Dynamic organizational structures

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Outline

Why am I here?

The question of what has brought us to this moment is always relevant.

- There are many lenses for the question "why am I here?"
- Physically, why have our atoms assembled here?
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- My understanding of PCE3 is very limited; mainly Eric Smith videos:
- Proto-life was the minimally complex "lab" that could perform...
- ...certain exothermic reactions (e.g. $CO_2 + 2H_2O \rightarrow CH_4 + 2O_2$).
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I'm fascinated by nature's capacity to develop understanders like us.

- Our prebiotic origin gives clues as to how this development occurs.
- I would like to make such ideas formal and systematic.

Mathematical fields as accounting systems

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- Hilbert spaces account for the states of elementary particles, as in QM.
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  - We can add and multiply #'s by #'s: 5 boxes $\times$ 10 widgets $=$ 50.
  - We can multiply \$'s by #'s: 100 * \$3 $=$ \$300.
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Category theory is the accounting system for coherent structures.

- It makes analogies—similarities of structure—into formal objects.
- It's been useful in math, CS, physics, materials science, linguistics, etc
- What sort of system accounts for PCE3?

My understanding of PCE3

Again, please excuse my ignorance of PCE3; here's how I naively see it.

- Our concept of the early earth is that life formed from chemistry.
- We see a repeated pattern regarding concentration of power.
- X's *power* is its capacity to quickly catalyze a change in conditions.
  - In physics, it is work divided by time. But more colloquially also:
  - Birthing a child is a 9-month catalysis: zygote + food $\rightarrow$ baby.
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- Life catalyzed certain chemical reactions on the early earth.
- To catalyze and not be dissipated during those reactions is "survival".
- We're interested in a formal account of power.
  - By what mechanism does it so consistently concentrate?
  - Is there a theme to the sorts of changes that life catalyzes?
  - In what respects are material conditions on the EE relevant?

Dynamic organizational structures

Concentration of power comes from organization, not elementary makeup.

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- But it is made only from the flies that the spider eats.
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Any life-form is a collective, a dynamic organization of smaller parts.

- The organization provides an interaction pattern for the parts.
- The RNA will interact with the nucleus and the ribosome, etc.
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I have a category-theoretic accounting system for such things.

Plan for the talk

During the remainder of the talk I will:

- discuss open dynamical systems and interaction patterns,
- explain dynamic organizational structures, and
- conclude with a summary.

Outline

Open dynamical systems

An open dynamical system (ODS) is a kind of "worker".

- It can interact with the outside world through a specified interface.
- This interface displays its position, attitude, various signals, and...
- ...can receive forces, materials, signals, etc.
- The ODS has an internal state, which dictates its position, etc., and...
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We can consider either continuous or discrete ODS's.

- In both cases, the outputs are given by a function of the state.
- In a cont'ous ODS, the state evolves according to a system of ODEs...
- ...and the inputs provide time-varying parameters to the ODEs.
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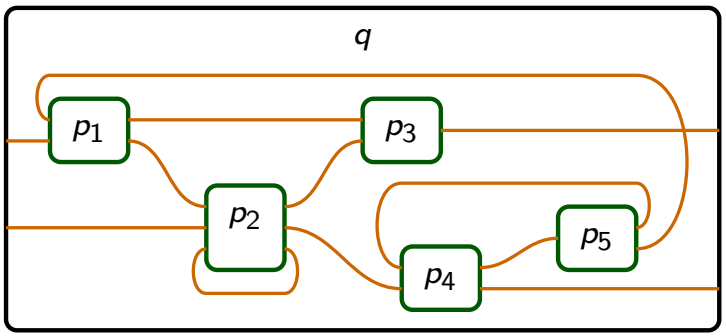
How can you visualize the interface of an ODS (continuous or discrete)?

- The interface may change through time, but at any point it can...
- ...be drawn as a box with inputs/outputs on the left/right: 

Wiring diagrams and interaction patterns

Open dynamical systems connect with each other in interaction patterns.

- The easiest sort of interaction pattern to visualize is a wiring diagram.



- This one interconnects interfaces $p_1, \ldots, p_5$ inside a boundary q.
- Let's denote the wiring diagram as $\varphi\colon (p_1, \ldots, p_5) \to q$.
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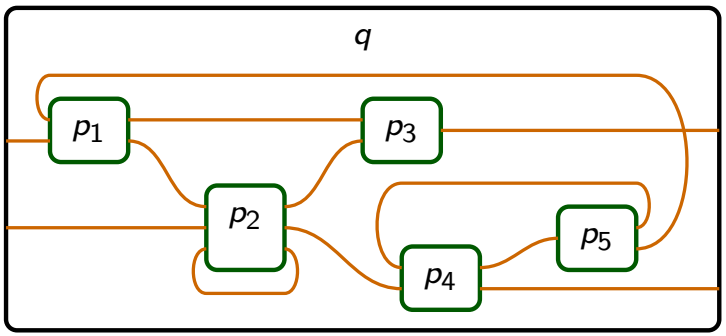

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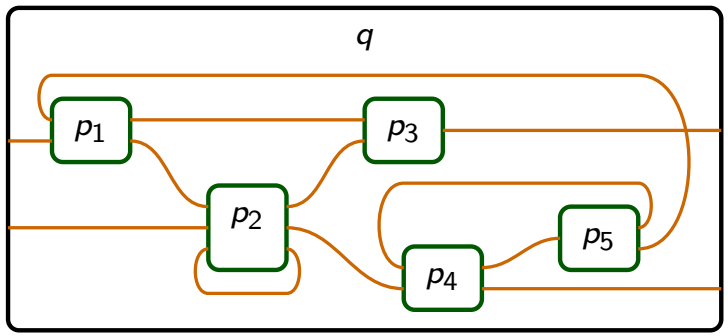

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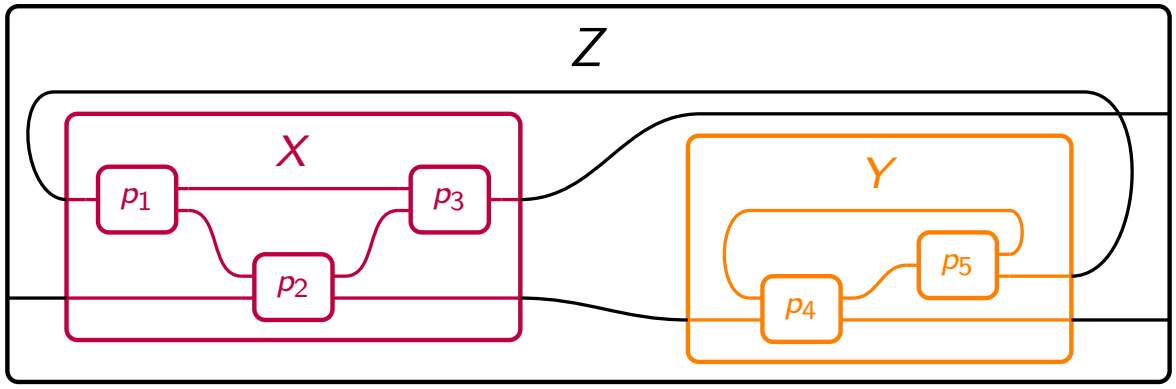
Interaction patterns can be more general, e.g. weighted, dynamic, prob'istic.

- It's harder to draw, but the unambiguous CT syntax generalizes easily.

Nesting

Interaction patterns can be nested.



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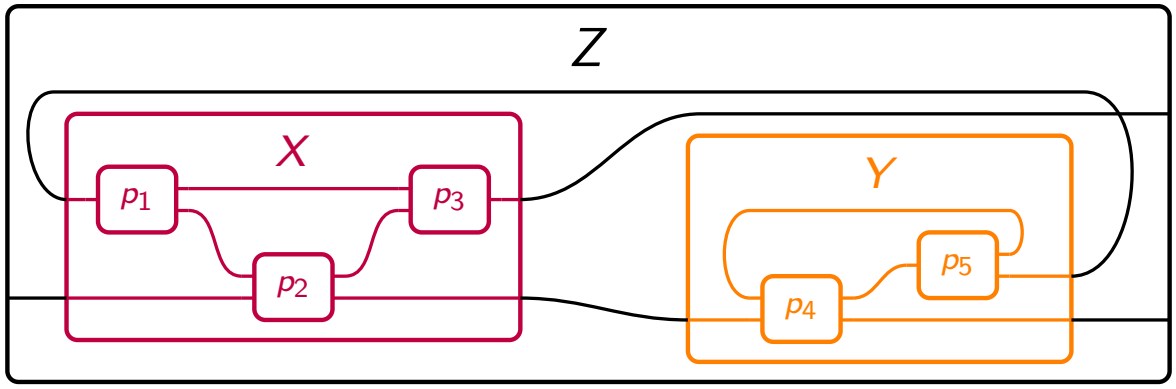

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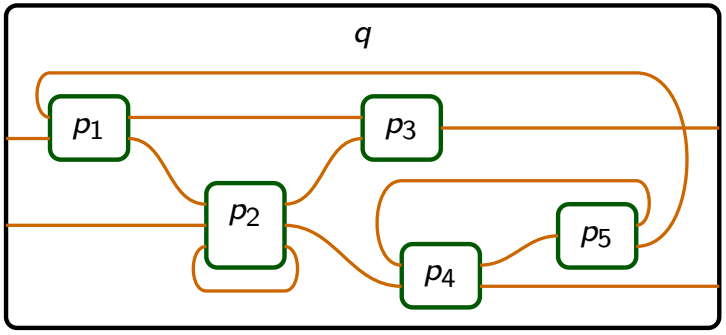

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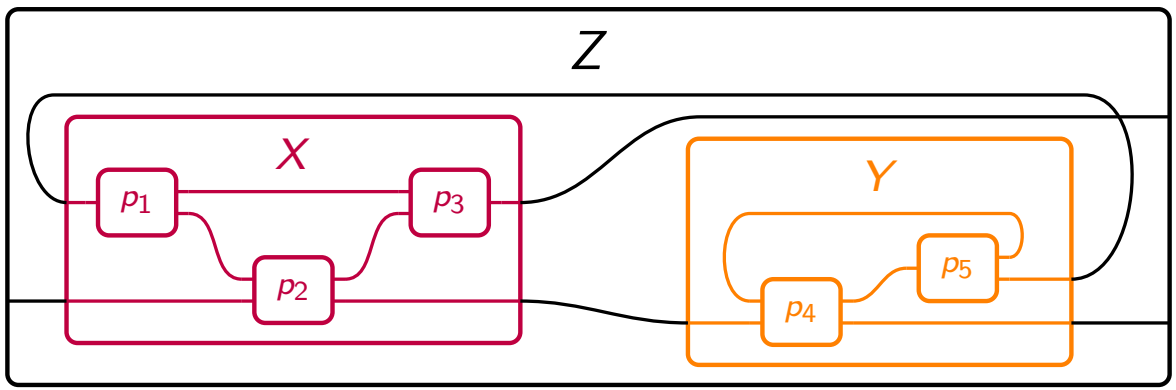

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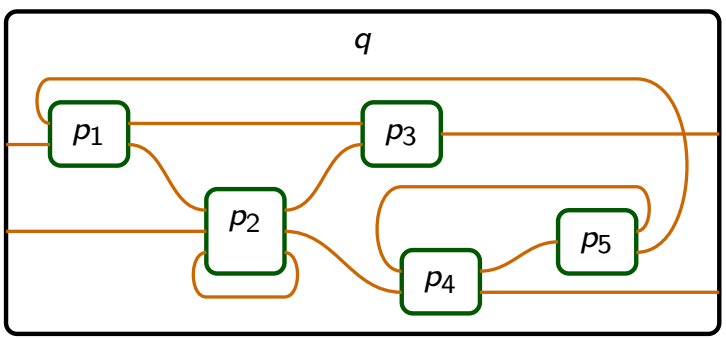

You can abstract an interacting population of ODS's as an ODS.

- The semantics of zooming or regrouping is *compositional* wrt nesting.

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Mode dependent interaction

In the above pictures, the interaction pattern appeared to be fixed.

- This works great for integrated circuits, but not for real life.
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The CT accounting system I've been alluding to can handle all this.

- The formal system is called polynomial functors; it accounts for:...
- ...ODS's in time-varying interfaces with time-varying inter'n patterns.

Dynamic organizational structures

A dynamic organizational structure[1] is a systematized version of the above.

- It's like a presentation of the laws of nature or the rules of a game.
- It tells you rules for how parts are allowed to form into wholes...
- ...where these laws/rules are required to be a compositional.

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More detail on dynamic organizational structures

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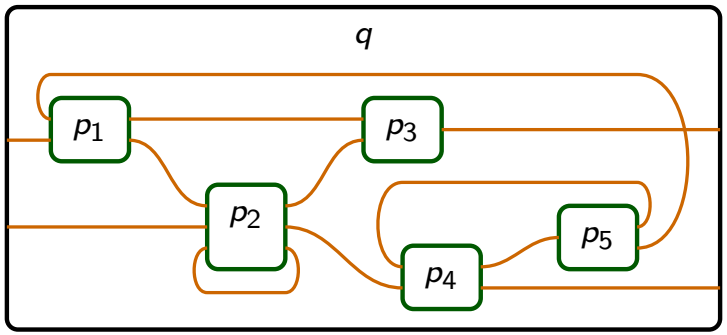

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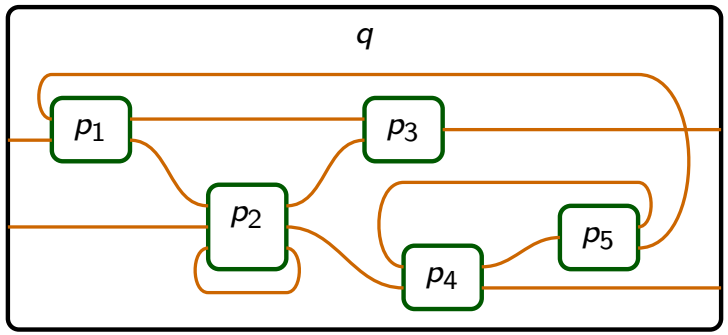

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This "formulaic and compositional" aspect shows up in our examples.

- Deep learning formula: gradient descent.
  - A population of gradient descenders forms a gradient descender.
- Prediction markets formula: update wealths based on Bayes rule.
  - A population of predictors with varying wealths forms a predictor.

Applications to PCE3

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The above gives an accounting system for ODS's inhabiting interfaces.

- It is compositional: continuous with respect to boundary-drawing.
- Individuality is a derived concept rather than metaphysically primary.
- Parts connect or disconnect based on what occurs during interaction.

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Only four known interesting examples, but PCE3 may offer another one.

- We'd need to find a system for how identity-flexible evolution works.
- The math gives guardrails (compositionality) that ensure integrity.
- Email david@topos.institute if you'd like to explore a collaboration.

Thanks! Comments and questions welcome...