

# BioR5: Biological Reasoning System

## A Three-Layer Tool-Calling Architecture

Peng Ding

Argonne National Laboratory

University of Chicago

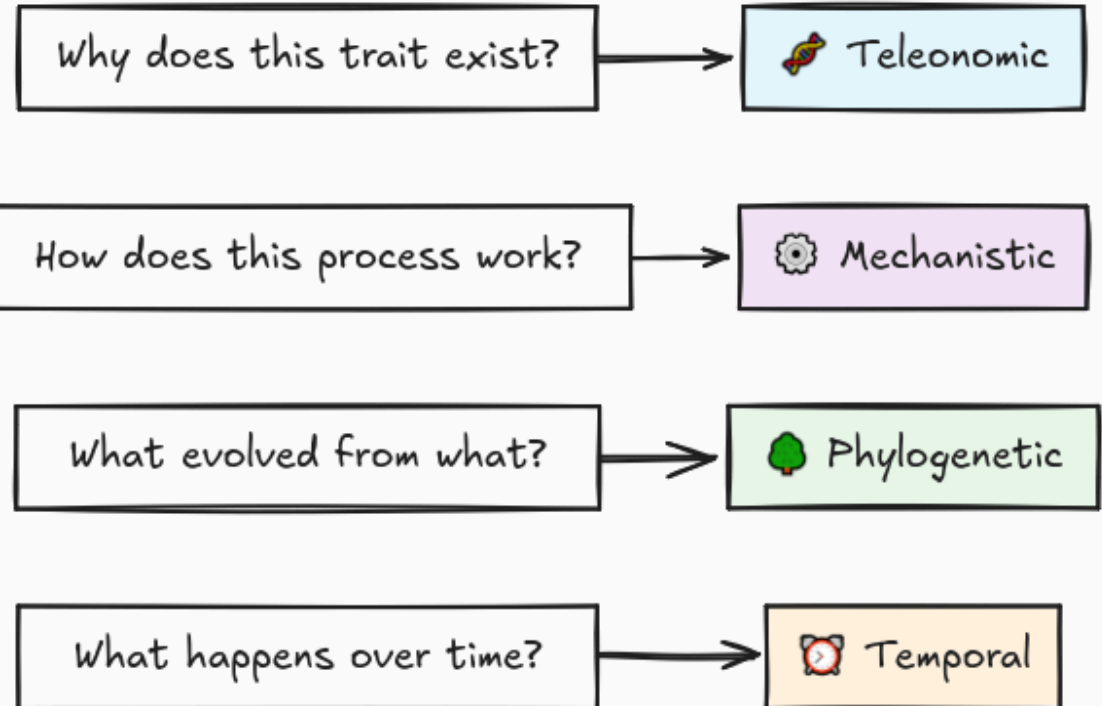
# The Problem

The challenge: Biologists use different reasoning modes

- "Why does this trait exist?" → Teleonomic
- "How does this work?" → Mechanistic

**Current AI:** One model, one approach

**Biology:** Eleven distinct reasoning modes



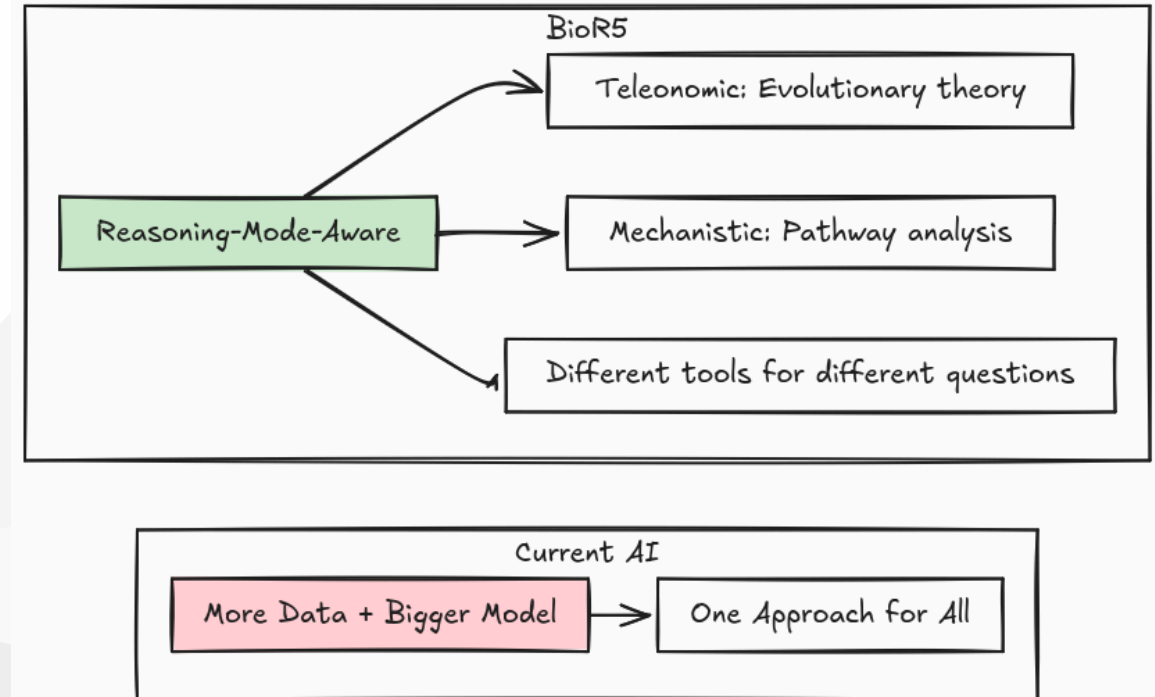
# Our Solution

**BioR5:** Different questions →  
Different approaches

**Current AI:** "More data + bigger model"

**Example:** "How does insulin regulate glucose?"

- Needs biochemical pathways + causal networks
- NOT just correlation in expression data



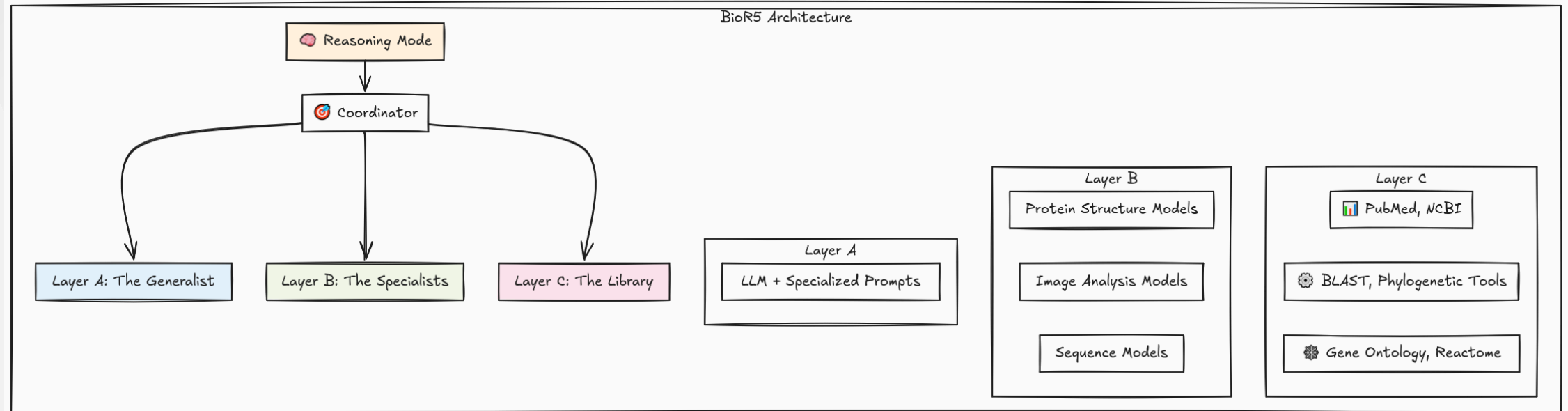
# Three-Layer Architecture

BioR5: Map reasoning modes to computational layers

Layer A: LLM + specialized prompts

Layer B: Specialized models (proteins, images)

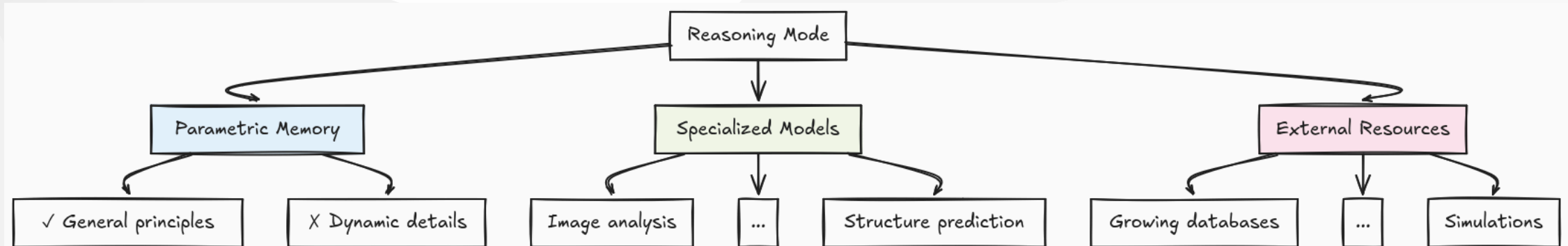
Layer C: External resources (databases, tools)



## Reasoning Mode Details - A Recipe

**Key Insight:** Each reasoning mode needs different resources:

1. **Model weights:** Principles ✓, Details ✗
2. **Specialized models:** Images, structures, etc.
3. **External:** Databases, simulations, etc.



## Layer Details - ToolRegistries

**Layer A:** `parametric_memory` = LLM + specialized prompts

- Same LLM, different prompts → Different knowledge distillation
- Status: 11 reasoning modes implemented

**Layer B:** Specialized models as tools

- Structure prediction, image analysis
- Packaged as callable tools

**Layer C:** External resources

- Databases, computational tools, knowledge graphs

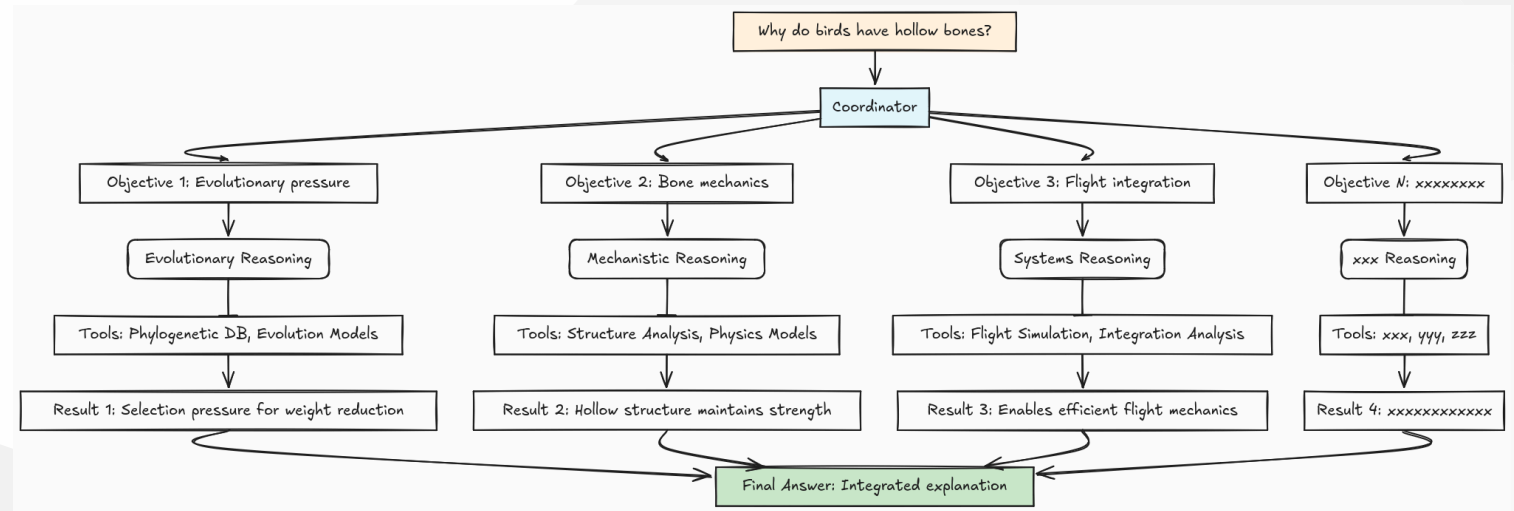
# Work in Progress

Next: Divide-and-conquer scheduling

Example: 'bird bone evolution' →

- Evolutionary pressure
- Bone mechanics
- Flight integration

Results merge into final answer



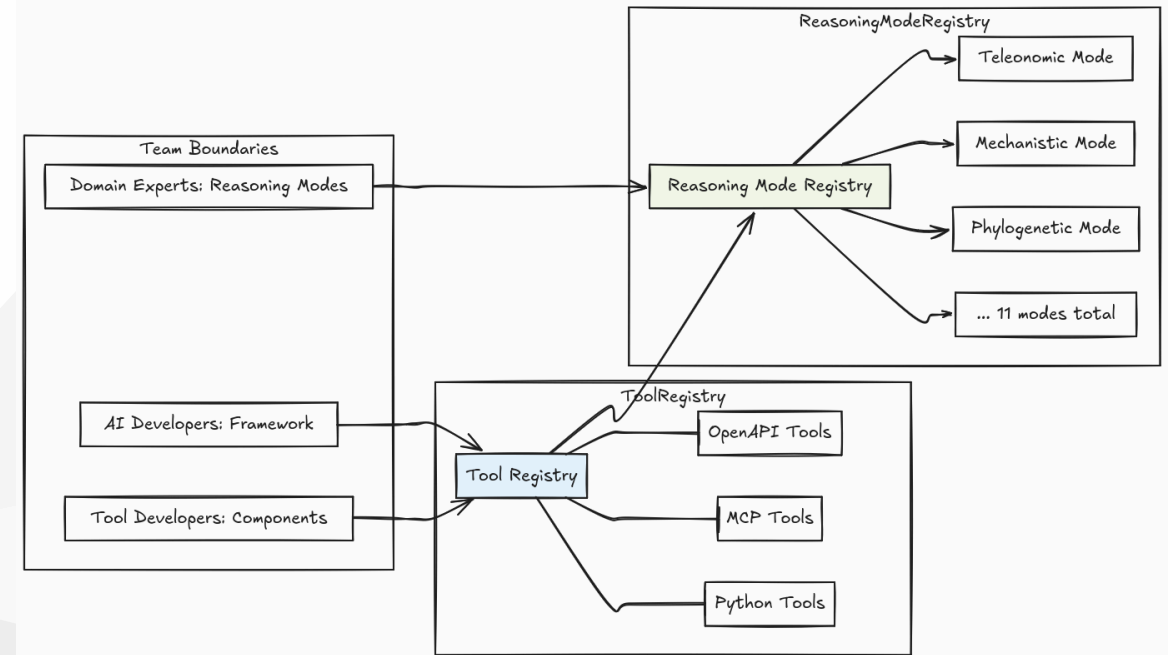
# Why This Matters

## Scalability:

- ToolRegistry: Any OpenAPI/MCP/Python function becomes a tool
- ReasoningModeRegistry: Recipes for reasoning

## Team boundaries:

- AI developers: Framework
- Domain experts: Reasoning modes
- Tool developers: Components





**Thank You**

Questions?