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A SHIFTING MOSAIC OF SCHOLARLY PUBLISHING, SCIENTIFIC DELIVERY, AND FUTURE IMPACT CHANGING THE FACE OF LEARNED SOCIETIES

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Nonprofit scientific societies hope that their activities advance their particular mission and impact their profession and, in the broadest sense, humanity in positive ways. The digital age has provided unprecedented mechanisms to enhance the delivery of science to the world. The marketplace of scientific publishing is a rapidly shifting mosaic of challenges and opportunities, and the responses of nonprofit and commercial publishers vary widely, but their outcomes are still uncertain. The response of the American Society of Mammalogists (ASM) provides an example of how a relatively small society has altered its scientific delivery to enhance member benefits while attempting to sustain its economic viability. Since 2000, ASM has moved from a self-publishing, break-even, print-only model to a copublishing agreement with a commercial publisher (Alliance Communications Group, a division of Allen Press, Inc., Lawrence, Kansas), which now offers members various print and electronic options and generates a shared royalty. Although it is too early to gauge the economic impact of these changes, the ASM leadership clearly attempted to signal its desire for members to view their society as a package of opportunities for edification and involvement rather than just a provider of serial subscriptions. Future challenges facing nonprofit scientific societies include open access, fiscal realities, archiving of publications, and scientific and societal impact; future opportunities include a strengthening of member responsibilities and professionalism, development of data registries to enhance scientific progress, and bundling of like societies. The manner in which nonprofit scientific societies respond to these challenges and opportunities will no doubt affect their sustainability and future impact.

Key words: data registries, digital age, electronic publishing, impact, online access, open access, print delivery, scholarly publishing, scientific delivery, scientific societies

Few changes have swept human civilization as quickly and thoroughly as Internet-based electronic delivery of and access to information—the ''digital age.'' In merely a few years, many professional societies and commercial publishers that focus on scientific, technical, and medical (STM) publications have made a transition to delivery of their scientific content from print-only to various combinations of print and electronically driven, Web-based platforms of individual or aggregated subscriptions, single-article pay-to-view, and open access (= free worldwide availability). At present, print is still the dominant part of the delivery process for most STM publishers (Tenopir and King 2000). However, the relatively uniform playing field of scientific delivery and scholarly publishing (i.e., print only) has morphed into a rapidly shifting mosaic of delivery options, but one that some argue is narrowing toward electronic delivery and access only, which certainly will affect the economies of nonprofit STM publishers.

All scientific societies want their activities to advance their particular mission and impact their profession and humanity in positive ways. Nonprofit scientific societies are involved mainly with dissemination of science in serials and at annual meetings where research results are shared with colleagues. Many of these societies also are constrained by break-even budgets and must balance revenues from members and institutional subscribers with serial production costs, up to 50% of which can be from printing and postage (Carpenter et al. 2004: table 4; Tenopir and King 2000). Many societies also use surplus income for other goods and services (e.g., student grant programs). Therefore, the digital age of electronic delivery poses both challenges and opportunities to scientific societies.

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Small to medium-sized scientific societies focus the majority of their societal efforts and budgets on publishing peer-reviewed serials that contain original research on a particular discipline or taxonomic group. Issues of delivery of their scientific content relative to costs are complex and rapidly changing (Committee on Electronic Scientific, Technical, and Medical Journal Publishing and Committee on Science, Engineering, and Public Policy and Global Affairs Division 2004; Regazzi 2004; Tenopir and King 2000). Scientists themselves still are torn between the ease and convenience of digital delivery and the perpetuation of scholarly publishing by learned societies (Rowlands and Nicholas 2005).

Recent changes to publishing and member benefits adopted by the American Society of Mammalogists (ASM) reflect a proactive response to the digital age relative to the desired continuance of ASM activities in the long term. Yet, the final outcome of this response remains difficult to predict, and thus deserves vigilance, given rapid changes in scientific delivery and user-based consumption and access. My objectives are to provide an overview of the impacts of the digital age on scientific societies, to outline the response of ASM to the rapidly changing environment of scholarly publishing, and to identify future challenges and opportunities for learned societies to assure their survival and to maximize their scientific delivery and impact.

The Digital Age and Scholarly Serials

The 1st completely electronic edition of a serial publication was the *Harvard Business Review* in 1982, thus ending the exclusivity of print that generally lasted about 340 years (Willinsky 2003). By the end of the 1990s, about 16,000 scholarly serials were published by >2,000 STM commercial publishers and nonprofit scholarly societies worldwide (Regazzi 2004); about 4,000 serials (25%) were available online in some form (Tenopir and King 2000). By 2005, 75% of academic serials offered some form of digital availability, and about 1,000 peer-reviewed serials (6.3%) were only available online (Willinsky 2003). An astonishing 1.2 million STM peer-reviewed articles are published each year by >2,000 STM publishers (Regazzi 2004).

The average university scientist reads about 190 articles/year (Tenopir and King 2000). Clearly, digital availability of scholarly serials has altered the manner in which those articles are found and research is conducted. Digital availability provides enhanced searchability and access to published materials that were heretofore difficult, or at least tedious, time consuming, and, in some cases, expensive to locate. As a case in point, all but 7 citations used in this paper were found online in full-text versions through library portals at Oklahoma State University. Unlike print, digital media allow opportunities to provide hyperlinks to cited literature and supplemental resources (e.g., data repositories—Ecological Society of America 2005) and to incorporate video and audio components to enhance research products (Honey 2005). These enhancements no doubt will improve in the future and increase in use, so it would seem that online availability soon will dominate delivery of scientific information.

Some have argued that digital publishing is less expensive than print publishing (Harnad 1992). Others are skeptical (Bergstrom and Bergstrom 2006; Miller and Harris 2004) and note that the number of subscribers determines savings from digital formats and that delivery of parallel media (i.e., print + digital) will persist for sometime (Tenopir and King 2000). With recent mergers, 3 publishers (Elsevier, Springer, and Taylor and Francis) now control the majority of peer-reviewed commercial STM journals. At least initially, some substantial price increases occurred and appeared to be based more on market power than real costs (Bosch 2005; McCabe 2002; Willinsky 2003). Even the promise of cost savings from bundled or individual serials in a digital format has not materialized uniformly (Bergstrom and Bergstrom 2006; Miller and Harris 2004). Nevertheless, speed, convenience, and connectivity of the Web-based digital format for delivery of scientific material seem to ensure its future (Groote and Dorsch 2001), albeit ''pricing will be the most important issue that publishers, libraries, and scientists will face over the next decade'' (Tenopir and King 2000:44).

Despite the success of online availability of scientific publications, the digital age poses challenges to scientists and nonprofit STM publishers (Miller and Harris 2004). Although most scientists in the developed world have access to the technology and support services needed to use digital resources, colleagues in developing countries may not be as fortunate. In response, some scholarly societies offer free or discounted Web-based access to their publications to colleagues in developing countries, and some aggregators of electronic journals (e.g., JSTOR, www.jstor.org, and BioOne, www.bioone.org) are beginning to provide discounts to customers in developing countries. Yet, considerably more work needs to be done in this area (Aronson and Glover 2005; Sahni 2005).

Hecker (2003) argued colorfully that future energy crises, relative to an unsustainable human demand, could render electronic production, dissemination, and particularly archiving of scholarly serials very risky. Regardless of the energy they consume, production, maintenance, and archiving of digital media are not free. Nonprofit societies, in particular, will be challenged financially as the variety of online portals to their publications increases, and institutional subscribers and individual members obtain their content through nonsocietal sources (e.g., in aggregations and from their institutional libraries, respectively). Institutional subscribers account for >65% of the total income of some biological publishers involved in BioOne (Carpenter et al. 2004). The push for free open access by some governmental agencies and a considerable number of research scientists (Rowlands and Nicholas 2005) will complicate further the economic picture for commercial and nonprofit STM publishers (Regazzi 2004). The future economics of these dynamics have yet to be resolved (Bosch 2005), but without change that involves cooperation among scholars, editors, publishers, and subscribers, some believe that they cannot be sustained (Miller and Harris 2004). Nonprofit scientific societies would seem to be at the greatest risk of economic uncertainty and delivery challenges.

American Society of Mammalogists's Response to the Digital Age

Characteristics of ASM.—The ASM is a nonprofit scientific society, founded in the United States in 1919 by a group of prominent federal government and academic naturalists with keen interests in mammals (e.g., Glover M. Allen, J. A. Allen, Joseph Grinnell, Hartley H. T. Jackson, C. Hart Merriam, Ned Hollister, and Walter P. Taylor—Hoffmeister and Sterling 1994). In the proposal to establish ASM, the goal was "to organize a society for the promotion of the interests and study of mammalogy ... [devoted] to the subject in a broad way, including studies of habits, life histories, evolution, ecology, and other phases" (Hoffmeister and Sterling 1994:13). The mission of ASM, as printed in each issue of the *Journal of Mammalogy*, has remained largely the same over the past 87 years and currently is stated as, "dedicated to promoting interest in mammals throughout the world through research, education, conservation, and communication among scientists and the general public."

The ASM has published the *Journal of Mammalogy* as its primary serial since 1919 (4 issues/annual volume from 1919 to 2003 and 6 issues/annual volume since 2004), *Mammalian Species* since 1969 (>800 stand-alone accounts on individual mammal species), and 13 Special Publications (books) from 1967 to 2005 (Verts and Birney 1994). The number of individual members grew from 443 in 1920 to 3,661 in 1990 (Kirkland and Smith 1994) and has remained stable at about 3,500 over the past 15 years. Given the steady increase in the number of scientists globally (Tenopir and King 2000), the leveling off of membership in ASM (and in other taxonomic societies) may reflect a shift in emphasis, with scientists self-identifying as ecologists, geneticists, physiologists, and so on rather than with a particular taxonomic group. In the last 10 years, the number of institutional subscribers to the *Journal of Mammalogy* was as high as 1,153 in 2000 and as low as 931 in 2005.

Over the years, the majority of the annual budget of ASM has been used to produce the *Journal of Mammalogy*, ranging from 90% of the overall budget in the 1940s to 73.7% in the 1990s (Kirkland and Smith 1994). Remaining annual revenues from annual membership dues and institutional subscriber fees, funds from investment of life and patron membership dues, and gifts have been used to support the other publications and functions of ASM, primarily student grants and fellowships (e.g., Genoways and Freeman 1997). In the late 1990s, ASM officers and the Board of Directors recognized that emerging electronic technologies and increasing publishing costs made it necessary to reevaluate ASM's approach to its publications and the sustainability of its economic position.

Strategic planning.—In 1997, the leadership of ASM, under the direction of Past President Robert Baker and President Alicia Linzey, began a stepwise strategic planning process to address challenges of delivering its scientific content in the emerging digital age while being vigilant about its economic sustainability (Table 1). From 1919 to 1999, ASM managed all aspects of membership and publications by volunteer members in various fiduciary and editorial positions (Layne and

Table 1.—Chronology of strategies and changes to publications of the American Society of Mammalogists (ASM), 1997–2006, in response to emerging trends in electronic publishing.

Years	Actions
1997	Began strategic planning process with emphasis on electronic delivery of publications, Web site development, changes to editorial responsibilities
1999	Received and evaluated bids from publishing companies to enhance publications and financial outlook
2000	Began 5-year copublishing agreement with Alliance Communications Group (ACG, division of Allen Press, Inc., Lawrence, Kansas) adding ACG Managing Editor and full-service production, copyediting, marketing, and permissions
	Increased institutional subscription rates for the *Journal of Mammalogy* from $45 to $170/year
2001	Current content of the *Journal of Mammalogy* and *Mammalian Species* enrolled in BioOne
2002	Created PDFs of all *Mammalian Species* accounts > 5 years old; free worldwide availability on server at Smith College
2003	Began implementation of electronic manuscript submission on AllenTrack for the *Journal* and *Mammalian Species*
	Approved inclusion of the *Journal of Mammalogy* in JSTOR (= Journal Storage) with a 5-year moving wall
	Began to consider options to provide member access to ASM publications at Web site (= "silo site" development)
	Increased number of associate editors for the *Journal* from 8 to 10
2004	*Journal of Mammalogy* changed from 4 to 6 issues/year in a larger layout and new article format
	Increased institutional rates for the *Journal of Mammalogy* from $170 to $190/year
	Initiated the development of a silo site at ASM Web site providing free member access to the *Journal* and *Mammalian Species* accounts from 2000 forward
	Increased voluntary page charges in the *Journal* from $60 to $80/page
	Implemented online manuscript submission to the *Journal* via AllenTrack
2005	Began second 5-year copublishing agreement with ACG
	Provided author-pay open-access option at $1,500/published article
	Journal of Mammalogy became available in JSTOR
	Mammalian Species invited to enroll in JSTOR
	Silo site completed providing members electronic access to the current content of the *Journal* and *Mammalian Species* at ASM Web site
	Conducted e-mail member survey focused on ASM publications and member benefits
	Increased number of associate editors for the *Journal* from 10 to 12
2006	Changed member benefits and dues structure to include online-only delivery options for regular, student, and developing-country memberships
	Eliminated print copies of *Mammalian Species* allowing free electronic access for all members
	Increased institutional subscription rates for the *Journal of Mammalogy* from $190 to $205/year
	ASM officers and others continued the strategic process with further emphasis on ASM publications:
	Approval to increase the Journal Editor's budget from $8,000 to $30,000/year
	Increased number of associate editors for the *Journal* from 12 to 16
	Began to solicit commissioned articles from high-profile scientists for the *Journal*
	Mammalian Species became available in JSTOR
2007	All manuscripts submitted to *Mammalian Species* via AllenTrack

Hoffmann 1994; Verts and Birney 1994). From 1957 to 2000, production, printing, and mailing of publications were accomplished under contract with Allen Press, Inc. (Lawrence, Kansas). Generally, the publishing operation of ASM was break-even; that is, revenues from individual members and institutional subscribers paid for production and dissemination of the *Journal of Mammalogy*. Other publications, *Mammalian Species* and Special Publications, operated at a loss at times and had to be subsidized by *Journal* revenues or investments (e.g., Reserve Fund—Kirkland and Smith 1994).

In 1999, ASM considered various copublishing agreements offered by commercial STM publishers (notably Allen Press and Taylor and Francis). In 2000 under the leadership of Past President Don Wilson, ASM entered into a 5-year copublishing agreement with Alliance Communications Group (ACG), a division of Allen Press (Table 1). Key features of the agreement were increasing institutional subscription rates from $45 to $170/year to generate more income and to permit the addition of full-service publishing options from ACG-Allen Press. These options included an ACG-employed Managing Editor and copyediting, marketing, advertising, and copyrighting services; such duties had been accomplished by volunteer members before 2000. Under the contract, ASM agreed to contribute a portion of the dues from each member (= member contribution) and all revenue from institutional subscribers to support the overall copublishing agreement and the enhanced production and editorial services of ACG-Allen Press. Quarterly, the balance of member's dues not contributed to the copublishing agreement and, annually, contractually agreed upon editorial and meeting stipends and awards were paid to ASM. Finally, a portion of any remaining income from publications at the end of the year was returned to ASM as a royalty.

Under the terms of the ACG contract, ASM maintained complete ownership of its publications and used its own volunteer Journal Editor and Associate Editors, who were solely responsible for the peer-review process and selection of content for societal publications. Any major decision involving ASM publications was made after consultation between both parties and approved by the ASM Board of Directors. Between 2000 and 2004, ASM moved from its historic break-even economic model accomplished largely by volunteer members, to a model that accomplished publication goals with enhanced publishing services and resulted in additional income from shared royalties. In 2001, ASM also became a founding participant of BioOne (Joseph and Carpenter 2005), a nonexclusive aggregation where current content of the *Journal of Mammalogy* and *Mammalian Species* from 2000 forward is collected electronically with other biological serials and sold to institutional libraries and other research organizations. Royalties from BioOne (Carpenter et al. 2004) provided new income and offset some loses from institutional subscribers who probably changed from print to electronic aggregations, a general trend noted by many STM publishers (Tenopir and King 2000).

At the end of the 1st ACG contract and encouraged by its success, ASM considered implementation of other digital technologies to benefit its members (Table 1). ASM began with electronic manuscript submission for the *Journal of Mammalogy* in 2003 via Allen Press's online manuscript tracking and submission system, AllenTrack; it became fully functional in 2004. In the same year, ASM increased the number of issues per annual volume of the *Journal* from 4 to 6 and published it in a larger layout and with a new article format. With its Web site fully functional (www.mammalogy.org and www.mammalsociety.org), ASM began to evaluate mechanisms to provide members and subscribers access to electronic content of its publications at a dedicated Web site—a benefit to members not able to access publications through institutional online subscriptions or aggregations such as BioOne.

The so-called ''silo site'' was developed by the Electronic Publishing Division of Allen Press and became fully functional at the ASM Web site in 2005. It currently provides all members password-based access to issues of the *Journal of Mammalogy* and *Mammalian Species*, as they are published, and an electronic archive of both publications dating back to 2000, which parallels that available in BioOne. Members also can receive e-mail notification as issues and accounts are published and electronically available. In contrast, nonmembers can enter the silo site and view table of contents, authors and their bylines, and complete abstracts of published manuscripts. Members can download articles as PDFs for personal use, whereas nonmembers can purchase individual articles for $25. The development costs of the silo site and ongoing maintenance were covered under the copublishing agreement as journal-related expenses. The investment appears to have enhanced availability and use of ASM publications and perhaps their impact. From January through May 2006, the silo site received 546,872 ''hits'' from 12,538 unique Internet addresses (not necessarily individuals), or about 2,500 unique visits/month—considered by ACG to be above-average use.

In 2005 under the leadership of President Guy Cameron, ASM and ACG entered into their second 5-year contract under terms very similar to those in the 1st contract (Table 1). Virtually all operational elements of the contract remained the same, except that the member contribution to ACG and institutional subscription rates were increased 32% and 17%, respectively. During year 1 of the 1st contract, ACG projected that ASM could quickly lose up to 25% of its institutional subscribers because of the >370% price increase, but that did not happen initially. However, during the entire 5 years of the 1st contract, ASM lost about 19% of its institutional subscribers from a high of 1,153 in 2000 to 931 in 2005. That decline paralleled similar losses of institutional print subscriptions experienced by many STM publishers (Joseph and Carpenter 2005; Tenopir and King 2000). Carpenter et al. (2004) noted an 11.9% decrease in institutional subscribers from 2000 through 2002 in a sample of BioOne publishers.

Because of potential losses of income from institutional subscribers and prevailing member opinions (see section on member survey below), ASM and ACG began to consider other revenue-generating options. Invitations from JSTOR to include the *Journal of Mammalogy* and *Mammalian Species* were approved by the ASM Board in 2003 and 2005, respectively (Table 1). Currently, JSTOR maintains nonexclusive electronic

Table 2.—Questions posed to and responses of members ($n = 569$) of the American Society of Mammalogists (ASM) from an e-mail survey conducted in April 2005.

Question	Response category (percent response rate)
How many years have you been a member of ASM?	1–5 (34.9); 5–10 (15.7); 10–15 (7.8); 15–20 (7.8); 20+ (33.8)
Please indicate your membership status.	Regular (60.2); student (24.7); life (10.5); patron (3.6); emeritus (0.6); honorary (0.4)
What is your primary reason for being a member of ASM?	Publications (58.4); scientific interactions (28.7); professional networking (6.8); annual meeting (4.4); society activities (1.7)
How many other scientific societies similar to ASM do you belong to?	0 (4.8); 1 (18.8); 2 (23.4); 3 (23.8); 4 (11.9); 5 (5.2); >5 (12.1)
Relative to those other societies, rank ASM's importance to you professionally (1 = most, 5 = least).	1 (30.6); 2 (31.0); 3 (23.5); 4 (9.5); 5 (5.4)
In the past 10 years, how many ASM Annual Meetings have you attended?	0 (38.8); 1–2 (32.6); 3–4 (14.8); 5–6 (4.4); 7–8 (3.1); 9–10 (6.3)
How would you prefer to receive ASM publications?	Print + online (66.2); print only (21.1); online only (12.7)
Would you be interested in a single package of all member benefits including the *Journal of Mammalogy* and *Mammalian Species* and online access to current and archival content of both publications at an increased cost?	Yes (62.5); no (37.5)
Along with the student discount, should ASM provide a discounted membership rate for online access to colleagues from developing countries?	Yes (89.1); no (10.9)
Please indicate your age.	<20 years (0.2); 20–29 (17.8); 30–39 (24.5); 40–49 (18.0); 50–59 (26.7); 60–69 (9.3); 70+ (3.5)
Please indicate where you reside.	North America (87.1); Europe (5.9); South America (3.0); Asia (1.9); Australia (1.7); Central America (0.2); Africa (0.2)

archives of 641 scholarly journals, of which about 100 cover the biological sciences. JSTOR pays enrollees royalties based on statistics of sales and use. Extensive access to JSTOR is mainly available through institutional libraries, but anyone with Internet access can enter JSTOR and purchase individual articles. In May 2005, the *Journal of Mammalogy*, dating back to 1919 but excluding the most recent 5 years, became available at JSTOR; accounts of *Mammalian Species* became available there in October 2006. As a benefit of membership, members can access free of charge both JSTOR archives through the ASM Web site. Initial monthly use of the *Journal of Mammalogy* in the JSTOR archives increased 190% from May through December 2005 (2,524 articles viewed/month) to January through mid-June 2006 (7,318 articles viewed/month), suggesting some degree of member satisfaction.

To further enhance access to the *Journal of Mammalogy* while generating revenues, ASM offered an open-access option to authors in 2005, whereby they can pay $1,500 to have their published articles freely accessible online at the ASM silo site and BioOne. In June 2006, the ASM Board approved solicitation of commissioned articles, with compensation, from high-profile scientists in any discipline but with a focus on mammals. If such papers represented syntheses of scientists' important contributions to various aspects of mammalogy, the Board assumed that they would be used widely and would enhance the profile of the *Journal of Mammalogy* and ASM.

Member survey.—The ASM leadership recognized the need to evaluate its members' opinions and the dues structure because of the various changes implemented, and their associated costs, between 2000 and early 2005 (Table 1). To help guide future decisions regarding changes to publications, ASM conducted an e-mail member survey in spring 2005. The survey focused primarily on preferences for journal delivery, member benefits, dues structure, and history of affiliation with the society. To maximize the response rate, only 11 focused questions were asked (Table 2). E-mail addresses were available for 70% of the 2,792 individual members who had renewed their memberships by late March 2005. A total of 569 members responded to the e-mail survey (i.e., 30% response rate). Collectively, almost 70% of respondents had been members for 1–5 years or 20+ years (Table 2). Regular and student members, the 2 membership categories that pay annual dues, accounted for 83.4% of the responses. Changes in dues structure, coupled with online access to ASM publications such members have from other sources, might affect their willingness to renew their membership and compromise revenues needed to pay for the production and dissemination of the ASM publications.

Members join the ASM for a variety of reasons, but 58% belong to receive publications and 27% belong for scientific interactions (Table 2). Annual meetings appear to be a secondary reason for involvement with ASM; almost 40% of respondents never attended an annual meeting and only about 14% attended ≥5 meetings in the past 10 years. In contrast, scientists in another recent survey ranked conference participation slightly higher than receiving societal publications (Grimwade 2003). Members of taxonomically based societies such as ASM often are involved in >1 professional orga-

Table 3.—Annual membership options and costs before 2006 compared with those implemented in January 2006 by the American Society of Mammalogists (ASM).

Before-2006 membership options (print only)		2006 membership options (print + online options)	
Category	Cost	Category[a]	Cost
Regular	$35	Regular (print + online)	$45
Student	$25	Regular (online only)	$30
Life[b]	$750	Student (print + online)	$35
Patron[b]	$5,000	Student (online only)	$30
		Developing-country[c] online only	$20
		Life[b]	$1,125
		Patron[b]	$5,000

[a] All categories of membership receive online access to electronic archives of the *Journal of Mammalogy* and *Mammalian Species* from 2000 forward at the ASM Web site (www.mammalogy.org and www.mammalsociety.org) and free access to ASM archives at JSTOR (www.jstor.org).

[b] One-time payment that can be paid in installments to received all benefits of ASM for life, except only patron members receive free copies of Special Publications.

[c] Available only to those members not living in the United States, Canada, Western Europe, Australia, Iceland, Israel, Japan, New Zealand, Republic of Korea, or Taiwan.

nization. When asked how many other societies an ASM member belonged to, 18.8% responded 1, 23.4% responded 2, and 57.8% responded $\geq$3, comparable to the Grimwade (2003) survey. When respondents were asked to rank the importance of ASM relative to the other societies to which they belong, only 30.6% and 31.0% ranked ASM as the 1st- or 2nd-most important society to which they belonged. Clearly, engaging members that do not rank a society as their primary professional affiliation will be important to the future fiscal viability of a society.

Responses regarding print and online options for publication delivery were mixed (Table 2). A total of 64.6% of regular members and 76.5% of student members preferred a ''print + online'' option. The survey question did not address costs and was posed in a manner that did not force the respondent to consider just 2 options, print only versus online only. Nevertheless, a hint that younger members preferred electronic delivery of their scientific material was reflected in their lower response (12.5%) to a print-only option compared with regular members (22.5%). The majority of respondents (62.5%) favored a package of member benefits, even at an increased cost, that included electronic access to current and archival content for all publications of ASM. Further, 89.1% of the respondents supported the idea of making ASM publications available online to colleagues in developing countries at a discounted rate.

With the results of the survey, the ASM Board implemented a new membership dues structure in January 2006 that had an emphasis on packages of member benefits rather than on individual subscriptions to ASM publications (Table 3). Dues increased by only $10/year, and all members were given electronic access to *Mammalian Species*, which no longer would be produced in print (Table 1). That change was made to increase the use, and thus impact, of *Mammalian Species*, which previously had a subscriber base of only about 400 members. Online-only options also were created for regular, student, and developing-country members (Table 3). Although it is too early to gauge the economic impact of such changes, the ASM Board clearly attempted to signal its desire for members to view their society as a source of opportunities for edification and involvement rather than just a provider of serial subscriptions.

Future Challenges and Opportunities

Online and open access.—Online access does not necessarily mean open access, and little agreement exists on how best to finance open access (Allen Press, Inc. 2005; Regazzi 2004). Many STM societies and publishers provide members and subscribers online access to a single journal or collection of journals at an annual cost. In contrast, open access provides free, immediate, unrestricted, and worldwide availability to any type of published material online in a digital format. Currently, universal (Regazzi 2004) open-access publishing is most prevalent in the medical and life-science disciplines, but it is growing in the areas of physics, engineering, and mathematics (McVeigh 2004). Maintaining rigorous peer review in open-access literature is very important to most scientists (Rowlands and Nicholas 2005).

Online access—not all of it open—to STM publications currently occurs in at least ''nine flavours'' (Willinsky 2003), which range from unlimited free availability to various author-pay and subscription-based models (Table 4). Typically, individual STM publishers and societies, such as ASM and others that publish serials on mammals, have adopted >1 approach to online access. For example, Willinsky's (2003) online ''lite'' is available at the Web sites of 4 of the 5 societies focused on mammals (Table 4). Such variety no doubt balances the societies' needs to maintain revenues for production and dissemination of their science against the spirit of expanded scientific exchange and impact.

Notable initiatives that provide portals to open-access STM articles include the Directory of Open Access Journals (www.doaj.org), Public Library of Science (www.plos.org), BioMed Central (www.biomedcentral.com), and High Wire Press (http://highwire.stanford.edu—contains links to 973 journals with 1.4 million articles). Each of these represents different models to provide open-access delivery, ranging from author-pay–privately subsidized serials (= Public Library of Science) that anyone with an Internet connection can access to Web platforms that provide links to open-access serials and articles (= Directory of Open Access Journals).

Along with enhancing global exchange of information, proponents of open access assert improved citation rates of individual STM articles (e.g., Henneken et al. 2006; Shin 2004) and, thus, increased impact of the research itself (Antelman 2004). In some disciplines (e.g., astrophysics), however, increased citation rates and use have not been noted (Kurtz et al. 2005). Although open-access journals can rank in the bottom 40–50% of all STM journals relative to their impact (McVeigh 2004; Regazzi 2004), the number of scientists publishing in them increased from 11% in 2004 to 29% in 2005 (Rowlands and Nicholas 2005).

TABLE 4.—The ''nine flavours'' of open access outlined by Willinsky (2003) and a comparison of the approach of the American Society of Mammalogists (ASM) with other global mammal societies or academies.

Open access type	ASM	Other mammal societies or academies[a]			
		Australian	British	Polish	German
E-print archive (discipline- or institution-based servers where authors can place published or unpublished work online)	No	No	No	No	No
Unqualified open-access journal (complete, immediate, and free online availability)	No	No	No	No	No
Dual-mode open access (complete and immediate online availability with a subscription or membership fee)	Yes[b]	Partial	Yes	No	Yes
Delayed open access (complete and free online availability after a set period of time; e.g., 1 year)	No	No	No	No	No
Author-fee open access (mandatory author-pay system providing complete, immediate, and free online availability)	No	No	No	No	No
Author-choice open access (voluntary author-pay system providing complete, immediate, and free online availability)	Yes	No	No	No	No
Partial open access (complete, immediate, and free online availability to only a part of a journal)	No	No	No	Yes	No
Per-capita open access (complete, immediate, and free online availability to those in developing countries)	Partial[c]	No	No	No	No
Open access ''lite'' (immediate, free online availability to abstracts, etc.)	Yes[d]	No	Yes[d]	Yes[d]	Yes[d]

[a] Serials: Australia = *Australian Mammalogy*, British = *Mammal Review*, Polish = *Acta Theriologica*, German = *Mammalian Biology*.

[b] Member and institutional access to the *Journal of Mammalogy* and *Mammalian Species* provided at the ASM Web site (www.mammalogy.org and www.mammalsociety.org).

[c] ASM provides online access to the *Journal of Mammalogy* and *Mammalian Species* to colleagues in developing countries at a 55% discount off regular membership dues.

[d] Provides unlimited and free open access to author names, bylines, keywords, and abstracts to all articles and a means to pay-to-view and upload an individual article (in United States dollars): *Journal of Mammalogy* = $25/article, *Mammal Review* = $39, *Acta Theriologica* = approximately $13, *Mammalian Biology* = $30.

The new author-pay, open-access option for those publishing in the *Journal of Mammalogy* has developed slowly. From the February 2005 issue through the August 2006 issue of the *Journal of Mammalogy*, only 4 papers were offered as open access, which generated $6,000 in new revenue. Albeit a small sample, use statistics from the ASM silo site suggested that those open-access articles received proportionately greater use than the great majority of articles that are not open access. As of October 2006, 3 of the 4 open-access articles ranked 3rd (Schmidly 2005), 4th (Baker and Bradley 2006), and 10th (Webb et al. 2005) relative to the total number of hits at the ASM silo site among 236 published articles in the *Journal of Mammalogy*. If that trend continues, more authors might pay the fee for open access, thereby increasing a revenue stream to ASM.

Although it is noble for nonprofit scientific societies to try to attain the widest dissemination of science, influence scientific advancement, and contribute to the public good, these societies need to generate revenues for production of their publications, even in an electronic format. Likely because of such economics (Bosch 2005; Harrington 2005), open access has been very slow to evolve; only about 2% of published STM articles were open access in 2004 (Regazzi 2004). Further, the important role of members of learned societies to establish a presence in a particular domain of science and foster their influence by unification around societal goals suggests that the standard membership fee–subscription model for their serials will not disappear easily (Gannon 2005).

Archiving STM publications.—As numbers of digital formats and online-only journals increase, publishers, societies, and librarians have become concerned with the proper and perennial archiving and redundancy of such materials (Hecker 2003; Honey 2005; Watson 2005). More and more libraries are canceling print subscriptions of serials in favor of digital online formats (Carpenter et al. 2004; Tenopir and King 2000), and the manner in which access to digital materials by library patrons will be assured through time is a growing challenge and even threat. In response, various electronic server-based initiatives are evolving, such as LOCKSS (= Lots of Copies Keeps Stuff Safe, http://lockss.stanford.edu—Bogdanski 2006; Seadle 2006) and Portico (an initiative of JSTOR that is publisher-library supported with >3,000 serial titles—Fenton 2006). Such initiatives ensure some degree of redundancy of storage—a critical role that libraries traditionally have played by archiving print copies of scholarly material (Honey 2005).

Honey (2005:60) contended that ''libraries, on behalf of future users, must rely more and more often on the foresight of the actual owners of the content ... to ensure [its] long-term availability.'' This might be most challenging for nonprofit publishers, particularly smaller ones such as ASM. In an important way, however, ASM, as owner of its publications, already has assumed some of this obligation by maintaining digital content of a growing number of issues of the *Journal of Mammalogy* and *Mammalian Species* at its Web site. Re-

dundancy also has been achieved by placing ASM content in aggregations such as BioOne, with the added hope that societal revenues will be enhanced (Carpenter et al. 2004; Joseph and Carpenter 2005). *Mammalian Species* no longer is disseminated in print, but because of concerns from some ASM Board members, archival print copies are still being produced and will be sent to a limited number of libraries to archive. At this point, then, ASM is just ''testing the waters'' in advance of a time when all of its publications might be available only in a digital format. Of course, such activities will require societies to upgrade extant and new content as technology changes (Honey 2005), which will represent ongoing and new expenses. However, such expenses could be offset somewhat by savings from the elimination of print and postage (Tenopir and King 2000).

Scientific and societal impact.—The impact of any discipline's science compared to others is controversial and, some would argue, nearly impossible to measure accurately (Monastersky 2005; Van Diest et al. 2001), albeit commonly quantified (Garfield 1999, 2006). The overall impact or importance of a discipline's science to the broader human society is a different matter altogether; I could find no indices to measure it completely. However quantified, both would appear to be important to the long-term survival of commercial and particularly nonprofit STM publishers.

Journal importance is measured most commonly by an impact factor developed by Eugene Garfield (1999, 2006) in the early 1960s; his ISI Impact Factor (Thomson Corporation, Philadelphia, Pennsylvania) is now widely used to rank the impact of one serial against another. A journal's impact factor is calculated with ''2 elements: the numerator, which is the number of citations in the current year to any items published in a journal in the previous 2 years, and the denominator, which is the number of substantive articles (source items) published in the same 2 years'' (Garfield 1999:979). Many librarians, rightly or wrongly, have come to depend on the ISI Impact Factor to determine what they purchase and what they cancel, and such decisions could be critical to financial viability of STM publishers. In contrast, some libraries (e.g., University of Notre Dame) have abandoned a singular approach in favor of other models that incorporate cost-per-use assessments (www.acs.org/4librarians/livewire).

Use of a journal's impact factor seems to be most pervasive in the biomedical fields, where assessment and debate can be found (Dong et al. 2005; Saha et al. 2003; Van Diest et al. 2001). Yet, extant measurements of journal impact do not even begin to address the importance of a journal's articles beyond the scientific communities who publish. In fields such as mammalogy, wildlife biologists and managers often use information in peer-reviewed articles to conserve particular species or groups of species. For example, Ecological Services Offices of the United States Fish and Wildlife Service mainly are responsible for upholding federal legislation to protect endangered species. Employees in such offices constantly search for and use peer-reviewed information that will enhance and legally justify their conservation decisions although they generally do not publish their reports and conservation plans in the peer-reviewed literature. Such use does not result in a citation in the peer-reviewed literature, but the impact to humanity can be high. Unfortunately, prevailing indices of scientific impact do not incorporate such dynamics into their calculations and are thereby limited to scientific circles.

Regardless of how impact is assessed, nonprofit STM publishers should be proactive in monitoring availability and use of their serials, whether in print, digital, or both media. Perhaps an alternate way for a society to track its impact is to assess the scientific output of prominent members. Hirsch (2005:16569) proposed ''index h'' as a way to rank individual physicists based on the number of papers they have published (h) that have been cited $\geq h$ times. While still only measuring characteristics of the scientific community that publishes, the advertising of collective indices of prominent members of a society (e.g., National Academy members or ISI Highly Cited Scientists) might encourage continuing and new individual memberships and institutional subscriptions.

Data registries.—Not all opportunities in the digital age will generate revenue, but some likely will enhance a society's contribution to and profile in the global scientific community. The Internet has fueled interest in free, open, and electronic access to the data upon which our science is built. Some funding organizations have focused their attention on the importance of open access to data from publicly funded research endeavors. For example, the Division of Environmental Biology of the National Science Foundation has strengthened ''its language on data sharing'' on projects they fund (Ecological Society of America 2005:61). Few would disagree that data sharing has a great potential to allow scientists to work synergistically to address large-scale environmental issues such as climate change, biodiversity, and emerging diseases, or that technology has improved rapidly making data sharing possible and practical. Reaching a consensus on how best to achieve and maintain such data registries is a daunting challenge (e.g., Esanu and Uhlir 2003), but scientific societies such as ASM could play a vital role in fostering such initiatives.

The Ecological Society of America, with sponsorship from the National Science Foundation, is developing protocols to establish digital data registries that will provide the means to electronically share data across scientific disciplines (Duke 2006; Ecological Society of America 2005). Such an effort is analogous to the National Institutes of Health's GenBank (www.ncbi.nlm.nih.gov/Genbank) and Ecological Society of America's VegBank (www.vegbank.org), where scientists deposit genetic sequence and vegetation-plot data, respectively, for open and free use by other investigators worldwide. Similarly, the National Center for Ecological Analysis and Synthesis at the University of California–Santa Barbara, under the directorship of ASM Past President Jim Reichman, has created a data registry, center, and informatics platform to foster data sharing called the Knowledge Network for Biocomplexity (http://knb.ecoinformatics.org/).

The Ecological Society of America already provides a voluntary data-sharing platform for authors of papers published in *Ecology* and *Ecological Applications* to direct other scientists to the data set about which their papers were written (http://data.esa.org/). The Ecological Society of America and

Table 5.—Societies and other organizations, as of July 2006, participating in an effort to establish digital data registries and centers, led by the Ecological Society of America and supported by the National Science Foundation.

Group type	Name
Society	American Geophysical Union
	American Society for Limnology and Oceanography
	American Society for Microbiology
	American Society of Mammalogists
	American Society of Naturalists
	American Society of Plant Taxonomists
	Animal Behavior Society
	Botanical Society of America
	British Ecological Society
	Ecological Society of America
	Ecological Society of Argentina
	Entomological Society of America
	European Society for Evolutionary Biology
	Mycological Society of America
	Society for Integrative and Comparative Biology
	Society for the Study of Evolution
	Society of Systematic Biologists
	Willi Hennig Society
Institutions	American Institute of Biological Sciences
	National Research Council Canada
	Federation of Ecological Societies of the Americas
	Global Biodiversity Information Facility, Denmark
	Institute of Systematic Botany, New York Botanical Garden
	Long-term Ecological Research Office, Albuquerque
	National Center for Ecological Analysis and Synthesis
	National Ecological Observatory Network (NEON)
	National Evolutionary Synthesis Center, Duke University
	National Science Foundation
	Peabody Museum of Natural History, Yale University

the National Science Foundation have promoted further data sharing by hosting 3 workshops (September 2004, July 2006, and December 2006) of 4 planned to bring together professional societies and scholarly organizations that produce serials in the areas of ecology, evolution, and organismal biology. Workshop goals have included the development of a joint strategy for creating and maintaining data registries, which will describe metadata (= ''documentation that describes the content, context, quality, structure, and accessibility of a data set''—Michener et al. 1997:330) and provide information on how to access them (e.g., URL addresses). To date, 25 societies, including ASM, and other organizations have participated in this initiative (Table 5). A final workshop is planned in 2007 to address barriers to data sharing.

Fiscal well-being and member responsibilities.—The digital age, with its projected decline in institutional revenues to STM publishers and apparent push toward free open access (Tenopir and King 2000), presents obvious fiscal constraints and may require a renewed sense of professional contribution from regular societal members. Members and authors will have to shoulder more of the economic responsibility of producing and disseminating a society's publications (e.g., increased and mandatory page charges) if revenues cannot be found elsewhere. Although enrollment of ASM publications in various electronic journal aggregations (e.g., BioOne and JSTOR) generates some revenue, it might not be sufficient to produce those publications if institutional subscriptions continue to erode (Carpenter et al. 2004). As a result, BioOne, for example, is rethinking its business model to better assist publishers by generating higher royalties (Joseph and Carpenter 2005).

Table 6.—Percentages of revenues in various categories for the American Society of Mammalogists (ASM) in 2000 and 2005 compared with the average for 12 biological publishers in BioOne in 2002.

Revenue category	ASM[a] 2000	ASM[a] 2005	12 BioOne journals in 2002[b]
Institutional subscriptions	61.6	47.4	66.0
Members dues	24.1	20.3	5.0
Page charges	5.2	10.4	11.4
Advertising	3.3	7.3	3.6
Reprints	3.2	2.8	4.0
BioOne royalties	0	9.1	4.7
Back issue sales	0.5	0.7	0.1
Miscellaneous[c]	2.1	2.0	5.2

[a] As adapted from the Publisher's Reports, Alliance Communications Group (Lawrence, Kansas); total revenues of $364,006 in 2005 were 18.5% higher than the $307,113 in 2000, despite declining institutional subscribers.

[b] From Carpenter et al. (2004:471) rounded to the tenths.

[c] Includes revenue generated from charges for color figures, sponsorships, and, in the case of ASM in 2005, author-pay charges for open access of individual articles.

For many decades, even very small nonprofit STM publishers have been able to bring their science to the ''marketplace,'' in large part by charging institutional rates necessary to pay for their publications and balance their budgets. For ASM, institutional subscribers accounted for 61.6% of the total revenue used to produce the *Journal of Mammalogy* in 2000 (Table 6), which was comparable to 12 other biological publishers enrolled in BioOne (Carpenter et al. 2004). By 2005, after ASM had changed the business model for its publications, institutional subscribers decreased to 47.4% of the total revenue used for production of the *Journal of Mammalogy* (Table 6). By diversifying revenue streams with encouragement from ACG, ASM increased total revenues from page charges, print advertising, and royalties (= a new source of income) by 215% between 2000 and 2005 (Table 6). Those 3 categories accounted for 26.8% of the revenue in 2005, which was greater than that generated by members' dues (20.3%). If that trend continues in those 3 categories and if existing (e.g., open-access option) and new revenue-generating categories (e.g., online advertising as print decreases) can be identified and fostered, members and authors will not have to shoulder all the burden of publication costs. If not, the burden will fall on members and authors to assume the responsibility, and if numbers of regular members decline, particularly in the category who do not rank ASM as their top 1 or 2 professional affiliation, the burden will be even greater.

Synthesis

The ultimate effect of the digital age on scholarly publications of nonprofit societies such as ASM is difficult to predict, largely because it will be driven by collective but

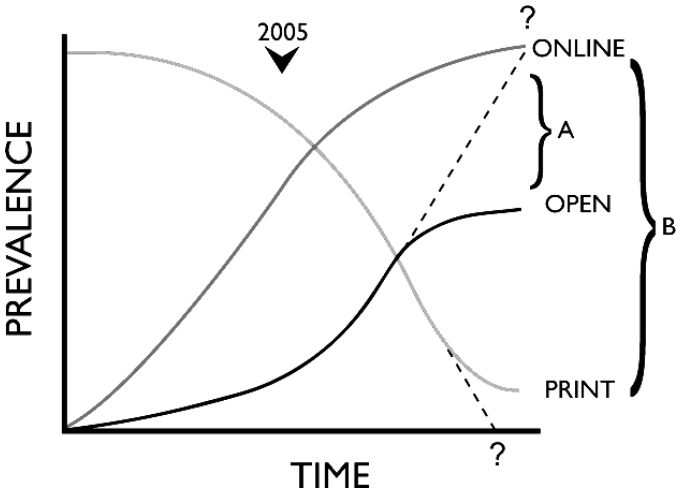

Fig. 1.—Hypothetical changes to the prevalence of print, online access with a charge, and free open access for scholarly serials throughout time. The arrow indicates the approximate mix of delivery options for STM serials in 2005. For any single society, the spread of the endpoints between online and open access (A) will vary depending on its ability to shoulder the burden of free access relative to revenues needed to produce its current content. Similarly, the extent to which online delivery will dominate print (B) will be driven by societal and commercial economics, albeit print is expected to assume a smaller and smaller role in scientific delivery with time (Tenopir and King 2000).

diverse responses of all STM publishers and the demands of the scientific community itself. Most publishers currently operate under a mixed business model of both print and online delivery, but one in which online delivery has become very prevalent and print is beginning to decrease (Fig. 1). In 2005, about 75% of STM serials were available online in some form (Willinsky 2003), but only a very small fraction was open access (Fig.1; Regazzi 2004). It is difficult to speculate if we will ever reach the point at which print disappears and all online access is open (i.e., question marks in Fig. 1). With measured open access and declining institutional subscribers, societal members should be able to shoulder the economic responsibilities of digital production, if their sense of professional responsibility remains keen. Nevertheless, open access appeals to the ''broader good,'' and demand for it is unlikely to wane. If that is true, societies will have to assess carefully the willingness of their members and authors to pay for production along with aggressively seeking other sources of revenue and maximizing investment income.

Online access of serials will dominate scientific delivery, but the extent to which it will be free to users will vary among societies and likely be a mixture of dues and free access for some time to come. More societies likely will abandon print in favor of exclusive digital formats but attain some balance among online access, open access, and income; therefore, the spread between the endpoints of the ''online'' and ''open'' trajectories in Fig. 1 will differ for each society. Relative to needed income, members and institutions always might have to pay some fee to view current content, but after a period of time (i.e., ''moving wall''), the content may be free and open to anyone. Some moving walls are becoming very short, such as the relatively new 6-month window for the high-impact *Journal of Cell Biology*; contents >6 months old are available free to anyone with an Internet connection (Mellman 2004). Ecological and taxonomic articles, however, have a considerably longer ''citing half life'' (Thomson Scientific, Philadelphia, Pennsylvania) than medical articles, so the lengths of the moving walls of such publications likely will be longer and determined by what societies can afford and how valuable their content is perceived to be through time (Held and Wells 2005).

Only about 30% of members rank ASM as their most important society, which suggests the need for encouraging involvement by those members in particular. Societal focus on packages of benefits for and responsibilities of members would seem appropriate in this transition. Older members of a society should assume prominent leadership roles, by their action, to instill the needed professional responsibility across all age groups. Specifically, such mentors can assume the important role of providing students with up-to-date insight on the changing world of scholarly publishing (e.g., Jones et al. 2006), its importance to their career objectives and the society's profile, and its cost to the society. Groups of scientists that are co-involved in various societies that face fiscal challenges might foster initiatives to bundle their publications (i.e., electronic aggregations beyond existing aggregators such as BioOne and JSTOR), while maintaining their unique missions. Markets for small electronic aggregations in like disciplines (i.e., taxonomically based) have been unexplored (e.g., at 2- and 4-year colleges, community libraries, and even public and private secondary schools); costs would have to be restrained to attract such customers.

It is impossible for me to predict definitely the outcome of the shifting mosaic of what scholarly publishing is today. Yet, I am optimistic because scholars traditionally have brought the products of their science to the attention of colleagues and the general public. Their energies and perennial dedication have created longstanding and revered serials, and the associated costs of production and dissemination have been paid by creatively generating revenues. Although challenges of generating those revenues may be heightened in the digital age, particularly if it features dominance of free open access, I am confident that society members will rise to the occasion with renewed professionalism, as they have in the past.

Resumen

Las sociedades científicas no lucrativas esperan que sus actividades avancen en su misión particular y tengan un impacto en su profesión y, en el sentido más amplio, impacten a la humanidad de manera positiva. La era digital ha proporcionado mecanismos sin precedentes para mejorar la entrega de la ciencia al mundo. El mercado de la publicación científica es un mosaico de desafíos y oportunidades que cambia rápidamente, y la respuesta de editores no lucrativos y comerciales varía extensamente. No obstante sus resultados siguen siendo inciertos. La respuesta de la Sociedad Americana

de Mastozoología (ASM) proporciona un ejemplo de cómo una sociedad relativamente pequeña ha alterado su entrega científica para mejorar los beneficios de los miembros mientras que pretende sostener su viabilidad económica. Desde 2000, la ASM ha cambiado de un modelo de auto-publicación, salir sin ganar ni perder, y de sólo publicación impresa, a un acuerdo de co-publicación con un publicista comercial (Alliance Communications Group, una división de Allen Press, Inc., Lawrence, Kansas), que genera derechos compartidos y ofrece a los miembros varias opciones electrónicas y de impresión. Aunque es aùn demasiado temprano para calibrar el impacto económico de estos cambios, la dirección de la ASM procuró señalar claramente su deseo para que los miembros vean a su sociedad como un paquete de oportunidades de edificación e implicación, más que solamente un proveedor de suscripciones seriales. Los desafíos futuros para las sociedades científicas no lucrativas incluyen el acceso abierto, realidades fiscales, archivo de publicaciones, e impacto científico y social; las futuras oportunidades incluyen una consolidación de responsabilidades y profesionalismo de los miembros, desarrollo del registro de datos para mejorar el progreso científico, y ligarse a sociedades semejantes. La manera en la cual las sociedades científicas no lucrativas responden a estos desafíos y oportunidades sin duda alguna afectará su sustentabilidad e impacto futuro.

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