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Report on the MiSAC Annual Competition 2023

Microbes and the Water Cycle

Sponsored by Thames Water

The aim of the 35th MiSAC Annual Competition was to increase an understanding among teenagers of the key roles of microbes in the water cycle. The requirements maintained the well-established approach of basing the competition on a topic that is associated with school curricula but with specifications that require students to explore material beyond the curriculum. It was evident that students had enjoyed researching the topic and demonstrated their enthusiasm in producing an illustrative web-page report in a variety of imaginative ways.

We welcomed back entries from regular school participants, though the number of newcomers to the competition was less than in previous years. As usual, there were two entry groups, KS3 and KS4 (S1/2 and S3/4 in Scotland). Entries were received from **58** establishments in England, Wales, Scotland & Northern Ireland and from France; 10 schools submitted entries to both entry groups. In total, there were 291 separate entries consisting of **201** in the KS3 (S1/2) group and **90** at KS4 (S3/4). Many participants took the opportunity to work together in groups of up to 4, making a total of **510** students having entered the competition. MiSAC would like to thank teachers for providing information on the entry form about how they heard of the competition; it is useful to us in that it helps us target efficient publicity of the competition for subsequent years. Judging, which took place at the University of Reading, was again hosted by the NCBE, one of MiSAC's sponsors. The judging panel consisted of Emeritus Professor Anthony Whalley, Liverpool John Moores University, Dr Fiona Lane, Head of the NCBE and Stephen Bullock, Microbiology Manager of Thames Water, together with officers of MiSAC.

The requirement was to produce information for an illustrated, web-page report explaining to teenagers the importance of microbial activities in the water cycle and processes involved in reusing water supplies. The report had to include a brief outline of the main features of the natural water cycle; a labelled illustration was sufficient. Students then had to explain how the activities of microbes involved in the cycling of water had either a beneficial or a detrimental effect - on water quality and/or to humans and other animals. They had to identify these microbes (ie, protozoa, bacteria, algae, etc), where possible giving their scientific names, and also describe where they are found in different stages of the water cycle and associated water treatments. **A table, describing microbial activities, summarises these beneficial/detrimental effects and is included at the end of this report.**

Students who produced the most-effective web-page reports carefully studied the different stages of the water cycle/water-treatment processes. They identified where different microbes were actively involved and explained how their actions contributed to purifying the water, had harmful effects in eutrophicated water and identified beneficial activities for humans and other animals. However, there was a substantial number of entries which made no attempt to outline the water cycle. Some students concentrated *solely* on describing the natural water cycle and failed to discuss microbial activities at all. Others presented meticulously-labelled diagrams of protozoa, algae and bacteria but did not offer any insights into how these microbes were involved in improving or harming water quality. Students regularly focused on pathogenic microbes, often producing lists of the diseases they cause, but some did not attempt to link their activities to the water cycle or to aspects of sewage treatment.

Many students demonstrated that they have learned how to write correctly genus and species names, such as *Pseudomonas syringae*, using an italic font and the appropriate initial letters of each word - but this skill has not always become habitual. Some students used an italic font to type all microbe names and then underlined these names as well, which is only required if the words are hand written. However, for a number of their students, teachers must continue to emphasise how microorganisms are to be correctly named when typed or hand written. Judges commented on examples they had encountered of "a bacteria" or even "the bacteriums".

The competition entry had to be printed on one **A3 sheet** (or two A4 pages attached side-by-side), *using only one side of the paper* and could be prepared either by computer or by hand. Most entries were of the required format but students who choose to write material on the ***reverse*** of their entry should be discouraged from this practice. (The material on the reverse was usually a list of sources used in the student's researches - an admirable feature which all students should consider including, but it should be placed where it can be seen!) Similarly, students who expanded the available surface area by creating a series of flaps which the reader had to lift, should be told that these are *not* recommended.

The creation of a well-designed, eye-catching, illustrated entry is not an easy task. The 2023 cohort of prize winners, and those students who gained a commendation for their entries, are to be congratulated for the high standards they achieved. There were also many exceptional entries that just failed to gain sufficient credit for an award. The biggest challenge is deciding on the right amount of textual information to include, whilst allowing sufficient space for attractive illustrations to produce an entry which has an immediate and visual impact. In their online searches, many students found a great deal of useful and interesting information. Some felt compelled to communicate everything they had learned. Inevitably, this resulted in the use of a smaller font to fit in all the information and the reduction of Illustrations, in size and number. Students should also be restrained in their choice of colours for their entries; multiple-background shades and too many different coloured fonts for the overlaid text make the information extremely difficult to read.

The judges were again impressed by the imagination and creativity of the students as they set about producing their entries. Many showed remarkable technical skills in using their computer to design their submission. A pair of collaborating students showed their technological initiative by incorporating a QR code which actually worked with a smartphone to connect to URLs giving further information. Those who chose to work by hand could also achieve great results. Some schools integrate the MiSAC competition into their science curriculum; teachers tell us of the pride of their students in the work that they do in producing their entries.

We should like to thank teachers for responding to the request to record full identification details on the back of each entry which eases the administration of several hundred entries, many involving more than one student. Only one aspect sometimes causes problems: our ability to decipher teachers' hand writing of *their e-mail addresses* and in the *spelling of their students' names*. The latter is particularly important in the production of students' certificates of entry, by which we acknowledge their contribution to this competition. We would also again thank teachers for their support of the competition. A total of £1415.00 was awarded to prize winners and their establishments, and several entries gained a high commendation for their design or content.

Winning and commended entries are displayed on the MiSAC web site www.misac.org.uk, which includes a list of the prize-winning students and their schools. MiSAC thanks the students for making the competition a success and their teachers for their support. We look forward to entries for the next MiSAC competition in 2024, which will explore the microbes causing various tropical diseases, sponsored by the Wellcome Centre for Integrative Parasitology.

Microbial activities in the water cycle and associated water treatments

Beneficial	**Detrimental**	**Location**
Aerobic bacteria and protozoa in activated sludge aeration lanes / filter-bed biofilm layers reduce organic/inorganic pollution.	Aerobic bacteria in water courses degrade dead algae/ plankton which initially bloom in eutrophicated water, depleting dissolved O_2, causing death of fish + other animals.	Sewage works aeration lanes/filter beds. Eutrophicated lakes/reservoirs.
-	Faecal-oral pathogenic bacteria, viruses and protozoa in untreated sewage/contaminated drinking or recreational waters, eg, *Escherichia coli, poliovirus, Cryptosporidium, Giardia.*	Rivers etc destined for drinking water/ recreation that receive agricultural run-off, treated/untreated sewage effluent and storm water.
Pseudomonas syringae: a biological ice nucleator helping to produce rain; relevant in drought conditions.	*Pseudomonas syringae*: a biological ice nucleator helping to produce rain; relevant to flooding during wet periods.	Cloud layer.
-	Toxin-producing algal blooms in water courses that have become eutrophicated because of excess nitrate/phosphate.	Eutrophicated lakes, reservoirs, etc destined for drinking/recreation.
Removal of ammonia by nitrification (ammonia –> nitrites –> nitrates) promoted by aerobic *Nitrosomonas, Nitrobacter/Nitrospira* spp.	-	Aeration lanes/filter beds in sewage works.
Removal of nitrate by denitrification under anoxic conditions by bacteria (*Pseudomonas denitrificans*) with release of N_2.	-	Activated sludge/sand filters/wetland lagoons in sewage works.
Anaerobic bacteria *(Methanobacterium* spp) in settled sludge held in closed, warmed ferment-ation tanks produce biogas (CH_4 + CO_2) from which electricity is generated. Digested sludge is suitable for use as a fertilizer on farmland.	-	Fermenters in large sewage works.
The flocculation of solids from treated sewage (settled sludge) occurs in settlement tanks to provide a clear effluent for discharge. This process is enhanced by protozoa (eg *Vorticella* spp.) which also clarify the supernatant layer by digesting suspended bacteria.	Rising sludge, that has settled out in a settlement tank, floats into the clear supernatant layer having been buoyed by bubbles of N_2 from denitrification or CH_4 + CO_2 from other anaerobic bacteria.	Sewage works settlement tanks.
Quality of sewage before and after treatment may be assessed by the BOD test which measures the amount of O_2 used by naturally-present microbes in a sample incubated under standard conditions.	-	Sewage works laboratory.
Assessment of the legal suitability of water for drinking includes measuring the number of faecal-indicator bacteria present (coliforms/faecal strept-ococci) at a water treatment works.	-	Water treatment works laboratory.