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The Future of Architecture: Biodigital Architecture and Genetics

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Abstract For the architects of our time, the question is not any more a simple caprice, neither an intellectual necessity, neither sensibility for losing less favoured people. Now, the necessity is global, without reservations of classes, races or religions. The whole planet is in front of danger of no-sustainability for all mankind. This paper introduces the different studies which generated in the context of genetics and biodigital architecture. It is suggested a soft, furry and sustainable architecture for the future. Architects have a lot to say and to do as regards environmental architecture considerations, if we want to see the world come to a happy end.

Keywords Genetic Architecture, Biodigital Architecture

Salvador Dalí defined when Le Corbusier asked him: "the future of architecture will be soft and furry". He said also that because of his fascination for the plasticity of Antoni Gaudí's architecture. However, more than a surrealist boutade, it has become an authentic prophecy. It has been as he said; because today technique permits making reality what only was a dalinian dream. Now it is only a question of money, of investment in research: An investment that has to be fostered for having soft and furry architecture.

In the twenties and thirties of the 20th century, when some architects were disposed systematically to configure modern world, they did it stimulated for a cultural pressure, for a correct adaptation to new times, and fighting for minimum conditions of human existence (Existenzminimum). On the other hand, today the urgency is bigger. It is about the entire planetary subsistence. The question is not any more a simple caprice, neither an intellectual necessity, neither sensibility for losing less favoured people. Now, the necessity is global, without reservations of classes, races or religions. The whole planet is in front of danger of no-sustainability for all mankind.

By chance, now in this crucial moment, are offered new techniques of an enormous potential: biological techniques and digital techniques. And even fusion of both, in something that can be named biodigital architecture: One that has incorporated the advantages proportioned by the understanding of genetics in both ways, the biological and the digital way, that permit to face with hope some continuity also worthy, but this time a dignity for all The Earth.

Then, as the ones that made efforts to break with the ancient classical tradition to found the new modern tradition, we are in front of the challenge of creating the future tradition of genetics and biodigital. For this is necessary to work on three key elements: teaching, research and practice. This is exactly what we have been doing in Barcelona from 2000, with the Biodigital Architecture Master's Degree, with the Genetic Architecture Research Group and Ph.D. Programme and with our professional Genetic Architectures Office. There we teach, we make research and we design. Knowing that there are sufficient differential parameters to predict a complete age's change, as it appears in The Diagram of the three ages of the architecture:

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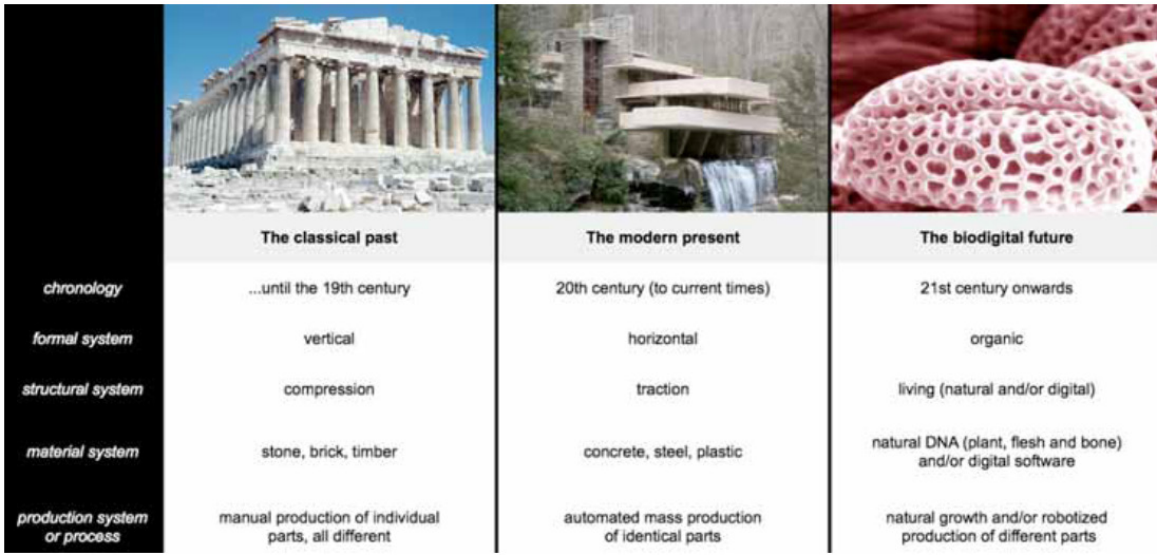

Figure 1. The Diagram of the three ages of the architecture, 2004 (©Alberto T. Estévez)

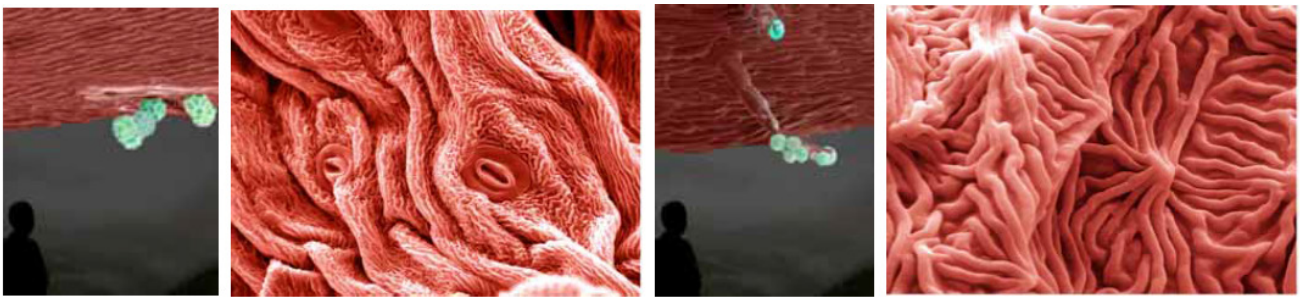

Figure 2. Different kinds of Biolamps, Bioceilings and Biowalls, 2009-2010 (©Alberto T. Estévez)

Figure 3. Our entire planet is crying, like crucified forest / Strange landscape, strange planet, 2009-2010 (©Alberto T. Estévez)

Figure 4. From left to right, Metaphysical park "Green is not a colour" (Serbia), Bioluminescence housing "Coals and sapphires" (Turkey), Housing structure "Ruins of the future" (Cuba), 2009-2010 (©Alberto T. Estévez)

And the first that came true was the consolidation of digital organicism as first avant-garde already at the beginning of this new 21th century. But time goes unstoppable and when a tendency is established it can be seen the roots of the next one. For this we can now exclaim with reason and enough indicators that the second avant-garde of 21th century is without doubt the bio-architecture: biological architecture, life architecture, and also —following a more specific way— biological organicism. But sooner or later it will appear a third one, as it is written in the text *It's not enough!* Declaration done by this author in ACADIA 2010 (New York):

It's not enough!

I went until the present capital of the world, still... I went to the annual event of the most important avant-garde architecture in this planet... I went to the most advanced meeting of architects of the Earth... I went there to say that IT'S NOT ENOUGH!

It's not enough to work with the last digital techniques anymore. The change to the fusion of the biological techniques with the digital techniques must be initiated. **Humanity has the responsibility of having a future.** And this only will happen across biodigital architecture, which will use the advantages that are given by the new biological and the new digital techniques. In fact, genetic motors are the ones that move both, similar genetic principles that are in the basis of biological and digital.

As the expressionists of the beginning of XX Century saw on the Christ of Grünewald a precedent, the geneticists of the beginning of XXI Century must see in the Garden of El Bosco the same precedent, both with half millennium of antiquity. It is normal that to start with this change I am addressing to the most qualified forum, the forum that knows already about digital techniques. The forum that must begin to be worried for crossing it with biology, genetics, real life, not only virtual, which was a necessary first step. An effort is needed for reaching maturity also with the use of biological techniques applied to architecture. For not losing a precious time, I hope that this won't be a question for only new generations…

In the developing of biodigital and genetic architecture there have been, from 2000 up to now, some genetic architectures' manifestos & cross-points done by the author of this writing, like the Genetic Architectures Manifesto, 2000, the three manifesto-images (The magic light of bioluminescent trees, 2005 / A house is not a box, 2006 / Ceci n'est pas un pavillon, 2007), the three Genetic Architectures books (VV.AA., 2003, 2005, 2009), the Barcelona Genetic Project, 2003-(2006/2007)-2010, the Biolamps, 2008, the Bioplasticity Manifesto, 2010… All what have to do not more with utopias, but with realities, research and designs realities, working together geneticists and architects.

All what you can find in relation with the next projects:

1. Working with natural "software" (DNA), with live elements, with application of real genetic processes to architecture, for "automation" natural growth: Genetic research to obtain living elements, building materials and useful living spaces for architecture. Architectural objectives with the application of genetics, illustrated with the *Biowall, Biolamp, Sporopollenin house 2, Genetic Barcelona Pavilion, Genetic Barcelona Project*, now in the third phase of the genetic creation of bioluminescent plants for urban and domestic use: The first time that geneticists are working for architects. Research is being carried out into the genetic control of growth to develop living cells that are converted into building materials and habitable space that are "directed" by means of their specific genetic design, thereby producing architecture that is 100% ecological, recyclable and sustainable, with maximum energy-saving throughout the construction process and no need for manual labour, as its growth is natural.

2. Working with artificial "DNA" (software), with computing elements, with application of real cybernetic processes to architecture, for automation of the robotized production of architecture digitally designed: Digital design and production seen as a genetic process. Knowing that "what can be drawn can be built", because what can be drawn using digital tools has a digital DNA, that allows automated emergence, robotized self-construction and artificial growth. Using digital technologies for not producing more models or moulds as is habitual in today's production systems ["No models, no moulds!"], but to produce real architecture at the natural scale of 1:1, illustrated with the *Digital Barcelona Pavilion, Barcelona Consulting rooms, Biodigital Barcelona Skyscraper, Biodigital Barcelona Pavilion*. This is a move beyond the mass production of uniform elements, since digital design and production can equally produce 100 identical or 100 different parts.

2 approaches to architecture, like you can see in the next 2 pavilions & 2 exhibitions... From one side, the *Genetic Barcelona Pavilion*, of Alberto T. Estévez, with the sentence *Ceci n'est pas un pavillon* became the title of a "manifesto-project" or a "manifesto-image". The work forms part of research into genetic control of cell growth, making living tissue grow as a building material. It was presented in the exhibition "Bios 4: Biotechnological and Environmental Art", CAAC Centro Andaluz de Arte Contemporáneo, Seville, 03.05.2007-02.09.2007. And from another side, the *Digital Barcelona Pavilion*, of Bernard Cache, was the first building to be completely designed and produced using digital media, in the Digital Architecture Laboratory of ESARQ (UIC), with collaboration of School's lecturers and students, in Barcelona. It was also presented in the exhibition "Architectures non standard", at the Centre Pompidou, Paris, 10.12.2003-01.03.2004.

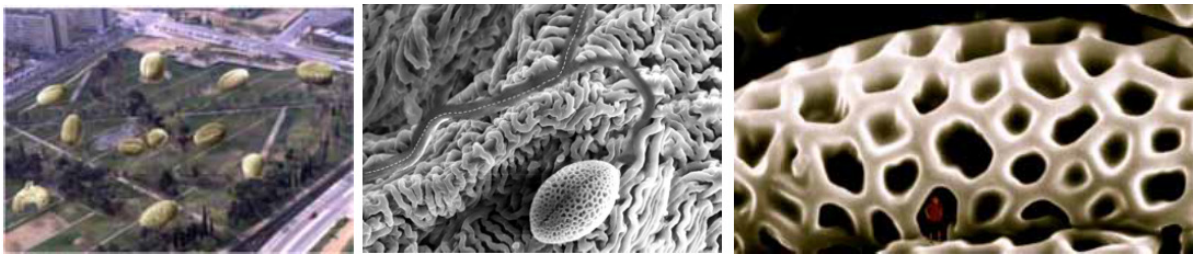

Figure 5. Different views of Sporopollenin Houses, 2009-2010 (©Alberto T. Estévez)

Figure 6. LEFT: Genetic Barcelona Pavilion: Ceci n'est pas un pavillon, Barcelona, 2007(©Alberto T. Estévez with Marina Serer) (genetic reform real soft and real eatable of the Mies German Pavilion). Photo: Alberto T. Estévez. RIGHT: Bernard Cache, Digital Barcelona Pavilion: L'Orme Pavilion, ESARQ (UIC), Barcelona, 2001 (Photo: Bernard Cache)

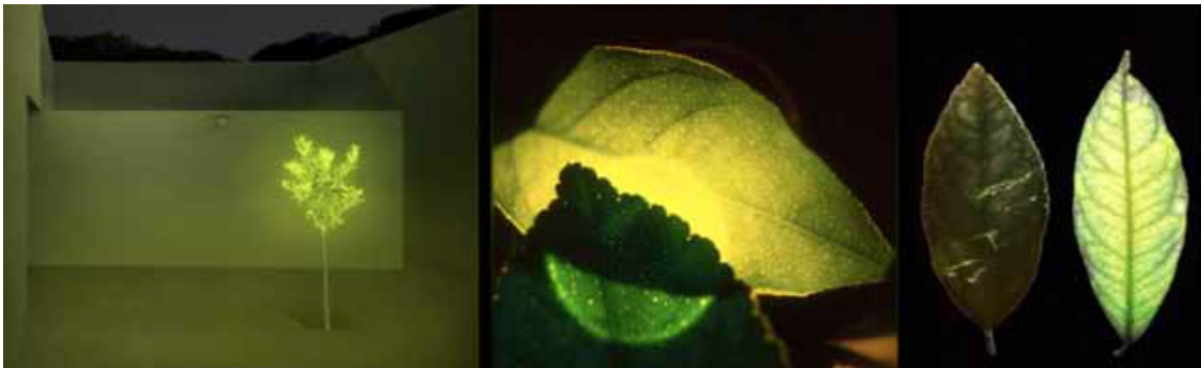

Figure 7. Genetic Barcelona Project, 1st phase, 2003-2006. Genetic creation of bioluminescent plants for urban and domestic use. LEFT: Manifesto-image, the magical light of the bioluminescent trees (©Alberto T. Estévez) CENTRE: Comparison between a real lemon tree leaf with GFP (Green Fluorescent Protein) and another without GFP, from the same lemon tree type (Photo: Alberto T. Estévez, with conventional reflex camera) RIGHT: Comparison between a real lemon tree leaf with GFP (Green Fluorescent Protein) and another without GFP, from the same lemon tree type (Photo: Josep Clotet and Alberto T. Estévez, with special UV photo camera)

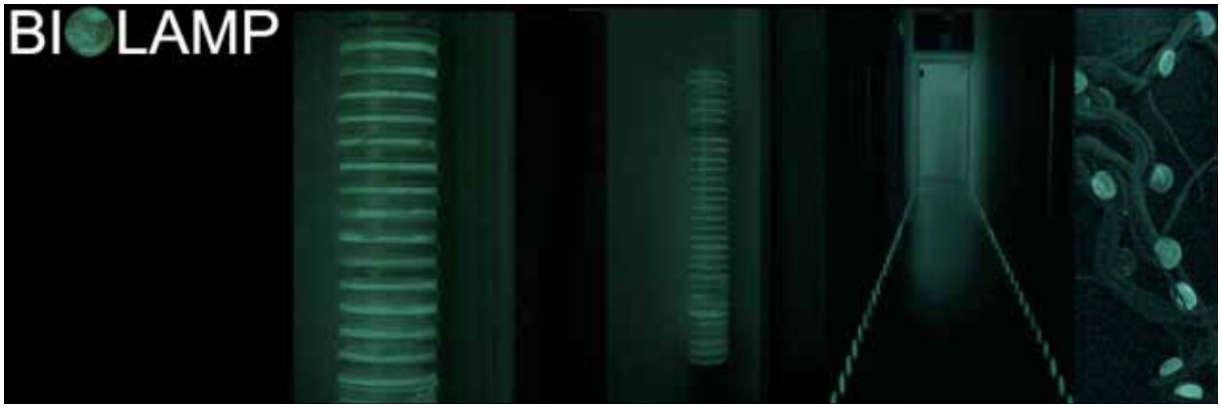

Figure 8. Biolamp, Genetic Barcelona Project, 2nd phase, 2007-2010 (© Alberto T. Estévez) Genetic creation of bioluminescent plants for urban and domestic use. LEFT: Bioluminescent batteries applied at the "Biolamp 2". CENTRE: Bioluminescent batteries applied at the "Biolamp skirting board", the first time in History that have been illuminated a whole apartment without cables, without installations, without electricity. RIGHT: Bioluminescent batteries applied at the "Biolamp Roots" (Photos: Alberto T. Estévez, with a conventional camera-human's eye vision)

A radical example of the reality of genetics in architecture is also that we are seriously working in the genetic creation of bioluminescent plants for urban and domestic use: the *Genetic Barcelona Project.*

First human's needs are about food and health. These are already covered by genetics. To have a roof, heat and light are the other three primary human's needs. Those, which are related with architecture, are researched by the Genetic Architectures Research Group in Barcelona. Taking advantage of natural characteristics of animals and plants (biolearning), making possible his use for improve our world's sustainability, designing DNA for letting grow human habitats, heating-plants and bio-light, our three general research objectives about genetics.

Genetic Barcelona Project is a research about the genetic creation of bioluminescent plants for urban and domestic use. In a first phase the focus was about possibilities of GFP (Green Fluorescent Protein). In a second phase the research has open other ways of bioluminescence and was created the *Biolamp*, a kind of bioluminescent batteries, with infinite number of applications, in walls, panels, ceilings, doors, skirting boards, decoration in general, fashion, exhibitions, parties, etc. With *Biolamps* we have illuminated a whole apartment without cables, without installations, without electricity, for first time in History, in Barcelona (2008).

Sustainability can be understood as the main objective physical justification of this kind of genetic research. And the *Bioplasticity Manifesto* is also a subjective metaphysical justification:

Bioplasticity Manifesto

The amazing plasticity of the figuration that we call 'nature' is also moulded through the random interaction of certain viruses that can mutate the DNA of other beings. Million years after, 'the will of mutation' of nature has made 'the perfect mutator virus', the human being (see this statement as a slap to the anthropocentric arrogance). Let this be, moreover, as basis or justification, in some way, in a not conservational viewpoint of 'nature': Itself, and humans in first instance, need to overcome such a vision to survive. In fact, plasticity is the main characteristic of nature, to the extent that it would be an act 'against nature' wanting to 'lock in' the life in each of their ever-changing appearances. The most peculiar of 'nature' is not to be an exotic collection of diverse species, but is the fluidity presented under different aspects that perform it. And so on, the human being is the most powerful vector it has produced. **Make it flow!**

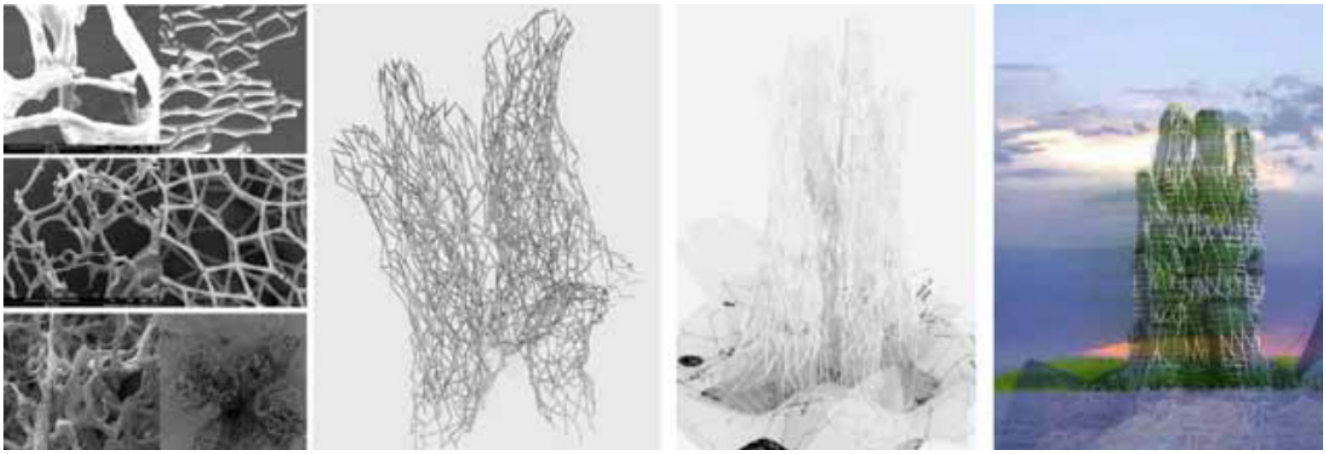

Figure 9. Biodigital Barcelona Skyscraper, Barcelona seafront, 2008-2009. (© Alberto T. Estévez - Aref Maksoud) 1st LEFT: Details of Caribbean's sea sponge, 100x, 400x and 3000x, made by Alberto T. Estévez with FEI Quanta 200 scanning electron microscope (SCT-UB). RIGHT: Renders of 3D scripting file show the results of implications of the genetic and structure rules of the sponge biomicroscopic research in parametric tools

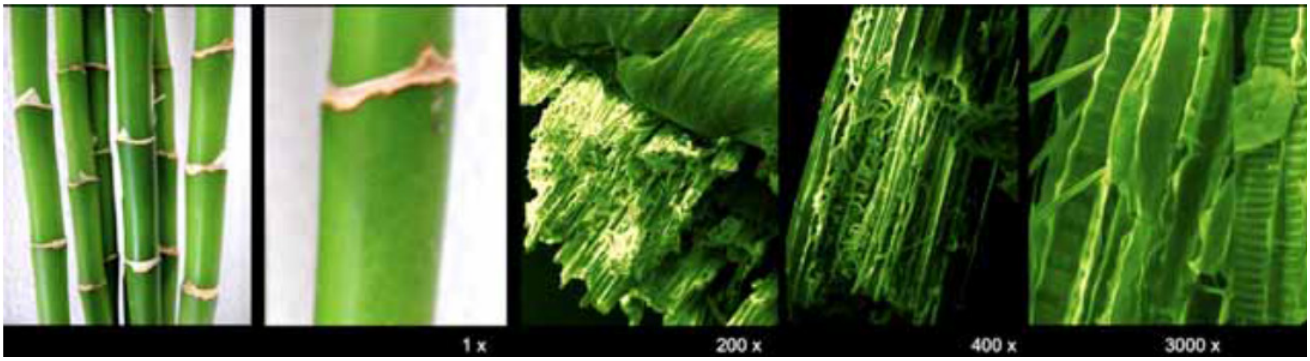

Figure 10. bamboos details, from left to right, 1x, 200x, 400x, 3000x, made with FEI Quanta 200 scanning electron microscope (SCT-UB): structural research until the first level of cells organisation, seeing how bamboos are formed by "little bamboos" that are organized by other more "little bamboos" that is how the masses of cells grow (© Alberto T. Estévez)

Other examples of biodigital works (that can be useful like projection of a possible future of architecture) can be the *Biodigital Barcelona Skyscraper*, of Alberto T. Estévez and Aref Maksoud, at the Barcelona seafront (2008-2009). It is a research about sea sponges and experimental bioparametrical studies, for extracting the genetic rules and the structural parameters for application with digital tools, that let the architectural design "emerge" alone, in the way that can also be produced and fabricated digitally, because of the designed digital DNA: "What can be drawn can be built". In the understanding that also a genetic research protocol can arrive to obtain it biological DNA. The definitive way is the fusion of the two possibilities, in the constant election in every building part of the most efficient process for its application.

Naturally, to start a genetic research protocol, it is necessary to understand that structures need to follow the fractal jump from one scale level to the other: for example seeing how sponges are formed by "little sponges" that are organized by other more little sponges that is how the masses of cells grow. We know that ants or humans can't grow for example until 15 meters high without the collapse of their own structure. But ants or humans can be added in his original natural scale for have something of 15 meters high, as also the typical Catalan tradition of human towers shows. Here is one of the most relevant life information for application in architecture: The exigency of fractality needs to be respected in biological structures and in digital structures.

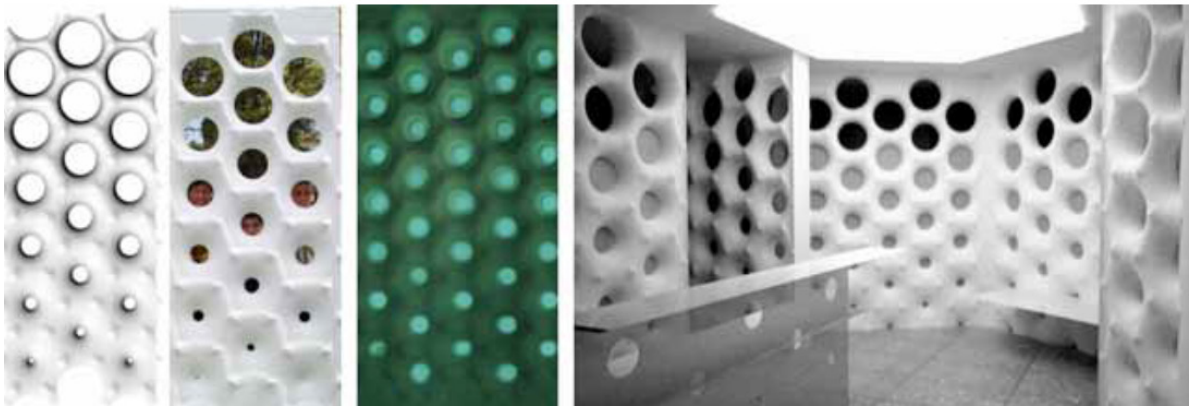

Figure 11. Consulting rooms, Barcelona, 2008-2009. (© Alberto T. Estévez) After "biolearning" process, CAD-CAM technologies for producing directly real 1:1 scale architecture, from genetic architectures points of views. LEFT: Digital drawing. CENTRE: real CNC digitally fabricated (with human scale behind) and real installed with Biolamps application. RIGHT: Interior view

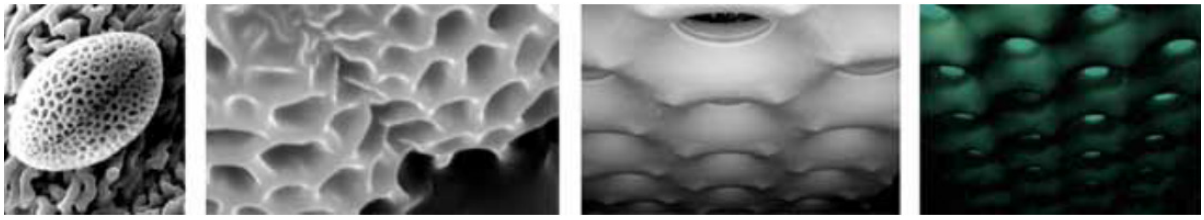

Figure 12. Pollen details, left, 6000x, and centre left, 20000x, made with FEI Quanta 200 scanning electron microscope (SCT-UB). Centre right and right, CNC real digitally fabricated natural scale 1:1 ceiling with real Biolamps application, 2008-2009 (© Alberto T. Estévez)

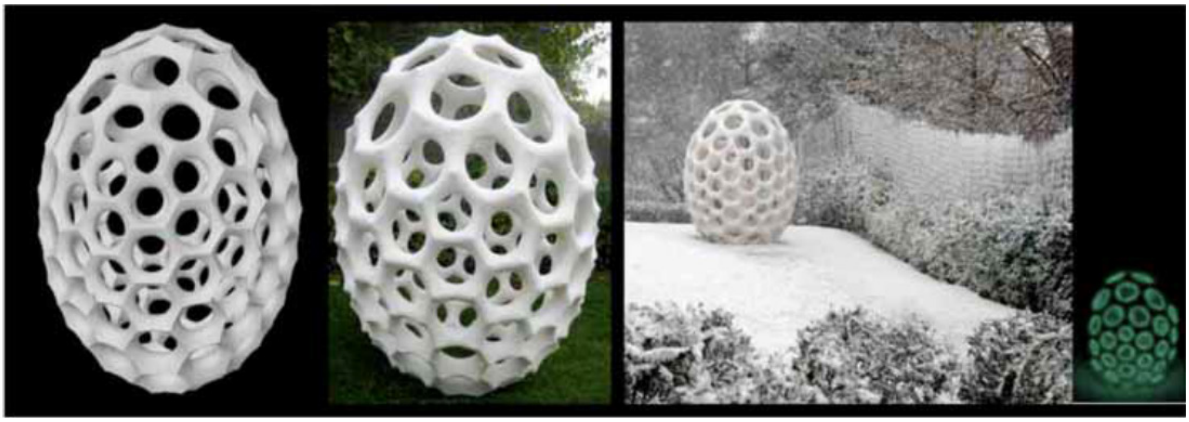

Figure 13. Biodigital Barcelona Pavilion, Barcelona, 2008-09. After "biolearning" process, CAD-CAM technologies for producing directly real 1:1 scale architecture. LEFT: Digital drawing. CENTRE / RIGHT: real CNC digitally fabricated and real installed in big architectural scale. (Right, with Biolamps application) (© Alberto T. Estévez)

Also, the *Consulting rooms*, of Alberto T. Estévez (Barcelona, 2008-2009), begin also with a microscopic research, in this case about radiolarian and pollen structures, like natural systems that have been perfected during million's years of evolution, until their high relation of efficiency/economy: heir application will take also these advantages. In this way started the studies, as mentioned for the *Biodigital Barcelona Skyscraper*, for extracting the genetic rules and the structural parameters for application with digital tools. Having its digital DNA that let also the architectural design "emerge" alone, we have produced it and fabricated digitally, with the effort to fulfil with the manifesto "No models, no moulds!" This means that only directly digital produced elements in real scale 1:1 are "allowed": after "biolearning" process, CAD-CAM technologies for producing directly real 1:1 scale architecture, from genetic architectures points of views.

Yes, "the future of architecture will be soft and furry", like the *Biodigital Barcelona Chair* (Barcelona, 2010) explains. This work is developed as an example of the determination for explaining the obsoleteness of the ancient techniques of the past, towards the application of "no models, no moulds": The determination for producing directly real architecture at 1:1 scale done with CAD-CAM technologies. The structure has been produced with a CNC machine in the Digital Architecture Laboratory of ESARQ (UIC), after a design with parametric and generative software, including the advantage of the structural, formal and process efficiency, obtained from learning of nature (biolearning). Besides, the use of recycled, soft and furry materials, is searching for opening ways for the acquisition of also a "soft and furry architecture" which Salvador Dalí prophesied in the past for the future, for our present, here, a soft chair of furry (real) grass: "let that live grows!"

Searching a really green planet, in the way of the *Green Barcelona Project*, of Alberto T. Estévez (Barcelona, 1995-1998): the Idea for the creation of a huge park by landscaping interconnected roofs in urban areas. But at the end **green over all our cities, houses and objects**. To combat that land becomes a desert, green Barcelona, blue planet!

Figure 14. Biodigital Barcelona Chair: "The future of architecture will be soft and furry", Barcelona, 2010

Figure 15. Green Barcelona Project, Barcelona, 1995-1998 Idea for the creation of a huge park by landscaping interconnected roofs in urban areas (© Alberto T. Estévez)

Figure 16. Farm, Paraguay, 2008 © Alberto T. Estévez (Diego Navarro, col.)

The temperature on the planet is constantly rising. How, then, is the overheating of cities (as a result of their hard surfaces) allowed? In cities, the square meter is ever more expensive; how, then, is the depopulation of roofs (as a result of underuse) allowed?

Since buildings cannot be sunk beneath the ground, the ground should rise over them and create cities on a high-rise, walk-on, drive-on continuity, interconnected by footbridges, with soft, green surfaces that are not barren but hairy (Dalí's "soft and furry/hairy/shaggy" architecture), guaranteeing cool shade without summer overheating or energy loss in the winter: all simply by landscaping roofs. Thanks to building techniques that came onto the market, the landscaped roof became possible.

All this architectural ideas, projects and possibilities of science and technology call for initiative. Architects have a lot to say and to do as regards environmental architecture considerations, if we want to see the world come to a happy end.

Figure 17. Genetic Barcelona Project, 1st phase, 2003-2006, Genetic creation of bioluminescent plants for urban and domestic use (© Alberto T. Estévez)