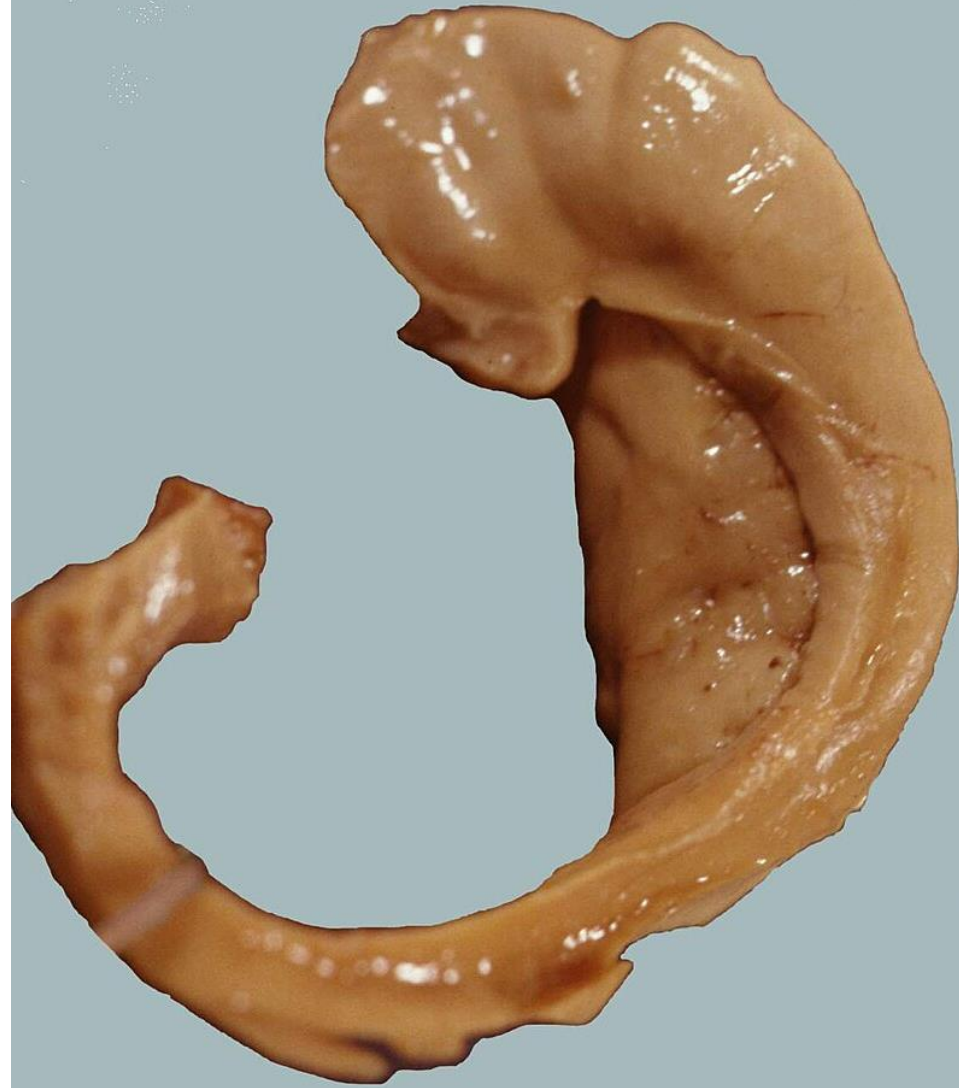


Applications of pynapple: Signal processing and decoding

Sarah Jo Venditto

Background: Hippocampal physiology

Place cells
Theta oscillations
Theta sequences
Phase precession

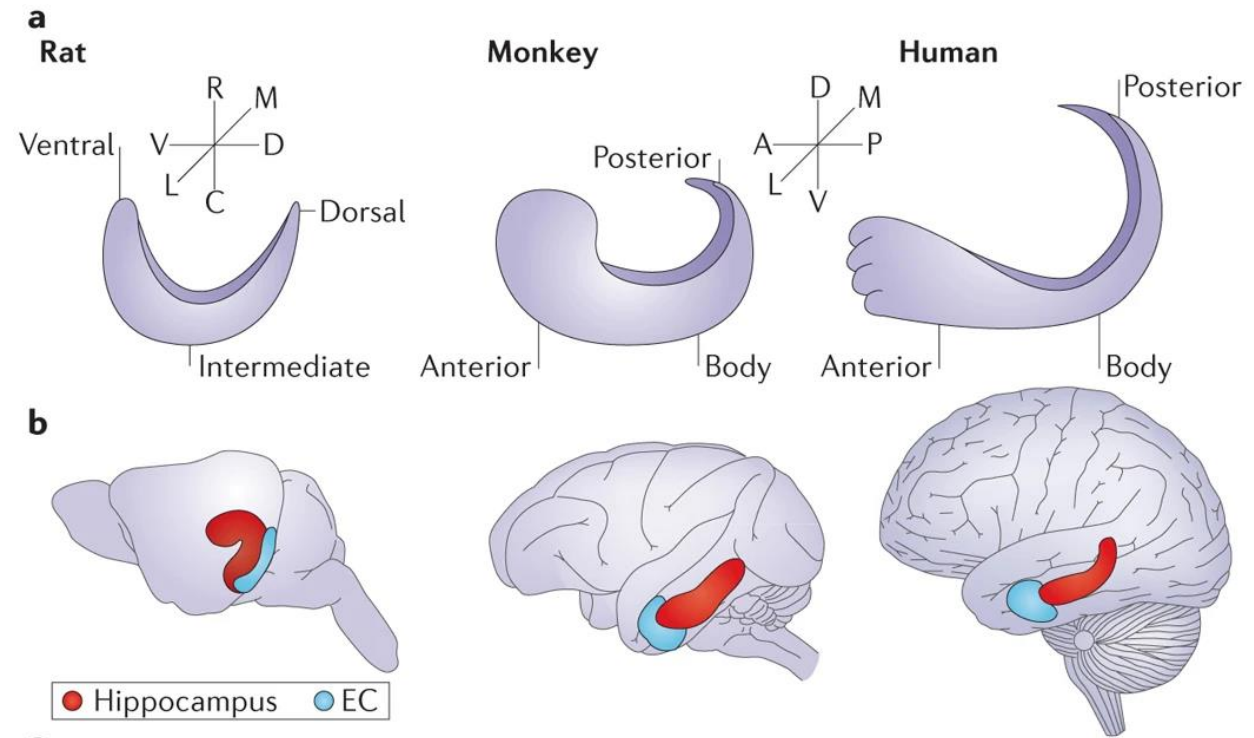


Hippocampus shows homologous function across mammals

Learning and memory
 Scoville & Milner, 1957

Spatial representations
 O'Keefe & Dostrovsky, 1971

Cognitive map hypothesis
 O'Keefe & Nadel, 1978



Strange, B., Witter, M., Lein, E. *et al.* Functional organization of the hippocampal longitudinal axis. *Nature Reviews Neuroscience* (2014).

Properties of hippocampal physiology

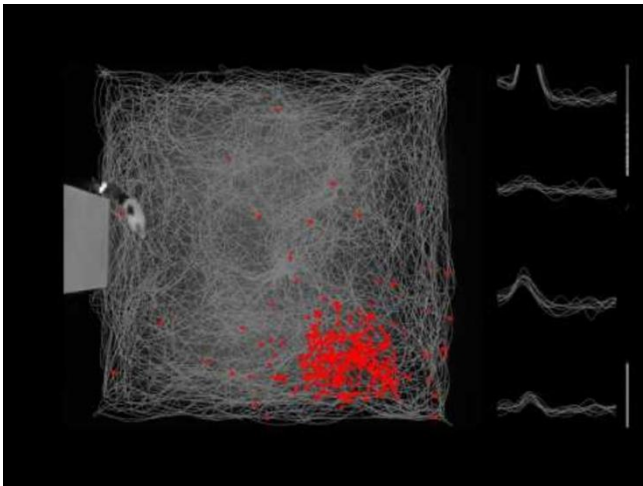
PLACE CELLS

Pyramidal cells in the hippocampus that preferentially fire when the animal is visiting a specific location

Properties of hippocampal physiology

PLACE CELLS

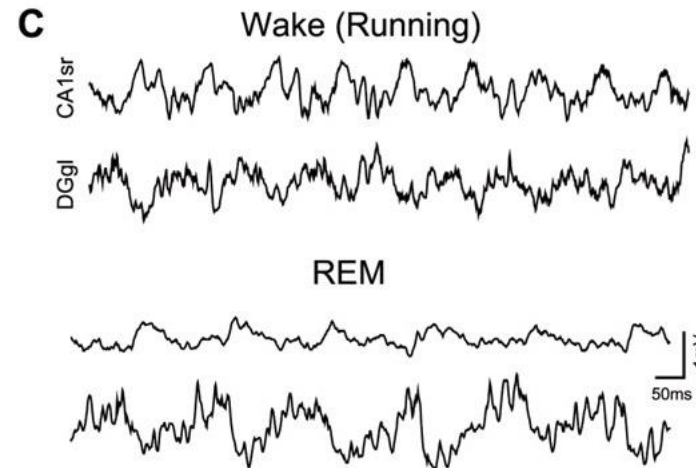
Pyramidal cells in the hippocampus that preferentially fire when the animal is visiting a specific location



Grieves, R.M., Jedidi-Ayoub, S., Mishchanchuk, K. *et al.* The place-cell representation of volumetric space in rats. *Nature Communications* (2020).

THETA OSCILLATIONS

A 6-12 Hz oscillation (in rodents) that dominates the local field potential (LFP) during awake behavior and REM sleep



Montgomery, S., Sirota, A., Buzsaki, G. Theta and Gamma Coordination of Hippocampal Networks during Waking and Rapid Eye Movement Sleep. *Nature Reviews Neuroscience* (2014).

THETA SEQUENCES & PHASE PRECESSION

Within each cycle of theta, place cells are organized into fast (~125 ms) spatial sequences representing past, present, and future locations.

This corresponds to a systematic relationship between where a place cell spikes within its place field and the coincident phase of the theta cycle, known as phase precession.

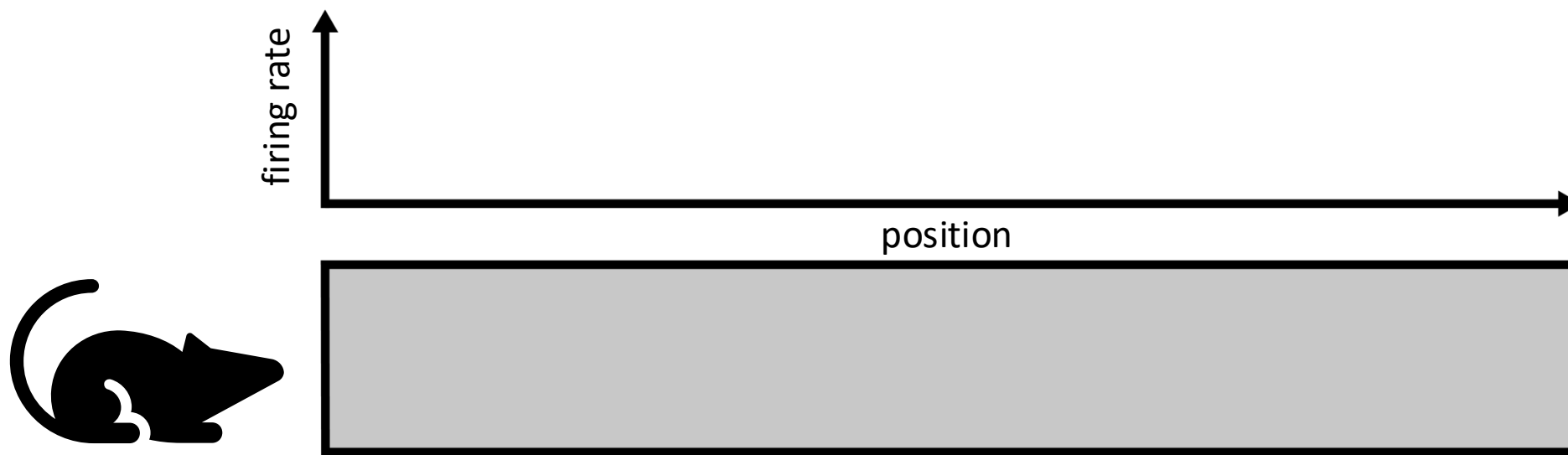
Illustrative example

Populations of **place cells** tile spatial environments.



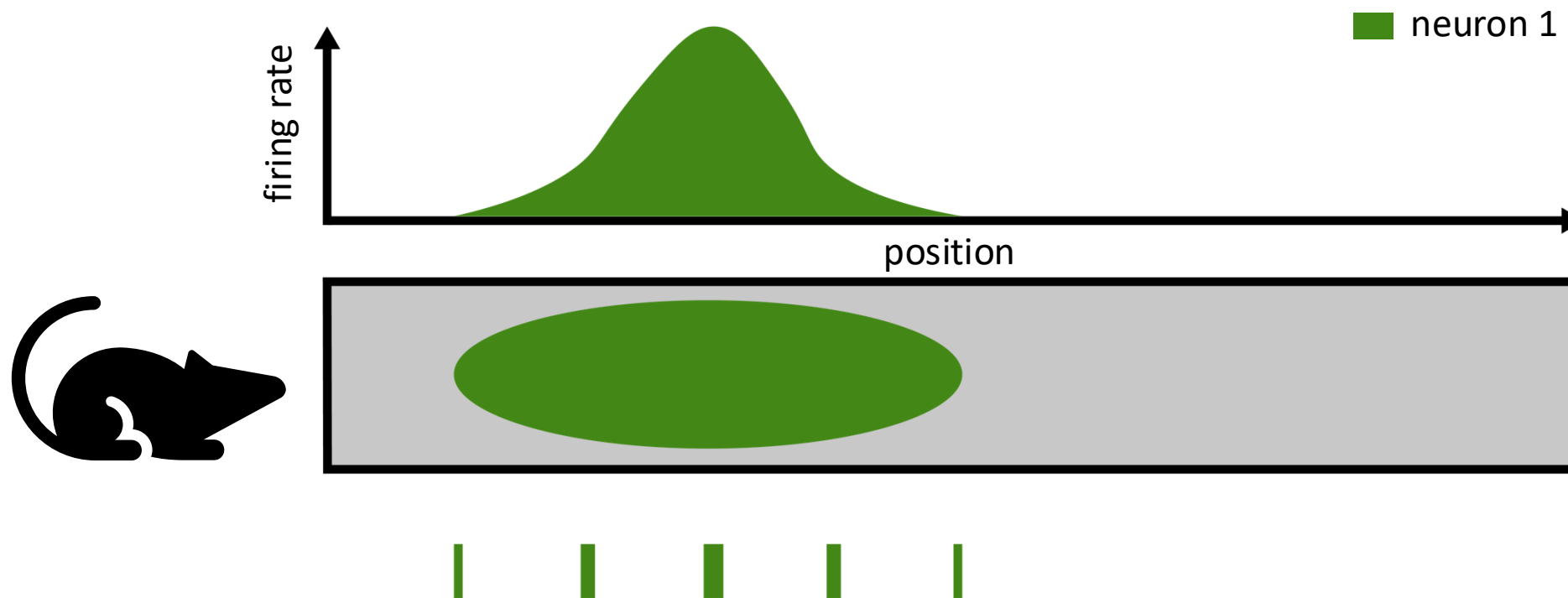
Illustrative example

Populations of **place cells** tile spatial environments.



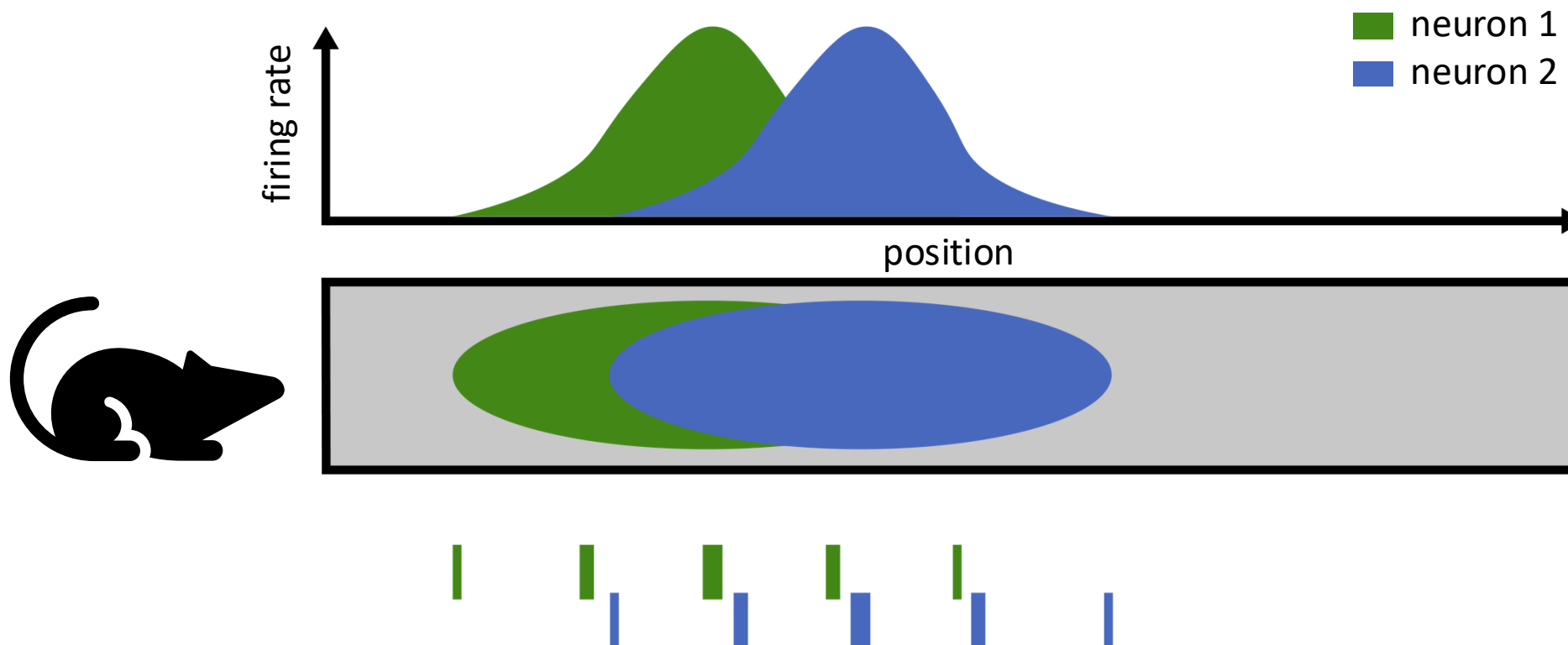
Illustrative example

Populations of **place cells** tile spatial environments.



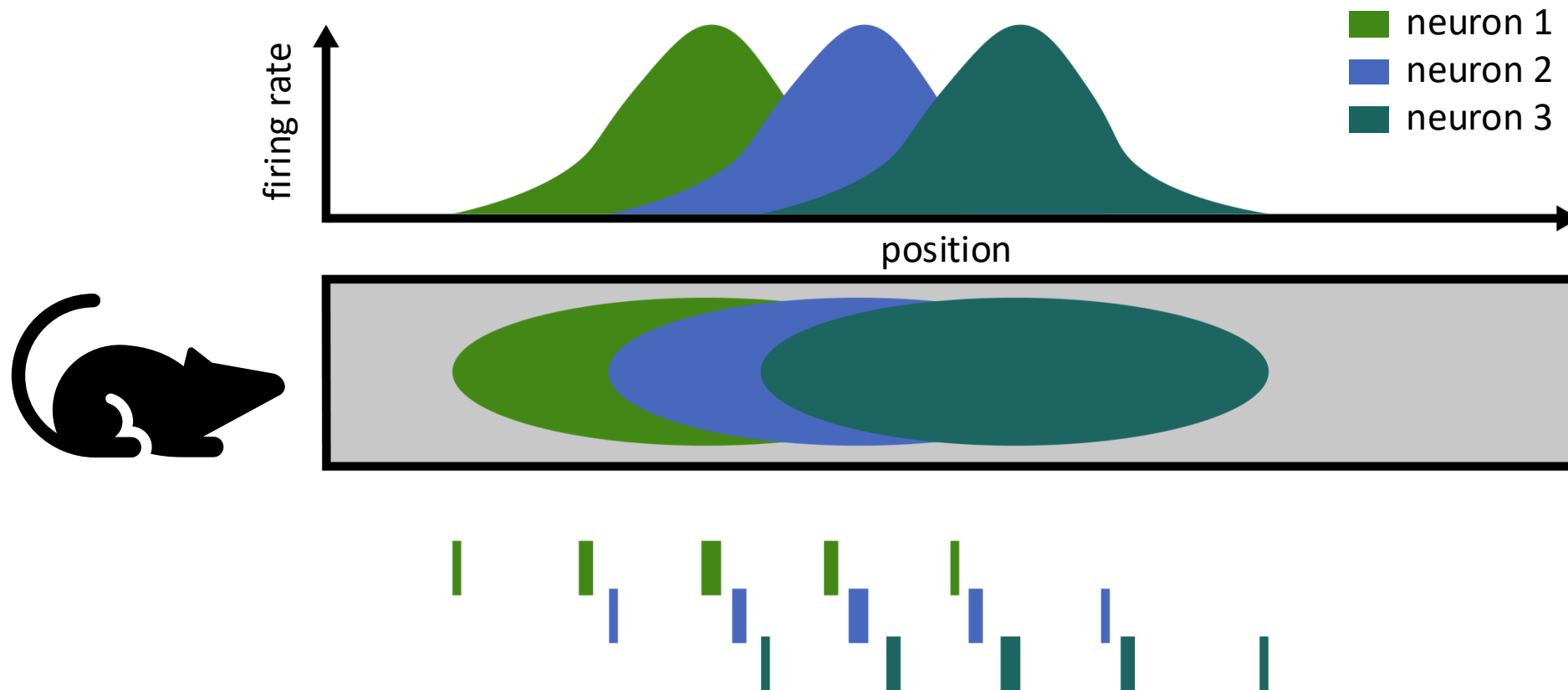
Illustrative example

Populations of **place cells** tile spatial environments.



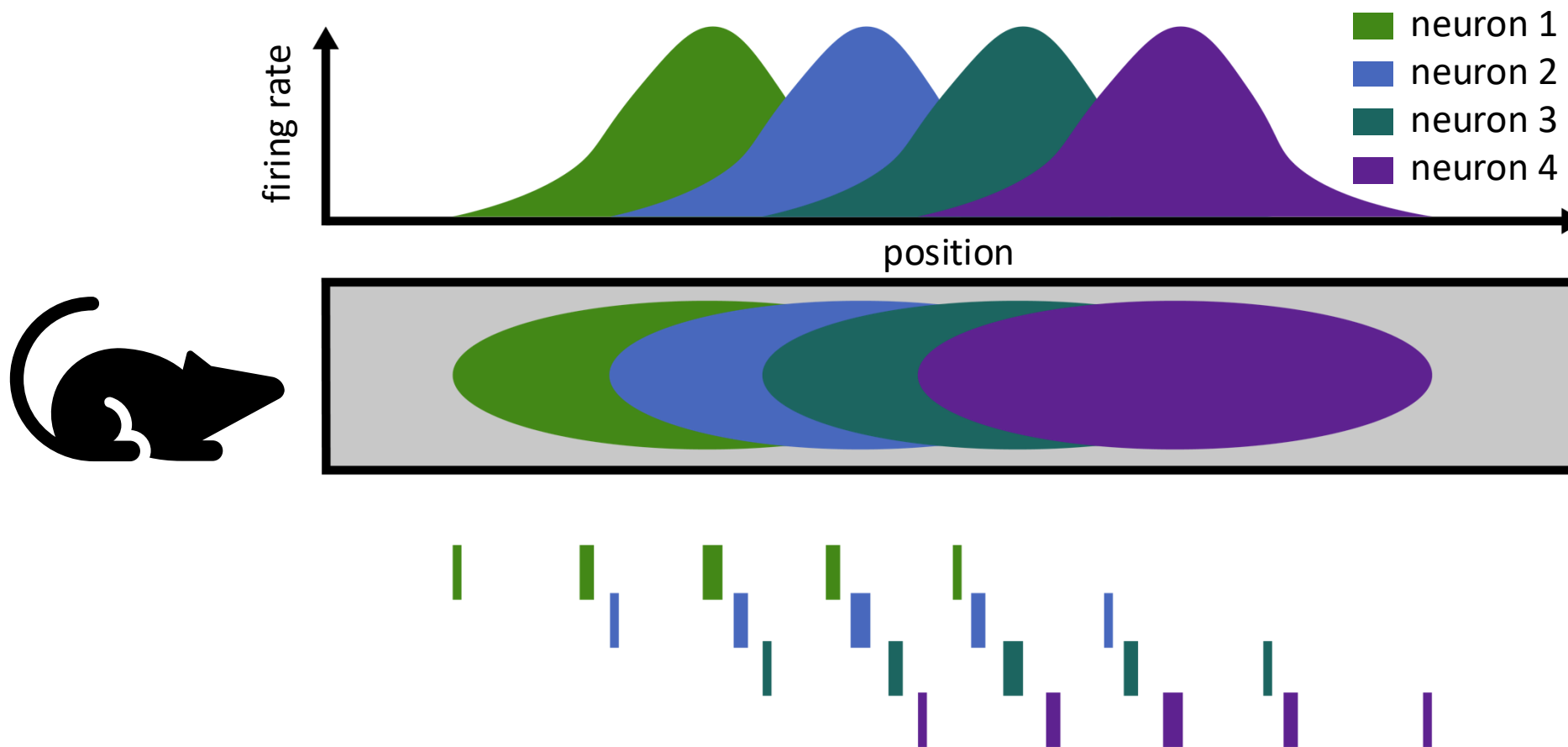
Illustrative example

Populations of **place cells** tile spatial environments.



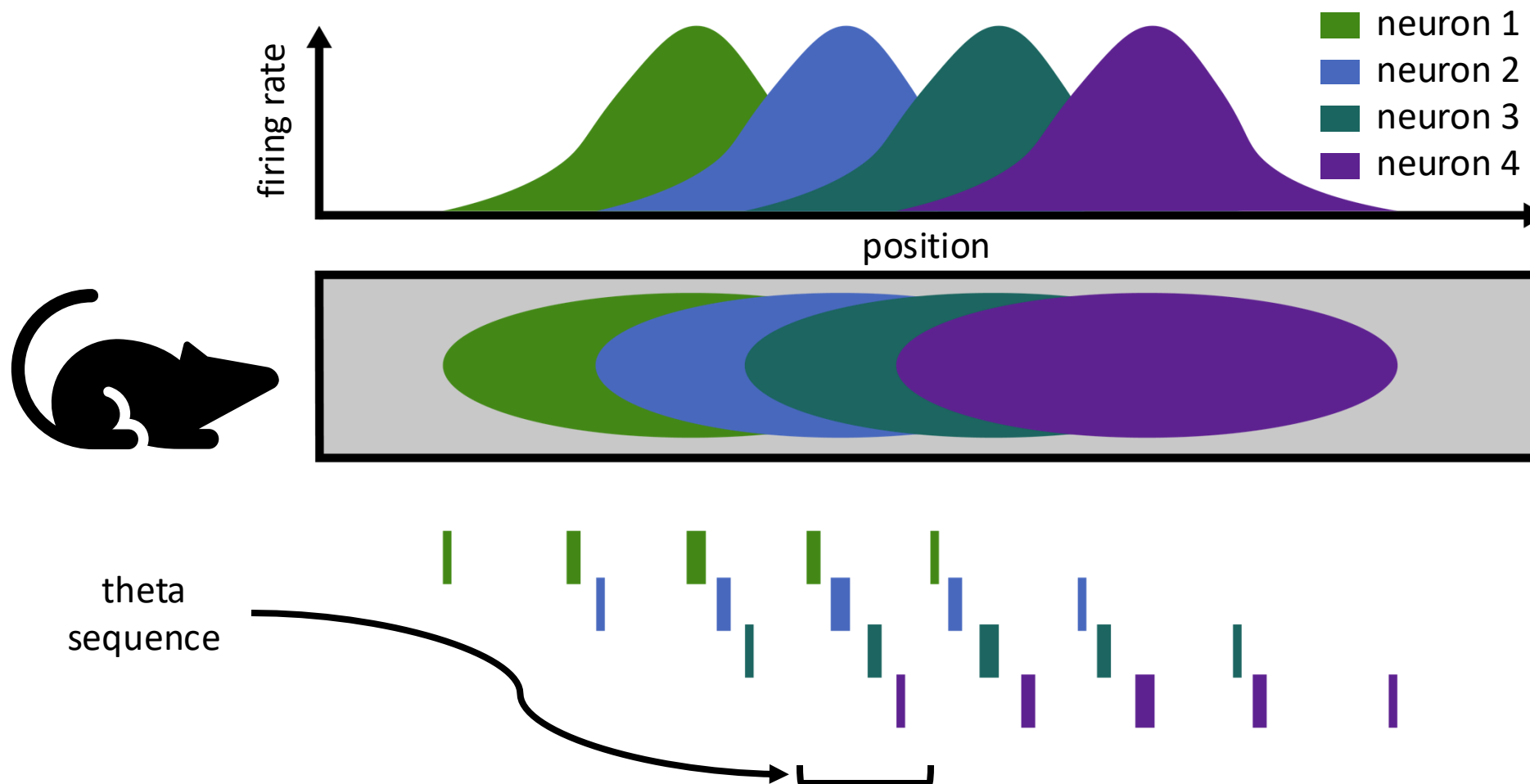
Illustrative example

Populations of **place cells** tile spatial environments.



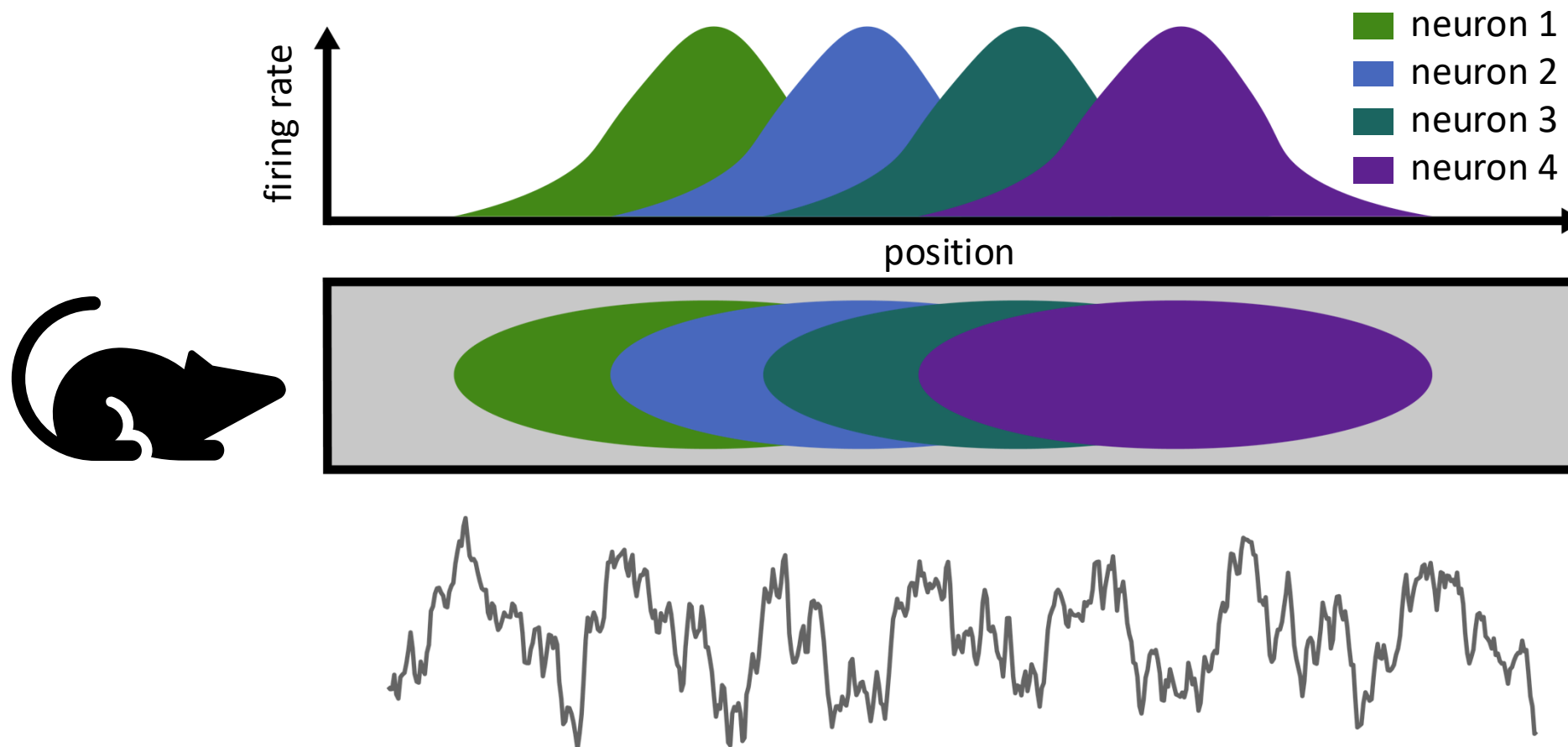
Illustrative example

Place cell activity is organized into fast *theta sequences*



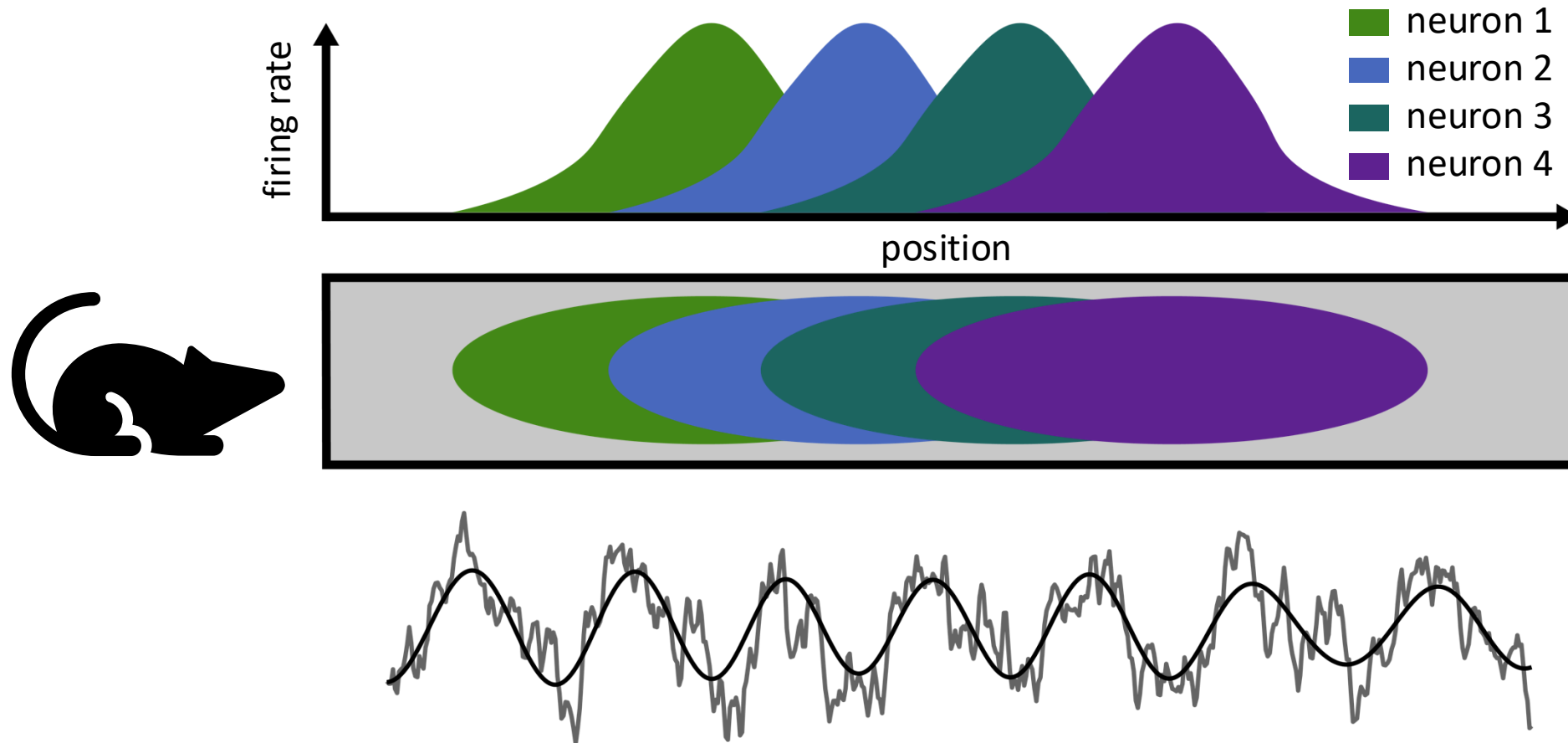
Illustrative example

Theta oscillations dominate the LFP while the animal runs down the track



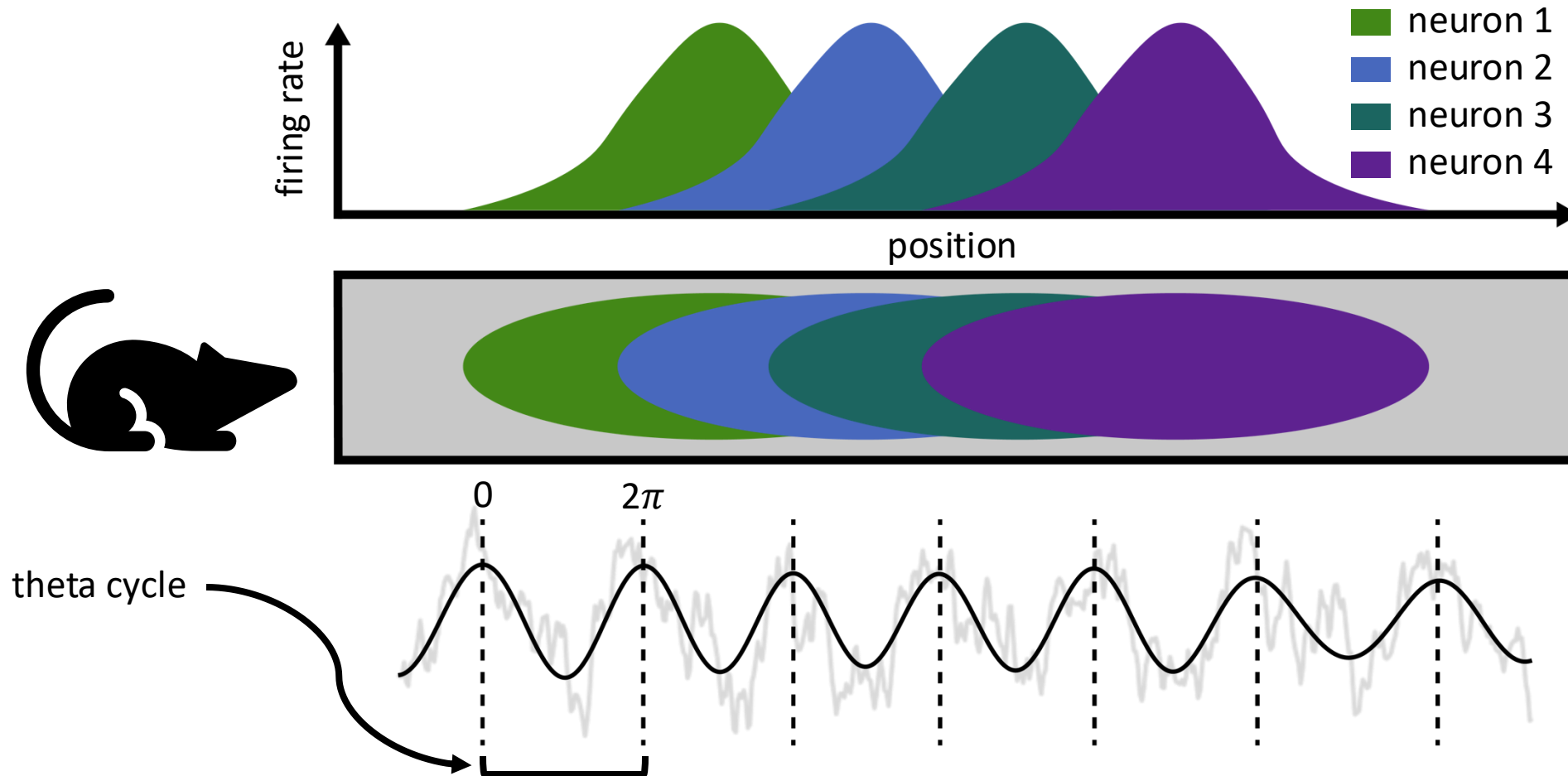
Illustrative example

Theta oscillations dominate the LFP while the animal runs down the track



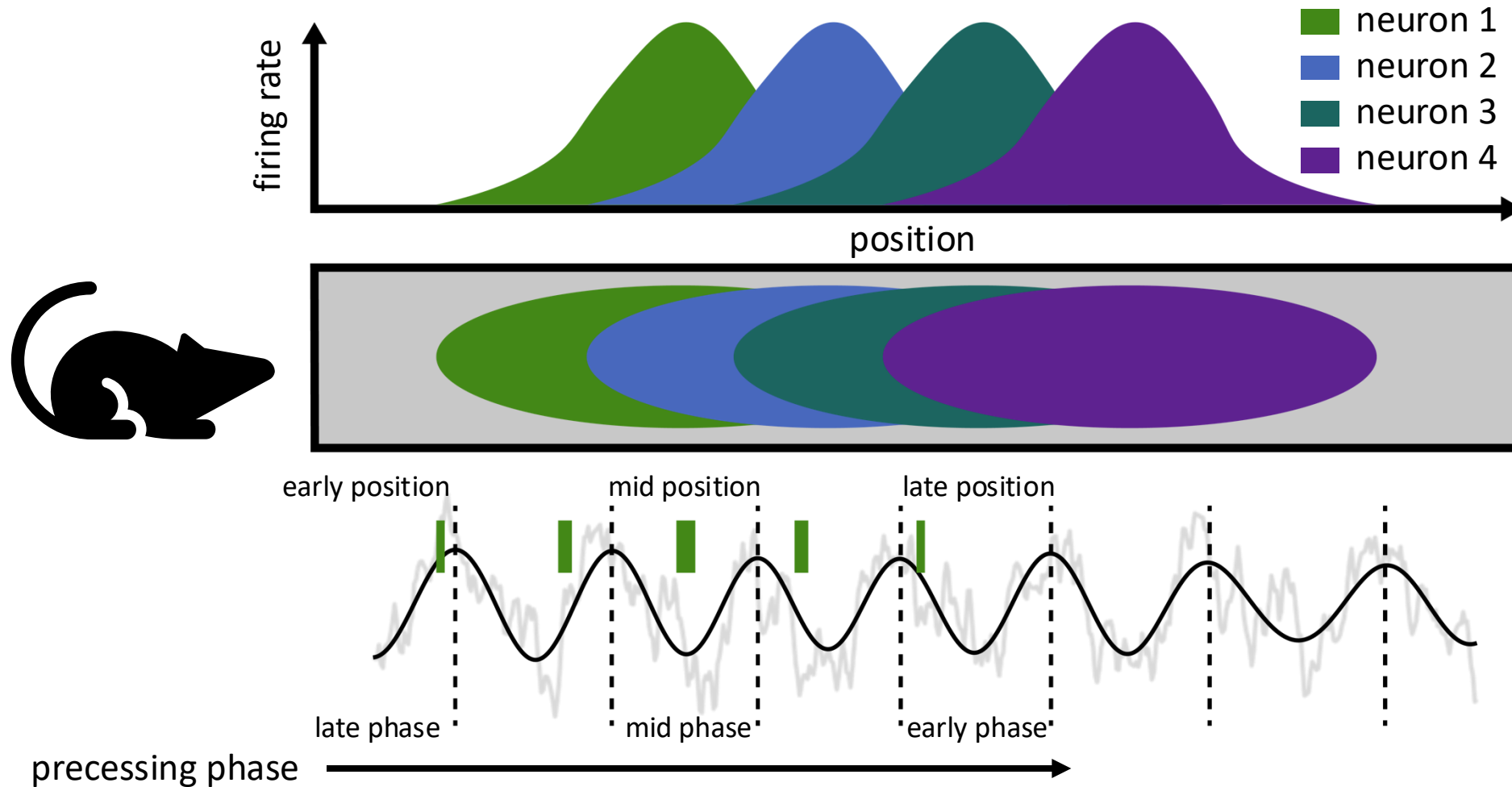
Illustrative example

Theta oscillations can be partitioned into *cycles*, described by a *phase* between 0 and 2π



Illustrative example

The phase at which a place cell fires *precesses* as an animal moves through its place field



Illustrative example

The phase at which a place cell fires *precesses* as an animal moves through its place field

