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COMMITTEE ON CHEMISTRY EDUCATION*,**

CHEMISTS AND "THE PUBLIC": IUPAC'S ROLE IN ACHIEVING MUTUAL UNDERSTANDING

(IUPAC Technical Report)

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Chemists and "the public": IUPAC's role in achieving mutual understanding

(IUPAC Technical Report)

Abstract: This report informs IUPAC's efforts to enhance the public understanding of and appreciation for chemistry by evaluating IUPAC's mandate, strengths, and weaknesses, and providing insights from a substantial review of the relevant science communication literature. It summarizes the recommendations of an IUPAC project whose overall goal is to provide a framework that will bring the same level of intellectual rigor to IUPAC's science communication activities as to its scientific activities. This implies that careful attention must be paid to the terminology used to describe these activities, to clear articulation of goals and motives for public understanding of chemistry initiatives, and to inclusion of rigorous evaluations of outcomes from the outset in the design of projects on the public understanding of chemistry.

Informed by our analysis of best practices for science communication, this report provides the following conclusions and recommendations:

1. IUPAC has an important role to play in enhancing public understanding of chemistry.
2. Public understanding of chemistry activities aimed at supporting teachers and students within the formal school system are more effective than those aimed at the general public.
3. IUPAC's primary targeted public should be IUPAC chemists and educators, and IUPAC's most important role is to help them understand and work with a variety of other publics.
4. It is proposed that IUPAC's niche be to focus on activities that indirectly enhance public understanding, such as:
   (a) Helping scientists identify and understand their publics.
   (b) Influencing international organizations.
   (c) Supporting science education systems, particularly in countries in transition.
   (d) Supporting scientists and educators by communicating relevant findings from IUPAC projects, conferences, and activities at an appropriate level.
   (e) Supporting national chemical societies and other organizations.
5. Recommendations are presented for steps to be undertaken by IUPAC to implement these recommendations and to develop a clearer strategy for public understanding of chemistry initiatives and activities.

Keywords: public understanding of chemistry; science communication; public appreciation of chemistry; recommendations; terminology; literature survey; IUPAC role; IUPAC Committee on Chemistry Education.

1. INTRODUCTION

> **"The panel was struck overall by the general lack of intellectual rigor applied to science and technology communication activities, especially as contrasted with the very rigorous scientific environment in which this communication arises. Public communication…should be amenable to the same experimental paradigms as laboratory science."**
>
> *Communicating the Future: NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century [1]*

This report informs IUPAC's intention to enhance public understanding and appreciation of chemistry, by evaluating IUPAC's mandate and providing insights from a review of the public understanding of science literature, including the report of NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century, cited above.

Enhancing public understanding of chemistry is an explicit, central element of IUPAC's strategy to "contribute to the worldwide understanding and application of the chemical sciences, to the betterment of the human condition". The most recent IUPAC strategic plan (2002–2003) includes long-range goals to "provide leadership as a worldwide scientific organization that objectively addresses global issues involving the chemical sciences", and to "utilize its global perspective and network to contribute to the enhancement of chemistry education, the career development of young chemical scientists, and the public appreciation of chemistry". The strategic plan (2000–2001) expressed the goal to "advance the public understanding of chemistry and the scientific method".

IUPAC has envisioned a strong role for the Committee on Chemistry Education (CCE) in setting directions for the organization's efforts to enhance the public understanding of chemistry. CCE's terms of reference, listed below, highlight this mandate:

- To advise the President and the Executive Committee on matters relating to chemistry education, including the public appreciation of chemistry.
- To maintain a portfolio of educational projects and to coordinate the educational activities of IUPAC.
- To monitor chemistry education activities throughout the world and to disseminate information relating to chemical education, including the public appreciation of chemistry.
- To develop liaisons with international organizations such as UNESCO, national and regional chemical societies, chemical education committees, and organizations concerned with the public appreciation of science.

Flowing out of the first point in CCE's terms of reference, IUPAC Project #2004-047-1-050 has the objective of "proposing to the IUPAC Bureau an appropriate niche for IUPAC and CCE in promoting public understanding of science". The present report is an outcome of that project, and was presented in draft form to a joint workshop involving CCE, the Committee on Chemistry and Industry (COCI), the Committee on Chemistry Research Applied to World Needs (ChemRAWN), and members of the IUPAC Bureau at the 2005 General Assembly in Beijing. Following the Beijing workshop, the report was posted on the IUPAC Web site for public review and comment. A symposium featuring this report and other contributions on the public understanding of chemistry was then held at the 19th International Conference on Chemistry Education (ICCE) in Korea (August 2006). Feedback from these events was incorporated by project task group members into this final report to the IUPAC Bureau, assisting it in determining its role and strategy on public understanding of science. The draft report was approved by the Bureau at its November 2006 meeting.

The project task group asked the following questions about IUPAC's motivation and goals for involvement in the public understanding of chemistry:

- Does IUPAC want the public to know more chemistry?
- Does IUPAC want the public to know more about the processes of science?
- Does IUPAC want the public to know more about the benefits of chemistry?
- Does IUPAC want to understand more about what the public needs and desires to know about chemistry?
- Does IUPAC want the public to be better equipped to evaluate the potential benefits of chemistry?
- Does IUPAC want to promote the chemical industry?
- Does IUPAC want a greater public profile for itself?
- Does IUPAC want the public to trust chemists?

The task group identified strengths and limitations of IUPAC as an organization for communicating chemistry to the public. Strengths include

- IUPAC's international make-up, with special attention given to the needs of developing countries;
- IUPAC's considerable scientific credibility in setting global standards on nomenclature, physical constants, and in other areas;
- IUPAC's links to other unions and international organizations; and
- IUPAC's track record of support for formal chemistry education through the work of the former Committee on Teaching of Chemistry (CTC) and the present CCE.

On the other hand, IUPAC's effectiveness in public understanding of chemistry initiatives may be limited by

- lack of IUPAC chemists' understanding of the public(s) who might be served by initiatives;
- limited knowledge within IUPAC of the research base for educational and public understanding of chemistry initiatives;
- insufficient articulation of motives, goals, and outcomes for public understanding of chemistry initiatives;
- limitations of a largely volunteer organization without central resources to support substantial public understanding of chemistry initiatives; and
- lack of knowledge of IUPAC on the part of the general public.

An overarching goal for the present project is to provide a framework that will bring the same level of intellectual rigor to IUPAC's science communication activities as to IUPAC's scientific activities. Careful attention to nomenclature is a distinguishing feature of IUPAC's scientific activities. Careful attention must also be paid to the purposes and therefore to the terminology used to describe science communication activities. This implies clear articulation of goals and motives for public understanding of chemistry initiatives, and that the design of public understanding of chemistry projects should include rigorous evaluation of outcomes from the outset.

This goal is realized in part through consideration of how to draw on insights from the science communication literature to provide focused, credible public understanding of chemistry activities that build on both the strengths and the mandates of IUPAC and CCE.

To facilitate that discussion within IUPAC, this report

- clarifies terminology used in this report for science communication activities;
- summarizes insights from the research literature on science communication;
- articulates motives and goals for IUPAC involvement in public understanding of chemistry initiatives;
- suggests public(s) for targeting by IUPAC;
- proposes mechanisms for evaluating IUPAC public understanding of chemistry initiatives;
- makes recommendations regarding IUPAC's niche in science communication; and
- proposes steps to implement these recommendations.

2. TERMINOLOGY FOR SCIENCE COMMUNICATION ACTIVITIES

"The scientific community and managers of the science enterprise routinely fail to distinguish between understanding of science—and appreciation for science and research-performing institutions."

Communicating the Future: NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century [1]

IUPAC uses a variety of terms for science communication as do other organizations. Chemists derive great benefit from precision in the use of terminology in their scientific work. Precise use of language will help clarify the purpose of science communication, so we propose the following practical definitions for IUPAC.

Public understanding of chemistry: Understanding of chemistry matter by non-chemists, including the content of chemistry, the nature and methods of chemistry (as a social enterprise), and the roles and uses of chemistry in society.

Public awareness of chemistry: General knowledge of chemistry content, processes and societal roles, without detailed and precise understanding.

Public appreciation of chemistry: A positive attitude to chemistry, including respect and/or admiration for its methods, its contributions (and potential contributions) to society.

Other terms, such as public attentiveness to chemistry and chemical literacy are also used in the literature.

3. INSIGHTS FROM THE RESEARCH LITERATURE ON PUBLIC UNDERSTANDING OF SCIENCE

"Developing literacy in one particular area of science may be likened to climbing a mountain. It is dynamic, participatory, and it inevitably changes the participant's view of the world. This climbing process is facilitated by science communication. Appropriate skills, media, activities, and dialogue are used to improve individuals' awareness, enjoyment, interest, opinions, or understanding (AEIOU) of science. When viewed at the public level, this is equivalent to moving upward through the continuum of public awareness of science, public understanding of science, and scientific literacy."

Science Communication: A Contemporary Definition [2]

3.1 Geographic focus

The literature on public understanding of science focuses almost exclusively on research into, and analysis of, initiatives in the western, developed world, and very little on countries in transition. Perhaps this also reflects a geographical imbalance in the magnitudes of public understanding of science efforts.

3.2 What's meant by understanding science?

It has been generally accepted that there are three main aspects of understanding science:

- Understanding substantive scientific knowledge (content).
- Understanding the methods of enquiry and progress in science (process).
- Awareness of the impact of science on people, as individuals and as a society (social).

There is considerable discussion concerning whether communication of the process component should overtly convey the tentativeness and the limitations of science, as well as the debates among scientists—particularly those with societal currency. Some writers argue that scientists are reluctant to admit to uncertainties in their knowledge for fear of losing status (and sources of funding), and that this disguises the true nature of scientific progress.

3.3 Analysis of the public understanding of science enterprise

IUPAC's current concerns mirror those of NASA's Space Science Laboratory which, in the late 1990s, established a panel of highly reputable science communicators, communication researchers, journalists, and scientists to make recommendations for its own public understanding of science program, based on a thorough review of the then-current literature on science communication, as well as surveys of science communication activities both in the USA and internationally. Although four years had passed since publication of its report [1], it seemed sensible to highlight their findings because of (i) the thoroughness of their analysis, and (ii) the considerable similarity between IUPAC's and NASA's motivations. Much of the following, therefore, is summarized from the NASA report, and amplified and/or supplemented by the writings of others.

3.3.1 The status of public understanding of science

Borchelt [1] reports:

> "The panel was struck overall by the general lack of intellectual rigor applied to science and technology communication activities, especially as contrasted with the very rigorous scientific environment in which this communication arises. Communication often remains an afterthought, a by-product of scientific endeavor somehow removed from the scientific process itself and often funded by a different mechanism than the scientists who perform the research. The panel firmly believes that public communication of research results is, and should be, integrated into the scientific process itself. It is not an optional activity at the conclusion of a research program. It should be amenable to the same experimental paradigms as laboratory science."

3.3.2 Modes of science communication and their effectiveness

In the past, the public understanding of science movement has often been characterized by a one-way transmission of knowledge from those who know to those who know less, and which has been labeled the *deficit model* of communication. This practice has been dependant on identification by the scientific experts of what they think the public ought to know. Underlying this approach is an implicit belief that more of this knowledge transmission will give rise to better understanding of the findings and constructs of science, as well as enhanced trust in science and scientists.

However, despite massive public understanding of science programs in the United States and the United Kingdom, for example, measured levels of public understanding of science content remain disappointingly low. Furthermore, there is ambiguous evidence concerning whether there have been benefits in terms of citizen support for the scientific enterprise. Comment has been made that we should not be surprised by this if we look to the analogy of public understanding of politics, where "political ignorance flourishes in spite of heavy coverage, knowledgeable reporting, and media-savvy participants" [1].

Increasingly, in recent years there has been criticism of the deficit model of communication for attempting to teach science content to people which they may have no interest in knowing. This ap-

proach does not fit easily with current views of learning that give high weight to active learner participation, including in the choice of subject matter.

A UK House of Lords report [3] was scathing of even the connotations of the label "public understanding of science":

> "…the words imply a condescending assumption that any difficulties in the relationship between science and society are due entirely to ignorance and misunderstanding on the part of the public; and that, with enough public-understanding activity, the public can be brought to a greater knowledge, whereupon all will be well."

Notwithstanding literature proposals of a range of models for science communication, most of these can be included in a category called a *contextual model*, which demands understanding of the target audience by the scientist, and calls for two-way discussion among equals. The contextual approach recognizes the status of personal values and local knowledge in the decision-making processes in science-related issues. Claims have been made that scientists know just as little about the public as the public knows about science.

After a wave of hostility to the deficit mode of science communication, it seems now that a more rational attitude is becoming prevalent that recognizes that both the deficit and contextual models can be appropriate in particular circumstances.

In summary, it can be said without qualification that the process of science communication is a very complex undertaking that is not yet well understood, but certainly involves more than the experts telling more ignorant people that which the experts have decided is appropriate.

3.3.3 The mass media

The general public in highly developed countries often has a remarkably high level of expressed and demonstrated interest in science-related programs, higher than scientists in these countries perceive to be the case. Despite this, there is evidence that the mass media are an ineffective vehicle for enhancement of understanding of scientific content of adults. It appears that the role of school-level (kindergarten through secondary school) formal education is far more important than subsequent exposure to science communication. Furthermore, cautions have been expressed about the popular treatment of scientific material in mass media for reasons imposed by its own demands. Trachtman, in "The public understanding of science effort: a critique", [4] suggests that popular treatment of scientific material is likely to

- be highly selective in choice of materials, using questionable selection criteria;
- oversimplify, and hence to misrepresent, the methods and the character of scientific enquiry;
- treat scientific news as discrete events and hence to create another false impression of science;
- draw undue inferences about the meaning and significance of particular lines of research;
- report on inadequate, incomplete and poorly designed research as readily as on competent research, as long as the subject matter is relevant to immediate popular concerns;
- create false expectations of what science is capable of doing; and
- occasionally create stress among readers more damaging than the real risks being reported.

3.3.4 The public

The NASA report [1] finds:

> "There is no such thing as a general audience for science and technology communication; rather, there are many people with many different uses for science and technology information and many levels of understanding with which to deal."

3.3.5 Confusion of motivations

Many public understanding of science initiatives have suffered from either (i) their own uncertainty in regard to ambiguous and/or diffuse motivations, or (ii) a mismatch between expressed motivations or goals and the real, but less overt, motivations. In particular, according to Borchelt [1]:

> "The scientific community and managers of the science enterprise routinely fail to distinguish between understanding of science and appreciation for science- or research-performing institutions."

While it is valid to have either of these goals, the NASA panel believed that far too often programs intended to enhance the reputation of agencies expressed the altruistic intention of benefiting the citizenry. The goals are not necessarily compatible, and can lead to either a confused focus by the agency, or loss of trust by the public.

As discussed below, precise and clearly expressed goals are a necessary component of effective evaluation.

3.3.6 Designing an effective public understanding of science program

Gregory and Miller [5] recommend a protocol for communication for (the public understanding of) science. Only the titles of each component are reproduced here:

- Acknowledge the place of popularization;
- Be clear about motives;
- Respect the audience;
- Negotiate new knowledge, understanding and attitudes;
- Establish a basis for trust;
- Acknowledge the social in science;
- Facilitate public participation.

To these the project task group would add:

- Decide which audience is most appropriate in terms of need and accessibility; and
- Engage in evaluation of the program.

3.3.7 Evaluation

Consistent with the views of several other writers, the NASA panel [1] expressed the view that little formative or evaluative research is carried out in support of science and technology communication. Such research is necessary to help formulate messages and evaluate their impact.

Reporting on the outcomes from a meeting of the Scientific Committee of the Public Communication of Science and Technology group at a World Conference on Science, Gascoigne [6] also referred to this common weakness of public understanding of science programs:

"Furthermore, whenever inadequate evaluation exists, it undermines the credibility of much of what science communicators strive to do in these programs.

Unless the benefits of these programs can be demonstrated, skeptical governments are entitled to doubt the programs' achievements and question their continued funding. The proponents of these programs need to be able to show they have made a difference—that the activities they have designed and put into action have led to the desired outcomes. Evaluation is a key issue."

Gascoigne acknowledges the value of both formative evaluation (conducted during the course of a program, in order to adjust the process according to findings), and summative evaluation (conducted after the program, to assess its effectiveness).

We recognize that defining some goals in measurable terms is not easy.

4. WHY SHOULD IUPAC BE INVOLVED IN PUBLIC UNDERSTANDING OF CHEMISTRY INITIATIVES?

"Science and technology communication should not be driven by the research enterprise's desires about what the public should know. Communication should be driven by a desire to meet audience needs and interests."

Communicating the Future: NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century [1]

While we may not agree with this polarized characterization of science communication, IUPAC has yet to define clearly its motivation and goals, targeted public(s), desired outcomes, and methods of evaluating success for participation in public understanding of chemistry initiatives.

This lack of clarity has led to (and perhaps resulted from) imprecise and sometimes transposable use of terminology such as public understanding, public appreciation, and public awareness of chemistry.

4.1 Suggested articulation of IUPAC's motivation and goals for public understanding of chemistry initiatives

Building on IUPAC's overall goal to support the development by chemists around the world of new knowledge with potential benefits to society, we suggest the following description of IUPAC's motivation for public understanding of chemistry.

- IUPAC wants to provide leadership to enable chemists to address global issues that involve the molecular sciences.
- IUPAC acknowledges that the public ultimately decides whether and to what extent the benefits of chemistry are realized.
- Chemists therefore need to engage with the public to create a climate in which the potential benefits of chemistry can be realized.
- To create and support effective two-way communication, chemists need to understand the needs and concerns of the public.
- Good decision-making in society depends on mutual understanding and trust between chemists and the public.
- IUPAC needs strategies to promote this mutual understanding.

The media and the public will see through any imbalance or confusion of motives and will spot anything that is self-serving.

5. IUPAC'S PUBLICS

"Despite long-standing awareness of the diversity of the consuming publics for science and technology information, the panel noted that most science communication still fell into one of only two categories: peer communication aimed at fellow scientists and technologists and public communication aimed at everyone else. The literature the panel reviewed and the best practices it observed in use make very clear that there is no such thing as a one-size-fits-all public communication message for a mythical lay public. Single messages designed to reach all public audiences typically end up reaching none of them very well, especially in an information environment with a myriad of media channels (which is growing daily) from which an audience may choose what suits it."

Communicating the Future: NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century [1]

Who are the public(s) IUPAC should be trying to reach?

IUPAC can be considered to be at the centre of a set of concentric circles each of which represents a "public" with which IUPAC may wish to interact in relation to public understanding of chemistry.

IUPAC is closest to and/or can readily interact with its own adhering bodies and national chemical societies, other multinational organizations and the scientific and educational arms of national governments. It is relatively remote from most chemists, who are members of national bodies rather than of IUPAC itself, and very remote from most teachers, students and the general public.

IUPAC has neither the resources, nor the expertise to address all of these "publics". It needs to concentrate its activities with those publics with which it is well placed (and perhaps better placed than others), while interacting indirectly with those publics that are more remote (and who are better addressed by others).

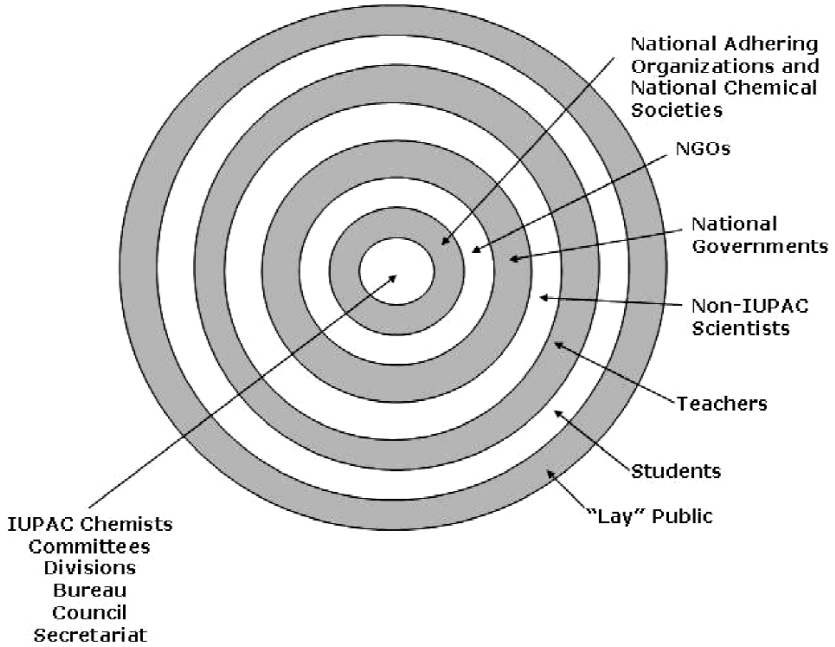

Fig. 1 IUPAC and its publics.

Primary publics for IUPAC are therefore those chemists and chemistry educators that are closely associated with IUPAC (the inner circle), helping to equip them to engage in public understanding of chemistry activities, particularly with respect to IUPAC activities and conferences. A particularly important task is to equip those IUPAC chemists and educators to understand who their audiences are and what needs and aspirations those audiences have.

Non-IUPAC chemists, educators, students and the lay public are generally most effectively addressed indirectly through adhering national organizations, national chemical societies, and scientific and educational arms of national governments, which IUPAC chemists and educators can influence.

This is explored more fully in Section 7 where the project group identifies particular roles for IUPAC and the publics it is best equipped to address.

6. EVALUATION BUILT INTO ANY IUPAC PUBLIC UNDERSTANDING OF SCIENCE INITIATIVES

> **"The panel also was very concerned about the dearth of formative or evaluative research that underpins the vast majority of science and technology communication in the United States (and as far as the panel was able to determine, the rest of the world). For a data-driven enterprise, science demands very few data from communicators of science, either to craft and frame appropriate messages and message content or to evaluate the impact of messages on scientific knowledge or behavior."**
>
> *Communicating the Future: NASA's Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century [1]*

Gascoigne proposes a simple model [6] that could be used for the evaluation of programs or projects that aim to change or influence public views on science and technology. This model includes the following five steps:

1. Identify clear objectives for the program or project, for example, to increase the awareness of high school students about career opportunities in science. This project could have as a performance indicator the students' level of awareness about science career options.
2. Identify the audience to be influenced, and then establish baseline data. For the example of high school students, this baseline data could be a measurement of the current awareness of students before implementation of the awareness project.
3. Identify the most appropriate method to assess change by choosing from the range of assessment tools listed earlier. Using the school example, the selected method could be to conduct telephone interviews with a representative sample of students.
4. Carry out ongoing assessment during a project as a way to shape the program. The aim is to improve effectiveness and to save time and money. Again, in the school example, the project team may discover that the photographs of scientists used in the project reinforce negative images, and so the material needs to be revised. This revision can be made while the project progresses.
5. Carry out post-project assessment, again by choosing from the possible tools listed earlier.

7. CONCLUSIONS AND RECOMMENDATIONS TO IUPAC

1. In keeping with its mission to "contribute to the worldwide understanding and application of the chemical sciences, to the betterment of the human condition," IUPAC has an important role to play in enhancing public understanding of chemistry.
2. Public understanding of chemistry activities aimed at supporting teachers and students within the formal school system are more effective than those aimed at the general public.

3. IUPAC is just one of many actors in public understanding of science, and will frequently need to work collaboratively with the other scientific unions and other bodies. IUPAC cannot cover the full range of possible activities and address all audiences, not least because it is remote from the general public. IUPAC's primary targeted public should be IUPAC chemists and educators, and IUPAC's most important role is to help them understand and work with a variety of other publics.
4. We propose IUPAC's niche as focusing on activities that indirectly enhance public understanding, such as the following:

   (a) Helping scientists identify and understand their publics.

   Goals: A crucial first step is for scientists involved in reaching out to the public to understand the needs and aspirations of their target audiences. IUPAC first needs to educate itself in this regard. The analysis of public understanding of science initiatives presented in this report should provide the basis for beginning this process of self-education. IUPAC, its Executive, Divisions, Standing Committees and staff should support chemists and educators within the IUPAC family to enhance their understanding of the public(s) they seek to address by defining the target public, clarifying motives, terminology, strategies, resources, approaches to evaluation, etc.

   Examples: Dissemination of the outcomes of this project, together with publication of resources on the CCE Web site, the Symposia on Public Understanding of Chemistry at the 2003 IUPAC Congress in Ottawa and the 19th ICCE are examples of this strand.

   Targeted public: The "public" addressed in this strand is IUPAC itself and those closely associated with it.

   (b) Influencing international organizations.

   Goals: A key strength of IUPAC is its scientific expertise and scientific credibility. IUPAC should build upon this strength and the work that it is already doing by bringing this work more effectively to the attention of key international organizations. As a global organization IUPAC is well placed to interact with multinational non-governmental organizations, scientific unions, etc.

   Examples: Recent examples of IUPAC initiatives which could be effectively communicated at other levels to targeted publics would include endocrine disruption, chlorine, and medicinal chemistry. This would require an explicit goal of dissemination to NGOs, close collaboration with CCE, appropriate Divisions, standing committees, and commitment by the Bureau and Executive Committee to promote such reports to decision makers in key organizations.

   Targeted public: The "public" addressed in this strand is non-governmental and intergovernmental organizations, such as WHO, UNESCO, ICSU, ICASE, and the World Chemistry Leader's Meetings.

   (c) Supporting science education systems, particularly in countries in transition.

   Goals: IUPAC has the international standing and the expertise within its networks to support the development of science education in countries in transition to raise public awareness and understanding of chemistry to meet basic human needs. This means working at a national or regional level, often in partnership with other agencies, rather than with individual institutions, whose needs are better met by other organizations.

   Examples: Examples of this type of activity are CCE's Young Ambassadors for Chemistry (YAC) and Flying Chemists programs. Partners include organizations such as UNESCO, ICSU regional offices, and Science Across the World.

   Targeted public: The "public" in this strand is national governments and education systems in developing countries.

   (d) Supporting scientists and educators by communicating relevant findings from IUPAC projects, conferences, and activities at an appropriate level.

Goals: An international organization with the scope of IUPAC has the scientific expertise to make available authoritative information on a non-partisan basis on major global issues. It can make unique contributions in serving the needs of scientists and educators for an awareness and understanding of issues. If scientists and educators are to engage with their own particular audiences they must have access both to authoritative scientific information as well as guidance on how to use it.

Examples: Examples of such issues are many topics which have been the focus of special issues of *Pure and Applied Chemistry*, such as green chemistry, the science of sweeteners, chemical and biological weapons, climate change, endocrine disrupters, and chlorine. While some of these issues have been addressed at a level appropriate for IUPAC specialists, scientists and educators could benefit by communication at other levels.

Targeted public: The "public" in this strand is scientists and educators, who are mainly reached through national societies for chemistry and for science education.

(e) Supporting national chemical societies and other organizations.

Goals: IUPAC is poorly placed to undertake public understanding initiatives in individual countries. It has neither the expertise nor the human and financial resources to do so. It is, however, well placed to facilitate communication among IUPAC member countries regarding existing public understanding of chemistry initiatives, and provide ideas and resources that can be adapted and adopted by countries in transition to initiate sustainable and appropriate public understanding of chemistry activities and, where appropriate and resources permit, suggest ways to coordinate such activities.

Examples: Examples of such activities would be a world chemistry poster competition, activities for National Chemistry Weeks, an International Year of Chemistry, World Chemistry Day/Week, and Internet links (the latter probably brokered by a major chemical society).

Targeted public: The "public" in this strand is national chemical societies and other organizations.

It is equally important to note what we are not recommending as part of IUPAC's strategy. We do not think that IUPAC is sufficiently close to, nor has the expertise or resources for itself to interact directly with the general public, whether that part of the public that attends educational institutions as teachers or students, or the lay adult public. These are the tasks of other organizations that are much closer to the target audiences. IUPAC's work therefore is indirect in enhancing public understanding.

5. We recommend that IUPAC implement these recommendations by taking the following steps toward developing a clearer strategy for public understanding of chemistry initiatives and activities.
   (a) Adopt the strategy outlined in Section 7, Points 1–4, and communicate the strategy within the IUPAC family, NAOs, and partner organizations.
   (b) Educate itself about effective methods for delivering public understanding of science initiatives, including understanding the public's needs and requirements.
   (c) Build public understanding of science considerations into relevant projects, conferences, and IUPAC activities from the outset. IUPAC might consider amending the project form, to require consideration of public understanding dimensions to proposed projects. Divisions and standing committees might be asked to regularly consider ways to more broadly communicate initiatives to appropriately targeted publics. Regular liaison with CCE is a critical component.
   (d) Ensure initiatives are carefully focused and can be undertaken within available human and financial resources.
   (e) Build an evaluation component into any supported public understanding of science initiatives.
   (f) Evaluate success in implementing this strategy.

(g) Suggest practical strategies and activities to NAOs for enhanced public understanding of chemistry.

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