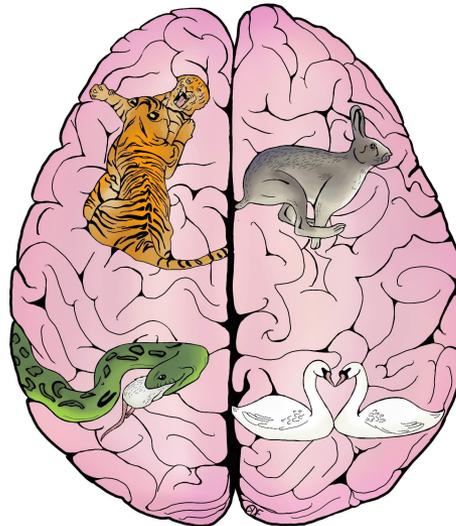


The Study of Instinct

Unraveling the neurobiological
basis of behavior

Outline

- **Part I:** basic concepts in the study of the biological basis of behavior
- **Part II:** modern tools for studying behavior
- **Part III:** recent discoveries in the neurobiology of behavior; implications for human health.



Motivation

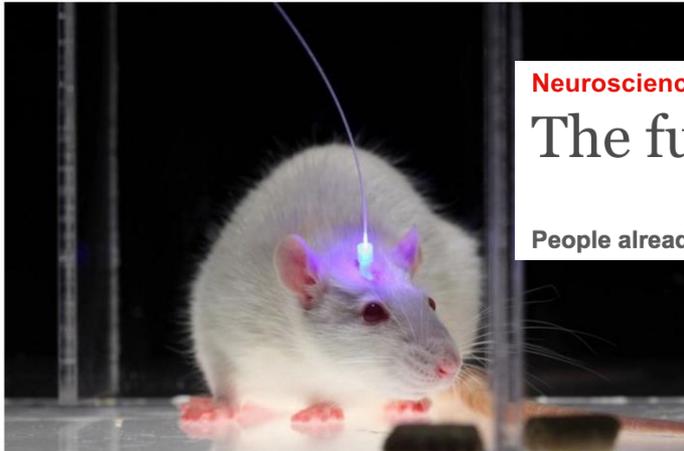
Risky Rats Give Clues on Brain Circuitry Behind Taking a Chance

SCIENCE

By PAM BELLUCK MARCH 23, 2016



Brain Control in a Flash of Light



Neuroscience

The future of mind control

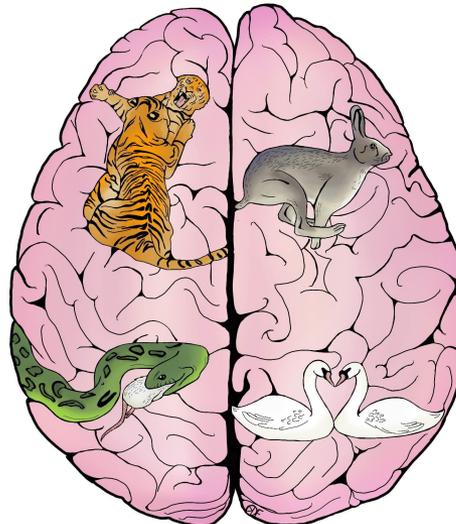
People already worry about genetics. They should worry about brain science too

SCIENCE

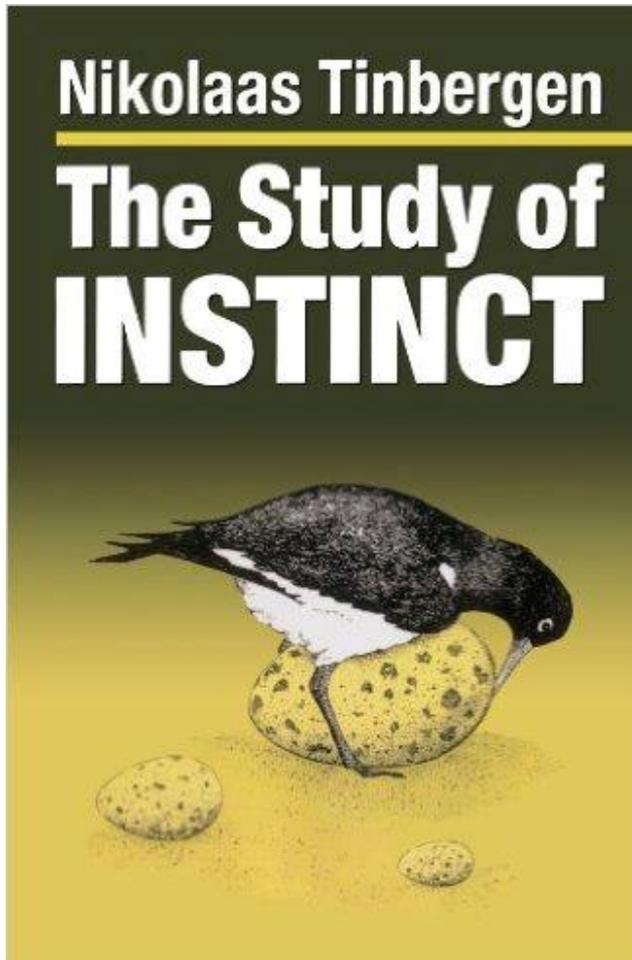
A Mouse Switch Turns Off Appetite

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Basic concepts of behavior



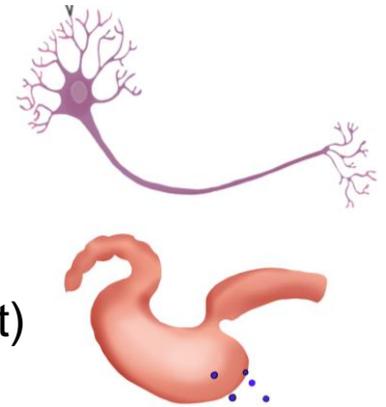
Behavior

the total movements made by an intact animal.

Innate or **instinctive** behaviors those that are not changed through learning.

External and **internal** stimuli

- external = things in our surrounding environment
- internal = our “drives” and motivations (e.g. hunger, thirst)



Two historical approaches to studying behavior

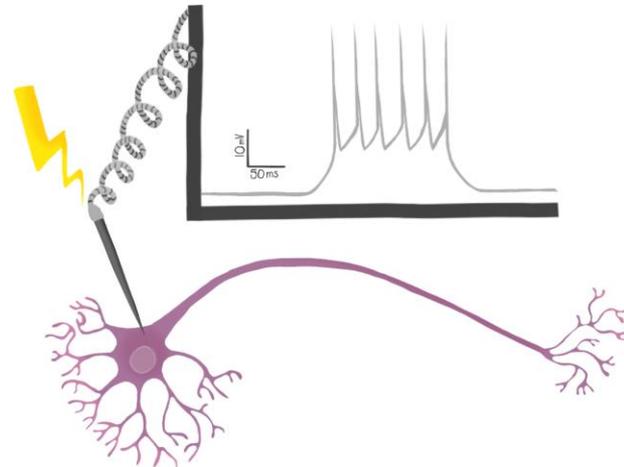
Ethological approach

- **Pros:** observe whole animal in natural environment.
- **Cons:** subjective; lacks mechanistic insight.



Neurophysiological approach

- **Pros:** controlled experiments; rigorous and quantitative
- **Cons:** Constrained, non-naturalistic conditions.



The four Fs of evolution

- **Fighting**



- **Fleeing**



- **Feeding**

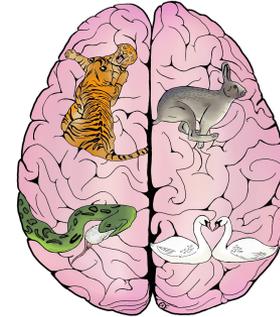


- **And...**



Drive, homeostasis, and valence

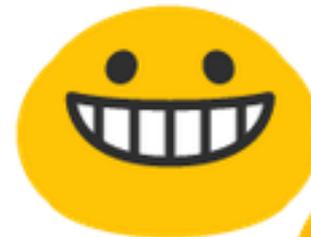
- Hunger, thirst, mating, sleep, thermoregulation, etc. are universal ***motivational drives***.



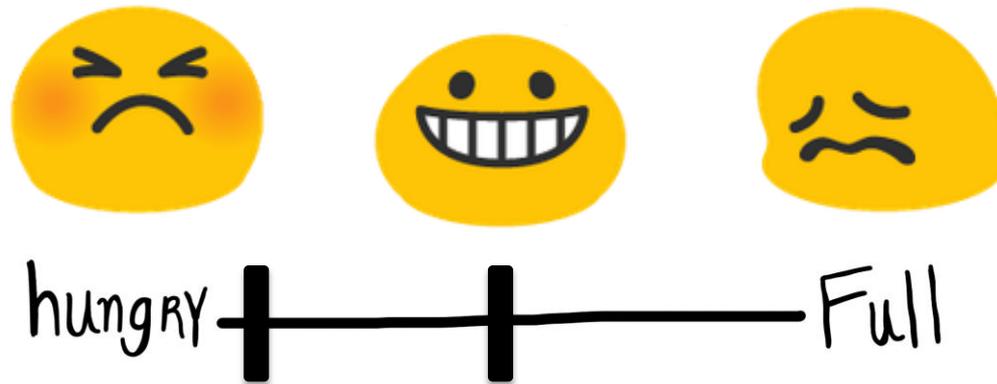
- **Homeostasis:** The regulation of biological systems such that internal conditions remain stable, at some predetermined “set point.”



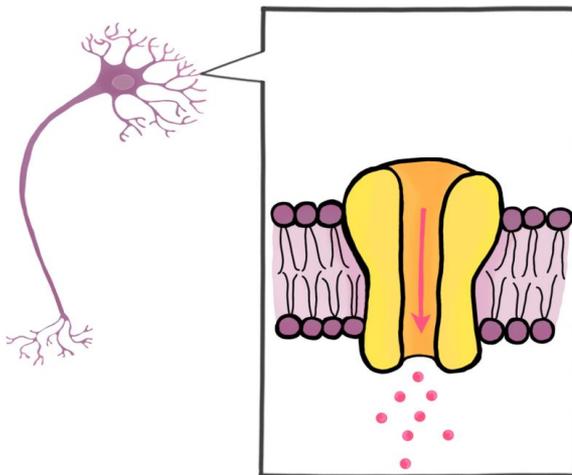
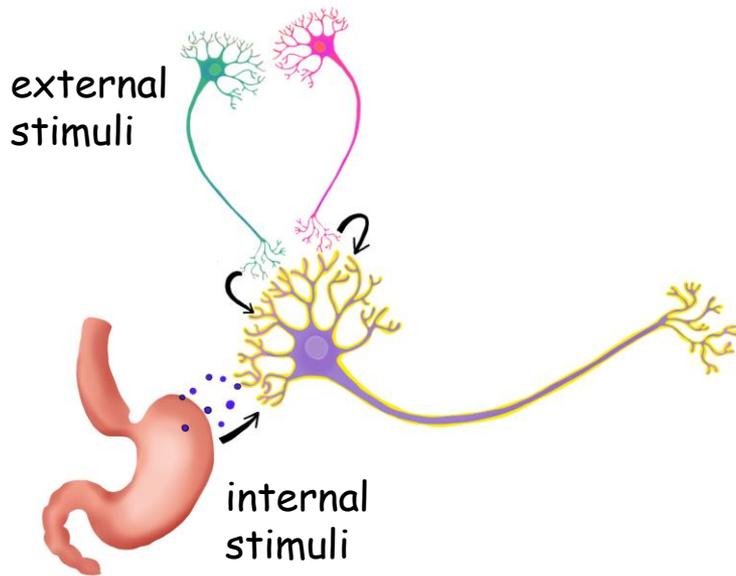
- Things that bring us closer to our set point take on a ***positive valence*** (good/pleasurable)
- Things that move us away from our set points take on a ***negative valence*** (bad/unpleasant)



Homeostasis, drive, and valence



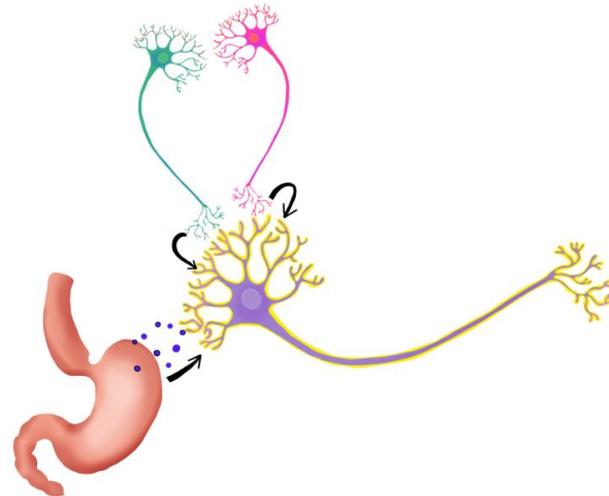
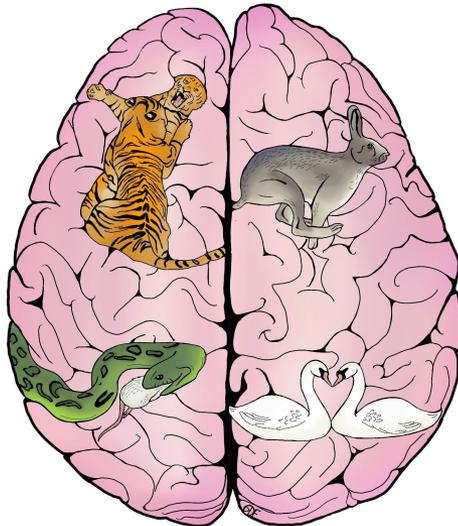
The **hypothalamus** contains circuits controlling our basic drives



- Hypothalamic neurons controlling basic drives **integrate** information from the brain and body.
- Drive circuits **coordinate** the brain and body in order to produce adaptive behaviors.
- Achieve this by sending neural signals to multiple brain regions in parallel.

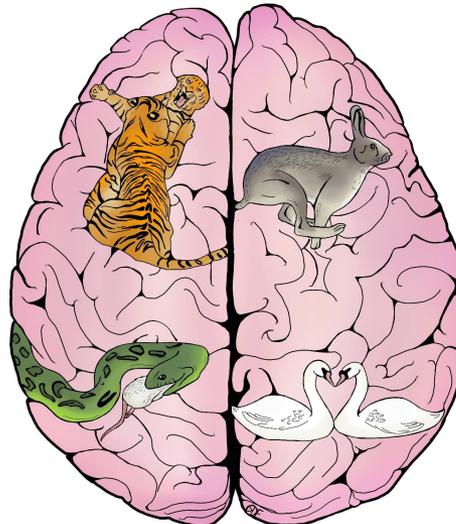
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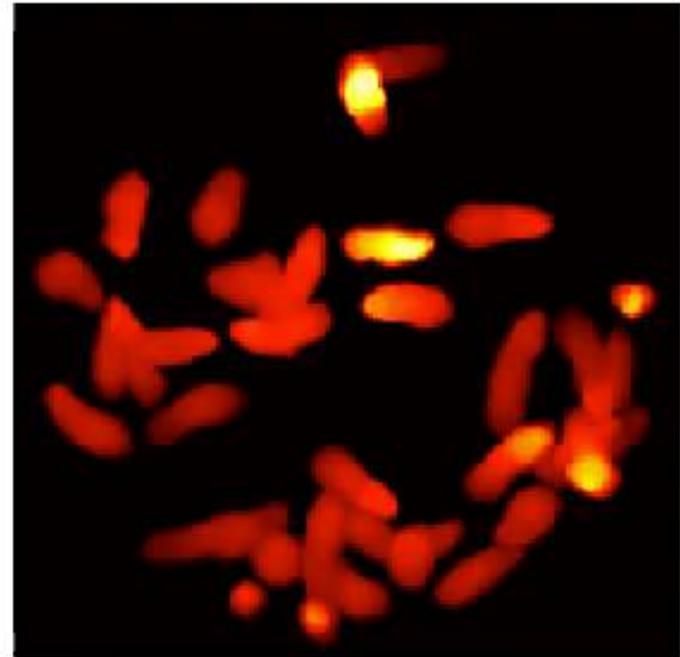


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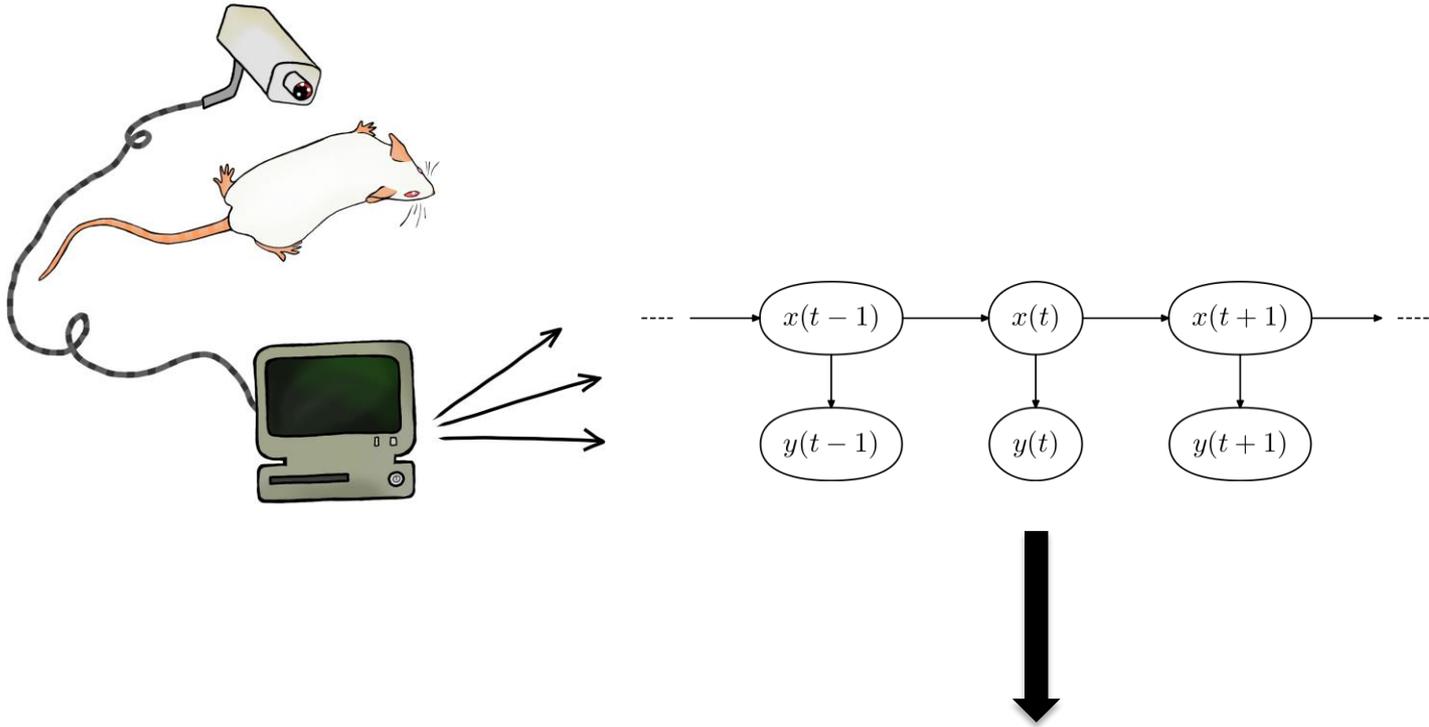


Unbiased methods for observing behavior



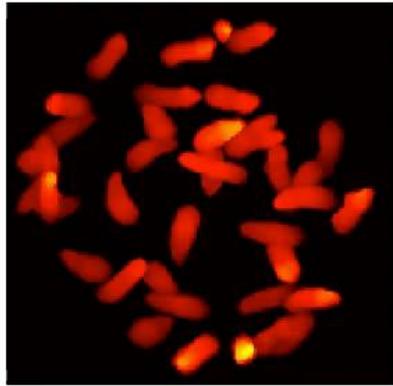
“Turn to Right”

Unbiased methods for observing behavior

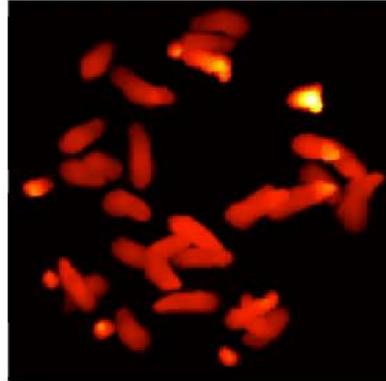


Objective classification of behaviors

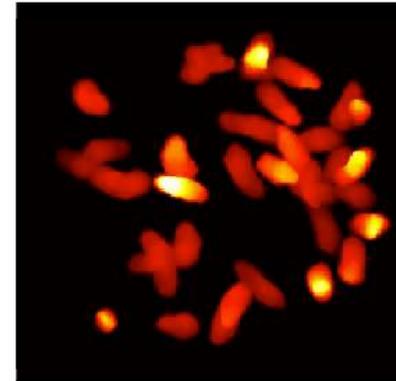
Unbiased methods for observing behavior



Sway



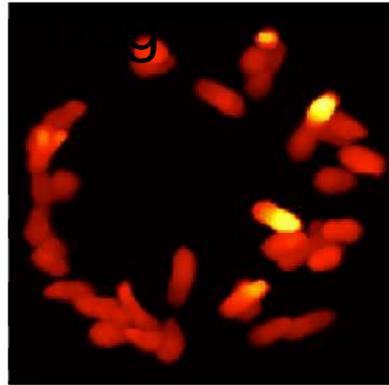
Hunting



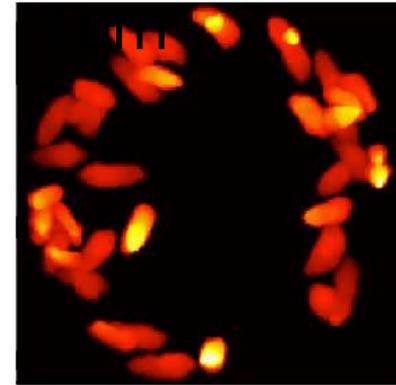
Rear and



Pause

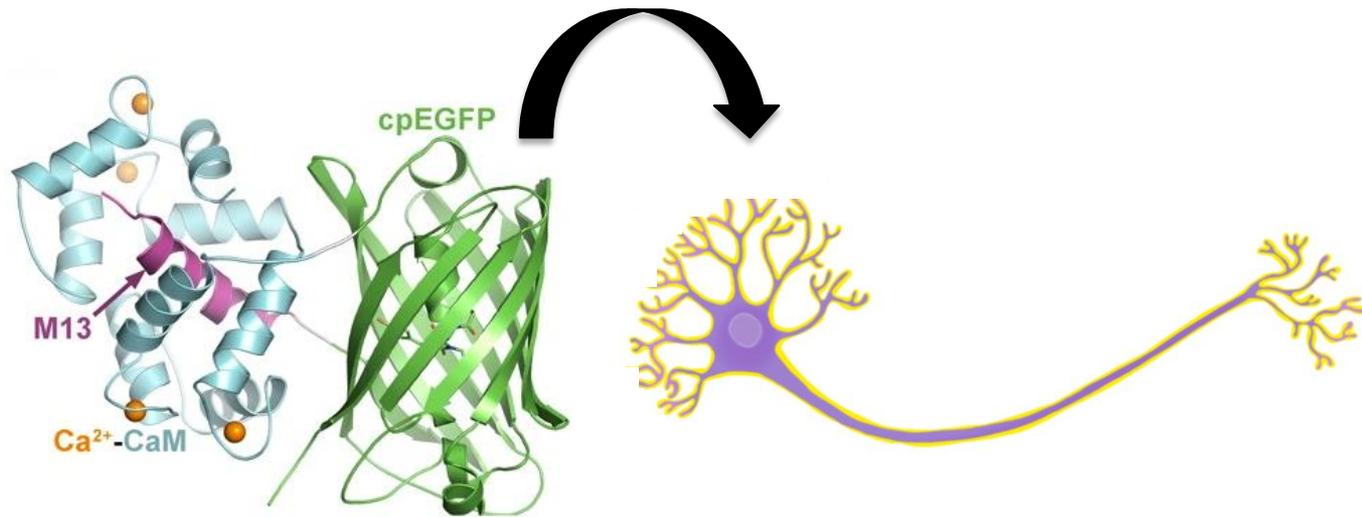


Hunch
And Freeze

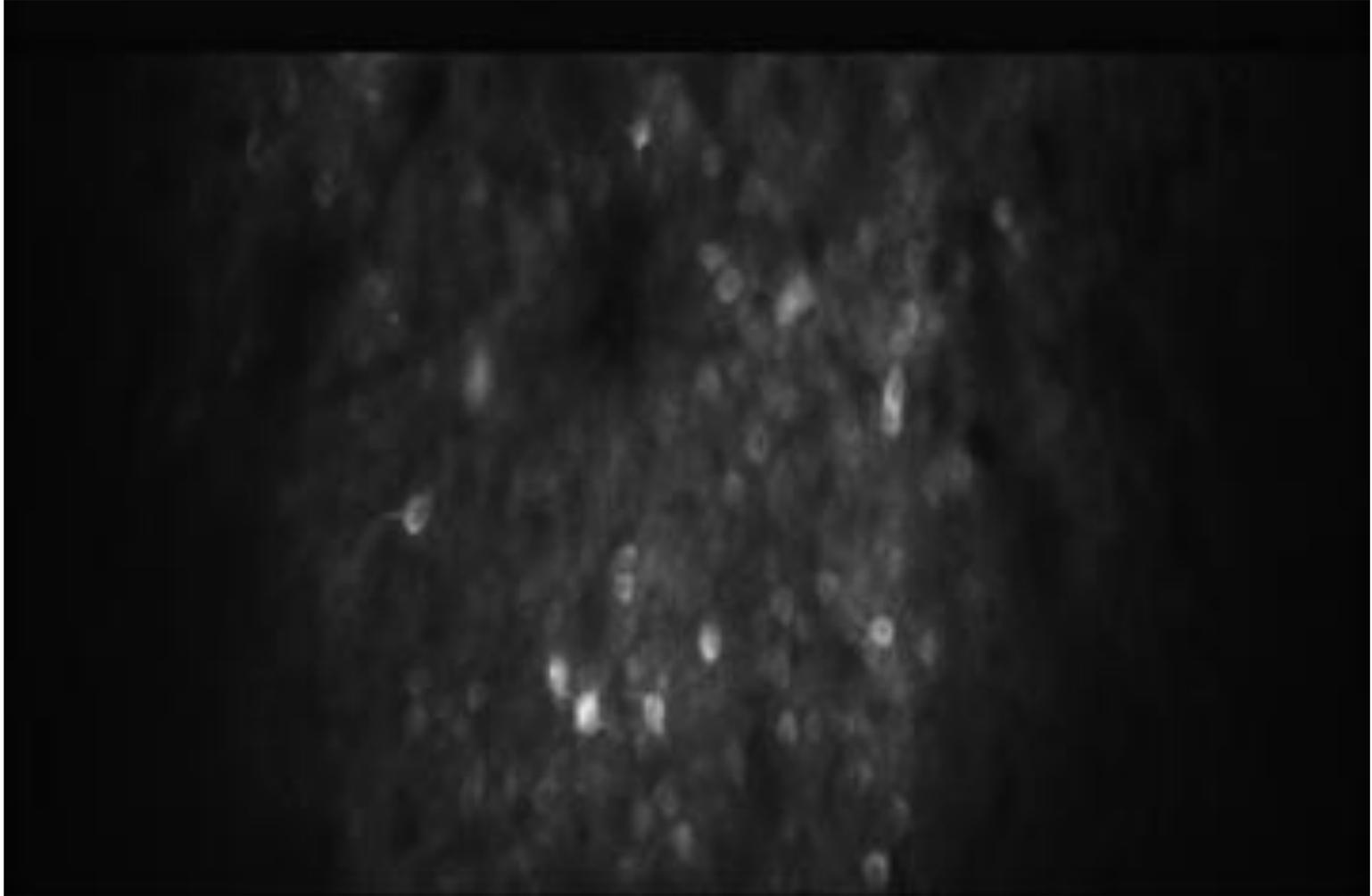


Run, Forrest,
Run

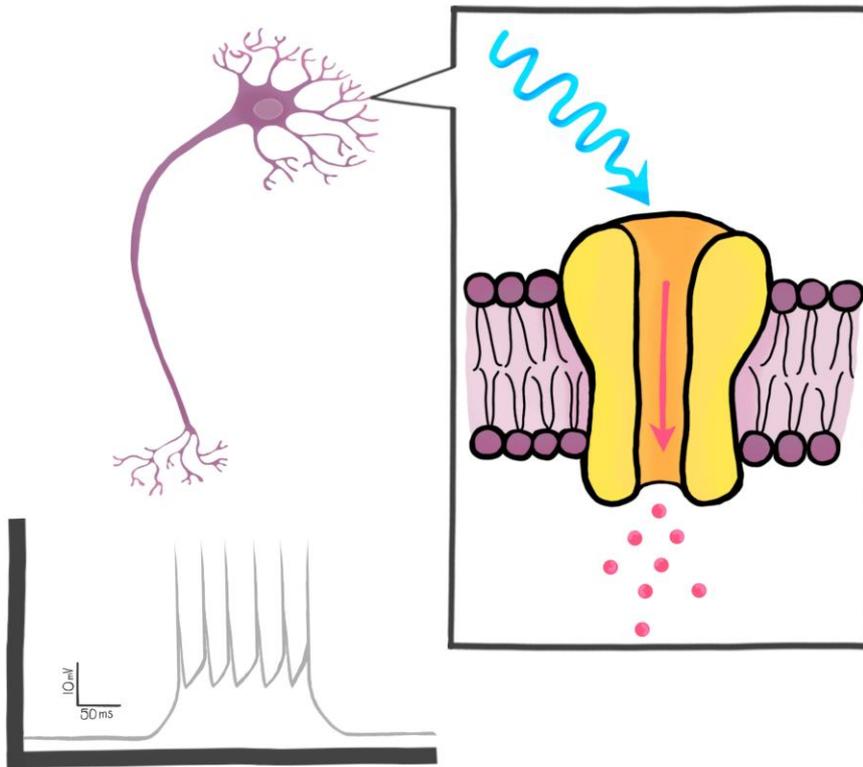
Measuring neural activity: calcium imaging



Measuring neural activity: calcium imaging



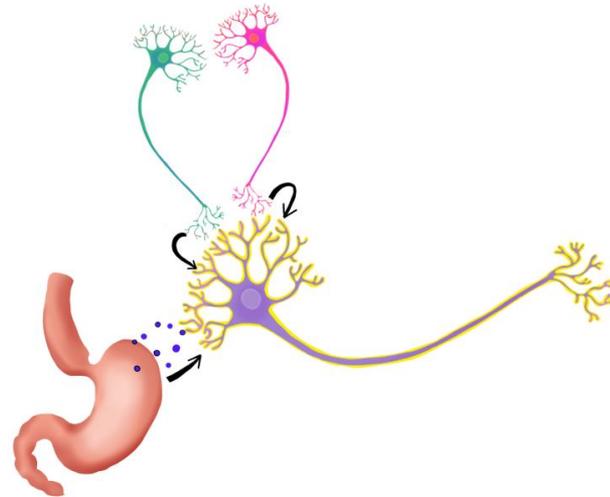
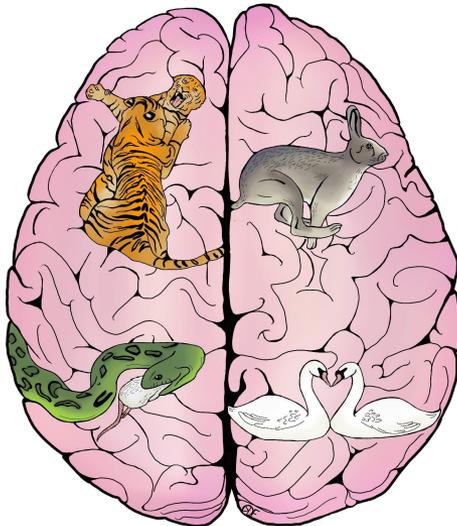
Controlling neural activity: optogenetics



Genetically engineered animal + fiber optic

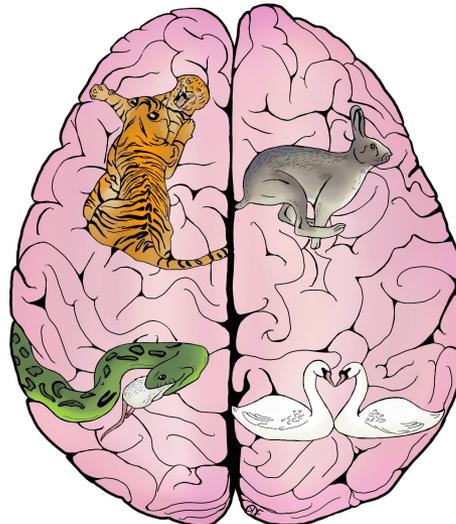
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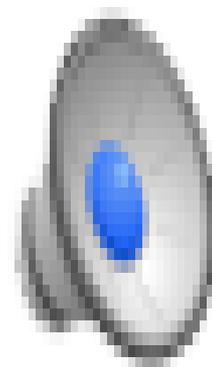
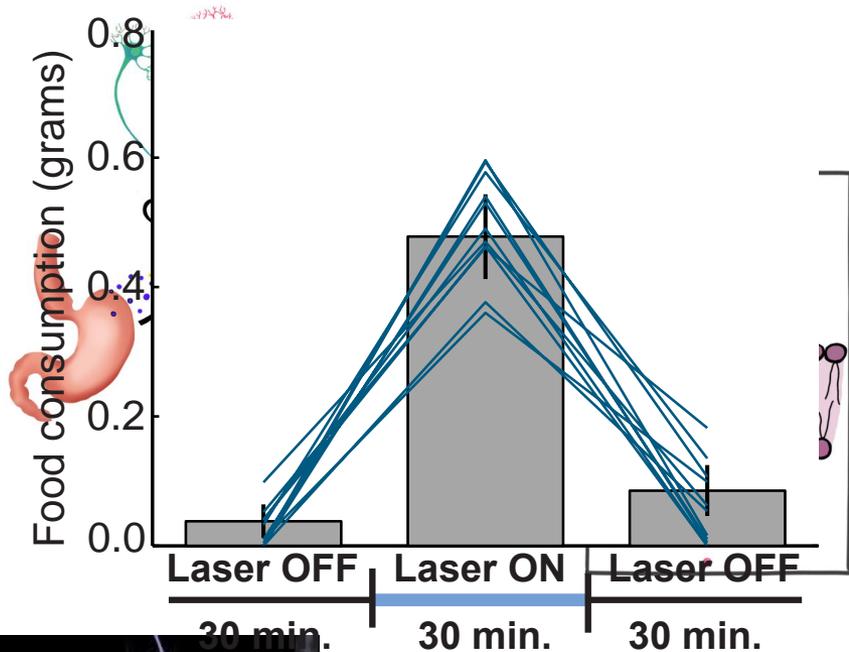


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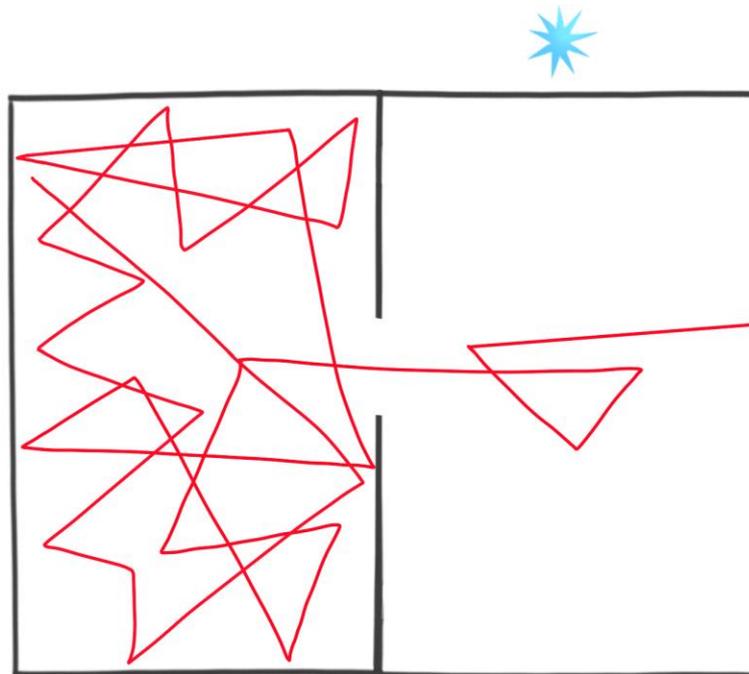


Optogenetic control of “hunger neurons”



Genetically engineered animal + fiber optic

“Hunger neurons” carry a **negative valence**



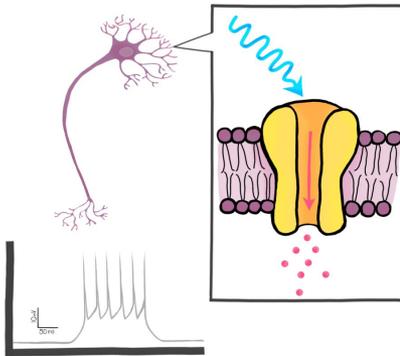
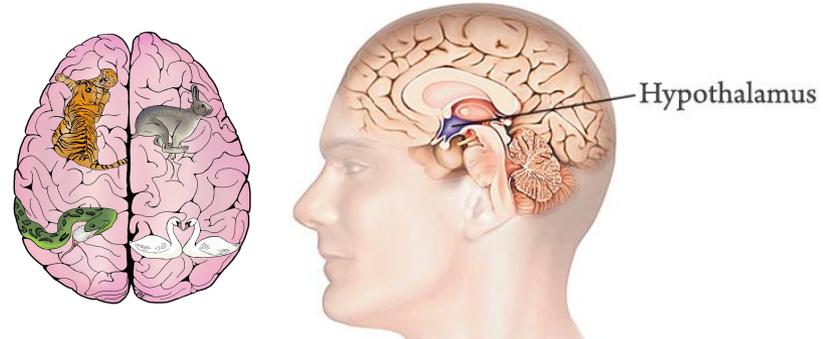
Optogenetic control of “aggression neurons”



Video courtesy of
Dr. Dayu Lin (NYU)

Conclusions

- The **hypothalamus** is a key brain region controlling the basic **motivational drives** common to all animals.



- New technologies allow neuroscientists to rigorously **observe** behavior, **record** neural activity, and **manipulate** neurons in awake, behaving animals.

- Techniques such as **optogenetics** allow us to attribute **causality** to specific brain circuits in the control of motivational drives



Clinical applications... and beyond?

- **Therapy** – variable effectiveness; doesn't work for certain problems, e.g. epilepsy, neurodegeneration



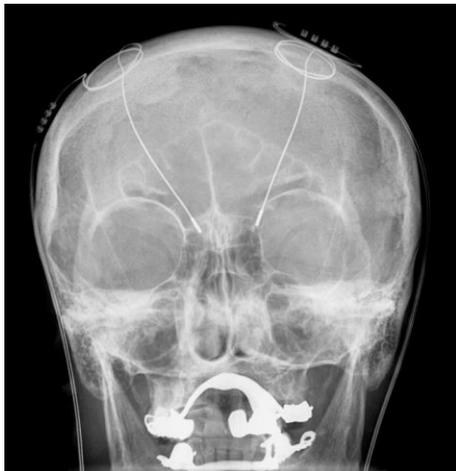
- **Drugs** – Variable effectiveness, commonly have multiple side effects

- **Surgery** – Highly invasive; irreversible.



Clinical applications... and beyond?

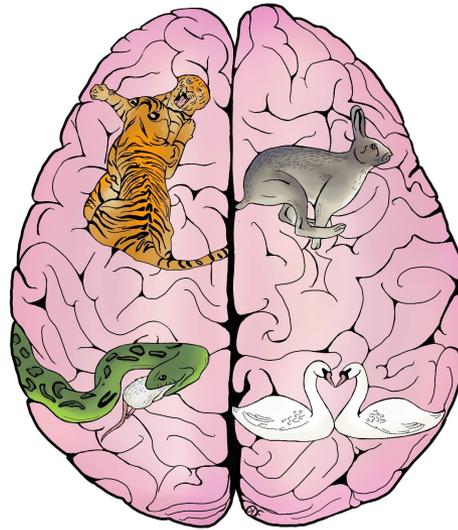
- Optogenetic therapies?
- Recently used to control pain in mice; opiates are common treatment in humans



- Reversibly “turn off” parts of the brain, e.g. intractable epilepsy
- ...in principle, could also control more “psychological” traits e.g. depression, aggression.

Acknowledgements

- **Co-directors:** Steph Guerra, Katie Wu (sitnboston@gmail.com)
- **Seminar series directors:** Jordan Wilkerson, Stephen Portillo
- **Graphics artist:** Olivia Foster



The Study of Instinct:

unraveling how the brain generates behavior

Wednesday, May 18th, 7:00PM

Pfizer Lecture Hall,

12 Oxford Street, Cambridge, MA

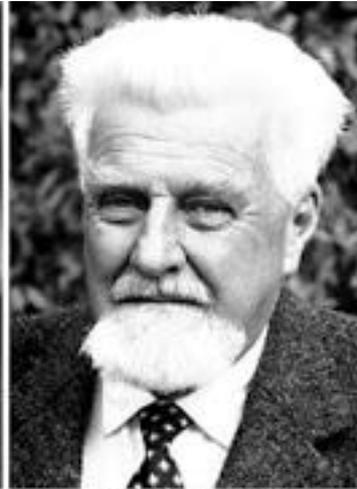


Questions?





Karl von Frisch
(1886 - 1982)



Konrad Lorenz
(1903 - 1989)



Nikolaas Tinbergen
(1907 - 1988)

