

# FROST MUSEUM OF SCIENCE

GRIMSHAW



**Location** Miami, Florida, USA  
**Completion** 2017  
**Client** Phillip and Patricia Frost Museum of Science  
**Certification** LEED Gold



↓ The museum breaks down traditional boundaries that exist between visitor and exhibit, fostering a two-way dialogue. Cenotes, a geological form found in this ecoregion, inspired the design of several of the aquatic tanks in terms of spatial engagement.



## SUSTAINABILITY AND REGENERATIVE DESIGN CASE STUDY

Frost Science, located in Museum Park in downtown Miami, is a five-story centerpiece of an expanded cultural campus. The partly open-air structure is home to science galleries, a planetarium, classrooms and an aquarium, which also features terrestrial species showcasing southern Florida's fauna and flora. It provided the institution with a new and much larger facility than their previous one in Vizcaya.

The response to the project brief and program resulted in a campus of four buildings situated in an open-armed stance. It orientates the facility with its many outdoor program spaces to the prevailing wind coming in from the Atlantic. This conscious effort to link the building to the outdoors connects the world at large to the science exhibits within and reinforces the museum's ties to both the city and nearby marine habitats. A covered open-air courtyard threads between the individual buildings, connecting them to one another and creating a dynamic environment that

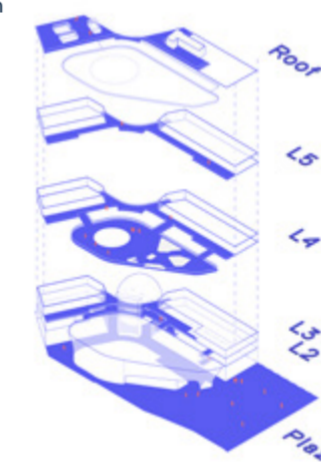
directly links the community to the experience of the natural as well as the urban setting around them.

The buildings' orientation and form enable constant breezes passing through, guaranteeing visitor comfort even in the hot and humid parts of the year. The entire building circulation and some key exhibit and other program spaces are in shaded, open-air spaces. This approach differed from conventional approaches and expectations that such spaces need to be interior and fully air-conditioned.

**Achieving a high LEED rating was a major undertaking. Energy performance/ calculations under LEED v2009 had to count in all plug-loads for first time, and with that the aquarium infrastructure. An aquarium is very energy intensive (around 60% of the building's total energy consumption) and every effort was made to improve on its efficiency, but its intensity required that all other systems had to work extra hard and undergo additional rounds of scrutiny. The reduction of energy consumption was achieved by optimizing the envelope, mechanical and lighting design.**



**Project Partners/Lead** Vincent Chang, William Horgan (collaborating Partner)/ Christian Hoenigschmid-DeVeaux  
**Project team** Grimshaw, Rodriguez and Quiroga, Arup, Atelier Ten, Lord Cultural Resources, Fraga Engineers, Syska Hennessy, MHW, ArquitectonicaGEO, DDA, Heitman, Thinc, Lyons Zaremba, Ralph Appelbaum, Casson Mann, Oppenheim Lewis, Hill International, Skanska



← This exploded floor plan shows, in the shaded areas, just how much floor area is outdoors.



↑ Looking up into the Gulf Stream aquarium

A broad and intricate water strategy includes the use of seawater from nearby Biscayne Bay to avoid use of potable water for aquatic exhibits. It also includes the collection of rainwater for use of HVAC Make-up water. Rainwater that is not collected and stored is fully infiltrated on-site, feeding back into the local aquifer.

### Alignment with UN Sustainable Development Goals

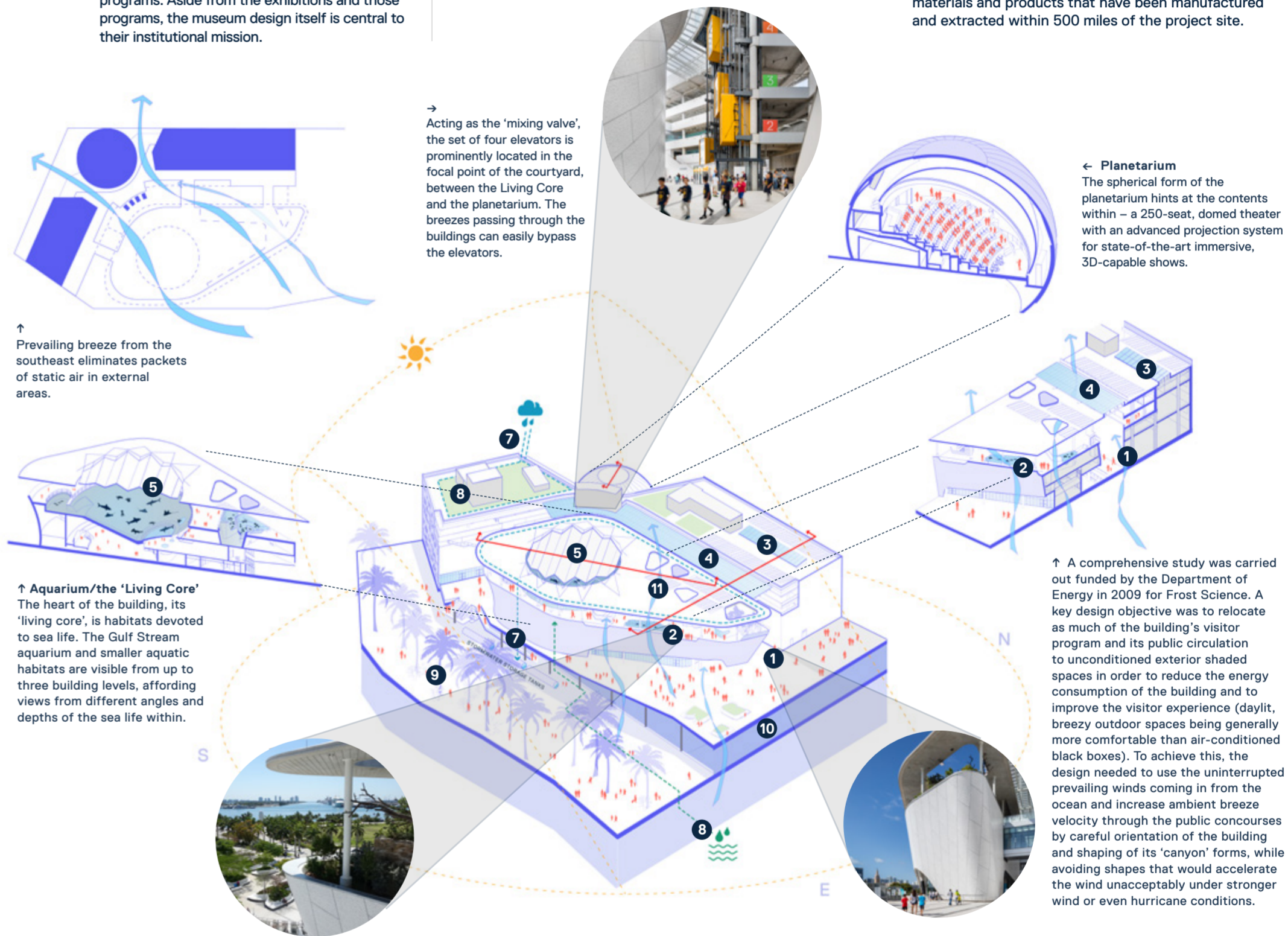
- SDG 6 CLEAN WATER AND SANITATION**  
**SDG 14 LIFE BELOW WATER**  
 The interconnected and engineered infrastructure for the various usages of water provide, in terms of health and well-being and ecology, an innovative project template for the region.
- SDG 11 SUSTAINABLE CITIES & COMMUNITIES**  
 The design of shaded exterior areas for thermal comfort of visitors and staff was achieved through detailed analysis and optimization of the building forms, supporting health, well-being and energy efficiency, and leveraging the publicness of the program by re-introducing passive design in a major institution to this region.
- SDG 4 QUALITY EDUCATION**  
 Frost Science seeks to provide high-quality, inclusive, educational programs; it does so through extensive school outreach programs as well as research partnerships and other youth programs. Aside from the exhibitions and those programs, the museum design itself is central to their institutional mission.

### Key Sustainability Facts

- PROJECT SITE**  
 Greyfield
- TRANSECT ZONE / CLIMATE ZONE**  
 Urban center zone / 1A
- ECOREGION**  
 Neotropical / South Florida Coastal Plain, Tropical Wet Forest
- OPERATIONAL ENERGY/CARBON:**
- > Reduction in energy cost from an equivalent new building: 26%
  - > Total site PV annual energy generation is 66 kW, 1.7% renewable
  - > Optimizations were focused on reducing energy consumption. Energy efficiency measures incorporated into the building design include an improved thermal envelope, reduced interior lighting power densities, occupancy sensors, exhaust air heat recovery, demand control ventilation, variable speed pumps, and on-site renewable energy production.

- WATER**
- > Reduction of potable water use from an equivalent new building: 36%
  - > Optimizations were focused on reducing potable water consumption which – aside from basics like low-flow plumbing fixtures – include an intricate water strategy which uses seawater from Biscayne bay to avoid use of potable water for the seawater exhibits.
  - > Rainwater is collected for use as HVAC make-up water and to irrigate the rooftop gardens (estimated 350,000 gallons per year in city water savings), and a gray water collection system is utilized for flushing toilets and urinals (estimated 250,000 gallons per year in city water savings).

- EMBODIED CARBON**
- Reductions in embodied carbon focused on the following:
- > The project has diverted 90% of the on-site generated construction waste from landfill.
  - > 26% of the total building materials content, by value, has been manufactured using recycled materials.
  - > 28% of the total building materials value includes materials and products that have been manufactured and extracted within 500 miles of the project site.



### Axonometric diagram ↑

- Natural ventilation** – Design of campus and building forms are optimized to improve thermal comfort through wind tunnel and computational fluid dynamics analysis, leveraging the prevailing winds from the southwest for passive cross ventilation.
- Views** – The design is meant to be a welcoming, "living" building, relying not only on its architecture but the local environment as well to create a full experience. The natural world plays a huge role in making the architecture what it is. The design presents great views of the surroundings, to the park, the bay, to a growing downtown and Miami Beach and the Atlantic in the distance.
- Skylights for daylight** – Skylights provide daylight into the classrooms and labs. Additionally, lighting controls are provided to enable occupants to make adjustments to suit individual task needs and preferences.
- Glazed courtyard canopy** – A dense fritting reduces solar heat transmission, but still allows ample daylight into the five-story space.
- Gulf Stream aquarium** – The 550,000-gallon aquarium, with its unique cone shape, spans three floors to provide a cornerless environment for ocean-cruising wildlife. The bottom of the cone resolves in a massive, 31-foot diameter circular viewing window that allows visitors a dramatic view up and into the seawater aquarium from below, immersed in the blue depths of the Gulf Stream.
- Green roof areas** – The bar building roof supports several green roof areas for biofiltration, temporary retention of rainwater, thermal comfort on the roof (given the roof is also used for public programming), and biophilia.
- Rainwater, stormwater and water reuse** – Rainwater is collected off all roof surfaces and stored on grade in the carpark area in a 500-gallon greywater tank; this rainwater is then used for HVAC make-up. The cooling tower makeup water consists of at least 50% non-potable water from harvested rainwater, and metering equipment has been installed to measure the makeup water quantities used from non-potable and potable sources. Excess rainwater overflow, 90% of the average annual rainfall, is sent to on-site injection wells to recharge the local aquifer. Greywater from basins, showers and building services is treated and reused for toilet flushing (80% of the flush fixture load is supplied from greywater).
- Seawater intake** – A seawater supply from Biscayne Bay avoids the use of potable water for the seawater exhibits. Natural seawater is provided to the Gulf Stream tank and the other aquatic exhibits, including the coral reef tank.
- Native and adaptive vegetation** – The project has provided 255% more open space than required by local zoning regulations. Additionally, 77% of this dedicated open space is vegetated. The project has restored or protected at least 20% of the total project site area including the building footprint using native or adapted vegetation. The landscaping and irrigation systems have been designed to reduce potable water consumption for irrigation by 65%. A total of 29,490 sq ft of site habitat is being provided, including the green roof.
- Preferred parking for low-emission vehicles & public transport** Two electric vehicle charging stations and twelve preferred parking spaces for car/vanpool vehicles are provided. Public transportation options via bus and an onsite Metromover station are adjacent to the museum (Metromover is Miami's free mass transit, an elevated and automated people mover train). Naturally ventilated parking is available under the plaza to prevent heat islands typically caused by parking lots exposed to direct sunlight.
- Photovoltaic system** – The project has offset 1.7% of the total energy costs through on-site renewable energy. A set of monocrystalline PV arrays are installed on the "Solar Terrace at Frost Science", totaling about 66 kW.