Research Seminar, FDCT, 18 April 2007

The World of Information - where Science, Art and Technology Meet

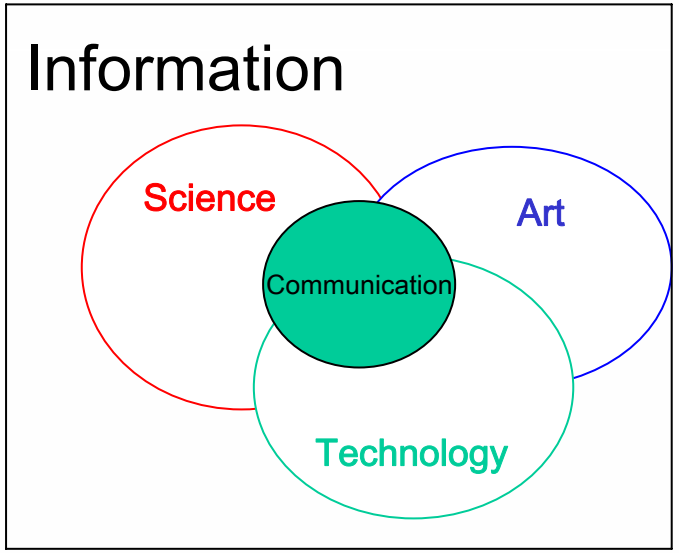
Prof. Nikola Kasabov and the KEDRI Team

http://www.kedri.info

In the World of Information, Science, Art and Technology Interact Through Communication

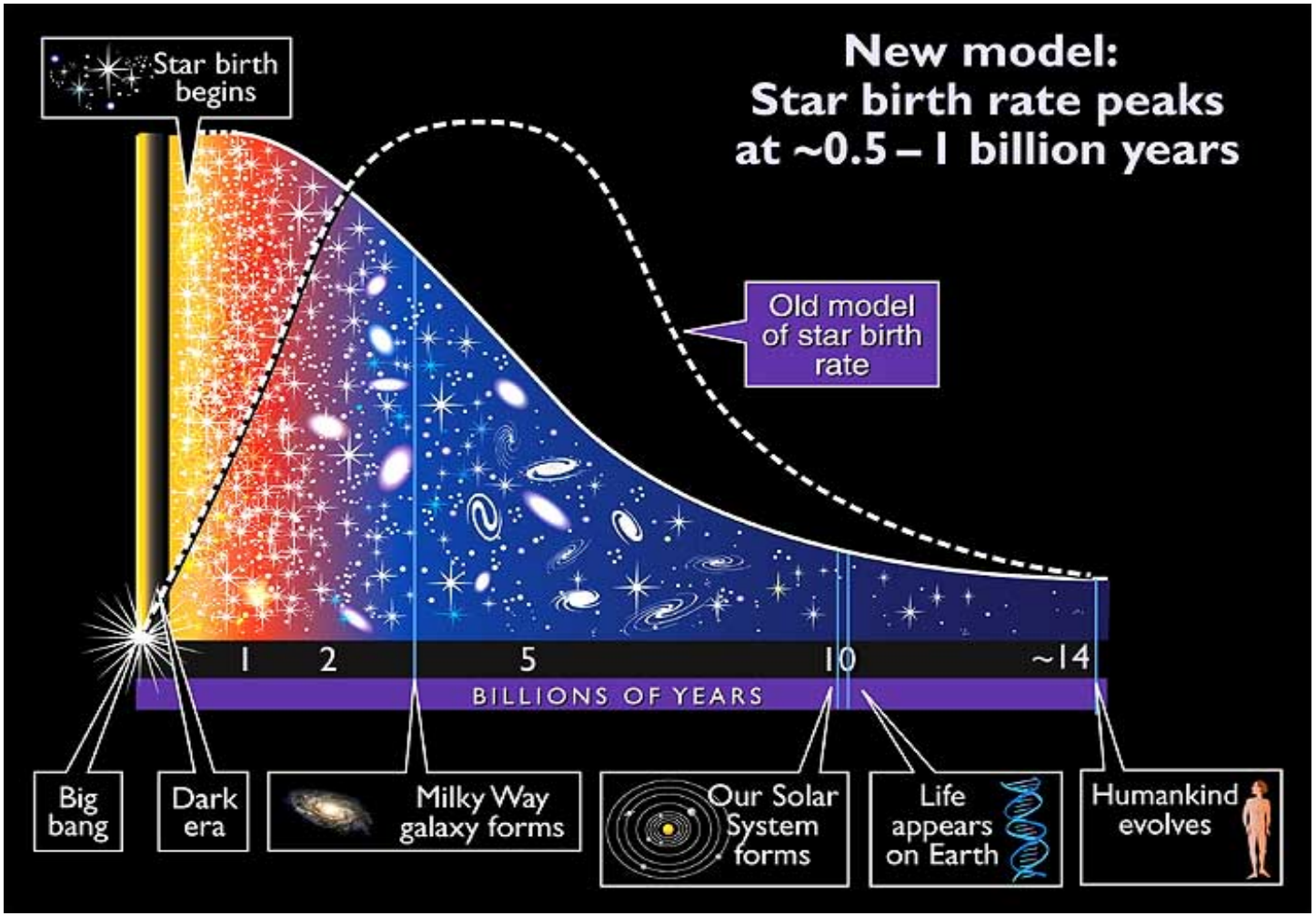
- Data, information and knowledge:

  Data are the numbers, the characters and symbols, the quantities operated on. *Information* is the ordered, structured, interpreted data. *Knowledge* is the theoretical or practical understanding of a subject, her/his gained experience, the way we do things.



- Science relates to understanding of Nature
- Arts relate to the human perception of the world
- Technology and Engineering create means to observe and interact with Nature
- We communicate Science, Art and Technology

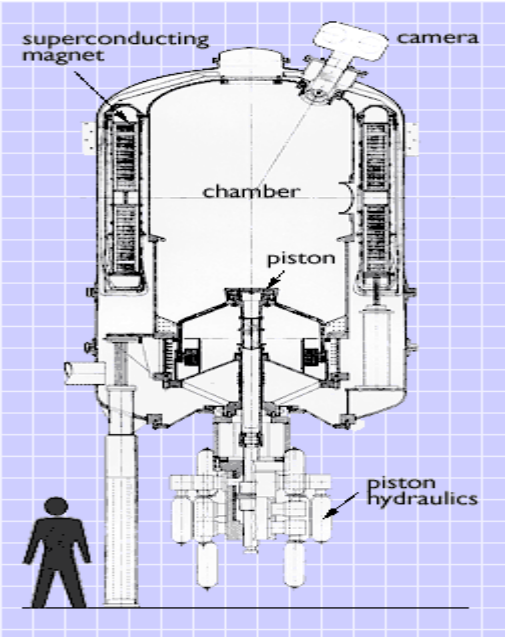
Nature – The Ultimate Source and Destination for Science, Art and Technology: From the Universe and the particles to the genes and the brain

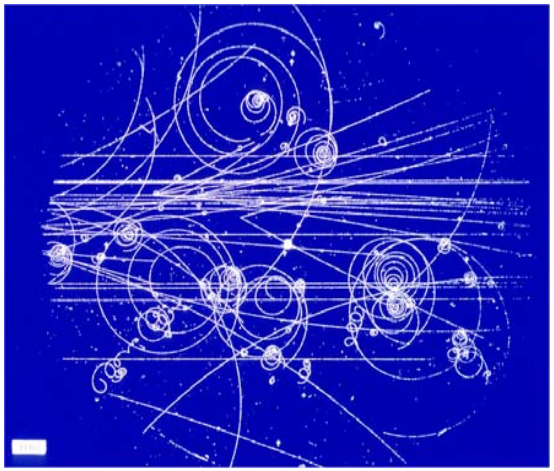


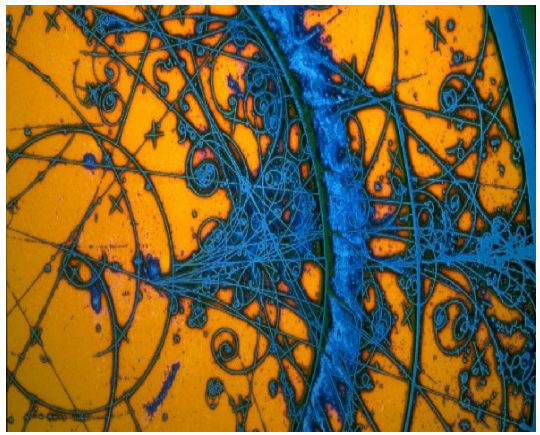
Visualisation of Particle Movement - Physics meets Art for new discoveries

7-foot Bubble Chamber: Particle detector used to discover the charmed baryon, a particle composed of three quarks, one of which was the "charmed" quark. This result helped physicists confirm a new member of the quark family.

Particles from the Alternating Gradient Synchrotron (AGS) were made to pass through liquid hydrogen which was chilled to super-cold temperatures of minus 415 degrees Fahrenheit. As particles passed through the liquid, the volume of the chamber was rapidly expanded by a large hydraulic piston. This expansion caused bubbles to form along the tracks of passing particles. Cameras atop the chamber captured the short-lived bubble tracks for analysis.

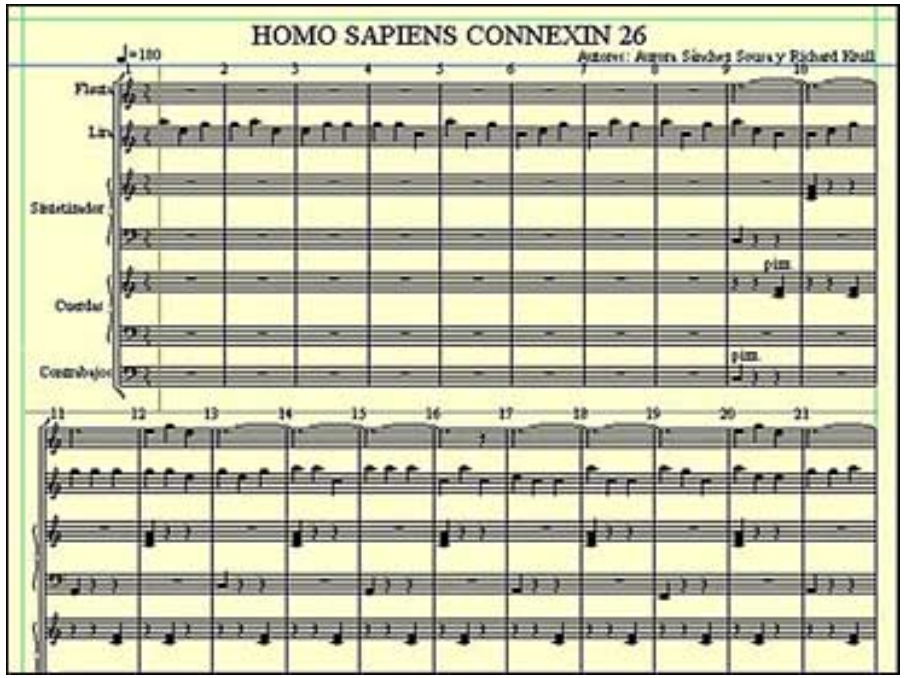


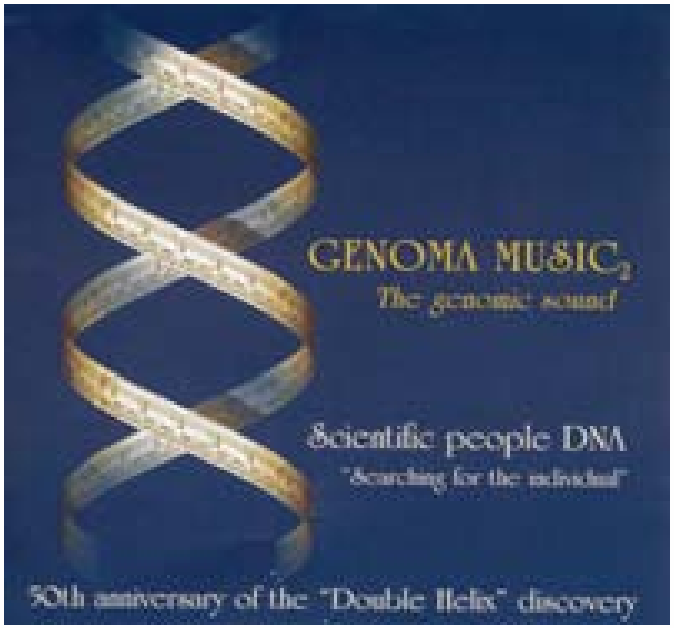




DNA as Music

A DNA sequence is lined up and each of the four chemical basis A,C,T and G is assigned a note (e.g.: C = do, T = re, G = sol, and A = la, the length of which depends on the number of the consecutive basis.



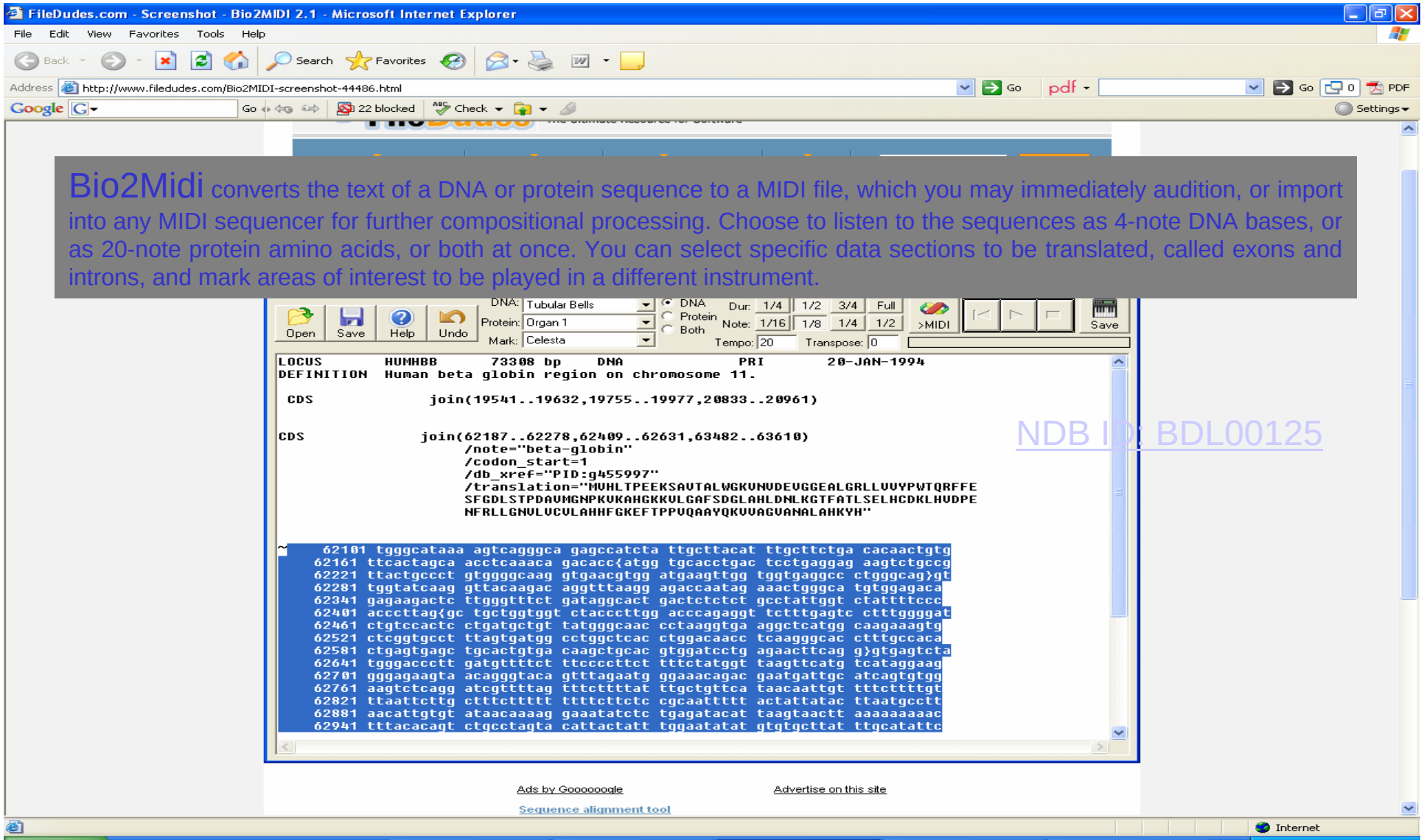


Music sheet from song based on DNA of human gene called Connexin 26

Spanish scientist (Sanchez Sousa) did that just for fun and recorded a CD, what they call an audio version of the blueprint for life ["Genoma Music"

http://www.genomenewsnetwork.org/articles/2004/02/20/genoma_music.php

Do you want to be a DNA musician ?



Bio2Midi converts the text of a DNA or protein sequence to a MIDI file, which you may immediately audition, or import into any MIDI sequencer for further compositional processing. Choose to listen to the sequences as 4-note DNA bases, or as 20-note protein amino acids, or both at once. You can select specific data sections to be translated, called exons and introns, and mark areas of interest to be played in a different instrument.

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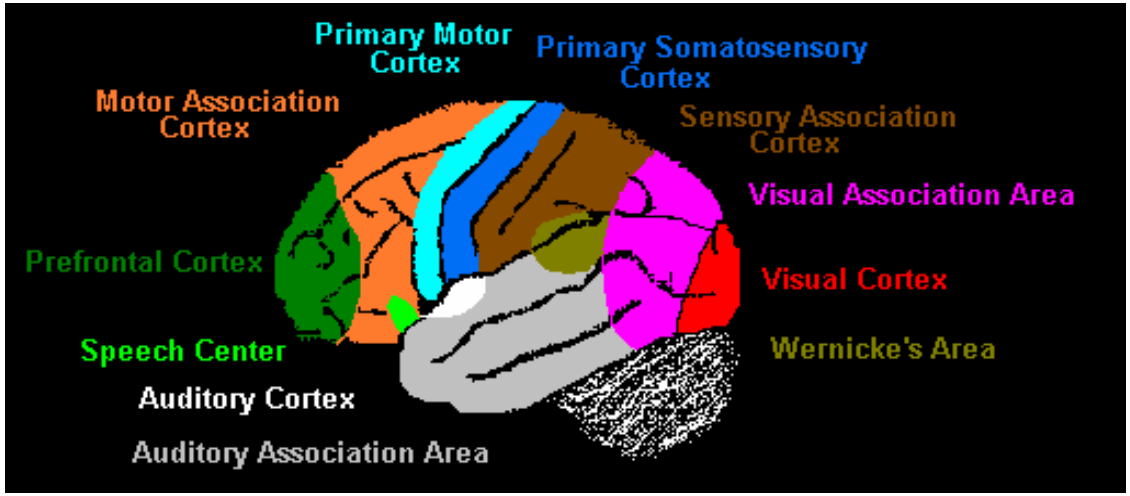
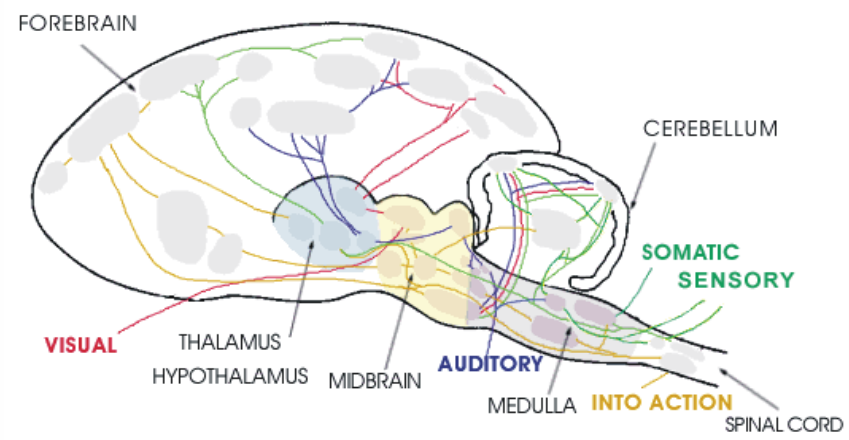
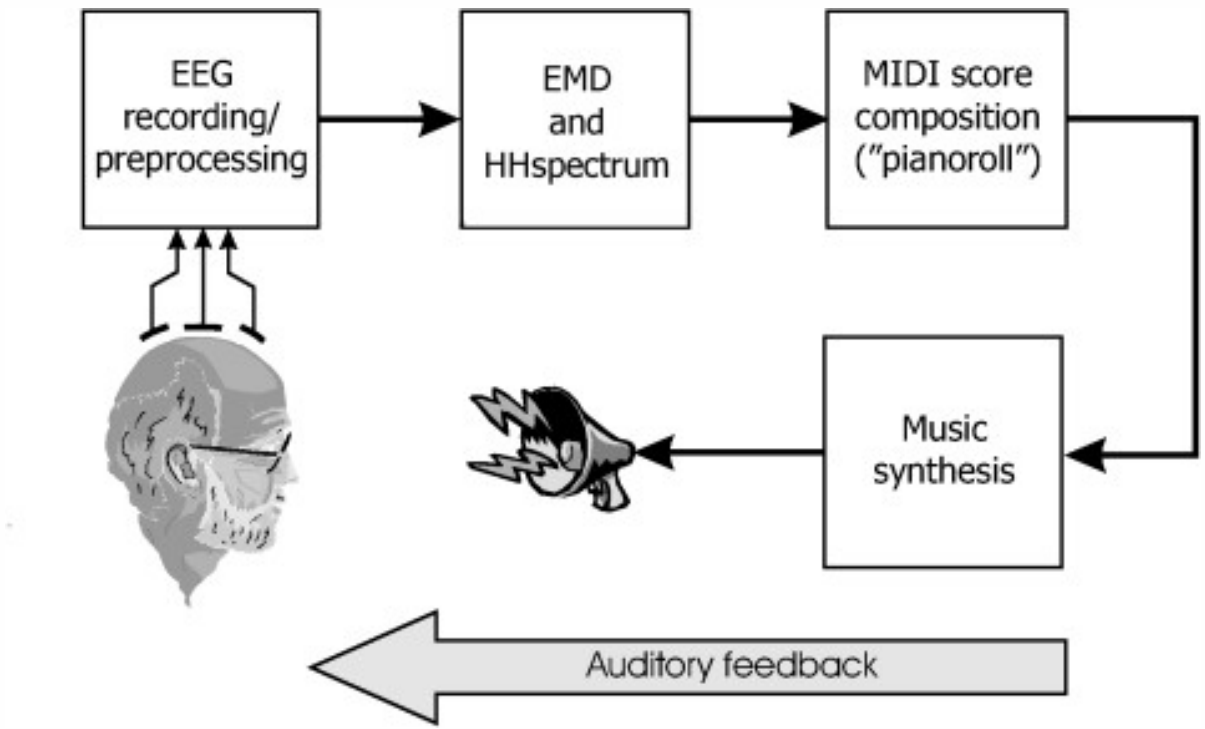
The Human Brain and Mind Create, Perceive and Communicate Science, Art and Technology,



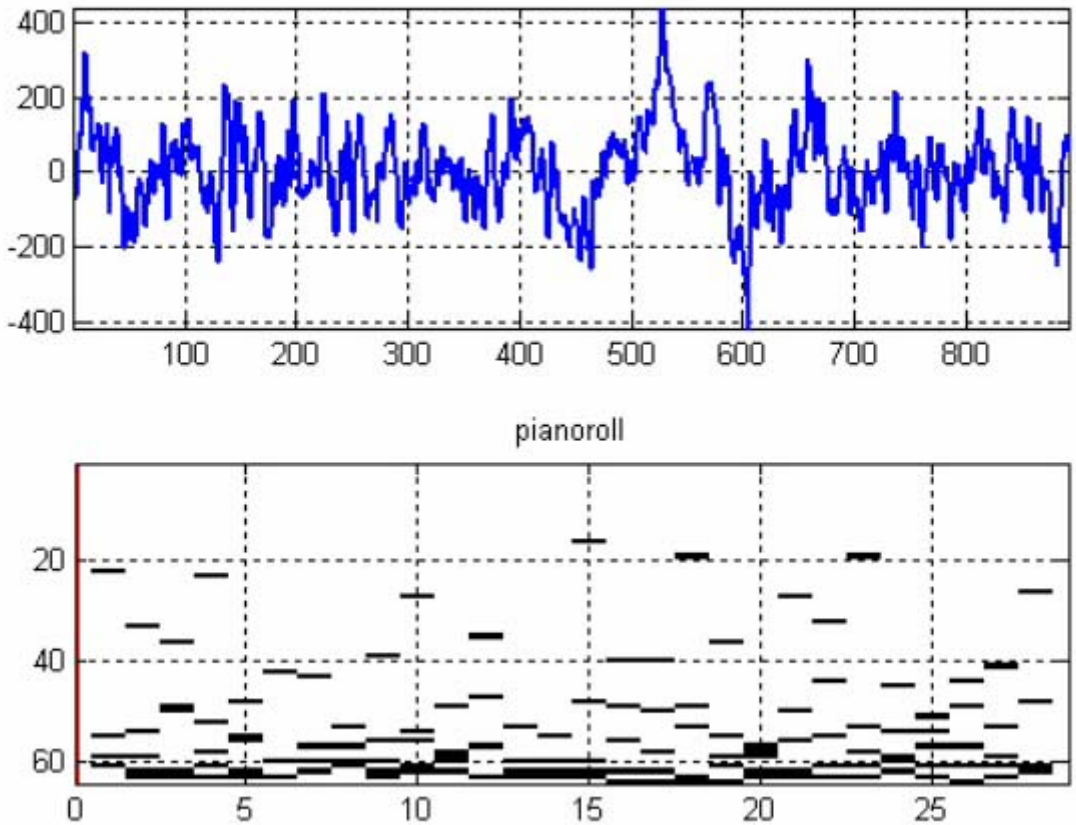


Turning the brain functioning into music. Could that help to better understand the state of the brain ?

Sonification of EEG signals is a procedure in which electrical brain activity captured from human scalp is transformed into an auditory representation. (RIKEN, Japan)



Example of EEG sonification (Rutkowski, Cichocki et al.,2006)

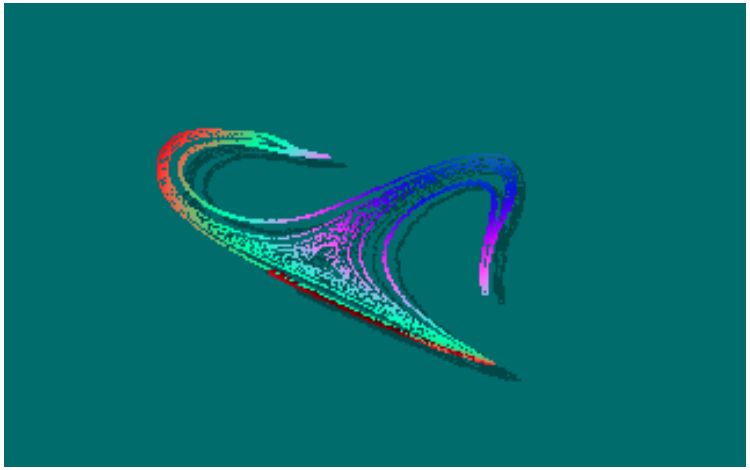


Mandala images, their healing properties for the brain and the design of information

Mandala means literally "that which extracts the essence." There are many different types of *mandalas* used by *Tibetan Buddhists*. They can be created in either two or three dimensions.
The mandala symbol visualizing a circle or a sphere, has the meaning of a centre, wholeness and unity. Because of its fundamental meaning it is the most important symbol being used in both individual and collective human creativity.
Its healing effect on mental illnesses has been studied.
Carl Jung, http://www.netreach.net/~nhojem/jung.htm

Mathematics and Art: Turning Formulas into Dynamic Images

Deterministic Chaos: strange attractors, local development, fractals,



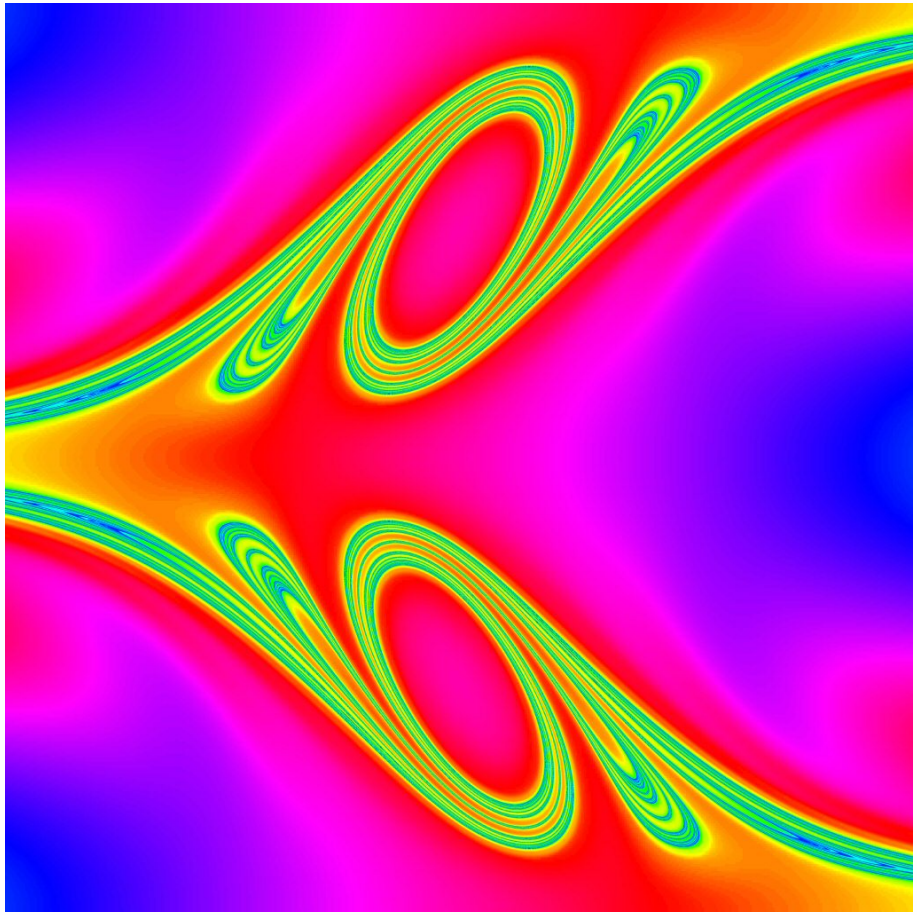
iterated mapping

$x_{new} = a + bx + cx^2 + dy + ez + f \sin(pi\ t/8)$,

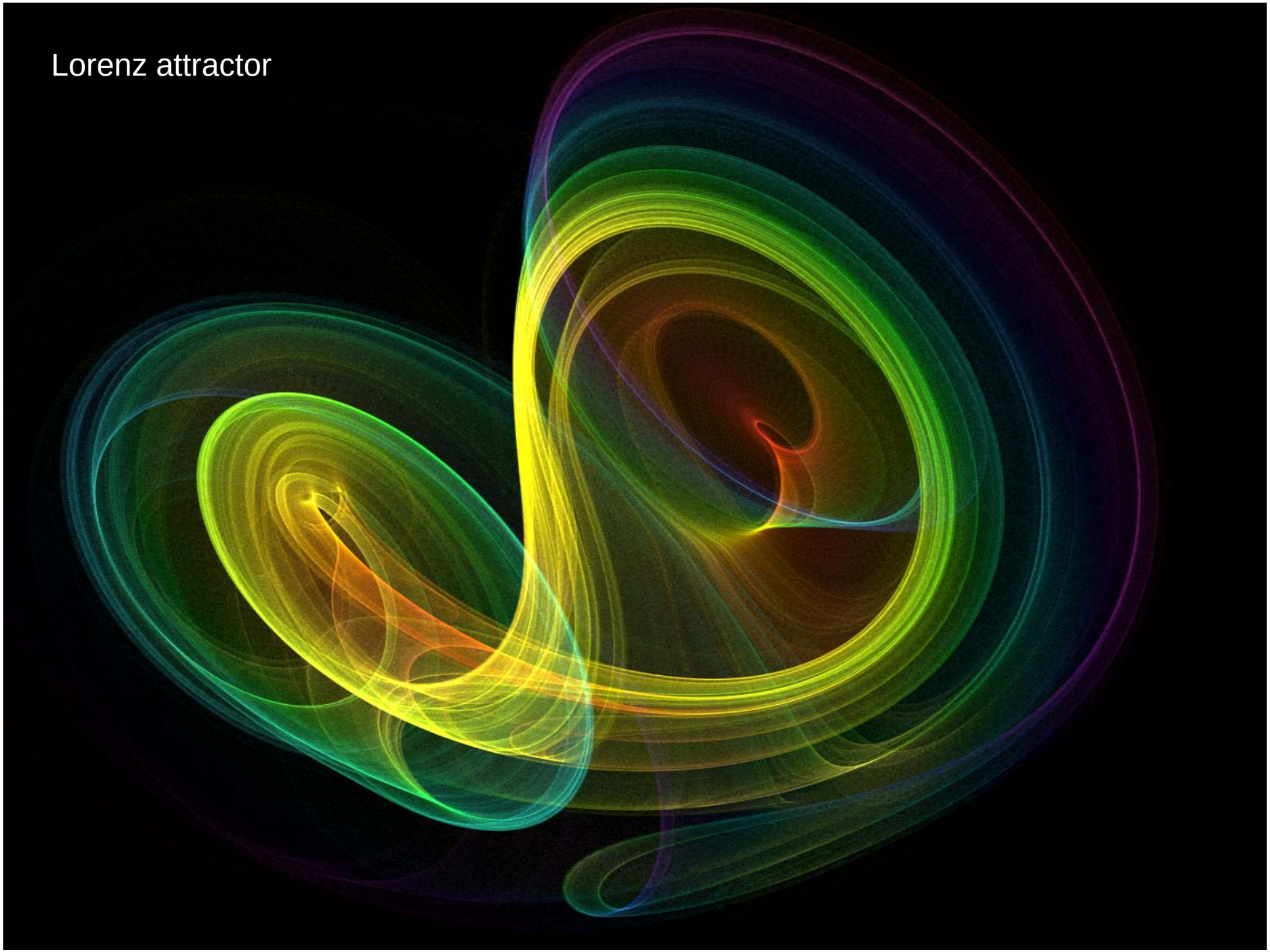
$y_{new} = x$,

$z_{new} = y$,

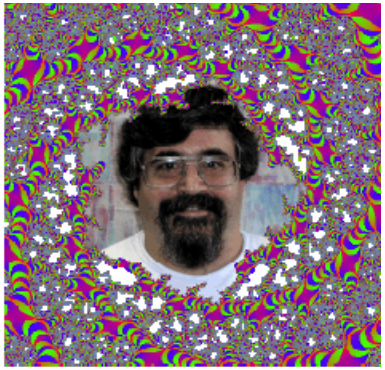
where *a* through *f* are constants

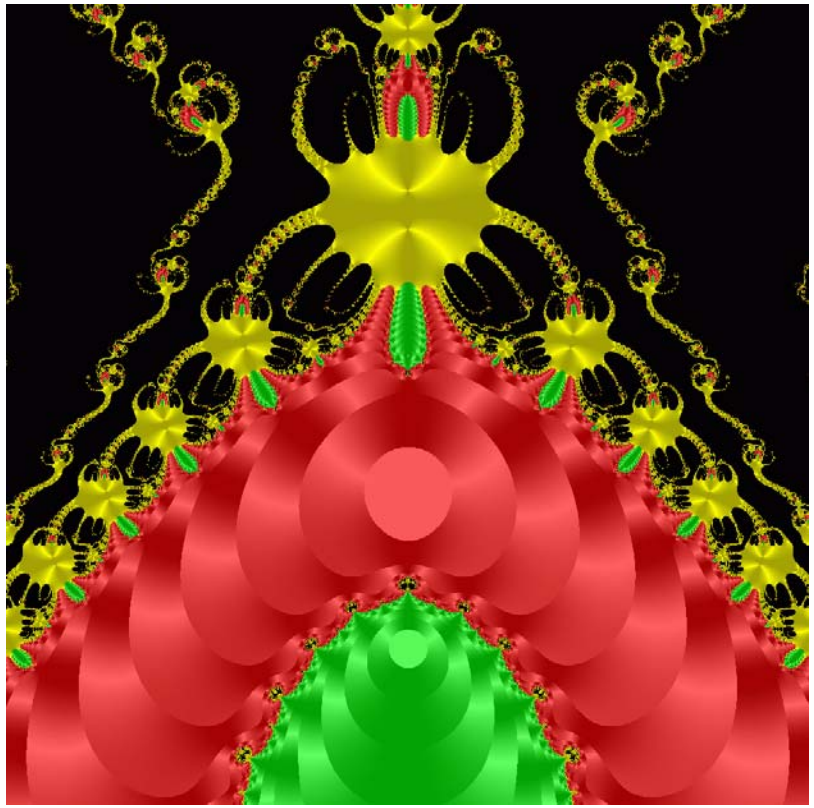


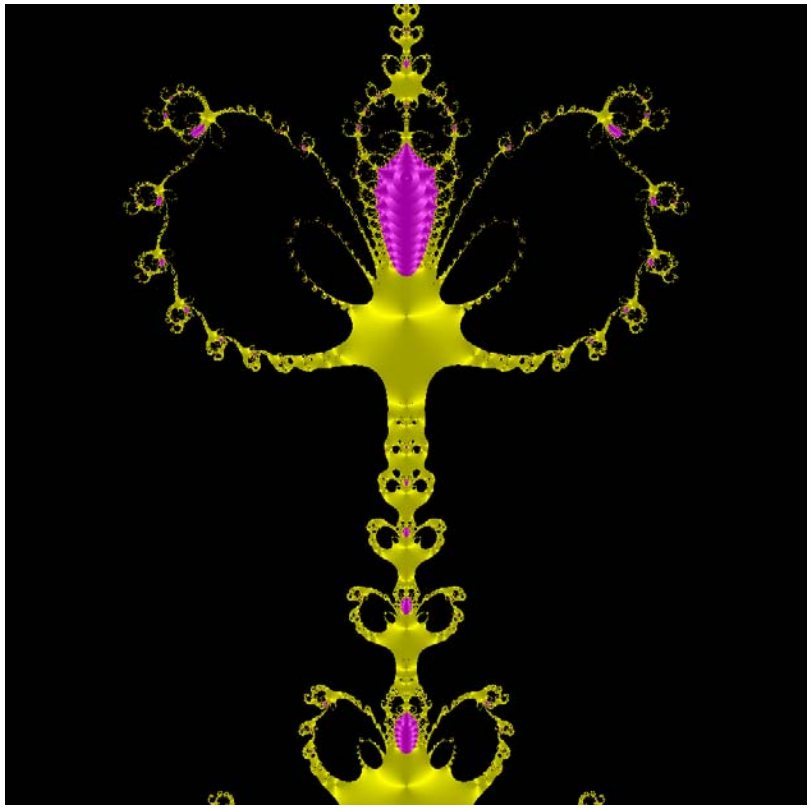
$V(x,y)=(x^2)*(y^2)*\exp[-(x^2+y^2)]$


Lorenz attractor

Jewellery, designed through visualisation of mathematical functions and fractals - Dan Ashlock, http://orion.math.iastate.edu/danwell/fractals.html

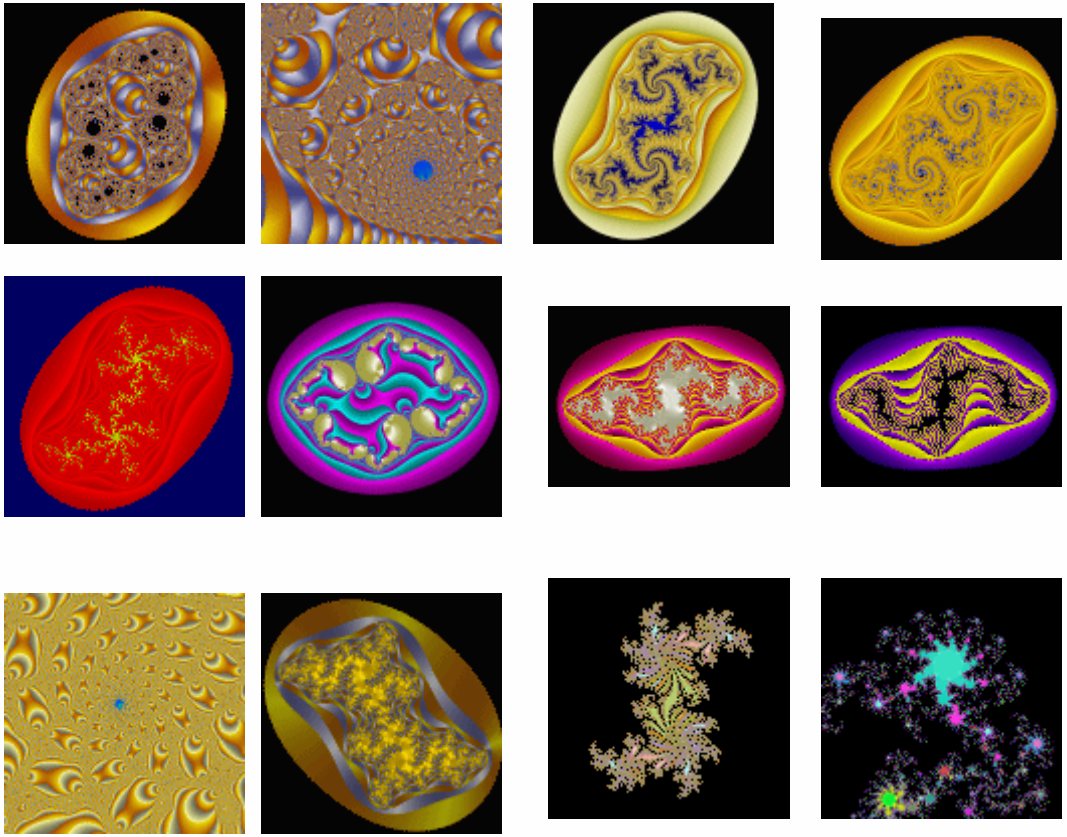






Computer ceramic and textile design

http://orion.math.iastate.edu/danwell/julia4.html

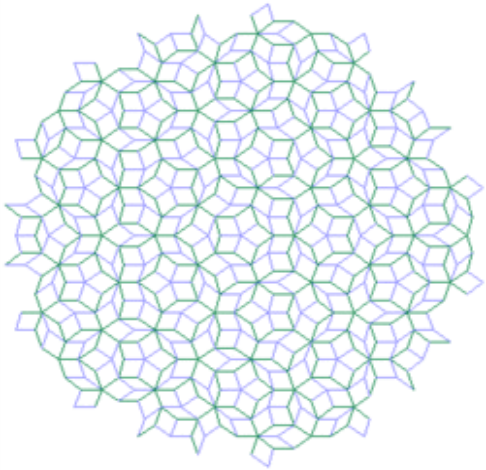


A fascinating history of Arts and Mathematics

Ancient Islamic Penrose Tiles

Did people 800 years ago know complex mathematical functions?

When the Harvard graduate student in physics Peter J. Lu travelled to Uzbekistan, he found an entirely unexpected level of mathematical sophistication in the designs, pointing at mathematical ideas that weren't formally developed until hundreds of years later.



Architectural Design Integrates Science, Art, Technology and…

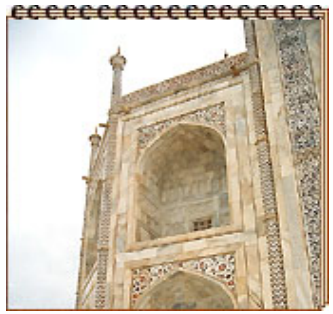
Taj Mahal

- The Taj Mahal was built by a Muslim Emperor Shah Jahan in memory of his wife Mumtaz Mahal. It was constructed over a period of twenty two years and was completed in 1648.

- The Taj rises on a high red sandstone base (186x186 feet) topped by a huge white marble terrace on which rests the famous dome (58ft in dia and 213 ft in height) flanked by four tapering minarets (162.5 ft each) forming an unequal octagon.

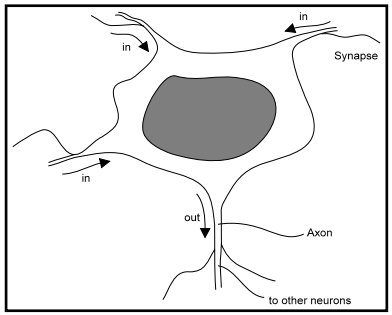
- The principles of *self-replicating geometry* and a symmetry of architectural elements were used in construction.

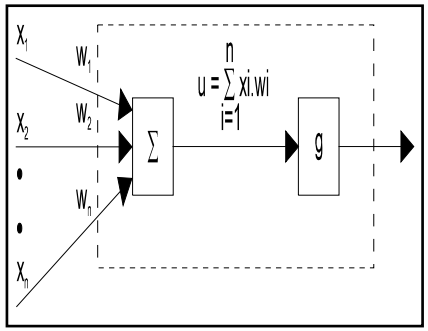
- The features of the construction demonstrate the ability of the Indian architects to reconcile the illusionary effects created by distance and light.



Artificial neural networks (ANN) can learn to speak, but can they learn and create music ? …or painting?

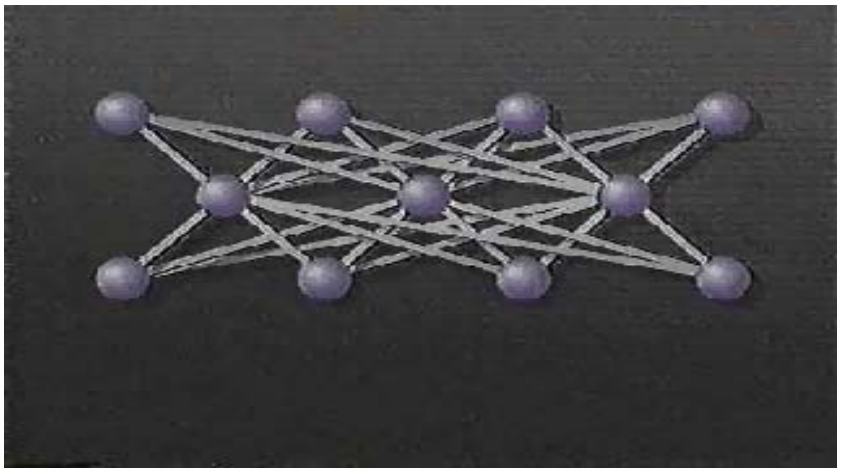
- ANN are computational models that mimic the nervous system in its main functions of adaptive learning and generalisation.





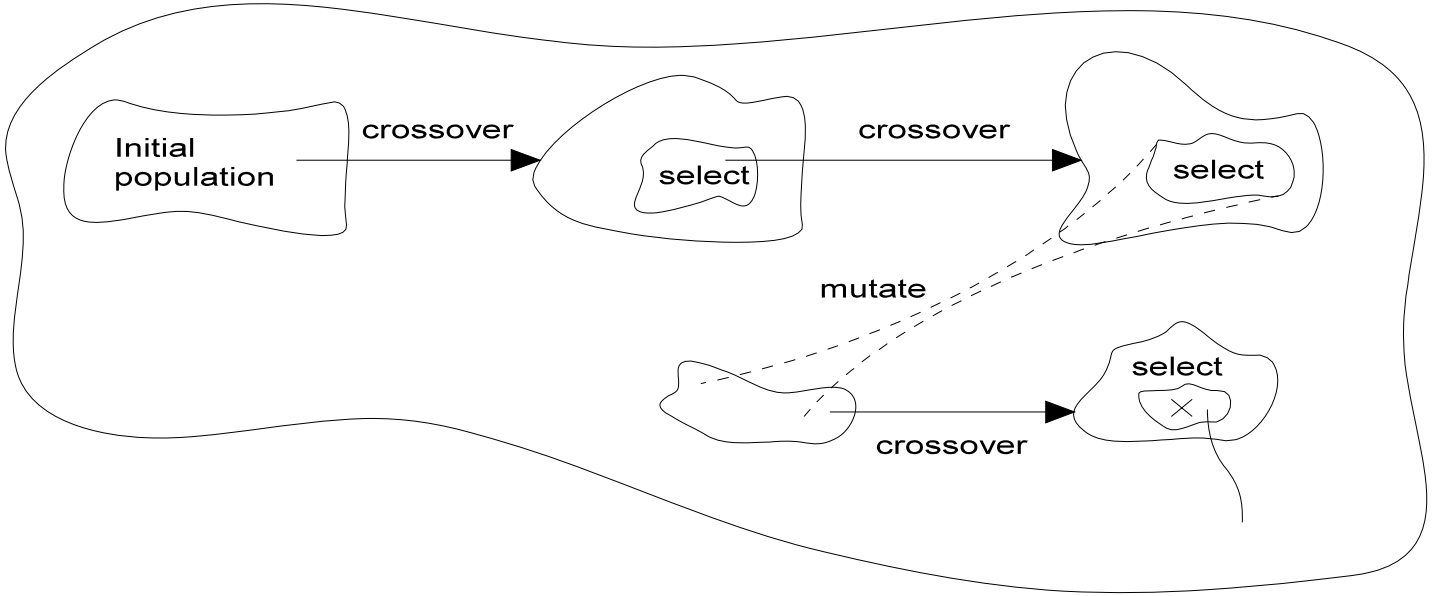
- ANN can learn to “speak” (e.g. NetTalk by T.Sejnowsky)

- ANN can learn music as a time series and generate (predict) next musical segments (e.g.:
- Unfinished Bach music:
- HeavyMetal (E. Trentin):
- ANN can learn a style of painting and recognise a true van Gogh from a fake one (Uni Maasatricht, Postma and Herik).



Evolutionary Computation for Design

Could we achieve something beyond the human imagination?



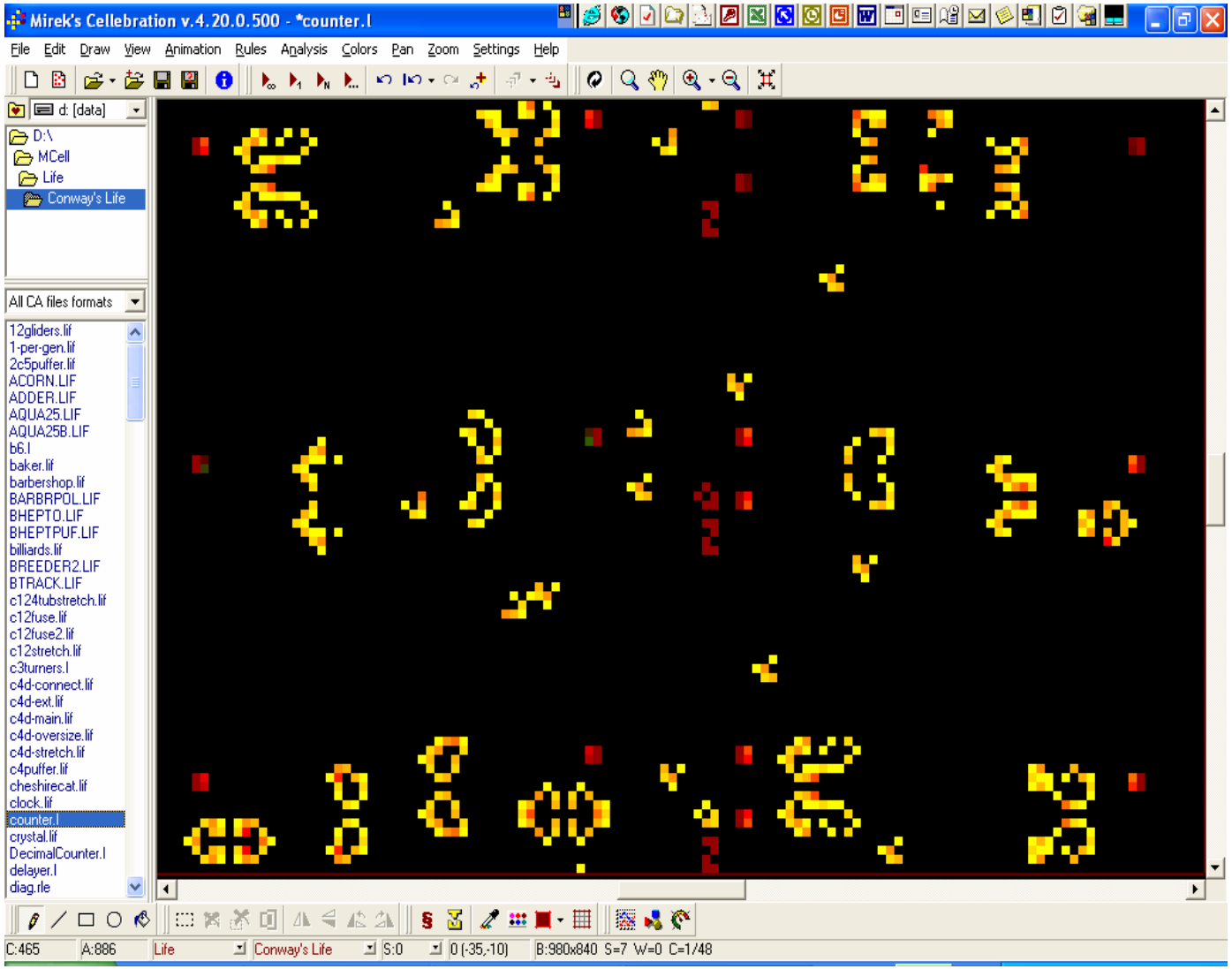
- Many individual objects, each having different parameter values, are evolved simultaneously in a population. A chromosome represents each individual and a gene – a parameter of it.
- Individuals are evaluated based on goodness (fitness) criteria.
- The "best" individuals are selected to create the next generation. Mutation may apply.
- The process goes until the goodness criteria is met or the evolution (design) time has expired
- Interactive human- EC design of:
  - architectural objects, prosthetic limbs, holography, music (MIT Media Lab , http://www.media.mit.edu/)
  - Music, images (H.Takagi, Kyushu University, Fukuoka)

Cellular automata, Artificial Life – Is this Art?

Example: John Conway's Game of Life - the 2,3/3 rule of life creation

0	0	1	2	2	1	0	0
0	0	2	3	3	2	0	0
0	0	3	5	5	3	0	0
0	0	2	3	3	2	0	0
0	0	1	2	2	1	0	0

0	0	1	2	2	1	0	0
0	1	2	2	2	2	1	0
0	1	2	5	5	2	1	0
0	1	2	2	2	2	1	0
0	0	1	2	2	1	0	0



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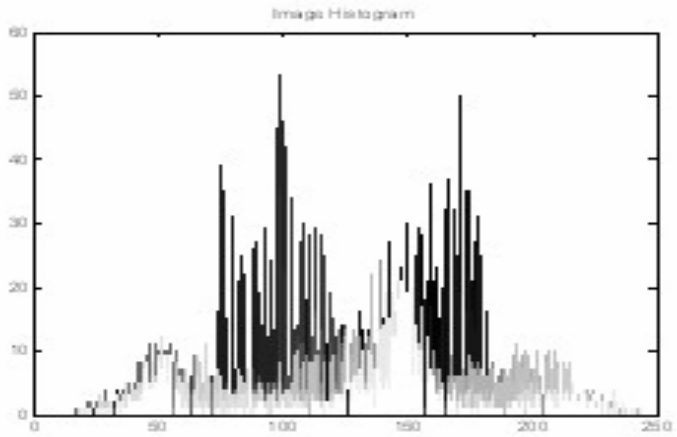
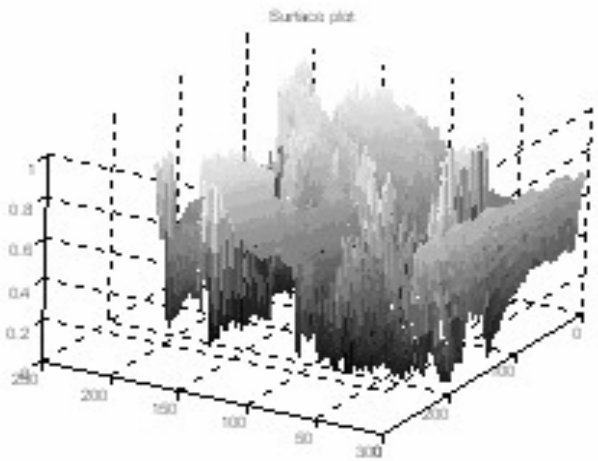
Data Mining and Knowledge Engineering for Arts

Original Image

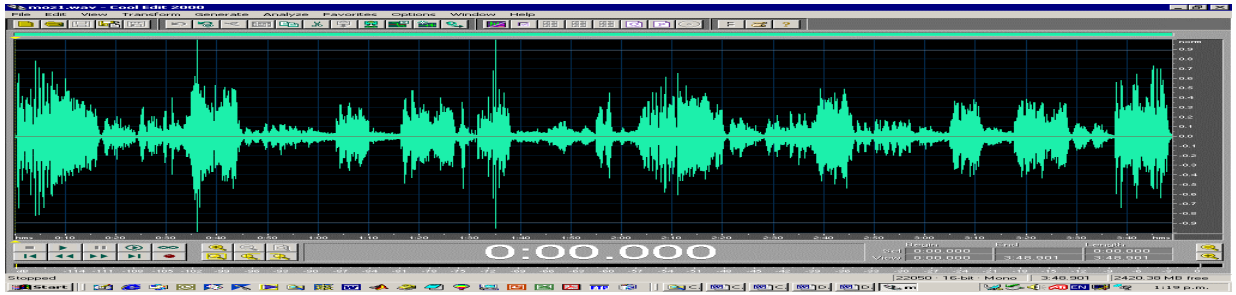


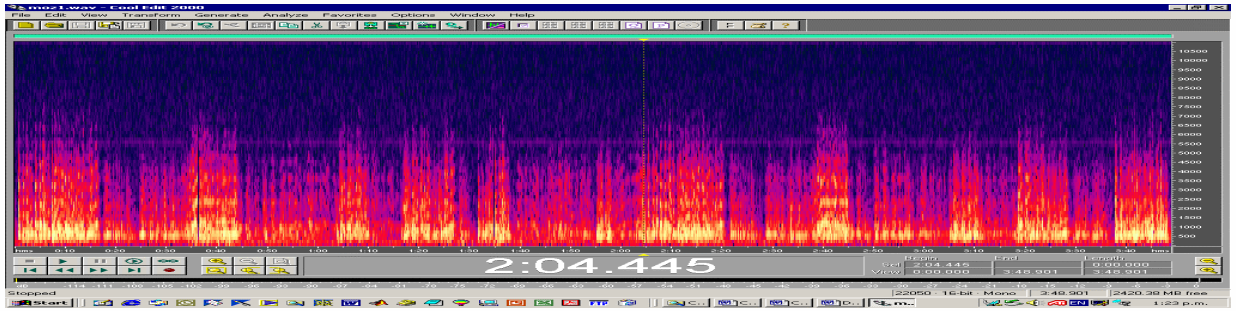


Spectral analysis of music and brain signals

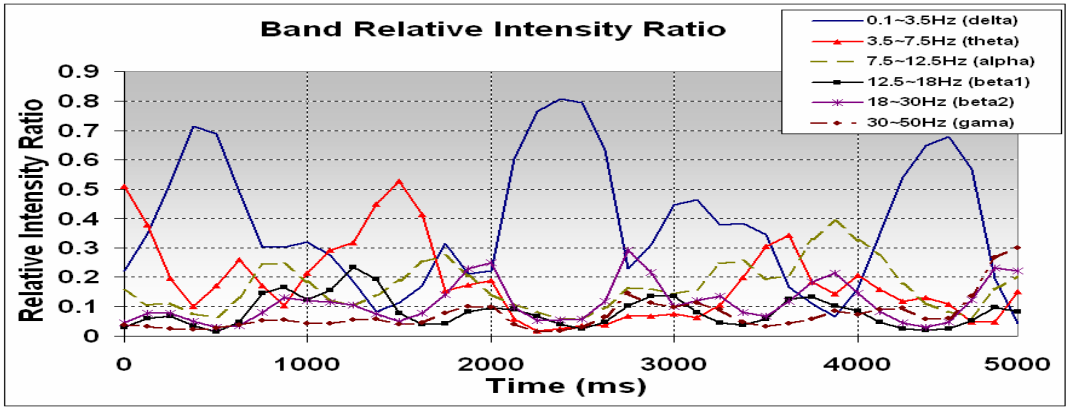
Why Mozart's Music is considered to stimulate creativity?

The answer may be found through spectral analysis.





We can apply spectral analysis on brain signals (EEG) and find the power of the main frequency bands, but can creativity be measured?



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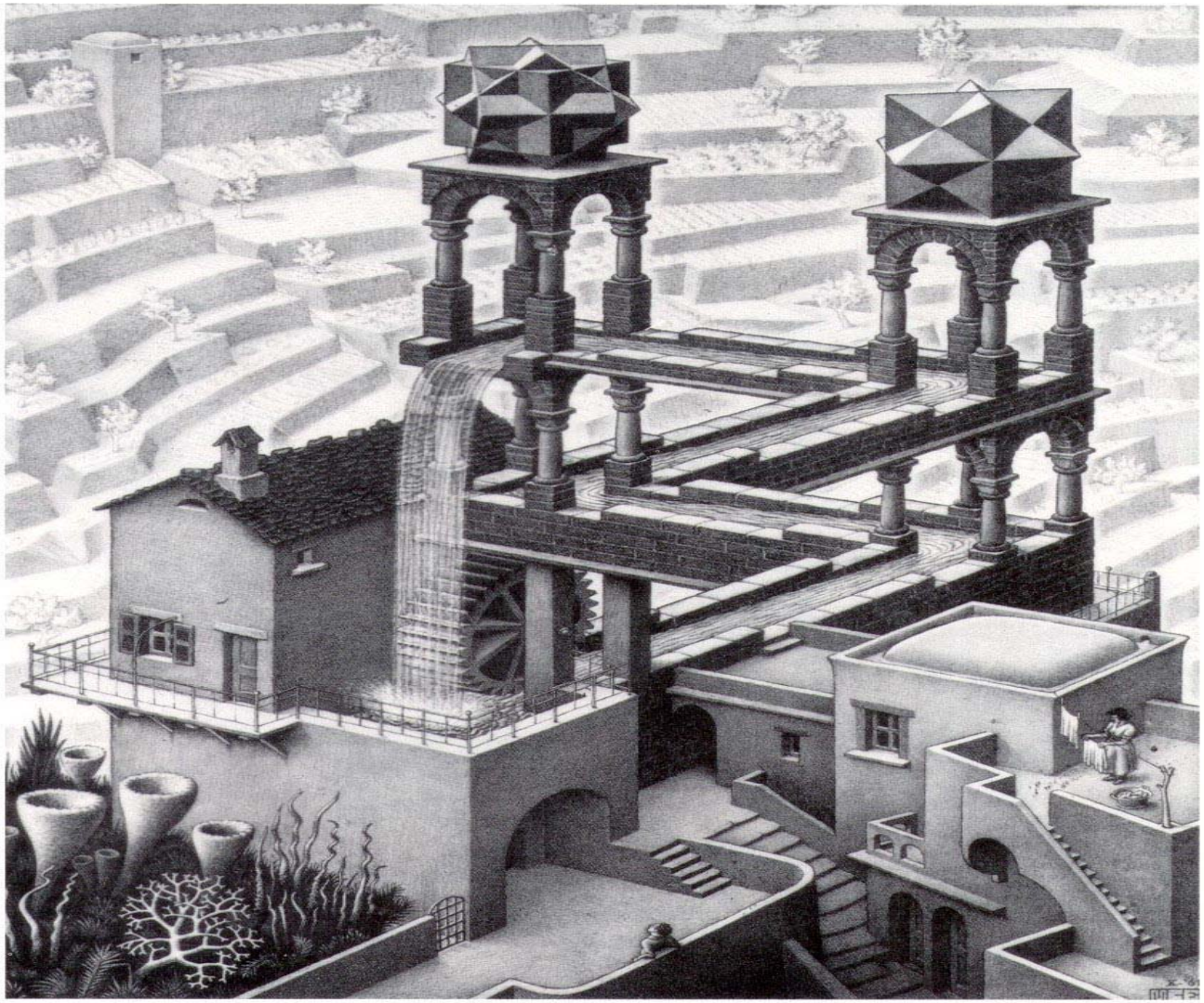
Art and Illusion. Is it where Art departs Science?



Waterfall

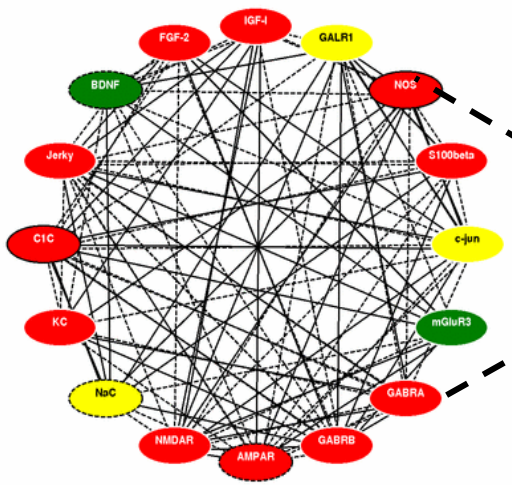
M.C. Escher

KEDRI Examples of Integrating Science, Design and Technology

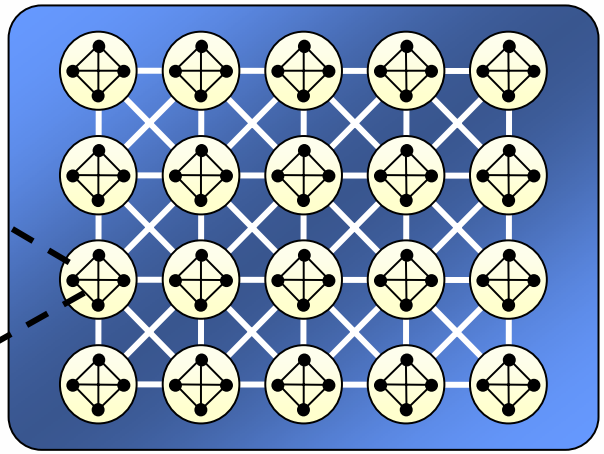
KEDRI's Computational Neuro-Genetic Simulator and Brain-Gene Ontology

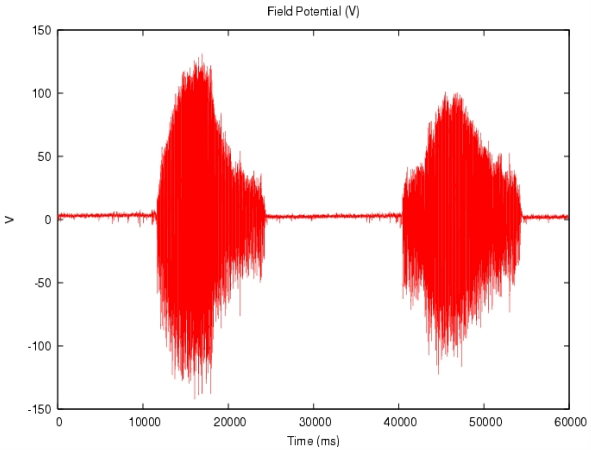
The system must be properly *communicated* to students, researchers and commercial partners.

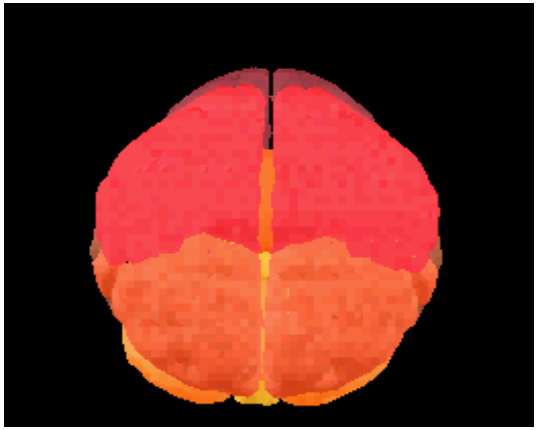
GRN



SNN







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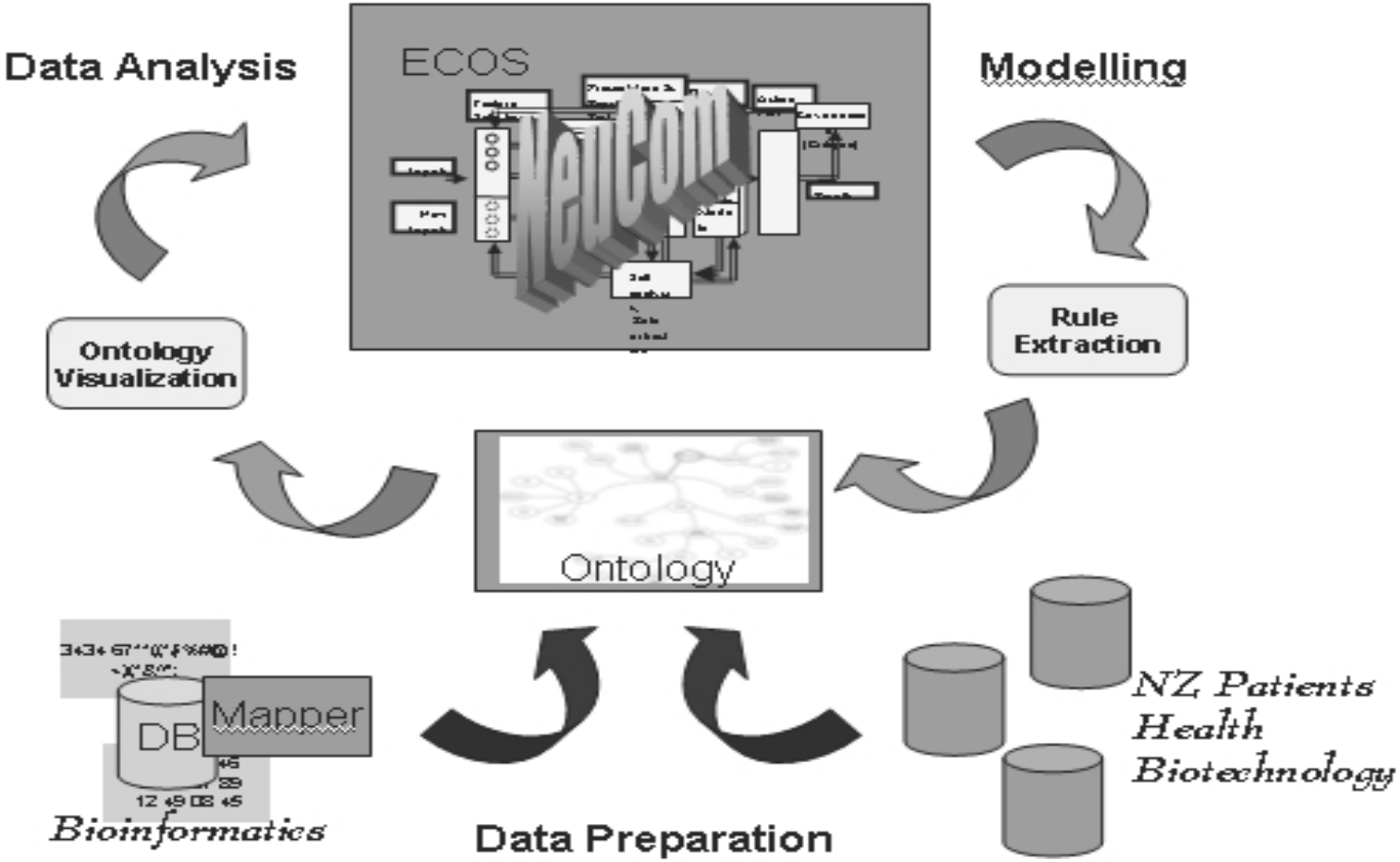
KEDRI's ontology-based personalised decision support systems



The Knowledge Engineering and Discovery Research Institute – KEDRI, AUT, NZ, http://www.kedri.info

- Established in June 2002
- Funded by NERF (FRST), AUT, NZ industry.
- Ext. funds appr $800,000 pa
- 11 Research staff
- 15 PhD students;
- 25 associated researchers
- Both fundamental and applied research (theory + practice)
- 120 refereed j. publications
- 2 monograph books
- 2 patents PCT
- Multicultural environment (10 ethnic origins)
- Strong national and international collaboration
- Research informed teaching: 2 courses at AUT; 1 in Germany.
- Mentoring AUT staff