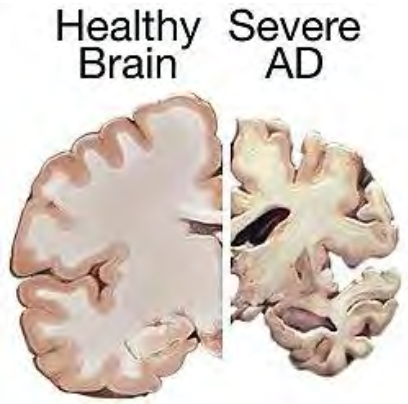


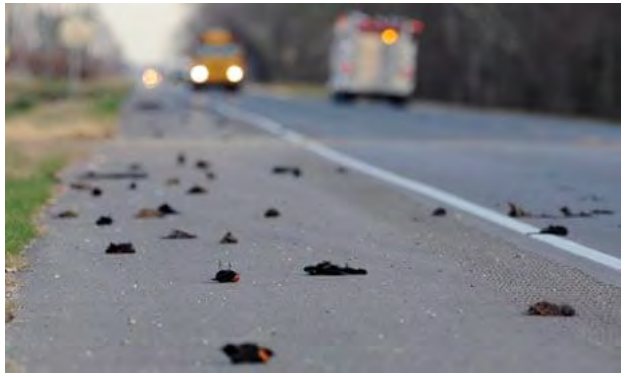


LLI: Human Impacts on Brain and Behavior

Dr. Kate Susman, Department of Biology, Vassar College







Our course road map

- Class 1(today): Introduction to the field, a little on neural plasticity and capacity for change, examples from each topic
- Class 2: Chemical poisons: acute effects on sensory systems, chronic impacts, endocrine disruption and neural development
- Class 3: Light and Noise Pollution impacts on wildlife and humans
- Class 4: Extreme heat, wildfire and class summary discussion- what can we do

Introductions to each other

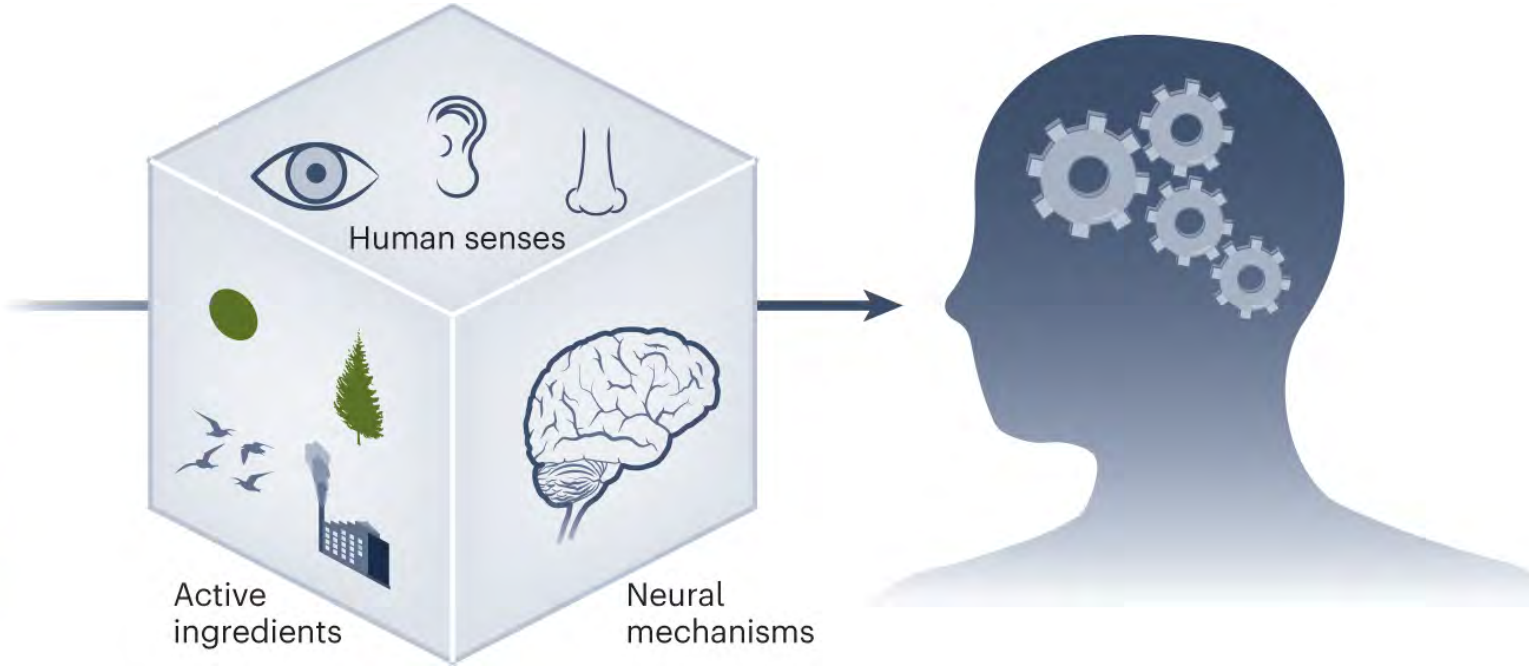
- Name, why this course? One thing hope to learn

Environmental Neuroscience

Brain's relationship with its environment

(it goes both ways)





https://www-nature-com.libproxy.vassar.edu/articles/s44220-023-00137-6

What is that environment?

- Physical surroundings- shelter, climate, seasons, day/night, etc
- Physiological surroundings- food/nutrition, chemicals, sounds, internal organs…
- Social surroundings- predator/prey, conspecifics, parent/offspring
- Temporal surroundings- time of lifespan (developmental stage)





(a)

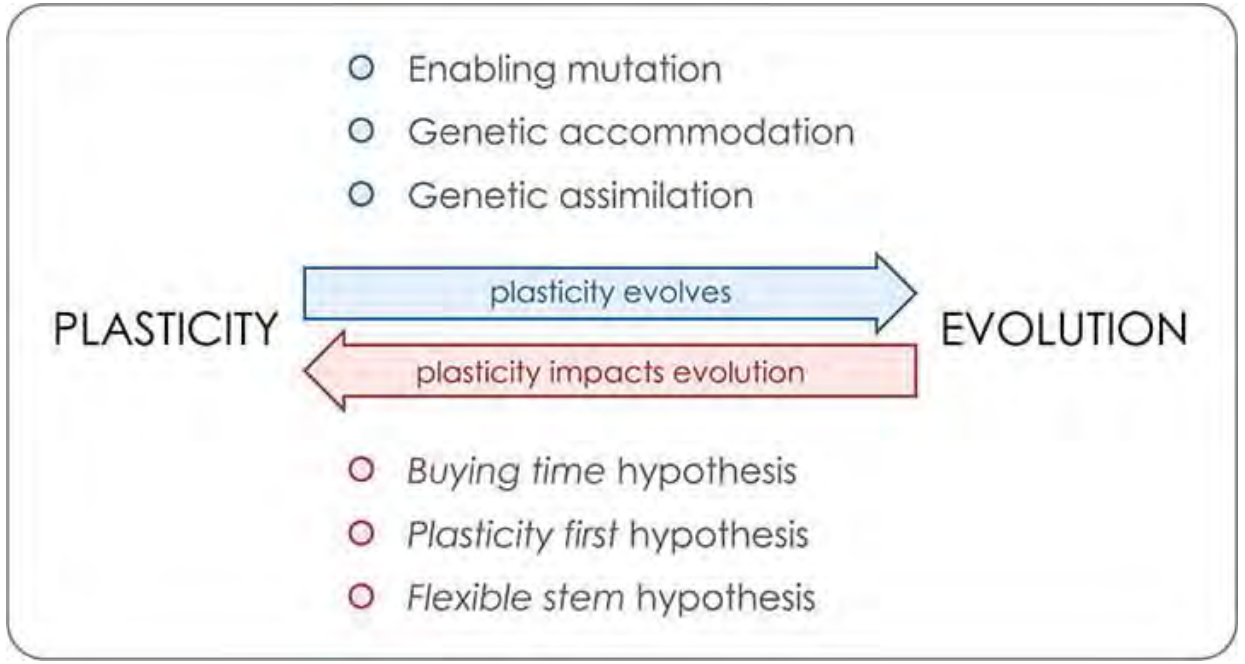


(b)

The importance of change and responding to change

- Change in temperature
- Change in season
- Developmental change

- Phenotypic plasticity/variation
- Sensory processing
- Behavioral plasticity (adaptation)



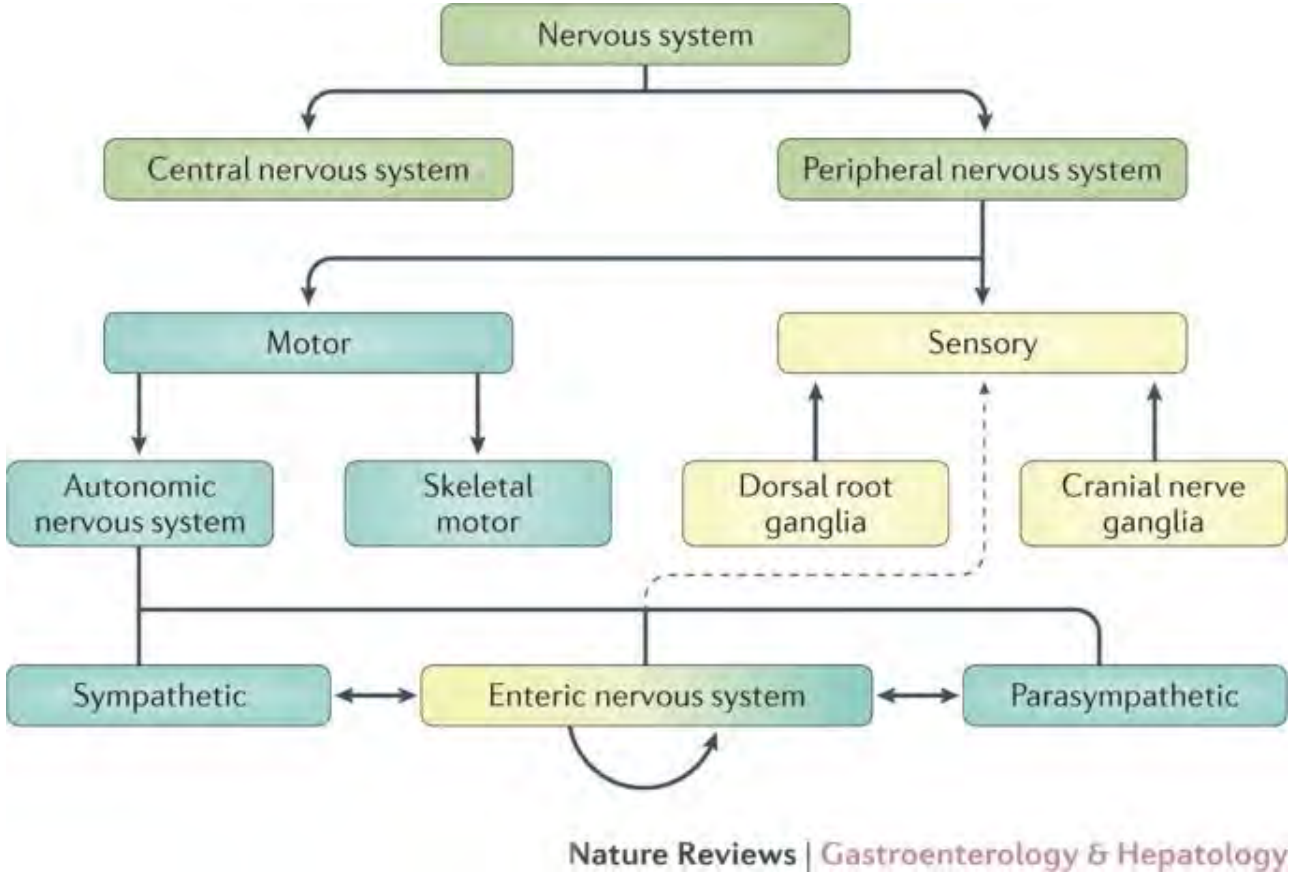
Adapted from: O'Donnell, 2018. The neurobiology of climate change. The Sci. Nat. 105:11

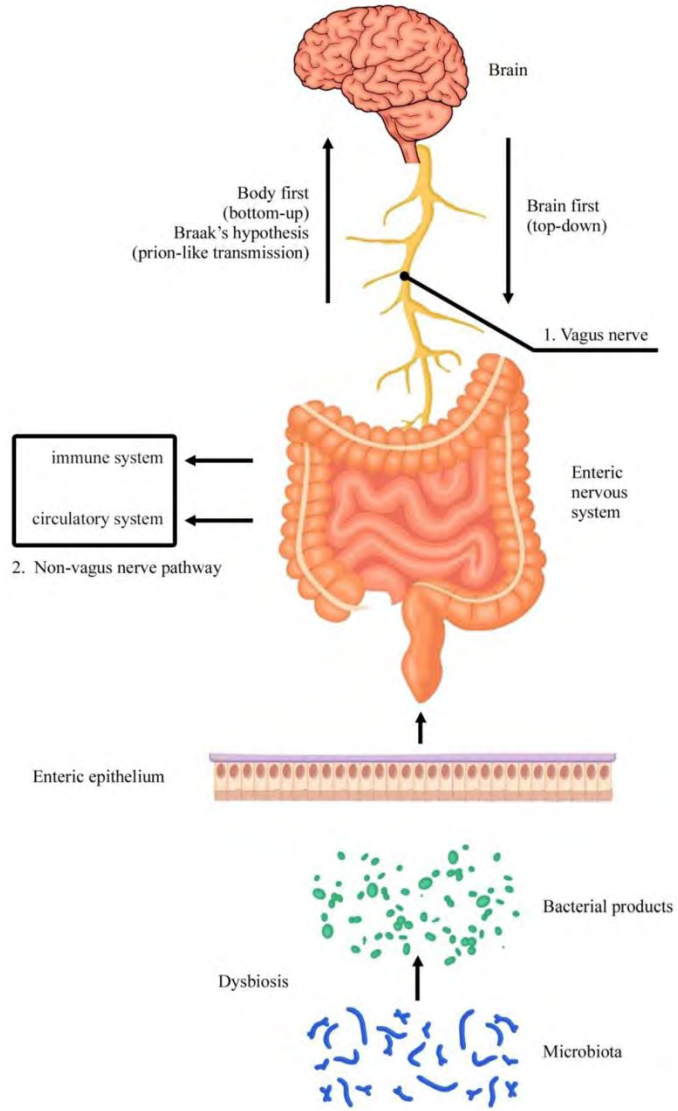


In order to survive a sudden and profound change in the environment, you need a nervous system that is receptive, that is responsive and that is flexible

- **Adaptive capacity** at multiple levels or organization: cell/molecule, circuit, biochemical/hormonal, developmental, physiological, behavioral

Brief overview of our nervous systems





The major impacts we have on ourselves and all life (our focus animals)



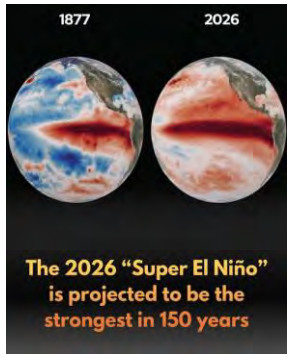
- Habitat destruction/fragmentation
- Climate change, extreme weather, wildfire
- Chemical toxins (fossil fuels, plastics, pesticides, PFAs)
- Noise Pollution
- Artificial light at night
- Urbanization/suburbanization





Marine life where it normally isn't

- 2014-2016 warmer waters in Northeast Pacific- seabird die offs because:
  - Some fish moved 500 miles north and for some, loss of invertebrate prey
  - Fish experienced hypoxia because less oxygen dissolved in warmer water
  - Also saw expansion in range of some warm water-adapted fish









Increasing human noise pollution

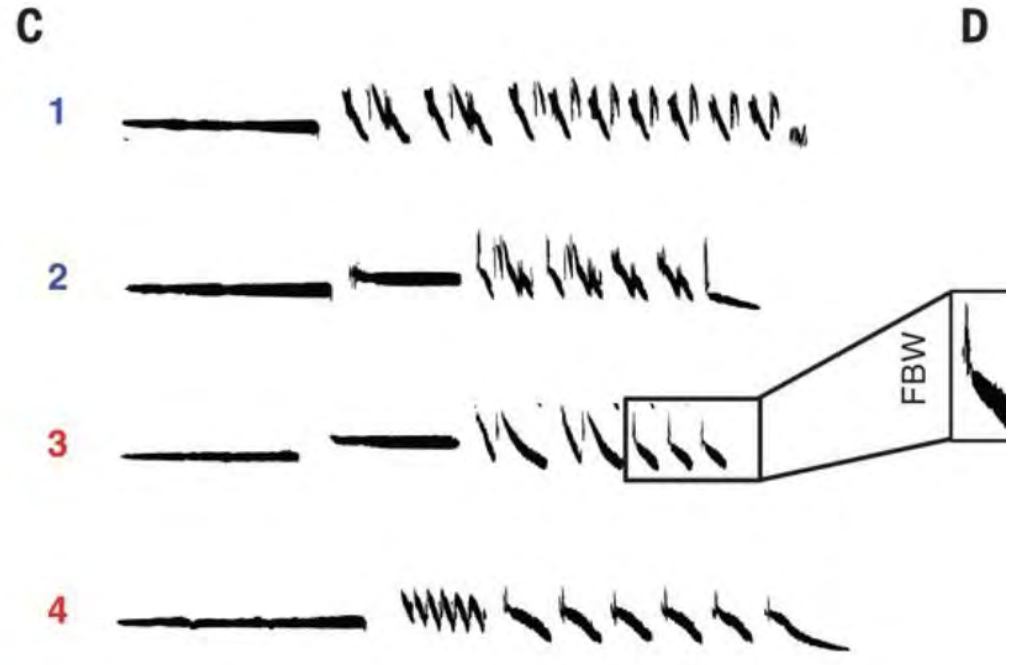


- Traffic noise – birds sing more loudly, or at higher frequencies, or earlier in the morning. Others have moved away from the noise.

Pandemic “study”….. White-crowned sparrows in San Francisco Bay area

Elizabeth Derryberry et al. 2020 (https://www.science.org/doi/10.1126/science.abd5777)





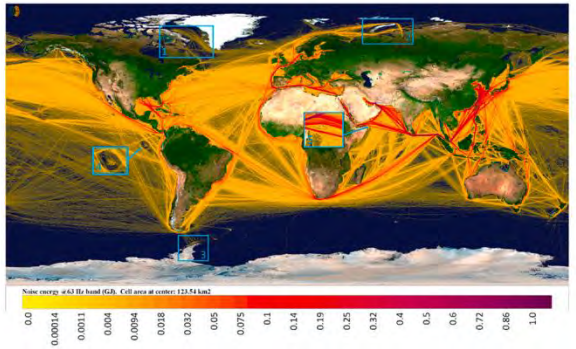


https://time.com/5936110/underwater-noise-pollution-report/

https://www.vox.com/videos/2017/7/18/15988494/ocean-noise-pollution

Example: Noisy seas and neighborhoods

- The change in environment
- The animal response
- Mechanism(s)
- Long-term or speed of change?



https://www.youtube.com/watch?v=sjkxUA041nM

https://www.youtube.com/watch?v=E96nGbzKL2Y





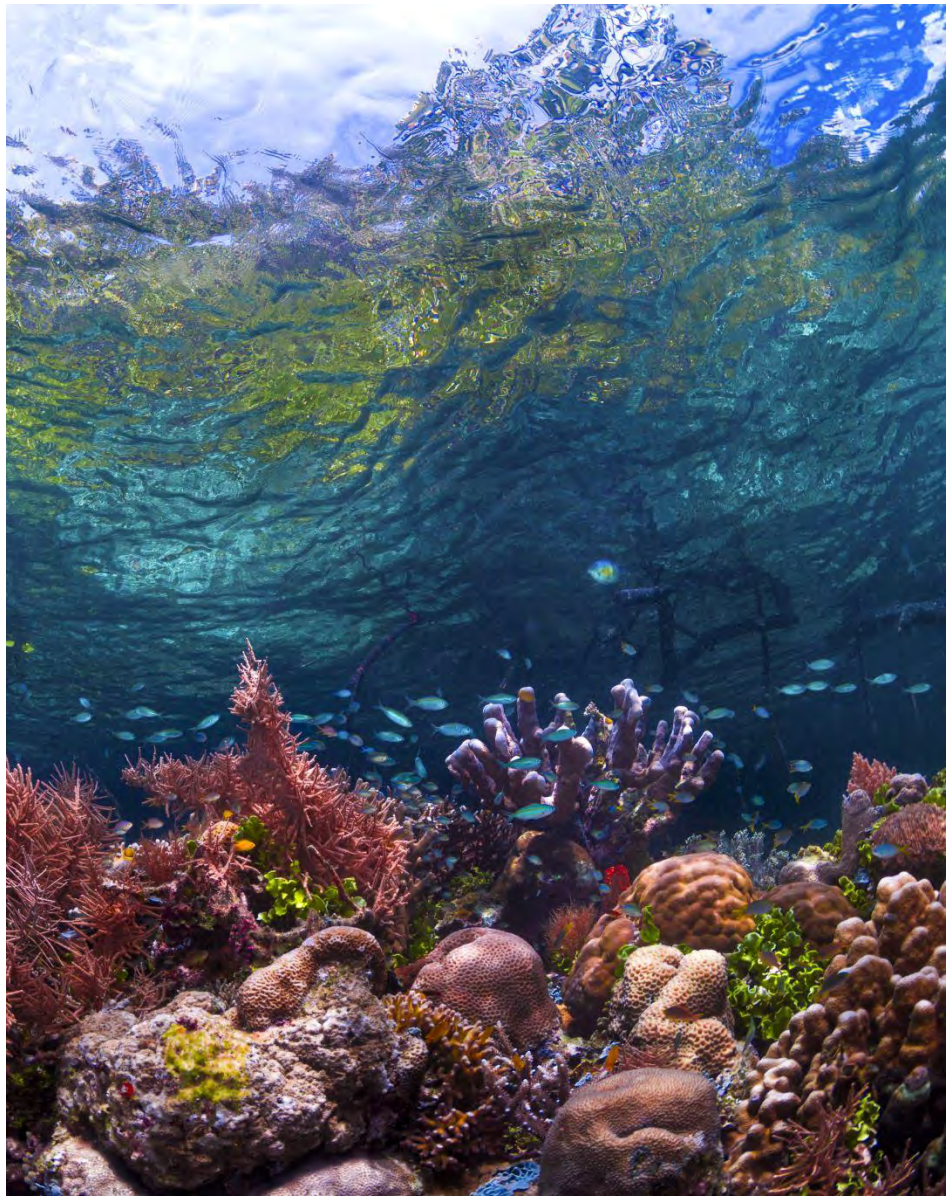


Human light at night, turbid waters

- Night light for navigation: sea turtle hatchlings, coral reef gamete release, bird/bat/insect migration- how to adapt, mitigate?
- Turbid waters affecting mating (color discrimination), predator/prey detection- how to adapt, mitigate?

Acidification of oceans and freshwater

Effects at levels of ion channel/receptor protein function, circuit-level function, behavior



Rapid and enduring changes in behavior in response to changing conditions: Cultural transmission across generations



- Cultural change in olive baboons after the tuberculosis-tainted meat at the garbage dump associated with a tourist camp in Kenya in the 1980's





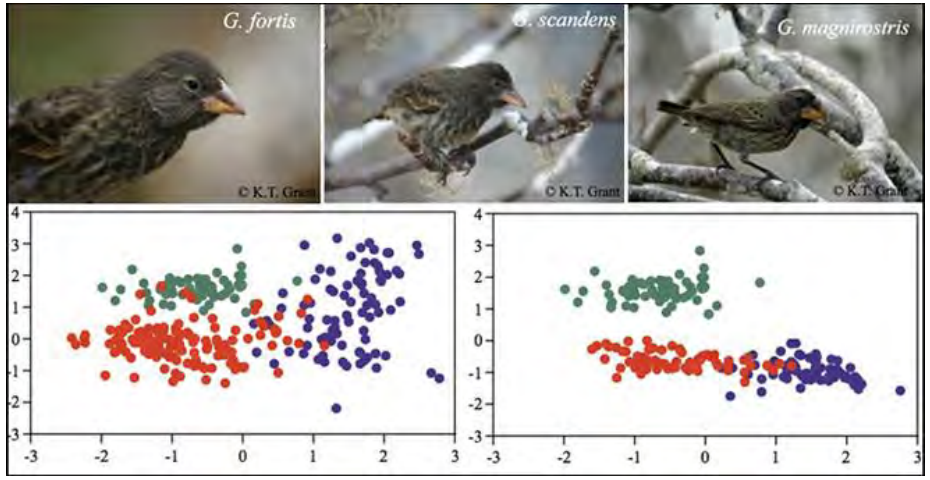
Main ideas for us to consider

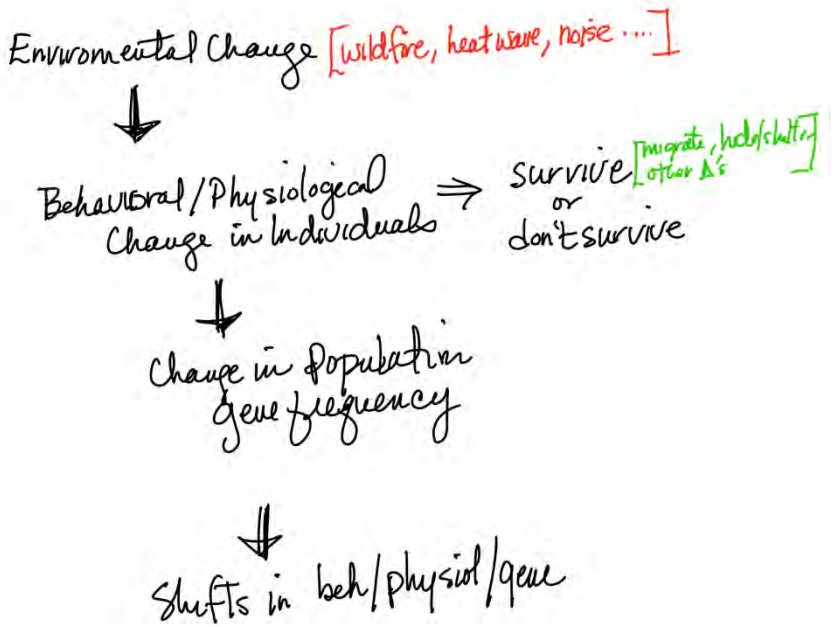
- Nervous system **adaptive capacity** at the root of ability of animals to respond successfully to anthropogenic environmental changes
- **Modes of adaptation**: sensory proteins, circuits (inhibition/excitation; excitability)
- **Genetic variation** for compensation, population level changes
- **Damage/impairments** to sensory systems play a key role
- **Developmental** changes (eg. Sex determination/temperature)
- Constraints on tolerable **ranges** of changes

Successful adaptation depends on:

- Prior exposure to extreme conditions
- Phenotypic plasticity
- Genetic variation present in population
- The rate and duration of the environmental change
- Interactions with other organisms, or other changed conditions







Plasticity- the ability to change

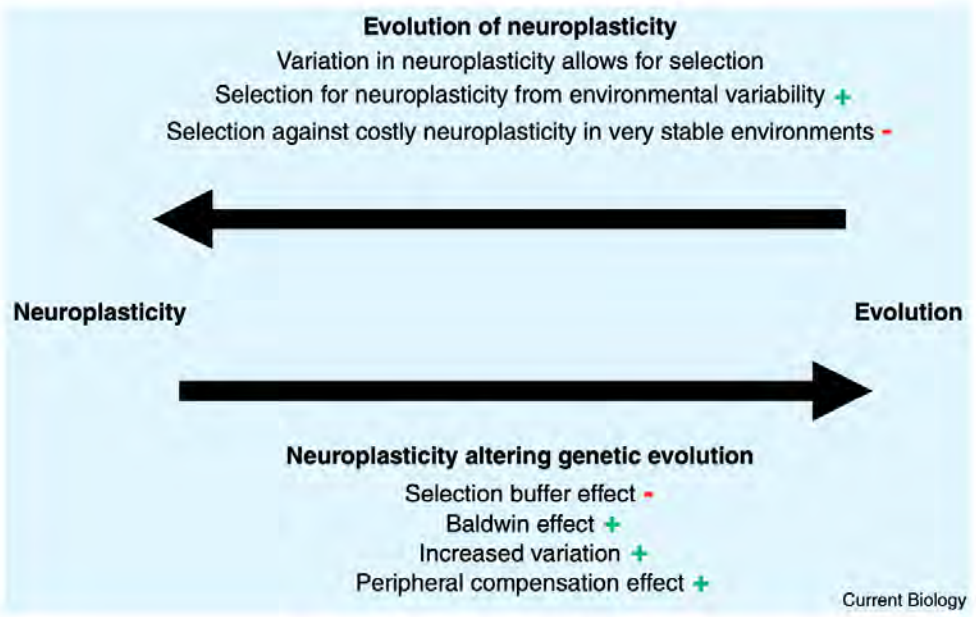


Figure 2. An integrative framework for studying the evolutionary causes and consequences of neuroplasticity.
The top arrow indicates mechanisms by which evolution can change levels of neuroplasticity. The bottom arrow indicates mechanisms for how neuroplasticity can affect rates of genetic evolution. Plus and minus signs indicate the direction each mechanism is expected to influence either levels of neuroplasticity (top) or rates of genetic evolution (bottom).

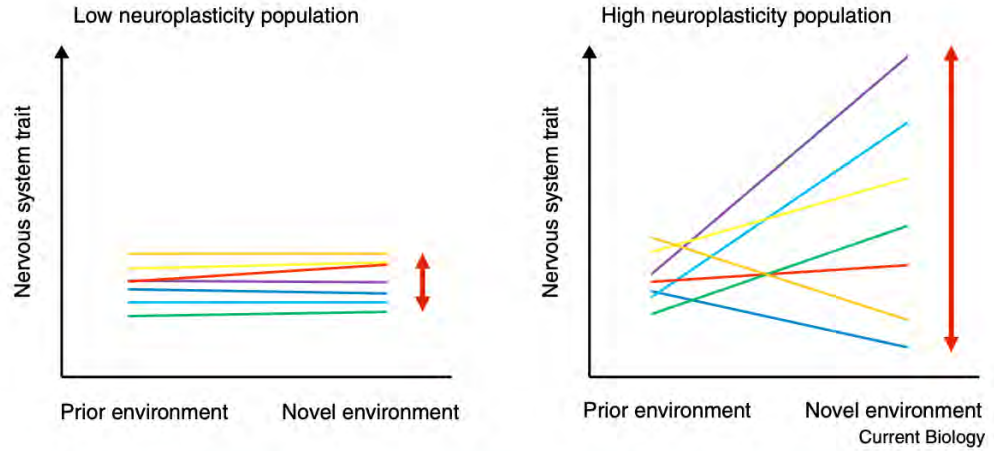


Figure 3. An integrative framework for studying the evolutionary causes and consequences of neuroplasticity.
Example of theoretical reaction norms for two populations (left: low neuroplasticity, right: high neuroplasticity) demonstrating how higher levels of neuroplasticity can increase trait variation in novel environments. The Y-axis represents any aspect of the nervous system that could undergo plasticity. The X-axis represents two environments: 1) a prior environment where selection has shaped trait variation; and 2) a novel environment where selection has not yet shaped trait variation. Lines represent different genotypes within each population. The population with higher neuroplasticity generates greater trait variation in the novel environment, resulting in increased strength of selection.

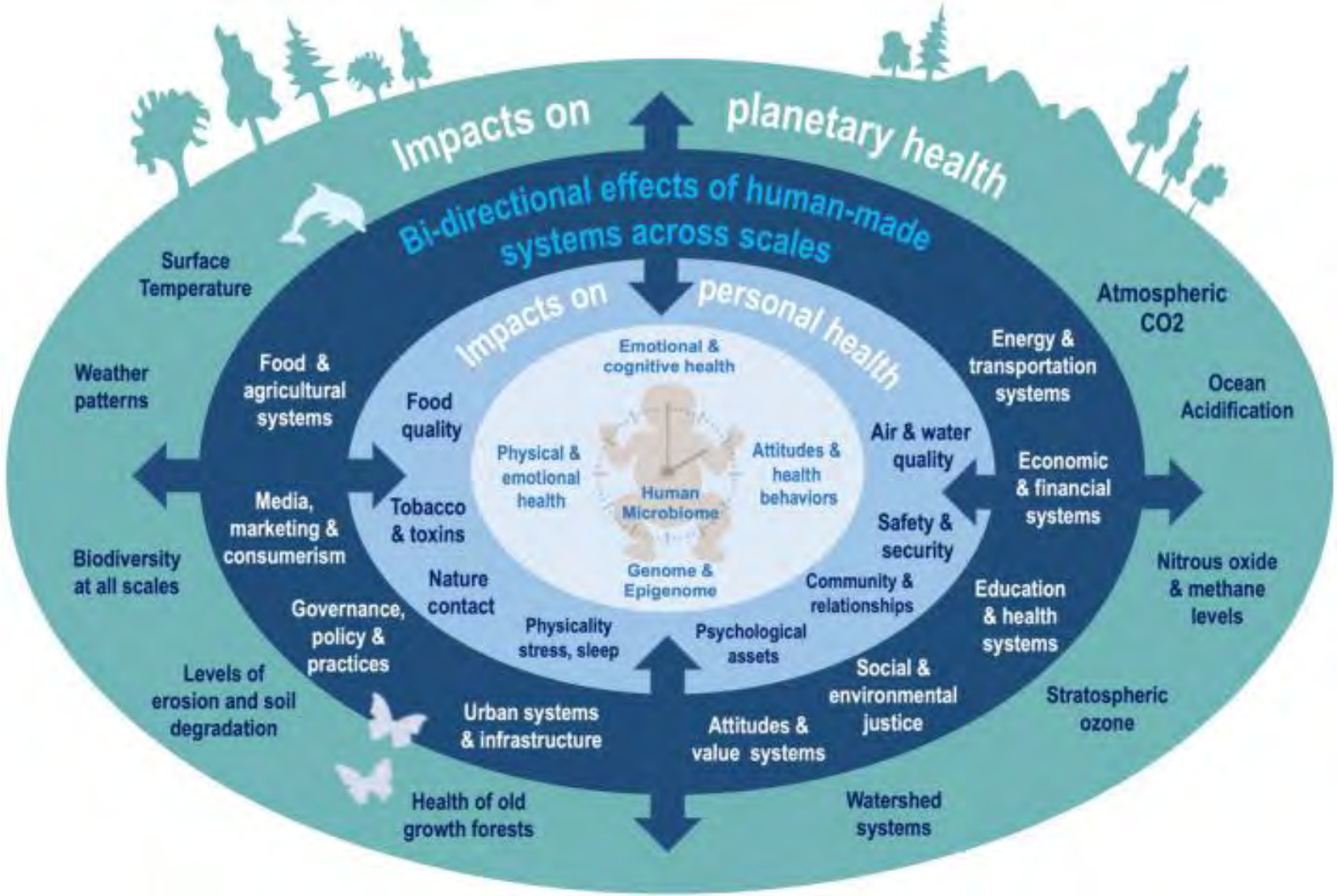
Today's Main Take-Aways

- All forms of environmental impacts involve the nervous system
- There are multiple impacts all at once, so mixtures are important to keep in mind
- Time of exposure, duration, amount all important in adaptability to change
- A key to adapting is neural plasticity
- Animals have different adaptive capacity

- **For next week**: https://youtu.be/_TIvi6B61l0?si=kVeerRuWF8Rnss4E
- https://www.youtube.com/watch?v=fMW_GSWHv5g

Sources consulted

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- https://www-nature-com.libproxy.vassar.edu/articles/nature.2014.15323#:~:text=To%20protect%20themselves%20from%20their,of%20Kauai%20quickly%20stopped%20chirping.&text=The%20change%20seems%20to%20have,of%20producing%20the%20chirping%20noise.
- Michaiel and Bernard
- Grant et al, 2017


Impacts on planetary health
Bi-directional effects of human-made systems across scales
Impacts on personal health
Surface Temperature
Weather patterns
Biodiversity at all scales
Levels of erosion and soil degradation
Health of old growth forests
Watershed systems
Stratospheric ozone
Nitrous oxide & methane levels
Ocean Acidification
Atmospheric CO2
Food & agricultural systems
Media, marketing & consumerism
Governance, policy & practices
Urban systems & infrastructure
Attitudes & value systems
Social & environmental justice
Education & health systems
Economic & financial systems
Energy & transportation systems
Air & water quality
Safety & security
Community & relationships
Psychological assets
Physicality stress, sleep
Nature contact
Tobacco & toxins
Food quality
Emotional & cognitive health
Physical & emotional health
Attitudes & health behaviors
Human Microbiome
Genome & Epigenome