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Research Article

Science teaching for school students – Simple innovative experiments on Paramecium

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Abstract

Innovative teaching (of Science) is the process of implementation of new methods, tools and contents which benefit learners, leads to creative and self learning and promotes learning to learn. In this context, the present study aims to design and propose a group of innovative, improvised and relatively low-cost experiments for the school students (IX-XII class) to study the behavioral response of Paramecium to various stimuli. A critical review is made on the studies which made an effort to explain the behavioral responses of Paramecium to various environmental stimuli. Paramecium is a genus of unicellular ciliated protozoa, commonly studied as a representative organism of the ciliate group; some species are readily cultivated and used in laboratories to study its' biological processes.

In the present study, Paramecia are cultured by 'hay infusion' method with the use of hay and rice grains. Simple experimental setups are designed by using low-cost materials like black paper, thermo coal piece, sponge, battery cells, micro-slide etc. To study the chemo, photo, thermo, electro and magnetotaxic behavior of Paramecium. The effectiveness of these experiments was also tested with I semester B.Sc. Ed students of RIE Mysore. Since the very basic aim of Science Education is that the learner not only should learn the concepts of Science, but also the method and the process of it, we strongly believe that the present newly designed simple experiments will definitely help to stimulate such ability of learning to learn. It will also give an insight to the learners to improvise/design such experiments for other organisms. In addition, because of its' simplicity, relatively low-cost, attractive and innovativeness, we happily and confidently propose these experiments for the school students (IX-XII class) to achieve the valuable aims of Science Teaching.

Keywords : IX - XII class school students, Paramecium, environmental stimuli, hay infusion and behaviour

Introduction

Science is the systematic knowledge of the physical or material world gained through observation and experimentation. Children learn science by being involved not only with its content, but also with its methodology; hence effective science teaching should accommodate both. The field concerned with the process of sharing of scientific content with learners is the Science Education. The position paper of NCERT (2006) clearly states the aims of Science Education as; it should enable the learner to know the facts and principles of science and its applications, understand the methods and processes of science, develop a historical perspective of science, relate science to the environment, acquire the requisite theoretical knowledge and practical technological skills, nurture the natural curiosity and creativity, imbibe the values and cultivate scientific temper. To achieve such valuable aims innovative and

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creative teaching practices are vital. Innovative teaching (of Science) is the process of implementation of new methods, tools and contents which benefits learners, leads to creative and self learning, promotes learning to learn and develops lifelong learning skills and competences. In this context, the present study aims to design and propose a group of innovative, improvised and relatively low-cost experiments for the school students (IX-XII class) to study the behavioral responses of Paramecium to various stimuli.

What is Paramecium?

Paramecium is a genus of unicellular ciliated protozoa, commonly studied as a representative organism of the ciliate group. Paramecia are widespread in freshwater, brackish and marine environments and are often very abundant in stagnant basins and ponds. Paramecia propel themselves by whiplash movements of their cilia with fast "effective stroke" and slow "recovery stroke". It can live and reproduce (by conjugation and binary fission) under variable conditions of the external environment and has a highly developed capacity of motor response towards chemical, mechanical, photic, thermal, electric, and gravitational stimuli. The relatively high rate of swimming of the organism and the perception of chemical stimuli ahead of it provide additional advantages for finding favorable living conditions and for avoiding noxious effects in the surrounding medium. Because, some species are readily cultivated in the lab to study its' biological processes.

Glancing through past research studies on behavioral assay in Paramecium

Behavior may be defined as the tendency of an organism to make a complex and specific response to environmental stimuli without involving reason (Hallberg and Leif, 2008). There are studies which made an effort to explain the behavioral responses of Paramecium to various environmental stimuli. With reference to chemotaxis of Paramecium, Judith (1978) observed two mechanisms (accumulate in or disperse from the vicinity of chemicals) of chemotaxis in Paramecium. Kung and Saimi (1982) enlightened the physiological basis of taxes in Paramecium, and Masaaki *et al.* (2003) reported that hypo-osmotic or Ca^{2+}-rich external conditions trigger extra contractile vacuole complex generation in *Paramecium multimicronucleatum*. Brehm and Eckert (1978) noted the entry of calcium leads to inactivation of calcium channel in Paramecium. Further, Noboru *et al.* (2002) studied the behavioral responses of *Paramecium caudatum* to 2,4-dichloro phenoxyacetic acid and its analogues and found that the avoiding reactions allowed *Paramecium caudatum* to escape from the harm caused by this herbicide. Judith (1977) observed that a mutant of Paramecium was defective in chemotaxis, Dryl (1963) stated that, Paramecia showed a more or less typical "avoiding reaction" towards pH changes of the medium and to many other chemotactic stimuli, such as NaCl, $CaCl_2$, $MgCl_2$. Apart from these, Gregory *et al.* (1983) noted the possible ecological significance of chemotaxis in certain other ciliated protozoa.

In the case of phototaxis, Matsuoka and Nakaoka (1988) reported that, *Paramecium bursaria* showed phototaxis by accumulating in a lighted region and a step-increase in light intensity induces the steady depolarization and causes the decrease in swimming velocity, resulting in the accumulation of cells in the lighted region. Circadian changes in behaviour and electrical properties of the membrane were investigated in *Paramecium bursaria* by Nakajima and Nakaoka (1989) and found that both photo accumulation and swimming velocity were at a higher level during the day than at night. Saji and Oosawa (1974) analyzed the mechanism of photo accumulation in *Paramecium bursaria* and found that resting Paramecia showed direction changing response (photophobic response) to a sudden decrease of light intensity, whereas no response was shown to an increase in intensity.

Further, Tawada and Miyamoto (1973) concluded that *Paramecium caudatum* detects temperature changes by locomotion through space and thus exhibits thermotaxis, provided the rate of change is >0.055 C/sec. Very little is known about the influence of magnetic fields on growth of primitive eukaryotes such as the ciliate Paramecium. However, Khouaildi and Danny (2006) made a preliminary study and suggested that magnetic fields, irrespective of polarity and the exposure period reduce Paramecium growth by triggering early senescence of the population and Armus *et al.* (2006) found that *Paramecium caudatum* may be trained through the application of a 6.5 volt electrical current to discriminate between brightness levels.

In addition, Yutaka and Roger (1969) found the ionic mechanisms controlling behavioral responses of Paramecium to mechanical stimulation and Nagel and Machemer (2000) investigated the physical and physiological components of the graviresponses of wild-type and mutant *Paramecium tetraurelia*. Furthermore, Saimi and Kung (1987) studied the behavioral genetics of Paramecium. Murakami *et al.* (1999) found that, the swimming behavior of Paramecium is affected by media of various specific gravities.

Materials and methods

For doing this experiment following materials are required: conical flask (250ml), hay, rice, distilled water, microslides, black polythene sheets, acidic, alkaline and saline solutions, colored (red, green, yellow etc.) transparent sheets, 1.5V battery cells, bar magnets and stove.

Preparation of culture medium

Take 200ml of distilled water in a 250ml conical flask and add 10 pieces of hay and 4 rice grains. Boil it on a stove till it reaches straw /pale-yellow colored solution. After 24 hrs inoculate with a few drops of pond water which contains paramecium and keep the flask in a dark place. After 10 days, the culture medium will be with, full of Paramecium.

Conducting experiments/ behavioral assay

The effect of various chemicals, light, temperature, voltage and magnet on behavior of Paramecium can be assayed/ studied individually by the following procedures.

Assay of chemotaxic behavior of Paramecium

Place a black-PVC sheet on a dissection microscope and arrange four clean micro slides on it. On left side of each slide place one or two drops of culture medium. On the right side of first slide add 1 or 2 drops on control medium (i.e. culture medium without Paramecium). Place 1 or 2 drops of low (0.5%), medium (1%) and high (2%) acidic (acetic acid) solution on 2nd, 3rd and 4th slides respectively. Using a needle connects the culture medium with respective experimental solution in the form of a narrow bridge. Periodically (10, 20 anf 30min) observe the movement of Paramecium and record your observation (With black background Paramecia are seen as white particle moving in the solution). Similar setup can be arranged for simultaneously to study the effects of alkalinity (KoH) and salinity (NaCl) (Fig.-1).

Fig.-1. Chemotaxic behavior of Paramecium

Assay of phototaxic behavior of Paramecium

Like the previous experiment, place four slides on a black sheet and spread culture medium equally on each slide. Leave the first as control and on second place a black paper folding/cup to cover half (right) of the slide/ medium. On the third slide place similar paper folding which has a hole fitted with red colored transparent PVC sheet. In such setup half (left) of the slide /medium is exposed to light and the other half (right) is in dark or in colored light. After 1hr observe where the Paramecia are accumulated and record your observation (Fig.-2)

Assay of thermotaxic behavior of Paramecium

Arrange three slides on a black PVC sheet which is kept on dissection microscope. Below each slide at the left side keep a cubical ($2cm^3$) thermo-coal piece and at the right side keep cubical ($2cm^3$) sponge. Spread culture medium almost to the entire slide. The first slide is treated as control i.e. at room temperature (30°C). In the second slide periodically add warm water of 40°C to the sponge and similarly add cold water (20°C) to the sponge of third slide. Such setup maintains 10°C variation (more/ less) in temperature at the right half of the slide or medium. After 20 or 30 min observe and record the movement or accumulation of Paramecia (Fig.-3).

Assay of electrotaxic behavior of Paramecium

Keep a slide on a black sheet and spread the medium. Take 1.5V battery cell connects/ fix two pieces of wire to +ve and -ve sides. Hold these +ve and -ve poles of the wire at the left and right ends of the culture medium and observe. After some time reverse the poles, observe the movement or the accumulation of Paramecia and record your observation (Fig.-4).

Assay of magnetotaxic behavior of Paramecium

Like to the above experiment spread the culture medium on a slide and keep south and north poles of a bar magnet under left and right side of the slide. Observe the movement or accumulation of Paramecia and record your observation. Later reverse the pole and record your observation (Fig.-5).

Results

From the above observation, it may be interpreted that, if Paramecia are accumulated or

Fig.-2. Assay of phototaxic behavior of Paramecium

Fig.-3. Assay of thermotaxic behavior of Paramecium

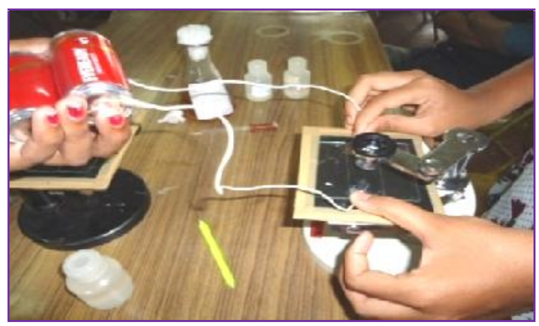

Fig.-4. Assay of electrotaxic behavior of Paramecium

Fig,-5. Assay of magnetotaxic behavior of Parameciumc

moves towards the stimulus which are kept at the right side of the slide i.e. acidic, alkaline and saline medium, light, cold or warm water and magnetic field, then it may be interpreted as positive response/behavior of Paramecium otherwise negative. Further, these behavioral patterns can be discussed in the light of its' ecological and physiological significance.

Conclusion

Since the very basic aim of Science Education is that the learner not only should learn the concepts of Science, but also the method and the process of it, we strongly believe that the present newly designed simple experiments will definitely help to stimulate such ability of learning to learn. It will also give an insight to the learners to improvise/design such experiments for other organisms. In addition, because of its' simplicity, relatively low-cost, attractive and innovativeness, we happily and confidently propose these experiments for the school students (IX-XII class) to achieve the valuable aims of Science Teaching. Further, this view was accepted by many pre-service teachers.

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