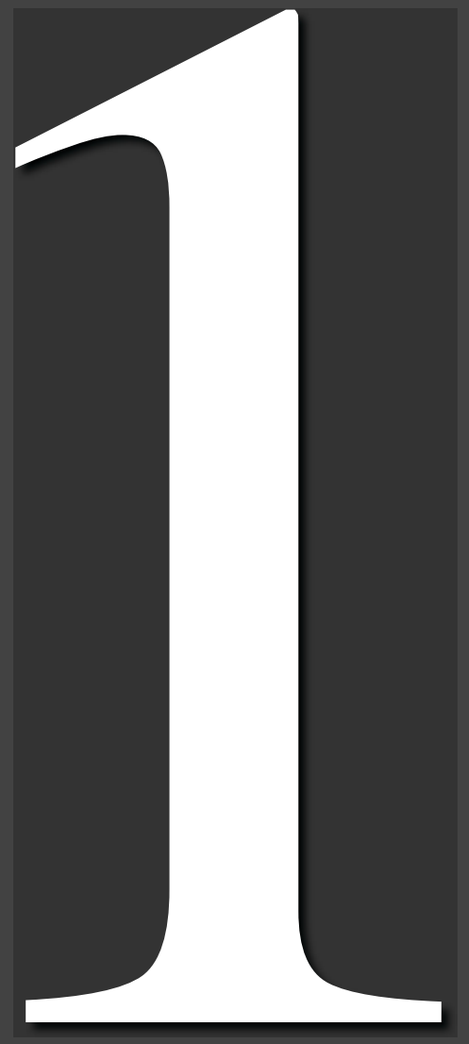
the process of making a representation

. . . clarifies your thinking



the process of making a representation

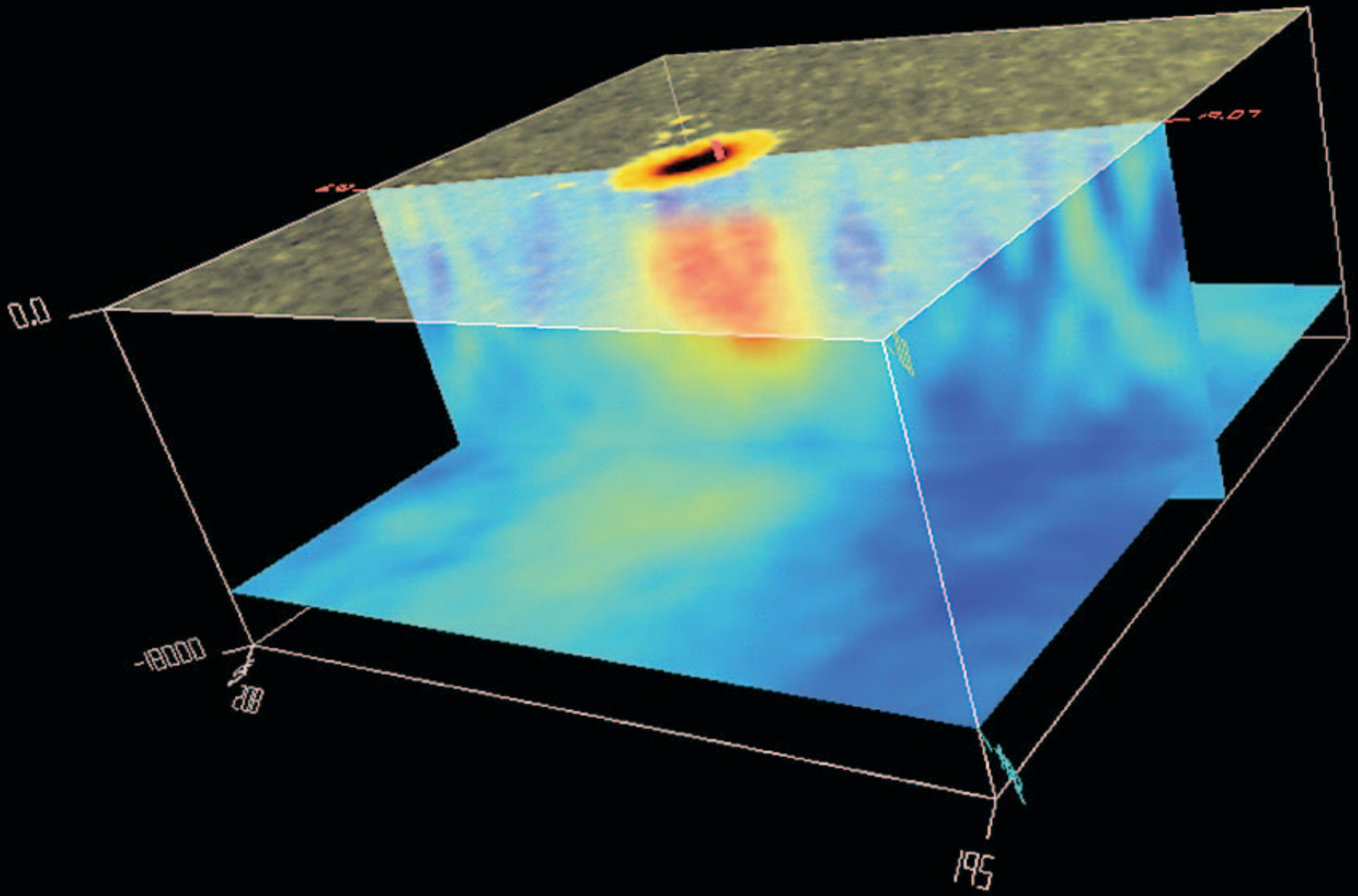
. . . should be collaborative

the process of making a representation

. . . teaches

the challenges are

. . . universal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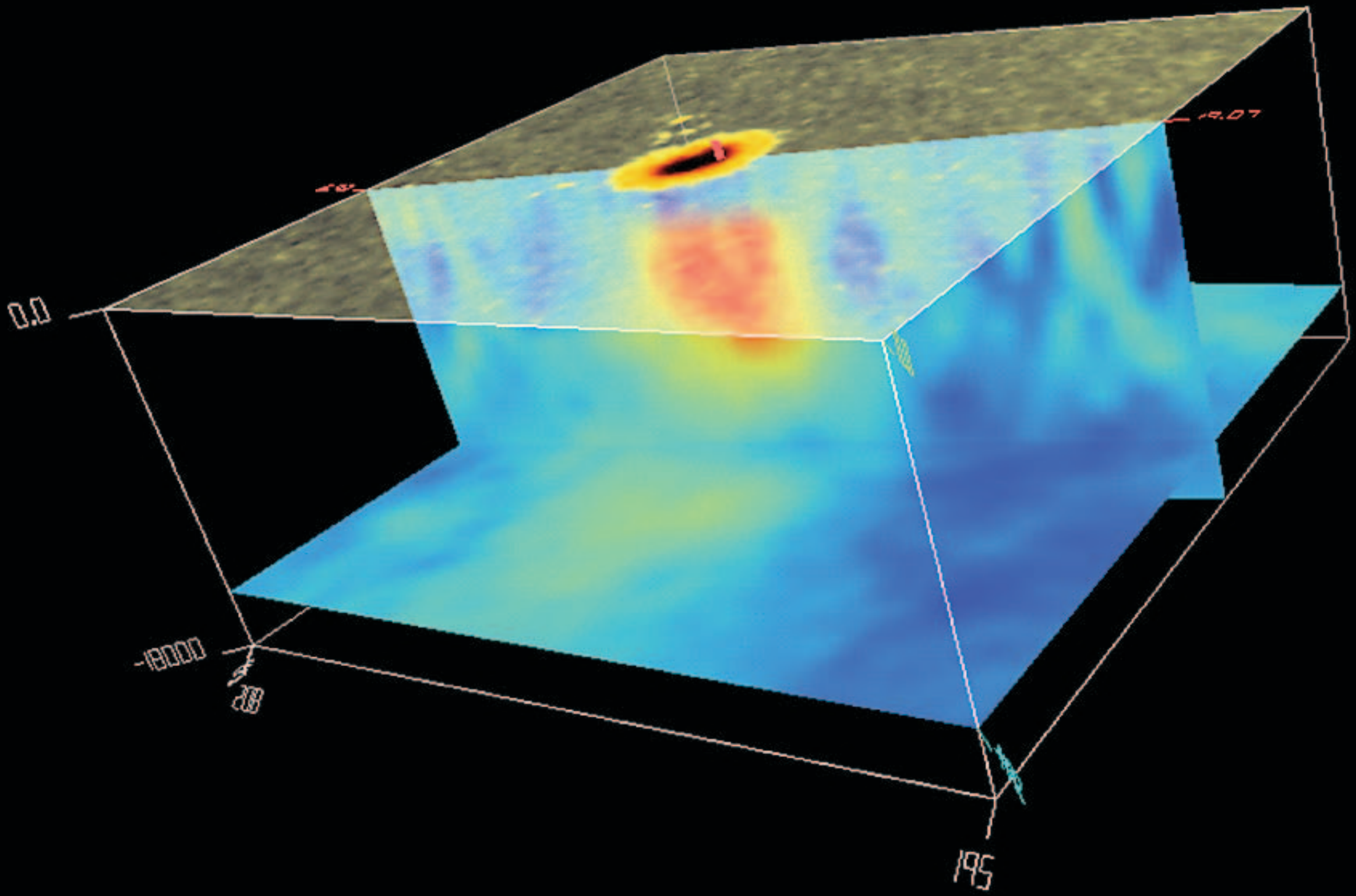
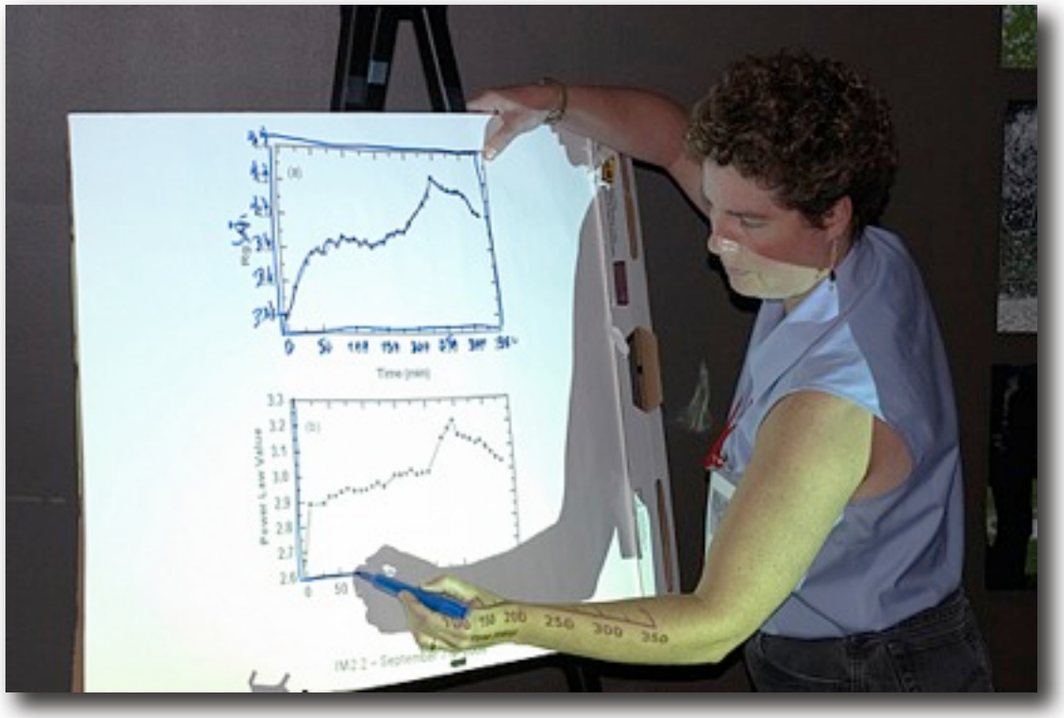
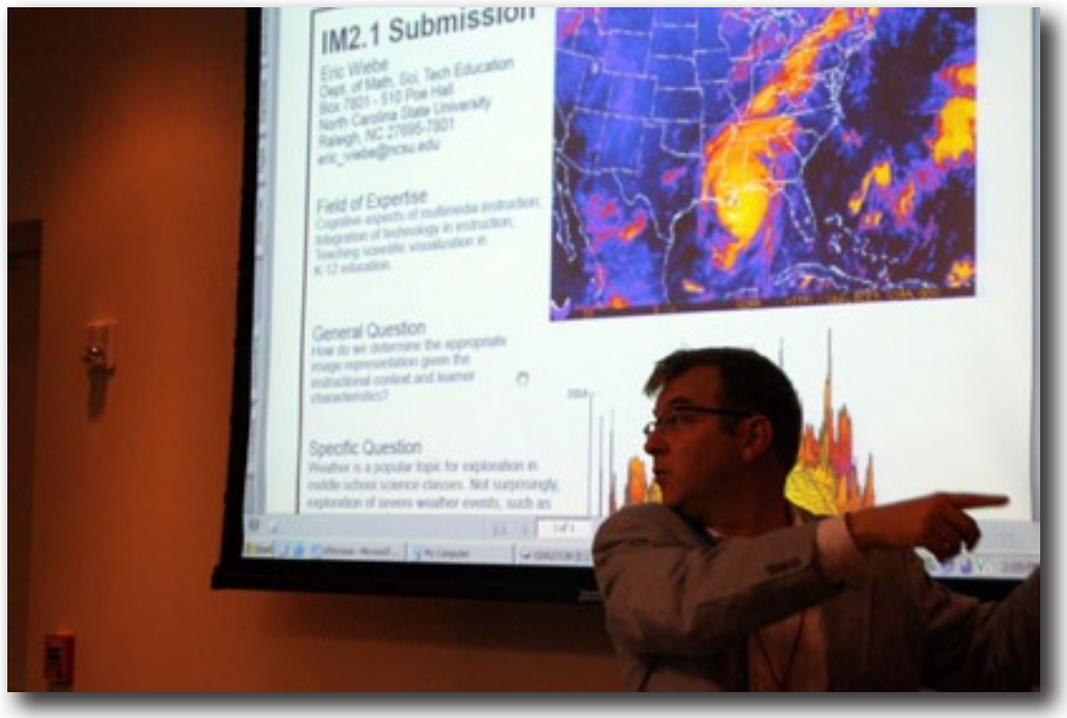



the subsurface structure below a sunspot using time-distance helioseismology


www.imageandmeaning.org

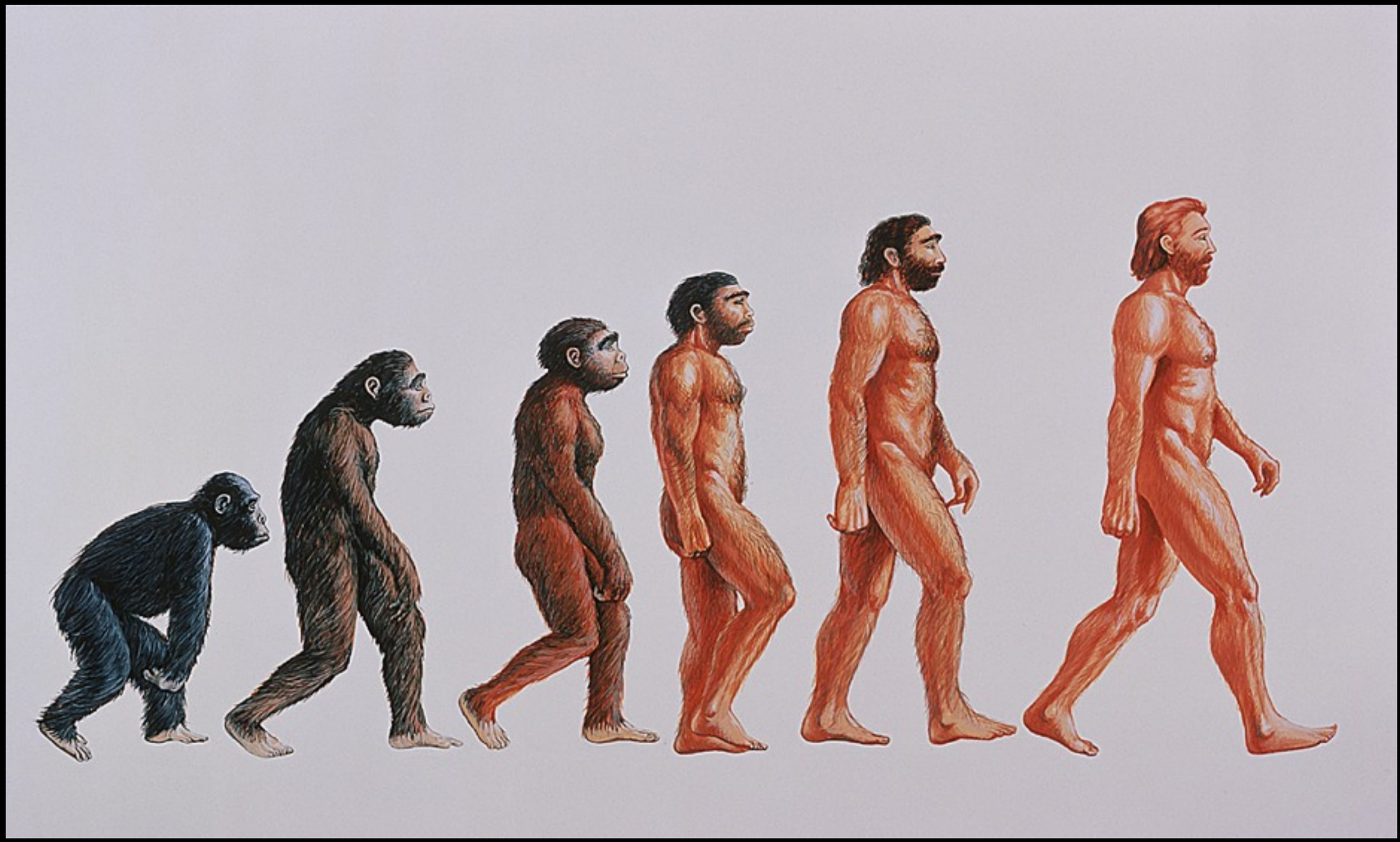


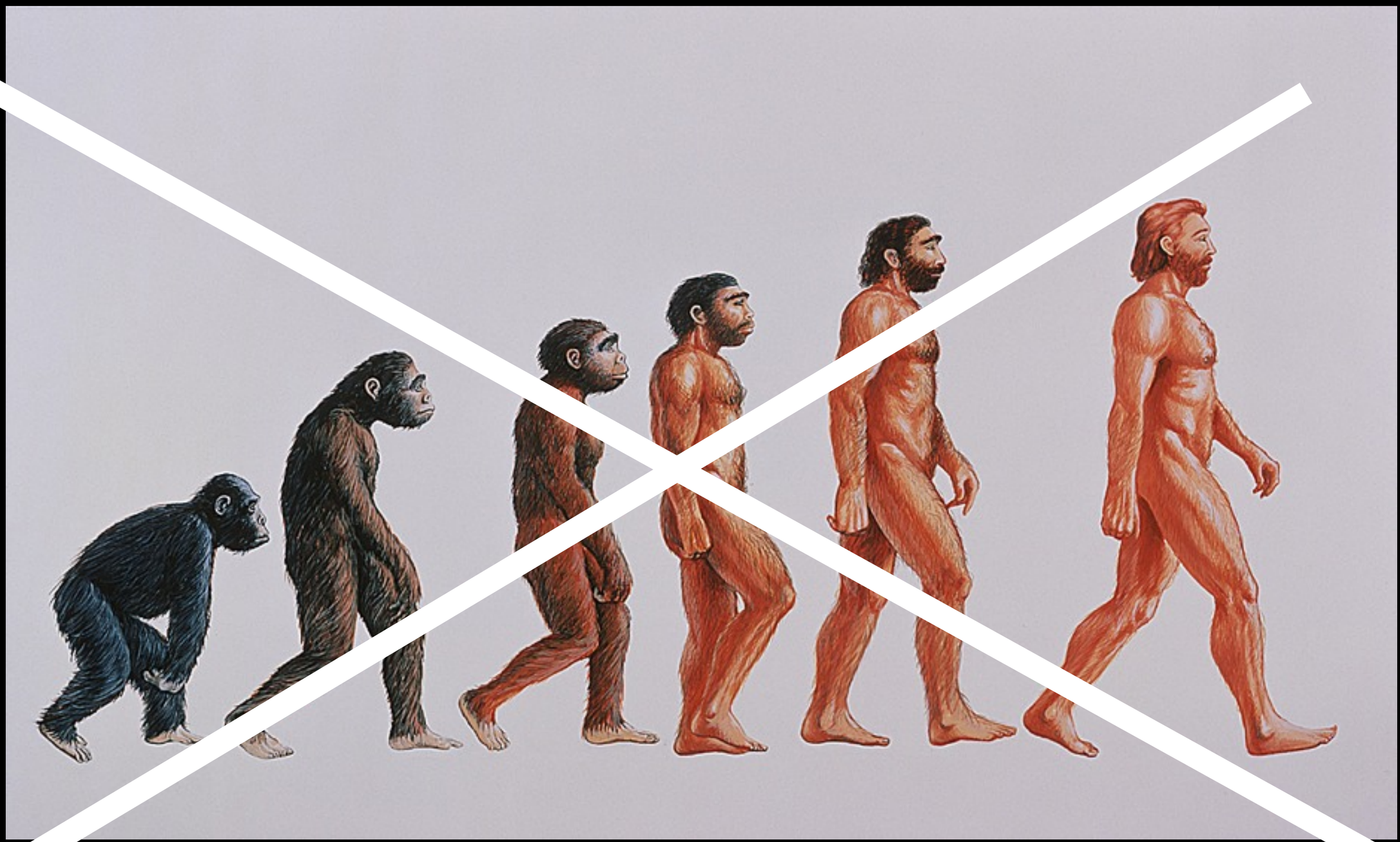

Kurt Rasselmann
IM2.1
Peter Coppin
IM2.1


IM2.1 Submission
Eric Wiebe
Dept. of Math, Sci, Tech Education
Box 7801 - 510 Poe Hall
North Carolina State University
Raleigh, NC 27695-7801
eric_wiebe@ncsu.edu
Field of Expertise
Cognitive aspects of multimedia instruction;
integration of technology in instruction;
Teaching scientific visualization in
K-12 education
General Question
How do we determine the appropriate
image representation given the
instructional context and learner
characteristics?
Specific Question
Weather is a popular topic for exploration in
middle school science classes. Not surprisingly,
exploration of severe weather events, such as

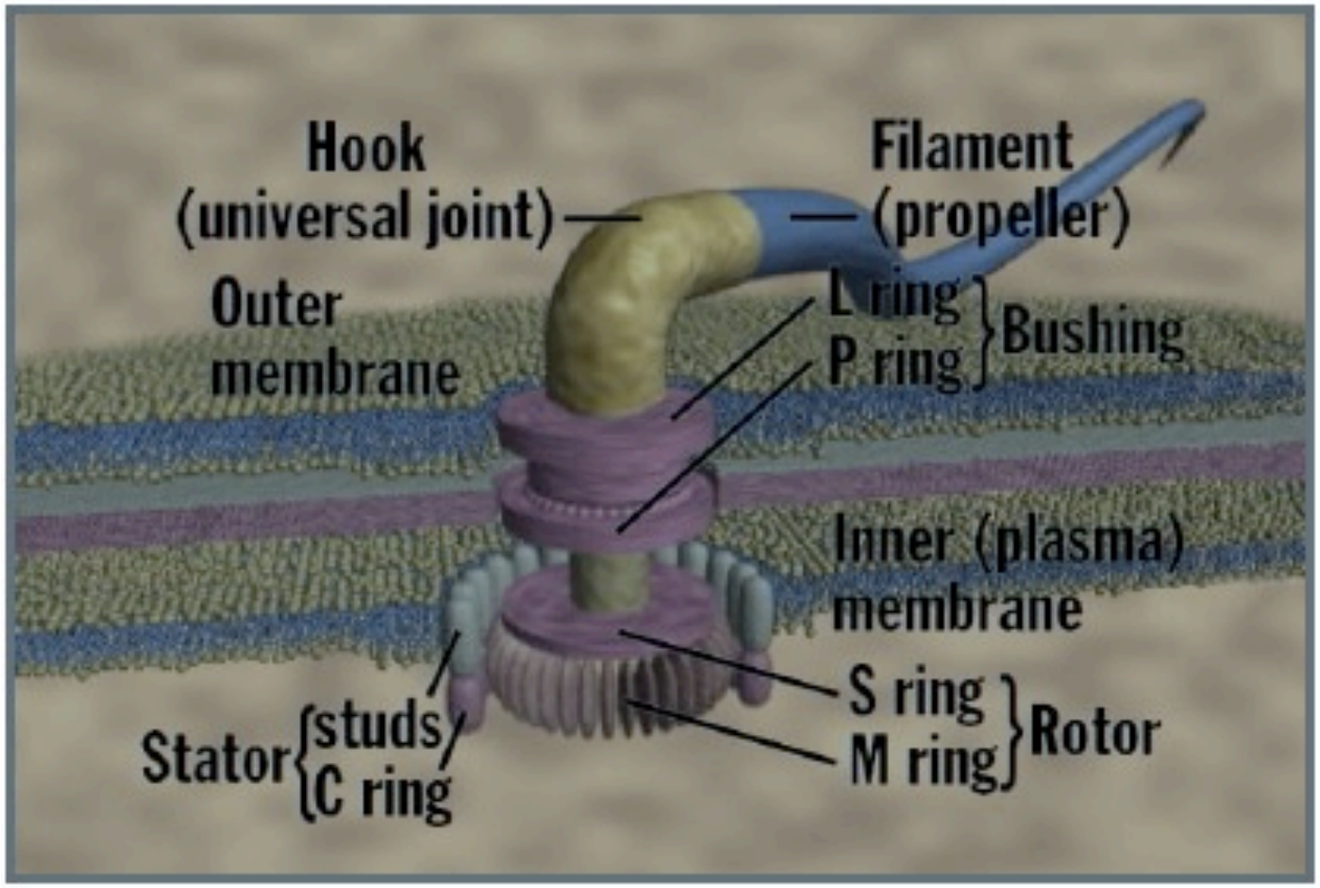
being

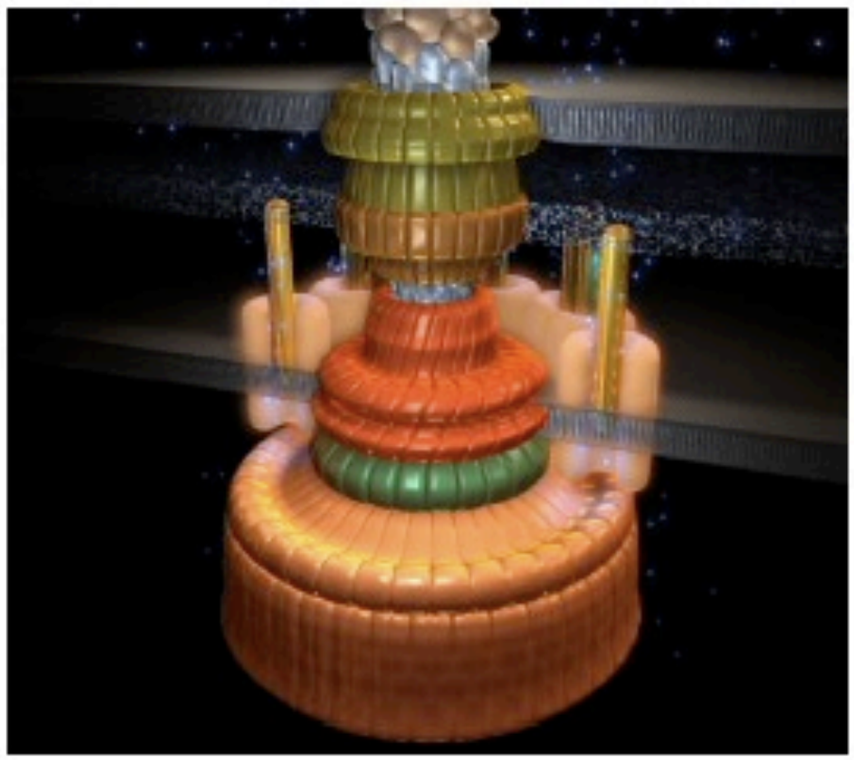
. . . responsible



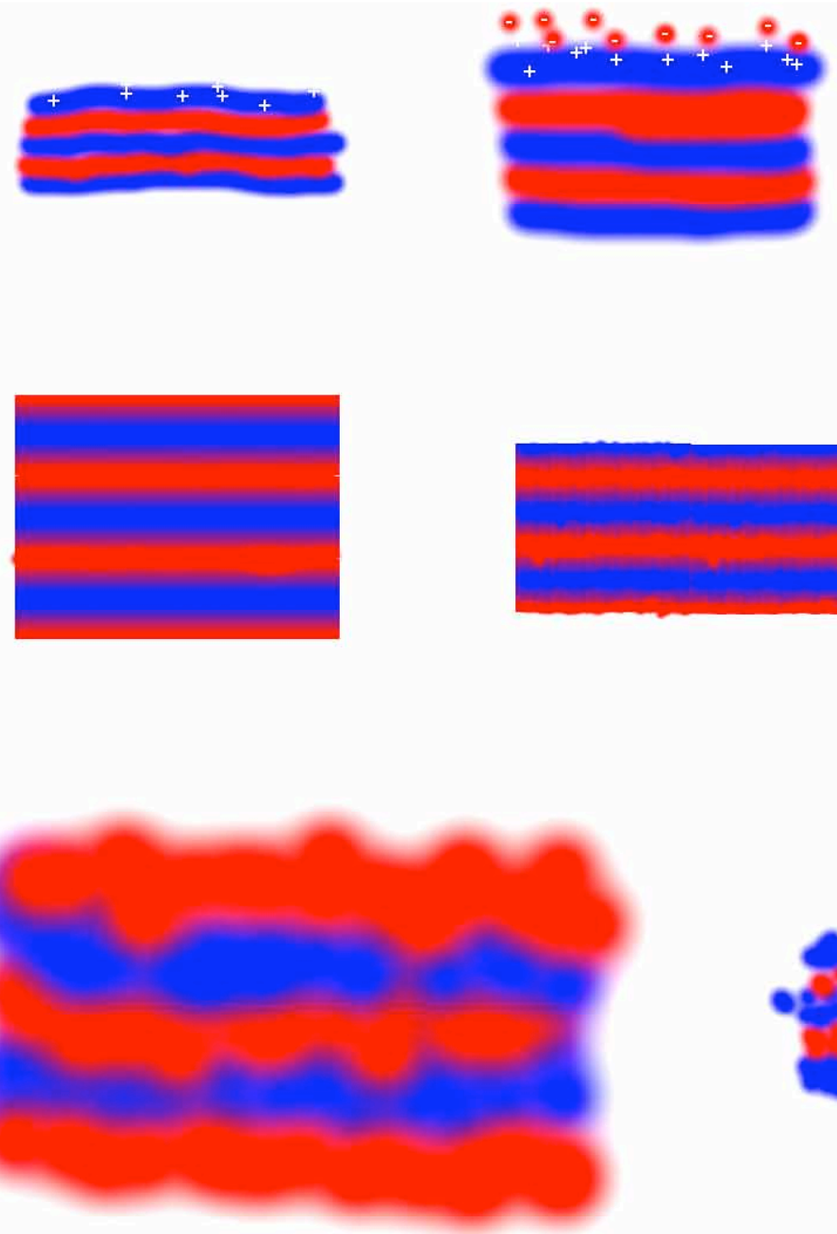


Below is the image at: www.evidencesofcreation.com/nature08.htm



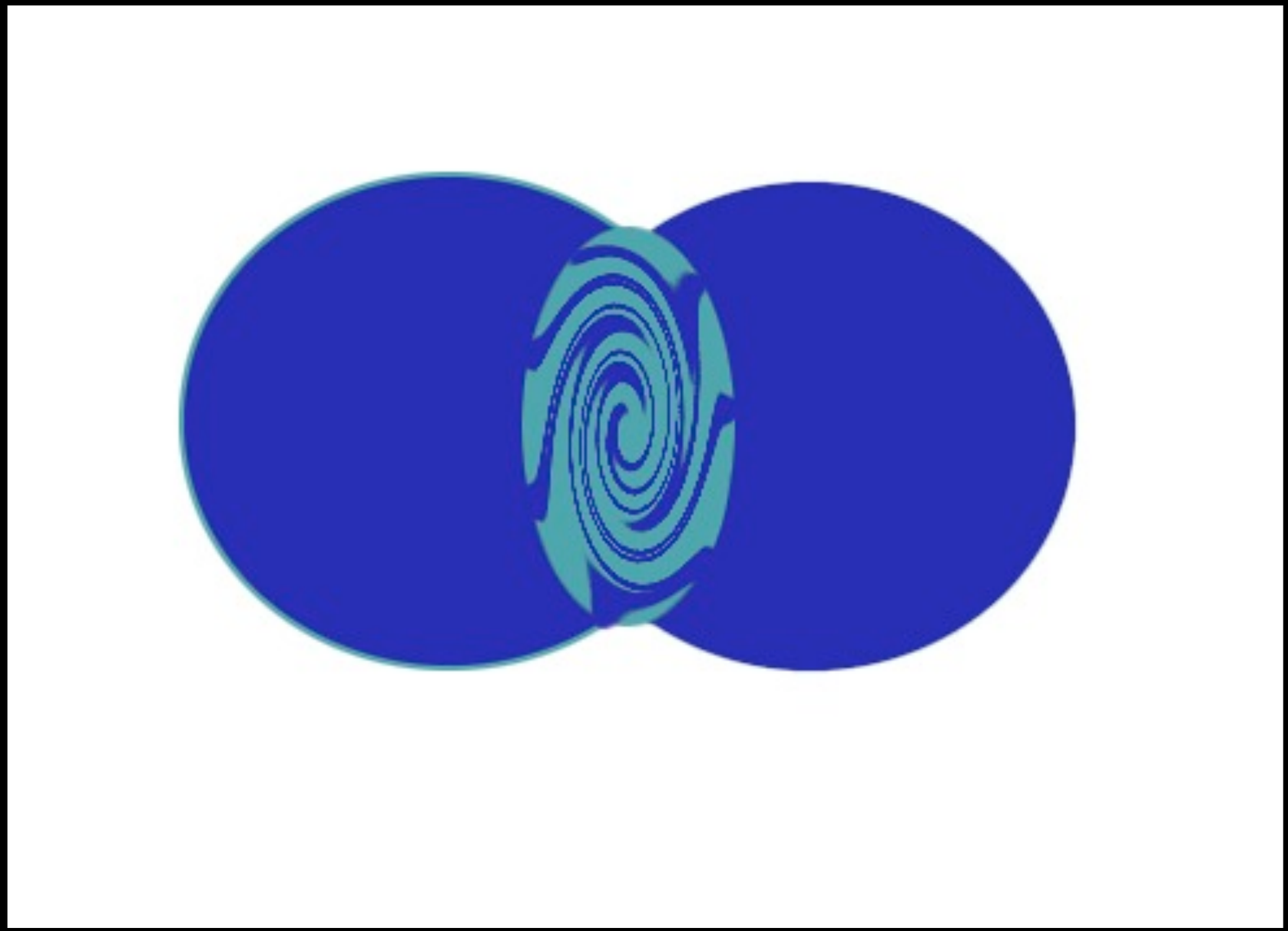



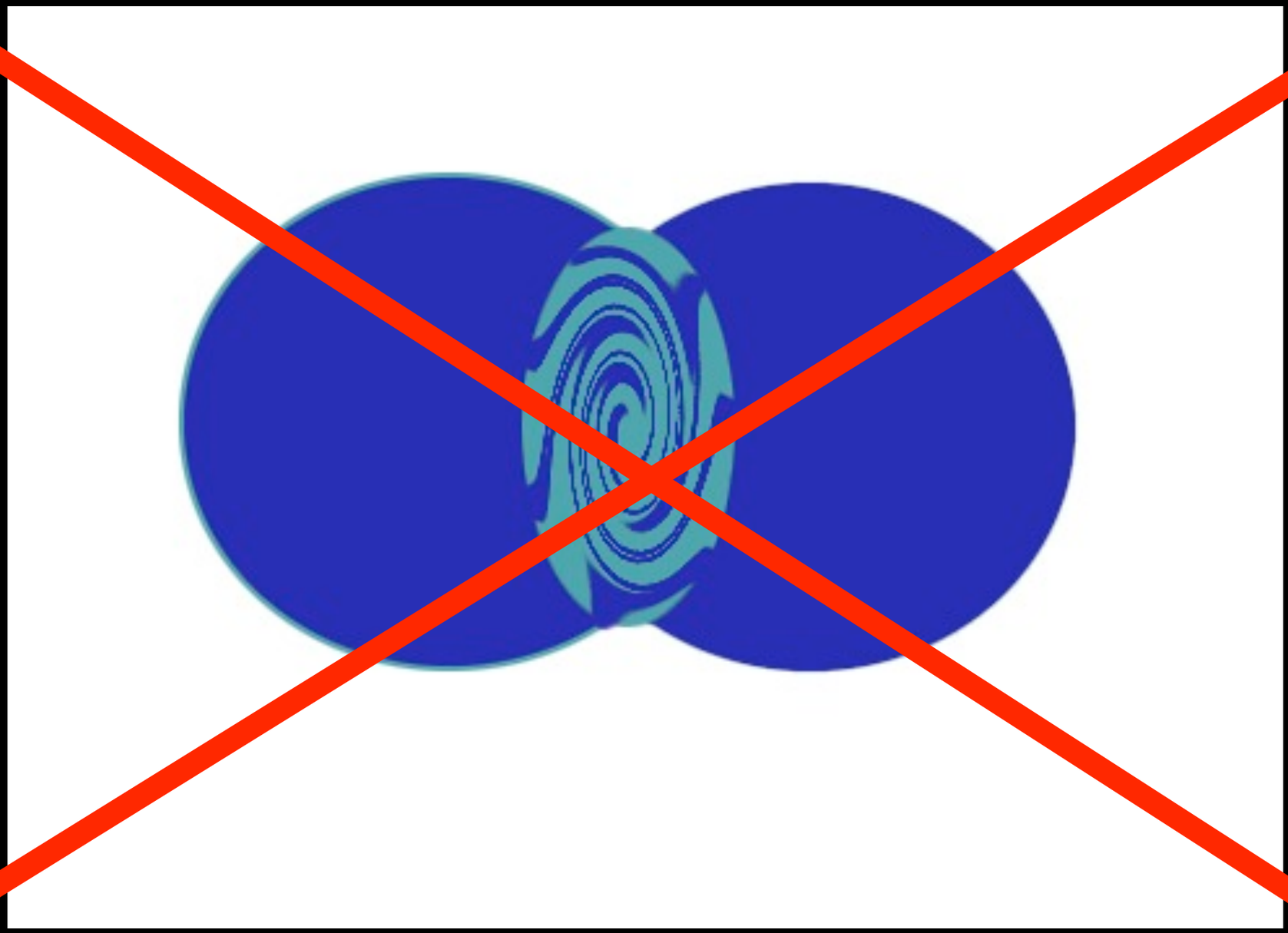
That is, intelligent design is a better explanation for entities exhibiting complex specified information than are appeals to the inherent capacities of nature (i.e. chance and/or physical necessity).

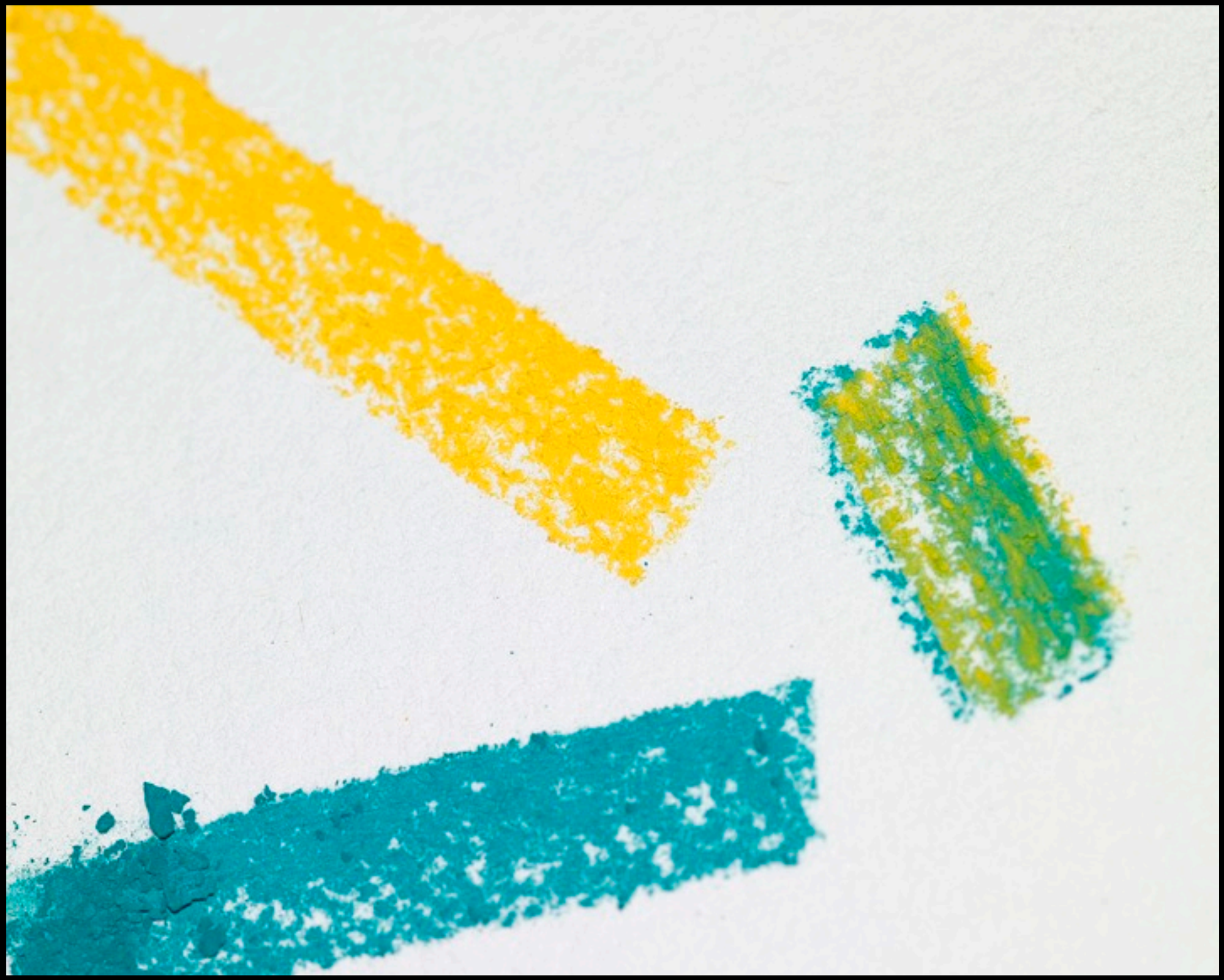


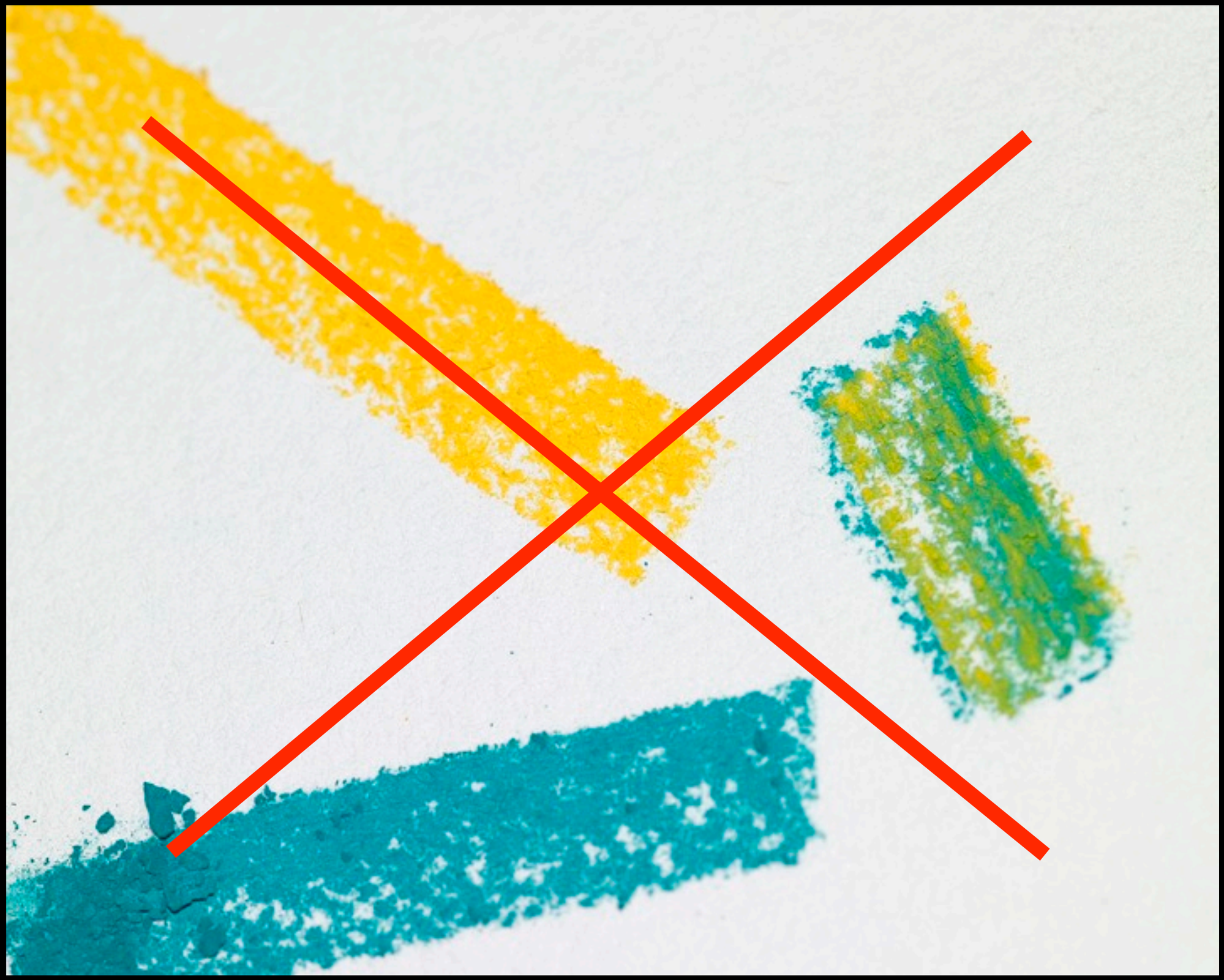
patterned polymer layers

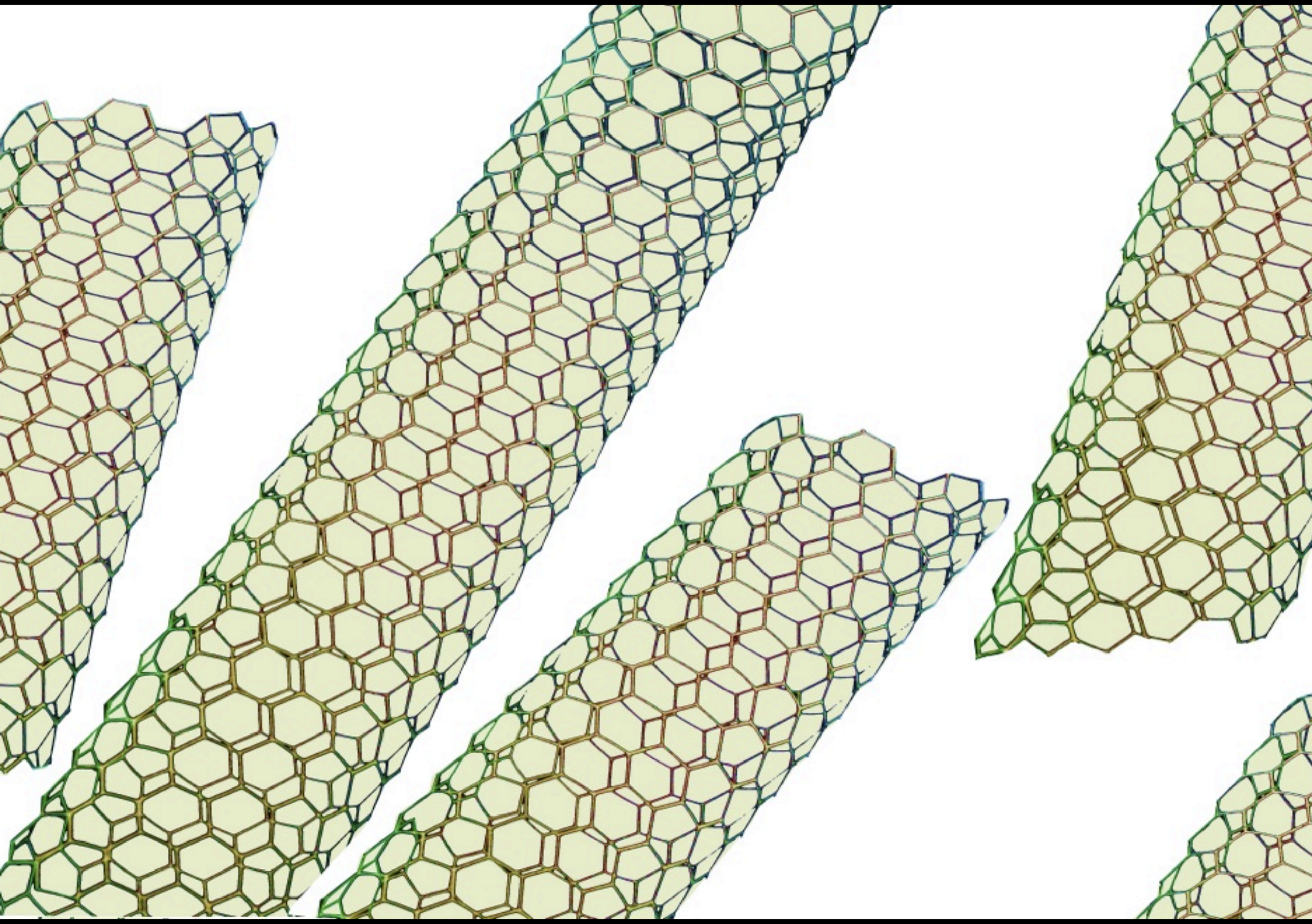
sarah h, 1994

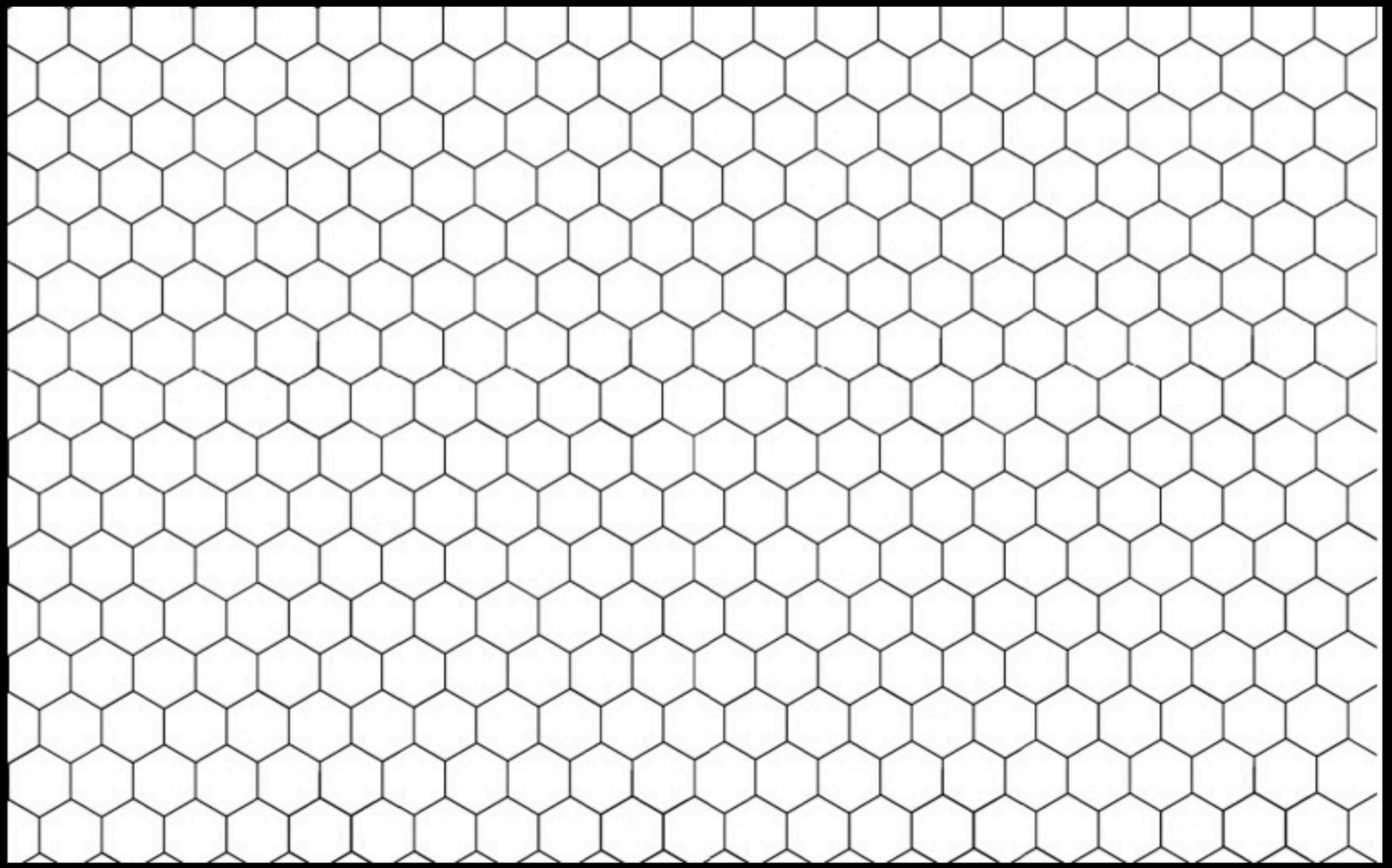


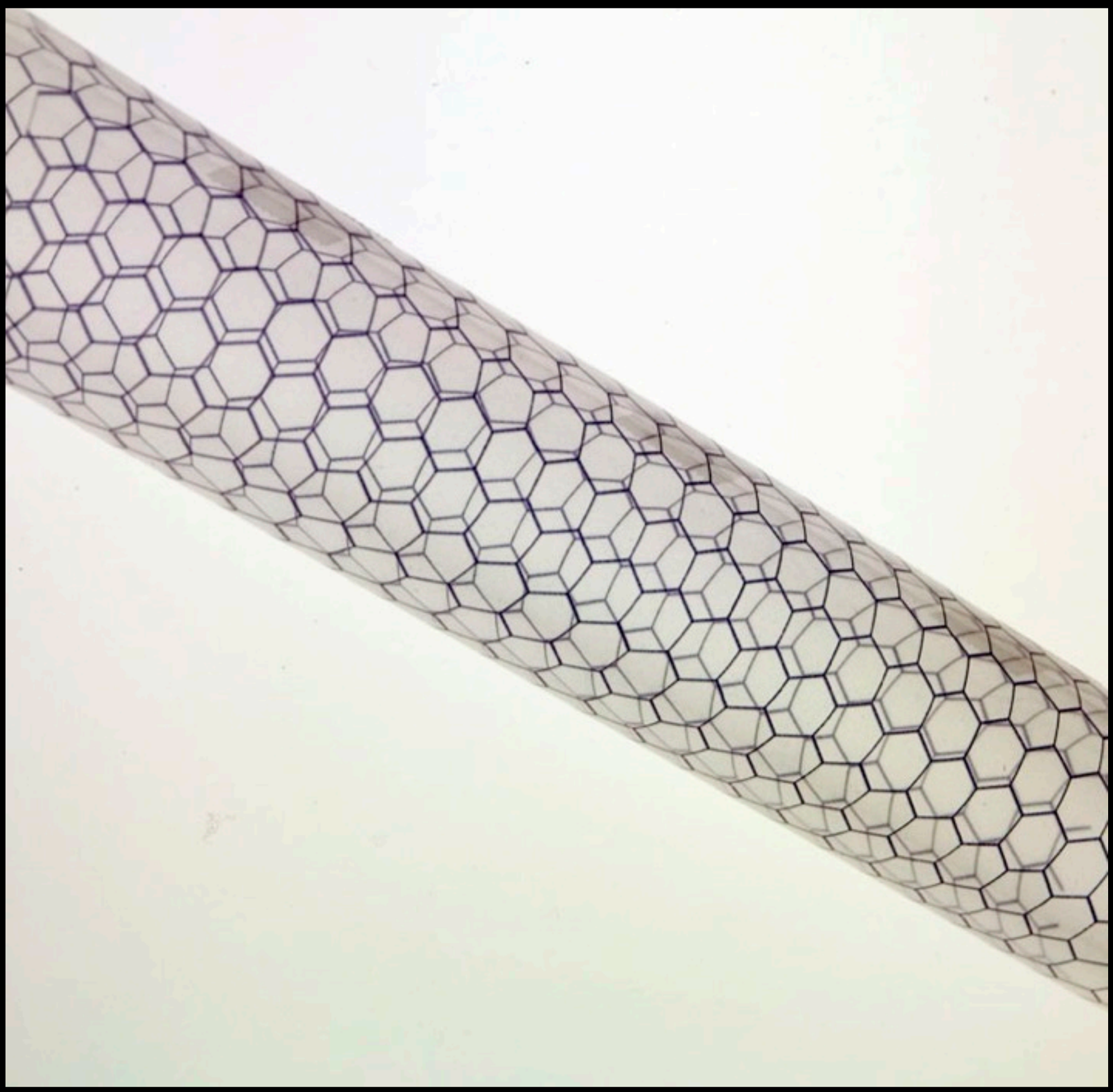


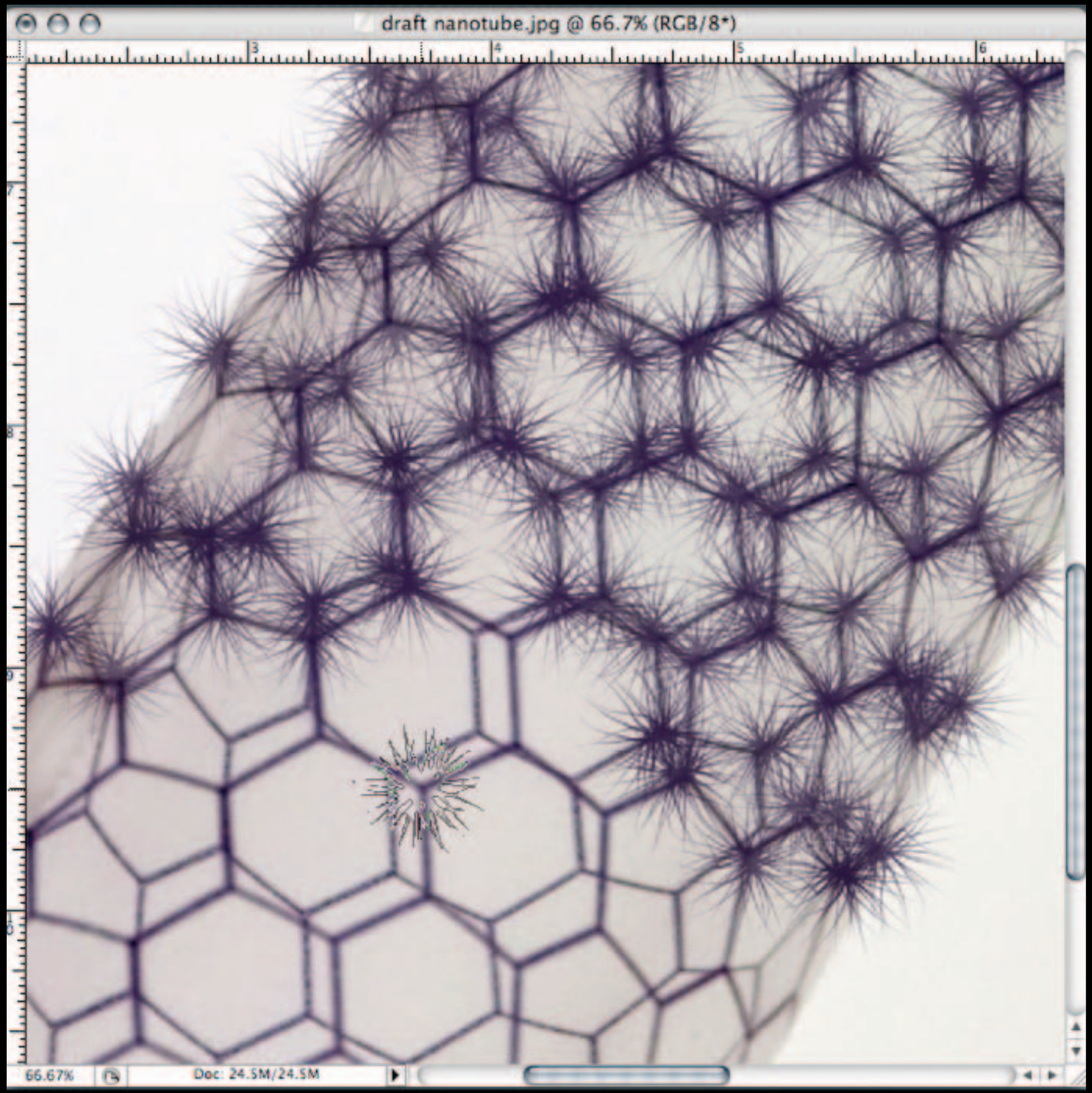











draft nanotube.jpg @ 66.7% (RGB/8*)
66.67%
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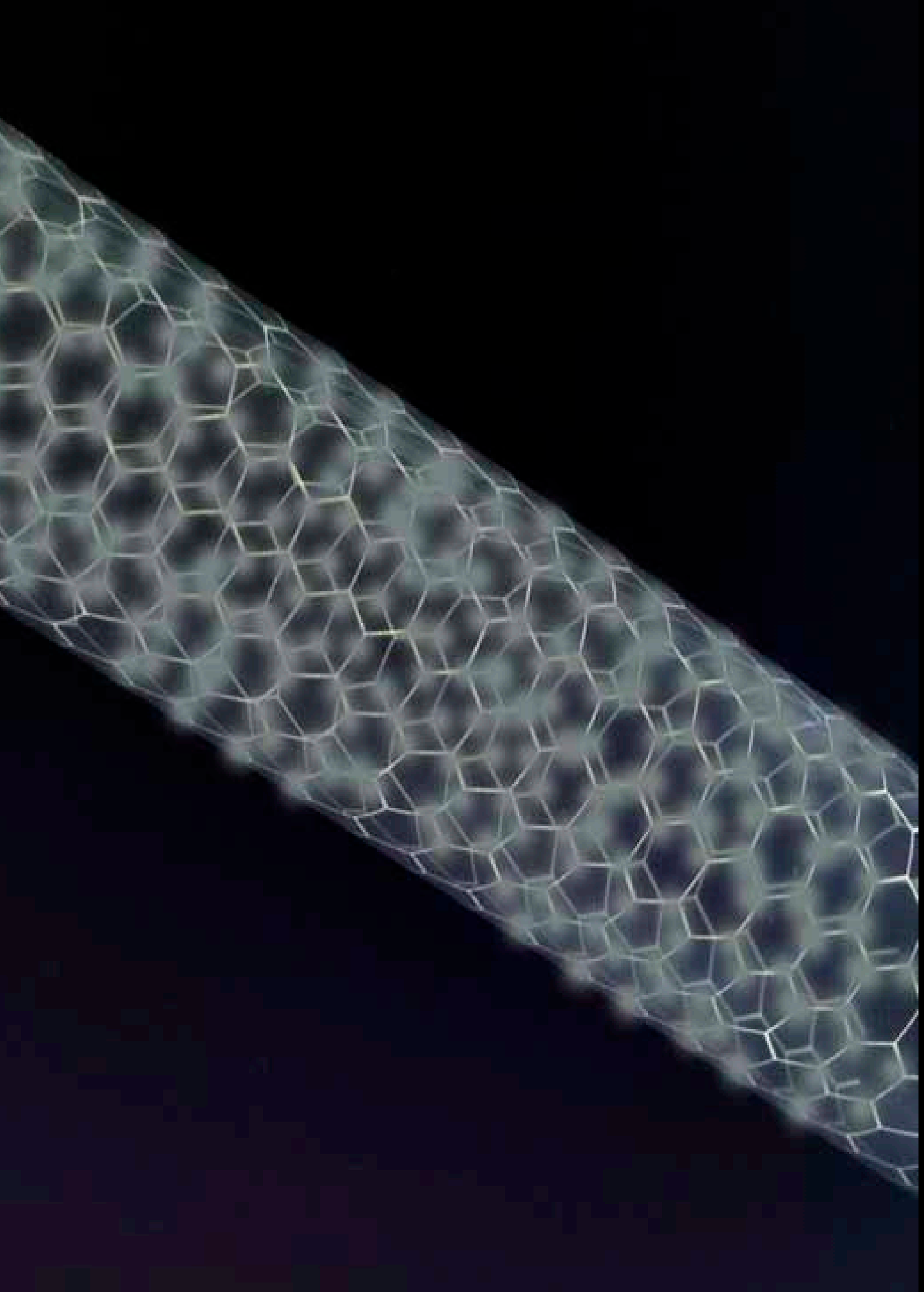
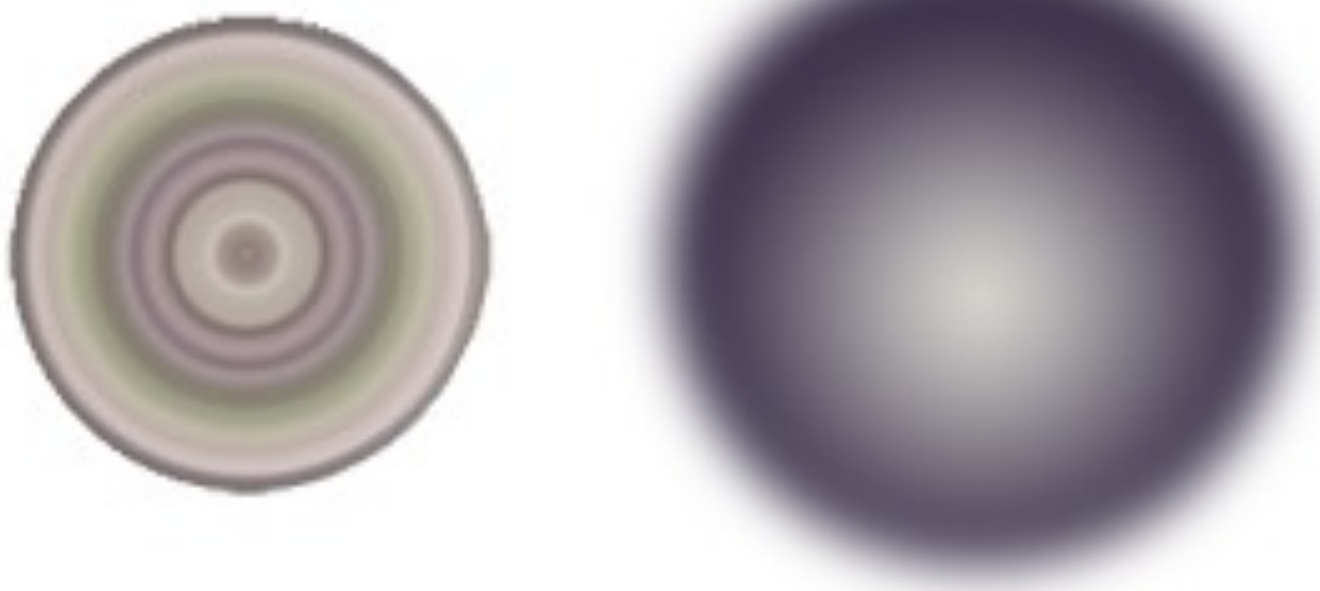
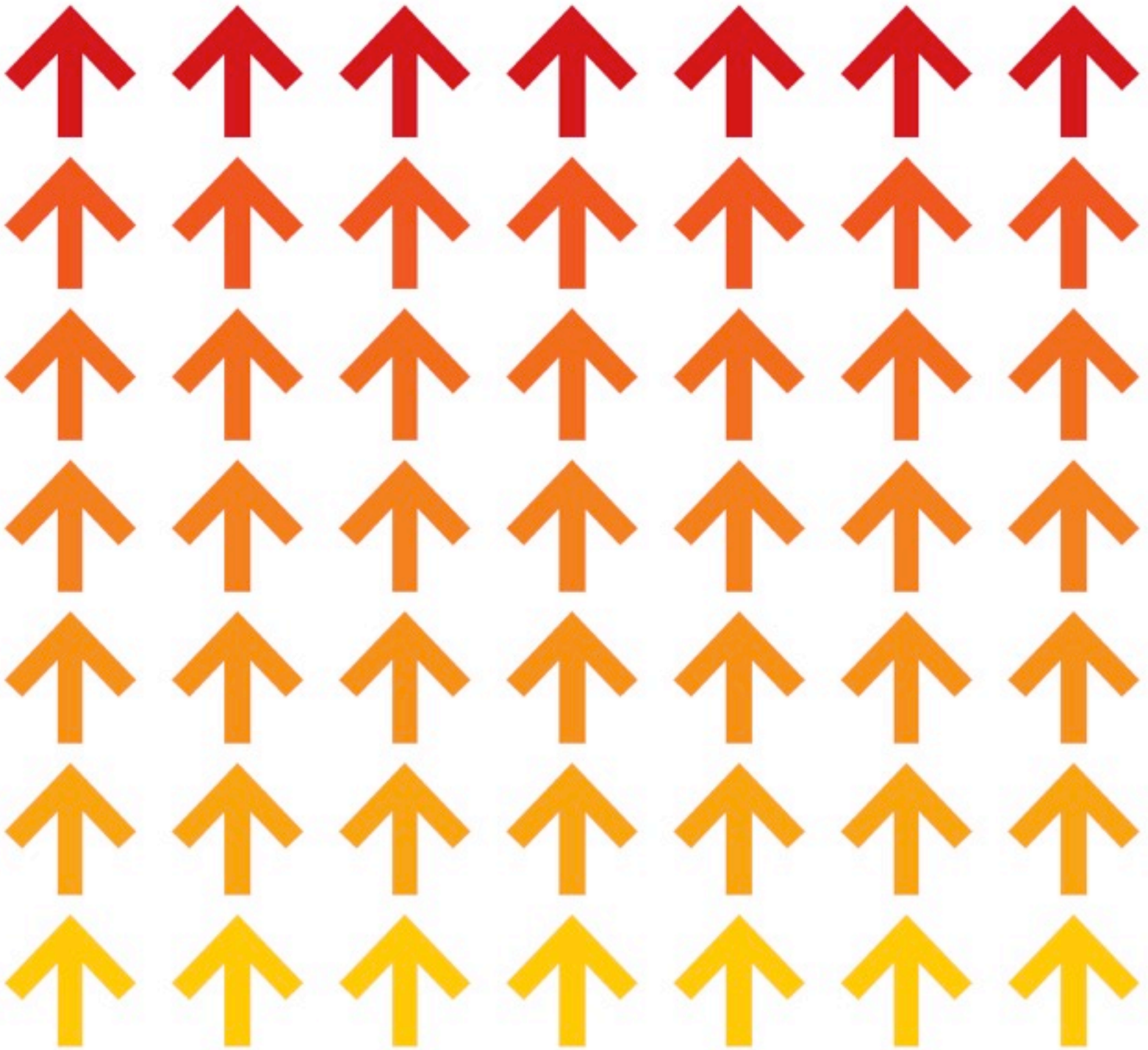
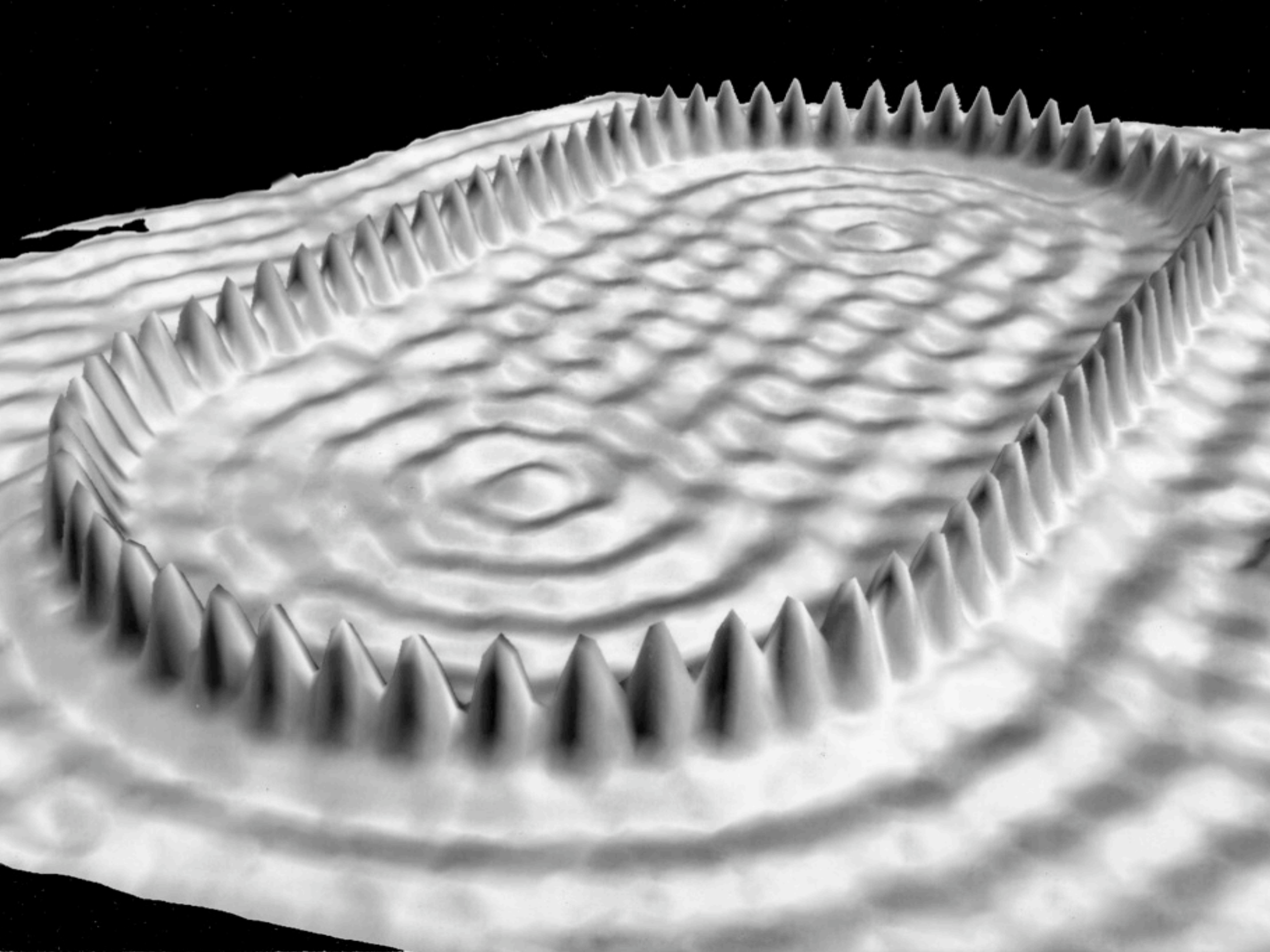




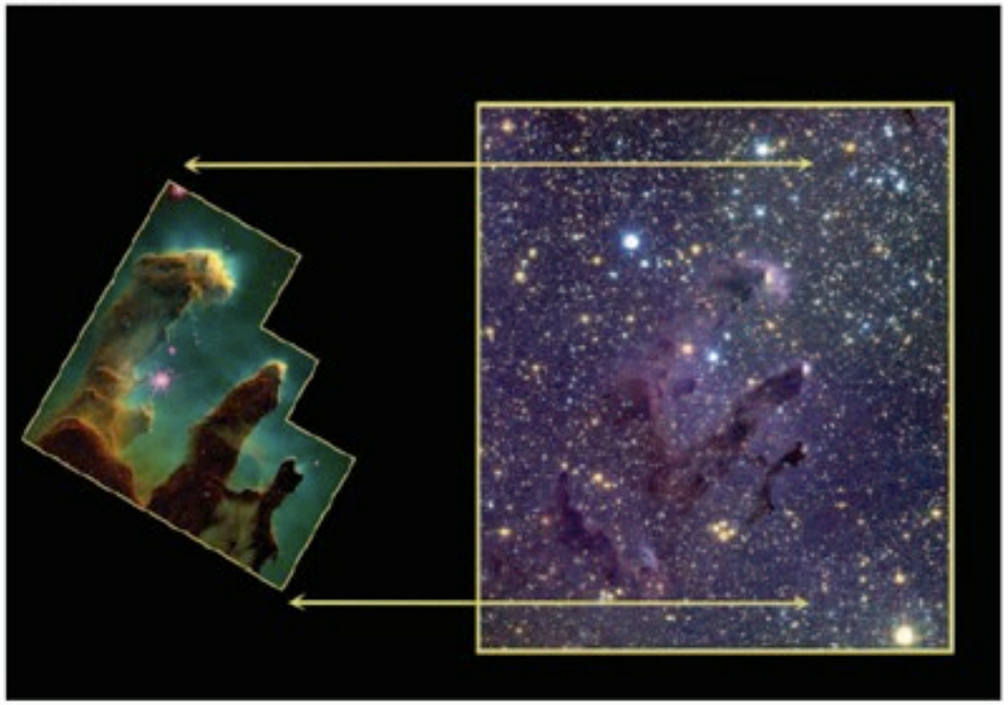


# VISUAL STRATEGIES FOR SCIENTISTS

don eigler



BEFORE



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**Hdghieo lduijo gha Jendtra Lamsnoth dol loatelk Frawber Tum**
H.B. Richer, et al. Science 18 August 2006: Vol. 313. no. 5789, pp. 936 – 940Hliquod et om. Ut voluptatus.

**We see** od qui ipiendam ipitiatur saes et ommoluptat ditionsed.

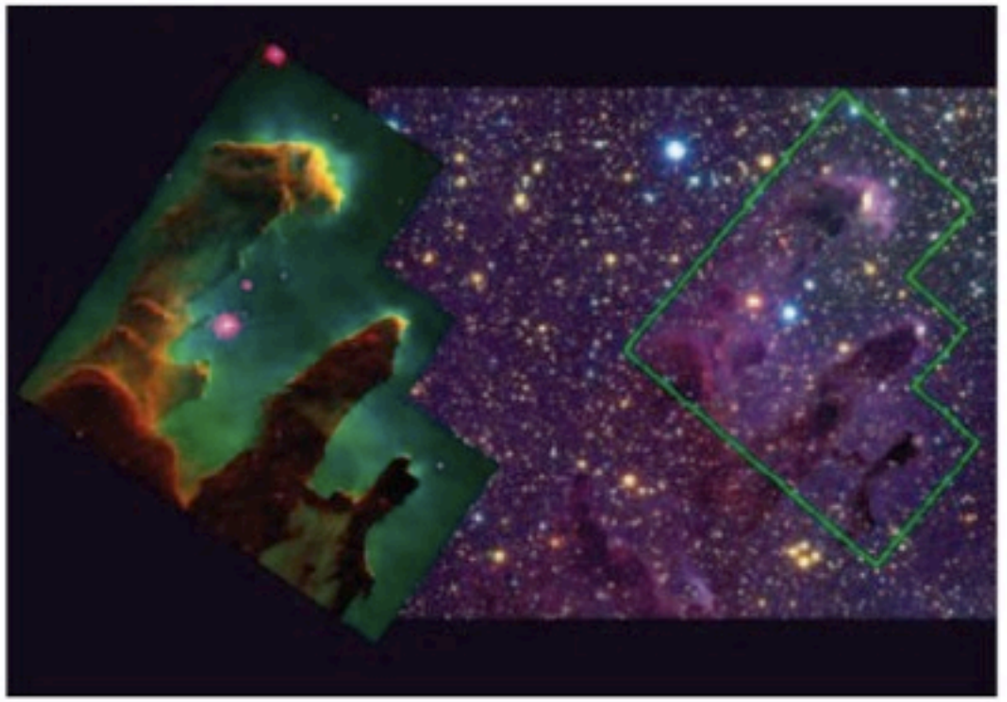
**The goal** expla volupic tiuntusa consed ut moles molup tae molor expla empos pa commo tem facest.

**The challenge** is oribu sciasin ctoresto blam quatemp eribus.

**Suggestions**
Ut moles moluptae molorempos pa commo tem facest volo quiatum quassimagnam sedis et poris sin es molupti dipsandi quide cullendi optatiorem fugia. Dolupta estiati beatendae volestem id que exero isquo dolum quo int abore serspiet anturio nsente aperia dolest fugiae volupis sincimi nctur, volupta tiande delia debitamus aut faceperspis ipsapic, sum alit pro illaut ate volupta sitisquiam.

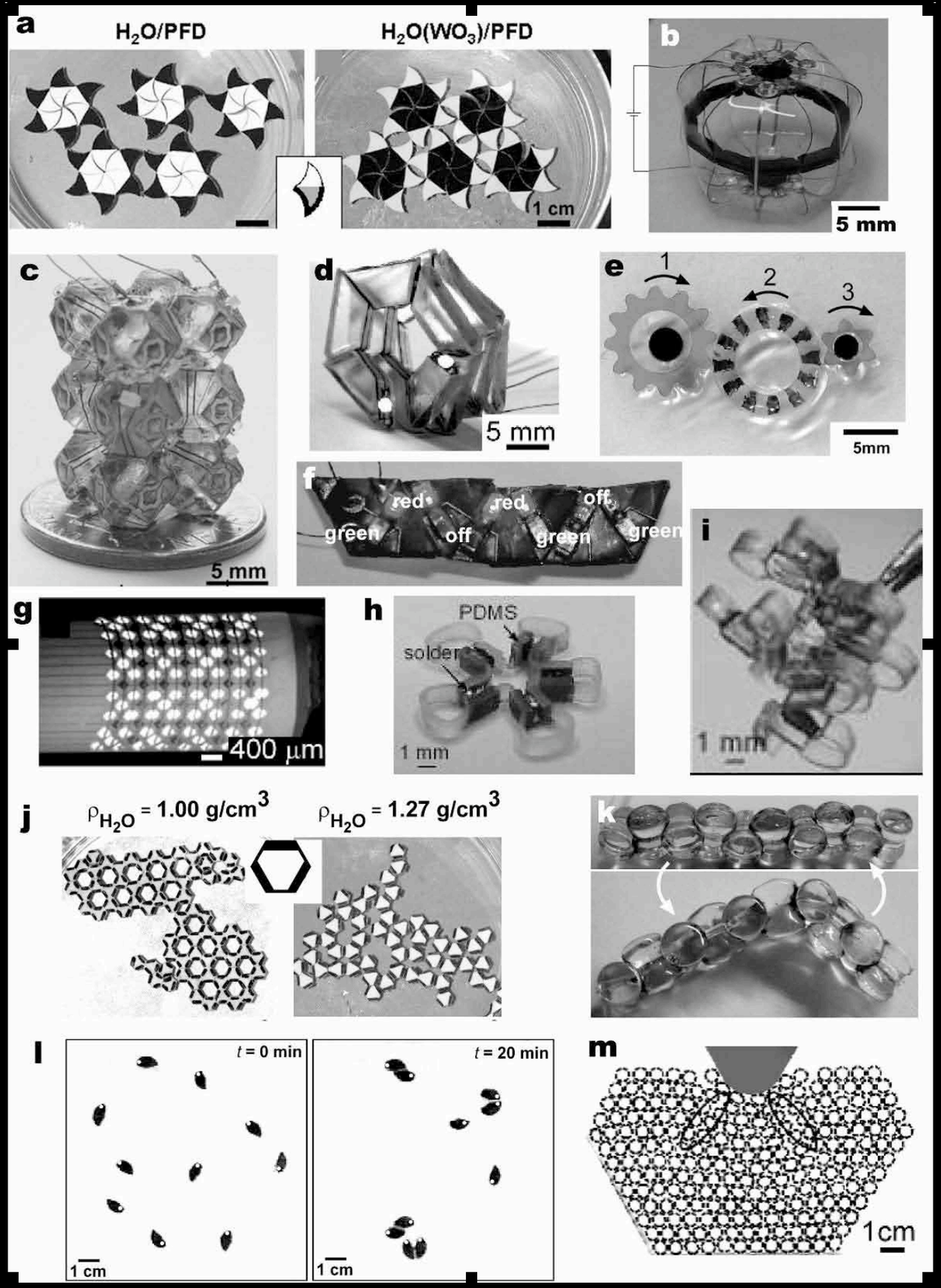


AFTER

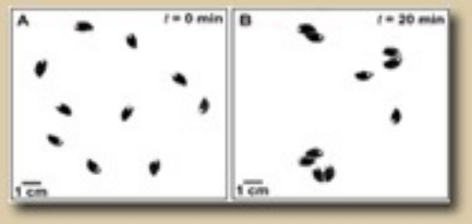


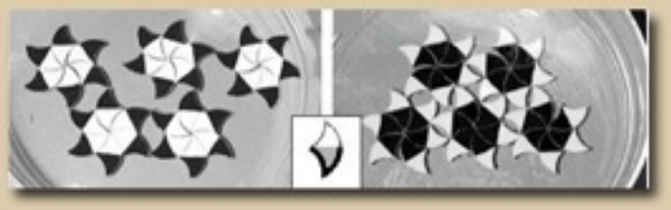
## Graphical Strategies:

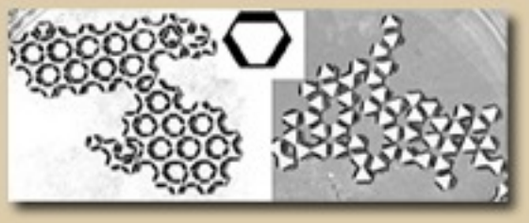
| | |
|---|---|
| ABSTRACT | Coloring makes it easier to refer to both of these types. |
| COLOR | Our eyes go immediately to the color. |
| LAYER | Coloring makes it easier to refer to both of these types. |
| COMPOSE | Our eyes go immediately to the color. |
| REFINE | Coloring makes it easier to refer to both of these types. |


a
$H_2O$/PFD
$H_2O(WO_3)$/PFD
1 cm
b
5 mm
c
5 mm
d
5 mm
e
1
2
3
5mm
f
red
red
off
green
off
green
green
g
400 μm
h
PDMS
solder
1 mm
i
1 mm
j
$\rho_{H_2O}$ = 1.00 g/cm$^3$
$\rho_{H_2O}$ = 1.27 g/cm$^3$
k
l
t = 0 min
t = 20 min
1 cm
1 cm
m
1cm

gmw group

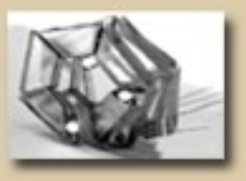


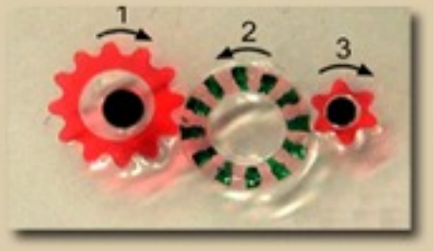



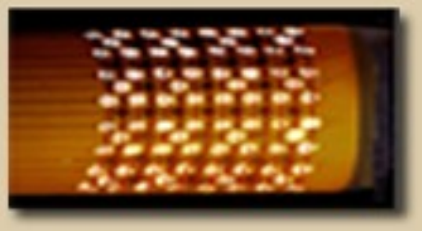


2 cm

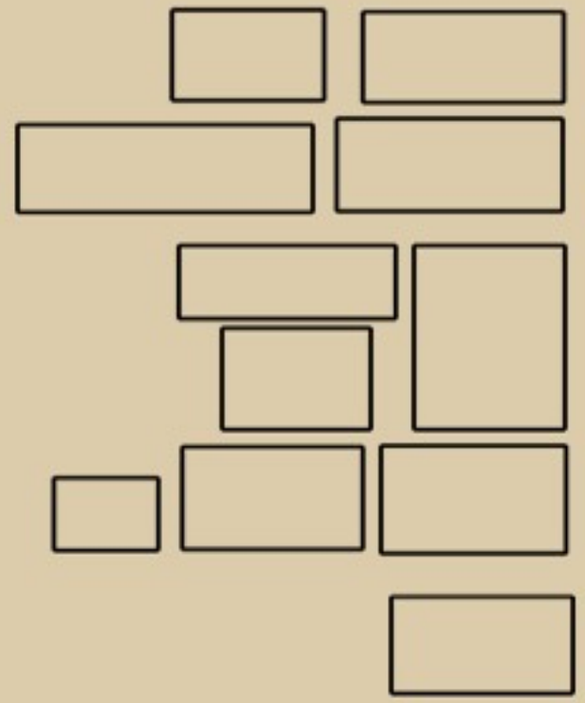
5 mm



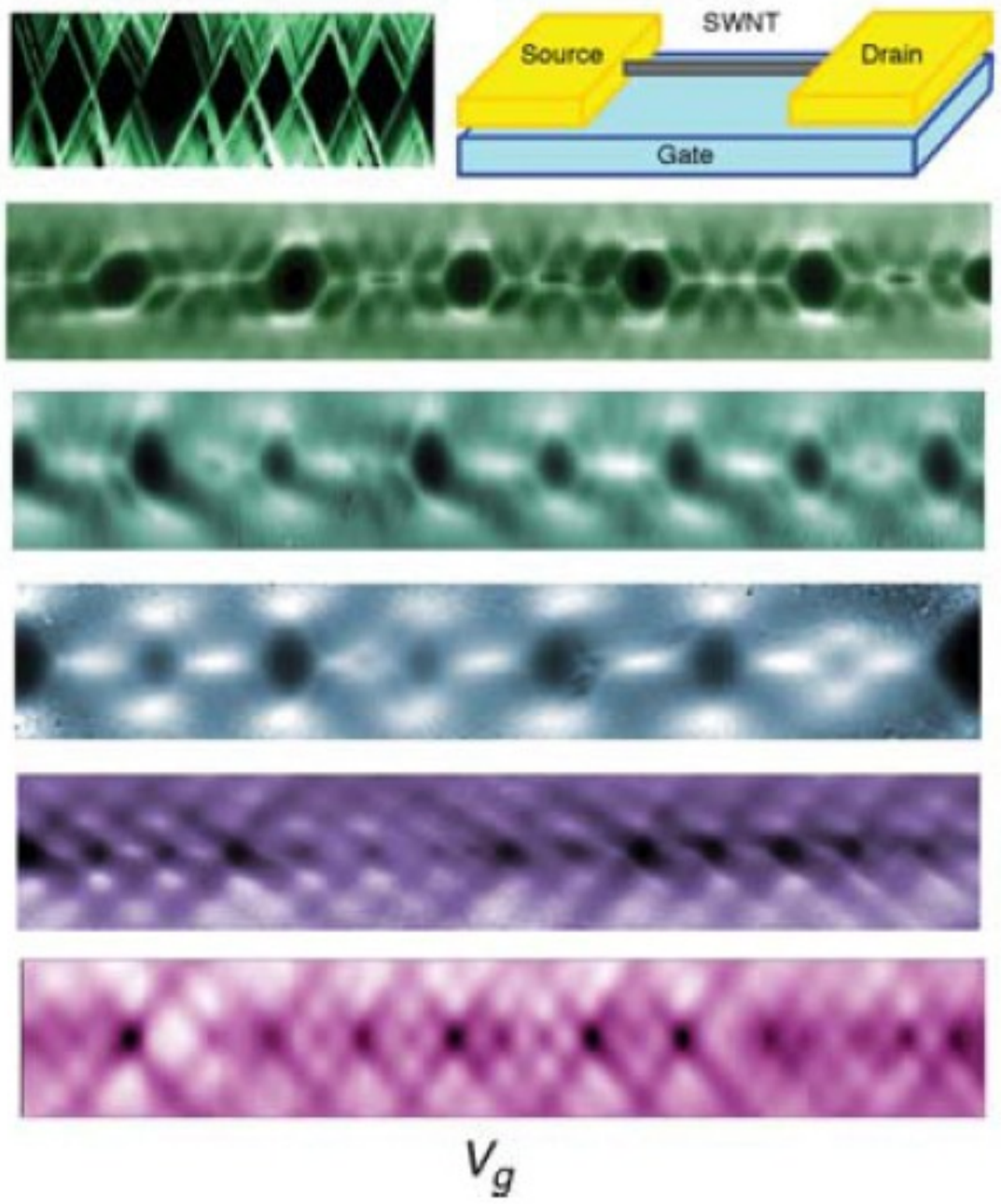


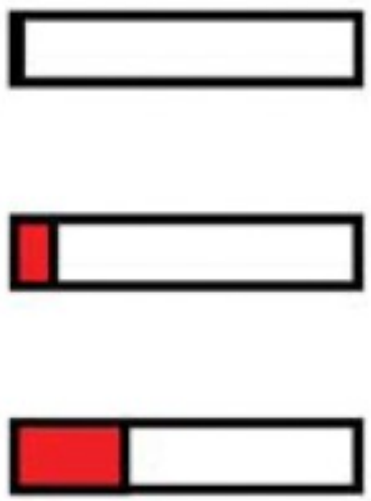
1 mm



## *dI/dV-V-$V_g$ Diagram*

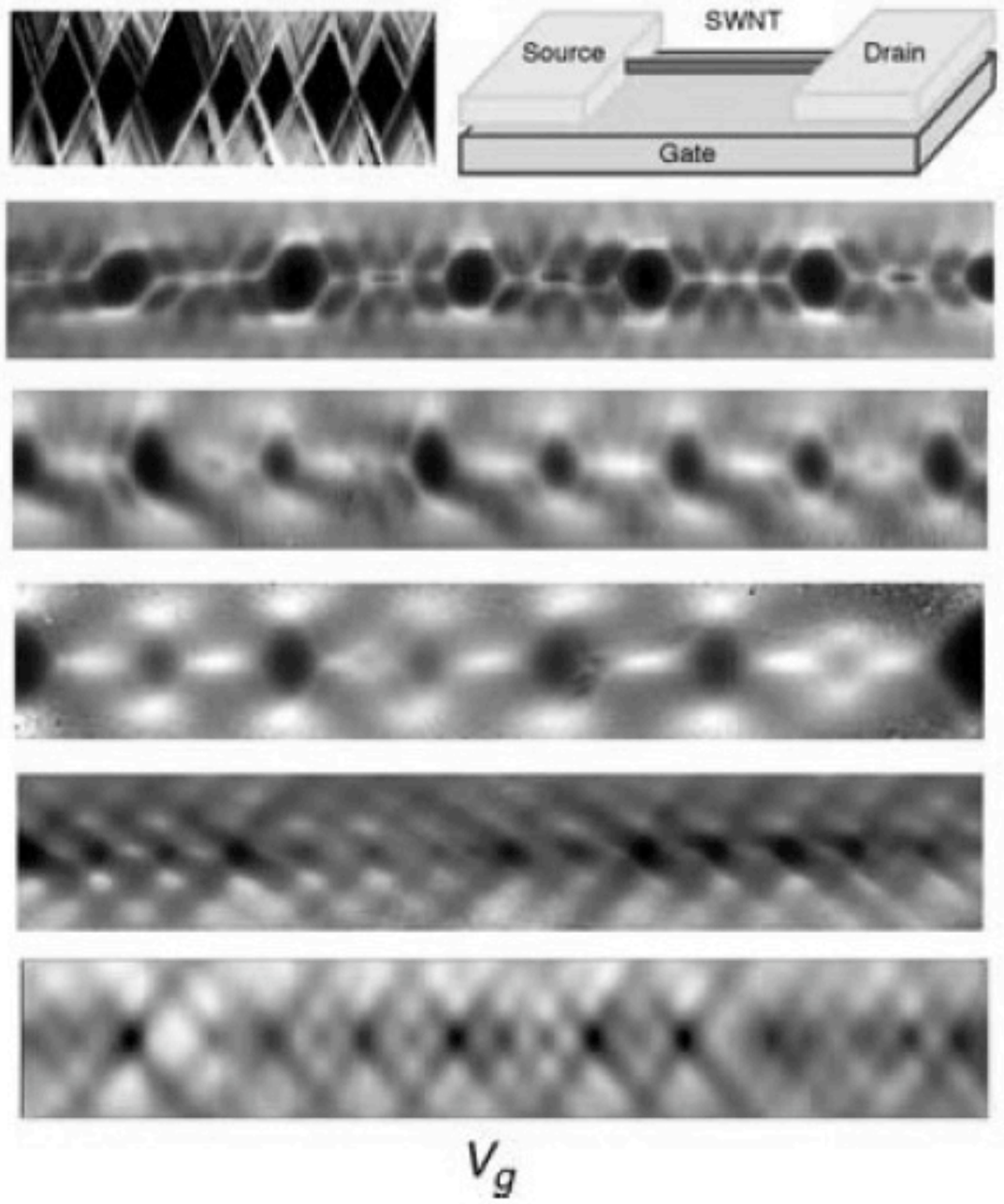



Conductance

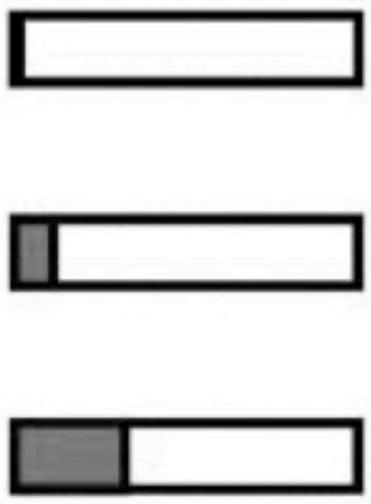


0 $4e^2/h$

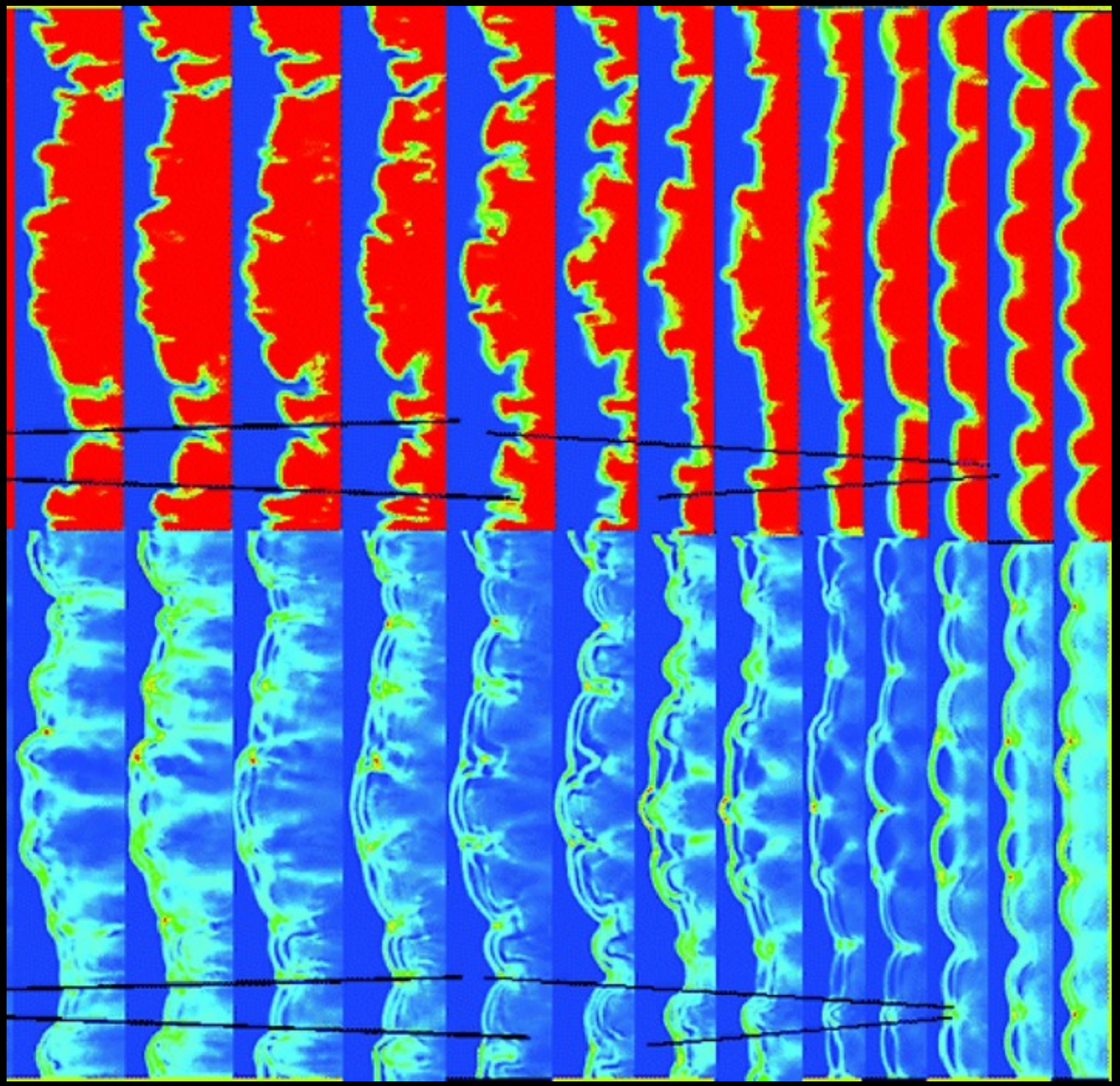
## *dI/dV-V-$V_g$ Diagram*

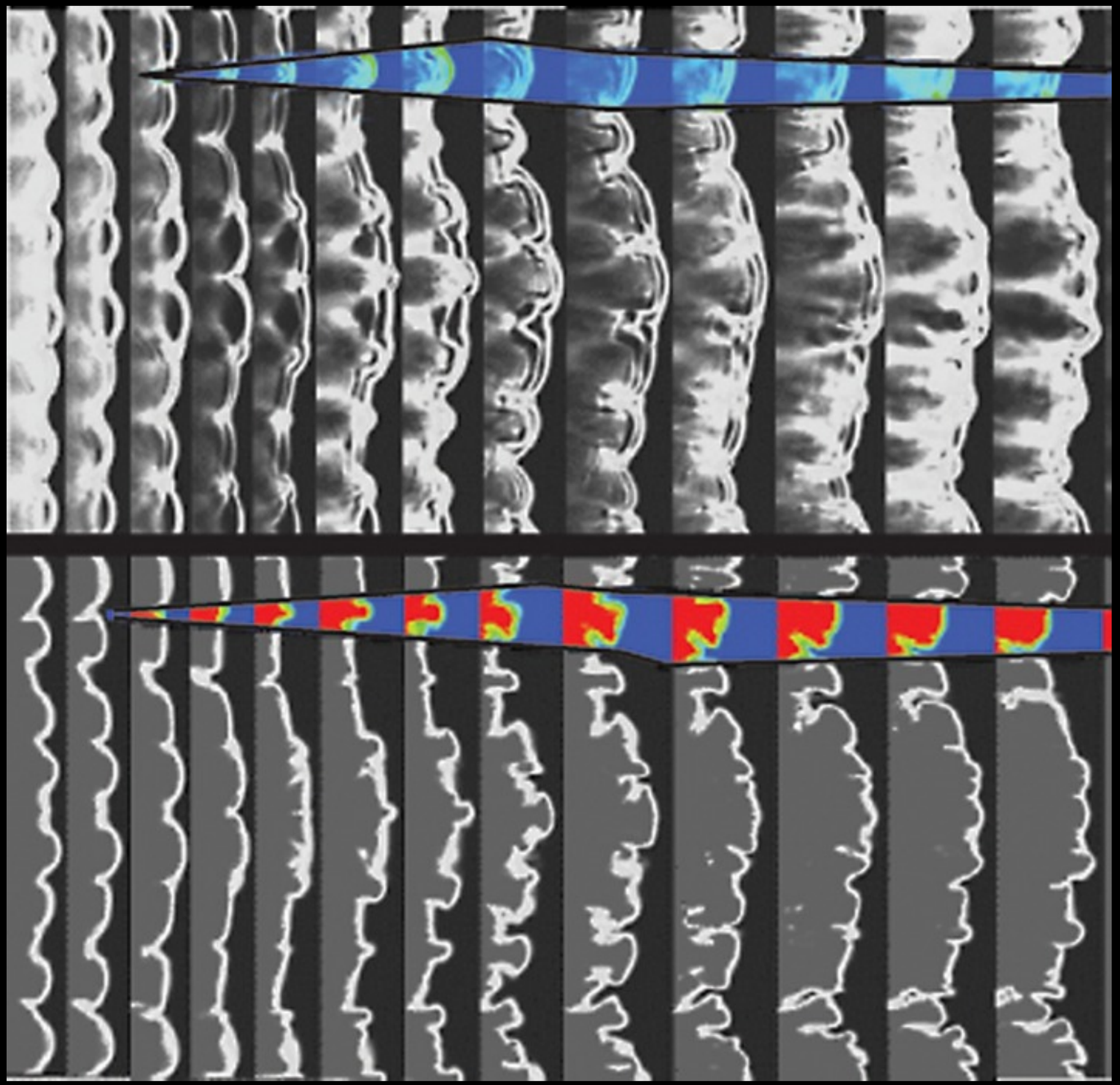


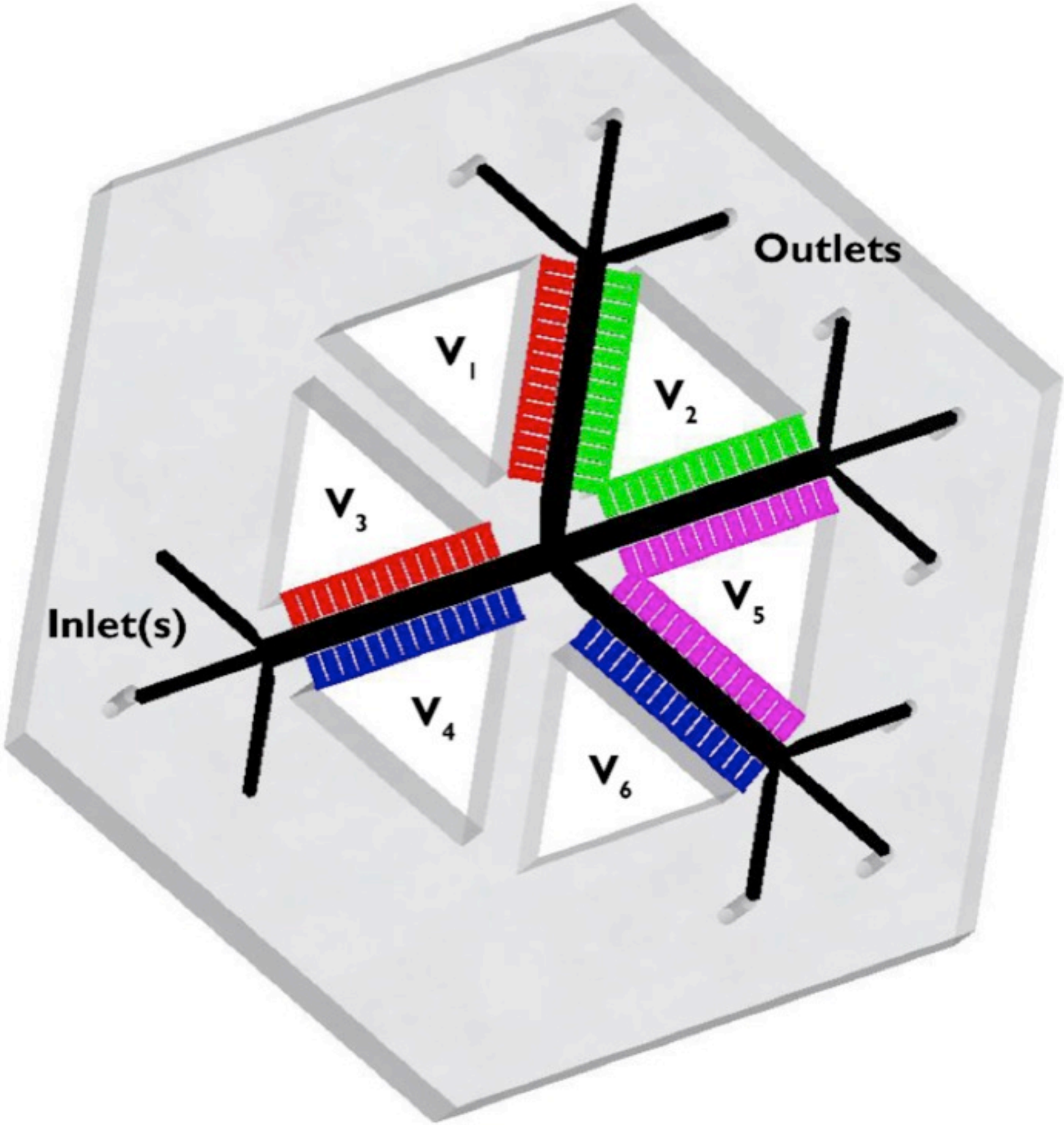

Conductance

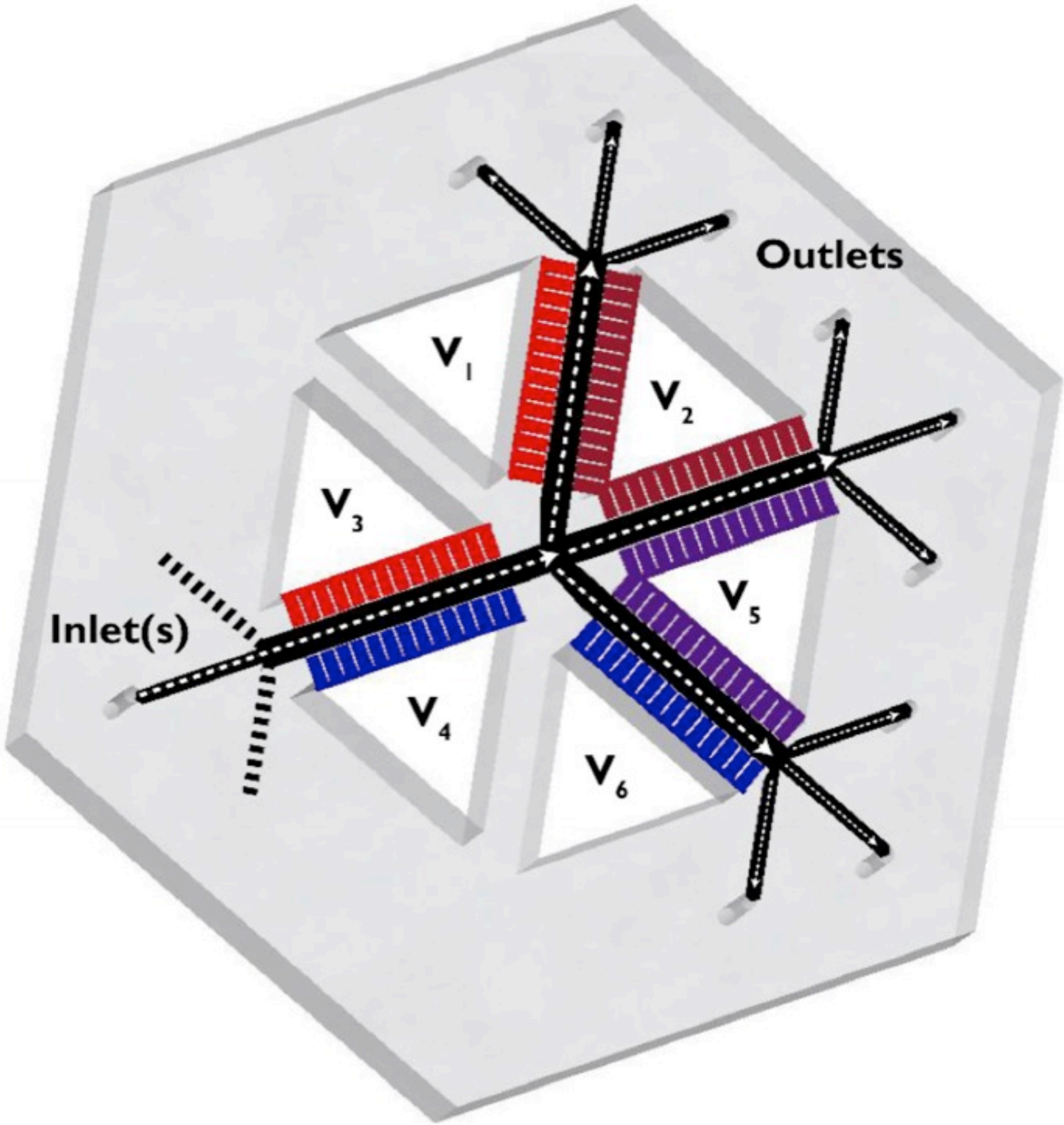


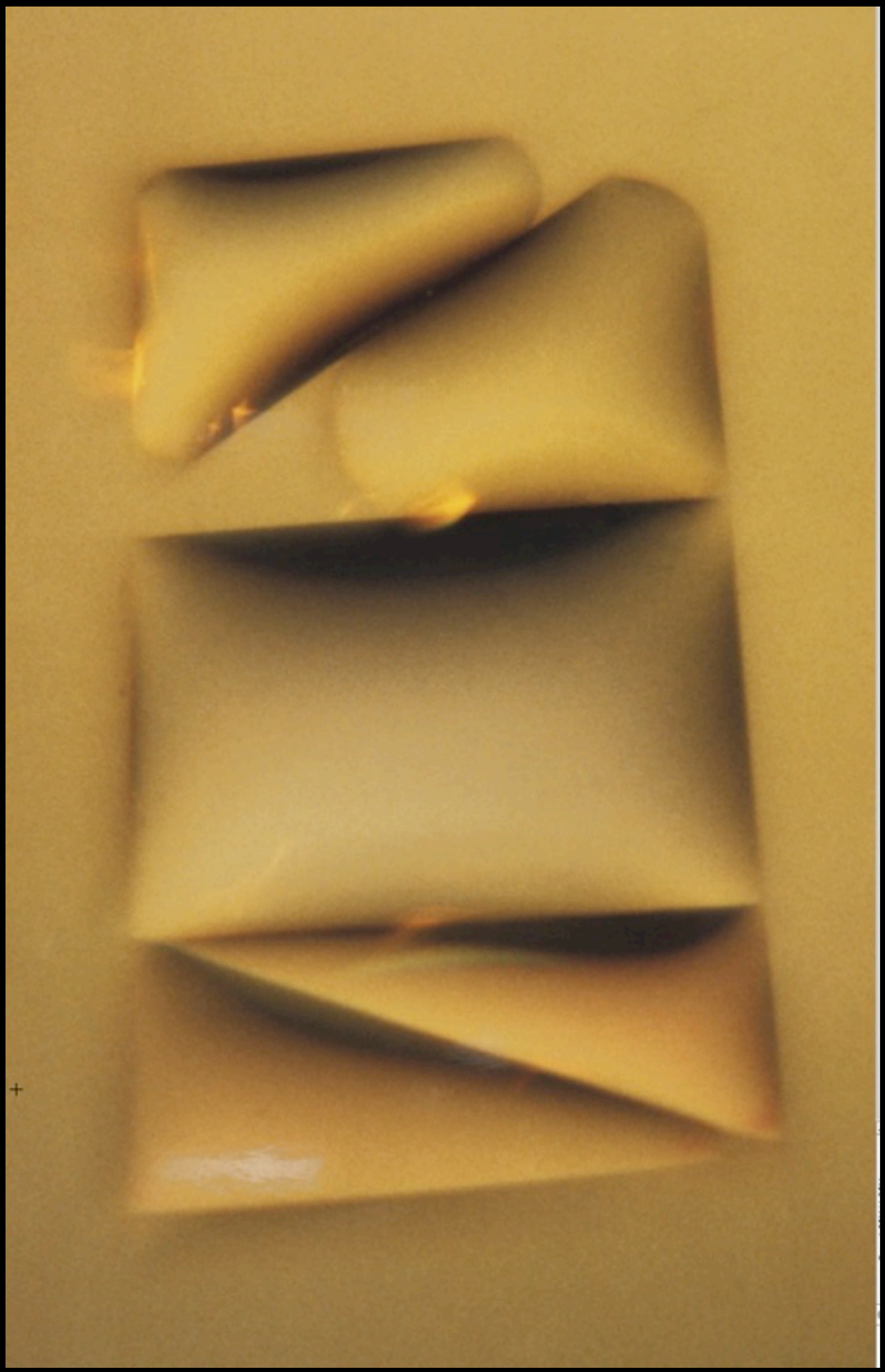
0 $4e^2/h$

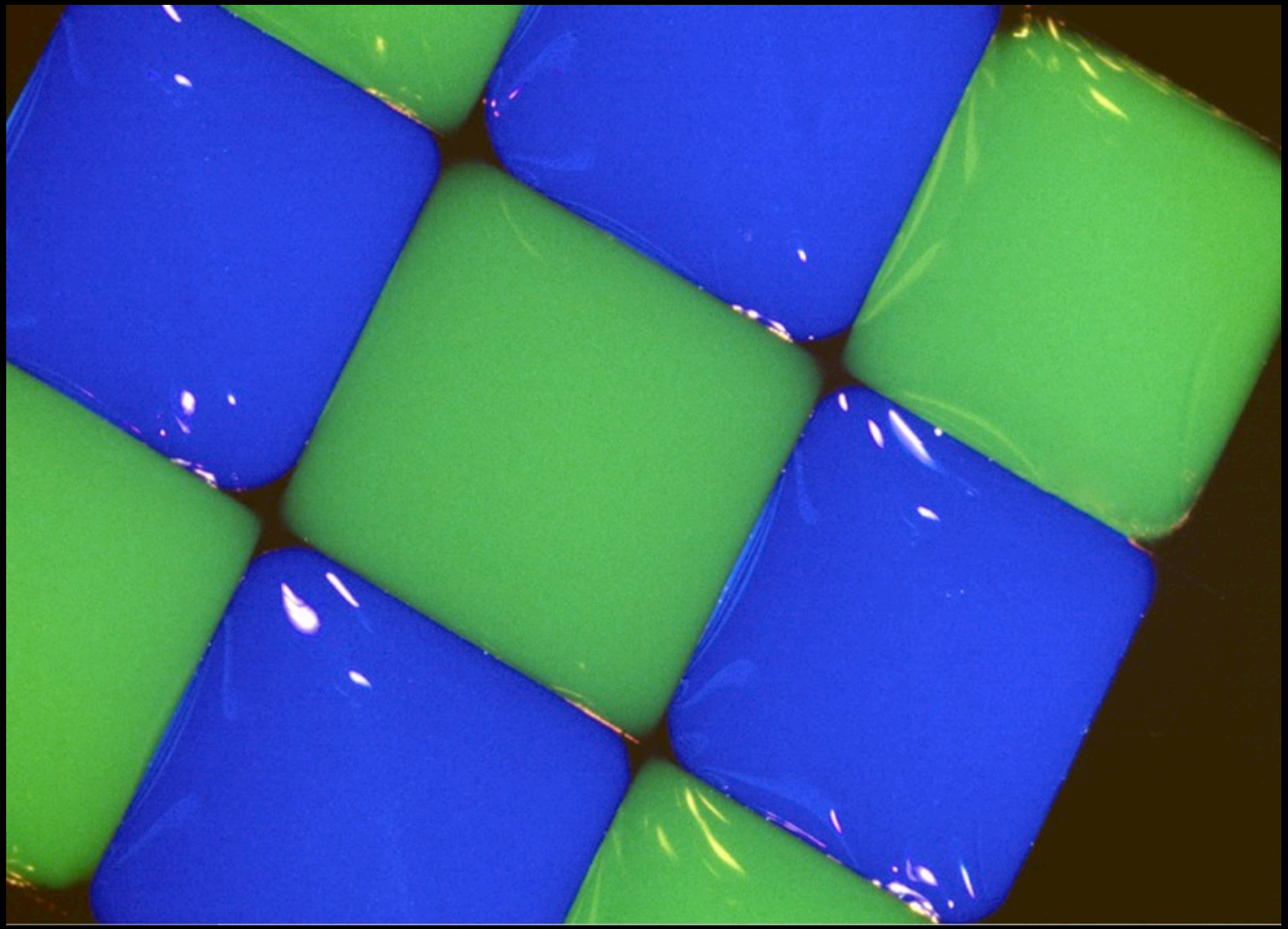





Outlets
V1
V2
V3
V4
V5
V6
Inlet(s)


Outlets
V1
V2
V3
V4
V5
V6
Inlet(s)





Before

*Patella depressa*

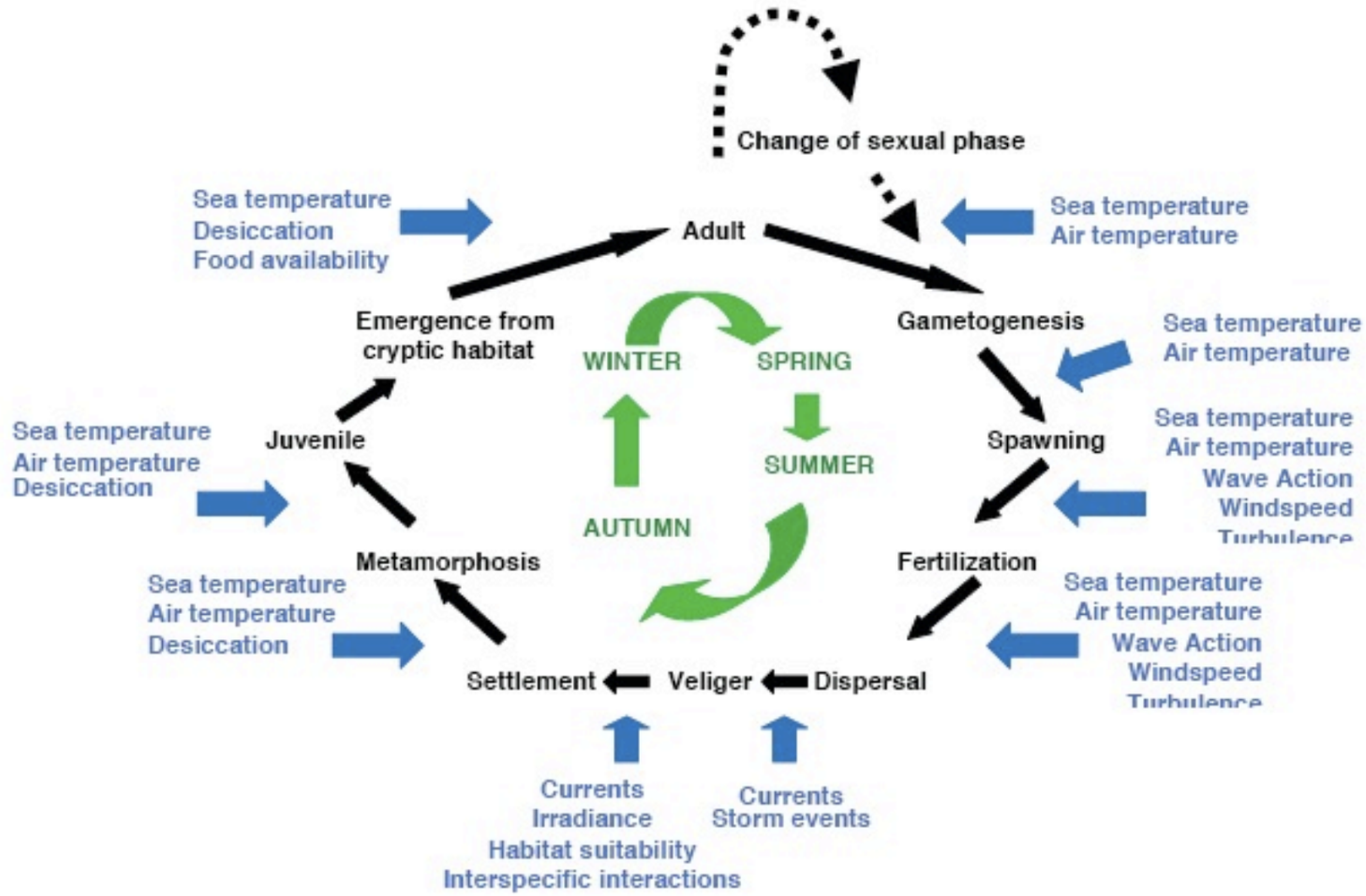
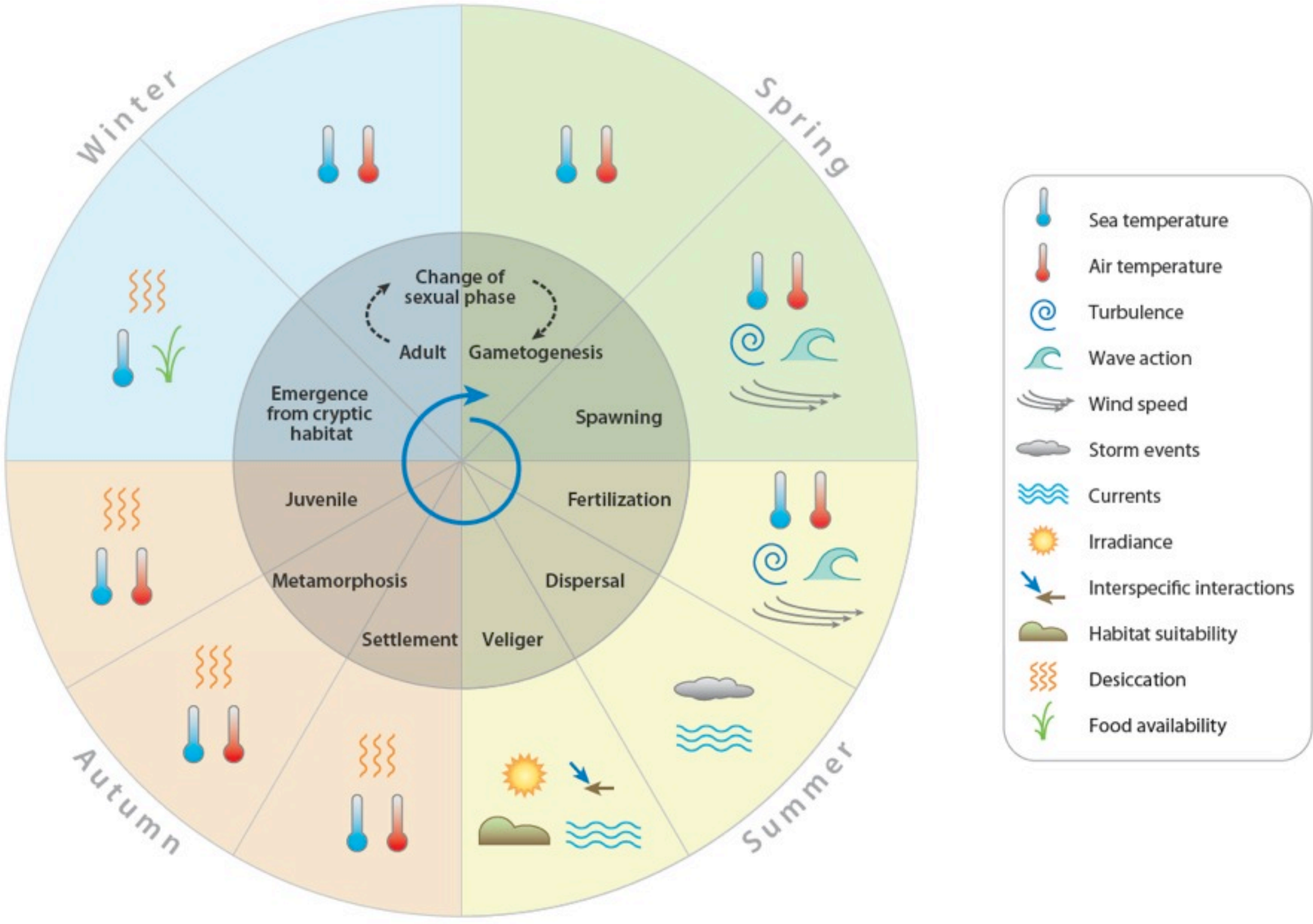
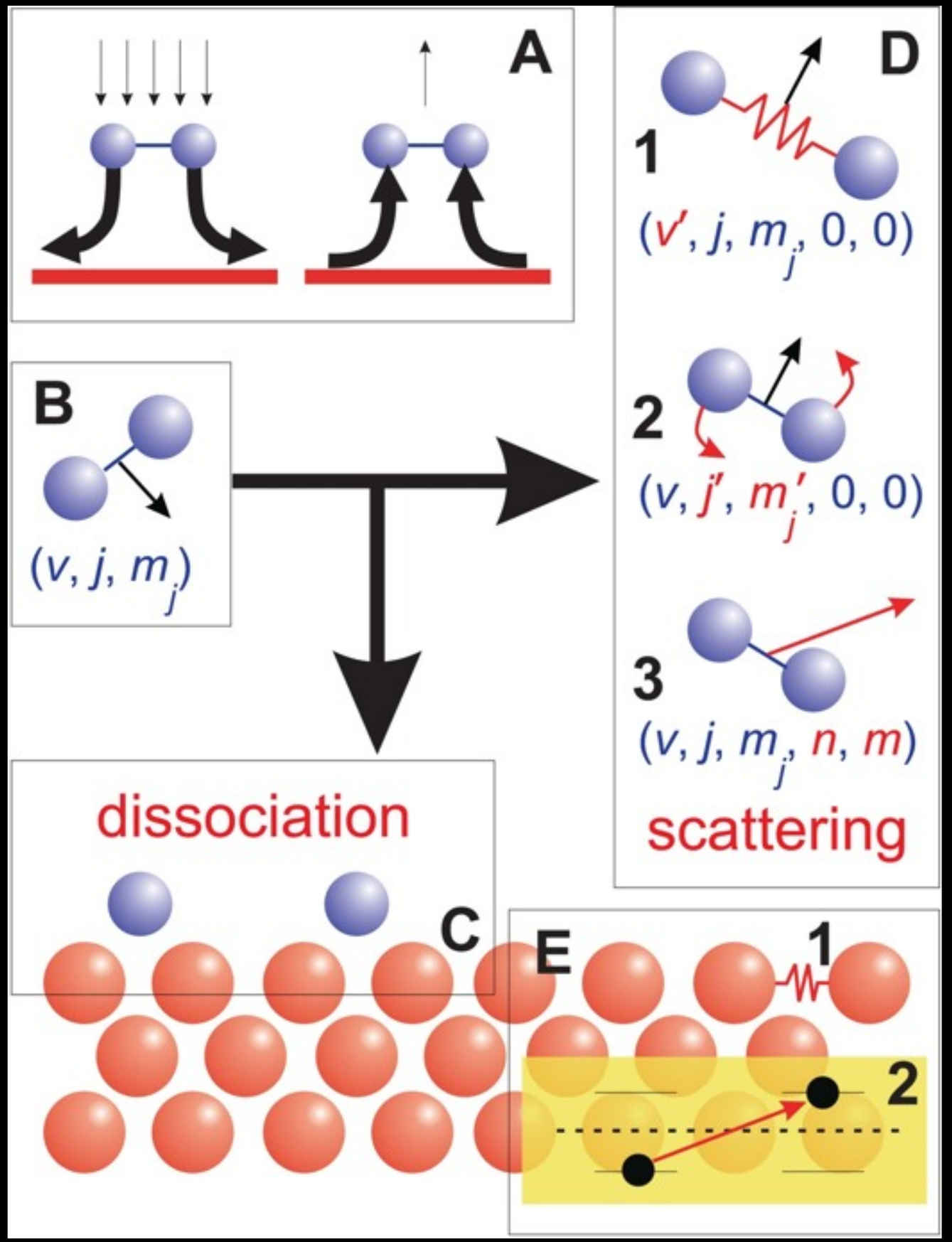
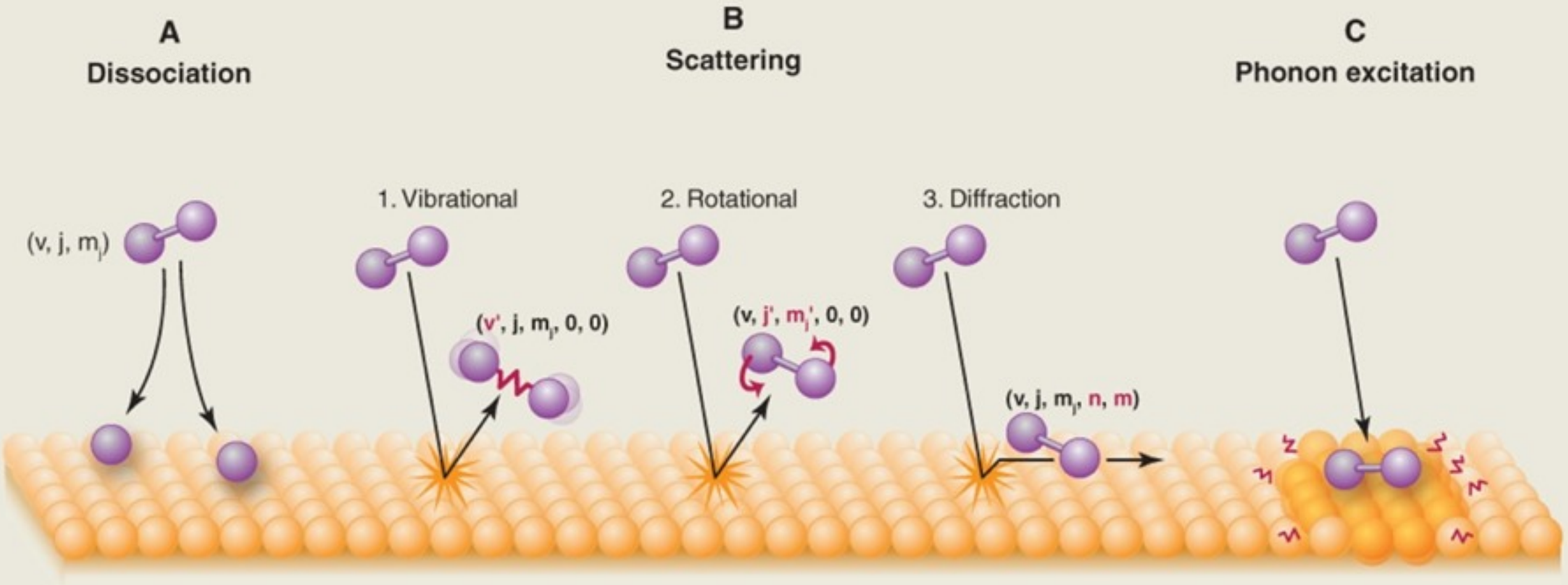


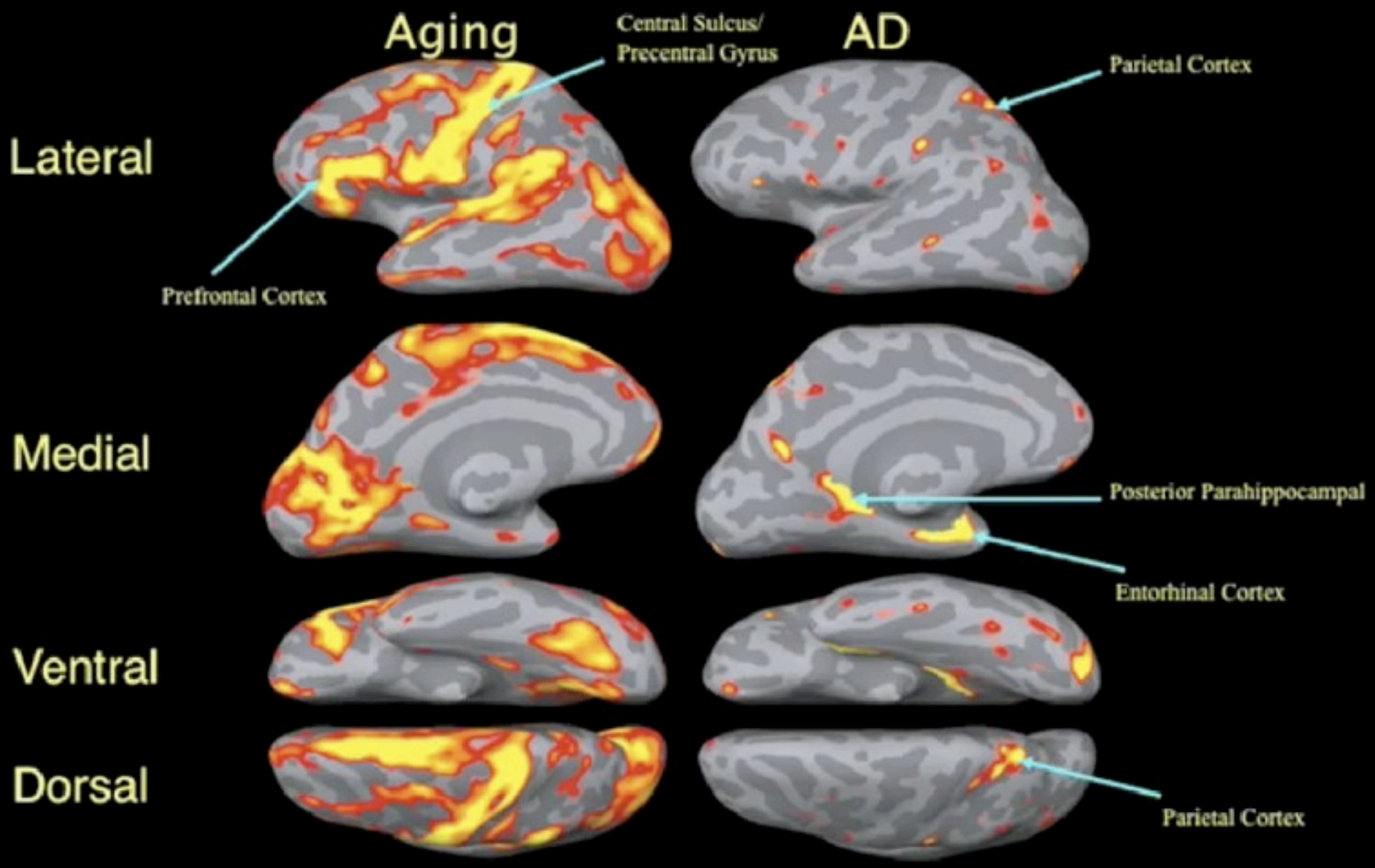

Figure 1. Variable importance of multiple climatic and nonclimatic factors on physiological performance and survival of *Patella depressa* during different stages of the limpet's life history.

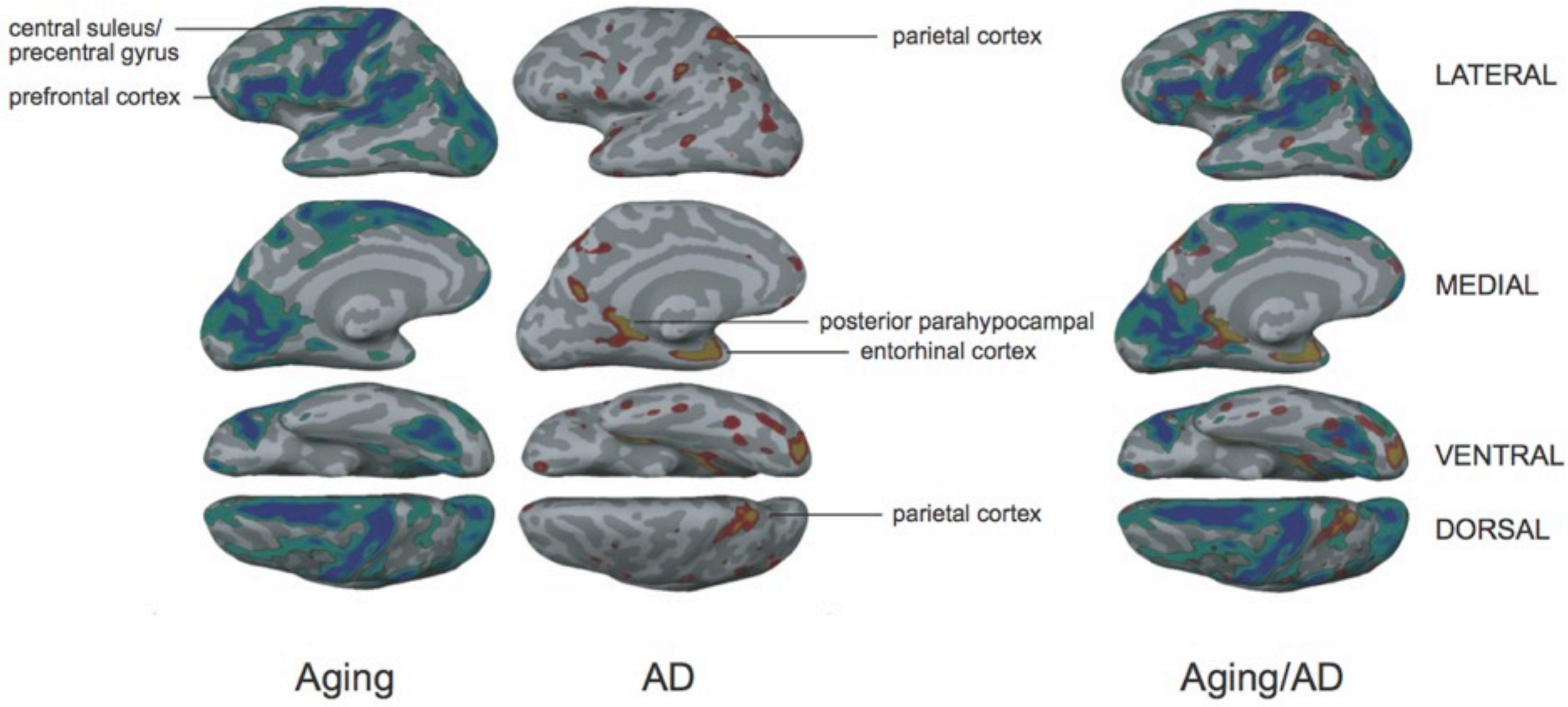

Winter
Spring
Summer
Autumn
Change of sexual phase
Adult
Gametogenesis
Emergence from cryptic habitat
Spawning
Juvenile
Fertilization
Metamorphosis
Dispersal
Settlement
Veliger
Sea temperature
Air temperature
Turbulence
Wave action
Wind speed
Storm events
Currents
Irradiance
Interspecific interactions
Habitat suitability
Desiccation
Food availability


A
B
$(v, j, m_j)$
D
1
$(v', j, m_j, 0, 0)$
2
$(v, j', m_j', 0, 0)$
3
$(v, j, m_j, n, m)$
scattering
dissociation
C
E
1
2


A
Dissociation
B
Scattering
C
Phonon excitation
(v, j, m_j)
1. Vibrational
(v', j, m_j, 0, 0)
2. Rotational
(v, j', m_j', 0, 0)
3. Diffraction
(v, j, m_j, n, m)

# Selective Regional Thinning in AD




central suleus/
precentral gyrus
prefrontal cortex
parietal cortex
LATERAL
MEDIAL
posterior parahypocampal
entorhinal cortex
VENTRAL
DORSAL
parietal cortex
Aging
AD
Aging/AD

what do you want me to see?

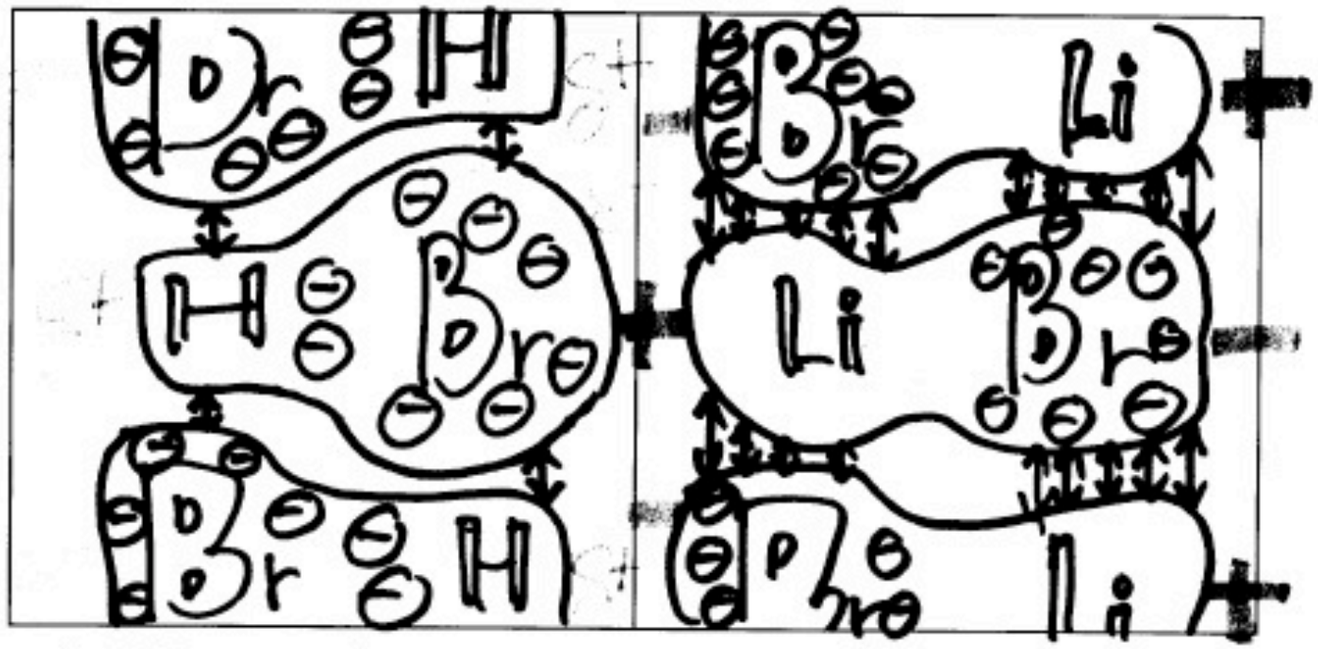
what do you want me to see?

first?

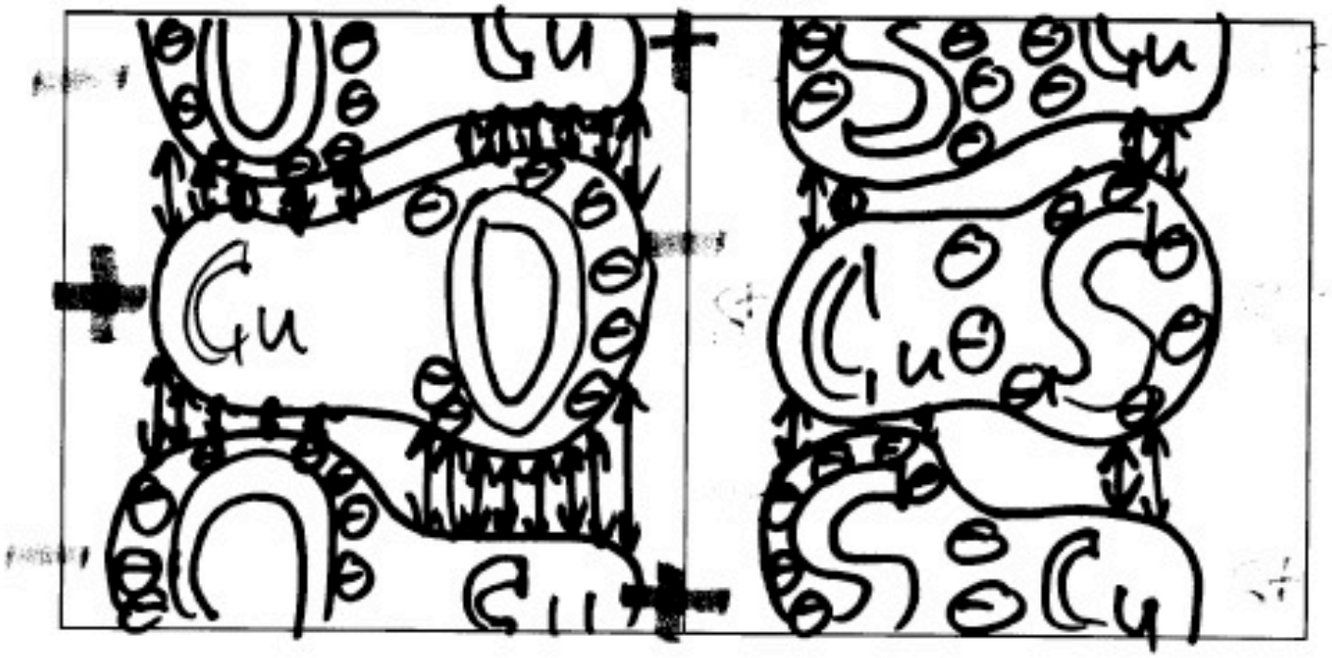

National Science Foundation: DUE-0925110

www.picturingtolearn.org

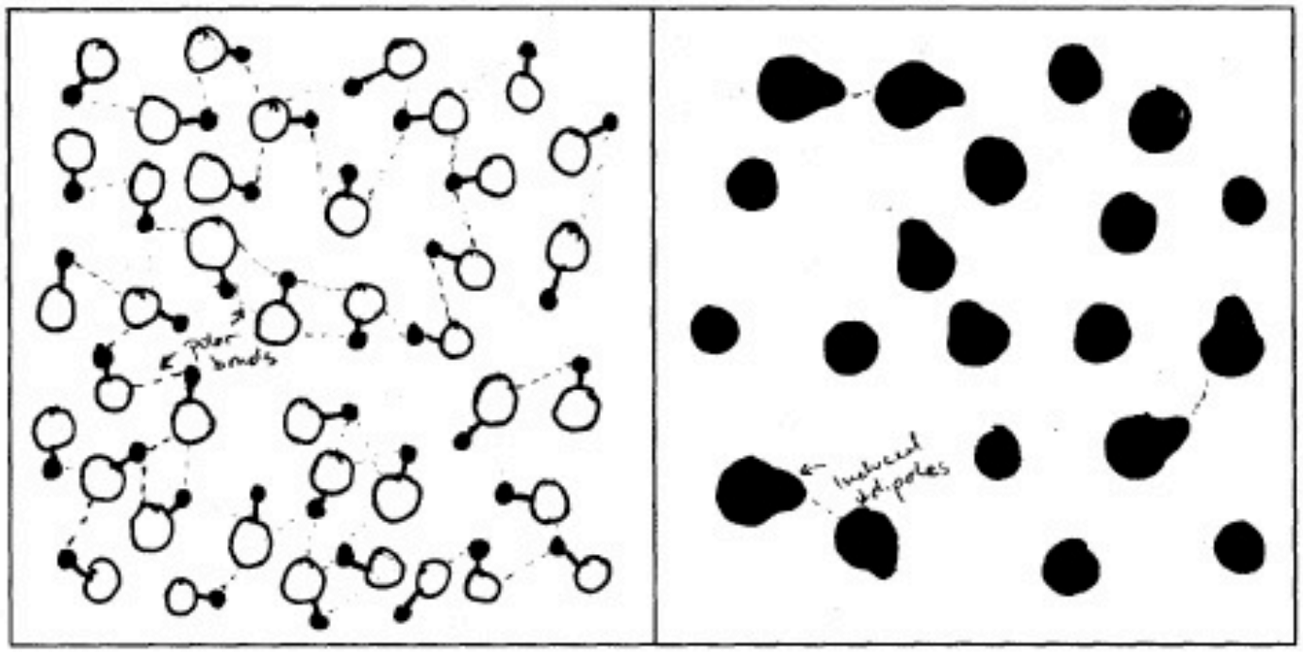
a. HBr and LiBr



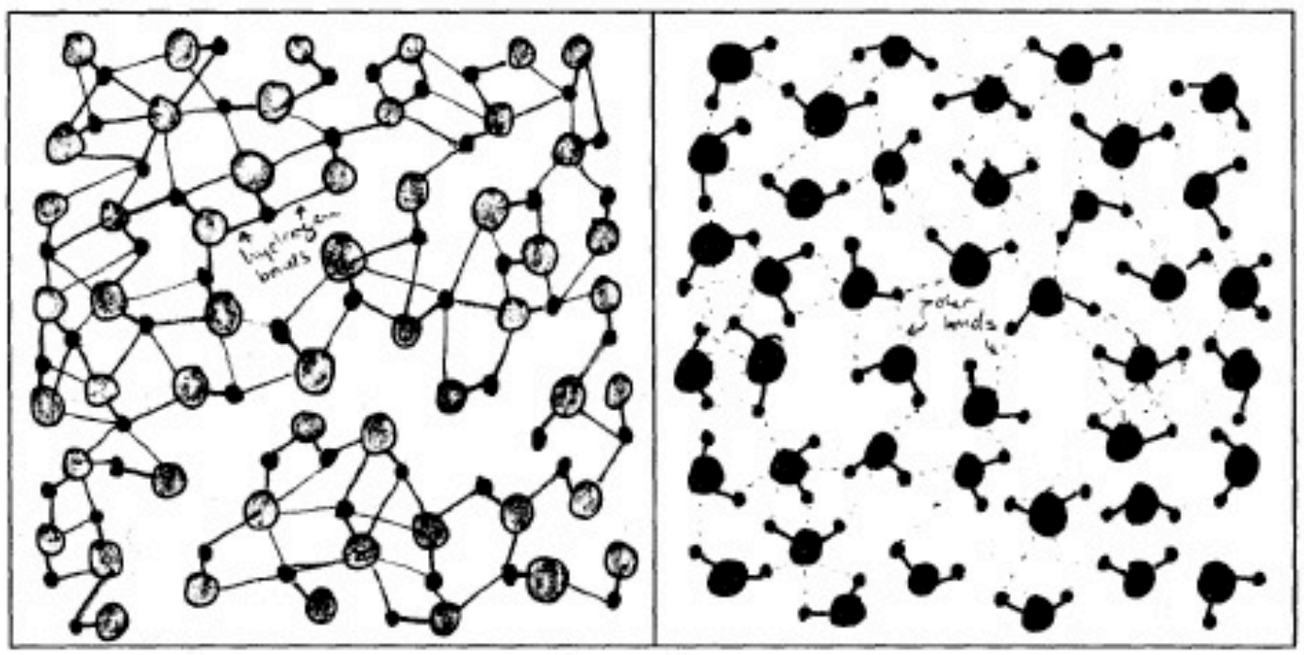
b. CuO and CuS



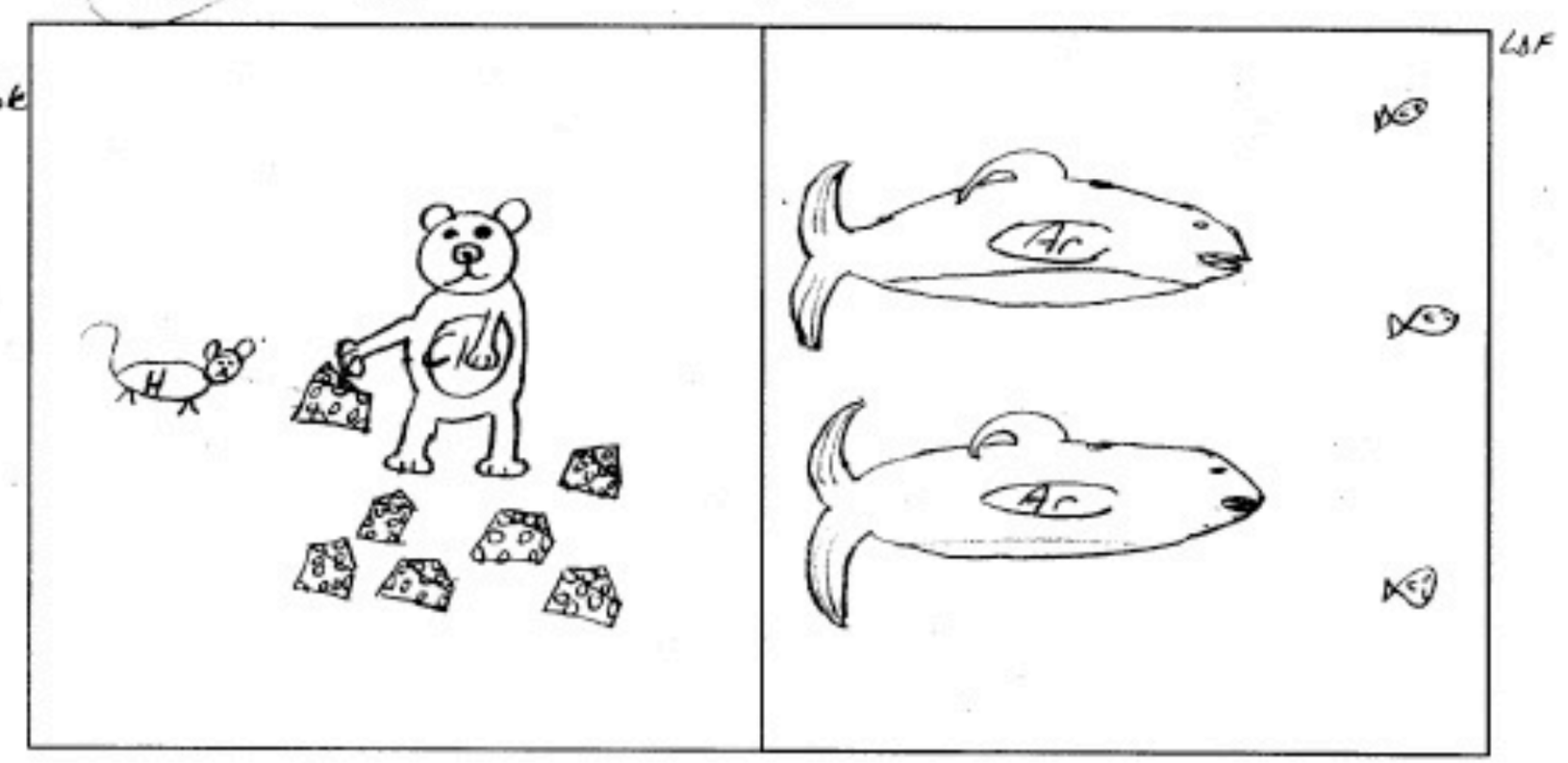
c. HCl and Ar



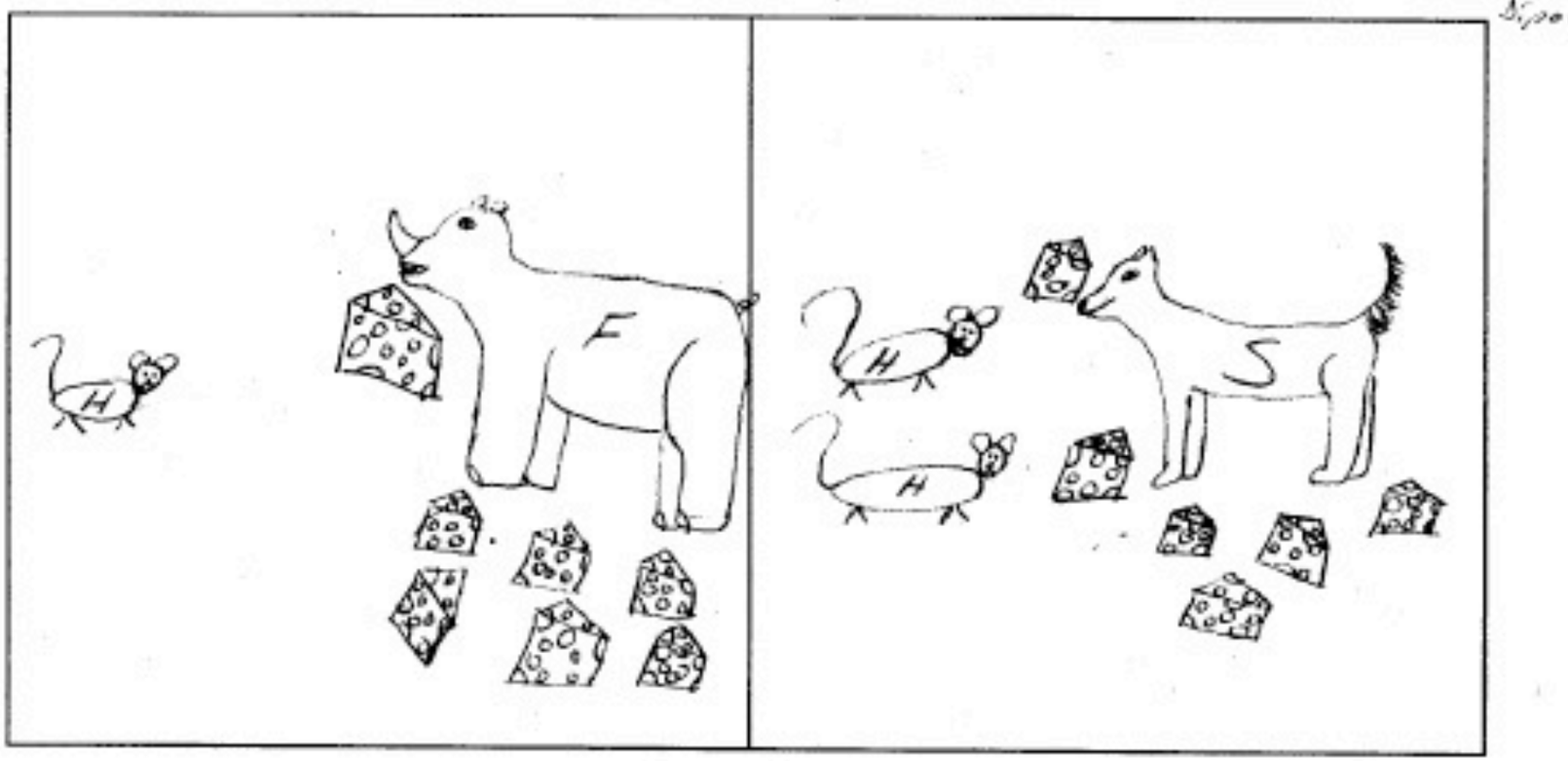

d. HF and $H_2S$



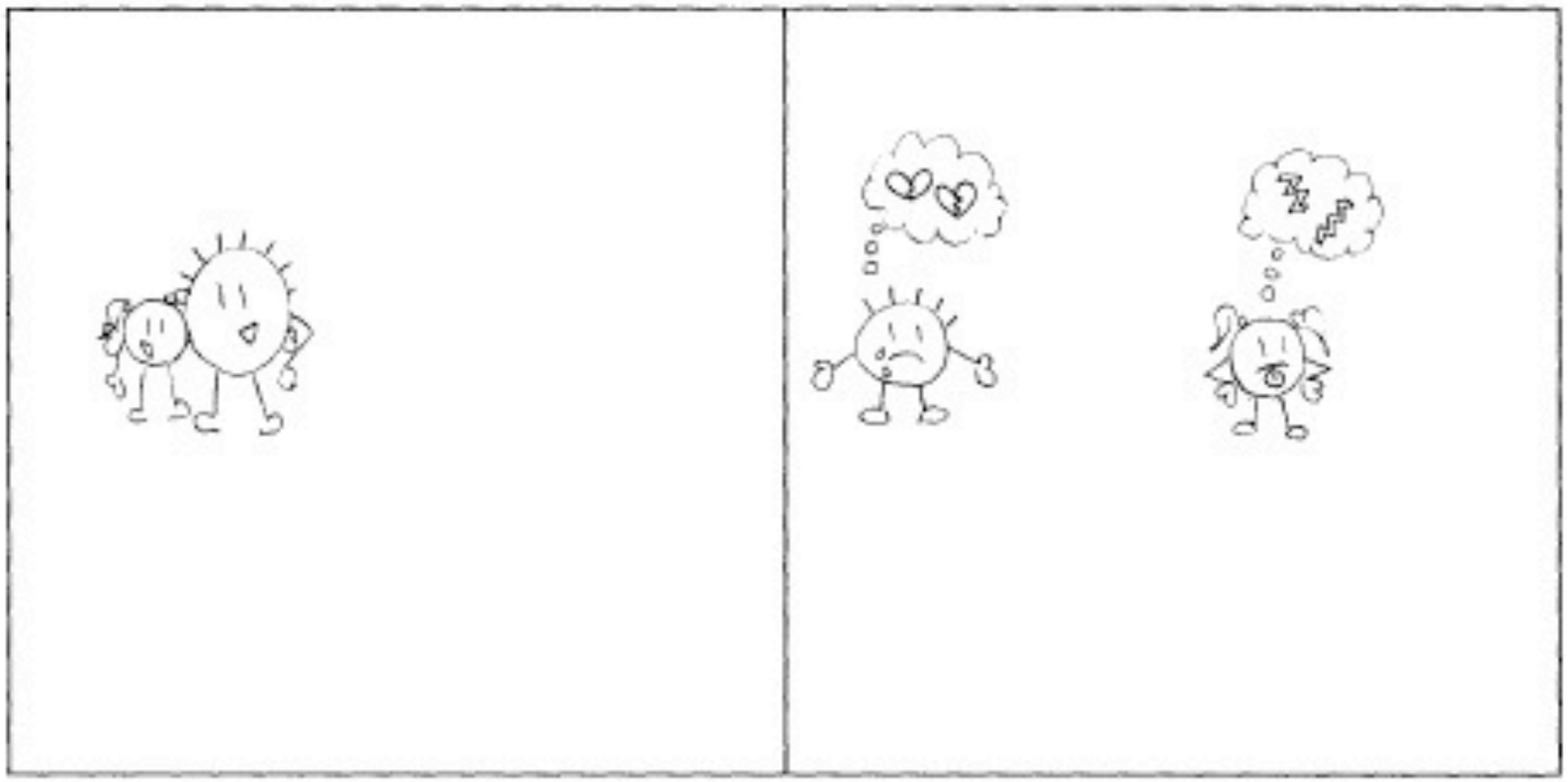
c. HCl and Ar



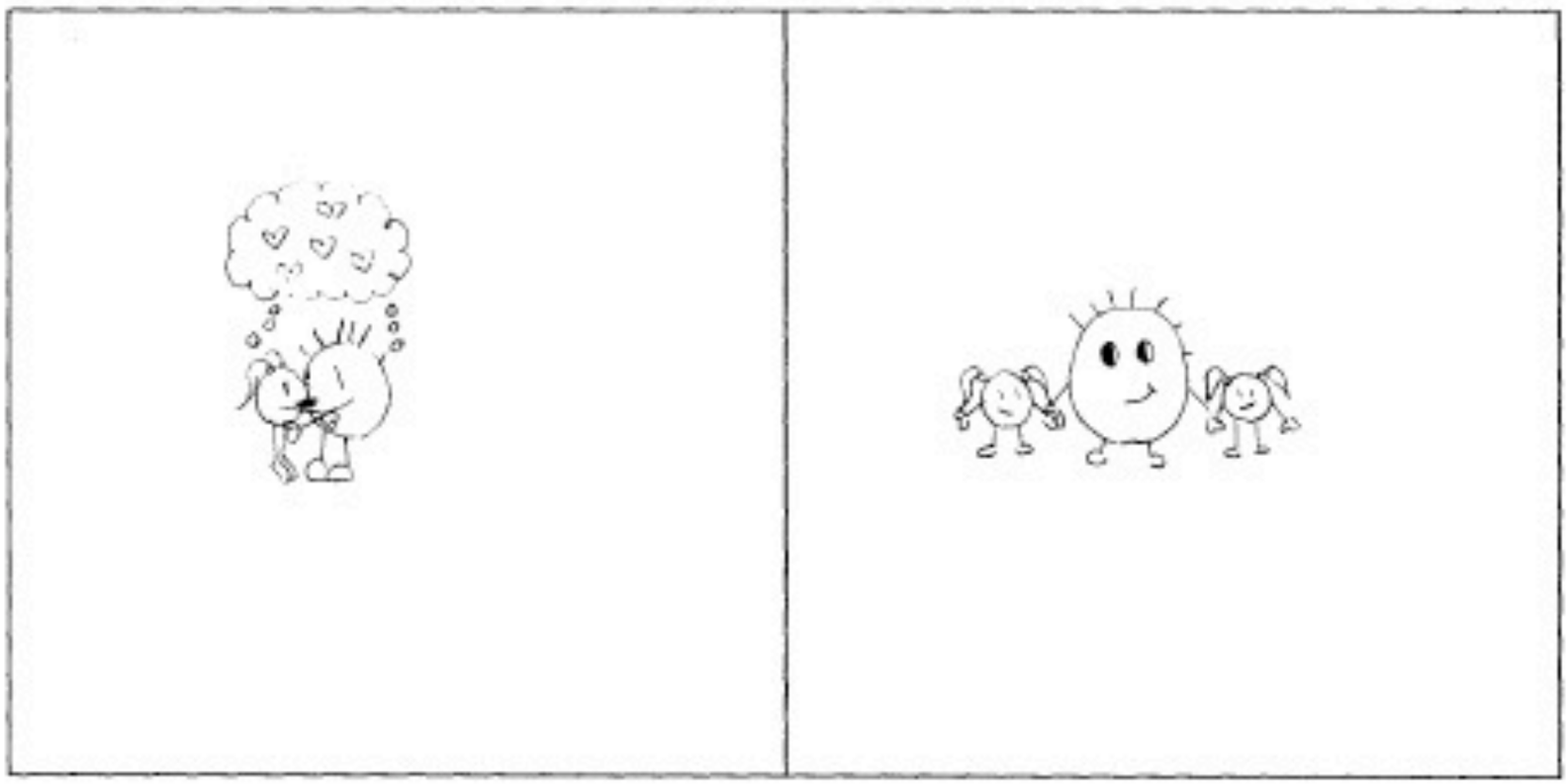

d. HF and $HS_2$

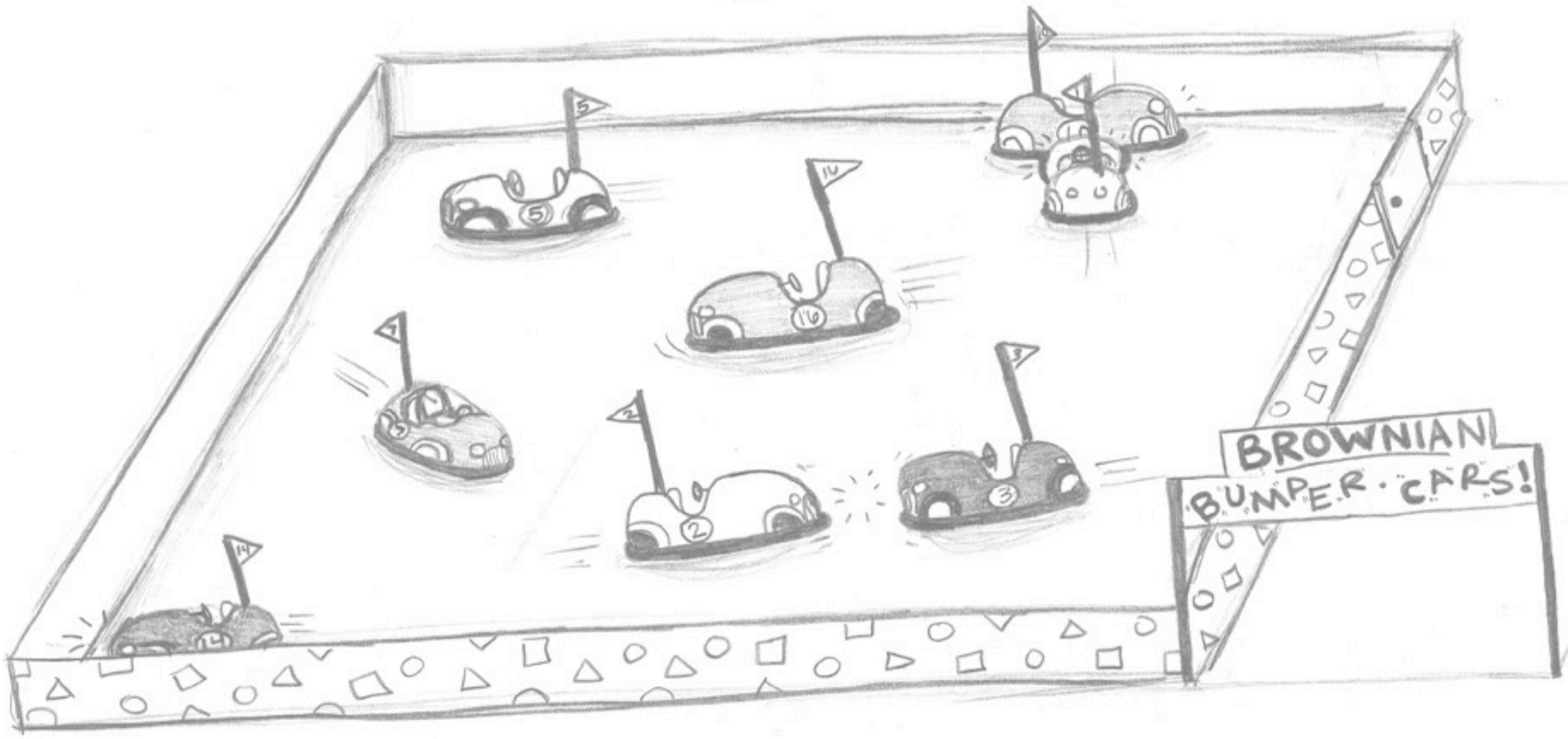


c. HCl and Ar



d. HF and H2S






* more energy/speed [caused by higher temperature] causes more collisions & more intense chaos!

Your drawing goes here.

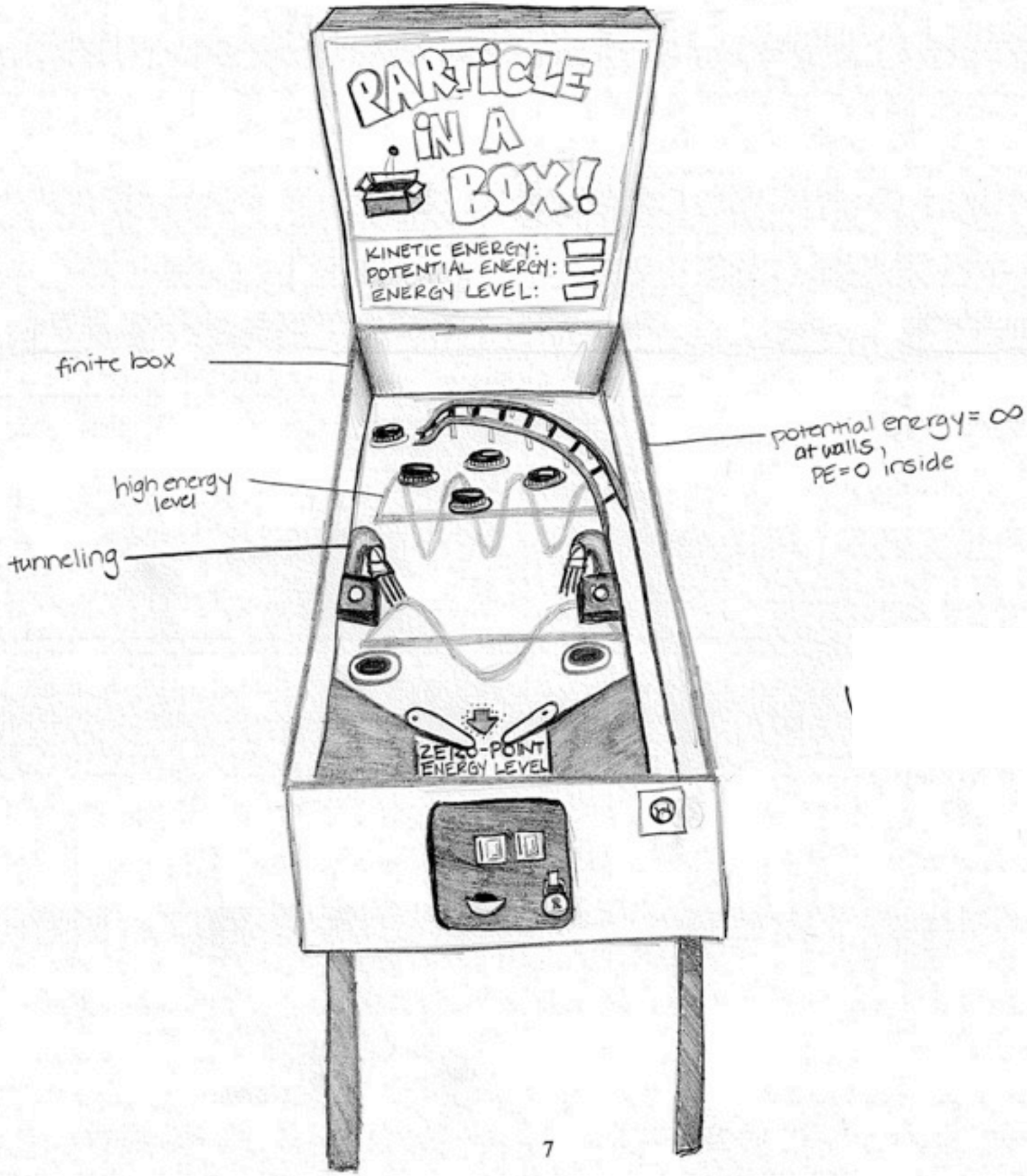


image # enter

# picturing to learn


click image to enlarge

You currently have
**140**
drawings selected.

**Filter the drawings pile:** +/- add or subtract filters

Assignment question:

Draw, as if explaining to a high school student, why and how solute molecules in a fluid diffuse along a concentration gradient (in other words, explain how random motion leads to Fick's first law).

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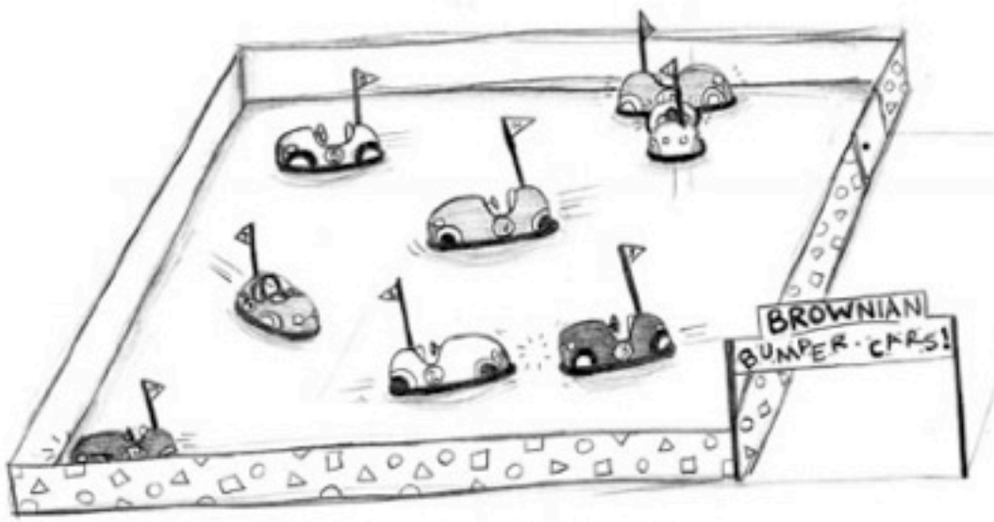
BETA tester survey

NSF, DUE-0925110

Your drawing goes here




• more energy/speed [caused by higher temperature] caused more collisions & more intense chaos!

6

## Topic: *Brownian Motion*

Draw, as if explaining to a high school student, how the motions of large and small particles suspended in a fluid are affected by an increase in temperature of the fluid.

## Course Info: [ + expand/collapse ]

## Rubric: [ + expand/collapse ]

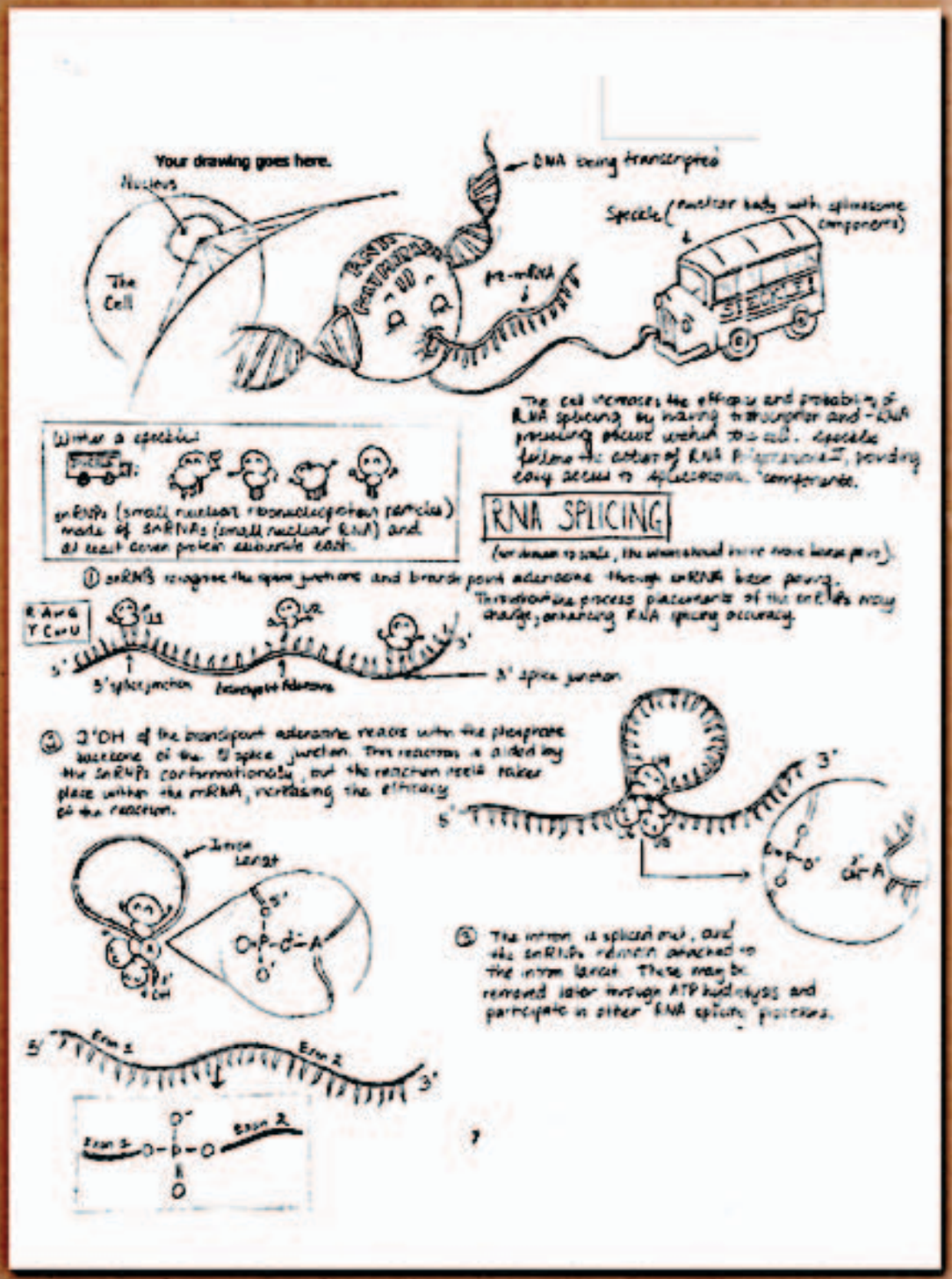
## Misconceptions and/or Omissions: [ + expand/collapse ]

The following concepts were not clearly depicted

- role of fluid
- particle motion
- particle size
- particle motion: size

## Style of Representation: [ + expand/collapse ]

## Take Note: [ + expand/collapse ]




[275 of 384] #4319
previous next

bookmark this drawing | return to filters panel | return to file cabinet

**Topic:** *Central Dogma and Effective Concentration (2008)*

Draw, as if explaining to a high school student, the problem of achieving a high enough effective concentration of reactants for a chemical reaction to occur, and how the cell solves this problem at one step of the Central Dogma using the specific example

**Course Info:** [ + expand/collapse ]

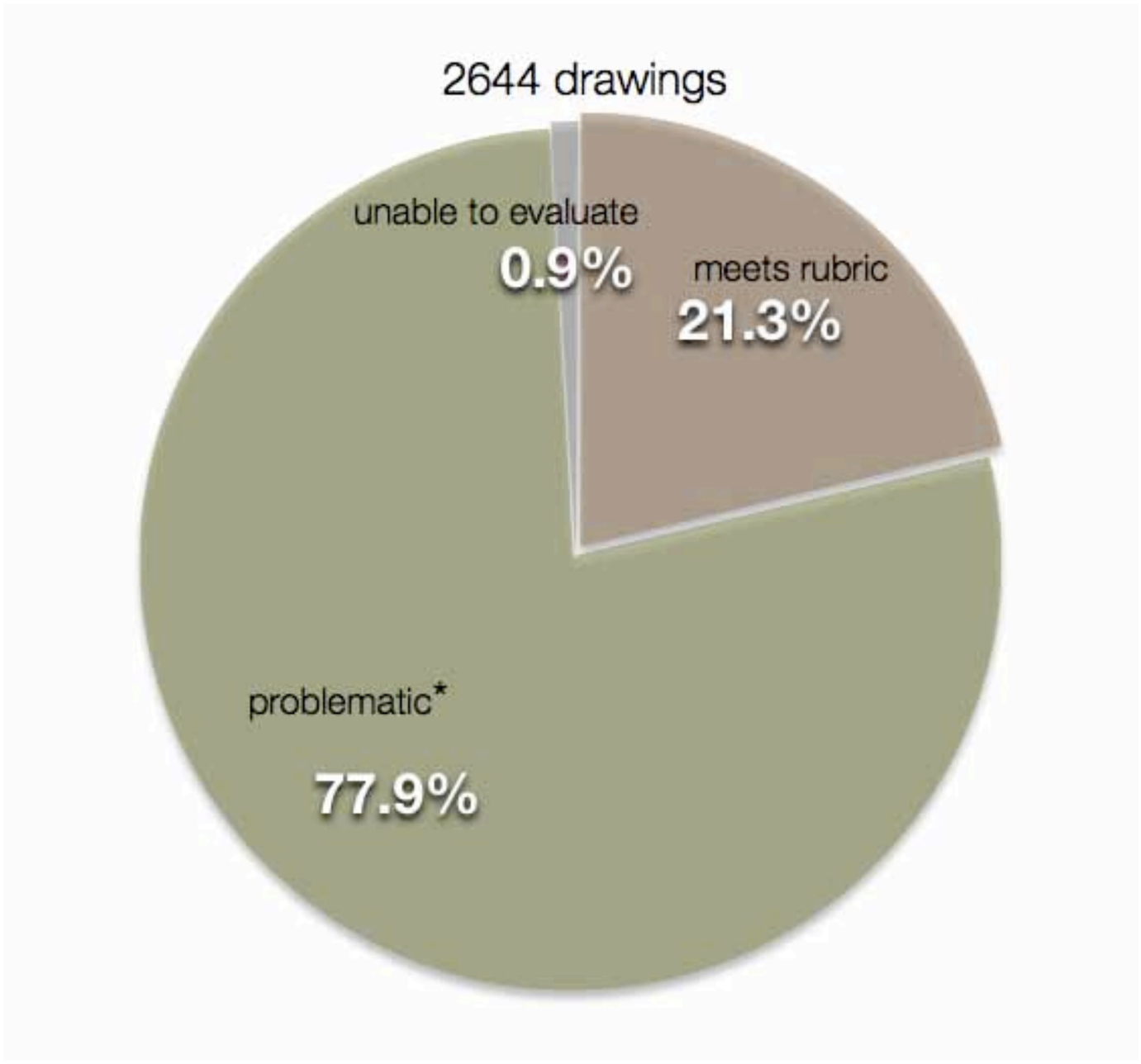
**Rubric:** [ + expand/collapse ]

**Misconceptions and/or Omissions:** [ + expand/collapse ]

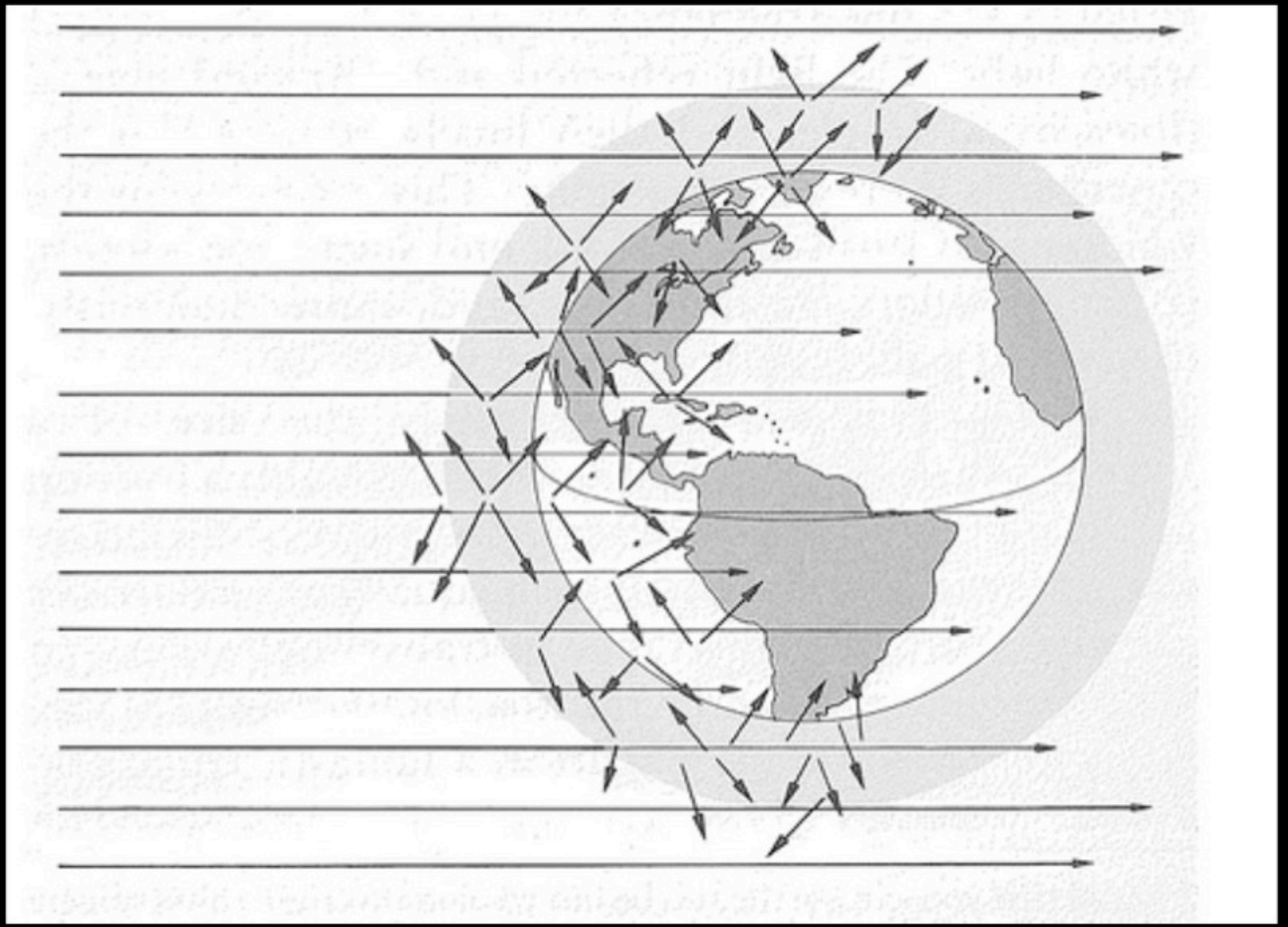
**Style of Representation:** [ + expand/collapse ]

**Take Note:** [ + expand/collapse ]

NSF, DUE-0925110


2644 drawings
unable to evaluate
0.9%
meets rubric
21.3%
problematic*
77.9%

why is the sky blue?



**WORKSHOP** Donald G. McNeil Jr.

# Back to the Drawing Board

AARON LEE FINEMAN FOR THE NEW YORK TIMES

**THE ASSIGNMENT:** Draw a picture explaining why the sky is blue.

**THE CLASS:** Four Harvard physics students and four School of Visual Arts design students.

Even combining their talents, members of the class, assembled for a weekend workshop at the Manhattan art school, found it tough. So many concepts jumbled together: How many colors make up sunlight. Why atmospheric nitrogen scatters blue light more readily than it does red. Why blue's higher-frequency wavelength allows that. Why the same light hits clouds but leaves them white. And something about "omega to the fourth."

"This was a good problem because it's one of those questions everyone asks in kindergarten," says Nick Krasney, one of the Harvard students. "And there are so many bad answers, like 'It's blue because it reflects the water.'"

The exercise was part of a continuing collaborative project called Picturing to Learn, supported by a $500,000 National Science Foundation grant and also involving Duke University and Roxbury Community College in Boston. The project is an effort to improve basic science education. Felice Frankel, a science photographer who teaches at Harvard and the Massachusetts Institute of Technology, got the idea for the project, she says, "because every time I sit down with a scientist and ask them to describe their work, they inevitably take out a cocktail napkin and a pencil."

Having students draw, she says, forces them to prove they understand the concepts. Donald R. Sadoway, who teaches introductory chemistry at M.I.T., collaborates with Ms. Frankel. He assigned his 600 students to answer a question about the boiling points of calcium oxide and calcium sulfide by drawing a picture for a high school student. The crux was to see if they understood which forces holding molecules together are stronger. A typical answer showed atoms holding hands while others tugged at them.

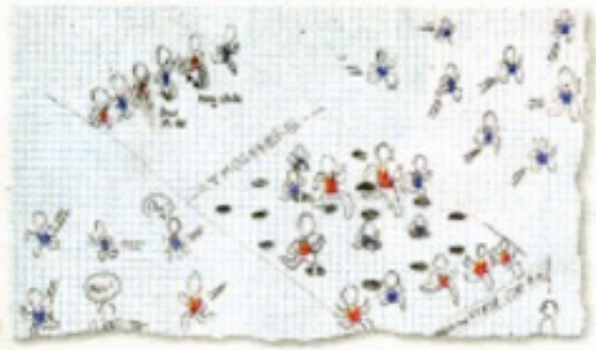
"M.I.T. students are usually good at math," he says, "but sometimes you discover they've memorized the equations and use the right buzzwords. You don't know if they're just not a good writer or if they've bungled the whole concept. If you make them do a picture, you can zero in on things that words might conceal."

One problem all the professors have learned to watch for: it's tempting to draw physical forces and chemicals as little humans. But then viewers often assume the stick figures will act like people, and bad science creeps in.

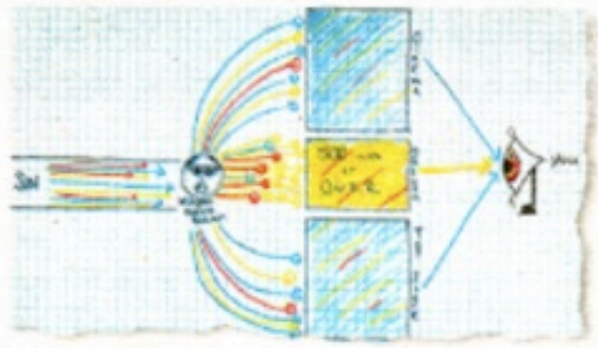
"There's a lot of literature about the misconceptions people get from illustrations," says Vinothan N. Manoharan, a Harvard physics professor whose class collaborated with the New York art students. "And those misconceptions stick with them." ■

## Why Is the Sky Blue?

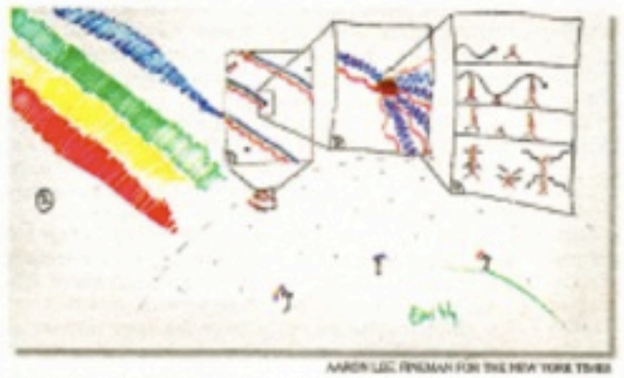
Put simply, sunlight — or white light, containing all the colors of the spectrum — strikes air particles and is scattered. The amount of scattering is greater for short wavelengths of light (which we see as blue) than for long (red), so whichever direction you look the sky appears blue. Ah, but the answer is far more complex. Below is how students tried to illustrate it.



A pack of short-legged sprinters (blue light) competes with long-legged ones (red). Potholes (nitrogen molecules in the air) trip up and scatter more blue runners because of their short stride. *BUT:* Molecules are not like holes. Light has more than two colors, and doesn't behave like people. (People run at different speeds, and trip even with long legs.)



A bouncer at a saloon lets in long-wavelength colors, deflecting short ones to other entertainments — an indirect path to a human eye. *BUT:* Molecules don't "bounce" light; they absorb it and then radiate it out. And light doesn't curve.

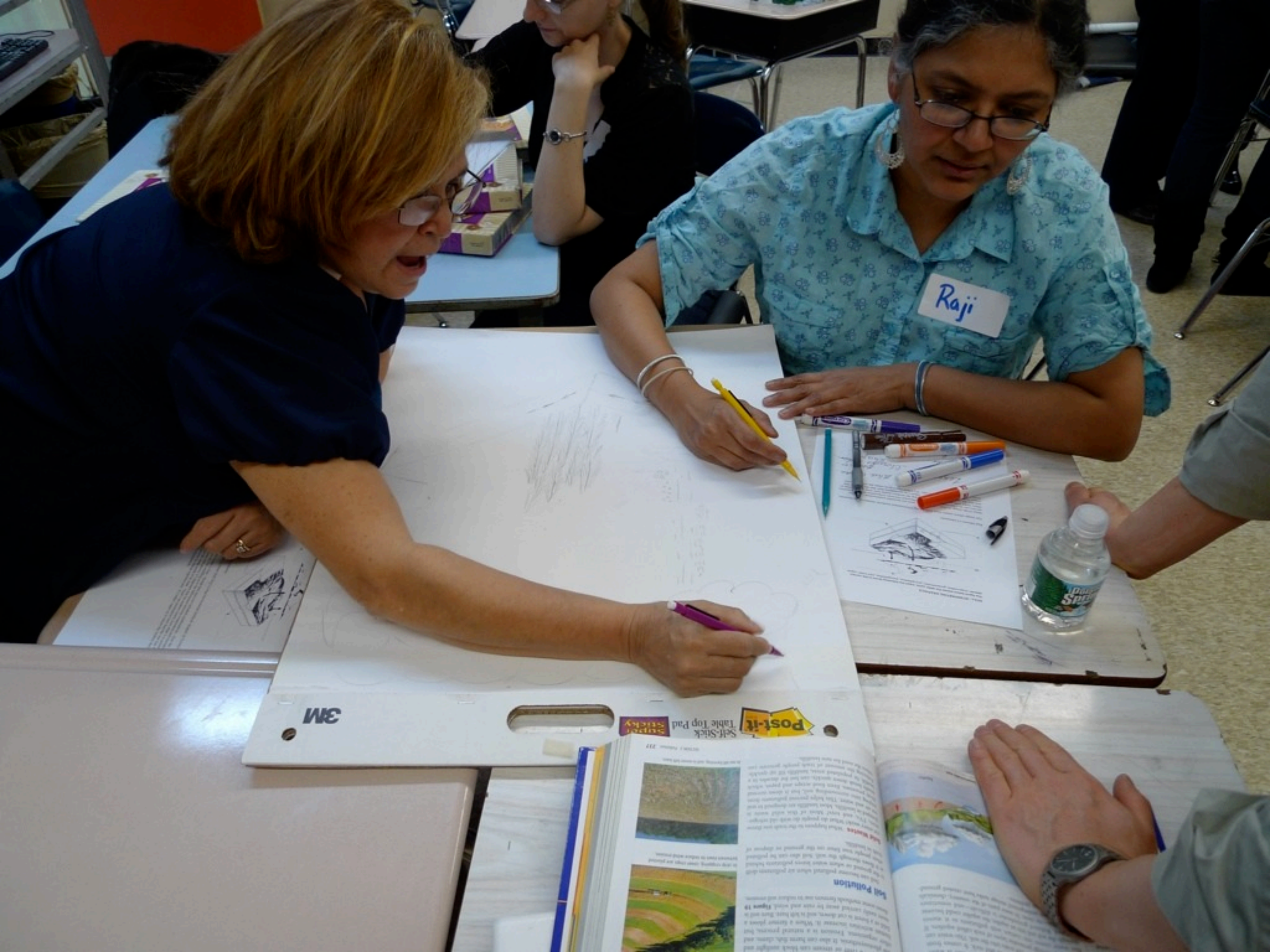


AARON LEE FINEMAN FOR THE NEW YORK TIMES

To get the science right, a final drawing requires numerous color pens and boxes that magnify detail. The position of the observer also matters. Bonus: the figure on Earth at far right, looking across at the horizon, suggests why a sunset is red.


Harvard
wireless
STEFAN


3M
Self-Stick
Table Top Pad
Super
Sticky


Raji
3M
Post-it
Self-Stick
Table Top Pad
Super Sticky


Maria
Tracy
Crayola
COLORED PENCILS
50

the process of making a representation

. . . cultivates CRITICAL THINKING

4