Abstract

Artificial Life is known to cultivate an appreciation for diversity in viewpoints, theories, and methods, a trait many of us value highly. Consequently ALife is more open to different backgrounds than many other academic communities. Even the adjective “academic” is not a pre-requisite for participation in and contribution to ALife.

Is this tendency inspired by a widespread appreciation for evolutionary thinking? Perhaps. But it does mean that teaching ALife is a rich source of opportunities to reach learners that you would not normally find in a computer science course (which may be the most represented department designation in ALife).

Reaching an audience with starting from a variety of different entails teaching challenges, most notably how to balance these backgrounds against the oft-intimidating equations and code from which the life-like aspects of the subject matter emerges.

Day One - TALK #2

Q. Tyrell Davis

Reaching (for) Critical Maths

Format

~15+5

Find on Discord

@rivesunder

Boulder, CO, USA

Post questions and brutal commentary to #talk-davis-to-code-or-not-to-code!

ALife-Edu

Talk Outline

- The setting: ALife
- The challenge (the mythical “math person”)
- The reward (gateways and side effects)
- Strategies
  - ‘Form and rhythm’ (From P. Scott Carney, now at SBU)
  - Empowerment by visualisation
  - Rosetta Stone approach.
- The CLASS (Cross Labs Alife Summer School) experience
- Conclusions and open discussion

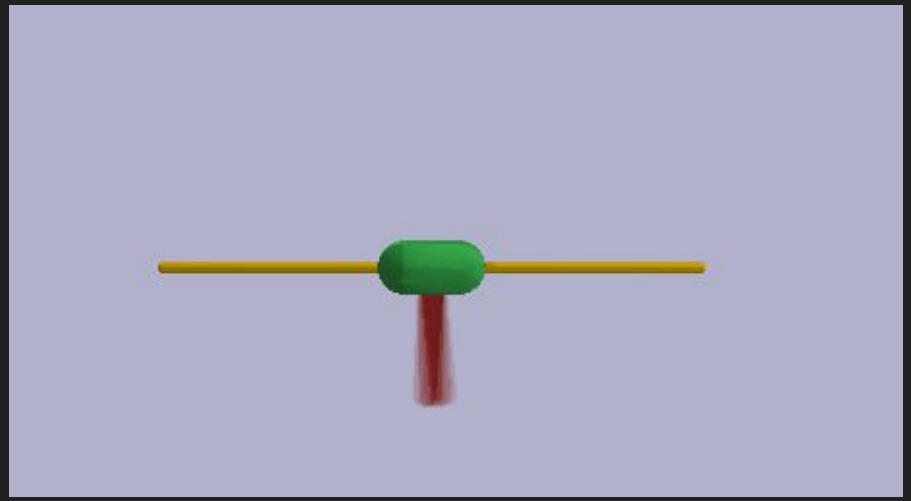
Interdisciplinarity Cultivates Theoretical Diversity

- Melanie Mitchell, in *Complexity: a guided tour* (2009):
-
    - “By the mid-twentieth century, many scientists realized that such phenomena cannot be pigeonholed into any single discipline but require an interdisciplinary understanding based on scientific foundations that have not yet been invented.” (p. x)

- Murray Gell-Mann, writing about bridging in *The Quark and the Jaguar* (1994):
-
    - “One of the great challenges of contemporary science is to trace the mix of simplicity and complexity; [...] up the ladder from elementary particle physics and cosmology to the realm of complex adaptive systems.” (pp. 119-120)

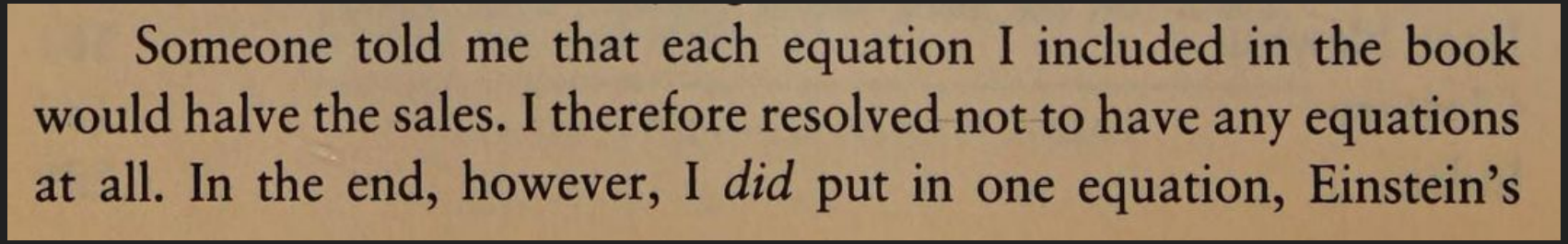
ALife a Melange of Viewpoints, Methods, and Theory

- Recent discussions about an identity crisis: is ALife a field or something else?
  - *e.g.* (Beer, 2024) ~ ALife should consolidate commonalities as a mature discipline.
  - and (Harvey, 2024) ~ ALife more of a nursery ecology for novel interdisciplinary research ideas and collaboration.



https:github.com/rivesunder/PGENs

The Challenge



Someone told me that each equation I included in the book would halve the sales. I therefore resolved not to have any equations at all. In the end, however, I *did* put in one equation, Einstein's

From Stephen Hawking *A Brief History of Time* (1988) p. vi

Has morphed into general advice/joke for academic conferences.

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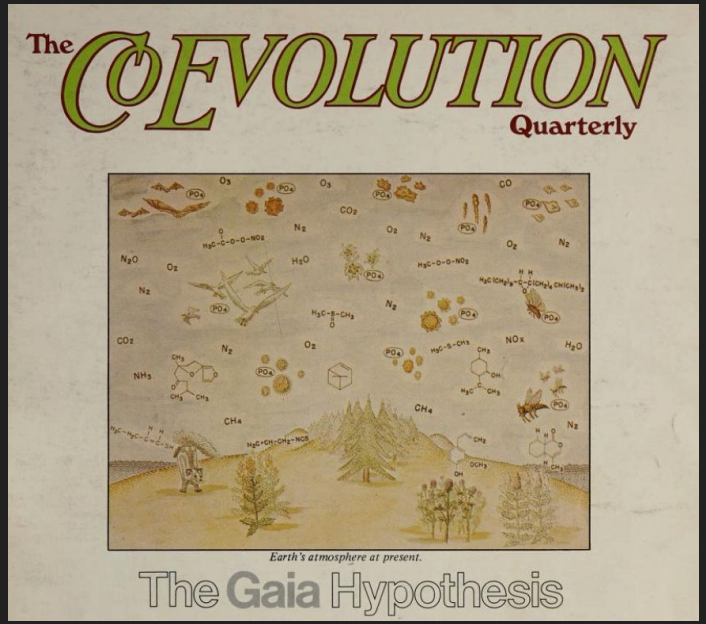
$$N_i = N_0(1/2^i)$$

The Reward 1/2

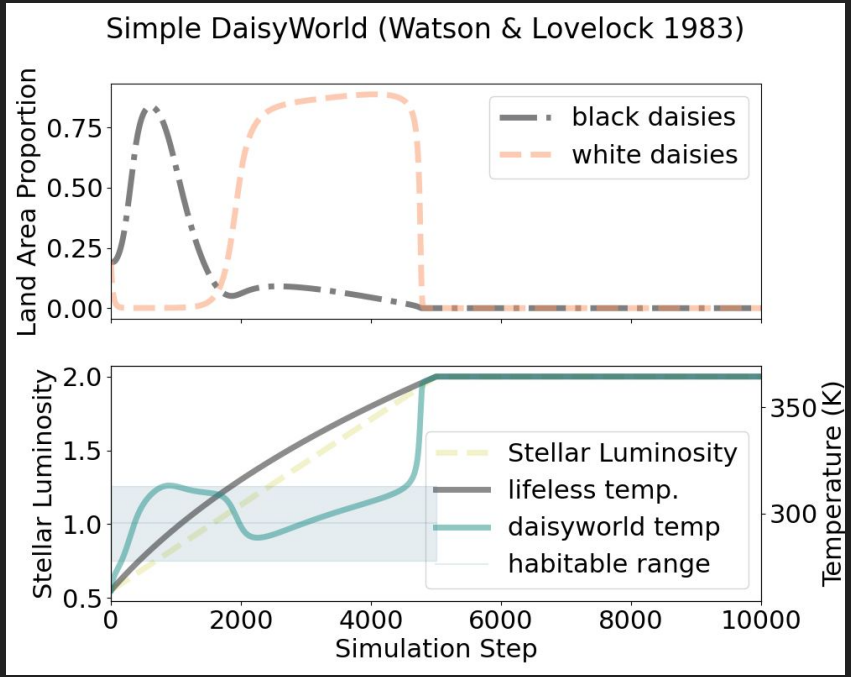
- ALife can be a “gateway course”.
- Many may advocate for STEM on purely economic grounds.
- Less STEMful professions, beneficial side effects -> competent citizens.

NCA Gila texture from CLASS

The Reward 2/2



From *Coevolution Quarterly* Summer 1975



Daisyworld model output (from CLASS)

Leveraging Context and Structure (1/3)

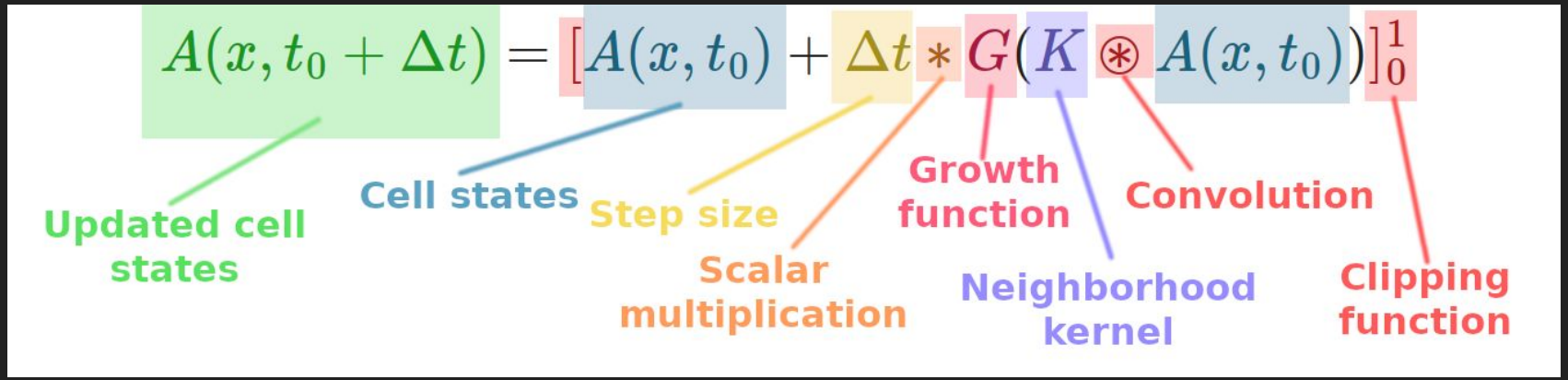
Johann Wolfgang von Goethe (~1780)

Über allen Gipfeln
Ist Ruh',
In allen Wipfeln
Spürest du
Kaum einen Hauch;
Die Vögelein schweigen im Walde.
Warte nur, balde
Ruhest du auch.

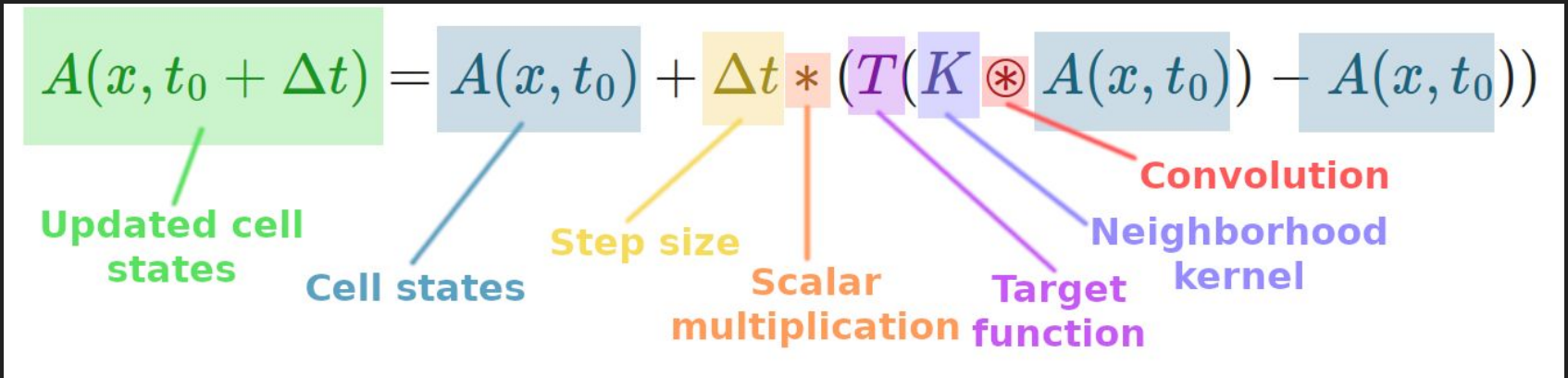
Drawing of a photo of a replica of Goethe's handwritten poem, the second part of "Wandrers Nachtlied". Photo by August Linde (~1869), drawing from "Die Gartenlaub" (~1872). Image in the public domain.

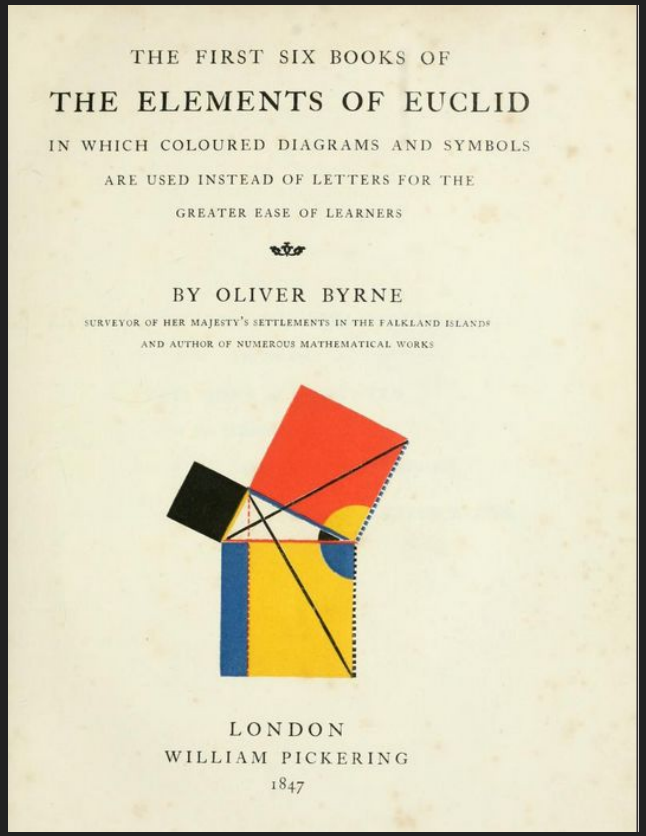
Credit to P. Scott Carney and his Inverse Problems Lecture for this approach (form and rhythm).

Leveraging Context and Structure (2/3)



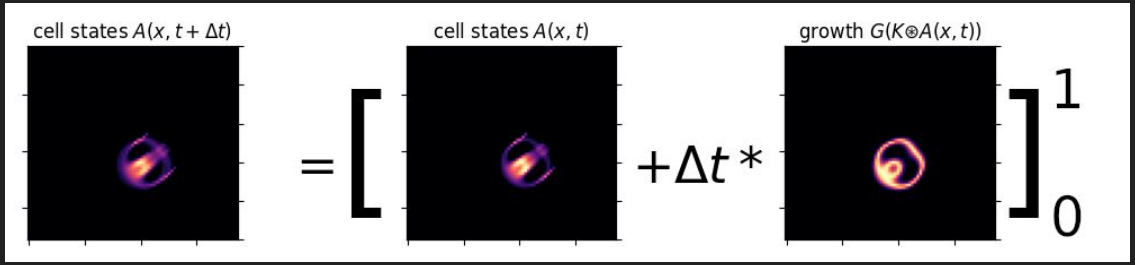
Leveraging Context and Structure (3/3)





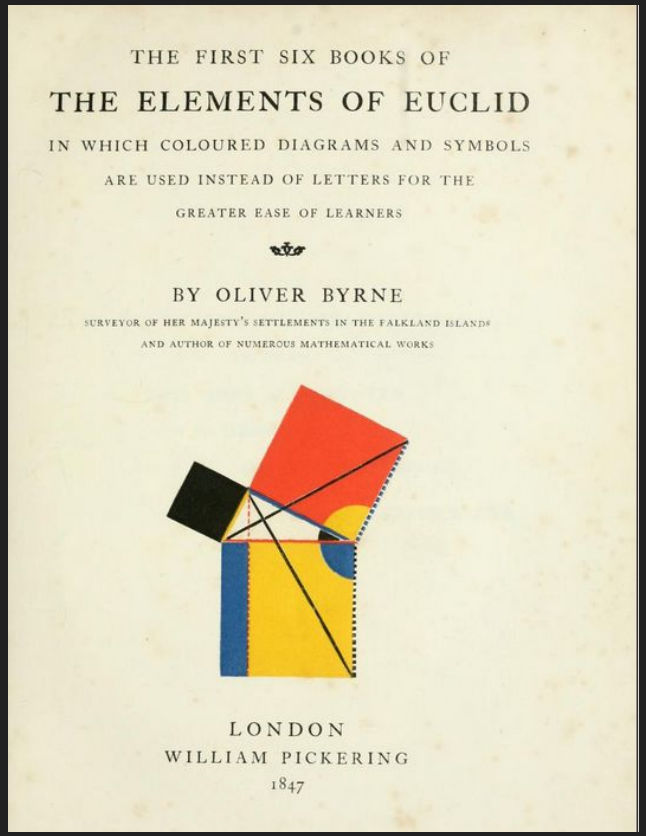
Oliver Byrne 1847, CC0: archived

Empowerment by Visualisation (1/3)



From (Davis 2024)

Empowerment by Visualisation (2/3)

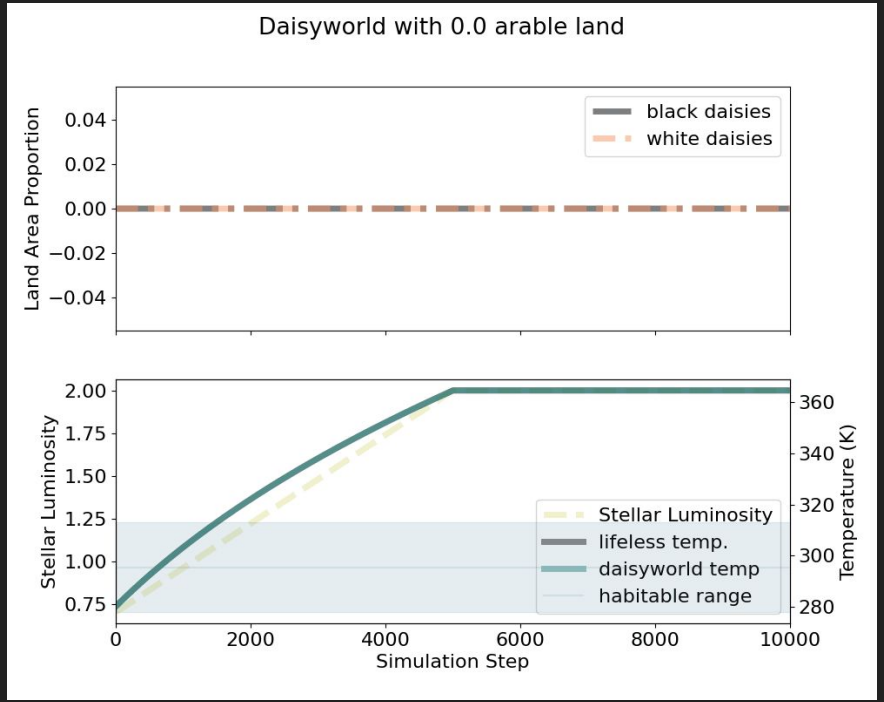

THE FIRST SIX BOOKS OF
THE ELEMENTS OF EUCLID
IN WHICH COLOURED DIAGRAMS AND SYMBOLS
ARE USED INSTEAD OF LETTERS FOR THE
GREATER EASE OF LEARNERS
BY OLIVER BYRNE
SURVEYOR OF HER MAJESTY'S SETTLEMENTS IN THE FALKLAND ISLANDS
AND AUTHOR OF NUMEROUS MATHEMATICAL WORKS
LONDON
WILLIAM PICKERING
1847

Oliver Byrne 1847, CC0: archived

$$\mathrm{I}(X;Y) = \sum_{y \in \mathcal{Y}} \sum_{x \in \mathcal{X}} P_{(X,Y)}(x,y) \log \left(\frac{P_{(X,Y)}(x,y)}{P_X(x)\, P_Y(y)} \right)$$

From 'Mutual Information' on Wikipedia

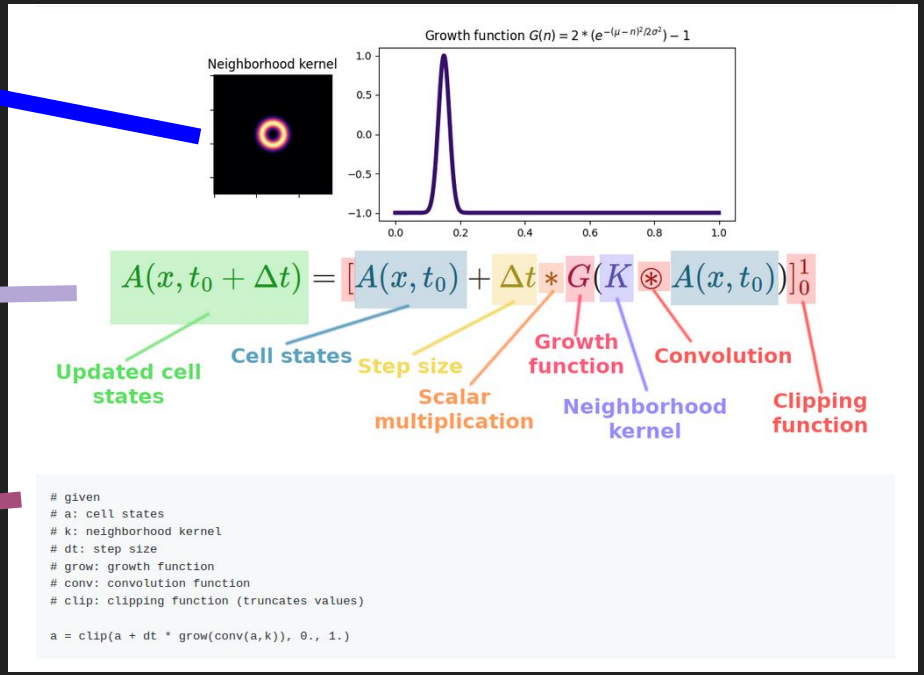
Empowerment by Visualisation (3/3)



From CLASS

Carve a Rosetta Stone 1/2

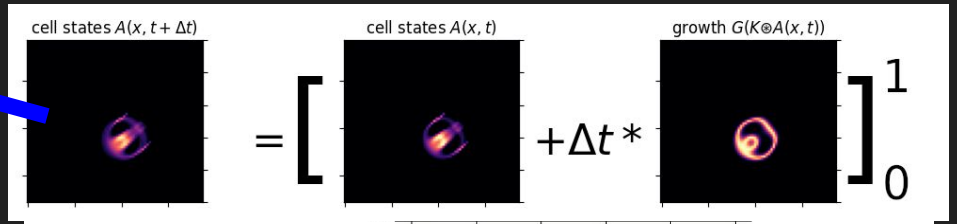
- Graphical overview
- Equation
- Code



Slide from (Davis 2024)

Carve a Rosetta Stone 2/2

- Graphical equation
- Equation
- Code



$$A(x, t_0 + \Delta t) = [A(x, t_0) + \Delta t * G(K \circledast A(x, t_0))]_0^1$$

Updated cell states
Cell states
Step size
Scalar multiplication
Growth function
Neighborhood kernel
Convolution
Clipping function

```
# given
# a: cell states
# k: neighborhood kernel
# dt: step size
# grow: growth function
# conv: convolution function
# clip: clipping function (truncates values)

a = clip(a + dt * grow(conv(a,k)), 0., 1.)
```

Slide from (Davis 2024)

The CLASS experience 1/3

- Concise summer workshop: 4 sessions of ~3 hours + additional work/study sessions.

- The **goal** of the workshop was for students to gain exposure to the concept of falsifiable experiments and modeling through exploration of ALife ideas and systems.

- Our **objective** was presentation of an experiment in poster form at the 2025 ALife Conference.

The CLASS experience 2/3

- Good:
  - Poster presented at ALife.
  - Basic understanding of Daisyworld.
  - All students made it through the process
- Less than ideal:
  - Time too short.
  - Too many systems, too little details.
  - Too little time spent on presentation and poster skills (also new to the students).

The Imaginary CLASS 2.0

In the interest of conducting a broad survey in a short amount of time, I thought I could get away with abstracting away most of the beautiful details, focusing on high level descriptions and visuals instead.

- Focus on one system (*e.g.* Daisyworld or CA)
- Don’t hide the details; instead build bottom-up, slowly and deliberately. (Strange Poetry: Structure and Context).
- Approach from multiple angles (Rosetta Stone)
- Focus on building tools that help CLASSmates see effects when they make changes (Empowering Visualisation)

Open for discussion and questions

- Thanks for listening, special thanks to the other organizers.

- Questions and comments to
  #talk-davis-to-code-or-not-to-code!