Lecture 2. Embodiment: Concept and Models

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Intelligence:

Hard to agree on definitions, arguments

- **necessary and sufficient conditions?**
- **are robots, ants, humans intelligent?**

more productive question:

“Given a behavior of interest, how to implement it?”

Successes and failures of the classical approach

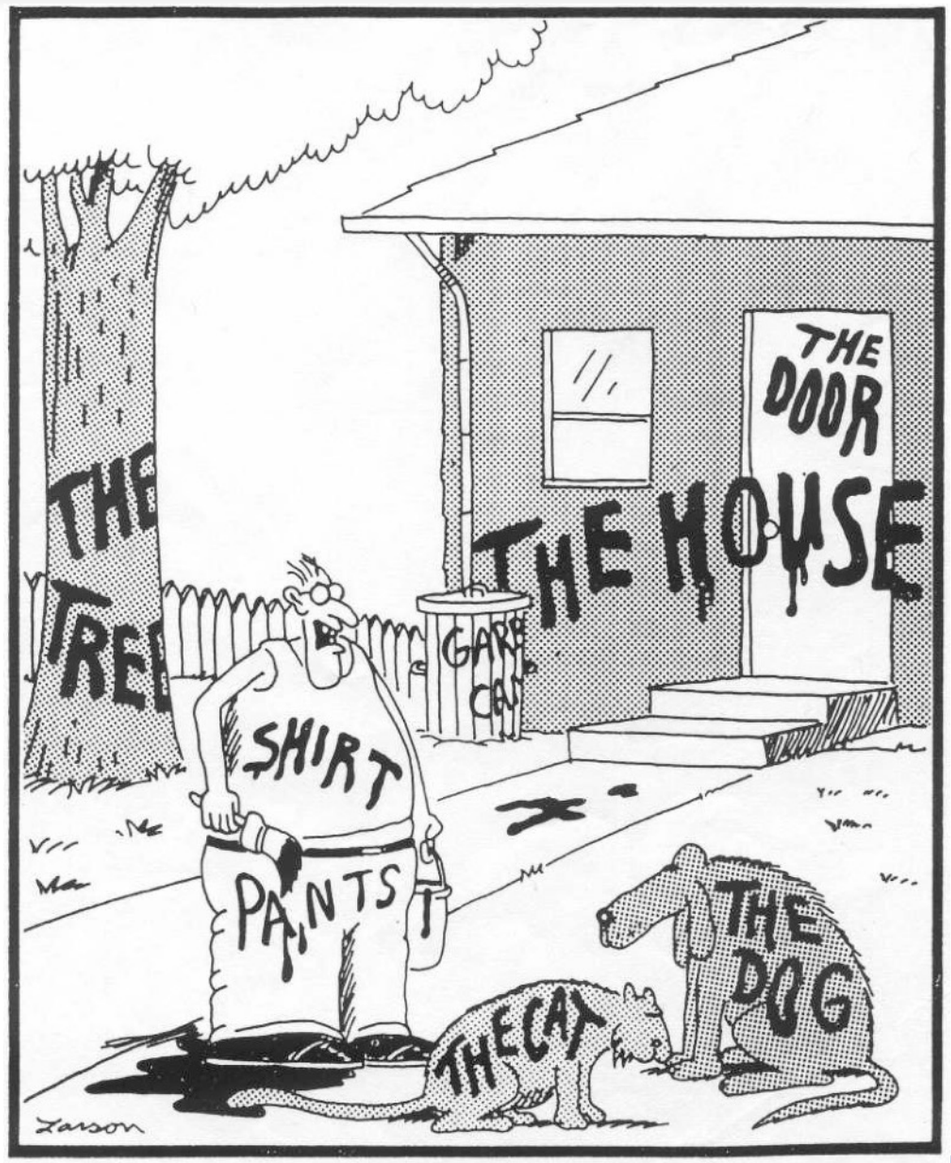
successes	failures
applications (e.g. Google)	**foundations of behavior**
chess	**natural forms of intelligence**
manufacturing	**interaction with real world**
(“controlled”artificial worlds)	

The “symbol grounding” problem

real world: doesn’t come with labels …

How to put the labels??

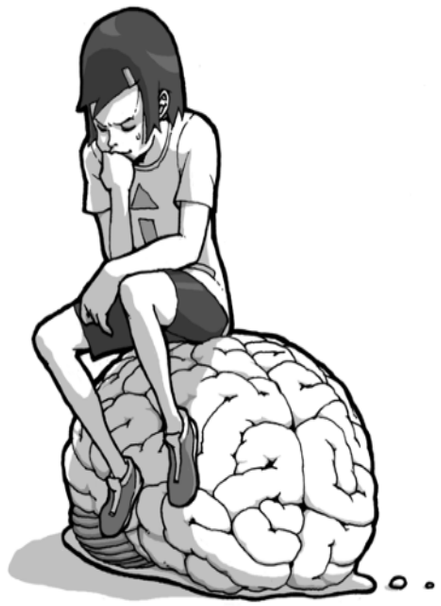
Gary Larson



“Now! ... *That* should clear up a few things around here!”

Two views of intelligence

classical:
cognition as computation

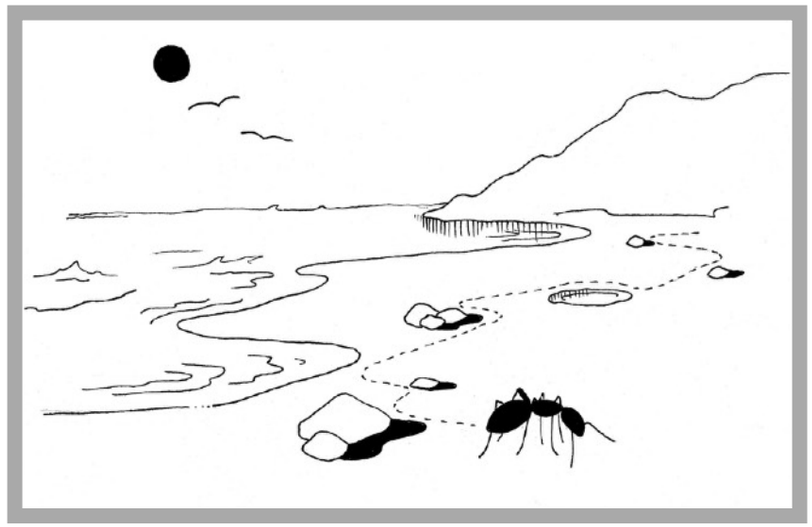


embodiment:
cognition emergent from sensory-motor and interaction processes

The need for an embodied perspective

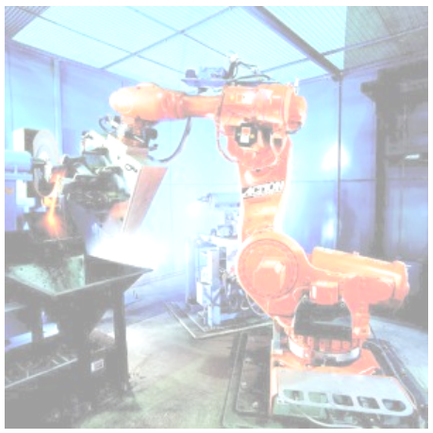
- **“failures” of classical AI**
- **fundamental problems of classical approach**
- **Wolpert’s quote: Why do plants not …? (but…check…Barbara Mazzolai’s lecture…)**
- **Interaction with environment: always mediated by body**

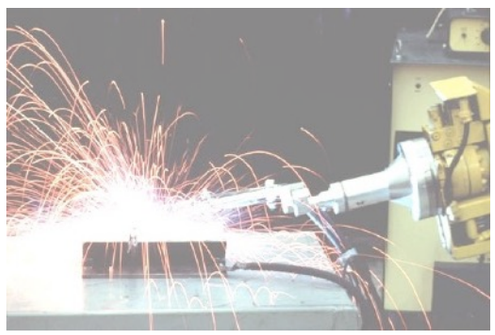
“Frame-of-reference” Simon’s ant on the beach



- **simple behavioral rules**
- **complexity in interaction, not — necessarily — in brain**
- thought experiment: **increase body by factor of 1000**

Industrial robots vs. natural systems





robots

principles:
- **low precision**
- **compliant**
- **reactive**
- **coping with uncertainty**

humans

→ **no direct transfer of methods**

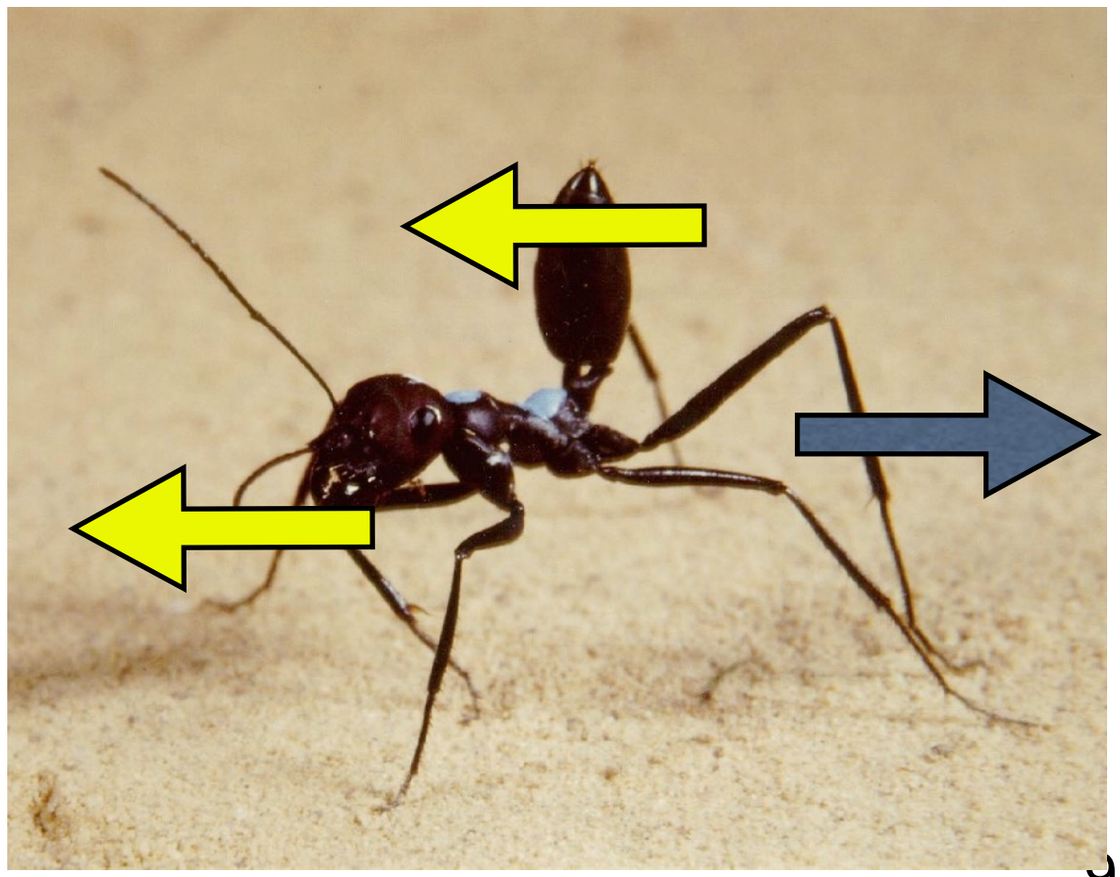
Communication through interaction with

- **exploitation of interaction with environment**

→ **simpler neural circuits**

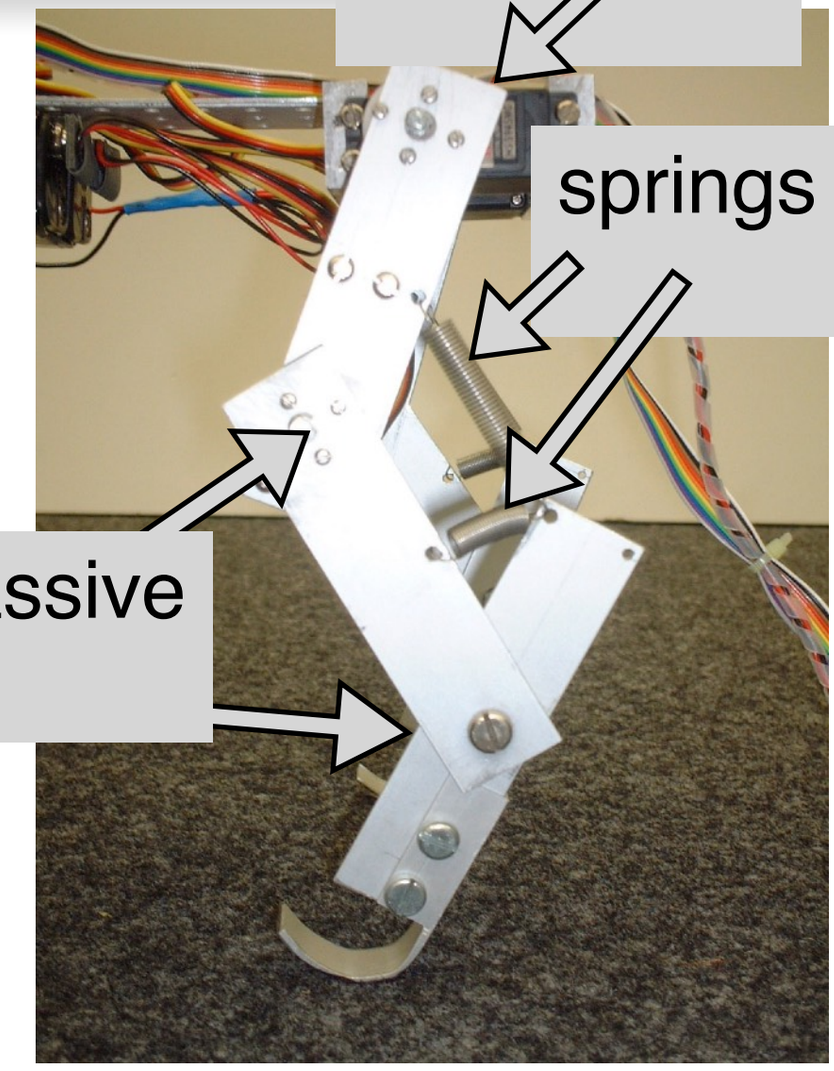
angle sensors in joints

"parallel, loosely coupled processes"



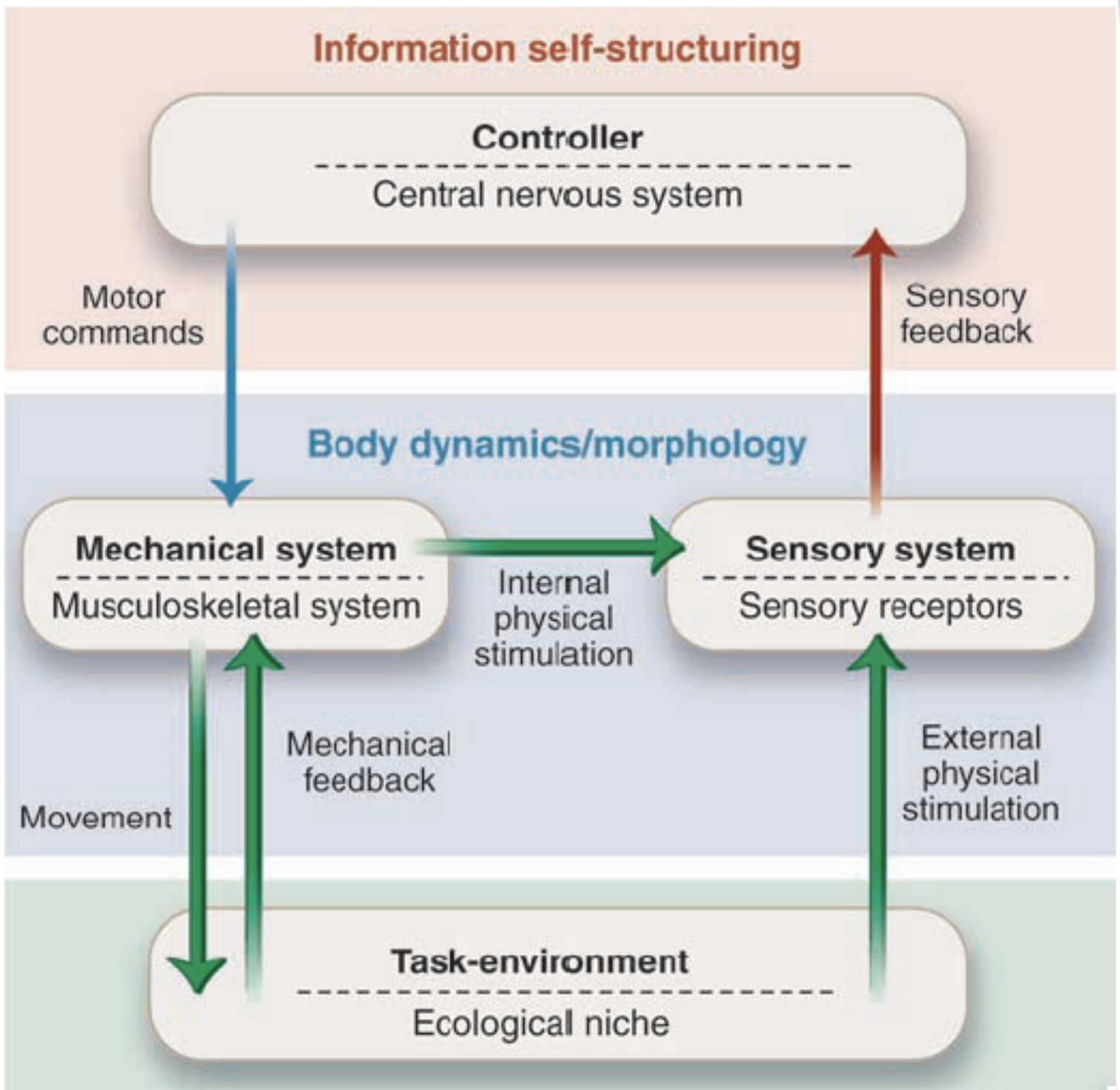
Emergence of behavior: the quadruped “Puppy”

- **simple control (oscillations of “hip” joints)**
- **spring-like material properties (“under-actuated” system)**
- **self-stabilization, no sensors**
- **“outsourcing” of functionality**



→ morphological computation

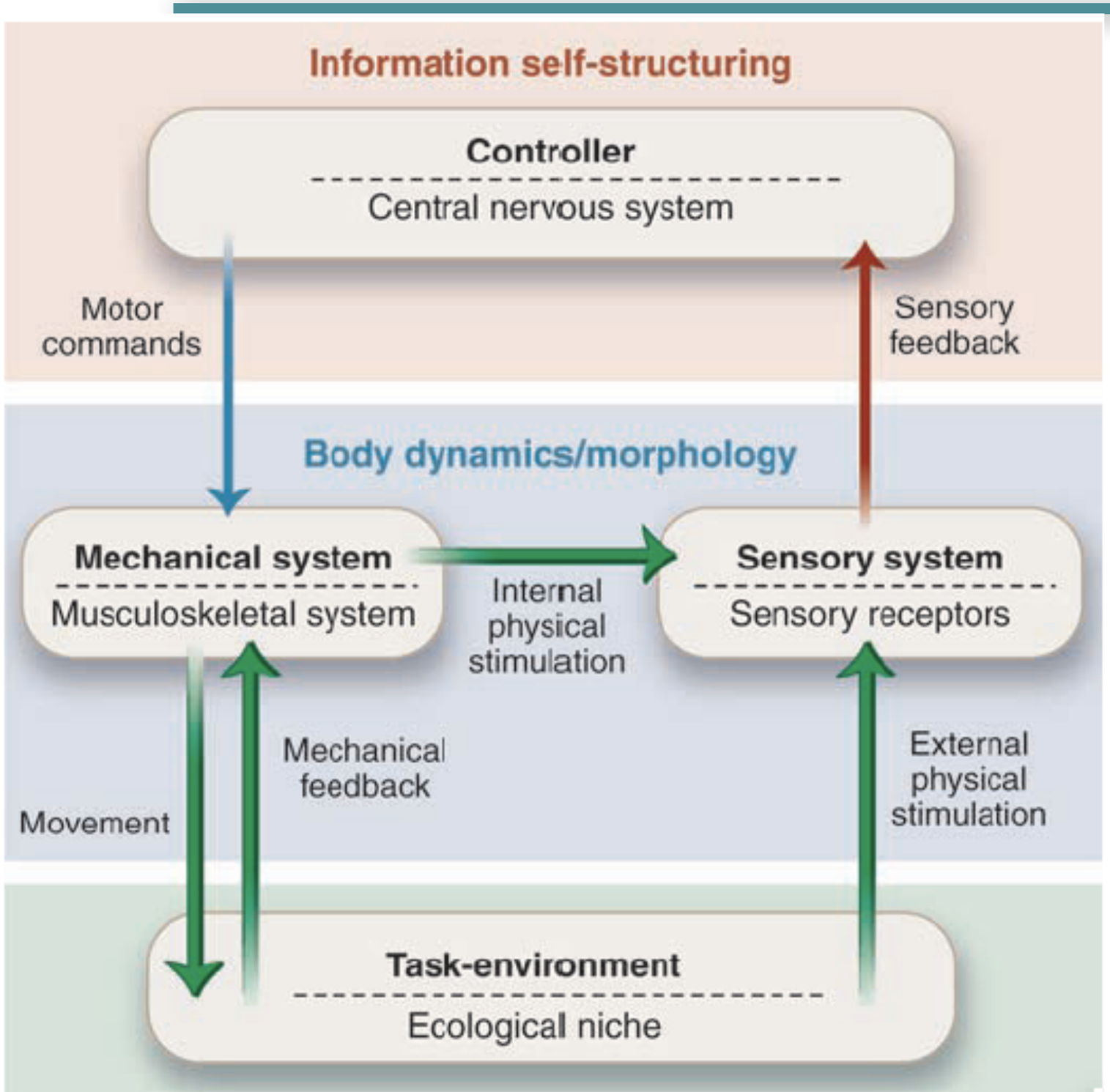
Implications of embodiment



"Puppy", But Also Crus

Pfeifer et al.,Science, 16 Nov. 2007

Implications of embodiment



"Puppy"

which part of diagram is relevant?

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Pfeifer et al.,Science, 16 Nov. 2007