A history of studies of agency

Manuel Baltieri

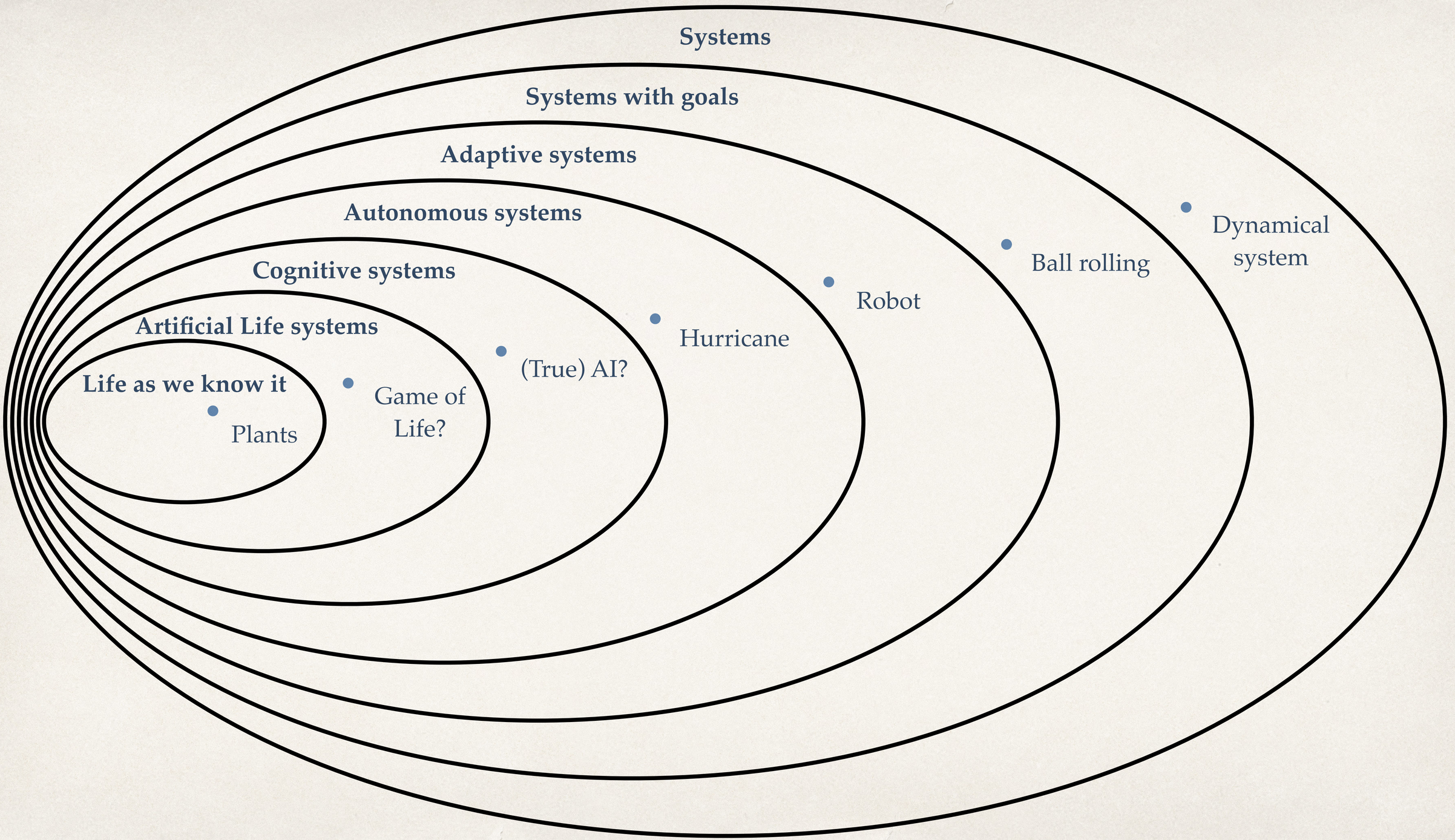
7th Feb 2023

ARAYA

Outline

Agency vs. life, cognition, autonomy, adaptation, etc.

What is agency?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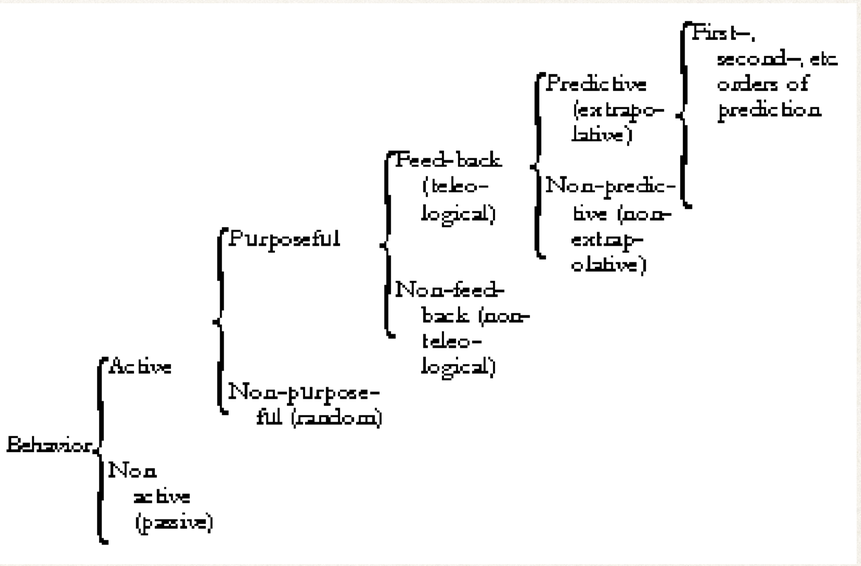
(True) AI?
Hurricane
Robot
Ball rolling
Dynamical system

Inspirations

- Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, purpose and teleology. Philosophy of science, 10(1), 18-24.
- Di Paolo, E. A., & Iizuka, H. (2008). How (not) to model autonomous behaviour. BioSystems, 91(2), 409-423.
- Barandiaran, X. E., Di Paolo, E., & Rohde, M. (2009). Defining agency: Individuality, normativity, asymmetry, and spatio-temporality in action. Adaptive Behavior, 17(5), 367-386.
- McGregor, S., & Virgo, N. (2011). Life and its close relatives. In Advances in Artificial Life. Darwin Meets von Neumann: 10th European Conference, ECAL 2009, Budapest, Hungary, September 13-16, 2009, Revised Selected Papers, Part II 10 (pp. 230-237). Springer Berlin Heidelberg.
- Beer, R. D. (2014). The cognitive domain of a glider in the game of life. Artificial life, 20(2), 183-206.
- Biehl, M. A. (2017). Formal approaches to a definition of agents (Doctoral dissertation, University of Hertfordshire).



Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, purpose and teleology. Philosophy of science, 10(1), 18-24.

What are “agents”?

What are “actions”?

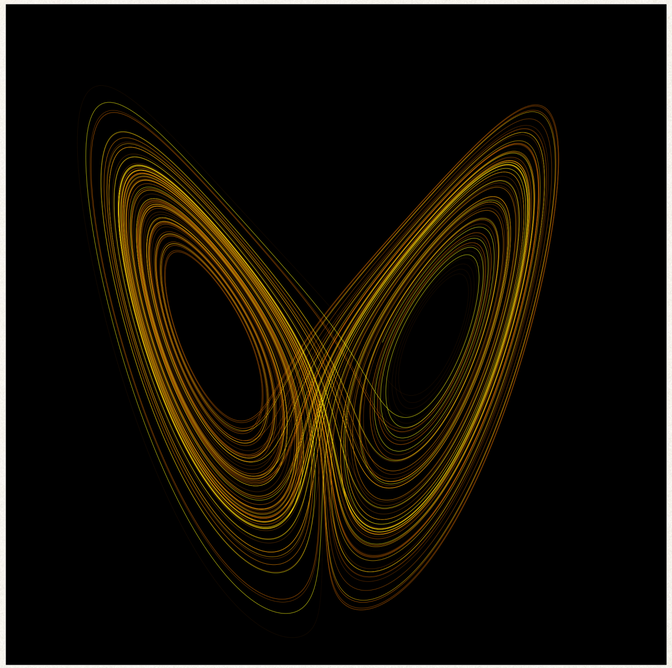
A dynamical system - 1800-900

Definition.

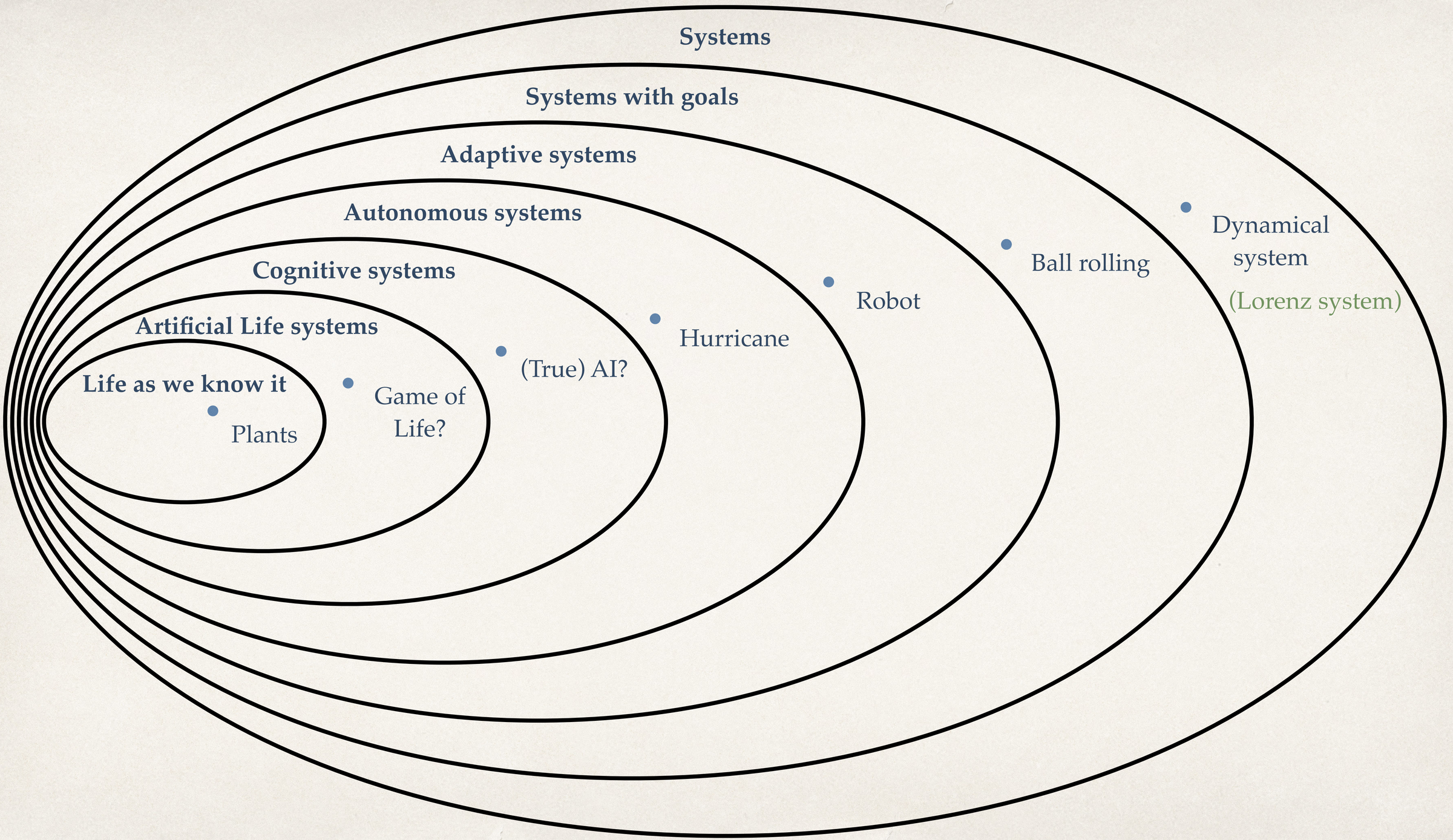
A discrete deterministic dynamical system is a pair (X, α) where X is a set and α is a state-transition map $\alpha : X \to X$.

Continuous and non-deterministic ones require some more machinery, otherwise no qualitative difference.

$$\frac{\mathrm{d}x}{\mathrm{d}t} = \sigma(y - x)$$
$$\frac{\mathrm{d}y}{\mathrm{d}t} = x(\rho - z) - y$$
$$\frac{\mathrm{d}z}{\mathrm{d}t} = xy - \beta z\,.$$



Wikimol, Dschwen - Own work based on: images Lorenz system r28 s10 b2-6666.png by Wikimol and Lorenz attractor.svg by Dschwen, https://en.wikipedia.org/wiki/Dynamical_system#/media/File:Lorenz_attractor_yb.svg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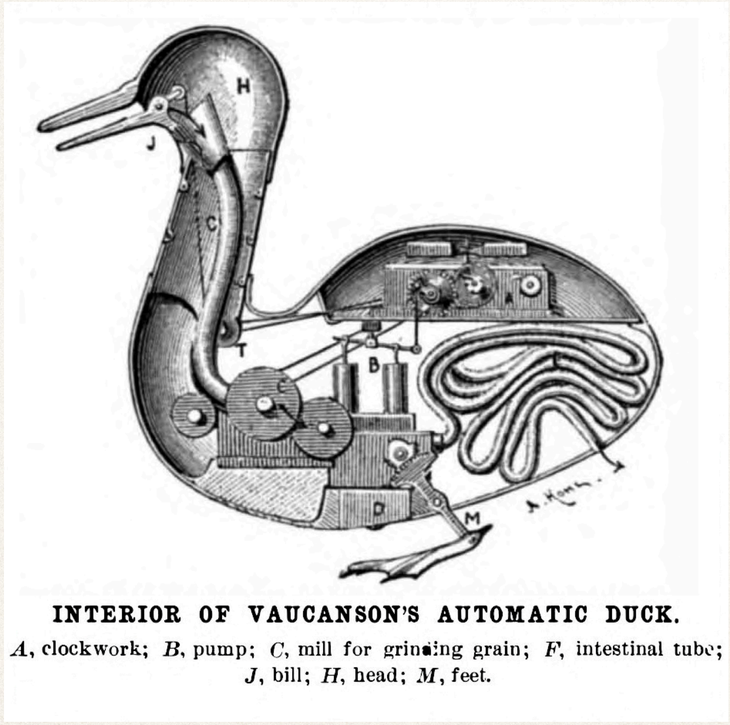
The digesting duck - 1739



INTERIOR OF VAUCANSON'S AUTOMATIC DUCK.

A, clockwork; *B*, pump; *C*, mill for grinding grain; *F*, intestinal tube; *J*, bill; *H*, head; *M*, feet.

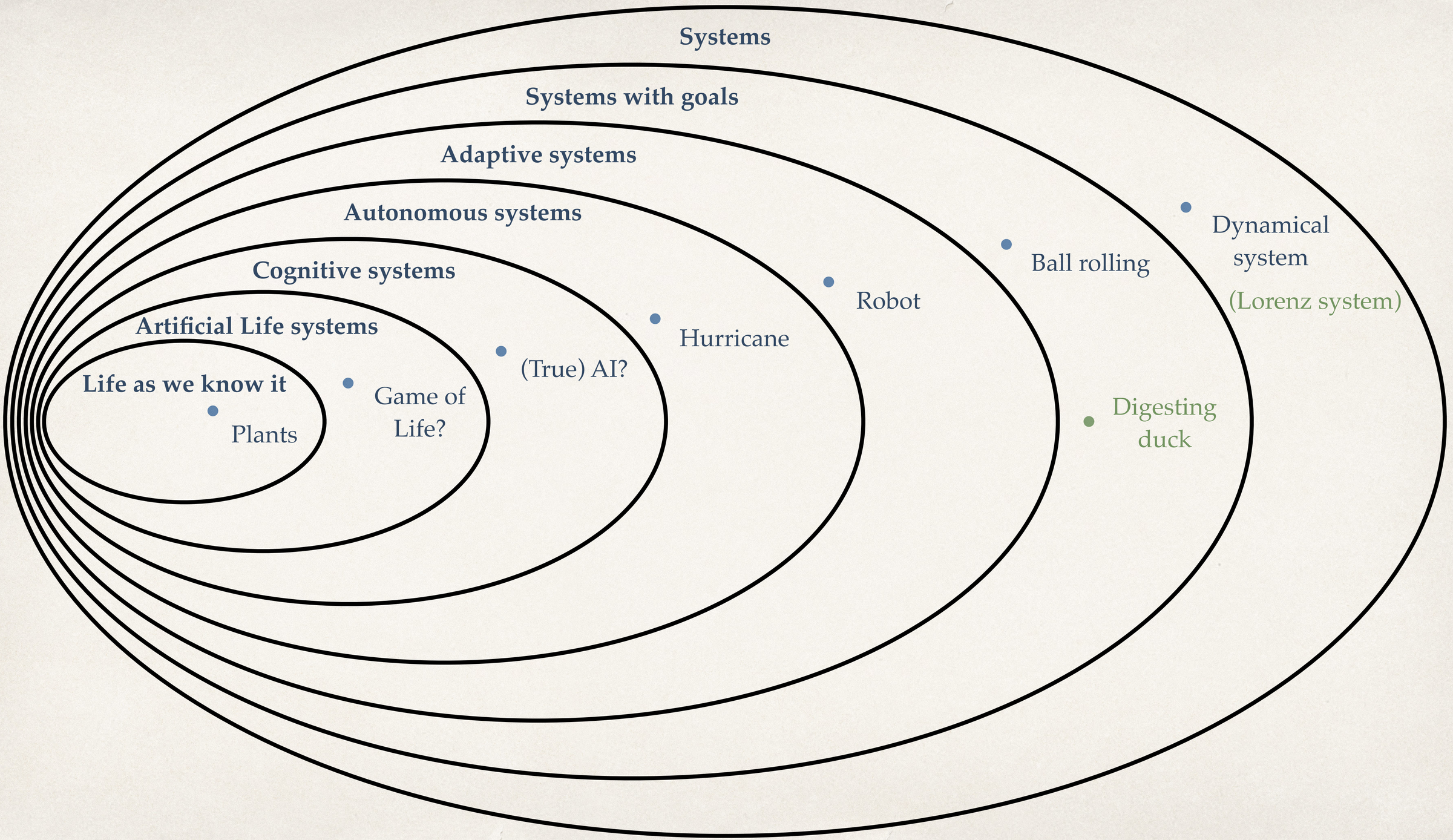
de Vaucanson, Jacque (1739). **Canard Digérateur**, or Digesting Duck.

doug goodwin (2011). A replica of Vaucanson's mechanical duck, created by Frédéric Vidoni. https://vimeo.com/14904318

The “duck test”

“If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.”

https://en.wikipedia.org/wiki/Duck_test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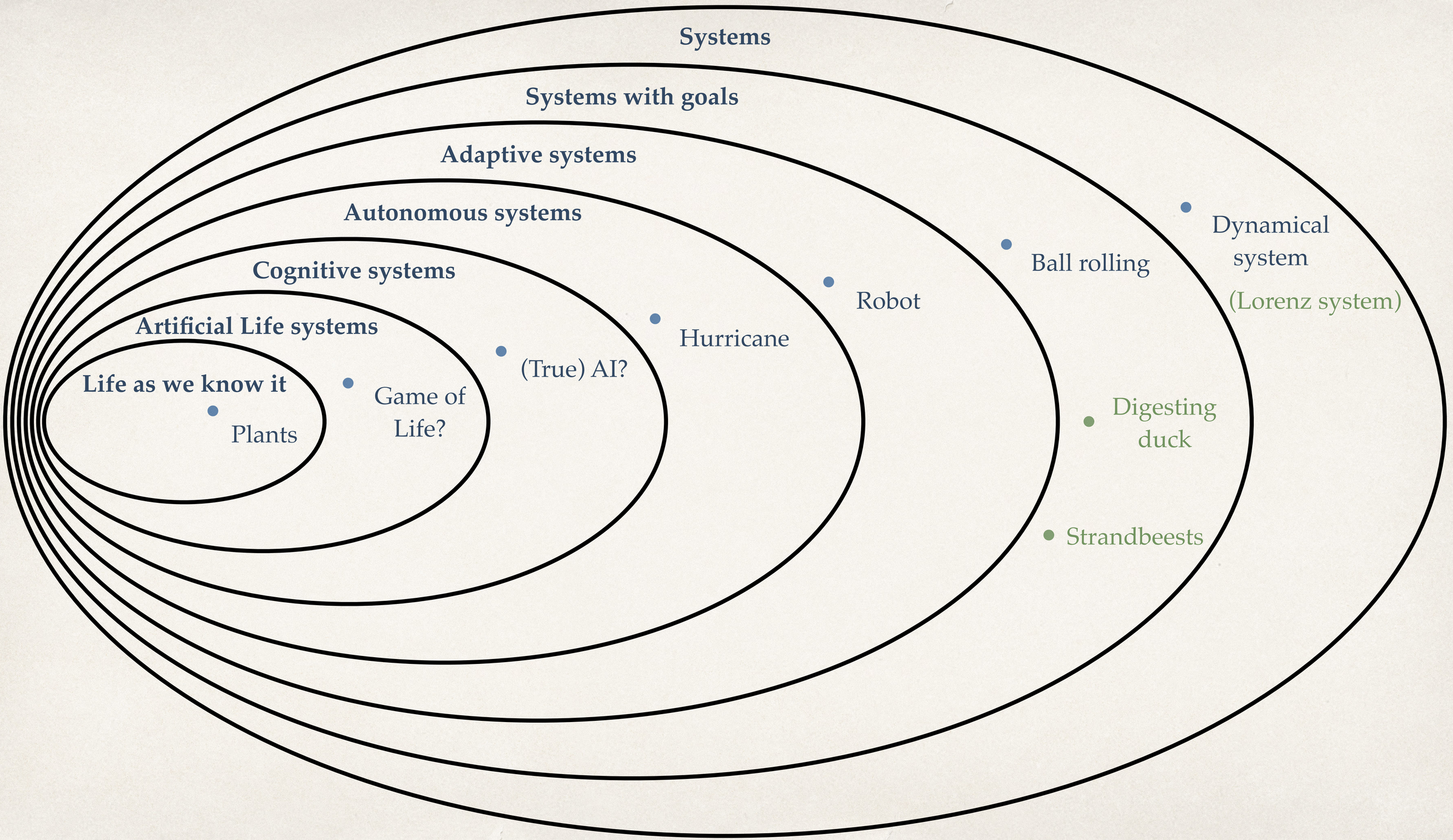
The strandbeests - 1990

"Animaris Umerus, Scheveningen" (2009). Photo by Loek van der Klis, https://www.thisiscolossal.com/2022/04/theo-jansen-flying-strandbeest/

Jansen, Theo (2022). Strandbeest Evolution 2021. https://www.youtube.com/watch?v=C97kMKwZ2-g&t=2s&ab_channel=theojansen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Chatbots - 1960s

https://openai.com/blog/chatgpt/

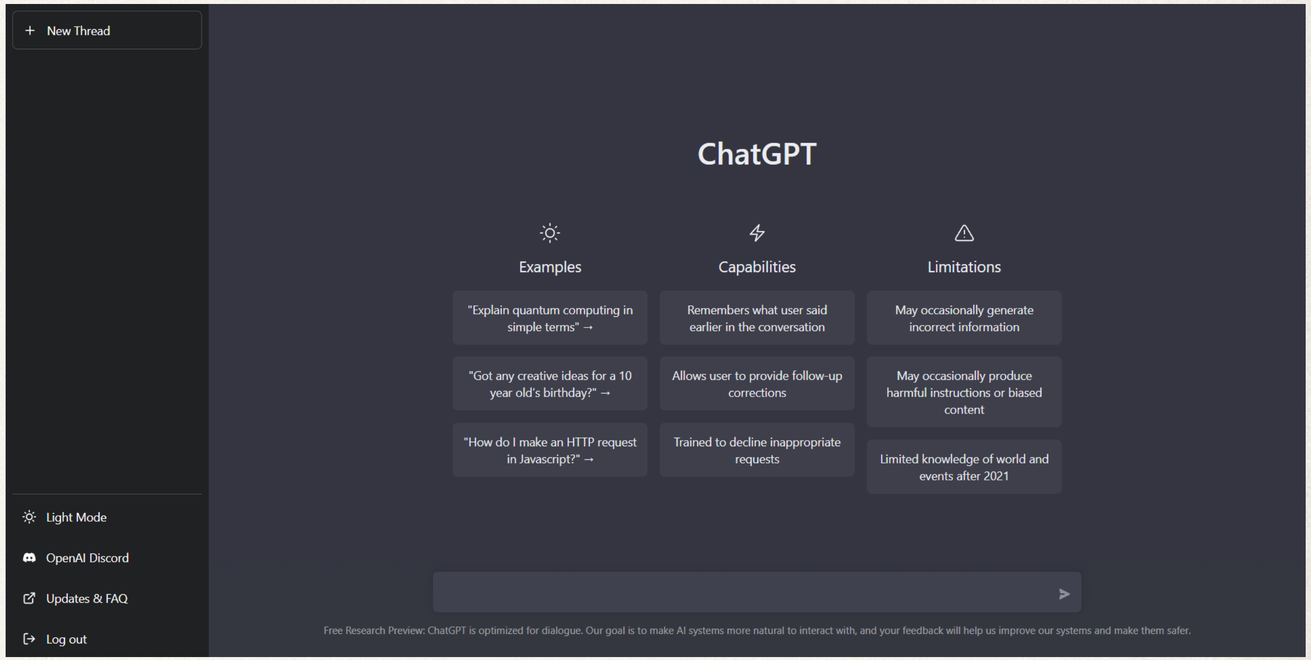
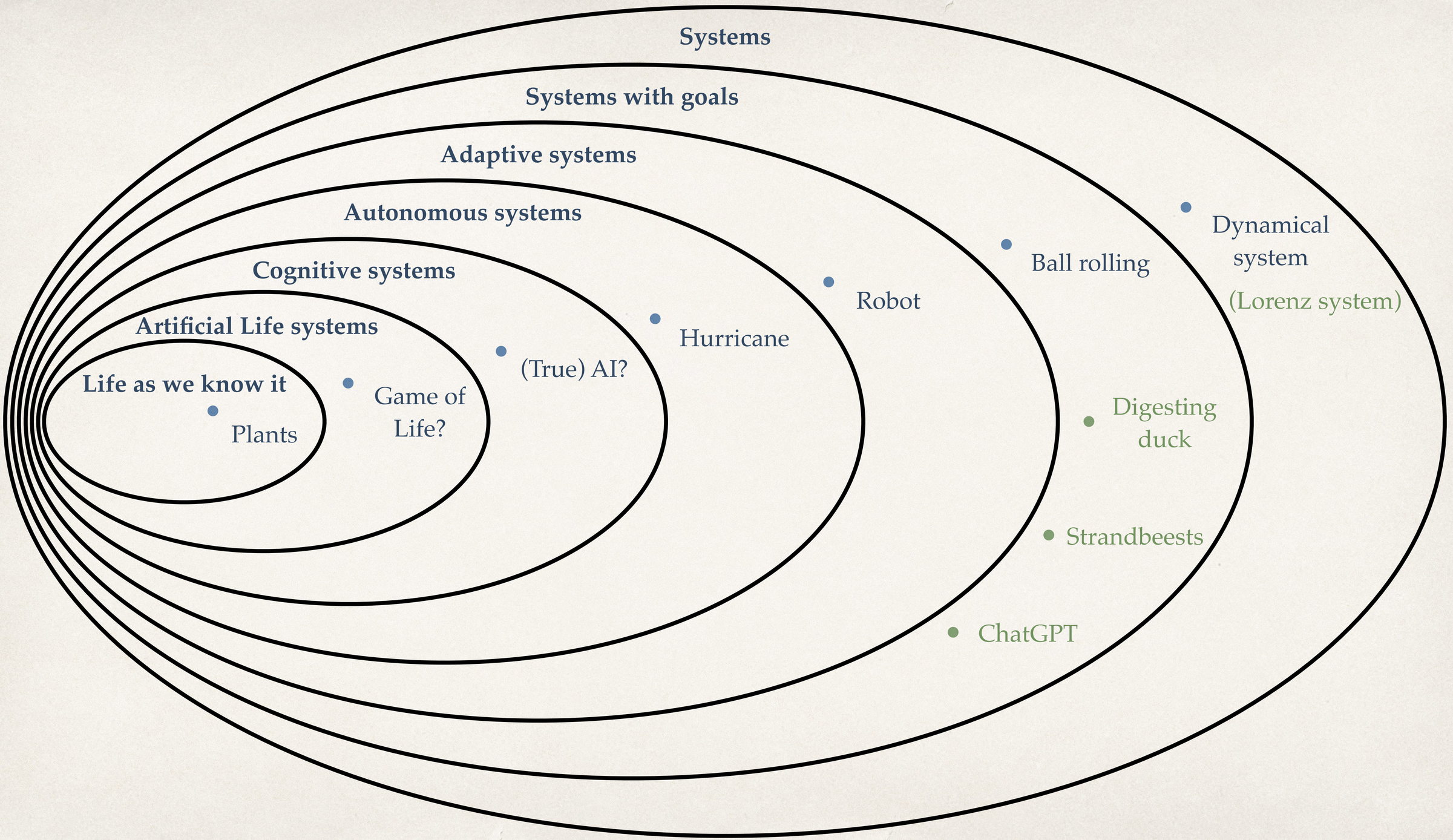


Photo: https://en.wikipedia.org/wiki/ChatGPT#/media/File:ChatGPT.png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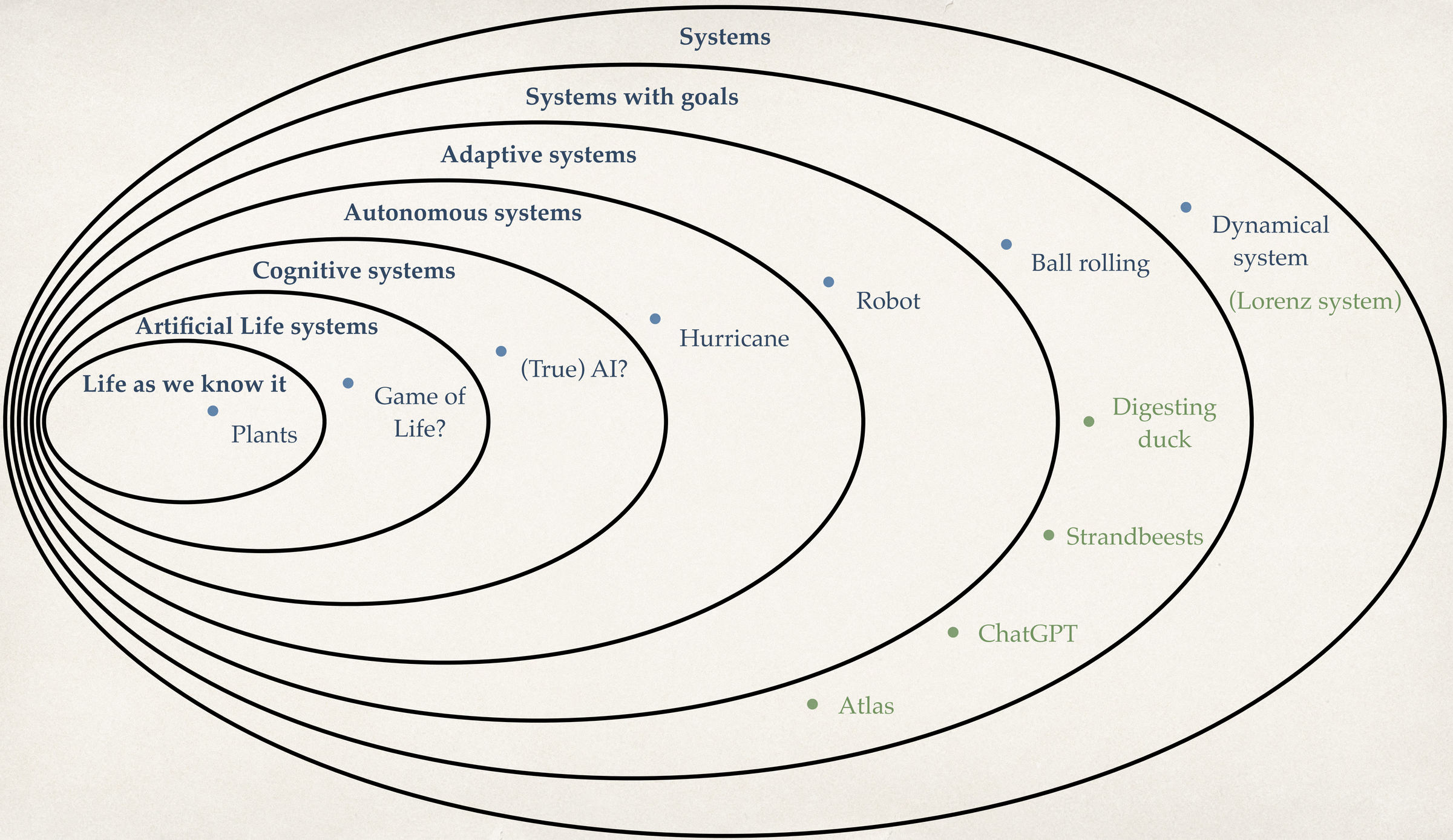
Atlas - 2013

Is it all prerecorded without any adaptation (beyond joint-level maybe)?

Atlas, by Boston Dynamics. https://www.youtube.com/watch?v=-e1_QhJ1EhQ&t=5s&ab_channel=BostonDynamics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The Watt governor - 1788

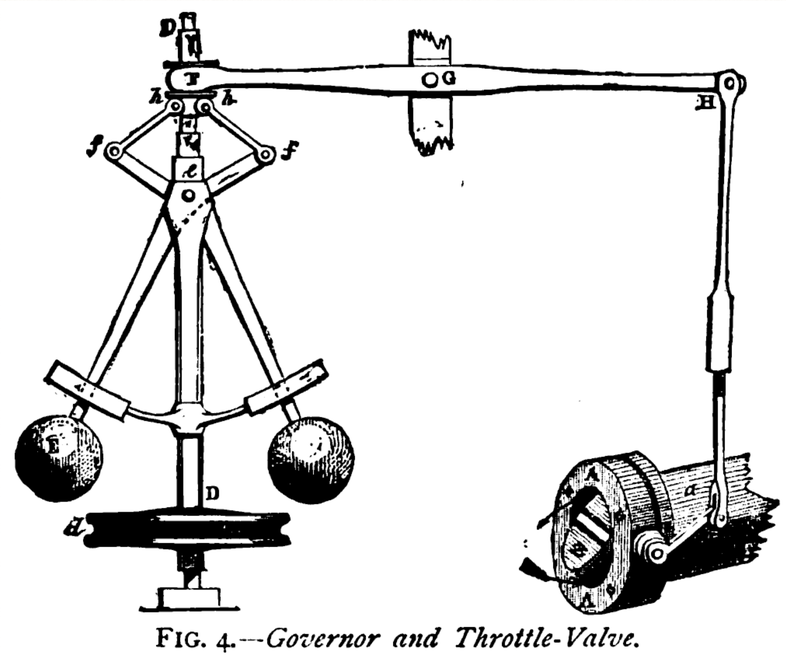
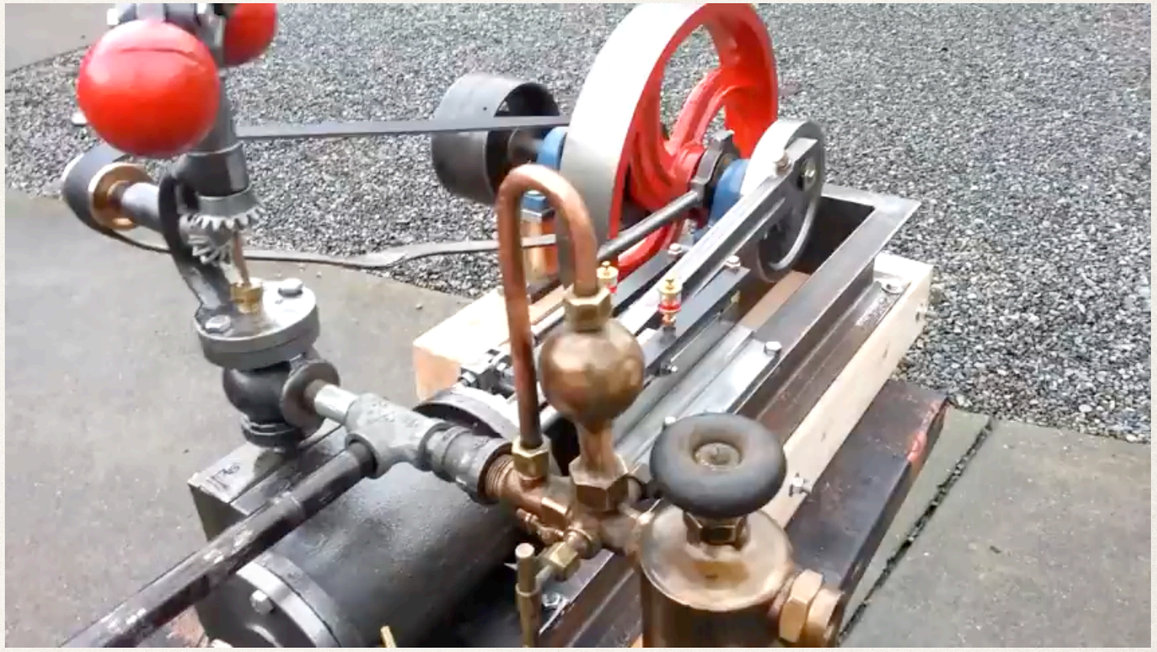
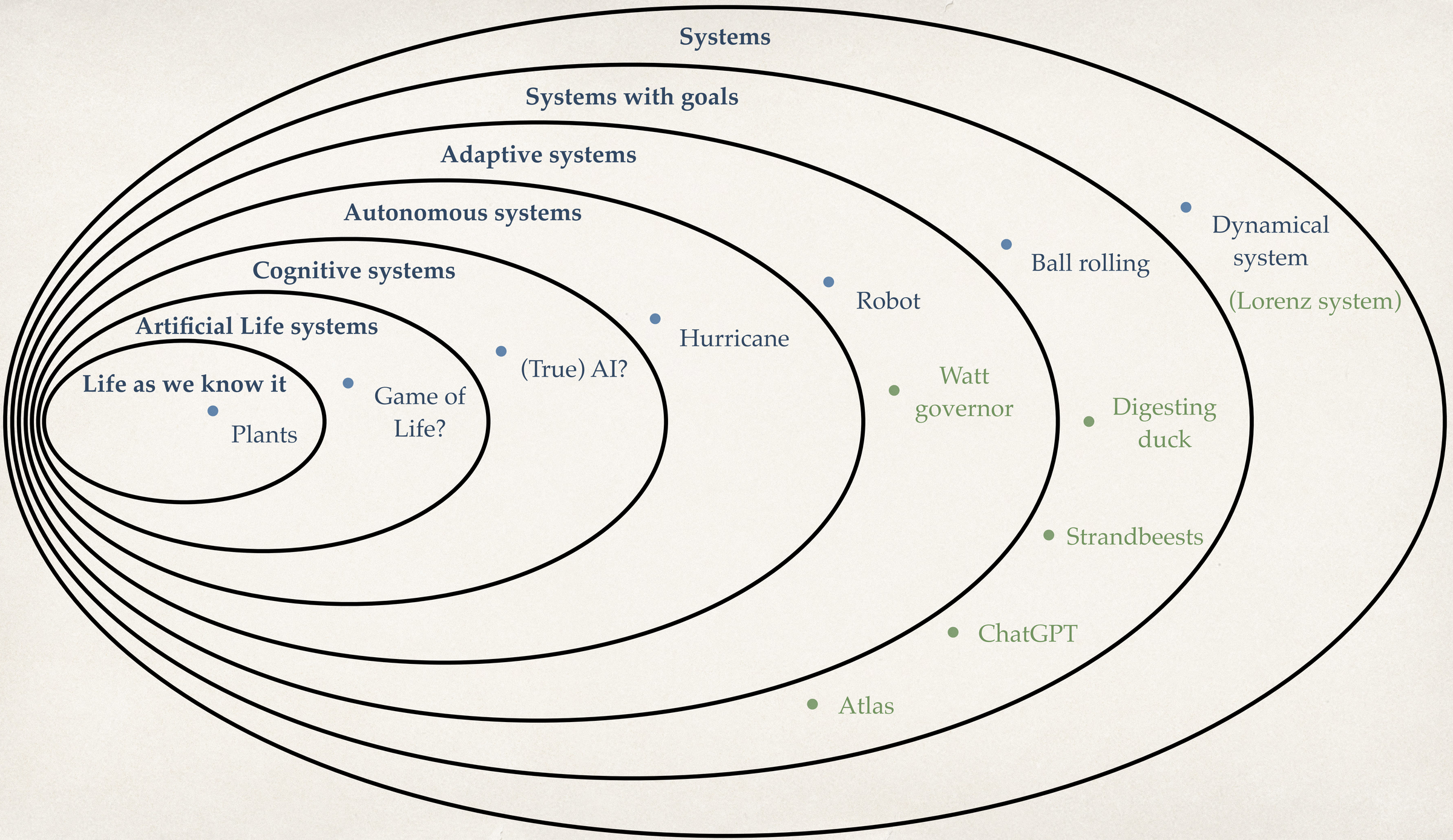


FIG. 4.—*Governor and Throttle-Valve.*

R. Routledge - Image from "Discoveries & Inventions of the Nineteenth Century" by R. Routledge, 13th edition, published 1900. https://en.wikipedia.org/wiki/Centrifugal_governor#/media/File:Centrifugal_governor.png



https://www.youtube.com/watch?v=OFcnXblfdJg&t=70s&ab_channel=RossBendixen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Ashby’s Homeostat - 1948

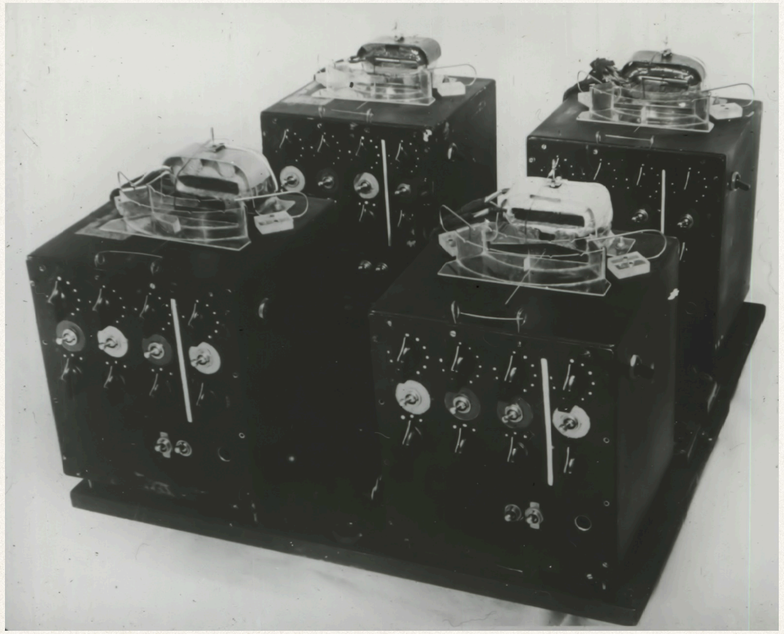


Photo: Mick Ashby, on behalf of the Estate of W. Ross Ashby - Own work, https://en.wikipedia.org/wiki/Homeostat#/media/File:W._Ross_Ashby's_1948_Homeostat.jpg

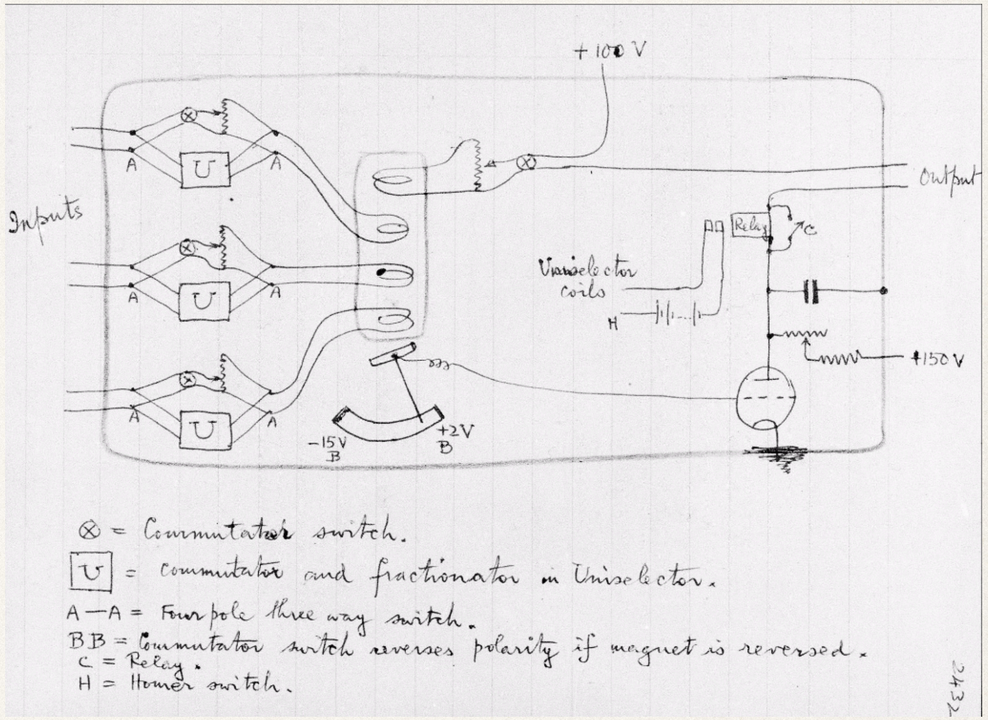
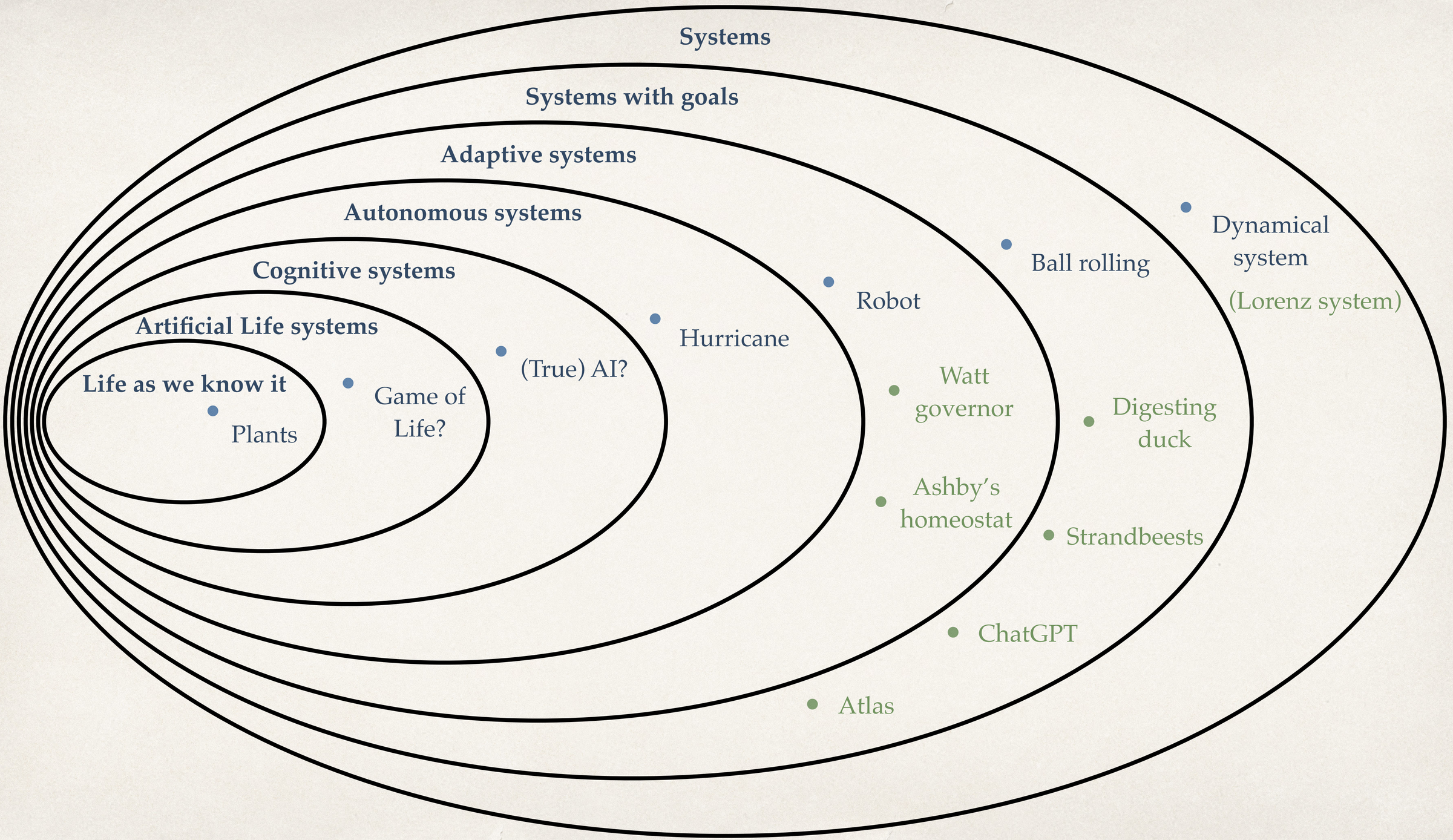


Image of Ashby’s hand drawn diagram for the final version of the Homeostat from page 2432, Journal 11. https://blogs.bl.uk/science/2016/04/the-thinking-machine.html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Walter tortoises - 1948

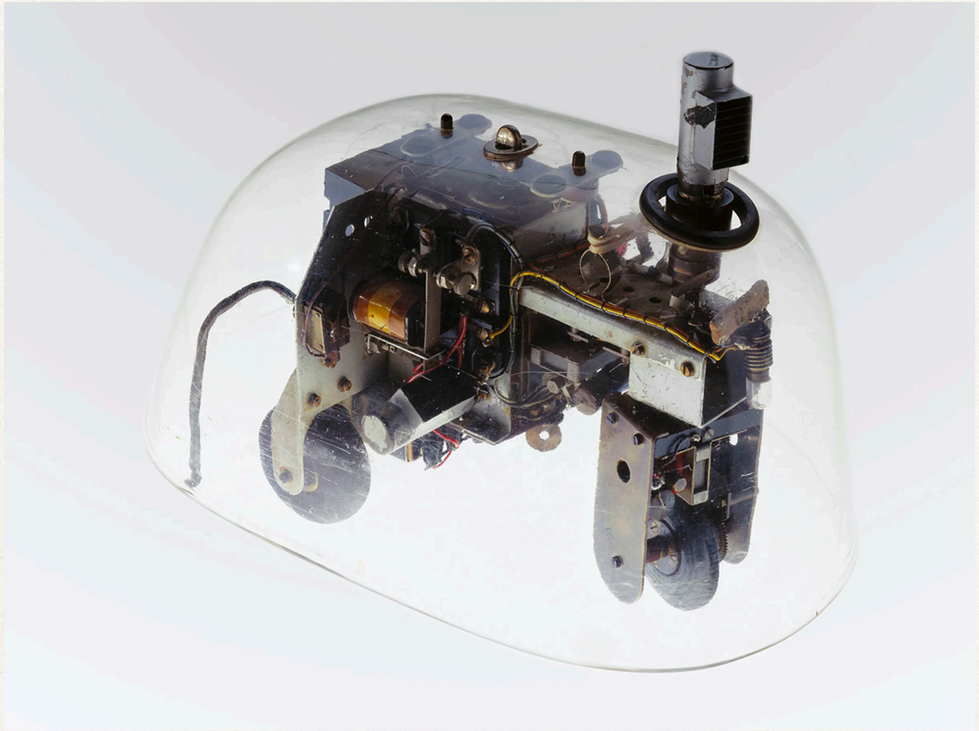
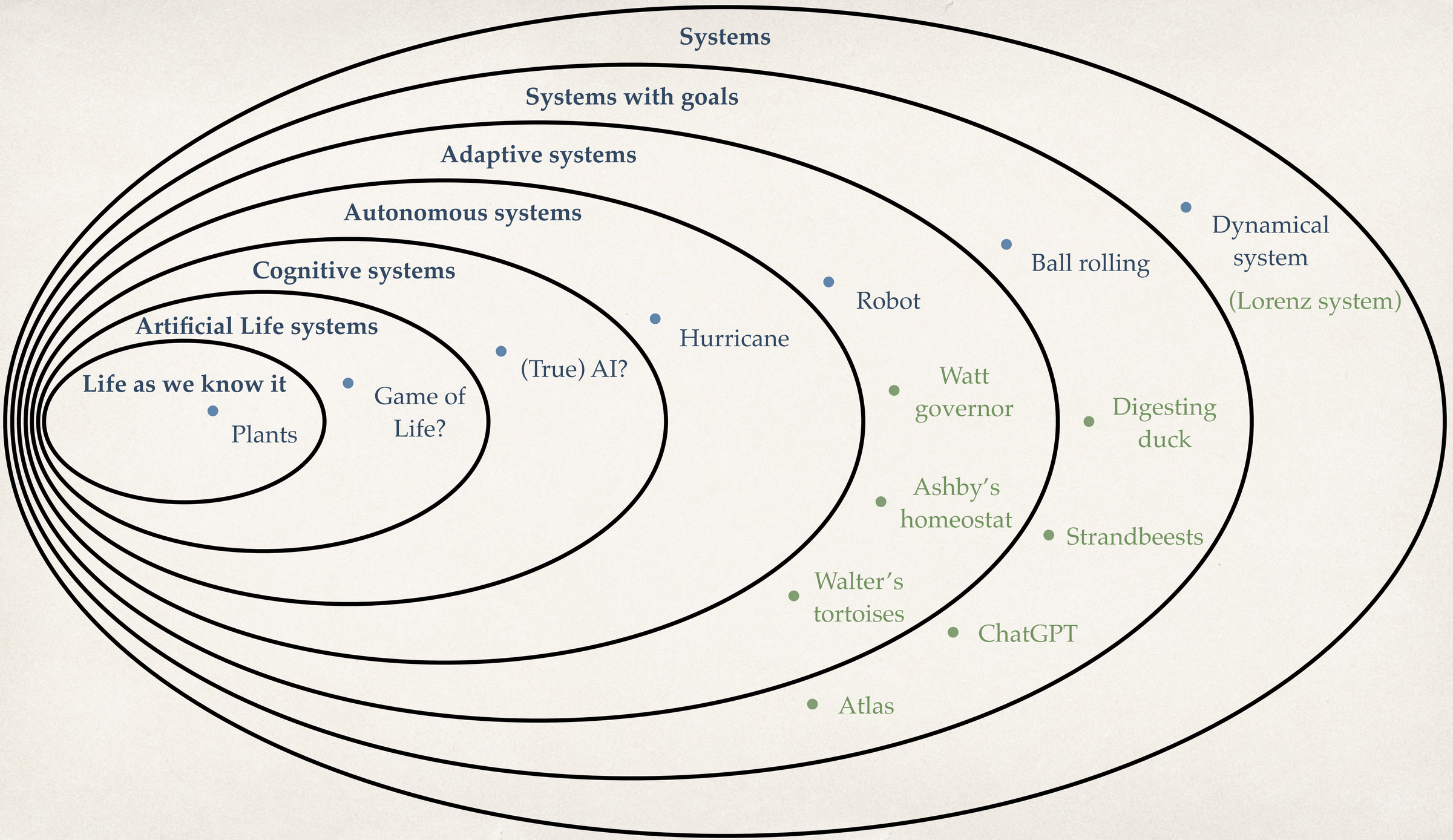


Photo: Science and Society Picture Library/Getty Images, https://spectrum.ieee.org/meet-roombas-ancestor-cybernetic-tortoise

https://www.youtube.com/watch?v=lLULRlmXkKo&ab_channel=skitterbot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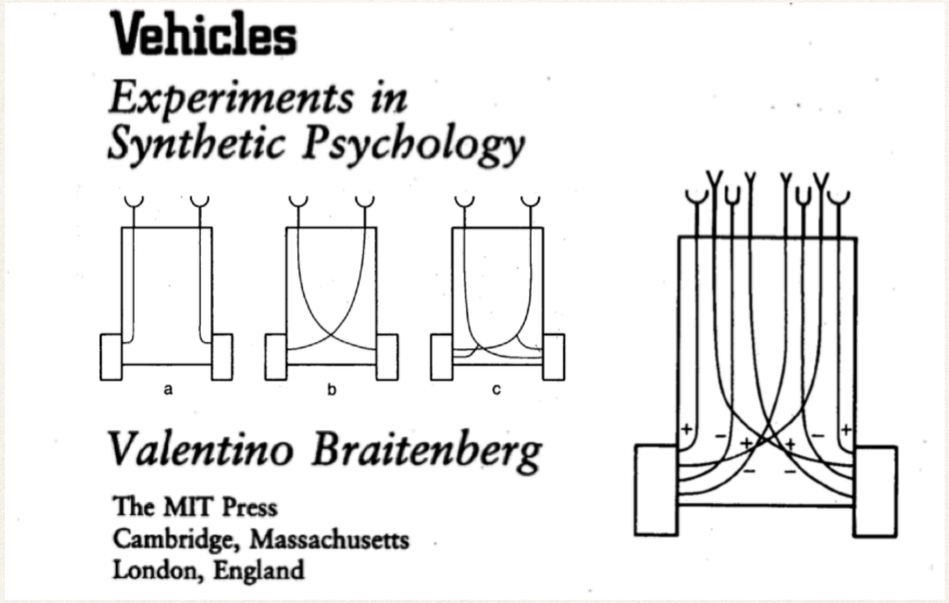
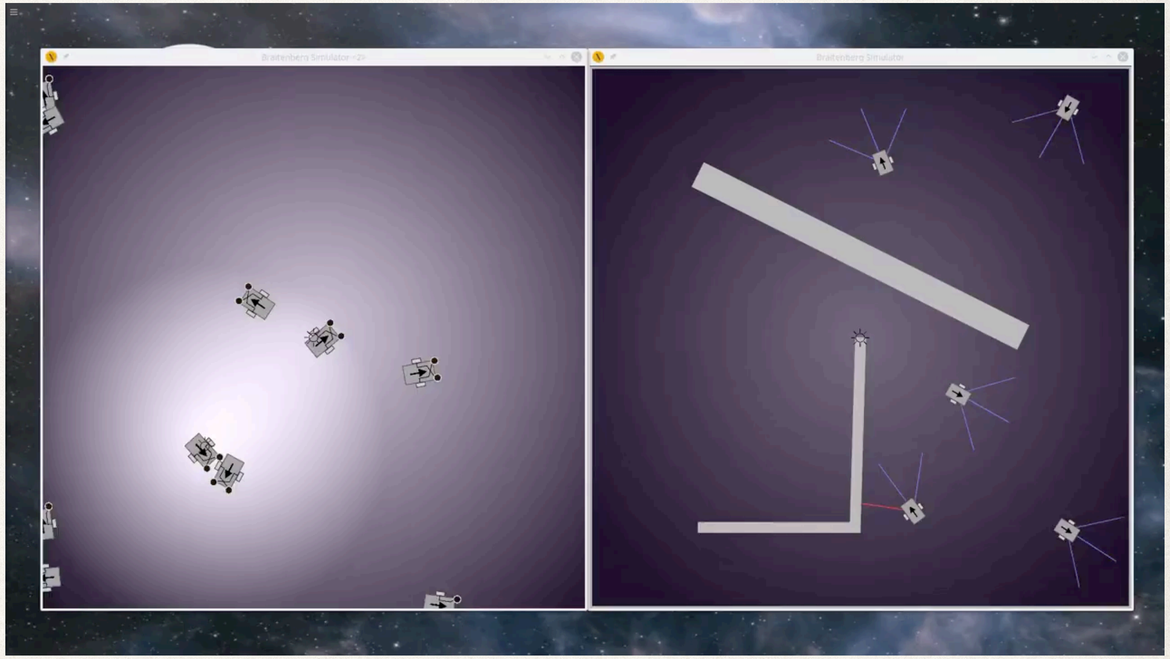
Braitenberg vehicles





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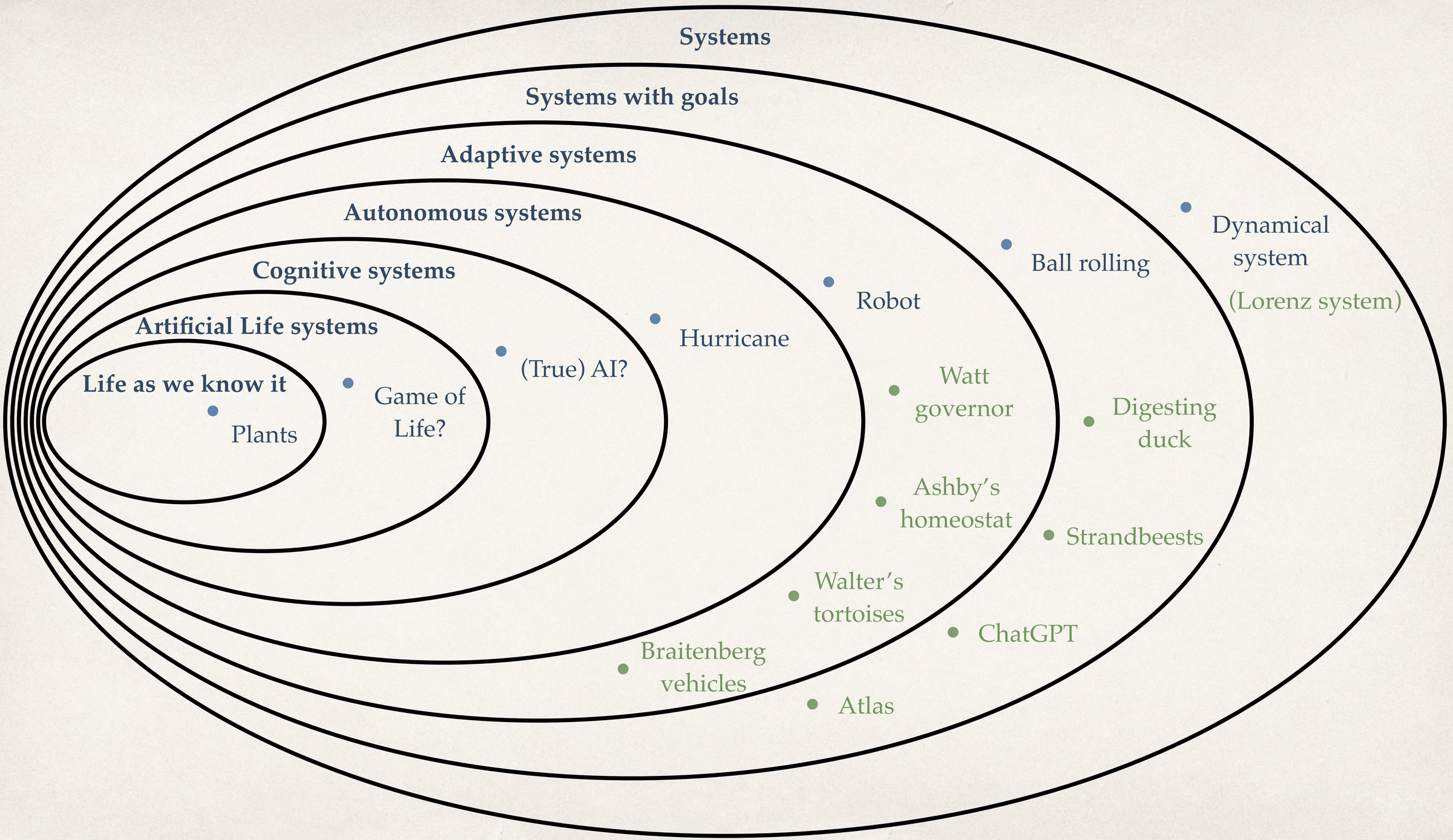
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Braitenberg vehicles
Atlas

Self-driving cars - 1970's

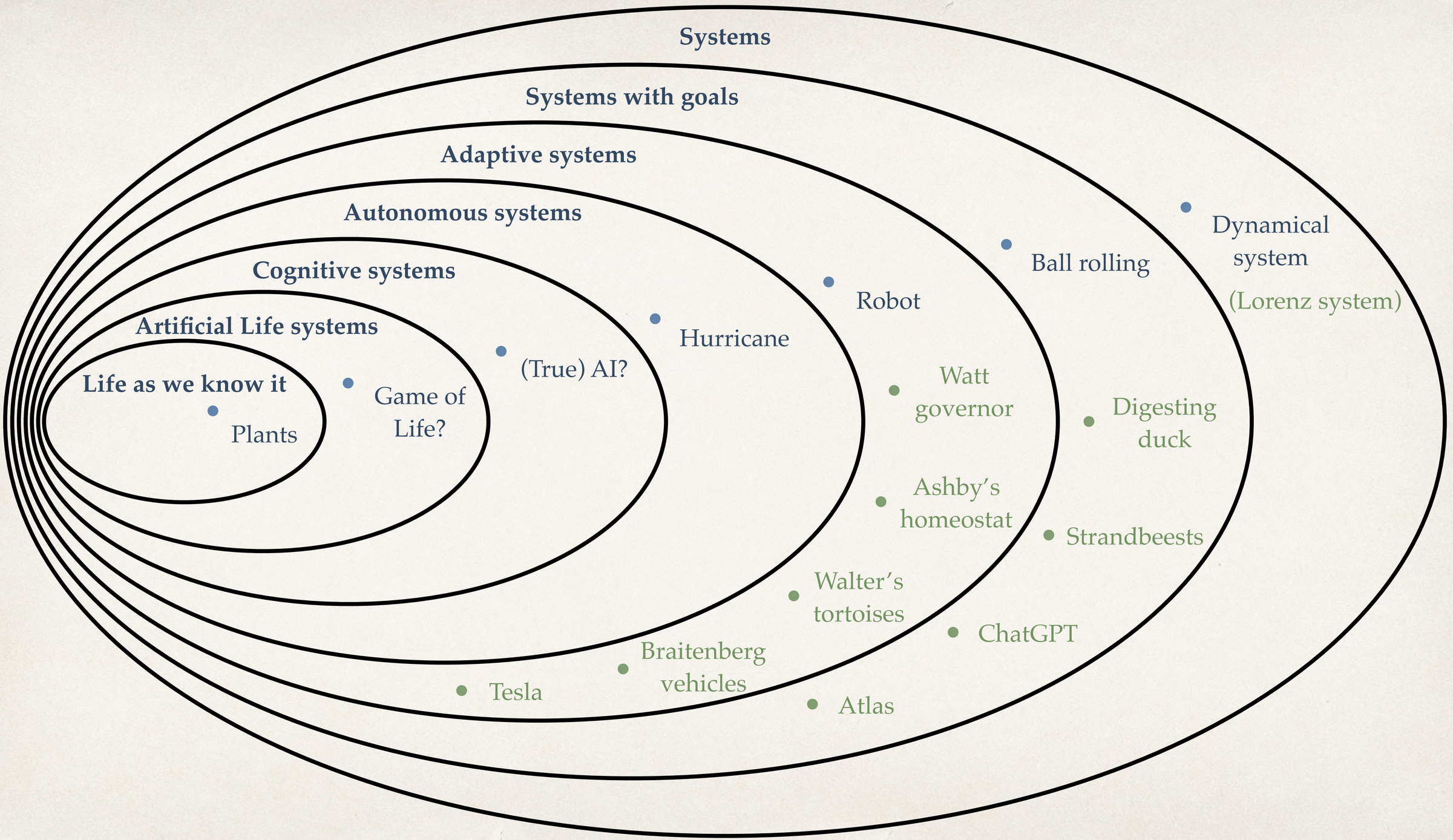
"Autonomous" cars didn't like fixies

https://www.washingtonpost.com/news/innovations/wp/2015/08/26/how-fixed-gear-bikes-can-confuse-googles-self-driving-cars/

"Autonomous" cars didn't like traffic lights to be installed

https://www.reddit.com/r/teslamotors/comments/nq2hse/tesla_model_3_display_bug_showing_constant/

https://www.which.co.uk/reviews/new-and-used-cars/article/car-brand-reviews/should-i-buy-a-tesla-car-at7e69b56bp6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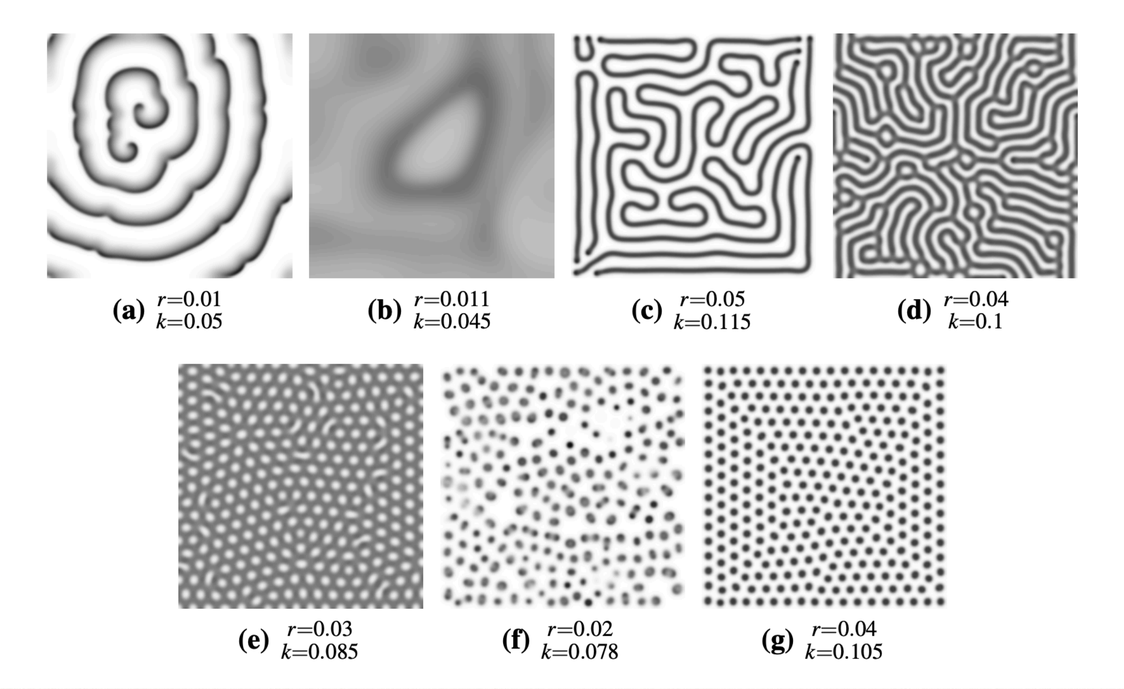
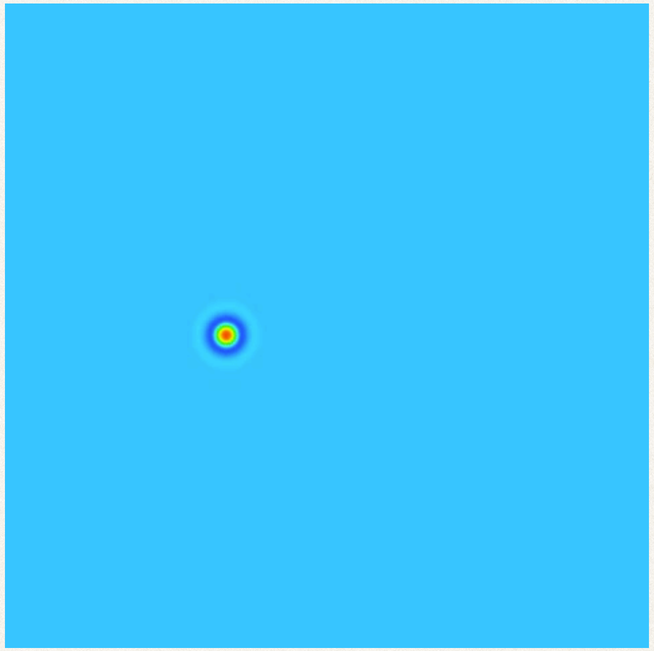
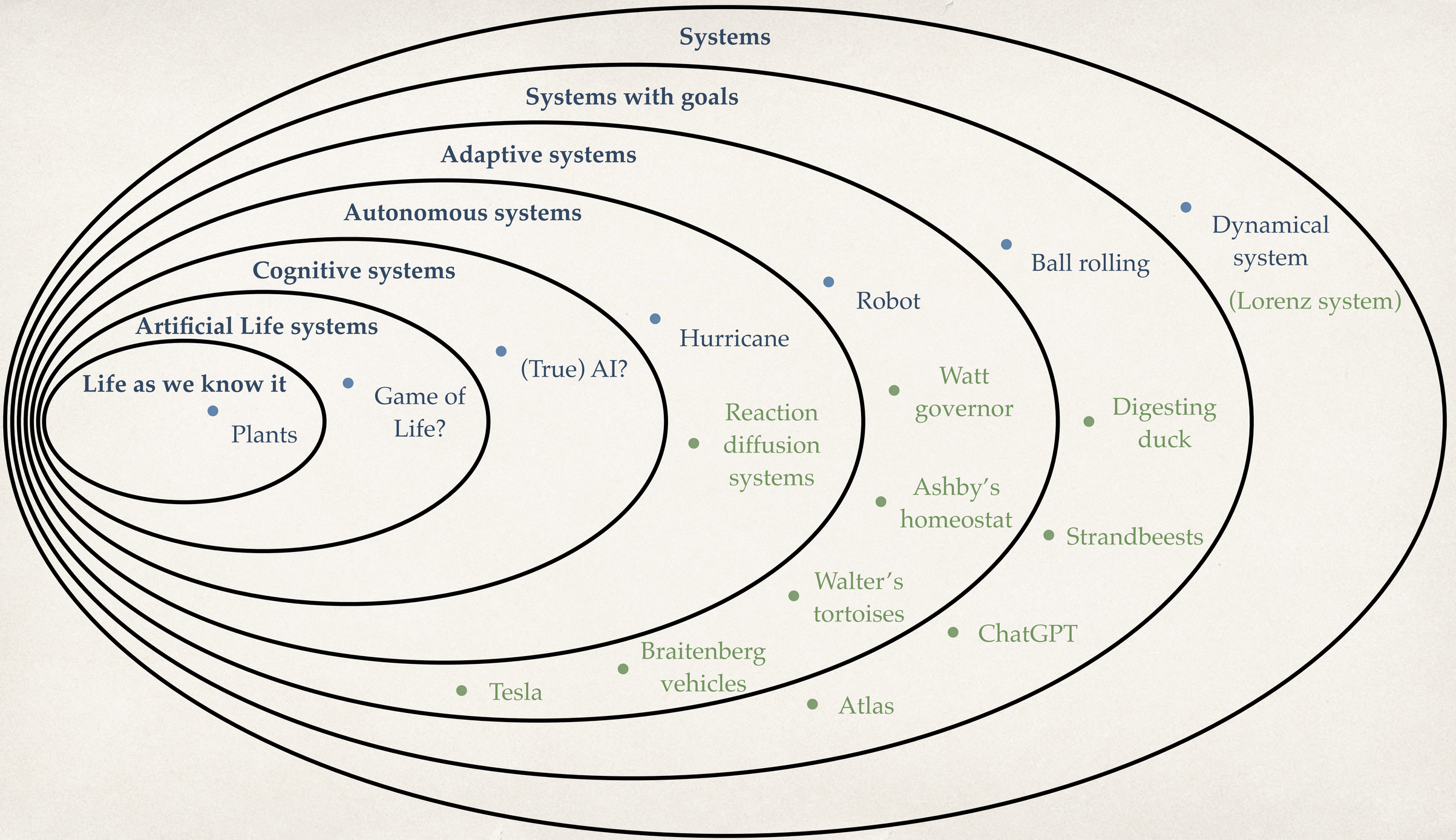
Reaction diffusion systems - 1952



Virgo, N. D. (2011). Thermodynamics and the structure of living systems (Doctoral dissertation, University of Sussex).



https://www.youtube.com/watch?v=F5oKgVZ6bTk&ab_channel=TimHutton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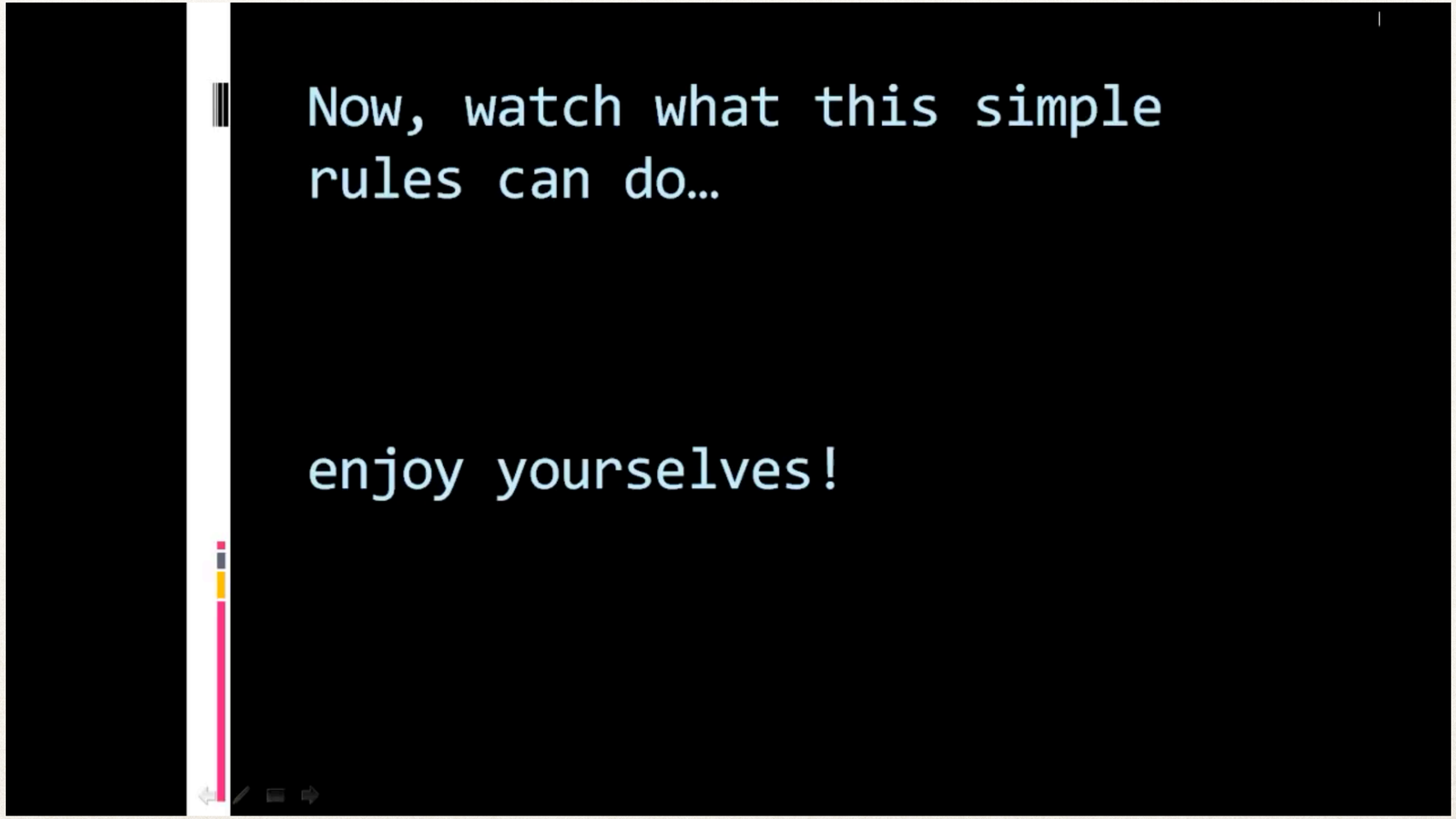
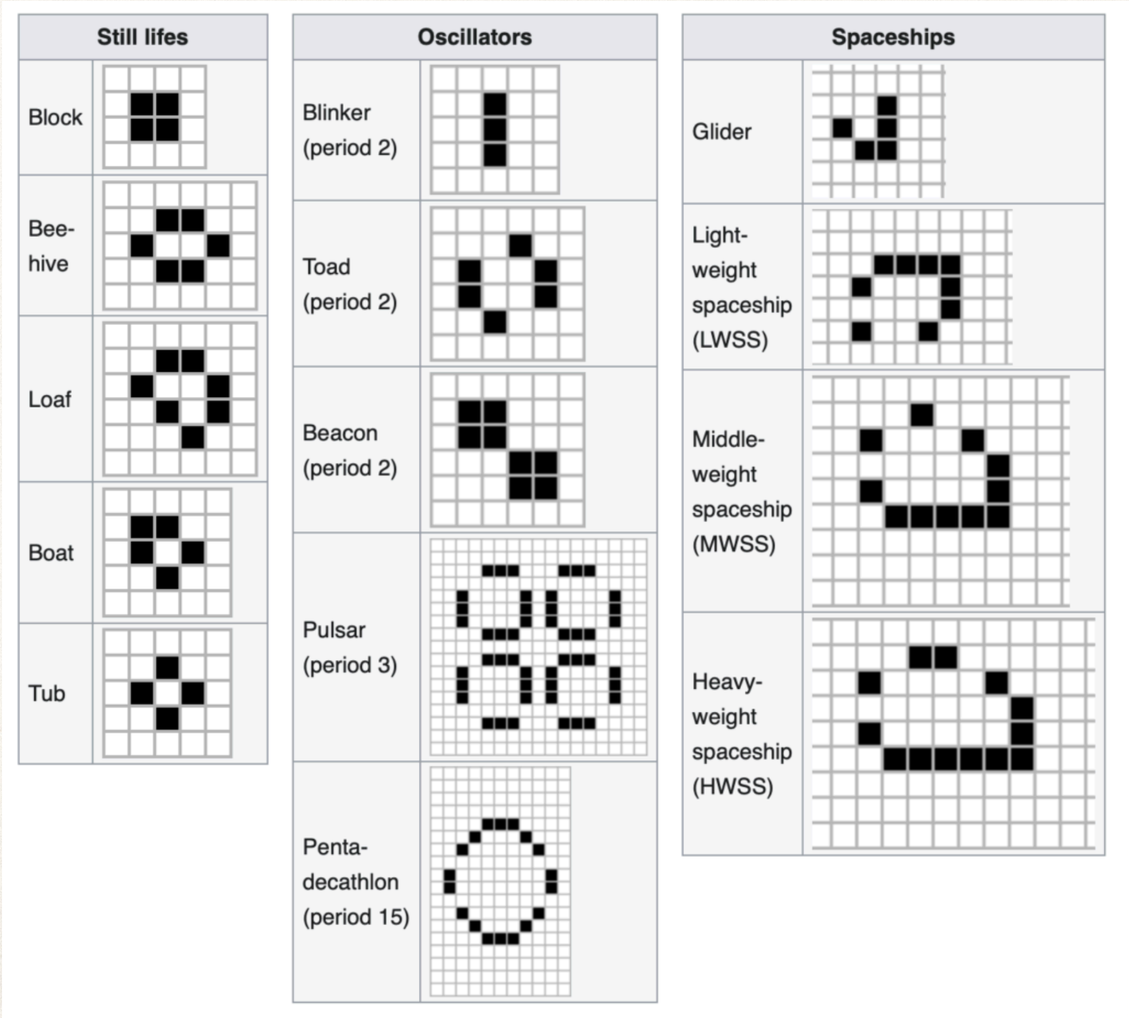
Try it here: https://pmneila.github.io/jsexp/grayscott/

Conway's Game of Life - 1970



https://www.youtube.com/watch?v=C2vgICfQawE&t=218s&ab_channel=RationalAnimations

The Game of Life's zoo



https://en.wikipedia.org/wiki/Conway's_Game_of_Life

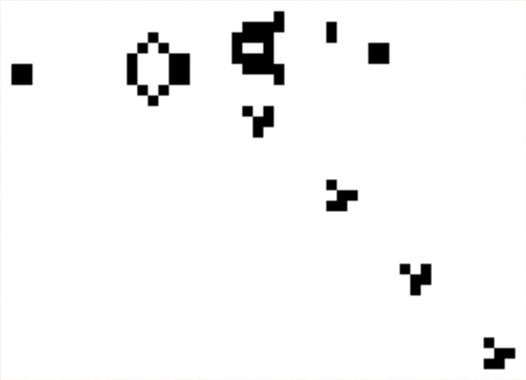
GoL: the rules

From Wikipedia (https://en.wikipedia.org/wiki/Conway%27s_Game_of_Life):

- Any live cell with fewer than two live neighbours dies, as if by underpopulation.
- Any live cell with two or three live neighbours lives on to the next generation.
- Any live cell with more than three live neighbours dies, as if by overpopulation.
- Any dead cell with exactly three live neighbours becomes a live cell, as if by reproduction.

Autopoiesis in the GoL?

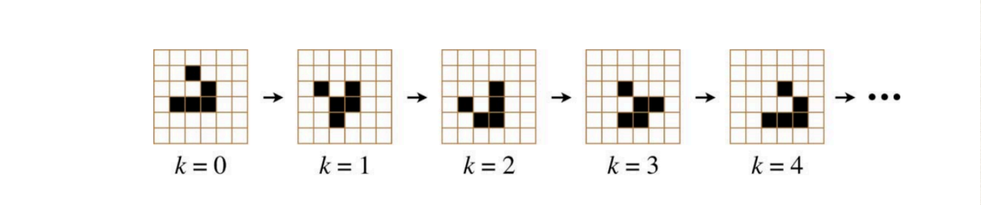
Randall Beer has been using the GoL to study agency and autopoiesis for ~ 15 years



https://en.wikipedia.org/wiki/Conway%27s_Game_of_Life

Example.

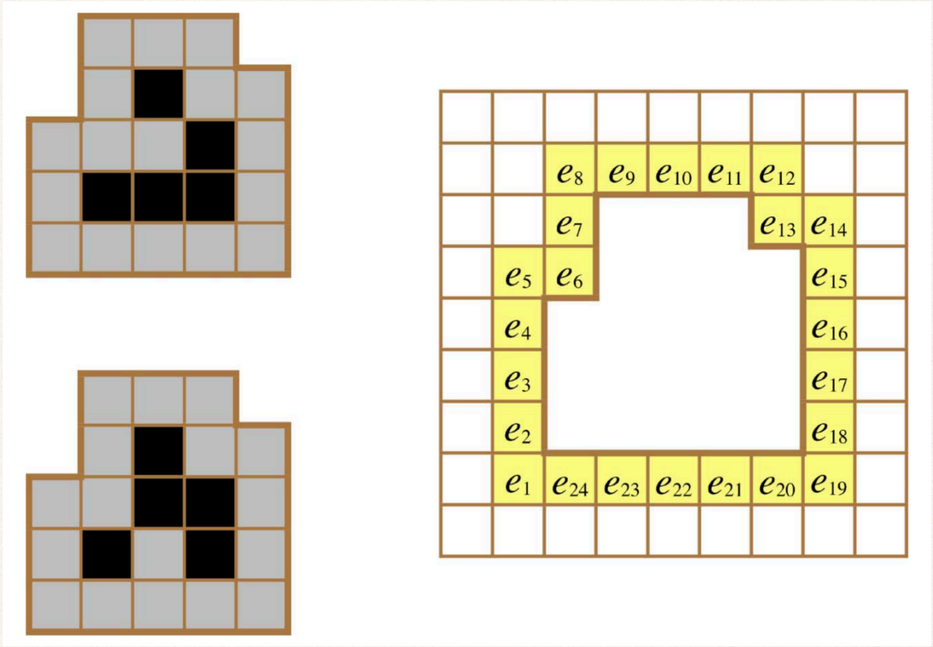
Cognitive domain: “an entity’s cognitive domain is the set of all interactions in which it can participate without loss of identity”



https://direct.mit.edu/artl/article/20/2/183/2768/The-Cognitive-Domain-of-a-Glider-in-the-Game-of

A sketch of the study

- Find invariances of glider (orientation), used to reduce the 4 states to 2
- Apply all the possible 2^24 perturbations to the glider in those 2 states
- ~ 95% kill glider in one state, ~ 99% in the other one
- Determine glider transitions for nondestructive perturbations
- …
- Study behavioural trajectories (extend the study temporally)
- Study structural coupling (extend the study spatially)



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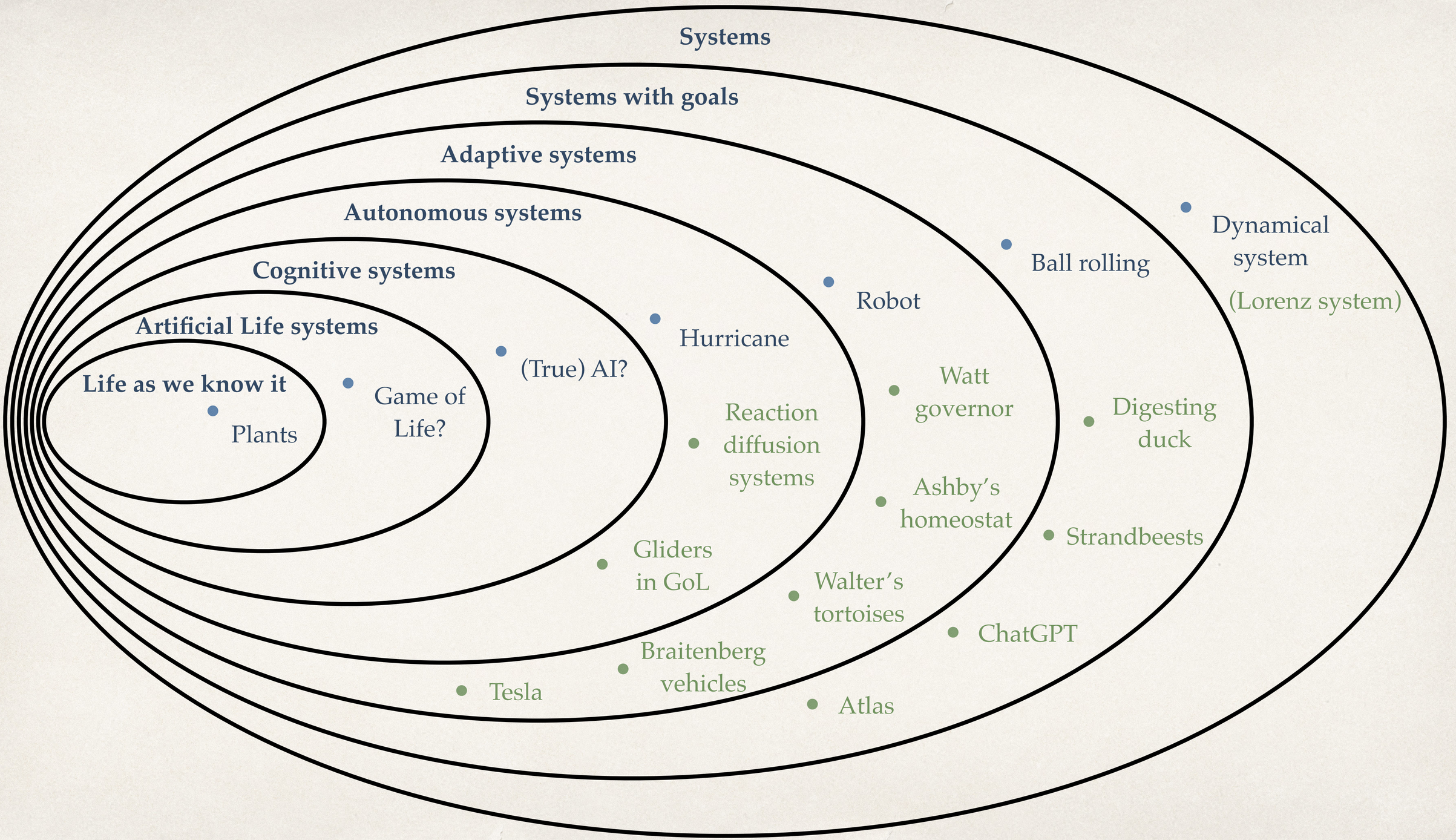
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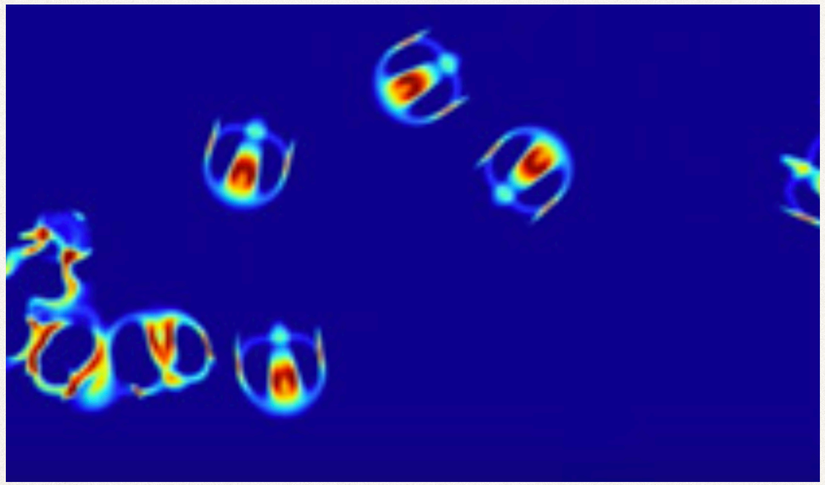
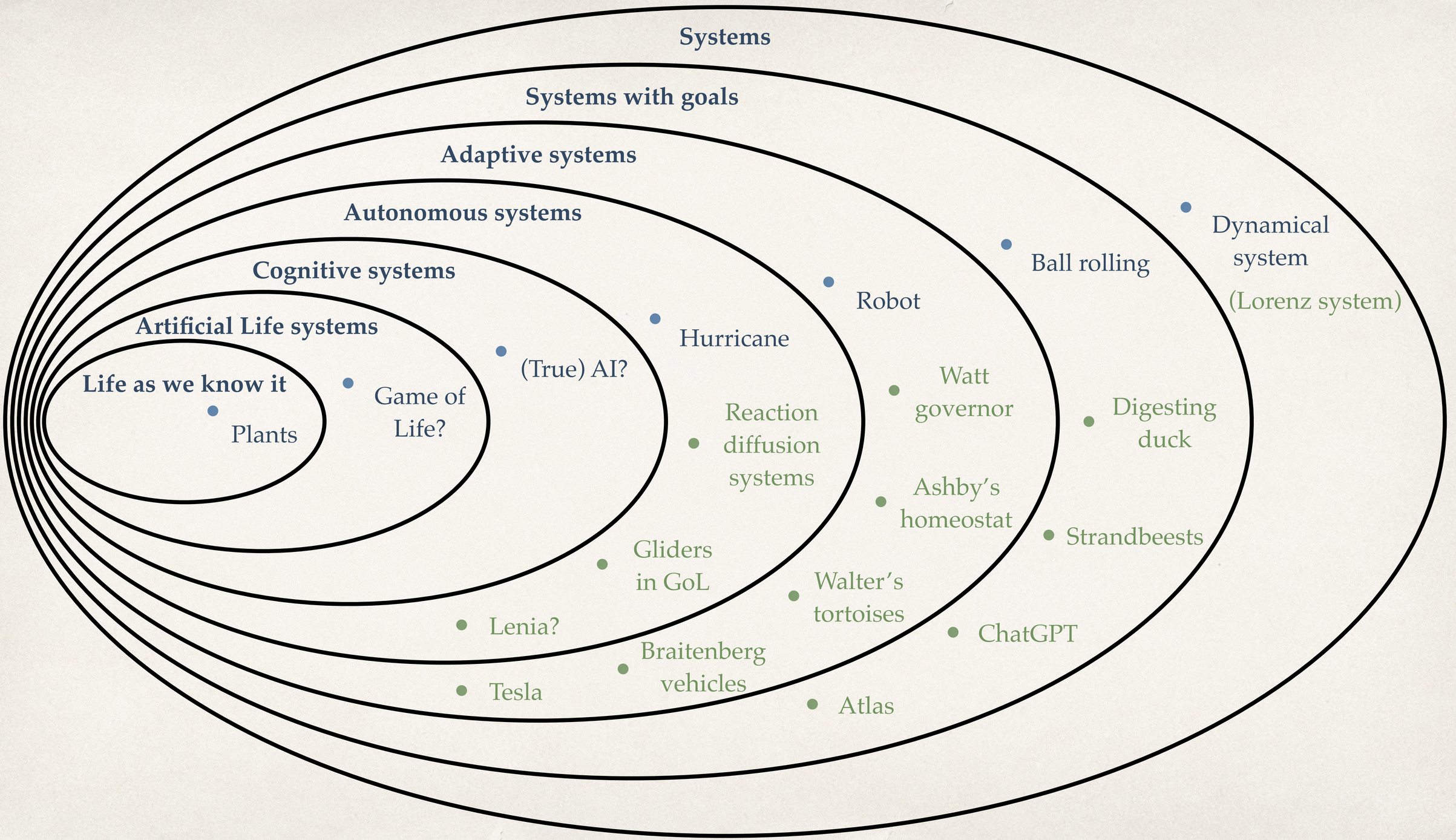
Lenia - 2018



Link (online version) + Project with code

https://www.youtube.com/watch?v=HT49wpyux-k&ab_channel=BertChan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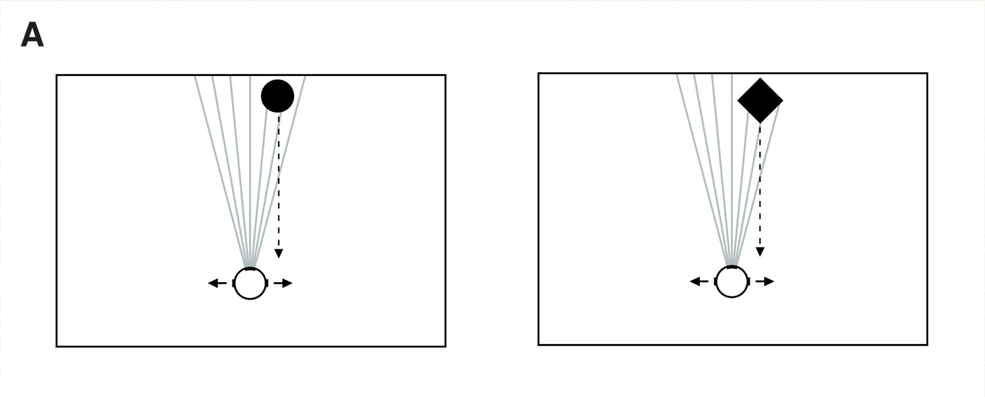
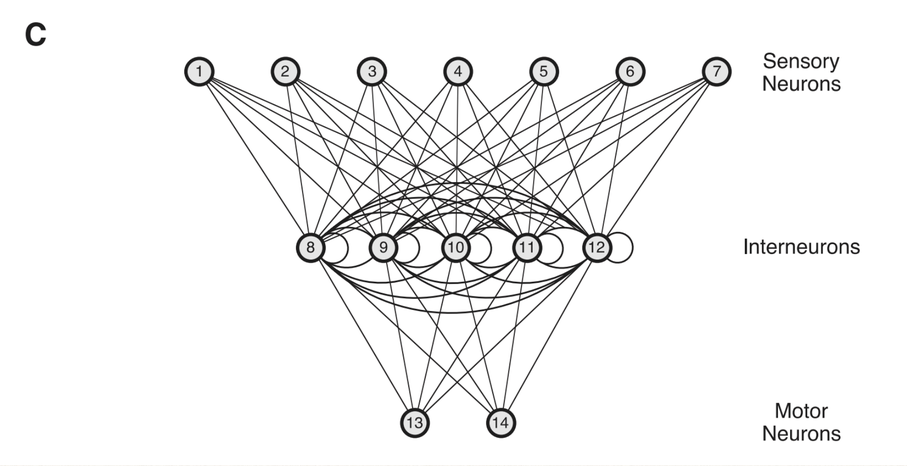
Beer's "agents" - 1990s

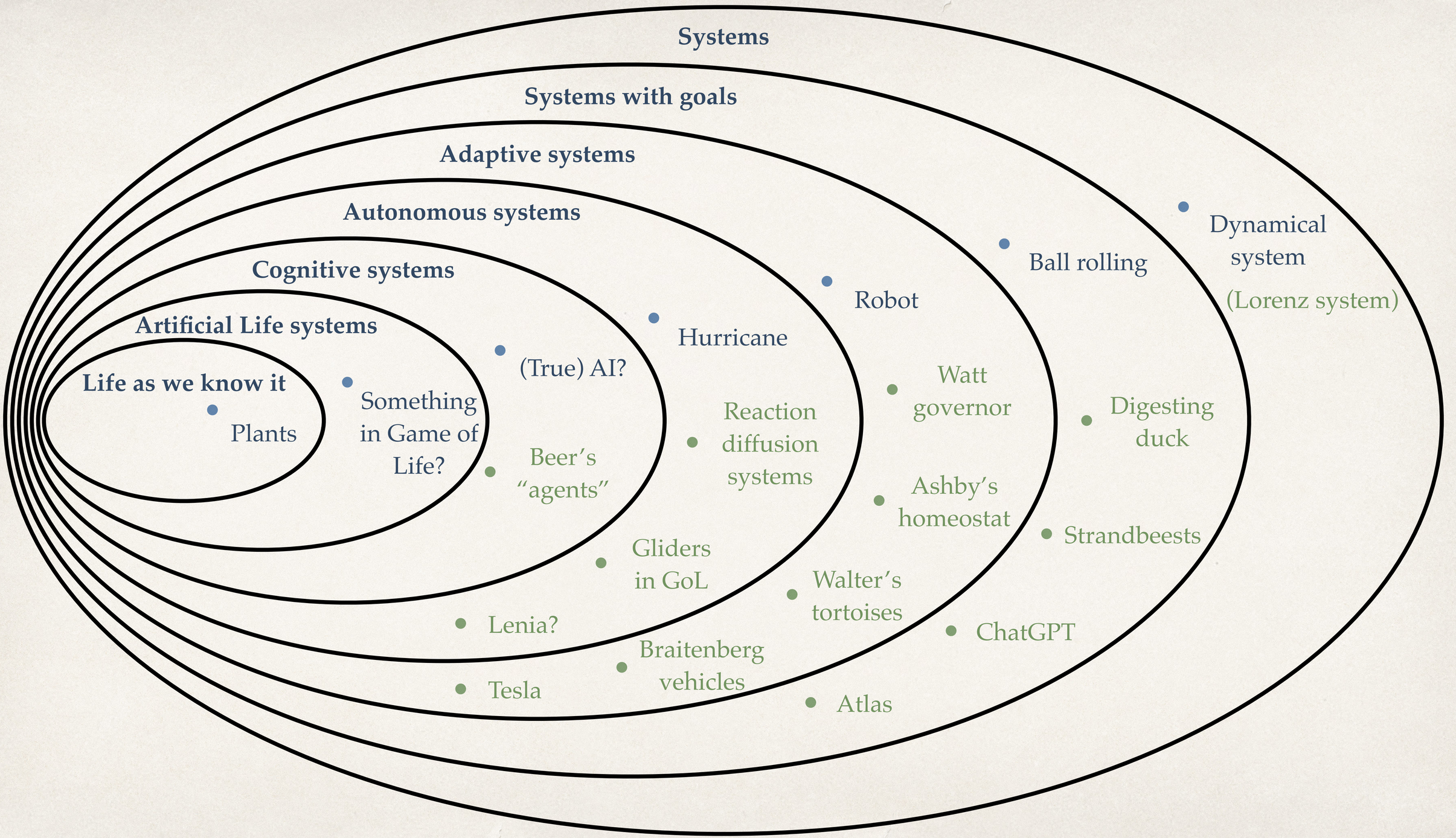
Minimally cognitive behaviour example

- 1-dimensional system
- Task: catch circles, avoid diamonds
- Neural network evolved to solve task





https://journals.sagepub.com/doi/abs/10.1177/1059712303114001?journalCode=adba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Walter's tortoises
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Ball rolling
Digesting duck
Strandbeests
ChatGPT
Dynamical system
(Lorenz system)

Suzuki's protocells - 2008

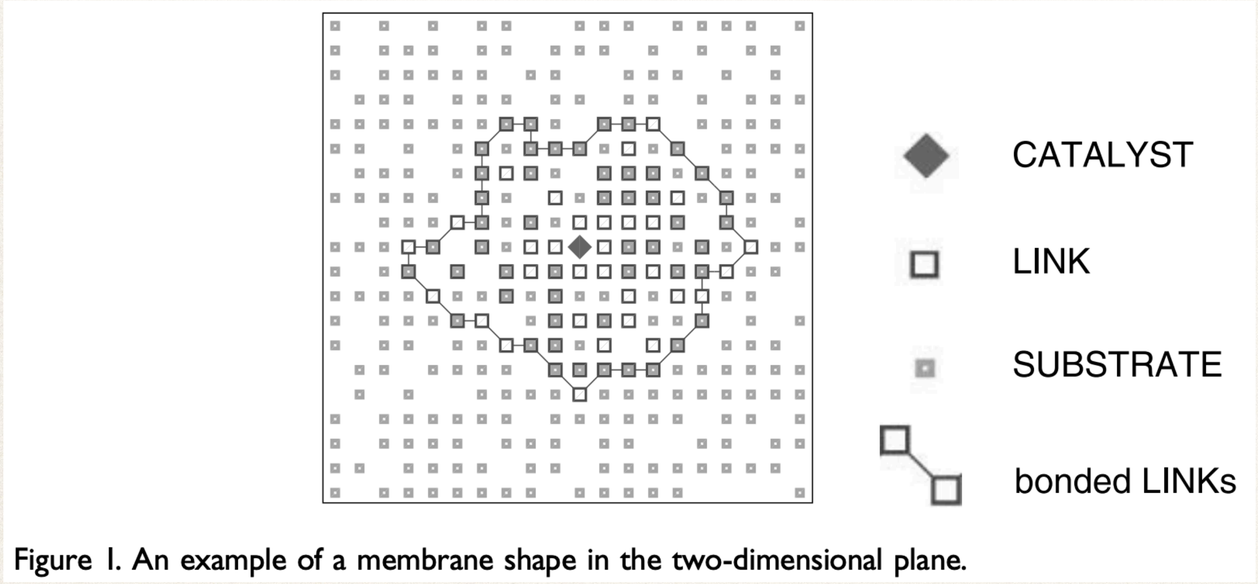
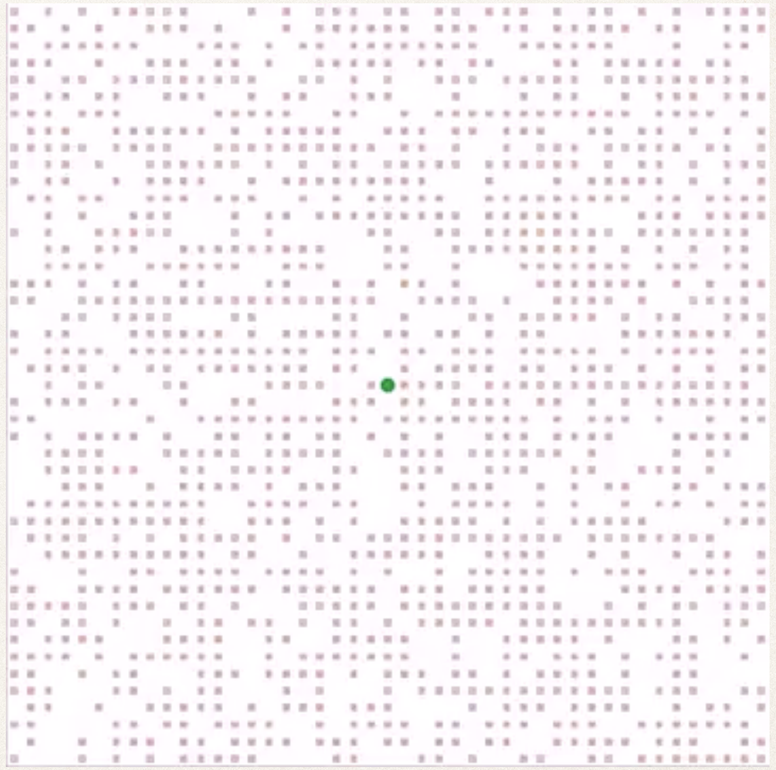
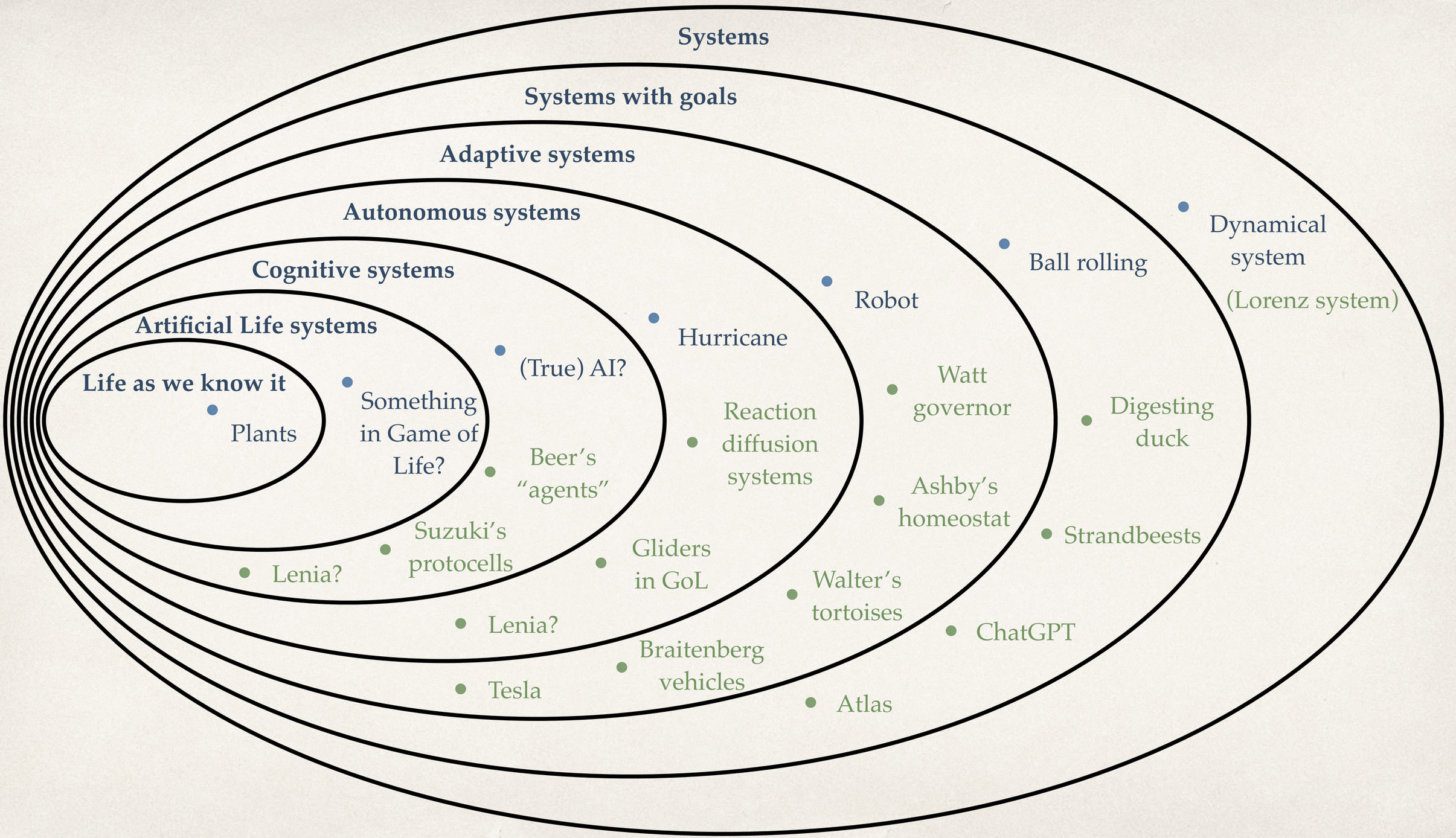


Figure 1. An example of a membrane shape in the two-dimensional plane.

Suzuki, K., & Ikegami, T. (2009). Shapes and self-movement in protocell systems. *Artificial Life*, *15*(1), 59-70.



https://www.youtube.com/watch?v=jI9o8V4Dl7w&t=5s&ab_channel=KeisukeSuzuki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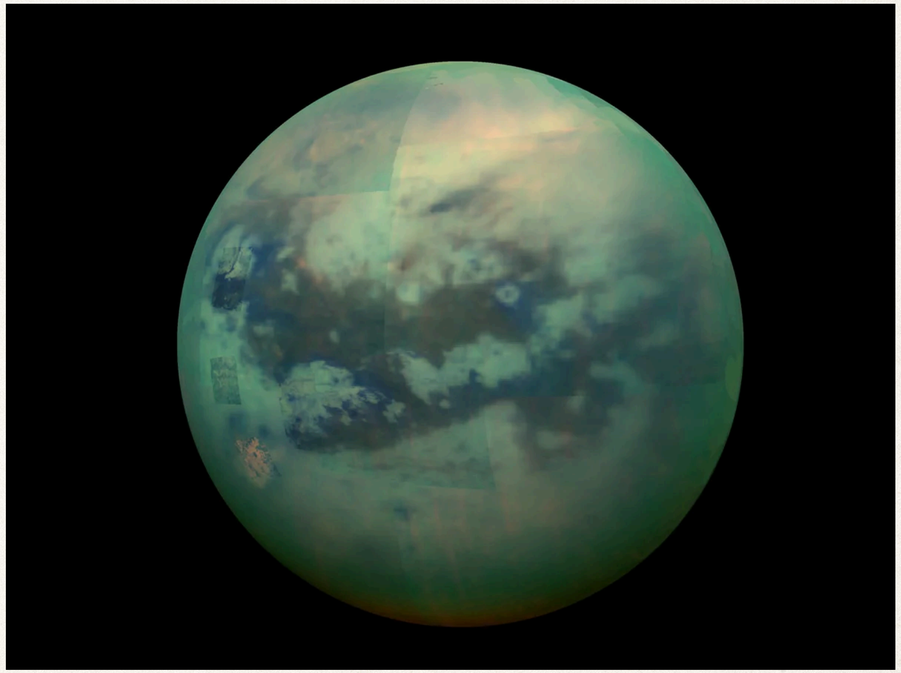
Life on Titan - maybe never

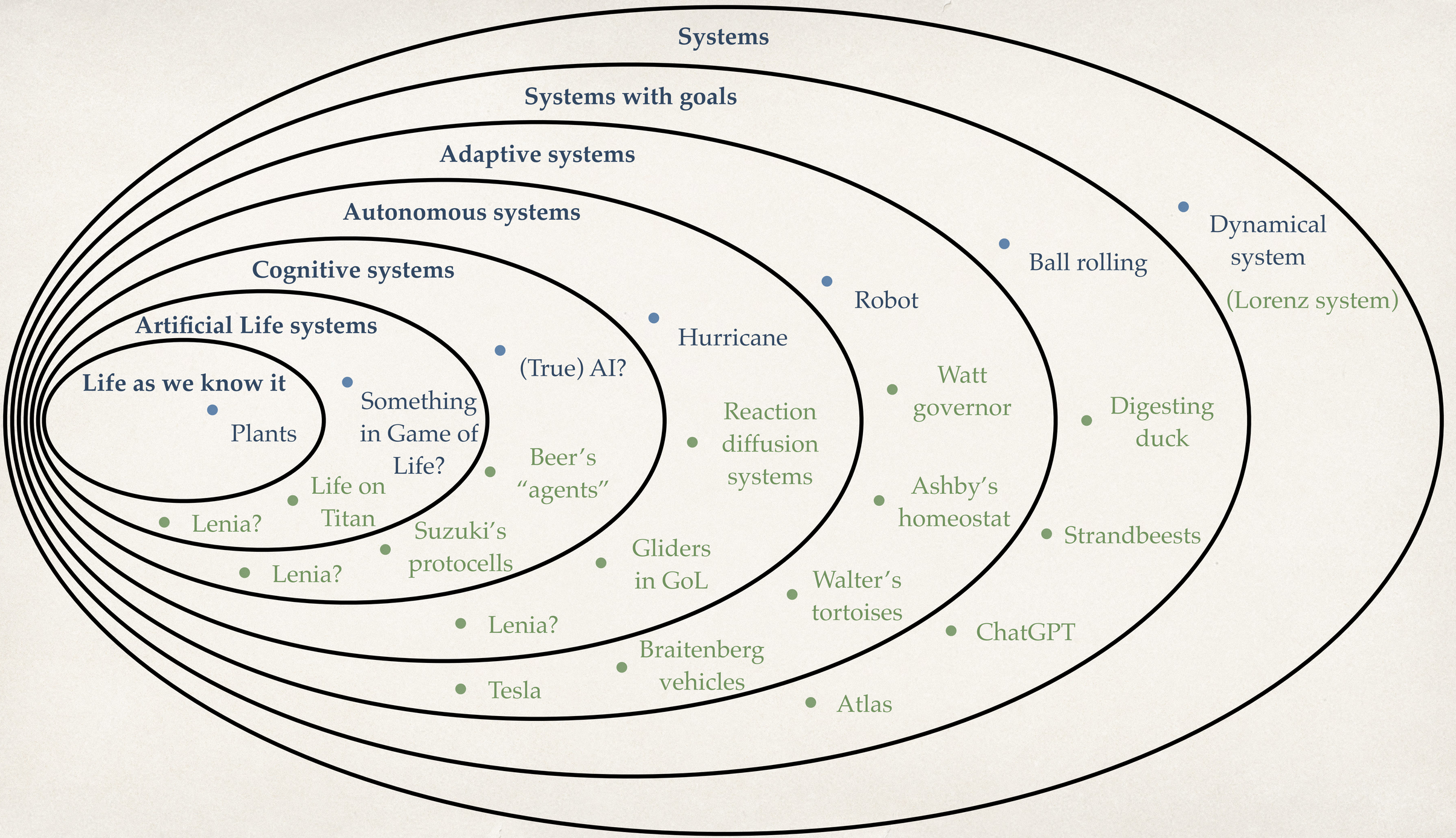
Titan

- One of Saturn's moons
- Liquids on its surface
- Chemically active atmosphere
- Methane + ethane + water for life

https://en.wikipedia.org/wiki/Life_on_Titan



Credit: NASA. https://www.npr.org/sections/13.7/2017/10/16/555045041/confession-of-a-planetary-scientist-i-do-not-want-to-live-on-mars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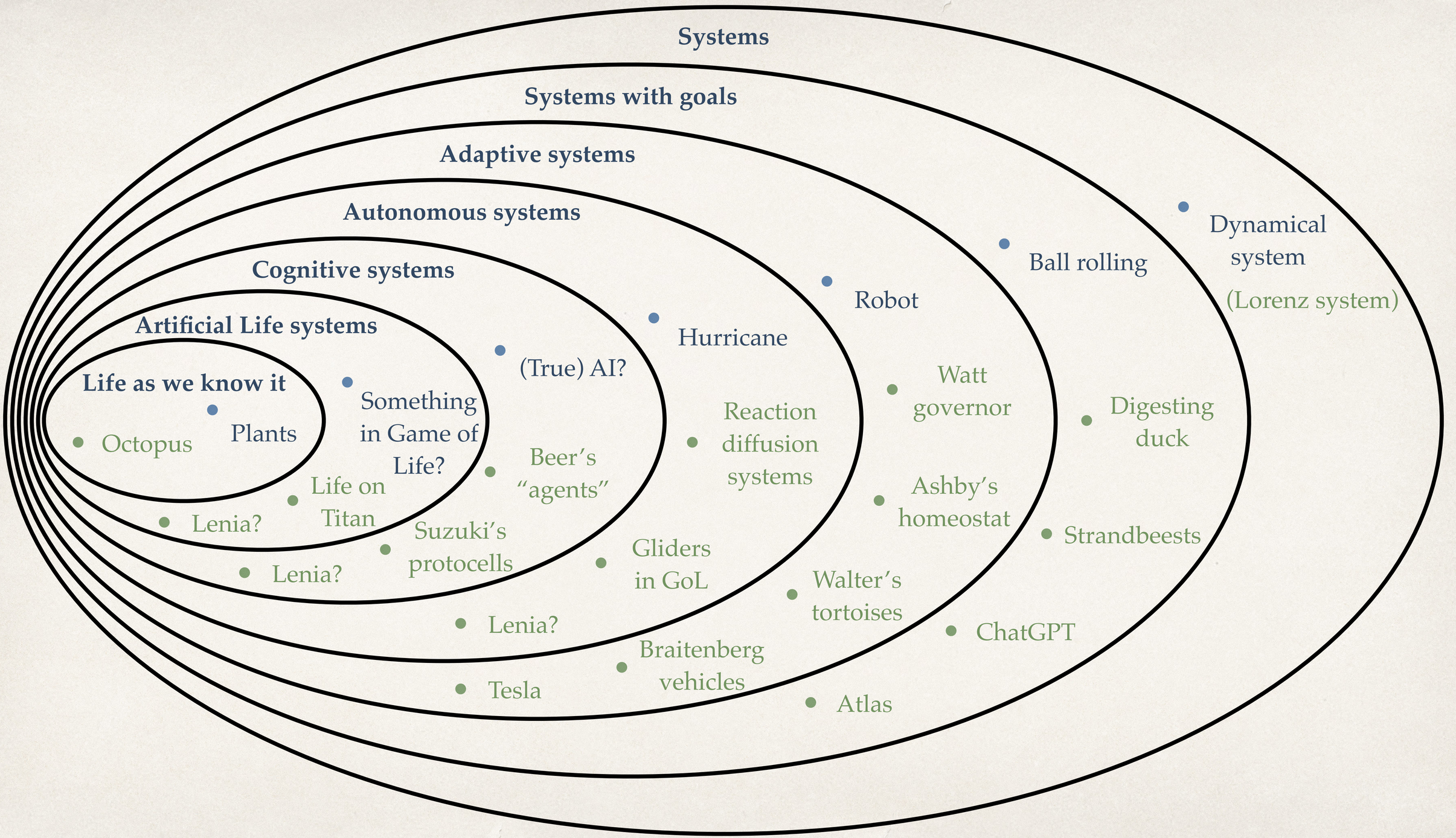
Octopus - millions of years ago

- Can solve puzzles/mazes
- Can recognise different people
- Can use tools
- Can run (on two tentacles), crawl (like a snake), etc.

https://www.nhm.ac.uk/discover/octopuses-keep-surprising-us-here-are-eight-examples-how.html

https://www.youtube.com/watch?v=dKWssIQplw8&ab_channel=OctolabTV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Food for thought: example #1

The boundaries of an agent

“Brewers make wort. Yeast makes beer.”

https://psyche.co/ideas/the-brewer-the-yeast-and-the-boundaries-of-human-agency

Food for thought: example #2

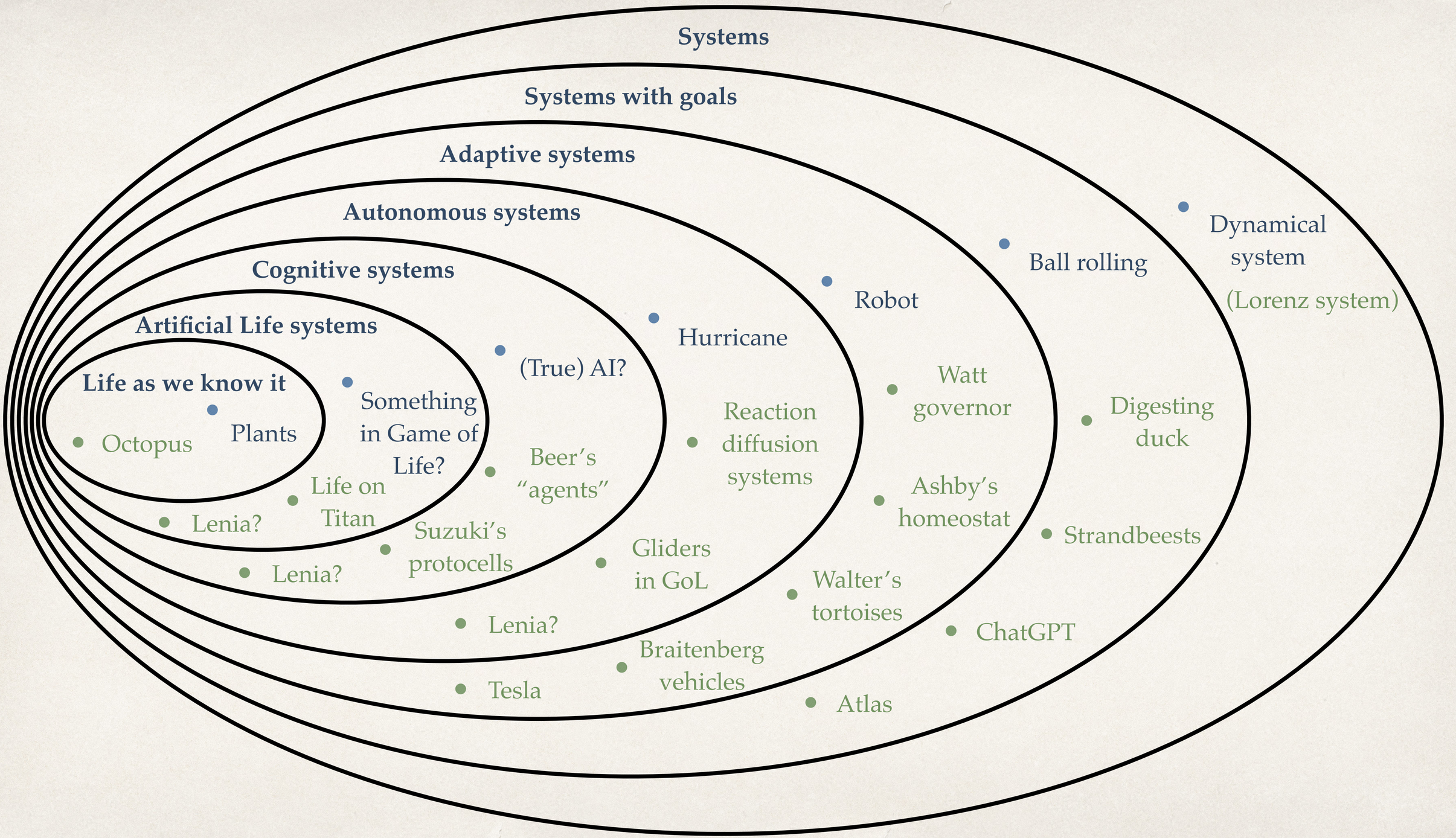
A different way to look at agency?

文楽 (Bunraku)

https://www.japan-guide.com/e/e2092.html

It is thus vain to wonder whether the spectator can forget the presence of the manipulators. Bunraku practices neither the occultation nor emphatic manifestation of its springs; it rids the actor's animation of all sacral staleness and abolishes the metaphysical connection the West cannot keep from making between the soul and the body, cause and effect, motor and machine, agent and actor, destiny and man, God and creature. If the manipulator is not hidden, why—how?—do you want to make him a god? In Bunraku, the puppet is not controlled by strings. No more strings, therefore no more metaphors, no more destiny. The puppet no longer apes the creature, man is no longer a puppet in the hands of divinity, the *inside* no longer rules the *outside*.

Barthes, R. (1971). On bunraku. *The Drama Review, 15*(2), 76-80.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