Photography, Physics, and Complexity: Strange Bedfellows or a New Aesthetic?

Morrison House Presentation, August 2011

...with just a little bit of tao sprinkled in!

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Preamble

What am I here to talk about?

By day...
I am a physicist, specializing in chaos, complex systems, and mathematical modeling.

At all other times (that often intrude on the day)...
I am a photographer, who forgets all about physics, complexity, photography, even my “I”
I’m here to (attempt to) describe what the world that exists at the cusp of these two realms looks like from the **point of view of one ineffable “I”** (and to show a few photographs along the way ;-)

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**Preamble**

What am I here to talk about?
Photography
The art of capturing what a “thing” is to communicate what else a thing is

Physics
The science of distilling perceived order into simplest possible form

Complexity
Self-organized emergence of global order that arises from local simplicity

Themes / Questions
- Who decides what is “order”?
- Aesthetics ( “order principle”), patterns, emergence local vs. global, self-reference/organization, dynamics, multidimensional spaces, objective vs. subjective
- What does observed order say about the observer?
Let’s cut right to the chase

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

In a certain Chinese encyclopedia called the *Heavenly Emporium of Benevolent Knowledge*, (perhaps imagined, perhaps real), Jorge Luis Borges writes that

“...animals are divided into:
(a) those that belong to the emperor;
(b) embalmed ones; (c) those that are trained;
(d) suckling pigs; (e) mermaids;
(f) fabulous ones; (g) stray dogs;
(h) those that are included in this classification;
(i) those that tremble as if they were mad;
(j) innumerable ones;
(k) those drawn with a very fine camel's-hair brush;
(l) etcetera; (m) those that have just broken the flower vase;
(n) those that at a distance resemble flies.”
Let’s cut right to the chase

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)
Let’s cut right to the chase
Physics and photography both define and revel in categories, divisions, groupings, labels, orders, and partitions;

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

Let’s cut right to the chase

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

Art is the transcendence of subjective categories

Kandinsky, “First Abstract Watercolor” (1910 / 1911 ?)
Let’s cut right to the chase

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

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**Motion**
\[
\begin{align*}
\mathbf{v} &= \frac{\Delta \mathbf{x}}{\Delta t} = \mathbf{x}_2 - \mathbf{x}_1 \\
\mathbf{a} &= \frac{\Delta \mathbf{v}}{\Delta t} = \mathbf{v}_2 - \mathbf{v}_1 \\
s &= \mathbf{v}_1 t + \frac{1}{2} \mathbf{a} t^2 \\
v_f^2 &= v_i^2 + 2a(\mathbf{x}_f - \mathbf{x}_i)
\end{align*}
\]

**Forces**
\[
\begin{align*}
\Sigma \mathbf{F} &= \mathbf{ma} \\
F_i &= m \mathbf{a}_i
\end{align*}
\]

**Angular motion**
\[
\begin{align*}
\omega &= \frac{\Delta \Theta}{\Delta t} \\
\Theta &= \omega_0 t + \frac{1}{2} \omega t^2 \\
\omega^2 - \omega_0^2 &= 2a_0 \theta
\end{align*}
\]

---

**Gravity**
\[
F = \frac{G m_1 m_2}{r^2}
\]

**Work and energy**
\[
\begin{align*}
p &= m \mathbf{v} \\
KE &= \frac{1}{2} m v^2 \\
t &= \text{time} \\
W &= \mathbf{F} \cdot \mathbf{s} \\
KE &= \frac{1}{2} m v^2
\end{align*}
\]

---

**Simple harmonic motion**
\[
\begin{align*}
s &= A \cos \omega t \\
v &= A \omega \sin \omega t \\
a &= -A \omega^2 \cos \omega t
\end{align*}
\]

**Springs**
\[
T = \frac{1}{2} k x^2
\]

---

**Pendulums**
\[
T = 2\pi \sqrt{\frac{l}{g}}
\]

**Thermodynamics**
\[
\begin{align*}
C &= \frac{1}{2} (C + 2D) \\
F &= \frac{1}{2} (C + 2D) \\
K &= C + 2D + 1.5
\end{align*}
\]

---

**Electricity and magnetism**
\[
\begin{align*}
F &= \mathbf{E} \cdot \mathbf{q} \\
E &= \frac{F}{q} \\
W &= qV \\
C &= \varepsilon_0 \varepsilon
\end{align*}
\]

---

**Magnetic field from a wire**
\[
B = \frac{\mu_0 I}{2\pi r}
\]

**Magnetic field from a current loop**
\[
B = \frac{\mu_0 I}{2\pi r}
\]

**Magnetic field from a current loop**
\[
B = \frac{\mu_0 I}{2\pi r}
\]

---

Physics is a reduction / distillation of “objective categories”
Let’s cut right to the chase

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

Complexity and Tao remind us of the absurdity of dividing the world in this way! 😊

Tatsuya Ishida (http://sinfest.net/comikaze/comics/2010-02-01.gif)
What Do I mean by “New” Aesthetic?
Speculations spurred by a provocative question by a blogger friend

Q: How does solving a difficult problem is physics compare to capturing a great image in photography?

A: The *experience* – in each context – is exactly the same!

Half the talk is a discussion about what I mean by “exactly the same”
The other half is about the potential implications if this is really so;
*psychologically, creatively, and spiritually*
Most popular entries...

- Ergodicity and (Abstract) Art  
  May 2006

- Learning to See from the Blind  
  January 2009

- Unconscious Influence and the Creative Process  
  February 2009

- Sting, Goethe, and the Creative Process  
  August 2010

- Implicate Order, Enfolded Centers  
  January 2011

- Toward an Aesthetic Grammar  
  April 2007

- Traversing an N-Dimensional Aesthetic Space  
  March 2009

- The Click of the Shutter Button... and A Deep Mystery  
  November 2008
Outline

Part 1: Andy as photographer-physicist

• Who am “I” – Take #1 / Take #2
• A few lessons from a physicist, photographer, and taoist
• What a physicist does vs. what a photographer does
• Aesthetics – a physicist’s take; a “baby step” experiment
• Evolving landscapes (take #1 / #2 / #3)
• Complexity – a gentle introduction
• Steps Towards a Universal Language of Aesthetics?
• Who am “I” – Take #3

Part 2: Andy as physicist-photographer

A sampling of portfolios: examples of how one “photographic eye” is informed / shaped by physics, complexity, and Tao

– Chaos, Order, Complexity, Entropy (“Sudden Stillness” book)
– Micro Worlds
– Abstract Glyphs
– Swirls, Whorls, and Tendrils
– Tao
– “As Above; so Below” (latest project: Luray caverns, VA)

Physics, Complexity, and Photography: One Last Take
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Physics, Complexity, and Photography: One Last Take
Who Am I? – Take #1

Whatever I may know about light, tone, texture, form, and composition, I learned by watching my dad. He was not a photographer, but was an artist par excellence.

- 1960: Born / Glen Cove, Long Island, NY
- 1970: First camera
  Polaroid instamatic / Christmas gift
  First picture: (abstract?) closeup of my right toe
- 1978: First encounter with Tao Chuang-Tzu: Inner Chapters
- 1982: First “serious” camera
  Canon AE-1
- 1988: Ph.D. / theoretical physics
  Discrete Complex Systems
- 1998: First digital camera
  Nikon Coolpix 950
- 2001: First published book
  Cellular Automata (physics)
- 2002: First “serious” DSLR
  Canon D60
- 2007: First Solo Show
  Coral Gables, Florida
  First Lenswork portfolio
  DVD Edition #71 / July-August
- 2008: First self-published book
  Hawaii, Blurb.com (photography)
  First art co-op
  One of 14 founding members of Lorton Arts, Occoquan, VA
Who Am I? – Take #2

Who am I?

Physicist

Andy

Photographer

Complexicologist

1960: Born / Glen Cove, Long Island, NY
1970: First camera
Polaroid instamatic / Christmas gift
First picture: (abstract?) closeup of my right toe
1978: First encounter with Tao
Chuang-Tzu: Inner Chapters
1982: First “serious” camera
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Who Am I? – *Take #2*

**Physics**
- Dissolving distinctions between inner and outer experiences
- Building the objective world out of imagined parts

**Complexity**
- Seeing imagined worlds in objective realities
- Who am I?

**Photography**
- Andy
- Physicist
- Complexicologist
- Photographer

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Who am I?
Sometimes I *ponder about physics* when something catches my eye.
Sometimes I *ponder about complexity* ...
Sometimes I use my physics to **steer my eye / camera**.
Sometimes I use my complexity to **steer my eye / camera**
In truth, the core “Andy” 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)
Who Am I? – Take #2

“"I" am a creature on a creative journey, whose path is both informed by - and shapes - many "subjective" and "objective" categories.

Hypothesis

The best way to discover this "I" is to examine what it has spent a lifetime creating.

Seeing imagined worlds in objective realities

Dissolving distinctions between inner and outer experiences

Building the objective world out of imagined parts

Physics

Who am I?

Photography

Complexity
Outline

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Physics, Complexity, and Photography: One Last Take
“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
Physicist (1911 - 2008)
A Lesson from a Complexicologist

“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

Philosopher & Systems Theorist (1932 - )
“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, Photographer / Artist (1908 - 2004)
“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")
Takeaway #1
All partitions are arbitrary

“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
(Anthropologist, 1904 – 1980)
“All is process. That is to say, there is ‘no thing’ in the universe. Things, objects, entities, are abstractions of what is relatively constant from a process of movement and transformation.

They are like the shapes that children like to see in clouds..”

— DAVID BOHM

(Physicist, 1917 – 1992)
Takeaway #3
All is organized energy

“Science shows us that the visible world is neither matter nor spirit; the visible world is the invisible organization of energy.”

— HEINZ PAGELS
(Physicist, 1939 – 1988)
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Physics, Complexity, and Photography: One Last Take
What Does a **Physicist** Do?

The multidimensional “art” of selection / pattern spaces

- **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
What Does a **Photographer** Do?

The multidimensional “art” of selection / aesthetic spaces

• Experience / view the world – *experiment* / *interact*

• Find “something” interesting
  ... in a given context, for a particular reason(s)

• Select “something of that something”
  ... you wish to capture, deliberately excluding everything else

• **Focus viewer’s attention**
  ... on the message you wish your photograph to communicate

• **How does this “something” fit into whole body of work?**
  ... that the photographer has produced over a lifetime
What Does a Photographer Do?

The multidimensional “art” of selection/aesthetic spaces

Core of Creative Process Is Selection

- Selecting **where to look**
- Selecting **what to take a picture of**
- Selecting **camera, lens, aperture, exposure, ...**
- Selecting **what to emphasize in post-processing**
- Selecting **who/where to show**
- Selecting **what to keep in (long-term) portfolio**

Aesthetic
An artist’s pattern of selections
(in some n-dimensional feature space)
Outline

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Physics, Complexity, and Photography: One Last Take
Aesthetics (a Physicist’s Take... ;-)

“To me, photography is an art of observation. It’s about finding something interesting in an ordinary place... I’ve found it has little to do with the things you see and everything to do with the way you see them.”

- Elliot Erwitt, Photographer (1928 - )

• Why **this** instead of that?

• An ordering principle

Is this really random?

[Diagram showing a 3D perspective change with text: Rotate axes, Change perspective]

Seeing with a new “aesthetic”
A “Baby Step” Experiment

Sudden Stillness
Visual Echoes of Timeless Rhythms
Photographs by Andy Bachinski

Chaos | Order | Complexity | Entropy

Dialectic
Transition
Figure / Ground
Repetition
Distinction
Stability
Balance
Organization
Coherence
Geometry
A “Baby Step” Experiment

Sudden Stillness
Visual Echoes of Timeless Rhythms
Photographs by Andy Bachinski

http://www.blurb.com/bookstore/detail/245471

Chaos  Order  Complexity  Entropy

Extrusion
Fine / Course
Dislocation
Stability
Modularity
Planarity
Opposition
Overlap
Geometry
Proximity

COSMIC MYSTERY 2
A “Baby Step” Experiment

Sudden Stillness

Visual Echoes of Timeless Rhythms

Photographs by Andy Bachinski

http://www.blurb.com/bookstore/detail/245471

Chaos
Order
Complexity
Entropy

Geometry
Gestalt
Dissonance
Dominance
Organization
Interlock
Assembly
Connection
Angularity
Scale

FROZEN SPIRIT

(See entry in “Notes” section on page 160)
**A “Baby Step” Experiment**

**Sudden Stillness**  
Visual Echoes of Timeless Rhythms  
Photographs by Andy Bachinski


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**Most Common Features**  
Harmony  
Interlock  
Interpenetration  
Stillness  
Unity

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A “Baby Step” Experiment

Sudden Stillness
Visual Echoes of Timeless Rhythms
Photographs by Andy Rachinski

Most Common Feature-Feature Pairs
- Figure-Ground / Geometry
- Coherence / Harmony
- Dialectic / Gestalt
- Dynamics / Stillness
- Distinction / Interpenetration

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<td>Process</td>
<td>Topology</td>
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<td>Imitation</td>
<td>Proportion</td>
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<td>Proximity</td>
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<td>Instability / Stability</td>
<td>Randomness</td>
<td>Transparent / Opaque</td>
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<td>Dissimilarity</td>
<td>Integration</td>
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<td>Repetition</td>
<td>Unpredictability</td>
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<tr>
<td>Diversity</td>
<td>Interlock</td>
<td>Resonance</td>
<td>Variety</td>
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A “Baby Step” Experiment

Sudden Stillness
Visual Echoes of Timeless Rhythms
Photographs by Andy Bachinski

http://www.blurb.com/bookstore/detail/245471

Most Common Feature-Feature Triplets
Balance / Coherence / Synergy
Dialectic / Gestalt / Resonance
Interlock / Unity / Unfolding
Dynamics / Stillness / Process
Balance / Interpenetration / System
A “Baby Step” Experiment

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http://www.blurb.com/bookstore/detail/245471

Chaos
Order
Complexity
Entropy

- Analogy
- Angularity
- Assembly
- Asymmetry
- Attraction
- Balance
- Boundary
- Centeredness
- Clusteredness
- Coherence
- Coincidence
- Combination
- Compound
- Connection
- Convergence
- Cooperation
- Coordination
- Dialectic
- Diffusion
- Direction
- Dislocation
- Dissimilarity
- Dissonance
- Distinction
- Diversity

- Dominance
- Dynamics
- Enfolding
- Equilibrium / Disequilibrium
- Equivalence
- Extrusion
- Field
- Figure / Ground
- Fine / Coarse
- Geometry
- Gestalt
- Gradient
- Group
- Harmony
- Heterogeneity
- Hierarchy
- Holarchy
- Homogeneity
- Imitation
- Influence
- Instability / Stability
- Integration
- Interaction
- Interdependence
- Interlock

- Interpenetration
- Interrelation
- Intersection
- Mixture
- Modularity
- Negative / Positive
- Neutrality
- Opposition
- Organization
- Orientation
- Overlap
- Parallel
- Partition
- Penetration
- Perspective
- Planarity
- Position
- Process
- Proportion
- Proximity
- Randomness
- Redundance
- Reflection
- Repetition
- Resonance

- Scale
- Separability
- Sequential
- Similarity
- Space
- Stability
- Stillness
- Stress
- Subtraction
- Superposition
- Surface
- Symmetry
- Synergy
- Synesthesia
- System
- Tension
- Tonality
- Topology
- Transformation
- Transition
- Transparent / Opaque
- Unfolding
- Unity
- Unpredictability
- Variety

Andy’s aesthetic space
as observed by Andy
observing his own photographs
Photography in 100 Words: David Clark

David Bailey
Henry Benson
Y.-A. Bertrand
Steve Bloom
Nick Brandt
Joe Cornish
David Doubilet
Elliot Erwitt
Ralph Gibson
David Hurn
Michael Kenna
Steve McCurry
J. Meyerowitz
Martin Parr
Paolo Pellegrin
Dennis Stock
Denis Thorpe
Charlie Waite
Art Wolfe

... ideas ... stories ... motion ... crisis ... wonder ... provoke ... metaphor ... exploration ... emotional ... challenge ... truth ... serendipitous ... inquisitive ...
Part 1: Andy as photographer-physicist

- Who am “I” – Take #1 / Take #2
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A sampling of portfolios: examples of how one “photographic eye” is informed / shaped by physics, complexity, and Tao

- Chaos, Order, Complexity, Entropy ("Sudden Stillness" book)
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- Abstract Glyphs
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- Tao
- “As Above; so Below” (latest project: Luray caverns, VA)

Physics, Complexity, and Photography: One Last Take
Evolving Landscapes: *Take #1*

- **1960**: Born / Glen Cove, Long Island, NY
- **1970**: First camera
  Polaroid instamatic / Christmas gift
  First picture: *(abstract?) closeup of my right toe*
- **1978**: First encounter with Tao Chuang-Tzu: *Inner Chapters*
- **1982**: First “serious” camera
  Canon AE-1
- **1988**: Ph.D. / theoretical physics
  *Discrete Complex Systems*
- **1998**: First digital camera
  Nikon Coolpix 950
- **2001**: First published book
  *Cellular Automata* (physics)
- **2002**: First “serious” DSLR
  Canon D60
- **2007**: First Solo Show
  *Coral Gables, Florida*
  First *Lenswork* portfolio
  *DVD Edition #71 / July-August*
- **2008**: First self-published book
  *Hawaii*, Blurb.com (photography)
  First art co-op
  One of 14 founding members of *Lorton Arts*, Occoquan, VA

<table>
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<tr>
<th>Transition #1</th>
<th>B&amp;W / Darkroom</th>
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<tbody>
<tr>
<td></td>
<td>Photography: <em>Everything</em></td>
</tr>
<tr>
<td></td>
<td><em>(that catches the eye)</em></td>
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</table>

<table>
<thead>
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<td>“Serious” printing: <em>outsourced</em></td>
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<tr>
<td></td>
<td>Photography: <em>Things / Places</em></td>
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</tbody>
</table>

<table>
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<tr>
<th>Transition #3</th>
<th>B&amp;W / Photoshop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“Serious” printing: <em>self</em></td>
</tr>
<tr>
<td></td>
<td>Photography: <em>Feelings / Mood / Projects</em></td>
</tr>
<tr>
<td></td>
<td>Started entering juried contests</td>
</tr>
</tbody>
</table>
Evolving Landscapes: Take #2

Stage 1: Joyful snapshots of anything and everything
   → First camera, excited about anything & everything

Stage 2: A passive stirring of aesthetic value
   → Certain objects draw a deeper attention than others

Stage 3: Willful engagement of the aesthetic environment
   → Photographer actively seeks out images of interest
   → Both difficult to see "from the outside" and dramatic

Stage 4: Recognition of the power of expression
   → Photographer discovers how to express not the object itself, but what draws attention to the object

Stage 5: One picture is not enough
   → Photographer begins to see the world as a patchwork; a tapestry of images

Stage 6: Need to tell a story
   → Focus on portfolios of interrelated images as elements of narrative
   → Interested in telling a story about what the eye (and heart) is drawn to, and why

Stage 7: Portfolios of Portfolios
   → Work begins to transcend a “mere” aesthetic impression of the world to an imprint of a deeper aesthetic order of the external world
   → Photographer “discovers” the patterns of the world by observing her own work

Stage 8: Self-discovery
   → Outwardly similar to Stage-7 (to others)
   → Inwardly, photographer “discovers” truths about her own soul
Evolving Landscapes: Take #3

- Andy's photography
- Andy's physics
- Andy's music

Meta-patterns in the landscape.
Evolving Landscapes: *Take #3*

Remember earlier illustration?

Is this really random?

Rotate axes

*Change perspective*

Seeing with a new “aesthetic”
Evolving Landscapes: *Take #3*

Is there a way to “rotate the aesthetic axes” so that ...
Evolving Landscapes: Take #3

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

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

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

Interactive Map → http://www.art-sciencefactory.com/complexity-map_feb09.html
Bertalanffy / Wiener / Ashby / ...
(Cybernetics & Systems Theory, 1940s-1950s)

Shifted focus from mass, energy, and force to **feedback**, **control**, **information**, and **communication**

→ *Introduced new “aesthetic” components for a new (and still evolving) worldview of nature*
Complexity: Timeline

Varela / Maturana / Kauffman / ...  
(Complexity Science, 1970s-1990s)

Autopoiesis = Self-Creation  
(Greek: auto = “self” and poiesis = “creation”)

1. Dynamic form is only incompletely specified by properties of “objects”
2. Systems defined by self-referential form-preserving transformations

Interactive Map →  http://www.art-sciencefactory.com/complexity-map_feb09.html
Complex Systems: A Gentle Introduction

Holons

Individual components on various levels of a system are simultaneously...

- wholes
- (self-assertive)
- and parts
- (integrative)

Arthur Koestler (1967)
The Ghost in the Machine
Complex Systems: A Gentle Introduction

To which we can add an inner creative tendency

Self-reflective

Self-assertive

Integrative

Holons

Individual components on various levels of a system are simultaneously...

wholes

(self-assertive)

and parts

(integrative)

Arthur Koestler (1967)
The Ghost in the Machine

“Self-excited Circuit”
JOHN ARCHIBALD WHEELER
Law Without Law (1983)

http://www.idiagram.com/examples/complexity.html
Complex Systems: A Gentle Introduction

To which we can add an *inner creative* tendency

**Self-reflective**

**Self-assertive**

**Integrative**

Arthur Koestler (1967)
*The Ghost in the Machine*

**Holons**

Individual components on various levels of a system are simultaneously...

*wholes*  
*(self-assertive)*

and *parts*  
*(integrative)*

“Your vision will become clear only when you can look into your own heart. Who looks outside, dreams; who looks inside, awakens.”

---

JOHN ARCHIBALD WHEELER

CAVUS

“Your vision will become clear only when you can look into your own heart. Who looks outside, dreams; who looks inside, awakens.”

---

CARL JUNG
Complex Systems: A Gentle Introduction

Properties

- **Diverse heterogeneity**
  - Components defined by many properties and behaviors

- **Nonlinear interactions**
  - Small perturbations may cause a large effect

- **Local information processing / decentralized**
  - Components only know a small “part” of the system

- **Relationships contain feedback loops**
  - Both negative (damping) and positive (amplifying) feedback

- **Multiple simultaneous scales of resolution**
  - Agents, meta-agents, .... system

- **Self-organization & phase transitions**

- **Emergent behavior**
  - Global patterns cannot be deduced from local behavior

- **Open to the environment**
  - Nonequilibrium patterns & order; boundaries difficult to define; observer dependent

- **Adaptive**
  - Prior states influence present states; learning

- **Understanding requires both analysis & synthesis**
  - Components may themselves be “complex systems”

http://www.idiagram.com/examples/complexity.html
Complex Systems: A Gentle Introduction

Examples

- Brain / nervous system (Kandel & Squire, 2000)
- Biological cells, organisms
- Biosphere (Levin, 1998)
- Combat dynamics (Ilachinski / CNA, 2000+)
- Communication networks (Barabasi, 2000)
- Economies / financial markets (Arthur, 1994)
- Ecosystems (Sigmund 1993)
- Gene-regulatory networks (Kauffman, 1993)
- Global climate (Lovelock, 1995)
- Human culture (Luhmann, 1984)
- Immune system (Segel, 2000)
- Insect colonies (Bonabeau, 1999)
- Internet / WWW (Mayer-Kress, 1995)
- Natural evolution (Smith & Szamary, 1995)
- Organizations (Forrester, 1960s)
- Pedestrian / vehicular flow (Still, 2000)
- Social networks (Wasserman & Faust, 1994)
- Terrorist networks (Ilachinski / CNA, 2007+)
A “simple” demonstration of how complexity arises from simplicity...
1-Dimensional Cellular Automata

*Using very simple “agents” (building blocks) to generate complexity...*

- Consider a one-dimensional row of cells:
1-Dimensional Cellular Automata

*Using very simple “agents” (building blocks) to generate complexity...*

- Consider a one-dimensional row of cells:

  ![Cellular Automata](image)

- Suppose each cell is either on (■) or off (□)
1-Dimensional Cellular Automata

Using very simple “agents” (building blocks) to generate complexity...

- Consider a one-dimensional row of cells:

```
.....
```

- Suppose each cell is either on (□) or off (☐)

- Suppose each cell turns on or off depending on whether it was on or off before and whether its left and right neighbors were on or off
1-Dimensional Cellular Automata

*Using very simple “agents” (building blocks) to generate complexity...*

• Consider a one-dimensional row of cells:

```
... [cells] ...
```

• Suppose each cell is either on (■) or off (□)

• Suppose each cell turns *on* or *off* depending on whether it was on or off before and whether its *left* and *right neighbors* were on or off

• Choose a specific rule for this (out of a total of $2^8=256$ possible rules):

```
... [rules] ...
```
1-Dimensional Cellular Automata

Using very simple "agents" (building blocks) to generate complexity...

• Consider a one-dimensional row of cells:

• Suppose each cell is either on (■) or off (□)

• Suppose each cell turns on or off depending on whether it was on or off before and whether its left and right neighbors were on or off

• Choose a specific rule for this (out of a total of 2^8=256 possible rules):

Pretty simple!

But, what happens after a row of random cells “evolves” in time?
Let’s Look at a Few Steps …

Still pretty simple..nothing interesting yet!

What if we look at many cells evolving for longer times?
Simplicity Breeds Complexity!

Alternative “explanation” → *Particles* of form...

\[
\cdots \text{BBBBPPBB} \cdots \text{BB} \cdots \text{BBBBP’BB} \cdots \text{BBBBP''BBB} \cdots
\]
Other Rules: A Universe in 1-Dimension...

Wolfram CA-Classification:

- **Class 1**: Fixed State
- **Class 2**: Periodic State
- **Class 3**: Chaotic State
- **Class 4**: Complex State

Conjectured to be **Universal Computers**!
Other Rules: A Universe in 2-Dimensions

John Conway’s Life Rule

Consider one particular rule out of $2^{512} \sim 10^{154}$ possible rules!
Other Rules: A Universe in 2-Dimensions

John Conway’s Life Rule

- **Birth**
  - \( \begin{array}{c}
  0 & 0 \\
  0 & 0 \\
  \end{array} \)
  - \( \begin{array}{c}
  0 & 0 \\
  1 & 0 \\
  \end{array} \)

- **Death**
  - \( \begin{array}{c}
  1 & 1 \\
  1 & 1 \\
  \end{array} \)
  - \( \begin{array}{c}
  0 & 0 \\
  0 & 0 \\
  \end{array} \)

- **Survival**
  - \( \begin{array}{c}
  0 & 0 \\
  1 & 1 \\
  \end{array} \)
  - \( \begin{array}{c}
  1 & 1 \\
  0 & 0 \\
  \end{array} \)

Conway’s “Life” is a general purpose computer → Halting Theorem holds!
Self-enlightenment from a humble automaton?

“If patterns of ones and zeroes were 'like' patterns of human lives and deaths, if everything about an individual could be represented in a computer record by a long string of ones and zeroes, then what kind of creature could be represented by a long string of lives and deaths?”

— Thomas Pynchon, Vineland

http://farm3.static.flickr.com/2038/1603390142_e641501dfa_o.gif
Outline

**Part 1: Andy as photographer-physicist**

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- **Steps Towards a Universal Language of Aesthetics?**
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**Part 2: Andy as physicist-photographer**

*A sampling of portfolios: examples of how one “photographic eye” is informed / shaped by physics, complexity, and Tao*

- *Chaos, Order, Complexity, Entropy* (“Sudden Stillness” book)
- *Micro Worlds*
- *Abstract Glyphs*
- *Swirls, Whorls, and Tendrils*
- *Tao*
- “*As Above; so Below*” (latest project: Luray caverns, VA)

Physics, Complexity, and Photography: One Last Take
Language of Physics

\[ \dot{p} = -\frac{\partial H}{\partial \dot{q}}, \quad \dot{q} = \frac{\partial H}{\partial \dot{p}} \]

\[ \nabla \cdot E = 4\pi \rho \quad \nabla \times E = \frac{1}{c} \frac{\partial B}{\partial t} \]

\[ \nabla \cdot B = 0 \]

\[ PV = nRT \quad S = k \ln \Omega \]

\[ \frac{dS}{dt} \geq 0 \]

\[ \Delta x \Delta p_x \geq \frac{1}{2} \hbar \]

\[ \nabla \times B = \frac{4\pi}{c} J + \frac{1}{c} \frac{\partial E}{\partial t} \]

\[ \Delta E \Delta t \geq \frac{1}{2} \hbar \]

\[ dE = dQ - dW \]

\[ G_{\mu\nu} = -8\pi G T_{\mu\nu} \]

\[ i\hbar \frac{\partial \Psi}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \Psi}{\partial x^2} + V(x) \Psi(x,t) \equiv \hat{H} \Psi(x,t) \]

---

**Particles** (P, n, e, \( \pi \), \( \nu \), ...)

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

---

Graphical elements adapted from www.idiagram.com
Language of Complexity

Complexity

\[ D(s) = s^{-\beta} \]

\[ P(k) = k^{-\alpha} \]

\[ S(t) = -\frac{1}{N} \sum_{i=1}^{2^N} p_i \log_2 p_i \]

\[ D_F = \lim_{\epsilon \to 0} \frac{\ln[N(\epsilon)]}{\ln(1/\epsilon)} \]

Self-Organized Criticality

Metastability

Emergence

Autopoiesis

Reality

Parts

(Conceptual Building Blocks)

Syntax

Grammar

Language

Graphical elements adapted from www.idiagram.com
Towards a Universal Language of Aesthetics?

1. Levels of Scale
2. Strong Centers
3. Boundaries
4. Alternating Repetition
5. Positive Space
6. Good Shape
7. Local Symmetry
8. Deep Interlock & Ambiguity
9. Contrast
10. Gradients
11. Roughness
12. Echoes
13. The Void
14. Simplicity / Inner-Calm
15. Not-Separateness

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
Nature of Order

Everything is alive, it is only a matter of degree

“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

- 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
Christopher Alexander, Architect (1936 - )

Nature of Order

Everything is alive, it is only a matter of degree

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

The Luminous Ground
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- Tao
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Physics, Complexity, and Photography: One Last Take
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
At first, the photographer finds the picture...

...the pictures discover a *path*...
...the path *assembles* itself...

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)
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Physics, Complexity, and Photography: One Last Take
My creative process is very simple: 
*I take pictures of what calms my soul.*

There may be other, more poetic words that may be used to define the “pattern” that connects my images, but the simplest meta-pattern is this:

I capture moments in time and space in which a peace washes gently over me, and during which I sense a deep interconnectedness between my soul and the world.

Not Cartier-Bresson’s “Decisive Moment,” but rather a…

*Sudden Stillness*
The book is a meditation on using photographs as tokens of a visual grammar to communicate one photographer’s fragmentary impressions of some of nature’s basic patterns; partly as a physicist (with a physicist’s eye and understanding of chaos, order, complexity and entropy), and partly as an artist (with an appreciation of the subjective character of each of these four rhythms).

I am hoping that the book can also serve as a palimpsest of the author’s – and reader’s – process of self discovery: as nature is quietly revealed, through four “movements” of snapshots of its timeless rhythms, the reader will discover visual echoes of herself experiencing nature, as sudden stillness.

Chaos

“To divine the significance of pattern is the same as to understand beauty itself.”
— Yanagi Soetsu, Philosopher (1889 – 1961)
Order

“We have to remember that what we observe is not nature in itself but nature exposed to our method of questioning.” — W. Heisenberg, Physicist (1901 – 1976)
Complexity

“I’ve always been fascinated with the idea that complexity can come out of such simplicity.”

— Will Wright, Game Designer / Systems Theorist (1960 – )
Entropy

“Only entropy comes easy.” — Anton Chekov, Author (1860 – 1904)
No one also was in the same century as emotional crying was recognized. He wrote that "weeping - a natural emotion - is not a form of expression but a means of communication in secret." The same-century theory of emotional crying was set aside in the early 19th century, as a new form of expression was discovered. The new form, called "psychogenic" or "emotional" crying, was not recognized until the 1890s.

In the same year, Auguste Moreau, a French psychologist, published a book on the "psychogenesis of emotions." He wrote: "Theories of emotional crying are based on the hypothesis that crying is an expression of emotional distress. However, this hypothesis is not supported by scientific evidence."
Outline

Part 1: Andy as photographer-physicist

• Who am “I” – Take #1 / Take #2
• A few lessons from a physicist, photographer, and taoist
• What a physicist does vs. what a photographer does
• Aesthetics – a physicist’s take; a “baby step” experiment
• Evolving landscapes (take #1 / #2 / #3)
• Complexity – a gentle introduction
• Steps Towards a Universal Language of Aesthetics?
• Who am “I” – Take #3

Part 2: Andy as physicist-photographer

A sampling of portfolios: examples of how one “photographic eye” is informed / shaped by physics, complexity, and Tao

– Chaos, Order, Complexity, Entropy (“Sudden Stillness” book)
– Micro Worlds
– Abstract Glyphs
– Swirls, Whorls, and Tendrils
– Tao
– “As Above; so Below” (latest project: Luray caverns, VA)

Physics, Complexity, and Photography: One Last Take
A “planned” day of rocks & water variety

Came home from a long photo-safari at Great Falls, during which I took many soon-to-be-forgotten photos of the usual rocks-and-water variety

Sat down to dinner with my family

As my fork was about to pierce the skin of a potato, my wife nonchalantly placed two small acrylic candle holders with trapped air bubbles inside on the table

My “eye” was consumed for the next 4 months

“Micro Worlds” portfolio

*Lenswork*, Issue #76
(May-June, 2008)
Outline

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Physics, Complexity, and Photography: One Last Take
“Everything in the world has a hidden meaning. . .. Men, animals, trees, stars, they are all hieroglyphics.

When you see them you do not understand them. You think they are really men, animals, trees, stars.

It is only years later that you understand.”

— NIKOS KAZANTZAKIS
(1883 - 1957)
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Physics, Complexity, and Photography: One Last Take
My younger son (Josh, 7) accidentally dropped a newspaper that I had written something on with a fountain pen into the sink

*I noticed an interesting pattern* ...
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Physics, Complexity, and Photography: One Last Take
“The use the order of words to try to explain life is really as clumsy an operation as trying to drink water with a fork.”

— ALAN WATTS, Philosopher (1915 – 1973)
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Physics, Complexity, and Photography: One Last Take
Despite having visited Luray Caverns countless times...

I never took anything other than a small “point and shoot” camera, relegating family picture taking chores to my wife.

Until earlier this year, when I finally got the nerve to ask (and be granted!) a full day in the caverns!

“As Above, So Below” portfolio
Lenswork, Issue #95 (July-August, 2011)
Sneak Peek: Work in Progress ...

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

**Physics: let it guide your eye & camera**
- Search for nature’s forms: fractals, dynamics, symmetry, order, pattern, ... *out there!*

**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!*

**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!*

**The observer is *outside* the stream**
(Newtonian physics)

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

**The observer is *outside* the stream**
(Complexity theory / Tao)

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

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

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

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

- **Nature’s Chaos**
  J. Gleick, Eliot Porter

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

- **The Great Image Has No Form**
  Francois Jullien

- **Exploring the Invisible**
  Lynn Gamwell

- **Nature of Order**
  Christopher Alexander
Please visit my website...
http://www.sudden-stillness.com

Sudden Stillness
Fine-Art Photography by Andy Ilachinski
“When words become unclear, I shall focus with photographs. When images become inadequate, I shall be content with silence.”

— ANSEL ADAMS