Some problems of science education in a world with an exploding population and enormous disparities of affluence and poverty

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The presentation I had planned was to be on "*Problems of Science publishing for those with limited access, particularly in Africa*", and was concerned with issues of printing and distribution.

In the light of so many interesting contributions in the plenary sessions of the last three days, I want to broaden my brief and to offer a new title: "*Some problems of Science Education in a world with an exploding population and enormous disparities of affluence and poverty*"—a title that covers many of the big issues we are addressing

What are the problems facing, for example, a 16-year old boy in the Congo who desperately wants to become a mathematician? It's no use telling him that "all the world's knowledge is nowadays available to everyone on the Internet." In principle this may be (partly) true, but there are many obstacles to actually getting hold of it! Before looking at them one first asks *why* he wants to do mathematics.

I believe we all start life with an innate *curiosity* about the physical world around us and how it works. That curiosity is the platform on which the *scientific mind* can be built. Thinking back to my own first steps into science I realize how easy it was for me, compared with a young person in a rural village in Africa. I had a decent school to go to when I was five years old; and then my natural curiosity survived the trials of formal education and led me on to graduate in Physics at 20 and to follow this with 50 years of research, teaching and writing. The end result, for me was a Scientific Mind—but exactly how did I get it? The building process doesn't just happen: it has to be given an impetus at many points along the way, some small sparks of 'inspiration'; and it has to be sustained by an expectation of success.

One of my earliest memories was of my grandfather, who was a watchmaker, giving me an old alarm clock and asking if I could find what made it tick and what made the bell ring—quite a challenge for a 7-year old! That was the beginning of my 'apprenticeship.' I took it apart, noting where all the bits and pieces came from, cleaning and re-assembling them as I had seen him do. It worked; and I had found exactly *how* it worked. I still remember the pride and satisfaction it gave me. Grandfather showed me how to *use tools* and *make things*. I might easily have become an engineer, but in fact I turned towards experimental physics after discovering the Public Library, where I found many books on popular science. I was fascinated by the Physics books of the day, especially those showing machines for generating static electricity and making gigantic sparks. 'Inspired' I went home and with help from granddad, built a Wimshurst machine which worked and confirmed that what the books said was really true! By the time I was 12 I knew I wanted to do *physics*.

Another big influence came from a new teacher at my school. Mr. Siddons was a Cambridge graduate and had been taught by Dirac (who by that time—about 1937—had become one of the great physicists of the century). Some of Dirac's greatness had 'rubbed off' on my teacher, who convinced me by his brilliance that the best way of doing science was to start whenever possible from 'very first principles': if you understand the basic principles all the rest will follow by rational argument!

After this excursion into 'building the scientific mind' let me come back to the problems of passing on to future generations all the things we ourselves have learnt in a lifetime of scientific activity: this has traditionally been done by publishing books; the best ones survive, by a kind of natural selection, and give their readers the means of arriving most easily at the new frontiers of current science. But the situation is now rapidly changing as a result of technological progress based on the development of the computer, in particular the Internet and the World Wide Web. My own efforts over the last few years have been devoted to editing, and in large measure writing, the Series '*Basic Books in Science*' which is already available on the Web, for free downloading (e.g. from <www.learndev.org> by following the link to *For the Love of Science*).

Unfortunately, initiatives of this kind do not offer a complete solution to would-be readers in, for example, rural Africa or Latin America. They will usually lack easy access to computers, as well as the means of paying for time on-line, and any related costs for down-loading and printing. Even when computers are within reach most users are not able to stay on-line long enough for serious study. In fact, many readers find it easier to work from printed versions but have no facilities for producing their own copies.

Commercial publishing houses have the facilities for both printing and distribution, but will not handle open-access material, viewing it as unwelcome competition. Experience shows that there is no conflict: potential readers (forming a vast market) will purchase their own hard copies of books they have seen on the web if they are available at low cost. The publishers have nothing to lose: there are no type-setting costs, all the work they once had to do is nowadays done for them by the authors themselves. Printing from pdf files is easily done by unskilled printers in the countries where the books will be used. But the publishers, even in low-cost countries such as India, fail to be convinced.

Who will make the end product available in the places where it is most needed?—and at a price affordable by students and their teachers.