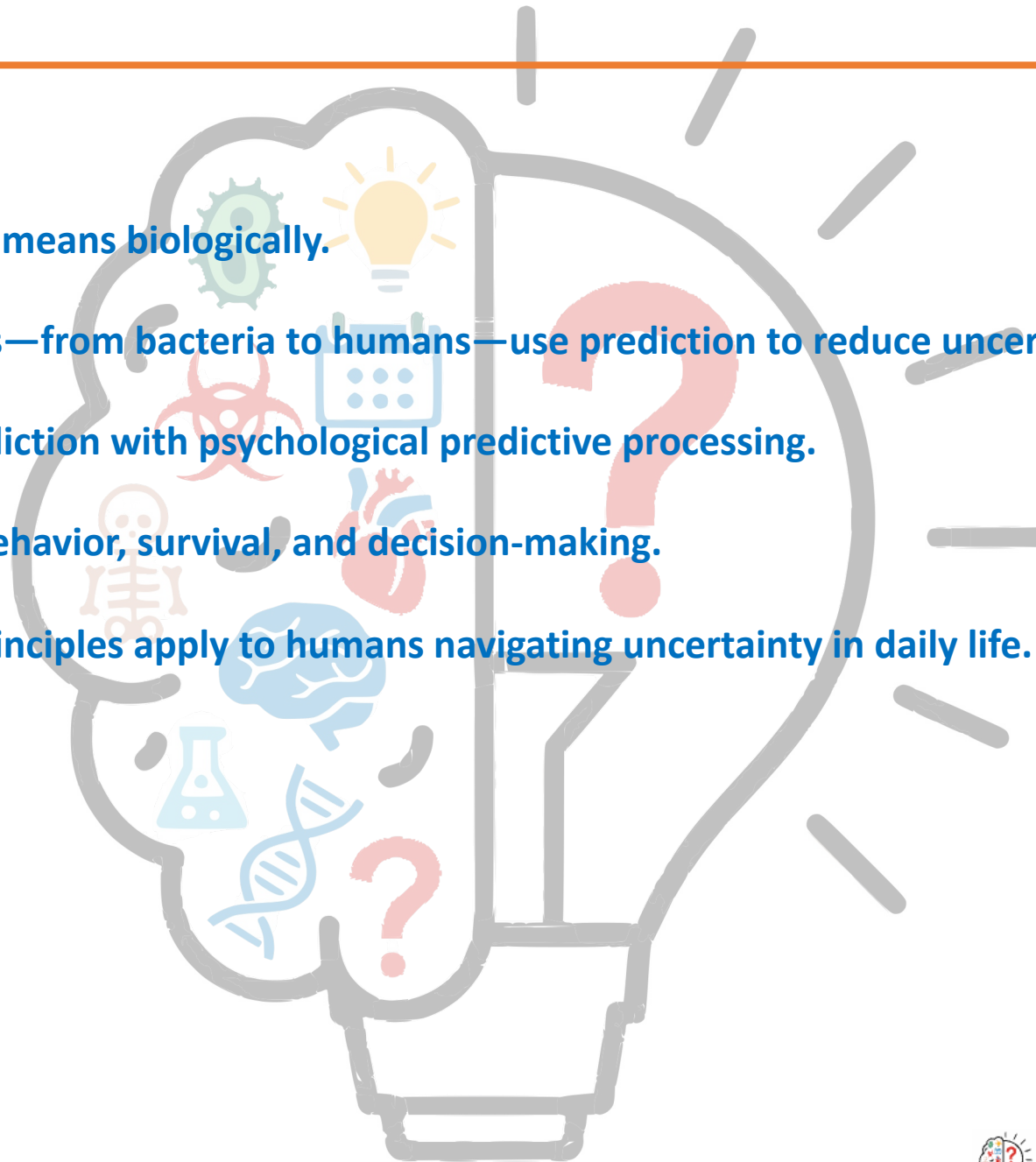


**Predicting the Future !**

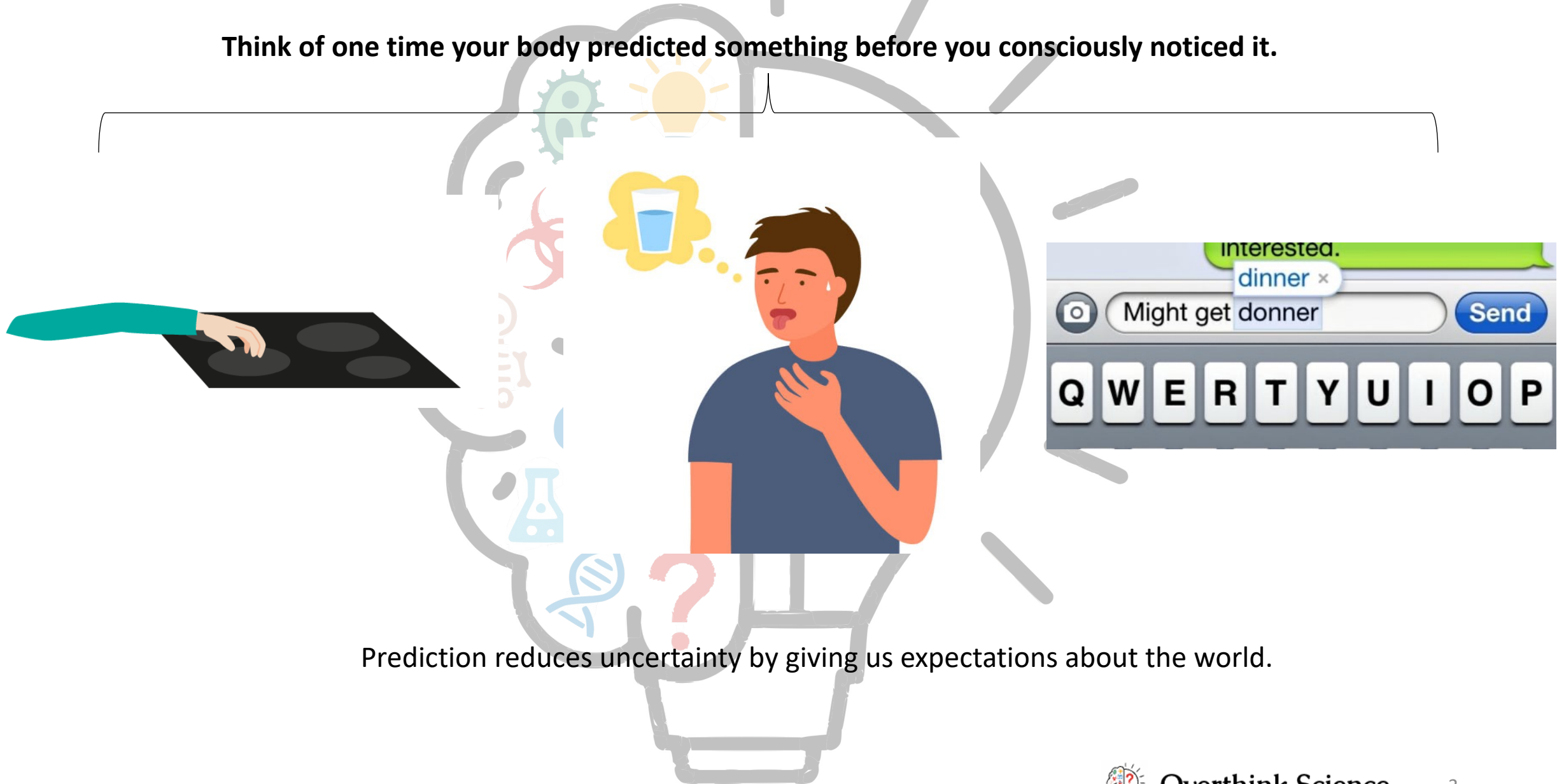
How Living Systems Navigate Uncertainty?

1. Explain what prediction means biologically.
2. Describe how organisms—from bacteria to humans—use prediction to reduce uncertainty.
3. Compare biological prediction with psychological predictive processing.
4. Connect prediction to behavior, survival, and decision-making.
5. Reflect on how these principles apply to humans navigating uncertainty in daily life.



# Prediction 😊 A biological, cognitive, and evolutionary perspective

Think of one time your body predicted something before you consciously noticed it.



Prediction reduces uncertainty by giving us expectations about the world.

# Prediction 😊 A biological, cognitive, and evolutionary perspective

**Prediction = Energy saving + Survival advantage**

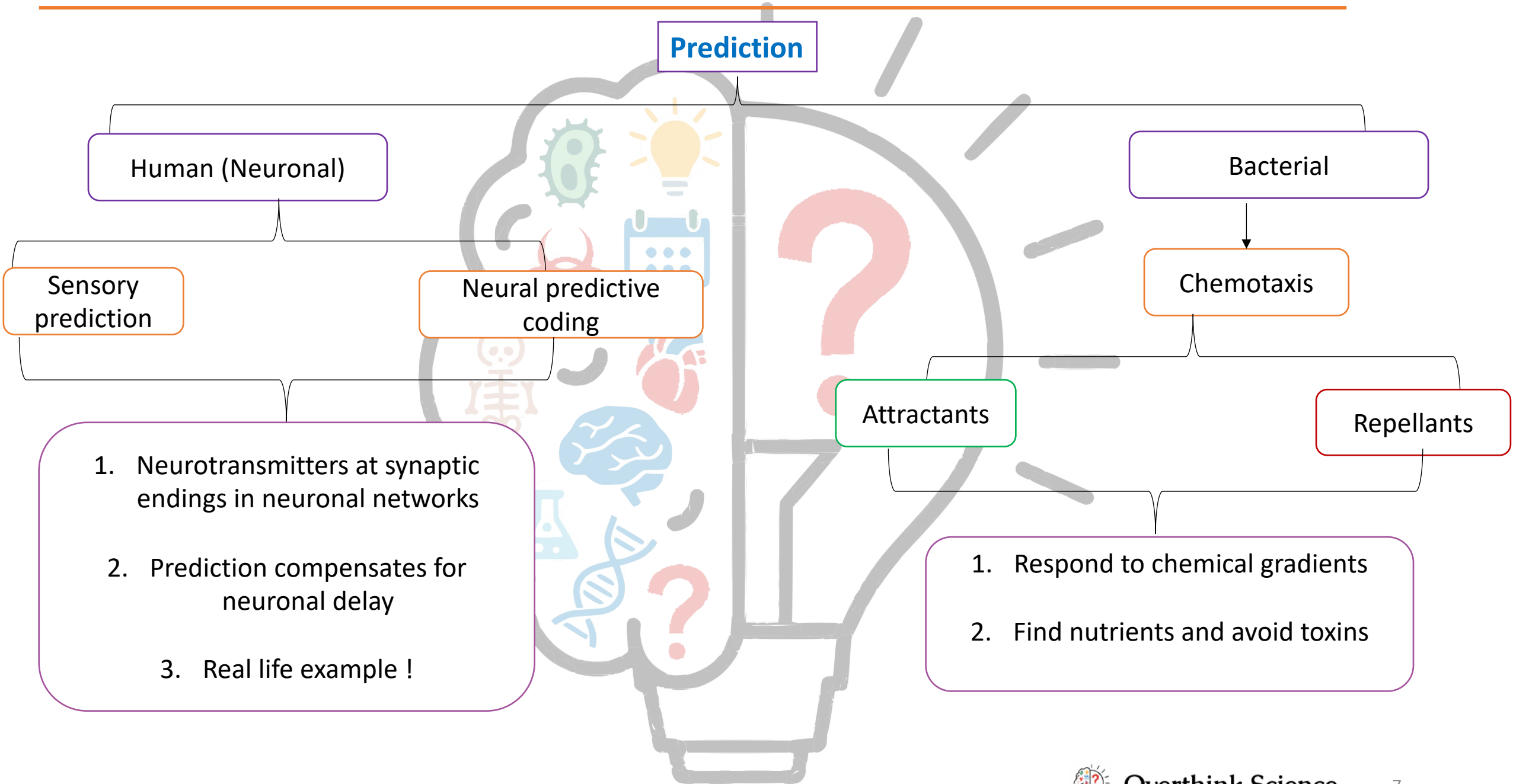
Level	Example of Prediction	What Uncertainty Is Reduced?
Bacteria	<b>Chemotaxis:</b> Move toward chemical gradients predicting higher nutrients	Where the food is?
Plants	Open/close stomata based on circadian rhythms	Temperature and humidity changes
Animals	Predict predator behaviour through learning	Threat level
Humans	Predict social cues & outcomes using past experience	Social uncertainty, decision-making

# Overview !

Aspect	Mechanism	Concept	Examples / Details
1. Animals	a) Sensory prediction	Animals use past sensory inputs to forecast future events such as danger and resources.	<ul style="list-style-type: none"> <li>• Birds adjust migration timing based on predicted seasonal temperatures.</li> <li>• Gazelles predict predator movement from subtle cues.</li> <li>• Bats update object-location predictions using echolocation.</li> </ul>
	b) Neural predictive coding	Brains constantly generate predictions and correct errors when sensory input arrives.	<b>Helps animals:</b> <ul style="list-style-type: none"> <li>• Move smoothly</li> <li>• Catch prey</li> <li>• Avoid collisions</li> <li>• Communicate effectively</li> </ul>
2. Plants	a) Photoperiod prediction	Plants predict seasonal changes by measuring day length.	Triggers flowering, dormancy, seed germination.
	b) Circadian rhythms	Internal clock predicts daily changes (e.g., sunrise).	<ul style="list-style-type: none"> <li>• Stomata open before dawn</li> <li>• Photosynthesis enzymes adjust</li> <li>• Leaves move in anticipation</li> </ul>
	c) Stress prediction	Plants pre-emptively prepare for stress.	Slight drought → produce abscisic acid → reduce growth before severe drought occurs.
3. Microorganisms / Cells	a) Bacterial forecasting	Microbes adjust physiology based on predictable environmental shifts.	E. coli leaving the gut “predicts” lower salinity and adjusts ion pumps.
	b) Gene regulatory networks	Cells activate proteins in advance of expected stress.	Produce heat-shock proteins, detox enzymes, DNA repair systems.
	c) Immune system prediction	Immune memory predicts future infections.	Memory cells + long-term antibody repertoires.
4. Evolution	Evolution as prediction	Natural selection preserves mutations that prepare organisms for future environments.	<ul style="list-style-type: none"> <li>• Desert plants evolve water storage</li> <li>• Arctic animals evolve thick fur</li> <li>• Bacteria develop multidrug resistance</li> </ul>

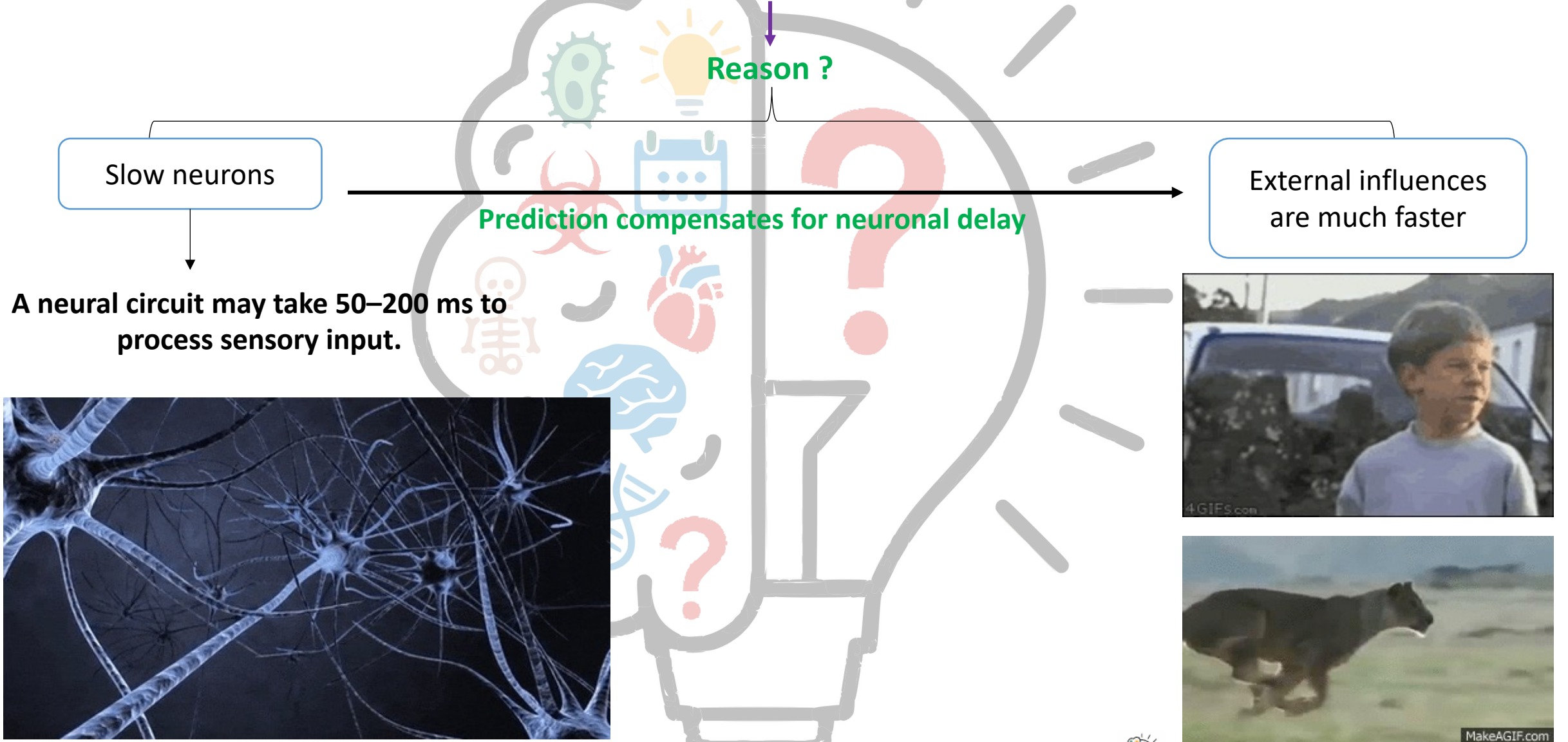
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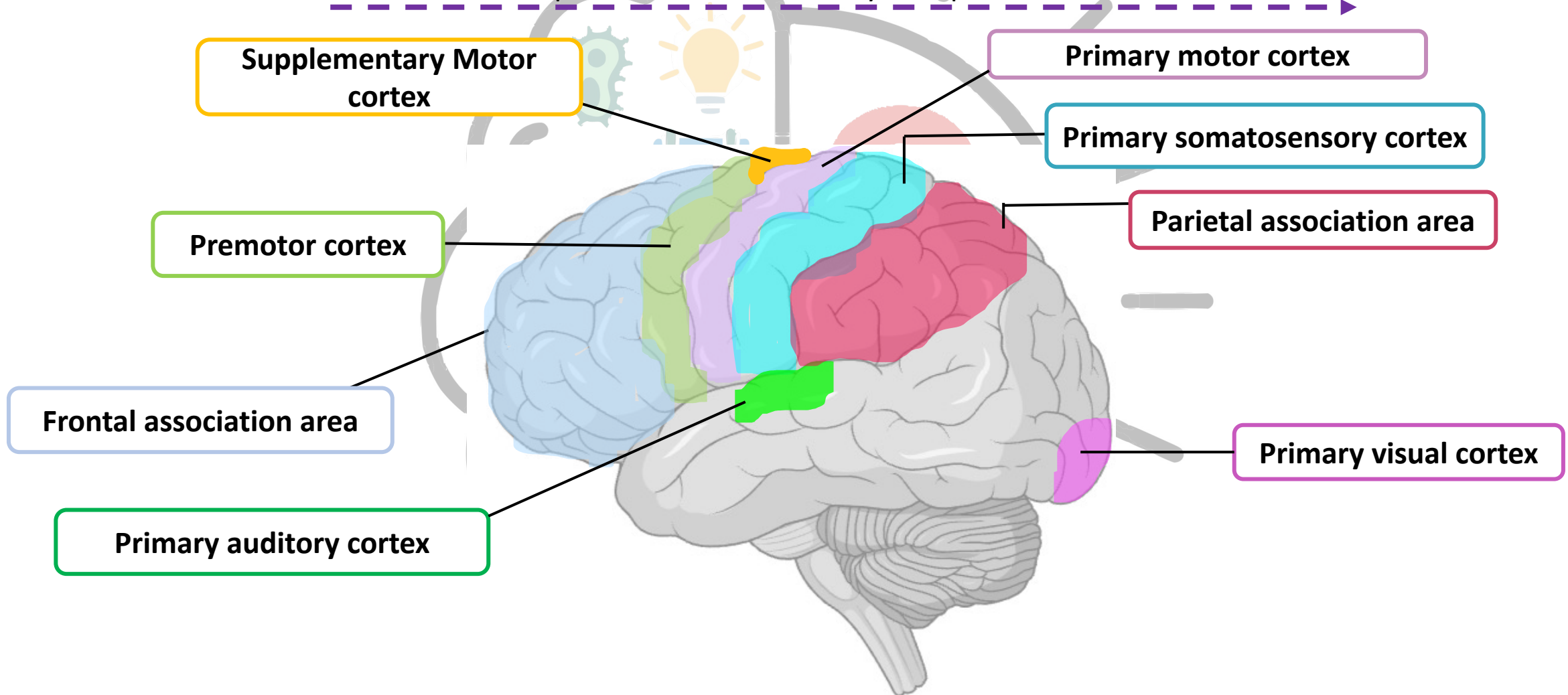
# Prediction: 1- Human sensory prediction

The brain attempts to predict incoming sensory information before it arrives.



# Prediction: Biology not Philosophy !!

**Top-down pathway=** from higher cortex → sensory cortex)  
send predictions about what you expect to sense



**Bottom-up pathway=** (from sensory organs → cortex)  
deliver actual sensory input.

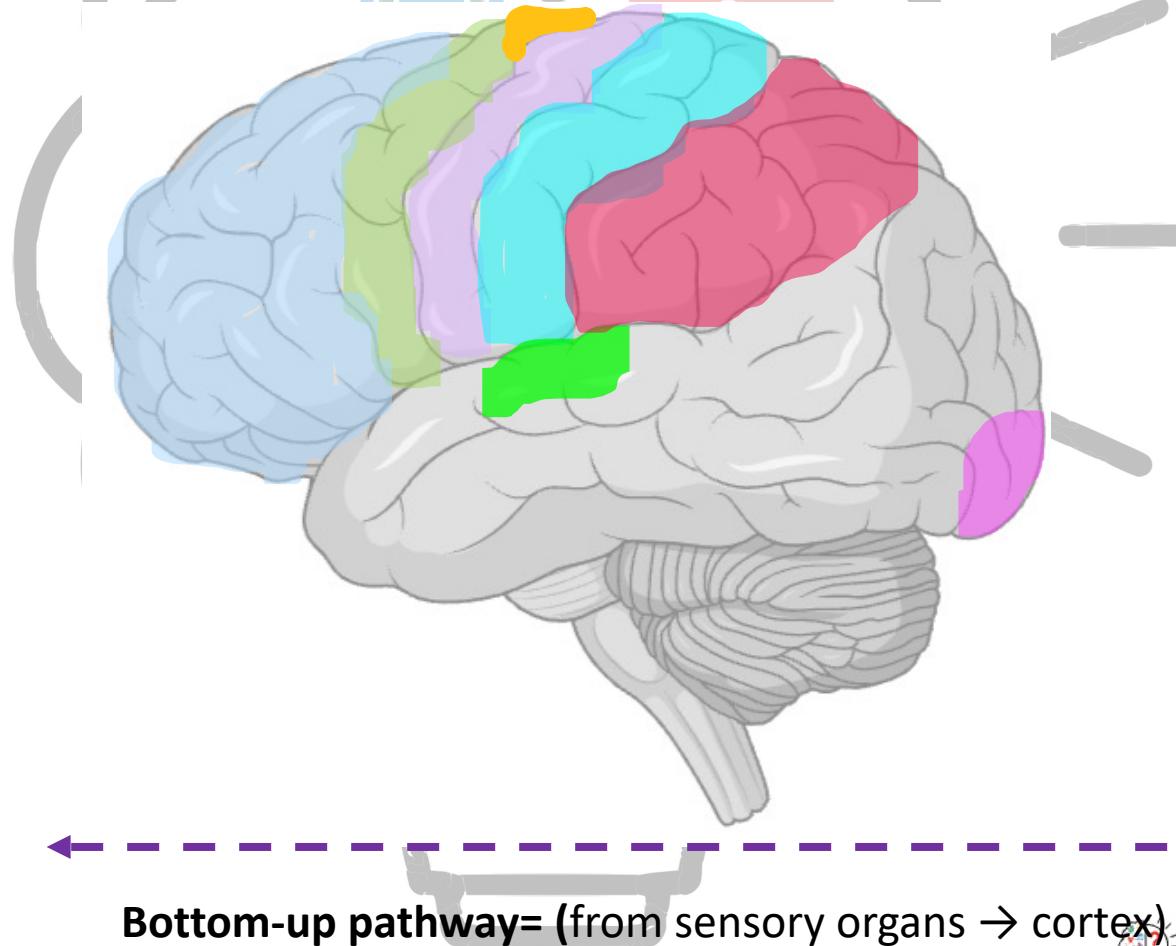


# Prediction: Biology not Philosophy !!

- expectations
- memories
- learned associations
- emotional biases

**Top-down pathway=** from higher cortex → sensory cortex)  
send predictions about what you expect to sense

They modify how sensory input is processed before the signal even arrives fully.  
This is what psychology calls predictive coding.



Prediction Error=  
Actual Input-Exp  
ected Input

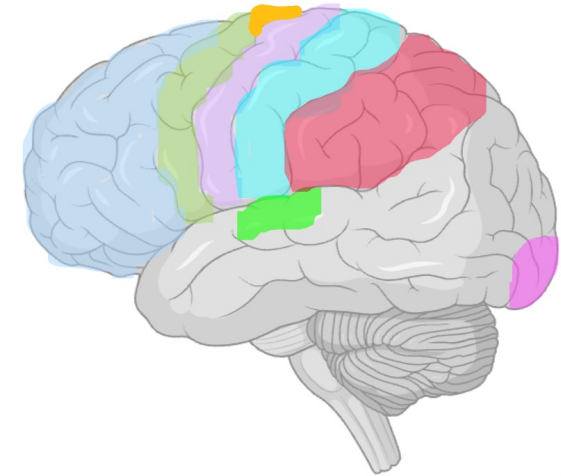
**Bottom-up pathway=** (from sensory organs → cortex)  
deliver actual sensory input.

**These signals represent what is actually happening in the environment right now.**

# Prediction: 2- Neural predictive coding : basic concept 😊

Steps	Mechanism	Simplified explanation	Why? (evolutionary ?)
<b>1. Brain Predicts</b>	<b>Top-down signals</b> = The brain creates a guess about what it expects to sense.	Your brain says: "I think this is what's going to happen next."	Saves energy by preparing in advance.
<b>2. Senses Send Input</b>	<b>Bottom-up signals</b> = The eyes, ears, skin, etc., send real information to the brain.	Your senses report: "Here's what is actually happening."	Gives the brain real data from the world.
<b>3. Compare Signals</b>	Brain compares the predicted signal Vs. the real sensory input.	Brain checks: "Did my guess match reality?"	Helps the brain see if it was right or wrong.
<b>4. Find Errors</b>	<b>Any difference between prediction and actual input = prediction error.</b>	<b>Brain notices: "Oops, something didn't match."</b>	<b>Shows the brain what needs changing.</b>
<b>5. Update Model</b>	Brain updates its internal model to improve future predictions.	Brain adjusts: "Okay, next time I'll predict better."	Learning and adaptation

**Top-down pathway**= from higher cortex → sensory cortex)  
send predictions about what you expect to sense



**Bottom-up pathway**= (from sensory organs → cortex)  
deliver actual sensory input.



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