Student Greenhouse Project
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SGP Background

The Student Greenhouse Project originates from the closure of the Botany greenhouse and butterfly house formerly located on the north campus of Michigan State University. This 22,000 square foot marvel contained a sixty-foot long stream flowing from a five-foot waterfall down a canyon to a small pond at the end, in the tropical room. In the subtropical room, there was a fishpond and more unique, exotic plants. There was also an arid habitat room full of large cacti and a 900 square foot butterfly house teeming with different types of colorful butterflies. Many more plants and displays were housed in the connecting hallways.

Free and open to the public year-round, this green-space was extensively used for student activities: poetry readings, drum-circles, and concerts. The community used the greenhouse for weddings, health walks for heart patients from nearby Sparrow Hospital, school tours for elementary students from as far away as the Saginaw /Bay City (90 miles); and informal drop-in visits from many, many faculty, staff, families and students during the day. Naturally, the facility also provided the basis for a variety of classes and educational programs.

Early in the fall of the 1997 school year word leaked out that in a closed-door session administrators had decided to raze the facility. The Botany greenhouse was in the news as the community moved to prevent such a terrible loss. The Botany greenhouse had touched many lives. People had become connected to the plants and were willing to fight to prevent the closure of the only tropical area of its kind on our campus. Due to this strong personal connection and public support for the greenhouse and butterfly house a demonstration march was planned and a public forum was organized.

On October 8, 1997, the forum was held between administrators, students, and community members to discuss the value of the greenhouse on north campus. Many students stressed the importance and necessity of an accessible greenhouse for the MSU community. As a result, an idea to construct a new student greenhouse on the original site on north campus was agreed upon by all parties in attendance.

Since that pivotal meeting and the agreement for a collaboration to build a new Student Greenhouse, the golden opportunity to build a community facility has moved steadily forward. Collaborative work with administrators and an outpouring of information from a large survey have contributed to this success. The Associated Students of Michigan State University (ASMSU) officially support the Student Greenhouse. When ASMSU accepted the 2020 Vision Master Plan, the resolution included a provision to have the Student Greenhouse in all future plans. The MSU community looks forward to enjoying the tropical Biodome.

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Biodome Basic Technical Details

Estimated cost of project: $11 million
Diameter: 150’ (45.7 m)
Height: 75’ (22.86 m)
Materials:
-3.5” Aluminum Stock Struts, ¼” thick walls
-Triangular Acrylic Panels/PV Panels
Foundation: insulated poured concrete ring to allow proper drainage and integration into local environment
Solar coverage: 60% of the dome exterior will be covered with photovoltaic solar glass to significantly reduce the electricity load of the facility
Water catchment: rainwater from the dome will be captured, and stored for watering plants inside the biodome

Biodome Engineering Summary

A Biodome provides the most natural outdoor environment achieved in a structure because it is a free span construction. This means there are no columns or internal roof supports taking up space or distracting the eye and reminding the viewer they are in a building. Once inside, the clear walls go almost straight up, out of sight, out of mind. The 75' apex provides plenty of height to grow a forest canopy. The hemispheric dome has the maximum structural stability because there are no corners or edges where stresses occur and the structure's weight is evenly distributed, pressing directly down, eliminating any spreading forces on the foundation.

A Biodome catches more light than a standard greenhouse. It's larger panels and more widely spaced supports screen out less light than a conventional small paned greenhouse. The curving dome also provides a face that is perpendicular to incident sunlight at any angle through the seasons. The overall light increase in the greenhouse exceeds 20%. This can be particularly important during Michigan's low light season for the tropical plants.

Because of its efficient design a dome require less equipment to control temperature. No sunscreens, whitewashing or mechanical evaporative coolers in the summer, just a quiet exhaust fans at the top where the heat collects and lower vents to draw cool air, releasing the heat at the top like a chimney. Other botanical garden domes are up to eight degrees cooler than the outdoor temperature in the summer because evaporative cooling from the plants, waterfalls and misting system is enhanced by the efficient airflow pattern. In winter, close the vents and reverse the fan to blow down the warm air from the days capture of solar heat. During the winter a heating system is still necessary, but good use of the solar potential can significantly offset the heating requirements.

The circular interior of the dome is particularly conducive to producing the natural contouring layout. Continuously curving paths give the most outdoor quality by blocking straight look through lines of sight. This then gives more of a feeling of being surrounded by nature and in your own space, a quality of larger outdoor environments.

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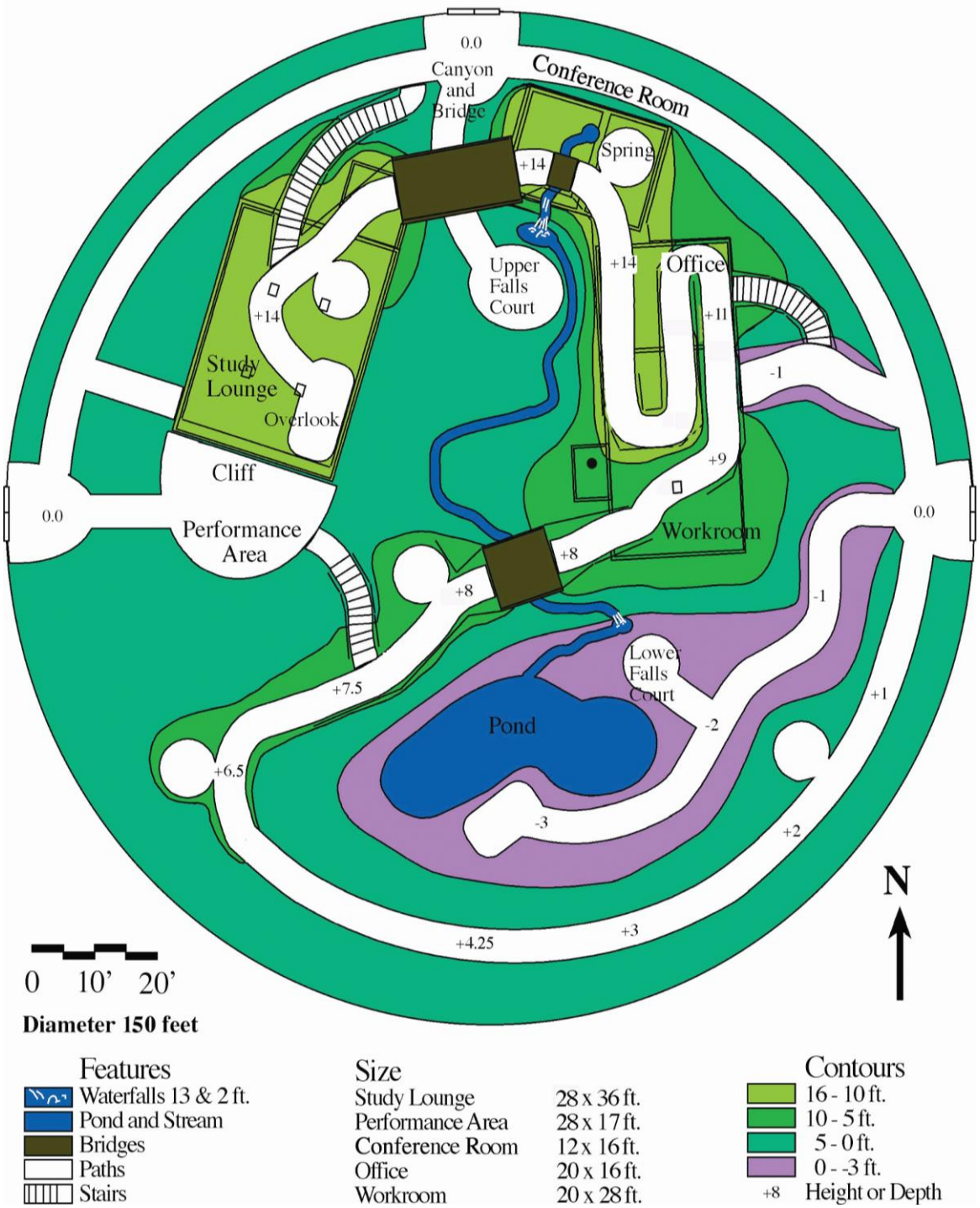
Biodome Interior Details



The interior of the proposed Biodome will be contoured like a small tropical valley.

In the north, the 14 foot high ridge has the taller of the two interior waterfalls cascading from it. The ridge is split into two sections by the canyon, which will be offset slightly west of the north entrance. Entering from the north, sunlight shining through the gap from the south provides mystique because the central area is not quite visible without rounding the bend in the trail. This central courtyard is where the high falls splash over the rocks to the pool below and is at one end of the largest continuous internal green space. The study area, overlook, upper bridge and surrounding ridge trail look into this area. Being centrally located under the dome trees in this zone will have the greatest opportunity to reach forest-like heights.

On the west end the horseshoe shaped ridge ends in a natural stone cliff face. This is the backdrop for the performance area. Underneath this end of the ridge is the study lounge, which looks into the thick of the garden to the east. The study area's entrance near the performance area allows it to double as a 'backstage' preparation area for concerts, theatrical events and a dressing room for weddings.

The east end of the ridge slopes down to the lower falls and the southern pond. Beneath this section of the ridge are the restrooms and the office and garden maintenance room.

The large southern pond and lower falls are situated below ground level, adding to the dynamic range of the contouring. By lowering this area, its separation from the encircling upward trail is increased, enhancing the out-of-the-way character for this section while still providing a vista from the main trail above. The quietness of the pond and lower fall is also maintained by the upward trail separating and screening activities at the performance area.

Distinctiveness of places within an environment adds to the impression of depth and extent. The highs and lows of the contouring in this plan create terrain features that are recognizable places. Within the interior design there are at least eight definable 'places'. These are the Upper Falls, Lower Falls, Pond, the Spring, Cliff and Performance Area, Bridge over the Canyon, Study Lounge, and Overlook. Using contouring and waterscapes to create these features magnifies the dome's interior space in a visitor's experience by adding content and separating the space into multiple places. Each unique configuration can be its own distinct experience.

The curved paths provide a 'what's-around-the-bend' quality of mystery that adds intrigue and imply an invitation for further exploration. (Kaplan, Kaplan & Ryan 1998) The layering of different levels within the Biodome provides a variety of niches and destinations to explore. Mists and fog add to the mystery of a scene, so even the misting system, planned for maintaining the plants and cooling in the summer, can add mystique to a visitor's experience.

Fish and frogs, birds and other creatures all add to the fascination people feel in a natural setting. Interest in other living things contributes to getting outside one’s own daily concerns and allows mental rest and rejuvenation. Watching a placidly floating fish or the antics of a chipmunk or listening to the chirp of frogs or insects calling to each other begins the process of unwinding, lessens self-absorption and allows mental reflection, perhaps leading to a refreshed view or

insight. The interior plan includes fish in the pond, birds, gecko lizards and other aquatic creatures.

Scientific research in environmental psychology has investigated meanings, attachment and defining characteristics of favorite places. (Korpela & Hartig 1996) Favorite places are often restorative environments providing a respite or break from daily concerns or a chance to find solitude or "get away". These are also frequently natural environments. Many studies have investigated landscape preferences and found mountain waterscapes, waterscapes in general and forests to be robustly preferred across cultures, classes and age groups. (Herzog 1995, Hull & Revell 1995) These have also been demonstrated to be the most restorative natural environments. The interior of the Biodome is focused on producing the best facsimile of an outdoor environment with waterfalls, stream and pond and a tall forest of trees. All of these are the most preferred aesthetic aspects of a beautiful favorite place.

The overriding design principle in laying out the interior has been accessibility. The size, depth, width and roundness of the dome are the minimum necessary to make the interior design work. The nearly 350-foot long giant S-curve encompassing the central region of the dome has a gentle slope for easy use. The length of this walkway allows the northern ridge to reach 14 feet for a significant waterfall and grand overlook. It also has adequate height to provide for required soil depth above reasonable room heights underneath. A careful balance between paving and plant space was maintained as the width of the paths was increased to four feet with the final paved area in the dome at 30 percent. The bridges are eight feet wide, so that anyone who wishes can stop and look out while others can pass by without disturbance. All destinations are accessible, but stairs have been included at different levels to siphon off excess traffic on the main upward path. The grade of accessible slopes and the path length required to gain height or depth have been the determining factor in the design's contours.

Many features of the design are aimed at utilizing solar heat. The cliff face angled toward the south will intercept 90% of the day's incident sunlight during the winter. As a passive solar thermal mass over a foot thick, it will absorb heat during the day and re-radiate the stored heat overnight. The performance area in front of the cliff is both a reflector of low angle winter sun onto the cliff face and an additional absorbent storage mass. The dark shade of brown used for the trail paving stones increases their absorbing efficiency. The paths also add to the heat storage capacity. The large southern pond serves the same heat absorbing/ storing purpose, as does the rest of the water system, though the stream will be more shaded.

In the summer these same features continue to help with the thermal regulation of the Biodome interior. The pond, stream and waterfalls now become evaporative coolers. Opening inlet vents around the bottom and a large vent port at the top takes advantage of the dome's chimney-like flow pattern to cool the interior. The cliff's heat accumulating function is eliminated during the summer by having shading foliage above the cliff lean outward about five feet. At lower winter sun angles, the sun shines directly on the absorbent stone but in the summer, higher sun angles cause the overhanging foliage to shade the stone and minimize heat capture.

The Biodome's combination of beauty, efficiency and accessibility will provide a superlative garden experience. With curving paths to provide mystery just around the bend, fish in the pond and birds or other creatures, this will be a winter garden of year-round vibrancy to revive spirit's on campus and in the community.

Research on Impact of Nature

The Student Greenhouse's Biodome could enhance the physical health, mental health and personal well-being of students and members of the public. Plants and greenery contribute to job satisfaction and community quality of life. Having a view of nature can affect the course of hospital stays and even the condition of prison inmates. The studies are numerous and range from national inquiries to many investigations conducted here in Michigan.

The Biodome could be a healthful and prestigious enhancement to Michigan State University or any University or community. Academic performance would be enhanced by providing a high-quality year-round garden to students fatigued or stressed by intense study. Extensive scientific research has documented the restorative health benefits gained by spending time in nature. (Kaplan & Talbot 1983, Hartig et al. 1991, Talbot & Kaplan 1991, Browne 1992, Ulrich & Parsons 1992, Tennessen and Cimprich 1995, Taylor et al. 1998).

The effects of nature on mental health and well-being have been demonstrated by reproducible empirical evidence definitely confirming a causal link. (Wilson 1972, Ulrich 1979, 1981, West 1985, Kaplan et al. 1988, Cimprich 1989, Kaplan & Kaplan 1989, Honeymen 1990, Hartig et al. 1991, Ulrich et al 1991, Kaplan 1993, Tennessen and Cimprich 1995) Experimental investigations of restorative environments containing green plants, trees, flowers and waterscapes show two main effects:

- Stress reduction or decrease in the after effects of stress
- Recovery from mental fatigue, specifically the capacity of directed attention required to focus on tasks in the face of distractions or extended mental effort

These are the studying-fatigue effects which impact students here on campus.
Cimprich (1989) has shown that after a demanding examination, college students exhibited a decline in directed attention capacity. In her own words, "Thus, the development of attentional fatigue is salient in the college experience and could undermine a student's ability to succeed at a university." (Tennessen and Cimprich 1995). The accumulated data show that access to nearby nature is significant for students' mental functioning as a buffer against fatigue and stress in learning situations.

In a study of university residence hall occupants, their directed attention capabilities were evaluated and compared between groups who had different amounts of nature visible from their windows. (Tennessen and Cimprich 1995) Across the view categories, from all built to all natural, there was a trend of improved rating of the various measures with increased natural elements in view. Students with all-natural views scored significantly higher on several of the

tests. In addition to performing significantly better, students with the most natural views rated their own attentional functioning, i.e. planning, deciding, concentrating on details, as more effective than those in all other view categories. This study demonstrates the positive effect of nature viewed from a residence hall window on student's intellectual functioning. How much greater would the benefits be if only a short walk away one could be immersed in natural surroundings?
A study by Ulrich (1979) of students who were experiencing mild stress after a final exam showed that the group viewing color slides of everyday nature had greater recovery than those viewing city scenes lacking vegetation. When this study was repeated by Honeymen (1990) she found the group viewing the urban scenes actually registered increased stress and less positive affect.

Amongst many assessments psychologists use of mental functioning, proofreading is considered a rigorous and valid method of gauging attentional focus. This familiar scholastic endeavor, has a clear relationship to educational performance. Hartig et al. (1991) reported two studies where proofreading was used as a test of nature's attention-restoring effect. In the first study, three groups were compared; one that went on a wilderness trip, one that went on an urban vacation, and the third group had no vacation. Only the wilderness vacationers showed improvements on their proofreading scores. In the second study, after 40 minutes of tasks designed to induce attentional fatigue participants were given a break period consisting of a nature walk, or a walk around town, or passive relaxation sitting back. Then they were given a proofreading test. Those who had taken the nature walk scored the highest.

Most telling is Ulrich's (et al. 1991) investigations into recovery from stress. 120 undergraduate volunteers underwent a 10-minute stressor period while viewing a black and white film about the prevention of work accidents, "It Didn't Have to Happen", that has been found to be an effective stressor in previous studies (Lazarus 1965). This was followed up with another viewing session where the volunteers were instructed to relax while looking at either scenes of trees and streams or pedestrians moving through an outdoor shopping mall, or traffic on urban streets in a business district. During these experimental periods blood pressure, heart rate, muscle tension and skin conductance of the subjects was recorded. Along with the physiological recordings subjective mental states of the students were assessed using the Zukerman Inventory of Personal Reactions (ZIPERS) (Zuckerman 1977), a test used throughout the various studies previously mentioned.

As shown in the reprinted graphs of data from Ulrich's study, the simulated natural environment produced a significantly different recovery course than did the urban environments. The skin conductance recordings in figure 1, familiar as the polygraph test or lie detector, show the natural scenes caused very rapid recovery toward the pre-experimental unstressed baseline. In only four minutes about 80% of the electrical fluctuations caused by involuntary sweating had regressed to a calmer state and continued to improve up to 95% of the way to normal in the next three minutes. The pulse transit times in figure 2, which reflect blood pressure, also showed nearly 80% recovery in four minutes for the group experiencing nature as a relaxer. By contrast, the group exposed to a follow up of street traffic didn't show any significant relaxation or stress recovery after 10 minutes. Stress levels evaluated through changes in voluntary muscle tension

(figure 3) showed that muscle tension plunged for the nature viewing group; 90% relaxation in only four minutes.

The figures below show recovery from stress induced viewing a graphic accident injury movie. After the movie, subjects were exposed to everyday urban vs. natural settings: a busy street and an outdoor pedestrian mall vs. a forest environment. Figure 1 shows nervous sweating, figure 2 blood pressure, figure 3 involuntary muscle tension across the head and neck, and figure 4 heart rate. The nature setting produced the most and fastest recovery.
The heart rate data dramatically differentiates between urban and natural environments' effects on an individual. The graph in figure 4 shows completely different responses for the nature viewers as compared to the urban scene viewers during the recovery period. Heart rate is complex; situations stimulating the attention to external stimuli usually reduce heart rate. Both unpleasant and pleasant situations, if they elicit interest / intake, result in heart deceleration. Mental problem-solving stress and other tensions increase heart rate. The complete difference between the reaction elicited by natural scenes as compared to the urban ones indicate natural environments engage the attention and produce considerable perceptual intake, whereas the urban scenes are unengaging.
Along with the physiological readings, the administered psychological tests showed significant results as well. The 10-minute nature viewing experience had decreased feelings of fear, anger, aggression below the initially reported pre-experimental baseline and increased positive feelings (affect). The recovery associated with the natural exposure was so pronounced that those in the nature-viewing group were actually feeling better than before the beginning of the experiment.

The physiological findings indicate that nature settings produce significant recovery from stress in only 4 minutes. This rapid recovery demonstrates that brief contact with vegetation can foster restoration from daily stress and work pressure. The psychological data suggests the importance a nearby garden of warmth could have, even for a drop-in of only 10 minutes. On this campus short informal drop-ins were one of the more common ways the previous greenhouses were utilized by students and staff.

In the case of employees, research has shown the importance of plants, flowers, trees, in the daily work experience to buffer against job strain and mental fatigue. (Lavina 1983, 1985, Leather 1998) Other investigations have corroborated the availability of nearby nature resulted in less perceived job pressure and job stress, fewer ailments and headaches, greater satisfaction and was a strong positive factor in enthusiasm about work. (R. Kaplan 1993)

National surveys have shown (Fried 1982, 1984) that the strongest predictor of local residential satisfaction was the ease of access to nature and that this was the second most important factor, after marital factors, in overall life satisfaction. Other studies, done in Michigan, (Frey 1981, R. Kaplan 1981, 1982, 1983, 1985, Askawa 1984) found that neighborhood satisfaction was linked to the availability nearby nature and was significant in general life satisfaction as well. Therefore satisfaction at home with our local community could be strongly impacted by a green garden in January or February just across Grand River Avenue.

Actual physical health and medical recovery is affected by exposure to greenery and sunlight. Research has shown patients recovering from surgery who could see a small stand of trees from their hospital window recovered more quickly and required fewer painkillers than other patients whose windows looked at brick walls. (Ulrich 1984) In windowless intensive care units cases of delirium (Wilson 1972) and mortality rates (Wiley 1999) have been attributed to lack of sunlight and the deprivation of contact with any kind of nature. Many studies (Verderber 1982, 1986, Verderber, & Reuman 1987, Ulrich 1979, 1981, Keep 1980, Jesse et al. 1986, Heerwagen 1990) have convinced hospitals of the life-saving significance of nature. The Joint Commission for the Accreditation of Healthcare Organizations is reviewing new guidelines to ascertain the views a patient's room has of nature and how much can be seen lying flat in bed.

The Biodome would have numerous positive psychological and physical effects. In fact, these very real benefits were the basis for the public outcry against the impending loss of the Botany and Butterfly greenhouse set off in late 1997. Administrators were apparently unaware of the significance these greenhouses held for the campus community. This is not surprising as a quote from Rachel Kaplan illustrates, " In our current surroundings, a particular tree maybe the source of great individual affection, possibly because it has a special form or affords a comforting view or provides a comfortable place to sit and pause. How rarely any of us know of others' special places. In fact, one often does not become aware of such attachments until a threat arises." (Kaplan & Kaplan 1989)

Quiet, peacefulness and tranquility were the most prominent (79%) qualities reported in people's preferred settings at the Morton Arboretum in Chicago (Schroeder 1995). The Kaplan's long study (12 years) of the USDA's Outdoor Challenge (hiking) Program conducted in Michigan's upper peninsula found 85% of the participants commented in their journals on the peacefulness and tranquility they were experiencing, not just once but usually more than three times (Kaplan & Talbot 1983). Our own campus and community when surveyed responded with similar results; 61% looked forward to using the greenhouse for "Quiet time", or in peoples own words - "stress relief", "breaks", and "relaxation". Our objective is to provide a relaxing haven for a short break during the workday.

Clearly, nature can have a great effect on people; on campus, at work, where we live. Fortunately, Michigan and our beautiful campus are wonderfully endowed, and for 7 months of the year, one can go outside and enjoy. Unfortunately for students the majority of the school year is during the worst season. To breathe the moist, fragrant air of the tropical Biodome and clear one's mind of fatigue and stress would have great health and well-being benefits.