

## Invention Project Proposal **The Lightstream**

An ultraviolet LED strip, spectrally optimized and strategically placed to provide a convenient daily dose of vitamin D.

Studies<sup>1</sup> show that Vitamin D inadequacy has been reported in approximately 57% of general medicine in patients and is at epidemic levels in worldwide populations<sup>2</sup>. When converted to its biologically active form, Vitamin D serves multiple functions: activating immune defenses, regulating calcium and potassium, and promoting healthy bone growth to name a few. Vitamin D deficiency (Hypovitaminosis D) is the condition of having too little vitamin D in the body. It causes rickets, osteomalacia, exacerbates osteoporosis, and prevents children from developing peak bone mass. Hypovitaminosis D results mainly from a lack of dietary Vitamin D sources and an insufficient exposure to sunlight, specifically exposure to ultraviolet B (UVB) rays. Our invention, *Lightstream*, is designed to be a remarkably cheap, efficient, and convenient solution to this problem.

*Lightstream* is a small strip of aluminum that holds an optimized array of light emitting diodes (LEDs), designed to be placed on a wall inside a shower. The LEDs are designed to emit a spectrum of UVB light ranging in wavelength from 295-297 nm. This range of wavelength is optimized for maximal Vitamin D3 production in the skin<sup>3</sup>. The LEDs are capped by a lens that will direct the light through a small cone restricted to a polar angle of less than 15° and onto the bare skin of a person utilizing their shower. A company in North Carolina specializes in manufacturing deep ultraviolet LEDs that emit the specified spectral range of UVB light. At this chosen wavelength, the irradiated light simulates the natural UVB rays affecting vitamin D precursor levels in human skin. Our device would also maintain a much higher rate of exposure due to the lack of obstructions such as clothing as well as an angle of incidence perpendicular to the ventral and dorsal planes of the human body. Our prototype LED strips will be powered by an AC adapter, though the final design will incorporate a rechargeable battery. This eliminates all wires near the running water of the household shower. A single button will be used to start a 5 minute timer to prevent overexposure to the UVB rays as well as to systematize our test results.

The recent development and improvement in LED technology, has resulted in mass produced LEDs that are relatively cheap, very energy efficient, and longer lasting than nearly every other type of light-emitting device on the market. Though the materials for a single prototype would cost approximately \$800, the cost of high volume orders of LEDs would drop to 5% of the cost of low volume orders. Simple assembly, electronics, and cheap mounts would allow a large-scale production of each unit to drop in cost to an estimated fifty dollars. And the installation of one unit into a typical household has the ability to drastically improve 57% of the world's health and lifestyle.

Children, teenagers, and adults will be able to benefit from the *Lightstream*. The current suggested daily allowance is 600 IU of Vitamin D.<sup>4</sup> With five LEDs and one five minute shower, our calculations suggest that our strip can provide approximately 800 IU of vitamin D to a light-skinned person. Overexposure is not a problem: vitamin D toxicity is at 40,000 IU per day,<sup>5</sup> far beyond our suggested

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<sup>1</sup>Holick MF. High prevalence of vitamin D inadequacy and implications for health. *Mayo Clin Proc.* 2006;81:353–373.

<sup>2</sup>Gaugris S, Heaney RP, Boonen S, Kurth H, Bentkover JD, Sen SS. Vitamin D inadequacy among post-menopausal women: a systematic review. *QJM.* 2005;98:667-676. // Isaia G, Giorgino R, Rini GB, Bevilacqua M, Maugeri D, Adami S. Prevalence of hypovitaminosis D in elderly women in Italy: clinical consequences and risk factors. *Osteoporos Int.* 2003;14:577-582. // Plotnikoff GA, Quigley JM. Prevalence of severe hypovitaminosis D in patients with persistent, nonspecific musculoskeletal pain. *Mayo Clin Proc.* 2003;78:1463-1470. // Carnevale V, Manfredi G, Romagonoli E, et al. Vitamin D status in female patients with primary hyperparathyroidism: does it play a role in skeletal damage? *Clin Endocrinol (Oxf).* 2004;60:81-86. // Harwood RH, Sahota O, Gaynor K, Masud T, Hosking DJ. A randomised, controlled comparison of different calcium and vitamin D supplementation regimens in elderly women after hip fracture: the Nottingham Neck of Femur (NONOF) Study. *Age Ageing.* 2004;33:45-51.

<sup>3</sup>MacLaughlin JA, Anderson RR, Holick MF. Spectral character of sunlight modulates photosynthesis of previtamin D3 and its photoisomers in human skin. *Science.* 1982;216:1001-1003.

<sup>4</sup>Institute of Medicine of the National Academies. Dietary Reference Intakes for Calcium and Vitamin D, November 2010.

<sup>5</sup>Vieth, Reinhold. *Vitamin D supplementation, 25-hydroxyvitamin D concentrations, and safety*, Am J Clin Nutr 1999; 69:842

800 IU, 5 minute dosage. In addition, the *Lightstream*'s timer mechanism prevents the possibility of a sustained dosage by cutting the power to the LEDs after 5 minutes. Considering the intended location of our device, the shower, we also expect the average homeowner will be very reluctant to take a 50 minute shower. Adverse effects of UVB overexposure are well-known, e.g. skin cancer and cataracts. The strip is intended to be elevated to the height of the sternum and the light will always remain far below the level of the eyes. Though we cannot balk at the suggestion of skin cancer, one-third of the minimal erythema dose (the exposure required to cause reddening of the skin, aka "sunburn") is enough to provide an individual with 1000 IU of vitamin D.<sup>6</sup> Nonetheless, more research is admittedly required in this area.

The *Lightstream* project will require significant efforts to predict and test the utility of this invention. A team of students will be enabled to quantify the expected behavior of the apparatus, acquire the necessary electronics, and assemble the device. We will have to recruit a range of adult test subjects who are willing to have their vitamin D levels tested weekly for 5-7 weeks as well as keep a log of their daily clothing, diet and outdoor activities for the entire period of *Lightstream* exposure. The quality controls necessary to establish a baseline effectiveness of our device require substantial quantitative and empirical evidence that must not be compromised by unknown variables due to our lack of foresight in gauging our subjects' nutrition and lifestyle. Every effort will be made to ensure consistency in our testing and data and in maintaining the safety of our subjects.

The students who are already involved have a dedication and interest not only in the fields of math and science, but also in finance, marketing, and communications. Although research will be a significant part of this project, there is also a necessity for resource management operations to acquire the supplies for manufacturing our prototypes, as well as project presentation materials as indicated by the InvenTeam website. Students will be given a chance to fully develop their own individual talents while working as a team to fulfill these goals. Research and development work is typically an iterative process, so each sector of this project will require continual assessment and review. These applications of quality control are some of the most pedagogically effective methods of educating students of science. There will be no race, age, or gender discrimination for the members of this team, which is comprised of freshmen, juniors, and seniors of Asian, Indian, and Caucasian descent. Our school's student body is a highly diverse mix, e.g. the demographics show 34% Caucasian, 30% Indian, 26% Asian, 7% African American, and 3% Hispanic.

In order to maximize the efficiency and the productivity of our small team, each individual will be given a particular task and role in the development of the *Lightstream*. Students have been given a choice of "expertise." Making each student responsible for his or her own project facilitates the development of strong leadership skills and accountability. Students who have interests in the theoretical and mathematical aspects will conduct extensive research, while some will tabulate data sets. Students with interests and experience in engineering will focus on the materials and construction of the prototypes. Those who show mastery of scientific language and demonstrate confidence in their oral and public speaking skills will establish connections to the MIT InvenTeam administration and potential partners in business and develop the presentation materials required in our attendance of EurekaFest. Though the coach of the team will be deeply involved with all aspects of the project, every effort will be made to allow the students to direct themselves and independently pursue their chosen projects. The coach/teacher will be focusing on the financial components, e.g. purchasing, throughout the *Lightstream* project.

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<sup>6</sup>Holick MF. McCollum Award Lecture, 1994: vitamin D — new horizons for the 21st century. *Am J Clin Nutr* 1994; 60: 619-630.