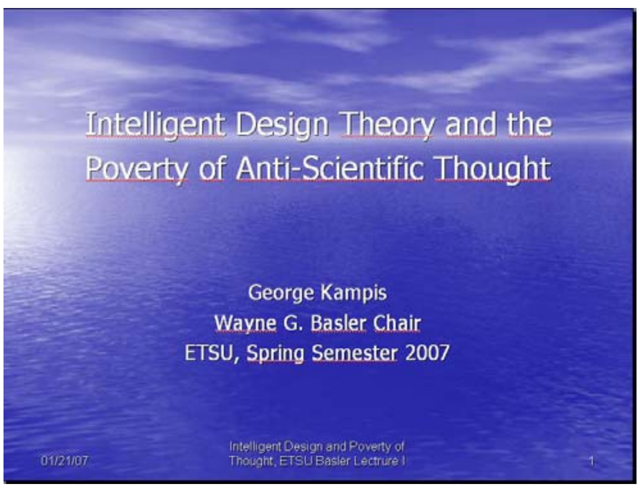
ALife Modeling of Evolution

George Kampis

Basler Chair, ETSU, 2007

Basler Lecture I



Basler Lectures II-IV

…, Kampis is presenting a series of free public lectures. Remaining lectures this semester will be held Feb. 6 (“The Evolution of Species in Artificial Life Models”), March 14 (“Complexity Theory in Biological and Social Systems”) and April 12 (“Consciousness in the Body”) at 7 p.m. in the Brown Hall auditorium.

http://www.etsu.edu/calendars/calendars_news.asp?EventID=5703

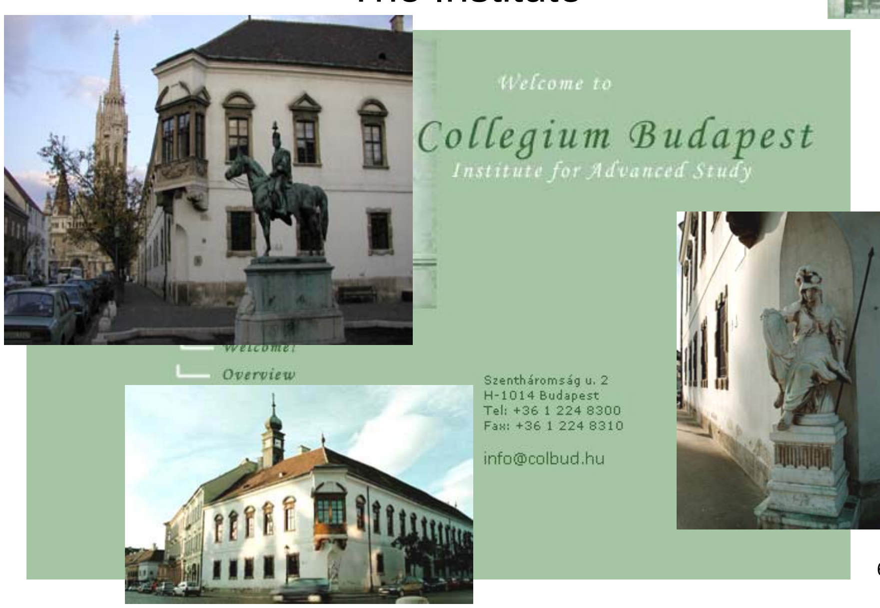
And now…

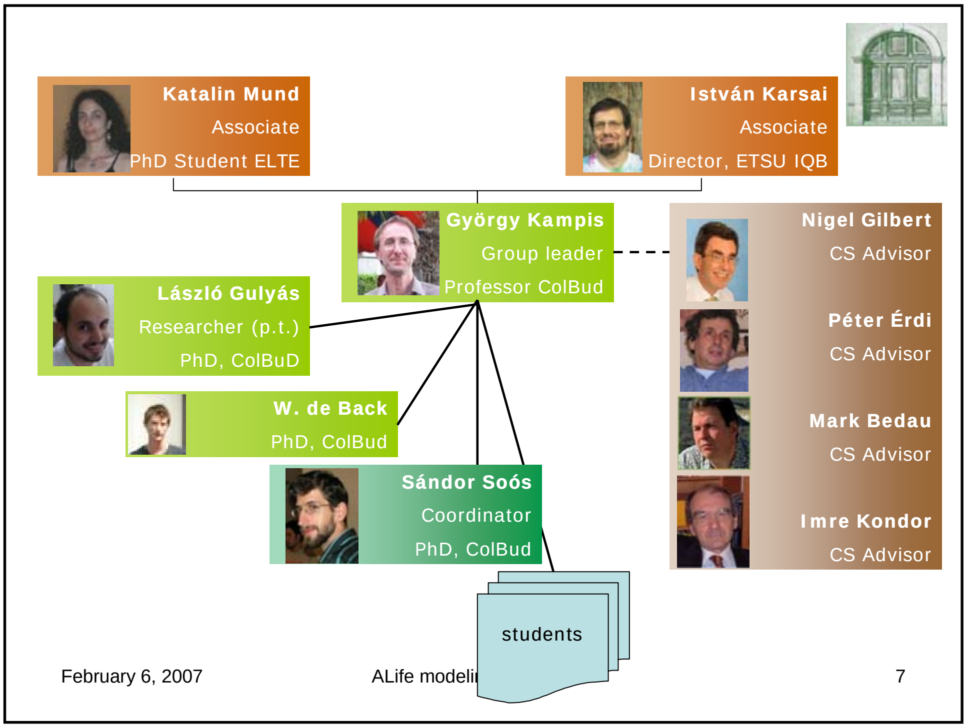
For something completely different….

The Plan

- The Project
- Artificial Life
- Artificial Evolution
- The FATINT/EvoTech system
- Evolution by phenotye plasticity
- The Model
- Results
- Future work

The Institute




Katalin Mund
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PhD Student ELTE
István Karsai
Associate
Director, ETSU IQB
György Kampis
Group leader
Professor ColBud
Nigel Gilbert
CS Advisor
Péter Érdi
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László Gulyás
Researcher (p.t.)
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Coordinator
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students
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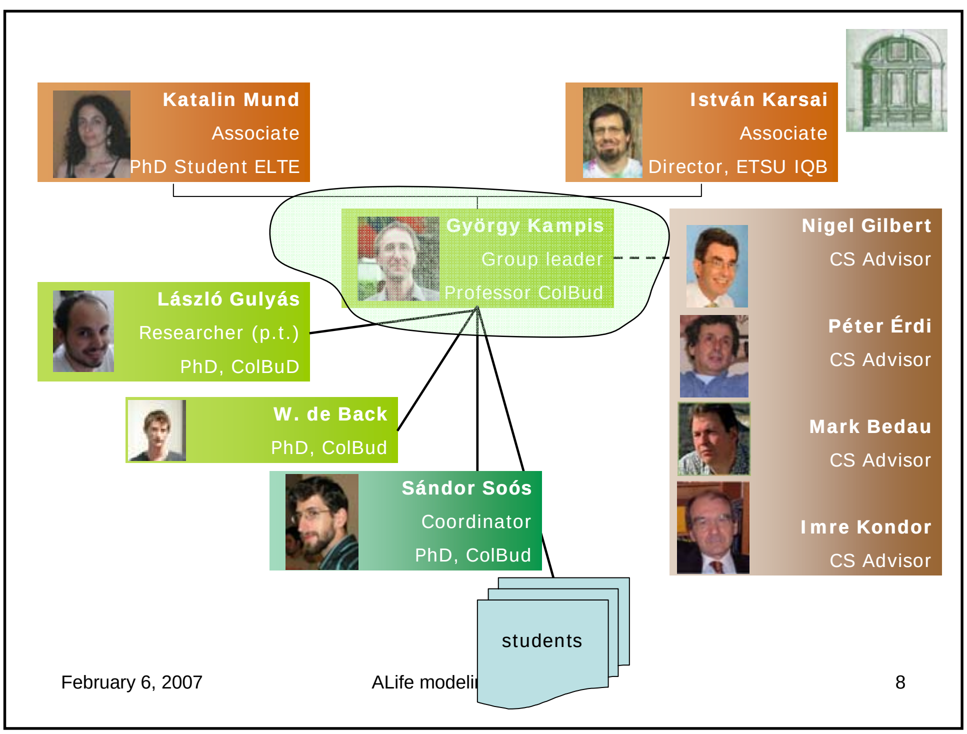
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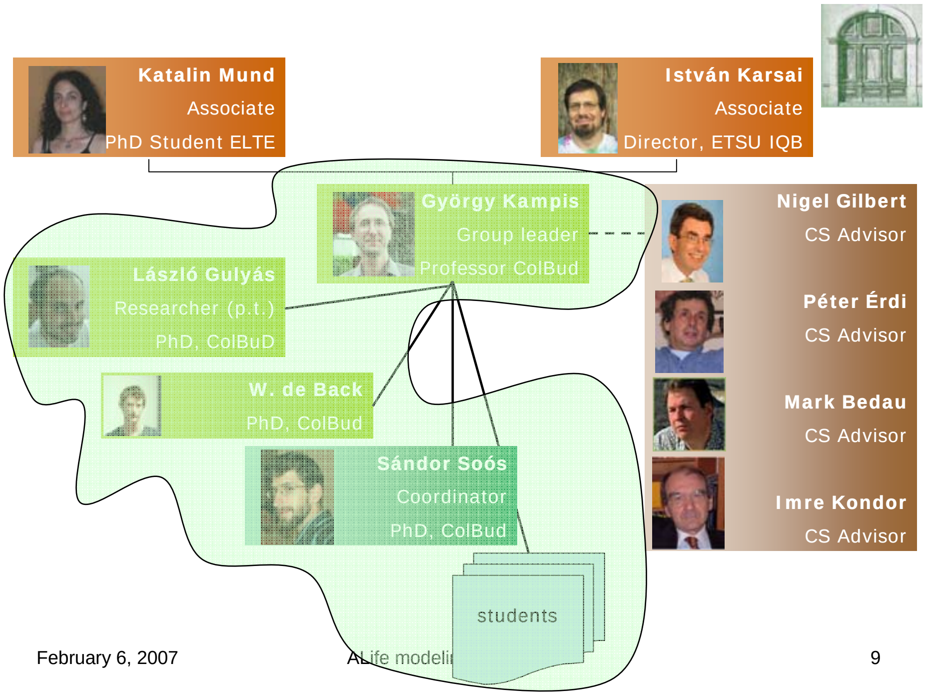
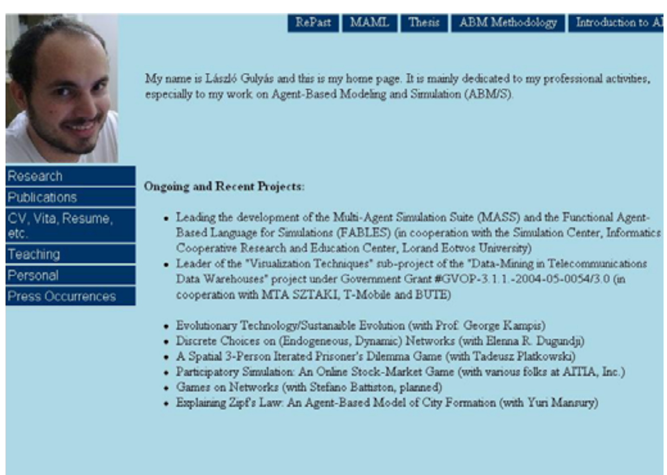
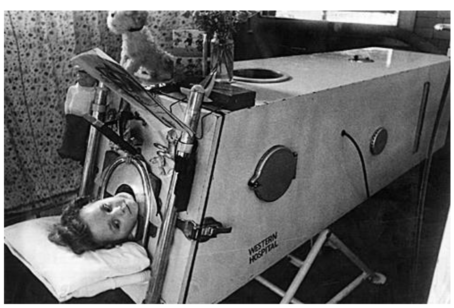


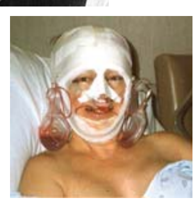
Special thanks to..



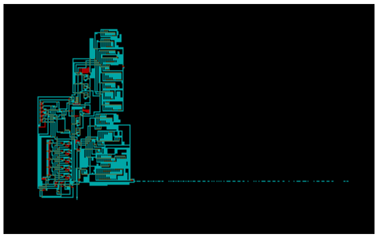
Artificial Life, what is it?

Artificial Life, what is it?

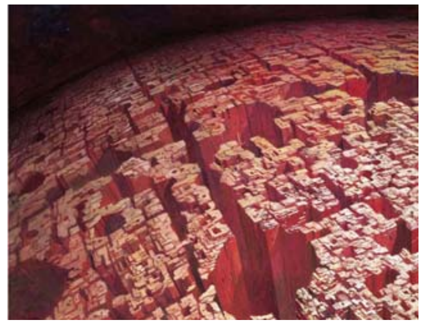




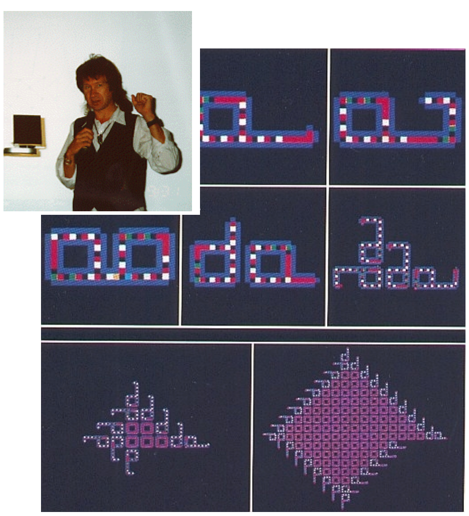
Life „in silico”

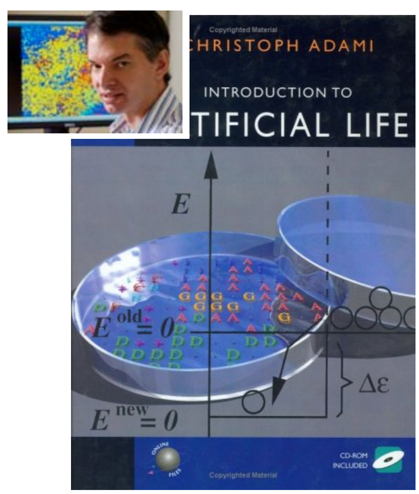


J. von Neumann (1966)
Self reproducing automata



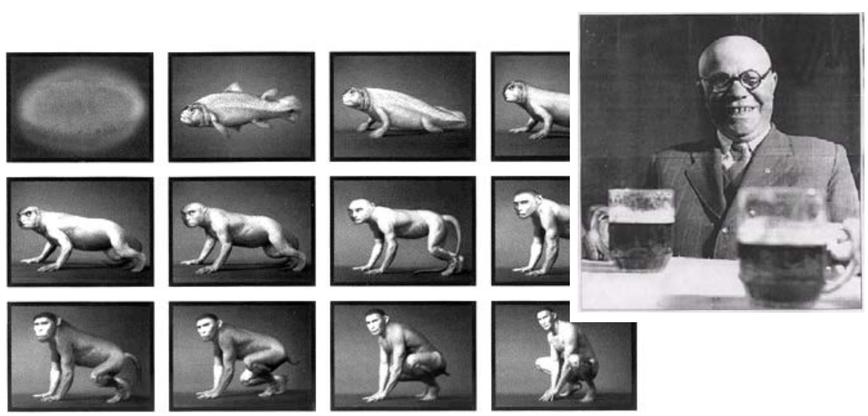
ALife modeling





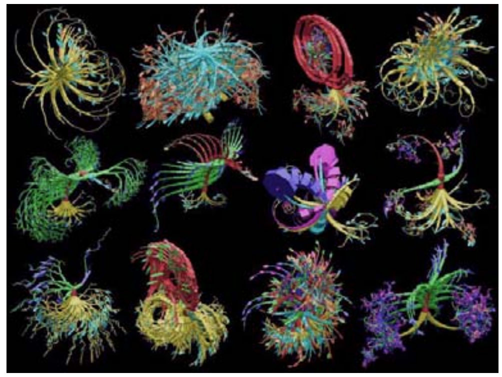
Evolution

Evolution



..is the origin of higher structure and increase of complexity

Artificial Evolution



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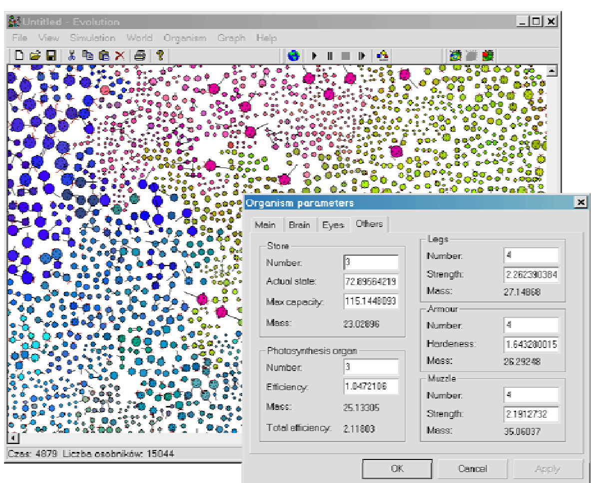
Evolution in the Lab I.



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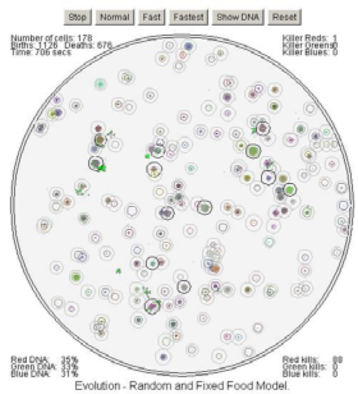
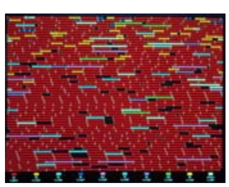
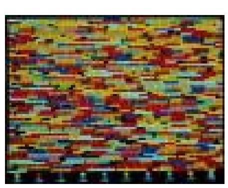
Evolution in the Lab II.

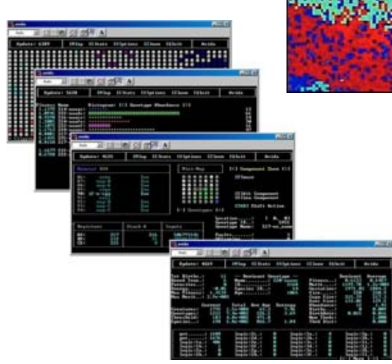
- http://www.hayles.demon.co.uk/mixed.html

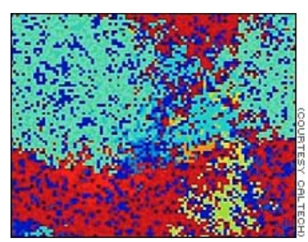


Tierra, Avida…







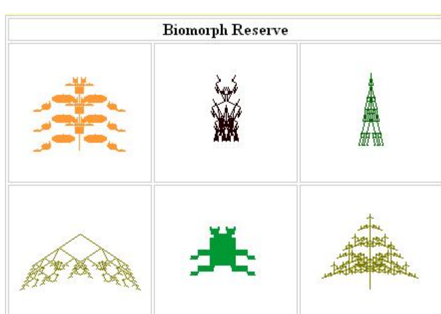


Limits from design

- „Running out of fuel”
- No emergence of higher structures
- No proof of complexity increase

BioMorphs

- http://www.well.com/~hernan/biomorphs/biomorphs.html



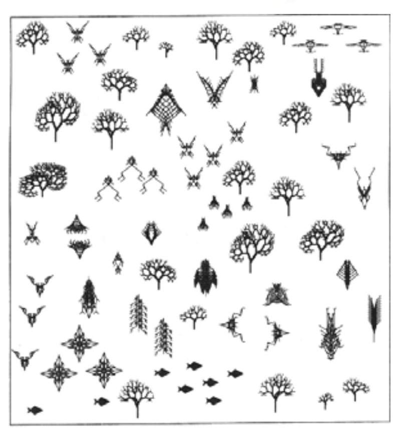
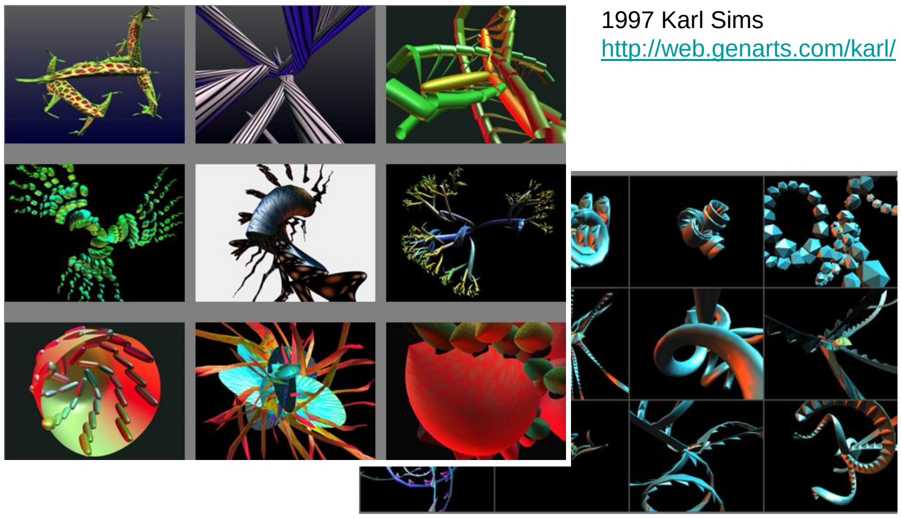


Figure 1.16 Safari park of black-and-white biomorphs, bred with the 'Blind Watchmaker' computer program.

„Galapagos”



1997 Karl Sims
http://web.genarts.com/karl/

Spore

Spore is…

Spore (video game)

From Wikipedia, the free encyclopedia

This article or section contains information about an unreleased computer or video game.
It is likely to contain information of a speculative nature, and the content may change dramatically as more information becomes available.

Spore is a computer and video game under development by Maxis, and designed by Will Wright. It simulates the complete history and future of life. Its concept, scope, and development philosophy (broad use of procedural generation) have drawn wide attention.

Spore is, at first glance, a "teleological evolution" game or god game: the player molds and guides a species across many generations, growing it from a single-celled organism into a more complex animal, until the species becomes intelligent. At this point the player begins molding and guiding this species' society, progressing towards a spacefaring civilization. Spore's main innovation is the use of procedural generation for many of the components of the game, providing vast scope and open-endedness. Wright said "I didn't want to make players feel like Luke Skywalker or Frodo Baggins. I wanted them to be like George Lucas or J.R.R. Tolkien."[1]

Spore	
Developer(s)	Maxis
Publisher(s)	EA Games
Designer(s)	Will Wright
Release date(s)	Late 2007
Genre(s)	Life simulation / evolution game
Mode(s)	Massively Single-Player
Rating(s)	ESRB: Rating Pending
Platform(s)	Windows, DS

The game was already in development in 2000 around the time that The Sims Online was starting development.[1] The game was first revealed and demonstrated to the public during a speech on procedural generation at the 2005 Game Developers Conference (GDC).

On October 8, 2006, the game, its development, and its developer were featured in an article by Steven Berlin Johnson in the Sunday New York Times magazine; the article was entitled "The Long Zoom". [2]

1. Tide Pool Phase, similar to *Pac-Man*
2. Creature Phase, *Diablo*
3. Tribal Phase, *Populous*
4. City Phase, *SimCity*
5. Civilization Phase, *Risk* and *Civilization*
6. Space Phase (a.k.a. UFO stage or Invasion) and later, sandbox gameplay.

a God game!

God game

From Wikipedia, the free encyclopedia

For the novel by Andrew Greeley, see God Game (novel).

Though there is no formal definition, **God games** are said to be generally large-scale strategic fantastic simulations, sometimes of entire worlds and populations, that cast you in the position of an entity with divine or supernatural powers (See references). God games are characterized by that:

- Actions taken by the player tend to be optional interventions into the system of the game world, for instance in the form of miracles or invoking calamities, rather than being a necessity for its continual progression.
- The game world is relatively self-sustaining and persistent.
- As a God, the player can affect the world and influence his subjects but not directly control them: i.e. there is a minimum of "click-select-order" gameplay, unlike other strategy games.

Contents [hide]

Categories of God games [edit]

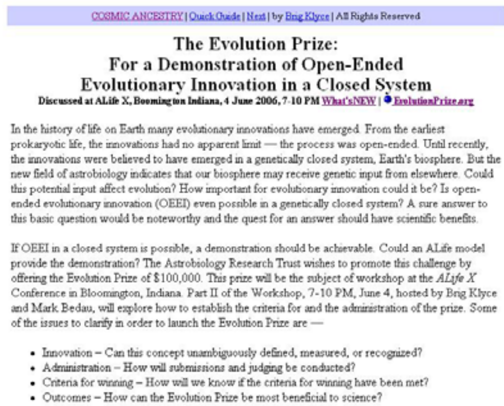
God games fall into two categories:

- Games in which the user plays a godlike entity that controls entire continents or worlds. The first God game of this kind on a console was *Utopia* by Don Daglow on Intellivision (1982), while the first such game on a personal computer was *Populous* by Peter Molyneux of Bullfrog Productions (1989). Both titles have been named to the GameSpy

Can we get any further?

Fun: The Evolution Prize

- http://www.panspermia.org/eprize.htm



COSMIC ANCESTRY | Quick Guide | Next | by Brig Klyce | All Rights Reserved

The Evolution Prize:
For a Demonstration of Open-Ended
Evolutionary Innovation in a Closed System
Discussed at ALife X, Boomington Indiana, 4 June 2006, 7-10 PM What'sNEW | EvolutionPrize.org

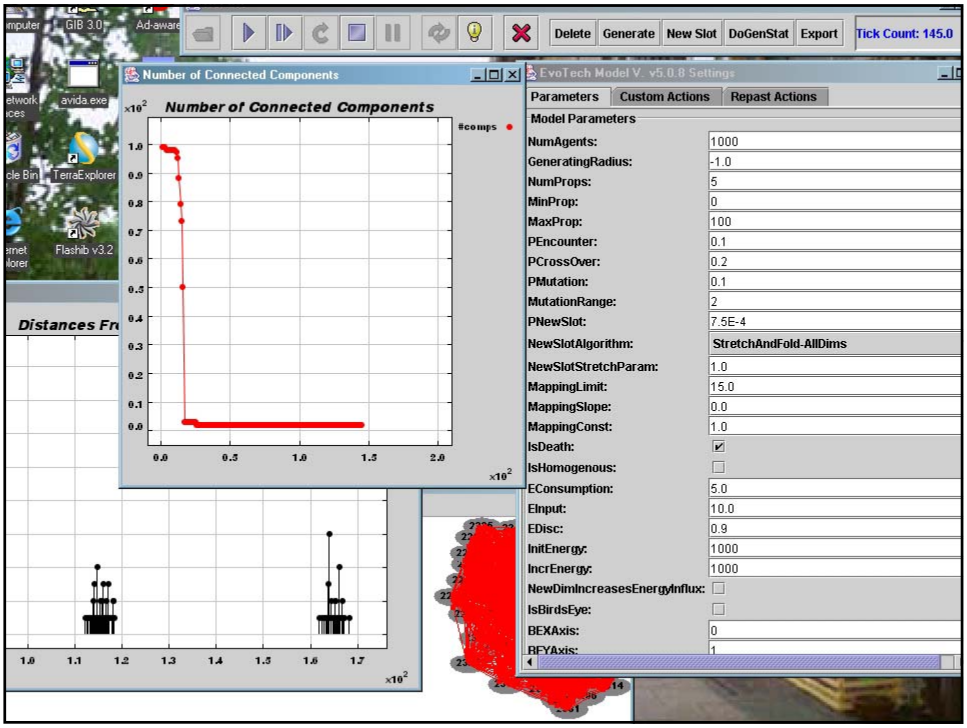
In the history of life on Earth many evolutionary innovations have emerged. From the earliest prokaryotic life, the innovations had no apparent limit — the process was open-ended. Until recently, the innovations were believed to have emerged in a genetically closed system, Earth's biosphere. But the new field of astrobiology indicates that our biosphere may receive genetic input from elsewhere. Could this potential input affect evolution? How important for evolutionary innovation could it be? Is open-ended evolutionary innovation (OEEI) even possible in a genetically closed system? A sure answer to this basic question would be noteworthy and the quest for an answer should have scientific benefits.

If OEEI in a closed system is possible, a demonstration should be achievable. Could an ALife model provide the demonstration? The Astrobiology Research Trust wishes to promote this challenge by offering the Evolution Prize of $100,000. This prize will be the subject of workshop at the *ALife X* Conference in Bloomington, Indiana. Part II of the Workshop, 7-10 PM, June 4, hosted by Brig Klyce and Mark Bedau, will explore how to establish the criteria for and the administration of the prize. Some of the issues to clarify in order to launch the Evolution Prize are —

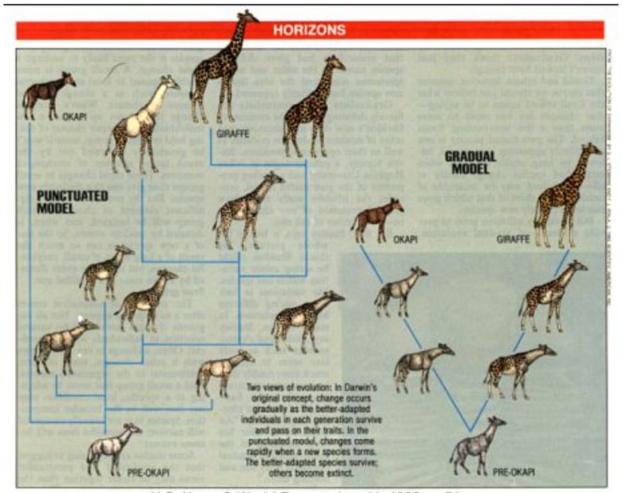
- Innovation – Can this concept unambiguously defined, measured, or recognized?
- Administration – How will submissions and judging be conducted?
- Criteria for winning – How will we know if the criteria for winning have been met?
- Outcomes – How can the Evolution Prize be most beneficial to science?

The FATINT/EvoTech system

- http://hps.elte.hu/~kampis/EvoTech/ET.html



Evolution produces diverse *species*...

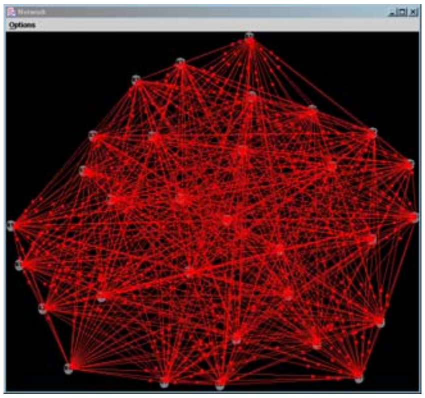


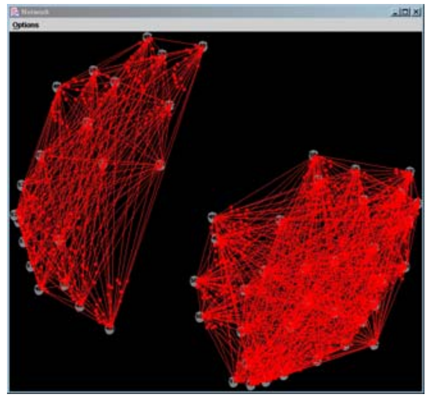
U.S. News & World Report, Jan. 11, 1988, p. 51.

.. usually splitting old ones, into two...

…or more.

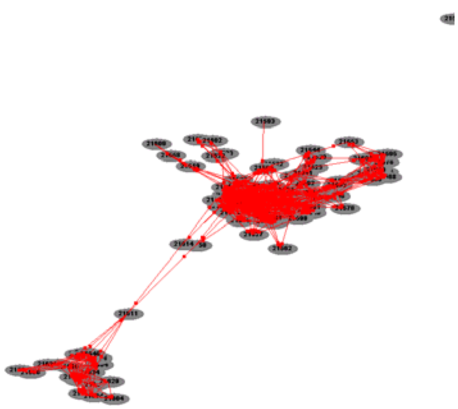
The key is: *Species*





- A species is a set of interbreeding individuals...

- Reproductively isolated from others
- (e.g. mechanically, behaviorally, in terms of mating preference, etc.)



A more realistic species.

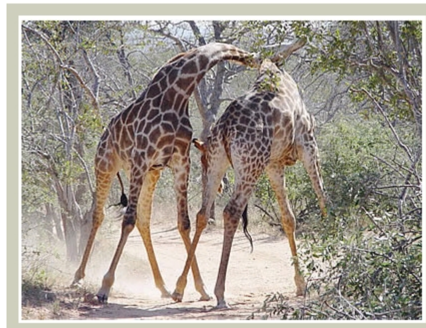
Not panmictic, yet stable .

In an evolutionary engine, a species, which responds to a selection force, just does not split.

Can we produce new species?

I.e., can we get existing species to split,
structurally, functionally,
repeatedly, and for internal reasons?

Back to the Giraffe…



Species splitting by sexual selection.

Simmons, Robert E. and Lue Scheepers. *"Winning by a Neck: Sexual Selection in the Evolution of Giraffe."* The American Naturalist Nov 96: 771-86.

Function change - interaction change

- The pre-okapi neck was always there, but was used differently

  - function change (Darwin), exaptation (Gould), tinkering (Jacob)
  - „niche construction" (Lewontin, Laland, Odling-Smee, Feldman……)
  - Phenotype plasticity (Karsai, Kampis..)

Explicit and implicit phenotype

- Our model: sexual selection from changing mating preference, not changing male behavior/changing use.
- Similar to the change of use, the change of mating preference means a change of an *implicit phenotype* trait into an *explicit phenotype* trait.
- This can be caused/accompanied by a mutation, or not (as in the case of phenocopies or imitative behavior change). Similar to the Baldwin effect.

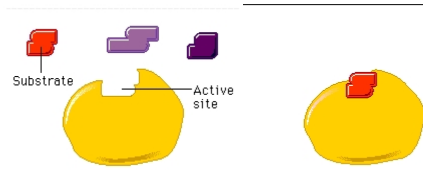
Conjecture and test

- Conjecture: a changing phenotype (i.e. interaction-) definition facilitiates speciation.
- A minimal test: study the effect of adding a new phenotype dimension.

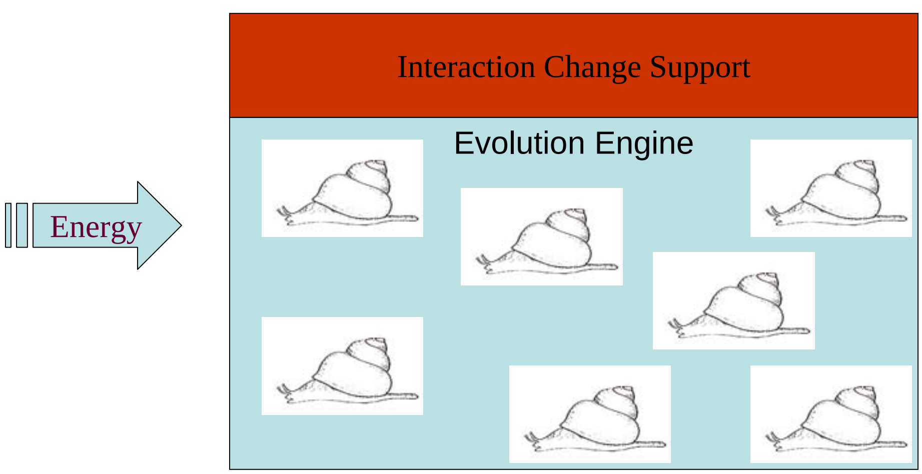
Mating preference in an Alife model

Finding the „right”
mating partner... is a matter of fitting together.

- … can be modeled as template matching,
- which defines a metric (similarity) space
- that can be used in any # of dimensions.

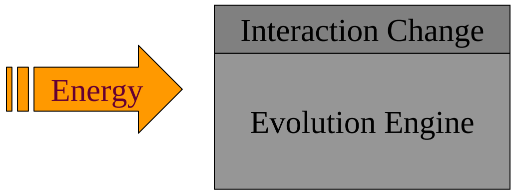


The Model



The Model

- **Evolution Engine**
  - agents in a non-spatial, partial artificial ecology
  - single resource, energy
  - full life-cycle (reproduction, aging, death)…
  - genderless sexual reproduction
  - standard evolutionary operators: mutation, crossing-over
- **Interaction Change**



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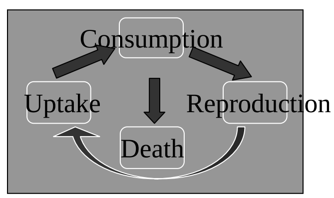

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  - full life-cycle (reproduction, aging, death)…
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  - standard evolutionary operators: mutation, crossing-over
- **Interaction Change**

Evolution Engine

- Agent:

  – Phenotype vector in N-dimensional space.

10 9 15 24 3 23 4 55 64 23 12 54 67 89 25 39 19 51 43 4

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Interaction Change

- Agent:

  – Phenotype vector in N+1-dimensional space.

10 9 15 24 3 23 4 55 64 23 12 54 67 89 25 39 19 51 43 4	32

  - Type-independent, and
  - Type-based methods.

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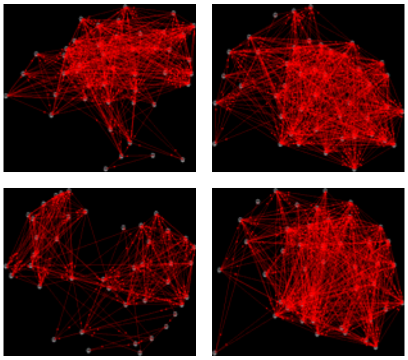
Emergent Phenotypes

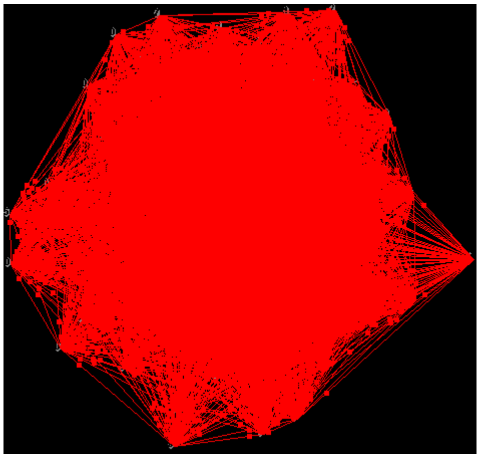
in natural and in model populations

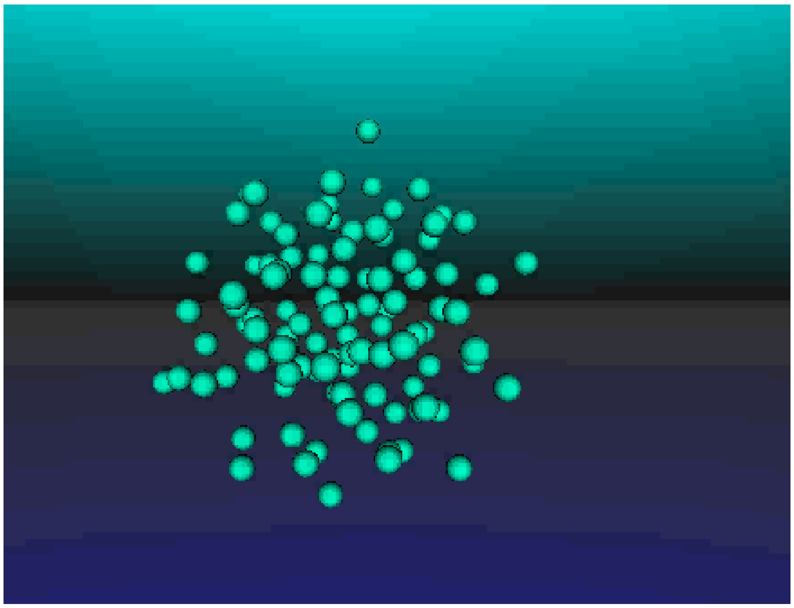


Form	Cause	Type
Point mutation	endog.	local
Phenocopies	exog.	part global
Epigenetic change	both	part global
Horizontal adapt.	both	global
Behavior change	social	global

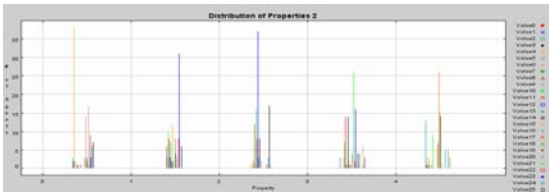
Results

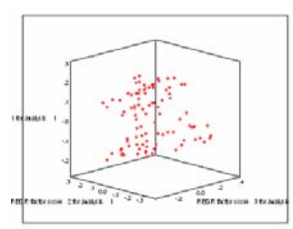
Species splitting

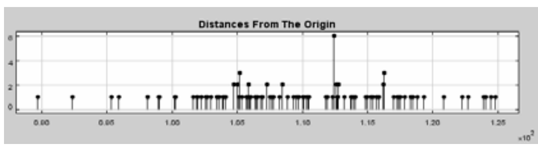




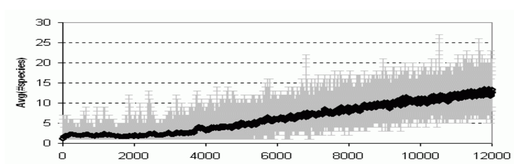
Ordinations



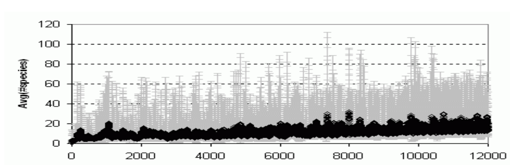




The production of species



type-dependent method



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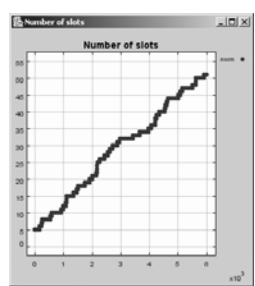


number of dimensions

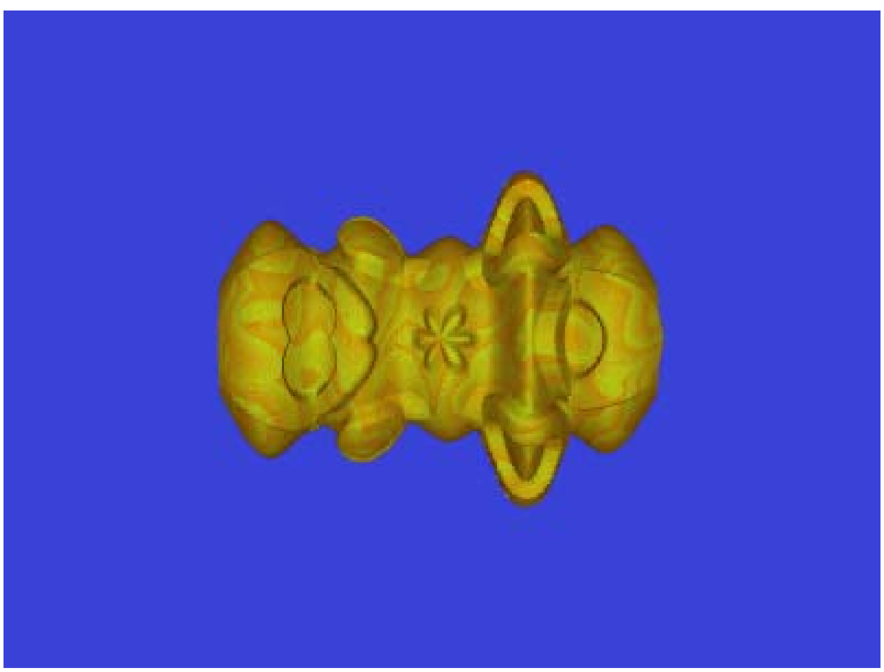
Conclusions

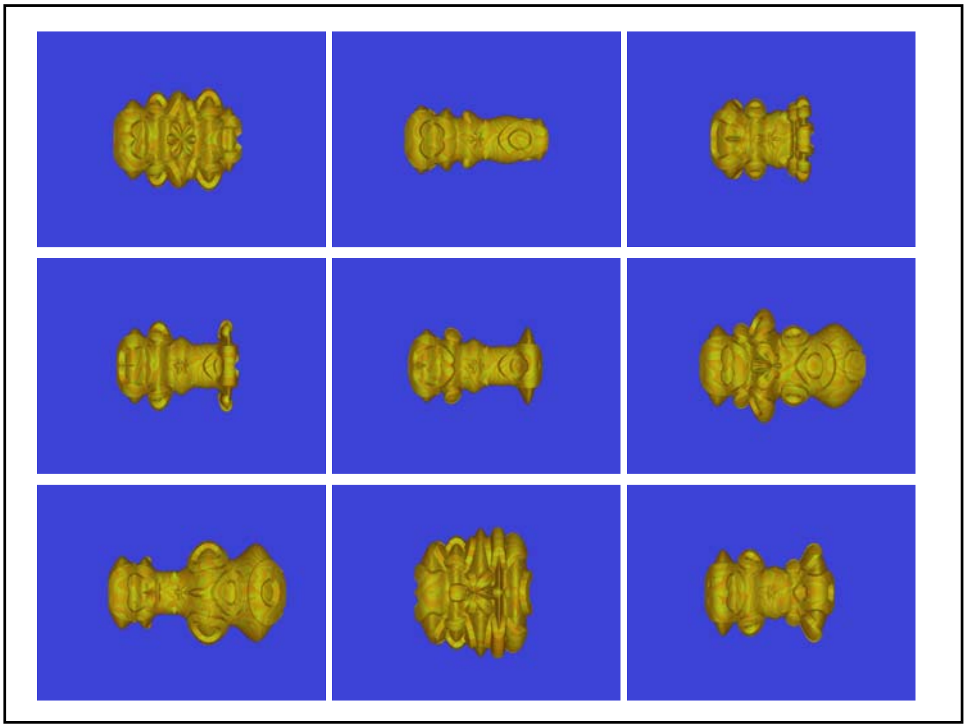
- The model yields simulation results in an interactions-based evolutionary model, which uses similarity-based sexual selection to approach open ended evolution.
- It demonstrates that changing phenotype-to-phenotype interaction (here: the adding of new dimensions to interaction space) can repeatedly split species by producing new selection constraints.
- We hypothesize that sustained ecological evolution proceeds by similar mechanisms.

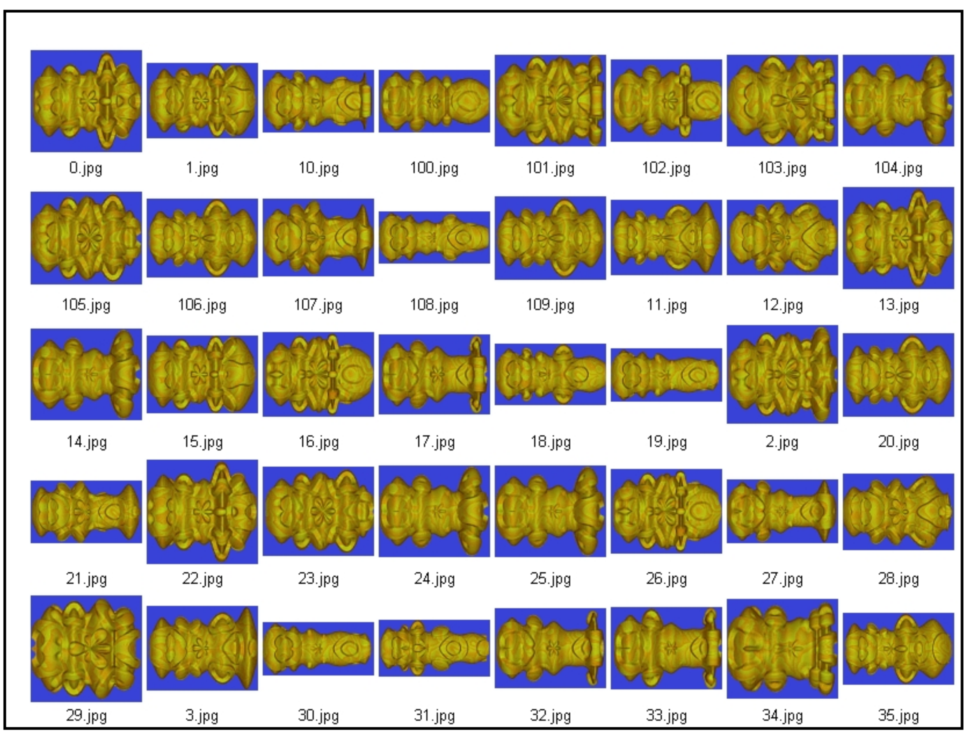
Future work

- Developmental modeling
- Ecosystems
- 3D physics

Aplysia



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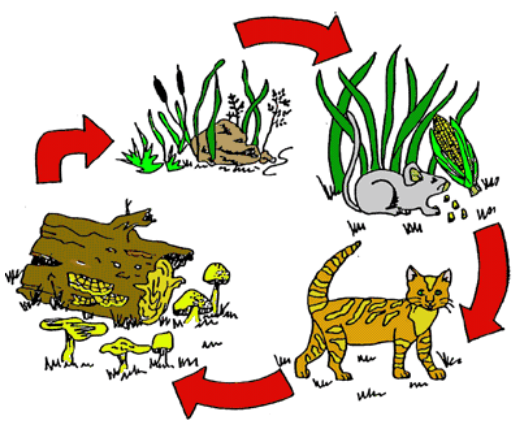
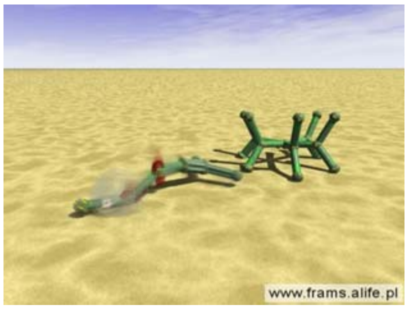
Dis/similarity in ecosystems.

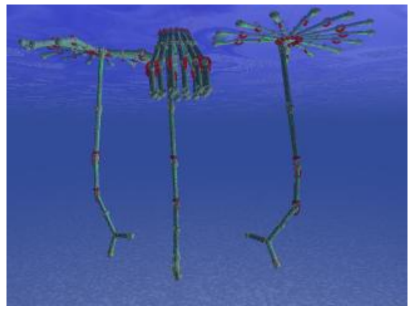
Can relational properties bootstrap whole ecosystems?



3D physics

Using http://www.frams.alife.pl/





Thank you!