Meiotic Recombination in Ruminant Livestock Species

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Goals

1. To quantify, characterize and compare the number of meiotic recombination/crossover (CO) between beefalo, cattle and sheep.

2. Test the relationship between the number of CO and chromosome length.

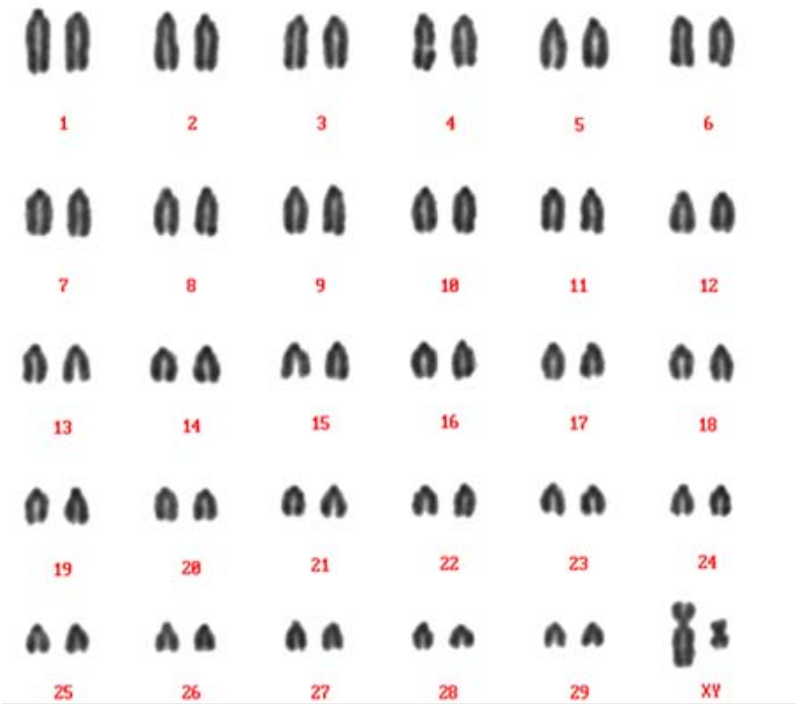
3. Examine the chromosomal structural integrity.

Meiotic Recombination

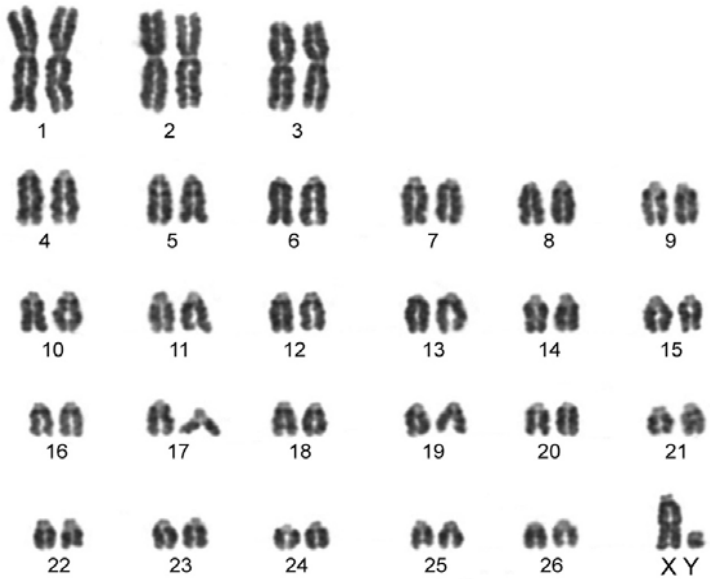
- Exchange of genetic material contributes to genetic diversity
  - NOT random
    - Associated with the number of chromosome arms
    - Interference
    - “Hotspots”
    - Sexual dimorphism
- Ensure faithful chromosome segregation

Karyotpe: Chromosome Arms

Cattle



Sheep



Mammalian Recombination

Sex averaged linkage map comparison to number of chromosome arms in different mammalian species.

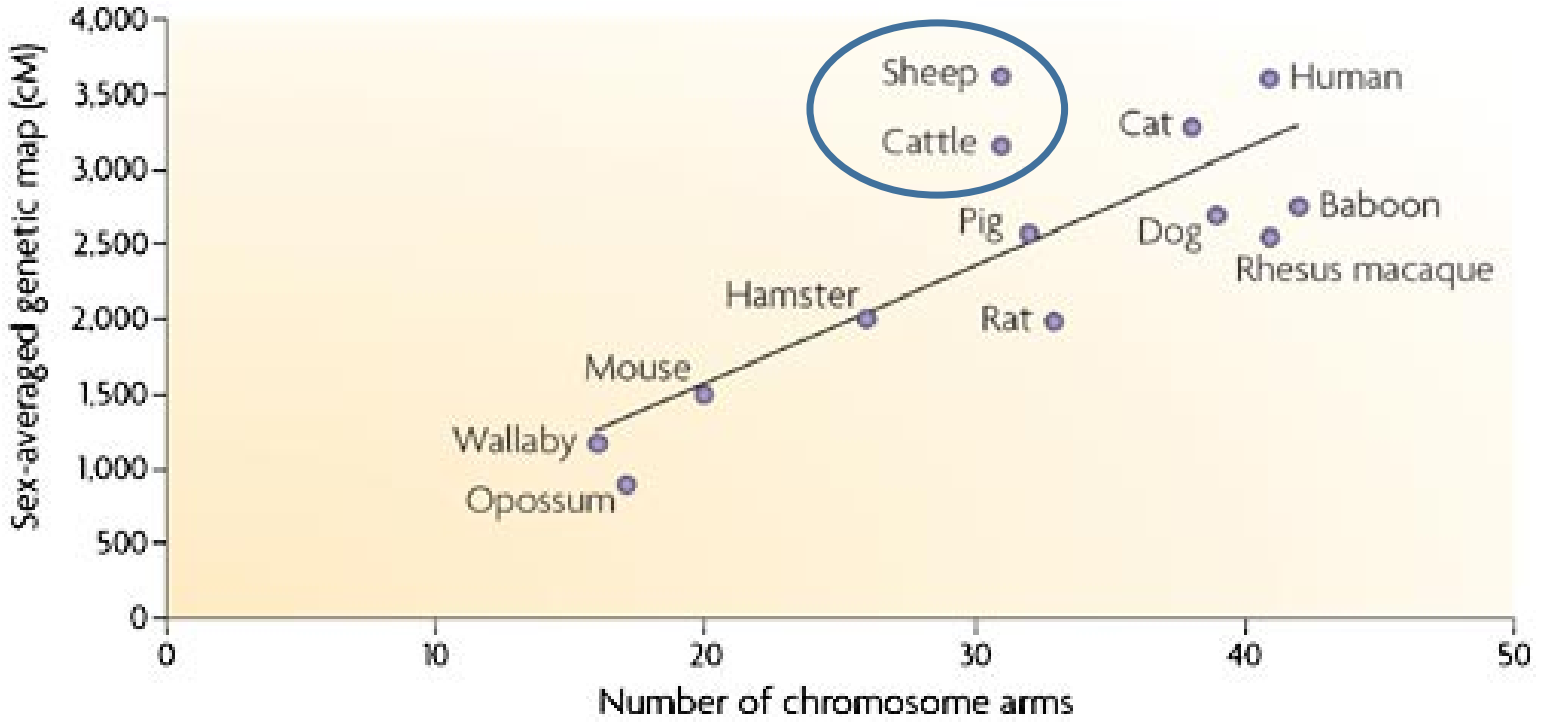
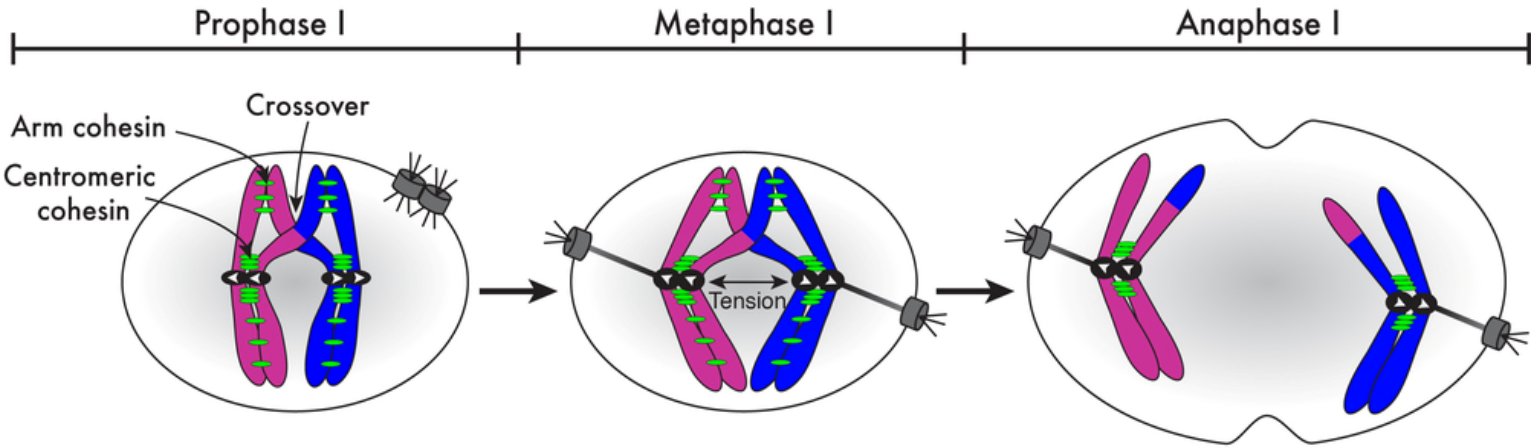


Figure adapted from Coop & Przeworski (2007), Nature Reviews Genetics 8.

Meiosis

- Ensure faithful chromosome segregation



- Mis-segregation or non disjunction leads apoptosis in males

http://www.unal-and-brar-labs.org/unal-cdk/

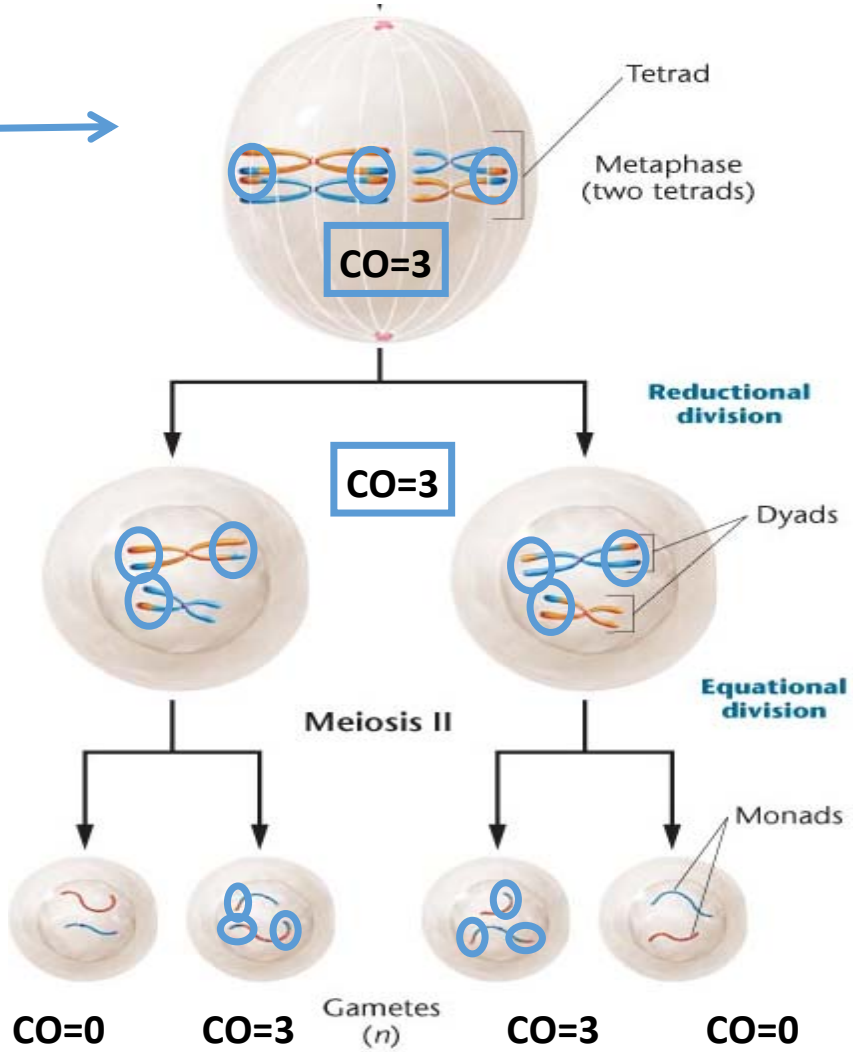
Method: Cytogenetics

- Allows us to characterize recombination directly
  - Has distinct advantages compared to linkage mapping
    - Reference genome
    - Large number of progeny
- Determine structural integrity

Prophase I
(synapsis)

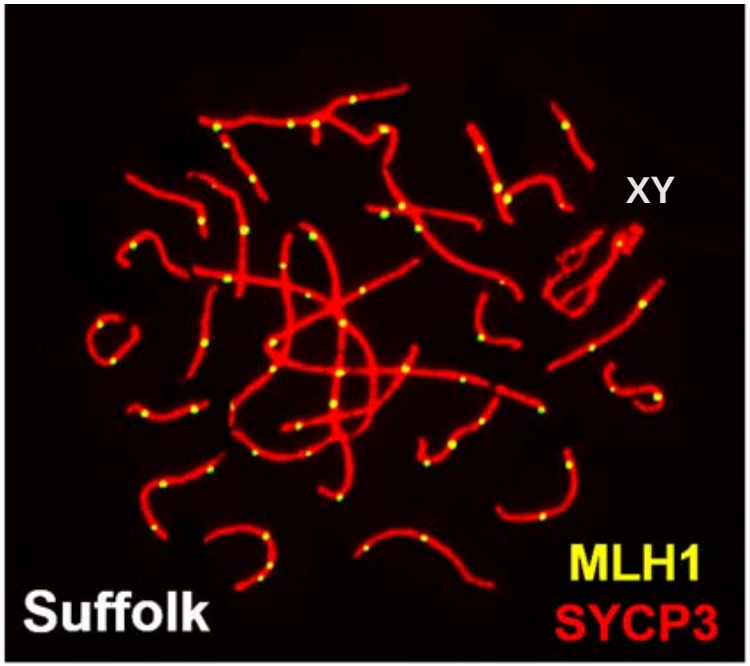
Recombination in prophase (pachytene cell) observed by immunofluorescence.

Recombination observed in gametes are lower due to independent assortment of chromatids.

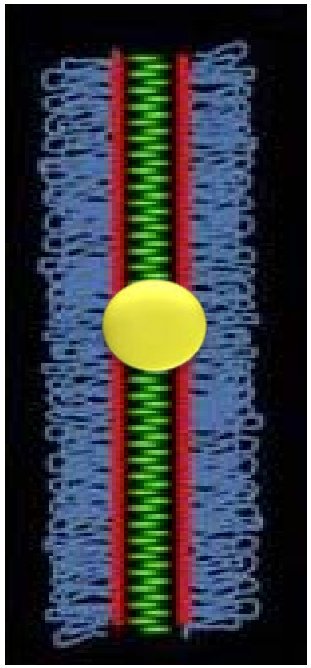


Average crossover counted in offspring = 1.5

Immunofluorescence

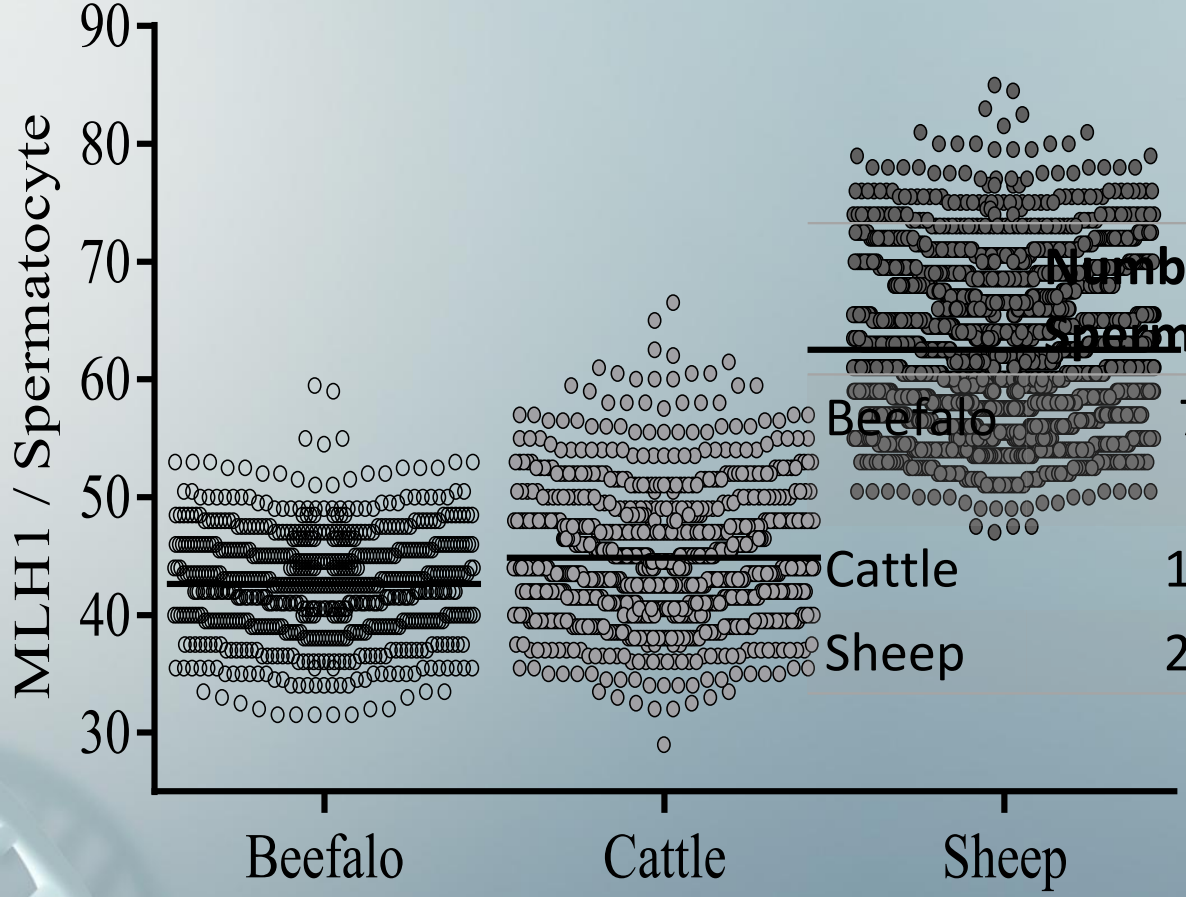


Synaptonemal Complex (SC)
SYCP3



MLH1
Crossover (CO)

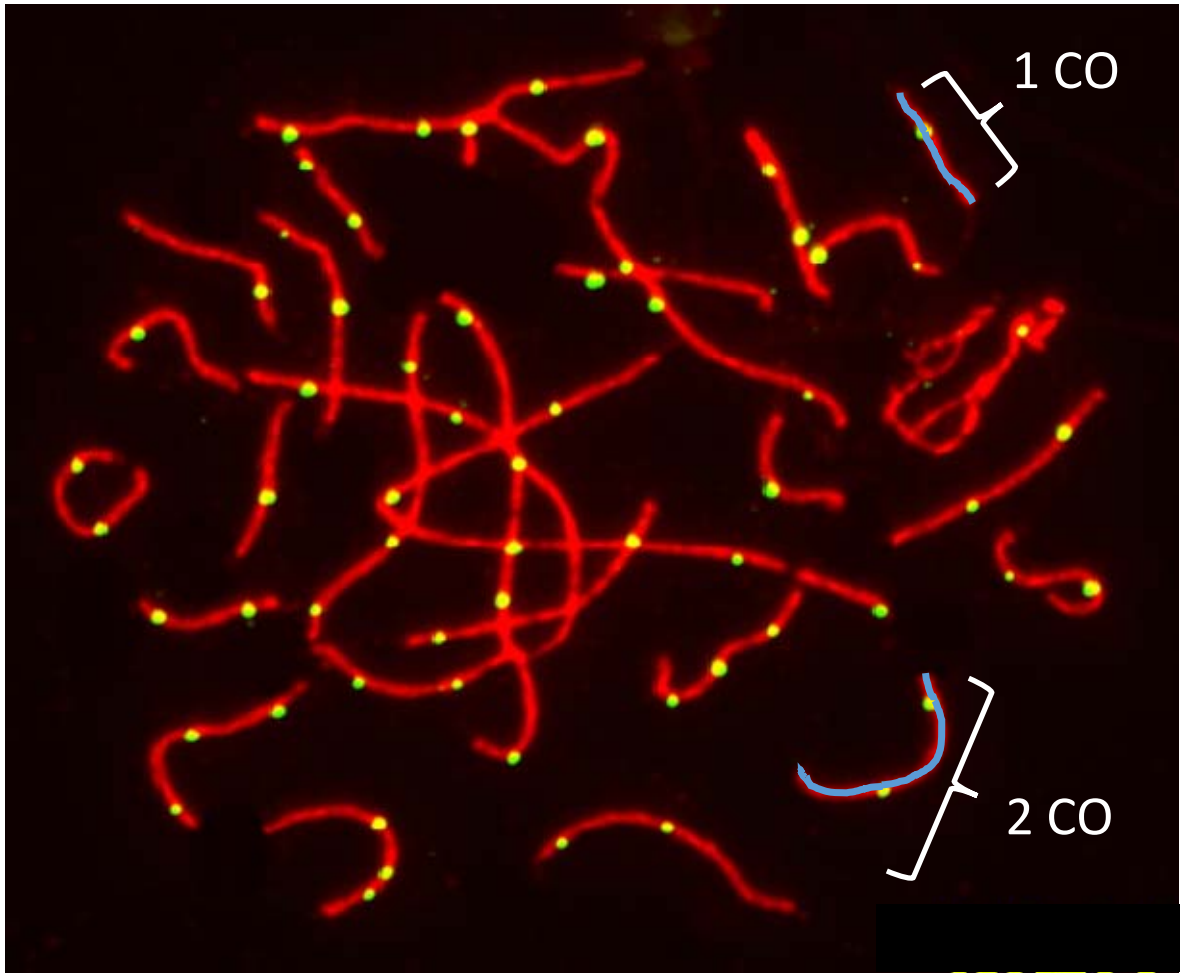
Number of COs



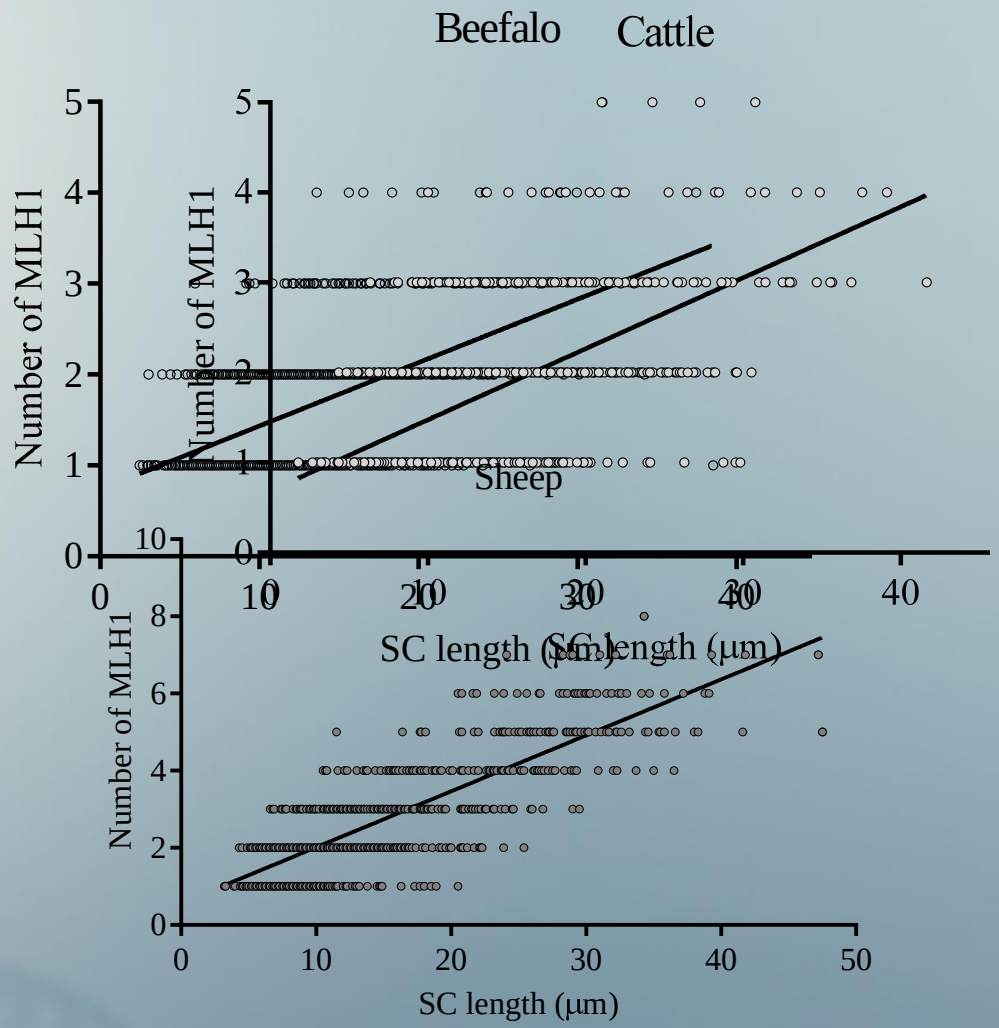
	Number of Spermatocytes	Average CO
Beefalo	713	42.6^{A} ±0.70
Cattle	1017	44.7^{B} ±0.79
Sheep	2749	62.5^{C} ±0.78

Each dot represents the number of COs from individual spermatocyte, black bars represent breed mean, and the letters above denotes significant differences ($P<0.01$).

Chromosome Length & CO Numbers



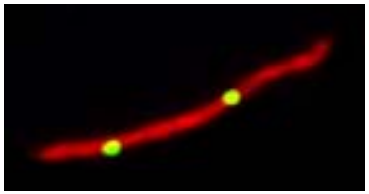
Length of Chromosome & CO Number

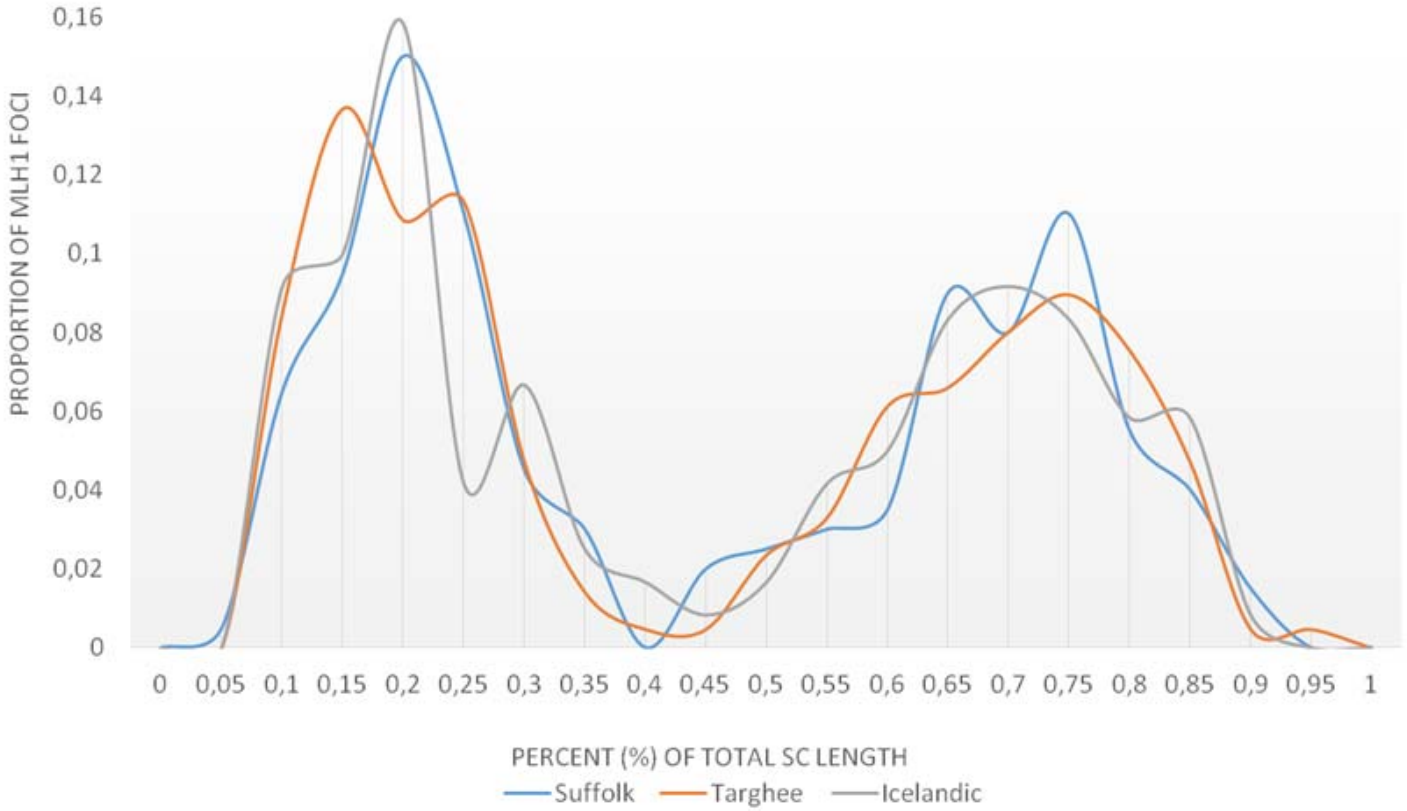


Beefalo (61 cells, r=0.53)
Cattle (86 cells, r=0.57)
Sheep (340 cells, r=0.70)

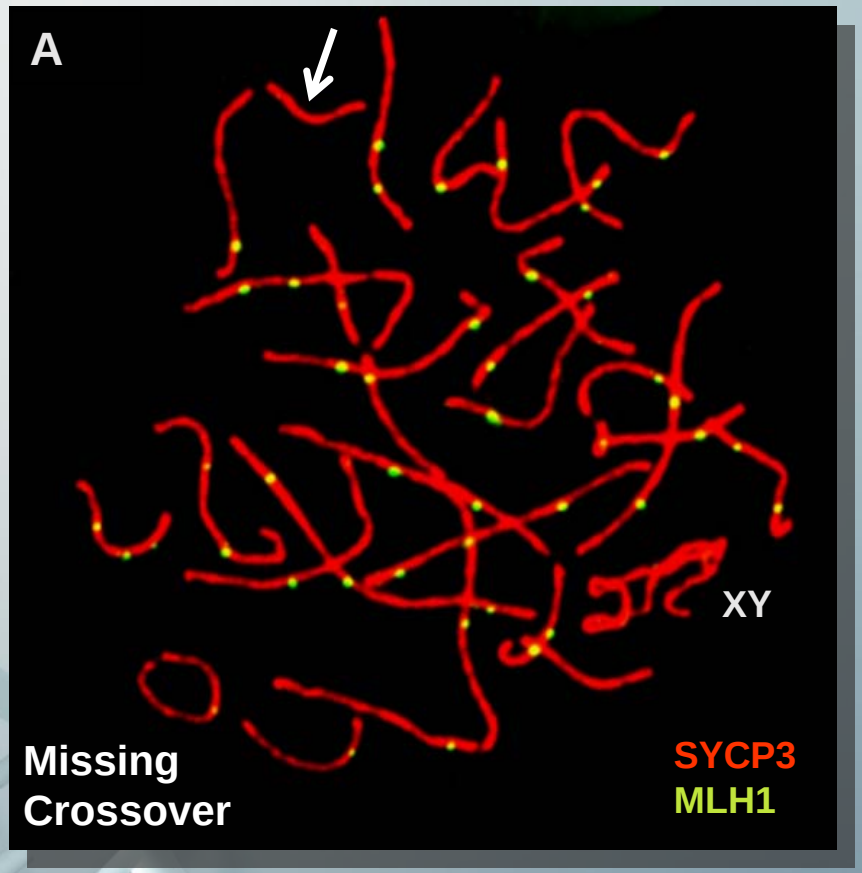
Chromosome Length & CO Position

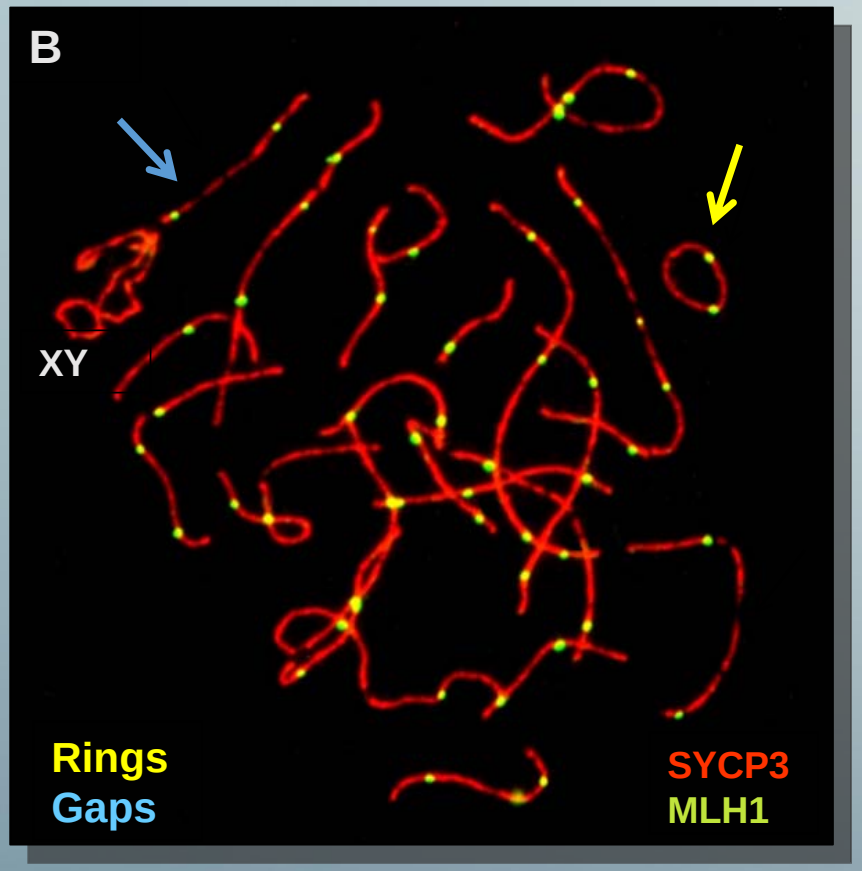
- Locations of CO on SCs with 2 CO



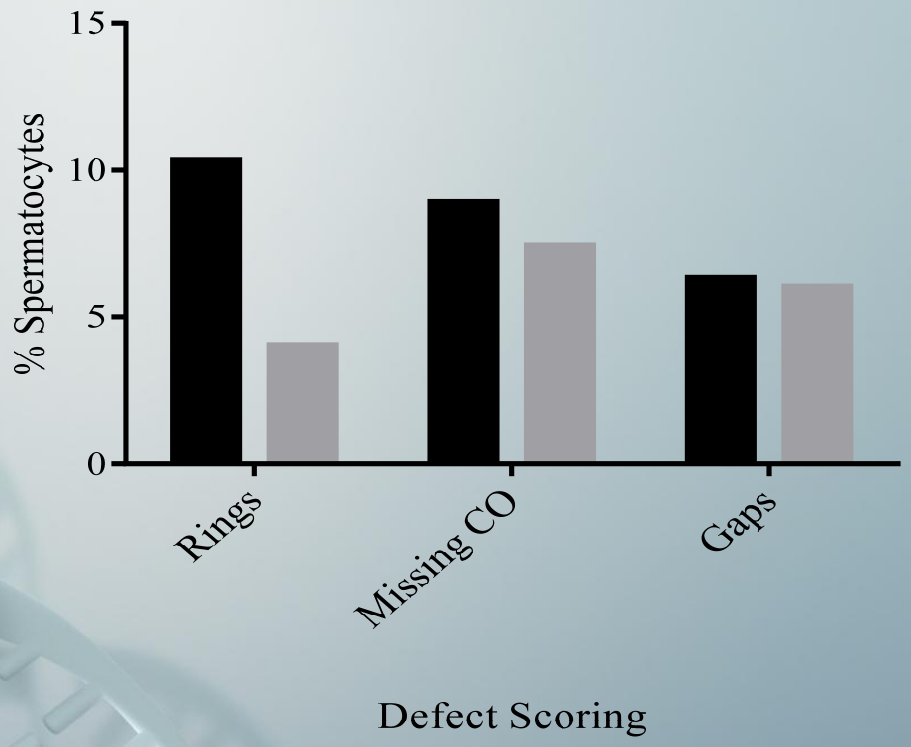


Chromosomal Defect Scoring





Chromosomal Defect Scoring



Defect	Beefalo	Cattle
Normal	74.6^{A}	83.6^{B}
Rings	10.3^{A}	3.8^{B}
Missing CO	8.9^{A}	6.2^{A}
Gaps	6.3^{A}	6.2^{A}
Total Defects	25.4^{A}	16.4^{B}

Letters denote significant differences ($P<0.01$)

Summary

- Sheep exhibit a significantly greater number of COs and cattle exhibit more COs in comparison beefalo.
- Larger chromosomes tend to have a greater number of COs.
- Beefalo spermatocytes have a greater number of structural defects.

Acknowledgements

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Lab

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Testicular Samples

- Pure Country Harvest
- University of Idaho Vandal Meats
- University of Idaho Sheep Experiment Station
- C&L Meat Locker

Questions?

Number of COs in Cattle

Bulls	Spermatocytes	Average CO
Charolais	112	$48.9^{A} \pm 0.54$
Gelbvieh	97	$47.6^{A} \pm 0.58$
Jersey	100	$48.6^{A} \pm 0.39$
Angus 1	100	$43.3^{B} \pm 0.33$
Angus 2	100	$43.4^{B} \pm 0.30$
Angus 3	101	$41.5^{B} \pm 0.36$
Angus 4	100	$42.4^{B} \pm 0.37$
Angus 5	100	$41.7^{B} \pm 0.41$
Angus 6	97	$43.2^{B} \pm 0.61$
Angus 7	98	$46.5^{A} \pm 0.52$