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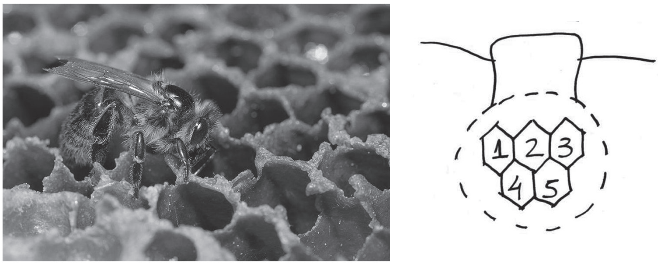

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Figure 6. Convertibility in Meles meles burrows (Note: a. Meles meles burrows. Source: Wikimedia Commons. Licensed by CC BY-SA 4.0 (original not in b&w); b. sketch by the authors). **Figure 7.** Personalization in Amblyornis inornata nest (Note: a. Amblyornis inornata nest by Raiyani Muharramah. Source: Wikimedia Commons. Licensed by CC BY-SA 4.0 (original not in b&w); b. sketch by the authors). **Figure 8.** Rationality in Apis mellifera (Note: a. Apis mellifera hive by Thomas Bresson. Source: Wikimedia Commons. Licensed by CC-BY-2.0 (original not in b&w); b. sketch by the authors).

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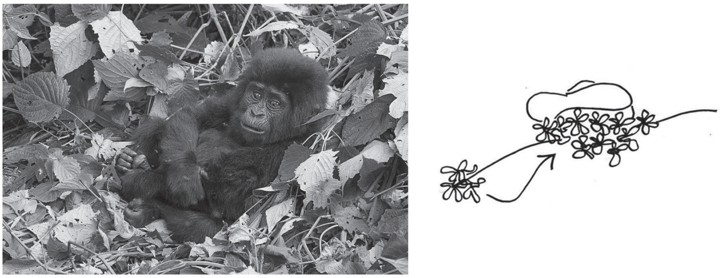

Figure 9. Reuse by the hornbill (Note: a. Hornbill by Aparajita Datta. Source: Wikimedia Commons. Licensed by CC-BY-2.0 (original not in b&w); b. sketch by the authors). **Figure 10.** Use of Local Materials in gorillas nest (Note: a. Baby gorilla by Charles James Sharp. Source: Wikimedia Commons. Licensed by CC BY-SA 4.0 (original not in b&w); b. sketch by the authors).

- *DSN7: Reuse* – the management of natural waste, creating savings, concerning the economy of materials, especially in places where there is a shortage of them or the use of existing structures (this is the case of the *Philetairus socius* nests in the deserts).

  (g) Wood is an excellent thermal insulator. The female hornbill (*Bucerotidae*), for example, settles in existing tree cavities during the incubation period of the eggs, which is sealed for safety, leaving only an opening for the male's beak to enter with food (Salvat, 1987) *(See Figure 9).*

- *DSN8: Use of Local Materials* – ease of access and assembly, reduction in energy expenditure and speed of construction, and facility in replacing. It creates stimuli for the regional.

  (h) Chimpanzees and gorillas gather and organize various types of plant branches to create beds and cushions during their periods of inactivity, generally during the day, and rarely occupy them more than once – they are temporary (Salvat, 1987) *(See Figure 10).*

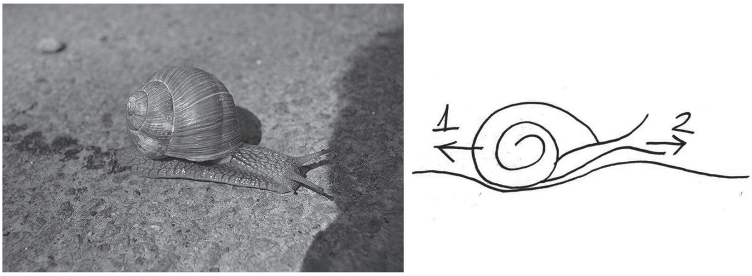

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Figure 11. Mobility in snail (Note: a. Snail by Olexandr Ostrovyi. Source: Wikimedia Commons. Licensed by CC BY-SA 4.0 (original not in b&w); b. sketch by the authors). **Figure 12.** Durability in Remiz pendulinus nest (Note: a. Remiz pendulinus by Erik Eckstein. Source: Wikimedia Commons. Licensed by CC BY-SA 4.0 (original not in b&w); b. sketch by the authors).

- *DSN9: Mobility* – allows movement to different habitats, enabling adaptation to different contexts.

  (i) The shells in snails (e.g., *Polymita picta*), or exoskeleton, serve to shelter and protect the entire visceral body of these animals when there are external threats. When not in danger, the snails project their bodies outside the shells and move, leaving behind a mucus trail. These "back houses" can have different shapes and colors *(See Figure 11).*

- *DSN10: Durability* – resistance to time and protection from enemy attacks. Many animals adopt this strategy to protect themselves and reuse their homes for future generations.

  (j) Pallasmaa (2020) points out examples of some almost impenetrable constructions, such as those of the black-faced tit birds (*Remiz pendulinus*), which use flexible vegetable fiber and other materials such as dust, wool, or even webs.

Discussion

One can notice that the adaptable DSs in Human Architecture relate to the adaptable DSNs found in Nature by Animal Architecture. For instance, Expandability (DSN1), a strategy used by the Caddis fly larva, relates to Unfinished Design (DS8), that is, a capacity to add or complete an aspect/layer of a building; or Climate Control (DSN3) with Passive Techniques (DS7), both aiming maximize indoor comfort. Moreover, all strategies are bonded: at least one DS connects to one DSN.
By the comparative method, the similarity between the strategies is defined by the proximity of their goals, a specific attempt to extend the life of the built environment. The connection can be singular when directly related (one strategy to one strategy, as DSN3 – *Climate Control* and DS7 – *Passive Techniques*, both aiming to increase indoor comfort); or multiple when links to more than one strategy (DSN2 - *Multifunctionality* relates to DS2 – *Design 'In' Time*, DS5 – *Loose Fit*, DS6 – *Spatial Planning*, and DS9 – *Maximize Building Use*). As the categorization followed a subjective process, the multiplicity is justified in cases when the DSN is more general – and it occured because, in this initial stage, they were not decomposed in groups as the DS. This decomposition helps in visualizing the strategy's application in the building's layer.
Furthermore, one can point out divergences in terms of easily recognizable elements, such as the strategies' nomenclatures – explained by the process of creating the DSN, based exclusively on the Literature review. The strategies' categorization by the *Adaptable Futures Research Group* followed more solidified criteria, while the DSNs from a more generic perspective. Some DSNs, for instance, are more linked to the typology of Adaptability (Schmidt III & Austin, 2016), such as DSN1 with *Scalable*; DSN4 with *Convertible*; DSN9 with *Movable*.
While the divergences indicate a necessity of deepening the study of Adaptability in Animal Architecture to clarify strategies and discover particular solutions, the similarities suggest concrete connections between human and animal architecture toward Adaptability. This finding inspired the creation of a proposition of investigation for future studies, which dialogues the fields of Design, Architecture, and Biology: **Design for Adaptability *(DfAD)* as a Biomimicry design practice to be applied in Architecture to maximize a building's future performance.** Having Nature as a model, measure, and mentor (Benyus, 1987) has become urgent. The search for an interface between the natural environment and Architecture can enable the emergence of solutions that are more integrated with the future of the Planet concerning the CEC.
For instance, provisioning non-existing spaces or components can improve a building's ability to change size by adding or removing components according to the user's needs (DS8), as in the Caddis fly larva (DSN1). Concerning materiality and orientation can increase a building's indoor comfort and reduce the necessity of mechanization, such as for air conditioning and heating (DS7), as in the termites' mounds (DSN3). Alternatively in addition, encouraging local labor through aged materials can provide construction speed, with lower built-in expenses (such as transportation), in addition to stimulating regional development (DS3, DS11, DS12), as in the gorillas' nest (DSN8). Table 2 summarizes the connections between the strategies as long as launch considerations to maximize a building's future performance related to them.

DESIGN FOR ADAPTABILITY
the process of extending the life of our built environment

***DFAD* IN NATURE** Animal Architecture	***DFAD IN ARCHITECTURE*** Human Architecture	
DSN	**DS**	**CONSIDERATIONS TO MAXIMIZE A BUILDINGS FUTURE PERFORMANCE**
DSN1: EXPANDABILITY Aiming to change size	**DS8: UNFINISHED DESIGN**	Provisioning non-existing spaces or components can improve a building's ability to change the size by adding or removing components according to the user's needs.
DSN2: MULTIFUNCTIONALITY Aiming to allow multiple activities in the same space/ component	**DS2: DESIGN IN TIME** **DS5: LOOSE FIT** **DS6: SPATIAL PLANNING** **DS9: MAXIMIZE BUILDING USE**	Providing options for the users, both physically or spatially, can increase the life cycle of buildings due to the ease of accommodating different demands.
DSN3: CLIMATE CONTROL Aiming to increase indoor comfort	**DS7: PASSIVE TECHNIQUES**	Shapes, materiality, and orientation can increase a building's indoor comfort and reduce the necessity of mechanization, such as for air conditioning and heating.
DSN4: CONVERTIBILITY Aiming to transform an space/component	**DS5: LOOSE FIT** **DS6: SPATIAL PLANNING**	Spatial considerations beyond the brief can generate open plans which support different configurations.
DSN5: PERSONALIZATION Aiming to create an aesthetic (for procreation)	**DS8: UNFINISHED DESIGN** **DS10: INCREASE INTERACTIVITY** **DS11: AESTHETICS**	Searching for participatory solutions, which place the user as a true protagonist, especially in the initial stages of the project, can emphasize the feeling of awareness, belonging, and affective memory, in addition to creating a unique image.
DSN6: RATIONALITY Aiming simple construction methods	**DS1: MODULARITY** **DS4: SIMPLICITY AND LEGIBILITY**	Functional separation, along with the economy in the use of resources and simple and legible components, facilitates the general organization of the process and future maintenance and repairs.

DSN7: REUSE Aiming waste management	**DS3: LONG LIFE** **DS11: AESTHETICS**	To consider the parts to last a long time can contribute to reducing obsolescence and demolitions – consequently the production of CO^2 - and also preserves the narrative of valuing the old appealing to society's appreciation.
DSN8: USE OF LOCAL MATERIALS Aiming to reduce energy expenditure	**DS3: LONG LIFE** **DS11: AESTHETICS** **DS12: MULTIPLE SCALES**	Expanding debates about the vernacular and encouraging local labor through aged materials can provide construction speed, lower built-in expenses (such as transportation), and stimulate regional development. Furthermore, it enables longevity and comprehension of the surrounding environment.
DSN9: MOBILITY Aiming the possibility of changing location	**DS12: MULTIPLE SCALES**	Exploiting the environment can expand considerations beyond the building, including concerns on the site and surrounding areas.
DSN10: DURABILITY Aiming time resistance capacity	**DS3: LONG LIFE**	Increasing the longevity of physical parts can guarantee resistance to external stresses (e.g., climate), reducing waste generation and costs with maintenance.

Note. Made by the authors (2023).

Table 2. Synergies between DfAD in Nature and in Architecture.

Conclusion

The contemporary environmental challenge (CEC) characterizes a world in crisis in the Anthropocene Era (Wahl, 2020). Such a challenge is mainly marked by climate change, by excessive carbon dioxide emissions into the atmosphere, which brought irreversible consequences (IPCC, 2021), demonstrating a separation between man and the natural environment. Recognize the CEC is an attitude of stimuli to the role of designers and architects towards perceiving the past (Kolbert, 2021), the consideration of ecological teaching (Papanek, 1995), the transdisciplinarity between areas, including Biology (Mazzoleni, 2013; Myers, 2012); and the awareness for environmentally friendly decisions (Mackenzie, 1991), but not neglecting the fact that they are not the only creative protagonists in the design process (Schmidt III & Dainty, 2015).
The focus on nature-based solutions for human artifacts has increased in the last few years. Having Nature as a model, a measure, and a mentor (Benyus, 1997) is a path because Nature generates less cost to the planet than man's actions for more than 3.8 billion years.

In this sense, the interest in areas such as *Biomimicry,* a design centralized in environment solutions (Pawlyn, 2016; Vicent, 2012), is justified to help reduce the CEC.
The construction sector is responsible for a considerable portion of the emission of CO^2 into the atmosphere (GABC, 2021), and a position toward the reduction is essential. Design for Adaptability in Architecture (*DfAD*), "the process of extending the life of our built environment" (Adaptable Futures, n.d.), is understood here as an alternative, as buildings can become obsolete and even demolished when not suitable for changes (Charitini, 2019), a situation that further aggravates the problem under analysis.
This paper summarized the results of a concluded master's dissertation focusing on two lenses of the investigation: (1) DfAD in Human Architecture and (2) DfAD in Animal Architecture (representing Nature). The main objective was to reflect on to what extent the design strategies of both lenses relate. In total, 12 DSs launched by the *Adaptable Futures Research Group* were compared with 10 DSNs defined by the authors with the *Biodesign Lab*.
From the results, it was possible to infer that DfAD's strategies in both lenses are connected; that is, they have similar aims to extend the life of the built environment. These similarities suggest that Animal Architecture can inspire innovative, adaptable solutions to Human Architecture. In this sense, a proposition was generated: Design for Adaptability ***(DfAD)*** as a Biomimicry design practice to be applied in Architecture for a building's future performance.
Some divergences, such as the nomenclatures and the generalization of some DSNs compared to the DSs, indicate a necessity to deepen the studies. Nevertheless, although initial, this research can inspire many future investigations. For instance, exploring how adaptable design strategies from Animal Architecture can relate to particular geographic contexts and provide distinct building solutions; or search for connections between animal and human behaviors in terms of the adaptable strategies - despite the complexity, Sugasawa and Pritchard (2022) reinforce the examination of animal's behavior on their architecture and not only form and function.
Therefore, this article positions the importance of biomes conservation aligned with environmental activism, highlighting the look into Nature as a model, a measure, and a mentor (Benyus, 1997) in design practices. In a manifesto tone, it inspired the creation of the Letter to Young Designers and Architects in Support of Design for Adaptability[1] (in Appendices), a poem written by the authors that reunite many of the concerns regarding the role of young practitioners, appealing to the next generations of activists to Design for Adaptability.

Acknowledgment

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Notes

1. *The Letter to Young Designers and Architects in Support of DfAD* was directly inspired by the texts “The Young man in Architecture” by Sullivan (1979) and “To the Young man in Architecture” by Wright (1955).

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Appendix

Letter to Young Designers and Architects in Support of Design for Adaptability (DfAD)
Our Role
End of graduation. Career start.
End. Start.
Crossing
with turbulence
and many chains of uncertainty.
fear.
anxiety.
in a world
Fast. Accelerated. No time.

Our Role
Among many ways,
and a tough and competitive market.

Our Role
Facing an era in which the most significant challenge is to stop ourselves.
We lose balance: we move away from the natural.

Towards Nature, bucolic.
Far from what only Nature can provide us
True belonging.

We now recognize the designers and architects who emphasized the importance of looking into the natural.
And we identify ourselves
Nature is the basis of Design and Architecture.
Acknowledge it.
As a model, measure, and mentor
Our real Role.

Starting point?
the adaptable.
It is priceless and worth
a life-changing process
of animal and human coexistence
Natural.

invitations to
Design for Adaptability
Modify ways of thinking
Dialogue teaching fields
Transform Earth
Face the contemporary environmental challenge

Our Role
our youth
our revolution
Architecture, Design, Biology
The reunion of man with the natural environment
a return
to what it always was,
essential.
Dear architect, Design for Adaptability!

Resumen: Este artículo hace hincapié en el Diseño para la Adaptabilidad (DfAD) como alternativa de diseño disruptivo en auge, con el objetivo de comprender hasta qué punto se relacionan las estrategias de diseño desde dos ópticas. El primero se centra en una investigación teórica sobre la adaptabilidad en la arquitectura humana y en la descripción de las estrategias de diseño adaptable (DfAD) divulgadas por el Adaptable Futures Research

Group. La segunda se inspira en el campo de la Biomímesis, explorando las estrategias de diseño adaptable en la Arquitectura Animal (DSN). Por lo tanto, dado que ambas estrategias están íntimamente relacionadas, se posicionó una comprensión de la DfAD como una práctica de diseño de Biomímesis a aplicar en Arquitectura para maximizar el rendimiento futuro de un edificio. Por último, se lanzó una Carta a los jóvenes arquitectos y diseñadores en apoyo del DfAD.

Palabras clave: Diseño para la adaptabilidad - Arquitectura - Biomímesis - Arquitectura animal - Cambio climático

Resumo: Este artigo enfatiza o Design para Adaptabilidade (DfAD) como uma alternativa de design disruptiva em ascensão, visando compreender até que ponto as estratégias de design de duas lentes se relacionam. O primeiro foco é uma investigação teórica da Adaptabilidade na Arquitetura Humana e a descrição de estratégias de design adaptável (DS) lançada pelo Adaptable Futures Research Group. A segunda é inspirada no campo da Biomimética, explorando estratégias de design adaptável em Arquitetura Animal (DSN). Portanto, como ambas as estratégias estão intimamente relacionadas, posicionou um entendimento do DfAD como uma prática de projeto de Biomimicry a ser aplicada na Arquitetura para maximizar o desempenho futuro de um edifício. Finalmente, foi lançada uma Carta aos Jovens Arquitetos e Designers em Apoio ao DfAD.

Palavras-chave: Design para Adaptabilidade - Arquitetura - Biomimética - Arquitetura Animal - Mudança Climática