The Science of Dogs: Genetics

1) Genetics of Dogs

2) How Dog Genetics Can Help Humans

Pan-Pan Jiang

1) Genetics of Dogs - Meet *Canis*

Canis lupus

Canis lupus familiaris

Canis latrans

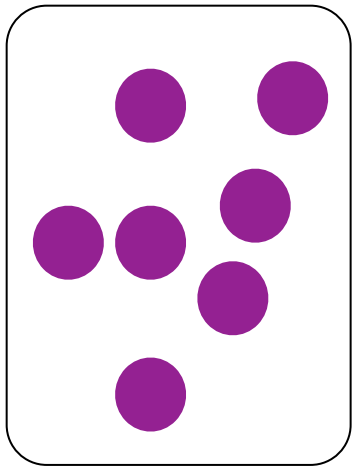
Canis aureus,
Canis mesomelas,
Canis simensis

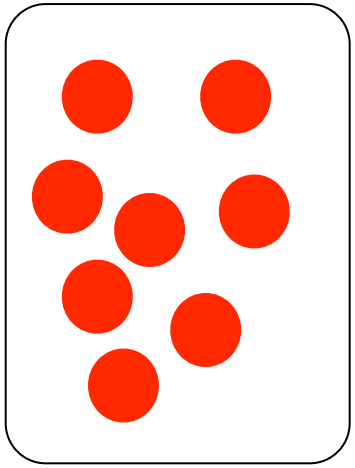
Artificial selection creates breeds

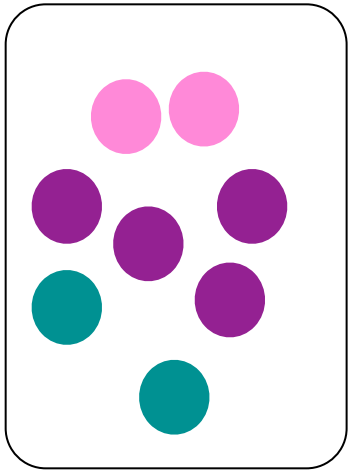
Dog breeds are homogeneous

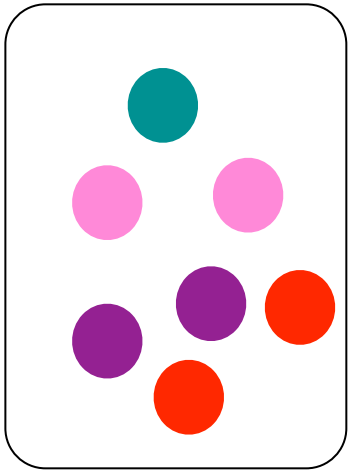
Dogs

Humans









Chihuahua

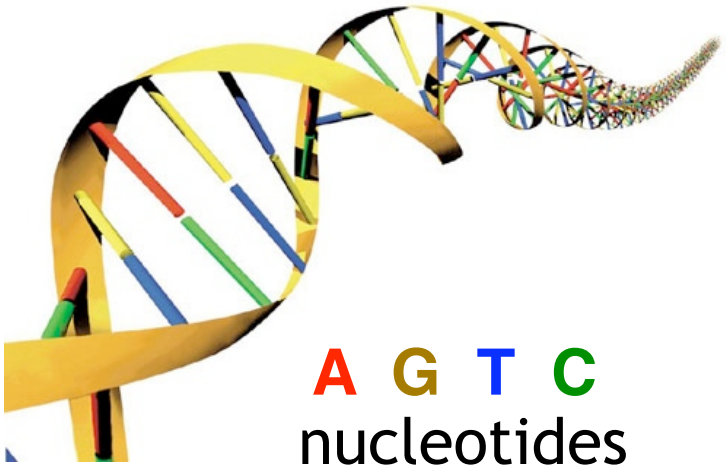
Great Dane

Africans

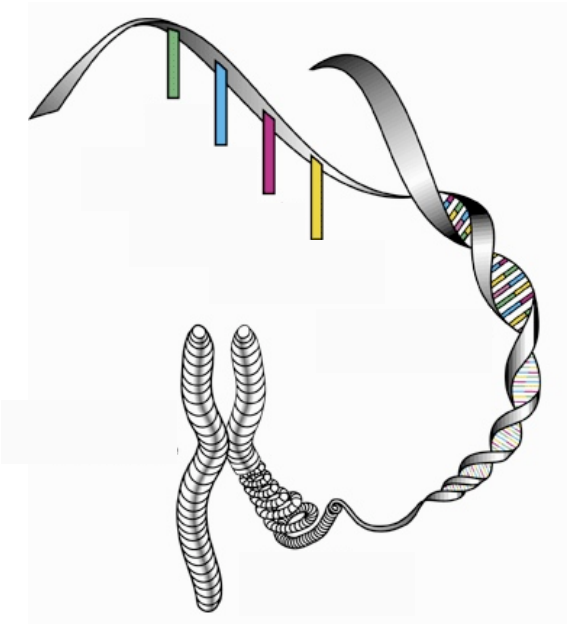
Asians

What is Genetics?

Genetics – study of genes and heredity



A G T C
nucleotides



DNA

Chromosomes

Humans: 3.0 billion nucleotides
Dogs: 2.4 billion nucleotides

Humans: 46
Dogs: 78

Different breeds, different species?

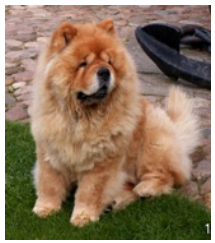
ref: ATCGTCAATG
1: ATGGTCAATG 1/10 differences - 10%
2: ATGGTCACTG 2/10 differences - 20% More different

5% different

8% different

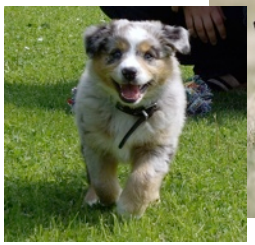
5% different

DNA gives us 4 major dog groups

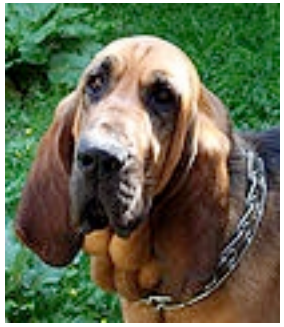
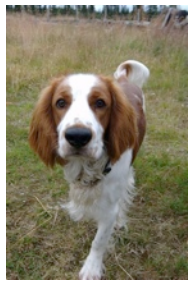




A) Asian breeds, Asian-descent hounds, spitz-type


B) Broad frames and large head



C) Working breeds

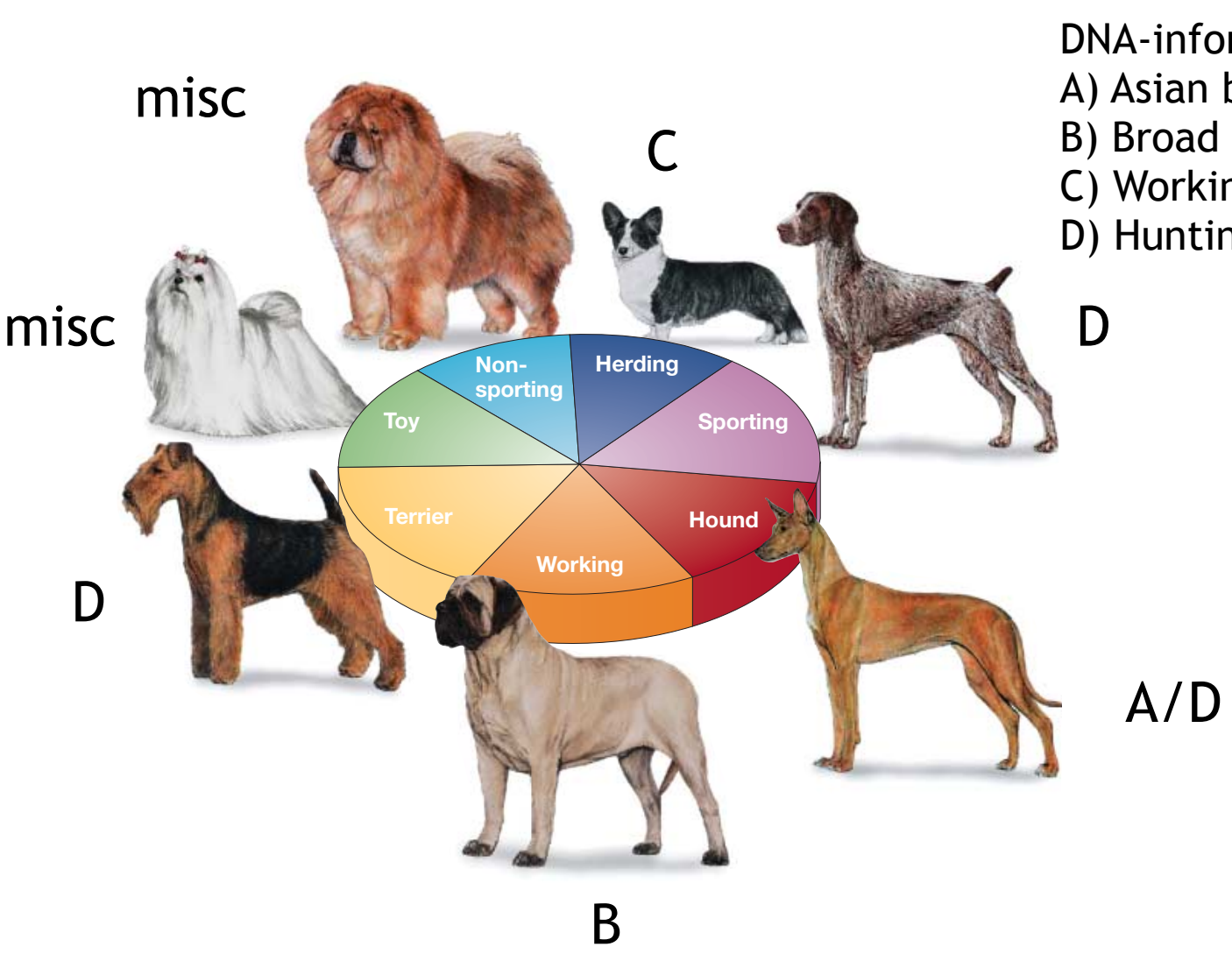




D) Hunting breeds

Microsatellites - repetitive regions in our genome
Individual 1 - CACACACACA - $(CA)_5$
Individual 2 - CACACACACACACACA - $(CA)_8$

Use number of repetitions to assign dogs to breeds with 99% accuracy, assign breeds to major groups

American Kennel Club Recognized Groups



DNA-informed dog groups
A) Asian breeds, Asian hounds
B) Broad frames
C) Working breeds
D) Hunting breeds

Trait mapping

```
pos      3      8
ref:   ATCGTCAATG
  1:   ATGGTCAATG
  2:   ATGGTCACTG
```

Pos 3	Wrinkly	Smooth
C	101	105
G	105	95

Pos 8	Wrinkly	Smooth
A	6	98
C	93	7

Traits mapped:
Wrinkliness
Coat color, curl, length
Size

2) Dog genetics and humans

Dog genome sequenced in 2005

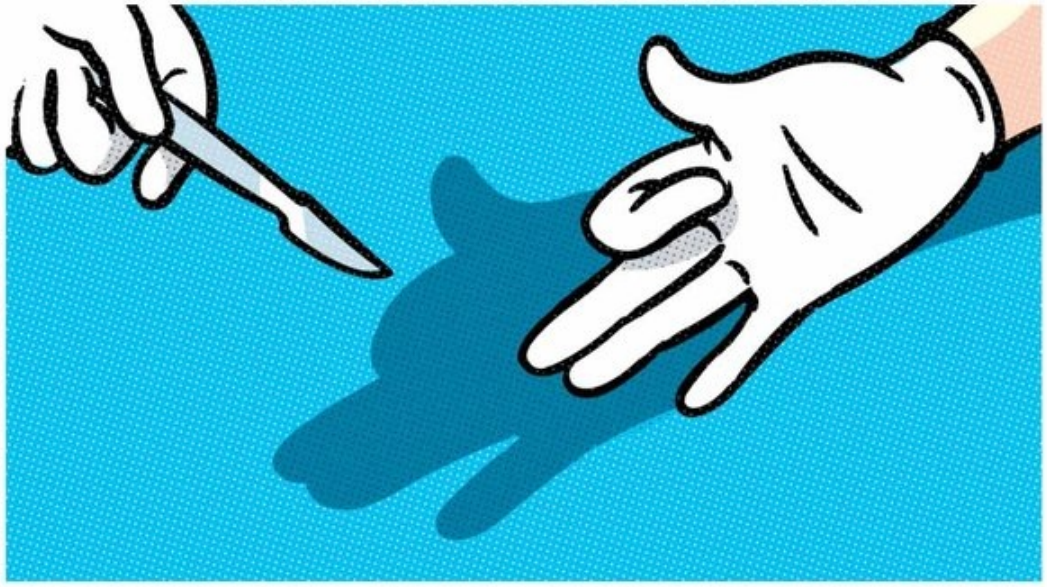
"The incredible physical and behavioral diversity of dogs — from Chihuahuas to Great Danes — is encoded in their genomes. It can uniquely help us understand embryonic development, neurobiology, human disease and the basis of evolution."

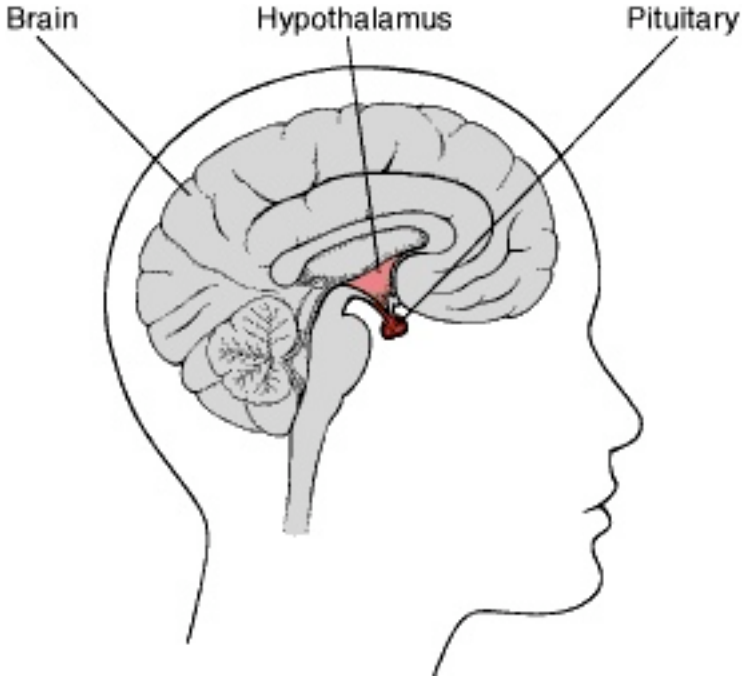
- Eric Lander, 2005

An Anecdote

"They Fetch, They Roll Over, They Aid Tumor Research"

New York Times, Oct 22, 2010





How dogs can help us understand diseases

350 inherited disorders in dogs

Inadvertently amplified diseases

Boxer - hip dysplasia

Dobermann pinscher - narcolepsy

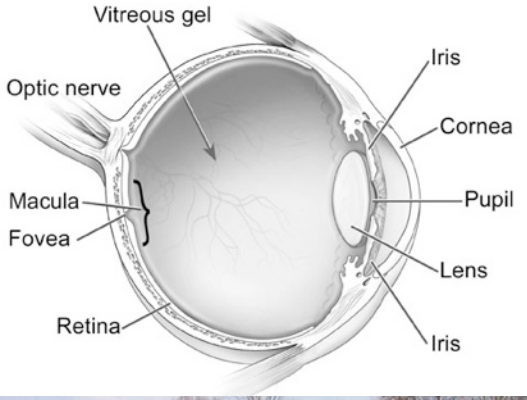
Common maladies

St. Bernard - heart disease

A Success Story - Blindness

Dog model for Leber congenital amaurosis

blindness caused by mutation (RPE-) in gene called RPE (retinal pigment epithelium)



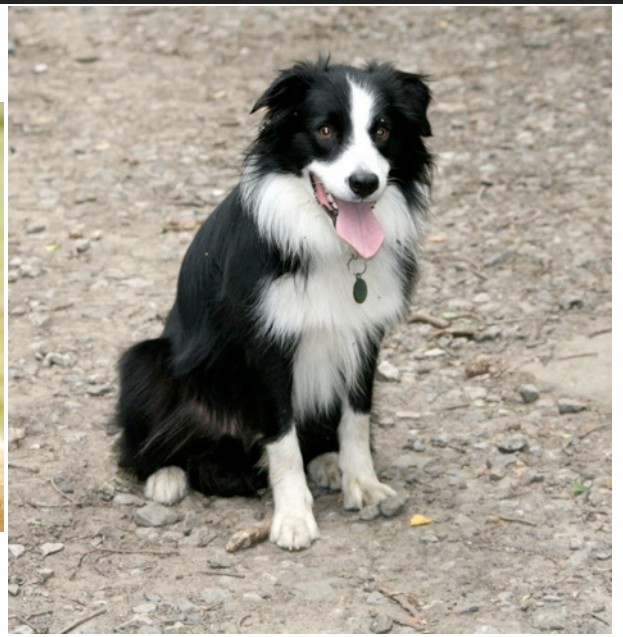
Dog gene therapy steps

1) Inject RPE- cells with virus carrying RPE+

2) treat dogs with newly created cells carrying RPE+

3) vision restored

Psychological Disorders



	Dalmatian	Golden Retriever	Collie
Breeding	Carriage dog	Retrieving felled waterfowl	Herding
Psychological disorder	aggression	obsessive compulsive	anxiety, noise phobia

Summary

1) Dog Genetics
- dog breeds are as different from each other as dogs are to wolves
- individual dogs can be accurately assigned to breeds by DNA alone
- breeds can cluster into 4 working categories

2) How Dog Genetics can help humans
- some breeds are predisposed to certain disorders (physical and psychological)
- homogeneity of breeds helps us uncover genes responsible for those disorders

Thank you!

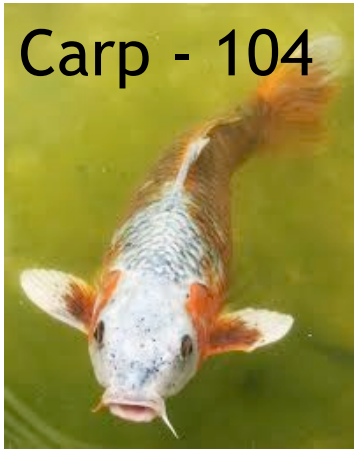
SITN would like to acknowledge the following organizations for their generous support:

- Harvard Medical School
  - Office of Communications and External Relations
  - Division of Medical Sciences
- The Harvard Graduate School of Arts and Sciences (GSAS)
- The Harvard Biomedical Graduate Students Organization (BGSO)
- The Harvard/MIT COOP
- Restaurant Associates

- SITN is a student organization at Harvard GSAS-

1) Genetics of Dogs Chromosomes

Fruit fly - 8



2) How dog genetics can help humans - Obsessive compulsive disorder in dogs

Dog chromosome 7

	OCD	non OCD
WT	0.40	0.88
Mutant	0.60	0.22
	1	1

gene of interest in region - CDH2, encodes for protein cadherin 2

CDH2 involved in forming connections between neural cells

Next step: knocking out cdh2 function in specific brain regions of mice to test whether that produces OCD-like behaviors