

Chaos, Fractals, and the Arts

Ralph Abraham
www.ralph-abraham.org

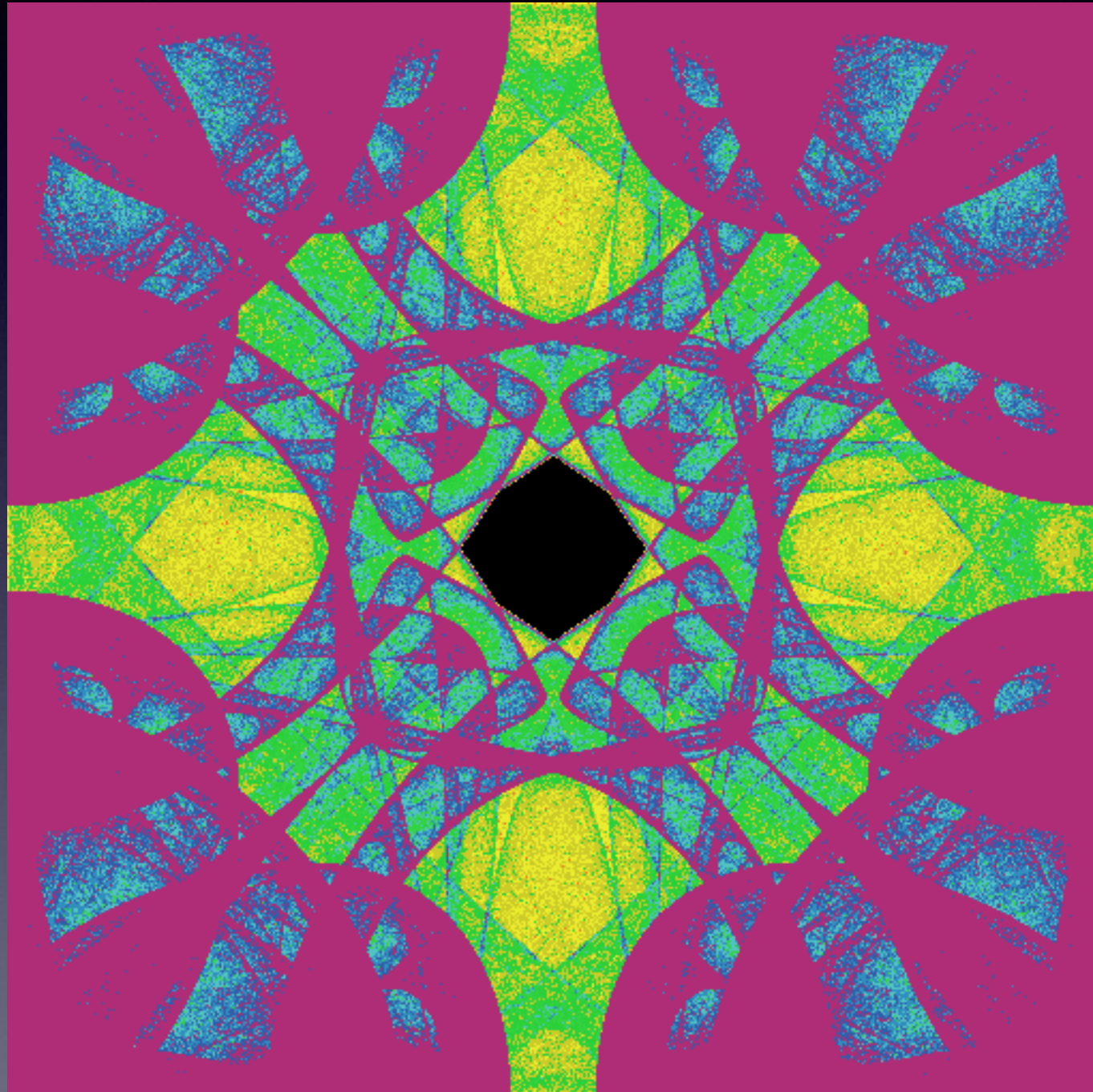
Porter College 34B, UCSC
Winter 2016

Winter 2015, Series #10



Dedicated to HH the 14th Dalai Lama
for his 80th birthday
July 5/6, 2015

Symmetric Chaos



Tentative Syllabus by Week

- A. Vibrations and Forms
 - A1. Models of Consciousness
 - A2. Cymatics
 - A3. Chaotic attractors
 - A4. Bifurcations and periodic windows
 - A5. Symmetric chaos

Meeting #2, January 12

- A. Cymatics
- B. ID demo
- C. Thumb harp

A. Cymatics

- Mickey Hart of the GratefulDead
- <https://www.youtube.com/watch?v=6pBbmOBxsvQ>

Cymatics Time-line

- 1490, leonardo's dusty table (cf capra p.234)
- 1680, robert hooke
- 1787, ernst chladni, 1756--1827
- 1831, michael faraday, beer truck waves
- 1883, lord rayleigh
- 1954, benjamin and ursell
- 1967, hans jenny

Spanda-karikas

- By Vasugupta or Kallata, ca 900
- Commentary by Abhinavagupta, ca 1000 CE
- “Spandana means some sort of movement. The characteristic of 'somewhat' consists in the fact that even the immovable appears 'as if moving,' because though the light of consciousness does not change in the least, yet it appears to be changing as it were.”

Cymatics discovery, water

- Leonardo, 1490. on intersection water waves
(From Fritjof Capra, 2007; p. 230)
- "Therefore, the disturbance of the water being a tremor rather than a movement, the circles cannot break one another as they meet, because, water being of the same quality in all of its parts, it follows that these parts transmit the tremor from one to another without moving from their place."

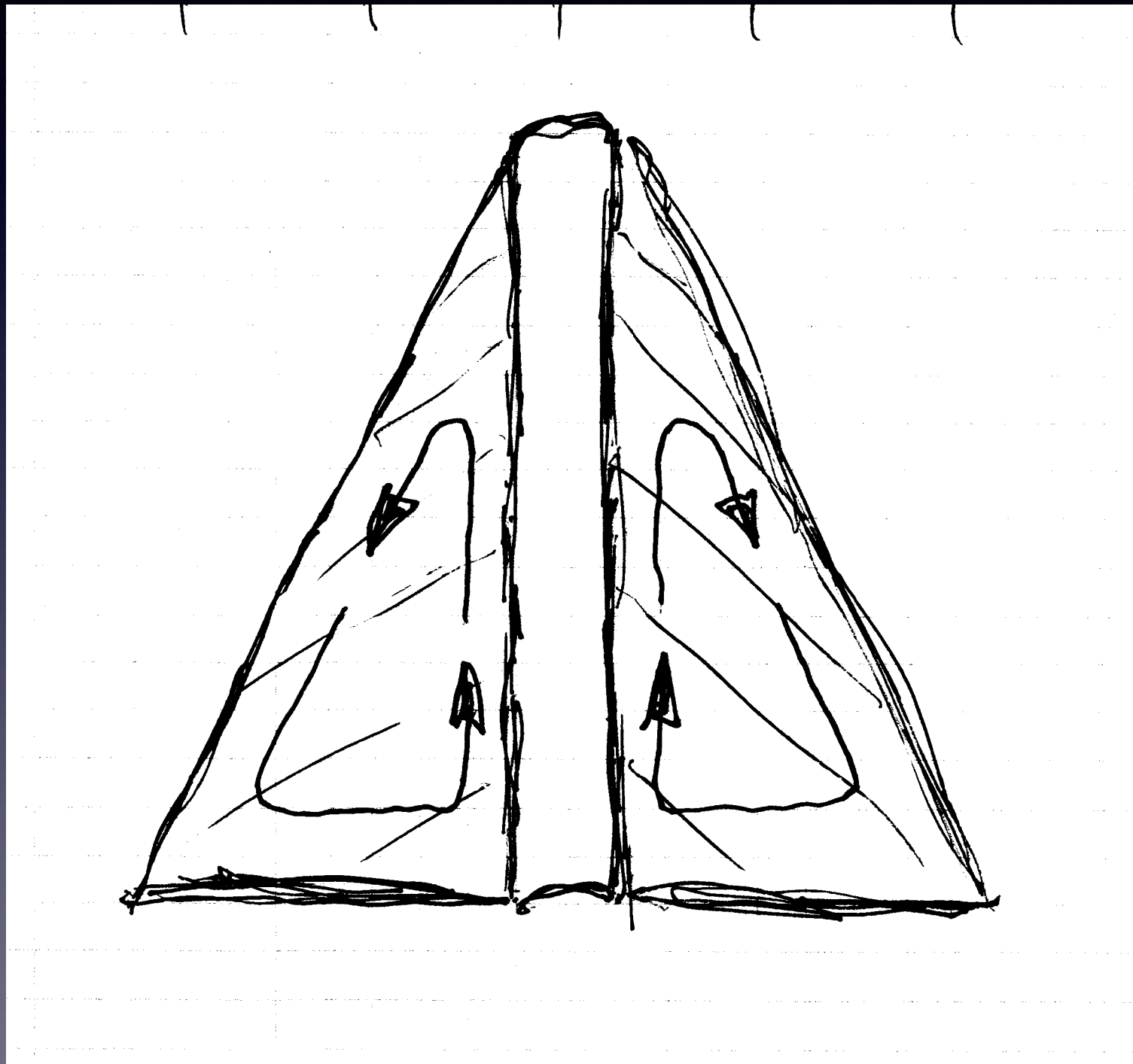
Cymatics discovery, air

- Leonardo, 1490. on sound waves
(From Fritjof Capra, 2007; p. 233)
- "Leonardo also explored the nature of sound, and from experiments with bells, drums, and other musical instruments, he observed that sound is always produced by "a blow on a resonant object." He correctly deduced that this causes an oscillating movement in the surrounding air, which he called a 'fanning movement' ..."

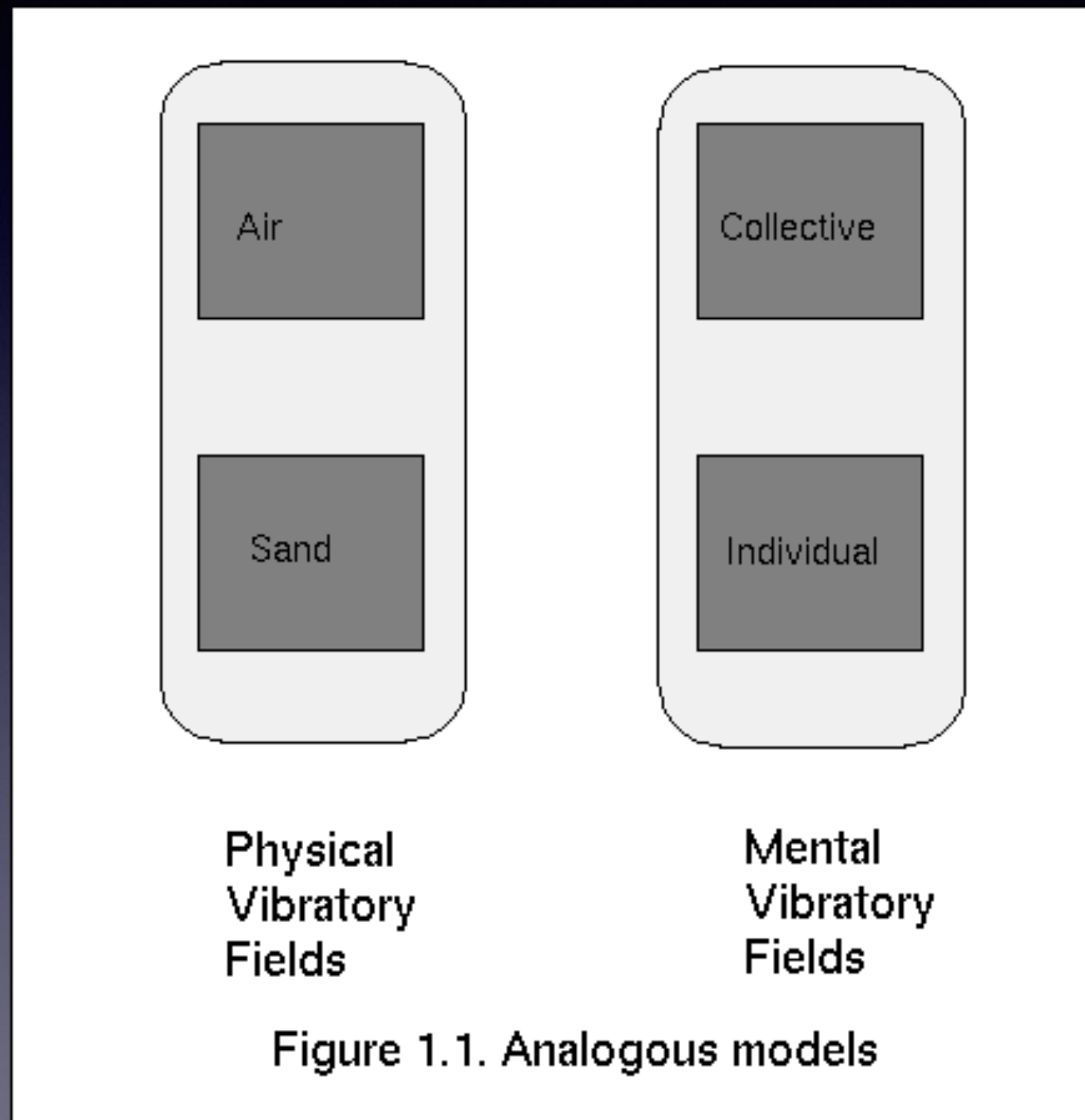
Cymatics discovery, dust

- Leonardo, 1490. on cymatics
(From Fritjof Capra, 2007; p. 234-5)
- "One of Leonardo's most impressive discoveries in the field of acoustics was his observation that, "If you tap a board covered with dust, that dust will collect in diverse little hills." ... The hills will always pour down that dust from the tips of their pyramids to their base ... From there, it will re-enter underneath, ascend through the center, and fall back again from the top of that little hill. And so the dust will circulate again and again ... as long as the percussion continues.""

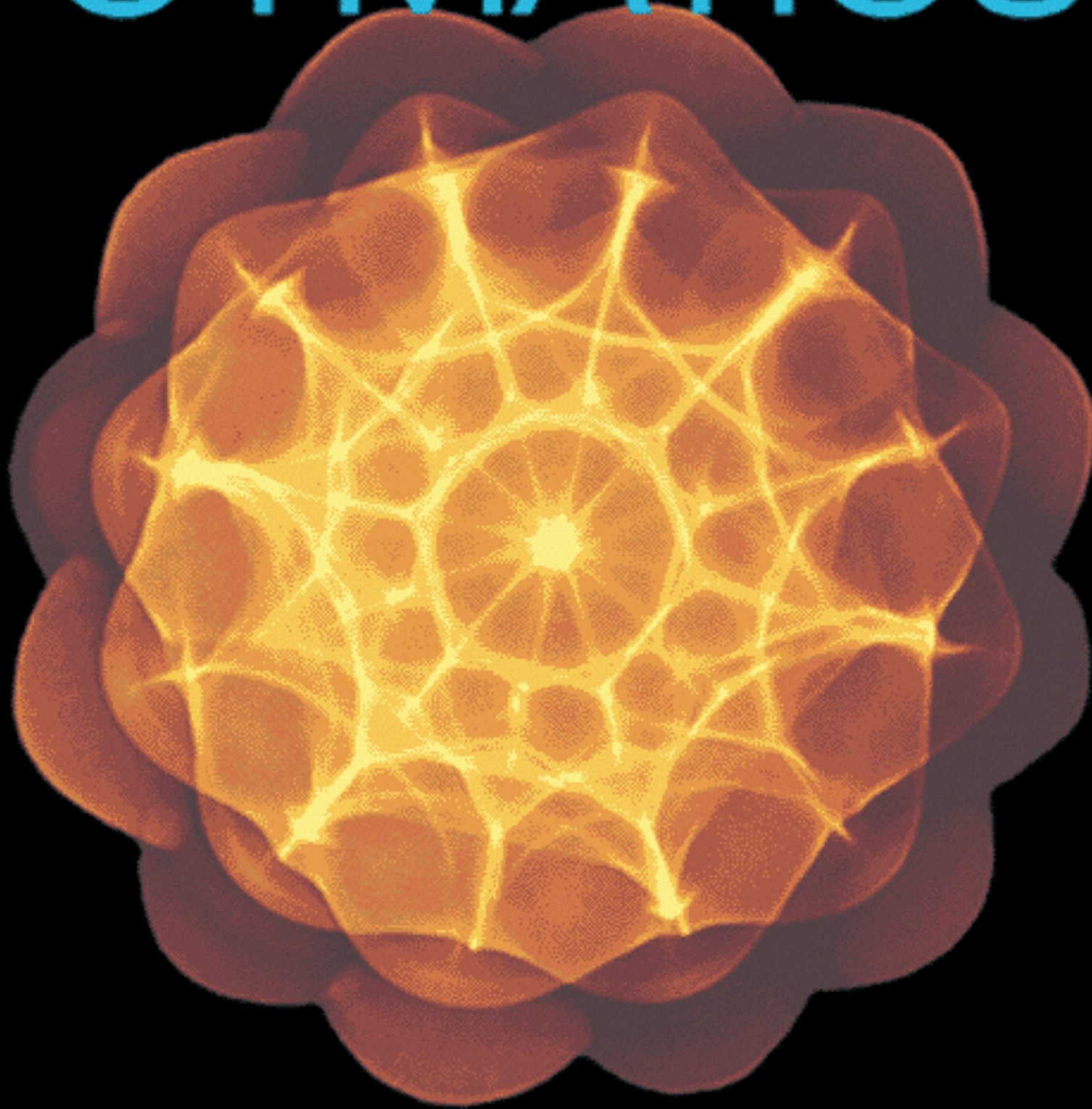
A grex (aka Benard cell)



A Metaphor

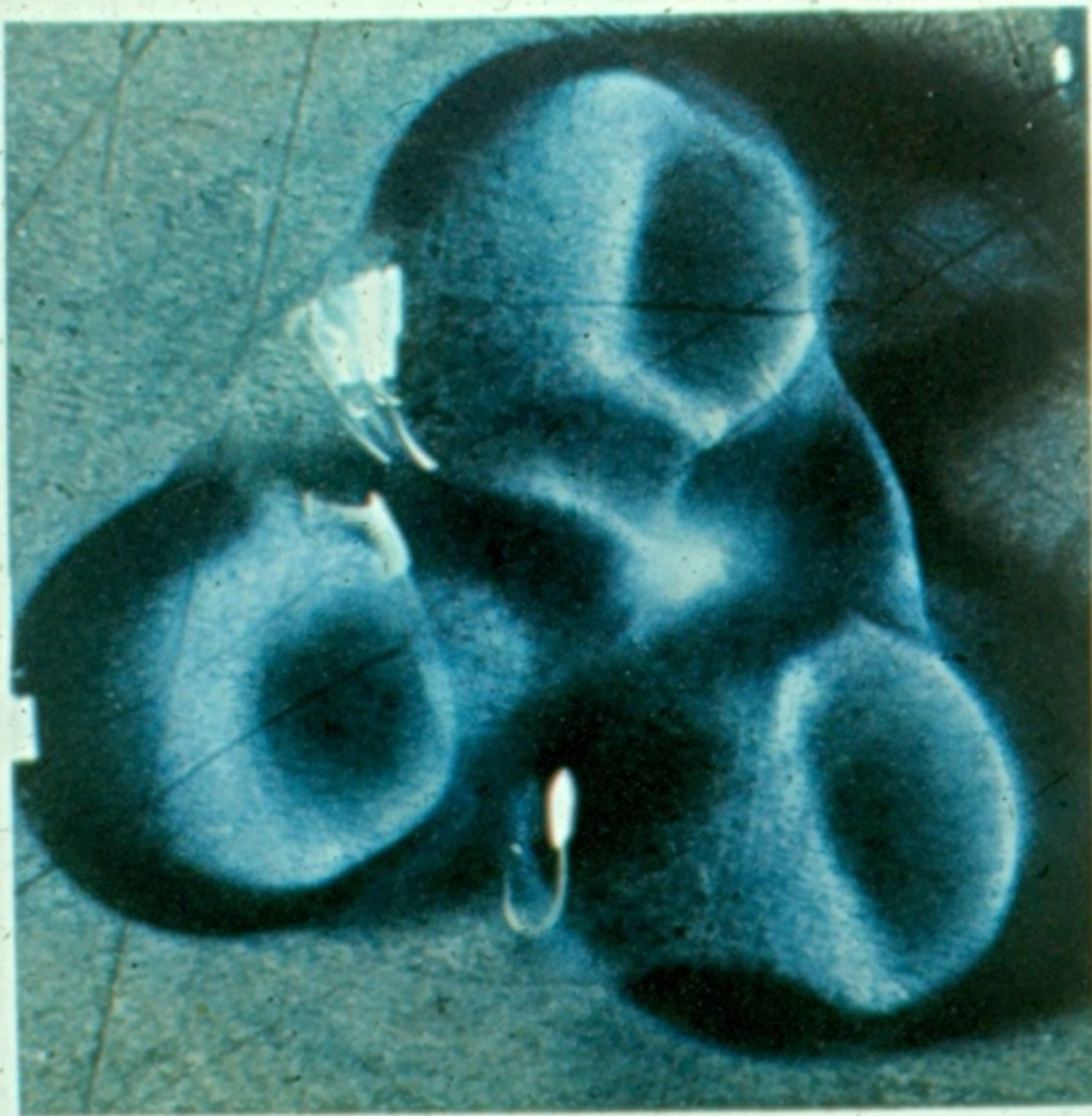


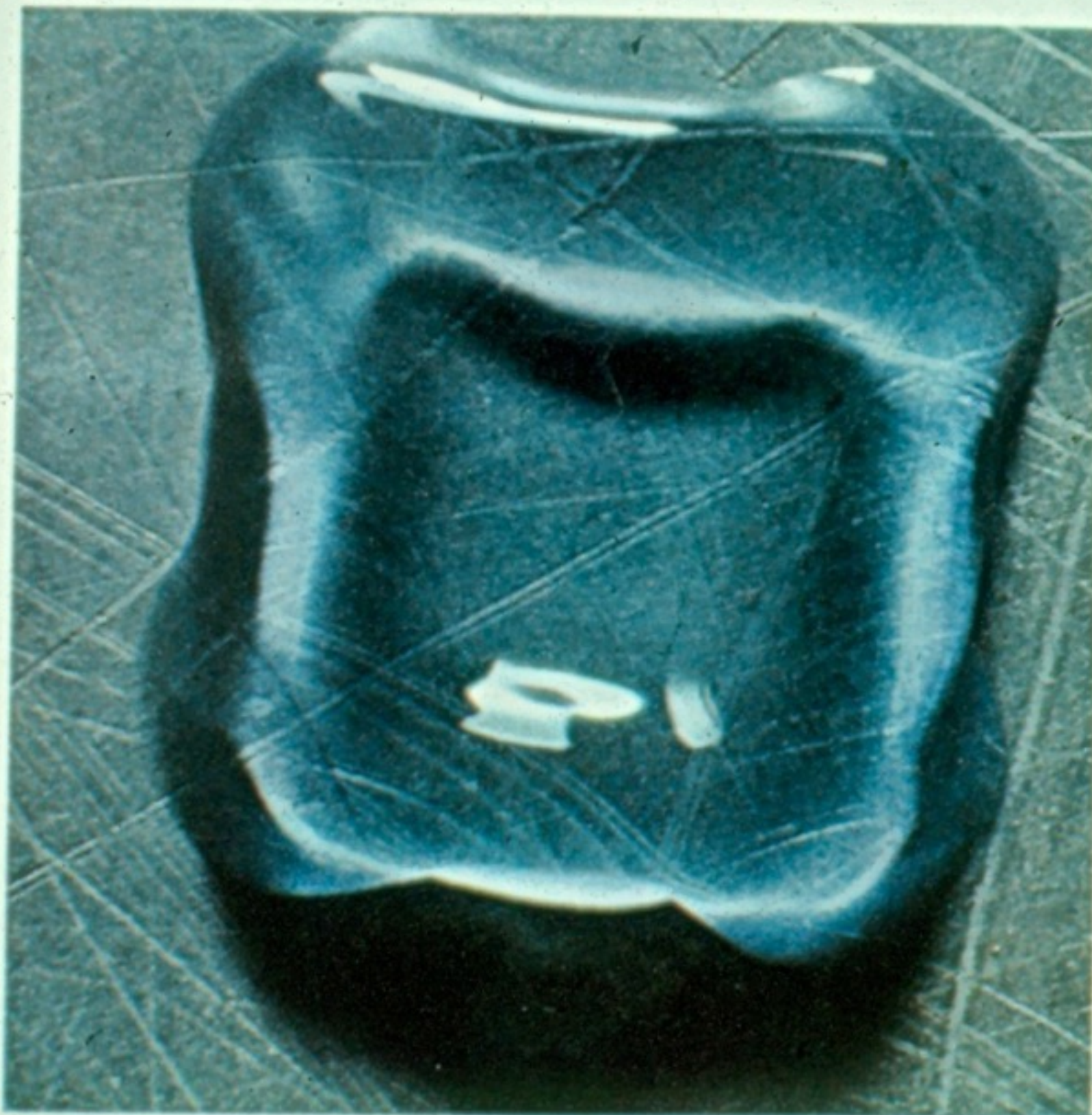
CYMATICS



Hans Jenny

20





21

22



Differentiation of two media

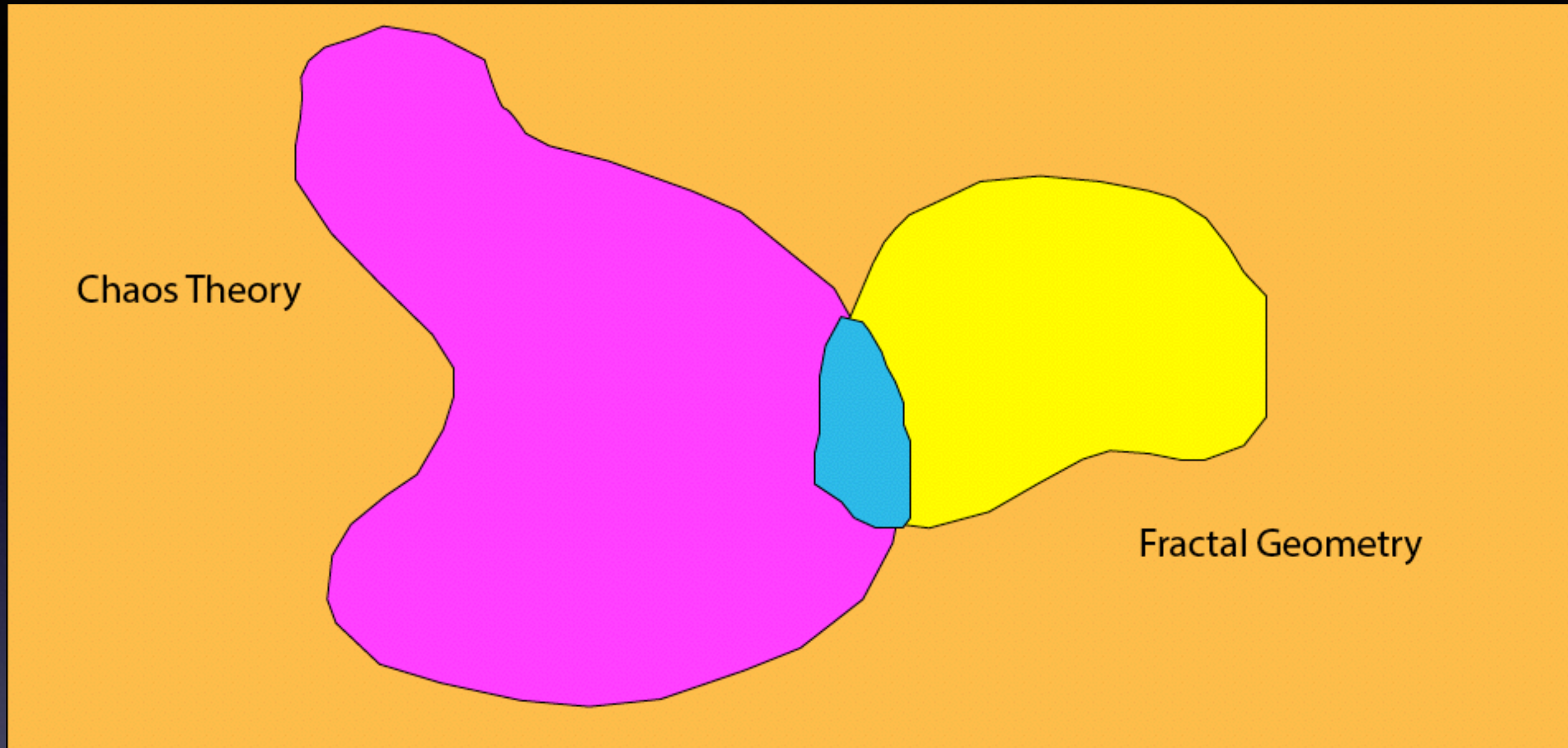


Jenny's caption, figure 78













- “Figure 78 shows how characteristically the various substances behave. Hexagonal steel plate, 3600 cps. The strewn material is quartz sand and lycopodium. The sand moves into the nodal lines and the powder into the antinodes, where it circulates in the center as a round shape.”

B. Basic Chaos Theory

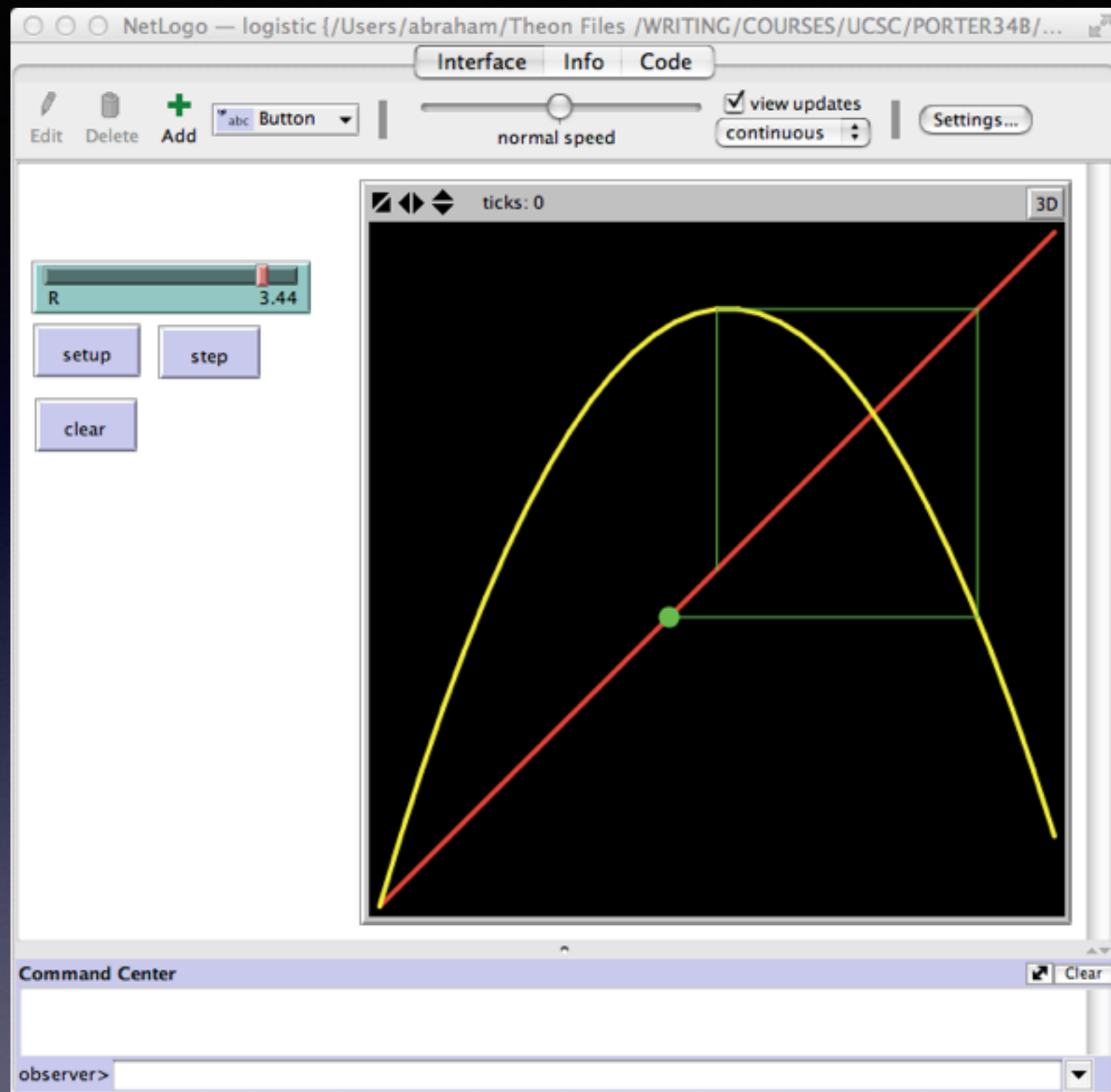
- Chaos and fractals
- Stairway to chaos
- Attractors, basins, and separatrices
- Bifurcations
- 1D: The logistic scheme
- NetLogo demo



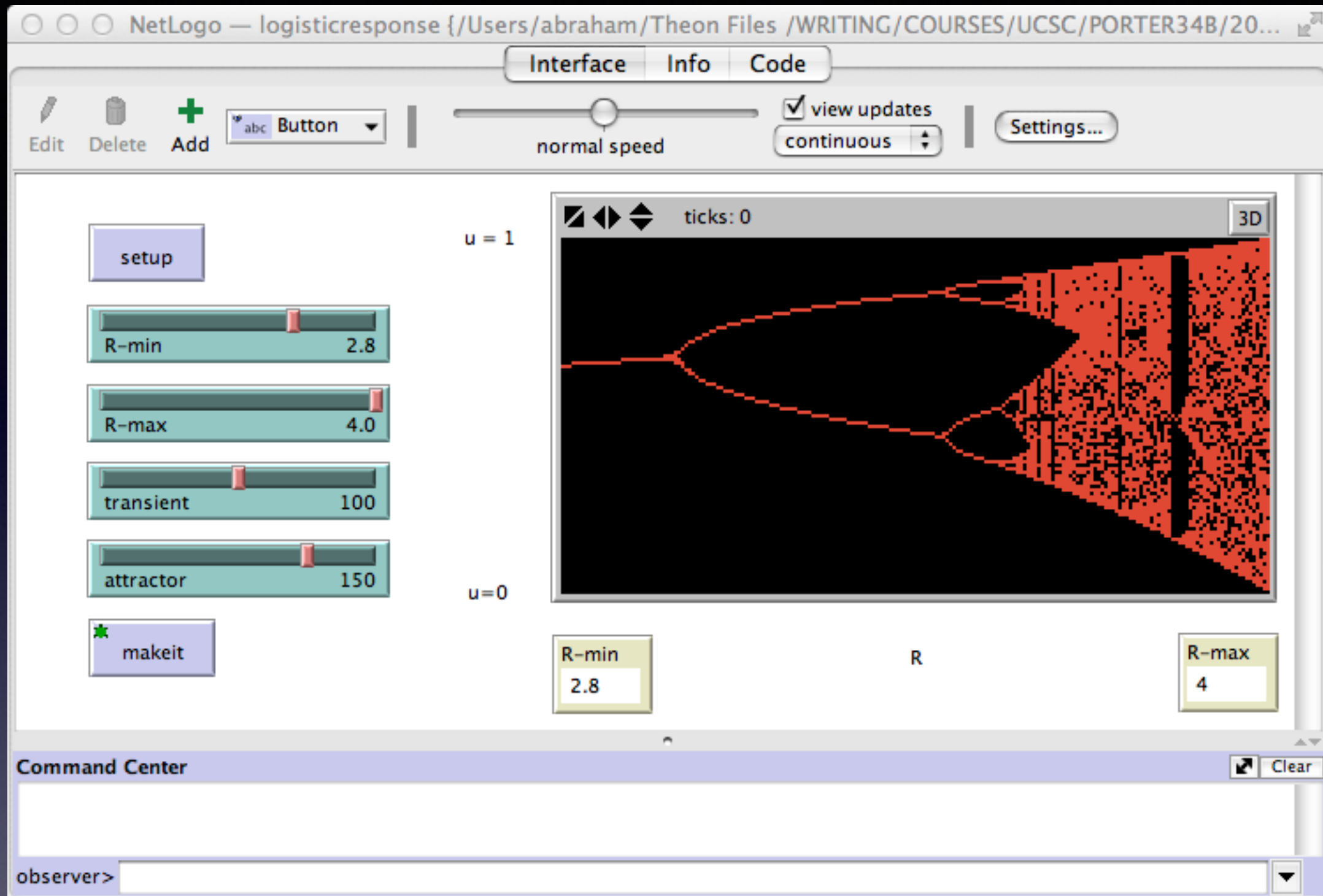
The Mathiverse

Dimension	0	1	2	3
Flows				
Cascades				
Iterations				

The Stairway to Chaos



Logistic
Map



Logistic Response Diagram

C. NetLogo Programming

- NetLogo models
- Agents, images, movies, sounds
- Performance, recordings, projects

Porter 34B 2016 Meeting #1

The End