二零二零年香港學生科學比賽

Hong Kong Student Science Project Competition （HKSSPC）2020

目錄

主題

孕育科學創意 · 匯聚世界精英

Incubate Scientific Ideas ・ Bring Talent Together

副主題

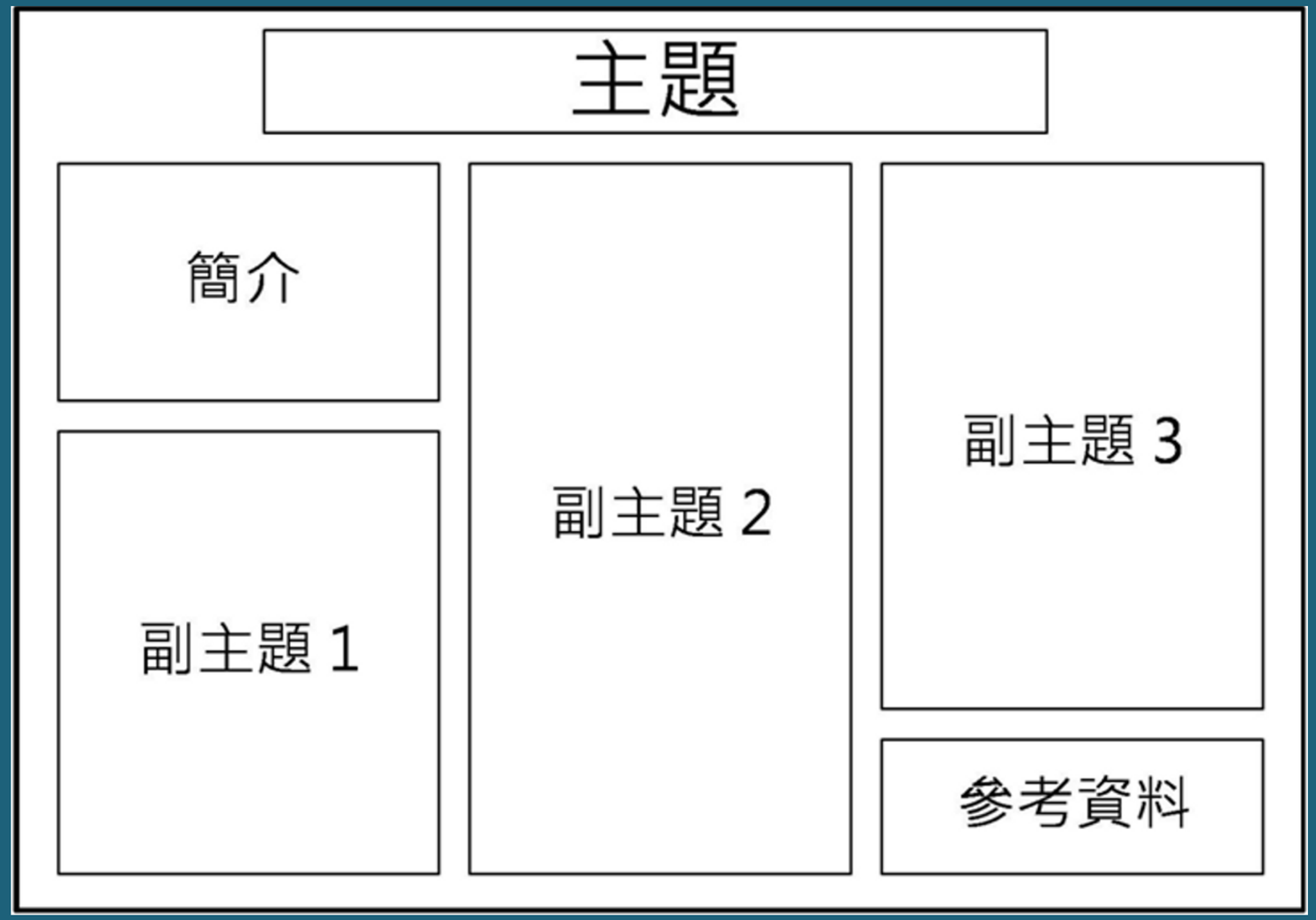
能源、工程及環境

Energy, Engineering & Environment

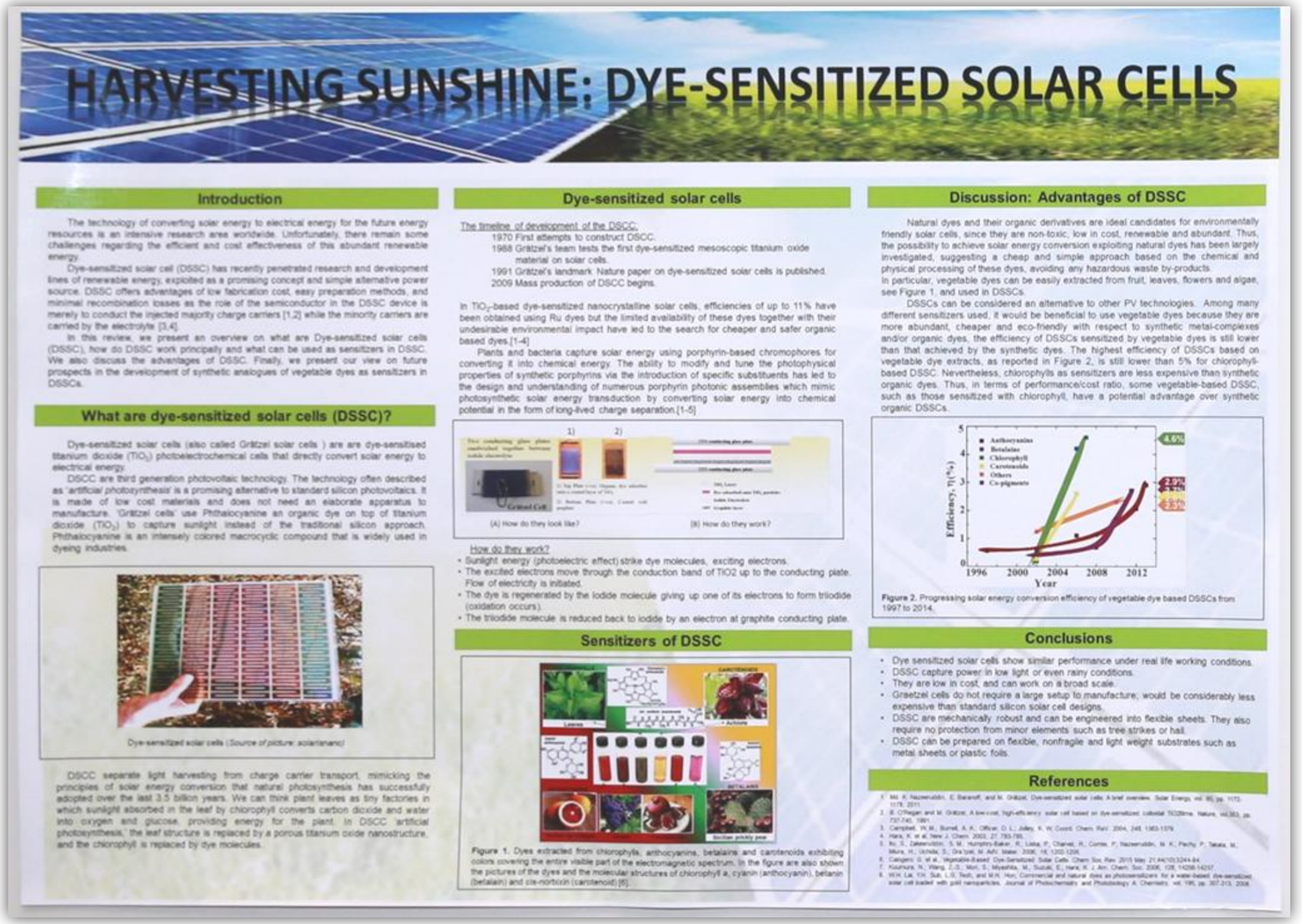
參賽組別概覽

	科學海報組	初中組	高中組
年齡	中一至中六 19歲或以下	中一至中三 17歲或以下	中四至中六 19歲或以下
參加資格	由學校提名 1名學生提交一張海報 每間學校可提名最多**5名**學生	由學校提名，每隊2至5名學生 每間學校可提名最多**8支**隊伍	
比賽類別	製作從科學角度探討與**「能源、工程或環境」**有關的知識的海報	A. 發明品 **或** B.研究項目 主題為「**物理及工程**」或「**生物及化學**」 可選擇競逐「能源、工程及環境大賞」	
參賽條件	一張A1大小海報	1.作品介紹 2.報告 3.參賽作品 (只限發明品)	

科學海報組



科學海報組


HARVESTING SUNSHINE: DYE-SENSITIZED SOLAR CELLS
Introduction
The technology of converting solar energy to electrical energy for the future energy resources is an intensive research area worldwide. Unfortunately, there remain some challenges regarding the efficient and cost effectiveness of this abundant renewable energy.
Dye-sensitized solar cell (DSSC) has recently penetrated research and development lines of renewable energy, exploited as a promising concept and simple alternative power source. DSSC offers advantages of low fabrication cost, easy preparation methods, and minimal recombination losses as the role of the semiconductor in the DSSC device is merely to conduct the injected majority charge carriers [1,2] while the minority carriers are carried by the electrolyte [3,4].
In this review, we present an overview on what are Dye-sensitized solar cells (DSSC), how do DSSC work principally and what can be used as sensitizers in DSSC. We also discuss the advantages of DSSC. Finally, we present our view on future prospects in the development of synthetic analogues of vegetable dyes as sensitizers in DSSCs.
What are dye-sensitized solar cells (DSSC)?
Dye-sensitized solar cells (also called Grätzel solar cells) are are dye-sensitised titanium dioxide (TiO_2) photoelectrochemical cells that directly convert solar energy to electrical energy.
DSCC are third generation photovoltaic technology. The technology often described as 'artificial photosynthesis' is a promising alternative to standard silicon photovoltaics. It is made of low cost materials and does not need an elaborate apparatus to manufacture. 'Grätzel cells' use Phthalocyanine an organic dye on top of titanium dioxide (TiO_2) to capture sunlight instead of the traditional silicon approach. Phthalocyanine is an intensely colored macrocyclic compound that is widely used in dyeing industries.
Dye-sensitized solar cells (Source of picture: solaritanano)
DSCC separate light harvesting from charge carrier transport, mimicking the principles of solar energy conversion that natural photosynthesis has successfully adopted over the last 3.5 billion years. We can think plant leaves as tiny factories in which sunlight absorbed in the leaf by chlorophyll converts carbon dioxide and water into oxygen and glucose, providing energy for the plant. In DSCC 'artificial photosynthesis,' the leaf structure is replaced by a porous titanium oxide nanostructure, and the chlorophyll is replaced by dye molecules.
Dye-sensitized solar cells
The timeline of development of the DSCC:
1970 First attempts to construct DSCC.
1988 Grätzel's team tests the first dye-sensitized mesoscopic titanium oxide material on solar cells.
1991 Grätzel's landmark Nature paper on dye-sensitized solar cells is published.
2009 Mass production of DSCC begins.
In TiO_2-based dye-sensitized nanocrystalline solar cells, efficiencies of up to 11% have been obtained using Ru dyes but the limited availability of these dyes together with their undesirable environmental impact have led to the search for cheaper and safer organic based dyes.[1-4]
Plants and bacteria capture solar energy using porphyrin-based chromophores for converting it into chemical energy. The ability to modify and tune the photophysical properties of synthetic porphyrins via the introduction of specific substituents has led to the design and understanding of numerous porphyrin photonic assemblies which mimic photosynthetic solar energy transduction by converting solar energy into chemical potential in the form of long-lived charge separation.[1-5]
1)
2)
(A) How do they look like?
(B) How do they work?
How do they work?
• Sunlight energy (photoelectric effect) strike dye molecules, exciting electrons.
• The excited electrons move through the conduction band of TiO2 up to the conducting plate. Flow of electricity is initiated.
• The dye is regenerated by the Iodide molecule giving up one of its electrons to form triiodide (oxidation occurs).
• The triiodide molecule is reduced back to Iodide by an electron at graphite conducting plate.
Sensitizers of DSSC
Figure 1. Dyes extracted from chlorophylls, anthocyanins, betalaines and carotenoids exhibiting colors covering the entire visible part of the electromagnetic spectrum. In the figure are also shown the pictures of the dyes and the molecular structures of chlorophyll a, cyanin (anthocyanin), betanin (betalain) and cis-norbixin (carotenoid) [6].
Discussion: Advantages of DSSC
Natural dyes and their organic derivatives are ideal candidates for environmentally friendly solar cells, since they are non-toxic, low in cost, renewable and abundant. Thus, the possibility to achieve solar energy conversion exploiting natural dyes has been largely investigated, suggesting a cheap and simple approach based on the chemical and physical processing of these dyes, avoiding any hazardous waste by-products.
In particular, vegetable dyes can be easily extracted from fruit, leaves, flowers and algae, see Figure 1, and used in DSSCs.
DSSCs can be considered an alternative to other PV technologies. Among many different sensitizers used, it would be beneficial to use vegetable dyes because they are more abundant, cheaper and eco-friendly with respect to synthetic metal-complexes and/or organic dyes, the efficiency of DSSCs sensitized by vegetable dyes is still lower than that achieved by the synthetic dyes. The highest efficiency of DSSCs based on vegetable dye extracts, as reported in Figure 2, is still lower than 5% for chlorophyll-based DSSC. Nevertheless, chlorophylls as sensitizers are less expensive than synthetic organic dyes. Thus, in terms of performance/cost ratio, some vegetable-based DSSC, such as those sensitized with chlorophyll, have a potential advantage over synthetic organic DSSCs.
Efficiency, η(%)
Year
Anthocyanins
Betalains
Chlorophyll
Carotenoids
Others
Co-pigments
4.6%
4.2%
3.8%
Figure 2. Progressing solar energy conversion efficiency of vegetable dye based DSSCs from 1997 to 2014.
Conclusions
• Dye sensitized solar cells show similar performance under real life working conditions.
• DSSC capture power in low light or even rainy conditions.
• They are low in cost, and can work on a broad scale.
• Graetzel cells do not require a large setup to manufacture; would be considerably less expensive than standard silicon solar cell designs.
• DSSC are mechanically robust and can be engineered into flexible sheets. They also require no protection from minor elements such as tree strikes or hail.
• DSSC can be prepared on flexible, nonfragile and light weight substrates such as metal sheets or plastic foils.
References

初中組及高中組

參賽項目必須是學生的原創作品，隊伍必須負責查核
其作品所使用的設計是否受版權保護

A 類：發明品

參賽項目必須有實際用途及應用價值

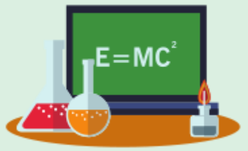
B 類：研究項目

參賽項目必須屬於科學現象的調查或科學理論的應用，並以實驗數據証明其可行性

初中組及高中組

生物學及化學
Biology & Chemistry

可包括化學、化工、自然生態、
生命科學、生物科技、食物科學、
健康科學及醫藥等



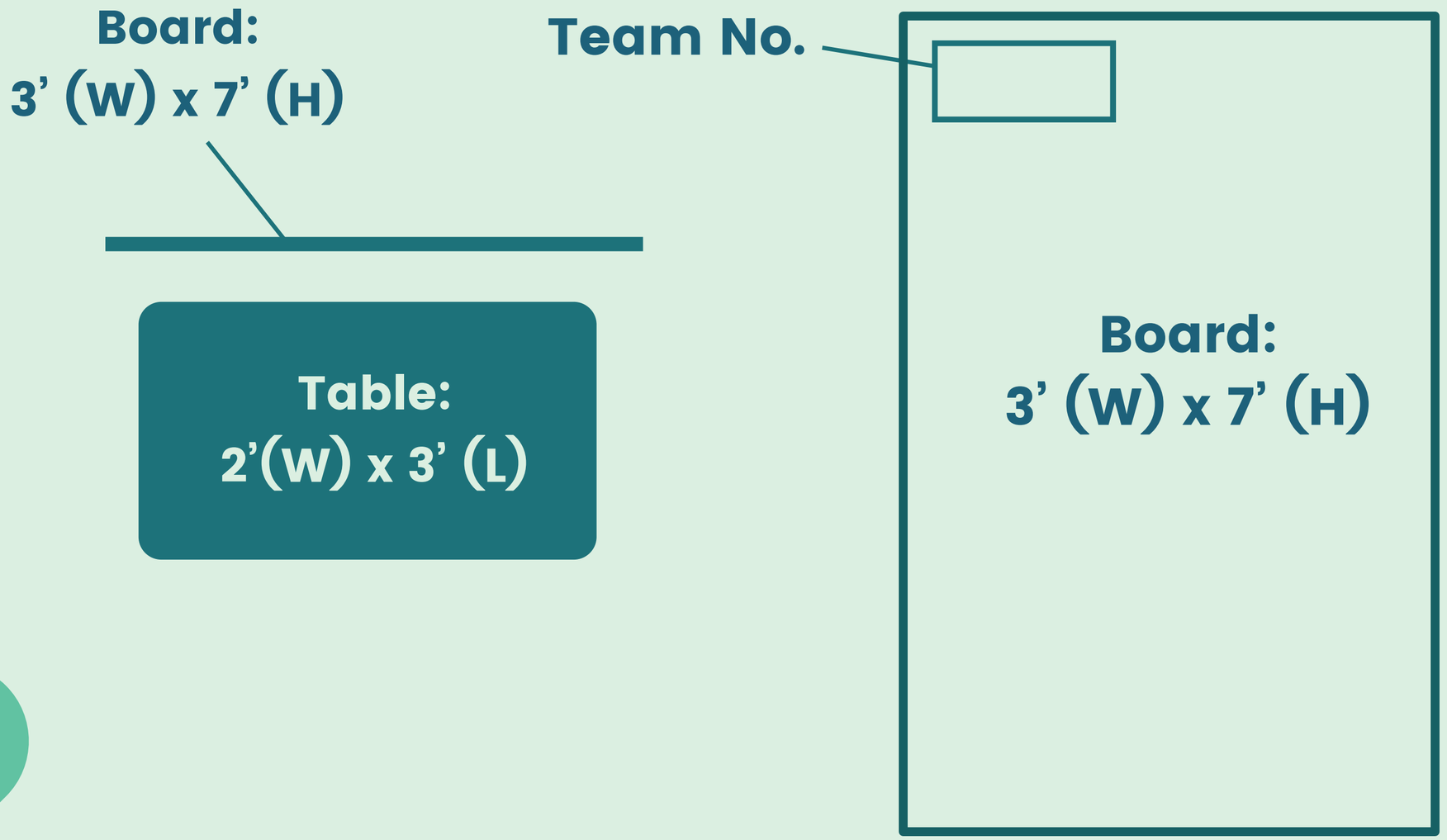
物理及工程科學
Physics & Engineering

物理學、天文學、氣象學、材料
科學、地球科學、環境科學及各
類工程科技（如電子、機械、通
訊、資訊科技、電腦、能源等）

初中組及高中組

1. 作品介紹
2. 報告
3. 參賽發明品 - 於初賽當日展示

初中組及高中組


Board:
3’ (W) x 7’ (H)
Table:
2’(W) x 3’ (L)
Top View
Team No.
Board:
3’ (W) x 7’ (H)
Front View

獎項

科學海報組

一等獎

二等獎

初中組及高中組

- 發明品及研究項目各選出冠、亞、季軍及優異獎
- 冠軍獲資助參與海外交流活動
- 冠、亞、季軍獲資助參與科學及科技交流活動

- 能源、工程及環境大賞
- 社區關懷大賞
- 新秀大賞
- 最具潛質獎

導師角色

- 啓發學生獨立思考
- 激發學生的好奇心
- 引導學生自行研發作品
- 鼓勵學生主動匯報進度
- 提供學術及技術支援

安全守則

無論進行任何實驗或研究，確保安全皆同樣重要，以下網址為教育局的學校實驗室安全守則，所有參賽隊伍必需閱讀並遵守當中指引。

中文版

英文版

重要日子

提名比賽截止日期

2019年11月13日（星期三）

提交參賽作品截止日期

2020年2月26日（星期三）

初賽暨作品展覽

2020年3月21日（星期六）

決賽暨頒獎典禮

2020年4月18日（星期六）

隊伍資助

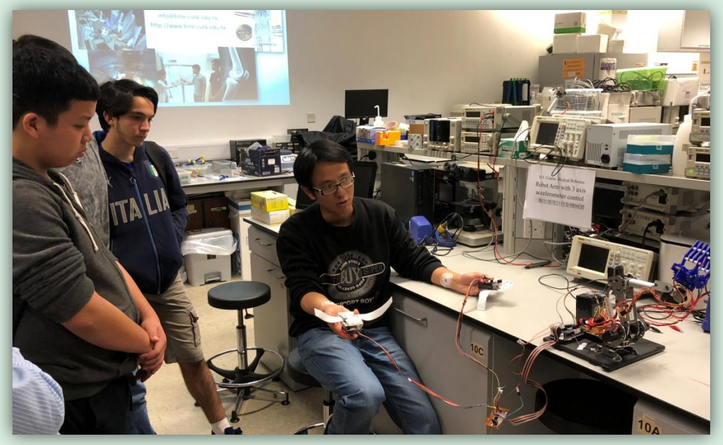
每隊參賽隊伍可獲得港幣200元的資助
只可以用於2020年香港學生科學比賽的參賽作品的製作、進行研究的材料，以及攤位佈置。

- 必須提交參賽作品資助申請表和材料支出申報表
- 不用提交收據

學術支援

顧問分享會

參觀實驗室/科創公司



Buddy Team 招募

- 加強香港學生與國際組海外學生交流
- 歡迎所有對科學有興趣的中四至中六學生參與
- 每隊Buddy Team有2-3名學生及1名老師
- 負責接待海外隊伍及協助發佈大會資訊
- 費用全免
- 必須出席簡介會

Buddy Team 日程

日期	時段	時間	活動
20 Mar 2020 (Fri)	A	4:30pm – 6:00pm	接待海外隊伍和頒獎典禮彩排
21 Mar 2020 (Sat)	B C D	9:00am – 1:00pm 1:00pm – 5:00pm 6:00pm – 9:30pm	協調比賽的安排 頒獎典禮及與海外學生交流 晚餐及文化之夜
22 Mar 2020 (Sun)	E	10:00am – 12:00pm	參觀香港濕地公園

可同時出席A至E五節的Buddy Team優先接納申請

重要日子

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決賽暨頒獎典禮

2020年4月18日（星期六）

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