

Breathing wall skins

Theorizing the building envelope as a membrane

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Sebbene il termine "membrana" deriva principalmente dal campo dell'anatomia, riferendosi al confine essenziale delle cellule, ha ampiamente attraversato il discorso architettonico, così da descrivere l'avvolgimento spaziale. Al di là dei limiti del suo uso metaforico, questo articolo individua momenti decisivi nella storia dell'architettura moderna nei quali la nozione membrana ha segnato un cambiamento nelle prestazioni dell'involucro architettonico e la sua relazione a concetti di modernità.

Membrana, Metafore scientifiche, Performance, Le Corbusier, Siegfried Ebeling

Although the term "membrane" principally derives from the field of anatomy, referring to the essential boundary of cells, it has gained entrance the terrain of architectural discourse, so as to describe the spatial envelopment this time. Going beyond the limits of its metaphorical use, this article identifies key moments in the modern architectural history in which the membrane notion has marked a change in the performance of the building exterior and its relation to concepts of modernity.

Membrane, Scientific metaphors, Performance, Le Corbusier, Siegfried Ebeling

When the windows became walls

In the early 1920s, a charcoal and graphite drawing entitled “Honeycomb [Wabe]” came to light, featuring a prismatically shaped skyscraper which appeared to be still under construction, due to the fact that its inner structure of vertical slabs remained visible. A cog in Ludwig Mies van der Rohe’s wider experimentation into «an essentially simple structure, as fundamental as the molecular construction of the elements» (Neumeyer, 1991 p. 116), the 1922 Hochhaus am Bahnhof Friedrichstrasse competition project [fig. 01], of which the drawing formed part, reflected on the structural potential of the steel skeleton – its enclosure into, and its exposure through, an all-glass façade. «We can see the new structural principles most clearly when we use glass in place of the outer walls, which is feasible today since in a skeleton building these outer walls do not actually carry weight» (Rohe, Taut, 1921-1922, p. 212), Mies wrote with reference to the project. The interpretation of these new structural principles, however, was not freed from analogies to the biological formation, and more precisely to the separation between structure and envelope that the pattern of the “skin and bones” distinction, coined by Mies, revealed.

But Mies was not alone in exploring this distinction at the dawn of the twentieth century. The 1915 Dom-ino house project of Le Corbusier, circulated through the perspective drawings of a two-floor, open-plan and naked of enclosure structure, was also «a striking demonstration of the separation of structure from enclosure» (Benton, 2012, p. 284). Meanwhile, the praise for the integration of glass into architecture «not merely through a few windows, but through every possible wall», as expressed by Paul Scheerbarth (Scheerbarth et al., 2014, p. 100), testified to the ongoing interest in the independent and continuous character of the glass façade. It was an interest which had arisen as early as the emergence of an «unprecedented conquest of matter» (Giedion [1928], 1995, p. 137), articulated through buildings such as Joseph Paxton’s 1851 Crystal Palace or Ferdinand Dutert’s 1889 Galerie des Machines that saw the combination of iron skeletons with the all-glass envelope. Picking up on the “skin and bones” metaphorical mechanism, the latter was compared to a membrane due to the thinness of its structure, its influence on the visual and physical boundaries between interior and exterior space, as well as its ability to introduce new aesthetic and perceptive values. As modernism «rendered ambiguous the role of the wall as a device of definition, confinement and separation and as carrier of symbolic dressing» (Neumeyer, 1999, p. 245), however, attention

Nur im Fluss befindliche Werkstoffe zeigen die höchsten konstruktiven Festigkeiten, und überflüssig ist dann der Eindruck der kantigenen Stahlsäulen. Mit der Ausmessung der Formen wird dieser Eindruck vollständig verworfen, die konstruktive Gedanke, die notwendige Gestalt für die kinematische Gestaltung verändert und mit von einem einzelnen und weichen Formelement überweicht. Im besten Fall inspiriert jetzt nur die natürliche Größe, und doch können diese Formen mehr sein können als eine Manifestation unserer technischen Künste. Allerdings sollte man auf das Vermeiden, mit den überlieferten Formen eine neue Aufgabe zu lösen, vielmehr ist vor dem Wenden der neuen Aufgabebereiche die Gestaltung ihrer Form zu versuchen.

Das ursprüngliche konstruktive Prinzip dieser Formen wird dann klar hervorgehoben, wenn man für die sie nicht mehr tragenden Außenwände Glas verwendet. Die Verwendung von Glas erzieht allerdings zu neuen Wegen.

Der meiste Entwurf für die Hochhäuser am Friedrichshagen in Berlin, für die ein dreieckiger Bauplatz zur Verfügung stand, schien mir für dieses Bau eine das Dreieck angepasste prismatische Form die richtige Lösung zu sein, und ich wollte die einzelnen Frontflächen leicht gegeneinander, um der Gefahr der teten Wirkung auszuweichen, die sich oft bei der Verwendung von Glas in großen Flächen ergibt. Meine Versuche an einem Glastisch weisen mir den Weg, und ich erkannte bald, daß es bei der Verwendung von Glas nicht auf eine Wirkung von Licht und Schatten, sondern auf ein reiches Spiel von Lichtreflexen ankommt. Das habe ich bei dem nächsten klar veranschaulichten Entwurfsentwurf (S. 127-131) Bei oberflächlicher Betrachtung erscheint die Oberfläche des Grundrisses vollständig, und doch ist sie die Ergebnis vieler Versuche an dem Glastischmodell. Für die Kurven waren bestimmt die Reflexion der Gebäudeteile, die Wirkung der Räume im Straßenschnitt und zuletzt die Spiel der erweichenden Lichtreflexen. Umfaltungen des Grundrisses, bei dem die Kurven auf Licht und Schatten berechnet waren, erwies sich ein Modell bei der Verwendung von Glas als gleich ungeeignet. Die strahlen im Grundriß festschließenden Punkte sind die Treppen- und Aufzugstürme.

Alle weiteren Unterteilungen des Grundrisses sollen den jeweiligen Bauteilen angepasst und in Glas ausgeführt werden.

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Mies van der Rohe



01

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GLAS

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would shift away from such values and issues of architectural performance would come significantly to the fore, and stay on to the present day.

Contemporary discourse on architecture draws extensively meaning on the biological sciences, and the building exterior is being invariably described as a membrane – as a breathing or living structure – in a way that surpasses the use of several other linguistic terms that refer to an enveloping surface. Aligning with former discussions on the architectural discourse and the biological metaphors (Forty, 2004; Picon, Ponte, 2003), this article aims to form a critical inquiry into, and contextualize, the metaphor of the membrane in the theory- and design-focused approach to the building envelope, as this was deployed by the architects Le Corbusier and Siegfried Ebeling, respectively, at the beginning of the twentieth century. From here it follows that it seeks to provide a deeper understanding of how the membrane notion – of a breathing wall skin – has fostered new methods in the interpretation of the building exterior, not least of how it has been used as a trope for new approaches towards its architectural performance – a key aspect to concepts of modernity as well.

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Ludwig Mies van der Rohe, Honeycomb [Wabe] drawing – Hochhaus am Bahnhof Friedrichstraße competition project, 1922, in Bruno Taut, *Frühlicht. Eine Folge für die Verwirklichung des neuen Baugedankens* (1922), n. 4, Berlin, Gebr. Mann, 2000, p. 124
- 02
Title page, Arthur Korn, *Glas im Bau und als Gebrauchsgegenstand*, Berlin, Pollak, 1929

When the walls became membranes

«Never before did man succeed in enclosing and dividing up space by a single membrane» than in the application of glass to the building's exterior surface (Korn, 1929, p. 6), the architect Arthur Korn observed at the end of the 1920s, in his book *Glass in modern architecture [Glas im Bau und als Gebrauchsgegenstand]* [fig. 02], while exploring the innovative properties that glass brought along in those days. «It is the great mysterious membrane, delicate and strong at the same time» (id., pp. 5-6), he went on to observe, shifting the attention of readers towards a shift in the interventions in and the interpretation of the building envelope. In their ability to form a continuous surface around the building and admit views, light and thermal energy, the glass façades that complemented the iron skeletons of that time justified to a great extent their characterization as membranes. This gives rise to the interesting question whether such envelopes can assume characteristics of the traditional solid wall, such as the provision of security, sound and heat insulation, and thus to mediate efficiently between interior and exterior environments.

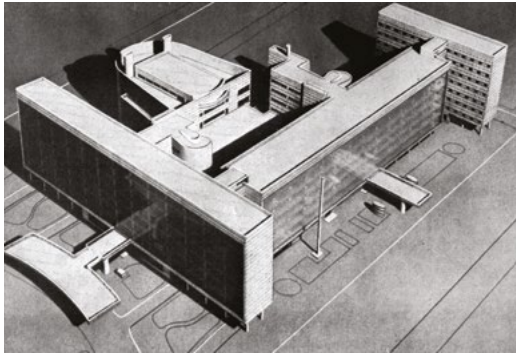
In the theorization of the building envelope as a membrane, it is imperative to take into account the diversity that the term entails and the necessity that enabled its integration into the architectural discourse. On biological grounds, the membrane is defined as a pliable sheet-like structure, acting as a boundary, lining or partition of an organism. It also stands for a selective surface between the cell's inner space and the space surrounding it – one which preserves the individuality of the cell, determines its form and plasticity, and regulates its inner environment (Frabetti, 2011-2012, p. 2). Further than its association with an aesthetic impact – such as the «organic illumination of the interior» (Giedion [1946], 1967, p. 483) –, the success of the membrane metaphor in the architectural discourse should consequently be sought in the performative aspects of the building envelope. Not only is the membrane relevant to concepts of surface architecture – in carrying connotations of a thin and fragile, transparent and luminous, pliable and sculptural entity – but it is also key to concepts of architectural behavior, in referring to a selectively permeable, regulating and unifying element.

With the growing demand for the insulation of wide and continuous glass surfaces in the early decades of the twentieth century and appropriate ventilation of the space that was found therein, the permeable aspects of the building envelope came into question. To this, Le Corbusier responded with a concept borrowed from the function of the lungs. As we breath fresh air through our

membraneous bodies, the building envelope – he hypothesized – ought to be similarly able to admit fresh air and deploy it in order to regulate the thermal behavior of the building. His vision was formalized through the “respiration exacte” (exact respiration) and “mur neutralisant” (neutralizing wall) techniques, which were to articulate a new interpretation of the membrane metaphor on architectural grounds. «Our invention, to stop the air at 18°C undergoing any external influence» (Le Corbusier [1930], 1991, p. 64), Le Corbusier writes in the 1930 publication “Précisions sur un état présent de l’architecture et de l’urbanisme” – a collection of his lectures in Latin America during the summer of 1929 – referring to the above mentioned techniques. «These walls are envisaged in glass, stone, or mixed forms, consisting of a double membrane with a space of a few centimeters between them» (id.), he continues, with regard to the building envelope within which regulated air would circulate, so as to maintain the temperature of the interior space on a fixed level. Not only was this double surface envisioned to enclose the full volume of the building, in correspondence to the continuity of the biological membrane, surrounding «the building underneath, up the walls, over the roof terrace» (id.), but it also aspired to perform a breathing function.

It was “living air” what Le Corbusier aimed at infusing within the outer surface of the building, accentuating in this way the allusion to the biological process of breathing. More than its aesthetic and perceptive qualities, the building envelope is placed here under scrutiny in terms of its performance – that is the impact on the mediation between interior and exterior environments –, and the terms related to the human skin are deployed so as to articulate this influence. The concept of maintaining temperature at the fixed level of 18 degrees Celsius aimed at rendering the thermal and humidity conditions in the interior space of the building appropriate and at admitting an ineffable amount of sunlight in its interior. It aligned with the architect’s visions for a standardized type of architecture, independent from the climatic conditions of the surroundings, and relied greatly on the regulating properties of the building exterior.

Even though this intervention in the building envelope was described by Le Corbusier as a “breathing” system, fresh air was not meant to find its way into the interior space. Instead, the latter would be mechanically ventilated and fresh air would solely spread within the exterior wall, leaving the enclosed volume of the building completely airtight, so as to benefit from the insulation benefits provided by the double window wall. The Palais de la Société



des Nations project in Paris (1927) would serve as a platform for Le Corbusier to investigate these techniques, and further explore them on the occasion of the Centrosoyuz ministry building in Moscow (1928) [fig. 03] and the Cité de Refuge project in Paris (1929-1933). The high maintenance costs and state of technology in those days, however, would lead to the unsuccessful adaptation of these techniques to the latter, restricting the comparison of the said surfaces to the regulating properties of the physiological membrane on a theoretical – and, for the greater part, practically ineffective – level.

Although glass, for Le Corbusier, embodied the «ideal of the de-materialized building skin, the minimum membrane between indoors and out» (Banham, 1969, p. 155), its extensive use in replacement of the load-bearing wall, ignored significant environmental qualities and carried along important issues to reflect upon and to solve. The layers of glass that contained warmed air on the interior, according to this technique, were described by Banham as part of the “clip-on elements” added posteriorly on the structure, aiming at replacing the «performance factors that a massive wall had contained homogeneously and organically» (id.). And although the “respiration exacte” and “mur neutralisant” techniques would come to an early conclusion, they would stand for an early indication of the deployment of air as an integral material of architecture. More than a “clip-on element”, air would soon act as a «life support system» (Latour, 2006, p. 106): it would permeate through the building exterior and expand across the interior space of a building, accounting for a principal factor in the achievement of hygiene, through comfort, and through temperature regulation.

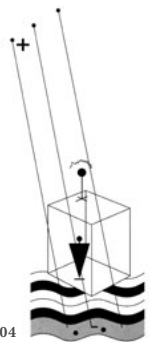
Simultaneous to Le Corbusier’s exploration into the “respiration exacte” and “mur neutralisant” techniques, yet on

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Le Corbusier, Centrosoyuz project, Moscow, Russia, 1928, in Willy Boesiger, *Le Corbusier*, Zürich, Artemis, 1972, p. 56

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Sketch featuring in the cover of the original edition of Siegfried Ebeling’s “Space as membrane [Raum als Membran]”, in Siegfried Ebeling, *Raum als Membran*, 1926 (tr. eng. *Space as membrane*, London, Architectural Association, 2010)



04

German grounds, a Bauhaus alumnus would make similar enquiries into the “breathing” potential of the building envelope. Siegfried Ebeling would publish in 1926 in Dessau his essay entitled “Space as membrane” [Raum als Membran] [fig. 04], and through this he aspired to a plasmatic expression of the built artifact – an informative exchange between the human body and the building exterior. In opposition to the plastic and formal architectural experimentations of his epoch, Ebeling stressed the significance of the “content [Gehalt]” over “external appearance [Gestalt]” and articulated the idea of an ecologically efficient, naturally lit, porous envelope.

In describing an architectural stance informed by the properties of the biological membrane, Ebeling coined the term “Wandhaut” (breathing wall-skin) (Ebeling [1926], 2010, p. 8) – an element which held a central role to his description of an architectural type informed by the properties of the biological membrane. With his conception of the “Wandhaut” (breathing wall-skin), Ebeling distanced himself from all the architectural models associated with the stiffness and rigidity of concrete construction, as the foreword of the English translation of *Space as Membrane* suggests. Instead he sought for a dynamic spatial enclosure that would frame and inform a self-sufficient architectural type in terms of energy consumption. Such an enclosure would be made out of wood, mud, stone or their substitutes, and would reconcile the adjacent architectural and natural environments.

Despite the fact that glass has served as a material widely associated with the notion of the biological membrane – from Arthur Korn’s comparison of glass to a mysterious membrane through to Reyner Banham’s hypothesis that «Bauhaus teaching, and the example of the Bauhaus buildings in Dessau [fig. 05] must have turned men’s minds in the direction of transparent membranes» (Banham, 1959, p. 33) – it remains absent from Ebeling’s treatise. And while for Le Corbusier glass served as a pivotal material for his “respiration exacte” and “mur neutralisant” techniques – as he envisioned these to take glass, stone, or mixed forms, Ebeling sought for an alternative architectural expression in terms of materiality. He intended the building envelope to be constructed out of wood, mud, stone or their substitutes and went on to realize building prototypes made entirely out of metal. The All-Metal Circular House (1930-1931), for instance, aimed at admitting the maximum amount of natural light due to its round form and absence of internal walls or partitions and was a step forward to the definition of an autarkic house.

The nearest Ebeling arrives to a mention of the glass facade is when he refers to a «thinner medium that is penetrated

by rays of light of variable quality, alternating periodically» (Ebeling [1926], 2010, p. 8) in his synopsis of the state of architecture in those days, pointing out the thinness and the permeability of this medium in terms of light admittance; or when he describes an “indifferent spatial enclosure” and, by extension, an “indifferent spatial tension”, which appears, as he writes, particularly lifeless in grey daylight. His theory kept a differentiated position towards the then widespread building envelopes, constructed in their majority out of glass. Despite its thinness and ability to admit, under certain circumstances, light and visibility, glass was unable to filter air through its continuous surface. It remained an element which would still have to «close and open, not only in one but in many directions» (Korn, 1929, p. 5) in order to perform such action, as Arthur Korn had described in his extensive description of glass in his 1929 book publication. It was therefore linked to a series of deficiencies and triggered a reassessment of the relationship it established with both the interior and exterior environments. Through a biological approach to architecture, this relationship would be expressed in terms of porosity: it would allow boundaries to become fluid and space to become flowing: «the inside and the outside, the upper and the lower, fuse into unity» (Moholy-Nagy [1938], 1939, p. 198) [fig. 06]. Ebeling referred to a “breathing skin” which would be independent from the materiality of the structure: his hy-

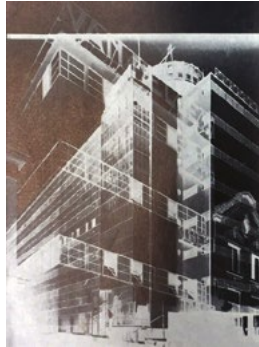
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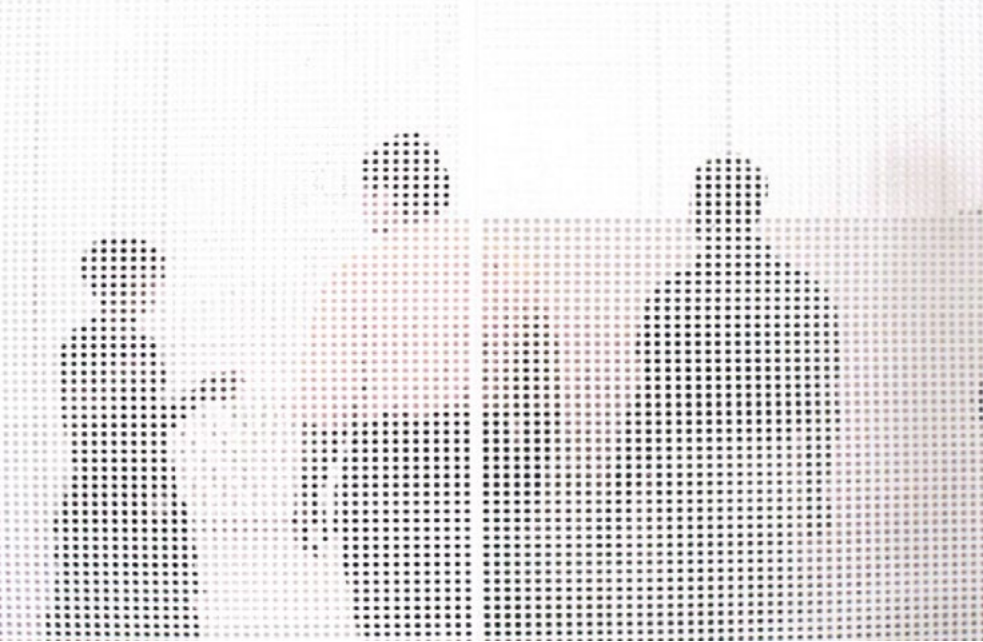
Perspective of the Bauhaus Dessau building by Walter Gropius, 1925-1926, in Arthur Korn, *Glas im Bau und als Gebrauchsgegenstand*, Berlin, Pollak, 1929, p. 23

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Jan Kamman, Schiedam, in László Moholy-Nagy, *The new vision. Fundamentals of design, painting, sculpture, architecture*, (1938), London, Faber and Faber Limited, 1939, p. 204



07

pothesis explored the performance of the structure and not its formal or physical characteristics. As László Moholy-Nagy would similarly stress a few years later, a biological approach to architecture «did not have to do with a “sculptural” exterior, but only with space relationships, which establish the content of experience necessary for a plan of creation» (Moholy-Nagy [1938], 1939, p. 198). «The last and highest stage of spatial creation is evidently its grasp from the standpoint of biological possibilities» (Moholy-Nagy [1938], 1939, p. 198), as the last chapter of his book “The new vision. Fundamentals of design, painting, sculpture, architecture”, entitled “The biological pure and simple taken as the guide”, revealed. For Ebeling, as for Moholy-Nagy after him, the building envelope conceived as a membrane had first and foremost a biological importance: biological not only in the sense of borrowing meaning from a physiological term, and by extension mimicking a physiological process, but biological also in terms of influencing the physical condition of the human occupant of architecture. And this because the building envelope as membrane – envisioned as «a path for future architecture» (Moholy-Nagy [1938], 1939, p. 198) – bore a dual task: defining both the space-enclosing wall that would exclude the harmful elements, for man, in the atmosphere and the surface that would admit all the necessary elements, for him, in the interior space.

07

Kazuyo Sejima,
Ryue Nishizawa,
SKIN, Extension
of the Institut
Valencia d'Art
Modern, 2005, in
Kazuyo Sejima,
Ryue Nishizawa,
Kazuyo Sejima
and Ryue
Nishizawa/
SANAA. Works
1995-2003,
Tokyo, TOTO,
2003

Breathing wall skins. From metaphor to performance

In conclusion we might consider the richness that the term membrane from within the modern architectural discourse entails, in referring to our bodies not only as entities that one should address when conceiving and constructing architecture, but also as faculties that lend themselves to the interpretation of the architectural artifact. Following the aforementioned attempts to bridging the building envelope with the biological membrane, the former has not been solely envisioned as an element that merely surrounds and defines space, but also a threshold that inasmuch as it provides an efficient space for human experience, it also establishes an efficient relationship with the environment. The exploration into the theorization of the building envelope as membrane has therefore attempted to broaden architectural discussions towards the relation between built space, human body and the overall environment, not only in terms of aesthetic or experiential perception, but also in means of a performative exchange. Today, this exchange continues to fascinate architects and architectural theorists alike. The performance of the building envelope, in terms of ecological efficiency, appears to embrace a pivotal concern for various other experts than architects – from façade engineers to energy consultants to botanists –, rendering the idea of the building exterior *as* a membrane a cogent topic once more. The perforated metal roof of the 2002 extension to the Institut Valencia d'Art Modern project, designed by Kazuyo Sejima and Ryue Nishizawa, for instance, bears the title SKIN [fig. 07], due to its ability to «allow light, wind, and rain to gently pass through» (Sejima Nishizawa, 2003). Meanwhile, the double-glass façade of the 2001 Mediatheque Sendai building, projected by Toyo Ito, acts as a skin in its ability to filter both exterior sounds and solar gain, as well as featuring a nearly continuous surface due to the minimum number of joints between its glass panels. Following the theses of the 'breathing wall-skin' previously discussed, we are prompted to retrace the origins of the contemporary architectural skins deeper into the modern architectural historiography and uncover their complex evolution. Following Adrian Forty, the borrowing of terms from the scientific field and their incorporation into the field of the architectural discourse is a literary phenomenon that belongs «exclusively to the modern era» (Forty, 2004, p. 100). In the present discussion, the exchange between architecture and the biological world was sought at the time when «the solid architectural wall was melting away under the pressure of modernity» (Koolhaas, Boom, 2014, p. 203) – when this dissolution brought to the fore issues of resilience and

lightness, enclosure and openness, form and performance concerning the building envelope.

«These *détournements*, these unorthodox misappropriations», Antoine Picon and Alessandra Ponte write, in reference to the interconnections between architecture and science, «can perhaps become the most interesting examples of cross-pollination, capable of producing the effects at which architecture excels – namely the transposition and materialization of the most original ideas of an epoch» (Picon Ponte, 2003, p. 16). If the transparency of the glass membranes in the early twentieth century was compared to the aspirations for political transparency, then the membrane metaphors that followed were associated with the then rising issues of hygiene and cleanliness, not least with the rising phenomena of spatial thermal comfort and environmental control. In our days, the «gentle hum of the air conditioner is heard at all times, and at all scales – including that of the global warming of planet Earth itself» (Latour, 2006, p. 106) and we are prompted to revisit the analogies of the building envelope to a breathing membrane, in the context of the current, and most importantly the forthcoming, sociocultural meanings. It is, however, by looking further than the discursive significance of the biological metaphors in architecture and into their role as vehicles for the improvement of the material and construction technologies, that new perspectives to the negotiation between architecture and the environment at large will open up.

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