The Cathedral Is Alive: Animating Biomimetic Architecture

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Abstract By analyzing *The Cathedral* as an animation with implications for genetic architecture and strategies for design-biomimetics, this article argues (with experimental illustrations) for the use of animation in architectural research that is consistent with software visualization and fully capable of contributing to the design-thinking process. Repudiating the use of animation as merely a medium for architectural presentation and affirming the coupling of animation and design-biomimetics, Dollens considers how animation can stimulate and develop architectural ideas, forms, and design through the digital revisualization of natural elements evolving from plants, shells, and skeletons.

Keywords animation, architecture theory, biomimetics, biomimicry, design, generative design, morphology, *The Cathedral*

There is no surprise in claiming that the potential for animation as a tool for architectural research, as a generator of ideas, as a medium for testing spatial and material relationships, is vastly underrated. Floating architecture in the medium of animation, which may seem like the prospect of emulsifying oil in mirroring water, creates a bit of uneasiness about architectural production and generation. The uneasiness translates into awkwardness as testified to in the banal way architects frequently relegate computer animations to the status of mere

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presentation devices, producing walk-through and fly-over promotional propaganda or graphic website trinkets. Conversely, animation seems to demonstrate an almost inherent incapacity, or at least an enormous handicap, when it comes to allowing architecture to be more than a set, to allowing it to evolve as active subject and star. The reason for the apparent misfit does not seem complex: animation is a narrative 2D medium, and architecture is a sheltering 3D medium; both are visual, but one is moving in time, the other stationary; one is haptic, the other virtual; one is immersive, the other physically encompassing, an environmental element to be negotiated.

My paired listing opens a heuristic for articulating differences between animation and architecture; yet, simultaneously, such a listing neglects the perceptual differences encountered in the sensory, and sometimes, unconscious states of experiencing architecture or animation, which become critical factors for discussing these differences. While animation can simulate reality, architecture embodies and encases it – atmospheric pressure, heat, smell, cleanliness, and noise, all in addition to the designed visual substance of a building, are evidence of differences outweighing animation's particular abilities that might introduce the possibility of architectural dialogues. This is not to imply that one medium speaks to higher states of contemplation than the other, or that one is a finer expressive force than the other; it is simply to highlight architecture's difficulties in telling narrative and animation's showing without it.

Witness the spectacular organic growth transforming into buttresses, tracery, and pillars in *The Cathedral* (Baginski, 2002) – the most austere and, teasingly, *almost* architecture-as-subject animation I have ever seen. In this brief film, a wanderer/survivor crossing a desolate universe or off-world, when struck by light from an orbiting planet, is morphed into branching plant-structures – trapped alive – as the living composition of a partially ruined Gothic cathedral. In *The Cathedral* we are confronted with a mysterious, even existential narrative, suggesting that architecture is a natural growth botanically rooted in the cosmos and literally seeded by human bodies or body parts. In fact, however, recent architecture (while its origins may be genetic) is a growth and expression of civilization; more precisely of a particular zeitgeist filtered through an individual, a team of builders, a set of economics. If architecture is seeded, it is in thought: consciously and/or unconsciously.

Nevertheless, *The Cathedral* establishes its own conscious, generative forces for structures, encapsulating them in narrative with architecture as a co-star. This animation's post-apocalypse, off-world universe situates architecture not in the fixed position of a space, material, form, or function but in a proceeding metamorphosis of human life – life mutated from humans into a physically alive, seemingly sentient cathedral. Its powerful rendering, conception, and action brazenly illustrate how effectively animation can articulate

aspects of complex architectural transposition and visualization in cinematographic form. By delineating plant growth evolving into architectural elements, and architectural elements evolving as hybrid tree-people, *The Cathedral* soars into conceptual, experimental spatial speculation that leaves the static realm of design behind.

Visualizing grown architecture, *The Cathedral* models a process of anthropomorphized nature evolving with and encompassing architecture (see Figure 1). Still, despite the central role of architecture in this intellectual animation, the film is only incidentally architectural – its human, environmental, and cosmic angst constitutes *The Cathedral*'s narrative story and not a demonstration of experimental architecture. (In all fairness, the producers, to my knowledge, never claimed *The Cathedral* as architectural research. For my purpose here, I have chosen it as an outstanding example of narrative architecture existing in animation that, with an alternative reading, proffers a theoretical path to biological architecture. *The Cathedral* illustrates, beyond a doubt in my mind, that research into experimental architecture already exists in animation.)

Figure 1 *The Cathedral*. Stills progressing from human figure transforming into botanic growth; the botanic growth developing into an architectural pillar; and the pillar comprised in the cathedral. *The Cathedral* © 2002 Platige Image.

Animation as a design tool

Since I am interested in growing architectural elements digitally, using software based on plant morphology and botanic algorithms, and then testing my results in animations, *The Cathedral*'s visualization of humans as tree seeds sprouting into architecture is thrilling and provoking. Even if *The Cathedral* is narrative fiction written around architecture (in much the same way as John Hejduk's *Berlin Masque* (1985) is narrative expression with metaphorical architecture alternating between text, drawing, and structural expression), the work's epiphanal moments are so technically accomplished and artistically realized that it sets a benchmark against which my desktop research-animations look like stick-figure flipbooks next to illuminated manuscripts. Be that as it may, *The Cathedral*'s artistic and technical ur-level is a landmark for animation as design research.

Architectural research could be reverse-engineered into *The*

Cathedral or extended on its foundations. I could imagine altering the animation's organic growth process and intention – by which humans are morphed into branches and take root, becoming live architectural tracery – and redeploying the animator's efforts to new effect, illustrating, for example, an evolutionary, cellular growth process. I'm thinking now of *The Cathedral* itself as a seed. A seed for thought, a thought of how, if it were planted differently, *The Cathedral* could grow and illustrate a new breed of urban, environmentally active, semi-alive architecture that addresses some of today's sustainability issues as encountered in experimental architectural discourse: monitoring, even sequestering pollution or mitigating noise, etc. Poignantly, and more than anything else for my consideration, *The Cathedral* demonstrates that the low volume of architectural research, visualized and tested in animation, results from a lack of imagination in architects and design schools, not from animation's inapplicability or technical limitations.

There are, of course, other types of architectural animations that deal with the experimental potential of digital media for presenting architecture. The excellent volume *ArchitectureAnimation*, edited by Fredy Massad and Alicia Guerrero Yeste (2002), is a case in point. Browse through its pages and note the predominating uses of animation by architects. This book stems from the festival of the same name the authors jointly curated in Barcelona in 2002 at the Catalan Association of Architects (COAC). The book's portrait of how architects use animation reveals that architects are, for the most part, placing their work within narrative frames. While these narrative frames may be comprised of beautiful and digitally accomplished renderings, most of their designers are not aspiring to articulate their generative or material research by means of animation (one notable exception is the work of Winka Dubbeldam, pp. 268–83). Again, this is not criticism, solely an observation aimed at the limited use of animation in architectural research – especially when architectural and design software offers possibilities for animation at almost every step in the design process. Guerrero Yeste confirms my point:

> Indeed we do share the same opinion about architects and animation – and I agree this is what the *AA* book shows. That's why I am so very interested in doing a new edition, to understand how architecture and animation have evolved since 2002 . . . Like you, I am absolutely persuaded that architects are not fully aware of the potential of animation or the complexities involved in the word 'visualization'. (Email to author, 13 October 2005)

The metaphysical *Cathedral* surely establishes that: *Architecture is alive*! Even if the animation's encapsulated souls are tortured and their bodies morphed into trunks and branches, they are animate within *Cathedral*'s apocalyptic matrix of living structure. Moreover, *The Cathedral*'s arboreal life *is* an architectural matrix. And researching biological matrices is necessary if eventual biomimetic materials (and

potential semi-live materials) are to be integrated into architecture, historic preservation, and urban design. With programmed, generative cellular and/or chaotic algorithms mediated in a software's test parameters, matrices could be generated as structure or infrastructure experiments – the research agenda, combining aspects of science, history, and design intention, could be suited perfectly to animation's abilities. In such a scenario, animation's inherent narrative would be submerged into the physical depiction of the mutating form and research visualizations. In this light, *The Cathedral*, an Academy Award nominee, may prove the most important production for architecture since *Blade Runner*'s dystopic, computer-generated, animated special effects of a future Los Angeles.

Contemporary sciences and engineering are testing biological computing and biomimetic extrapolations for new materials (Ball, 1999). For example, scientists are appropriating the chemical properties of electroluminescence in jellyfish for developing products. Such research could lead to new materials for luminous skins or membranes on buildings as it is currently leading to new LEDs (Sailor, undated). *The Cathedral* presents a direct mimetic model for studying and visualizing such developments; its demonstrations may inspire ways to visualize advances in materials and form as manifested in animation, simulating real-world conditions in order to stimulate and grow ideas that eventually lead to fabrication and building.

Near-living or semi-living materials are distinct possibilities in the next decades and, in conjunction with biologically based, or at least more advanced, computing will usher in buildings that act as environmental monitors and mediators. As we strive for 100 percent recyclable and non-toxic buildings (as well as industrial and consumer designs), animation holds out a prime visualizing tool for checking visual properties of buildings and materials, and inspecting forms for spatial relationships, night-time presence, etc. In this employ, animation becomes an analytic tool – useful and important, potentially indispensable.

Yet equally or more exciting is the pairing of digital animation with other software in a collaborative process for generating ideas, forms, and structures pushing into the realms of new architectural conceptualization. Thus paired, animation then becomes a generative tool for researching complex geometries, spatial relationships, and environmental impact; it becomes a primary pathway for a designer's mind's-eye visualization of built environmental forms.

Envisioning a near future of biomaterials and biomimetic architecture, thinking of what an architecture-animation hermeneutics would ask seems an appropriate task to intensify. Without overt narrative, perhaps even without entertainment value, digital animation for architecture could easily become a more advanced research tool. In a visual-biomimetic context, animation might occupy a position similar to that occupied in urban and regional planning by environmental simulation

where video, modeling (physical and digital), and animation processes are devoted to envisioning and documenting positive and negative aspects of, for example, inserting a skyscraper into a historic neighborhood, or opening roads in a forested area. Tests from environmental simulations reveal what happens to the quality of sunlight and shadow and to water run-off, it determines microclimate behaviors such as intolerable wind gusts, it reveals visual impact on street, skyline, and natural views, as well as focusing basic, quality-of-life research data for decision making in both urban and wild contexts. Expecting different research results, architects could anticipate assistance, information, and visualizations from research animations.

Animation morphology and biomimetics

Biomimetics is the search for and implementation of extractable processes and/or qualities from nature – providing science and engineering with models for chemical, medical, and structural research. In an architectural context, biomimetics is an investigative process for evolving and/or mimicking methods in order to extract ideas, processes, attributes, forms, textures, spatial relationships, and sometimes life characteristics – for example, phototropism (Dollens, 2005). Additionally, as a process, design-biomimetics becomes a tool related to morphology, useful for visualizing, extrapolating, and creating biological elements in industrial design, furniture, fashion, and textiles. Design-biomimetics establishes questions for designers to ask: How would nature build my project? Has nature already built it, or part of it? What materials and process did nature use? And: How can I visualize nature's work in a digital context? (Benyus, 1997).

Questioning what form research may take becomes a factor in addressing the need to stem what I have come to call 'a priori design': the often hubristic practice of imposing design as determined by the will and ego of an architect, not by the circumstances of the site, the general environment, or the needs of the clients. Such an a priori syndrome can at least be treated harmlessly in education when students are given tools for imaginatively realizing buildings. Digital animation should now be one of those tools to aid the study of design-biomimetics, with morphology as part of the animation and design curriculum illustrating and relating form to form, and forms to environment as natural transitions, or as morphological processes. Animation as a research tool provides a way of establishing a flow of visual information – design testing and analysis that could act as a significant antidote to a priori inflictions and infections.

Goethe's coining of the word *morphology* in his essay 'The Metamorphosis of Plants' led to its application in all developing sciences during the late 18th and early 19th centuries (Goethe, 1952[1790]: 31). But, overshadowed by his great literary achievements, Goethe's

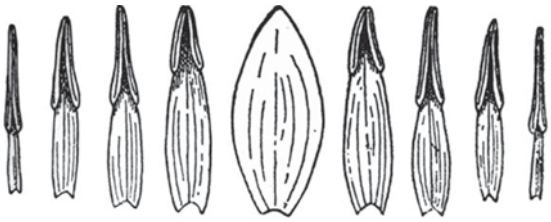

Figure 2
Prototype Morph. Goethe's morphological development of a water lily petal into a stamen. Recharted by the author after a drawing in 'The Metamorphosis of Plants', 1790.

science is seldom granted its importance. Written before the discovery of cell theory, 'The Metamorphosis of Plants' outlined a series of steps that considered the generative development of plants based in an ur-form, the leaf. Today, while morphology is no longer the primary route of biological research, its methods as well as its definition – the study of form and transformation – are embedded and central to visualizing movement and critical to animation. Essentially, in 1790, Goethe articulated a theory of graphic transition of plant-form development seen in morphological growth and development that may now be looked at as proto-animation.

Suzanne Buchan, editor of this journal, has observed: 'A key phenomenon in animation is its ability to simulate metamorphosis and its digital progression, the morph' (personal communication, 12 October 2005), which prompted me to bring Goethe's morphology into the discussion. His conceptualization and discussion of plant development provide a transforming, conceptual link in the history of understanding and visualizing movement and growth that later would be replicated in early animation-like, scientific photography and still later in animation cinema – for example, in the research images of Eadweard Muybridge or Etienne-Jules Marey, where stop action in photography became the cousin of the morph as well as a morphological tool: cells of graphic information yielding data derived by capturing form-in-motion (but only revealing scientific data when analyzed sequentially) (see Figure 2). Stop-motion and digital morphs are now common technical devices in animation, but they also generate metaphors for everyday thinking and expression, by which ideas and our mind's-eye images can be extracted and then reinserted in an iterative cycle of investigating ideas or designs. The morph, as we know it technologically, was obviously not available to Goethe, yet he intellectually engendered and imprinted its development and use. We now carry his coined *morphology* almost as a cultural genetic impulse, which makes me wonder if Lamarckian theory should be morphed back into Darwinian evolution (Steele et al., 1998). In any case, we are now able to read into Goethe's *word* meaning added to his intended gist, even as we are able to see a morphological experiment explored, reanimated in works such as *The Cathedral*. Whereas Goethe's morphology looked to the *Urpflanze* (Urplant), *The Cathedral*'s morphology perhaps leads us to his *Urphenomenon*, especially if we

take his echoing words as a voice-over: 'An idea is independent of space and time; experience is restricted within them. The simultaneous and the successive are therefore intimately bound together in an idea, whereas they are always separated in experience' (Goethe, 1952[1790]: 219).

Case study I

In 2000, Ignasi Pérez Arnal invited me to teach with him in the newly created Genetic Architectures Program that Alberto T. Estévez had recently established at the Universitat Internacional de Catalunya. Determined to define and then develop a future 'genetic architecture', Estévez encouraged our research into new digital visualization techniques and made it possible for us to become part of the first group of schools in Europe using rapid prototyping (usually found in industry) for directly fabricating architectural models from digital files and so, in a sense, directly fabricating visualizations (Estévez et al., 2003). Shortly after, in 2004, Pérez Arnal received a commission for housing and a small pedestrian-bridge in the French Pyrenees. He approached me with the idea of applying to the proposed bridge the process of design-biomimetics and morphological research as we had been teaching it.

With a series of preliminary studies behind us, we decided that we would combine structural aspects of the sponge *Euplectella* and the spiral flight pattern created when a *Tipiana tipu* leaf fell/flew to the ground, yielding a biologically based prototype. Our model, with the potential for forming a lightweight, environmentally sensitive bridge, also resembled a traditional African rope bridge. It turned out that the spicules grown in a *Euplectella*'s skeletal lattice are silica-based

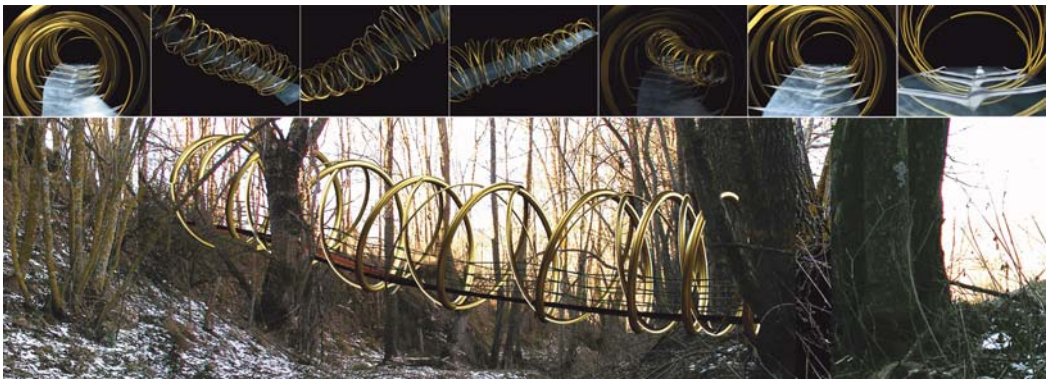

Figure 3 Spiral Bridge Group. *Top*: Animation sequences for the Spiral Bridge, French Pyrenees. *Bottom*: Rendering of the bridge on the site. Bridge design: D. Dollens and Ignasi Pérez Arnal. Animation: D. Dollens.

materials (purer than man-made fiber optics) whose individual elements, seen microscopically, could be revisualized and scaled up as struts and deck supports for the bridge (*The Economist*, 23 August 2003: 66). To visualize and understand the changing and shifting geometries of our variously different, intersecting, curving, and tapering spirals, I created study animations (see Figure 3). These animations indicated that we were maintaining form and aesthetic relationships to our extracted trace-spirals from the wind-blown, flying leaf. It also gave us perspective for visualizing the spicule-like cross bars and spiral intersections, indicating that we would not be aesthetically off-key even with such a huge scaling-up of the microscopic spicule. The animations became our way of visualizing not only aesthetics, but also several pre-engineering processes determining the bridge's relationship of parts, materials, and their scale.

Case study II

In a slightly earlier animation, I had evolved an experimental digital growth based on the work of the American skyscraper designer, Louis H. Sullivan. I was specifically looking to his use of morphology, botany, and design method as presented in his 1924 book, *A System of Architectural Ornament: According with a Philosophy of Man's Powers*. This transcendental book, one of the most important theoretical books produced by an American architect, details a system for viewing nature and considering ways of integrating geometries and botanic growths both as visual units in architectural ornament and as an expression of our human, poetic nature and social condition (Sullivan, 1967[1924]).

For the animation, I took geometric vortices from the terra-cotta ornament on Sullivan's 1914 Merchant's National Bank (Grinnell, IA, USA) and projected those points into Xfrog[1] so the points might simulate tendrils in order to elongate and transform the ornament, as digital plant growth, into a structural base system for branching. Later I directed Xfrog to grow leaves and pods that further referenced the facade's terra-cotta vegetation. My digital exfoliation then underwent development and spatial articulation leading to its animation in 3D Studio MAX. Only with the animation completed did I realize that my hybridization of Sullivan's design and my digital generations led not to a horizontal growth, as I had imagined, but to a vertical growth. This imposed vertical metamorphosis of design seems ironically appropriate in that Sullivan's greatest fame came from skyscraper design, construction, and theory which my digital growth found best (if coincidental) expression in as a hypothetical skyscraper (see Figure 4).

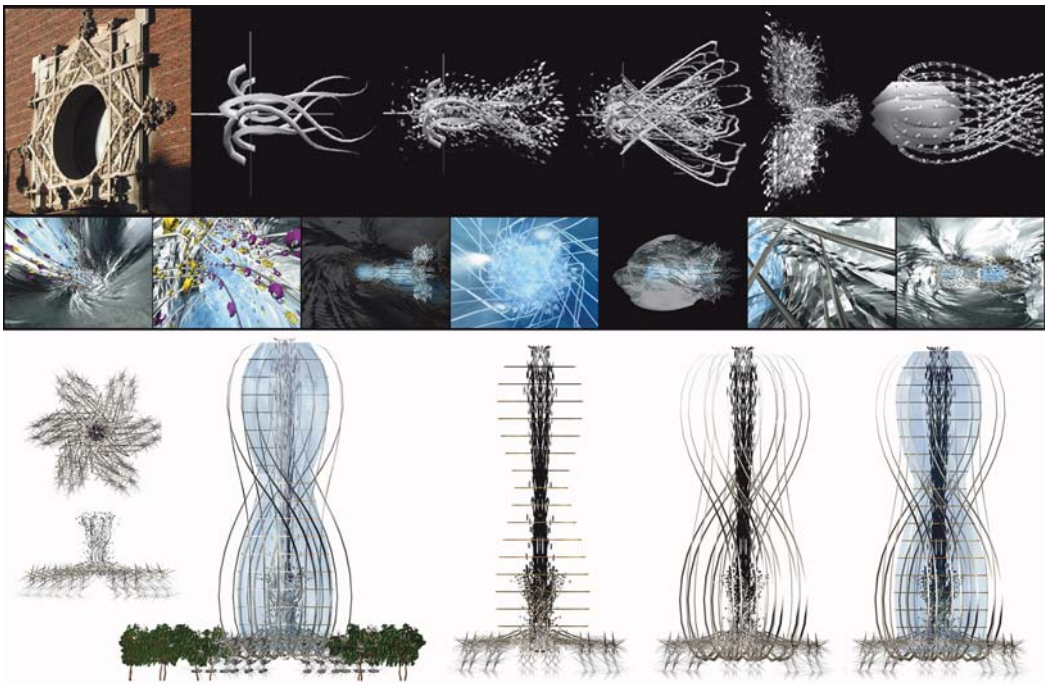

Figure 4 Sullivan Inspired Group. *Top row*: Louis Sullivan's ornament; sequence of hypothetical digital growths seeded by his terra-cotta ornament. *Middle row*: Animation cells from the study of the digitally grown forms. *Bottom row*: Digital growths evolved as a coincidental skyscraper. Photograph, drawings, animations, building: D. Dollens.

Case study III

I look to plants and flowers but sometimes search shells, skeletons, and crystals for subjects of basic visual research documented in digital photography, X-rays, and digital microscopy. Some plants I find in their native settings, others I grow; occasionally, I attempt hybridization and grafting. With Xfrog software I generate digital-biomimetic growths inspired by the forms and spatial relationships I study. This process involves subverting – hybridizing – the growth parameters in Xfrog to grow, for example, seedpods at an architectural scale as spatial modules for a building or to manipulate a seed stalk's clustering forms to study massing, or to grow trees and control their trunk and branch formations until they function as columns or structural trusses. Such digital growths are partially calculated in Xfrog's use of L-Systems, the algorithms developed to simulate natural biological growth (Prusinkiewicz and Lindenmayer, 1990). This software can also factor in natural phenomena such as leafing, branching, phototropism, etc. I intend not only to explore the visual potential for mimicking botanic sources but also to explore ideas for orientating more complex facades

thus again, for example, increasing surface area and tracking potential for light and photovoltaic instillation, to study possible kinetic mobility, while always following aesthetic relationships.

Once an initial growth is developed I export it to other software, especially Rhinoceros and 3D Studio MAX for editing, scaling, rendering, detailing, and animation (see Figure 5). The resulting animations are small, bare-bone studies frequently rendered without material attributes, thus reducing processing time for quick results. These are working animation sketches simply rendered, primarily gray with only one or two colors to highlight the intended feature being studied. The studies provide shifting, perspectival relationships of scales and forms which cannot as easily be discerned in single-panel renderings. For example, one set of recent animations illustrates the relationship of windows in a multi-storeyed building whose apartment units were evolved from the seedpods and seed clusters of *Penstemon palmary*. Another animation articulated movement of solar panels tracking the sun while at the same time shading the building. These working animations provide a fast way to visualize and think about movement, relationships between materials, transitions between forms and massing, as well as ideas concerning light and shadow; and even if vague, these animations communicate a sense of the buildings as 3D environmental works. Working tools, these animation tests serve as a kind of environmental simulation.

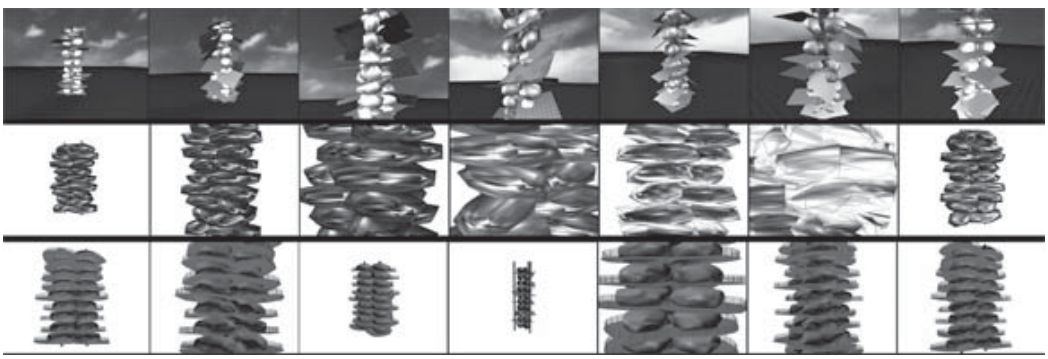

Figure 5 Test Animation Group. Three (different) test animations. *Top row*: Solar panels tracking and shading a core structure based on seedpods. *Middle row*: Flower seedpods morphologically elongated. *Bottom row*: Stalk, leaves, and seedpod with leaves morphed into balconies, windows inserted, and service core highlighted in red.

Conclusion

If one filters the viewing of *The Cathedral* through the sieve of animation as a research and design tool – along the narrow lines I have articulated here – it is possible, without too much effort, to consider *The*

Cathedral outside of its intended narrative message: seeing in place of its apocalyptic view of human wanderers hounded by a photocosmic force, imagery as idea-seeds, as morphological impulses. Read in a kind of narrative reversal, *The Cathedral* can be parsed as a metaphysical, morphological, and metaphorical study of genetic potential for architecture.

In hindsight, *The Cathedral*'s weakest element is a question of premise: how did a Gothic cathedral come to entomb the descendants of its living human creators (when it once only entombed the dead)? More importantly, ask: how did cosmic light forces, after striking a human body, transform it into a sprouting plant growth that subsequently transforms into part of a Gothic superstructure? Cosmic light, human genes, plant biology – all elements of genetic development that fracture and subvert *The Cathedral*'s narrative (in my reading) into a vision of cellular manipulation fertilizing the idea that architecture is genetic. Genetic if one reasons along the lines of Richard Dawkins's *extended phenotypes*: since the nest of a bird is a genetic expression, so also is man's early impulse to build with mud and twigs nest building and, consequently, genetic (Dawkins, 1990). While this is not the place to argue genetic architecture, noting the argument, vis-a-vis my example of *The Cathedral*, usefully illustrates the centrality and potential of animation as a tool for developing design according to currently emerging ideas, not merely as a method and medium of presentation.

My virtual thought experiment – reanimation of an animation in this text – brings *The Cathedral* into my framework as a working tool for thinking and generating ideas different from those intended by its creators. In the realm of animating thought and design, I further hybridize with this text and my sketch animations, metaphorical material from viewing *The Cathedral*, now hybridized in me. While my much humbler levels of accomplishment generate the design sketches I create with animation, they are now, having seen *The Cathedral*, conceptually referenced to that work as a wanderer references landmarks. Those little animation studies I make in 3D Studio MAX illustrate what I think of as biological ideas flowing in a genetic, neuronal soup of thought – yet, they may actually be animate ideas, spawned and framed in cellular animation.

Note

1 Xfrog is a landscape-generating software from Greenworks, Germany [http://www.xfrog.com/]. It produces lifelike trees, plants, and flowers and can also be programmed, with its proprietary icon-based interface and underlying biological (L-Systems) modeling, to creatively transform or hybridize its digital growths into experimental, schematic files. For my work, the hybrid digital plant files must then be exported from Xfrog and imported and transformed in 3D modeling or architectural software; for this development and articulation process I primarily use Rhinoceros (www.rhino3d.com).

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