The Genomics of the American Mutt
How genes affect appearance and behavior in mixed-breed dogs

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How can we safely place shelter dogs with unknown history and unknown genetics?

Retrievers like to retrieve...mostly

Labs and Retrieving Interest
retriever objects (e.g., balls, toys, sticks) strongly agree - strongly disagree
Retrieving is heritable...mostly

MuttMix: A project to collect guesses about mixed-breed ancestry

- 31 mutts
- At least 3 breeds
- Guess top 3
MuttMix.org: What we found

Some dogs had 19+ breeds!
Number of breeds doesn’t correlate with correct answer
432,743 questions answered
25% accuracy overall
Professionals: 28% accuracy

Could we genetically test for behavior?

Single Nucleotide Polymorphisms (SNPs)

<table>
<thead>
<tr>
<th>one letter</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog #1</td>
<td>ATGCCGATCGTT</td>
</tr>
<tr>
<td>Dog #2</td>
<td>ATGCCATCGTT</td>
</tr>
</tbody>
</table>

Most SNPs don’t DO anything
Useful markers for tracing ancestry

"Is this SNP correlated with my trait?"
Coat Color in Boxers

<table>
<thead>
<tr>
<th>Color</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>9</td>
</tr>
<tr>
<td>Flash</td>
<td>1</td>
</tr>
<tr>
<td>White</td>
<td>10</td>
</tr>
</tbody>
</table>

White & deafness hypothesis:
regulation of M is disrupted

M makes protein needed for pigment cell migration

Find region with most correlated SNPs

over gene MITF

difference

position in dog genome

Karlsson et al, Nature 2008

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Hypothesis:
regulation of M is disrupted

Karlsson et al, Nature 2008

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Single gene "Mendelian" traits

White coat & deafness
Breeders'hippovola
Rhodesian ridgebacks
Salmon-H.

Cone-rod dystrophy
ALS
Osteodystrophy

Karlsson et al, Nature 2008

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Compulsive disorder in dogs

- Normal behavior done too much
- Distressing, time-consuming and impairing
- Onset in adolescence
- Highly heritable
- Poor response to treatment (including SSRIs)

Movies by Alice Moon-Fanelli

Compulsive disorder in dogs

Compare genomes of 92 affected and 67 healthy dobermans

Function of CDH2

- Neural cadherin
- Found in glutamatergic synapses
- Synaptic plasticity (learning and memory)

17 18 19 20
10% chance they had CCD

25% chance they had CCD

60% chance they had CCD

Darwin's Ark: the genetics of dog behavior

Example question

Citizen science dog genetics = more DNA samples
June 2018
19,044 dogs
2,198,453 answers
4000+ DNA samples

Darwin’s Dogs includes all dogs

Where did you get your dog?

Morphological traits

Behavioral traits
Does it work?

When DOG is standing next to someone of average height, how high are HIS shoulders?

We can predict height – pretty well!

Does it work?

How much time in a normal day does DOG spend chasing HIS tail, or circling?

Does it work?

DOG minutes objects (e.g., balls, toys, dishes)
Thank you to the organizations, owners, and dogs!
darwinsark.org