MyMicroscope: Development of New Techniques for DIY PET Bottle Microscope

Nozomi Hotta
Science & Education Center, Ochanomizu University
2-1-1, Otsuka, Bunkyo-ku, Tokyo 112-8610, Japan

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Abstract

PET bottle microscopes are a useful apparatus for Do-It-Yourself science. However, those currently in use are only for observation for dry samples. To observe samples suspended in water such as *Volvox*, I have improved the microscope called MyMycroscope which is with a spool as the stage and a penlight as the light source. Furthermore, MyMicroscope was introduced in workshops at science fairs and professional developments. The outcome of workshop evaluation implies that the MyMicroscope is a good educational toy to make children aware of the wonders of science.

Introduction

Do-It-Yourself (DIY) science is trying your hand at fun and easy science experiments and activities. There are many science project websites based on DIY such as those of CSIRO (www.csiro.au/diy), Pinterest (www.pinterest.com/natalierodrig/diy-science-projects/) and Do It Yourself Activity Resource Center at Pennsylvania State University (www.sciencecamps.psu.edu/diy-science-activities), etc. They suggest that to explore science concepts and discover the world around us, we can use simple materials found around the home or school. It also implies that we find the underlying importance and complexity of things using cheap, disposable everyday objects from our daily life. Among them, DIY microscopes, telescopes, and kaleidoscopes are incredible tools for visually connecting us to this wonder world (Suzuki, 2013; Cybulski et al, 2014). For example, Cybulski et al. (2014) present paper-based foldable microscopes, named Foldscope, which combine the principles of origami with optical design.

In this article, I introduce a new kind of DIY microscope, made from a polyethylene terephthalate (PET, sometimes PETE) bottle that replicates the design of a light microscope for microscopy of a sample suspended in water. The tool, which I call a MyMicroscope is easily constructed by children (Figure 1A). The important new improvement of techniques are that setting a spool into the lip of the PET bottle as a stage, and a penlight as a light source, makes the MyMicroscope stable and bright enough to observe a sample suspended in water, e.g. one containing *Volvox aureus* (Figure 2A).

In recent years, PET bottle microscopes have been introduced as DIY science projects for children in Japan. For example, the Canon SCIENCE LAB for KIDS (web.canon.jp/technology/kids/experiment/e_05_01.html) and the Japanese Society for Leeuwenhoek (microscopy.jp/leeuwenhoek/petbottle.html). The structure of a light microscope consists of ocular lens, objectives lens, condenser lens, and light source; the PET bottle microscopes have no objective lens or condenser lens （Figure 1B-1）. Using a round-bottomed (soda) PET bottle, they sealed a dry sample on the lip of the bottle with a scotch tape and illuminated the sample with natural light. Therefore, it was necessary to raise or hold the PET bottle microscope up toward the light (Figure 1B-2). However, the PET bottle microscope designs I mentioned above either required children to expose the lens to direct sunlight or were impossibly challenging for samples suspended in water. Moreover, because of their small size, the 2mm glass beads used in PET bottle microscope did not allow sufficient distance between the lens and the eye. Eyelashes touched the surface of the lenses every time (Figure 2B). The MyMicroscope I describe herein addresses these issues.

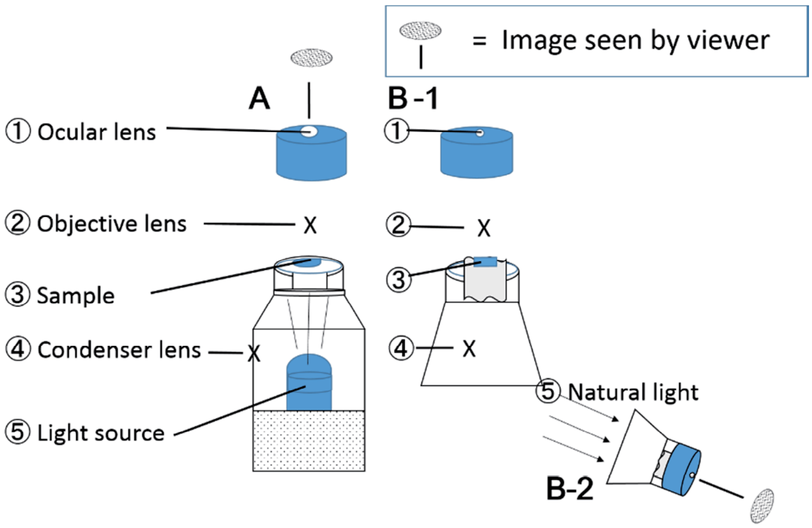


Figure 1. Structure of the MyMicroscope (A) and the PET bottle microscope (B-1) (B-2).

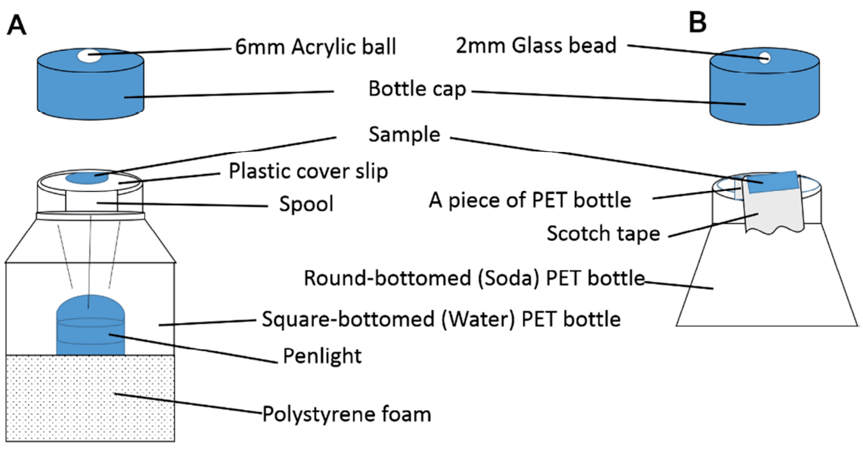


Figure 2. Design of the MyMicroscope (A) and the PET bottle microscope (B).

Materials and methods

Materials

Square-bottomed (water) PET bottle with cap, Polystyrene foam (50mm x 50mm x 20mm), AAA battery, silicone sheet, scotch tape, vinyl tape, drill and 5 mm drill bit

Ball lenses. The 6mm acrylic ball is PMMA (Polymethyl-methacrylate) from Sato Tekkou (Specific gravity: 1.2 g/cc, Hardness: M100, Visible transmission: 93%, Refractive index: 1.49)

Spools. Daiso Japan (Model 494519405824)

Plastic cover slip. ASONE (Model 12-547, PVC, Size 22x22mm, Thickness 0.17~0.25)

Penlights. Daiso Japan (Model 4993420750104, Sizspecie 23x83mm [φx H], miniature ball 1.2V, 0.22A)

Construction of MyMicroscope

Lens and lens holder. A hole in the center of the PET bottle cap was made using a drill and the acrylic ball placed into the hole (Figure 3A).

Assemble of the base. The base of the bottle was cut off approximately 6-7 cm from the bottom by the scissors (Figure 3B). The polystyrene was cut to size and placed inside the base of the bottle. A hole was cut in the center of the polystyrene and the penlight was placed upright in the hole.-If the penlight was not in tight enough, it was secured with scotch tape (Figure 3C).

Stage. The plastic cover slip was cut into a circle using the spool as a template (Figure 3D). The penlight was turned on. The top half of the PET bottle was placed into the bottom half of the PET bottle over the penlight (Figure 3E). The spool was placed into the lip of the PET bottle. Any spaces between the spool and bottle were covered by vinyl tape. The plastic cover slip was placed on top of the spool (Figure 3F). The item to be examined was placed on top in the middle where the light shone through the hole in the spool

Dry sample: Lily pollen and a salt crystal. Some pollen or a salt crystal were put on a piece of scotch tape which was stuck onto the plastic cover slip (Figure A).

Fluid sample: Plankton in water (Volvox aureus). To examine a fluid, first the silicone sheet was put on top of the plastic cover slip (Figure 4B). An eyedropper container of Volvox in the water was hold upside down for 10 seconds. Once the Volvox particles sank to the bottom, one drop was placed onto the silicone sheet in which a hole had been made (Figure 4C).

Examination. The PET bottle cap was gently placed on top (Figure 4D). The sample was examined by looking through the acrylic ball (Figure 4E). Furthermore, the bottle could be decorated to personalize the MyMicroscope (Figure 4F).

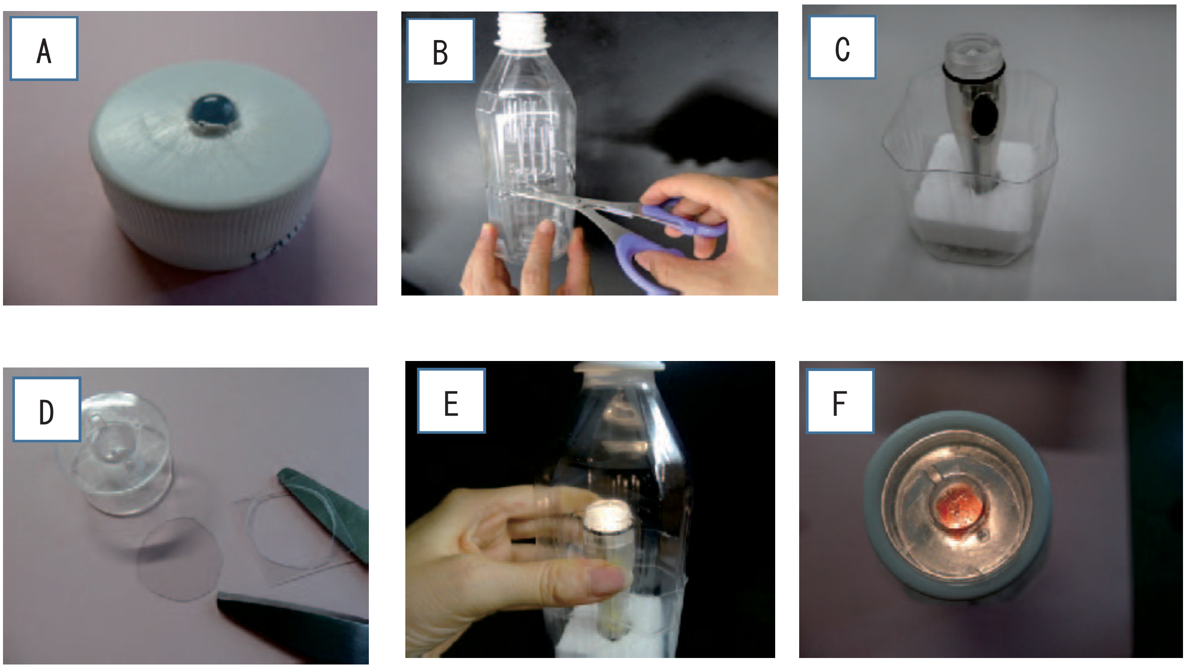


Figure 3. Notes on assembly operation. (A) Acrylic ball placed into the hole. (B) Position for cutting off the base of the bottle. (C) Position of the penlight. (D) The plastic cover slip cut. (E) The top half of the PET bottle fitting into the bottom half. (F) Position of the plastic cover slip.

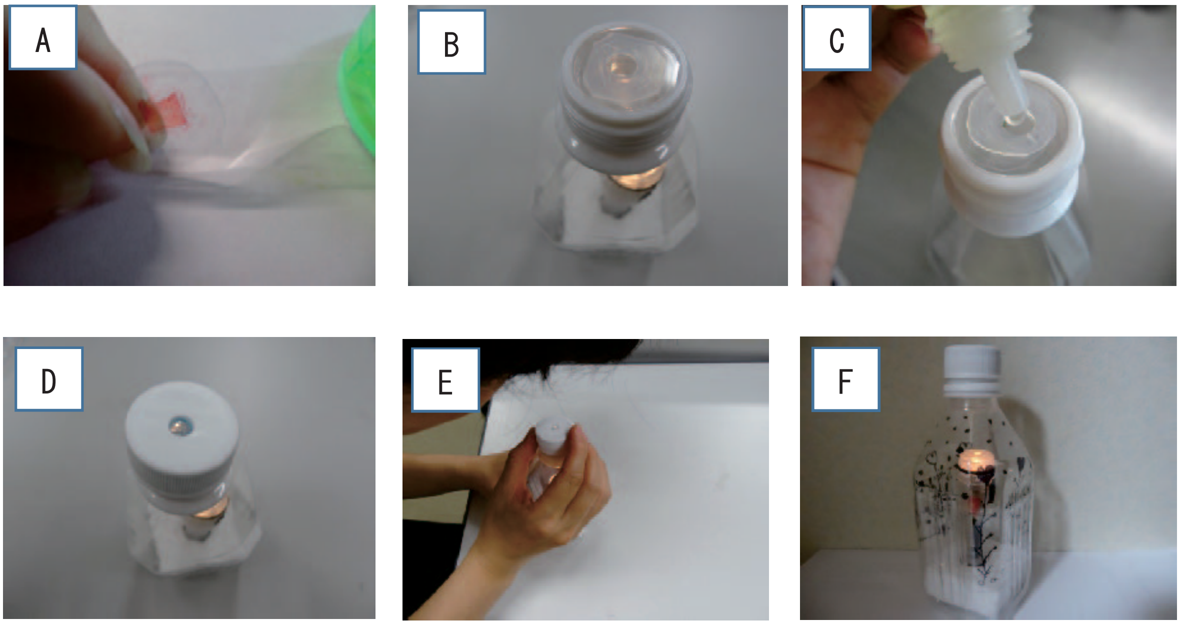


Figure 4. Notes on examination of samples. (A) The dry sample on a piece of scotch tape. (B) The silicone sheet on the top of the plastic cover slip for examining a fluid. (C) The fluid sample at the center. (D) PET bottle cap on top. (E) The sample examination. (F) The bottle decorated for fun

Results and Discussion

MyMicroscope observation

Lily pollen and a salt crystal, and Plankton in water *(Volvox aureus)* were chosen for MyMicroscope observation of the samples. The resulting MyMicroscope images of dry samples and a sample suspended in water are shown in Figures 5 & 6. In comparing observations without a microscope and MyMicroscope, the exact magnification was unknown, however, the MyMicroscope image was obviously a few times larger. Doing similar experiments using fluid samples with a silicone sheet allowed us to notice *Volvox aureus'* responses to surface tension and spinning in our field of view.

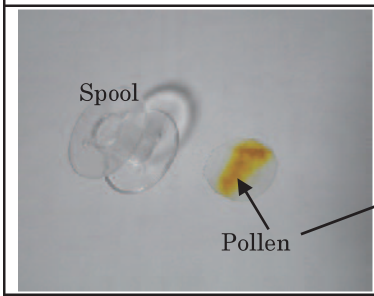
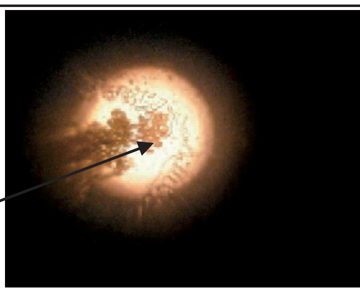
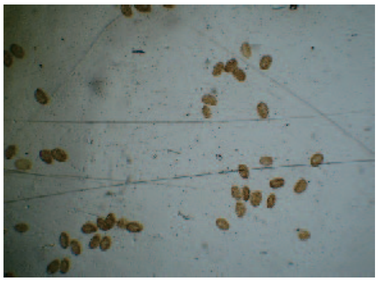
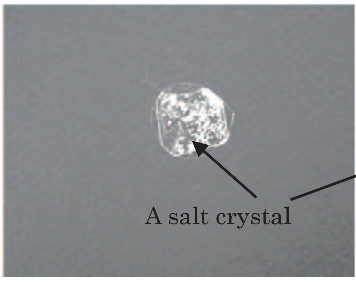
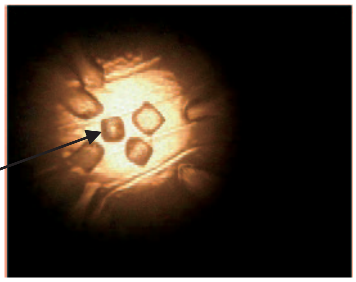
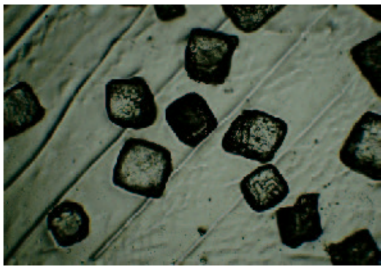
Without a microscope	MyMicroscope	Light microscope (40X)
		
Lily pollen covered by scotch tape		
		
A salt crystal covered by schotch tape		

Figure 5. Images of the dry sample through without a microscope, MyMicroscope and light microscope

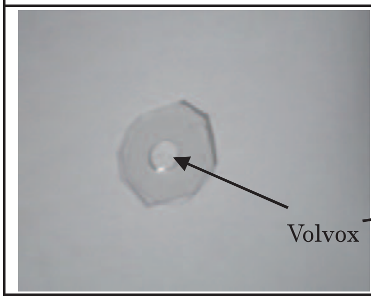
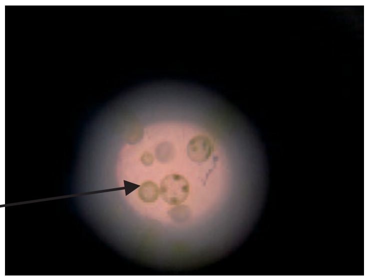
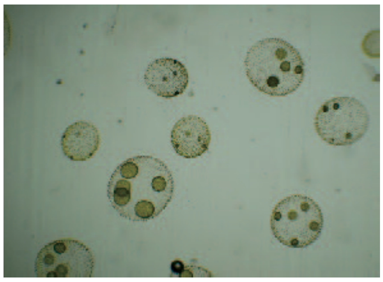
Without a microscope	MyMicroscope	Light microscope (40X)
		
Volvox aureus on silicone sheet		

Figure 6. Images of the sample suspended in water through without a microscope, MyMicroscope and light microscope

Workshop Evaluation

MyMicroscope was introduced in workshops at science fairs and professional developments (Table 1). A total of 150 children (grades 1~6) and 30 adults in three districts participated in the workshops at science fairs between July 25, 2014 and July 22, 2015.

Table 1. Schedule of the practice

Group	Members	Workshop type and date		Place
No.1	60 elementary school children	July 25, 2014	Science fair (Limited to first come first served)	Toda City, Saitama
No.2	60 elementary school children	August 7, 2014	Science fair (Limited to first come first served)	Miyako City, Iwate
No.3	20 public elementary school teachers	August 21, 2014 15:50~16:50 ① Making PET bottle car 30min ② Making MyMicroscope 30min	Professional development	A public elementary school, Saitama
No.4	30 children (grades 1~6) and 30 adults	July 22, 2015 ① 13:30~14:30 (15 groups of children and parents) ② 14:45~15:45(15 groups of children and parents)	Science fair (pre-registration)	Bunkyo-ku, Tokyo


Figure 7 . Photos during workshop. Toda City (Left) Miyako City (Right)

Regarding the response of the participants in science fairs, the investigation was conducted through the workshop sponsor on July 22 in Bukyo-ku, Tokyo. Among the 30 children and their parents, 29 responded to a questionnaire from the workshop sponsor. 20 were first or second graders supported by their parents, and 9 were third to sixth graders working by themselves. All of the children reported that they enjoyed making a microscope from a PET bottle and that the process was easily understood.

In the workshops for professional development, a leaflet of MyMicroscope was distributed to the teachers (See Appendix 1) and 20 elementary school teachers completed the questionnaires (See Appendix 2). The workshop was divided into a first half of training for a PET car (Approximately 30 minutes) and second half for MyMicroscope (Approximately 30 minutes). With the leaflet as a guide, the teachers constructed the MyMicroscope and observed dry samples and a sample suspended in water. After the workshop, a survey with the following open-ended questions was conducted to determine teachers' conception of making the MyMicroscope (approximately 5 minutes).

1) What is your current teaching level?
2) Do you understand of the content?
3) What is your impression of the content?

Among the 20 teachers, eight are currently teaching grade 1 or 2, five are teaching grade 3 or 4, and seven are teaching grade 5 or 6. All participants understood the mechanism of the MyMicroscope. Most teachers' written responses emphasized the positive impact of the workshop. First, teachers indicated that making the tool is enjoyable.

> *I did not think it was possible to make such an amazing device with such common, everyday items* [Grade 1 teacher].
> *I think after making one and using it, some children will be inspired to create new inventions* [Grade 2 teacher].

Second, teachers had positive views about teaching MyMicroscope.

> *Previously, the idea of teaching science made me uneasy. But now, I want to see children have as much fun as I did! I want to try to teach this!* [Grade 2 teacher]
> *It was quick to make and samples looked as if they were examined under a real microscope. I think the whole process makes for good educational material for children* [Grade 3 teacher].

Third, making a tool gave the impression that teachers want their students to try it.

> *I want to show children how to make the microscope in class. I really was so surprised at how well it functions. It was so successful that it made me feel like sharing my impression with others* [Grade 1 teacher].
> *I was impressed that I could see microorganisms with a microscope I made myself* [Grade 4 teacher].

Many comments expressed such impressions as “so surprised” and “amazed”. The findings of this study imply that a MyMicroscope is a good educational toy to make children aware of the wonders of science. The findings of this study suggest teachers will gain the desire to tell their impression of observations to their students through making a MyMicroscope. Just as the teacher demonstrates how to make a microscope out of a PET bottle as an educational toy, children feel the wonder of science for pleasure. Nevertheless, this study has limitations, including limited sampling and lack of data from children under teachers’ instruction.

Conclusion

The previous PET bottle microscope was not for samples suspended in water; however, MyMicroscope solved this issue and opens new PET bottle microscopy world where we can observe suspended in water, e.g. one containing *Volvox aureus*. As for the DIY PET bottle microscope overall, this educational toy may provide motivational and experiential links between everyday experiences and the science world for teachers and students alike. Furthermore, with the outcome of workshop evaluation, this study has led me to think that MyMicroscope can be introduced through teachers’ demonstrations in first and second grade classes as an educational toy; and for third to sixth graders it can be used as a science educational instrument with students making it themselves in school.

Acknowledgements

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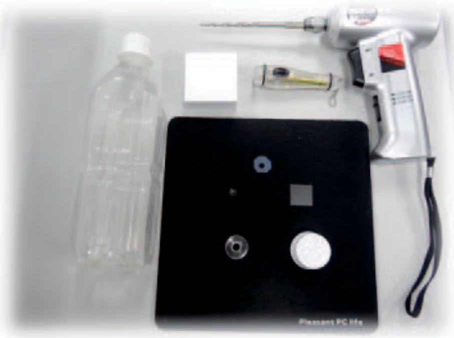
Appendix 1.

ペットボトル顕微鏡のつくり方

① 顕微鏡作成の材料の確認をします。
角型のペットボトル、炭酸用ペットボトルキャップ、
発泡スチロール、ミニサイズの懐中電灯、
（懐中電灯用単４乾電池）
アクリル球（６㎜）ボビン、カバーガラス、
シリコンシート
（ペットボトル用はさみ、工作用はさみ、５㎜ドリル刃、ドリル）

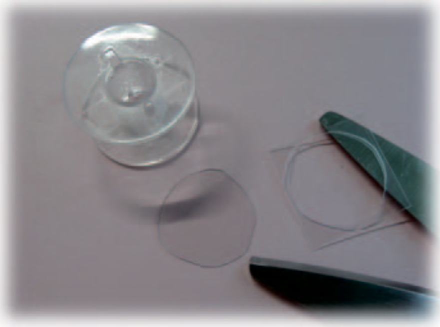


② 炭酸用のペットボトルキャップの中央に
ドリルで穴を開け、アクリル球を埋め込みます。
*本日の研修ではアクリル球は
すでに埋め込まれています。

③ ペットボトルは下から約６～７㎝のところを
ペットボトル用はさみでカットします。

④　発泡スチロールの真ん中にはさみで穴をあけ、懐中電灯をさし込みます。
（懐中電灯がぐらぐらするときには、セロテープで固定します）

⑤　カバーガラスをボビンより一回り小さいサイズにカットします。

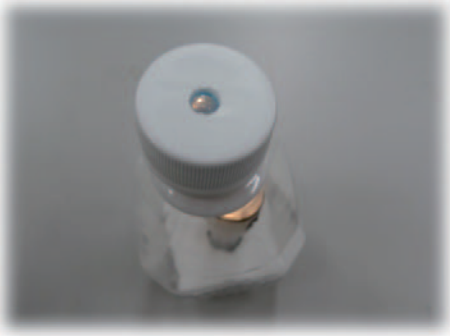


⑥　懐中電灯のスイッチを入れ、点灯します。
ペットボトルの上部分をへこませて
下部分に重ねていれます。

⑦　ペットボトルの上部の飲み口にボビンをセットします。ボビンの隙間はビニールテープで埋めます。ボビンの上に、カバーガラスをのせ、ボビンの穴から光のあたる中央に、観察試料をおきます。

⑧　液体の試料の場合には、カバーガラスをのせてから、シリコンシートを載せ、中央の光の当たるところに液を落とします。

⑨　静かにペットボトルのふたを載せます。



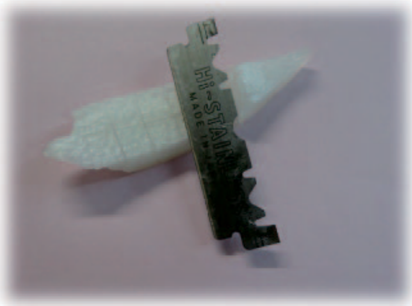
⑩　アクリル球をのぞいて、観察します。

⑪　子どもたちには好きなイラストを描いてもらうなど、オリジナルな顕微鏡づくりを楽しんでもらいたいと思います。

ペットボトル顕微鏡での観察試料作り

＜液状（ボルボックス）の観察方法＞
カバーガラスで作ったスライドガラスをセットし、
その上にシリコンシートを載せます。
点眼容器に入ったボルボックスの液はスポイト部分を
下にして１０秒ほど待ちます。
ボルボックスが沈澱してきたところで、
１滴をシリコンシートの穴部分に垂らします。

＜試料の作り方と染色＞
①　観察する試料の準備をします。タマネギから
５㎜四方の表皮をはがし、酢酸カーミンで
染めます。



②　染めた表皮はカバーガラスにのせ、
セロハンテープで上から押さえます。
（髪の毛も同様の方法で行います）

③　花粉はセロテープに付着させてから
カバーガラスに貼ります。

Appendix 2.

★ア　ン　ケ　ー　ト★

担当学年（　　　　　）　教職歴（　　　　　）　現在の得意分野（　　　　）

<u>今日の研修について</u>

１．ペットボトルカー

内容について　　　　（理解できた・理解できなかった）

もし、ご自身が小学校３年生にこの授業を行うとしたら・・・どのようなことが考えられますか。

２．ペットボトル顕微鏡

内容について　　　　（理解できた・理解できなかった）

今、思い浮かべられたことをご自由にお書きください。

３．その他ご意見・ご要望等ありましたら、裏にお書きください。

—ご協力ありがとうございました—