DISEASE DETECTION CANINES: A ONE HEALTH APPROACH!

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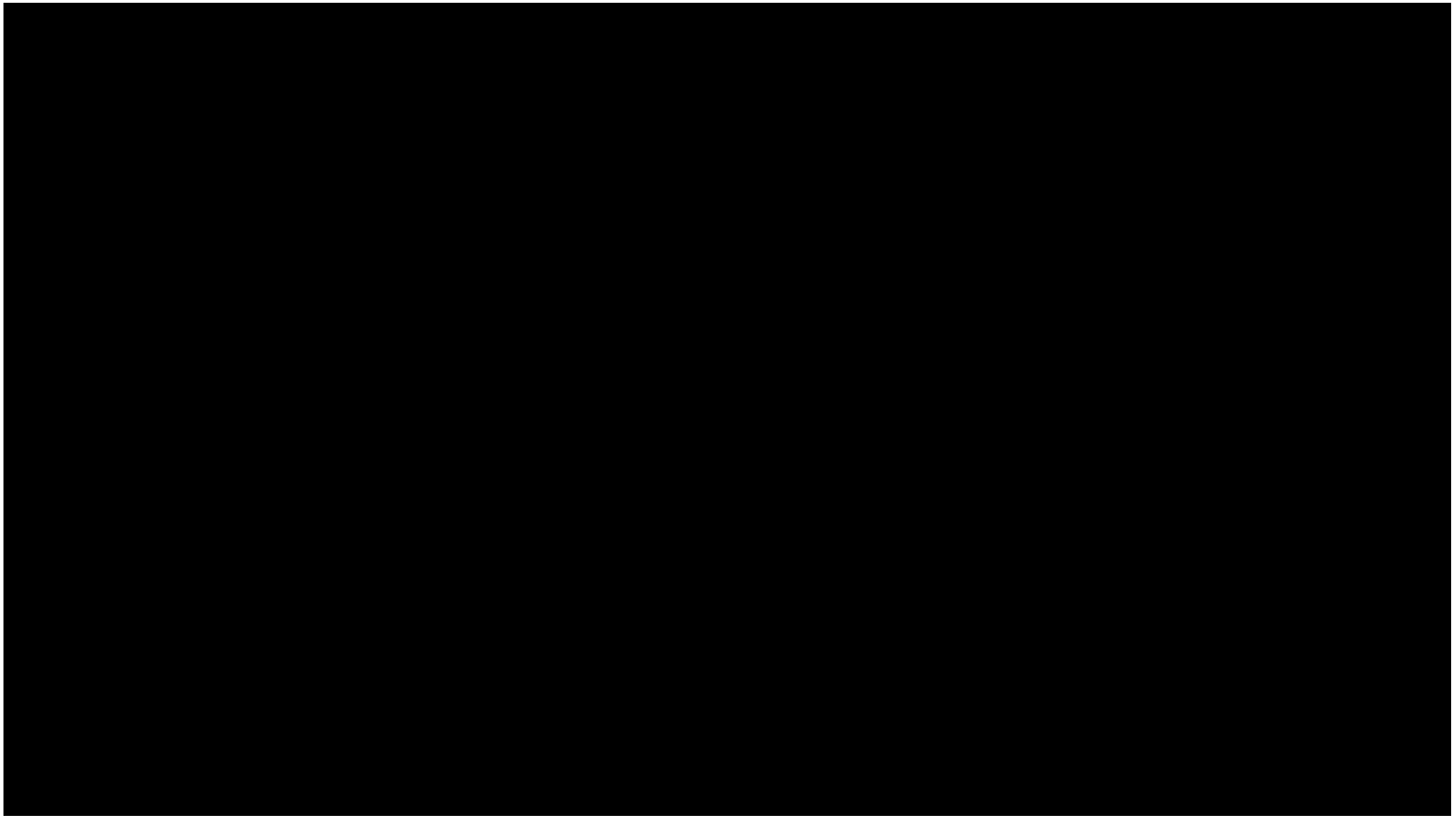

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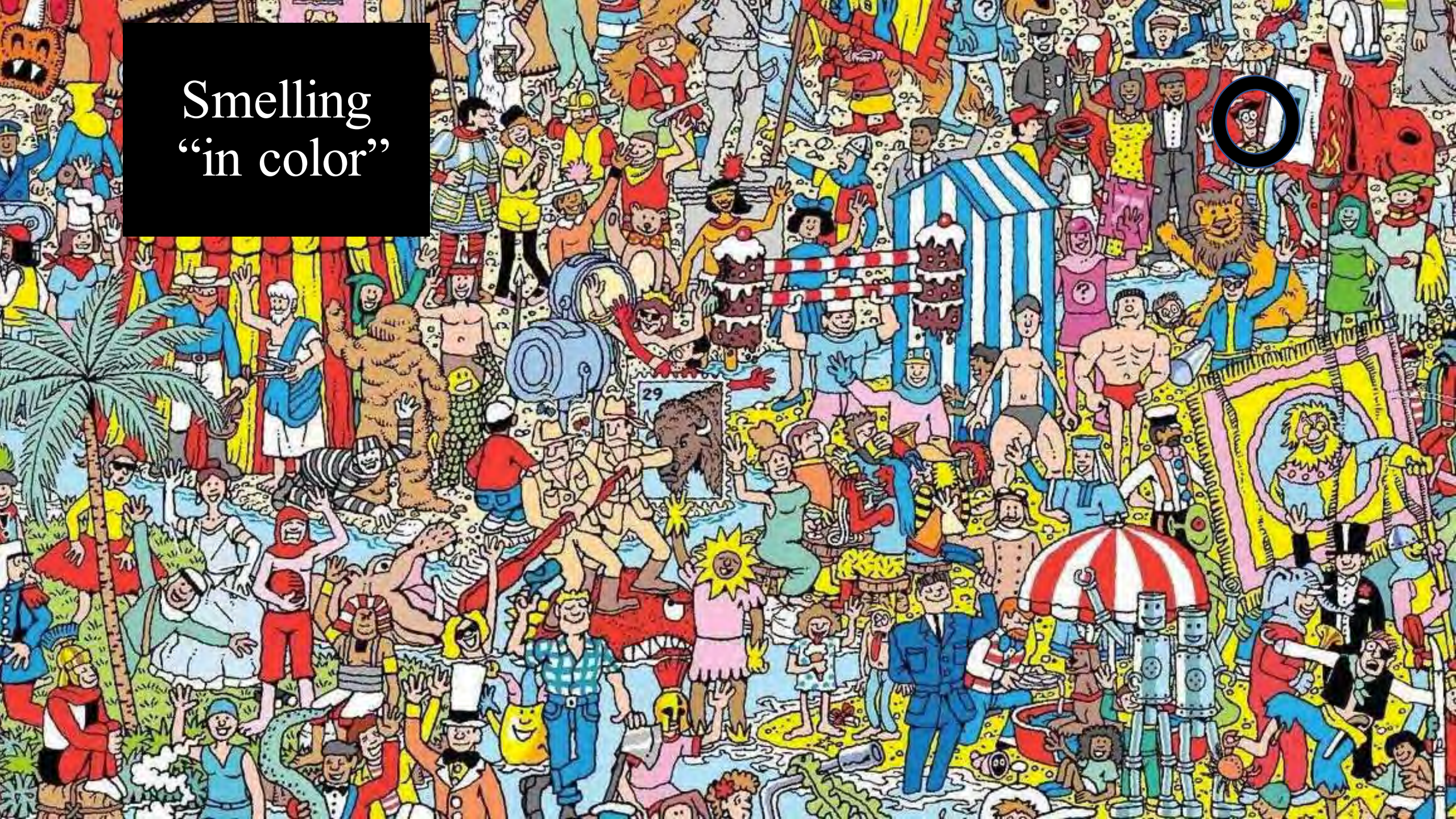
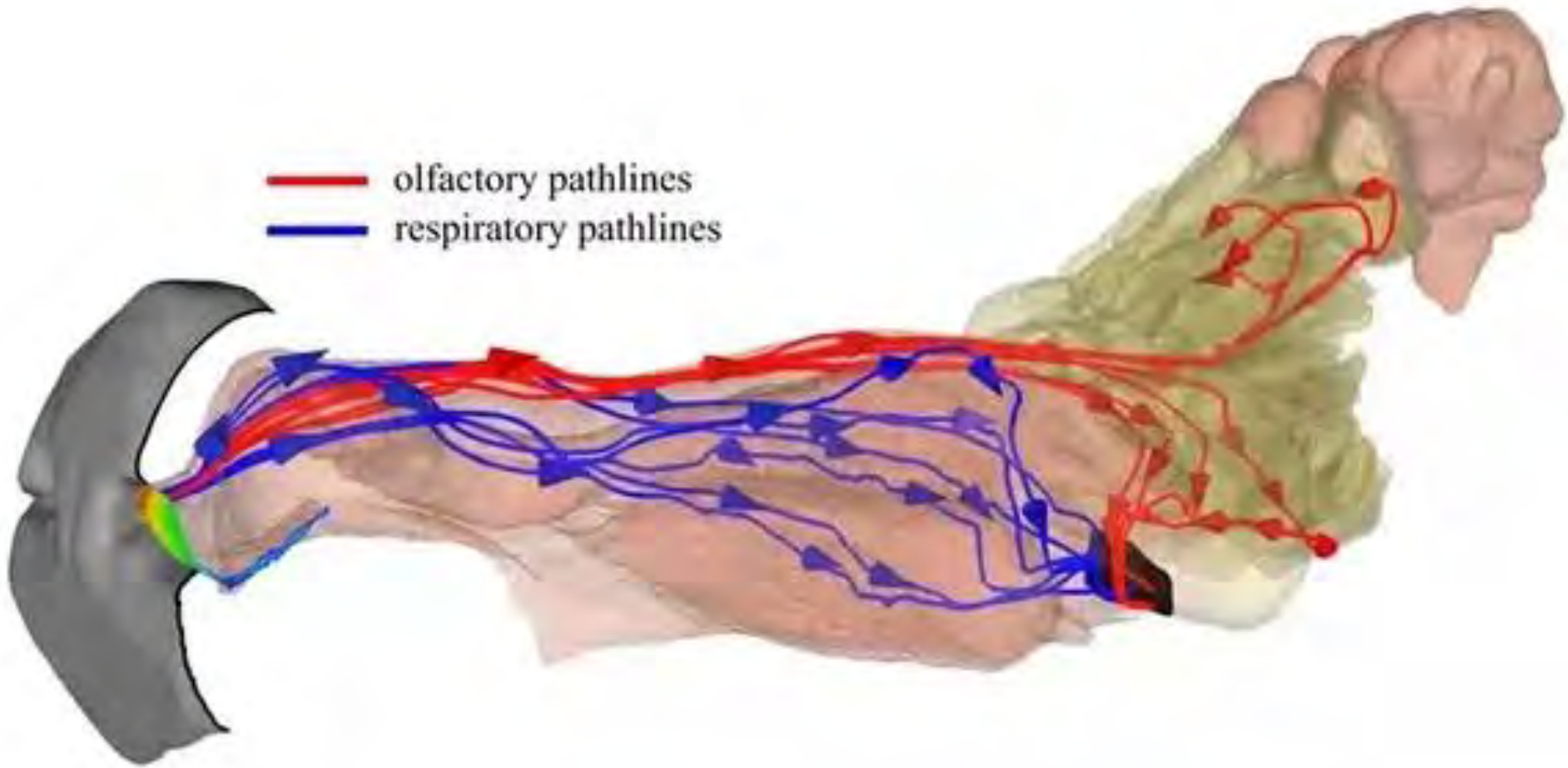

Smelling
“in color”

sniffing

https://www.nist.gov/video/dog-nose-visualization-1

Video created by Dr. Nathan Hall Texas Tech University



Lawson et al 2012 Chem Senses

Olfactory Epithelium

A catacomb at the back of the nasal passage houses sensory receptors.

Humans	*Dogs*
1 in² surface area	**30 in²** surface area
~6 million receptors	**~250** million receptors

cross section

Olfactory Bulb

A brain region that processes signals from the olfactory epithelium. Canine olfactory bulbs are **3 times larger** than those of humans, even though their brains are **10 times smaller**.

Vomeronasal Organ

A sensory organ that detects pheremones, VOCs, other molecules picked up by a dog's wet nose.

Nostrils

Air is exhaled through the side slits, so it doesn't dilute the scent of incoming air.

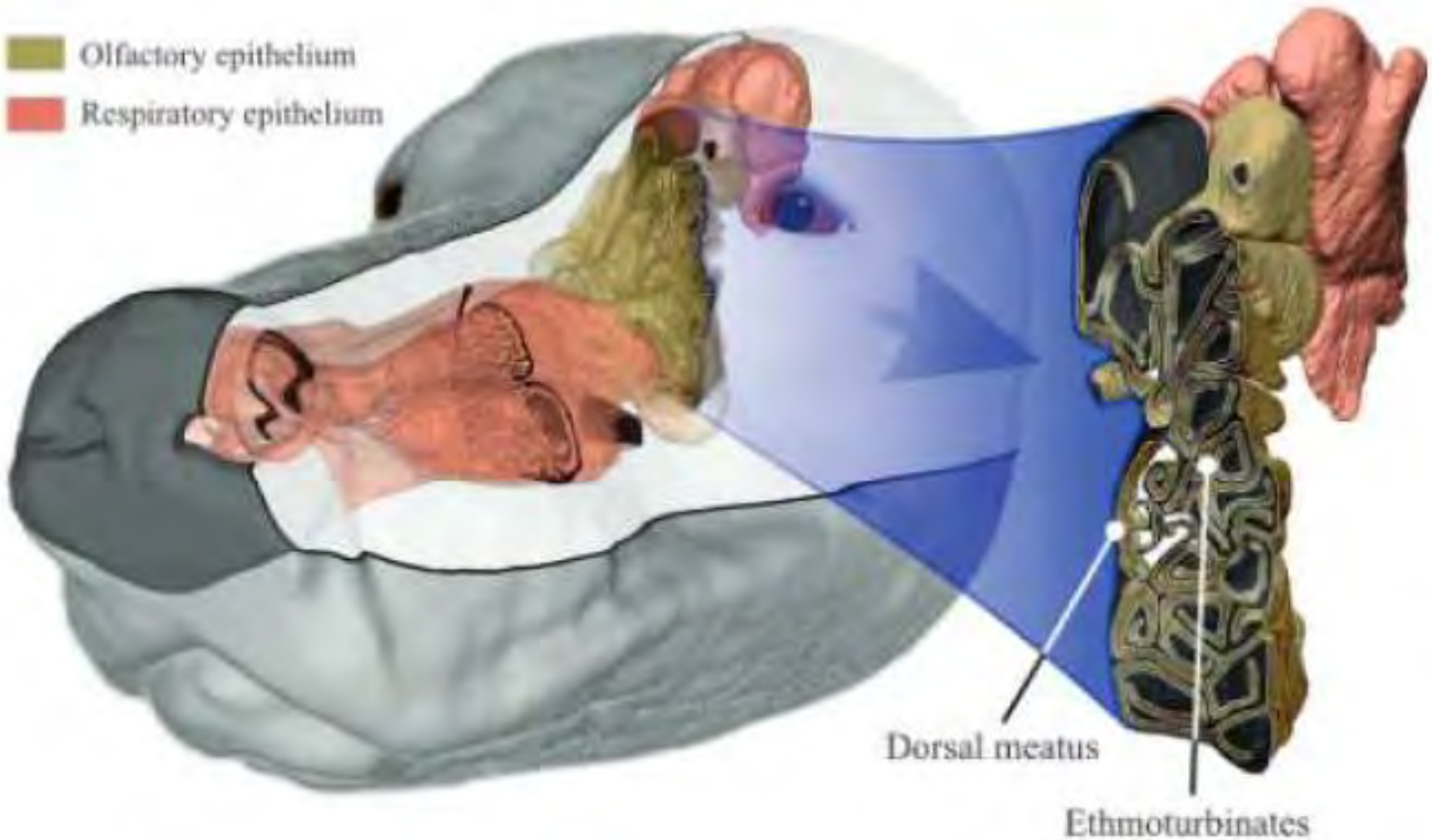
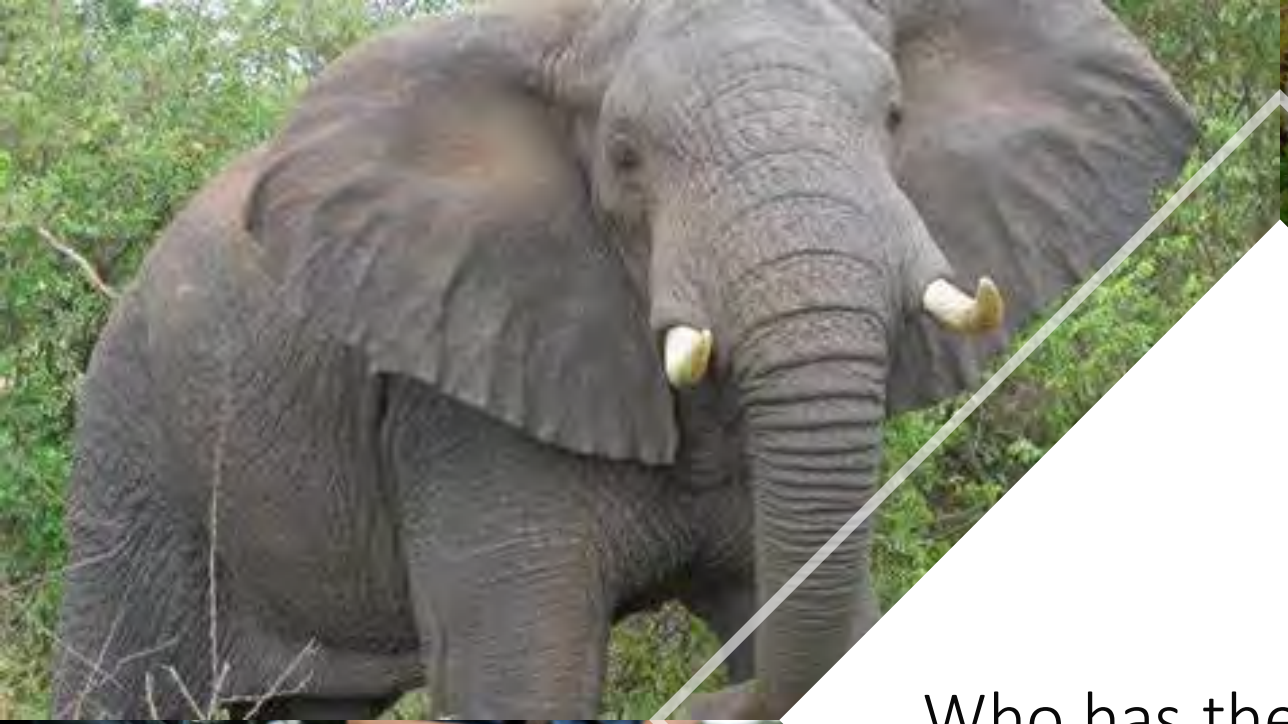
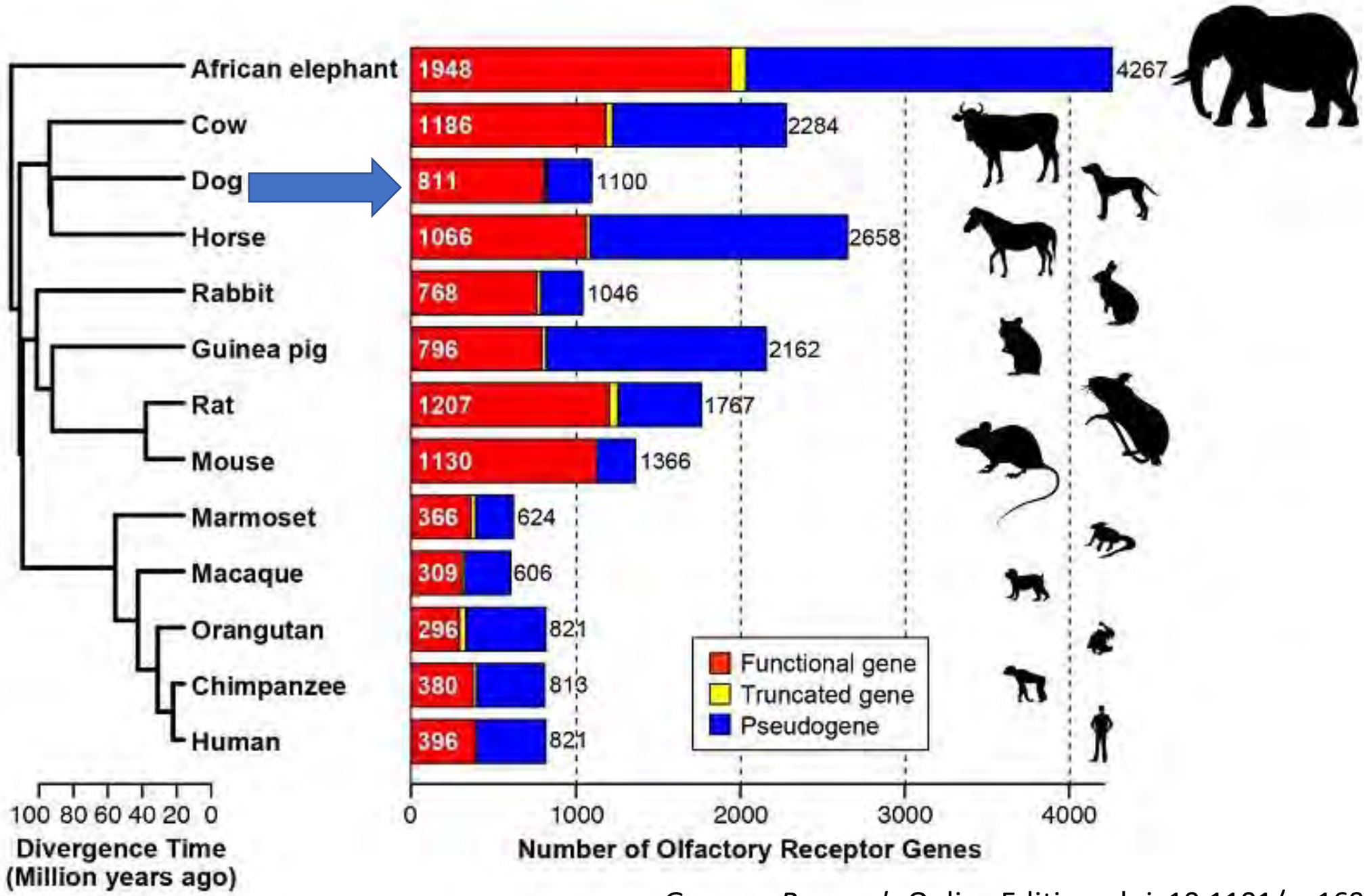


Figure 1 The computer model of the canine nasal airway.

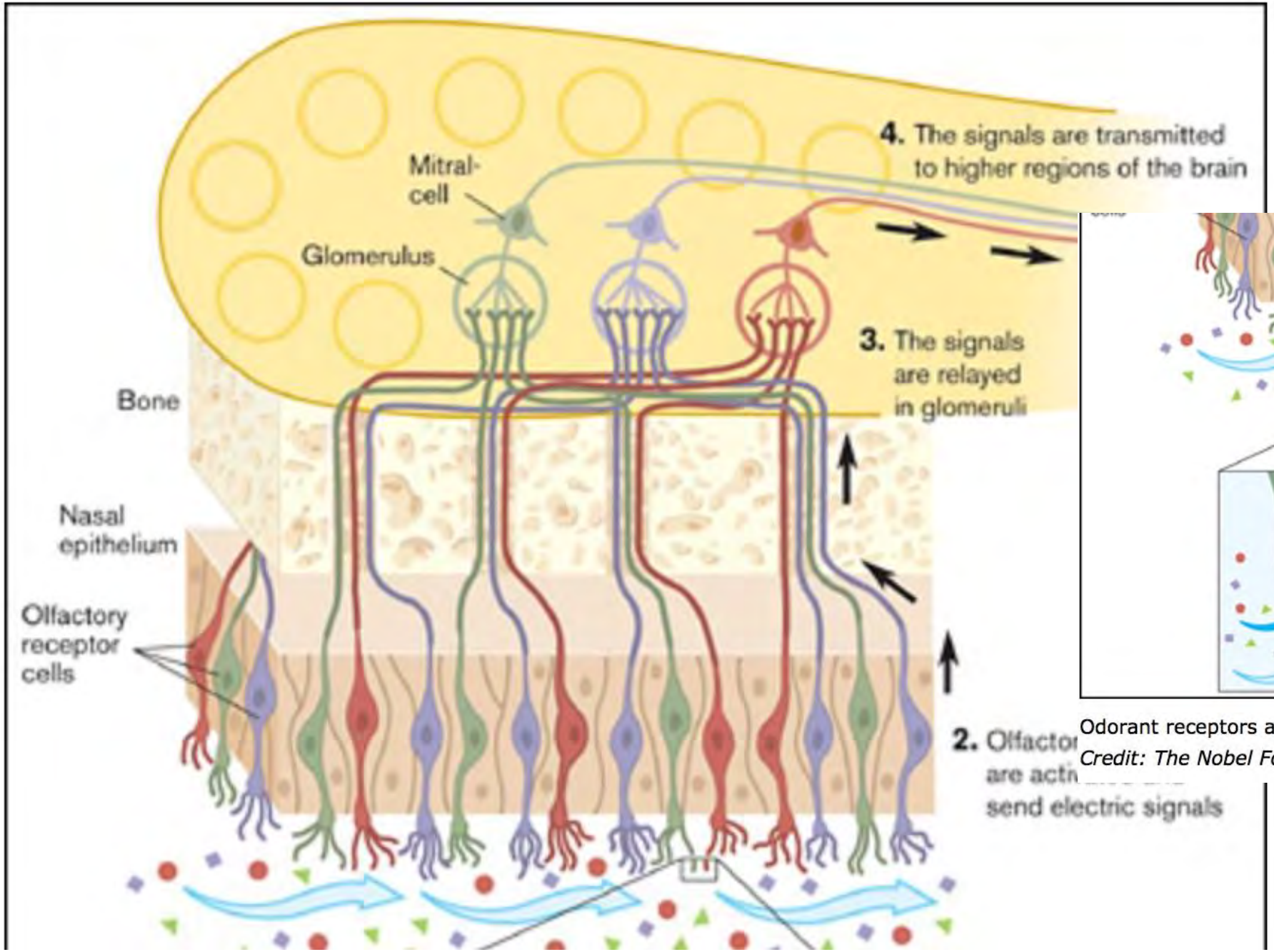
From MRI of Labrador nasal airway – Lawson et al 2012 Chem Senses

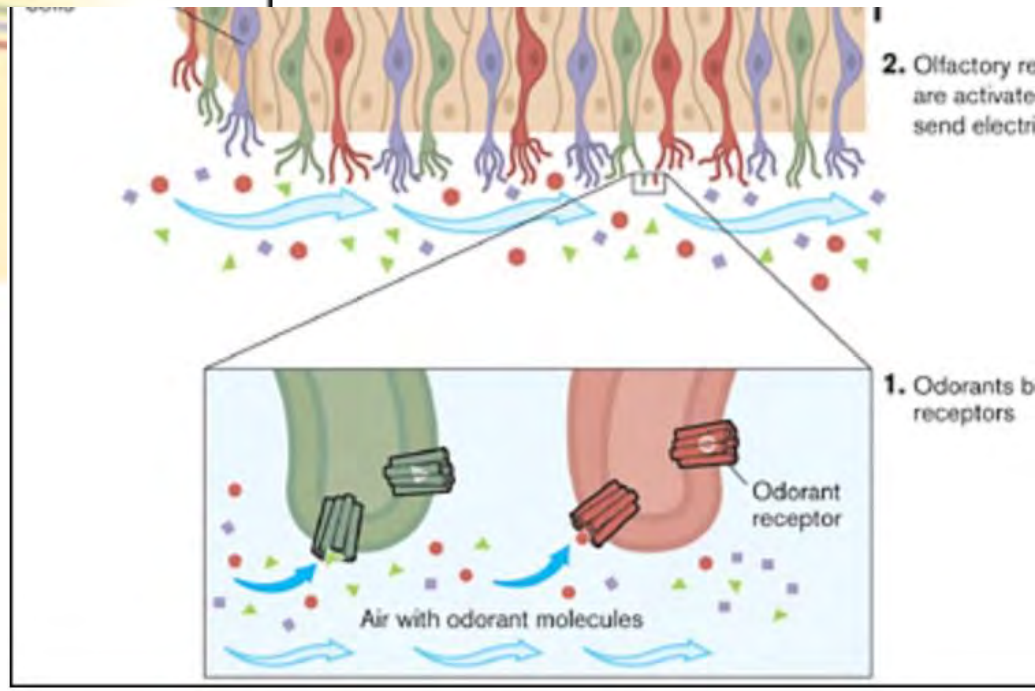


Who has the best nose?



Genome Research Online Edition: doi: 10.1101/gr.169532.113





Odorant receptors and the organization of the olfactory system.
Credit: The Nobel Foundation

VOCs of disease

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Ovarian Cancer

Late diagnosis results in poor survival

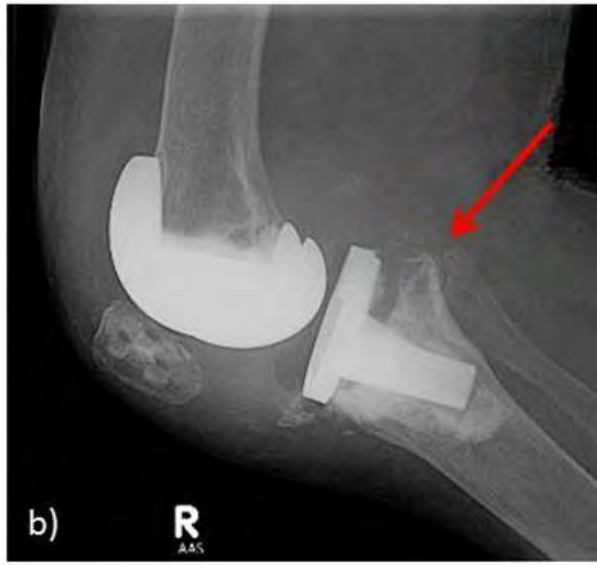
If diagnosed at the localised stage, the 5-year survival rate is 93%. However, only about 15% of all cases are diagnosed at this stage.

Localised	Regional	Distant	Unknown
Confined to primary site	Spread to regional lymph nodes	Cancer has metastasised	Unstaged
15% at diagnosis	17% at diagnosis	62% at diagnosis	7% at diagnosis

Source: American Cancer Society. Cancer Facts and Figures 2007. Atlanta, American Cancer Society 2007. SEER (Surveillance Epidemiology and End Results, National Cancer Institute, US) 2002

Bacterial Biofilm

- MTR project Meghan Ramos (initial funding NIH/Merck)
- Collaborators T Schaer NBC, G. Preti Monell, AT Johnson Penn Physics



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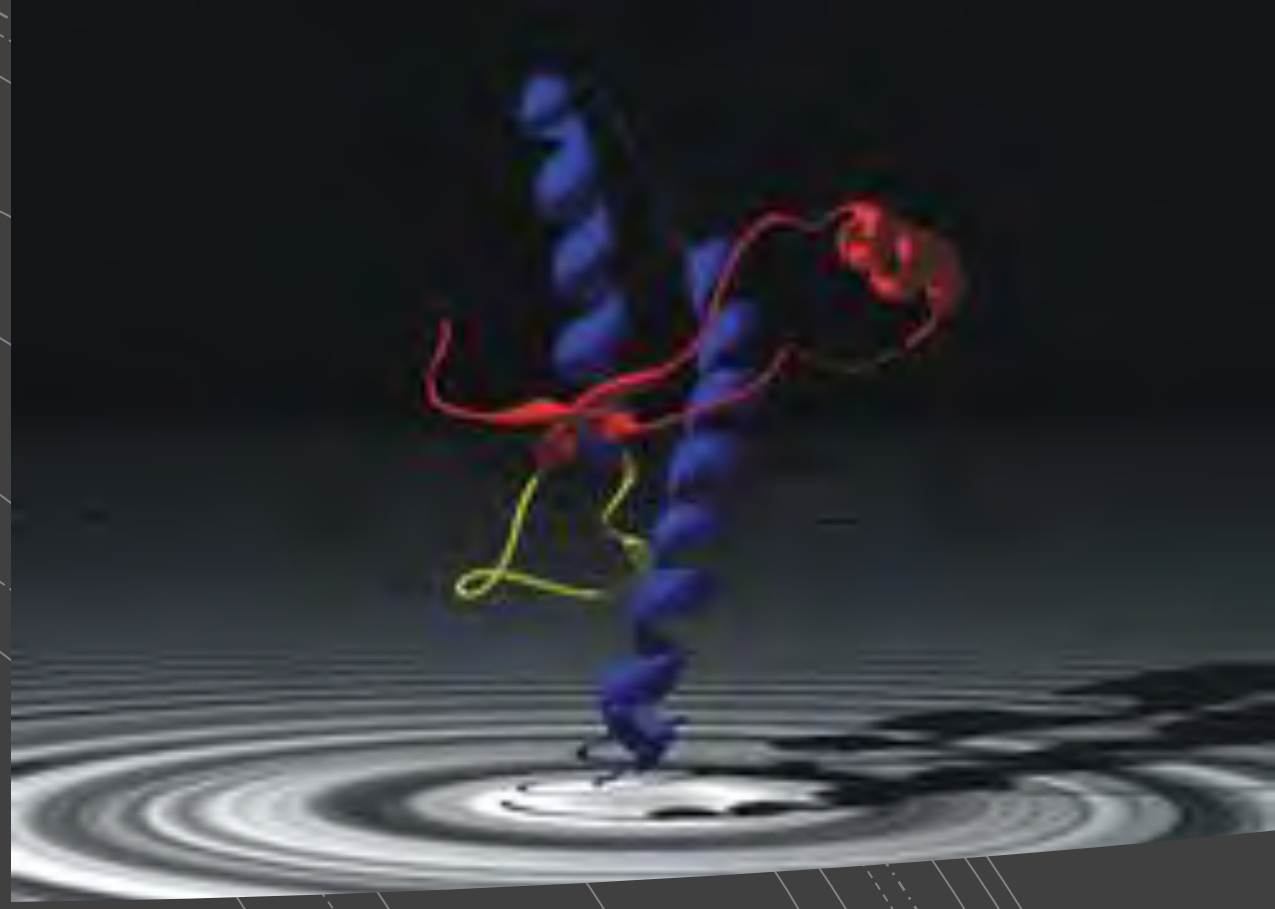

Screening White-tailed deer (*Odocoileus virginianus*) for chronic wasting disease (CWD)

- Cynthia M. Otto, DVM, PhD; Lisa Murphy, VMD; Julie Ellis, PhD; Michelle Gibison

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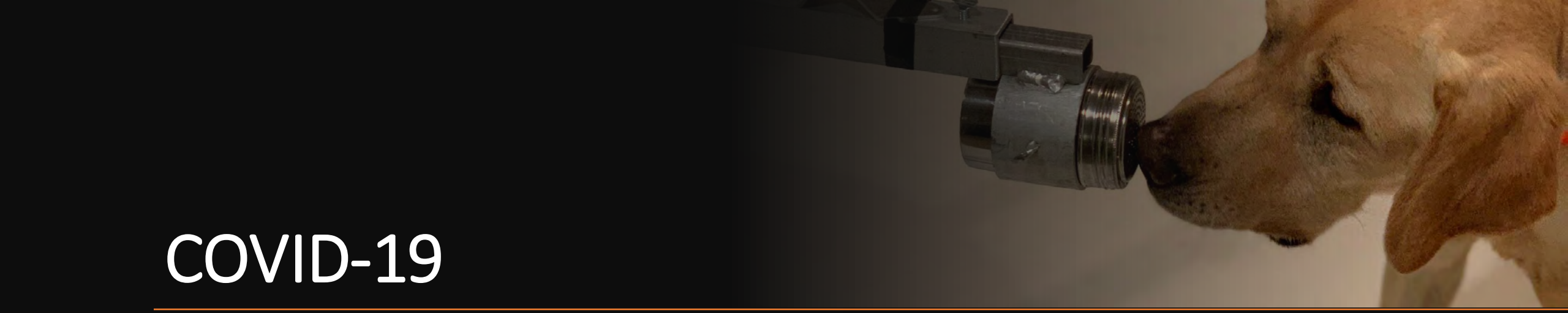
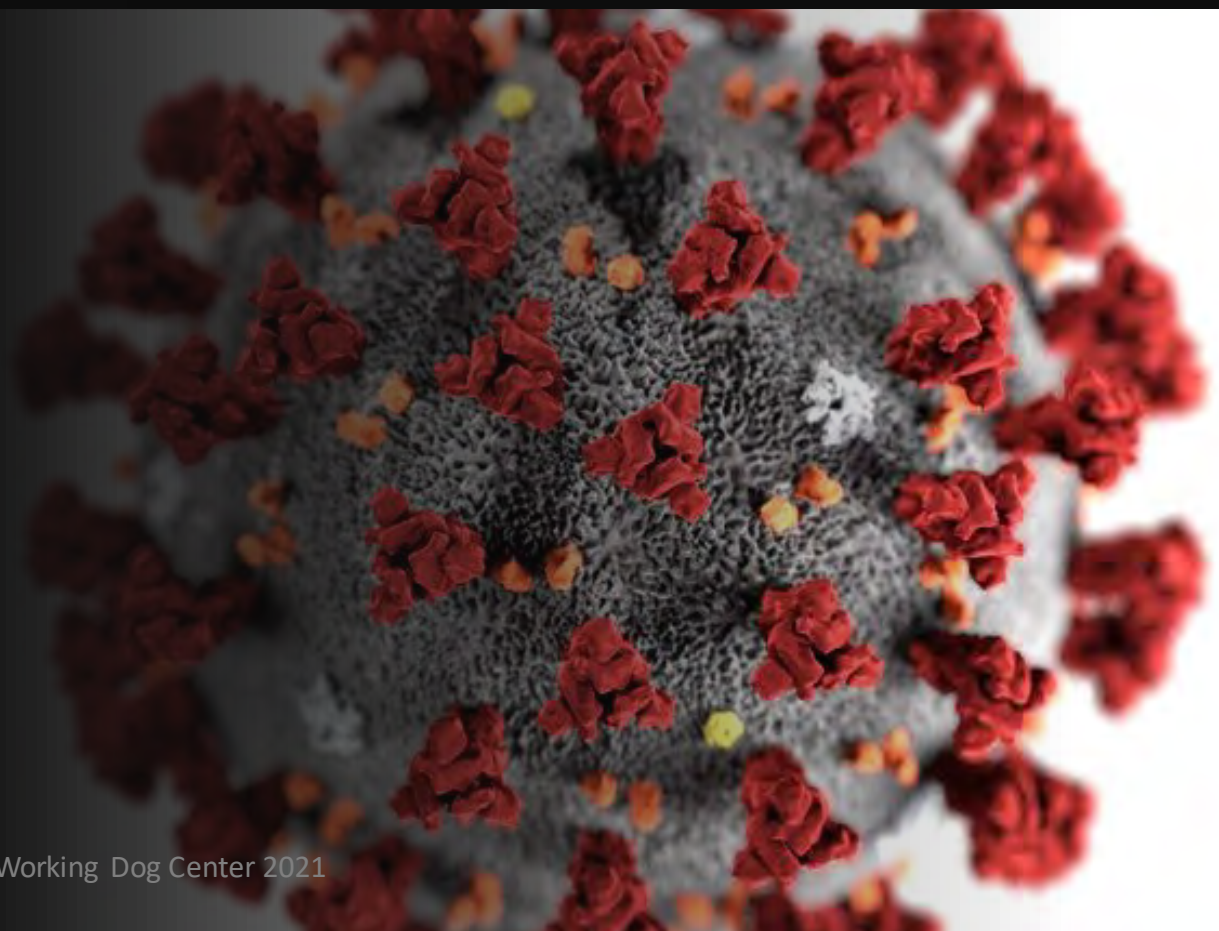


COVID-19

- 1) Determine if there is a unique VOC Profile associated with COVID-19: Evaluate the ability of dogs to discriminate SARS-CoV-2 (+) from SARS-CoV-2 (-) patient samples
  - urine from hospitalized patients
  - saliva from hospitalized patients
  - body odor (sweat) from outpatients
- 2) Determine if dogs can be used in a real world setting



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Methods

- Sample Collection
  - Children's Hospital of Philadelphia (urine, saliva) 15 (-), 12 (+) IRB 20-017503
  - Hospital of the University of Pennsylvania (urine, saliva) 3(-), 5(+) IRB 843452
  - Crowd sourcing (body odor/sweat on cotton T-shirts) 229 (-), 118 (+) IRB 843534 (*collection ongoing*)
- Virus inactivation
  - 1% NP 40 (urine) (38 unique + samples, 24 unique - samples)
  - 5 min at 95C (urine, *saliva*) (34 unique + samples, 51* unique – samples)
  - 24 hours at 21C (T-shirts)

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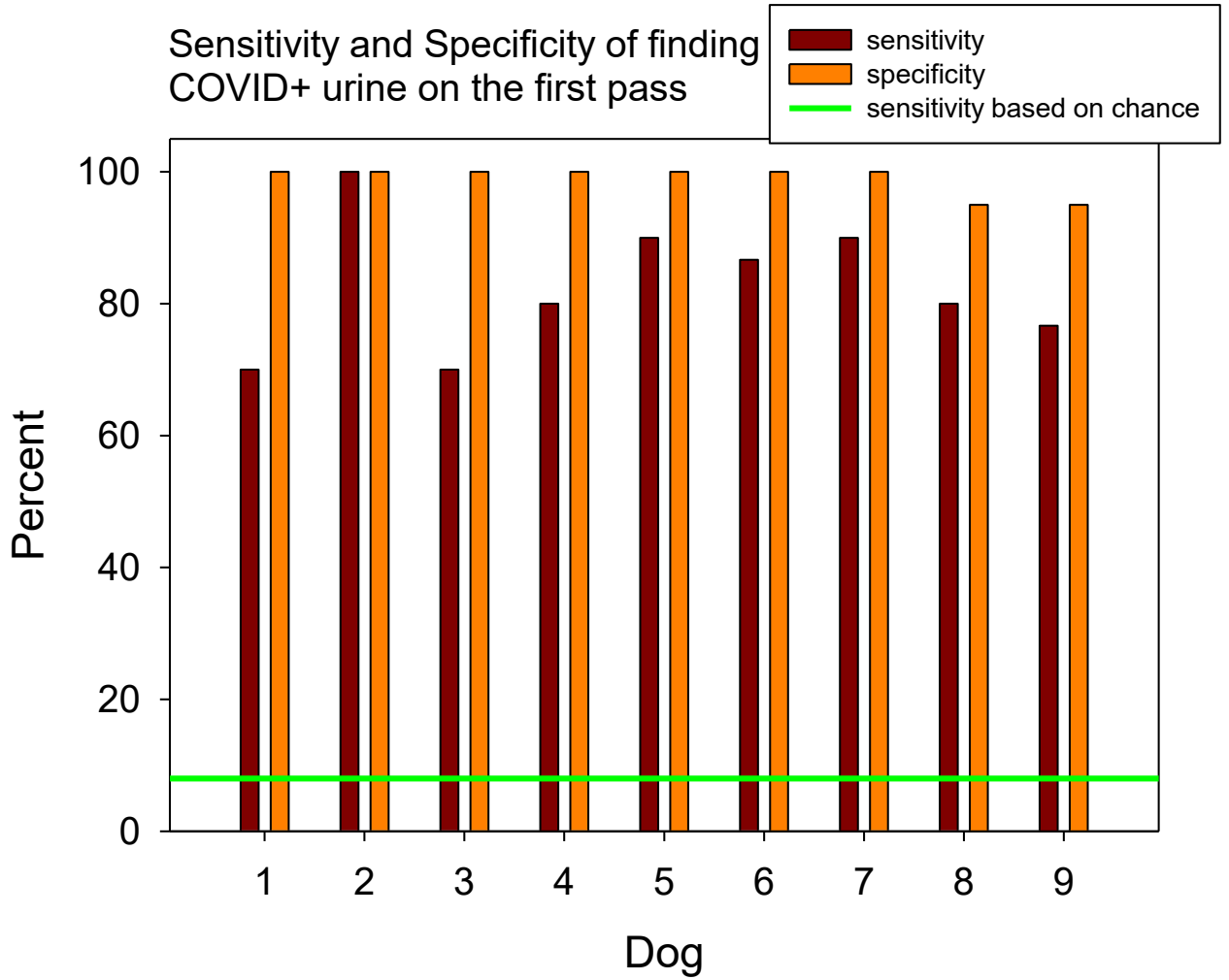
Results

- Blind testing
- 9 dogs, 5 trials
- 4 controls/trial
- 1 novel target/trial
- 68% of trials, dogs alerted on first pass
- 96% of trials, dogs alerted within passing the target twice
- 1% false alerts on controls



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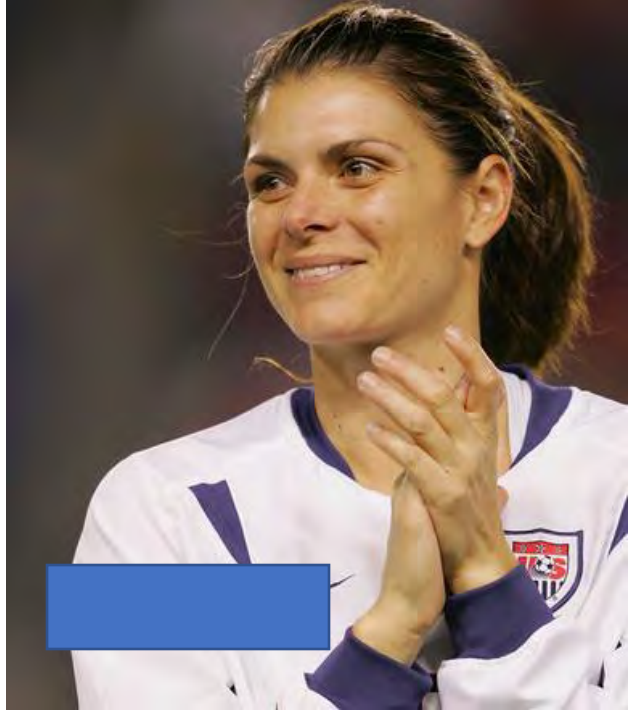
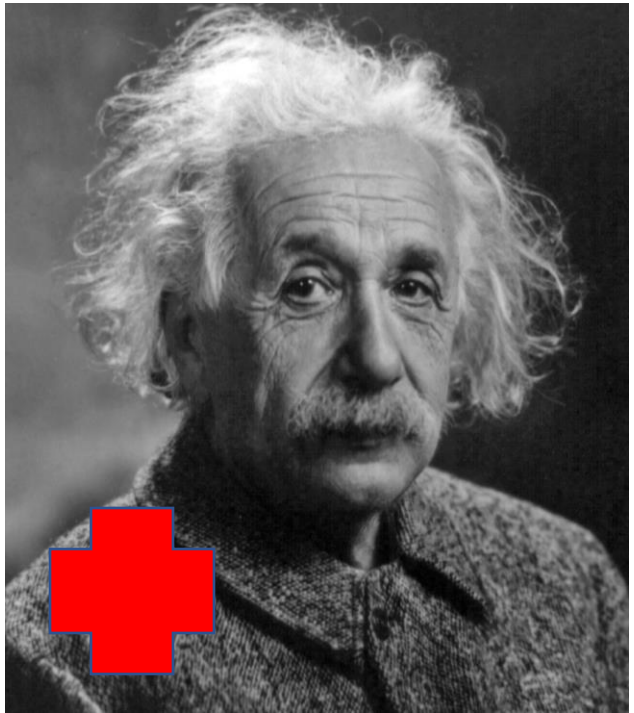
Essler et al PLOS One 2021





What if:

- There was a systematic bias in the samples used for training?
- What would the dogs learn?

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Our COVID T-shirt Detection Dogs

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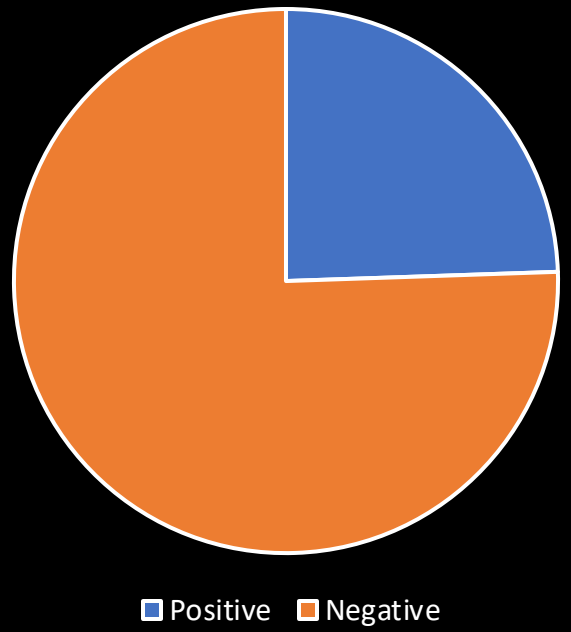
SARS-CoV-2 status



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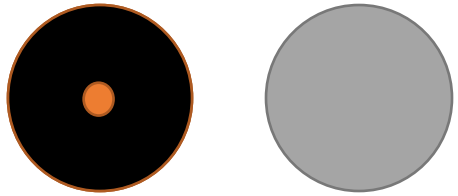
Training: Errorless Learning method

Phase 1

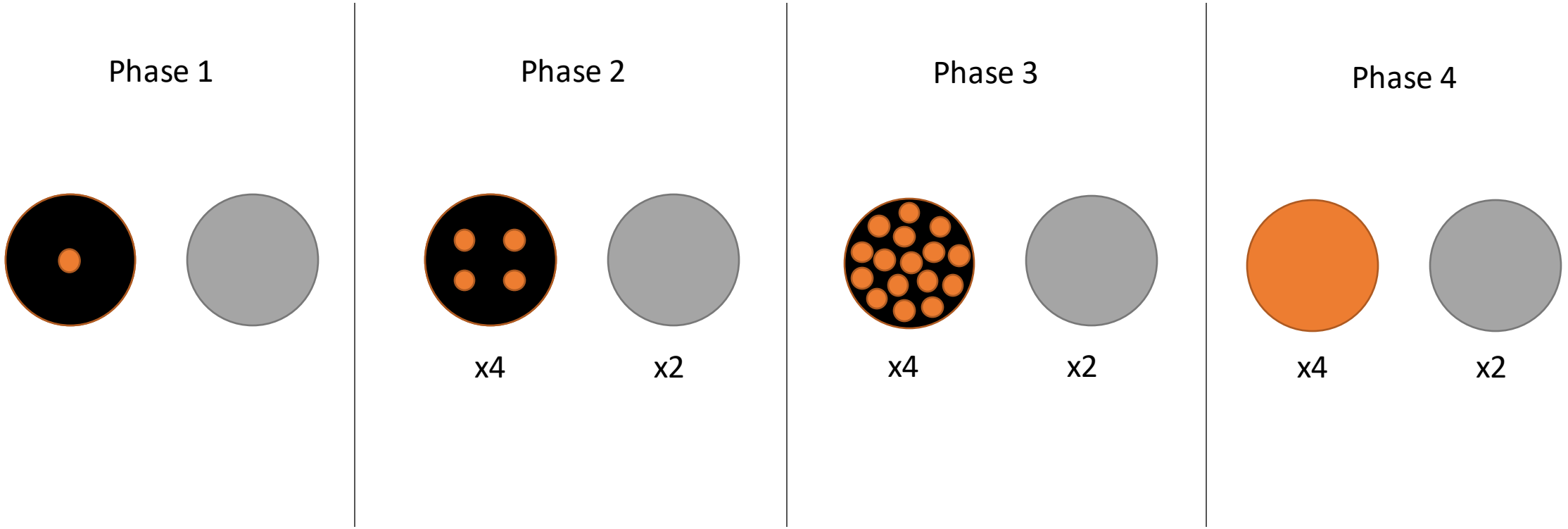
Imprinting + Wheel



Benchmarks For Moving to Next Phase:

80% Sensitivity
80% Specificity

Errorless Learning method



Results

- Double Blind Testing on T-shirt Samples on the wheel
  - Not all dogs are created equal!
  - 3/5 dogs were successful in advancing
  - 1 dog got bored with the game
  - 1 dog is continuing to make progress
- Transitioning from the wheel to people is challenging!

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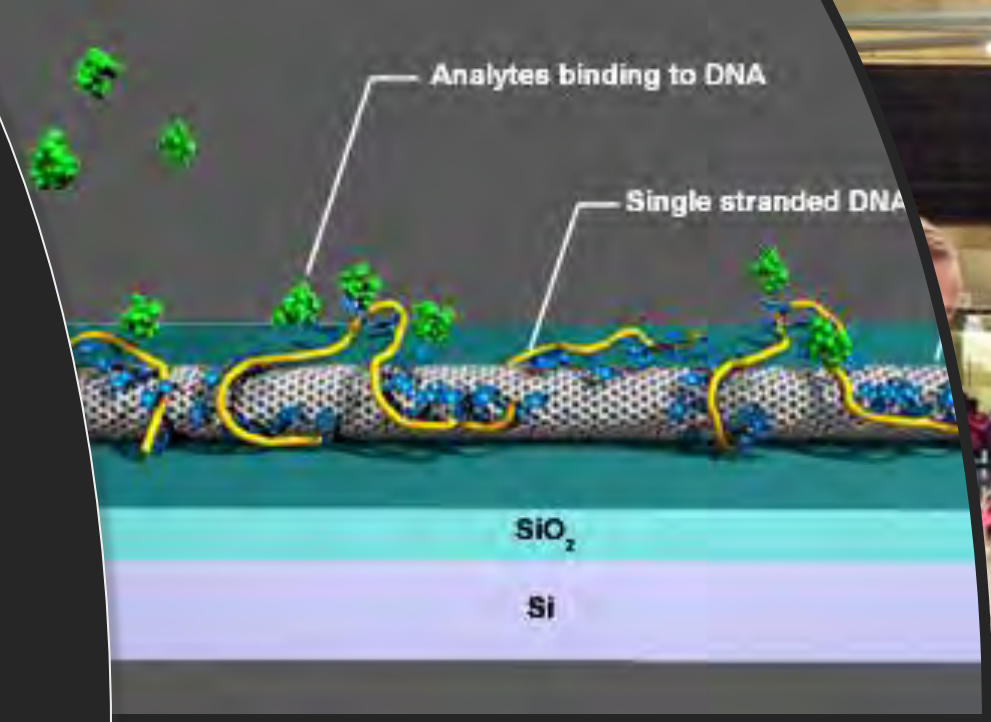
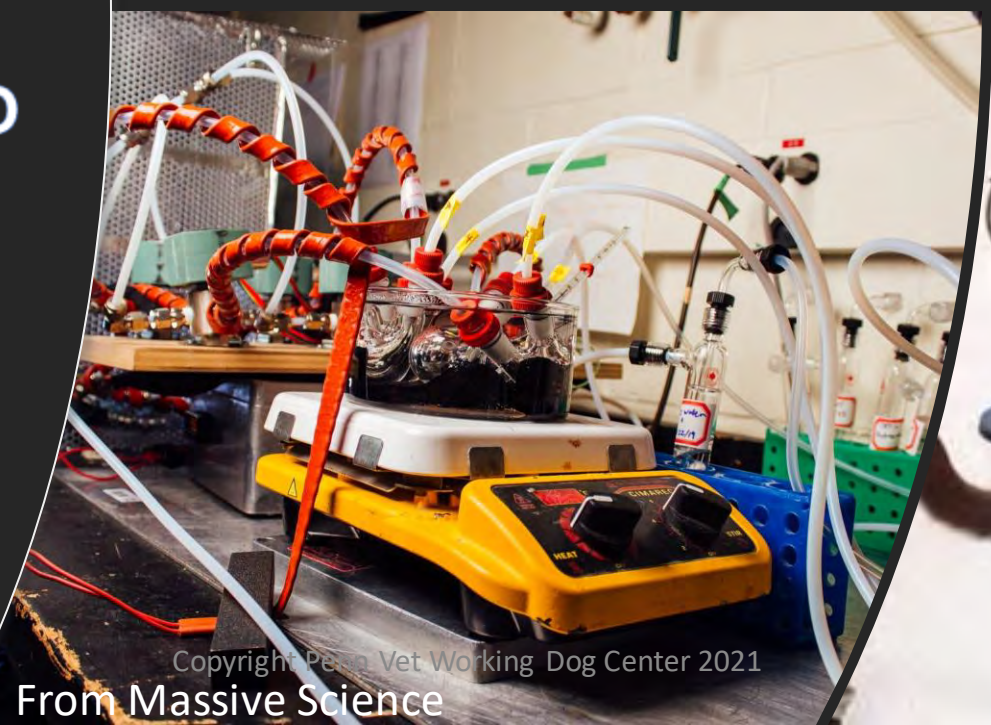
WHAT IS THE APPLICATION?





From Massive Science

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From wikipedia

What are the challenges?

- Training
  - Sample diversity
  - Sample number
  - Generalization
- Team Availability
  - Resource allocation
  - Handler availability
  - Dog availability
- Translation to operational world
- Quality control
- Standardization
- Safety

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What's next?

Willing to help Penn Vet Working Dog Center understand if dogs can identify people with **COVID-19 by smell**?

Get A Volunteer T-shirt!

If you are:

- Over 18 years of age, AND
- Will be tested OR have been tested in past 24 hours, then

Fill out the survey by scanning the QR code or going to the website to see if you are eligible!

Scan to open website

URL
https://www.surveymonkey.com/r/K9Tshirt

(Help out from your home & takes minimal time)

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- Facebook: www.facebook.com/PVWorkingDogCenter
- Instagram: www.instagram.com/penn_vet_working_dog_center/
- Twitter: www.twitter.com/pennvetWDC

Collaborators

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- Ian Frank, MD UPenn
- Richard Berk, PhD UPenn
- Jenny Essler, PhD UPenn
- Amritha Mallikarjun PhD U Penn
- Sarah Kane U Penn
- Charlie Johnson, PhD U Penn
- Victoria Plymouth U Penn
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  - WoodTiger Foundation
  - Private donations

- Dog Trainers
  - Pat Nolan
  - Connie Cleveland
  - Annemarie DeAngelo
  - Patricia Kayaroglu
- Students
  - Elikplim H Akaho
  - Amalia Berna Perez
  - Victoria Plymouth
  - Sarah Kane
- CCDC - Chemical Biological Center Collaborators
  - Patricia Buckley
  - Michele Maughan
  - Jenna Gadberry

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