

### Basic Genetics for the Responsible Breeder: Promoting Health and Vigor in a Small Gene Pool

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American Water Spaniels Nationals, 2018




### Learning Objectives


- Understand basic genetic concepts
- Learn how to select the best mates
  - What to look for
  - What to avoid
- Learn how to maintain breed health

### Decisions


One female & 3 stud options



#1 - Grandson of a popular grand champion



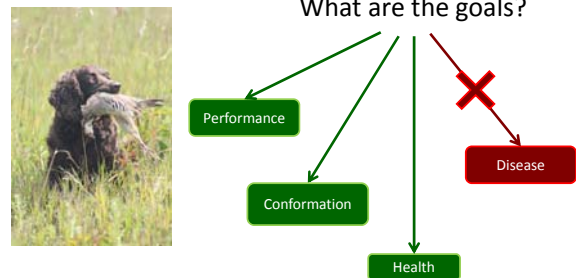
#2 - 1<sup>st</sup> cousin with excellent retrieving skills



#3 - New import from Canada; most unrelated

### Decisions

What are the goals?



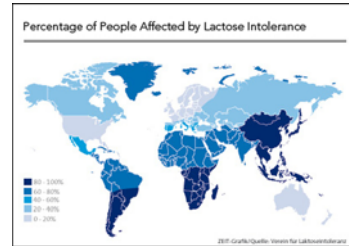
## Genetic Disease

What is a mutation?

AAGAGC → AACAGC

## Genetic Disease

What is a mutation?



## Genetic Disease

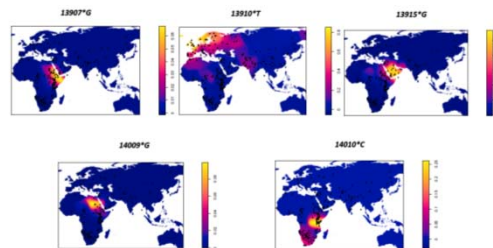
What is a mutation?

AA**C**AGC → AA**T**AGC

Lactose intolerance =  
ancestral allele (C)

Lactase persistence =  
dominant mutation (T)

## Selection



Liebert et al. *Human Genetics*, 2017.

## Genetic Disease

### What is a mutation?

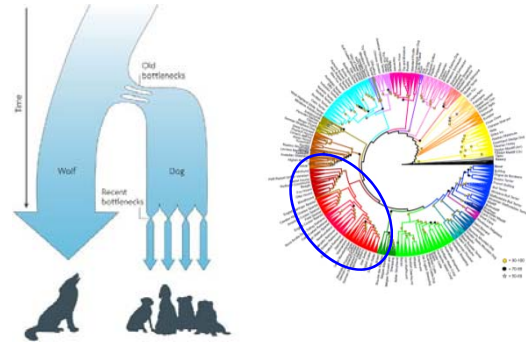
AAGAGC → AACAGC

“Variant”

“Polymorphism”

Not inherently bad

## Selection



Karlsson & Lindblad-Toh. *Nature Reviews Genetics*, 2008.

## Decisions



What are the goals?

Performance

Conformation

Health



Disease

## Selection

Breeding for performance



## Selection

Breeding for performance

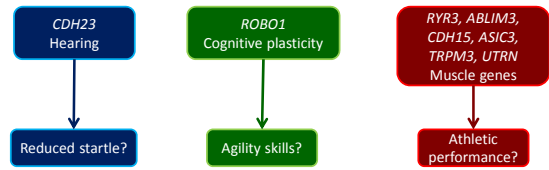


### Genetic selection of athletic success in sport-hunting dogs

Jaemin Kim<sup>a</sup>, Falina J. Williams<sup>a</sup>, Dayna L. Dreger<sup>a</sup>, Jocelyn Plassais<sup>a</sup>, Brian W. Davis<sup>a,1</sup>, Heidi G. Parker<sup>a</sup>, and Elaine A. Ostrander<sup>a,2</sup>

<sup>a</sup>Cancer Genetics and Comparative Genomics Branch, National Human Genome Research Institute, National Institutes of Health, Bethesda, MD  
Edited by Kevin P. Campbell, Howard Hughes Medical Institute and University of Iowa, Iowa City, IA, and approved June 1, 2018 (received for review 11, 2018)

## Selection



## Selection

Breeding for temperament

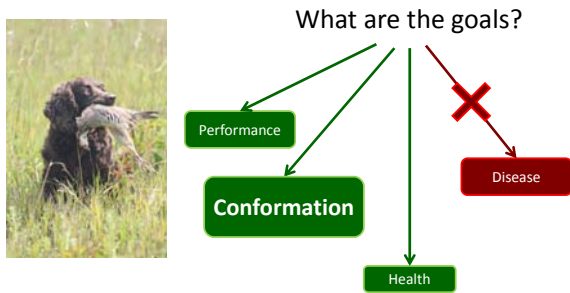


## General Guidelines

**Breed for performance and temperament**

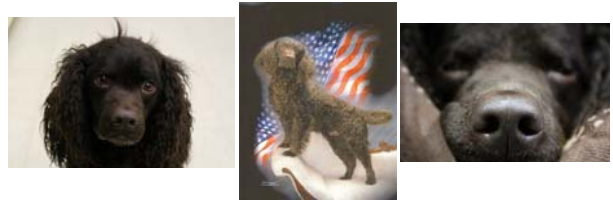


## Decisions



## Selection

Breeding for appearance  
*Part 1: External signs of health*



## Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*



## Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*

This can be problematic if it is done without regard to negative health impacts

### Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*



Short limbs  
FGF4 retrogenes



→ Risk for intervertebral disc disease

### Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*



Ridge  
FGF three gene duplication



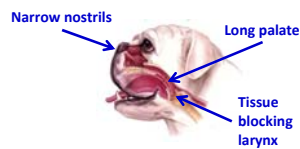
→ Risk for dermoid sinus (infection, pain, spinal cord damage)

### Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*



Short head  
Polygenic



→ Brachycephalic airway syndrome (breathing difficulty)

### Selection

Breeding for appearance  
*Part 2: Coat pattern or conformation*



Spotting linked to SLC2A9 mutation



→ Risk for urate urinary stones

## Selection

Breeding for **appearance**

### Part 2: Coat pattern or conformation



## General Guidelines

★ Breeding for external signs of physical health is advised

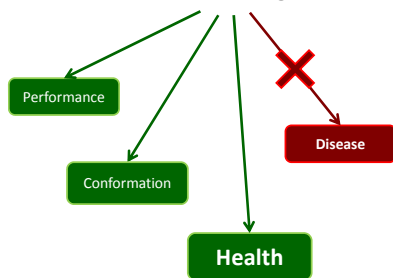
Avoid breeding for extreme appearances

If a disease is found to be associated with a certain look, avoid that look

## Decisions



What are the goals?



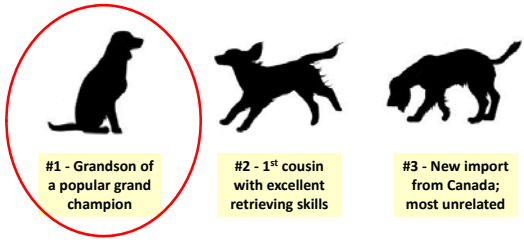
## General Guidelines

★ Breed towards favorable traits and away from unfavorable traits/disease

*But how do you accomplish this?*

### General Guidelines

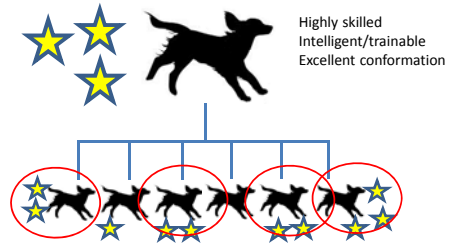
Breed towards favorable traits and away from unfavorable traits/disease



### Concepts

#### *Influential ancestor*

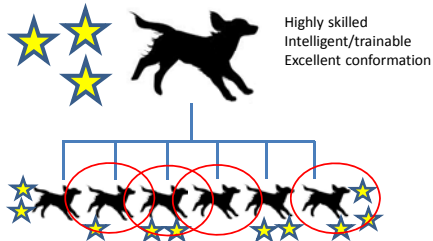
Common in pedigrees because of high quality offspring, grand-offspring, etc.



### Concepts

#### *Popular sire*

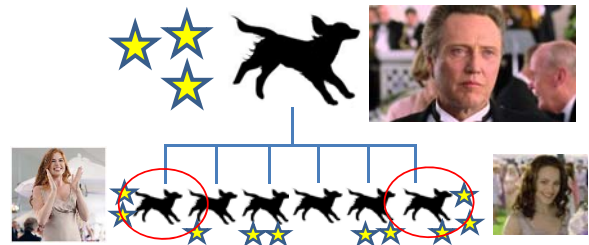
Common in pedigrees because of reputation, regardless of offspring performance/traits



### Concepts

#### *Popular sire*

Common in pedigrees because of reputation, regardless of offspring performance/traits





## Concepts

### **Popular sire**

Common in pedigrees because of reputation, regardless of offspring performance/traits



## Concepts

### **Why is a popular sire dangerous?**

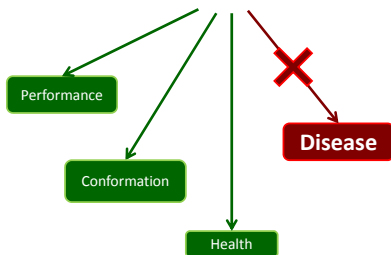
Breeding decisions must incorporate both the individual dog's health and family health

Otherwise, dogs with negative traits may be bred → increased disease in the breed

## Decisions



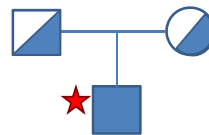
What are the goals?



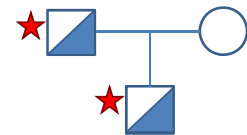
## Breeding away from Disease

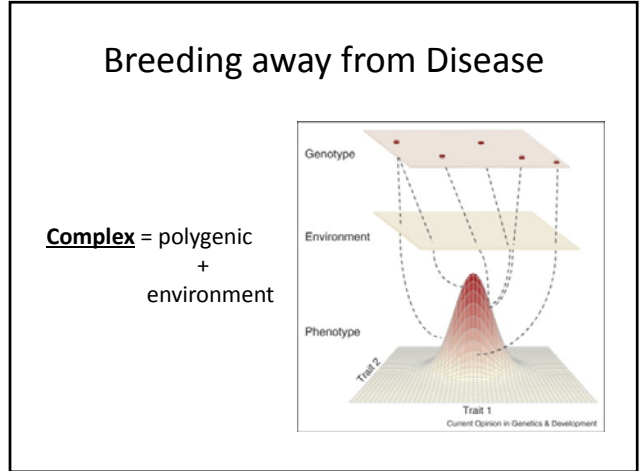
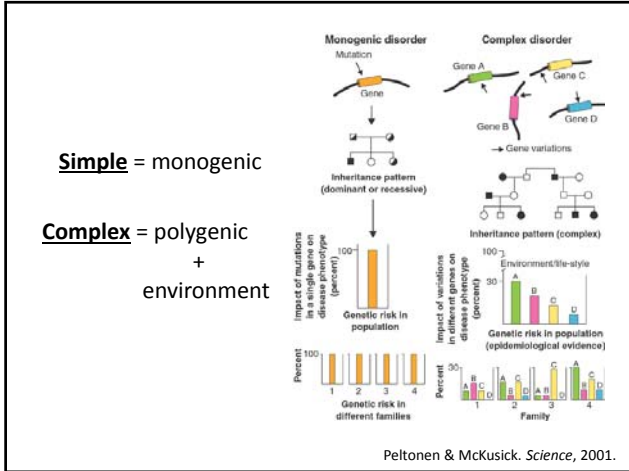
**Will you know if there is a genetic disease in a dog's lineage?**

Autosomal recessive  
2 mutation copies



Autosomal dominant  
1 mutation copy sufficient for disease





### Breeding away from Disease

*Will you know if there is a genetic disease in a dog's lineage?*

<https://youtu.be/Mc52XAulMeo>


### Breeding away from Disease

*Will you know if there is a genetic disease in a dog's lineage?*


Not just parents but also at siblings and half siblings → pedigree breadth

### Healthy Breeding


*What about "outbreeding"?*



#1 - Grandson of a popular grand champion



#2 - 1<sup>st</sup> cousin with excellent retrieving skills

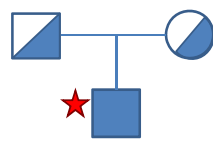



#3 - New import from Canada; most unrelated

### Healthy Breeding

*What about "outbreeding"?*

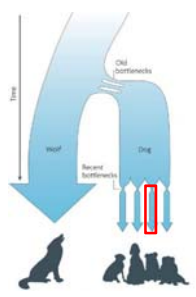
Autosomal recessive  
2 mutation copies





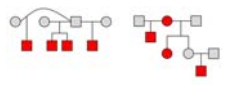
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### Selection



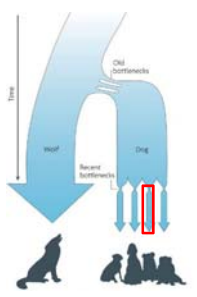
Individual dog breeds have relatively little genetic diversity

Many mutations are old and present in many "lines" within a breed




Karlsson & Lindblad-Toh. *Nature Reviews Genetics*, 2008.

### Selection



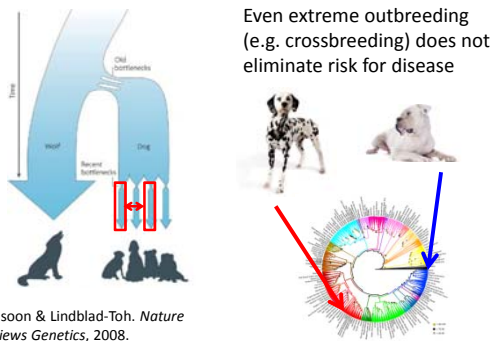
Individual dog breeds have relatively little genetic diversity

Many mutations are old and present in many or ***even all*** "lines" within a breed

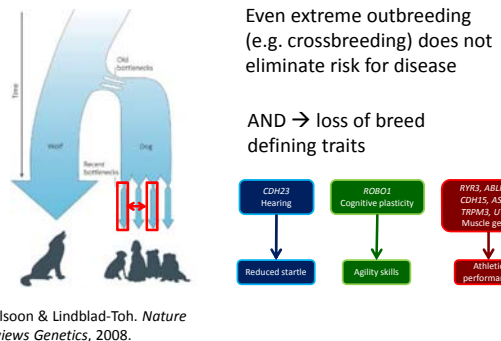


Karlsson & Lindblad-Toh. *Nature Reviews Genetics*, 2008.

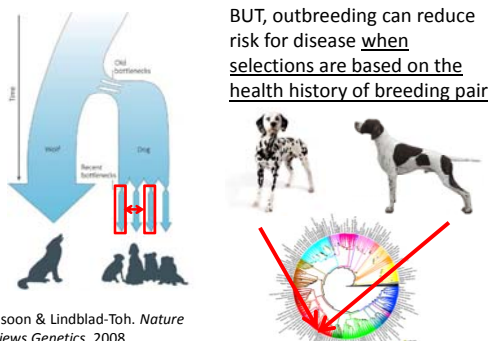
### Selection



### Selection

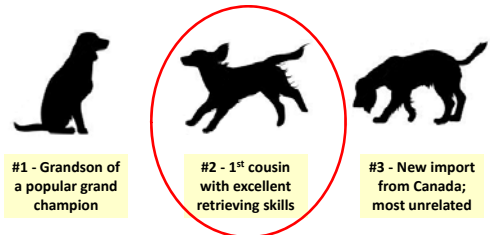


### Selection



### Healthy Breeding

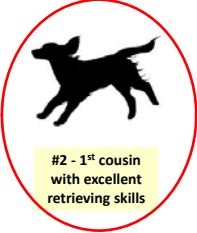
*What about "line breeding"?*



### Healthy Breeding

**Line breeding: How close is too close?**

24 states prohibit marriage between 1<sup>st</sup> cousins



#2 - 1<sup>st</sup> cousin with excellent retrieving skills


NOTE: North Carolina prohibits first-cousin marriage, though it prohibits double-cousin marriage, if two brothers from one family marry two sisters from another and if each couple has a child, those children would be double-cousins.

### Healthy Breeding

**Line breeding: How close is too close?**

**Inbreeding coefficient:** Probability that an offspring will inherit the identical variant from both parents

Autosomal recessive  
2 mutation copies



#2 - 1<sup>st</sup> cousin with excellent retrieving skills

### Healthy Breeding

**Line breeding: How close is too close?**


**Inbreeding coefficient:** Probability that an offspring will inherit the identical variant from both parents

2<sup>nd</sup> cousins = 1.5%  
1<sup>st</sup> cousins = 6%

2<sup>nd</sup> degree relatives (half-sibs, uncle-niece or aunt-nephew) = 12.5%

1<sup>st</sup> degree relatives (full-sibs, parent-offspring) = 25%

These numbers are underestimates for dogs:  
1<sup>st</sup> degree = 30 – 40%



#2 - 1<sup>st</sup> cousin with excellent retrieving skills

### Healthy Breeding

**What is the risk with a high inbreeding coefficient?**

#1 – Low frequency recessive mutations

Fatal recessive cardiac mutation in Toy Manchester Terriers



## Healthy Breeding

**What is the risk with a high inbreeding coefficient?**

#2 – De novo mutations

~50 – 100 per individual

Responsible for some cases of muscular dystrophy, malformations, autism, intellectual disability, epilepsy, etc.

If recessive, extremely unlikely to → affected offspring  
**EXCEPT in the case of high inbreeding**

## Healthy Breeding

**What is the risk with a high inbreeding coefficient?**

Human estimates:

- Most of us carry a fatal recessive mutation
- When 1<sup>st</sup> degree relatives are bred, the chance the offspring will have two copies of the same fatal mutation = 12%, i.e. **1 in 8 prenatal, infant, or juvenile deaths**

## General Guidelines

**Breeding to the least related individual should not take priority over breeding to the healthiest individual**

**Avoid breeding 1<sup>st</sup> & 2<sup>nd</sup> degree relatives**

## Decisions

One female & 3 stud options



#1 - Grandson of a popular grand champion

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#3 - New import from Canada; most unrelated

## Healthy Breeding

- Pay attention!
- Communicate with other breeders to detect problems early and properly pair dogs



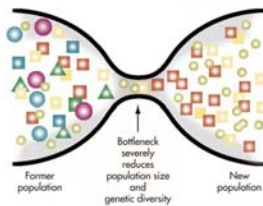
## Healthy Breeding

- Pre-breeding veterinary exam
- Health surveys from owners?
- Good record keeping



## Healthy Breeding

- Expand the population



## Summary

- **Breed for desirable traits**
  - Performance
  - Temperament
  - Health
- **Breed away from undesirable traits**
  - Full family history; pedigree breadth
- **Avoid 1<sup>st</sup> or 2<sup>nd</sup> degree matings**
- **Communicate with each other**
- **Expand the population**

## Questions

*Thank you to all  
AWSC members for  
caring about the  
future of your breed!*

