Tracing the Ancestry of Galaxies (on the land of our ancestors)
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Building on IYA2009: IAU Strategic Plan "Astronomy for the Developing World"

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Abstract. During the next decade the IAU intends to mobilize talented astronomers, engineers and teachers around the world, in the service of developing countries. I shall review the content of the IAU Strategic Plan 2010 - 2020 "Astronomy for the Developing World" and give you an update on its implementation. Astronomy is a unique tool for stimulating capacity building because it combines cutting-edge technology with fundamental science and has deep cultural roots. The plan envisages a substantial increase in IAU education and development activities during the next decade. These activities will be bottom-up, with a strong regional influence. An integrated approach tailored to the conditions and needs of each country will involve a mix of education at primary, secondary and tertiary levels and public outreach. As a crucial component of the strategy, the IAU together with the South African National Research Foundation will set up a small office to coordinate and plan the various global activities at the SAAO in Cape Town.

Keywords. astronomy, development, education

1. Introduction

Fostering astronomy in developing countries has long been regarded by the IAU as an important part of its mission. During the past two decades the IAU has conducted a range of educational activities under the auspices of Commission 46. These activities were directed mainly towards stimulating astronomy at university level. The success of the International Year of Astronomy (IYA 2009) and the increase in the scope and size of astronomy outreach activities that it has inspired led us to review our activities and to develop a new strategic plan for the next decade. This plan "Astronomy for the developing world: Building from IYA2009 was endorsed in August 2009 by the IAU General Assembly at Rio de Janeiro and the first steps in implementing it have been made. I am delighted that this talk is being given during an IAU symposium in Africa. As I will mention in the talk, Sub-Saharan Africa will receive special attention in the IAU Plan and the plan will be coordinated by an IAU office hosted by the SAAO in Cape Town.

2. Relevance of Astronomy for development and capacity building

The plan discusses at length the many reasons why astronomy can play a unique role in furthering education and capacity building throughout the world.

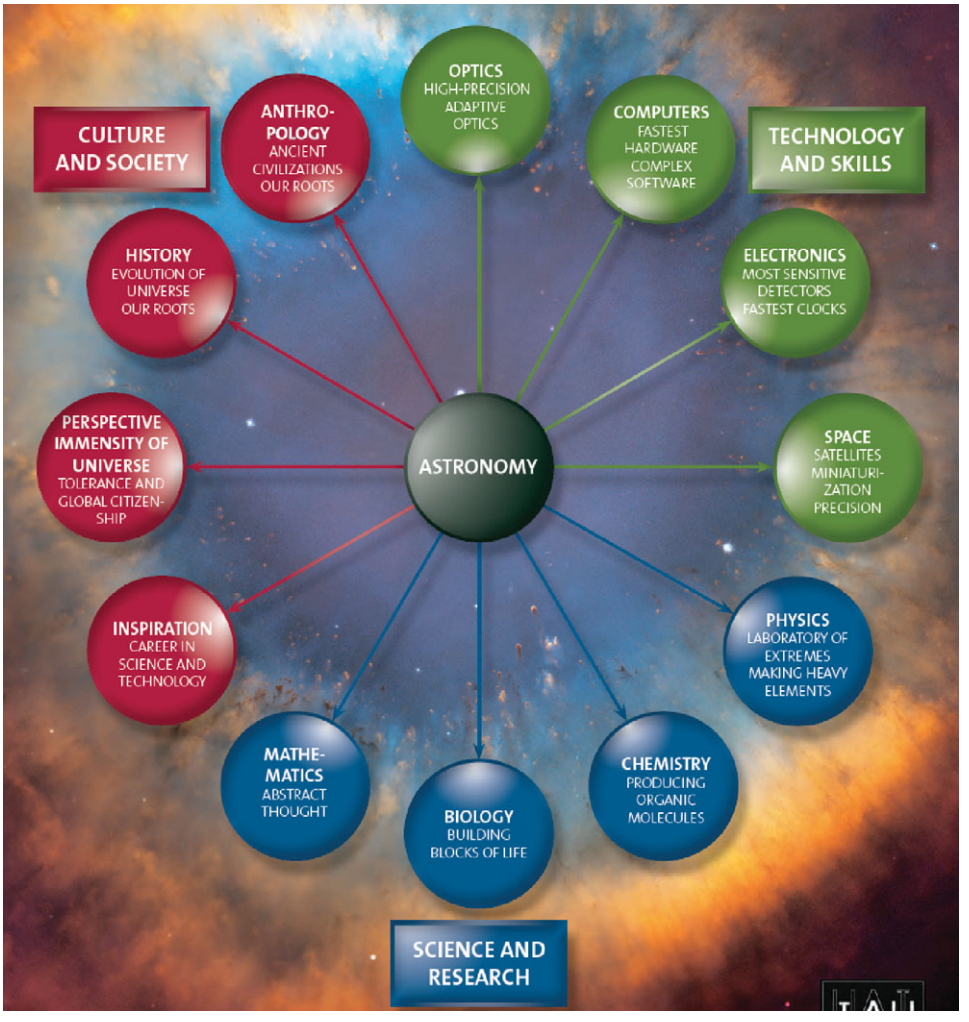

Figure 1. Cover of the IAU Strategic Plan document, illustrating why astronomy is an excellent vehicle for capacity building and international development.

• The Universe provides an inexpensive laboratory for studying extreme conditions that are inaccessible on Earth. Stars and galaxies are environments that have produced the chemical elements around us and formed organic molecules, the building blocks of life. During the last century astronomical studies have led to new discoveries in physics, chemistry and biology and to the creation of the new sciences of astrophysics, astrochemistry and astrobiology. Because of its mathematical basis, astronomy is also an excellent tool for teaching mathematics.

• Astronomy has been an important driver for the development of advanced technology, such as the most sensitive detectors of light and radio waves and the fastest computers. The need to study the faintest objects possible requires sophisticated

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electronics and extreme-precision adaptive optics as well as state of the art engineering. Astronomy has also played an important role in space technology that has opened the Universe for study throughout the whole electromagnetic spectrum. Modern optical and radio telescopes are among the most advanced machines ever built and are outstanding educational vehicles for becoming familiar with the latest complex technology.

Astronomy also contributes substantially to modern culture and is relevant to several topical issues of present-day society.

• As you well know, astronomers are super-historians. Large telescopes operating throughout the electromagnetic spectrum are "time machines" that routinely provide pictures and other information about of the observable Universe close to its birth, 13.7 billion years ago. Unravelling the history of the Universe has been a crowning achievement of humankind during the last half century.

• One of the most important societal functions of modern astronomy is as a tool for education in the broadest sense. Because it is one of the most approachable of sciences that consistently fascinates young people, astronomy is an excellent vehicle for introducing science and technology to children. The accessibility of the sky, the beauty of cosmic objects and the immensity of the Universe are inspirational and provide a perspective that encourages internationalism and tolerance. The excitement of astronomy has stimulated large numbers of young people to choose a career in science and technology, thereby contributing to the "knowledge economy" of many countries.

In summary, because astronomy combines science and technology with inspiration and excitement, it can play a unique role in facilitating education and capacity building and in furthering sustainable development throughout the world.

3. Elements of astronomy development

Astronomy can contribute to education at all levels and to raising public awareness about science.

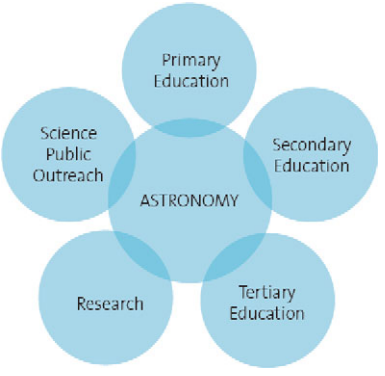

Figure 2. Elements of astronomy development.

3.1. *Primary education (ages 4 – 10)*

The early formative years are crucial in the development of the human value system. At these ages, children can readily appreciate and enjoy the beauty of astronomical objects and can learn to develop a 'feeling' for the vastness of the Universe. The sky and the Universe can excite young children and stimulate their imaginations. Exposure

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to inspirational astronomical themes can help broaden the minds and stimulate a world-view. Furthermore, astronomy is an excellent and exciting introduction to the scientific method and the concept that nature can be interrogated by rational means. This is the basis of the Universe Awareness programme <www.unawe.org>.

3.2. *Secondary education (ages 11 – 18)*

Astronomy is an outstanding medium for stimulating the interest of secondary school students in science and technology. The Universe and space travel are fascinating subjects in their own right. These topics can be integrated into physics, chemistry, biology and mathematics teaching and provide a link with technology and engineering studies. Recently, educational networks of telescopes have been developed that enable school children throughout the world to do astronomical observations by means of the Internet and introduce children to exciting scientific research.

3.3. *Tertiary education and research training.*

The link with astronomy is a frequent reason for young people to choose to study the physical sciences at University and the study of astronomy provides an excellent preparation for many careers in technology and management. Astronomy deals with material, which is much denser and much sparser than anything that can be produced on Earth. Analysing phenomena under the extreme conditions that are present in astrophysical objects develops problem solving abilities. Furthermore modern astronomical research is often carried out in international collaborative teams, which by necessity develops managerial and people skills.

3.4. *Research capabilities and infrastructures.*

Much modern astronomical research requires facilities that are too expensive even for individual developed countries to build and operate. The realization of such facilities has frequently necessitated large international collaborations. Nevertheless, many of the largest astronomical telescopes and satellites and their archival treasures can be used by astronomers throughout the world, no matter where they are based, providing an easy and relatively inexpensive entry for developing countries into inspirational and visible world-class international research.

3.5. *Public outreach.*

Astronomy is the most approachable of all sciences for the general public. Compare the relative attention that astronomy receives in the newspapers and other media of most countries with that devoted to most other sciences. Everybody can gaze at the sky and appreciate its beauty. The evocative images produced by modern telescopes fascinate, whereas stories about exotic cosmic objects and the evolution and origin of our Universe can inspire, entertain and stretch the imagination. Information about the state of the Universe in the distant past has deep implications about the roots and future of our species. Astronomy provides an ideal introduction for teenagers to the creative excitement of the exact sciences and frequently stimulates students to embark on a scientific career. The adventure of astronomy is a popular ingredient of adult education programs.

4. The Plan

The IAU plan <http://iau.org/static/education/strategicplan_091001.pdf> contains a vision, goals to be achieved during the next decade, a strategy for achieving these goals and a blueprint for implementation. The long-term vision of the plan is that eventually all

countries should participate at some level in astronomical research and that all children throughout the world will be exposed to knowledge about astronomy and the Universe. The "meat" of the plan is a strategy consting of several components.

- Using a phased integrated approach. This includes primary, secondary and tertiary education, research and public science outreach. For each country the mix of relevant activities will be based on the future potential for research and education. Because of its relative underdevelopment, sub-Saharan Africa will receive special attention.
- Using IYA2009 as a springboard. Several IYA global cornerstones will be continued and supported, after the IYA has finished. Examples of activities that have been adopted by the IAU include the Galileo teacher training program, UNAWE and the Galileoscope. Also, the huge network of IYA contacts that has been built up in IAU member states and other countries is a valuable resource that will be used for future capacity building activities.
- Enlarging the number of active volunteers. We shall recruit vigorously among our $\sim$ 10,000 members and augment the pool of member volunteers by doctoral students, postdoctoral trainees and talented non-member experts on pre-tertiary education and outreach, including amateur astronomers. It is hoped that expatriates will play an important role.
- Initiation of new activities. Major proposed new initiatives include (i) an endowed lectureship program to provide semi-popular lectures on inspirational topics at the high-school level and (ii) long-term institute twinning between established astronomy institutes and university departments in less developed countries. More details are given in the following section.
- Creation of a small Office of Astronomy for Development (OAD). Mobilizing large number of volunteers and implementing new programs need professional coordination.
- Increasing regional involvement. We shall adopt a bottom-up approach, with a substantial degree of decentralization and hope to create several regional nodes at institutes in various places throughout the world to take on local coordination of the activities.
- Exploiting innovative techniques. We shall encourage the use of innovative approaches to education and development, including the internet and new tools, such as archives, robotic telescope networks and the innovative Tunisian mobile science outreach "astro-bus".

5. Planned Activities

The core of our strategy is to expand existing IAU activities and initiate several new ones. Some planned capacity building activities are listed in Table 1.

- The creation of the Office of Astronomy for Development will facilitate the expansion of existing IAU activities such as the university teaching activities of the Commission 46 TAD Programme Group described by Ed Guinan in his talk.
- The IAU Plan adopts and will continue several important IYA activities, such as school teacher training courses and Universe Awareness, a programme that uses the perspective and excitement of astronomy to broaden the minds of very young children, introduce them to science and stimulate tolerance and a sense of world citizenship.
- We also plan to start several new activities, including (i) a long-term twinning between institutes and university departments in developed and developing countries and (ii) a lectureship programme in which articulate scientists and engineers will give semi-popular talks in developing countries about exciting developments in astronomy and astronomical technology.

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Figure 3. Universe Awareness (UNAWE) is a programme to expose underprivileged young children aged from 4 to 10 years to the inspirational aspects of astronomy. By raising awareness about the scale and beauty of the Universe, UNAWE attempts to stimulate tolerance, broaden the mind and awaken curiosity in science, at a formative age when the value system of children is developing. The photos show UNAWE activities in Tunisia.

Table 1. Some activities envisaged in the IAU Strategic Plan.

Development phase	Activity	Status for IAU
Public Outreach	Semi-popular lectures in astronomy and related technology	New
Tertiary education and research	Visits by astronomers and engineers	Pre-IYA
	National schools for undergraduates	Pre-IYA
	Regional schools for postgraduates	Pre-IYA
	Long-term (sustainable) institute twinning	New
Pre-tertiary education (for children)	Teacher training	New
	Universe Awareness (see Fig. 3)	New

The Plan envisages a flexible implementation of the strategy, in step with available funding. The annual direct cost will be several orders of magnitude larger than that the present cost of the IAU development program. The IAU Executive Committee has approved an increase in funding for relevant activities from 10.3% to 16.7% of the IAU budget. This amounts to 144 000 Euros annually, only a tiny fraction of what will be needed.

Obtaining sufficient resources will be a huge challenge that will need action on various fronts. Several possibilities are outlined in the plan. An excellent start has been provided by the South African Department for Science and Technology and the South African National Research Foundation, who have contributed substantially to the cost of the OAD. During the next few years a vigorous campaign will be coordinated by the OAD to raise additional funds. Organisations that we shall approach include international and regional development agencies, industry, national governments and philanthropic foundations. The existence of our plan and the professional approach demonstrated by the creation of the OAD, are prerequisites to any large-scale efforts to obtain funds.

6. Status of Plan

After its endorsement by the IAU General Assembly in August 2009, the IAU instigated a call for proposals to host the Office of Astronomy for Development. Forty letters of intent were received followed by 20 full proposals, many of which were excellent. In May

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2010, the IAU Executive Committee selected the South African Astronomical Observatory (Fig. 4) to host the OAD. The South African Department of Science and Technology and the National Research Foundation will co-fund the Office and we are very grateful to them.

The next stage was recruiting a Director for the Office. The position was advertised widely in the international press and several outstanding candidates applied. I am delighted to tell you that we have recent appointed Kevin Govender to the position. He will begin this position in March 2011. Kevin is a superb choice that will set the OAD and the Strategic Plan off to a great start. During the next year we shall proceed with selecting some regional nodes, start trying to raise funds and gradually begin implementing the Plan.

Figure 4. The South African Astronomical Observatory, the institute that has been selected to host the IAU Office of Astronomy for Development (OAD). This office will coordinate IAU capacity building activities globally and will begin operations in March 2011.

7. Closing remarks

Occasionally research astronomers ask me why they should become involved in such activities? My answer is to cite reasons of morality and of expediency. Facilities needed to carry out frontier astronomical research become more expensive every year. The willingness of society to fund these magnificent machines sets an ultimate limit of what can be achieved. The decision of whether or not to construct a billion-dollar astronomical research facility is inevitably a political one. By devoting a tiny fraction of astronomical resources to global development and education, we enhance the image of astronomy as a whole and make politicians more receptive to research proposals. Mobilizing astronomy in the service of global development is a cost-effective strategy for researchers.

From the earliest times astronomy has had a profound effect on human development and has been of enormous benefit to society. The IAU Strategic Plan will continue this role of astronomy as a practical discipline in the present age.

It is a pleasure to thank everybody who provided input and feedback into developing the IAU Strategic Plan. I particularly thank Kevin Govender and others for their visionary blueprint for astronomy education in outreach in Africa, that is included as Appendix C of our plan. I am also indebted to the large numbers of astronomers and others who devoted large amounts of time and effort to astronomy development activities that have laid the basis for the planned expansion. The plan would not have come about without input from the members of IAU Commission 46 and also several of those who worked hard to

make IYA 2009 such a success. Catherine Cesarsky and Bob Williams as past-President and President of the IAU have given exceptional support to these activities.

For the past year I have been looking forward to coming to Burkina Faso and speaking at this symposium, but unfortunately I was forced to cancel my attendance for personal reasons. I am extremely grateful to Claude Carignan for presenting this talk for me and on behalf of the IAU Execurive Committee I thank him for all his work in organising this symposium.