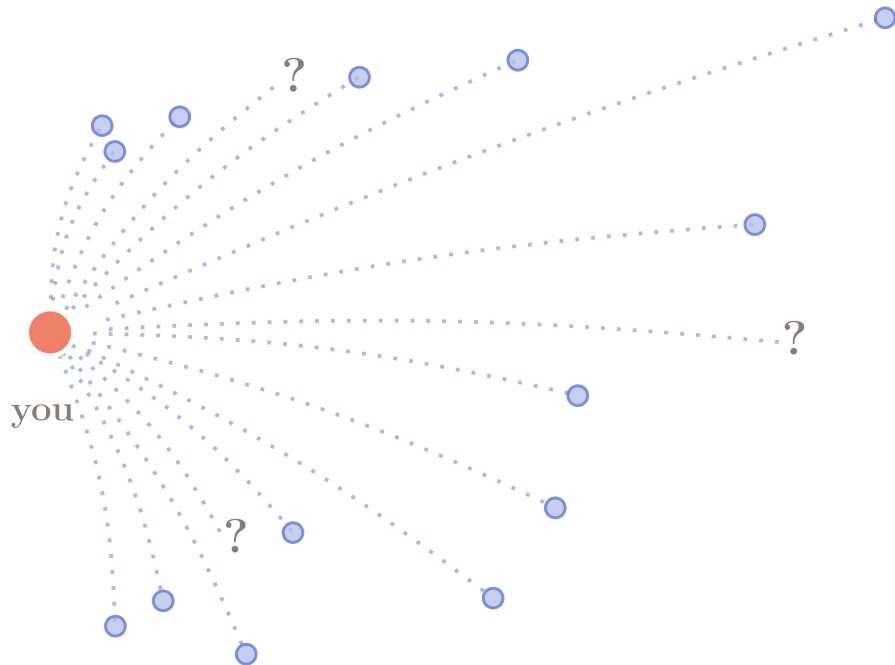


Scientific research and communication from the seed that grows and spreads



Fangzhou Xiao, Westlake University
PEBBLE, 202607

You are starting real research: it is vast and open-ended.



So many directions. Where do you even start, and how do you not drown?

P

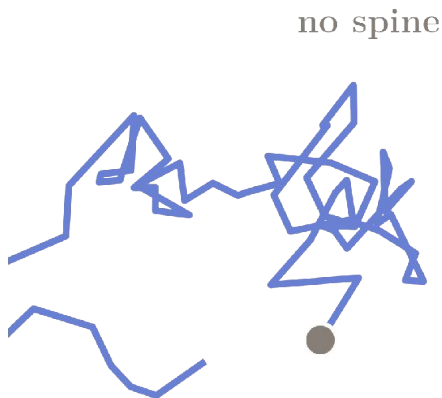
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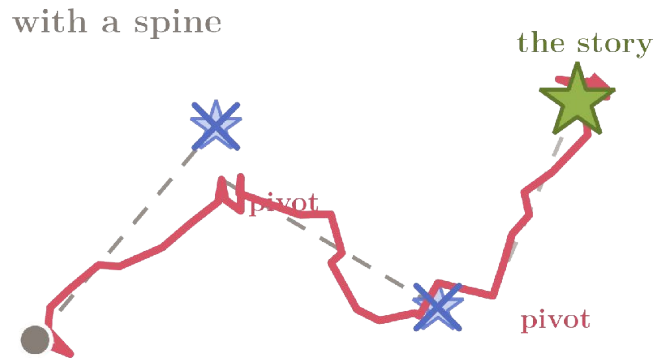
P

S

Do a lot and hope a story emerges: the project wanders.



do stuff, hope a story emerges



an imperfect spine still guides you

An imperfect first spine still gives direction: aim, hit a dead end, re-aim, and converge.

P

C

A

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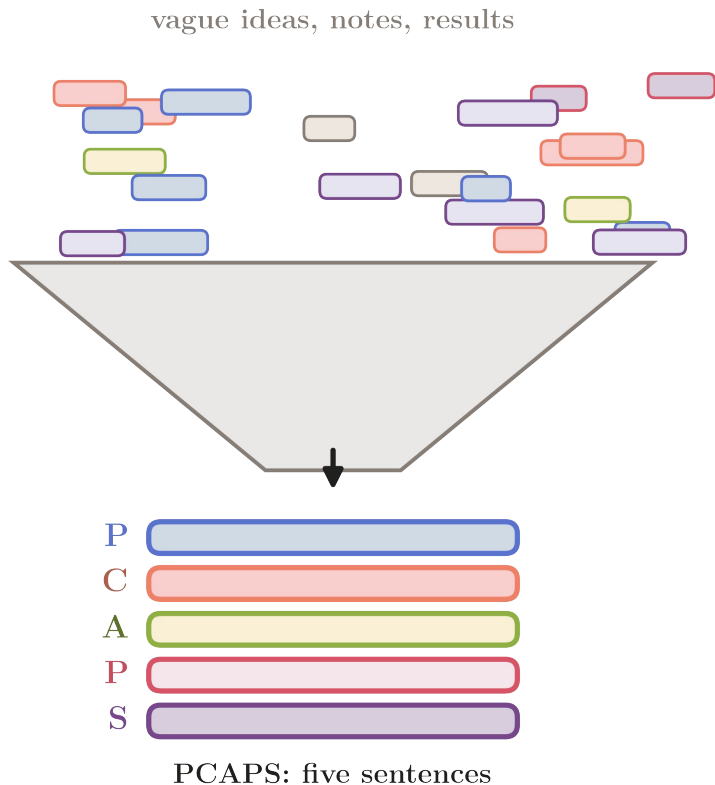
S

Start from the end: distill the seed first.

Distilling is subtractive.

Not “do the work, then write it up.”

Write the five-sentence core first. It is your starting point, not your conclusion.



P

C

A

P

S

The seed is five sentences: PCAPS -- the spine.



P

Problem

The setting and the stakes: why should anyone care?

C

Challenge

What people do now, and why it falls short.

A

Approach

Your one unique insight.

P

Proof

What you did that shows it works.

S

Significance

Back to the big problem: what changes now.

P

C

A

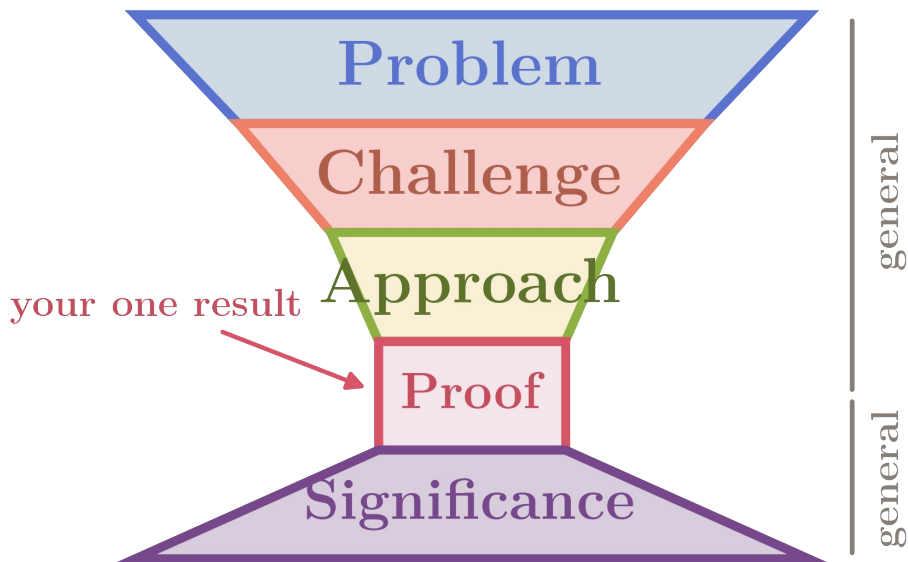
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S

Broad problem, narrow to your one proof, broad significance.

The hourglass.

Open wide so anyone cares. Pinch to the single result only you have. Open again to what it means.



P

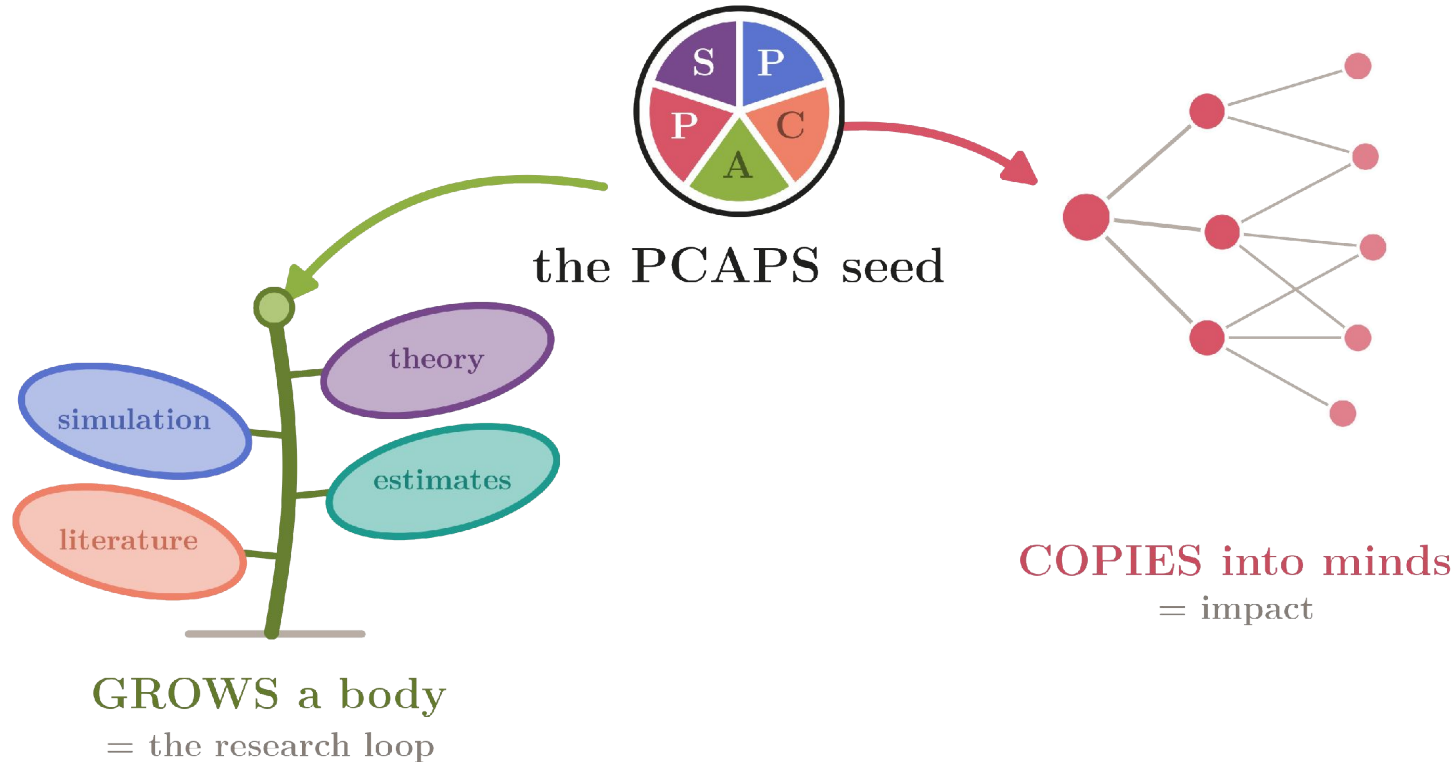
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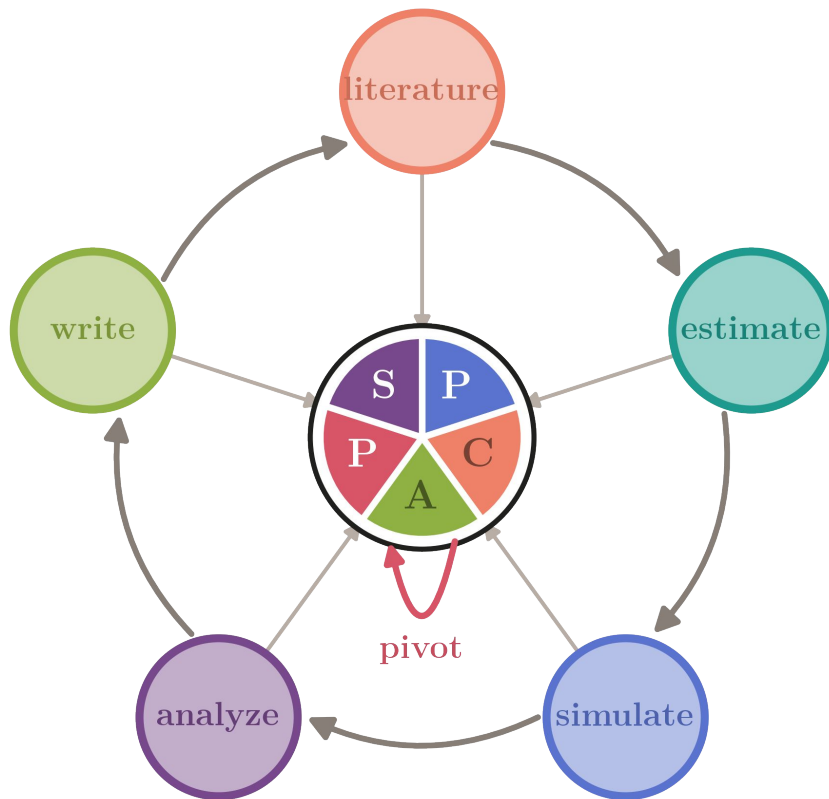
A seed does two things: it grows a body, and it copies into minds.



Growing the body is the research loop.

Everything orbits the seed.

Read, estimate, simulate, analyze, write. Each turn feeds the core -- and can force a pivot.



P

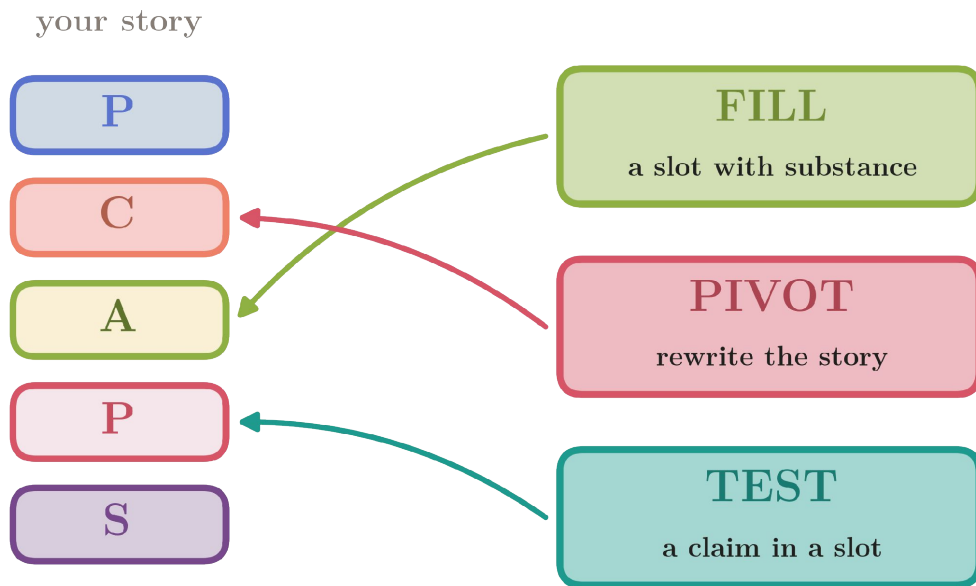
C

A

P

S

Every action fills a slot, tests a claim, or pivots the story.



none of the three? $\Rightarrow$ why are you doing it?

The convergence rule: hold every task against your seed before you start it.

P

C

A

P

S

Every paper you admire is, at its core, a PCAPS.

P

C

A

P

S

Kinetic proofreading (Hopfield 1974)

P

Replication and translation are far more accurate than binding-energy differences allow.

C

Selection by affinity alone is capped by the free-energy gap.

A

Add a driven, irreversible step: test the substrate twice.

P

Error rate falls to about (equilibrium error)², matching biology.

S

Spend energy to buy accuracy -- a universal fidelity principle.

DNA computing (Adleman 1994)

P

NP-hard search (Hamiltonian path) explodes for silicon.

C

Electronic search is essentially sequential.

A

Encode the graph in DNA; hybridization explores all paths at once.

P

A 7-node instance solved in a test tube, read out by PCR and gel.

S

First molecular computation: it births DNA computing.

My lab's project began as exactly these five sentences.

P

C

A

P

S

P

Problem

Biological systems show homeostasis, multistability, oscillation, adaptation. We need a mathematical foundation to understand and design them.

C

Challenge

For 100+ years people used Michaelis-Menten approximations: simple, but valid only under restrictive assumptions.

A

Approach

Describe bioregulation by reaction orders, not concentrations, to analyze the full landscape without those assumptions.

P

Proof

In the simplest case the full profile is a triangle in reaction-order space, and Michaelis-Menten is just one edge.

S

Significance

A holistic foundation that upgrades a 100-year-old tool, to describe and design complex biological behavior.

Now you: write your seed in 10 minutes. Then I retell it.

The protocol

1. 10 min, silent: fill the five rows for your project (or a paper you love).
2. Pass a few forward.
3. I read one once, then retell it in my own words.
4. Faithful retell = $R > 1$. A stumble shows which slot was loose.

The ones that transmit cleanly were tight in every slot.



Problem

What is the big problem? Why should anyone care?



Challenge

What is done now, and why does it fall short?



Approach

What is your one unique insight?



Proof

What did you do that shows it works?



Significance

Back to the big problem: what changes now?



Now you: write your seed in 10 minutes. Then I retell it.



Problem

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Challenge

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Approach

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Proof

What did you do that shows it works?



Significance

Back to the big problem: what changes now?





your PCAPS core

spreads like a virus

effective communication

wins strong supporters



We give talks to communicate our ideas / make impact and show our capabilities.

Relevant scenarios:

- Faculty/postdoc/research scientist/technical industry job interviews
- Talks at an academic/technological conference
- Presentations for project reviews during a job

Key: we need to impress the audience with our work.

Demonstrate our capabilities. Show, not tell.

Let's focus: talks are to win strong supporters and spread the ideas.

Win a strong supporter is NECESSARY to get a job in a competitive market or spread your ideas.

Think about how interview results are determined / scientific discussions happen...

Conversations in some form of a committee / group of scientists...

A candidate / idea is brought up for consideration or discussions...

There needs to be a **strong supporter** making a convincing case...



A strong supporter likes your work and can ALSO convince others.

Win a strong supporter is NECESSARY to get a job in a competitive market.

A weak supporter likes you and your work, but cannot convince others.

A strong supporter likes you and your work, and CAN convince others.

How?

They can recount the significance of your work.

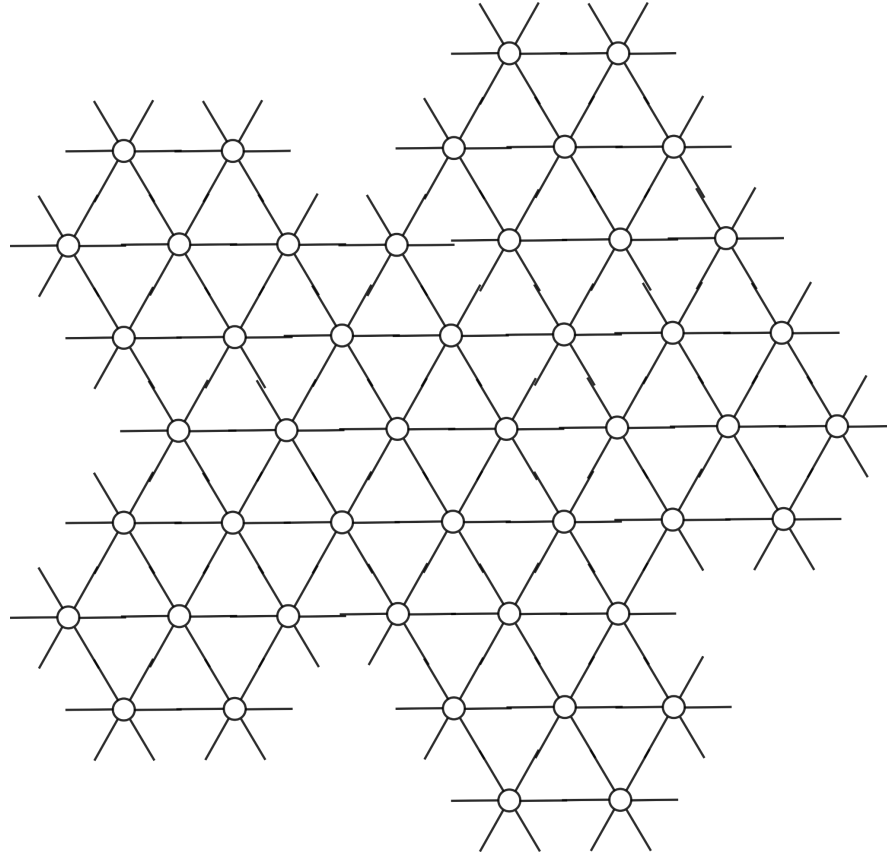
Make them understand, so they like your work.

Make it simple and clear, so they can convince others.



Strong supporters make ALL the difference in your impact!

- **An order of magnitude estimate.**

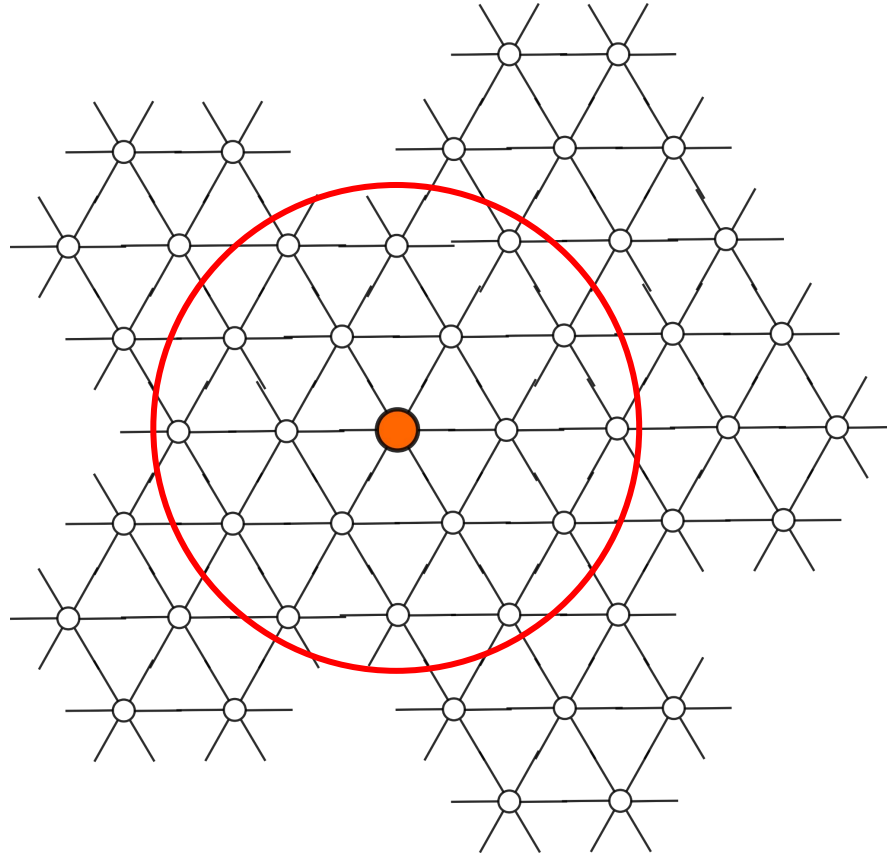


Social network

- ~ degree 6

Strong supporters make ALL the difference in your impact!

- An order of magnitude estimate.**

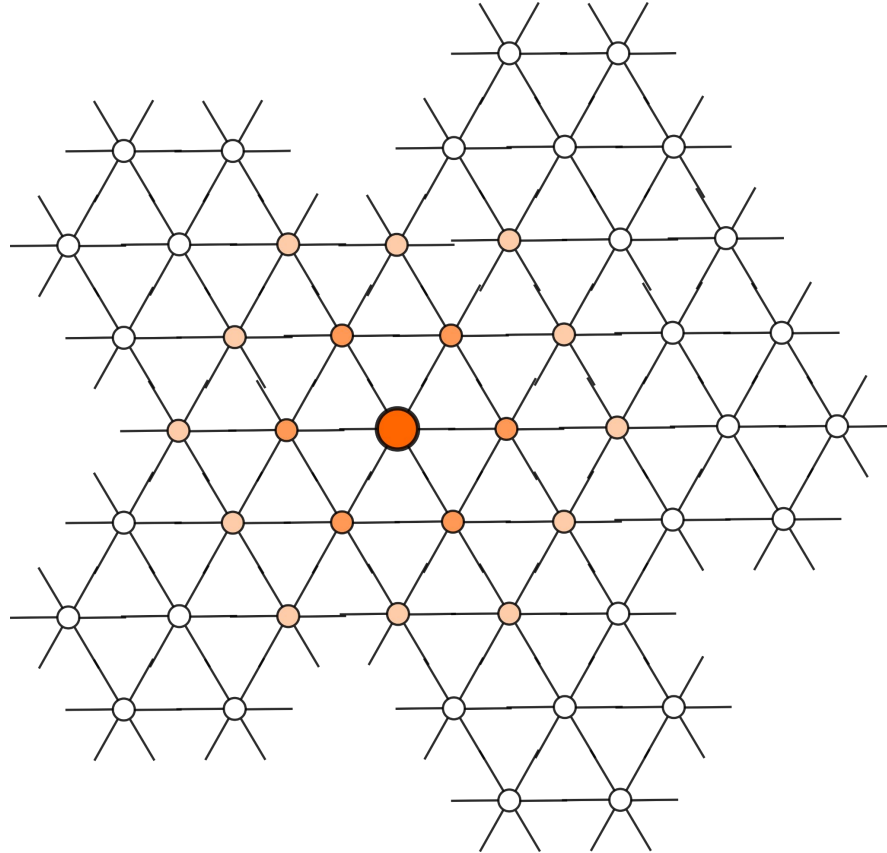


This is you.

You give a talk.

Strong supporters make ALL the difference in your impact!

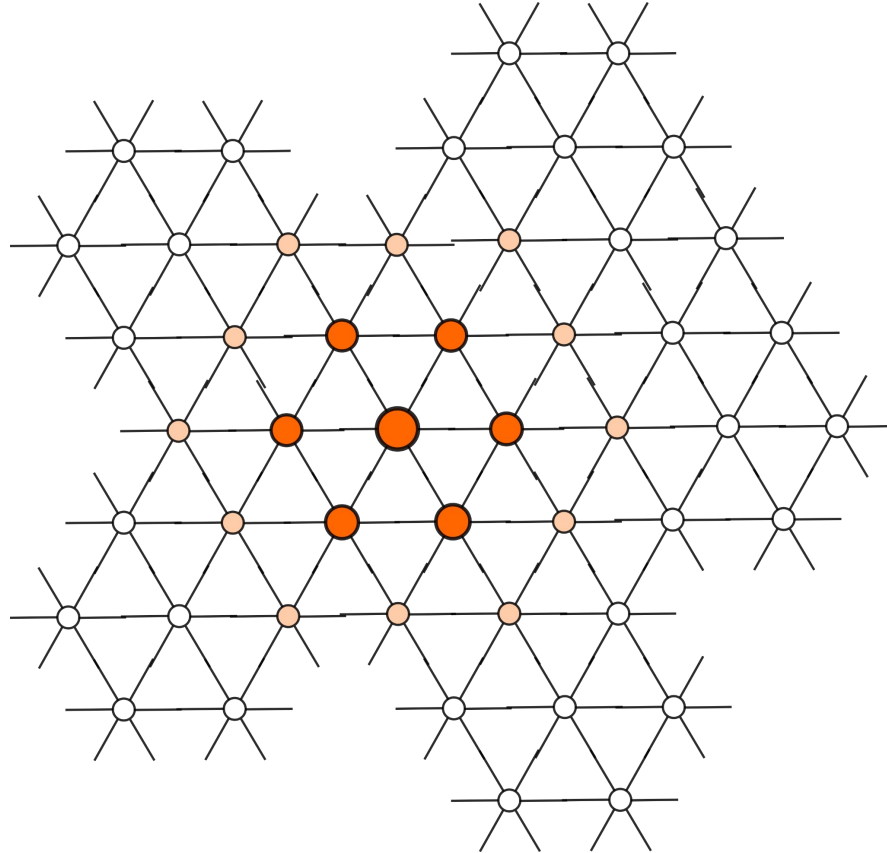
- **An order of magnitude estimate.**



A typical impact
you make...

Strong supporters make ALL the difference in your impact!

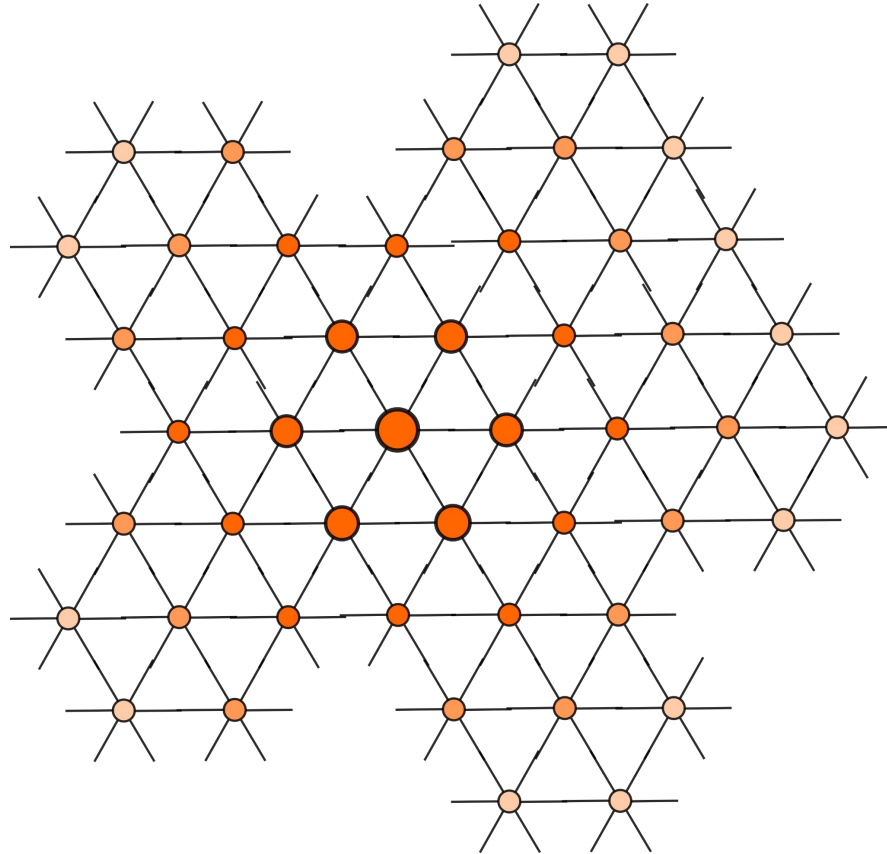
- **An order of magnitude estimate.**



If you win STRONG supporters...

Strong supporters make ALL the difference in your impact!

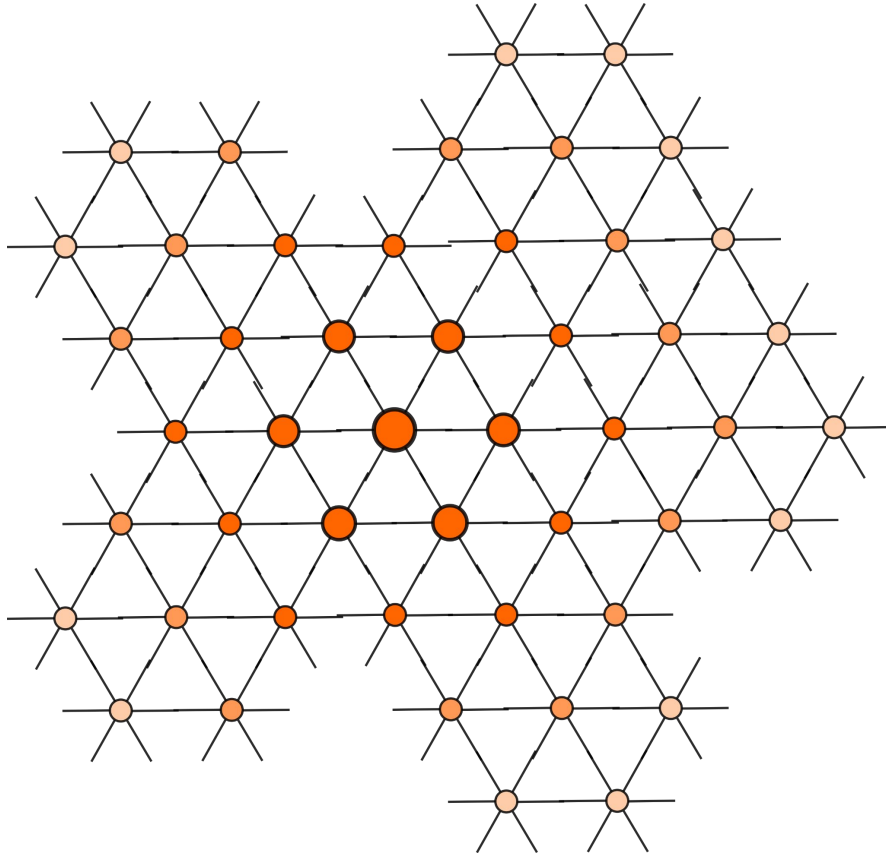
- **An order of magnitude estimate.**



If you win STRONG supporters...

Strong supporters make ALL the difference in your impact!

- An order of magnitude estimate.



N = steps before decay

$$\text{Spread} = 6^{(N+2)}$$

W/o strong supporters ($N=0$):

$$\text{Spread} = 6^{(0+2)} = 36$$

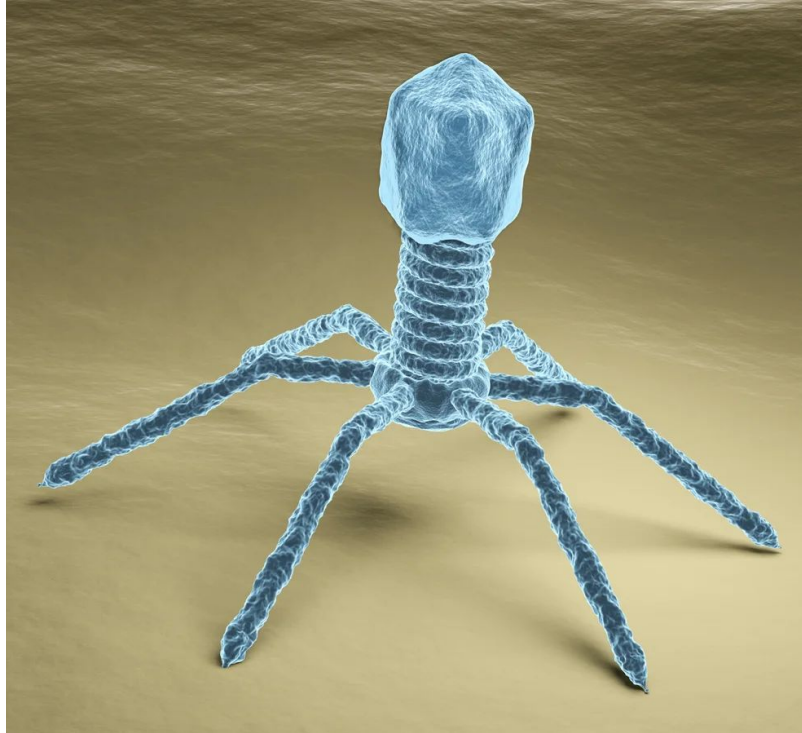
With strong supporters ($N=2$):

$$\text{Spread} = 6^{(2+2)} = \underline{\underline{1296}}$$

From 10s to 1000s!!!!

How to win supporters so it spreads like a virus?

- **Learn from biology: Package it simple and tight!**



<https://www.gettyimages.com/detail/photo/bacteriophage-virus-electron-microscopy-image-royalty-free-image/469922898>

P-CAPS

big problem

challenge

approach

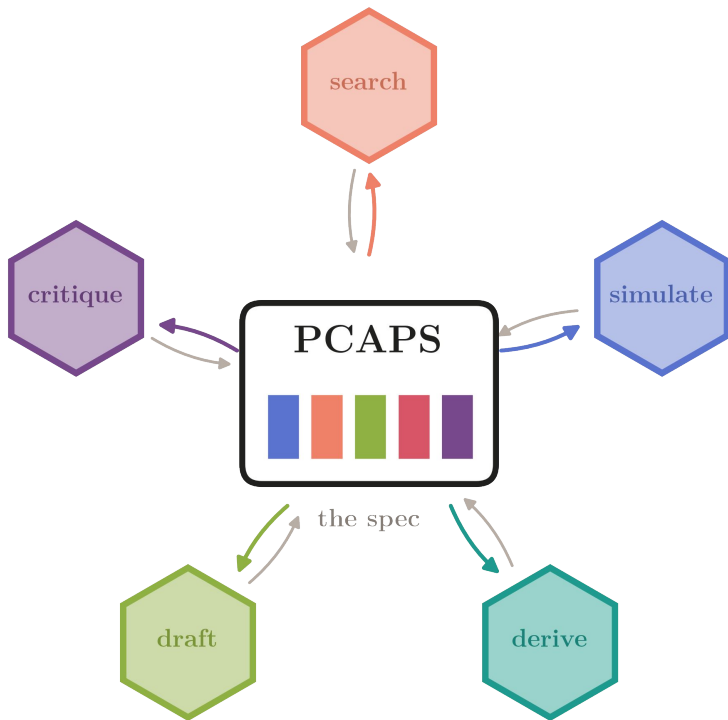
proof

significance

The seed is also the interface to your AI agents.

Five sentences = a spec.

Compact enough to hand an agent. Each slot spawns a worker.



next lecture: grow the seed into a manuscript with agents

P

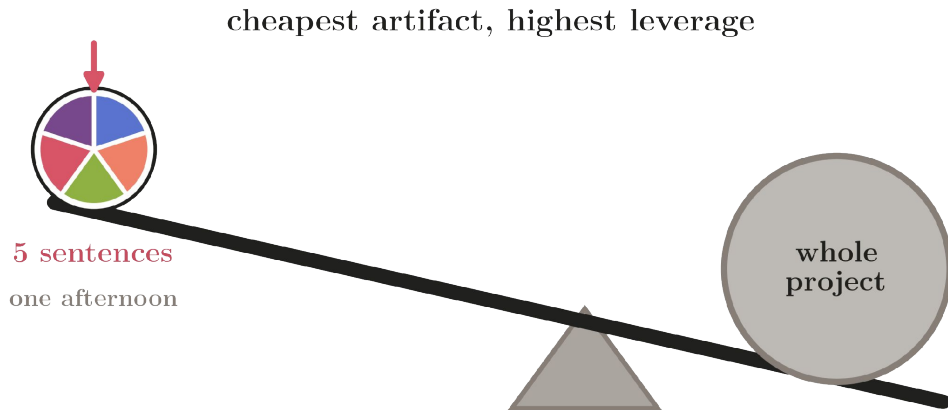
C

A

P

S

Cheapest artifact, highest leverage: always carry your PCAPS.



this talk is one PCAPS



Real research is vast: where do you start?



Do stuff and hope a story emerges: it wanders.



Distill the seed first: five sentences, PCAPS.



Lens, seed, replicator: three proofs, one live.



Cheap, convergent, communicable, AI-ready.



Organize your talk to most effectively transmit this chain of logic.

1. Hierarchical, not a detective story. Because people may miss pieces here and there.
 - a. Recap the chain of logic thus far.
2. Title of slides are always statements.
 - a. So even if people missed some words or sentences, they know your core chain of logic.
3. Every step of the logic should be visually represented on the slide.
 - a. What you say is only present for a few seconds, but what is on the slide can persist for a while.
4. Practice, practice, practice! So you are casual and friendly.
 - a. People pay more attention to what you say if you appear casual and friendly, fully immersed in what you present, rather than the form of your presentation.
5. Tailor to your audience.
 - a. Adapt parts of your chain of logic to your audience.
 - b. e.g. Motivation: Science vs Engineering. Challenge: holistic vs complexity.