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# Conference Report

## Crystal-clear – The '2014 Most Superlative Crystal Growth Contest' for School Classes

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*Abstract:* To celebrate the International Year of Crystallography among the general public, a consortium of chemists, physicists and crystallographers of the University of Geneva organised in Spring 2014 an incentive crystal growth contest for Geneva scholars aged 4 to 19. Starting from a kit containing a salt and user instructions, classes had to prepare a crystal that met specific criteria according to their category of age. The composition of the salt – potassium dihydrogen phosphate (KDP) – was only disclosed to the participants during the final Awards Ceremony. This contest positively exceeded our expectations with almost 100 participating classes (*ca.* 1800 participants) and 54 specimens received over all categories.

**Keywords:** Crystal growth contest · Crystallography and society · Education · Incentive science · International Year of Crystallography 2014 · School science · Potassium dihydrogen phosphate · Outreach initiative

### International Year of Crystallography: Scientists Deal not only with Scientists

2014 was declared the International Year of Crystallography (IYCr-2014; *http://www.iycr2014.org/*) by the UNESCO, prompting a number of dedicated publications and scientific events in Switzerland dealing with the past, present and future trends in crystallography.[1,2] At the beginning of 2014, issuing a series of Swiss stamps organised by the Swiss Society of Crystallography and a public exhibition organised by the University of Fribourg were, to our knowledge, the only popular events planned for a general audience. The other events were more a matter of scientists talking to scientists than an opportunity for Swiss crystallographers to meet the public and share their passions and the challenges of their science.

For this reason, scientists from the Chimiscope,[3] the PhysiScope[4] and the Laboratory of Crystallography,[5] University of Geneva (UNIGE), decided to take advantage of IYCr-2014 to propose the first and only Swiss immersion into the world of investigational approach and crystal growth. This initiative, which falls within the traditional policy of openness of UNIGE to the city, took the form of a contest for public and private Geneva school classes of the Primary, Secondary I and Secondary II levels. The contest was also completed by an exhibition of posters on crystallography in the halls of the School of Physics and of the School of Chemistry and Biochemistry, and the Laboratory of Crystallography opened its doors for a public visit.

### Rules, Rulers, Weighing Scales, and Creativity

The aim of the contest was to grow the 'most superlative crystal'. Behind this vague descriptive were a number of criteria depending on the age category of the participating classes:

– Primary level (Harmos 1–8) students had to grow the funniest or most original crystal, thus tickling their creativity and steering them to the wonders and fascination of a scientific activity.
– Secondary I level (Harmos 9–11) students had to grow the biggest and most sizeable crystal, thus bringing them to the concepts of scientific and quantitative approaches.
– Finally, Secondary II level (Harmos 12–15) students had to grow the crystallographically purest and most bulky crystal, thus stimulating them to go beyond the standard schemes of experimenting semi-quantitative demonstrative science in the classroom.

All participating classes received a kit containing 100 g of pure potassium dihydrogen phosphate salt ($KH_2PO_4$; KDP; AppliChem; pure Ph.Eur. 98–100%), a leaflet with the contest rules and the "advice of the specialist for growing crystals", a box to return their crystal, and a container to store and send back unused material for proper handling through our waste elimination channels. Of course, the composition of the white salt was kept confidential, to avoid having science teachers obtaining and using larger quantities of the starting material in order to produce nicer, larger, or purer crystals.

The choice of the salt had been a major concern to the organising committee. Finally elected as salt of choice, potassium dihydrogen phosphate cannot be identified without access to tedious tests or specific analyses, has no known toxicity, and is well known in everyday life (fertilisers, food additive E340, pH buffer) and in non-linear optics for the production of humongous, nicely shaped and ultra-pure crystals.[6] Participants were informed that the salt could contribute to algal growth in natural waters, and that all waste could be returned to us for proper elimination.

### A Contest is also a Powerful Communication Tool

To reach a large community of potential participants, the organising committee used the addresses of the Geneva teachers who had visited at least once the Chimiscope and/or the PhysiScope, the two edutainment and outreach platforms of the Faculty of Science, UNIGE. This represents approximately 200 teachers who received before Christmas 2013 an invitation to participate in the contest and to spread the invitation to their colleagues. Advertising was also made *via* the publicly available newspaper of UNIGE, and to visitors of the Chimiscope and PhysiScope.

Registration was open from mid-January to mid-April 2014, and 90 classes received their kit during this interval, thus reaching *ca.* 1800 schoolchildren in Geneva. It appears that the promotion campaign has also been conveyed by word of mouth, because an important proportion of teachers and/or schools were not initially recorded in the mailing lists of the Chimiscope and PhysiScope.

A very pleasing upshot of this contest is a significant number of new visitors to the Chimiscope and PhysiScope among Geneva

teachers and schools. Advertising for this scientific contest has thus allowed the awareness of our target audiences to these two outreach initiatives to be raised.

## Labwork for Schools – A Variety of Teacher-dependent Approaches

By the mid-April deadline, 54 sets of crystals had been returned to the organising committee, 46% of which originated from classes of the Primary level. For their first attempt in proposing a contest, the organisers were quite surprised by the high number of applicants and the high [crystal returned]:[kit sent] ratio (60%). Reasons for not returning a crystal were mostly that it dissolved during the last steps of growing, or because the experimental setups had been spoiled by uncontrolled temperature or volume changes, or simply because participants did not read carefully the tips and hints provided with the kit, discarding their solutions instead of recycling them – a good demonstration that an active reading of instructions is an important pre-requisite in science education.

Interestingly, equal amounts of transparent/white crystals (20 sets) and coloured crystals (19 sets) were produced by 'Kids' and 'Juniors' (only one coloured crystal from the 'Seniors'), which demonstrates that many classes experimented with the use of [most probably] food colouring additives. In the 'Kids' category, four specimens were monocrystalline or quasi-monocrystalline (21 were definitely polycrystals or twinned crystals). An equal proportion of monocrystals and polycrystals were received from the 'Juniors' while the vast majority of monocrystals (12 out of 15) came from the 'Seniors'.

During and after the crystal growth period, many positive feed-backs on the contest and fancy correspondence were sent by participants from all levels. For example, a teacher sent us a very detailed identification of the unknown salt received, using pH, solubility tests and simple chemical reactions for major ions, and even a flame emission test for cations; the teacher concluded, on the basis of her observations and the fact that the salt could favour algal growth, that the unknown salt contained potassium and phosphates, most probably a mono- or dipotassium phosphate! Several Primary level classes competed in the same school to obtain the nicest and most exotic crystal. The 26 children of a French Primary level class even sent each a handwritten letter to the committee, asking to take part in the contest. In another Primary level school, the children (*ca.* 5-years old) were invited to draw what a crystal would represent to them and then the concept of crystal growth was shown with simple illustrations (Fig. 1).


Fig. 1. Four of the drawings of crystals produced by 5-year-old participants from a class of the Primary School Vélodrome. One of the illustrations used to explain in simple terms how crystals grow from dissolved cations (pink angels) and anions (blue cupids) when water (grey clouds) slowly evaporates is shown in the centre.

## And the Winner is…

Due to the extraordinary diversity of the 54 sets of crystals received, the jury composed of Dr. Jacques Deferne (former curator of the Department of mineralogy and petrography, Geneva Museum for Natural History), Prof. Alan Williams (School of chemistry and biochemistry, UNIGE) and two members of the organising committee, Prof. Christoph Renner and Prof. Radovan Černý, had the very difficult task to evaluate the award-winning crystals. For quantitative evaluation purposes, the following parameters were used to score each specimen:

– 'Kids': 54% Originality + 36% Beauty + 10% First Sight Impression
– 'Juniors': 70% Mass + 1.5% Originality + 1.5% Beauty + 27% First Sight Impression
– 'Seniors': 75% Crystallographic Quality + 25% Aesthetic Quality
  with Crystallographic Quality = Crystallographic Purity × $Log_{10}$(Mass + 10)
  Crystallographic Purity = 50% Laue Measurement + 25% Visual Observation + 25% Observation under Polarised Microscope (Laue Measurement: recording the X-ray diffraction pattern produced by the monocrystal) and Aesthetic Quality = 90% First Sight Impression + 5 % Originality + 5% Beauty

All individual scores attributed by the members of the jury were averaged to determine which classes would receive an award. It was ultimately decided to attribute a fourth award in each category (see Fig. 2), because the First Sight Impression parameter proved to be a good way of differentiating particularly exotic and original crystals that didn't exactly fit into our expected evaluation criteria. The 12 award-winning specimens are shown in Fig. 2.

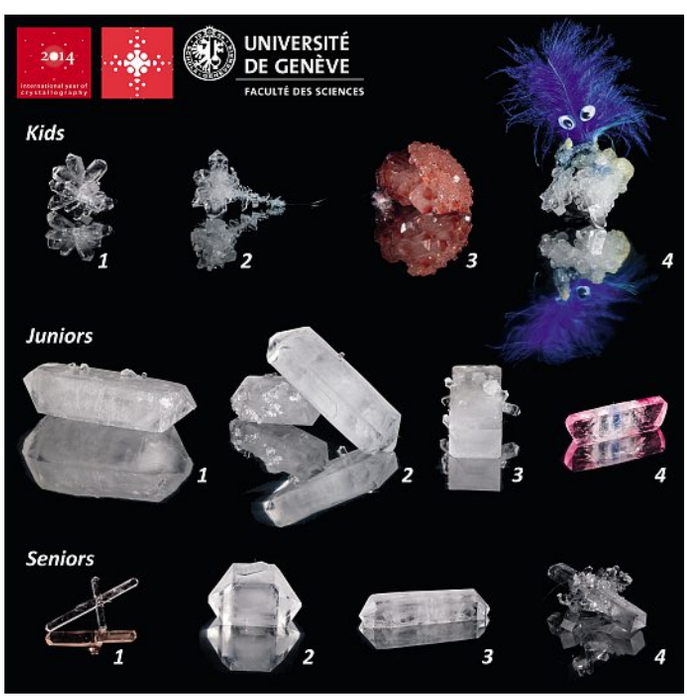


Fig. 2. The four award-winning crystal sets in each category of the contest.

## Award Ceremony and After Event

Shortly before the end of school term, on May 21, the public award ceremony was organised at the Faculty of Science, UNIGE, and all winning classes were invited to attend. After a short introduction by the president of the jury, three short incentive lectures were offered.

Prof. Radovan Černý presented the discovery of X-rays by Wilhelm C. Röntgen, the observations of Max von Laue that crystals diffract X-rays, and the opportunity for youngsters to pursue a career in science, if not in crystallography. He was followed by a fascinating talk by Dr. Jacques Deferne about the wonders of natural crystalline structures. He explained how such structures emerge from the subtle conjunction of Nature and ions, before concluding with the use of man-made crystals in industry. Finally, Prof. Alan Williams humorously demonstrated the organisation of atoms in the heart of crystals, insisting on the importance of a scientist's critical mind when using 3D visualisation programmes to better understand the microscopic dimensions of matter.

Then, all member elected classes were invited to receive their Prize from the members of the jury. For each class category, the first and second prizes were glass cubes with a laser engraving showing the 3D structure of potassium dihydrogen phosphate,[7] while the third prize was a large ball & stick model of this crystal[8] (see Fig. 3). The fourth prize, attributed for the originality of the crystals submitted, was a set of two scientific books on chemical elements,[9] one of which was authored and donated by Dr. Jacques Deferne. All winning students also received a nice centimetre-sized quartz crystal. The 54 submitted crystal sets were then displayed during the friendly tea party that followed, where schoolchildren and researchers of the Faculty of Science shared their experience.

To complete this nice story, the crystal sets were also exhibited in a large showcase of the Geneva Museum of Science History during the traditional Science Fair[10] organised every other year by the museum in the Parc de la Perle-du-Lac, that attracted up to 35'000 visitors during a week-end in July.

## By-products of the Contest and Rendez-vous in 2015!

At the conclusion of the event, a luxurious catalogue[11] presenting all crystal sets that were submitted to the contest was published and sent to all participating children and schools, as an acknowledgement for the efforts invested in a fancy, yet instructive and pedagogic scientific activity. An adapted version of Fig. 2 has also been selected for display in the beautiful Crystallographic e-Calendar produced by the Swiss Society for Crystallography in all four official Swiss languages and in English, and the minutes of the event have been requested by the Swiss Society for Crystallography for publication in their official Newsletter. Finally, the contest has also been published on the website of the International Union of Crystallography (*http://www.iycr2014.org/events/competitions/crystal-growth-competition-in-geneva*).

In view of the success of this competition among Geneva classes, the Chimiscope and the PhysiScope have agreed that the International Year of Light 2015 could be another good opportunity to organise a new exhilarating contest for schoolchildren. Let's meet again in 2015!

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[7] 3D laser engraving in glass cubes was produced by Crysalis (France); *http://www.crysalis3d.fr*
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[10] Nuit de la Science **2014**, 'Tout ce qui brille n'est pas or', Genève, *http://www.ville-ge.ch/culture/nuit/*
[11] The catalogue was produced by Trajets Imprimerie (Geneva); this printer shop is operated by the Fondation Trajets, which works for the integration of psychologically impaired people; *http://www.trajets.org*


Fig. 3. Members of the jury, from left to right: Prof. Černý, Dr. Deferne, Prof. Renner, Prof. Williams, with the collection of prizes (left). Detail of the 3D structure of $KH_2PO_4$ engraved in glass cube and as ball-and-stick model offered as prizes to the award-winning classes (right).