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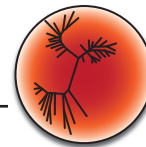
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Using Scavenger Hunts to Familiarize Students with Scientific Journal Articles[†]

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Primary scientific literature can be difficult to navigate for anyone unfamiliar with its foreign, formal structure. We sought to create a fun, easy learning tool to help familiarize students of all ages with the structure of a scientific article. Our main learning objective was for the student to realize that science writing is formulaic—that specific information is found in predictable locations within an article—and that, with an understanding of the formula, anyone can comfortably navigate any journal article and accurately predict what to expect to find in each section. To this end, we designed a Journal Article Scavenger Hunt that requires the user to find and identify a series of commonplace features of a primary research article. The scavenger hunt activity is quick and easy to implement, and is adaptable to various ages and settings, including the classroom, lab, and at outreach events. The questions in the scavenger hunt can be scaled in difficulty and specificity to suit the instructor's needs. Over many years of using this activity, we have received positive feedback from students of all ages, from elementary school students to lay adult-learners as well as science teachers themselves. By making the unknown seem predictable and approachable, the scavenger hunt helps a variety of audiences feel more comfortable with science and more confident in their ability to engage directly with the scientific literature.

INTRODUCTION

Reading a journal article from the primary scientific literature can be a daunting task for anyone—especially for K to 12 students and teachers. The barriers that inhibit people who are not professional scientists from being able to read a scientific article include: finding and accessing an article of interest; comprehending the field-specific jargon (8); and understanding how to navigate the structure of the article to locate the desired information. We at *The Journal of Emerging Investigators* (JEI, www.emerginginvestigators.org) aim to lower these barriers for middle and high school students and their mentors. (For a deeper discussion of these issues and how JEI addresses them, please see the

accompanying Perspectives article in this issue (3).) Increasing student engagement with the scientific literature is important because it is the most unbiased and direct way to learn scientific information. Moreover, it encourages students to think critically about the process of how scientific “facts” are discovered and teaches them how to apply the scientific method to their own questions. We also believe that making students comfortable with primary literature articles will break down the damaging stereotype that science is impenetrable and only for experts. Eliminating this commonly held but incorrect belief is one of the critical first steps in empowering scientific competency in all citizens.

The internet is a powerful tool to help students hurdle the first two barriers described above. Many online repositories of free, or “open-access,” articles now exist that can be easily accessed and searched for articles of interest, which can be downloaded in full (Table 1). However, once an article is in hand and jargon is defined, primary literature can still be very difficult to navigate for anyone unfamiliar with its foreign, formal structure. We sought to create a fun, easy learning tool to help familiarize students and their teachers, parents, and other mentors with the structure of a scientific article. Our main learning objective was for the student to realize that science writing is formulaic—that specific information is found in predictable and defined lo-

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†Supplemental materials available at <http://jmbe.asm.org>

TABLE 1.

Journal article collections available for free on the Internet.

Internet-Accessible Repositories of Free Scientific Articles	
PubMed Central	www.ncbi.nlm.nih.gov/pmc
Public Library of Science	www.plos.org
BioMed Central	www.biomedcentral.com
Directory of Open Access Journals	doaj.org
Journal of Emerging Investigators	www.emerginginvestigators.org
Google Scholar ^a	scholar.google.com

Primary scientific literature can be searched and accessed for free using these resources. Each website contains thousands of scientific articles that are all “open-access” and can be downloaded for free for use in the classroom, lab, or for personal interest. To find an article of interest, you can browse issues of specific journals or perform a targeted keyword search. Note: All articles from the *Journal of Emerging Investigators* are written by students, whereas all other sources contain articles written by professional researchers.


^a Google Scholar contains both free and fee-for-service articles.

cations within an article—and that, with an understanding of the formula, anyone can comfortably navigate *any* journal article and accurately predict what to expect to find in each section. Therefore, we designed the Journal Article Scavenger Hunt to require the user to find and identify a series of commonplace features of a primary research article (Fig. 1). This activity quickly highlights the similarities found across all journal articles, and it can be scaled up or down in difficulty to the level of the user. At *JEI*, we have had success using the scavenger hunt with students of all ages, from elementary school children to lay adult-learners, and in a variety of settings, from the classroom and lab to outreach booths at fairs. While many pedagogical approaches already exist to help students learn from primary literature (e.g., CREATE (5), Figure Facts (7), and others summarized in 7 and 6), most are geared toward using articles to teach college students scientific content and/or processes and require significant investments of classroom time. *JEI*'s Journal Article Scavenger Hunt complements these approaches by providing a novel focus on teaching the *structure* of a scientific article, rather than its content, in a manner that is accessible to school-aged children and can be accomplished in as little as five minutes.

PROCEDURE

Materials

All that is needed to complete this activity is the scavenger hunt (Fig. 1), writing utensils, and one or more primary research articles. For outreach events that engage



Journal Article Scavenger Hunt

Every scientific primary research article contains the following items
– can you find them all?

School where scientists did the work: _____

Date when article was received: _____

Date when article was published: _____

Main question being asked: _____

One method that was used: _____

Page of Figure or Table #1: _____

Main conclusion of the paper: _____

Reference #3 (first author's name): _____

BONUS QUESTION: What happens to an article between the time it is submitted for publication and the time it is published?

Check us out at emerginginvestigators.org and at www.facebook.com/EmergingInvestigators

FIGURE 1. Journal Article Scavenger Hunt. This generic template for the Journal Article Scavenger Hunt can be modified to suit the needs of the instructor. The questions can be adjusted to be more or less challenging, and/or more or less specific to the content of the journal article of choice.

the public, such as booths at science festivals, supplemental materials can be helpful, including visual aids that relate to the articles (e.g., sealed moldy agar plates for articles on microbes) and inexpensive incentives (e.g., neon bouncy balls for kids who complete the scavenger hunt). However, these items do not directly relate to the scavenger hunt itself and are not necessary to complete it.

Selection of research articles for the scavenger hunt

Primary research articles to be used with the scavenger hunt can be pre-selected by the instructor and distributed with the activity, or they can be found as part of the student's preparation for the activity (see Table 1 for where to find articles). We select articles with content that suits the students' interests and reading level. For example, when working with older teenagers and college students, we choose articles like “The relationship between sleep and wake habits and academic performance in medical students: a cross-sectional study” (2). This research asks whether late bedtimes and daytime sleepiness correlate with poor grades in school—a question that this age group

easily relates to and enjoys. For younger or broader audiences we recommend using articles published in the *Journal of Emerging Investigators*, where the research is designed, performed, and written by student authors in grades 6 to 12. These articles tend to have simpler methodologies and intuitive subjects such as “The effect of music on heart rate” (1) or the “Isolation of microbes from common household surfaces” (4). While being approachable, *JEI* articles are still peer-reviewed, primary research articles and so they conform to the standard of professional literature in terms of structure and layout and serve as excellent introductions to the science writing format.

Let’s do a scavenger hunt!

The activity itself is straightforward: each student receives one copy of the scavenger hunt for each article (Fig. 1). The worksheet is comprised of fill-in-the-blank questions that alert the reader’s attention to common features in all primary research articles, such as the authors, the main research question being asked, the publication dates, and the main conclusion of the work. The instructions state “Every scientific primary research article contains the following items—can you find them all?” The student must then scan the research article to find the items and write in the correct answers. The student should not statically read the article from beginning to end; rather, the activity should be done quickly by scanning for the pertinent information, with most students completing it within five minutes. For more mature and independent students, the activity can be performed individually but it is often more fun and interactive when done in small groups. In classroom settings, the scavenger hunt lends itself well to a “think-pair-share” format, where the pairs share their explanations with the entire class to generate discussion. We have found that the best way for students to grasp the structural similarities that all articles share is to have students perform the scavenger hunt iteratively with multiple, disparate articles. The students quickly recognize the pattern of where to find the desired information and can then more quickly find the same information in a new article. To emphasize this point and to build excitement, we make it a race: we use stopwatches to time how quickly a student can accurately complete the scavenger hunt for one article, and then see if s/he can beat that time when finding the same information in a new article.

Different ways to use the scavenger hunt

The scavenger hunt is easily adaptable to many learning scenarios. We have used it as a pre-lab assignment or as homework with high-school students and college freshmen to guide their reading of a primary research article. We have also had great success with the scavenger hunt as an outreach activity at science fairs, where we use prizes and races to incentivize engagement from children as young as elementary school-age. We find that students of all ages find comfort in

the predictability of where to find specific information within the foreign format of the article, and we see their scavenger hunt completion times decrease and their confidence grow in real time as they quickly succeed in finding correct answers. Similarly, we have used the scavenger hunt in professional development seminars for middle and high school science teachers to de-mystify the structure of the journal article and to encourage teachers’ inclusion of primary literature in their classrooms. Teachers’ evaluations of the scavenger hunt were universally positive, with one teacher writing that she now feels able to “introduce the structure of science writing to my [6th grade] students for the first time.” To more formally measure the efficacy and impact of the Journal Article Scavenger Hunt, *JEI* is currently in the process of developing summative assessments of its publication and outreach efforts (see our accompanying article published in this themed issue (3) for further information).

Not only is the scavenger hunt activity beneficial for various audiences and settings, the hunt itself is adaptable to the instructor’s needs. The questions within the scavenger hunt can be modified by the instructor to add variety to the assignment each year or to accommodate different learning styles. The content of the scavenger hunt can also be tailored to specific articles of interest to meet the instructor’s learning goals. For example, when we at *JEI* use the scavenger hunt to teach about the peer-review process, we include a bonus question that draws the reader’s attention to the difference between the submission date and the publication date. An example of a modified scavenger hunt used with college freshmen can be found in Appendix 1.

CONCLUSION

The Journal Article Scavenger Hunt is a fun, adaptable activity that quickly familiarizes the user with the structure of a primary scientific research article. Over many years of using this activity, we have received positive feedback from students of all ages, from elementary school students to lay adult-learners as well as science teachers themselves. By making the unknown seem predictable and approachable, the scavenger hunt helps a variety of audiences feel more comfortable with science and more confident in their ability to engage directly with the scientific literature.

SUPPLEMENTAL MATERIALS

Appendix 1: Modified science article scavenger hunt

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exclusively as volunteers for the *Journal of Emerging Investigators*, which is an educational non-profit organization based at Harvard Medical School.

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