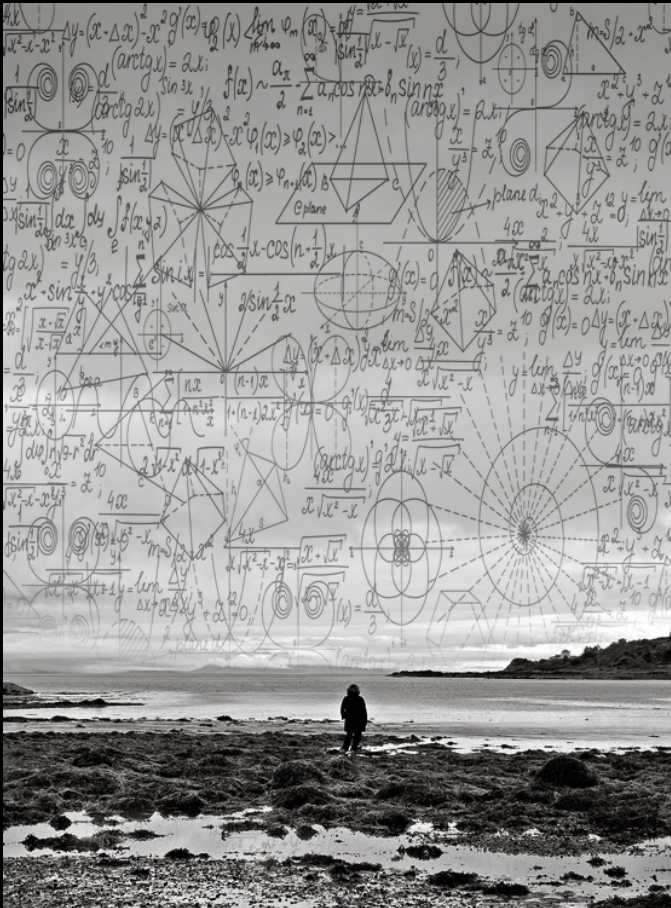


Science & Art: Self-Entangled Pathways Toward Inner & Outer Truths

2017 Humanities and Technology Association Conference



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<http://tao-of-digital-photography.blogspot.com>
<http://www.sudden-stillness.com>

Science & art: *separate, but entwined processes...*

<http://www.creativecriminals.com/images/mercedesleftrightbrain1.jpg>

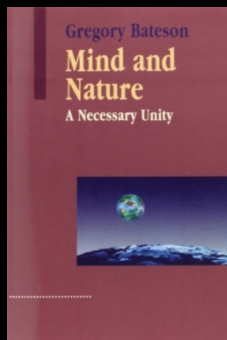


Science & art: *what do they have in common?*

$$e^{i\pi} + 1 = 0 \quad \sum_i F_i = ma \quad \frac{\partial^2 u}{\partial t^2} = v^2 \nabla^2 u \quad \left\{ \begin{array}{l} \nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \cdot \mathbf{B} = 0 \quad \nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \end{array} \right\} \quad (i\partial - m)\psi = 0$$

$$\delta \int_{t_1}^{t_2} L dt \quad S = k_B \ln W \quad E = mc^2 \quad \left(\frac{-\hbar^2}{2m} \nabla^2 + V \right) \Psi = i\hbar \frac{\partial \Psi}{\partial t} \quad G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

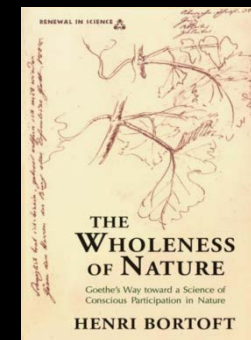
$$F = G \frac{m_1 m_2}{r^2}$$



Beauty

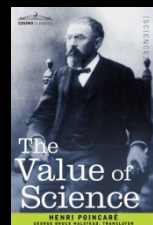
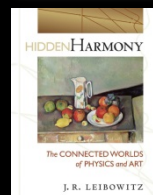
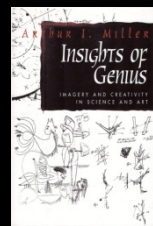
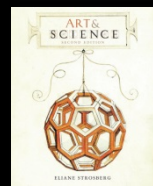
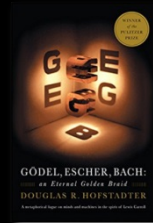
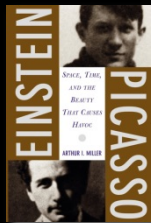
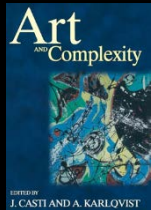
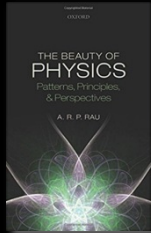
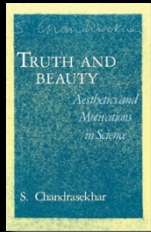
"Seeing the pattern of patterns
that connects;
Seeing the *metapattern*."

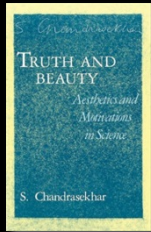
— Gregory Bateson
(1904 – 1980, *Anthropologist*)



Beauty in science and art

Dozens of books have examined
beauty in science & art ...





“One may ask the question as to the extent to which the quest for beauty is an aim in the pursuit of science. . . . It is, indeed, an incredible fact that what the human mind, at its deepest and most profound, perceives as beautiful finds its realization in external nature. What is intelligible is also beautiful...**Beauty is that to what the human mind responds at its deepest and most profound.**”

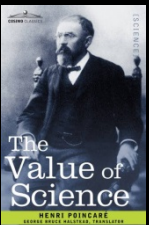
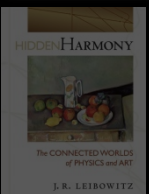
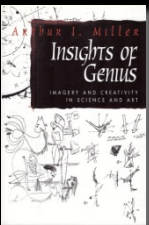
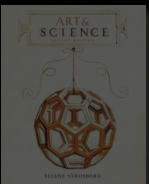
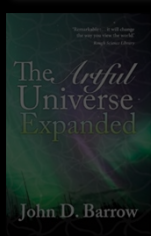
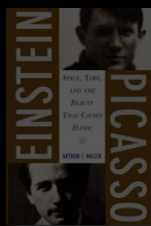
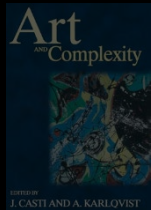
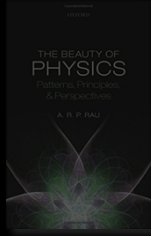
– S. Chandrasekhar (1910 – 1995, *Astrophysicist*)

“For there are 'made' laws, 'discovered' laws, but also *laws* – a truth for all time. These are more or less hidden in the reality which surrounds us and do not change. Not only science but art also, shows us that **reality, at first incomprehensible, gradually reveals itself, by the mutual relations that are inherent in things.**”

– Piet Mondrian (1872 – 1944, *Artist*)

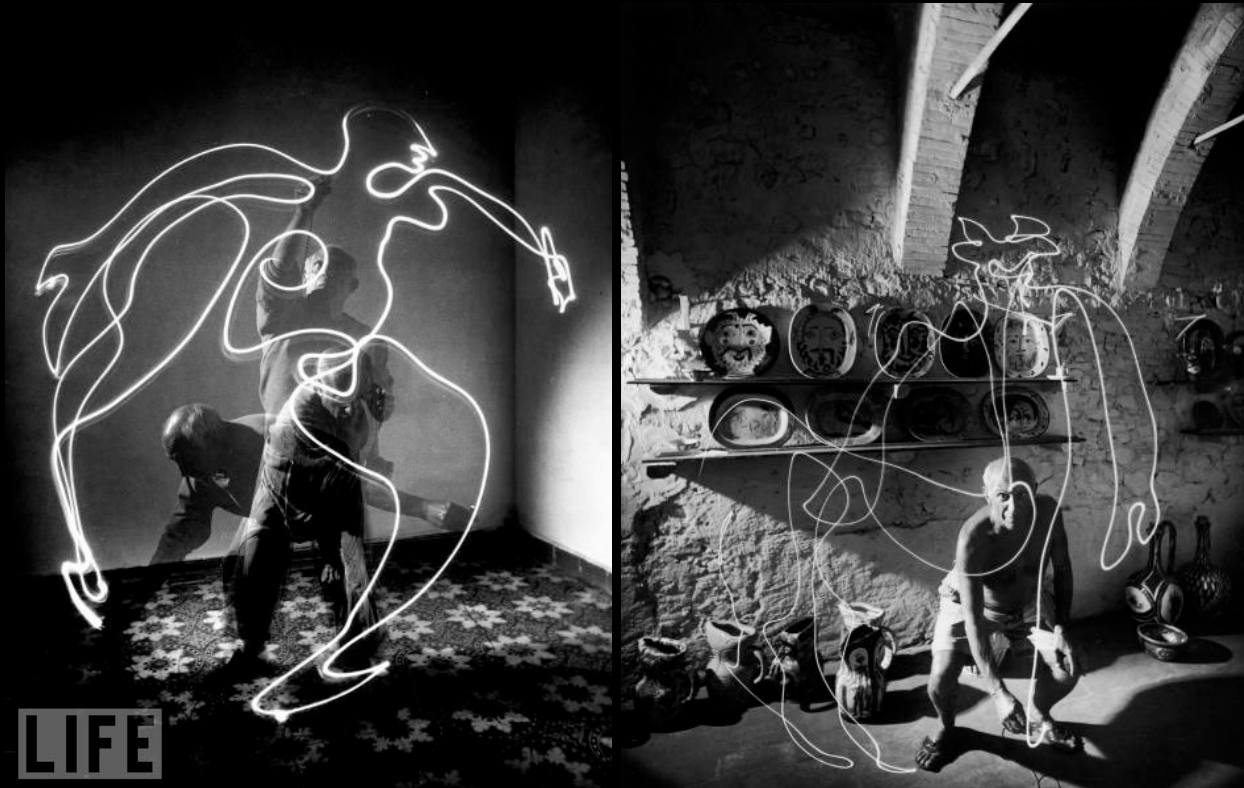
“The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it; and he takes pleasure in it because it is beautiful...I mean the **intimate beauty that comes from the harmonious order of its parts** and that a pure intelligence can grasp.”

– Henri Poincare (1854 – 1912, *Physicist/Mathematician*)



Physics and photography both define and revel in *categories, divisions, groupings, labels, orders, and partitions*

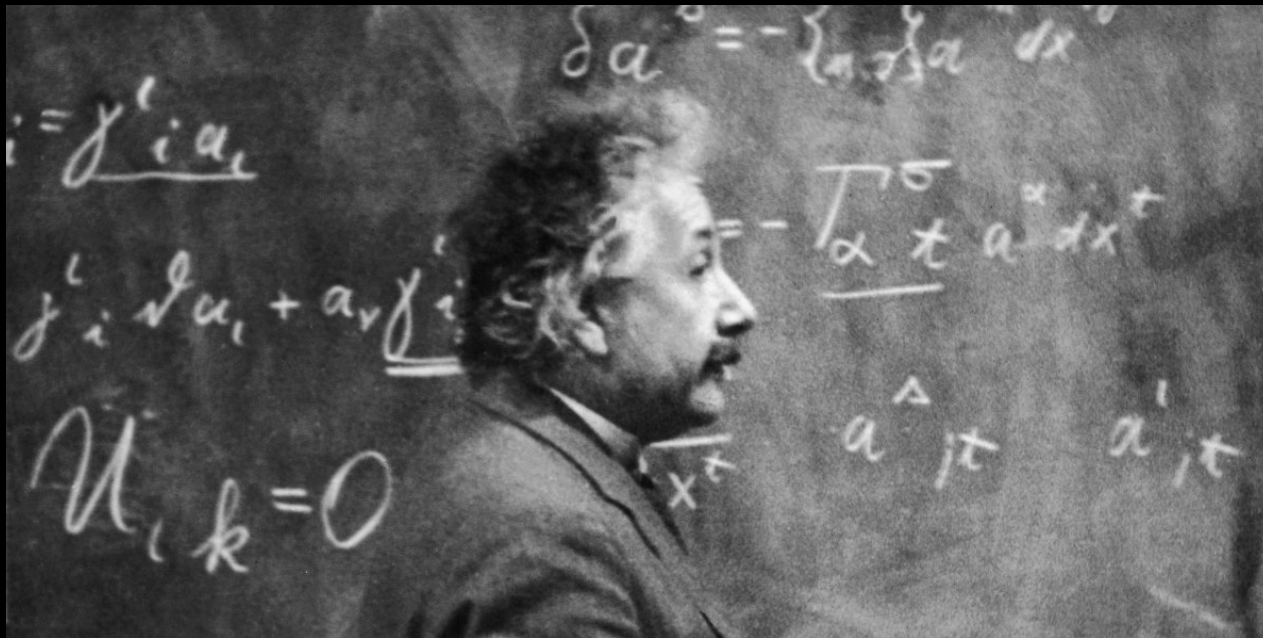
An artist is a meta-pattern of “subjective order”



Gjon Mili, *Life Magazine* (1949)

Physics and photography both define and revel in *categories, divisions, groupings, labels, orders, and partitions*

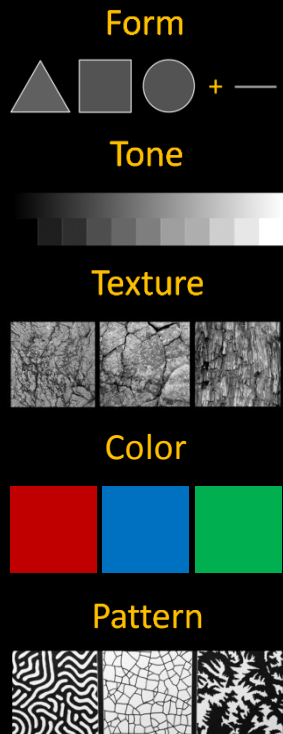
A **physicist** is a meta-pattern of “objective order”



<http://img.timeinc.net/time/2007/einstein/cuts/03.jpg>

Physics and photography both define and revel in *categories, divisions, groupings, labels, orders, and partitions*

Art is the transcendence of subjective categories



Wassily Kandinsky, *Improvisation 28* (1912)

Physics and photography both define and revel in categories, divisions, groupings, labels, orders, and partitions

Physics is a reduction / distillation of “objective categories”

NEWTONIAN MECHANICS

$$\begin{aligned} v &= v_0 + at \\ x &= x_0 + v_0 t + \frac{1}{2} at^2 \\ v^2 &= v_0^2 + 2a(x - x_0) \\ \Sigma \mathbf{F} &= \mathbf{F}_{net} = m\mathbf{a} \\ F_{fric} &\leq \mu N \\ a_c &= \frac{v^2}{r} \\ \mathbf{p} &= m\mathbf{v} \\ \mathbf{J} &= \mathbf{F}\Delta t = \Delta\mathbf{p} \\ K &= \frac{1}{2}mv^2 \\ \Delta U_g &= mgh \\ W &= F\Delta r \cos \theta \\ F_{avg} &= \frac{W}{\Delta t} \\ P &= Fv \cos \theta \\ \mathbf{F}_j &= -k\mathbf{x} \\ U_s &= \frac{1}{2}kx^2 \\ T_s &= 2\pi\sqrt{\frac{m}{k}} \\ T_p &= 2\pi\sqrt{\frac{\ell}{g}} \\ T &= \frac{1}{f} \\ F_G &= -\frac{Gm_1m_2}{r^2} \\ U_G &= -\frac{Gm_1m_2}{r} \end{aligned}$$

a = acceleration
 F = force
 f = frequency
 h = height
 J = impulse
 K = kinetic energy
 k = spring constant
 ℓ = length
 m = mass
 N = normal force
 P = power
 p = momentum
 r = radius or distance
 T = period
 t = time
 U = potential energy
 v = velocity or speed
 W = work done on a system
 x = position
 μ = coefficient of friction
 θ = angle
 τ = torque

ELECTRICITY AND MAGNETISM

$$\begin{aligned} F &= \frac{kq_1q_2}{r^2} \\ E &= \frac{F}{q} \\ U_E &= qV = \frac{kq_1q_2}{r} \\ E_{avg} &= -\frac{V}{d} \\ V &= k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \dots\right) \\ C &= \frac{Q}{V} \\ C &= \frac{\epsilon_0 A}{d} \\ U_c &= \frac{1}{2}QV = \frac{1}{2}CV^2 \\ I_{avg} &= \frac{\Delta Q}{\Delta t} \\ R &= \frac{\rho \ell}{A} \\ V &= IR \\ P &= IV \\ C_p &= C_1 + C_2 + C_3 + \dots \\ \frac{1}{C_s} &= \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots \\ R_s &= R_1 + R_2 + R_3 + \dots \\ \frac{1}{R_p} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots \\ F_B &= qvB \sin \theta \\ F_B &= BI\ell \sin \theta \\ B &= \frac{\mu_0 I}{2\pi r} \\ \phi_m &= BA \cos \theta \\ \mathcal{E}_{avg} &= -\frac{\Delta \phi_m}{\Delta t} \\ \mathcal{E} &= B\ell v \end{aligned}$$

A = area
 B = magnetic field
 C = capacitance
 d = distance
 E = electric field
 \mathcal{E} = emf
 F = force
 I = current
 ℓ = length
 P = power
 Q = charge
 q = point charge
 R = resistance
 r = distance
 t = time
 U = potential (stored) energy
 V = electric potential or potential difference
 v = velocity or speed
 ρ = resistivity
 θ = angle
 ϕ_m = magnetic flux

FLUID MECHANICS AND THERMAL PHYSICS

$$\begin{aligned} \rho &= m/V \\ P &= R_0 + \rho gh \\ F_{buoy} &= \rho Vg \\ A_1 v_1 &= A_2 v_2 \\ P + \rho gy + \frac{1}{2}\rho v^2 &= \text{const.} \\ \Delta \ell &= \alpha \ell_0 \Delta T \\ H &= \frac{kA\Delta T}{L} \\ P &= \frac{F}{A} \\ PV &= nRT = Nk_B T \\ K_{avg} &= \frac{3}{2}k_B T \\ v_{rms} &= \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3k_B T}{\mu}} \\ W &= -P\Delta V \\ \Delta U &= Q + W \\ e &= \left| \frac{W}{Q_H} \right| \\ e_c &= \frac{T_H - T_C}{T_H} \end{aligned}$$

A = area
 e = efficiency
 F = force
 h = depth
 H = rate of heat transfer
 k = thermal conductivity
 K_{avg} = average molecular kinetic energy
 ℓ = length
 L = thickness
 m = mass
 M = molar mass
 n = number of moles
 N = number of molecules
 P = pressure
 Q = heat transferred to a system
 T = temperature
 U = internal energy
 V = volume
 v = velocity or speed
 v_{rms} = root-mean-square velocity
 W = work done on a system
 y = height
 α = coefficient of linear expansion
 μ = mass of molecule
 ρ = density

ATOMIC AND NUCLEAR PHYSICS

$$\begin{aligned} E &= hf = pc \\ K_{max} &= hf - \phi \\ \lambda &= \frac{h}{p} \\ \Delta E &= (\Delta m)c^2 \end{aligned}$$

E = energy
 f = frequency
 K = kinetic energy
 m = mass
 p = momentum
 λ = wavelength
 ϕ = work function

WAVES AND OPTICS

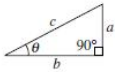
$$\begin{aligned} v &= f\lambda \\ n &= \frac{c}{v} \\ n_1 \sin \theta_1 &= n_2 \sin \theta_2 \\ \sin \theta_c &= \frac{n_2}{n_1} \\ \frac{1}{s_i} + \frac{1}{s_o} &= \frac{1}{f} \\ M &= \frac{h_i}{h_o} = -\frac{s_i}{s_o} \\ f &= \frac{R}{2} \\ d \sin \theta &= m\lambda \\ x_m &= \frac{m\lambda L}{d} \end{aligned}$$

d = separation
 f = frequency or focal length
 h = height
 L = distance
 M = magnification
 m = an integer
 n = index of refraction
 R = radius of curvature
 s = distance
 v = speed
 x = position
 λ = wavelength
 θ = angle

GEOMETRY AND TRIGONOMETRY

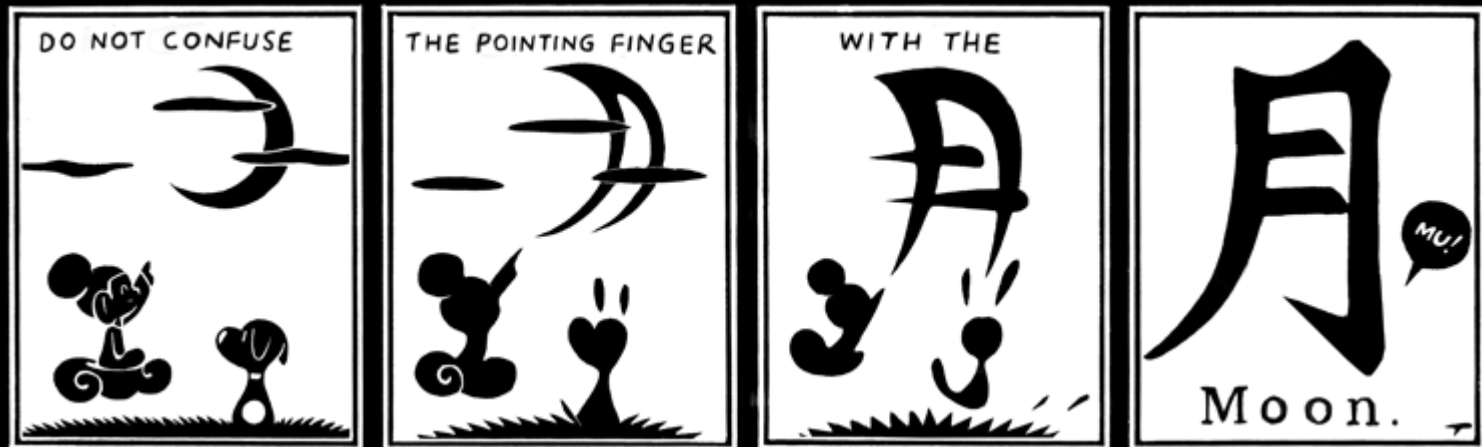
$$\begin{aligned} \text{Rectangle} & \quad A = ab \\ \text{Triangle} & \quad A = \frac{1}{2}bh \\ \text{Circle} & \quad A = \pi r^2 \\ & \quad C = 2\pi r \\ \text{Rectangular Solid} & \quad V = \ell wh \\ \text{Cylinder} & \quad V = \pi r^2 \ell \\ & \quad S = 2\pi r \ell + 2\pi r^2 \\ \text{Sphere} & \quad V = \frac{4}{3}\pi r^3 \\ & \quad S = 4\pi r^2 \\ \text{Right Triangle} & \quad a^2 + b^2 = c^2 \\ & \quad \sin \theta = \frac{a}{c} \\ & \quad \cos \theta = \frac{b}{c} \\ & \quad \tan \theta = \frac{a}{b} \end{aligned}$$

A = area
 C = circumference
 V = volume
 S = surface area
 b = base
 h = height
 ℓ = length
 w = width
 r = radius



Physics and photography both define and revel in *categories, divisions, groupings, labels, orders, and partitions*

However, there are good reasons for reminding ourselves of the arbitrariness of divisions, and of the implicit presence of the “I” in making them ...



Tatsuya Ishida (<http://sinfest.net/comikaze/comics/2010-02-01.gif>)

“Physical concepts are free creations of the human mind,
and are not, however it may seem,
uniquely determined by the external world.”

– Albert Einstein (1879 – 1955, *Physicist*)

Let's revisit the separate, but *entwined* processes...

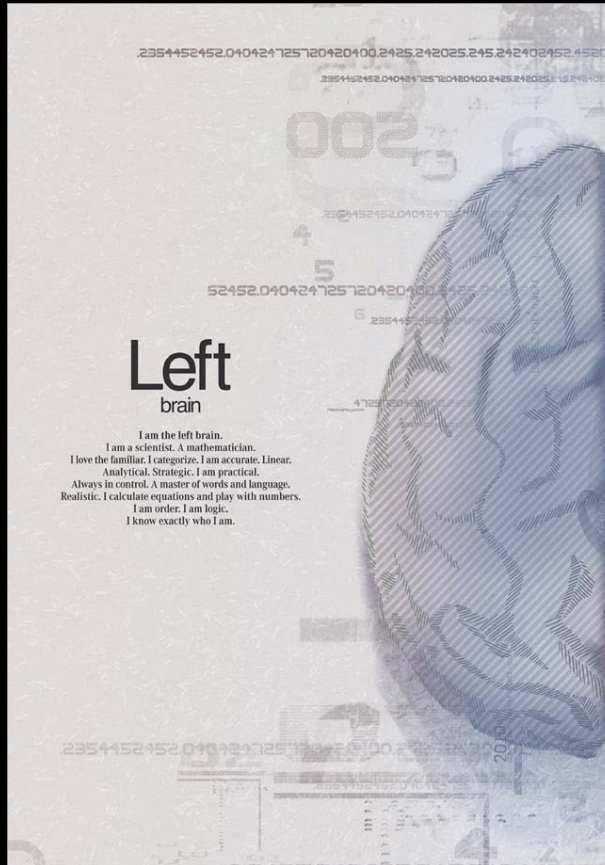
<http://www.creativecriminals.com/images/mercedesleftrightrain1.jpg>



...my left side

Physics: the science of distilling perceived order into simplest possible form
Complexity: self-organized emergence of global order that arises from local simplicity

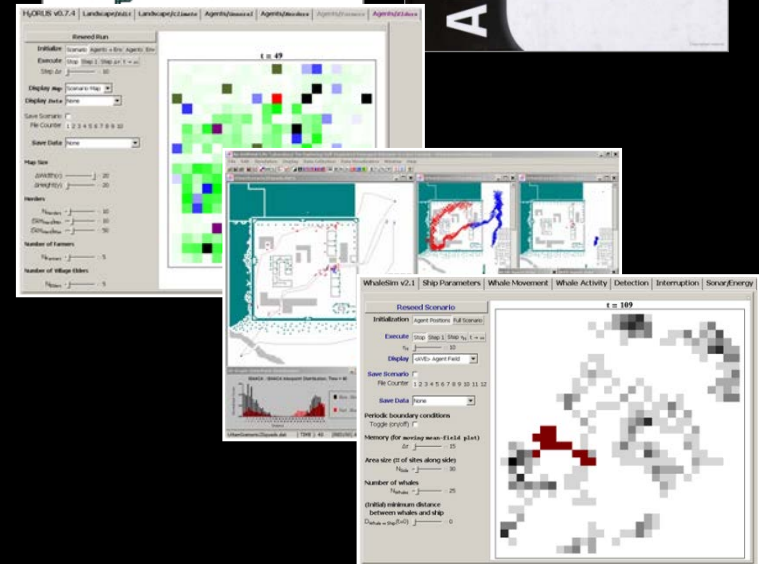
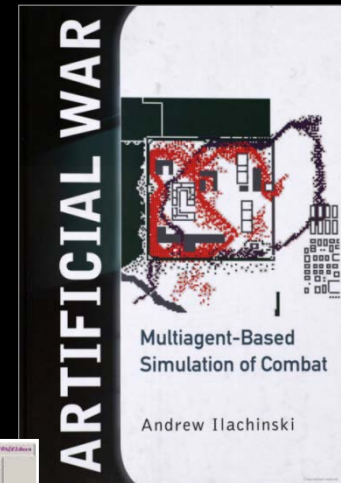
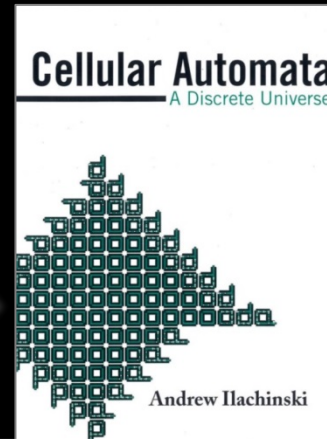
<http://www.creativecriminals.com/images/mercedesleftrighbrain1.jpg>



By day...

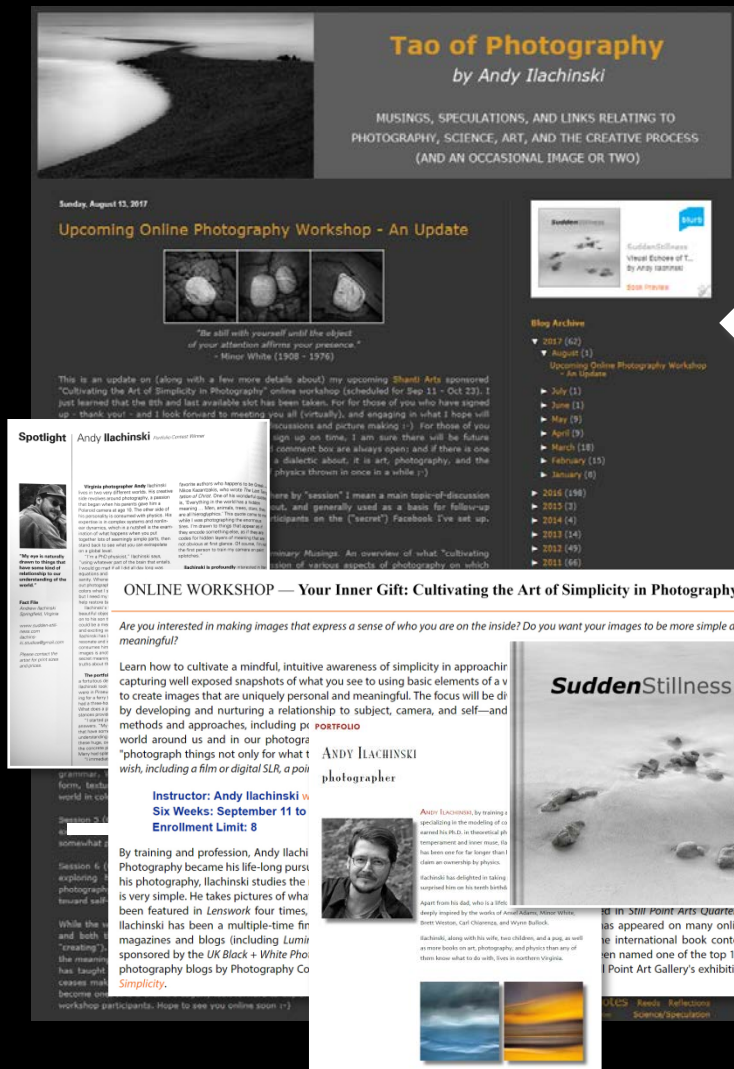
I am a physicist, specializing
in chaos, complexity theory,
and mathematical modeling

Andy Ilachinski, *Principal Research Scientist*



...my right side

Photography: The art of capturing what a “thing” is by communicating what else a thing is



Tao of Photography
by Andy Ilachinski

MUSINGS, SPECULATIONS, AND LINKS RELATING TO
PHOTOGRAPHY, SCIENCE, ART, AND THE CREATIVE PROCESS
(AND AN OCCASIONAL IMAGE OR TWO)

Sunday, August 12, 2013

Upcoming Online Photography Workshop - An Update

"Be still with yourself until the object of your attention affirms your presence."
- Minor White (1908 - 1976)

This is an update on (along with a few more details about) my upcoming **Shanti Arts** sponsored "Cultivating the Art of Simplicity in Photography" online workshop (scheduled for Sep 11 - Oct 23). I just learned that the 8th and last available slot has been taken, for those of you who have signed up. Thank you! and I look forward to meeting you all (virtually), and engaging in what I hope will be discussions and picture making :-). For those of you who sign up on time, I am sure there will be future comment boxes always open; and if there is one in dialectic about it in art, photography, and the physics thrown in once in a while :-)

Spotlight Andy Ilachinski *Journal Content Writer*

ONLINE WORKSHOP — Your Inner Gift: Cultivating the Art of Simplicity in Photography

Are you interested in making images that express a sense of who you are on the inside? Do you want your images to be more simple and meaningful?

Learn how to cultivate a mindful, intuitive awareness of simplicity in approach capturing well exposed snapshots of what you see to using basic elements of a v to create images that are uniquely personal and meaningful. The focus will be di by developing and nurturing a relationship to subject, camera, and self—and methods and approaches, including p world around us and in our photogra "photograph things not only for what t wish, including a film or digital SLR, a poi

Instructor: Andy Ilachinski
Six Weeks: September 11 to Enrollment Limit: 8

By training and profession, Andy Ilachi Photography became his life-long purs his photography, Ilachinski studies the is very simple. He takes pictures of wha been featured in Lenswork four times, Ilachinski has been a multiple-time fir magazines and blogs (including Lumi sponsored by the UK Black + White Pho photography blogs by Photography Co Simplicity.

workshop participants. Hope to see you online soon :-)

SuddenStillness

ANDY ILACHINSKI
photographer

After a successful career in business specializing in the modeling of an earned his Ph.D. in theoretical ph engagement and more time, he has been out for far longer than I claim an ownership by physics. Ilachinski has designed and taking captured him on his north beach Apart from his dad, who is a 1962 deeply inspired by the works of Arnold Schönberg, Minor White, from Thomas Carl Olshausen, and from Richard Ilachinski, along with his wife, two children, and a pug as well as more books on art, photography, and physics than any of them know what to do with, lives in northern Virginia.

Blog Archive

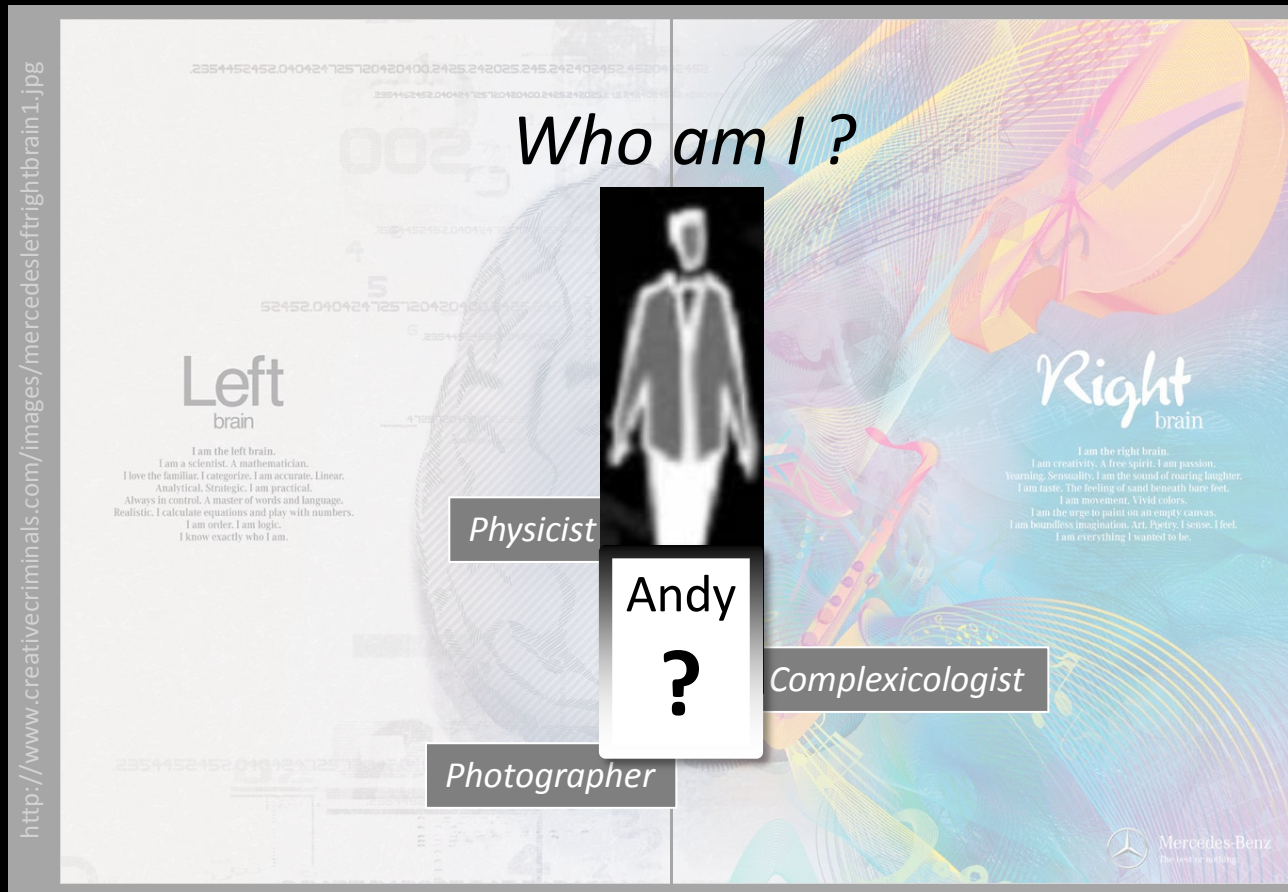
- ▼ 2017 (42)
- ▼ August (1)
 - Upcoming Online Photography Workshop - An Update
- July (1)
- June (1)
- May (9)
- April (9)
- March (18)
- February (15)
- January (6)
- 2016 (146)
- 2015 (2)
- 2014 (1)
- 2013 (14)
- 2012 (49)
- 2011 (66)



At all other times
(that often intrude on the day)...

I forget about physics and equations,
and just let my eye/"I" roam freely
Andy Ilachinski, *Fine-Art Photographer*

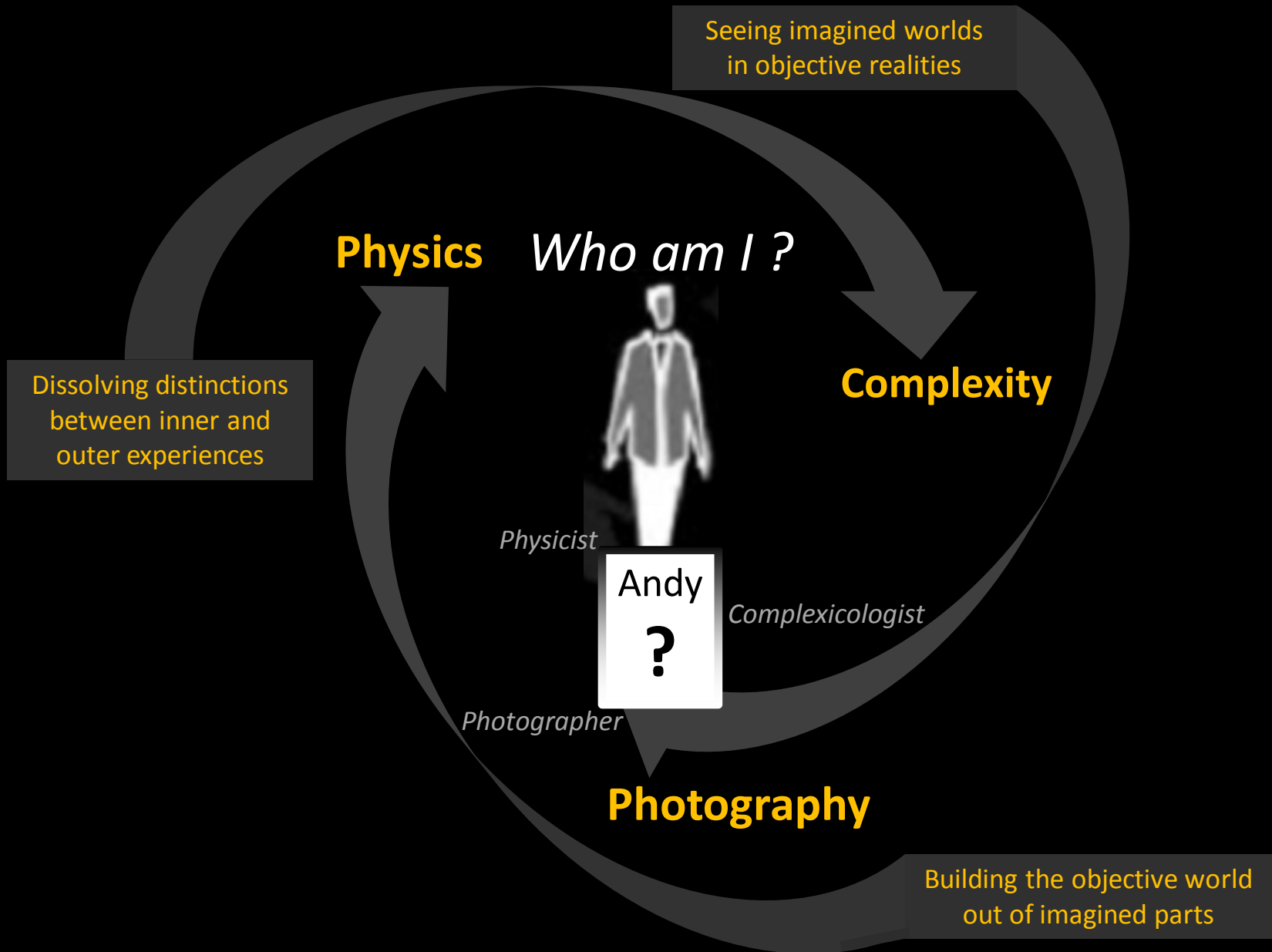
Separate, but *entwined* processes...



“The division of the perceived universe into parts and wholes is convenient and may be necessary, but no necessity determines how it shall be done.”

– Gregory Bateson (1904 – 1980, *Anthropologist*)

Separate, but *entwined* processes...



Seeing imagined worlds
in objective realities

Physics

Who am I ?

Dissolving distinctions
between inner and
outer experiences

Complexity

The best way to discover
this “I” is to examine what it
has spent a lifetime ***creating***

“I” am a creature on a
creative journey, whose
path is both *informed by*
– and *shapes* – many
“subjective” and
“objective” categories

Photography

Complexity

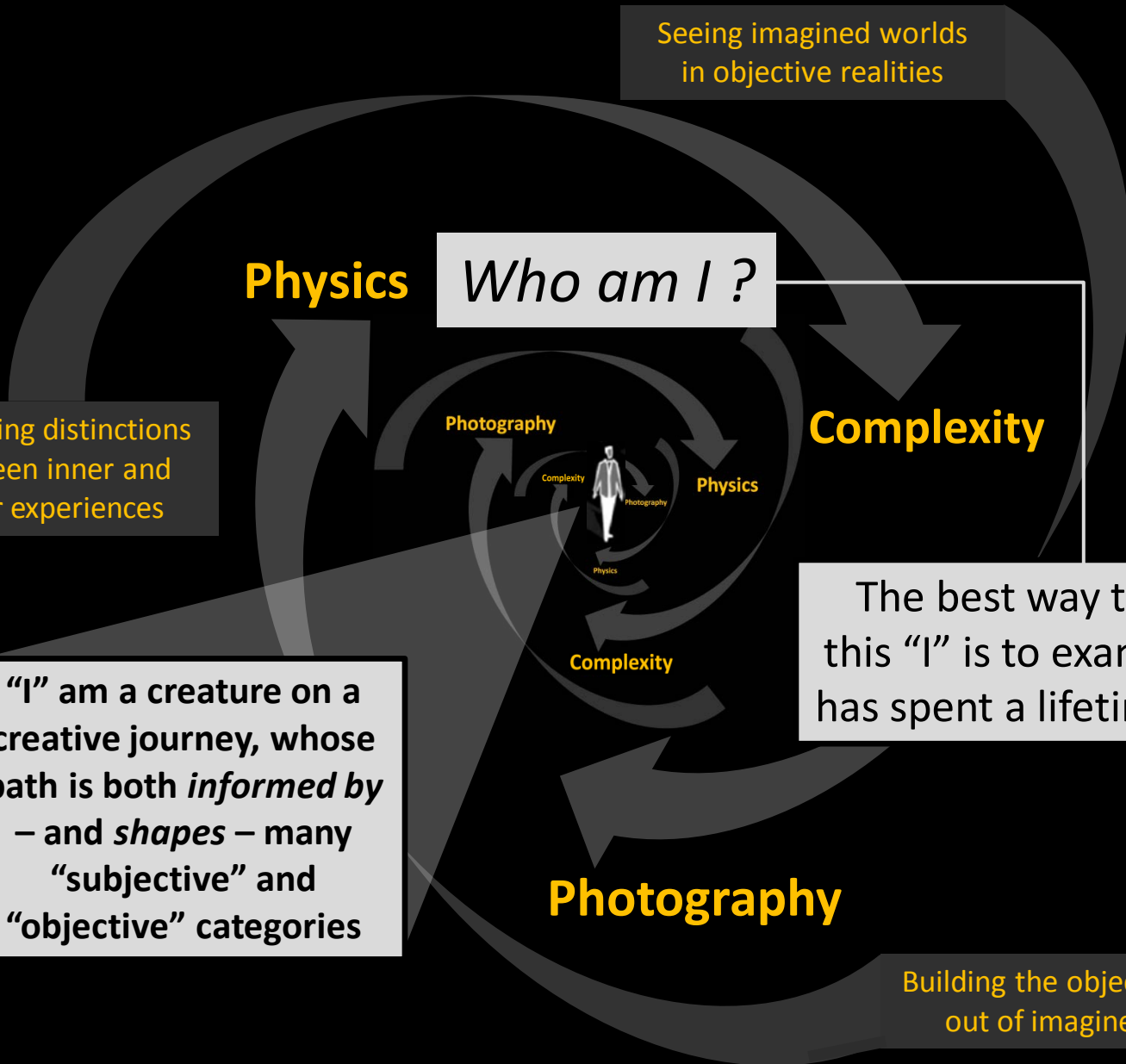
Physics

Physics

Complexity

Photography

Building the objective world
out of imagined parts



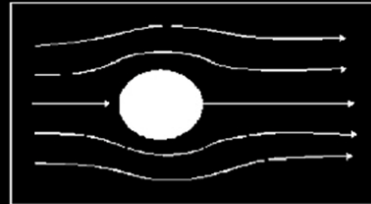
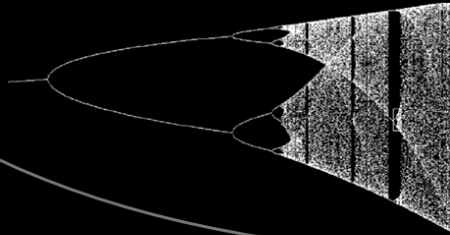
Sometimes I *ponder about physics* when something catches my eye...

**Navier-Stokes
Equations of Fluid Flow**

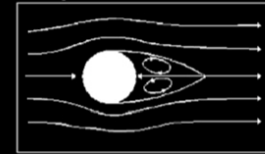
$$\begin{cases} \frac{\partial \vec{v}}{\partial t} + (\vec{v} \cdot \nabla) \vec{v} = -\frac{1}{\rho} \nabla p + \nu \nabla^2 \vec{v}, \\ \nabla \cdot \vec{v} = 0 \end{cases}$$

$$\delta \equiv \lim_{n \rightarrow \infty} \frac{\alpha_n - \alpha_{n-1}}{\alpha_{n+1} - \alpha_n} = 4.6692016091$$

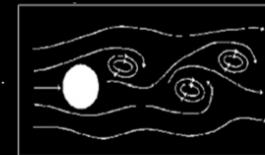
$$\Delta \equiv \lim_{n \rightarrow \infty} \frac{d_n}{d_{n+1}} = 2.5029078750 \dots$$



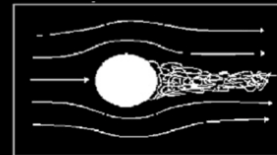
Reynolds Number $\sim 10^{-2}$



Reynolds Number ~ 10



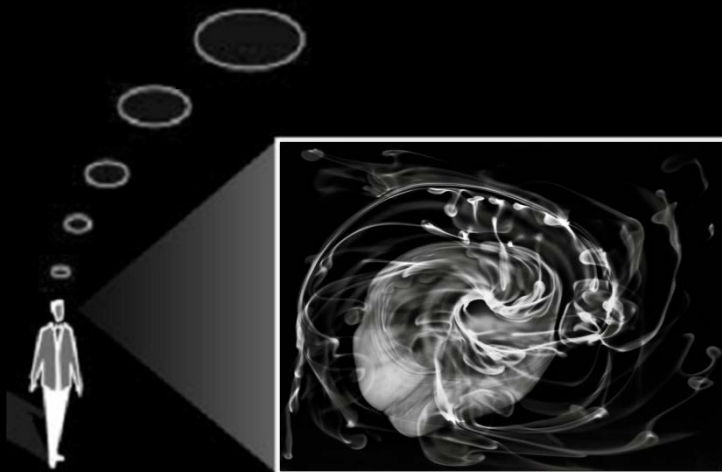
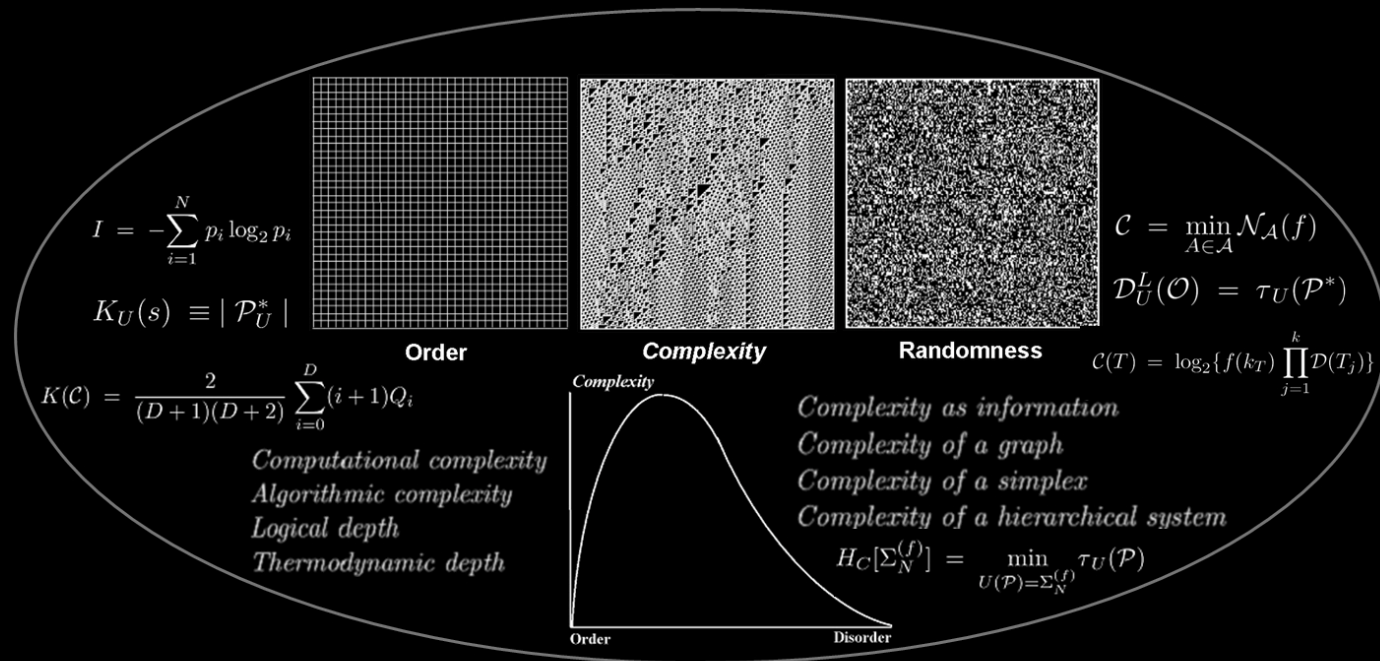
Reynolds Number ~ 100



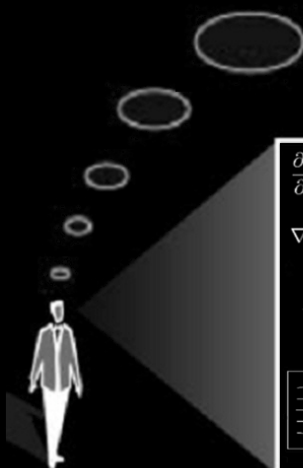
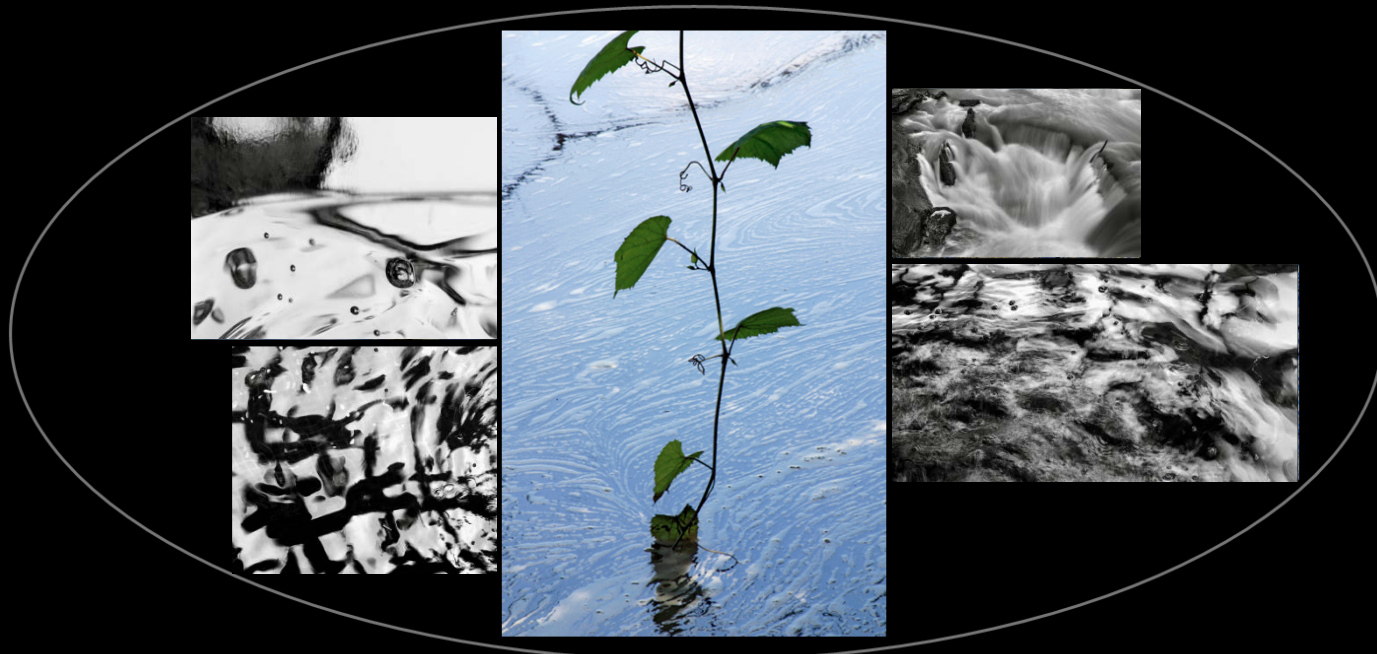
Reynolds Number $\sim 10^5$



Sometimes I *ponder about complexity* ...



Sometimes I use my physics to *steer my eye / camera*

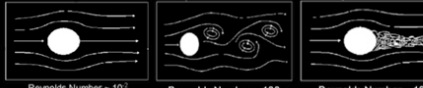
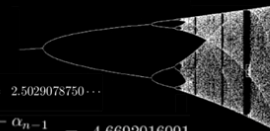


$$\frac{\partial \vec{v}}{\partial t} + (\vec{v} \cdot \nabla) \vec{v} = -\frac{1}{\rho} \nabla p + \nu \nabla^2 \vec{v},$$

$$\nabla \cdot \vec{v} = 0$$

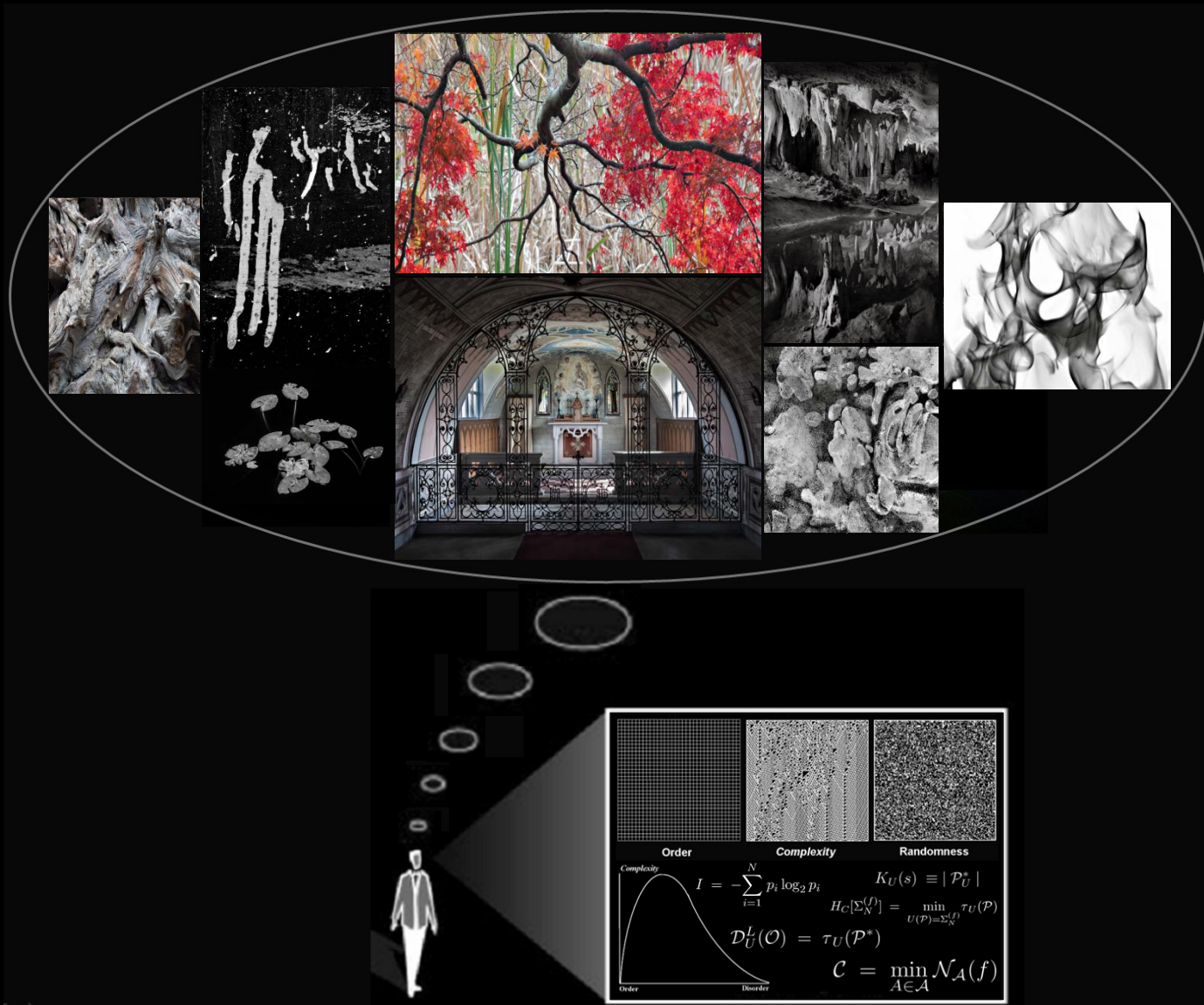
$$\Delta \equiv \lim_{n \rightarrow \infty} \frac{d_n}{d_{n+1}} = 2.5029078750 \dots$$

$$\delta \equiv \lim_{n \rightarrow \infty} \frac{\alpha_n - \alpha_{n-1}}{\alpha_{n+1} - \alpha_n} = 4.6692016091$$



Reynolds Number $\sim 10^2$ Reynolds Number ~ 100 Reynolds Number $\sim 10^3$

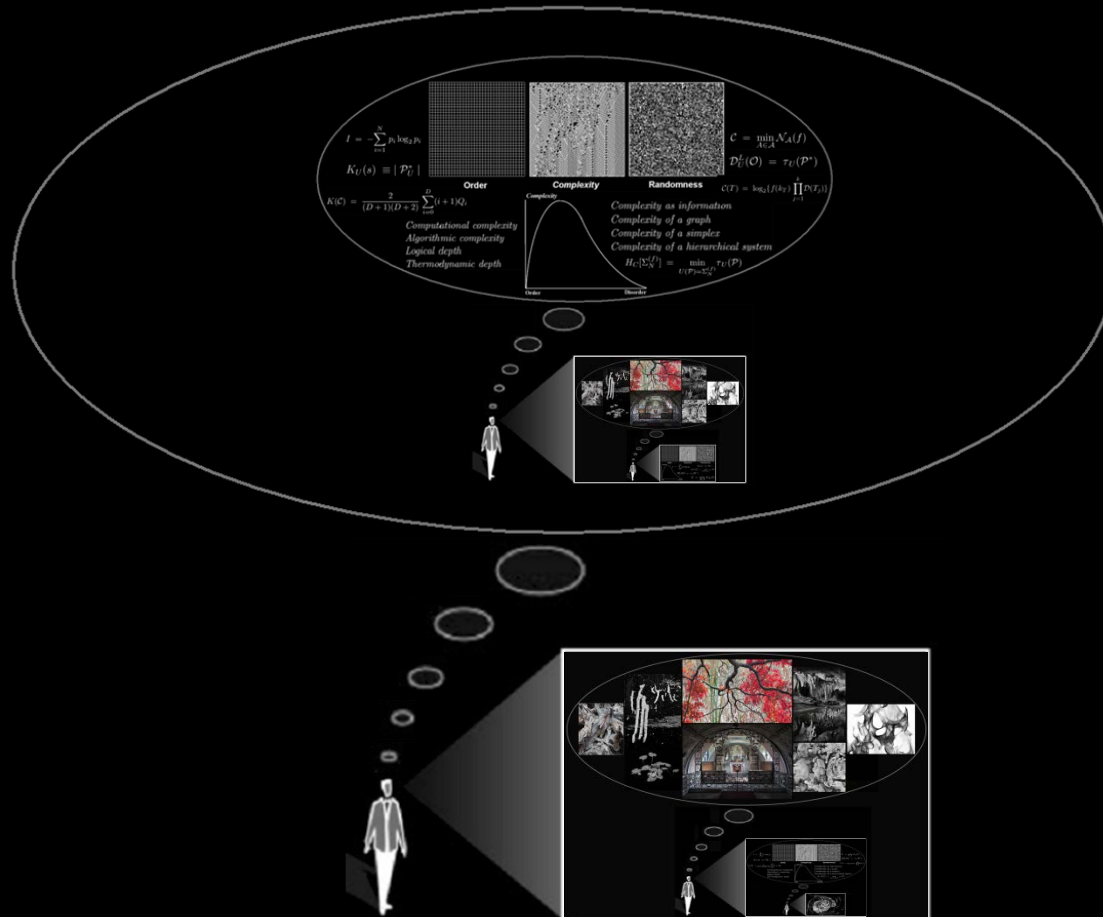
Sometimes complexity steers my eye / camera...



In truth, the “I” is a *complex nested creative process*...

[Art is a process] “...in which we give ourselves so deeply to our seeing that we take things right into ourselves and then give forth a new version of them from inside, tinted by all of the possibilities within us, transformed the way an oyster takes grit and makes a pearl.”

— Sean Kernan, *Photographer* (Lenswork, May 2004)



At first, the *photographer* finds the *picture*...

Something about the *photographer* draws him to it



At first, the *photographer* finds the *picture*...

Something about the *photographer* draws him to it

Physicist

Light,
Entropy,
Geometry

Poet

Romance, History,
Culture



Photographer A

Textures, Landscape

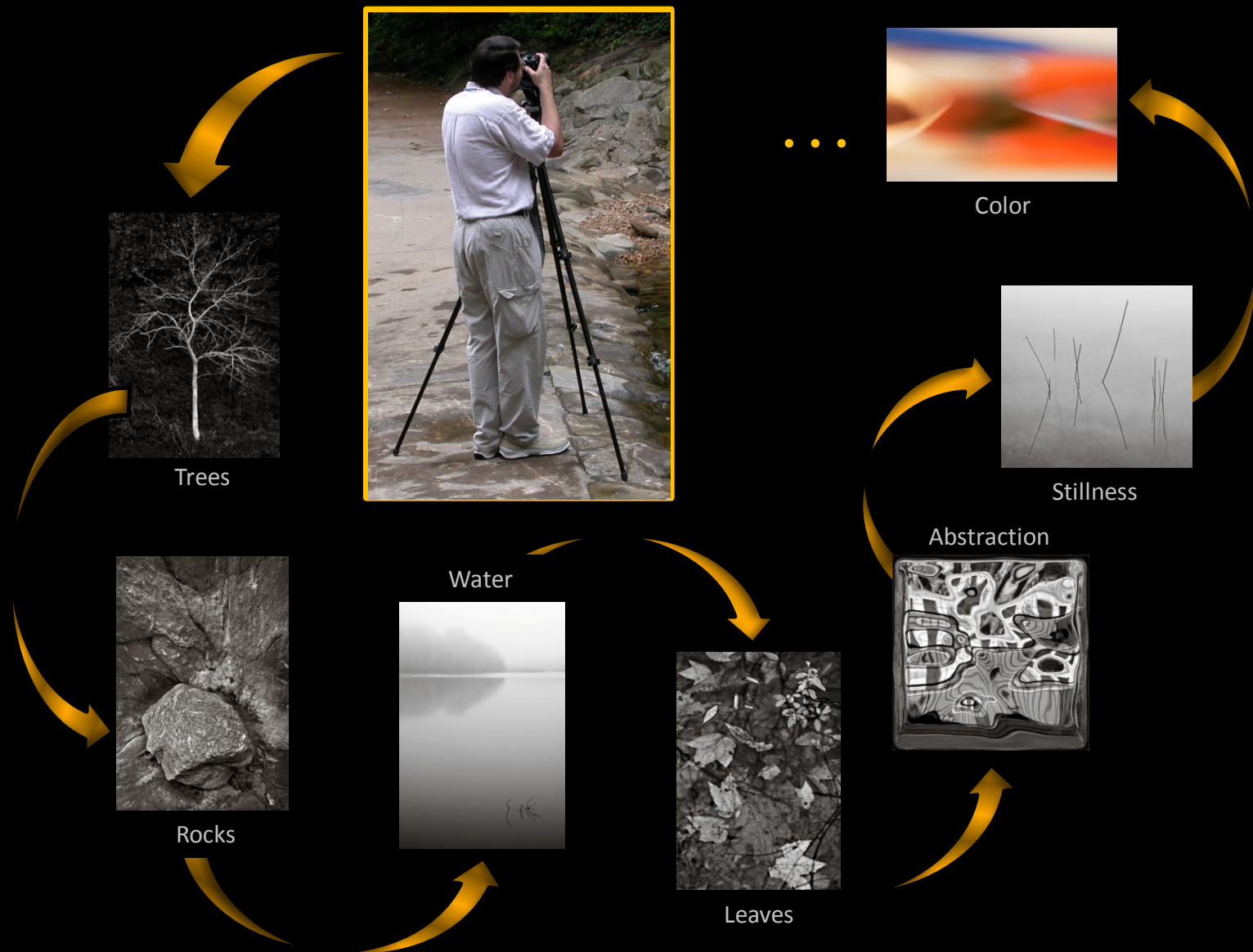
Photographer B

Dilapidated door,
Contrast

Photographer C

Tones, Forms

...the *pictures* discover a *path*...



...the path *assembles* itself...

Physics

Complexity

Photography

Common Theme

*Relationship between
the Whole and its Parts*

Physics

Patterns ↔ Order

Complexity

Micro ↔ Macro

Photography

*Compositional
Elements ↔ Image /
Meaning*

*Emergence,
Transcendence*

Eventually, the *path* defines the *photographer*



“Through the years,
a man peoples a space with images
of provinces, kingdoms, mountains,
bays, ships, islands, fishes, rooms,
tools, stars, horses and people.

Shortly before his death,
he discovers that the
patient labyrinth of lines traces
the image of his own face.”

— Jorge Luis Borges
(1899 - 1986)

Display/Portfolio: Synesthetic Landscapes

Synesthesia = Greek *syn* (“union”) plus *aisthaesis* (“sensation”) → “joined sensation”

Such as when something that is ordinarily “seen” is tasted as well

E.g., Wassily Kandinsky, Vladimir Nobokov, David Hockney, Richard Feynman, and Alexander Scriabin

How someone with *grapheme* → *color* synesthesia might perceive letters and digits

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
0 1 2 3 4 5 6 7 8 9

Synesthetic mapping	Freq (%)	Synesthetic mapping	Freq (%)
Graphemes → Colors	66.8	Personalities → Colors	4.4
Time → Colors	19.2	Pain → Colors	4.4
Music → Colors	14.5	Sound → Flavors	2.7
Sounds → Colors	12.1	Sound → Touch	2.7
Notes → Colors	10.4	Temperature → Colors	2.2
Phonemes → Colors	9.6	Sound → Smell	1.1
Flavors → Colors	6.3	Taste → Touch	1.1
Odors → Colors	5.8	Vision → Sound	1.1

Luminous Landscape

Online exhibit/essay; May 2015

Bodzin Art Gallery

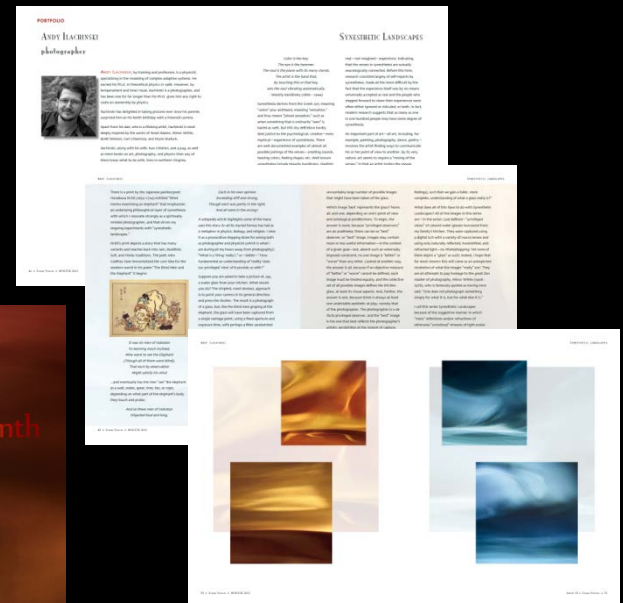
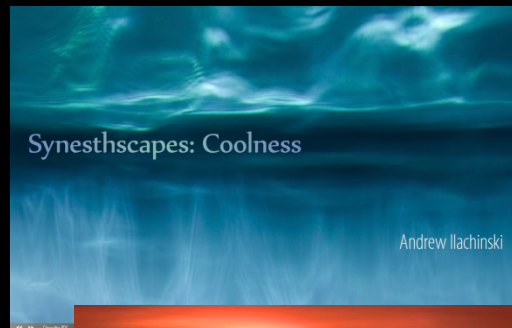
Solo Exhibit, Winter 2015

Lenswork Magazine

Issue #105, March-April 2013

Stone Voices Magazine

Winter 2013



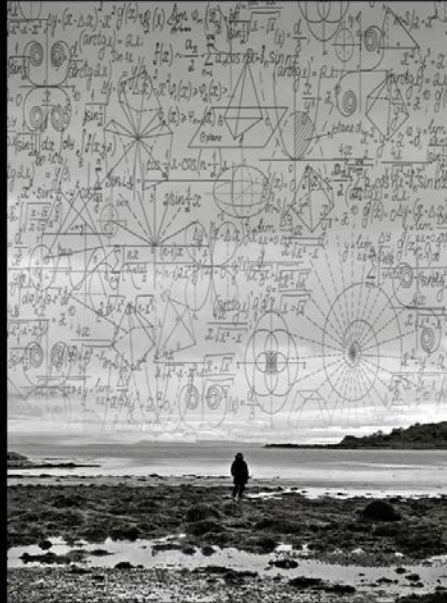


“When words become unclear,
I shall focus with photographs.
When images become inadequate,
I shall be content with silence.”

— ANSEL ADAMS

Science & Art: Self-Entangled Pathways Toward Inner & Outer Truths

2017 Humanities and Technology Association Conference



Dr. Andy Ilachinski
Center for Naval Analyses
703-824-2045
ilachina@cna.org

<http://tao-of-digital-photography.blogspot.com>
<http://www.sudden-stillness.com>

Questions?

Extra Slides →

A Lesson from a *Physicist*

“We are not only observers.
We are participators.
In some strange sense this is
a participatory universe...

...no phenomenon is a
real phenomenon; until it is
an *observed* phenomenon.”

— John Archibald Wheeler
(1911 – 2008, *Physicist*)



A Lesson from a *Complexity Theorist*



“There is a constant and intimate contact among the things that coexist and coevolve in the universe;

A sharing of bonds and messages that makes reality into a stupendous network of interaction and communication.”

— Ervin Laszlo (1932 - , *Systems Theorist*)

A Lesson from a *Photographer*



“There is no closed figure in nature
Every shape participates with another.
No one thing is independent of another,
and one thing rhymes with another,
and light gives them shape.”

— Henri Cartier-Bresson, (1908 – 2004, *Photographer / Artist*)

A Lesson from *Taoist Master*



“Before I had studied Zen for thirty years,
I saw mountains as mountains, and waters as waters...

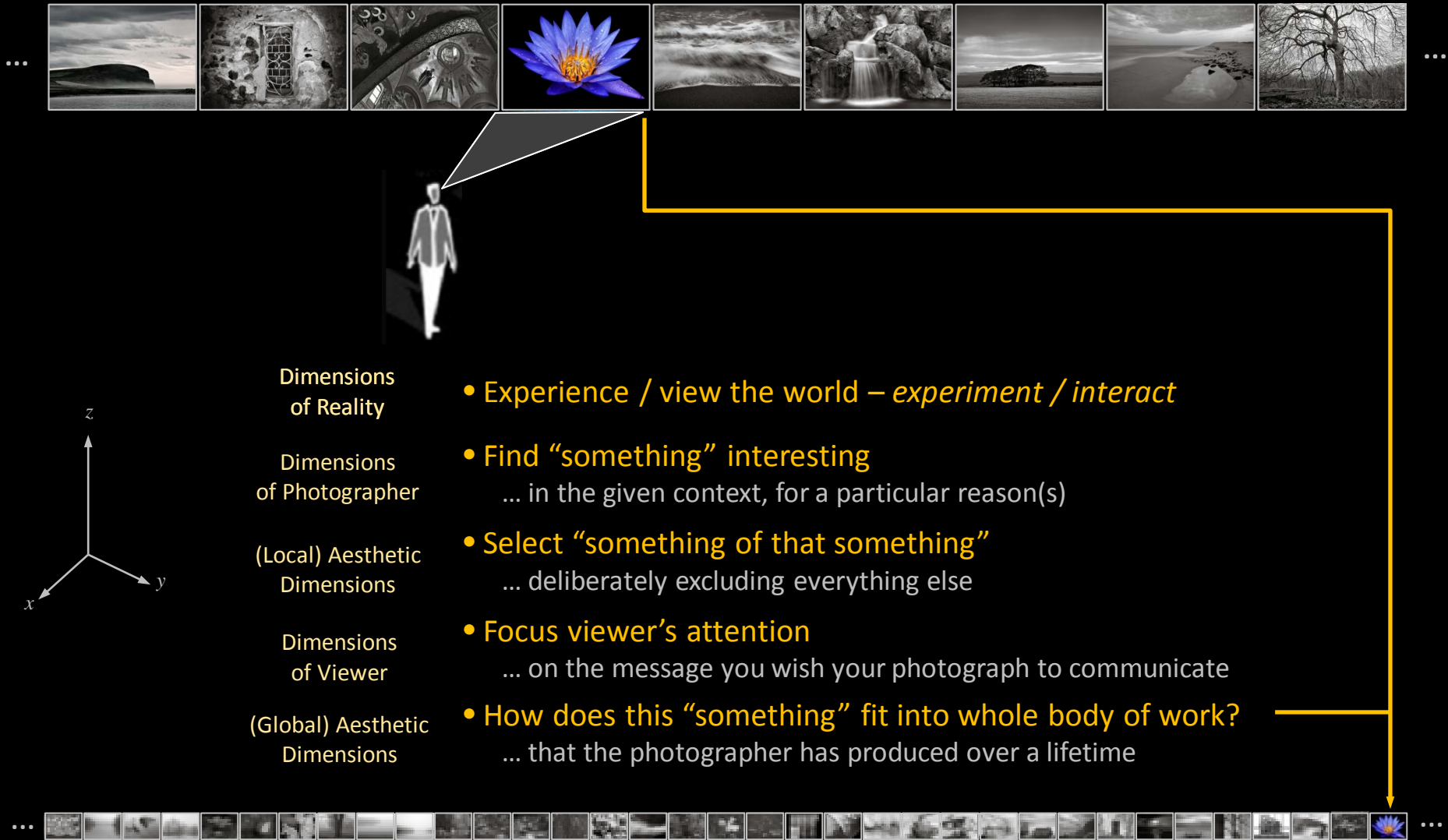
When I arrived at a more intimate knowledge, I came to the point where I saw
that mountains are not mountains, and waters are not waters.

But now that I have got its very substance I am at rest.
For it's just that I see mountains once again as mountains,
and waters once again as waters.”

— Ching-te Ch'uan Teng-lu (*“Transmission of the Lamp”*)

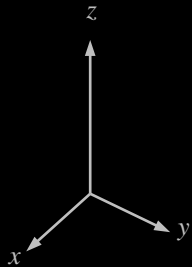
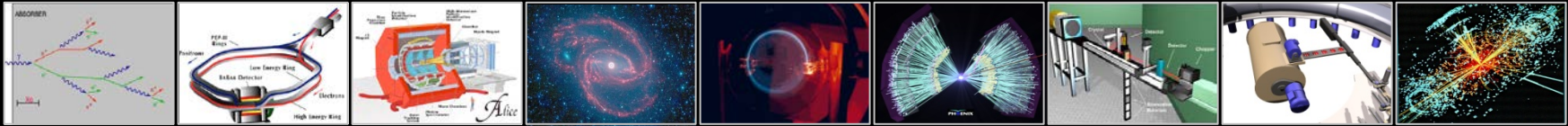
What Does a *Photographer* Do?

The multidimensional “art” of selection / pattern spaces



What Does a *Physicist* Do?

The multidimensional “art” of selection / pattern spaces



Dimensions
of Reality

Dimensions
of Physicist

(Local) Order
Dimensions

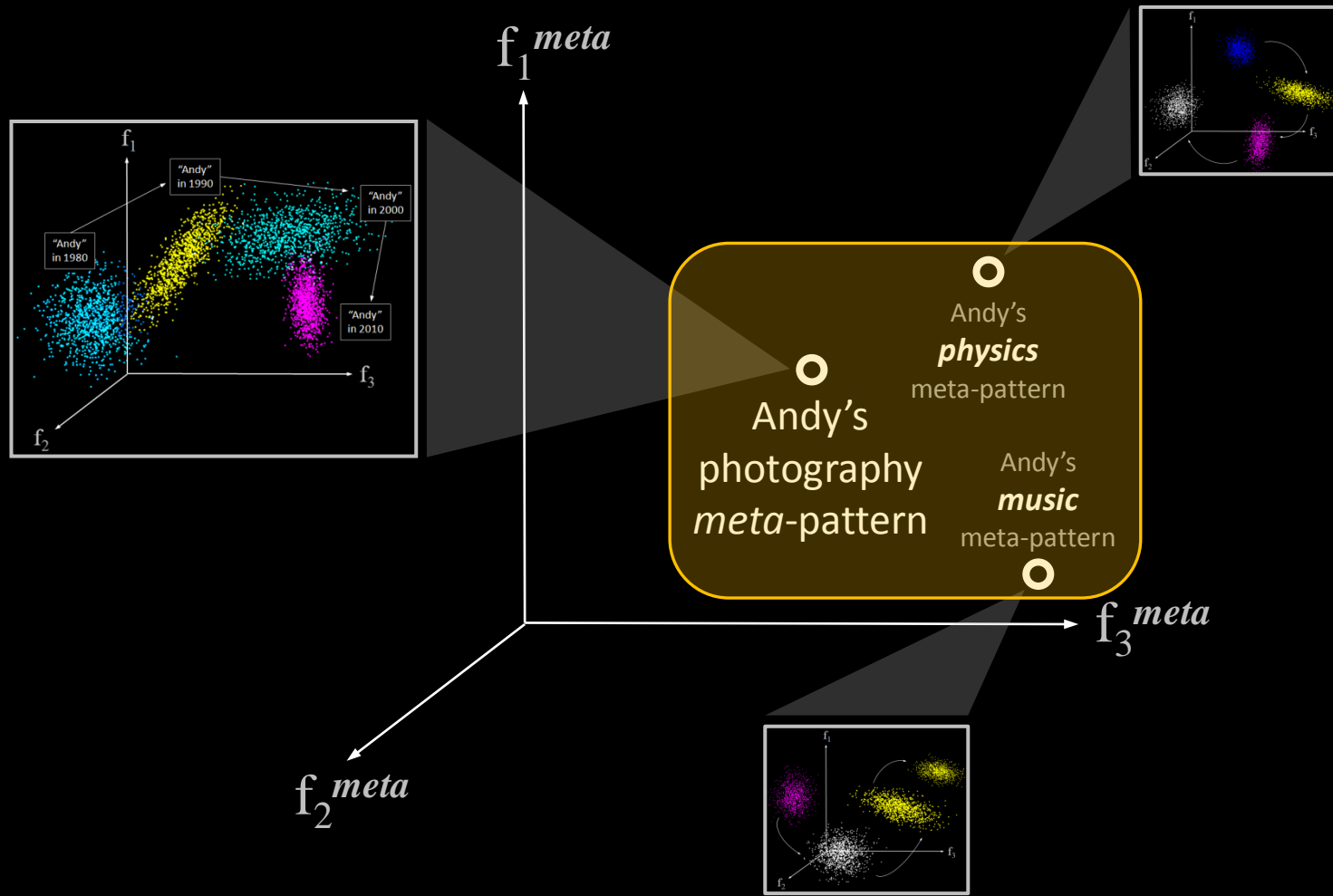
Dimensions
of Reviewer

(Global) Order
Dimensions

- Experience / view the world – *experiment / interact*
- Find “something” interesting
... in the given context, for a particular reason(s)
- Select “something of that something”
... deliberately excluding everything else
- Focus reviewer's attention (peer review)
... on the message you wish your physics to communicate
- How does this “something” fit into whole body of work?
... that the physicist has produced over a lifetime

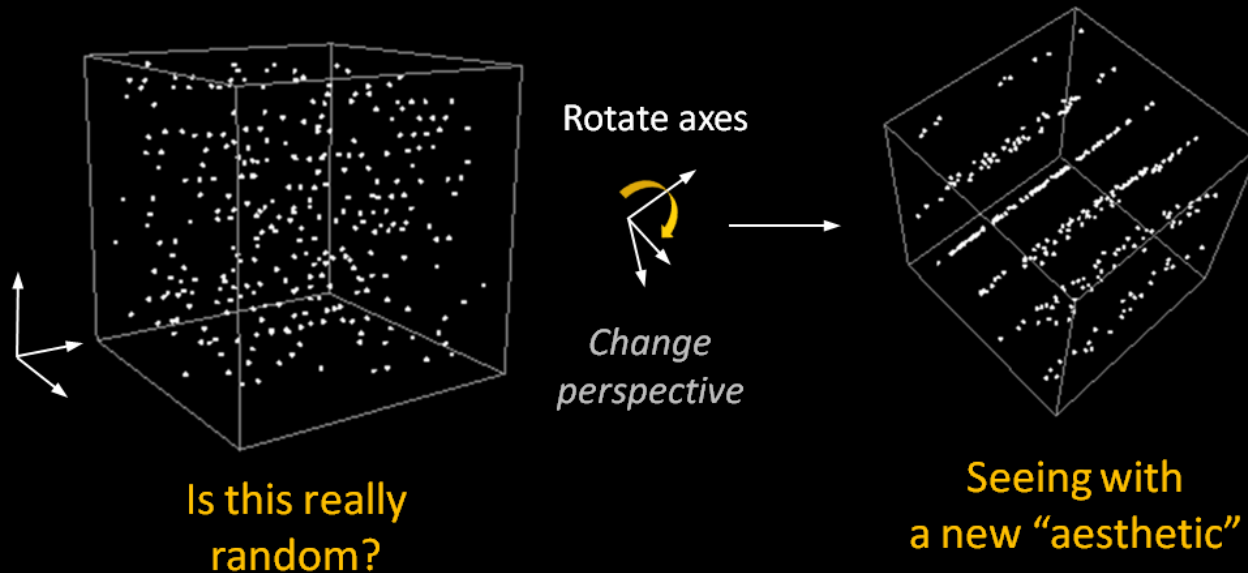


Evolving Aesthetic Landscapes



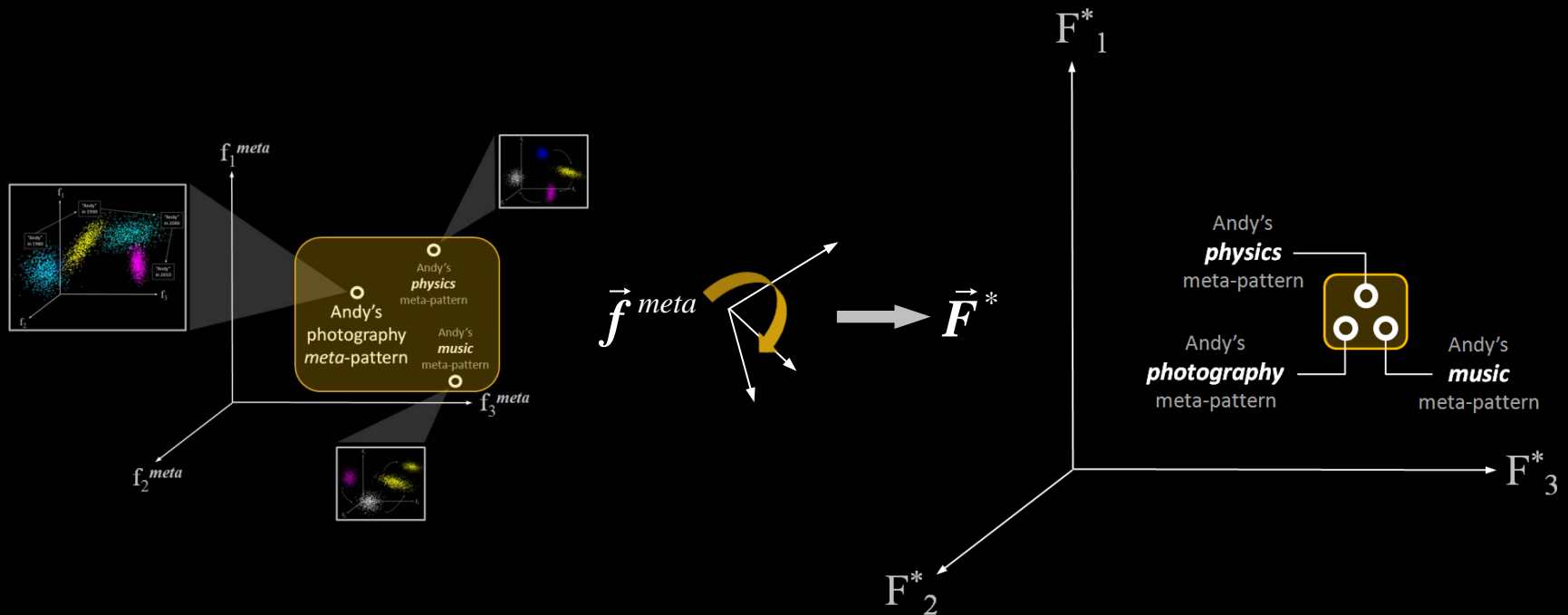
Evolving Landscapes

Point-of-View is everything!



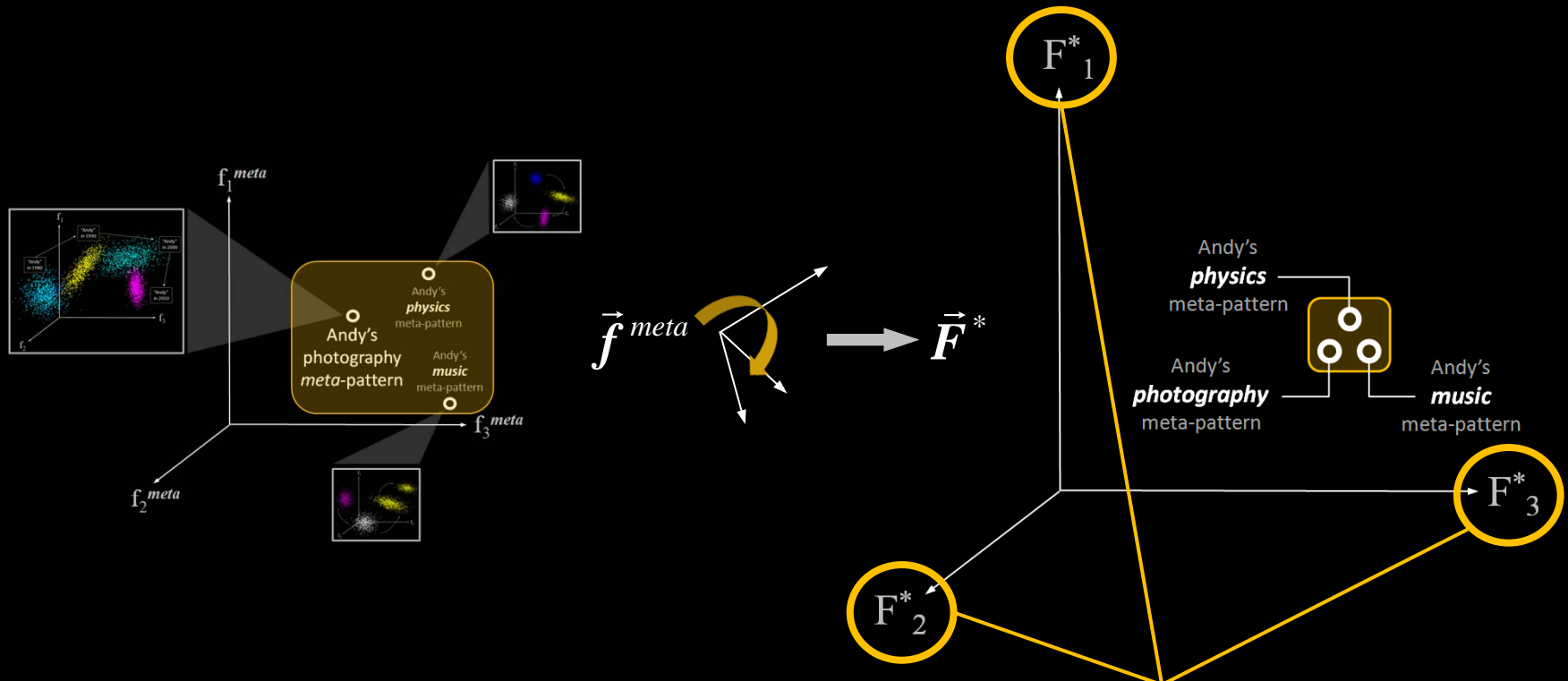
Evolving Landscapes

Is there a way to “rotate the aesthetic axes” so that ...



Evolving Landscapes

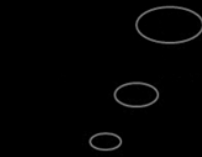
Is there a way to “rotate the aesthetic axes” so that ...



If so, then these features describe
“Andy’s” core meta-pattern – *his “I”* !

What do Physics & Complexity have to do with Art & Photography?

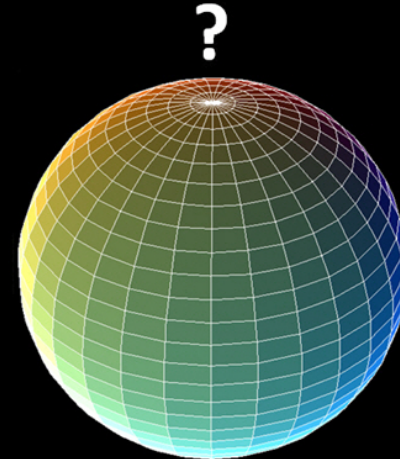
$$\begin{aligned} \dot{\mathbf{p}} &= -\frac{\partial H}{\partial \mathbf{q}} & \dot{\mathbf{q}} &= \frac{\partial H}{\partial \mathbf{p}} & \nabla \cdot \mathbf{E} &= 4\pi\rho & \nabla \times \mathbf{E} &= -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t} \\ \nabla \cdot \mathbf{B} &= 0 & PV &= nRT & S &= k \ln \Omega & \frac{dS}{dt} &\geq 0 \\ \Delta x \Delta p_x &\geq \frac{1}{2} \hbar & \nabla \times \mathbf{B} &= \frac{4\pi}{c} \mathbf{J} + \frac{1}{c} \frac{\partial \mathbf{E}}{\partial t} & \Delta E \Delta t &\geq \frac{1}{2} \hbar \\ dE &= dQ - dW & G_{\mu\nu} &= -8\pi G T_{\mu\nu} \\ i\hbar \frac{\partial \Psi}{\partial t} &= -\frac{\hbar^2}{2m} \frac{\partial^2 \Psi}{\partial x^2} + V(x) \Psi(x, t) \equiv \hat{H} \Psi(x, t) \end{aligned}$$



Particles (P, n, e⁻, π, ν, ...)

Mass (m)	Energy (E)
Inertia (I)	Fine-Structure Constant (α)
Momentum (p)	
Planck's Constant (h)	Spin (s)
	Speed of Light (c)
Gravitational constant (G)	

Traditional Physics



Reality

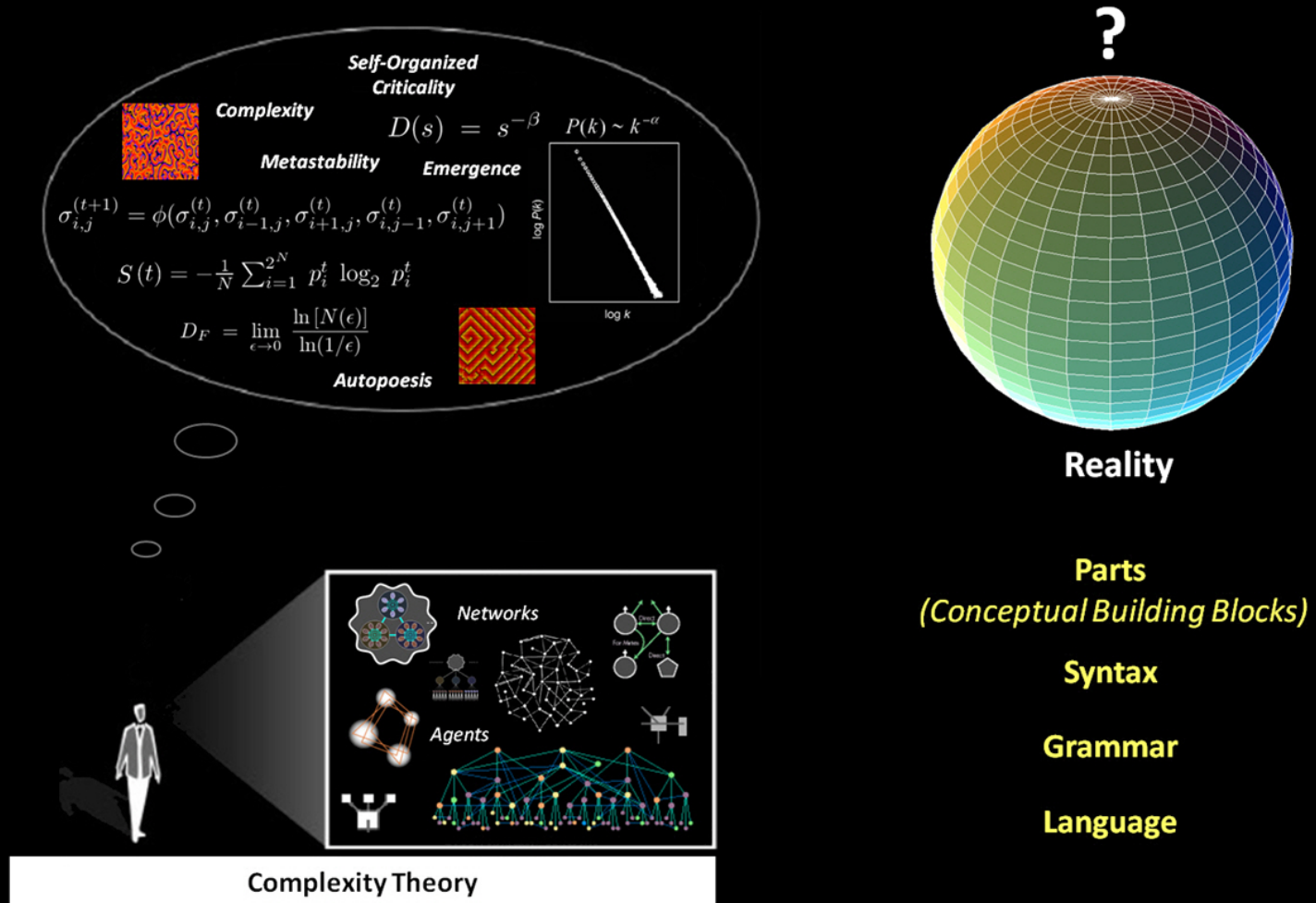
Parts
(Conceptual Building Blocks)

Syntax

Grammar

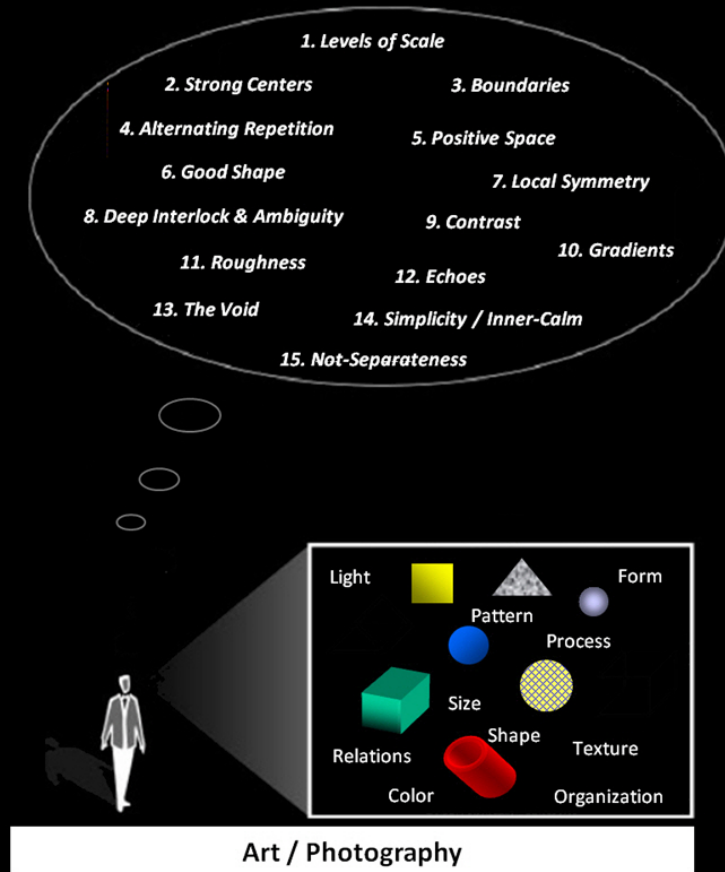
Language

What do Physics & Complexity have to do with Art & Photography?

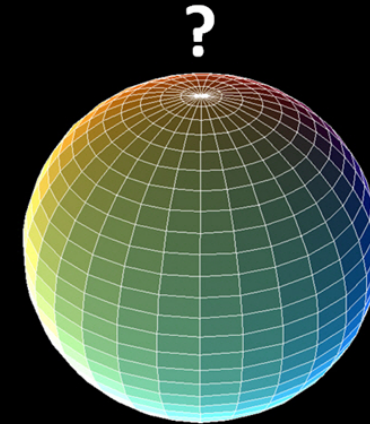


Graphical elements adapted from www.idiagram.com

What do Physics & Complexity have to do with Art & Photography?



Graphical elements adapted from www.idiagram.com



Reality

Parts
(Conceptual Building Blocks)

Syntax

Grammar

Language

Laws of Beauty?

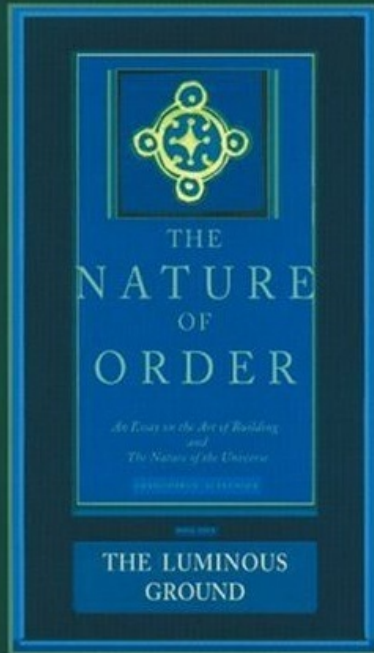
Christopher Alexander, *Nature of Order*
Center for Environmental Structure, 2003

Nature of Order

Everything is alive, it is only a matter of degree



Christopher Alexander, *Architect* (1936 -)



“Space itself, matter itself,
has life in varying degrees.

There is a consequence of function,
geometry, and feeling in space;
this space is conceived as a living fabric that
- through its structure - encompasses these things.

Space does not merely contain living structure.

Space has life, to a greater or lesser degree.

It is the space itself which resembles self,
which functions, which works,
which has living structure in it,
and which has life.”

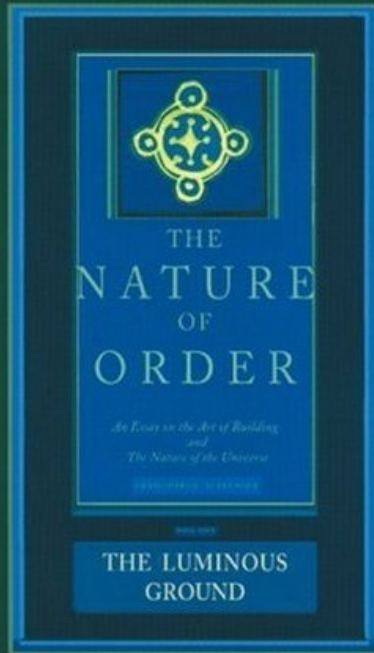
The life which appears
is an attribute of space itself.

Nature of Order

Everything is alive, it is only a matter of degree



Christopher Alexander, Architect (1936 -)



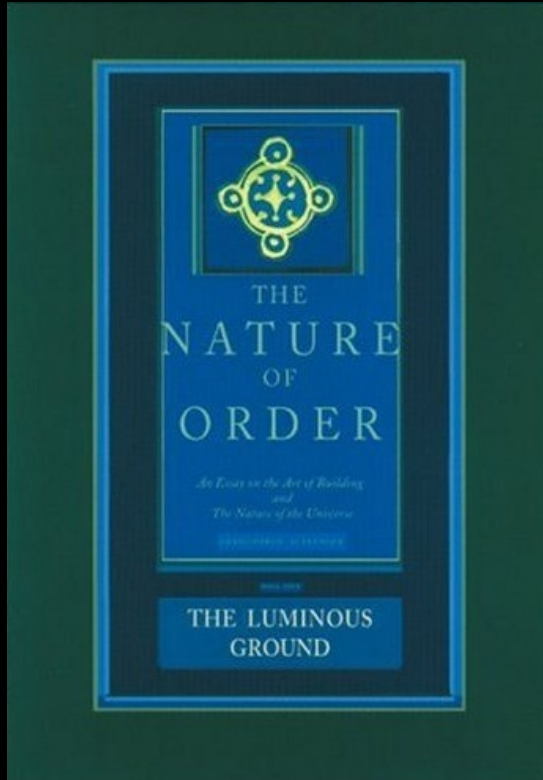
- There is a structure – called *wholeness* - visible in any given part of the world
- The wholeness is an abstract mathematical structure that exists at many levels of scale, and covers the interrelationships of the configurations at different scales
- The primary entities of which the structure is built are centers (which become activated in the space as a result of the configuration as a whole)
- Centers have different levels of strength or coherence, depending on relationships with other centers
- There are fifteen types of relationships among centers which increase or intensify the strength of any given center

Nature of Order

Everything is alive, it is only a matter of degree



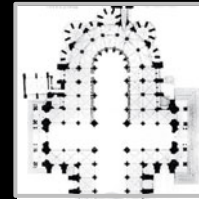
Christopher Alexander, *Architect* (1936 -)



Strong centers



Levels of scale



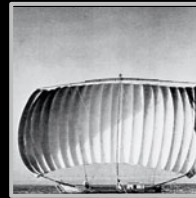
Boundaries



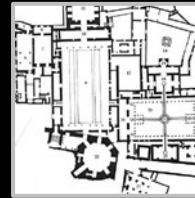
Alternating repetition



Positive space



Good shape



Local symmetries



Deep interlock & ambiguity



Contrast



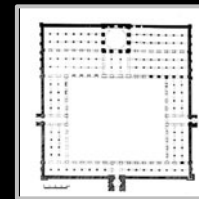
Gradients



Roughness



Echoes



The Void



Simplicity & inner calm



Non-seperateness

Physics, Complexity, and Photography: *One Last Take*

“...I see mountains once again as mountains, and waters once again as waters.”

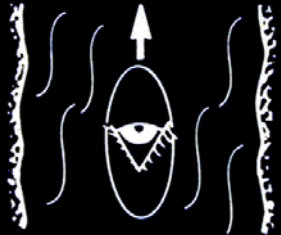


The observer is the stream
(Complexity theory / Tao)

Complexity / Tao: no fundamental distinction between “inside” / “outside”

- Forget about *things*...
- Forget about *categories*...
- Forget about *boundaries*...
- *Use camera to find the “I” behind lens!*

“...I came to the point where I saw that mountains are not mountains, and waters are not waters...”

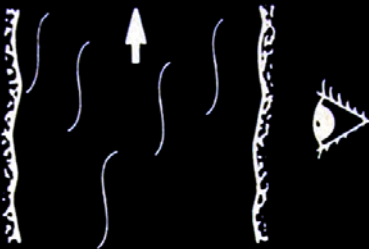


The observer attempts to steer a canoe in the stream
(Quantum physics / Photography)

Photography: find meaningful patterns

- Use *light, color, form, texture, and pattern* as primitive building blocks out of which to create “mini-worlds” interesting to you
- *You actively roam around the landscape!*

“Before I had studied Zen for thirty years, I saw mountains as mountains, and waters as waters...”



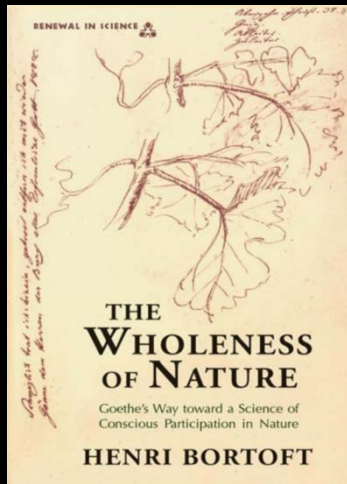
The observer is outside the stream
(Newtonian physics)

Physics: let it guide your eye & camera

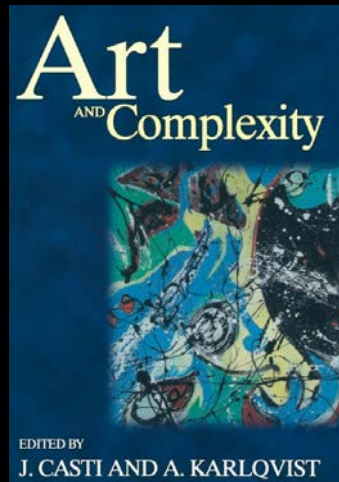
- Search for nature’s forms: *fractals, dynamics, symmetry, order, pattern, ... out there!*

References

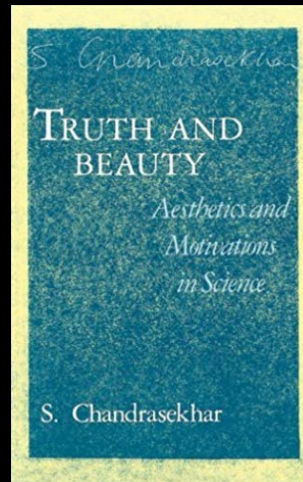
Some books on *physics / complexity / photography / art*



The Wholeness of Nature
Henri Bortoft



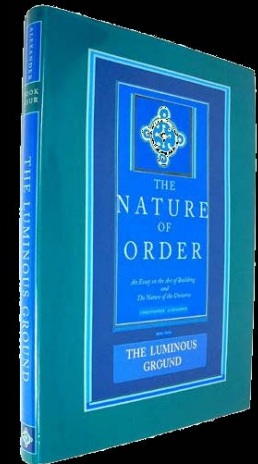
Art & Complexity
J. Casti, A. Karlqvist
(editors)



Truth & Beauty
S. Chandrasekhar



Exploring the Invisible
Lynn Gamwell



Nature of Order
Christopher
Alexander