conference in New York on the demographic problem of the Jews excluded Jews.

Israeli universities and research institutions are thus not independent of the Israeli State and its political agendas and acts. Rather, they, and many of the academics within them, are active creators and endorsers. As I emphasised in my Opinion column, a boycott is a tactic, not an end in itself. It

is an effort to persuade those boycotted to change their policies. Berlin claims that it is ineffective. If so, and the policies do not change, so much the worse not just for Palestinians, but for Israel itself and the wider world outside the Middle East.

REFERENCES

Keller U (2009) *Socioeconomic Bulletin No.23: Academic Boycott of Israel and the Complicity*

of Israeli Academic Institutions in Occupation of Palestinian Territories. The Alternative Information Centre

**Steven Rose is a professor of biology and neurobiology at the Open University, UK.
E-mail: s.p.r.rose@open.ac.uk**

EMBO reports (2010) **11**, 151–152.
doi:10.1038/embor.2010.13

Comment on 'Big science, little science'

In his recent Opinion article, Gregory Petsko raised concerns about the hegemony of 'big science' over 'little science' (Petsko, 2009). He argued that the scale of the resources sequestered to expensive, large research projects is "outrageous" and may be missing for small, investigator-driven research. As a result, he argues that big science might be detrimental to research in general. However, a consideration of the apparent anxiety and potential tensions between investigator-driven research and big science—that is, organized multidisciplinary collaborations—should not be based on budget allocations alone. Instead, the benefits of big science should be examined carefully in terms of discovery and value to little science, economic spillovers to industry and national innovation systems, and interactions with society. These realities should be used as guidelines to funding structures and big science may turn out to be the saviour of little science.

During the past decade or so, the breadth and goals of some scientific research have grown to a new dimension that warrants the term big science. This scaling-up has taken place mostly during the late twentieth century, which, according to Hughes (2002), saw the most remarkable growth in the scale, scope and cost of scientific research. In this sense, big science is a natural evolution of scientific research and its increasing interaction with a knowledge-based economy and the ever more connected modern world.

In the post-genomic era of biology, little science can benefit immensely from big science centres that perform high-throughput analyses. According to Wiley (2008), big science centres provide valuable resources

to the scientific community and thereby generate new research opportunities and directions for many areas in the life sciences. One important example is the rapid increase of genomic information, which is being made available directly to most research groups across the globe. However, it has also been stressed that big science, such as large-scale genomic analyses, cannot replace the traditional approach of little science but should rather complement it (Editorial, 2001).

The benefits of big science for economic growth and national innovation systems become more pertinent if we look at how it contributes to the knowledge-based economy and current changes in market capitalism towards so-called "technocapitalism" (Suarez-Villa, 2003). At the heart of technocapitalism are private and public enterprises that rely heavily on research and innovation—in contrast to industrial capitalism, which is production-driven (Suarez-Villa, 2000). It is therefore misleading to think that the only role of big science is the production of knowledge, because in reality it creates many non-epistemic benefits (Autio *et al*, 1996). The potential of spillover effects from big science to the economy via industrial knowledge transfers have been documented extensively: one of the most well known is the profound work that was carried out at CERN during the 1980s and 1990s to develop a Web Data Management system, which led to the establishment of the World Wide Web and the consequent economic and societal revolution (Byckling *et al*, 2000). In addition, big science centres can also serve potentially as an important source of knowledge spillovers in national and regional innovation systems (Autio *et al*, 2004).

Furthermore, the importance of big science to society may be evident in the interactions with non-scientific groups and actors. First, science itself has become a subject of study and debate outside the scientific community. Second, big science reaches beyond its boundaries as it attracts public and media interest and helps scientists to communicate with the public. These interactions will promote more awareness about science among the general public and decision-makers, which, in turn, benefits the scientific community.

In conclusion, big science has a major impact on national economies, societies and the advancement of little science. However, for little science to utilize the benefits of big science, the funding agencies should implement policies that guarantee the growth of little science along with big science.

CONFLICT OF INTEREST:

The author declares that he has no competing interests.

REFERENCES

Autio E, Hameri A-P, Nordberg M (1996) *J Eng Technol Manag* **13**: 301–314
Autio E, Hameri A-P, Vuola O (2004) *Res Policy* **33**: 107–126
Byckling *et al* (2000) *Technovation* **20**: 71–80
Hughes J (2002) *The Manhattan Project: Big Science and the Atom Bomb*. Icon
Editorial (2001) *Nat Cell Biol* **3**: E65
Petsko GA (2009) *EMBO Rep* **10**: 1282
Suarez-Villa L (2000) *The Invention and Rise of Technocapitalism*. Rowman & Littlefield
Suarez-Villa L (2003) *Growth Change* **34**: 390–414
Wiley S (2008) *Scientist* August 2008: 27

**Alex J. Valentine is at the Plant Biology Division, Samuel Roberts Noble Foundation, Ardmore, OK, USA.
E-mail: alexvalentine@mac.com**

EMBO reports (2010) **11**, 152. doi:10.1038/embor.2010.16