Do we need “more research” or better implementation through knowledge brokering?

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Abstract “More research is needed” is an iconic catchphrase used by scientists worldwide. Yet policy and management decisions are continually being made with variable levels of reliance on scientific knowledge. Funding agencies have provided incentives for knowledge exchange at the interfaces between science and policy or practice, yet it remains the exception rather than the rule within academic institutions. An important step forward would be the establishment and professionalization of knowledge brokering (i.e., as a complement to existing technology transfer and communications departments). This would require an explicit commitment of resources by both funding agencies and institutions. Many academic scientists are genuinely interested in the applications of their research. This interest could be stimulated by providing support for the process of knowledge brokering and by integrating the natural, social, and engineering sciences to address broad policy- and practice-relevant questions.

Keywords Knowledge brokering · Knowledge exchange · Research implementation · Science-policy interface · SPI

Introduction

Continuing concern is expressed in government administrations and funding agencies that policy-making and management do not benefit sufficiently from the knowledge generated by publically funded science (Chapman et al. 2010b; EC 2013; Holmes and Scott 2010; McNie 2007; Pahl-Wostl et al. 2011; Van Enst et al. 2014). This is particularly important in the environmental field, in which most policies and management relate to public goods (e.g., natural resources). Since externalities and market failures are commonplace in cases of public goods, key roles for government and regulation are recognized. This has led to substantial public funding for science that could (or should) contribute to policy-making and resource management decisions although science is, of course, only one of many inputs into decision-making (Choi et al. 2005; Cullen 1990). An estimated 450 water-related projects have been supported by European funding, yet it was noted in the 2012 Roadmap for Uptake of EU Water Research in Policy and Industry (http://www.hydroscan.be/uploads/b117.pdf) that “Unfortunately, the dissemination and uptake of the results of these projects is limited”. Recognizing the need to improve the uptake of research into regulation (specifically the Water Framework Directive), the water directors of the EU and associated States funded an ad hoc science-policy interface (SPI) activity with the goals of identifying relevant available research as well as research gaps and improving the transfer and usability of research (EC 2013).

These concerns and issues are not new and many of the possible remedies identified echo past recommendations (Cullen 1990). In the interest of formulating a path toward effective knowledge exchange at the interfaces of science with policy and/or practice (referred to herein collectively...
as $\text{SP}^2$), it is worthwhile to review briefly the key impediments and measures that have been previously been identified. Although this paper focuses mainly on the academic perspective, cooperation with non-academic partners is essential to effective knowledge exchange.

**Key impediments to effective knowledge exchange are well known**

Three key impediments to effective knowledge exchange relate to the accessibility, relevance, and timeliness of research. In the first case, research outputs, which generally appear in the peer-reviewed scientific literature, are not written in a way that is accessible to managers and/or policy makers. In the second case, research fails to provide usable information that is needed for policy and/or management decisions. And, in the third case, even relevant and accessible research outputs may not be available at the time when they would be needed as input to decision-making for policy and/or management (Choi et al. 2005; Kirchhoff et al. 2013; Martini et al. 2013; Opwanya et al. 2013; Sarewitz and Pielke 2007). Cultural mismatches between scientists and decision-makers have also been identified, in particular, that scientists seek to draw recommendations from the weight of the evidence while policy makers often seek evidence to support favored policy solutions (Cullen 1990). These are exacerbated by the lack of personal contact between members of these groups (Choi et al. 2005) as well as by the persistence of linear models of knowledge transfer (Calow 2014; Slob et al. 2007), the disconnect with academic incentive systems (Hering et al. 2012; McNie 2007), and time conflicts with other professional obligations (Pennell et al. 2013).

**Mismatch with the interests of (most) scientists and institutional incentives**

These key impediments are easily understandable when they are considered in the context in which academic research is conducted. Publications in the peer-reviewed scientific literature are the “currency” of academia. Despite the recent push-back against the tyranny of journal impact factors (Bladek 2014), academic institutions have made scant progress in defining and applying alternative metrics for promotion and tenure. The acquisition of funding for research is also often strongly tied to the applicant’s publication record. The identification of research topics and the initiation of research projects are, in the ideal, driven by curiosity (Zewail 2010) though the role of opportunity (e.g., through application of new technology) and pragmatic considerations of funding and career advancement cannot be ignored. Critically for the application of research, science and scientists are fundamentally oriented toward questions and new knowledge (Firestein 2012), which implies that meaningful consideration of relevance is likely to receive insufficient attention in the setting of research agendas in the absence of external incentives. Furthermore, the cutting edge of research (characterized by active debate among researchers and, often, of most interest to them) does not usually provide the most useful and usable information for policy and management (Hering et al. 2014; Holmes and Scott 2010).

**Knowledge brokering and boundary organizations as avenues for effective knowledge exchange**

First and foremost among the various measures recommended for effective knowledge exchange at the $\text{SP}^2$ is knowledge brokering (also called translation) either within academic research institutions or in separate boundary organizations (Bielak et al. 2008; Cash et al. 2003; Chapman et al. 2010a; Cullen 1990; Kiparsky et al. 2012; Lemos et al. 2012; Martini et al. 2013; McNie 2007; Pennell et al. 2013; Phipps and Morton 2013; PSI-connect 2012; Shaxson et al. 2012; Turnhout et al. 2013; Ward et al. 2009). As outlined schematically in Fig. 1, knowledge brokering is an iterative and bidirectional process of translation, tailoring of information for specific contexts, feedback, and integration. In addition to facilitating the uptake of research into policy and practice, knowledge brokering should help to identify the information that could be useful to support policy decisions so that research can be directed toward filling critical knowledge gaps. To promote information flow in both directions, knowledge brokers must have sufficient relevant expertise to engage with both scientific experts and policy makers or managers and must have a wide range of professional skills, most notably in communication (Phipps and Morton 2013). Knowledge brokers can sustain long-term partnerships with decision-makers that are needed to establish trust (Kirchhoff 2013; Pennell et al. 2013). Although knowledge brokers can be highly effective working within academic institutions, this is often embedded within specific projects without a clear professional outlook after the project ends (Kirchhoff 2013). Scientific experts within academia can act as knowledge brokers; this can be effective within targeted programs such as Cooperative Extension in the US Land Grant Colleges (Osmond et al. 2010) but can also be problematic due to the mismatch with expectations and incentives in academia as well as competing demands on time (McNie 2007; Pennell et al. 2013; Turnhout et al. 2013). Different models for knowledge brokering have been defined (specifically knowledge management, linkage/exchange,
and capacity building); these are often combined in practice (Turnhout et al. 2013; Ward et al. 2009). A wide range of tools and concepts for knowledge brokering have been developed and are available through various (and variably maintained) websites (Table 1). Two of these websites, the Knowledge Brokers’ Forum (KBF) and research to action (R2A), provide entry points to on-line communities engaged in knowledge brokering.

Knowledge brokering is well established within boundary organizations that operate at the interface between the scientific enterprise and politics or administration (Guston 2001; Osmond et al. 2010). Boundary organizations are hugely diverse, varying in size, scope, source and stability of funding, and legal basis or charter. They range from highly prestigious organizations with long histories such as the US National Research Council (which has an explicit mandate to “improve government decision making and public policy”, http://www.nationalacademies.org/nrc/) to large projects (see Table 1) that can function temporarily as boundary organizations but suffer from a lack of continuity. Boundary organizations can also be nested. For example, UN Water (http://www.unwater.org/) is an inter-agency coordination mechanism established by the United Nations in 2003; it counted 31 members and 34 partners at the end of 2013 (UN Water 2014). Some boundary organizations maintain a neutral and independent position while others either take on an explicit advocacy role or are perceived as advocates, often based on the source of their funding. Many industries, for example, support boundary organizations (i.e., professional or trade associations) to share information among members and sometimes to set common standards but often for outreach and lobbying. Consulting firms can also fulfill many functions of boundary organizations, though their orientation toward client satisfaction and financial constraints can limit their objectivity.

An important role played by some boundary organizations is the establishment and maintenance of knowledge portals. Interactive web platforms or tool-kits can provide a valuable mechanism for the dissemination of information and the creation of on-line communities (Lemos et al. 2012). The accessibility and usability of such platforms may, however, be insufficient for the non-expert user (De Lange et al. 2010); “intelligent filtering” is needed to ensure accessibility and usability (Brunner 2014). The temporary nature of knowledge portals and lack of updating is a significant problem for portals that are developed under the auspices of projects (Opwanya et al. 2013). Clearly, the value of such investments is not optimally captured if products languish on the web in an inactive form or disappear altogether (Blind et al. 2010; Kramer and Schneider 2010).
The way forward for academic institutions

Research and academic institutions are increasingly called upon to bring their expertise to bear on problems of relevance to policy and practice. These problems often involve complex socio-environmental-technical systems and hence require the solution-oriented integration of the natural, social, and engineering sciences. Knowledge exchange at the SP²I is an essential component of increasing the relevance of academic research, which requires the targeted commitment of human and financial resources by research and academic institutions, funding agencies, and government administrations. SP²I activities can be explicitly incorporated into relevant projects with a clearly defined scope and dedicated budget (Pennell et al. 2013; Slob et al. 2007). Targeted support will be required to allow early involvement of policy makers, managers, and stakeholders from industry and other interest groups in project planning. This would promote a need-oriented focus for research as well as a balancing of competing interests that could help to avoid later conflicts. Continuity is particularly important since it would allow scientific and technical knowledge to be quickly marshalled in response to events that create “windows of opportunity”. These activities can benefit from previously-developed tools and concepts (PSI-connect 2012; Young et al. 2013) as well as the experience gained from past projects (Martini et al. 2013; Shaxson et al. 2012) if sufficient investments of time and resources are made (Ward et al. 2009). The skills and role of knowledge brokers must be respected and supported; if such individuals are to be embedded in research and academic institutions, their positioning needs to be

| Table 1: Examples of web resources for knowledge brokering |
|---------------------------------|-----------------|-----------------|-----------------|
| Name                          | Type/owner                          | Focus                                                                 | URL                      |
| Integration and implementation | Website managed by ANU faculty       | I2S provides concepts and methods for conducting research on complex, real-world problems. It enhances: synthesis of disciplinary and stakeholder knowledge; understanding and management of diverse unknowns; provision of integrated research support for policy and practice change | http://i2s.anu.edu.au/   |
| KStar (K*) initiative          | Project website UNU-INWEH            | K* is the collective term for the set of functions and processes at the various interfaces between knowledge, practice, and policy. K* improves the ways in which knowledge is shared and applied; improving processes already in place to bring about more effective and sustainable change | http://inweh.unu.edu/kstar* |
| Knowledge Brokers’ Forum       | Website managed by the I-K-mediary network | The Knowledge Brokers’ Forum (KBF) is a collaborative space to promote knowledge sharing and dissemination around intermediary work in international development | http://www.knowledgebrokersforum.org/ |
| PSI connect                    | Project website FP7 EU contract number 226915 | Connecting policy and science through innovative knowledge brokering in the field of water management and climate change | http://www.psiconnect.eu* |
| Research to Action (R2A)       | Website managed by CommsConsult      | An initiative catering for the strategic and practical needs of people trying to improve the way development research is communicated and utilized | http://www.researchtoaction.org/ |
| SPIRAL: Interfacing Biodiversity and Policy | Project website FP7 EU contract number 244035 | Goals: improved understanding of why and when more effective science-policy interfaces are needed and allow for identification of some criteria for designing them; identification of good practice and additional actions needed to improve the effectiveness of science-policy interfaces for biodiversity | http://www.spiral-project.eu* |

* Website no longer actively maintained
incentivized, clarified, and incorporated into institutional structures (Phipps and Morton 2013; Shaxson et al. 2012; Turnhout et al. 2013).

Nearly all academic and research institutions house support departments for communications and technology transfer; an analogous department for knowledge exchange could provide an institutional home for knowledge brokers and a platform for the uptake and application of SPI tools and/or support and maintenance of SPI web portals. It would be important that such knowledge exchange departments not operate in the “supply-driven” mode that is characteristic of most institutional communications departments but rather fulfill an active and iterative brokering function. This could promote the identification and prioritization of research needed to support policy development and implementation. Academic and research institutions could also formalize agreements with external boundary organizations to ensure stability and continuity for knowledge exchange activities. In either case, cooperation among boundary organizations and knowledge brokers to share effective concepts, strategies, and practices should be actively promoted. Such harvesting of experience should also include real-world examples of both success and failure (Brunner 2014). Ideally, SP3I activities would no longer be ad hoc but rather sustainable and systematic (EC 2013).

Even if knowledge brokering becomes professionalized and established within academic or research institutions, knowledge brokers will need scientific experts as partners. There is dubious value to attempting to force this cooperation. Even within the context of the EU Framework Programs, which have strict requirements for knowledge exchange, surveys have indicated that project participants complied with these requirements reluctantly and often did not follow through (Holmes and Scott 2010). At the same time, there are some scientists who are genuinely interested in the application of their research; they should be supported and encouraged within their institutions (Hering et al. 2012). It is not necessary, and perhaps not even desirable, for scientific experts to take the full responsibility for knowledge brokering (Pennell et al. 2013), but there is a wide variety of ways in which scientific experts can contribute fruitfully to knowledge exchange (Hering et al. 2014; Spruijt et al. 2014). Appropriate support for these interested individuals (i.e., provided by knowledge brokers with relevant information about effective tools and processes) can help them to avoid wasting their time in rediscovering what does and does not work at the SP3I. In this context, the engagement of social scientists could provide a better conceptual basis for effective knowledge exchange, providing insight into the processes of policy implementation and political decision-making. It would also be productive for experts from the natural and social sciences to interact with their colleagues in engineering, who have professional experience collaborating with practitioners and stakeholders. Scientists and engineers exhibit different “habits of mind”, partly from natural inclination and partly developed through their training. The engineering habits of mind—systems thinking, creativity, optimism, collaboration, communication, and ethical considerations (Katehi et al. 2009)—are badly needed at the SP3I.

Knowledge brokers based in academic or research institutions will also need to establish strong and stable relationships with their counterparts in politics, administration, industry, and other target groups. Cooperation with non-academic boundary organizations will be important to complement and extend the contacts of academic knowledge brokers. The distribution of knowledge brokering activities across various types of organizations should promote the effectiveness of knowledge brokering and reflect the contexts in which knowledge is produced and applied.

Much has been written about the potential for science to contribute to decision-making in policy and management. In the environmental sciences, for example, there is an increasing understanding and acceptance of the influence of human activities on our environment at all scales, up to and including the global scale (Steffen et al. 2011). With this comes the realization that there are “not one but many ecological futures” and that “we must actually design and choose our future” (Priscoli 2004). Since environmental issues are inherently embedded in socio-environmental-technical systems and arise in specific contexts, these aspects cannot be ignored either in the decision-making process or in research that seeks to inform this process. The incorporation of scientific knowledge into decision-making for policy and management cannot guarantee that the best decisions are made and neither is scientific input the only, or even the most important, input to decision-making (Choi et al. 2005; Cullen 1990). Nonetheless, decisions that are inconsistent with the underlying biophysical reality are fundamentally flawed and publically funded science should help to avoid such outcomes. “Going to scale” with knowledge brokering offers the best chance for decision-making in policy and management to benefit from scientific knowledge.

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References

Bielak AT, Campbell A, Pope S, Schaef er K, Shax son L (2008) From science communication to knowledge brokering: the shift from ‘science push’ to ‘policy pull’. In: Cheng D, Claessens M, Gascogne NRJ, Metcalfe J, Schiele B, Shi S (eds) Communicating science in social contexts: new models, new practices. Springer, pp 201–226

Blad ek M (2014) DORA: San Francisco declaration on research assessment (May 2013). Coll Res Libr News 75:191–196. http://crln.acrl.org/content/75/4/191.full

Blind MW, Refsgaard JC, Borowski I, De Lange WJ (2010) Narrowing the science-policy-gap-experience from the Harmoni-CA concerted action. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 181–199

Brunner RD (2014) Harvesting experience for adapting to climate change. Weather Clim Soc 6:5–8. doi:10.1175/wcas-d-13-00072.1

Calow P (2014) Environmental risk assessors as honest brokers or stealth advocates. Risk Anal 34:1972–1977. doi:10.1111/risa.12225

Cash DW, Clark WC, Alcock F, Dickson NM, Eckley N, Guston DH, Jager J, Mitchell RB (2003) Knowledge systems for sustainable development. Proc Natl Acad Sci 100:8086–8091. doi:10.1073/pnas.1231332100

Chapman A, Quevauviller P, de Lange WJ, Vervier P (2010a) Role of translators in science-policy interfacing. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 400–413

Chapman A, Slob AFL, Rijnveld M, Merly C (2010b) Evolution of methods to link science and policy: the experience of EUPOL. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 153–164

Choi BCK, Pang T, Lin V, Puska P, Sherman G, Goddard M, Ackland MJ, Sainsbury P, Stachenko S, Morrison H, Clottey C (2005) Can scientists and policy makers work together? J Epidemiol Community Health 59:632–637. doi:10.1136/jech.2004.031765

Cullen P (1990) The turbulent boundary between water science and water management. Freshw Biol 24:201–209. doi:10.1111/j.1365-2427.1990.tb00319.x

De Lange WJ, Plyson J, Willems P, Vansteenekste T, Provost F, Hatterman F, Vaes G, Swartenbroeckx P (2010) WISE-RTD—a portal for science and technology transfer to policy making and implementation in integrated water resources management. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 310–332

EC (2013) Science–policy interface in support of the water framework directive—CIS-SPI activity report 2010-12. Luxembourg: European Commission, http://www.onema.fr/IMG/pdf/Cts_SPIEnrawlreport.pdf. Accessed 20 Jan 2015 (p 86)

Firestein S (2012) Ignorance: how it drives science. Oxford University Press, Oxford

Guston DH (2001) Boundary organizations in environmental policy and science: an introduction. Sci Technol Human Values 26:399–408

Hering JG, Hoffmann S, Mei erhofer R, Schmid M, Peter AJ (2012) Assessing the societal beneﬁts of applied research and expert consulting in water science and technology. Gaia-Ecol Perspect Sci Soc 21:95–101

Hering JG, Dzombok DA, Green SA, Luthy RG, Swackhamer D (2014) Engagement at the science-policy interface. Environ Sci Technol 48:11031–11033. doi:10.1021/es404225h

Holmes J, Scott A (2010) Bridging the gaps between science and policy: a review of the evidence and some principles for effective action. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 15–35

Katzeli L, Pearson G, Feder M (2009) The Status and Nature of K–12 Engineering Education in the United States. Bridge 39:5–10. https://www.nae.edu/Publications/Bridge/16145/16161.aspx

Kiparisy M, Milman A, Vicuna S (2012) Climate and water: knowledge of impacts to action on adaptation. Annu Rev Environ Resour 37:163–194. doi:10.1146/annurev-environ-050311-093931

Kirchhoff CJ (2013) Understanding and enhancing climate information use in water management. Clim Change 119:495–509. doi:10.1007/s10584-013-0703-x

Kirchhoff CJ, Lemos MC, Dessl S (2013) Actionable knowledge for environmental decision making: broadening the usability of climate science. Annu Rev Environ Resour 38:393–414. doi:10.1146/annurev-environ-022111-112828

Kramer KJM, Schneider X (2010) Analysis of EC framework programme and LIFE projects for the relevance to the water framework directive. In: Quevauviller P (ed) Water system science and policy interfacing. Royal Society of Chemistry, Cambridge, pp 101–134

Lemos MC, Kirchhoff CJ, Ramprasad V (2012) Narrowing the climate information usability gap. Nat Clim Chang 2:789–794. doi:10.1038/nclimate1614

Martini F, Gergely K, Fragakis C, Blanc BF, Amorsi N, Midgley S (2013) 3rd CIS-SPI Event, Water science meets policy: how to streamline knowledge to address WFD policy challenges? France: ONEMA, http://www.onema.fr/IMG/REV/plus/SPLBrochure.pdf. Accessed 17 May 2015 (p 140)

McNie EC (2007) Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. Environ Sci Policy 10:17–38. doi:10.1016/j.envsci.2006.10.004

Opwanya Y, Schuermans Y, Quevauviller P, Willems P, Vaes G (2013) Integration of scientific and technological progress into practical uses in water resources management. AQUA mundi 4:23–27. doi:10.4409/Aquamundi.10.0049

Osmond DL, Nadkarni NM, Driscoll CT, Andrews E, Gold AJ, Allred SRB, Borkowitz AR, Klems MW, Loecke TL, McGarry MA, Schwarz K, Washington ML, Grifﬁman PM (2010) The role of interface organizations in science communication and understanding. Front Ecol Environ 8:306–313. doi:10.1890/090090145

Pahl-Wostl C, Jeffrey P, Isendahl N, Brugmann M (2011) Maturing the new water management paradigm: progressing from aspiration to practice. Water Resour Manage 25:837–856. doi:10.1007/s11269-010-9729-2

Pennell KG, Thompson M, Rice JW, Senier L, Brown P, Suuberg E (2013) Bridging research and environmental regulatory processes: the role of knowledge brokers. Environ Sci Technol 47:11985–11992. doi:10.1021/es4025244

Phipps D, Morton S (2013) Qualities of knowledge brokers: refections from practice David Phipps and Sarah Morton’. Evid Policy 9:255–265. doi:10.1332/174426413x667784

Priscoli JD (2004) What is public participation in water resources management and why is it important? Water Int 29:221–227

PSI-connect (2012) Collaborative tools and processes for connecting policy and science: Hands on approach. http://public.cranﬁeld.ac.uk/e101732/psiconnect/documents/booklet_final.pdf. Accessed 20 Jan 2015 (p 23)

Sarewitz D, Pielke RA (2007) The neglected heart of science policy: reconciling supply of and demand for science. Environ Sci Policy 10:5–16. doi:10.1016/j.envsci.2006.10.001

Shaxson L, Bielak A, Ahmed I, Brien D, Conant B, Fisher C, Gwyn E, Klerkx L, Middleton A, Morton S, Pant L (2012) Expanding our understanding of K* (KT, KE, KTT, K Mb, KB, KM, etc.) a concept paper emerging from the K* conference held in Hamilton.
Slob AFL, Rijnveld M, Chapman AS, Strosser P (2007) Challenges of linking scientific knowledge to river basin management policy: aquaTerra as a case study. Environ Pollut 148:867–874. doi:10.1016/j.envpol.2007.01.048

Spruijt P, Knol AB, Vasileiadou E, Devilee J, Lebret E, Petersen AC (2014) Roles of scientists as policy advisers on complex issues: a literature review. Environ Sci Policy 40:16–25. doi:10.1016/j.envsci.2014.03.002

Steffen W, Persson A, Deutsch L, Zalasiewicz J, Williams M, Richardson K, Crumley C, Crutzen P, Folke C, Gordon L, Molina M, Ramanathan V, Rockstrom J, Scheffer M, Schellnhuber HJ, Svedin U (2011) The Anthropocene: from global change to planetary stewardship. Ambio 40:739–761. doi:10.1007/s13280-011-0185-x

Turnhout E, Stuiver M, Klostermann J, Harms B, Leeuwis C (2013) New roles of science in society: different repertoires of knowledge brokering. Sci Public Policy 40:354–365. doi:10.1093/scipol/scs114

UN Water (2014) Annual report 2013. Geneva: UN Water, http://www.unwater.org/fileadmin/user_upload/unwater_new/docs/UN_Water_Annual_Report_2013.pdf (accessed Jan. 20, 2105)

Van Enst WI, Driessen PPJ, Runhaar HAC (2014) Towards productive science-policy interfaces: a research agenda. J Environ Assess Policy Manag 16:1450007. doi:10.1142/s1464333214500070

Ward V, House A, Hamer S (2009) Knowledge brokering: the missing link in the evidence to action chain? Evidence Policy 5:267–279

Young JC, Watt AD, van den Hove S (2013) Effective interfaces between science, policy and society: the SPIRAL project handbook. http://www.spiral-project.eu/sites/default/files/The-SPIRAL-handbook-website.pdf. Accessed 20 January 2015 (p 36)

Zewail A (2010) Curiouser and curiouser: managing discovery making. Nature 468:347. doi:10.1038/468347a