



Fig. 1. BIOMOD website [1].

2. BIOMOD

BIOMOD is an open-ended competition. Competition of open-ended design is beneficial because participants can have experience of the whole research process from the brain storming to get the project idea to the final presentation to show the results, and it eventually provides an effective on-the-job training to develop the qualities and skills to become a scientist and engineer.

Definition of BIOMOD is given in its web site: “BIOMOD” is a design competition in which undergraduate teams compete to master control of biomolecules on the nanometer scale. Focus areas may include—but are not limited to—biomolecular robotics, biomolecular logic and computing, and structural bionanotechnology. Students conceive and execute projects during the summer and then gather in congress in November to present their work and win awards.

This competition is organized by Dr. Shawn Douglas at Wyss Institute, Harvard University (later he moved to UCSF). The first notice was delivered through E-mail around January 2011 announcing the concept of the competition for student level. We (Research group in Molecular Robotics, SICE, Japan) decided to join the competition through supporting student teams and sent Dr. Shogo Hamada (assistant professor of author’s lab at that time) to Boston to discuss about the rules and judging system for the competition. Many of our proposals about them have been reflected in the structure of the competition.

For the BIOMOD participants, it is required to report their activities by three different forms (Table 1). First and most important report is Wiki pages that expected to provide every details of the project. Second is a YouTube video that summarizes the outline of the project. Third is an oral presentation at the conference in Boston. Those items are evaluated by judges at the conference. The judges are volunteered from mentors from all the teams. Evaluations are given by a certain numerical rating system (this is a part of our proposal to give transparency to the competition), without a subjective evaluation such as comments and impressions.

An example of project timeline is given as follows (BIOMOD site [1]).

- January–March: Team organizers should recruit team members: post flyers and email announcements, interview



Fig. 2. Text book entitled “Introduction to DNA molecular Design” written by Molecular Robotics Research Group, SICE (in Japanese). Open textbook for BIOMOD students, released in April, 2016 [2]. A handy text book (the first text book of this kind in any language) is very helpful for beginners who want to learn necessary basics of DNA nanotechnology.



Fig. 3. Team Sendai of Tohoku University awarded Grand Prize at BIOMOD 2015.

interested students, and send notifications early while everyone is still finalizing their summer plans (in Japan, we have to start from April because of our academic term).

- April–May: Register your team. Students should begin independent background reading to start learning about topics that may interest them. Organize brainstorming meetings to determine project topic.

- June–August: Do the project! Also, start planning the YouTube video as early as possible. Book travel arrangements and apply for Visas if necessary.

- September–October: Complete project wiki, video, and presentation. Register for Jamboree (as mentioned above, we have domestic congress in September in Japan).

3. Project Example

In this section, as an example of BIOMOD project, we take Team Sendai’s project of 2015 [3] (Fig. 3). In this project, students of Tohoku University tried to design and fabricate DNA nanostructure module capable of controlling their stacking number. This work is later published as a journal paper [5].

3.1 Project motivation

In nature, various biological functions are realized by multimeric proteins (the same molecule binds together to form a cluster). Those proteins have intrinsic curvature