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Commentary

Time to step up: defending basic science and animal behaviour

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In 1975, Wisconsin's Democratic Senator, William Proxmire, awarded the first of his Golden Fleece Awards to the National Science Foundation (NSF) for 'funding a study on why people fall in love'. The award was designed to expose public officials who were judged to be squandering money ('fleecing' the public purse), and it included mostly examples of wasteful bureaucracy. However, several research initiatives also fell under Proxmire's scrutiny. The senator had a way of talking about research projects that made them sound truly outrageous. He routinely latched onto one isolated but memorable bit of information and distorted its background to make these projects sound laughable. Although he awarded NSF only a few of his 159 Golden Fleece Awards (http://content.wisconsinhistory.org/cdm/ref/collection/tp/id/70852), he made it politically fashionable to scorn basic scientific research. Proxmire's strategy provided him with short-term political gains at the expense of the national wellbeing. In 1988, Joel Widder, senior analyst for legislative affairs at NSF commented in response to Proxmire's awards that: 'Making fun of science in general, especially when it's taken out of context, seems detrimental to what might be a long-term national goal: To try to develop, educate, and train additional people in scientific fields' (Irion, 1988). Yet here we are, 25 years later, still faced with many of the same attacks, plus some new challenges.

In recent years, the vitriolic partisan environment in Washington has resulted in bitter fights over budget appropriations. Research projects are often highlighted as wasteful spending, not only by members of the House and Senate, but also by politically vested groups and organizations. Senator Tom Coburn, a Republican from Oklahoma, regularly highlights NSF and National Institutes of Health (NIH) projects he deems wasteful. Studies of organismal biology seem particularly vulnerable to these attacks because they involve unusual subject matter that can be easily understood by most people: duck penises, robotic squirrels, shrimp in a treadmill, snail sex and so forth (Brennan, Irschick, Johnson, & Albertson, 2014). Several active members of the Animal Behavior Society have been victims of media and/or political attacks including the authors of this commentary. Because these attacks are unlikely to cease on their own, we propose increased proactive effort towards discounting their impact. Therefore, we are writing this piece to outline our suggestions for dealing with unwanted media and political attention in a way that promotes the importance of our discipline, and a greater understanding of science among the general public, perhaps belatedly following advice from a Golden Fleece Awardee (Emlen, 1998). Although our arguments are based on experience in the United States, our recommendations may have wider implications in our field for improving science education and helping battle the arguments of science detractors elsewhere.

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BEFORE ANY ATTACKS HAPPEN

As soon as you receive government funds there are three things you can do immediately that will help you in the event that your research gets targeted as wasteful. First, we recommend setting up an online alert system (e.g. Google Alert), so that you are quickly aware of who is discussing your research online. The alert will inform you if any stories are negative. Second, prepare a summary document that explains the value of your research in terms that would make sense to a nonscientist. Highlight the big question your research is addressing, along with how many people are involved, and any papers you have already published on the topic. Third, consider creating a detailed Web site about the sponsored project, with layman descriptions and photographs that highlight both the intellectual merit and broader impacts of the research. Information from your summary document can be incorporated into this site. One of us (R.W.C.) created such a Web site and added quotes from undergraduate students on how participating in this project was a positive, sometimes life-changing experience (http://www.bio.sdsu.edu/pub/clark/Site_3/Project_Homepage.html). Such Web sites can be used to direct media outlets quickly to an in-depth description of the science behind the story. In addition, if any aspects of your project are subsequently misrepresented, you can use the Web site to point out that accurate information was readily available, but ignored by your attacker.

IF YOU ARE TARGETED

In the early days of the Golden Fleece Awards, scientists were directly affected by the negative attention, to the point where a lawsuit against Senator Proxmire for defamation, loss of income and invasion of privacy was settled out of court after ending up in the U.S. Supreme Court (Hutchinson, 2006; Irion, 1988). One consequence of this settlement was that Senator Proxmire had to write directly to grant-funding agencies promising 'not to interfere in the executive deliberation of grant proposals nor attempt to intercede in opposition to them' (Hutchinson, 2006). Other scientists like Hutchinson who responded immediately to the attacks were able to obtain retractions, and helped to bring media attention to the fact that their projects had been misrepresented (Benson, 2006). In subsequent years, scientists and much of the press became desensitized to the political targeting, and the impact of the awards was much reduced (Benson, 2006). Perhaps for this reason, scientists have been responding to political attacks less and less, despite the fact that some sectors of the press still publicize the attacks and continue to attract public attention.

Not responding to politically motivated attacks is likely to be the wrong strategy. Silence may further erode public confidence in science, as it may be interpreted as implicit acceptance that there is something wrong with your project. If your research is highlighted as an example of wasteful government spending, you will likely be contacted by media outlets to get your comments. Your response should not be limited to defending your project. Any scientific project when taken out of context can be made to sound silly and irrelevant, and therefore, these are attacks on our profession and science as a whole. To participate effectively in the defence we should be prepared to be the public face of basic science, and this paper may provide a useful starting point.

Who Should Know If You Have Been Targeted?

Inform your research collaborators, Department Chair, University Press Office and Program Officer immediately. They may be asked to comment and you should alert them so that they can be ready. Send them your summary document and a link to your Web site. Be aware that a funding agency like NSF is limited in its responses because government employees cannot lobby; they can only provide information on the project's intellectual merit and broader impacts, if asked.

What to Say

Explain that your project is basic science. Do not overreach to make connections between your project and applied science unless these legitimately exist in your research, in which case you should not be having much trouble anyway. This is an opportunity to highlight that basic science is critical for scientific advancement and innovation, and to give general examples where such gains have been realized.

As members of what is arguably the most curious species ever to walk the earth, we gain as a society from expanding knowledge for its own sake. The immense popularity (and economic success) of TV cable channels devoted entirely to learning about nature attests to the intellectual stimulation and growth that new discoveries can foster. Teaching is enriched by sharing this scientific process with students, many of whom become excited about science careers after learning about organisms and animal behaviour. These are the primary reasons why we became organismal biologists. However, when we need to defend basic science and justify why we need more funding, these arguments alone may be less compelling than illustrations of how science enhances our economy and health.

Talking points

(1) Basic science is the foundation of all applied science. Because we cannot predict which basic science projects will turn into an application, we must cast a wide net.

(2) The connection between basic and applied science is seldom a straight line; more often, it involves a network that connects novel ideas, methods and data in a new way, leading to innovations.

(3) The government must fund basic science because its potential economic gains are unpredictable and generally long term. No private investing company can invest under those conditions.

(4) Government investment in science guarantees that at least some of our discoveries are free of special interests, and therefore it protects the integrity of the scientific process. Federal investment in research and development was only 24% of all U.S. science investment in 2008 (http://www.nsf.gov/statistics/seind08/c4/c4h.htm).

(5) Funding decisions at NSF, NIH and other agencies are made by panels of scientists who judge projects on the basis of their intellectual merit and impact to society.

(6) These agencies are severely underfunded and, as a result, many high-priority projects do not get funded.

(7) The return on investment estimated from government funding of science is enormous. Not all projects turn a profit, but when they do, they can transform society: think Google, Taq polymerase (Brock, 1997) and green fluorescent protein (GFP).

(8) Federally funded basic science projects are the engine of many research universities. Without these projects, universities could not train the next generation of scientists. Involvement in basic research is often the highlight of a student's undergraduate experience and provides training that cannot be replicated through coursework.

(9) Organisms are exquisitely adapted to their environment and the study of these adaptations has allowed us to make great strides in medicine and technology (Brennan et al., 2014).

EXAMPLES OF APPLICATIONS DERIVED FROM BEHAVIOUR STUDIES

Basic research on animal behaviour can benefit human society in ways that may not be immediately apparent. The examples

below illustrate the principle that studies that address fundamental questions about behaviour have resulted in unforeseen applications with important economic and health benefits, none of which was foreseen at the outset.

The Sexual Behaviour of the Screwworm Fly

One of the recipients of a Golden Fleece Award was E. F. Knipling for his research into the sex life of parasitic screwworm flies. Knipling developed the sterile male technique to eradicate this cattle pest, based on observations during the 1930s that male screwworm flies will mate with many females, while females will mate only once. He used this information to devise a male sterilization strategy using X-rays. He released sterile males into the population and in a few generations completely eradicated this parasite. Knipling's $250,000 grant from the Department of Agriculture led directly to a program estimated to have saved at least $20 billion for U.S. cattle producers. The sterile male technique is currently used as a standard eradication technique on many agricultural pests (Knipling, 2005; http://www.innovationtaskforce.org/docs/Screwworm.pdf).

Neuroplasticity and Neurogenesis in the Brain

The discovery that humans can grow functional neurons in the brain during adulthood is revolutionizing our understanding of learning and memory, recovery from brain injury and disease, and the effects of addiction and neurodegenerative diseases. Several of the most influential early studies that discovered adult neurogenesis in the brain were conducted by Fernando Nottebohm, who showed that seasonal changes in the song nuclei of male canaries, *Serinus canaria*, were explained by recruitment of new neurons and death of old ones (e.g. Alvarez-Buylla & Nottebohm, 1988; Burd & Nottebohm, 1985; Goldman & Nottebohm, 1983; Nottebohm, 1984, 1985; Paton & Nottebohm, 1984). Nottebohm also showed that black-capped chickadees, *Poecile atricapillus*, grow neurons associated with spatial memory in the brain during the autumn, perhaps to facilitate finding their food caches during the winter months (Barnea & Nottebohm, 1994), further supporting a role of learning on neurogenesis. Nottebohm was an avid birder from childhood and his interests were centred on understanding how and why birds sing. When Nottebohm published his first papers on neurogenesis in the avian brain, the central dogma of neurobiology was that no new neurons grew in adult brains, but his careful and continued work served as a platform to develop new ideas on neurogenesis and neuroplasticity (Specter, 2001).

Antipredator Behaviour and National Security

A recent book details how national security policies could be informed by an evolutionary understanding of the natural world (Sagarin & Taylor, 2008). In that volume, Vermeij (2008) pointed out that biological entities, including cells, individual organisms and animal societies, are all organized as semiautonomous parts with weak central control. This modular organization, ubiquitous in the natural world, provides the flexibility and adaptability necessary to respond rapidly to unpredictable threats, such as predators or terrorist organizations. Human security agencies may be more effective if organized biologically, as a network of semiautonomous units that communicate with each other while operating with limited central control. In the same volume, Blumstein (2008) derived a series of principles from his studies of antipredator behaviour that are potentially relevant to national security. These principles demonstrate that basic research on predatory/prey interactions can provide guidelines on when and how we should engage threats to national security through signals of predator detection, why it is important to reduce uncertainty about risk, why defences should be generalizable against multiple threats, under what circumstances defences should be maintained even in the absence of a direct threat, and why habituation to the presence of risk may be problematic (Blumstein, 2008). Even if only one of these principles impacts the efficiency and reliability of our national security, few would argue that it was not worth the relatively minor investment made by the government in basic research on how animals deal with risk.

Host Manipulation by Parasites

Studies of host manipulation by parasites were not begun by behavioural ecologists, but we have embraced this field in the last two decades (Moore, 2012), rapidly advancing our grasp of how parasites change host behaviour (e.g. Adamo, 2012). The study of parasite manipulations has important applications to conservation, agricultural production and medicine (Poulin & Levry, 2012). One of the iconic examples involves infection of carpenter ants by the trematode *Dicrocoelium denditricum*, which affects wild and domestic ruminants. Ants are the intermediate host of this trematode, and the larvae form cysts that make the ants climb grass blades and grasp the top securely until a grazer comes by and eats it, thereby completing the parasites' cycle. In humans, toxoplasmosis infection has been linked to a variety of mental disorders, and this link has been particularly well studied in schizophrenia. Many studies have shown that schizophrenic individuals are more likely to be seropositive for antitoxoplasma antibodies (references in Poulin & Levry, 2012). Moreover, *Toxoplasma gondii* appears to have major effects on human behaviour, including several personality traits (Poulin & Levry, 2012).

Evolutionary View of Family Life

An evolutionary approach to the study of family life, proposed and developed from studies on white-fronted bee-eaters, *Merops bullockoides*, conducted by Stephen Emlen, has been used and referenced in the social sciences (Emlen, 1995, 1997). It is based on the premise that studies of animal species living in societies with multigenerational family groups can be excellent models to understand cooperation and conflict in humans living in similar social units. Incorporating knowledge of kin selection leads to predictions that step-families will be more prone to conflict because of the lower relatedness between step-parents, step-siblings and biological offspring. In addition, incorporating knowledge of the benefits of living in a social group and the potential for independent breeding of offspring that leave the household helps to create a framework for better conflict resolution in troubled households (Emlen, 1995, 1997).

Avian Migration and Air Space Safety

Avian migration has been studied for decades to understand the use of navigational cues, as well as the physiological costs associated with long-distance migration and the fitness effects of variation in migratory behaviour. However, studies of bird migration are crucial to the increased safety of flights, particularly during take-off and landing of commercial aircraft, as well as during low-altitude military flights (Dokter et al., 2010). Awareness of the conditions under which birds are likely to migrate and monitoring of large migrating flocks using radar and satellite technology are used as part of programs that seek to reduce bird/airplane collisions (e.g. Gauthreaux, 1974). As both the size of migratory flocks of many species and the size of commercial air traffic continue to increase, a

biological understanding of bird migration will continue to be important.

WHAT ELSE CAN WE DO?

The best possible outcome would be for politically motivated attacks on science to stop. How can we achieve this ultimate goal? We need to do a better job of educating the general public on the importance of science to make such attacks politically unviable.

Social media can be a powerful tool: guest blogs, online magazines and interviews with the press can reach thousands of people. Brennan (2013) wrote an opinion article on the recent debate about whether spending government funds on duck penis research was a waste of money. The article went quickly viral and was 'Shared' and 'Liked' in social media (Facebook and Twitter) over 20 000 times. As members of the Animal Behavior Society we can all share and comment on any pieces written by our colleagues to increase their online visibility, as well as write our own if needed. If you are not attacked, but one of your colleagues is, consider writing a blog, or an opinion letter in your local newspaper or your University's paper defending your colleague's work and highlighting why these attacks are misguided.

We must teach younger generations not only the distinction between basic and applied science, but their interdependence as well, in order to generate sustained progress, and therefore, teach them why funding basic science is so crucial. Amanda Hund (a graduate student at the University of Colorado Boulder) developed a curriculum for teaching 7th grade students about the importance of basic science, even when it sounds rather esoteric, based on the duck penis debate (see Supplementary material). Spending time in our college classes talking about these issues can have a ripple effect in how future generations view the importance of basic science in general and our field in particular. One of us (P.L.R.B.) will be teaching a one-credit college seminar on 'Oddball Science', where after explaining these principles, she will have students track down the basic science roots of a medical or technological application. If such courses are taught at several universities, we can gather the results and bring them to the public's attention.

Training and experience communicating science to non-scientists is another valuable tool for outreach efforts. If you are a good speaker you can engage audiences in Science-café style venues, offer to give public outreach talks at your local Rotary Club, Senior centre or other community hubs. These skills will also help you communicate with the press to ensure more accurate reporting of your work. Begin by connecting with your University Press Office and alert them to papers you are publishing that may get news coverage. When an interview is requested from a journalist, do not assume the reporting will be positive. Make sure to ask where the piece will appear and what the angle of the story is. Many journalists will ask whether you are willing to read the article before publication, but if they do not offer, you should ask. Then, make sure to check your e-mail often to help the journalists meet their deadlines.

If we can communicate the importance of basic science more effectively, we might be able to make a case for why we should not just hold on to our current small sliver of NSF funding, but advocate for significant increases that will allow further discoveries. This is particularly relevant now that Senator Elizabeth Warren (Democrat from Massachusetts) plans to introduce a bill to double the NIH budget, and discussions are in place to do the same with NSF (Gropp, 2014). Direct advocacy in Washington, D.C. through congressional visits can be effective, particularly from constituents in more conservative states.

Our impression is that the strategy of many animal behaviour researchers is to avoid discussing their projects in public arenas, hoping that they will not be targeted by those with a political agenda. While this strategy may be comfortable, we think it marginalizes our discipline needlessly. In the Internet age, we have an unprecedented ability to tell the general public about our research, and defend its importance. It is now time to own the beauty, quirkiness and importance of the research we love, by stepping up in defence of basic science in general and animal behaviour in particular.

OTHER RESOURCES

For additional resources on defending basic science we recommend the American Association for the Advancement of Science (AAAS) and the Association of American Universities (AAU) Web sites. AAAS now gives out the Golden Goose Award to science that sounded odd but ended up having important applications. AAU has published three volumes of the Scientific Enquirer, an exceptional short publication defending science written for the general public. The American Institute for Biological Sciences (AIBS) advocates on policy issues on behalf of general biological sciences in Washington, D.C. Their Web site has excellent resources on understanding budgeting for biological sciences research in Washington.

This commentary originated from a round table discussion at the annual 2013 Animal Behavior Society (ABS) meeting in Boulder, Colorado, U.S.A. We thank the participants who provided many ideas, Amanda Hund for sharing the curriculum she developed and Steve Emlen for sharing his 1998 ISBE presidential address and for being a source of advice and inspiration. Dr Robert Seyfarth also inspired us with ideas from his presidential address given during the 2013 ABS meeting. P.L.R.B. wishes to thank Prof. Richard Prum and her colleagues at University of Massachusetts for their support and many discussions during the 'duck penis gate' episode, especially Duncan Irschick, Teri Orr, Chi-Yun Kuo, Casey Gilman and Justin Henningsen. R.W.C. wishes to thank Sanjay Joshi for many productive and insightful discussions concerning the role of basic research in our society and for his help in constructing the 'robosquirrel' Web sites.

Supplementary Material

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References

Adamo, S. A. (2012). The strings of the puppet master: how parasites change host behavior. In D. P. Hughes, J. Brodeur, & F. Thomas (Eds.), *Host manipulation by parasites* (pp. 36–51). Oxford, U.K.: Oxford University Press.

Alvarez-Buylla, A., & Nottebohm, F. (1988). Migration of young neurons in adult avian brain. *Nature, 335*, 353–354.

Barnea, A., & Nottebohm, F. (1994). Seasonal recruitment of new neurons in the hippocampus of adult, free-ranging black-capped chickadees. *Proceedings of the National Academy of Sciences of the United States of America, 91*, 11217–11221.

Benson, E. (2006). All that's gold does not glitter: how the Golden Fleece tarnished psychological science. *Observer, 19*, 13–17. Retrieved from http://www.psychologicalscience.org/index.php/publications/observer/2006/june-06/all-thats-gold-does-not-glitter.html.

Blumstein, D. (2008). Fourteen security lessons from anti-predator behavior. In R. D. Sagarin, & T. Taylor (Eds.), *Natural security: A Darwinian approach to a dangerous world* (pp. 147–158). Berkeley, CA: University of California Press.

Brennan, P. L. R. (2013). Why I study duck penises. *Slate, 2 April*. Retrieved from http://www.slate.com/articles/health_and_science/science/2013/04/duck_penis_controversy_nsf_is_right_to_fund_basic_research_that_conservatives.html.

Brennan, P. L. R., Irschick, D., Johnson, N., & Albertson, C. (2014). Oddball science: why funding studies of unusual evolutionary phenomena is crucial. *BioScience, 64*, 178–179. http://dx.doi.org/10.1093/biosci/bit039.

Brock, T. D. (1997). The value of basic research: discovery of *Thermus aquaticus* and other extreme thermophiles. *Genetics, 146*, 1207–1210.

Burd, G. D., & Nottebohm, F. (1985). Ultrastructural characterization of synaptic terminals formed on newly generated neurons in a song control nucleus of the adult canary forebrain. *Journal of Comparative Neurology, 240*, 143–152.

Dokter, A. M., Liechti, F., Stark, H., Delobbe, L., Tabary, P., & Holleman, I. (2010). Bird migration flight altitudes studied by a network of operational weather radars. *Journal of the Royal Society Interface, 8*, 30–43.

Emlen, S. T. (1995). An evolutionary view of the family. *Proceedings of the National Academy of Sciences of the United States of America, 92*, 8092–8099.

Emlen, S. T. (1997). The evolutionary study of human family systems. *Social Science Information, 36*, 563–589.

Emlen, S. T. (1998). Relevance and responsibility in behavioral ecology. *ISBE Newsletter, 10*, 8–10.

Gauthreaux, S. A., Jr. (Ed.). (1974). *Proceedings of the Conference on the Biological Aspects of the Bird/Aircraft Collision Problem*. Clemson, SC: United States Air Force, Office of Scientific Research, Clemson University Press.

Goldman, S. A., & Nottebohm, F. (1983). Neuronal production, migration and differentiation in a vocal control nucleus of the adult female canary brain. *Proceedings of the National Academy of Sciences of the United States of America, 80*, 2390–2394.

Gropp, R. E. (2014). It's that time again: congress considers NSF legislation. *BioScience, 64*, 180. http://dx.doi.org/10.1093/biosci/biu014.

Hutchinson, R. R. (2006). Scientists provide a civics lesson for politicians. *Observer, 19*(12). Retrieved from http://www.psychologicalscience.org/index.php/publications/observer/2006/december-06/scientists-provide-a-civics-lesson-for-politicians.html.

Irion, R. (1988). What Proxmire's Golden Fleece did for, and to, science. *Scientist, 12 December*. Retrieved from http://www.the-scientist.com/?articles.view/articleNo/10030/title/What-Proxmire-s-Golden-fleece-Did-For–And-To–Science.

Knipling, E. D. (2005). *The life and vision of Edward F. Knipling concerning the erradication of the screwworm* [Speech]. Washington, D.C.: United States Department of Agriculture. Retrieved from http://www.ars.usda.gov/aboutus/docs.htm?docid=1604&page=1.

Moore, J. (2012). A history of parasites and hosts, science and fashion. In D. P. Hughes, J. Brodeur, & F. Thomas (Eds.), *Host manipulation by parasites* (pp. 1–15). Oxford, U.K.: Oxford University Press.

Nottebohm, F. (1984). Birdsong as a model in which to study brain processes related to learning. *Condor, 86*, 227–236.

Nottebohm, F. (1985). Neuronal replacement in adulthood. *Annals of the New York Academy of Sciences, 457*, 143–161.

Paton, J. A., & Nottebohm, F. (1984). Neurons generated in the adult brain are recruited into functional circuits. *Science, 225*, 1046–1048.

Poulin, R., & Levry, E. P. (2012). Applied aspects of host manipulation by parasites. In D. P. Hughes, J. Brodeur, & F. Thomas (Eds.), *Host manipulation by parasites* (pp. 172–194). Oxford, U.K.: Oxford University Press.

Sagarin, R. D., & Taylor, T. (2008). *Natural security: A Darwinian approach to a dangerous world*. Berkeley, CA: University of California Press.

Specter, M. (2001). Rethinking the brain. *New Yorker, July*, 42–53. Retrieved from http://www.cogsci.ucsd.edu/~rik/courses/cogs1_w10/readings/specter01.pdf.

Vermeij, G. J. (2008). Security, unpredictability, and evolution: policy and the history of life. In R. D. Sagarin, & T. Taylor (Eds.), *Natural security: A Darwinian approach to a dangerous world* (pp. 25–41). Berkeley, CA: University of California Press.