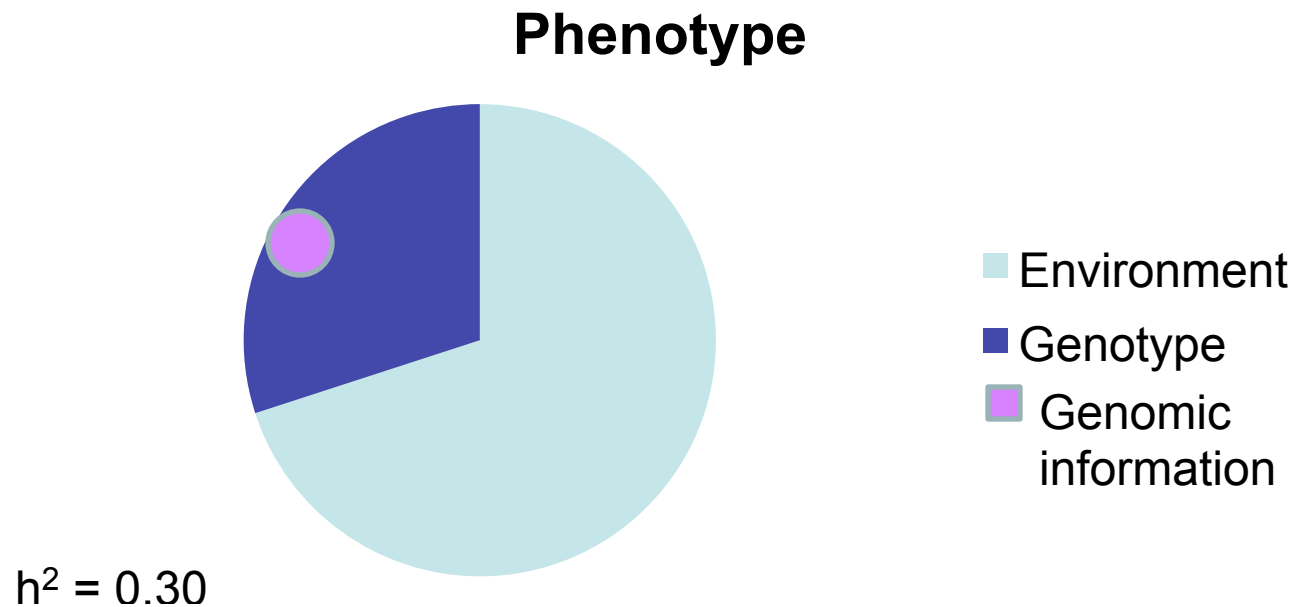
Current Opportunities

- Genetic improvement of beef cattle involves trade-offs between:
 - Accuracy of Selection
 - Intensity of Selection
 - Generation Interval
- Need to know:
 - as much as we can
 - about as many animals as we can
 - as quickly as we can



Key Questions

- How much can I learn from a DNA test?



- How much will that cost me?



Percentage of genetic variance explained by molecular breeding values in Angus

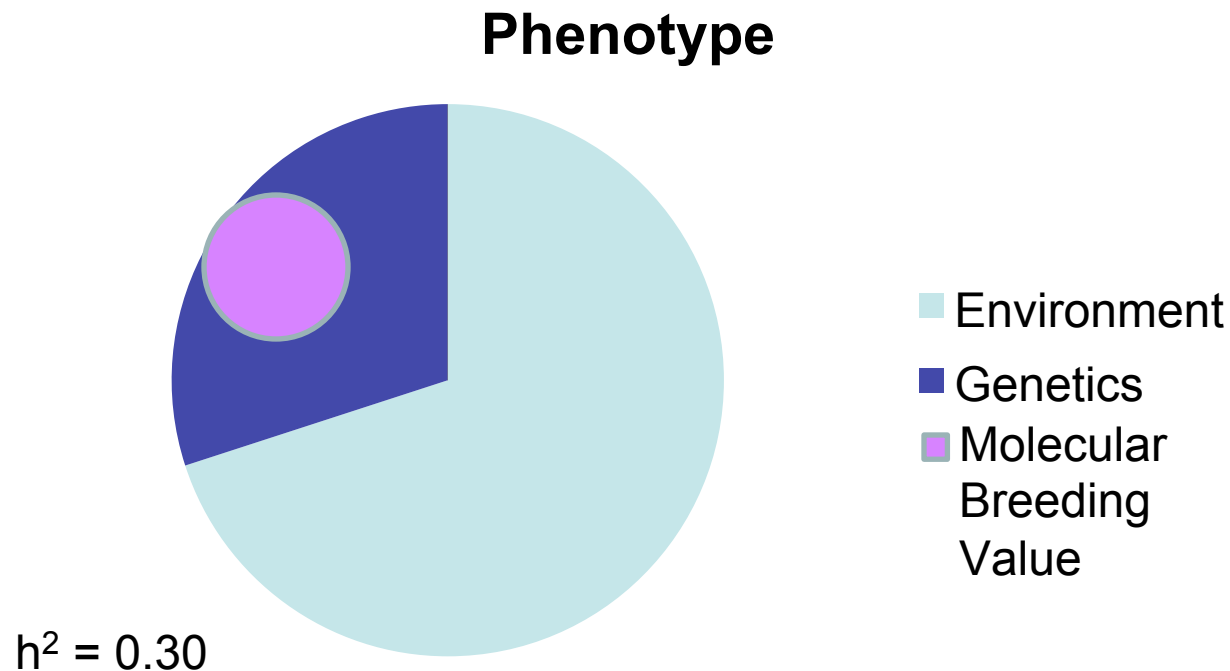
Trait	Igenity	Pfizer
Calving Ease Direct	22	11
Weaning weight	20	27
Yearling weight	12	41
Milk	6	10
Carcass weight	29	23
Marbling	42	32
Ribeye area	34	36
Rib fat	25	31

From American Angus Association, 2012



How Much Can I Learn?

The amount of genetic variation explained by DNA tests is increasing.



How Much Can I Learn?

- Angus examples (Northcutt, S.L., BIF 2010)
 - Angus calf with no ultrasound: parental average EPD with default accuracy = 0.05
 - Addition of genomic information increases accuracy to 0.28 – 0.38 depending on which carcass trait.
 - Angus cow with own ultrasound record and 11 scanned progeny: marbling EPD accuracy = 0.25
 - Addition of genomic breeding information increases accuracy to 0.37.



What About Other Breeds?

- Accuracy of DNA test results is somewhat breed-dependent.
 - Holstein panels do not work well in other dairy breeds (Hayes et al., 2009)
 - Angus panels do not work well in other beef breeds (Rolf et al., 2010)



What About Other Breeds?

- Major breeds will also incorporate test results into EPDs, at some point.
- Breed-specific models for DNA tests are needed.
 - Models developed in one breed may not work well in another breed
 - Model development requires testing large numbers of highly proven bulls



Using DNA Test Results

- The most accurate evaluation of a young bull incorporates all information into a single EPD.
 - Use a test that can be incorporated into a genetic evaluation if possible.
 - Once the DNA test results are incorporated into the EPDs, use **ONLY THE EPD** in selection.
 - DNA test results add very little new information on a progeny-proven sire.



Value Proposition-Seedstock

- Meet customer demands for information
 - Add accuracy to young bulls
- Accelerate genetic change via heifer selection
- Enhance reputation as progressive, leading-edge
- Recognize that half of tested bulls get worse



Value Proposition - Commercial

- Reduce risk
 - Calving ease, maternal traits
- Capture value
 - Carcass merit, feed efficiency
 - Requires retained ownership?



What Does the Future Hold?

- Different sized panels
 - Small (~400 markers), less popular breeds, feeder cattle, specific individual traits
 - Medium (~6 to 10K markers), yearling bulls in volume (now)
 - Large (~50K), yearling bulls in volume (soon?), AI sires (now)



What Does the Future Hold?

- Different sized panels
 - Extra Large (800K), unique phenotypes, AI sire candidates?
 - Sequence???



What Does the Future Hold?

