A Review of Genetics and Genomics

Joe Dalton, Holly Neibergs, Shannon Neibergs
Neibergs@wsu.edu
Washington State University

Thank you

NEOGEN (Igenity)

for providing lunch!

OUTLINE

1. DNA
2. Inheritance
3. Selection
4. Mating
5. Paternity
6. Profitability

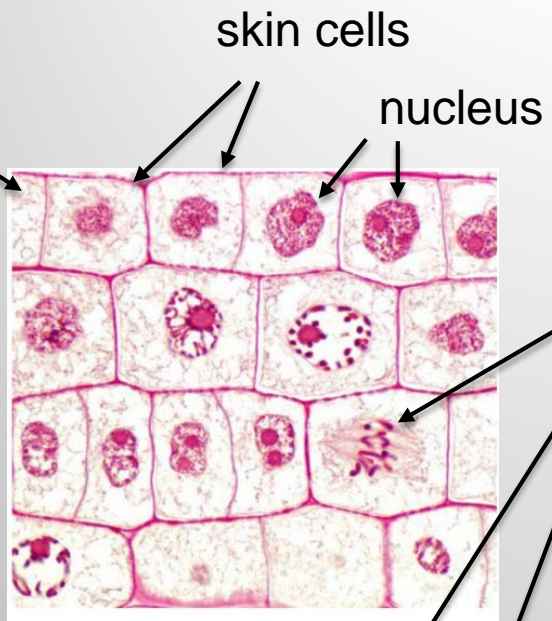Genetic improvement is part of a comprehensive plan to build and sustain profitable dairy production

DNA
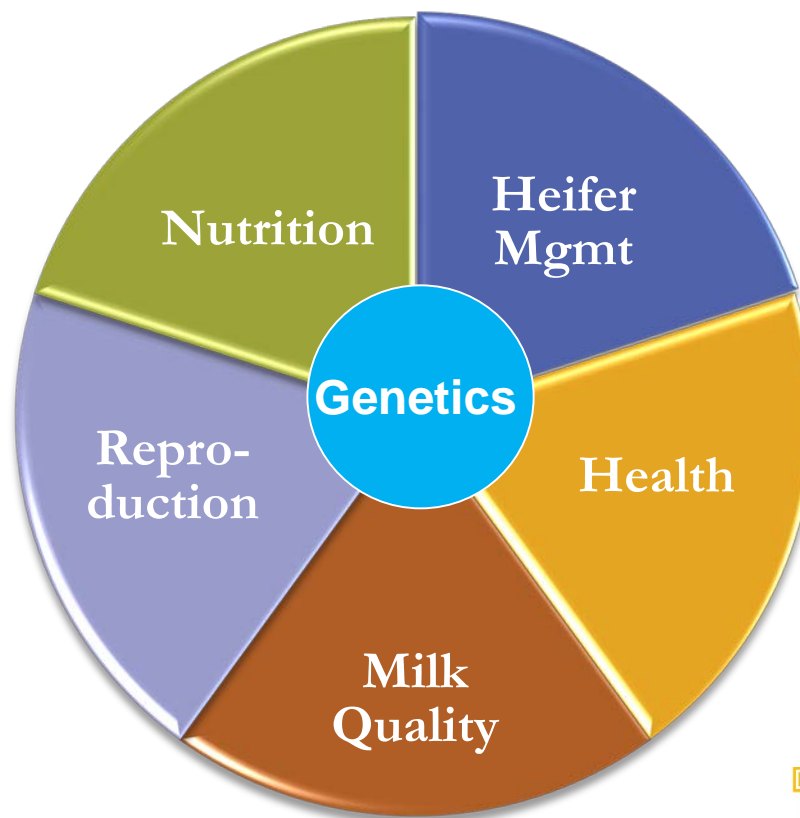
SINGLE NUCLEOTIDE POLYMORPHISMS
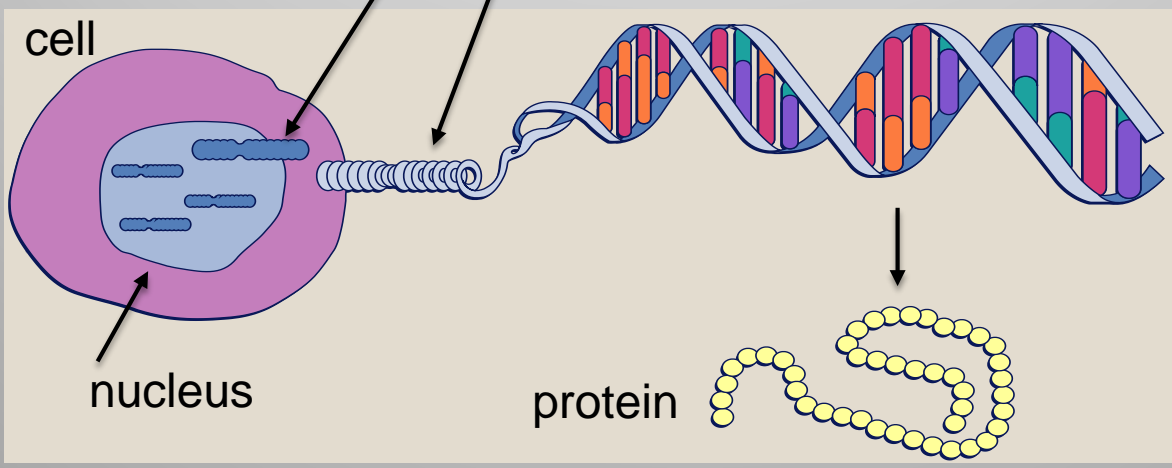
• A mutation is any change in the nucleotide sequence of DNA

• Single DNA mutations or single nucleotide polymorphism are called **SNPs**
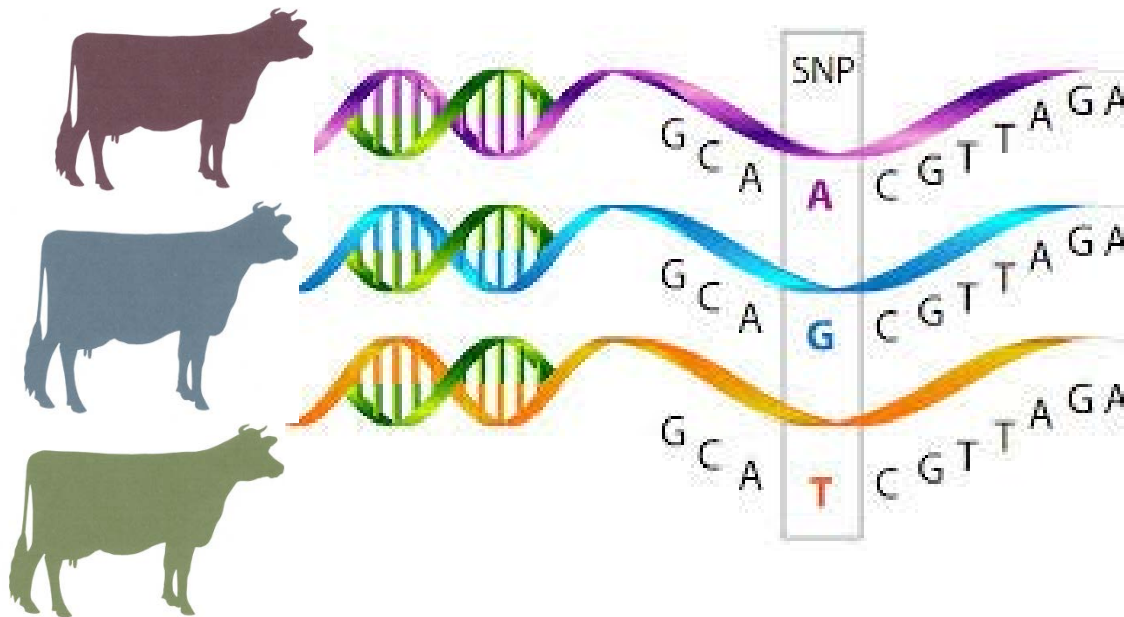
CHROMOSOMES ARE PAIRED

- There are 30 pairs of chromosomes in cattle
- One of each chromosome pair comes from each parent

Dam Sire

Chromosome 1

Dam Sire

Chromosome 2

Dam Sire

Chromosome 3…..

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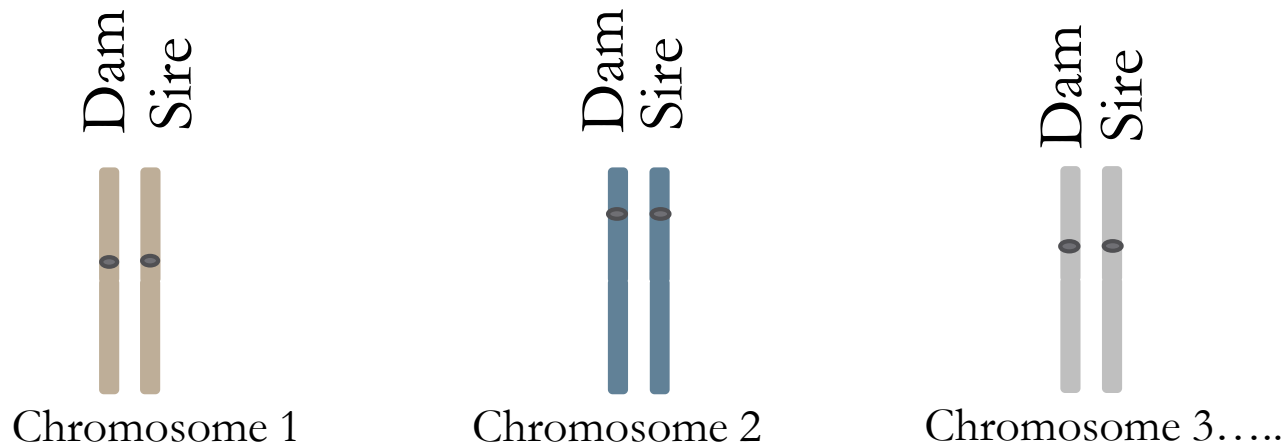
SNP FROM BOTH PARENTS FORM GENOTYPES

INHERITANCE

PREDICTED INHERITANCE

- Half siblings (common mother *or* father) share (on average) 25% of their DNA, full siblings share about 50%

Half sib with 2 & 3   Full sib (2 & 3)
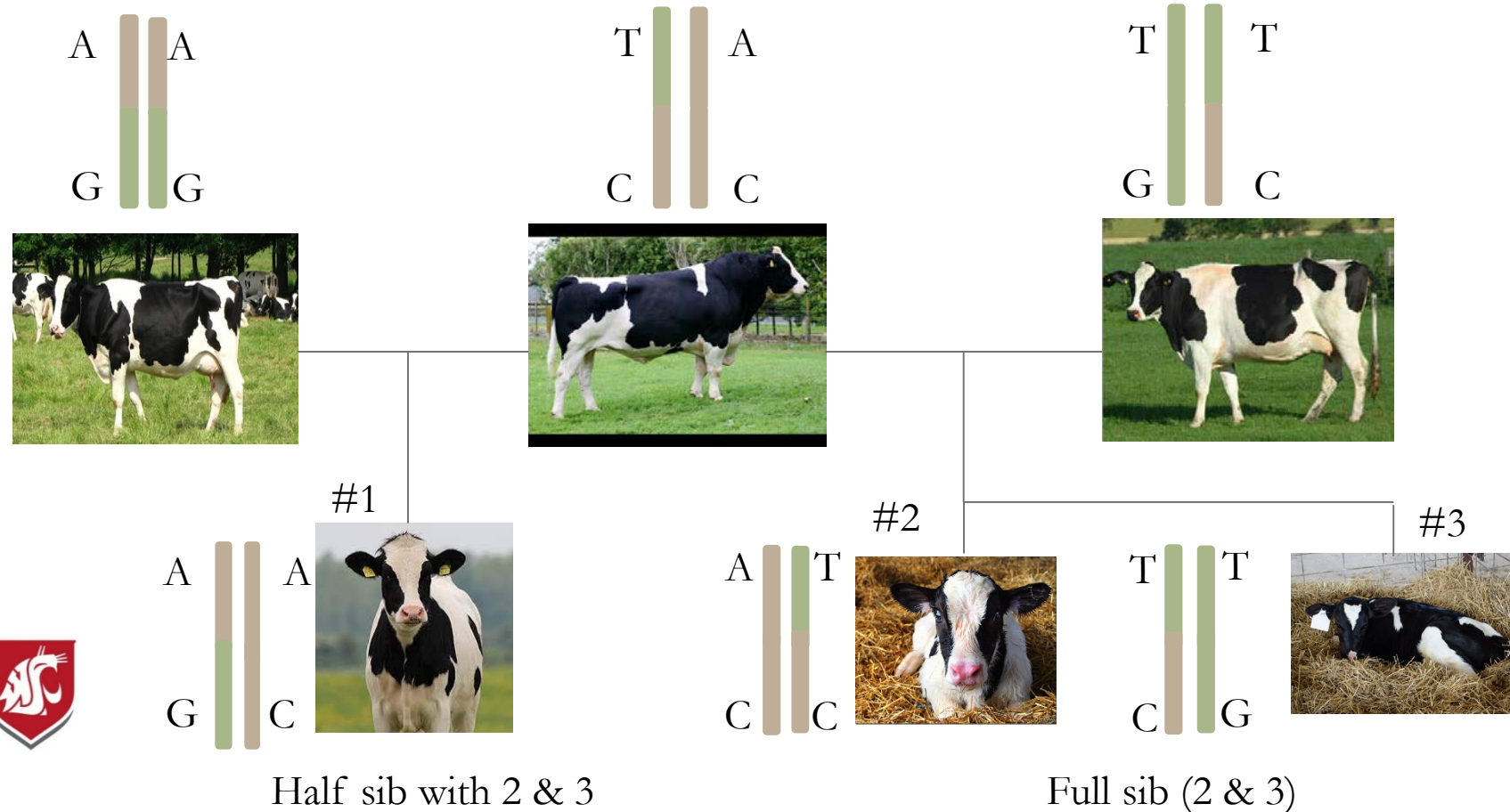
USING RELATIVES FOR PREDICTION

A

B

C

D

E

½ A ½ B

F

½ C ½ D

G

¼ A, ¼ B, ¼ C, ¼ D

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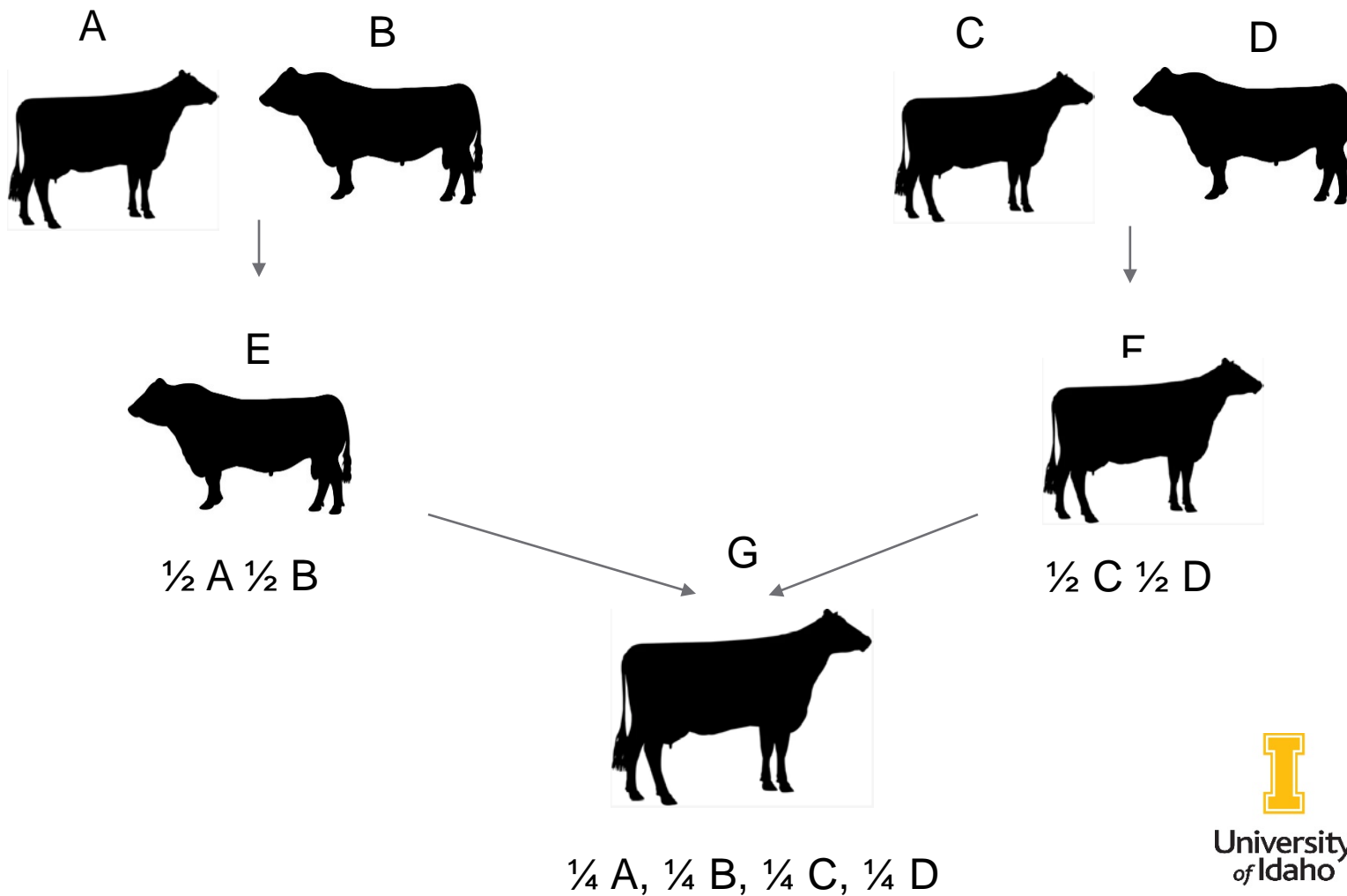
DNA TESTING TRACKS WHICH CHROMOSOMAL SEGMENTS THE OFFSPRING GETS FROM ITS PARENTS

A

B

C

D

*

*

*

E

F

*

*

G

*

*
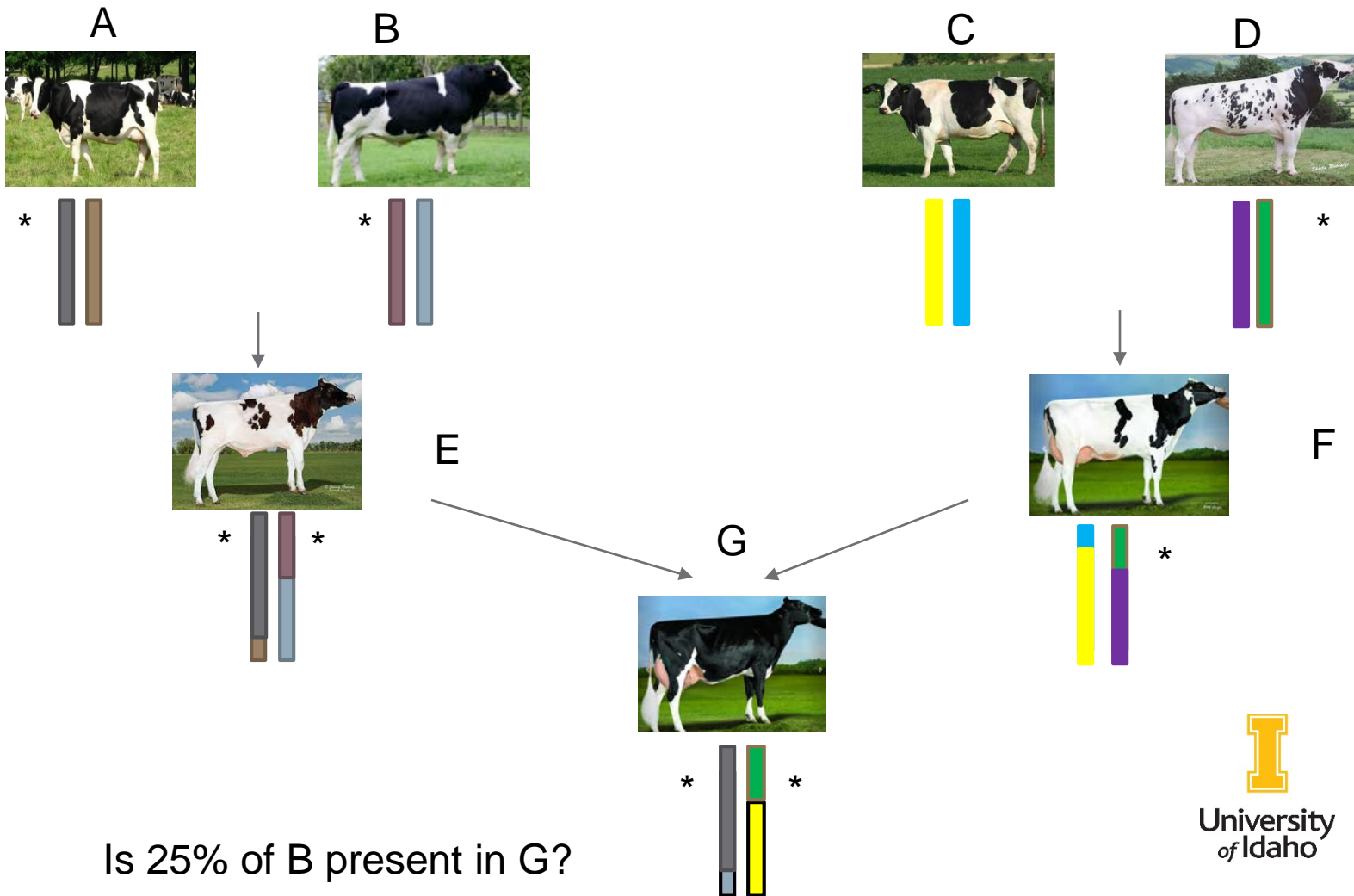
Is 25% of B present in G?

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SELECTION

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SELECTION

Selection - Deciding which animals will be in the breeding herd

How do we decide?

- Visually (phenotypic)

- Pedigree performance or predicted transmitting ability (PTA)

- Individual's PTA

Only good for traits with little environmental influence (high heritability)

- Mature size

- Conformation

PREDICTED TRANSMITTING ABILITIES (PTA)

- Predicted Transmitting Abilities (PTA) are an estimate of the genetic merit that will be transmitted to their offspring.

- PTA measures the expected difference between their offspring and the mean of all offspring for that trait.

mean of the herd's offspring = 25,000 pounds

mean of the cow's offspring = 27,000 pounds

PTA = +2000 lbs.

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SELECTION INDEXES

- Predicted transmitting abilities (PTA) of many traits are often summed into a selection index

- Selection indexes weight traits and gives a single value to select by

- Weights can be based on economic value or the prioritization of what is the most important traits

What is an example of an economic index?

1. Sire (PTA based on performance and genotypes)

2. Sire and maternal grandsire

3. Sire and dam

Problem: **we don't know what genetics was transmitted from the parent so we assume that half of the PTA will show up in the calf**

Genotypes of calf are used

- Know what was inherited from parents

- Increases accuracy of prediction of performance for traits influenced more by the environment/management

- Reduces financial risk by choosing replacements more likely to perform favorably

Trait	Reliability %				
	Genomic Average	Traditional Parent Average	Difference Young Holstein Bulls[1]	2013 Difference Holstein Heifers[2]	Genomic Daughter Equivalents[2]
Net Merit ($)	75	33	+ 42	+42	33.1
Milk (pounds)	78	35	+ 43	+44	26.6
Fat (pounds)	78	35	+ 43	+44	26.6
Protein (pounds)	78	36	+ 42	+44	26.6
Productive Life (months)	73	29	+ 44	+43	77.6
Somatic Cell Score	75	31	+ 44	+43	58.5
Daughter Pregnancy Rate (%)	71	27	+ 43	+42	146.3
Final Score	76	32	+ 44	+46	26.8
Sire Calving Ease	73	54	+ 18	+28	39.5
Daughter Calving Ease	61	36	+ 25	+28	45.1

[1] Genomic minus traditional for 1909 young bulls (CDCB, 2016). [2] Genomic minus traditional for = 240,618 Holstein heifers (AIPL-USDA, 2013)
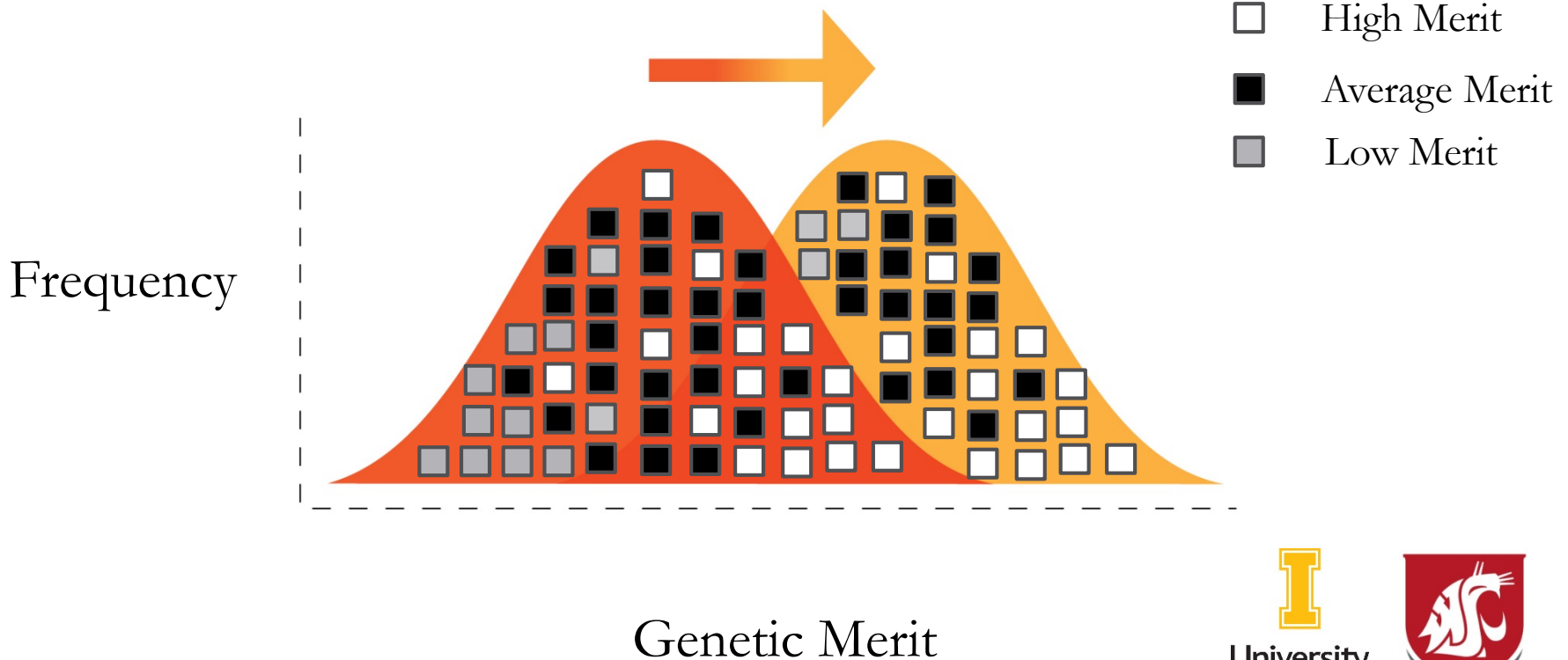
MATING DECISIONS

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USING GENOMICS FOR MATING DECISIONS

- Identify relatedness of heifer/cow with potential mates
- Identify sires that would be complementary to the strengths of the heifer for production and health traits
- Determine type of breeding or sire selection (elite dairy sire, standard dairy sire, flush, ET recipient, beef sire, etc.)

REPRODUCTIVE INFORMATION

Genotyping also serves to

- Identify errors in paternity and maternity
- Identify mature size for breeding

HEIFER PARENTAGE

Wrong sire, but real sire genotyped previously and identified as sire

Submitted Sire	Genomic Sire	Sire Status	Suggested MGS	MGSStatus	Submitted Dam	Genomic Dam	Dam Status
HO840003145966939	HO840003132349851	Confirmed	HO840003131131477	Likely		HO840003211603674	Confirmed
HO840003142181436	HO840003138498807	Confirmed	HOUSA000059109587	Unconfirmed			Unconfirmed
HO840003132198276	HO840003123615021	Confirmed	HOUSA000073953484	Unconfirmed			Unconfirmed
HO840003145627308	HO840003149759634	Confirmed	HOUSA000074072170	Unconfirmed	HO982000425910335	HO982000425910335	Unconfirmed
HO840003142332725	HO840003142710625	Confirmed	HO840003125982615	Unconfirmed	HO982000419848784	HO982000419848784	Unconfirmed
HO840003145627479	HO840003142332725	Confirmed	HO840003134408370	Unconfirmed	HO982000425910840	HO982000425910840	Unconfirmed

Wrong dam, but real dam previously genotyped and identified as dam

Submitted Sire	Genomic Sire	Sire Status	Suggested MGS	MGSStatus	Submitted Dam	Genomic Dam	Dam Status
	HO840003143721718	Confirmed	HO840003127565642	Likely	HO840003149613936	HO840003149613936	Confirmed
	HO840003141562808	Confirmed	HO840003131842689	Likely	HO840003149614107	HO840003149614107	Confirmed
	HO840003143721718	Confirmed	HO840003134443726	Likely	HO840003201754285	HO840003201754285	Confirmed
	HO840003143721718	Confirmed	HO840003134444214	Likely	HO840003201754340	HO840003201754340	Confirmed
	HO840003143721718	Confirmed	HO840003014334961	Likely	HO840003201730628	HO840003201730628	Confirmed
	HO840003142181491	Confirmed	HO840003128557644	Likely	HO840003143687504	HO840003147223795	Confirmed
	HO840003142181491	Confirmed	HO840003128557644	Likely	HO840003143687214	HO840003147223795	Confirmed

TESTS, COSTS & REPORTS

MEASURING PROFITABILITY

Costs of genomic selection

- Igenity Essential supported by CDCB (Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey) $29 - $32

- Igenity Merit – NM$, CM$, FM$ (Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey) $18

- Igenity Basic (crossbred) $25

- Igenity Basic plus (crossbred & parentage) $30

- Parentage only $15

EXAMPLE IGENITY® REPORT ON KEY TRAITS

ID	GM$	NM$	NM$ Rank	NM$ USA % Rank	Milk Yield	Fat lbs	Pro lbs	SCS	PL	DPR	DCE	IPI
1	635	627	1	99%	1102	49	30	2.84	5.8	2.7	5.8	2363
2	577	597	2	99%	1192	53	39	2.65	5.5	1.8	6.8	2322
3	360	375	4	98%	1431	26	28	2.95	3.4	0.9	5.9	2066

- **GM$** - grazing merit $
- **NM$** - net merit $
- **SCS** - somatic cell score
- **PL** – productive life
- **DPR** – daughter pregnancy rate
- **DCE** – daughter calving ease
- **Milk yield** – differences in pounds of milk for a 305 day lactation
- **Fat lbs** – differences in pounds of fat for a 305 day lactation
- **Pro lbs** – difference in lbs. of protein yielded for 305 day lactation
- **IPI** – Igenity production index (same as TPI)

- **SCE** - Sire calving ease
- **HCR** - Heifer conception rate
- **CCR** - Cow conception rate
- **DSB** - Daughter stillbirth
- **SSB** - Sire service stillbirth

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IGENITY® DASHBOARD

Interactive tool for interpreting genomic results

Customize, sort, filter results

Create custom indexes

Designate a consultant where they can have access to data

Compare rates of genetic gain between your and other herds

https://www.igenitydashboard.com/Home/Login

Igenity Dairy Dashboard

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Zoetis

- Clarifide products, includes health traits

STgenetics

Others…

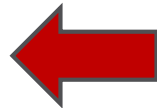# WHY DOES GENOMIC SELECTION INCREASE PROFITABILITY?

WHY USE SELECTION?

Estimated cost to raise a heifer is $1600-2000

Second greatest expense for dairy after feed costs

To improve performance

- Nutrition
- Hygiene
- Health program
- Genetics ⬅ **Selection and mating decisions**

Financial risk is reduced when:

1. Prediction is more accurate

- Less surprise on performance

- Increase genetic progress more rapidly – more product with less cows

2. Positive return on investment for genomics

- Gain profitability

- Improve ability to manage cattle

SUMMARY

1. Equal amounts of DNA are inherited from each parent
2. Selection decides who will remain in the breeding herd
3. Genomic selection uses genotypes of the individual to choose who to keep in the breeding herd
4. Genomic selection improves reliability or accuracy to make good selection decisions
5. Genomic selection increase genetic progress
6. Genomic information should also inform mating and management decisions
7. Genomic selection reduces financial risk and increases long-term profitability