The Picbreeder Experiment

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In Collaboration with

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EPLEX

Evolutionary Complexity Research Group at UCF

The Picbreeder Experiment

- Website: http://picbreeder.org
  - Crowd-sourced picture-breeding online service
- Seven years of operation
- Almost 10,000 evolved images (lineages)
- Over 1,000 users
- Like Dawkins' BioMorphs (from *The Blind Watchmaker, 1986*) on steroids
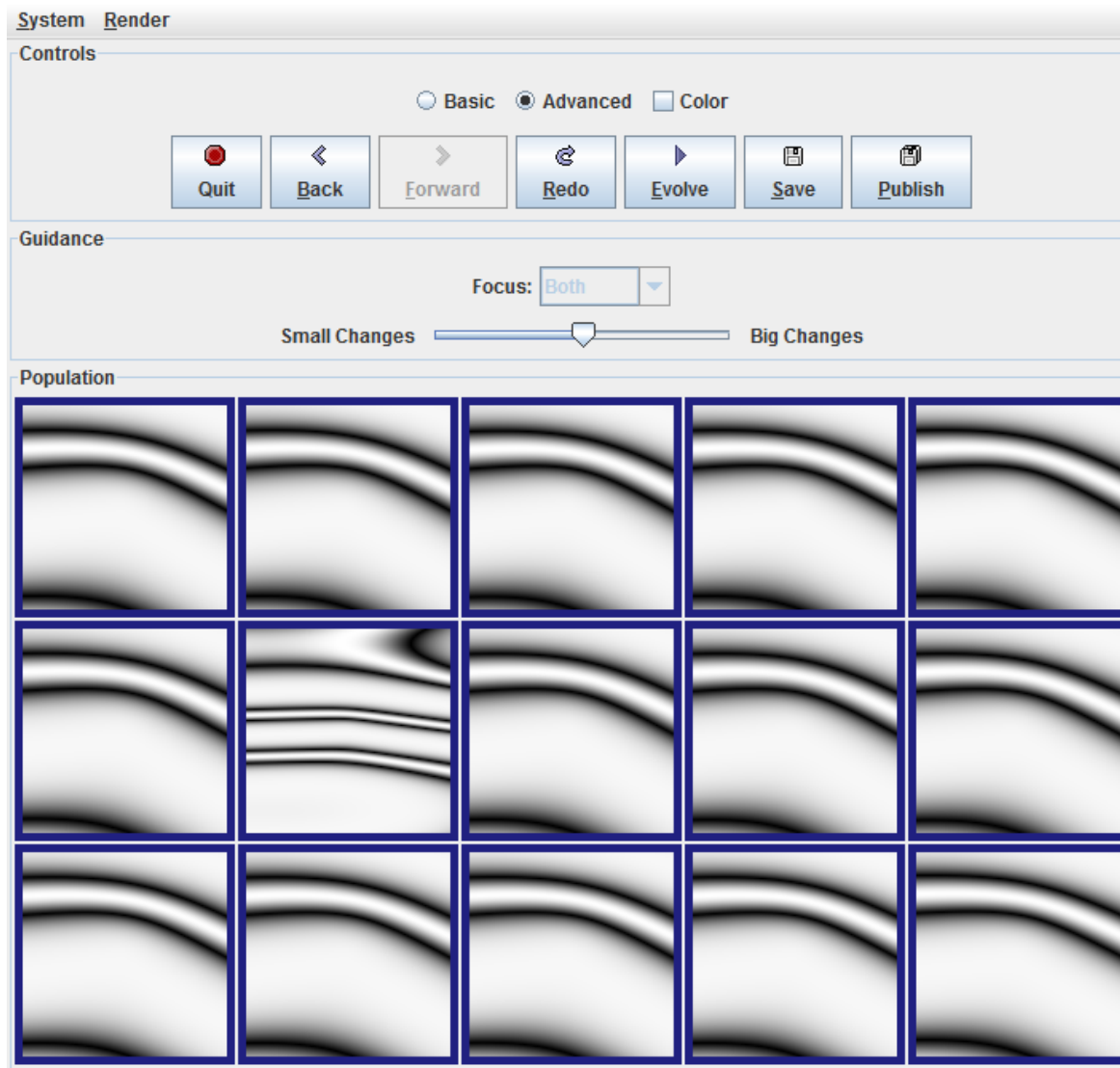- Users began to make surprising discoveries

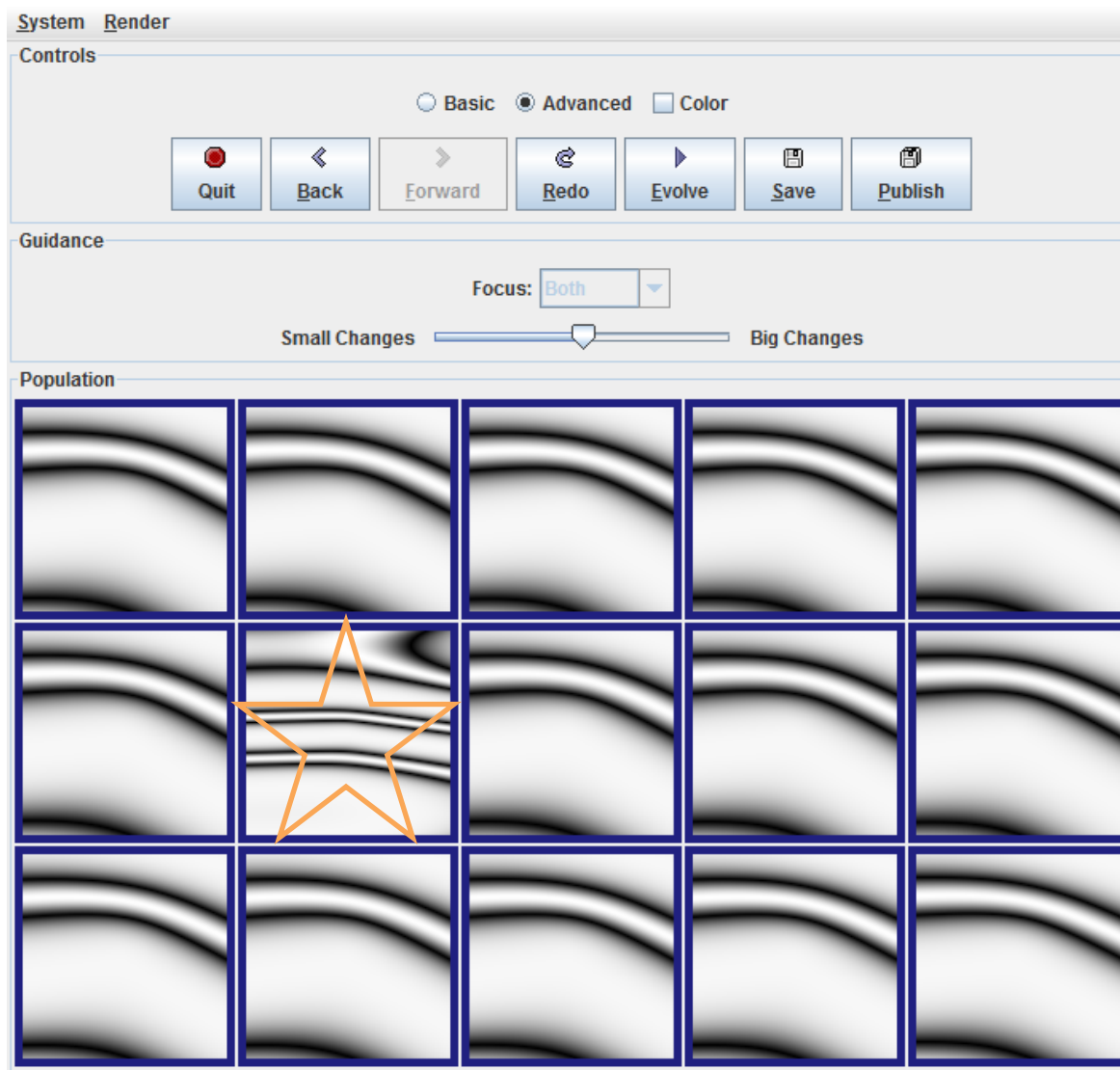# Basic Idea: Breeding Pictures
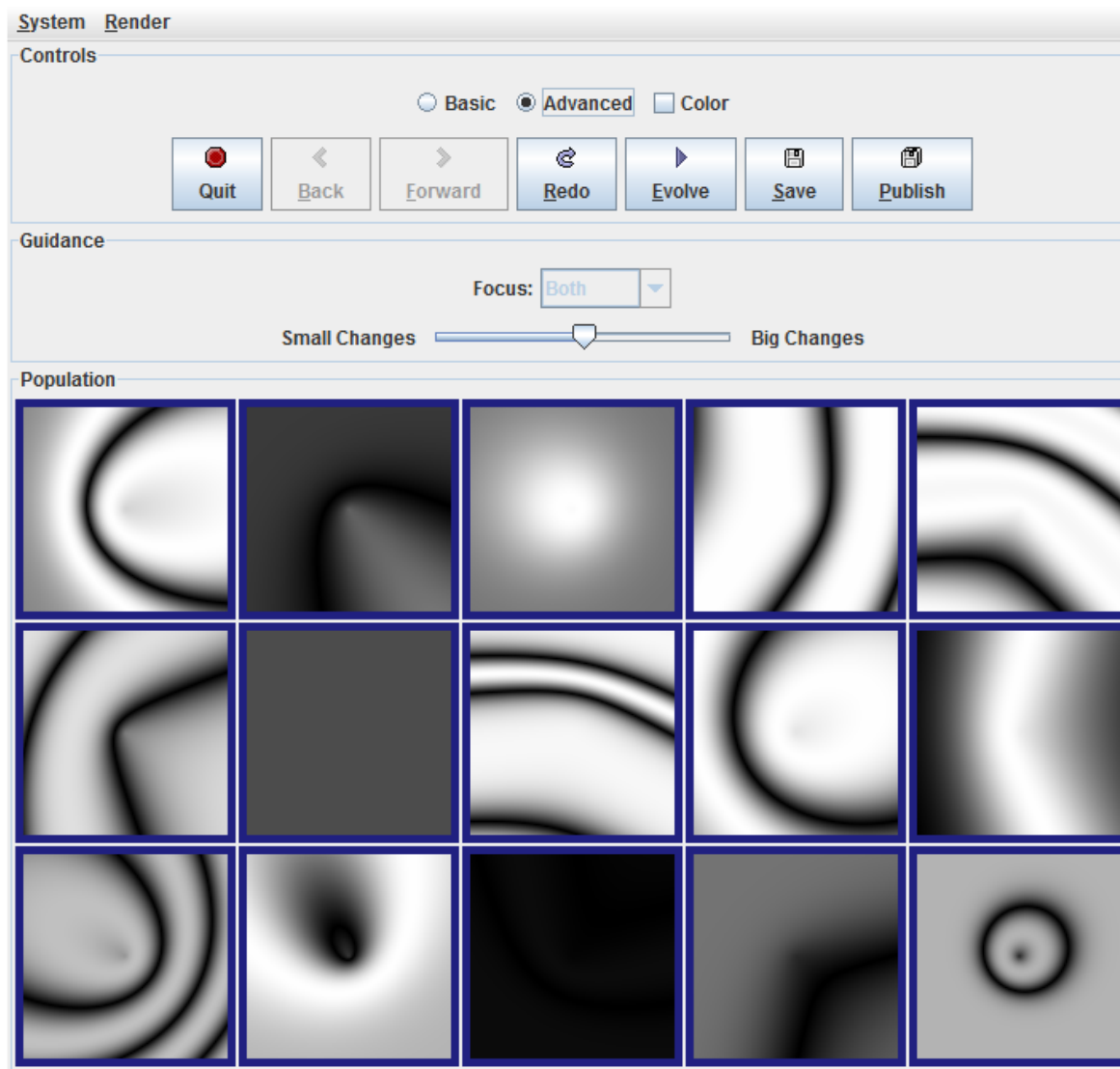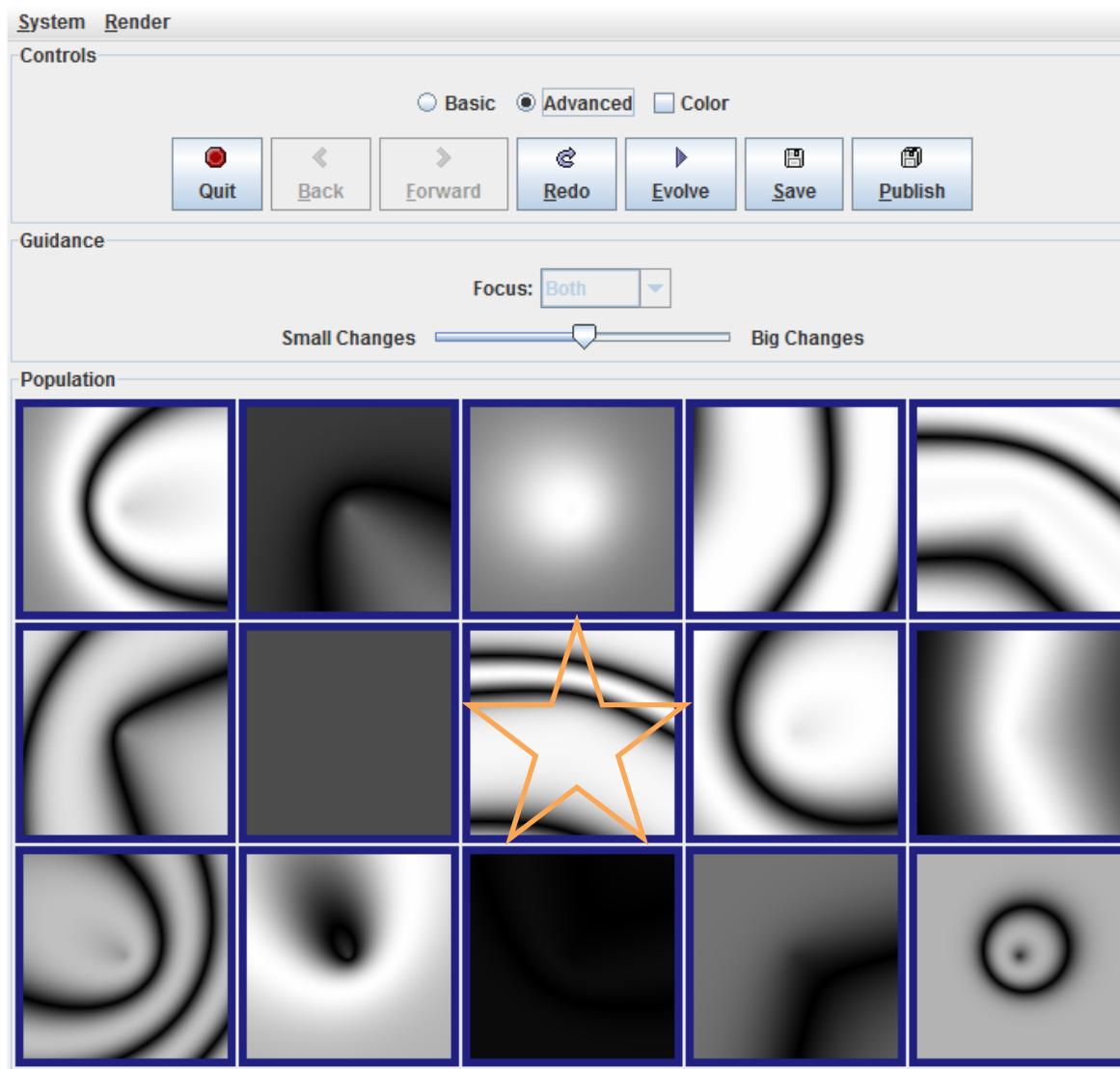
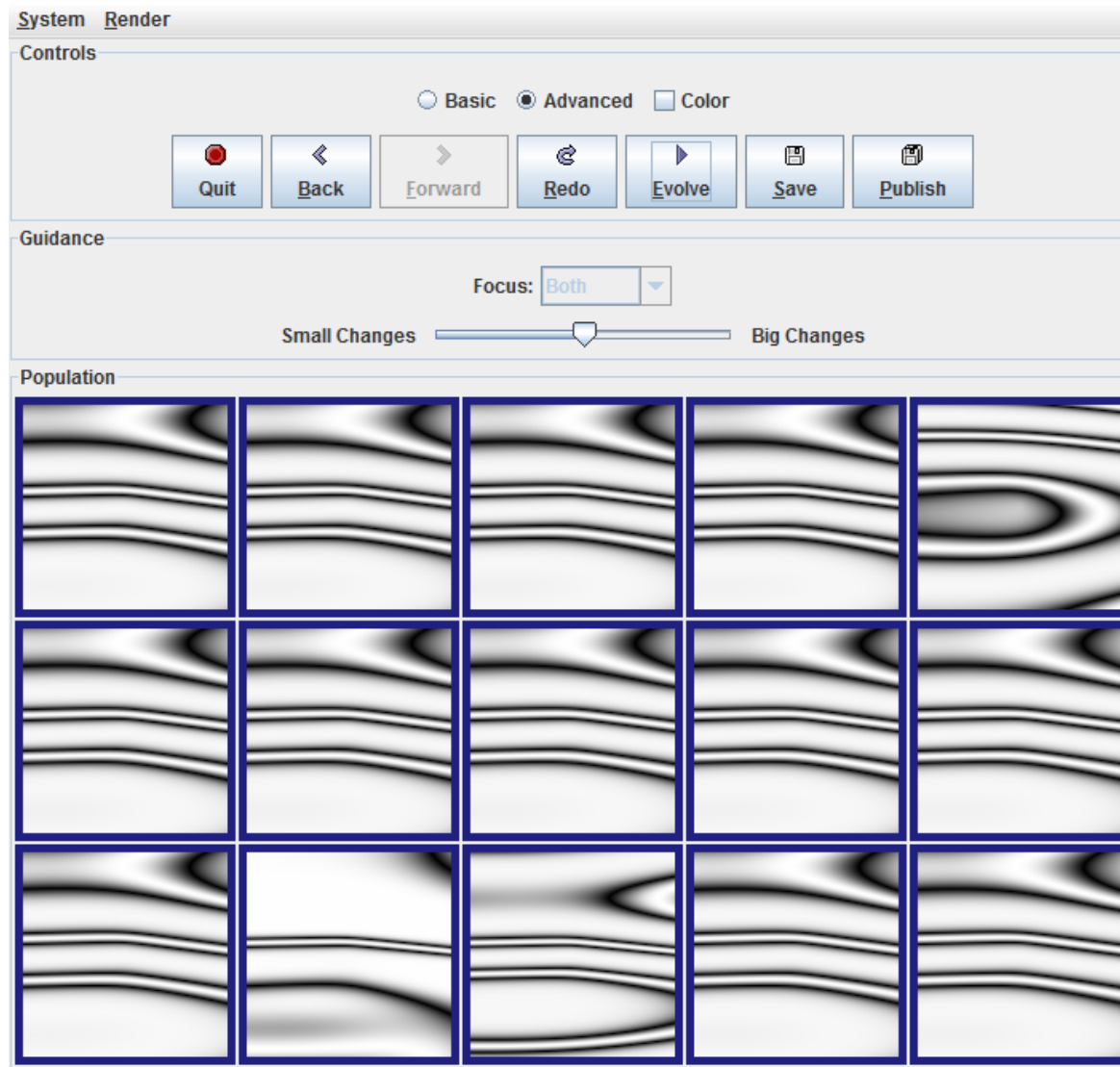# Basic Idea: Breeding Pictures

# Basic Idea: Breeding Pictures

Parent

Basic Idea: Breeding Pictures

Parent

Basic Idea: Breeding Pictures

Parent

And so on…

Picbreeder Image Representation

- Images are represented by *compositional pattern-producing networks* (CPPNs)
  - A composition of simple functions
- A new node is sometimes introduced through mutation
  - (algorithm called "NEAT")
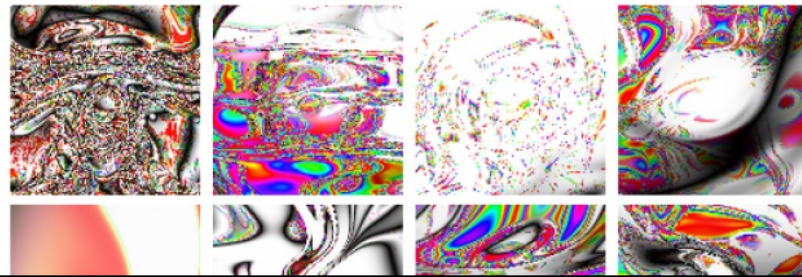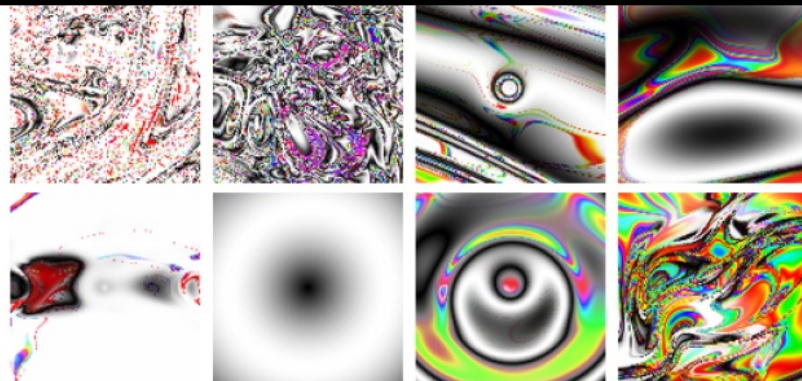- What kind of search space does this representation induce?
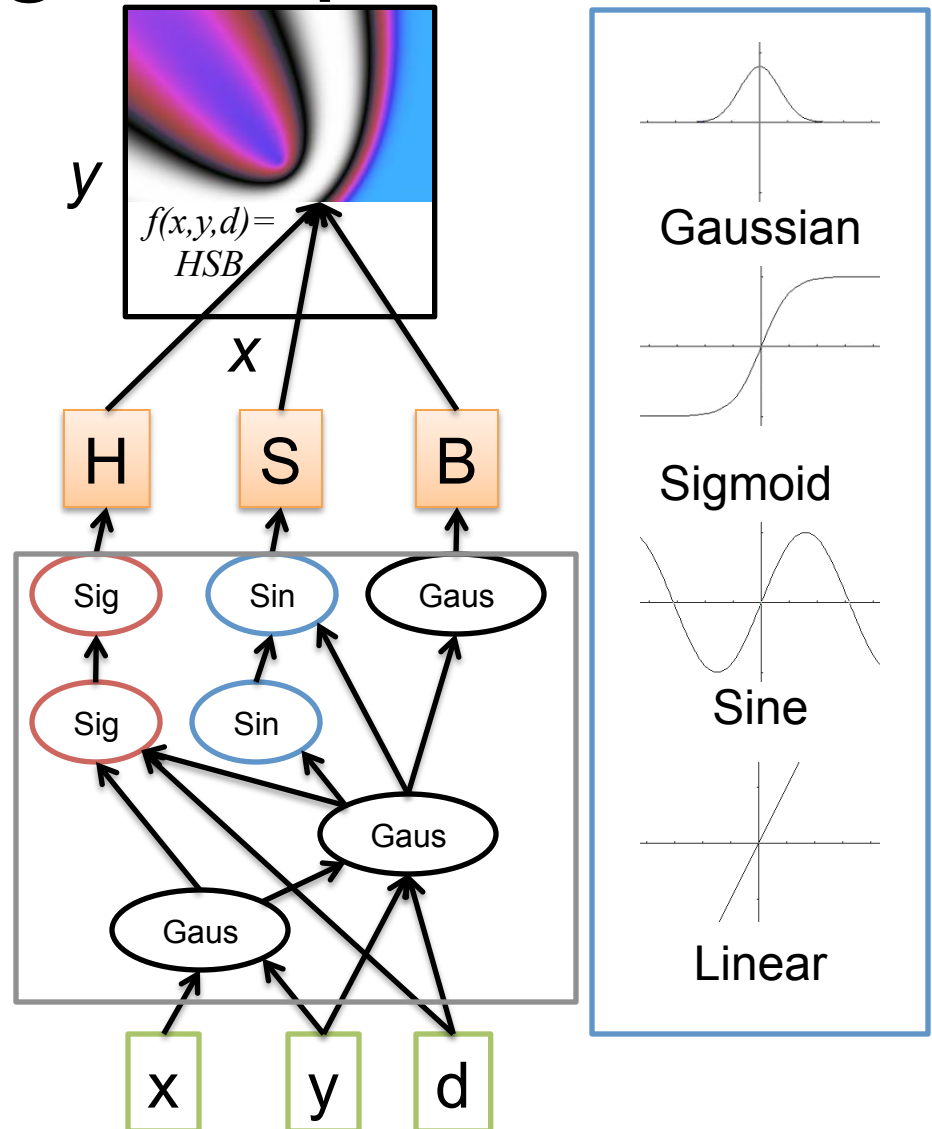
The Search Space is *Desolate*

- Almost every image looks like these
  - They have random weights and topologies:
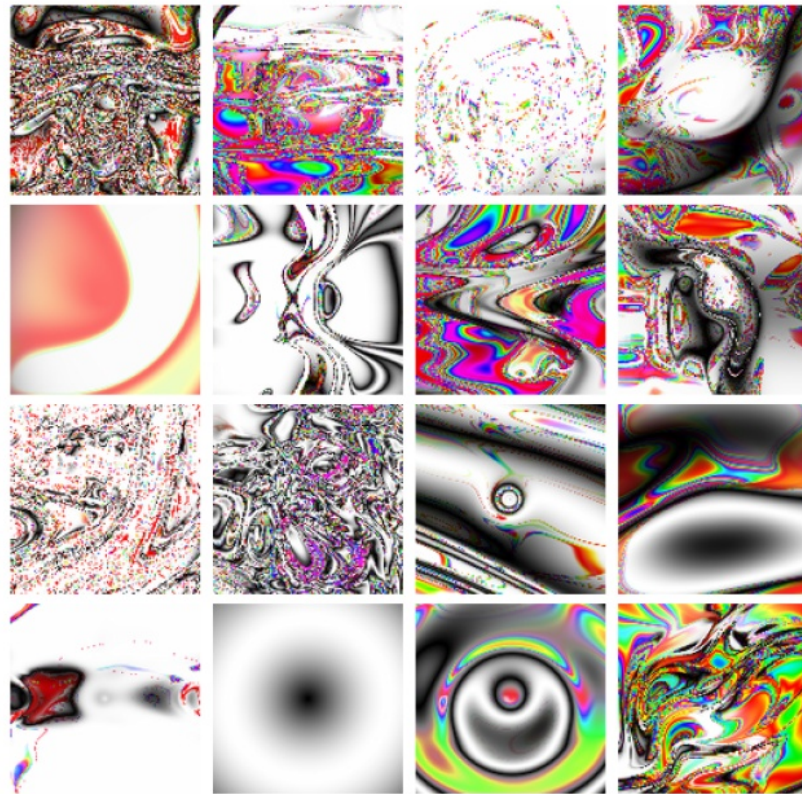
The Search Space is *Desolate*

- Almost every image looks like these
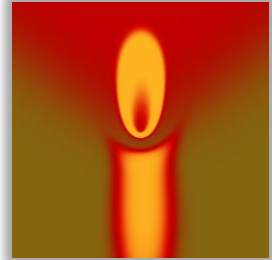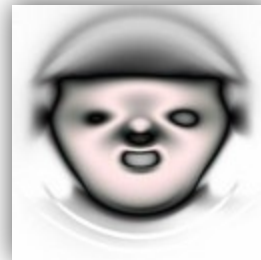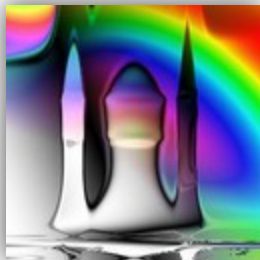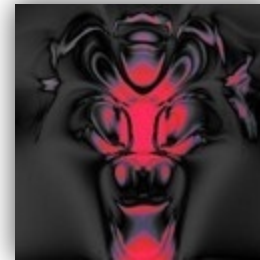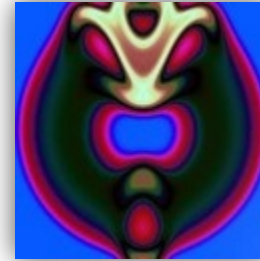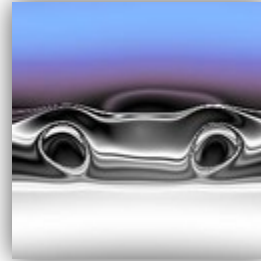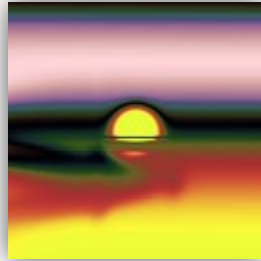 - They have random weights and topologies:

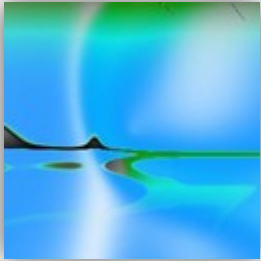So what do users find?

Picbreeder Users Found These…How?

(All are 100% evolved: no retouching)
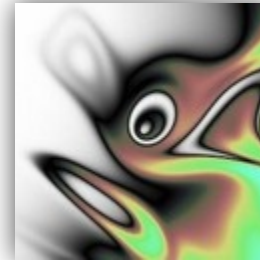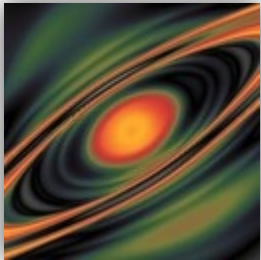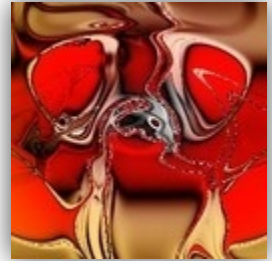
One Important Factor: Branching

- Users can browse previously evolved images
- Then can *branch* from any of them
  - Starts searching from existing image

What is Picbreeder?

Picbreeder is a collaborative art application based on an idea called *evolutionary art*, which is a technique that allows pictures to be bred almost like animals. For example, you can evolve a butterfly into a bat by selecting parents that look like bats. Read More

del.icio.us   Digg it   StumbleUpon

picbreeder TM

Inspired by how organisms evolve and complexify in nature

Home | **Getting Started** | **Search Images** | **Forums** | **News** | **Statistics** | **Zazzle** | **About** | **Legal Terms** | **Contact**

Browse Images By:
Best New
Highest Rated
Most Branched
Newest
Random
Category
Or:
Breeding Tips
See Popular Tags
Browse Users
Search Images

Member Login
Username

Password

Login Register
Forgot Password

Top Rated Artists:
1. opah
2. blurt25
3. mattrmunson
4. rubiks
5. a_rad
6. rawrface9
7. freewing00
8. webneat
9. loca
10. secretj

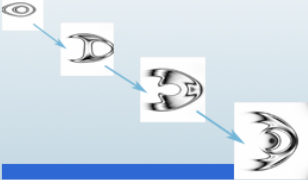Get started right away with our   Quickplay Console

Branch

Evolve new variations on other users' images. Try clicking these!

Evolve   Evolve

Start from **Scratch**

Create a whole new kind of image.

family **Tree**

See family relationships of any image. Try clicking these!

Family Tree   Family Tree

Custom **Merchandise**

Create custom products from any picture on the site. Try these:

Custom Products   Custom Products

Top Categories

Alien Animal bird cool pattern creature Dog eye eyeball Face Fish ghost happy insect mask

Find: Next   Previous   Highlight all   Match case

http://picbreeder.org/user/editgenome.php?sid=-1&pid=-1
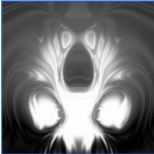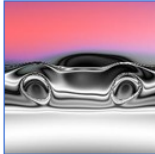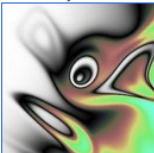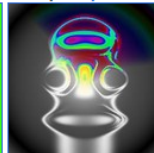
Top Categories
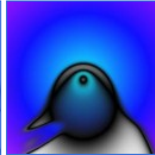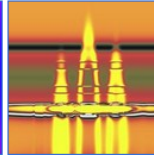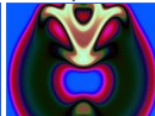
Alien Animal bird cool pattern creature Dog eye eyeball Face Fish ghost happy insect mask
Spaceship
View All Categories...

Editor's Picks

| Mystic baboon | sunset drive | devil | dolphin |
| By burndirt | By ken | By burndirt | By burndirt |

Evolve DNA   Evolve DNA   Evolve DNA   Evolve DNA

| Animal happy | butterfly | round face | homer simpson |
| By ken | By adeleinr | By robert | By Anonymous |

Evolve DNA   Evolve DNA   Evolve DNA   Evolve DNA

All Time Top Rated

| shiny Red apple | angry martian | penguin | river temple |
| By acow | By opah | By opah | By opah |

Evolve DNA   Evolve DNA   Evolve DNA   Evolve DNA

| Fat belly | Wizard of fire | snake symbol | fly |
| By 42Wired | By opah | By ken | By burndirt |

http://picbreeder.org/

Google
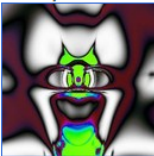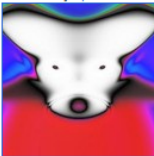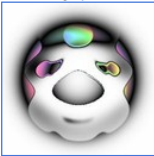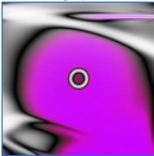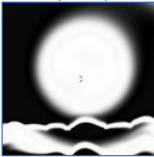
Picbreeder

Best New Images

mask ears superhero
By Timeroot

Mr Fox
By opah

Elvis
By ken

Picasso Face
By ken

Evolve   DNA   Evolve   DNA   Evolve   DNA   Evolve   DNA

Ball face
By opah

Worried face
By opah

scary face
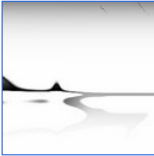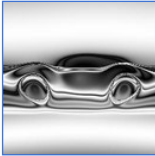By opah

Mumin face
By opah

Evolve   DNA   Evolve   DNA   Evolve   DNA   Evolve   DNA

More

Most Branched

Skull Skeletor
By acampbel

Moon Moonlight
By secretj

short SD coif
By ddambro

letter g g
By ken

Evolve   DNA   Evolve   DNA   Evolve   DNA   Evolve   DNA

butterfly
By adeleinr

Pirate Island Cove La...
By klorel

car road driving
By ken

She sees you now eye ...
By Evinced

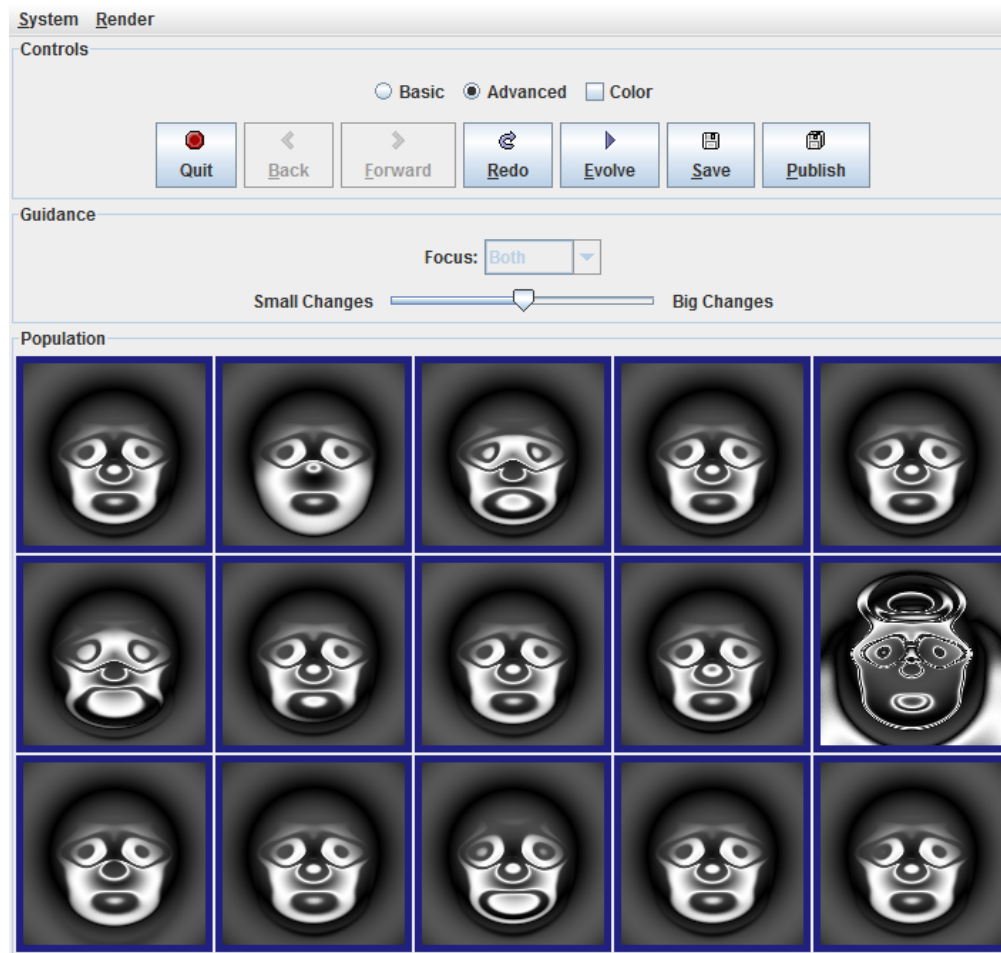Evolve   DNA   Evolve   DNA   Evolve   DNA   Evolve   DNA

More

Newest

Find: Next   Previous   Highlight all   Match case
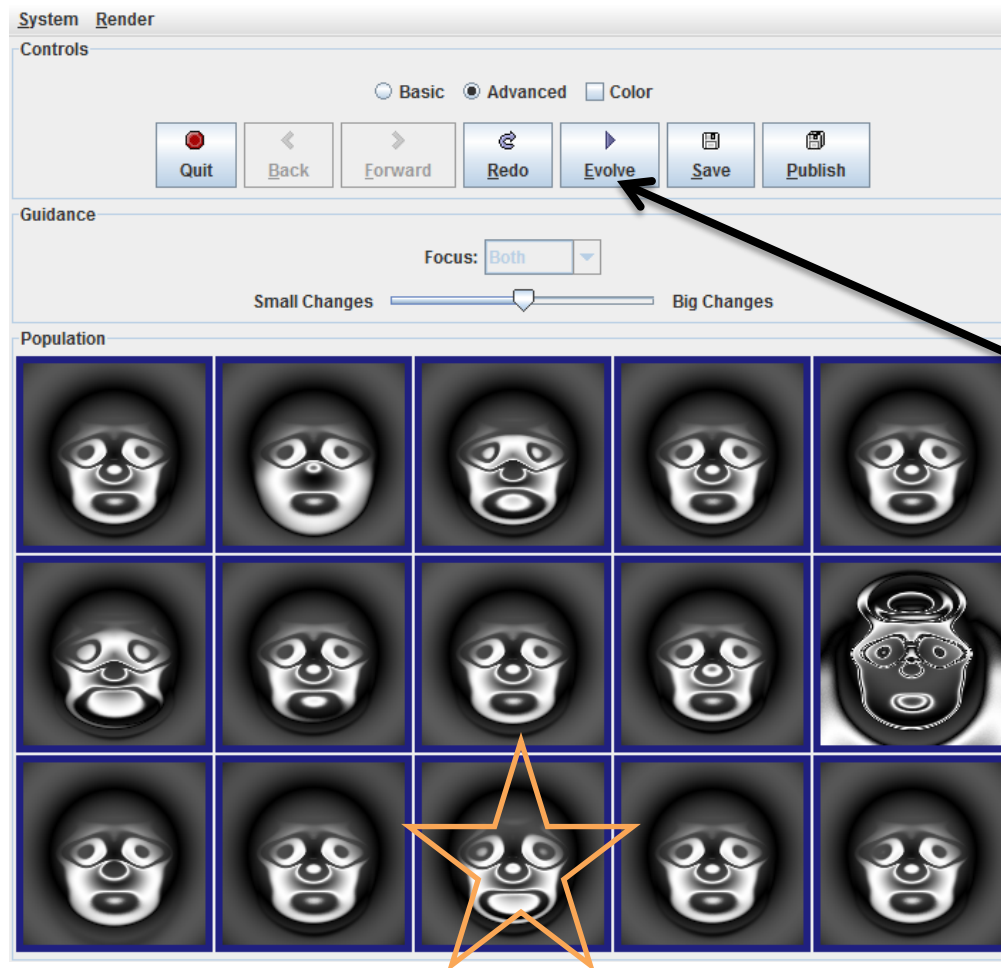
Done

Example: Branching from the Face

- Next: Select parent(s) – Which do you like?
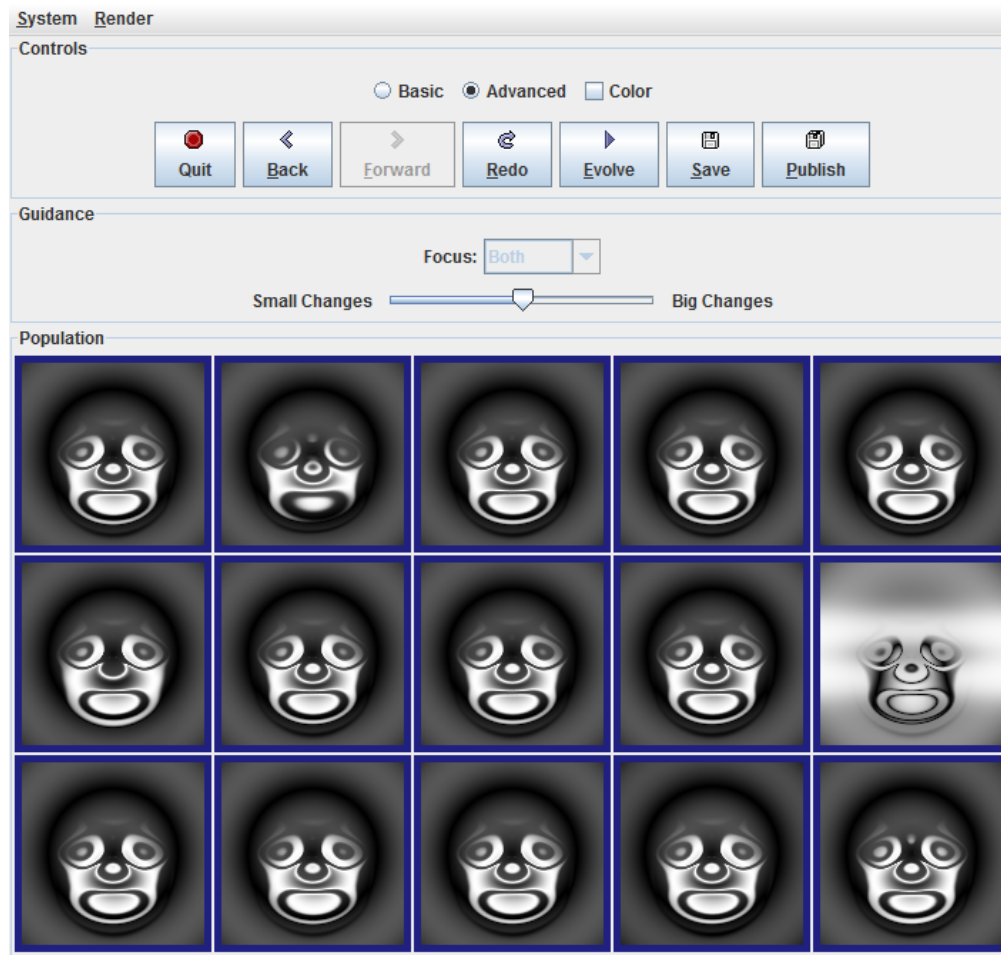
How Users Breed Images

- Next: Select parent(s) – Which do you like?

Press "Evolve" after selecting parents

How Users Breed Images
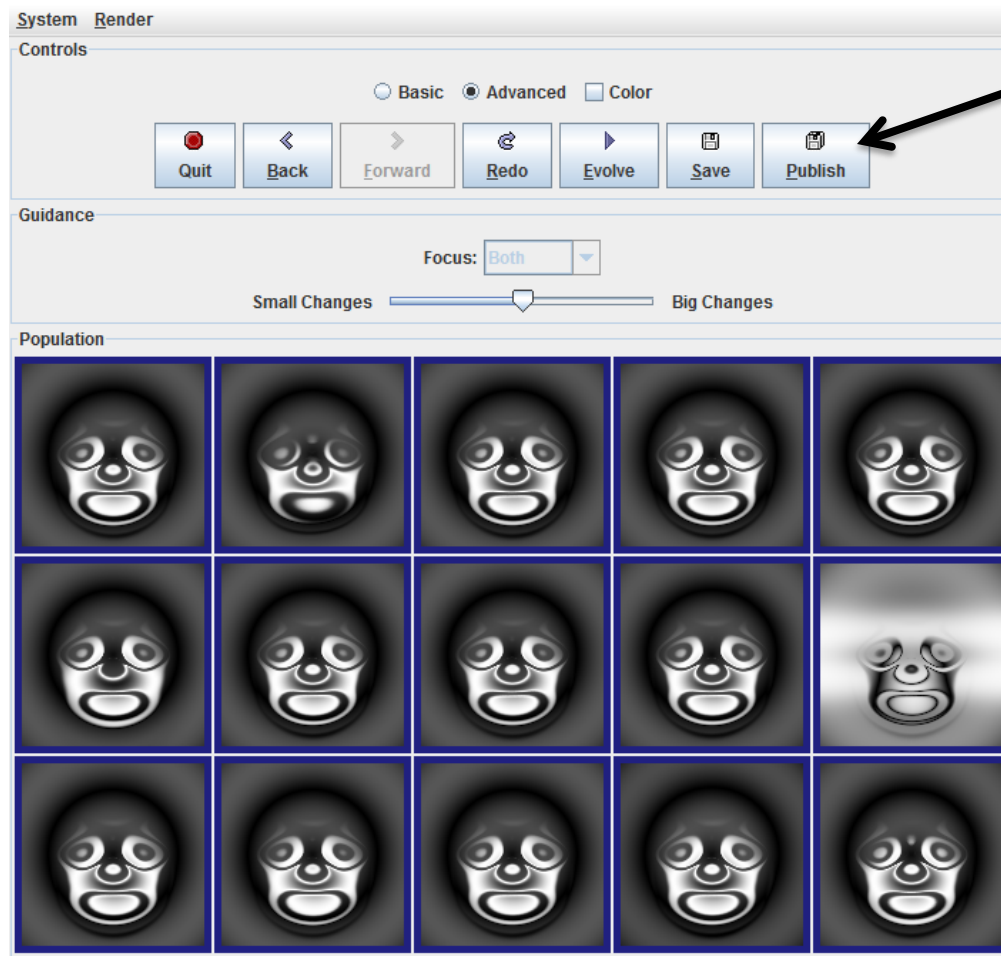
- Next: The offspring (next generation) appear

Parent

How Users Breed Images
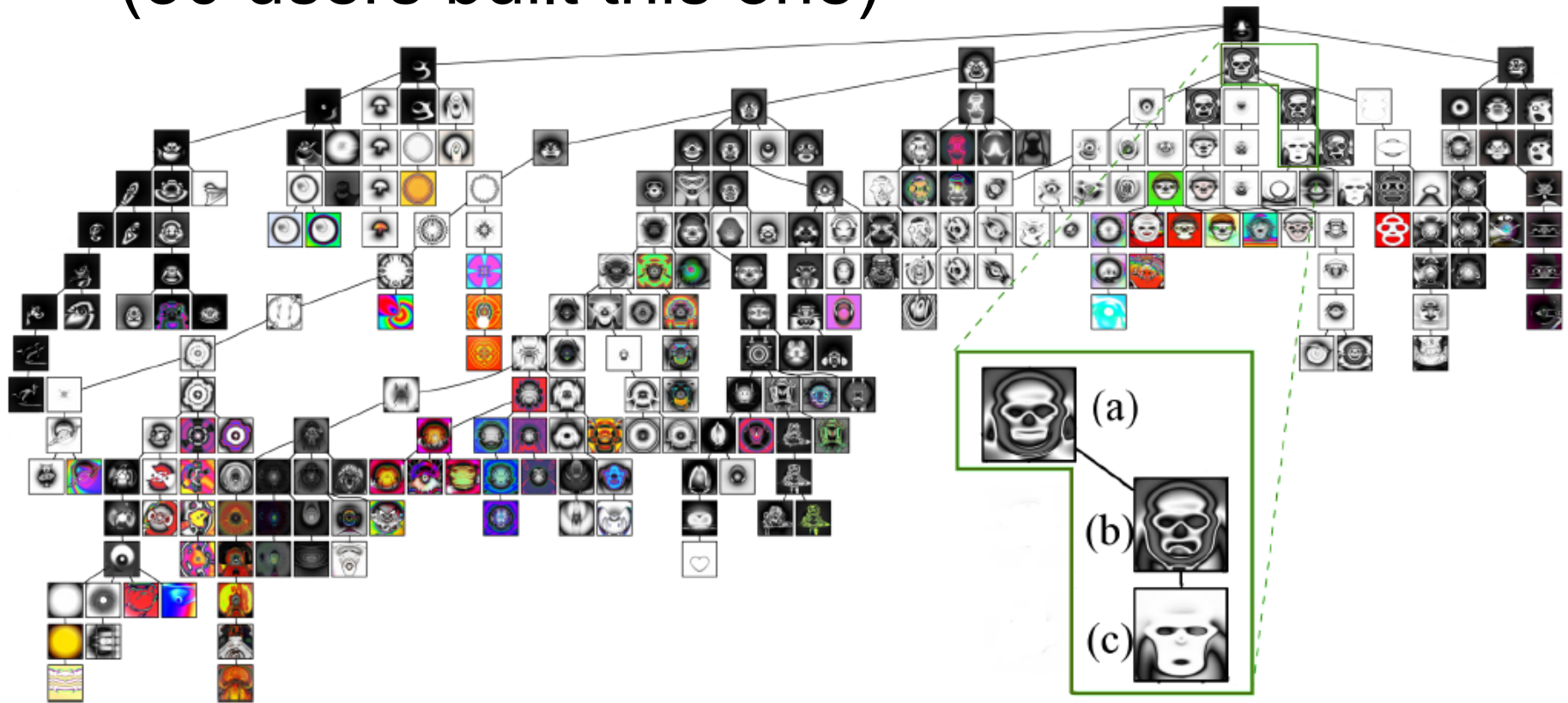
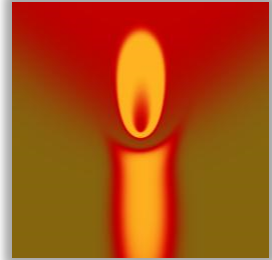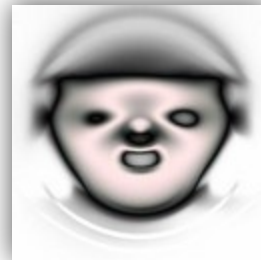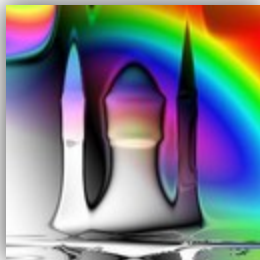- Next: Repeat until satisfied and then Publish

Parent

The Result:
Large, Growing Phylogenies

- Users build upon each other's discoveries (30 users built this one)

(a)
(b)
(c)

Discoveries After Many Branches

(All are 100% evolved: no retouching)
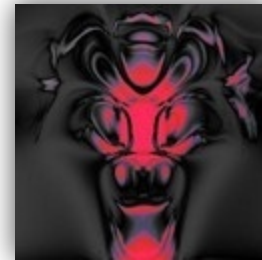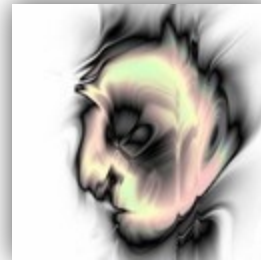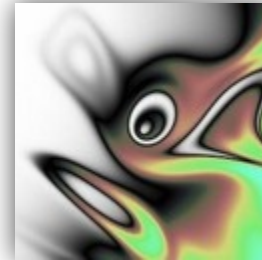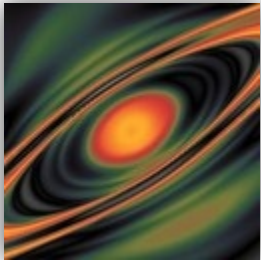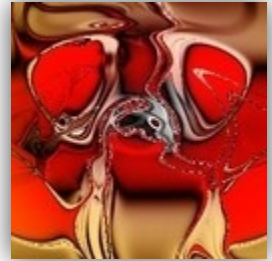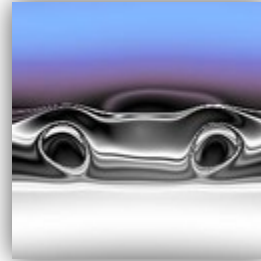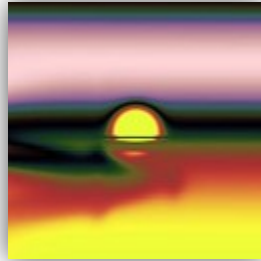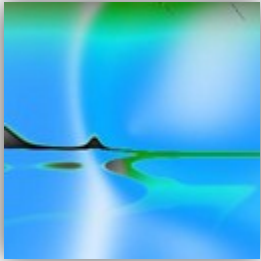
In A Desolate Space

(All are 100% evolved: no retouching)

…and entire "species"…
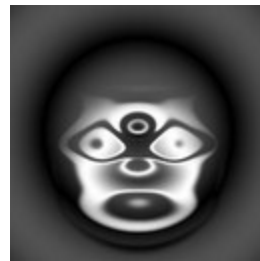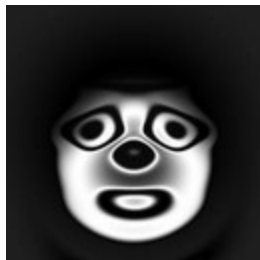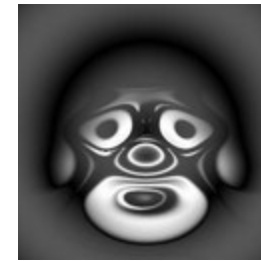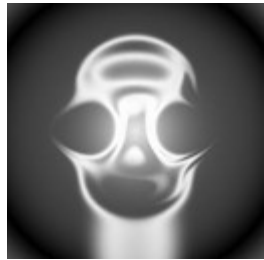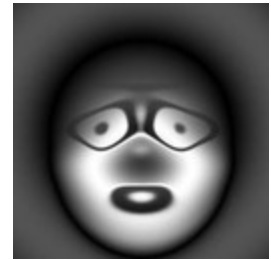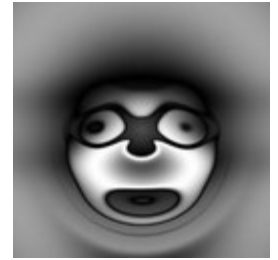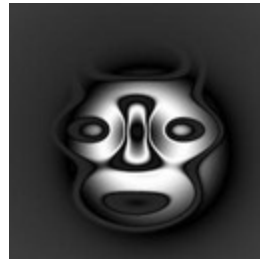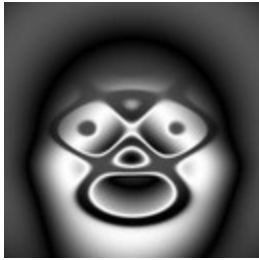
…and these…

(All are 100% evolved: no retouching)
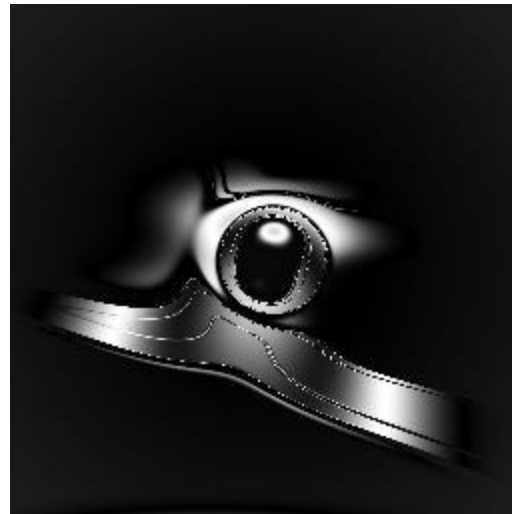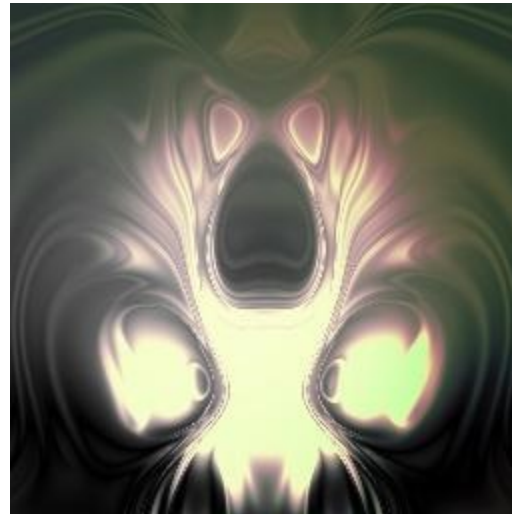
Why Is Branching So Powerful?

(All are 100% evolved: no retouching)
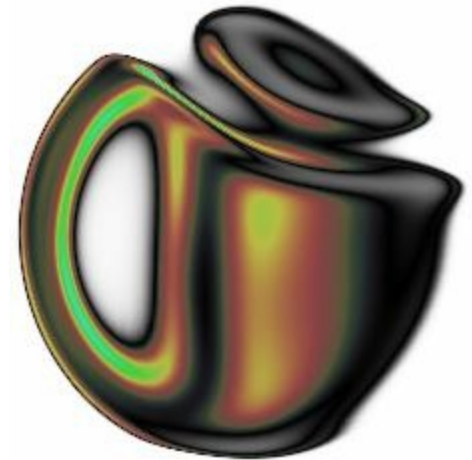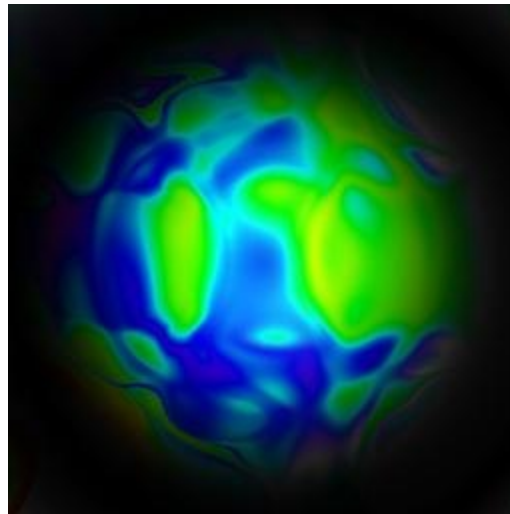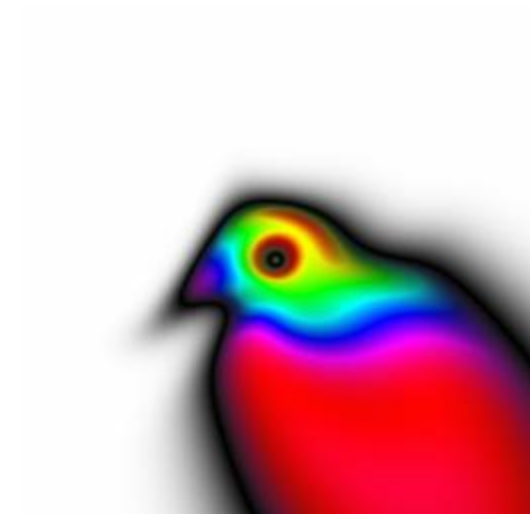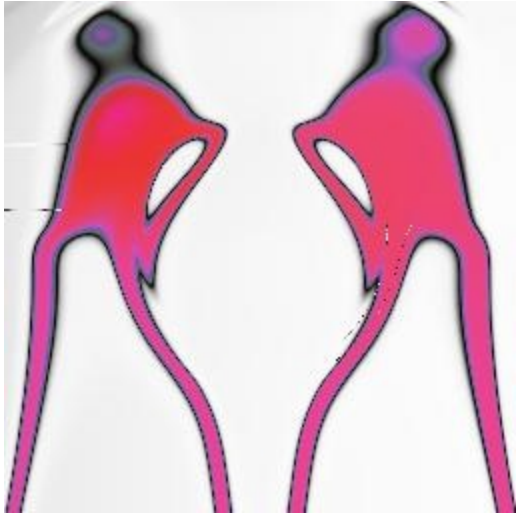
The Story of the Car
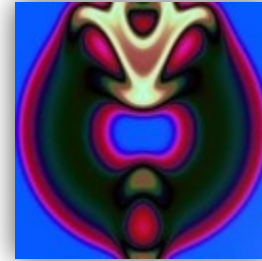
- Would you expect to find a car in this space?

- I didn't

- But then I found one
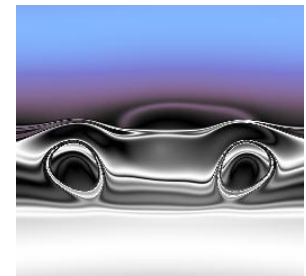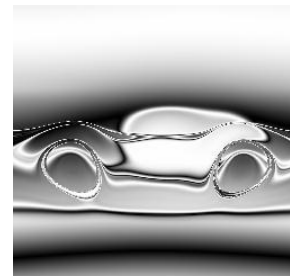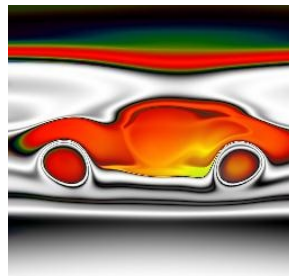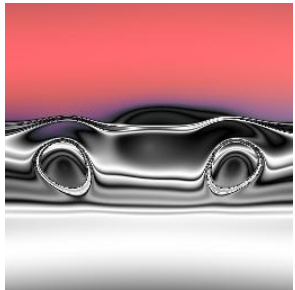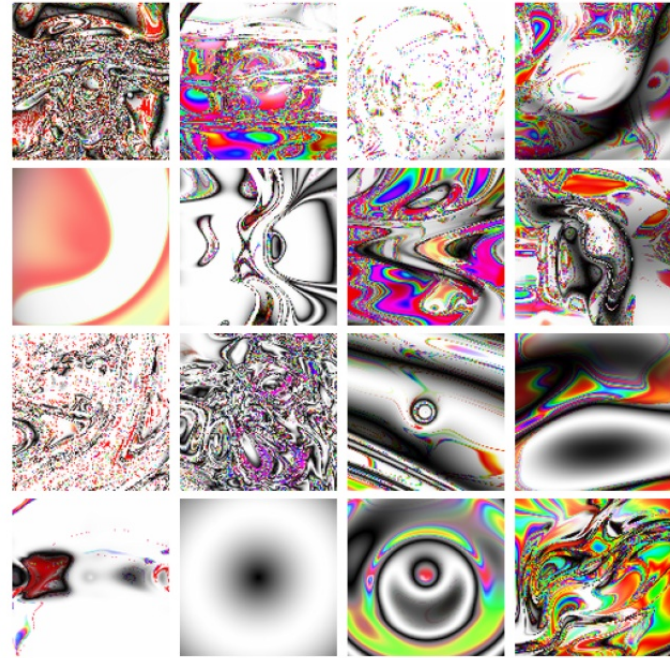
How Did I Find the Car?

- I was not looking for a car
- Rather, I chose to evolve the alien (ET) face to get more alien faces:
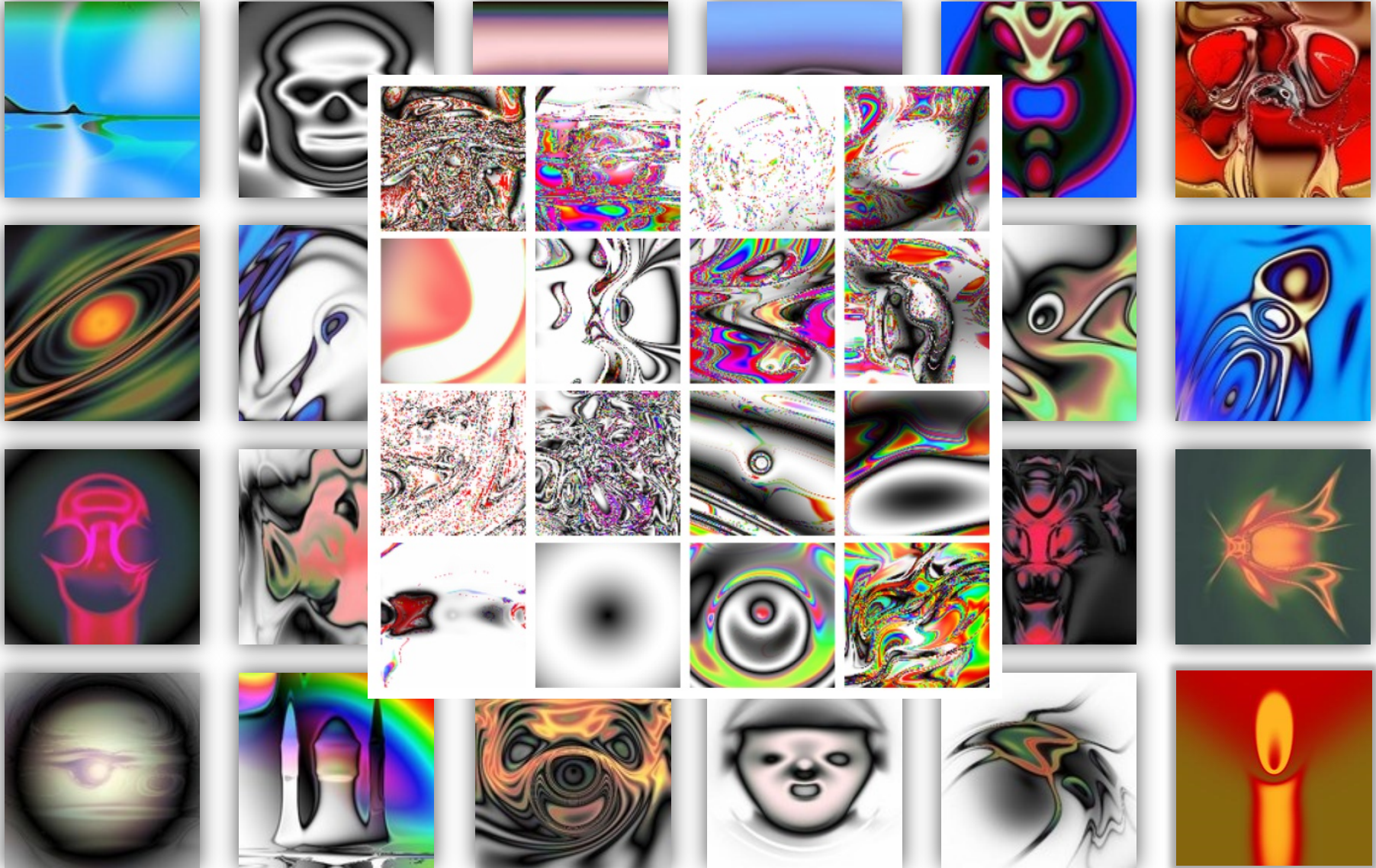
How Did I Find the Car?

- But then, the alien's eyes descended and turned into wheels
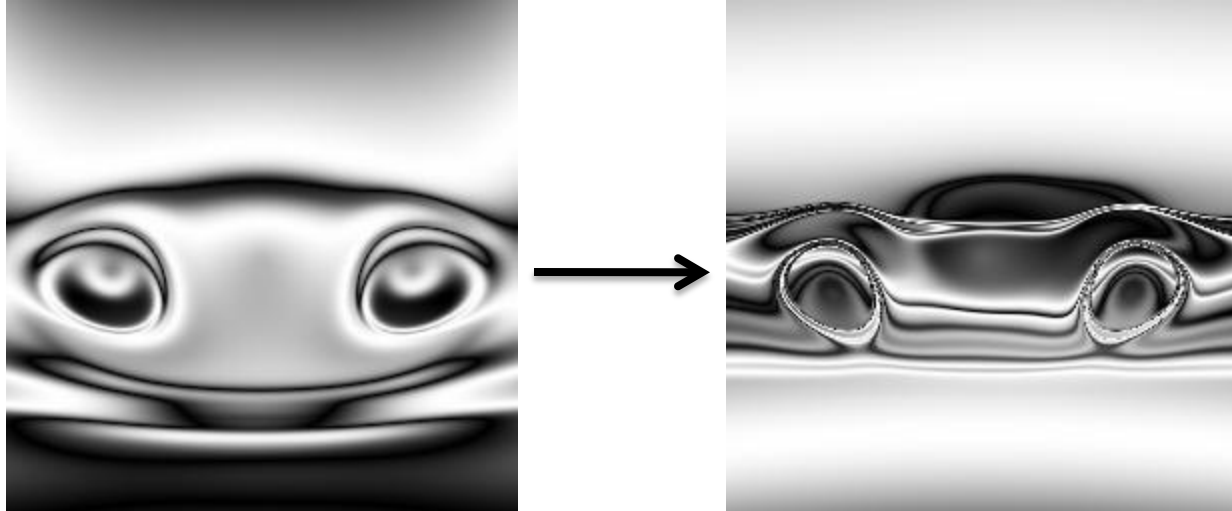
How Did I Find the Car?

- The only way to find the car was by *not* looking for it
- Otherwise, I would never have selected the alien
  - It does not look like a car
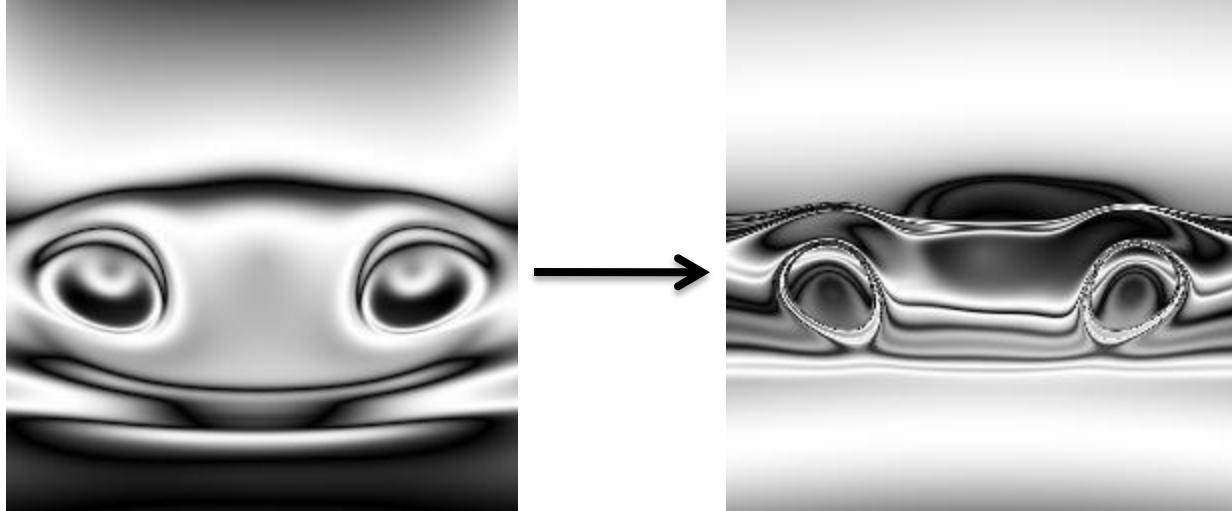
How Did I Find the Car?

- But I would not have evolved the alien either!
- *Someone else* had to evolve it for me to make my discovery
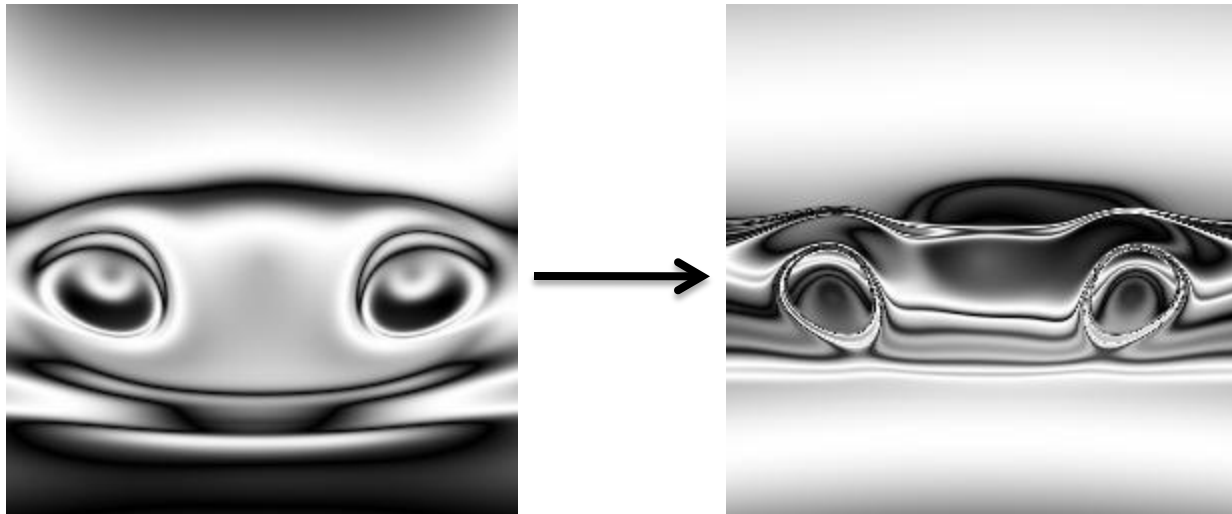
Most Top Images have the Same Story
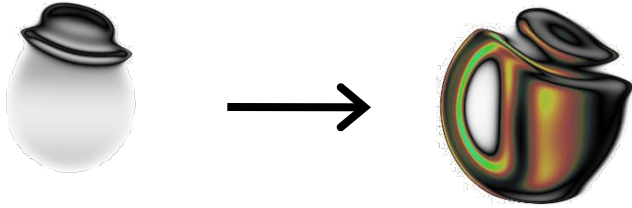
Stepping stone to the Teapot
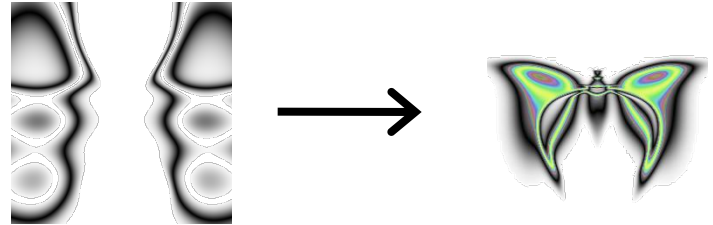
Stepping stone to the Butterfly
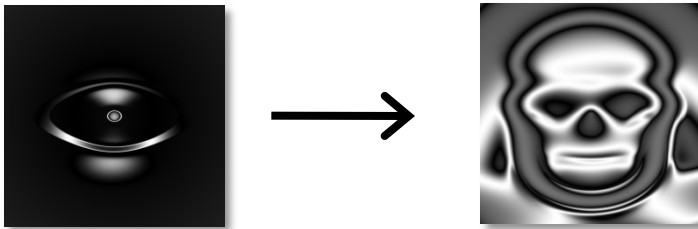
Stepping stone to the Skull
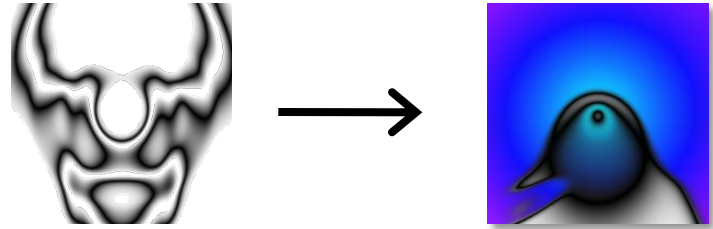
Stepping stone to the Penguin
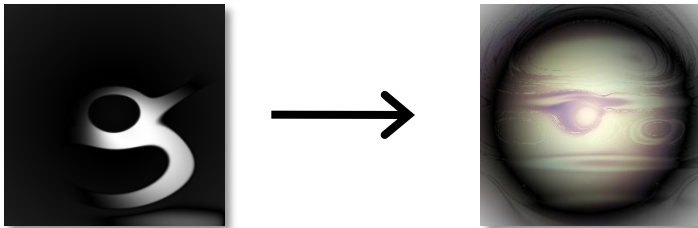
Stepping stone to Jupiter
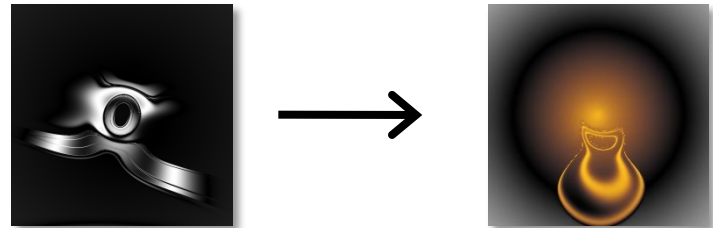
Stepping stone to the Lamp

The stepping stones almost never resemble the final product!
You can only find things by not looking for them

More Evidence: Re-evolving Won't Work

- Images cannot be re-evolved as targets

Moral: Innovation is a Divergent Process

- Natural evolution, technology, culture, Picbreeder – why do they work?
  - A powerful innovative process *preserves diverse stepping stones*
  - Not because of where they might lead
  - Not because they optimize an objective
  - But for their own unique reasons

Profound Implications

- The path to success is through not trying to succeed

- To achieve our highest goals we must be willing to abandon them

- It is in your interest that others *do not* follow the path you think is right
  - They will lay the stepping stones for your greatest discoveries

Wait, these implications are not about computer science!

Led to a New Computer Algorithm: Novelty Search

- Novelty search does not search for a specific objective

- Novelty search solves some problems faster and better than optimization algorithms trying to solve the problems!

- Also finds *diverse* high-quality solutions unlike optimization:
  - *Divergent search*
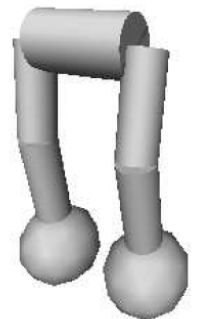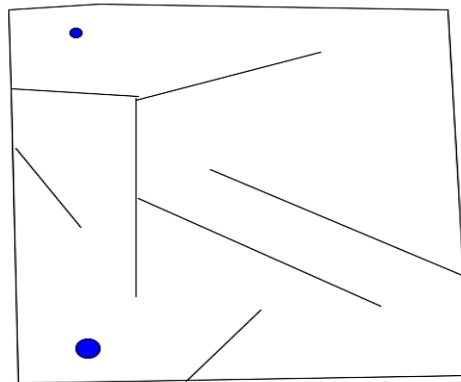
More information

- My Homepage:
  http://www.cs.ucf.edu/~kstanley
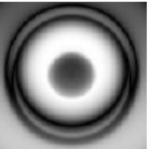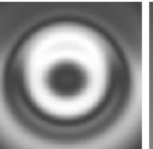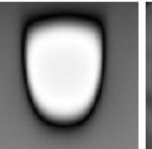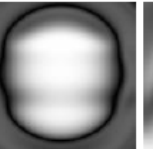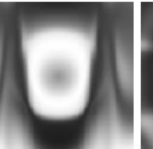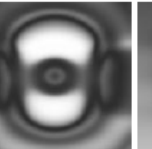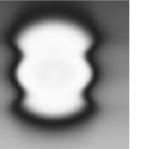
- Novely Search Users Page:
  http://eplex.cs.ucf.edu/noveltysearch/userspage/

- Evolutionary Complexity Research Group:
  http://eplex.cs.ucf.edu

- Picbreeder: http://picbreeder.org

- Email: kstanley@eecs.ucf.edu

More Computer Evidence:
A New Algorithm?
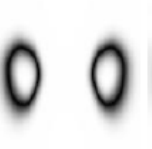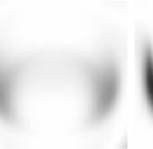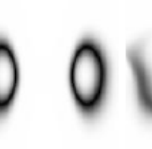
- Might search work better without objectives?
  - What if it tried to collect *stepping stones* instead of worrying where it is heading?

Results Are Terrible

- Typical best results given 30,000 generations (only odd runs shown)

Skull	Run 1	Run 3	Run 5	Run 7	Run 9	Run 11	Run 13	Run 15	Run 17	Run 19
	20f, 24c failed	20f, 29c failed	19f, 24c failed	22f, 28c failed	21f, 28c failed	16f, 22c failed	21f, 27c failed	23f, 29c failed	18f, 25c failed	25f, 28c failed

Butterfly	Run 1	Run 3	Run 5	Run 7	Run 9	Run 11	Run 13	Run 15	Run 17	Run 19
	22f, 27c failed	21f, 27c failed	22f, 25c failed	20f, 28c failed	18f, 23c failed	21f, 27c failed	27f, 34c failed	22f, 25c failed	24f, 29c failed	20f, 28c failed

- Question: *What is going wrong?*

Answer: Being "Close" to Target Is the Wrong Metric for Progress

- The fitness function is not the problem
  - A better image-matcher would be *worse*
  - Because stepping stones to the skull *do not look like the skull* – called **deception**
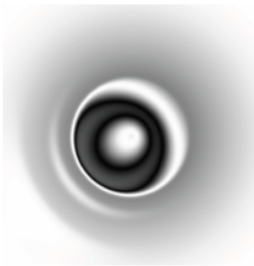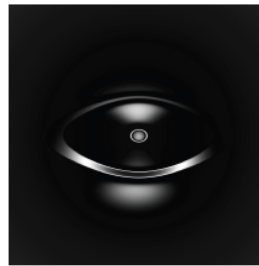
gen 12   gen 20   gen 36   gen 49   gen 74

- Humans chose these stepping stones because they were interesting for *other* reasons

This Story Is Universal
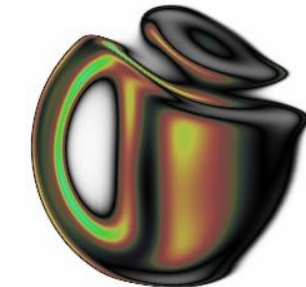
The stepping stones almost never resemble the final product
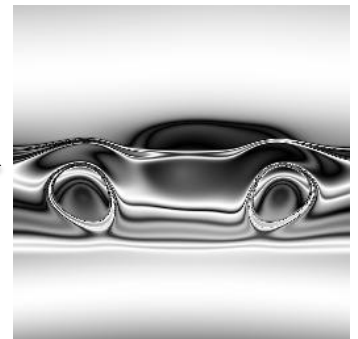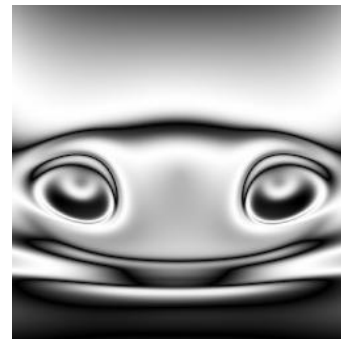
Algorithm: Abandon Objectives and Search for Novelty

- Can be hard to identify stepping stones a priori
- Novelty = proxy for stepping stones
  - Anything that does something different is a potential stepping stone
- Novelty is still based on information, just *different* information
- No final objective, just find new behaviors
- Encounter solution although not looking for it!

Testing Novelty Search

- Start with an evolutionary algorithm (NEAT)
  - Evolve *artificial neural networks* to control simulated robot behaviors
  - No fitness function
  - Instead, reward *any* behavior that is novel so far
    - No concept of better or worse
    - No objective
    - Changes over evolution

Novelty Search = Exhaustive Search?

- Not exactly, because novelty induces an *order*
  - Once simple behaviors are exhausted, novelty requires more complexity
  - More novelty requires accumulating *information*

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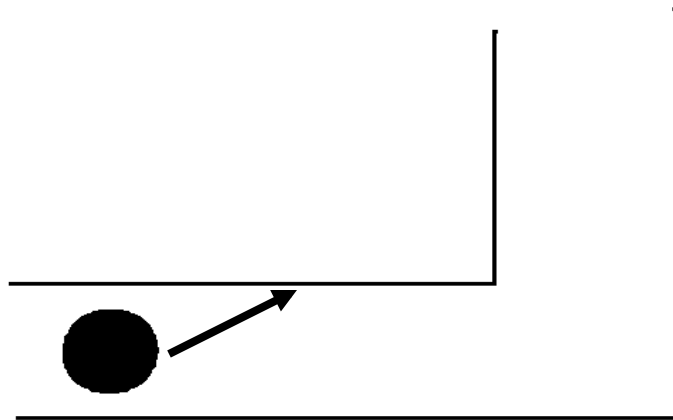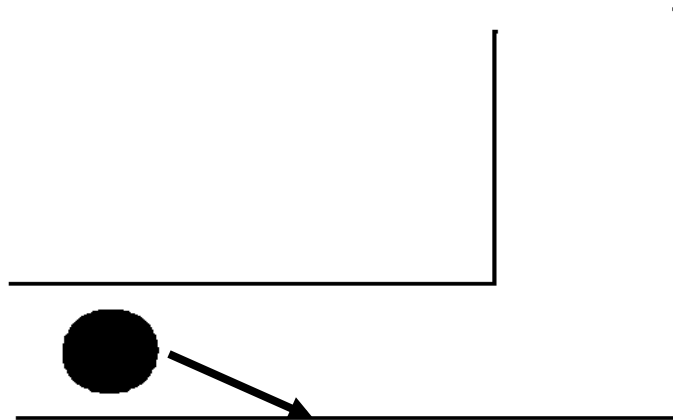 - More novelty requires accumulating *information*

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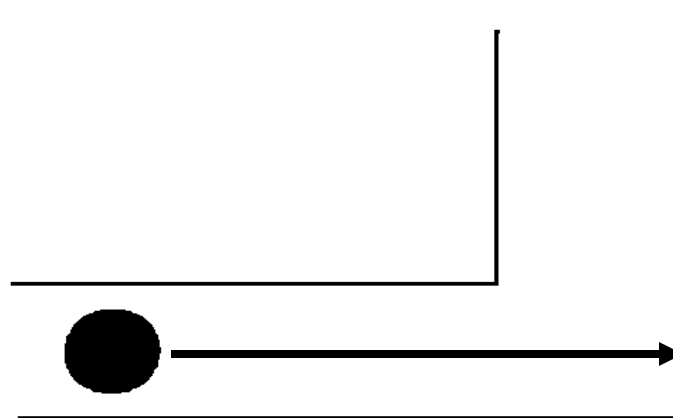 - More novelty requires accumulating *information*

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