

# Chapter 2

## The AskNature Database: Enabling Solutions in Biomimetic Design

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**Abstract** Practitioners of biomimetic design express one consistent need—access to relevant biological information. This information is most useful when the transferable elements have been abstracted from the biological principle, are organized by design and engineering function, and are supported by contextual search functions. However, the fine details of how the information is organized and accessed are critical. In this chapter, we reflect upon AskNature.org, a biomimetic database created to address these issues, and its key elements, including a Biomimicry Taxonomy, biological strategy pages organized by function, search and tri-browse features, and bio-inspired product pages as examples of bio-inspired design successes.

### 2.1 Introduction

Biomimetic design professionals need access to relevant biological information expressed in common language (Bar-Cohen 2006). For example, both a biologist and a civil engineer can talk about “managing temperature” and have a basic understanding of what the other means, whether one of them is talking about an elephant seal managing temperature or the other about the need to regulate temperature in a building. However, if the biologist starts the conversation by talking about the intricate structure of a northern elephant seal’s nasal turbinates, rather than their function, that information is not going to be of obvious interest or application to the civil engineer.

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**Table 2.1** AskNature.org website usage from November 12, 2008, through December 31, 2012

Years	Page views	Unique visitors
2008	125,568	22,386
2009	1,066,527	208,661
2010	1,195,928	236,117
2011	1,484,148	295,897
2012	1,790,709	478,486

Source Google analytics

We developed AskNature.org in an effort to translate biological information so it would be accessible to non-biologists, and to serve as a source of inspiration for biomimetic design. AskNature is a free, publicly available database of biological information and abstracts, most of which are drawn from peer-reviewed journals. The website catalogs biological information by function in “strategy” pages (described in Sect. 4.1) to bridge the gap between biology and fields like engineering, architecture, industrial design, chemistry, organizational development, and more. Since its launch at Greenbuild International Conference and Expo in 2008, the site has experienced rapid growth, recording almost 1.8 M page views in 2012 (see Table 2.1). Additionally, AskNature has been lauded by design professionals, winning an Earth Award in (2010) and becoming a finalist for an INDEX Award in 2011 (Biomimicry 3.8 Institute 2011).

Function is one way to interpret biological information in order to create a bridge of understanding across disciplines, and identifying function can be one key component to approaching biomimetic design (Helms et al. 2009, 2010; Stone and Wood 2000; Vattam and Goel 2011). The AskNature team developed the Bio-mimicry Taxonomy (taxonomy) as a means to organize biological data by function and present it to a design audience. The taxonomy represents the organizing schema for all of the biological strategy pages within the database. We will discuss the taxonomy in greater detail below.

2.2 Data

Trained biologists were responsible for gathering and generating the original almost 1,300 pages of biological data on AskNature. Researchers read scientific journals and books and perused scientific news, looking for leads on functional biology that might be of interest to innovators working to solve human challenges. Strategies were selected subjectively based on the researchers’ assessment of whether the strategy held some potential for being useful within the field of bio-inspired design. AskNature’s original data set represents a huge amount of human labor and was only possible due to generous funding from an independent investor.

Individuals continue to generate additional content for AskNature. Most of the biological data that has been added since 2008 has come from paid staff.

Qualified scientific curators are also able to add biological content. However, due to the rigors of maintaining the scientific integrity of the data and the need for strict adherence to the data's organizational structure, all curated content must be approved by AskNature's content editor.

## 2.3 The Biomimicry Taxonomy: Organizing Biology by Function

Once the strategy data were collected, the AskNature team began to look for patterns and to organize the data according to function. The result was a classification system we call the Biomimicry Taxonomy, shown in Fig. 2.1. The taxonomy categorizes strategies according to three levels: groups (highest level), subgroups, and function. Overall, the taxonomy includes 8 groups, 30 subgroups, and 162 functions. Individual strategies represent the next, most detailed level within the hierarchy.

As a specific example, an insect might face the challenge of protecting itself from other organisms that want to eat it. Its strategy to meet that challenge might appear like this within the taxonomy:

Group	Maintain physical integrity
Subgroup	Protect from biotic factors
Function	Protect from animals
Strategy	Nanoscale protrusions (AskNature <a href="#">2008a</a> ).

### 2.3.1 Compared to Other Taxonomies

AskNature staff consulted with external design professionals when creating the taxonomy, particularly from chemical and materials science disciplines, but this schema is subjective and represents a small group of biologists attempting to organize a huge amount of biological data by function. Unlike other schemas that have been developed to assist bio-inspired design (Glier et al. [2011](#); Vattam et al. [2010](#); Vincent et al. [2006](#); Yen et al. [2011](#)), the taxonomy has not been rigorously tested to assess its impact on its users.

## 2.4 A Tour of AskNature.org

AskNature consists of a number of components: biological strategy pages, biomimetic product case studies, a search engine, and a social network.



### 2.4.1 *Strategy Pages*

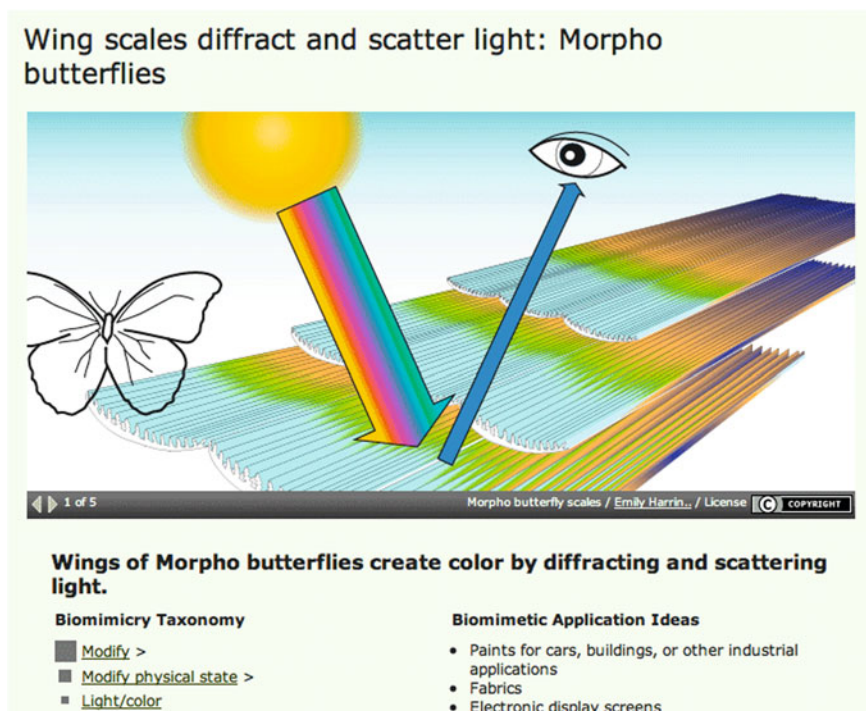
All the biological content on AskNature is captured on strategy pages. As of January 2013, the AskNature database contains over 1,600 biological strategy pages. Strategies are solutions a given organism or ecosystem uses to meet functional challenges.

Each strategy page consists of a carefully crafted title, a short sentence explaining the essence of the biological strategy, the strategy's place within the Biomimicry Taxonomy, a scientific excerpt, biomimetic application ideas and/or links to biomimetic product pages, and links to scientific references via Google Scholar or Scirus. In addition, most of the strategy pages include photographs and/or illustrations of how the strategy works, basic natural history information (including IUCN Red List (International Union for Conservation of Nature and Natural Resources 2012) status number, if applicable), links to videos that provide further context on a given strategy, and links to scientific experts and/or laboratories.

For example, the title “Wing scales diffract and scatter light: Morpho butterflies,” on the strategy page of the same name (AskNature 2008c), tells a user at a glance what function is being accomplished and by what organism (Fig. 2.2). The sentence below the illustration of the strategy provides more detail: “Wings of Morpho butterflies create color by diffracting and scattering light.” On every strategy page, the structure of this sentence is the same: part of the organism, organism, what it does, and how it does it. This sentence represents one level of abstraction regarding the biology of the strategy; that is, it represents one interpretation of function at a given scale. Depending on the content, the scale discussed may vary.

The level of abstraction depends on a combination of the perspective of the original biological researcher, the interpretation by AskNature staff, the level of scientific detail known, and the framework of the database. In this particular case, much more detail is known about the architecture of the wings and how morpho butterflies refract and scatter light, that is, the mechanism used to accomplish the function, but that information and level of abstraction do not fit neatly into the summary sentence. A user must read further to find out, for example, that “nano-sized, transparent, chitin-and-air layered structures that, rather than statically absorb and reflect certain light wavelengths as pigments and dyes do, selectively cancel out certain colors through wavelength interference while reflecting others, depending on the exact structure and interspatial distance between diffracting layers” or to learn any exact dimensions used in this strategy.

While AskNature's strategies allow users to see a wide cross section of the ways organisms have met functional challenges, they generally does not provide a great level of detail about the mechanism of function. For example, what specifically about the nasal turbinates of northern elephant seals makes counter-current heat exchange so effective? However, the sheer number of strategy pages, the



**Fig. 2.2** Screenshot of the top of AskNature's morpho butterfly strategy page (AskNature 2008c)

organizational structure, and the fact that the database is free to the public have made AskNature a much more widely used tool than others that are accessible only to select users.

## 2.5 Biomimetic Products

AskNature features nearly 200 biomimetic product pages for users to see how others have applied a certain strategy. A product's page describes the history of the product, what challenges it solves, how it is different from existing products, and its bio-inspired principles. For example, Fig. 2.3 shows users how one design group was inspired by the whitebark pine's spiral fibers (AskNature 2008b) to develop a distinctive, 100 % recyclable polyethylene terephthalate (PET) bottle. As the site grows, we hope to add even more biomimetic products to our database.



## Vitalis PET bottle

### PET bottle that uses less material

#### ABOUT THE PRODUCT

**Company:** Logoplaste Innovation Lab

**Product Phase:** Available

**Product Type:** Lightweight PET bottle

#### INSPIRING STRATEGY

[Spiral fibers strengthen tree trunks: whitebark pine >](#)

#### PRODUCT OR PROCESS

Vitalis produces a new bottle that is lighter than traditional PET bottles, and provides a strong brand identity. Vitalis one of the major bottled water brands in Portugal. In 2009 Unicer, the brand owner, challenged Logoplaste Innovation Lab to create a new range of PET bottles with an exclusive design that would establish a strong emotional link with the consumer, and be the lightest PET water bottles on the market, fitting their existing industrial filling lines and actively reducing their environment impact.



Logoplaste I... / License BY-NC-ND

#### CHALLENGES SOLVED

The traditional engineering solution to lower the weight of PET bottles is to add horizontal structures. The more you add, the stronger and lighter the bottle will be. The drawback of this recipe is that it ends with an industrial looking bottle, where brand values become secondary.



Torrey Ritte... / License COPYRIGHT

#### DIFFERENCES FROM EXISTING PRODUCTS

The new range of 100% recyclable PET bottles (33cl, 50cl and 1.5L) were released in the spring of 2010. Unicer, the brand owner, now exports Vitalis to a wide range number of regions in Western Europe, Africa, Latin America, United States, and Canada. The new bottles play an active role in the consolidation of both brand identity and sustainability strategies of Vitalis, allowing the saving of 250 tons of raw material per year.

**Fig. 2.3** Screenshot of an AskNature product page (AskNature 2011) showing the product details, history, and more

## 2.6 Searching AskNature

Searching is one of the most vital features on AskNature. Without it, most users would never discover the wealth of biological strategies available on the site. We provide two mechanisms for finding content: a traditional search and a taxonomy browser.

As shown in Table 2.2, visitors use our search engine more than the browsing option. Every page on AskNature includes a full-text search box with the prompt “How would Nature....” The prompt is meant to encourage users to search by function; that is, by inserting a verb: How would nature cool? How would nature create color? How would nature distribute fluids? How would nature build community? The search function defaults to return strategy pages before any other type of page within the system, such as user profile pages.

**Table 2.2** Search and tri-browse usage from November 12, 2008, through December 31, 2012 AskNature’s search engine is used more often than the tri-browse feature

Years	Page views	
	Browse	Search
2008	5,806	10,332
2009	45,286	130,731
2010	44,241	173,183
2011	61,602	271,777
2012	62,106	303,861

Source Google analytics

There are numerous possible queries, but they must be plausible and recognizable by the database. For example, if a user types in “build an airplane,” the search may not return any useful results. After all, Nature does not build airplanes, but it is a genius at flight. If the user refines his search to look for things such as “generate lift” or “reduce drag”—that is, functions he would like his design to accomplish—chances are he will find much more relevant results.

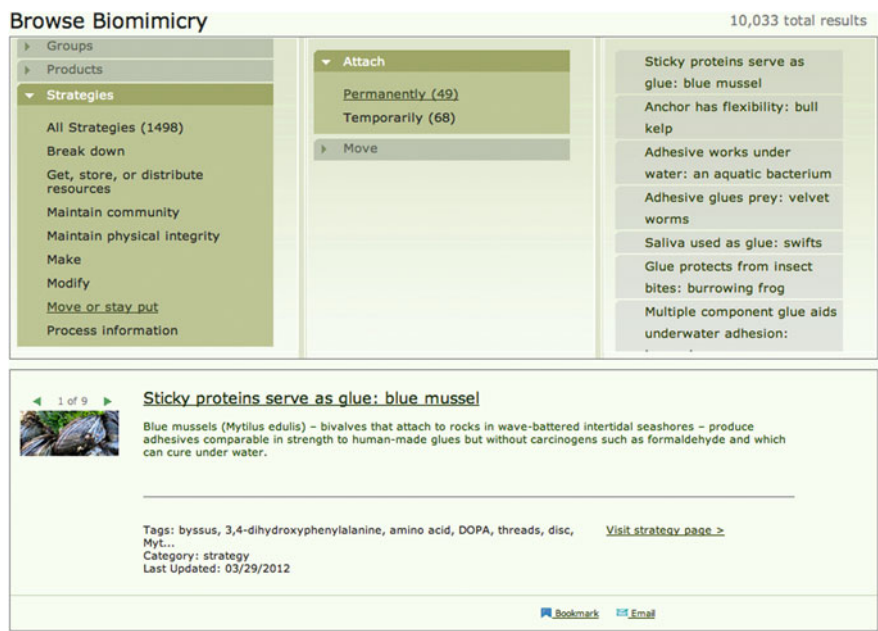
While finding strategies via search can provide immediate results, it may be useful for practitioners to view multiple strategies meeting similar functional challenges. To accommodate this, users can browse strategies and products by function in our “tri-browse” page shown in Fig. 2.4. The tri-browse page enables users to explore different strategies solving similar functional challenges, but users may find inspiration by browsing related subgroups as well.

2.6.1 Query Analysis

We have collected aggregate search queries since AskNature launched in 2008. Table 2.3 presents the top queries, and Table 2.4 presents a random selection. These tables reveal a number of observations. First, our suggested queries on each search result page attract a number of hits, indicating users are following them as a way of browsing. Second, users are searching without the Biomimicry Taxonomy and are instead using it as a generic search for organisms, environments, and other buildings. Third, literal questions are used as queries, which indicates inexperienced Web searchers (we ignore “how,” “what,” “the,” and other common function words to mitigate this).

In summary, visitors are using our search engine like a traditional keyword Web search engine and not searching using the Biomimicry Taxonomy. Further research is needed to determine whether recasting a user’s query in terms of the Biomimicry Taxonomy would increase user success rates.





**Fig. 2.4** Screenshot of the biomimicry taxonomy browser using group = modify, subgroup = attach, and function = permanently. Matching strategies appear in the rightmost column

**Table 2.3** Top 15 search queries based on aggregate search logs from September 14, 2008, through February 20, 2012

Hits	Query
24964	Adhere to water
19359	How to purify water
18933	Water
18242	Structural color for painting
18201	Sticky berries adhere with strength and ease
18124	Capture water from fog in an arid environment
15046	Negative pressure used to suck moisture from soil
15035	Capture water from fogs
14096	Adhere to water
11896	Mutualism in nature
11719	Capture water from fog
11592	Hovering in mid-air
11233	Insects that capture water from fog
11177	How would nature purify water
10634	Structural color

The queries with a leading capital letter are suggested queries on each search result page

**Table 2.4** Randomly selected queries from the same period as Table 2.3

Hits	Query
6172	A leaf capture water
5680	Green
4466	Plants that filter air
3267	How would nature resolve conflicts
2959	Solve green building challenges
2939	Green building
1698	Cool
1547	Improve air flow
1356	Organize an economy
1139	Build buildings
1207	Waterproof
1170	How to purify water, beavers
921	Solar
893	Glue
818	Desert

2.6.2 Social Network

AskNature is the execution of Benyus’ vision (1997, p. 291) of a place where engineers and biologists can collaborate and share Nature’s solutions to engineering problems. To support this, AskNature enables users to create profiles, comment on strategies and products, and discuss topics in forums. Users can connect with others in specific disciplines and countries also via the tri-browse page. We have not observed the level of collaboration desired, so we need to conduct a few user studies to determine how AskNature can be more conducive to collaboration.

2.7 Conclusion

In this paper, we have described AskNature.org and how we categorize its data according to the Biomimicry Taxonomy. We have learned four preliminary lessons from running a bio-inspiration database. First, if one is practicing biomimetic design, one needs tools to support it. AskNature is one such tool. Second, if a tool is going to support biomimetic design, it needs to provide a sizable corpus for inspiration. AskNature provides over 1,600 strategies. Third, it is important to provide a free and publicly available tool for anyone to use. AskNature’s content is free and licensed under a Creative Commons Attribution-Noncommercial 3.0 License. Finally, AskNature is under development. It is an experiment, and we look forward to adapting AskNature to our user’s needs.

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## References

- AskNature (2008a) Eyes are anti-reflective: elephant hawk-moth. <http://www.asknature.org/strategy/b389c40f5c8660fc082282bac3e00c3f>
- AskNature (2008b) Spiral fibers strengthen tree trunks: whitebark pine. <http://www.asknature.org/strategy/e70b6b7753773a7177fe8358ec26ed2c>
- AskNature (2008c) Wing scales diffract and scatter light: Morpho butterflies. <http://www.asknature.org/strategy/1d00d97a206855365c038d57832ebafa>
- AskNature (2011) Vitalis pet bottle. <http://www.asknature.org/product/b5dc4030c48e41b03442d34aecdf46b4>
- Bar-Cohen Y (2006) Biomimetics—using nature to inspire human innovation. *Bioinspir Biomim* 1(1):P1–P12. doi:[10.1088/1748-3182/1/1/P01](https://doi.org/10.1088/1748-3182/1/1/P01)
- Benyus JM (1997) *Biomimicry: innovation inspired by nature*, 1st edn. Morrow, New York
- Biomimicry 3.8 Institute (2011) Asknature selected as finalist for prestigious design competition. <http://www.asknature.org/article/view/index2011>
- Glier MW, Tsenn J, Linsey JS, McAdams DA (2011) Methods for supporting bioinspired design. *ASME Conf Proc* 2011(54884):737–744. doi:[10.1115/IMECE2011-63247](https://doi.org/10.1115/IMECE2011-63247)
- Helms M, Vattam S, Goel A (2009) Biologically inspired design: process and products. *Des Stud* 30(5):606–622
- Helms M, Vattam S, Goel A (2010) The effect of functional modeling on understanding complex biological systems. *ASME Conf Proc* 2010(44137):107–115. doi:[10.1115/DETC2010-28939](https://doi.org/10.1115/DETC2010-28939)
- International Union for Conservation of Nature and Natural Resources (2012) The IUCN red list of threatened species. <http://www.iucnredlist.org/>
- Stone RB, Wood KL (2000) Development of a functional basis for design. *J Mech Des* 122(4):359–370. doi:[10.1115/1.1289637](https://doi.org/10.1115/1.1289637)
- The Earth Awards (2010) Systems winner. <http://www.theearthawards.org/site/systems-win/>
- Vattam SS, Goel AK (2011) Foraging for inspiration: understanding and supporting the online information seeking practices of biologically inspired designers. *ASME Conf Proc* 2011(54860):177–186. doi:[10.1115/DETC2011-48238](https://doi.org/10.1115/DETC2011-48238)
- Vattam SS, Helms ME, Goel AK (2010) A content account of creative analogies in biologically inspired design. *Artif Intell Eng Des Anal Manuf* 24:467–481. doi:[10.1017/S089006041000034X](https://doi.org/10.1017/S089006041000034X)
- Vincent JFV, Bogatyrev OA, Bogatyrev NR, Bowyer A, Pahl AK (2006) Biomimetics: its practice and theory. *J R Soc Interface* 3(9):471–482. doi:[10.1098/rsif.2006.0127](https://doi.org/10.1098/rsif.2006.0127)
- Yen J, Weissburg M, Helms M, Goel A (2011) Biologically inspired design: a tool for interdisciplinary education. In: Bar-Cohen Y (ed) *To appear in biomimetics: nature-based innovation*. Newyork, Taylor & Francis



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