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Chemistry in Sweden—A Midsummer Night's Dream?

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In 1787, in the small village of Ytterby, situated northeast of Stockholm, the young chemist Carl Axel Arrhenius unearthed a black mineral, which he named Ytterbite. From this and other minerals collected from the same spot, nine new elements were isolated. They were named after the village and its surroundings: yttrium, ytterbium, terbium, erbium, holmium (from the Latin name of Stockholm), scandium, thulium (from the Latin name of Scandinavia), gadolinium, and tantalum. Some years later, the Swedish chemist Jöns Jacob Berzelius discovered several additional elements: silicon, selenium, cerium, and thorium. Furthermore, he assigned symbols, which we use still today, to all the elements.

To what extent have later generations of Swedish chemists been able to live up to this proud heritage? What is the state of Swedish and Scandinavian research today? About 1.8% of the world's scientific papers are produced in Scandinavia, 7% of which are assigned to the field of chemistry. Citations in the field of chemistry are above world average for Sweden and Denmark and just below world average for Norway, but although for Norway the number of citations is increasing, for Sweden and Denmark there is a slight decline (according to the research organization NordForsk). Denmark has the highest portion of most-cited papers among the Scandinavian countries. For both Denmark and Sweden, the most-cited papers are in the field of chemistry. The total number of ERC advanced grants awarded to Scandinavian scientists is 87 (7.9% of the total), and that of starting grants is 126 (6.3% of the total).

Recognizing that the number of scientific publications and that of citations are poor indicators of scientific quality and originality, several universities undertake Research Assessment Exercises at regular intervals. During these evaluations, panels of international experts make site visits and appraise the quality of the research activities at the particular institution. The results of such assessments are often used for prioritizing the internal distribution of resources.

Merely 24% of the funding in Sweden comes from the government

From an international perspective, Sweden's research expenditure is high at 3.4% of the gross domestic product (GDP), compared to the average of 3.0% within the OECD countries. However, merely 24% of the funding in Sweden comes from the government. Therefore, the closure of major industrial research sites, as recently that of AstraZeneca in Södertälje, will have a notable effect on the total funding. In Norway, only 1.64% of GDP is spent on research. However, as much as 45% of research funding comes from the government, which thus spends about the same fraction of the GDP on research as Sweden. Private foundations, such as the Swedish Knut and Alice Wallenberg foundation, are also instrumental for providing expensive equipment, as well as support for larger projects.

The high expenditures for research should be viewed in relation to the relatively high costs of research in Sweden. Akademiska Hus, which is a state-owned property company, owns more than 70% of the university buildings in Sweden. The company generates a profit, from which an amount corresponding to more than 25% of the research budget of the Swedish Research Council goes back to the state. Universities typically spend around 15% of their total budgets on rent for premises—these costs are of course particularly high for subjects that require laboratory space. Furthermore, graduate students often have full salaries and in many departments, costs for graduate student salaries exceed those for the faculty.

In autumn 2012, the Swedish government launched a bill that, after a period of four years, will result in a research budget amounting to 4×10^9 Euros, as compared to the present amount of 3.5×10^9 Euros. Life sciences will enjoy a particularly substantial increase in funding. One-third of the investments in the life sciences will be directed to the Science for Life Laboratory (SciLifeLab), which is a national scientific center for large-scale biosciences and bioinformatics, with a focus on health and environmental research, driven by the Karolinska Institute, Stockholm University, Uppsala University, and KTH.

Another national facility that will enjoy increased funding is the synchrotron light source facility at the MAX laboratories, located in Lund. Three storage rings are in operation, the first of which

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dates from 1986. These serve scientists within the natural sciences, engineering, and medicine, and support several hundred users from over 30 countries annually. Construction of the next-generation synchrotron radiation source MAX IV has recently started. It will be a world-class facility and will provide measurements with considerably higher accuracy than achieved previously.

A joint European research facility, the European Spallation Source (ESS), will also be located in Lund and will be the most potent neutron source in the world. The estimated cost is close to 1.5×10^9 Euros and annual running costs are estimated to about 100 million Euros. Part of the increased research budget will be directed to these new facilities. The plans for the ESS facility gained vast political support from all Scandinavian governments and universities, and many scientists, within academia as well as in industry, are supportive. However, whereas the support for the MAX IV project among scientists is widespread, many fear that the ESS project may take resources away from other fields of research.

Critical voices are being raised, from the government as well as industry, which feel that there is a lack of innovation, and that results from basic research are scarcely explored. In an attempt to address this issue by political means, the government will direct substantial amounts of the new resources towards innovations through the Swedish Governmental Agency for Innovation Systems—the bill that recently appeared is called the "Agenda for Research and Innovation", in contrast to previous agendas in which only research was mentioned. Maybe this is a general tendency today!

The Swedish political parties have been criticized, mainly by university scientists, for lacking a joint research program. In Denmark, the major political parties represented in the Danish Parliament have agreed on principles for research policy, with the aim of assuring optimum and stable conditions for research. This might be a clue to the success of Danish research.

Academic institutions have recognized the importance of establishing links to institutions in countries with "emerging economies". New partnerships and, in some cases, research centers, notably in Asian countries, have been established. Swedish universities attract a large number of foreign students at all levels. In 2010/2011, 13% of the students at undergraduate and masters level, and about 40% of those at graduate level, were of non-Swedish origin, but the former proportion has declined as a result of the introduction of tuition fees for non-European students in 2011.

Much money is invested in large-scale projects and applied research

Two political reforms have had great impact on the Swedish research landscape in recent decades. In the 1980s, the social democratic government decided to create a number of university colleges spread over the country. The need to increase the level of knowledge was the driving force for this expansion of academic education, with the particular aim of attracting young people from families lacking educational backgrounds. These efforts have no doubt been successful. The expansion of higher education also had consequences for Swedish research. As it is generally agreed that higher education needs to be accompanied by research and that university teachers should be engaged in research, resources for research are now allocated to a larger number of institutions, with a risk of subcritical financing.

The second reform dates from the late 1990s, when it was decided that lecturers who have the competence of professors, as evaluated by external experts, have the right to be promoted to professors. A similar reform in Norway dates from 1993. As a consequence, the number of professors has more than doubled, although the number of announced positions, and the resulting mobility, has decreased.

The Scandinavian countries have a long tradition of gender equality, which is also regulated by law. From around 20% women in the Swedish parliament in the mid-1970s, the proportion has steadily increased and since 2002 amounts to at least 45%. Similar numbers are valid for the other Scandinavian parliaments. The change within universities has, however, been less impressive. The proportion of female professors was merely 8% in 1995 and is close to 25% today, which is not more than the EU average of 27%. And in natural sciences and engineering, the share of female professors is considerably lower.

Slightly more than a century after the discovery of Ytterbite by Carl Axel Arrhenius, his namesake Svante Arrhenius became the first Swede to receive the Nobel Prize. Since then only two Swedish scientists have received the Nobel Prize in Chemistry. The government now finds that the time has come to strive for excellence. The "Agenda for Research and Innovation" therefore allocates substantial funding to the promotion of excellence. A higher portion of university funding will be distributed based on scientific quality, as assessed by peer review. Part of the faculty funding will be designated specifically for the support of young talents and for the recruitment of excellent international scientists.

Will all this make Sweden a leading research nation? If not, you should remember Puck's words: "That you have but slumber'd here while these visions did appear".