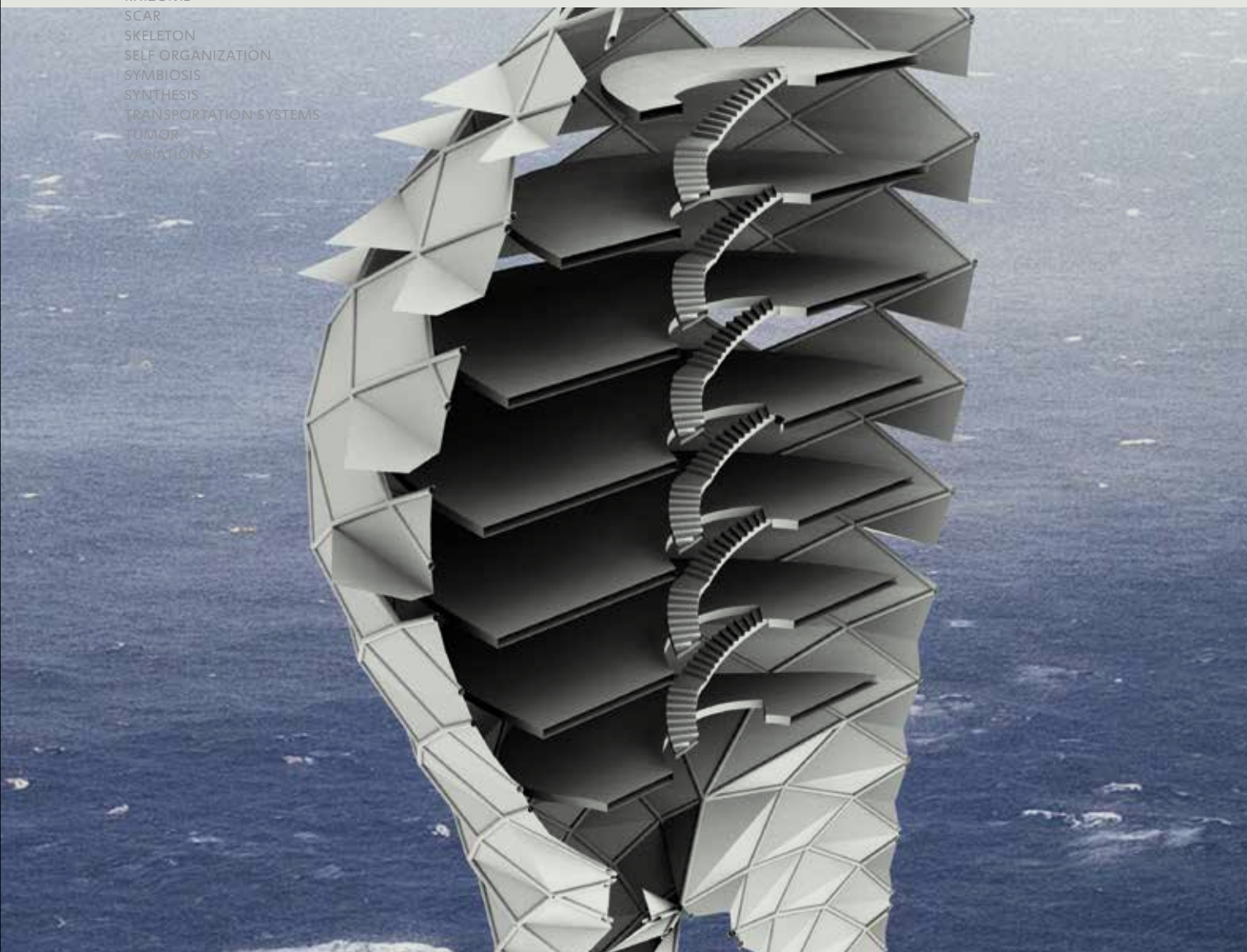
ADAPTIVITY
APOPTOSIS
AUTOIMMUNE DISEASE
BIOMINERALIZATION
BUDDING
COMMENSALISM
COMPOSITE MATERIALS
DEATH
DIFFERENTIATION
ECO-SYSTEM
CONTROL
FEEDBACK
PHENOTYPE-GENOTYPE
FIBERS
FOLD
GANGRENOUS NECROSIS
GROWTH
HIERARCHY
HYBRID
HYPERTROPHY
IMMUNE SYSTEM
INTELLIGENCE
ISOMER
MEMBRANE
MEMORY
METABOLISM
MITOCHONDRIA
MOVEMENT
PARASITE
LIQUID CRYSTALS
REFLEX
RESILIENCE
RESUSCITATION
RHIZOME
SCAR
SKELETON
SELF ORGANIZATION
SYMBIOSIS
SYNTHESIS
TRANSPORTATION SYSTEMS
TUMOR
VARIATIONS

THE BREATHING BUILDING

ARCH. FARAH FARAH, ARCH. MOTI BODEK
PROF. DAVID ELAD

Computer simulation of the Breathing Building



The breathing building proposes a bio-inspired building ventilation system that mimics the breathing process, where the nasal passage naturally conditions the inhaled environmental air. The proposed project presents a dynamic structurem which is the outcome of a joint collaboration between architects and bioengineers. Anchored in the Mediterranean Sea off the coast of Ashdod, the structure is designed to fulfill the challenging function of creating an optimal HVAC (Heat, Ventilation, Air-Conditioning) system by using natural resources in a sustainable and ecological manner.

In recent years considerable efforts have been made in the field of biomimetic architecture to create ventilation systems that preserve environmental balance and reduce the building's carbon imprint. Many of these new ideas are based on treating the architectural structure as a living body that synergizes with the surrounding ecosystem through mechanisms that mediate the movement of air. Michelle Addington of Yale University has conducted notable research that, drawing on convection patterns similar to those occurring around the human body, proposes systems for controlled ventilation comprised of dynamic plumes that heat and cool the air enclosing building surfaces.[1] Architect Doris Sung proposed to condition the interior environments by using architectural surfaces made of smart metals that respond to external stimuli without consuming external energy resources.[2] While most of the published attempts to create biomimetic ventilation systems were inspired by the large external surfaces of mammals, we have chosen to base our new concept on the functionality of the mammalian nose, a small interior air-conditioning organ, to create a dynamic breathing building.

1. "The Thinking, Breathing Buildings on the Horizon," *BBC.com*, 11 June, 2013, http://www.bbc.com/future/story/20130610-buildings-that-breathe-and-think

2. "Doris Sung's Living Architecture Morphs To Protect From The Elements," *The Creators Project* website, http://thecreatorsproject.vice.com/show/Video-doris-sung-creates-living-architecture-sensitive-to-heat-and-light

MAKING THE BUILDING BREATH

The nasal cavity is a complex three-dimensional structure with narrow passageways that facilitate the movement of respired air. The cavity is lined by mucus secreting cells situated on top of a rich blood vasculature. The cavity fosters communication between the environmental air and the interior lungs, and thus, it is the front line defender of the internal respiratory organs. Its defensive duties include alerting the system of hazardous environments, as well as adjusting the inspired air to suit the requirement of the internal lungs. Accordingly, the functional roles of the nasal cavity are: (i) to filter particles greater than 5 micrometers by trapping them in the ciliated mucosa, and removing them via the nasopharynx; (ii) to condition the inspired air via warming and moistening by the nasal mucosa and underlining blood vasculature; and (iii) to smell with the olfactory sensors at the ceiling of the nasal cavity. Thus, healthy humans normally breathe through their nose. The research group of David Elad[3] and Michael Wolf[4] at Tel Aviv University have demonstrated via comprehensive studies the efficacy of the human nose to condition the inspired air in various 'extreme' environments.

The project site is located at the estuary of the Lachish river on the Mediterranean shore, surrounded by a rich landscape stretching between the city of Ashdod in the south and its main port in the north. The proposed structure merges with the local port environment; the main building is erected above sea level and supported by 'legs' that are anchored to the sea floor. These legs have three functional roles: (i) to provide the building's foundation; (ii) to enable the delivery of fresh air into the building's interior; and (iii) to pump deep earth water into the structure, whose constant temperature is similar to the consistent temperature of mammalian blood. The water is part of geothermic system, so that as with the blood in our respitory system, it stays at a constant temperature throughout the year.

The new concept of bio-inspired ventilation mimics the self-regulated physical mechanisms within the nasal cavity, which are based on an exchange between heat and water vapor induced by the close contact between air and water. Similarly, the new concept for building a natural HVAC system will be implemented by forcing environmental air into the building's interior via a series of heat exchangers made of pipelines and folds, which are supplied with geothermic water taken from beneath the earth marked by a constant unchanging temperature. The Breathing Building's legs conduct environmental air into the structure via flapping wall units that mimic the flapping of a bird's wings. This inspired environmental air is then transferred via heat exchangers, with the constant temperature of the geothermic water, either cooling or warming the air according to the season. The flapping walls are activated by motor units made of smart

3. S. Naftali, M. Rosenfeld, M. Wolf and D. Elad, "The Air-conditioning Capacity of the Human Nose," *Annals of Biomedical Engineering* 33 (2005): 545-553.

4. M. Wolf, S. Naftali, R.C. Schroter and D. Elad, "Air-conditioning Characteristics of the Human Nose," *The Journal of Laryngology & Otology* 118 (2004): 87-92.

materials, and powered by solar energy. The proposed air conditioning process is based on the integration of environmental air with the geothermic water's natural properties, which enables the system to self-regulate throughout the seasons, in a manner similar to the way humans breathe through their noses.

Once the conditioned environmental air is introduced into the main building space, it is transported upward via the central atrium and a peripheral gap surrounding the working space of the building. The external envelope includes rigid flapping screens that increase the pressure gradients required to move the air upward. Pumping the air through the building's legs and sucking the polluted air through the building skin ensures a constant flow of fresh and conditioned air year-round. Protected openings in the building's ceilling allow for its efficient ventilation, as in the respiratory system of mammals. The system of double screen walls also supplies thermal insulation to the inner workspace.

Enlarging the scale of the nose's structure, and architectonically adapting it through biomimetic processes constitutes a conceptual breakthrough in the innovation of air conditioning and ventilation systems for buildings [Fig. 1,2] In the same way that our body exploits the resources at hand in an optimal fashion, carrying out processes of heating and cooling of air while maintaining a constant temperature within the blood, we are proposing a superior HVAC system that is far more sustainable than those currently in use. It seems likely that the integration of existing technologies adapted to this model will enable its application in the foreseeable future in an economic and efficient manner functioning independently, be able to function independently, without the external interventions that characterize conventional air conditioning systems.

Merging architectural innovation and advanced bioengineering research results here in a sophisticated and functional architectural structure that is environmental friendly and blends seamlessly with the local landscape. It is an excellent example of how biomimetic ideas can enhance urban structure's while simultaneously preserving vital ecological principles.

Modu Studio is an architecture and urban planning practice founded by architect Farah Farah, Senior Lecturer at the NB Haifa School of Design. The studio merges theoretical and practical approaches, focusing on different types of projects, including residential, mixed-use, public, commercial and urban planning.

Bodek Architects is an Israeli firm based in Tel Aviv, founded by Moti Bodek, Senior Lecturer at the Bezalel Academy of Art and Design. The office engages in the research, design and construction of buildings and projects, focusing on innovative techniques for manufacturing and construction inspired by nature.

Prof. David Elad, Professor f Biomedical Engineering at Tel Aviv University since 1985.

Modu Studio: Farah Farah.
Bodek Architects: Moti Bodek, Dan Shapira, Eyal Fourmansky and Alon Bodek (sound, electronics and acoustics); architecture students Roni Bodek Perets and Liron Munits.
Department of Biomedical Engineering, The Iby and Aladar Fleischman Faculty of Engineering, Tel Aviv University: Prof.r David Elad.

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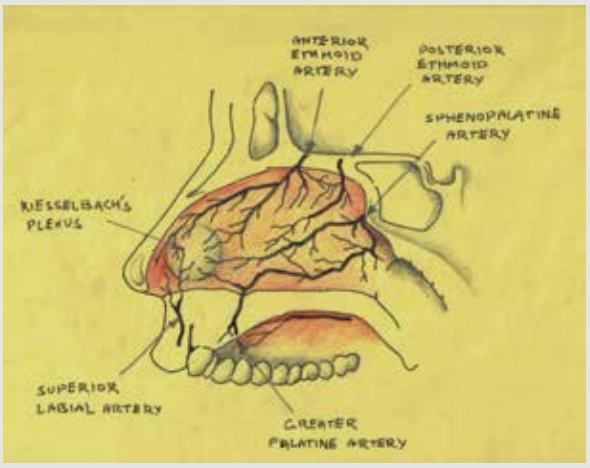
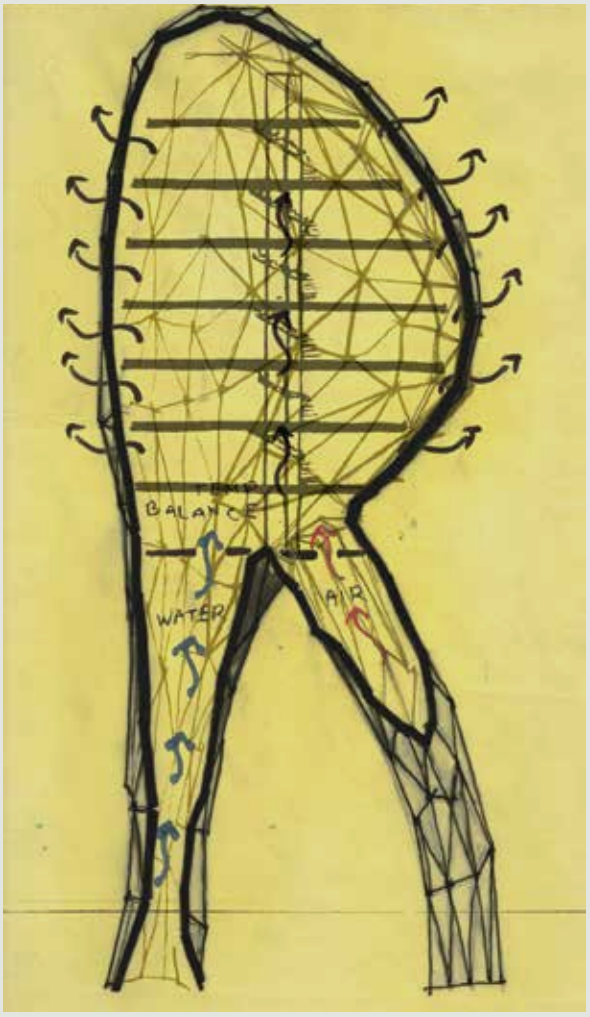
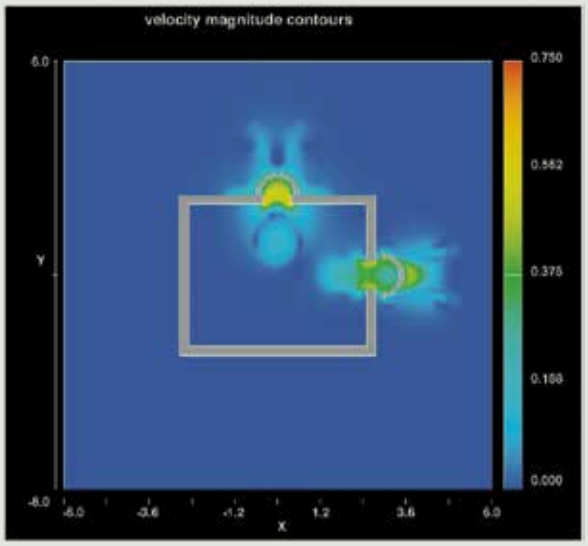


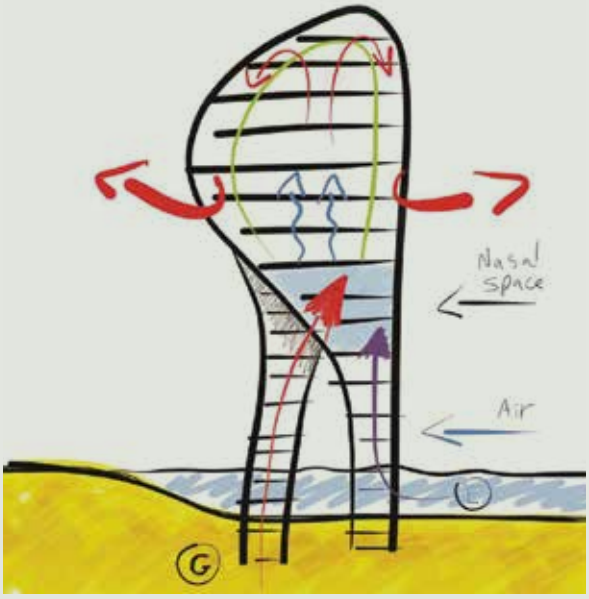
The Nasal Cavity anatomy.



Section of interior space development by Arch. Moti Bodek



Flapping windows air flow. Simulation by J-Rom Ltd.



Initial concept of the Breathing Building by Arch. Farah Farah