מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

Introduction to Neuroscience: Behavioral Neuroscience

Lecture 1: Introduction to Animal Behavior

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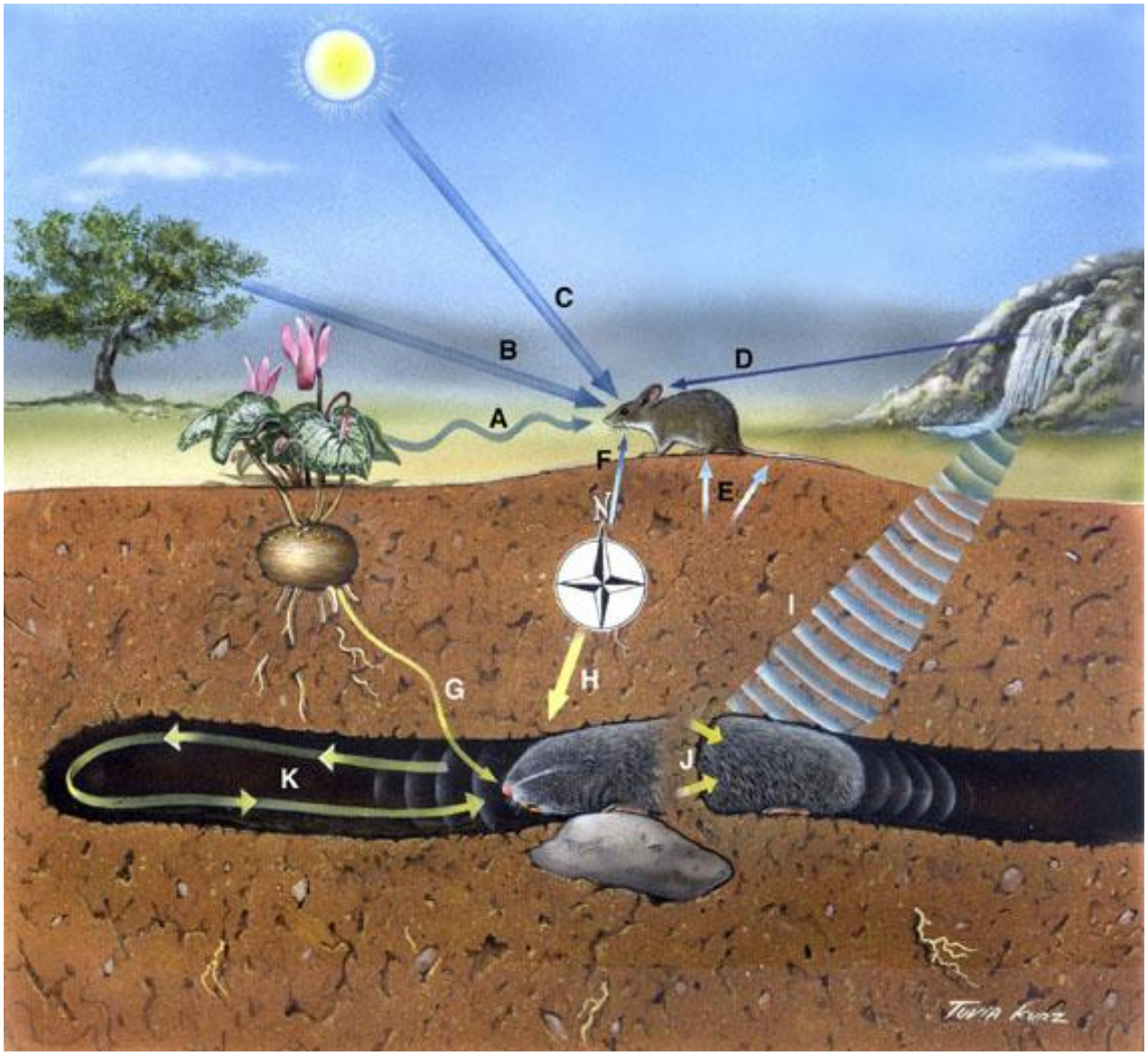
Processing & integration of sensory information is crucial for survival and successful breeding

Defending territory

Predator avoidance

Food finding

Mate finding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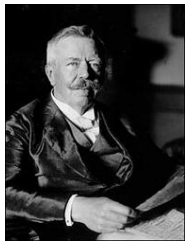
"Umwelt" is the organism's model of the world: the perceived things in the world, the signals emitted by both the subject and things, and the actions that are performed by each species.

- These information is perceived by set of sensory channels that are specially adapted to the species survival needs and its niche (biotic and abiotic components).

Von Uexküll (1921) intended his idea of the *umwelt* to apply principally to physical stimuli (i.e. it can be water, food, shelter, potential threats, or points of reference for navigation).



Jakob von Uexküll
(1864-1944)

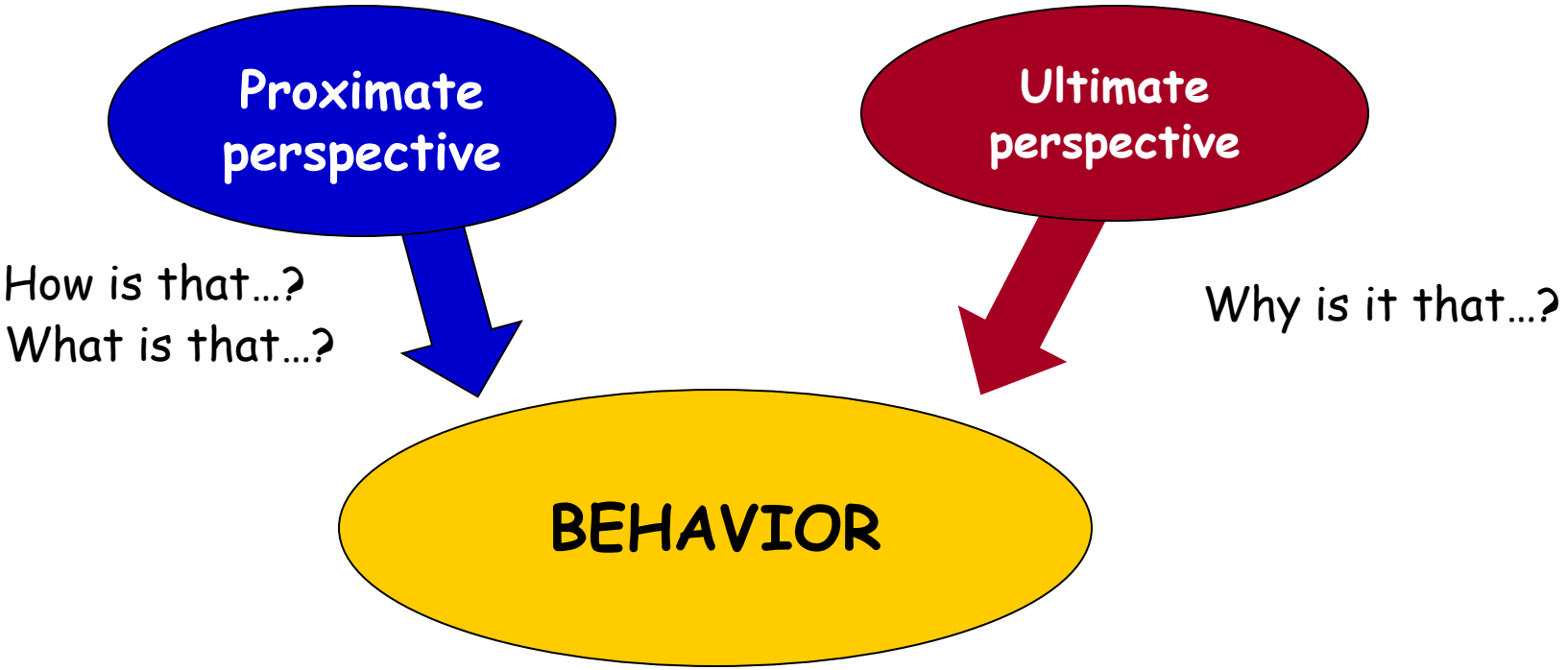
Lorenz (1935) extended this concept by recognizing that animals also have a social *umwelt* since signals from other individuals can have important influences on their behavior.

Konrad Lorenz
(1903-1989)

ANIMAL BEHAVIOR

What is Animal Behavior ?

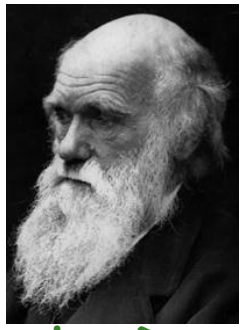
The study of *how* and *why* animals interact with each other (both within and among species) and their environment.



Studying the mechanisms responsible for interactions (behavioral act)

How these interactions influence an individual's survival and reproduction

Darwin's theory of natural selection of behavior (ultimate prespective)



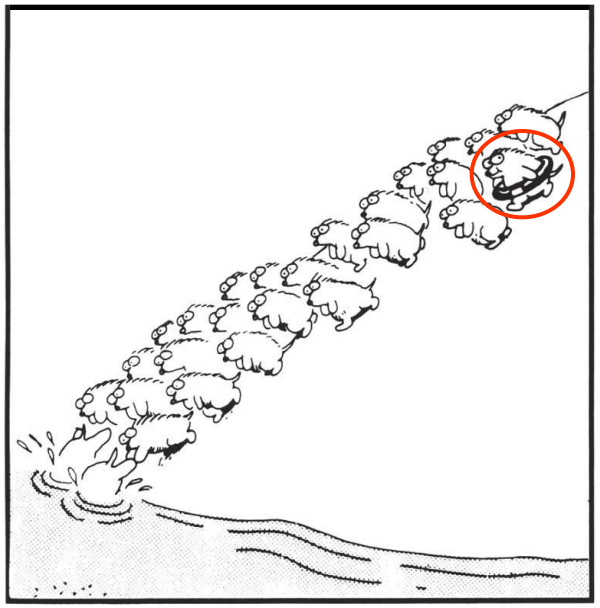
Charles Darwin
(1809-1882)

1. Variations also exist in behavioral traits.

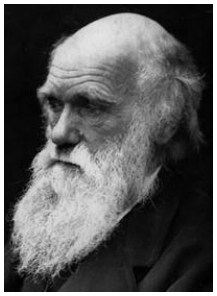
2. Some of these behavioral variations are heritable.

3. Certain behavioral variations make individuals better adapted to their environment.

4. These individuals have the chance to survive longer and leave more offspring than those with less successful behavioral traits.



Sexual Selection of behavior



Darwin realized that some (behavioral) traits directly relate to mate acquisition and mate choice.

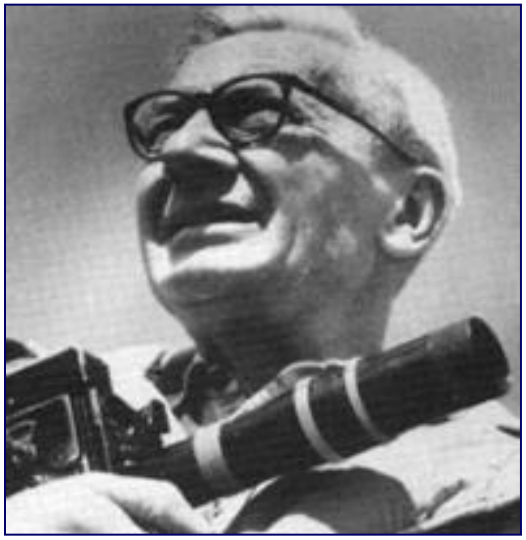
He termed this evolutionary process "**sexual selection**".

Sexual Selection "…depends on the success of certain individuals over others of the same sex, in relation to propagation of the species..."

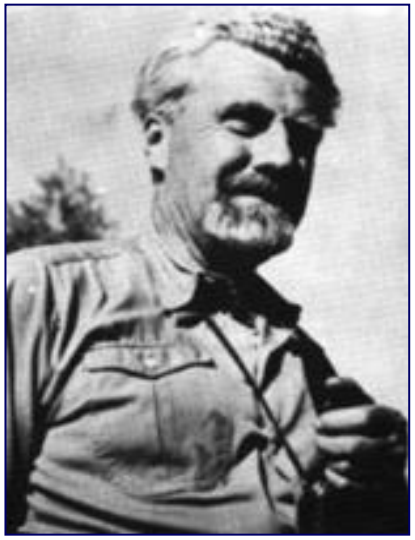
Charles Darwin 1871

Example: Sexual selection of behavior
The Lyrebird courtship behavior

Founders of animal behavior study in the natural habitats (Ethologist)



Niko Tinbergen
(1907-1988)

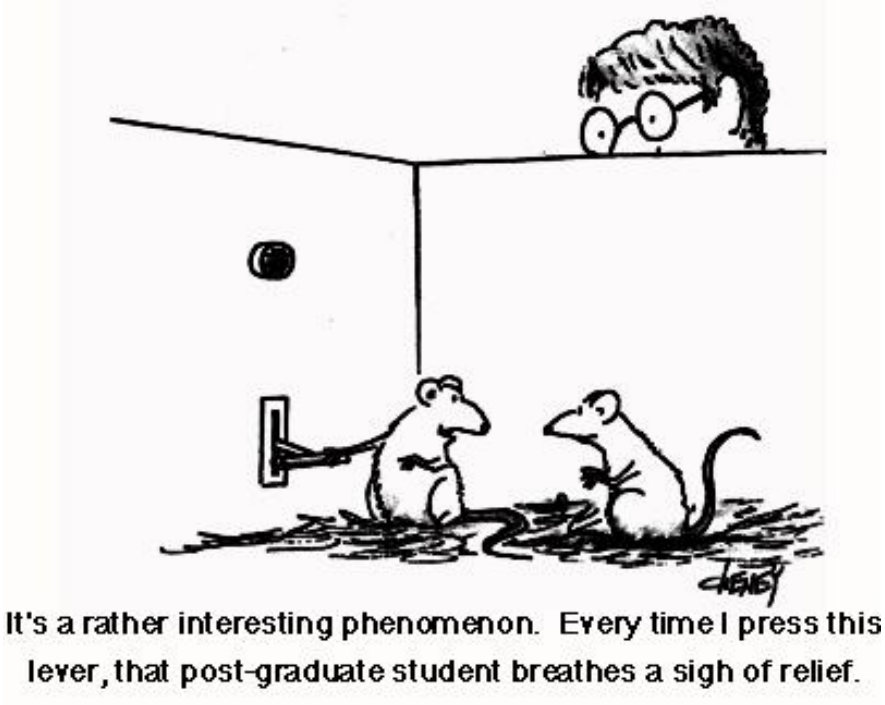


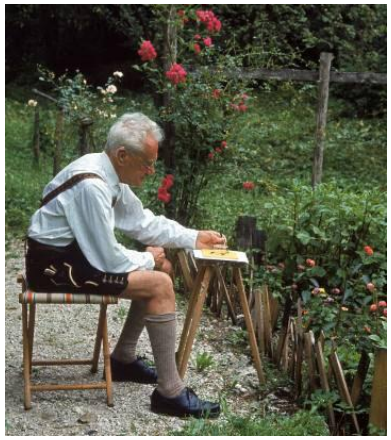
Konrad Lorenz
(1903-1989)

Karl von Frisch
(1886-1982)

The Nobel Prize in Physiology or Medicine 1973
"for their discoveries concerning organization and elicitation of individual and social behavior patterns"

Two ways to study animal behavior





Karl von Frisch

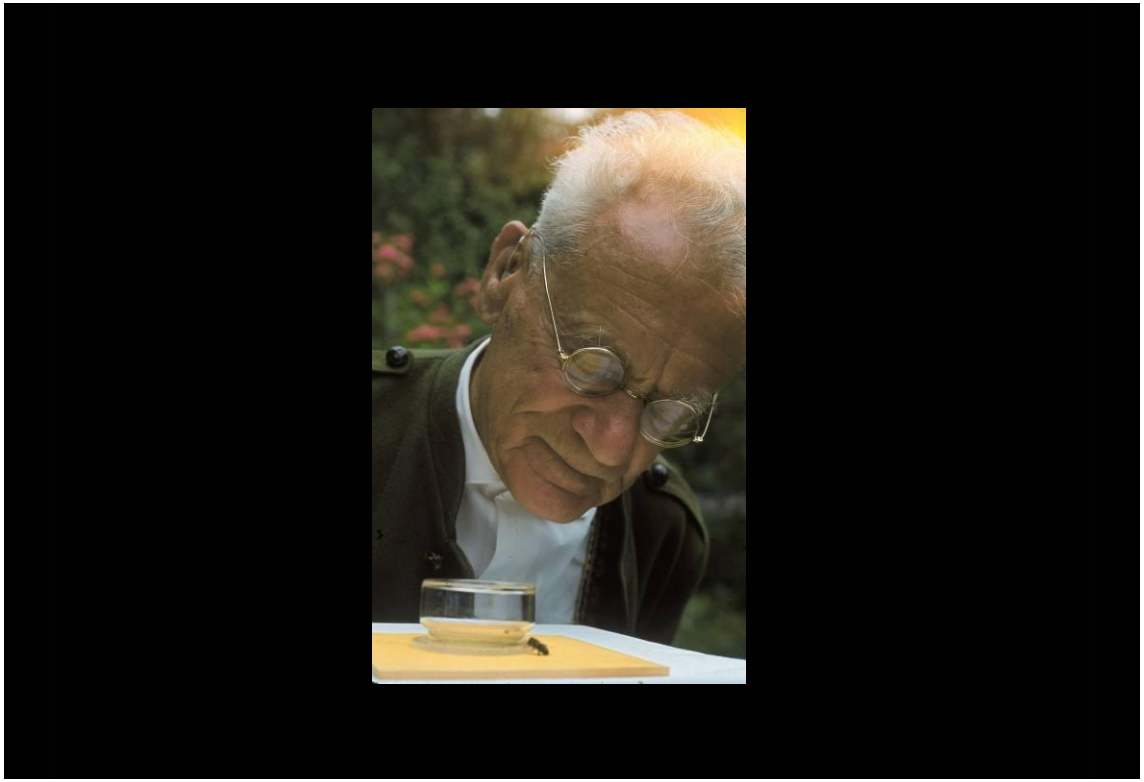
- Pioneered studies in bee communication and foraging.

- Demonstrated that honey bees use a dance language to communicate the location of food resources to other bees.

- The waggle dance uses for communicate the position of a distance food source.

- This dance communicates both the distance and direction using the sun, the hive, and the food source as reference points.

Honey bee waggle dance



Konrad Lorenz

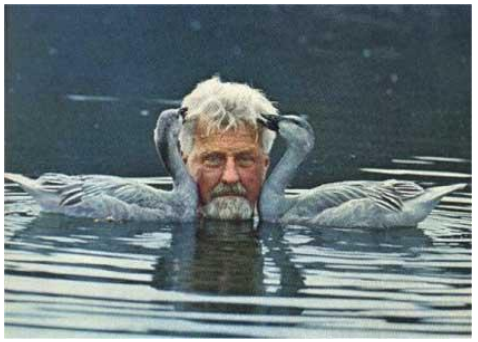
"It takes a very long period of observing to become really familiar with an animal and to attain a deeper understanding of its behaviour; and without love for the animal itself, no observer, however patient, could ever look at it long enough to make valuable observations on its behaviour."

Konrad Z. Lorenz, 1960

Imprinting

- Early recognition of the same group (morphology and behavioral pattern).
- Include both learning & innate components, and generally irreversible.
- Has a sensitive period (i.e. acquired during a limited critical period right after birth).

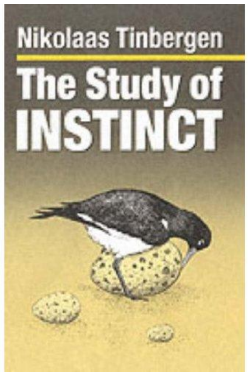
Gosling imprinting



Experiment: A clutch of goose eggs was divided between the mother goose and an incubator (treated by Lorentz).

Results: Goslings reared by the mother behaved normally and mated with other geese.
-Goslings that spent their first hours of life with Lorenz preferred humans for the rest of their lives and even tried to mate with humans.

Conclusions: Greylags goose have no innate sense of "mother" or "gooseness". They identify with and respond to the first object with certain characteristics they encounter. *The ability or tendency to respond is innate.*



Niko Tinbergen

Nikolaas Tinbergen (left), Konrad Lorenz (right)

Fixed Action Pattern (FAP) and Instinct behavior:

•In response to an external sign stimulus (a releaser) the organisms will initiate a fixed (unchangeable) responses which once begun must be carried to completion.

• FAP is innate (instinct) behaviour and highly stereotypically performed.

• In some cases, aspects of the FAP need to be learned (trained) in order to master the behavioral repertoire.

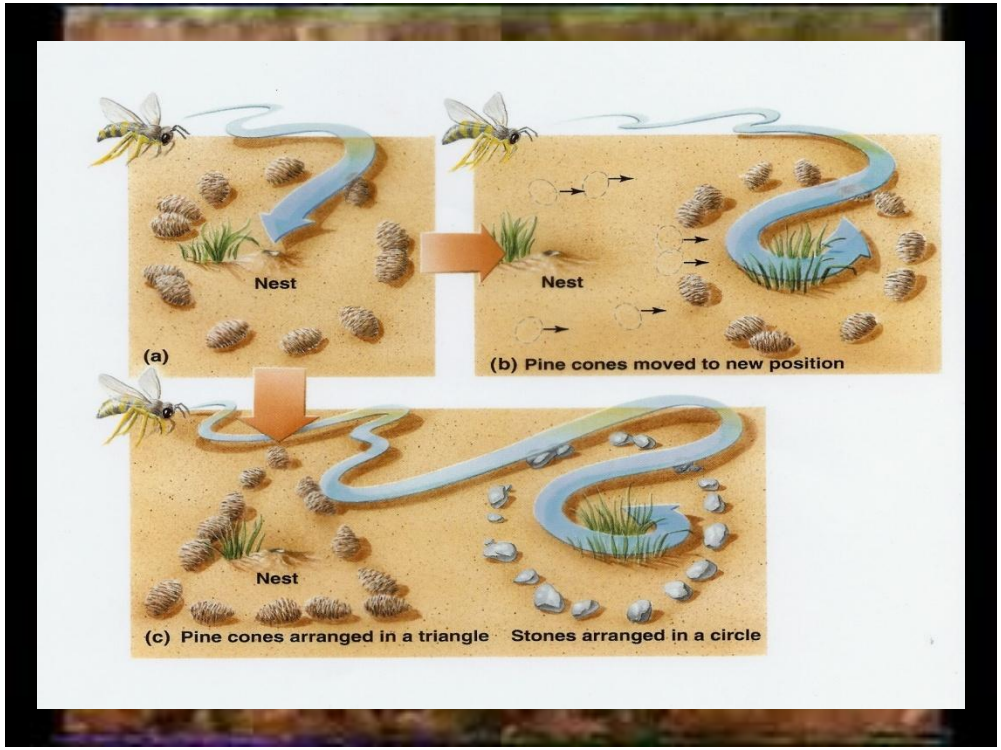
Nest finding behavior in wasp

How does the wasp find its way back to the nest after returning from a hunting trip?

- Tinbergen noticed that a waste circle its nest in exactly the same way each time it flew away to hunt.

- He suggest that this fixed action pattern is used to gather visual cues that will be used later to locate the position of its nest.

Tinbergen's Experiment:
fixed action pattern in wasp nest finding behavior



Fixed Action Patterns:
Egg-rolling behavior of the greylag goose

FIG. 69. Grey lag goose retrieving egg. After Lorenz and Tinbergen, 1938.

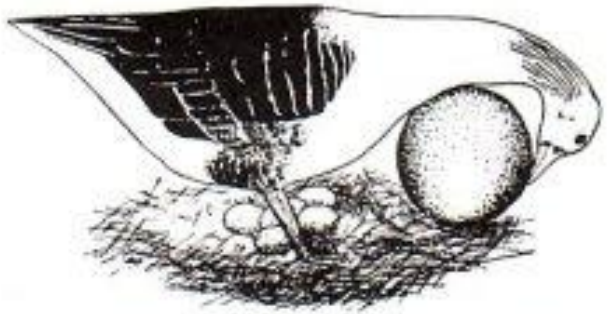
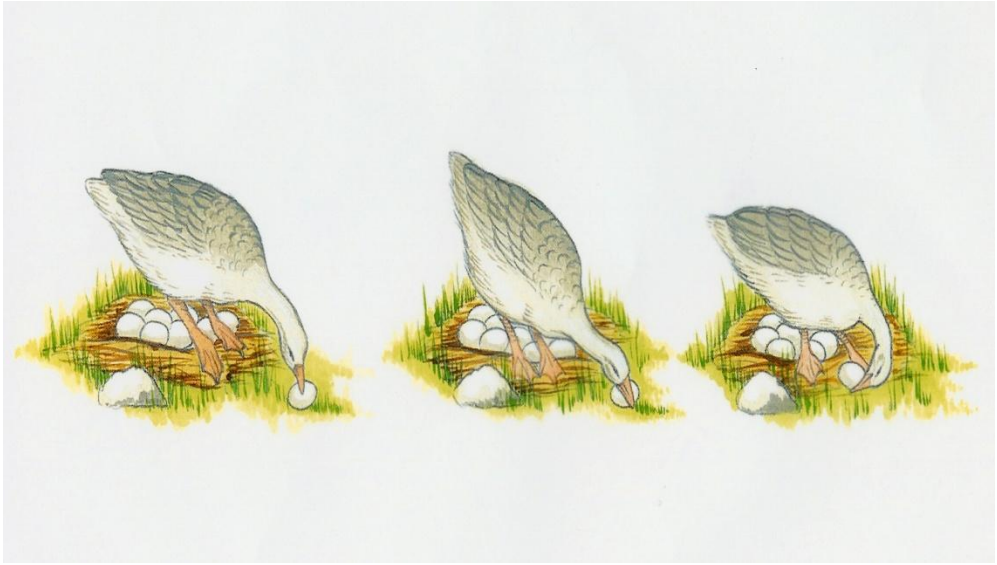
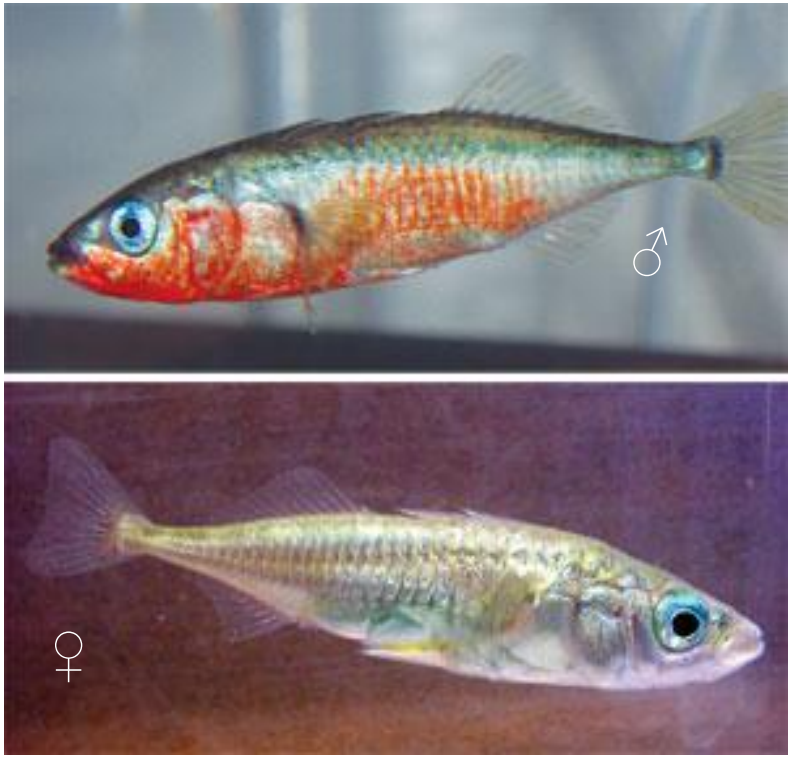


FIG. 70. Grey lag goose attempting to retrieve giant egg. After Lorenz and Tinbergen, 1938.



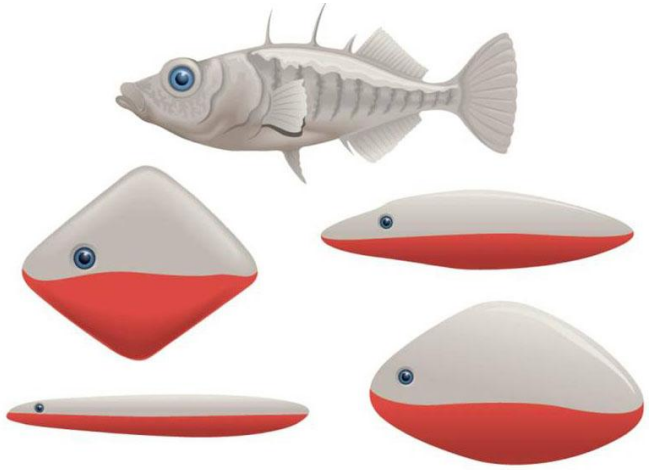
- The goose will roll an egg that is outside the nest back into the nest in the same manner every time.
- The goose will do this with any round object placed outside the nest.
- Each time this action pattern is initiated, it is carried through to completion.

FAP social behavior in three-spined stickleback
(Key visual sign stimulus releasing)

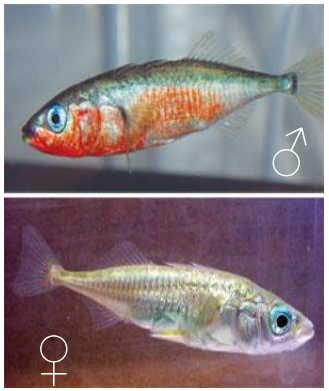


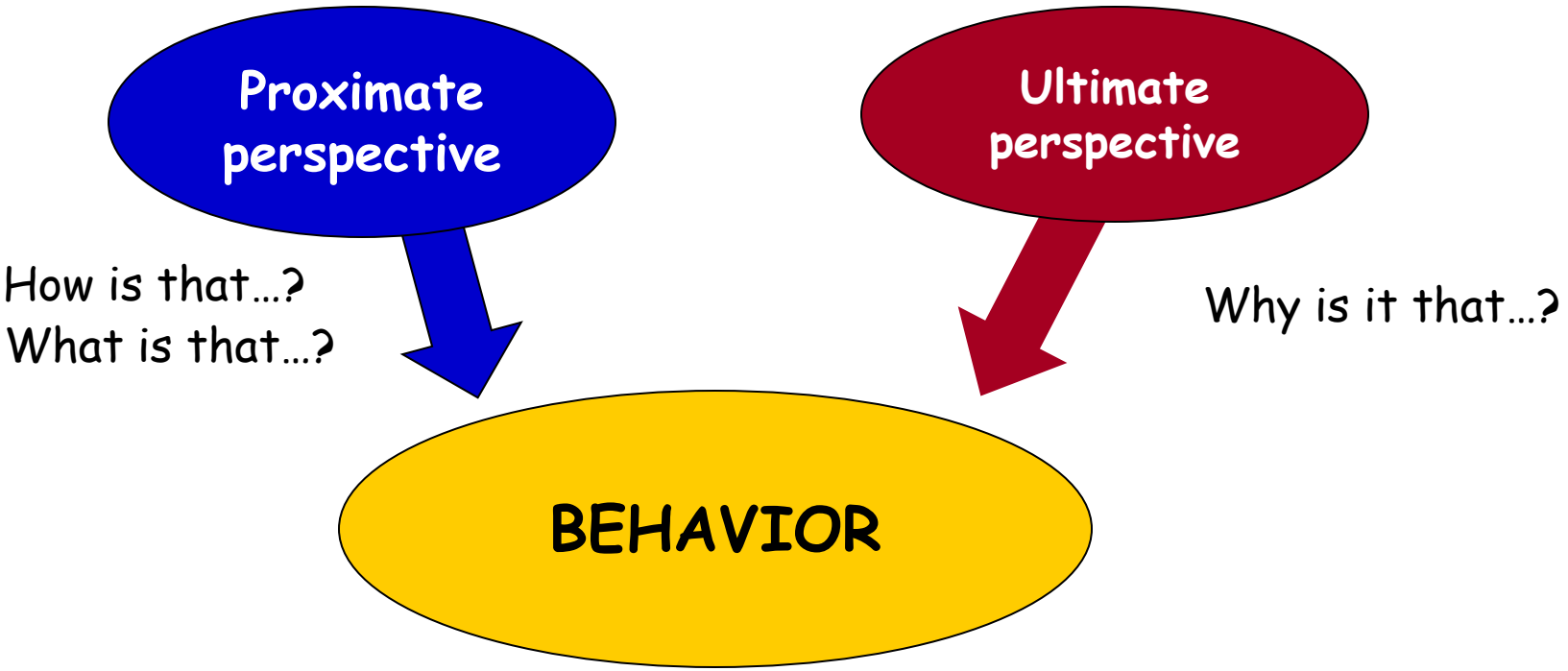
Fixed action pattern in three-spined stickleback

- Will attack as long as red spot present on the ventral body part.



- Will court if white swollen belly (i.e. a pregnant female)





Studying the mechanisms responsible for interactions

How these interactions influence an individual's survival and reproduction

Proximate and ultimate perspectives on aggressive behavior by male sticklebacks

BEHAVIOR: A male stickleback fish attacks other male sticklebacks that invade its nesting territory.

PROXIMATE CAUSE:

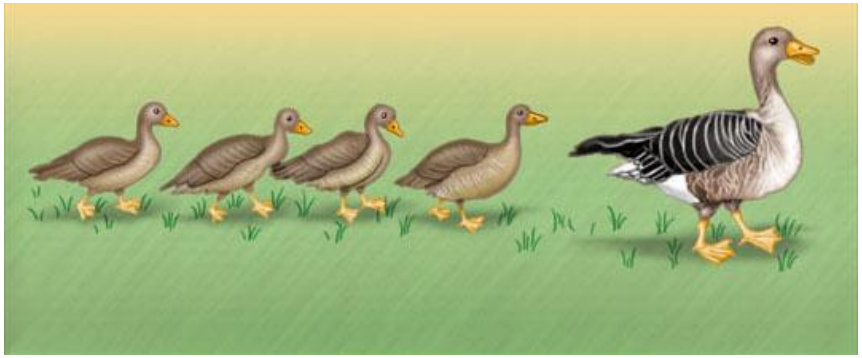
The red belly of the intruding male acts as a sign stimulus that releases aggression in a male stickleback.

ULTIMATE CAUSE:

By chasing away other male sticklebacks, a male decreases the chance that eggs laid in his nesting territory will be fertilized by another male.

Proximate and ultimate perspectives on imprinting in graylag geese

BEHAVIOR: Young geese follow and imprint on their mother.



PROXIMATE CAUSE:

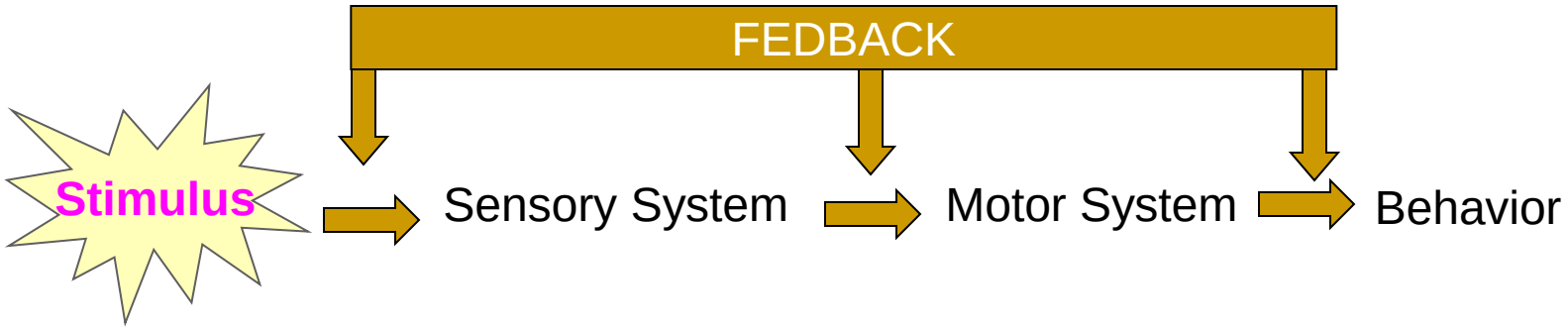
During an early, critical developmental stage, the young geese observe their mother moving away from them and calling.

ULTIMATE CAUSE:

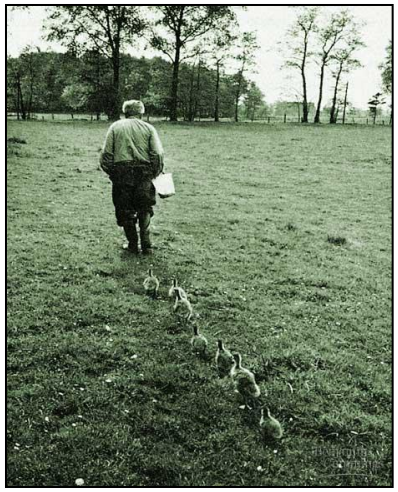
On average, geese that follow and imprint on their mother receive more care and learn necessary skills, and thus have a greater chance of surviving than those that do not follow their mother.

Innate versus Learned behavior

- Behavior is modified by experience (trial and error pattern).
- Flexible- Phenotypic is changing with time/experience
- Often affects even innately programmed behaviors, e.g. Fixed Action Patterns.



Learned behavior



Learned behavior

A young chimpanzee learning to crack oil palm nuts by observing an experienced elder

Instinct (innate) Behavior

- First time performance is completely functional
- Animals don't have to witness the behavior (inborn)
- Uniform, stereotyped
- Triggered by simple sign stimulus (sensory releaser)
- It has a strong genetic (inherited) basis: control by pre-programmed fixed neurological circuitries

Innate behavior

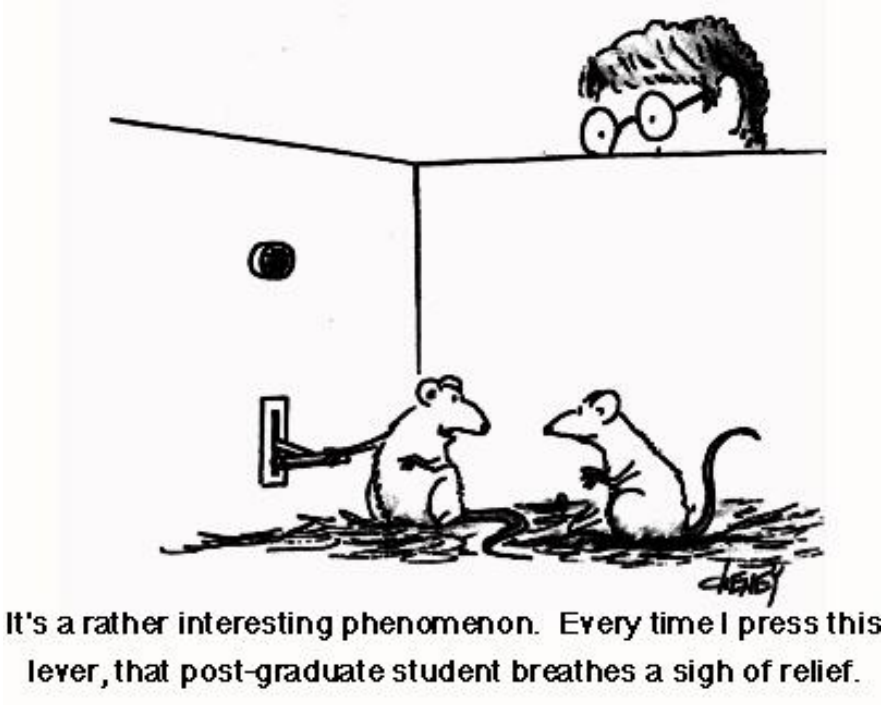
Innate behavior of the Cuckoo bird

Innate behavior of the Egyptian Vulture

More animal behavior videos?

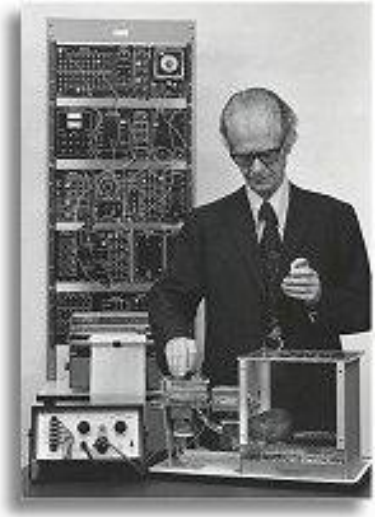
Innate or learned behavior?

Two ways to study animal behavior



Experimental studies of animal behavior in laboratory conditions

Ivan Pavlov
(1849-1936)



Burrhus Frederic Skinner
(1904-1990)

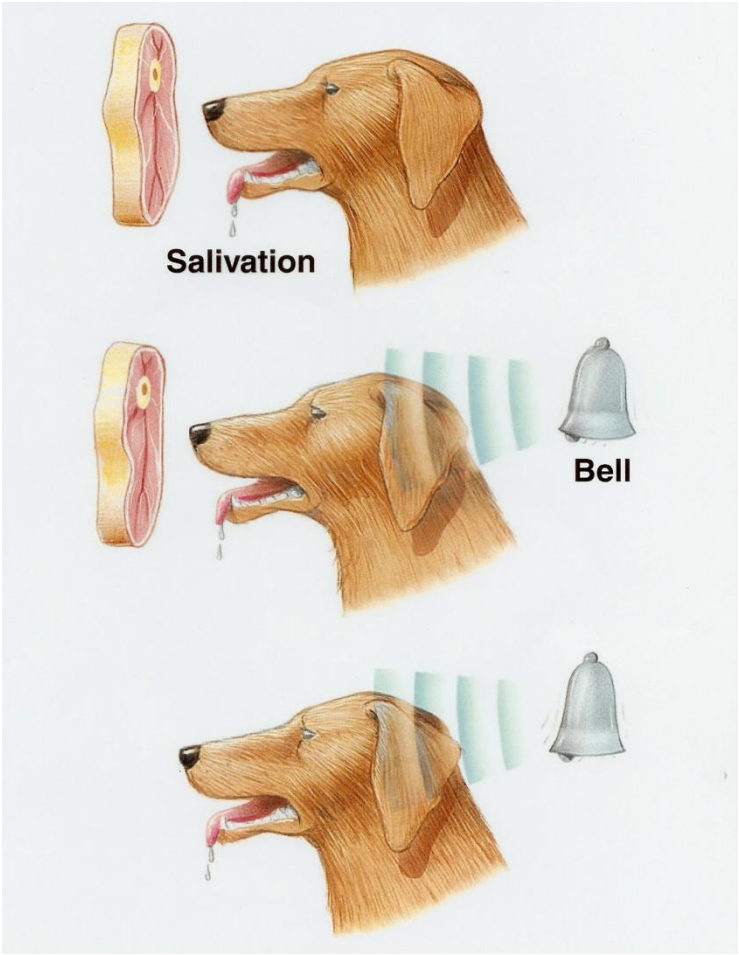
Ivan Pavlov

The Nobel Prize in Physiology or Medicine 1904

For his research in temperament, conditioning and involuntary reflex actions of the digestive glands

Pavlov's experiment:
The original and most famous example of classical conditioning involved the salivary conditioning reflex of Pavlov's dogs.

Pavlov's Classical Conditioning



Before Training/Conditioning

Food ⟶ Salivation

Tone ⟶ ???? (nothing)

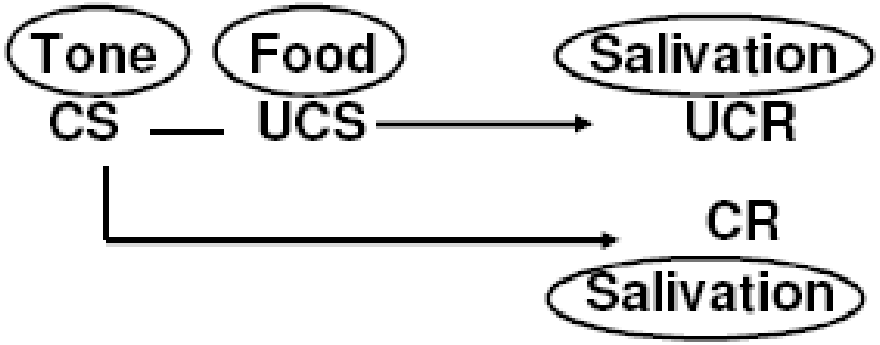
During Training/Conditioning

Tone — Food ⟶ Salivation

After Training/Conditioning

Tone — Food ⟶ Salivation

⟶ Salivation



Definitions:

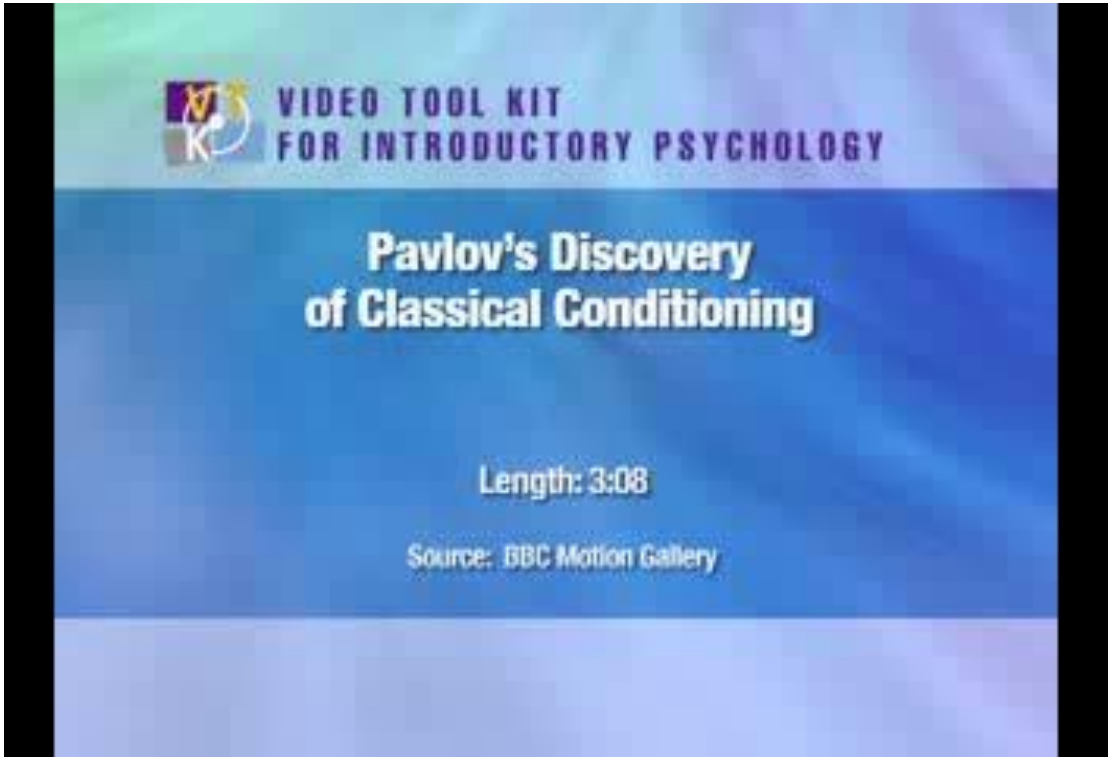
Unconditioned Stimulus (UCS): A stimulus that automatically elicits a response without any prior conditioning/learning

Unconditioned Response (UCR): That unlearned reaction/response to an UCS without previous conditioning.

Conditioned Stimulus (CS): Is a previously neutral stimulus that, through pairing with the UCS, also eventually elicits a response.

Conditioned Response (CR): That reaction/response that occurs to the CS.

Pavlov's Classical Conditioning



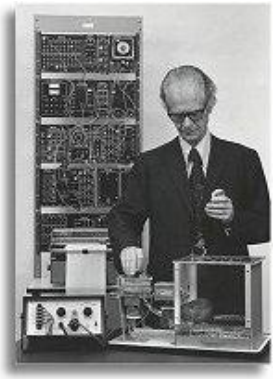
Skiner's Operant Conditioning

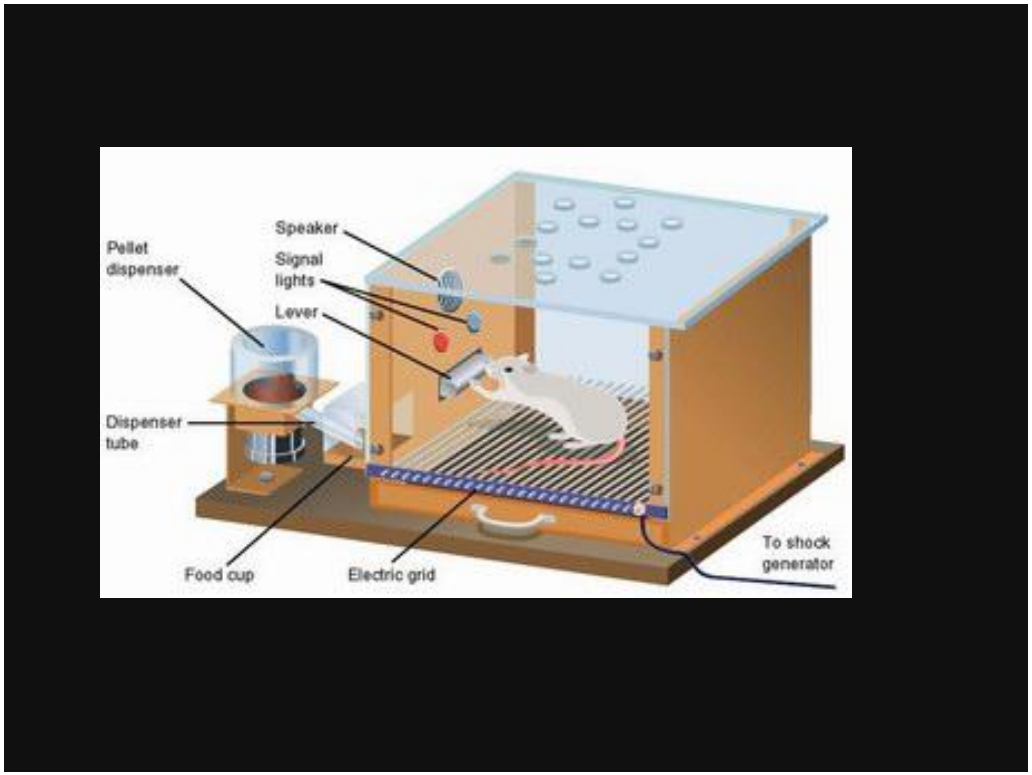
The study of how behavior is affected by its consequence.

•A process where an animal learns to associate one of its behaviors with a reward or punishment and then tends to repeat or avoid that behavior.

•In different to classical conditioning the response is voluntary (it is NOT a reflex).

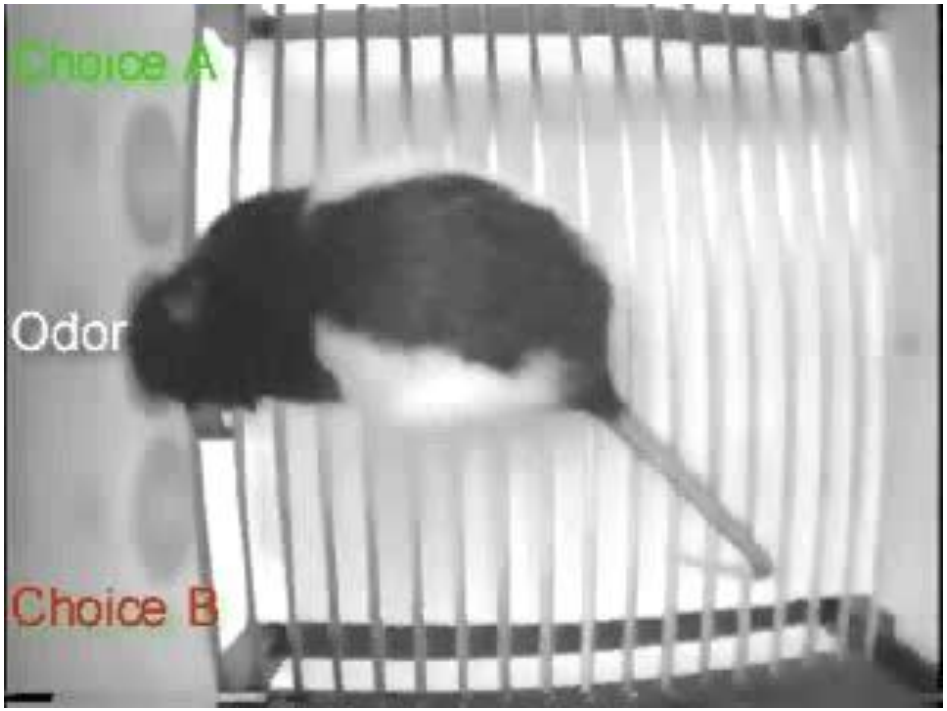
Operant Conditioning: The Skinner Box



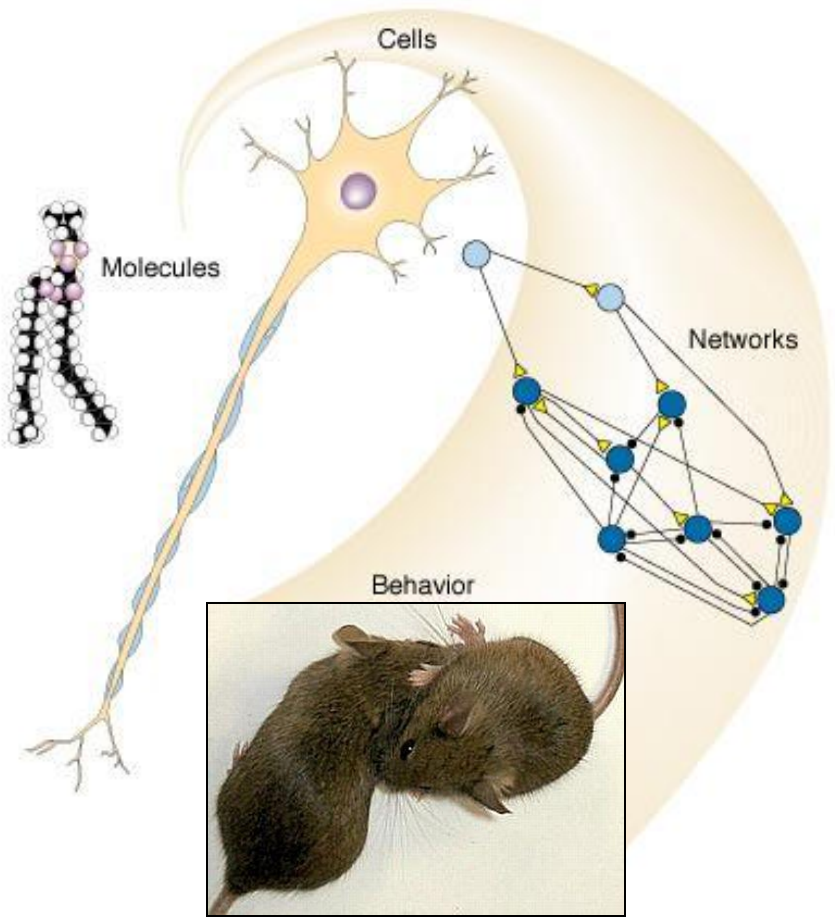


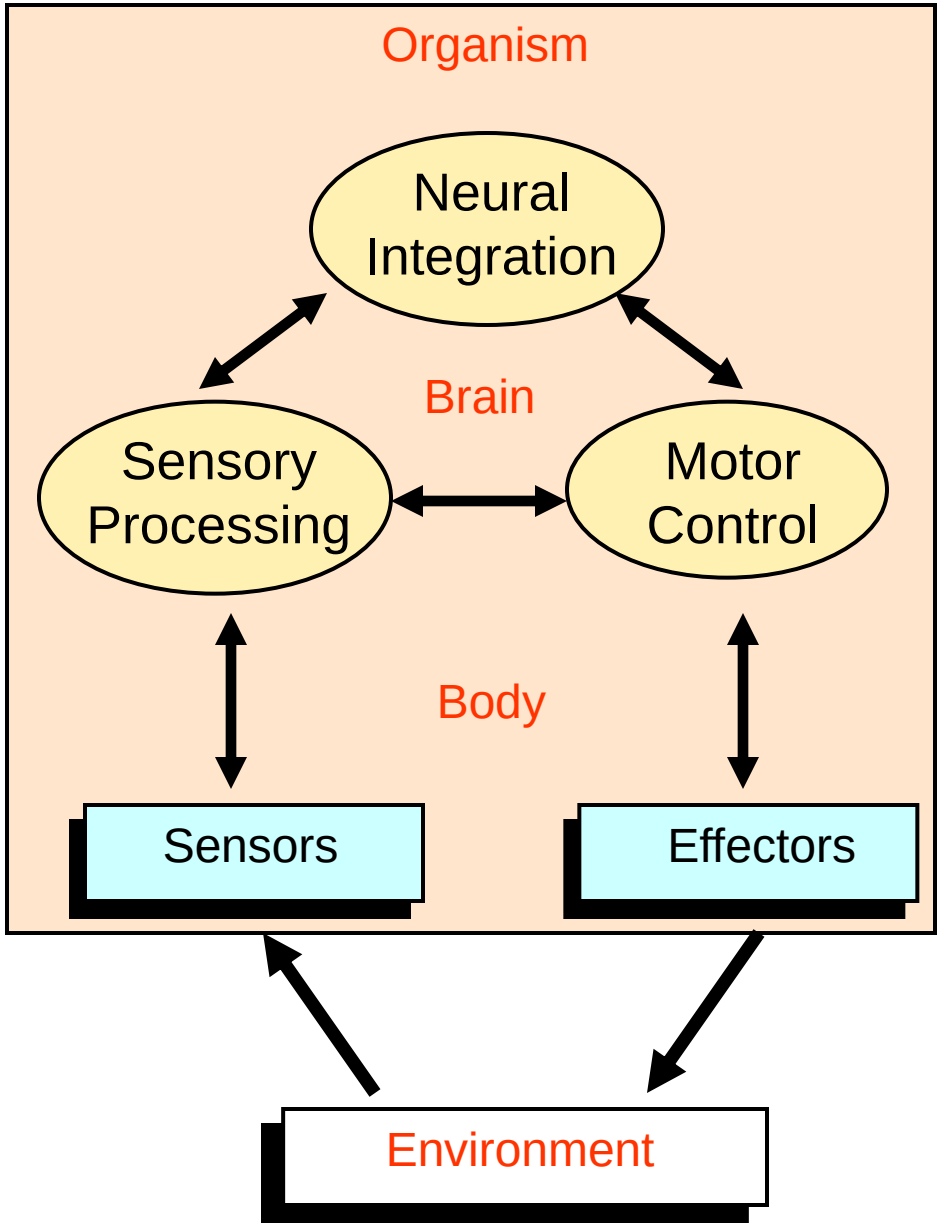
ABC

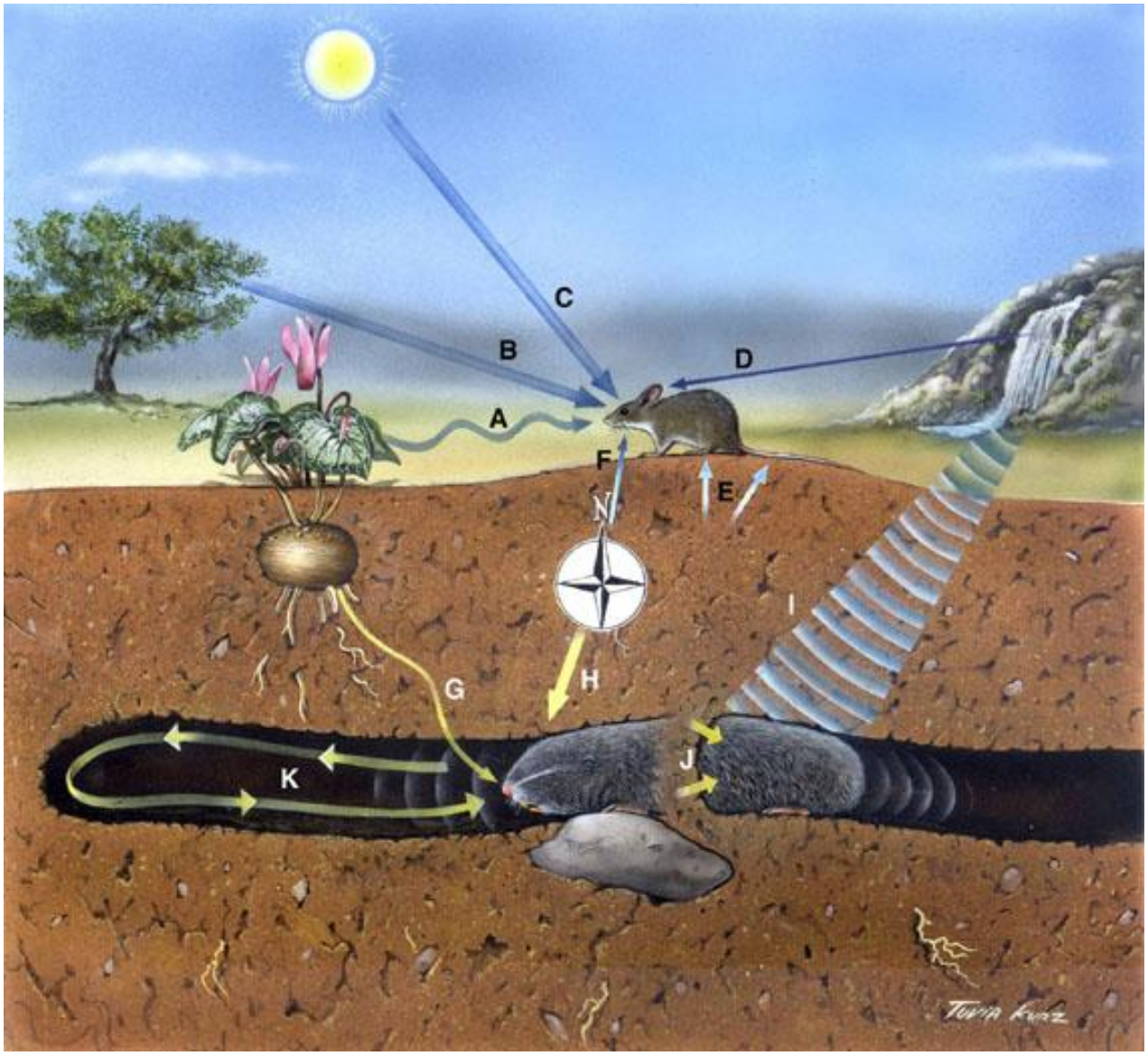
- **A**ntecedent (previous event)
- **B**ehavioral action
- **C**onsequence


Choice A
Odor
Choice B

Neuroethology: Neural Basis of Behavior



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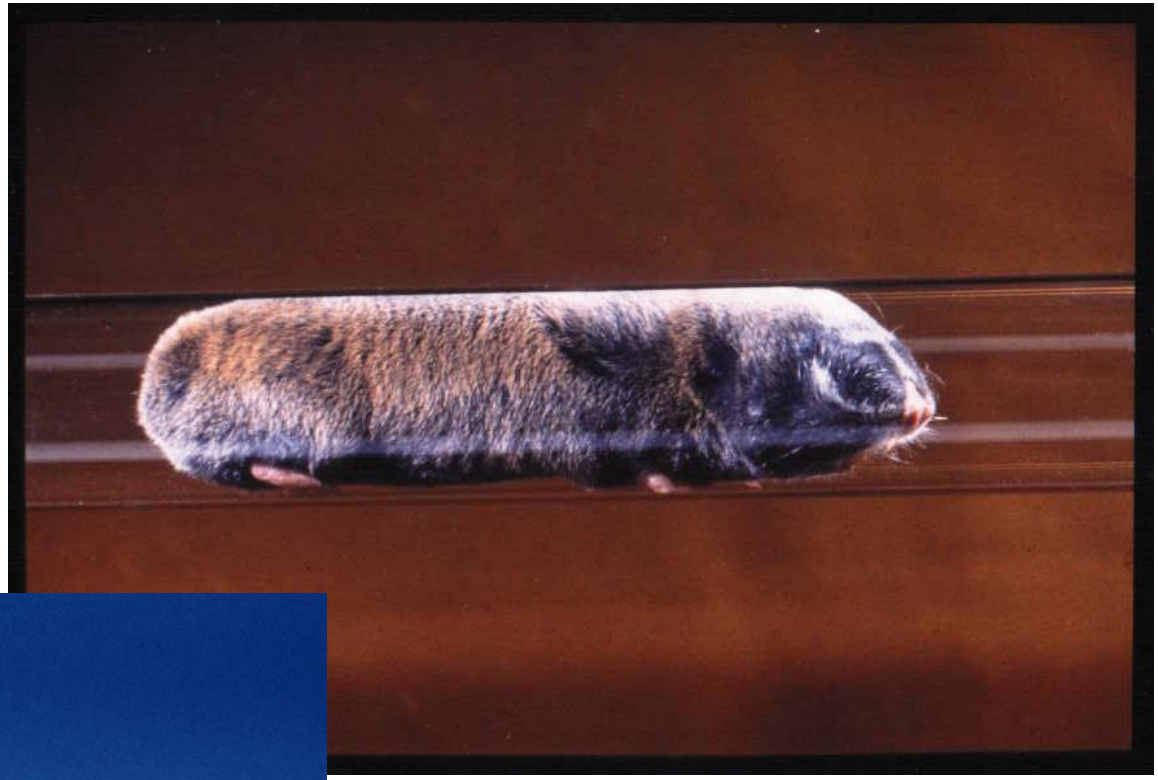
Rodentia

Mole-rat

Insectivora

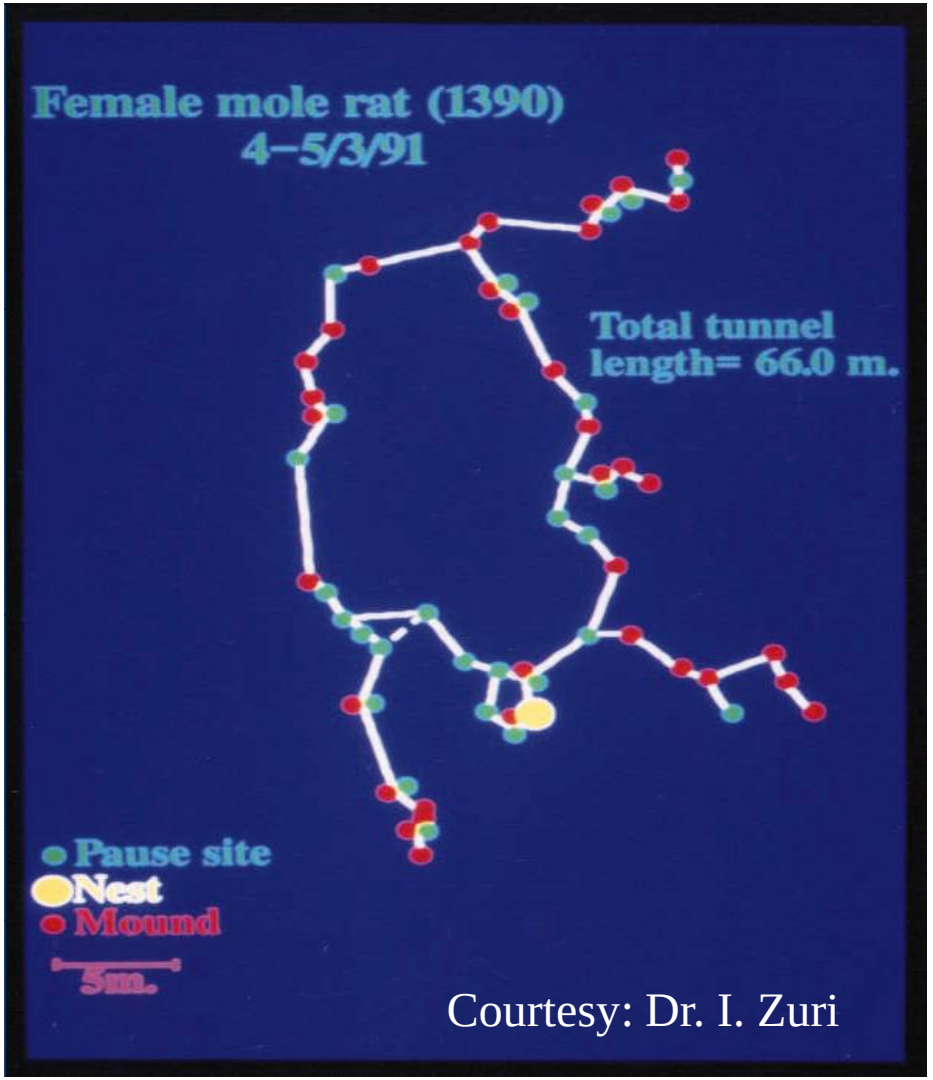
mole

Mole rat - side view

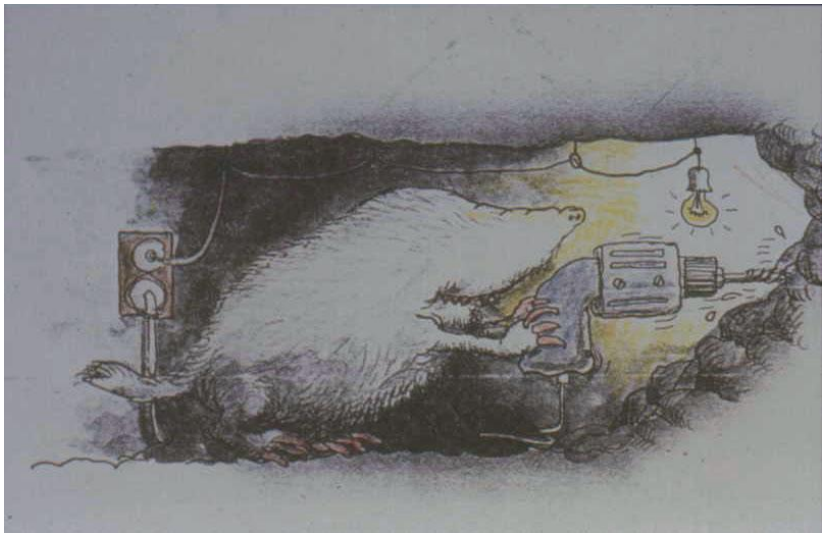


Mole rat - Front view

Two patterns of mole rat mounds in Israel



Courtesy: Dr. I. Zuri

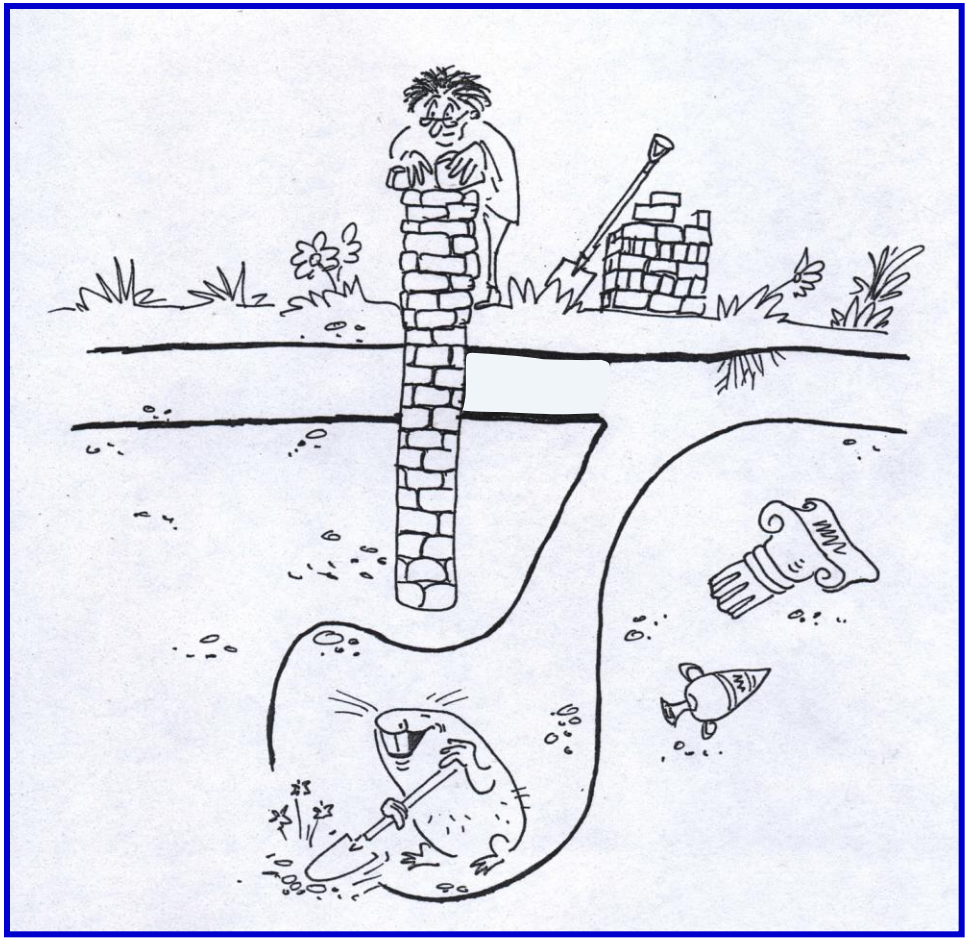


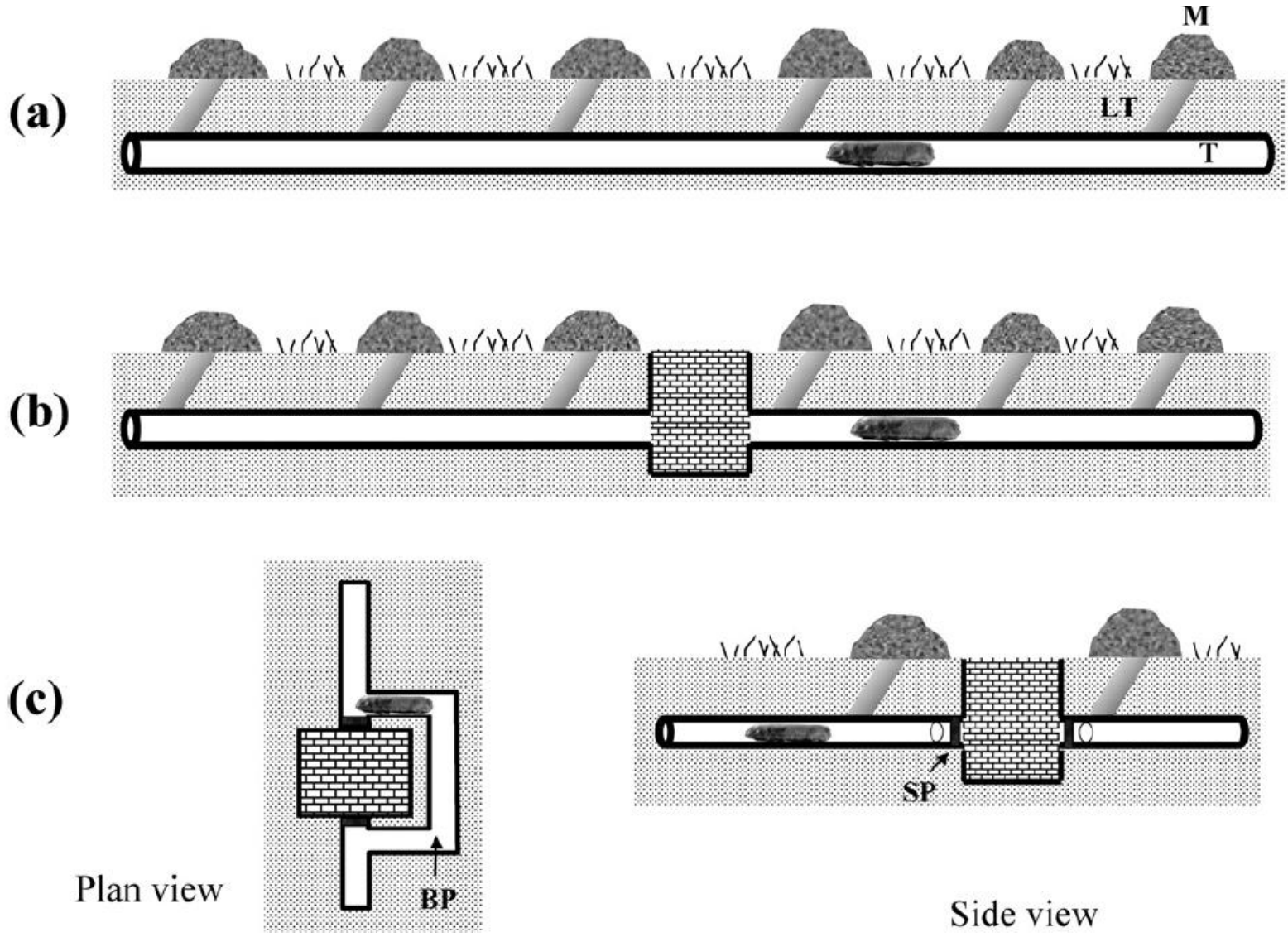
Burrows excavations is both costly and difficult

- High energy cost: up to 3400 times more than moving on surface
- High CO_2 pressure (~13.5%) and low O_2 pressure (~5.5%)
- High risk of body overheating (unventilated niche)
- High risk of losing water and consequent dehydration (food is the only water source)

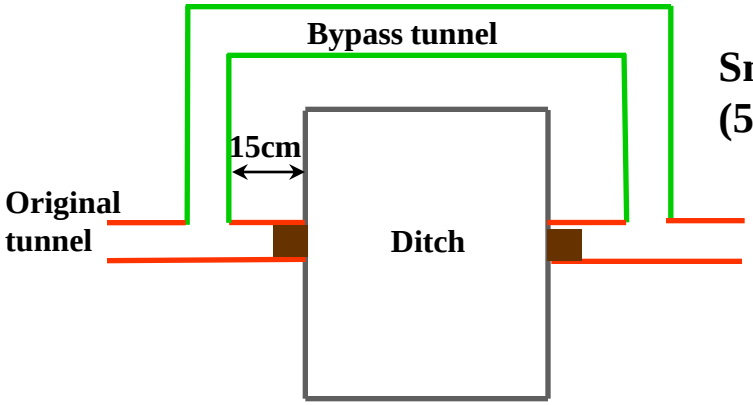
Mole rat sensory perception

How does the blind mole rat orient underground (avoid obstacles)?

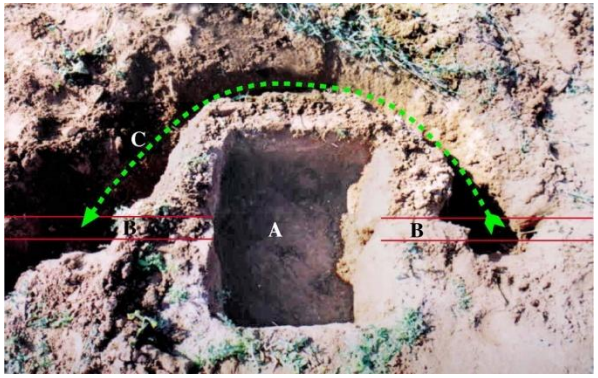



(a)
M
LT
T
(b)
(c)
Plan view
BP
SP
Side view

Type of bypass for different obstacles



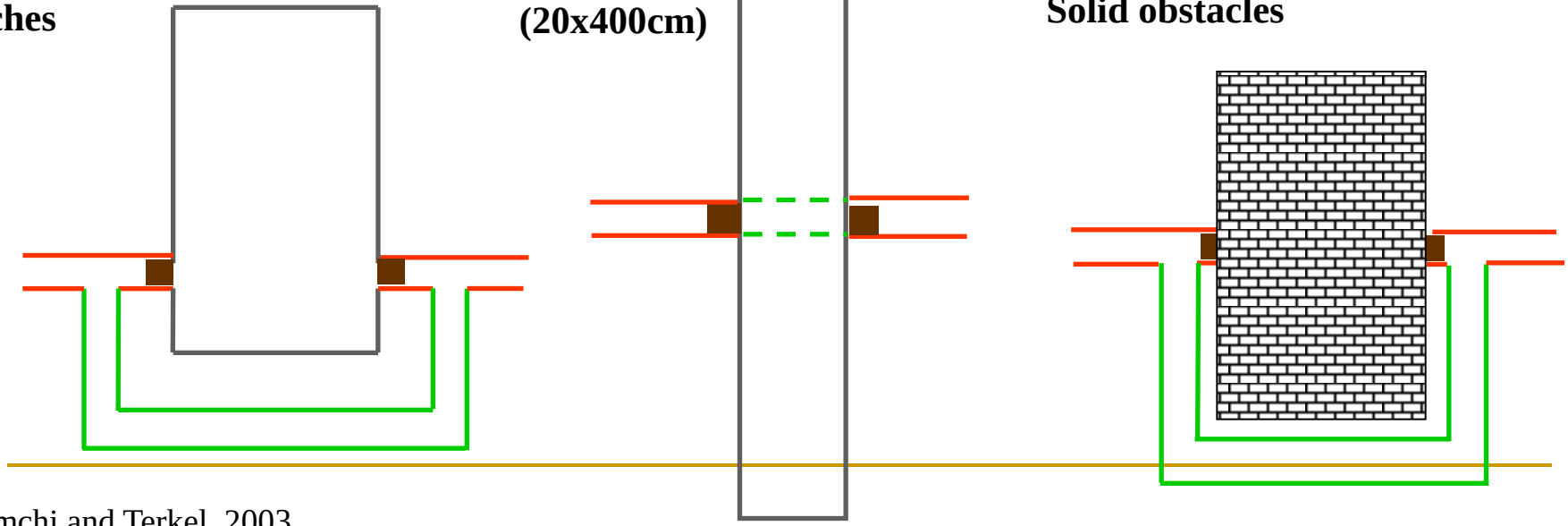
Small ditches (50x60cm)



Asymmetrical ditches

Large ditches (20x400cm)

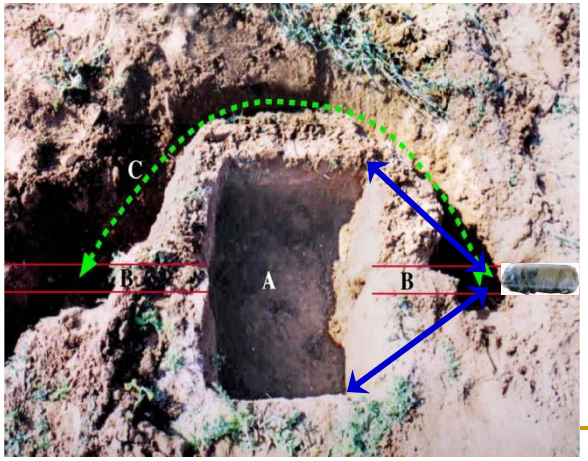
Solid obstacles

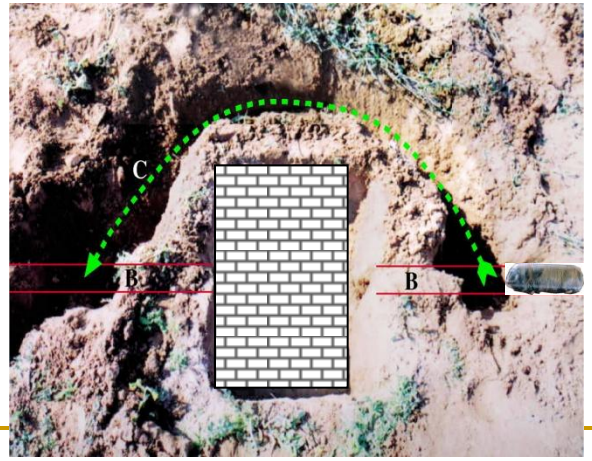


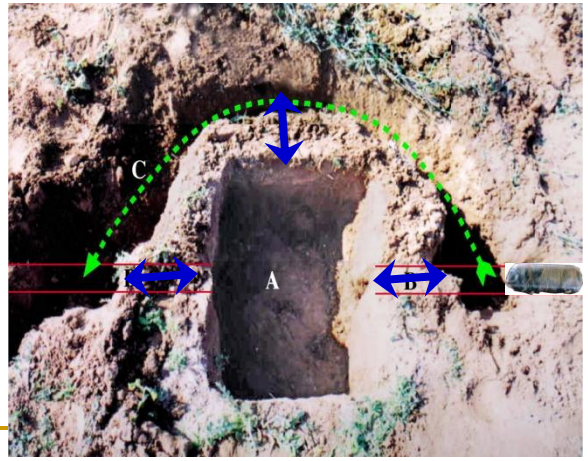
Kimchi and Terkel, 2003.
Naturwissenschaften; Animal Behaviour

Mole rats are able to assess:

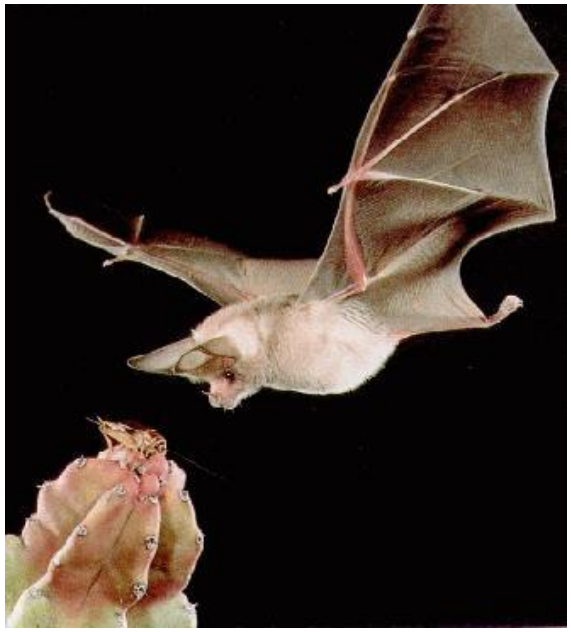
The dimensions and density (air vs. stone) of underground obstacles and their relative distance from the obstacle boundaries



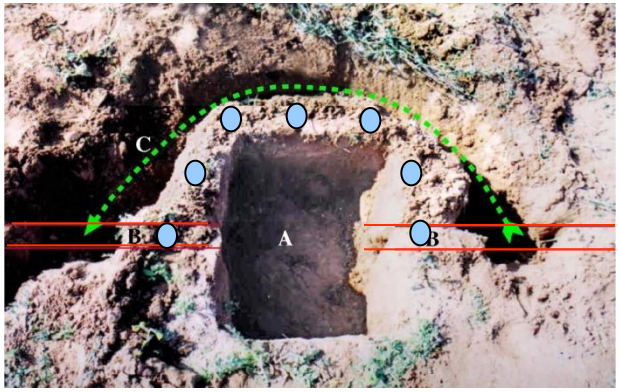


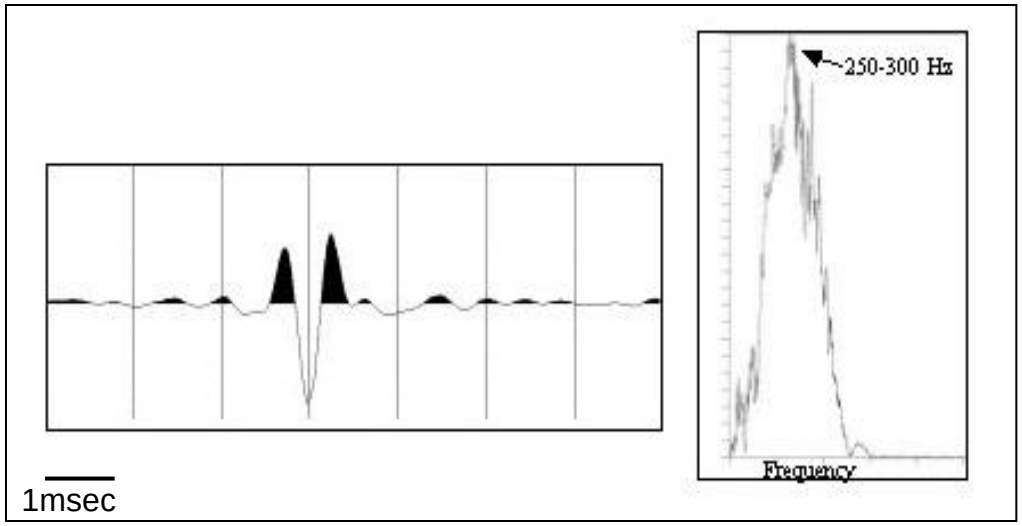


Do mole rats use seismic echolocation for spatial orientation?



Seismic signals produced by mole-rats during bypass burrowing

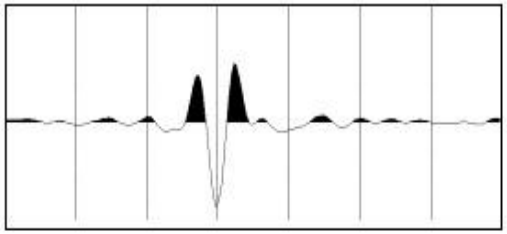


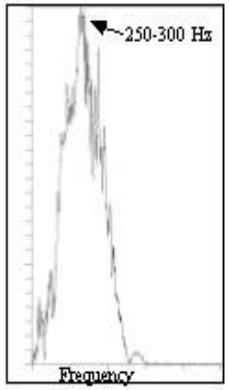


Kimchi, Reshef and Terkel, 2005.*Journal of Experimental Biology*

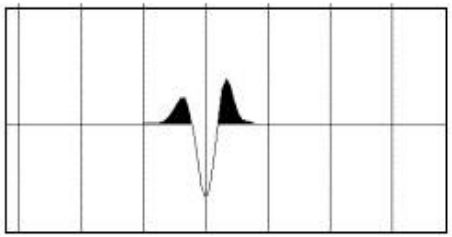
Computer seismic simulator modeling

Seismic signals produced by mole-rats during bypass burrowing

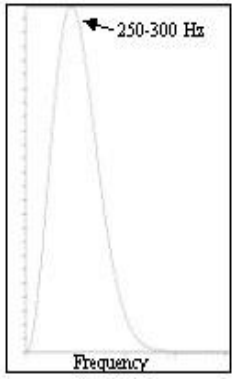


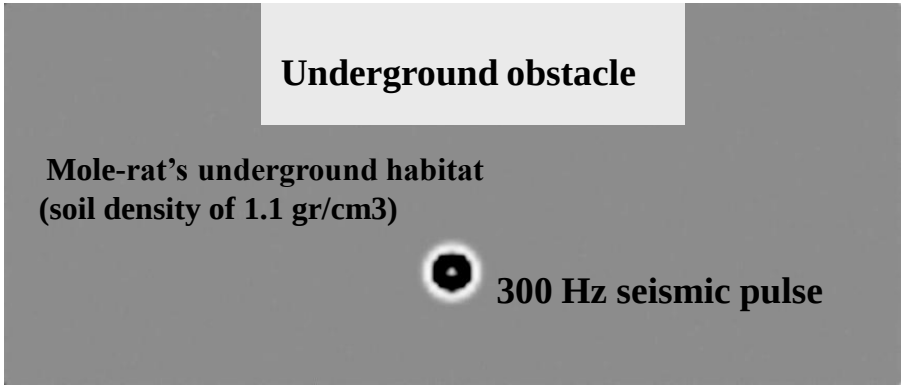


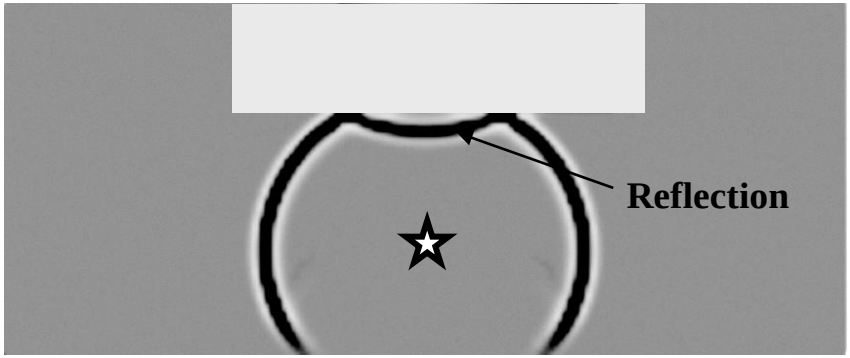
Synthesized seismic source wavelet

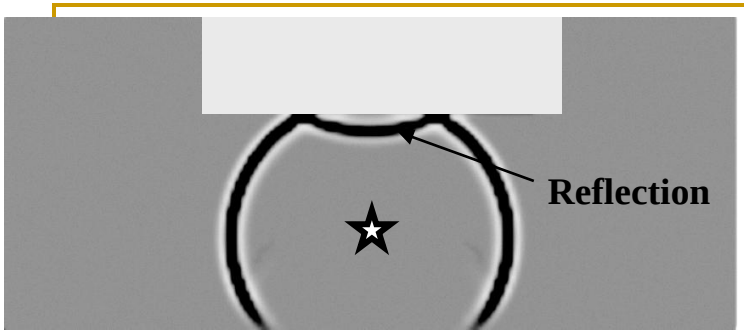


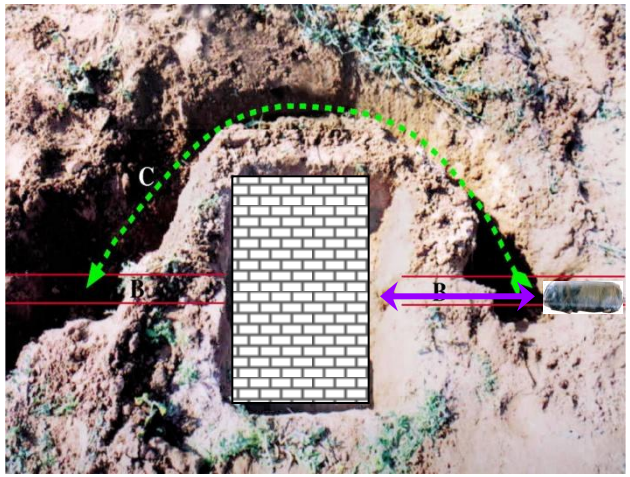
1msec





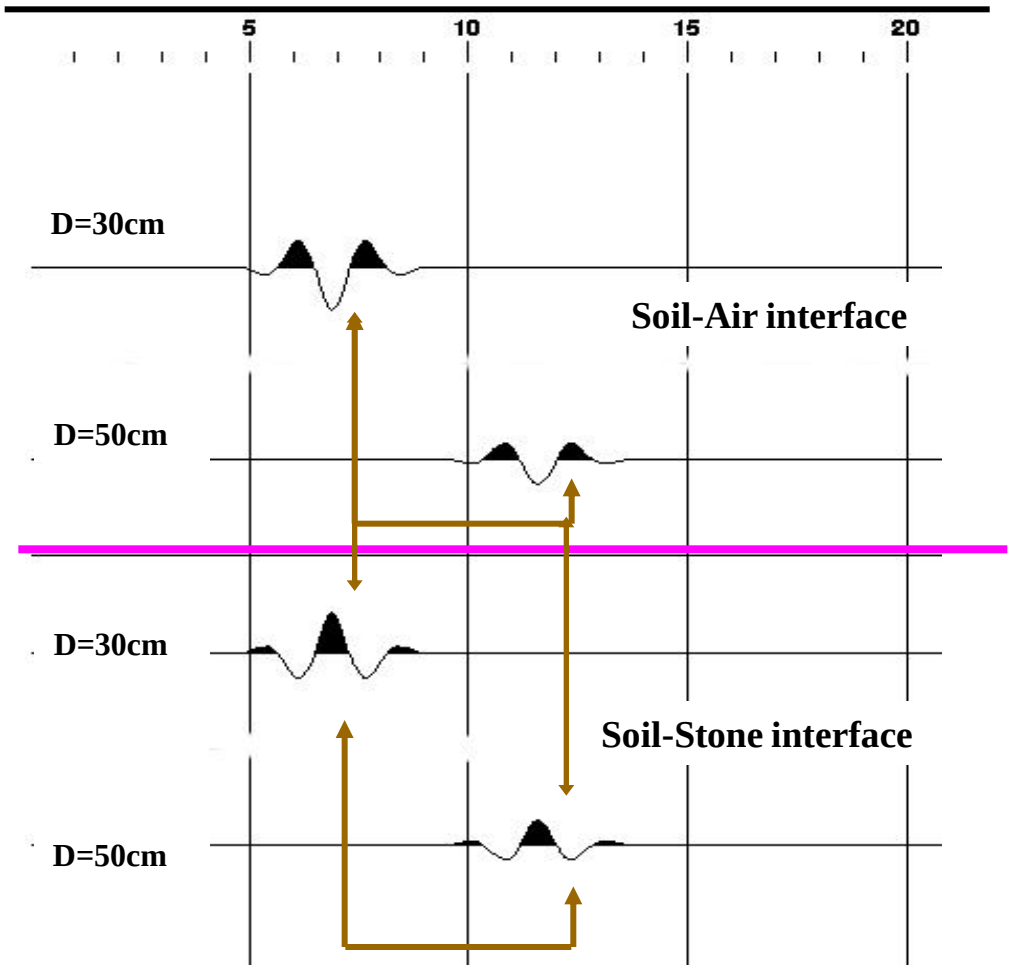


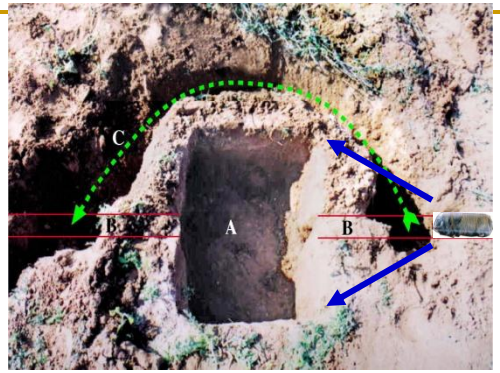


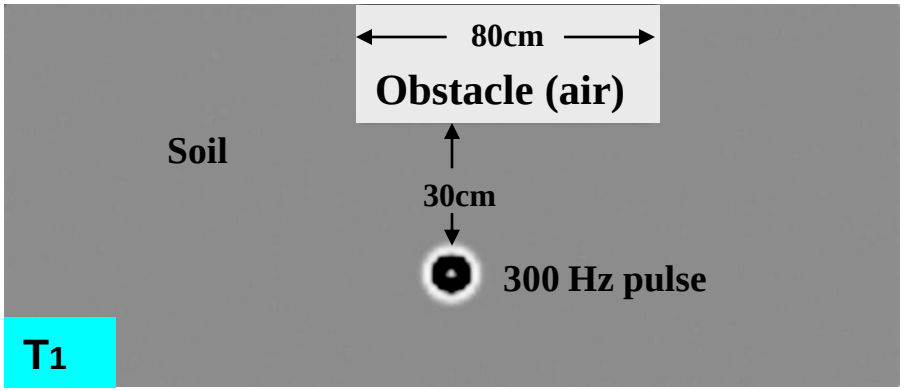


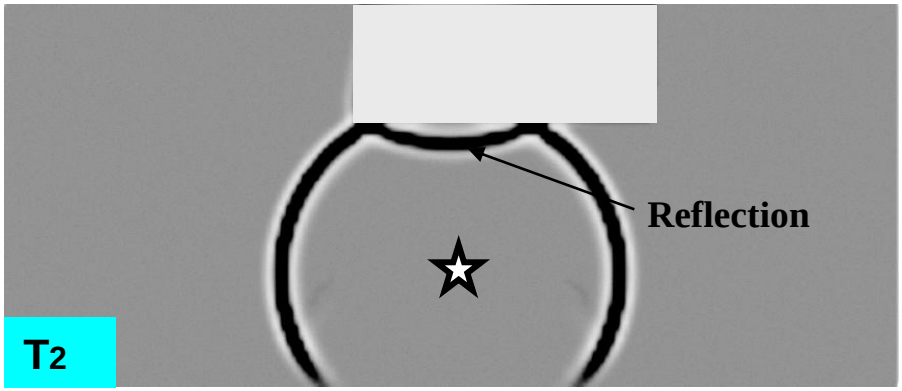
Time (msec)

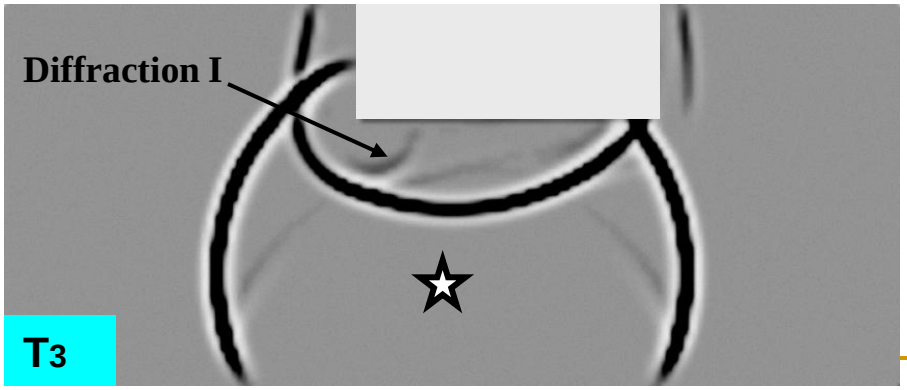
Relative amplitude

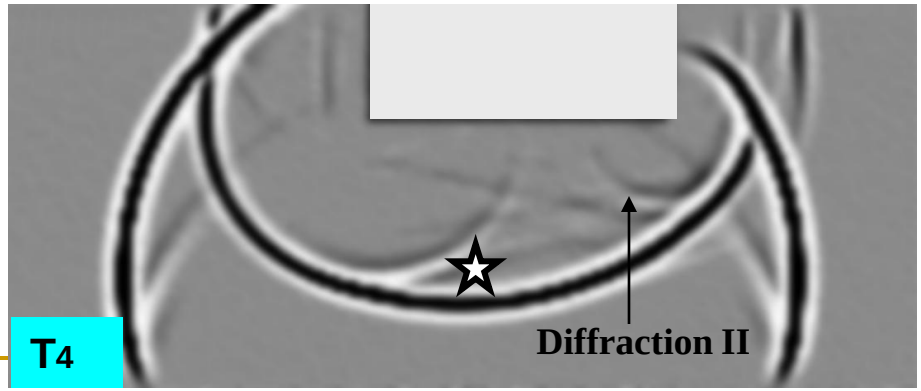



C
B
A
B

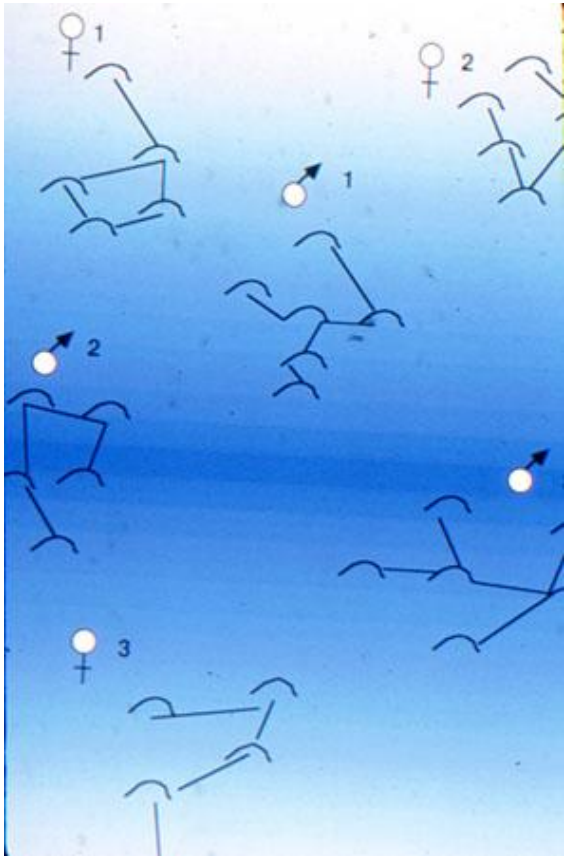

80cm
Obstacle (air)
Soil
30cm
300 Hz pulse
T1


Reflection
T2

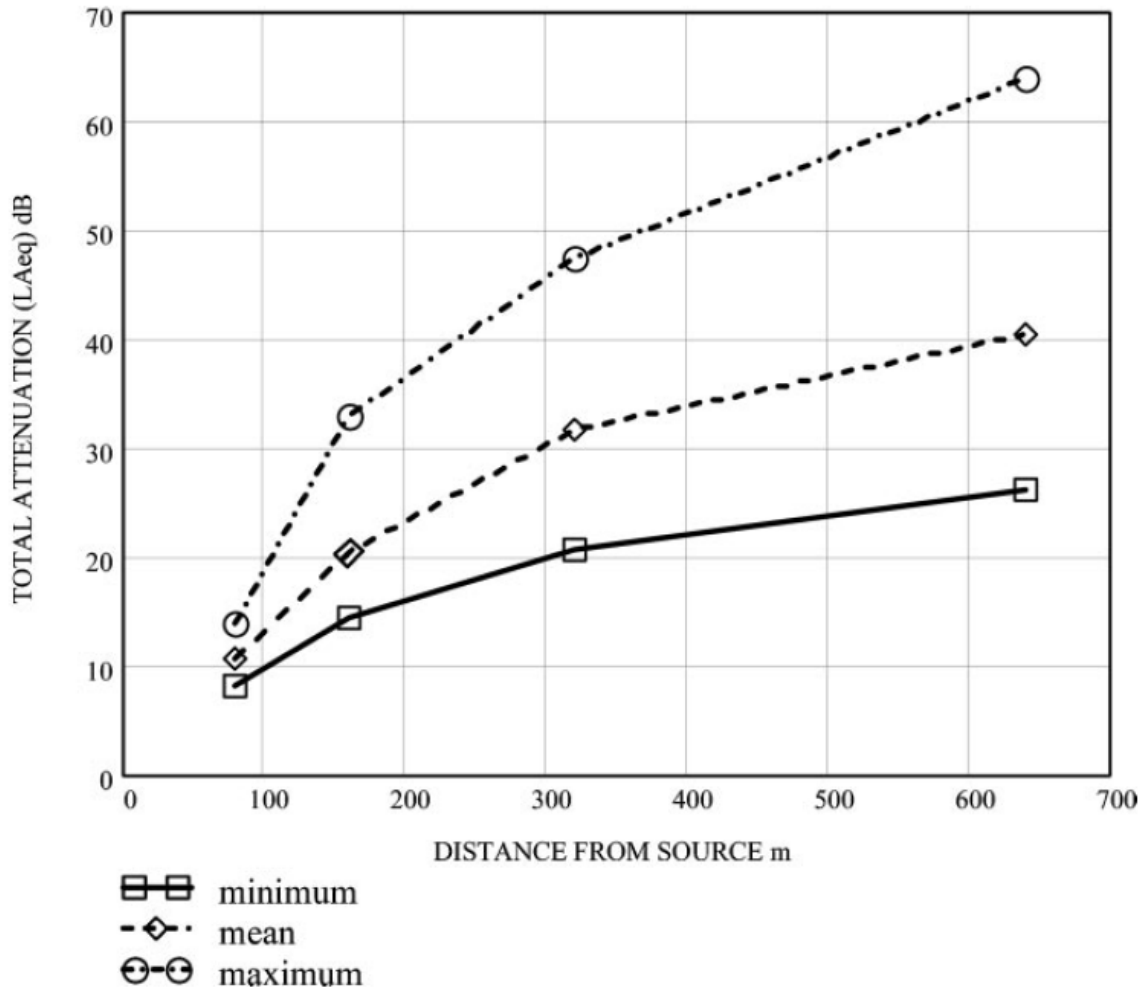

Diffraction I
T3


Diffraction II
T4

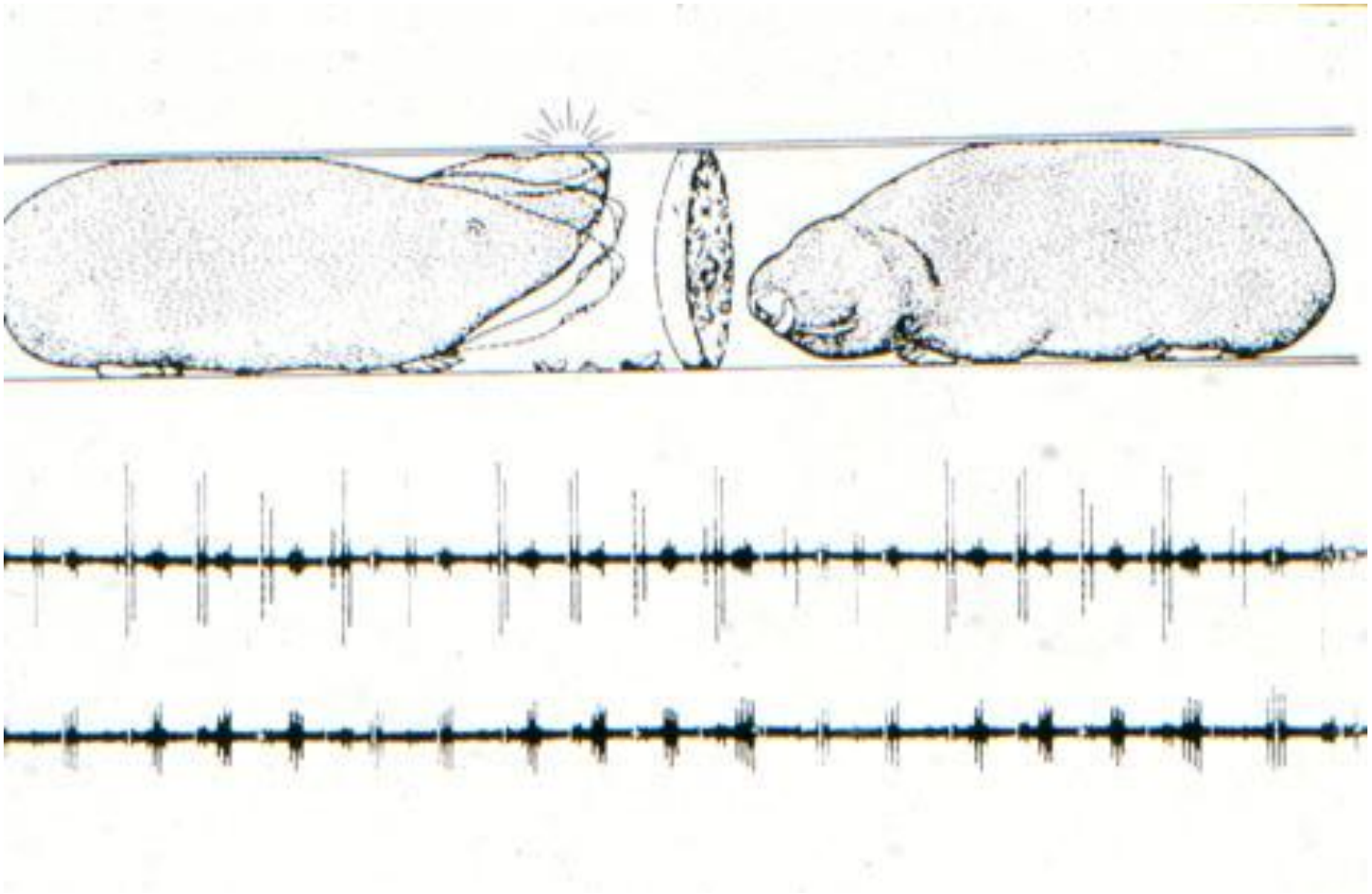
How does the blind mole rat communicate with each other (find their mate/ avoid aggressive males)?



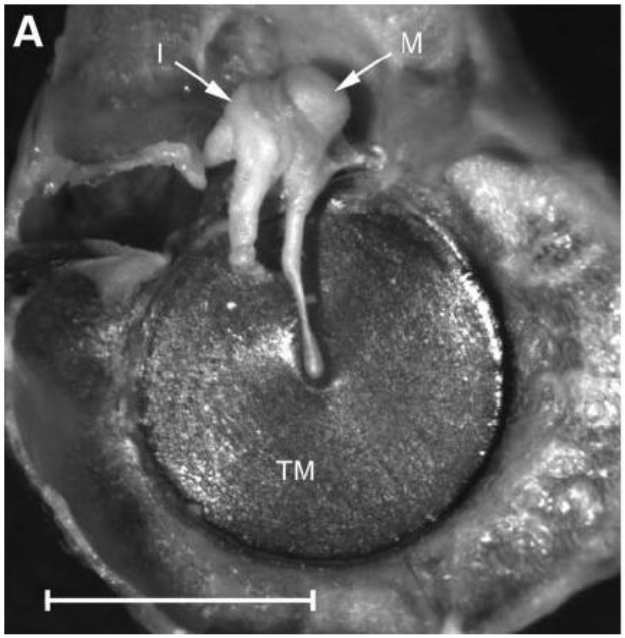
Airborne Sound is Quickly Attenuated in Soil

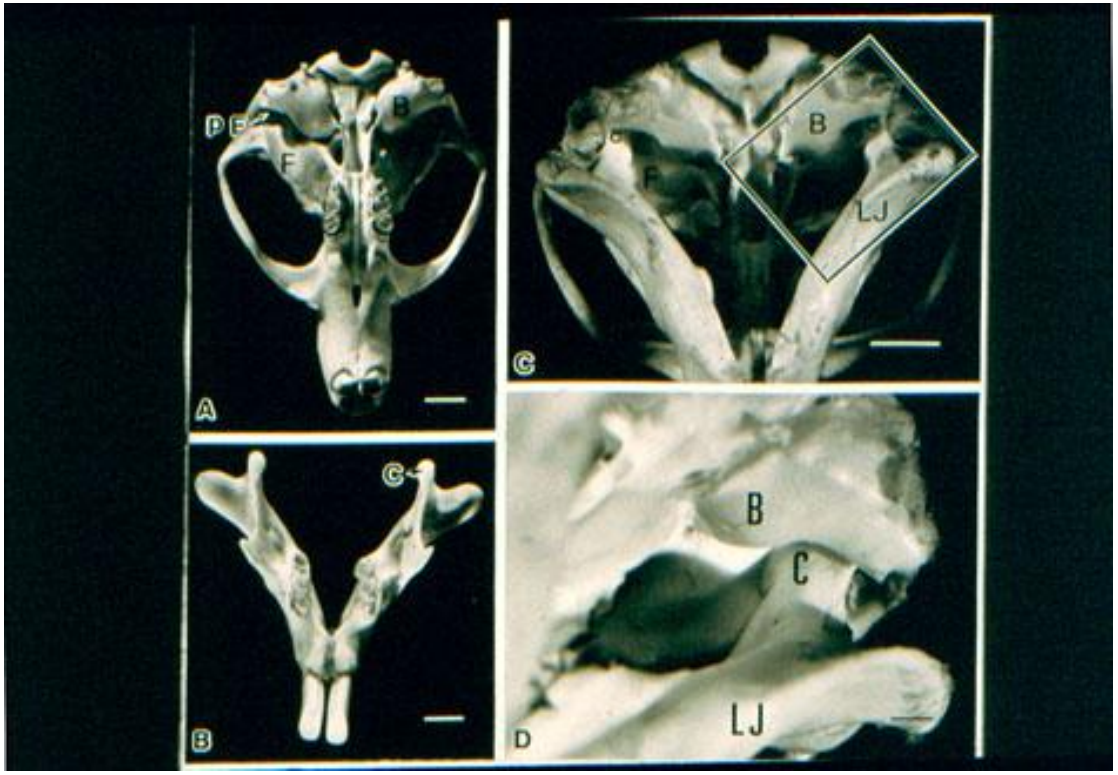


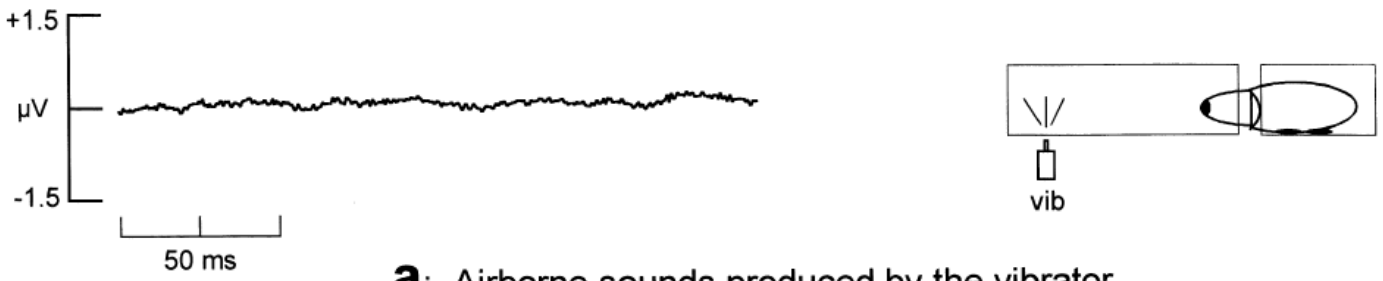
Attenborough 2002; *Annu Rev Fluid Mech*



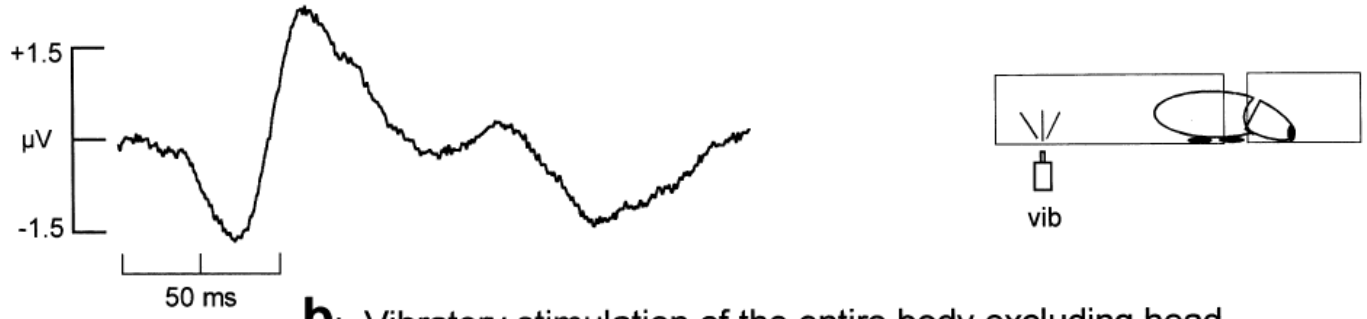
Rado, R (1998); J Comp Physiol


A
I
M
TM


A
B
F
C
B
C
B
LJ
B
C
LJ



a: Airborne sounds produced by the vibrator

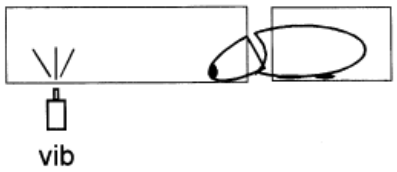


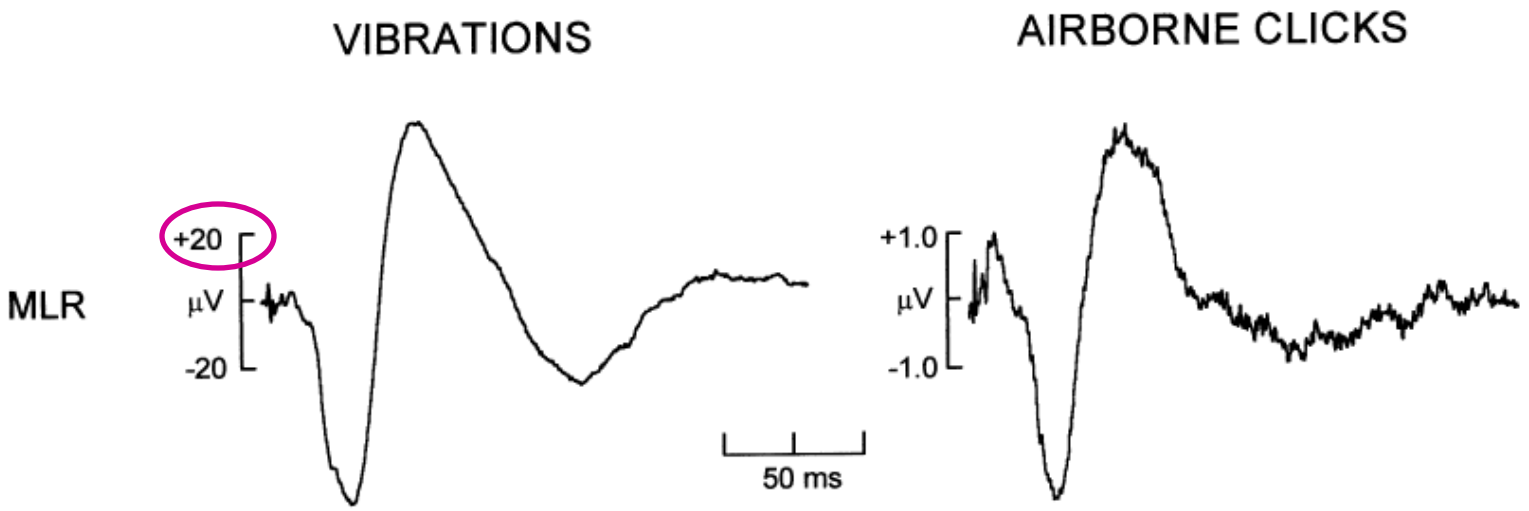
b: Vibratory stimulation of the entire body excluding head

c: Vibratory stimulation of the head - mainly the lower jaw

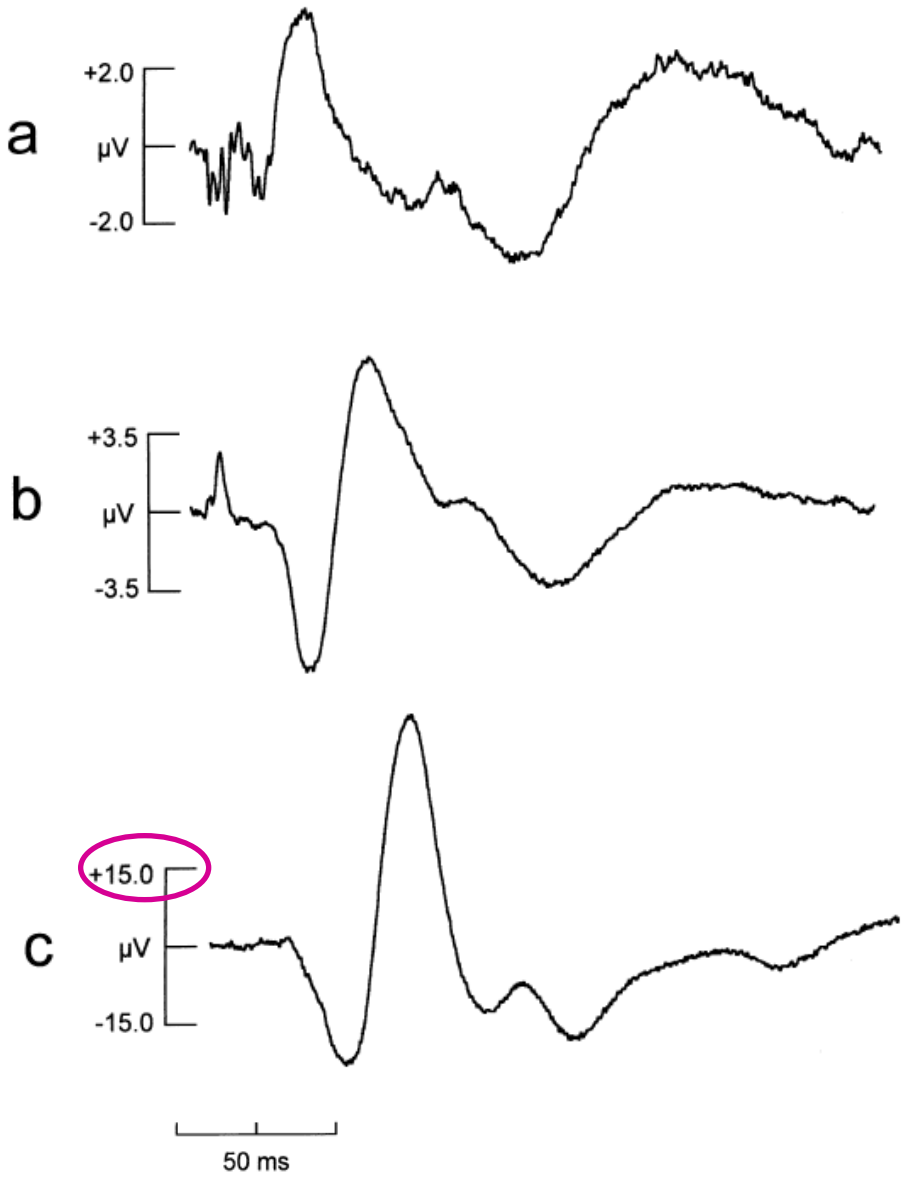
Middle latency response (MLR)

MLR is thought to represent the synchronous firing of neurones in the primary auditory cortex to an acoustic stimulus.





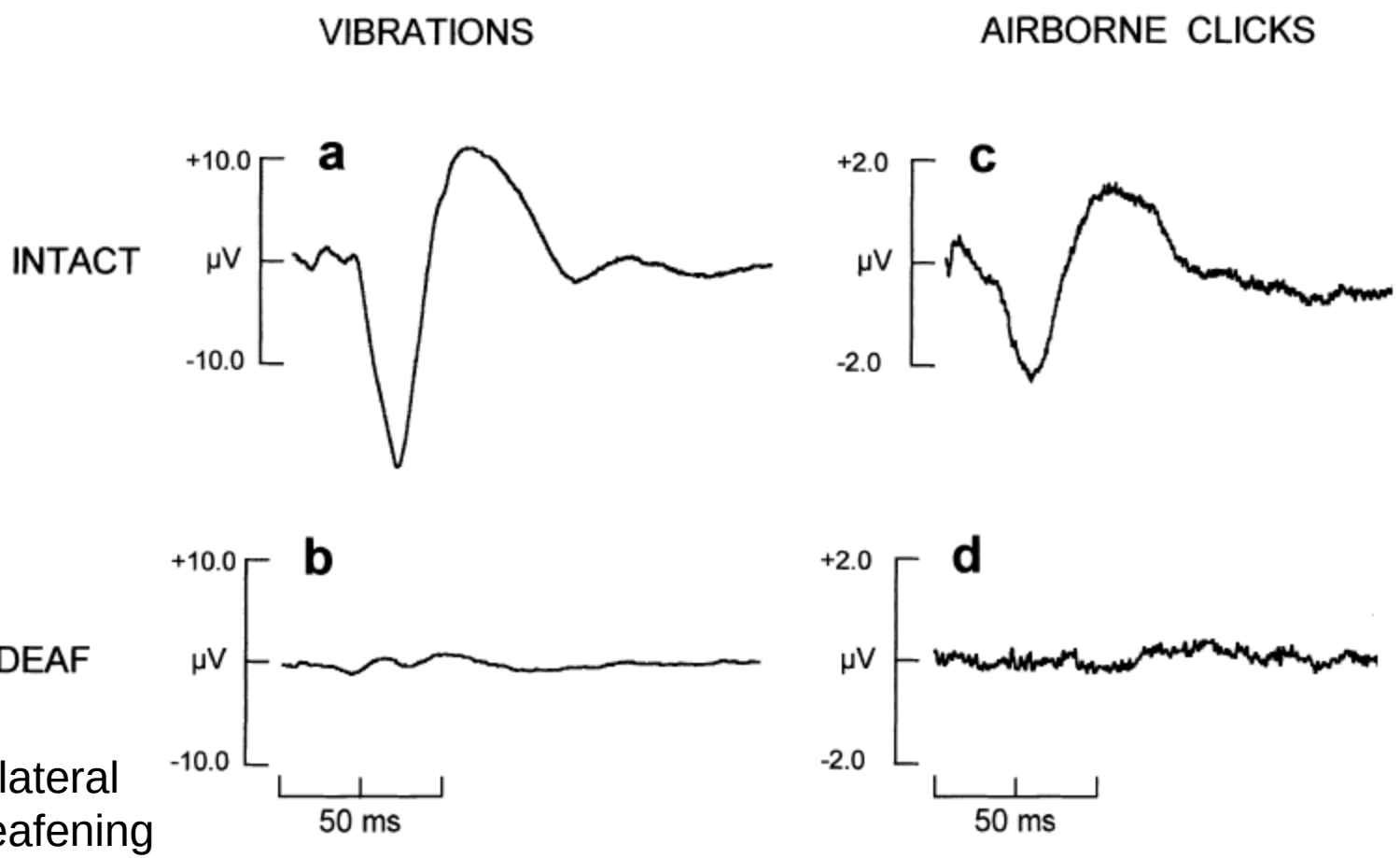
Middle latency response (MLR)



Jaw is barely touching the tube

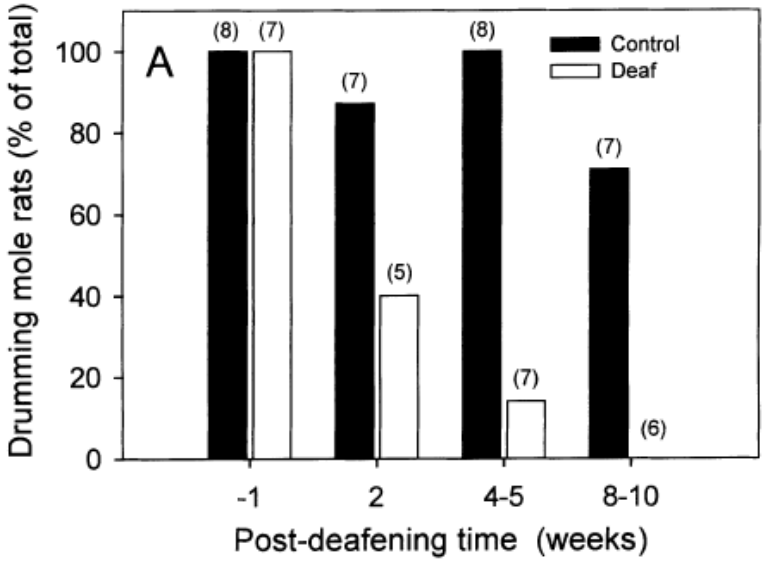
Jaw is laying on the tube

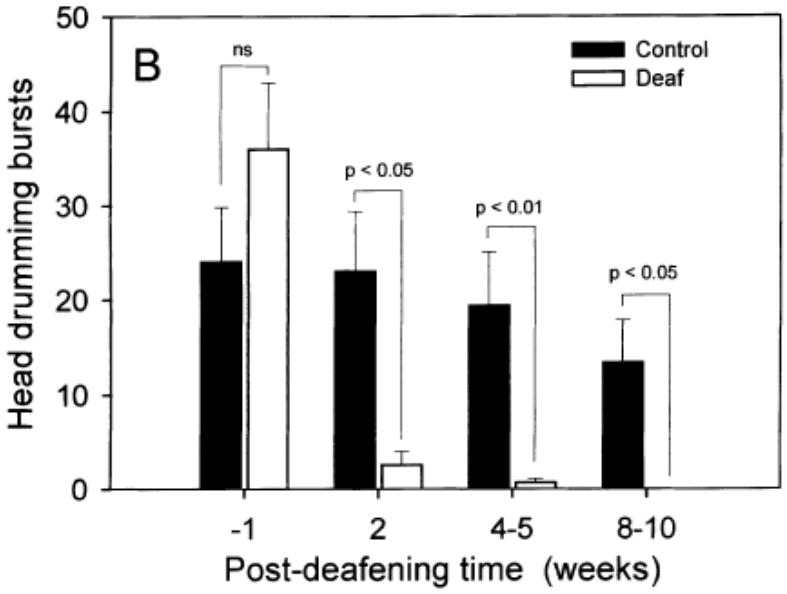
Jaw is firmly pressed against the tube surface



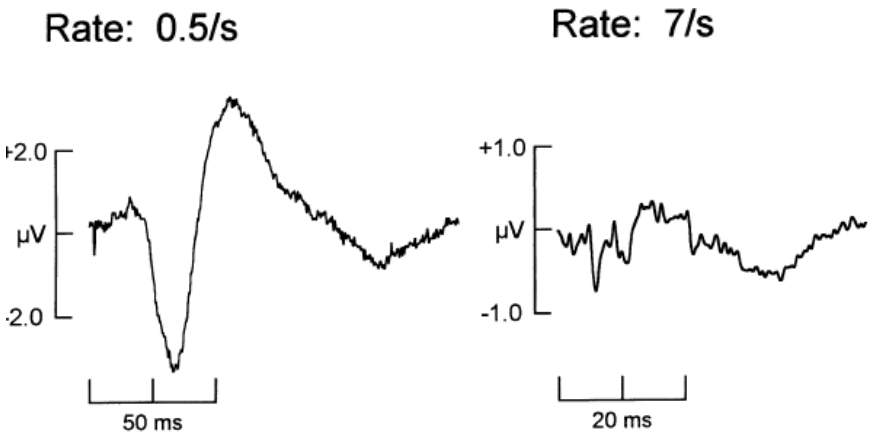
Bilateral deafening

Effect of bilateral deafening on the mole-rat head-drumining behavior

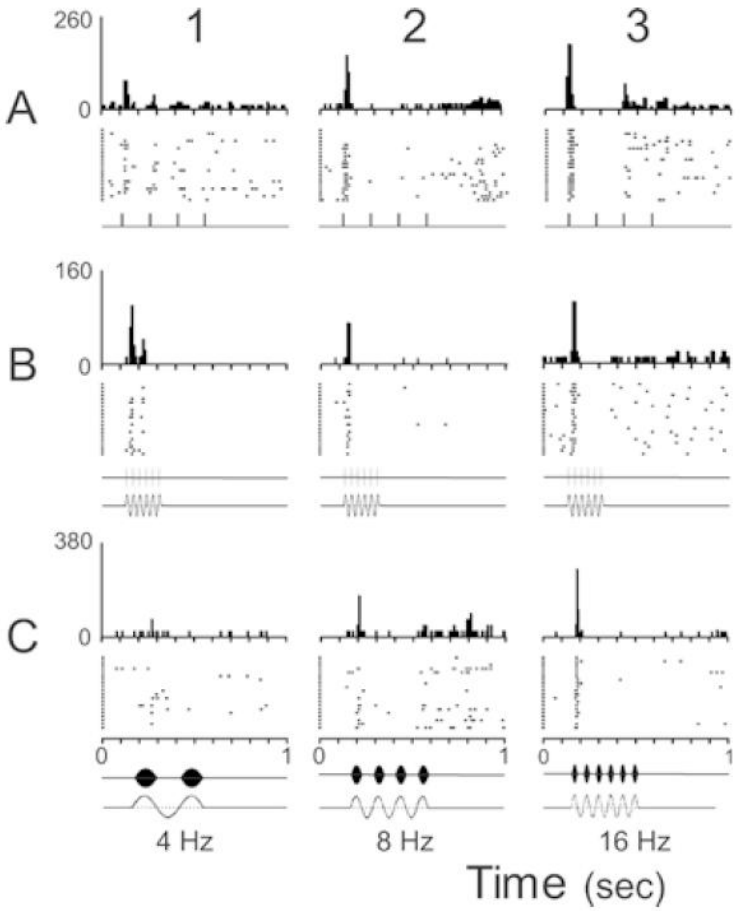




Vibration frequency



Middle latency response (MLR)



Single cell recording in the auditory cortex

Animal Communication