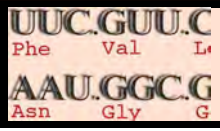
Coping with an Unpredictable Future: Unwanted Consequences of the Generation of Diversity and Civilisation as a Remedy

TRANSCULTURA INTERNATIONAL CONFERENCE

ORDER AND DISORDER

Beijing
March 5, 2007



Génétique des Génomes Bactériens
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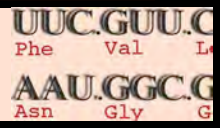

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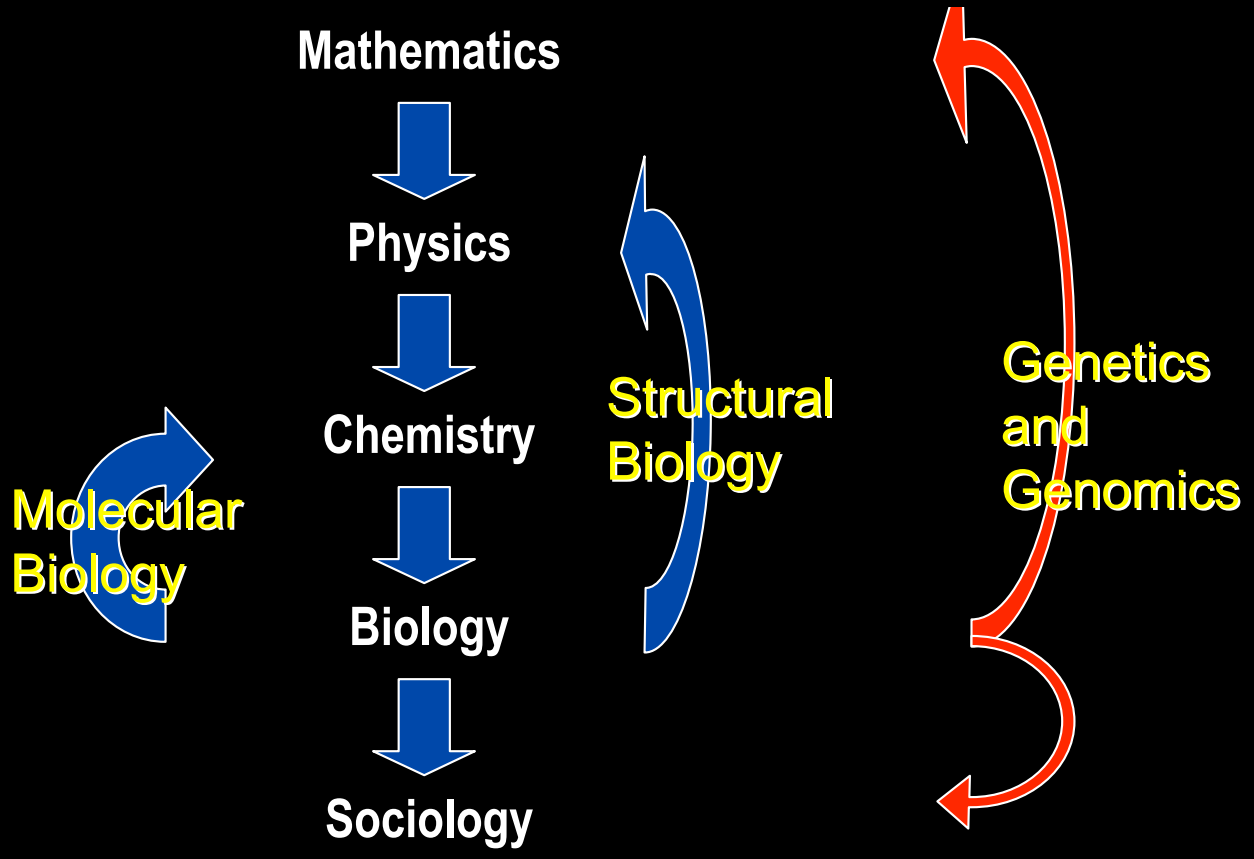
A tale of two cultures

A place for Transcultura

Science

Literature and Arts



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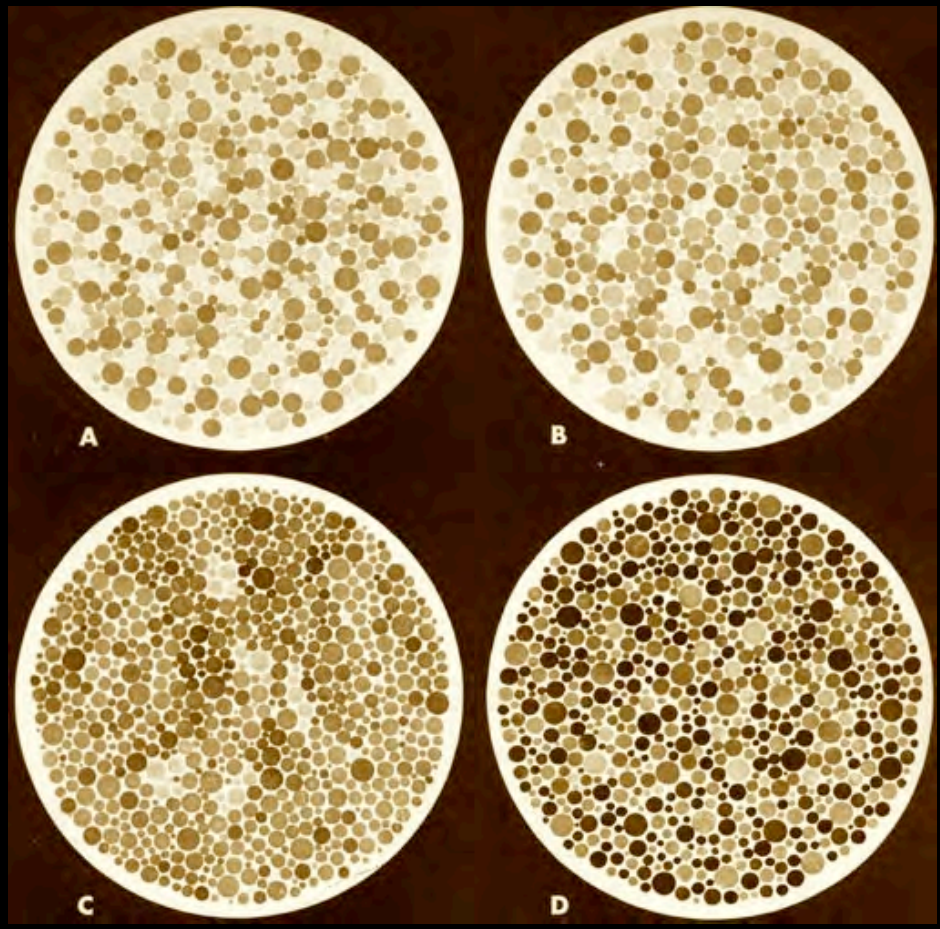
Order is a point of view

Is this ordered?



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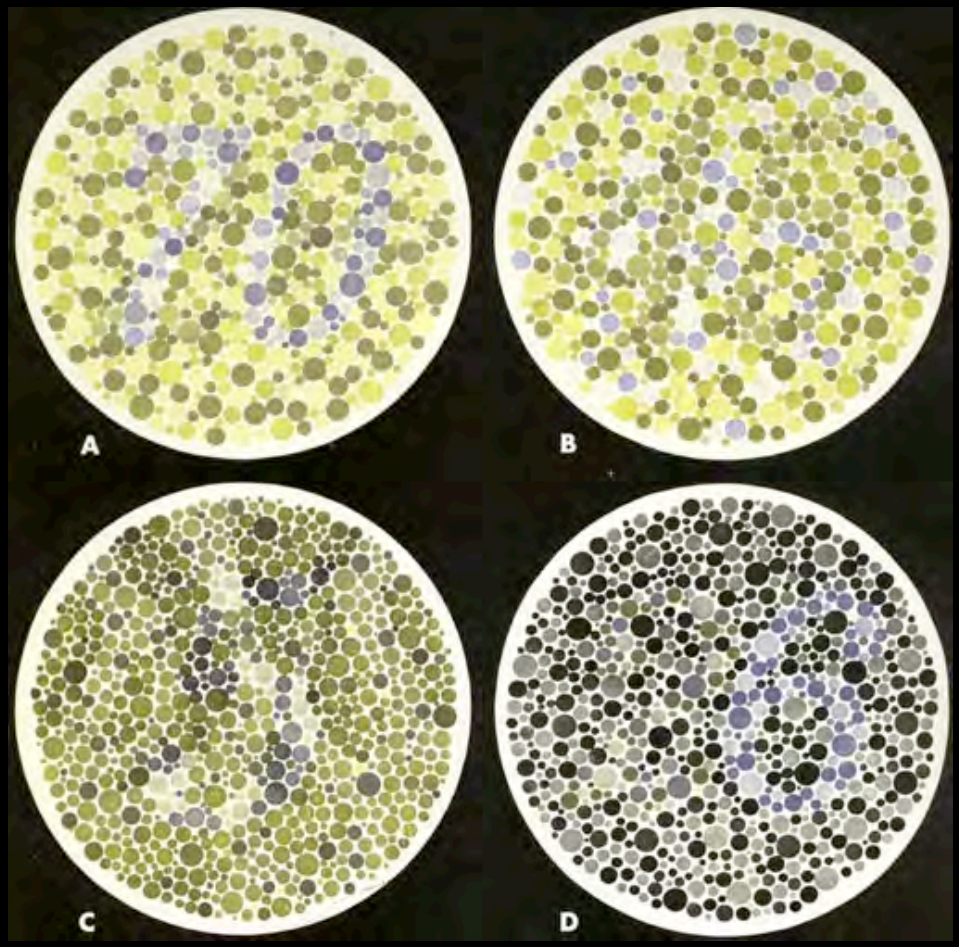
Some see this



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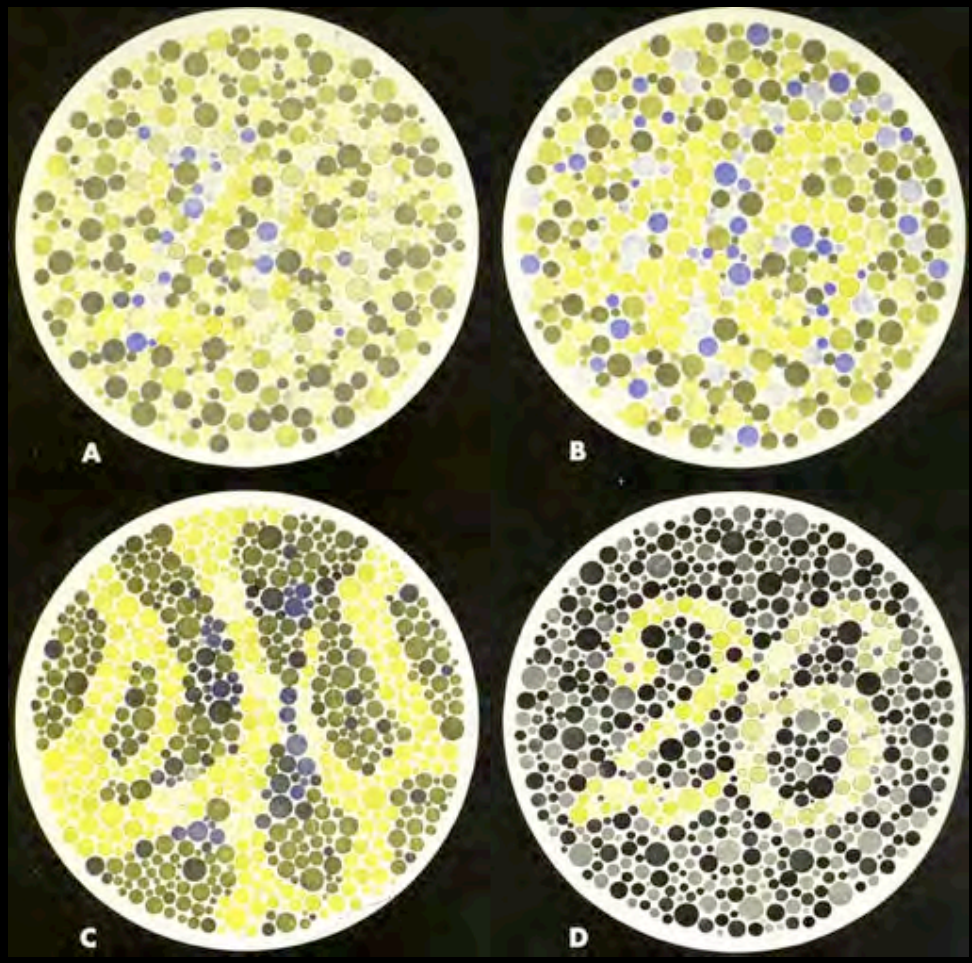
Others see this, and this is how black birds will see colours in the black shade because they see UV light...



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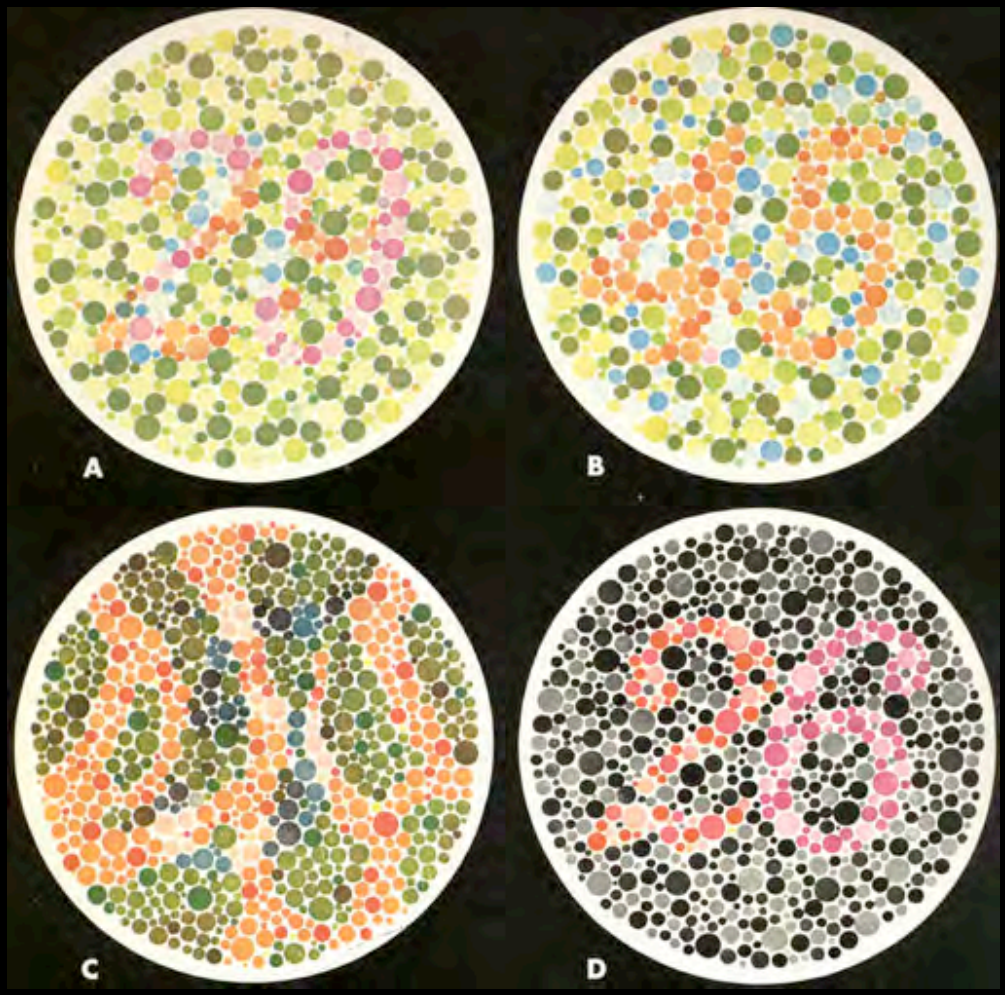
We all are color blind for something



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Order requires an observer and an observed

Order is the result of the convolution of the diversity in the observer with the diversity of the observed

⇒Generation of diversity is essential to create order

How is diversity created and maintained in living organisms?

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The alphabetic metaphor

As is the case when building up a machine, one needs a book of recipe to build up a cell

This asks for changing the text of the recipe into something concrete: this transfers « information ».

Naturally, the book of recipe is not the dish!

In a cell, information transfer is managed by the genetic program represented as an alphabetical text

Note: Copying the text implies introducing errors

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Creation of order in Biology

- Physics: *matter, energy, time*
- [Statistical physics: Physics + *information*]
- Biology: Physics + *information, coding, control...*
- Arithmetics: *strings of whole numbers, recursivity, coding…*
- Computing: Arithmetics + *program* + *machine...*

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What Life is

Three processes are needed for Life:

- **Information transfer (Living computers?)**

Driving force for a coupling between the genome structure and the structure of the cell:

- Metabolism (Internal organisation)
- Compartmentalization (General structure)

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What computing is

Two processes are needed for computing:

- A read/write machine
- A program on a physical support (typically, a tape illustrates the sequential string of symbols that makes up the program), split (in practice) into two entities:
  - Program (providing the goal)
  - Data (providing the context)

The machine is distinct from the program

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The cell factory

A cell behaves like a computer that would program the construction of similar computers

It has a magnetic tape, or hard disk (the « genetic program ») and reading devices which allow it to read the program and put it into action

The « cloning » of the ewe Dolly was exactly that: changing the program from a machine (an egg) to another one (an egg without a nucleus)

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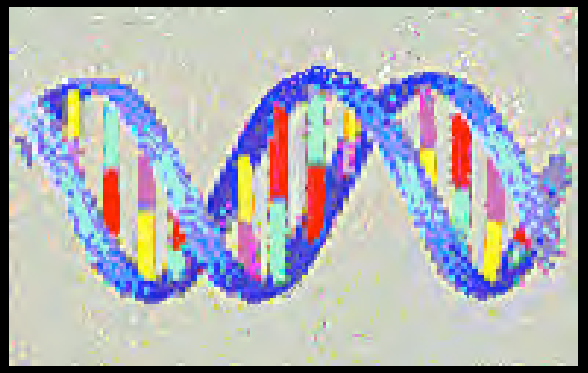
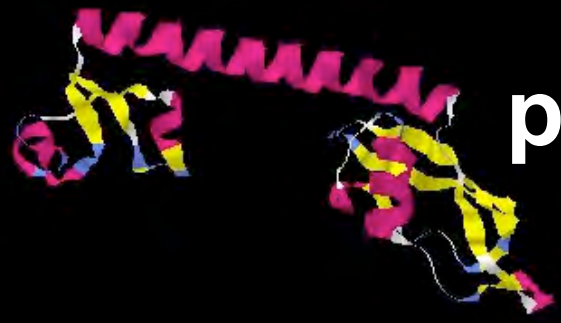
From the recipe to the dish: from the genetic program to the cell

When you read the recipe, you perform actions to make the dish. A special machinery reads the DNA and copies it into active agents, the proteins (enzymes are proteins).



DNA



protein

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Cells as computers

Genomics rest on an alphabetic metaphor, that of a text written with a four-letter alphabet, acting as a program

Conjecture: do cells behave as computers?

Genetic engineering

Viruses

Horizontal gene transfer

Cloning animal cells

all point to separation between

Machine

Data + Program

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A genetic computer

- In a computer, the machine is separated from the data, and the program
- Data and program play the same role (*i.e.* they can be thought of as ‘ declarations ’); they can be modified by the machine (Pol IV, Pol V...)
- General reflection (theoretical insights) considers the actions of the machine, but not the way it is constructed

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Order and Information

Expressing an algorithm which uses a code (a cypher) has remarkable consequences in terms of manipulation of information and creation of order

A rich order will carry a rich information. This is a prospective concept, following the classification of John Myhill:

effective	=>	immediately understandable
constructive	=>	requires reflection (a brain-mediated computation)
prospective	=>	the content of the concept changes each time it is discussed, in a recursive way

Myhill, J. (1952) Some philosophical implications of mathematical logic. Three classes of ideas. The Review of Metaphysics **6** : 165-198.

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Several types of information

- Probability of finding « words » in a text: Shannon's information (1944)
- Static features of the text: Algorithmic Complexity (1970)
- Dynamic features of the text, unfolding it in time: Logical Depth (1988)
- Self-consistency of the text: Critical Depth (1996)

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Algorithmic complexity

- Shannon's « entropy » does not care about the meaning of the message (replication)
- Kolmogorov and others proposed to define randomness of a sequence by stating that it cannot be described by a program with a length shorter than the sequence itself
- This provides us a research program: in order to approach algorithmic complexity of a sequence, we need to describe how it has been constructed (in the real physical world)
- Microbial genomes look « random »; higher organisms' genomes look « repeated »

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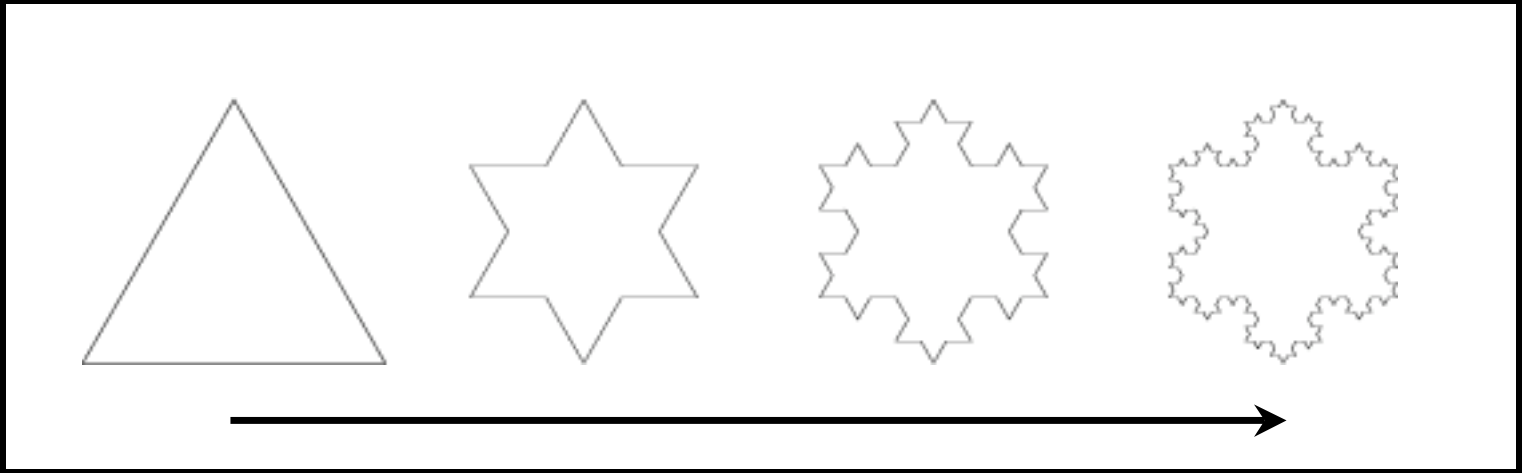
Logical Depth

A very short program (low algorithmic complexity) can describe a simple repeated sequence, but also a rich structure such as the fractal figure of Koch 's snowflake



Time appears as an essential ingredient in the definition of these figures: information requires a time dimension

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Unexpected properties of strings of symbols

- The DNA « text » can be considered as a string of symbols
- Logical depth indicates that there is no « junk » DNA
- Many theories know how to deal with such objects
- In particular they can play the role of « programs » that have remarkable properties (for example they can be « recursive », i.e. they can call themselves as routines). A machine run by a recursive program usually does not have standard mechanistic (i.e. predictable) properties

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Order and Logical Depth

A remarkable consequence of logical depth is that, when a program is complicated enough (branching and recursive), it becomes impossible to predict its outcome in a reasonable time. The only way to know it is to run the program….

Evolution has evolved DNA from DNA from DNA in such a way that every single base has a certain « depth », that makes that living organisms are, in principle and by construction, poised to be ultimately unpredictable…

This allows them to create some progeny that can survive in an unpredictable future

A phylogenetic view of the world

- Living systems evolve by mutations (sometimes simple rearrangements, without changing the genome « text »)
- Those that are not totally unable to survive and multiply create a progeny: survival implies that the local conditions of the environment carve an image of the world in the genomes that are retained
- This process creates, through assessment of the concrete functioning of a living organism its stability in the environment where it happened to be born
- Diversity in the progeny is the way to cope with an unpredictable future

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How life creates order

Three processes overlap to create the ultimate individual living entity

- ***Phylogenesis*** **(shaping the genotypes)**
- ***Ontogenesis*** **(shaping the 3D forms of organisms)**
- ***Epigenesis*** **(shaping the individual in context)**

Each one is stabilized under the selective pressure of events acting on the corresponding functions

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Caveat

One must note that epigenetic heredity, not being implemented in the genetic build up, is very unstable

We are still genetically almost the same as the *Homo sapiens* var. Sapiens which existed some 200,000 years ago; instability of epigenetic heredity means that we can very easily regress back to that state; for example we could lose the richness of our tongues (and of our thoughts) within just one generation...

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Order and Diversity

- Diversity permits life to cope with an unpredictable future (no diversity means « color blindness »)
  - Genetic diversity
  - Individual diversity (cf twins)
  - Cultural diversity (epigenetic)
- Maintenance of diversity

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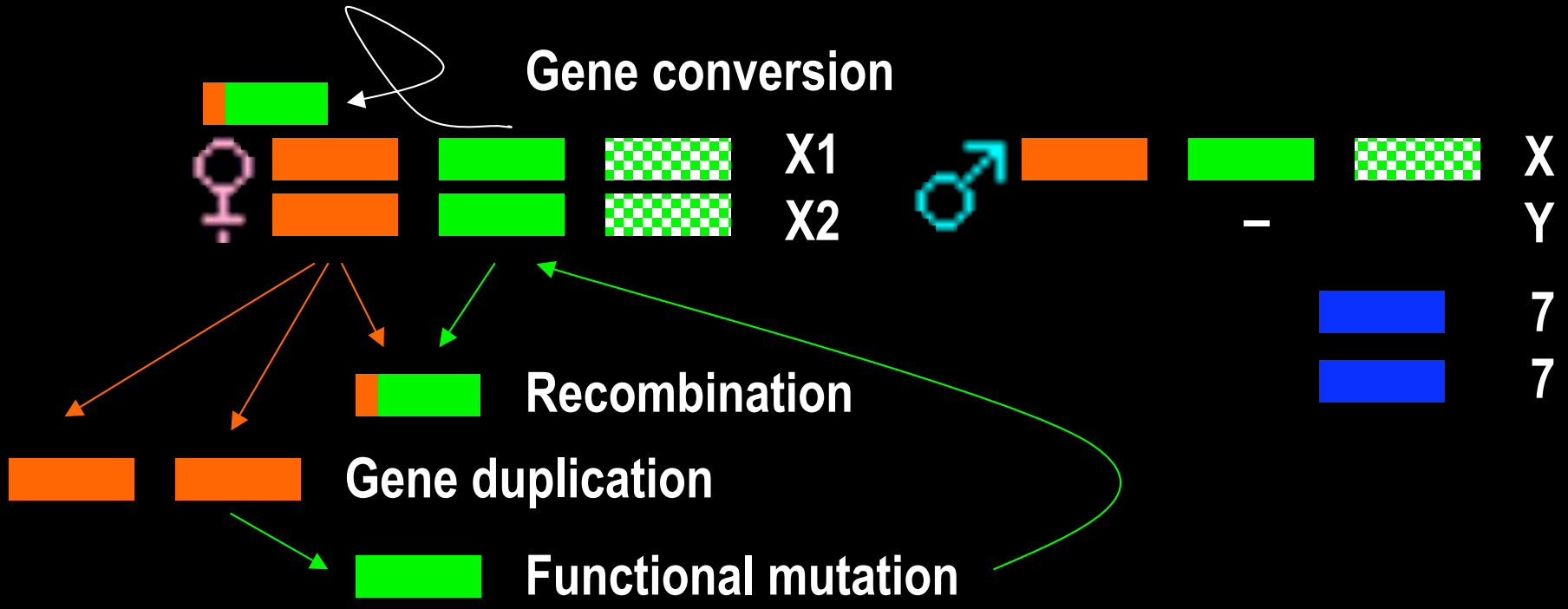
Generation of genetic diversity



Evolution creates new genes, increasing diversity
Note that the lack of a gene can sometimes be advantageous

In the case of languages: Creoles, Frananglais (Cameroon)...

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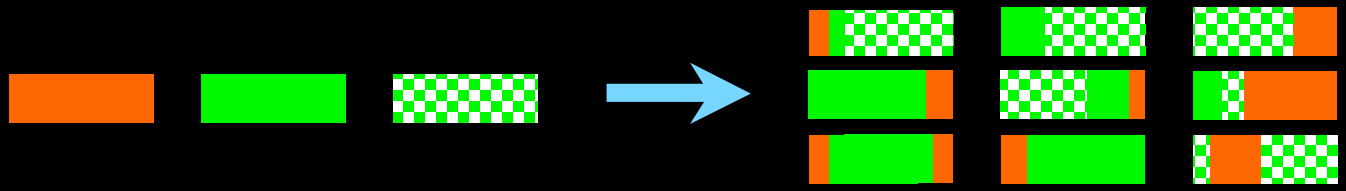
Three fates for diversity

Take over

Melting

Patchwork (mosaicism)



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Creating borders

- Mismatch repair and segregation
- Geographic isolation
- Deterrence (bad taste, bad smell, poisons... and extreme cruelty (Miroslav Radman))

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Joking about the others

Maintaining diversity supposes creating borders. Cruelty is a catastrophic but efficient way to proceed, as it is memorized over generations. Are we doomed to succumb to that horrible collective behaviour?

Another way is experienced in many people, in particular in Subsaharan Africa: joking about the neighbours. Formalized jokes exist, with insults, ridicules and all kinds of fake agressions that maintain the difference between families and ethnic groups. We should not go against this type of practice, but only care to avoid violence. Maintaining jokes maintain differences, and this is precisely what we need...

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谢谢

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