Innovative ESP Teaching Practices and Materials Development

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Abstract As tertiary-level students progress in their studies, they reach a point where they need to read and write the genres valued in their chosen disciplines. The transition from general academic English to English for specific purposes (ESP) begins at this juncture. ESP instruction facilitates this transition by equipping students with the language and genre-analysis skills needed to access their respective disciplinary genres. In this chapter, we introduce two approaches to ESP instruction that can be sequenced to ease students' progression toward disciplinary literacy. With the *read–and–notice* approach, ESP students are guided in noticing, comparing, and contrasting written disciplinary conventions. This pre-production stage serves as preparation for the later *read–analyze and write* approach. To illustrate what can be accomplished with both approaches, we highlight innovative teaching practices and materials developed specifically for students in an organic chemistry lab and in a subsequent reading-and-writing intensive course for chemistry majors. Particular attention is paid to an online read-and-notice module integrated into an organic chemistry lab. Examples from ten online assignments are provided, and implications for other disciplines are discussed.

Keywords Chemistry-specific writing · Disciplinary genres · ESP materials · ESP pedagogy · Genre-analytic skills · Genre-based instruction · Writing conventions

1 Introduction

As tertiary-level students progress in their studies, whether they are native or non-native speakers of English, they arrive at a point when they need to read and write the genres valued in their chosen areas of study. These disciplinary genres are

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challenging for them in part because they differ substantially from the general academic English, and corresponding texts, that they were exposed to at earlier stages in their studies (in high school, university-level English preparation programs, first-year composition classes, and other introductory university classes). As university students transition from general English for academic purposes (EAP) to English for specific purposes (ESP), they have a lot to learn. That they have to master disciplinary subject matter, including key terminology and concepts, goes without saying. They also need to gain access to and control of valued disciplinary genres and the linguistic variation that exists within them (Nesi and Gardner 2012; Paltridge 2013; Swales and Feak 2012; Tardy 2009). ESP classes can facilitate students' transition from EAP to ESP by helping students become (a) more skilled readers and writers in their chosen disciplines (Hirvela 2013, 2016; Hyland 2013) and (b) more self-regulated, autonomous learners (Andrade and Evans 2015). One major goal of ESP instruction is to equip students with language and genre-analytic skills that permit them to continue to learn on their own as they encounter new genres, and corresponding literacy expectations, during their academic and professional lives (Johns 2007).

ESP courses take on many different configurations. Some are taught by ESP faculty; some are taught by disciplinary faculty; and others are team taught by interdisciplinary teams, comprising an ESP specialist and discipline-specific instructor. Some ESP courses are geared toward students just entering their academic fields; others are geared toward students at more advanced levels of disciplinary study. ESP instruction sometimes is the sole focus of the course; in other settings, ESP is addressed as one component of a discipline-specific content class or lab. Instructional practices and materials used in this range of ESP classes vary, in part depending on (a) whether the class comprises students from one overarching discipline (e.g., chemistry), one sub-discipline (e.g., organic chemistry), or multiple disciplines (e.g., chemistry, engineering, forestry, psychology); (b) what the language-skill emphases are (e.g., reading, writing, speaking, and/or listening); and (c) which genres are targeted for instruction (e.g., engineering design reports, journal articles, law briefs, scientific posters). What these varied ESP contexts have in common, despite their differences, is the goal to tailor pedagogy, and corresponding instructional materials, to students' pressing discipline-specific language-skill and genre needs.

In this chapter, we focus on ESP at two different points in university students' progression toward disciplinary literacy, specifically at what we call the *read–and–notice* (pre-production) stage and the *read–analyze and write* stage (cf. Basturkmen 2006, who discusses input and input-to-output methods of teaching ESP). To illustrate what can be accomplished at these two different stages of ESP instruction, we highlight innovative teaching practices and materials developed specifically for chemistry students, though parallels certainly exist in other fields. We begin by providing some background on our interdisciplinary efforts. Then we explain briefly our read–analyze and write pedagogy (which has been documented elsewhere, as noted below). We then turn to a more extensive discussion of our read–and–notice pedagogy, supported by examples of ESP tasks developed for chemistry students enrolled in an organic chemistry lab. Our discussion is sequenced in this way, even though students benefit from the read–and–notice pedagogy first, because it is in the order in which we have developed these approaches to ESP. We conclude with implications for ESP across the disciplines.

2 Background

We have worked as an interdisciplinary ESP team, one applied linguist and one chemist, for more than 15 years. We have collaborated on chemistry-specific ESP research, the conceptualization of instructional approaches for ESP literacy-skill instruction, and the development of print and online instructional materials to support chemistry students' discipline-specific literacy-skills development. Our interdisciplinary collaboration has allowed us to combine our distinct areas of expertise and, at the same time, our shared interests in students' disciplinary literacy needs (Horn et al. 2008). Early on in our joint efforts, we analyzed the language of chemistry in four key disciplinary genres (journal articles, conference abstracts, posters, and research proposals) to ascertain their defining linguistic and nonlinguistic features (Stoller et al. 2008; Stoller and Robinson 2013, 2014a). From the findings of our analyses, we envisioned a context-specific teaching pedagogy (an iterative read–analyze and write approach) and developed corresponding instructional materials (Stoller and Robinson 2014b, 2015). The final outcomes of our efforts include a discipline-specific ESP textbook *Write Like a Chemist* (Robinson et al. 2008), an accompanying website (http://www.oup.com/us/writelikeachemist), and a discipline-specific ESP course offered at our university. Our subsequent efforts have been directed at the read–and–notice (i.e., pre-production) stage, which has been integrated into an already existing organic chemistry lab, taken by students before they enroll in the Write Like a Chemist course.

3 Read–Analyze and Write Approach to ESP Instruction

Our *read–analyze and write* approach to ESP instruction, and corresponding materials, was developed for 3rd year university students. In U.S. university contexts, it is at about this point when students (a) have acquired sufficient disciplinary content knowledge to begin to read and write in select disciplinary genres and (b) are prepared for an inaugural ESP course in disciplinary literacy skills. The textbook that we authored (*Write Like a Chemist*) was written specifically for such a course; the read–analyze and write approach (Fig. 1) runs throughout textbook materials and the course. Students read and analyze authentic passages (entire texts, full sections, excerpts, and textual elements, such as figures and tables) from professional chemistry genres. The read–and–analyze tasks are followed by a series of scaffolded writing assignments, during which students compose targeted genres (i.e., journal-quality papers, conference abstracts, scientific posters, and/or research proposals)

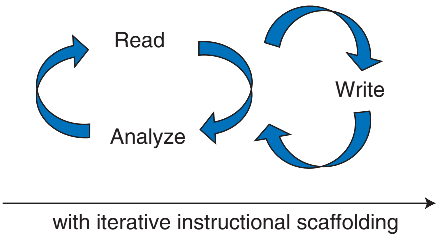

Fig. 1 Depiction of the iterative *read–analyze and write* approach (adapted from Stoller and Robinson 2015)

following a step-by-step process. When possible, students write about their own undergraduate research projects or, alternatively, they are provided with data from fictitious (though realistic) projects, making the writing experience more authentic. Following guided peer review and instructor feedback, students revise and edit their work, underscoring the importance of revision in the writing process.

The key characteristics of the read–analyze and write approach, though initially developed for ESP in chemistry contexts, are applicable, with adaptation, across the disciplines. Some distinguishing characteristics of the approach include the following:

- Before introducing students to the disciplinary genres targeted for instruction, students are introduced to the *read–analyze and write* approach by means of familiar, everyday genres (e.g., menus, used car ads, internship application letters). The early read–analyze and write tasks introduce students to the approach and guide them in looking at familiar written genres in new ways. To ease the transition from everyday genres to valued disciplinary genres, the same steps are taken with discipline-specific genres that students are already familiar with (e.g., in chemistry, this could be Safety Data Sheets [SDS], a genre that chemistry students commonly encounter in labs). In our context, we then juxtapose two articles—one written for a general audience and the other for an expert audience—on the same topic (one that we are certain that students have encountered in introductory chemistry courses). Students read and analyze both texts, iteratively, to identify similarities and differences. Such systematic scaffolding prepares students to read, analyze, and write the disciplinary genres targeted for instruction.
- By means of read–analyze tasks (with everyday genres, familiar disciplinary genres, and new disciplinary genres), students gain an understanding of the defining linguistic, non-linguistic, and organizational features of the target genres. More specifically, the approach guides students in discovering how five essential writing components (i.e., audience and purpose, organization, field-specific writing conventions, grammar and mechanics, and content) manifest themselves in different genres. As a result of these analyses, students learn to identify and appreciate the various aspects of writing that must coalesce, in different disciplinary genres, for written work to meet disciplinary expectations. Instructionally, these five writing components offer students (and instructors) a manageable way to break down larger analytic tasks into more manageable ones.

- After reading and analyzing multiple examples of target genres (section by section), students begin to write, using excerpts as models. While writing, students are encouraged to return to sample texts for additional rounds of reading and analysis to check and verify disciplinary practices or seek further insights about the genre that they are trying to emulate.
- Throughout the read–analyze and write cycle, there is explicit instruction, teacher modeling, class discussion, practice, teacher and peer feedback, and student reflection. The cycle, with time, helps students gain access to and control of target genres (Tardy 2009).

4 Read–and–Notice Approach to ESP Instruction

Recently, we have shifted our attention from read–analyze and write ESP instruction (with 3rd year, and more advanced, university students) to read–and–notice ESP instruction for 2nd year university students, who are ready to notice disciplinary conventions, but not ready to produce them. This stage serves as a useful "training ground" for the later read–analyze and write cycle. Our specific goal has been to integrate read–and–notice instructional materials into an already existing organic chemistry lab. Unlike the Write Like a Chemist course, described above, the read–and–notice ESP writing module has been developed to be delivered online via a Learning Management System (i.e., BlackBoard Learn). The writing module comprises short (15 min) weekly assignments, all scored electronically. Students complete the assignments entirely on their own, outside of lab. The online tasks guide students in noticing disciplinary conventions and are set up to provide immediate feedback upon task completion (both positive and corrective), without direct faculty assistance. The primary learning objective of the module is a simple one: to raise students' awareness of writing conventions in organic chemistry. Unlike our course centered around the read–analyze and write cycle, this module is intentionally preproduction; students are eased into disciplinary writing through activities that promote observational skills (e.g., noticing, comparing, contrasting), with no formal writing assignments. The module is intentionally low stakes, and students are allowed unlimited attempts to complete each task correctly. To encourage successful completion, the module comprises 10% of students' final grade in the lab. We envision the read–and–notice module to be a prerequisite for the reading and writing intensive Write Like a Chemist course.

With over a decade's experience in teaching our Write Like a Chemist course, we have learned that most 3rd year university students entering the course know very little about chemistry-specific writing. Moreover, they often believe that they know more than they do, in part due to their experience in preparing lab reports (see Parkinson 2017; cf. Kelly-Laubscher et al. 2017) in first- and second-year chemistry labs. They have been instructed in how to prepare these reports, so it is not surprising that they assume that a professional-level research paper is simply a more extensive version of a lab report. The goal of our read–and–notice module is to dispel such beliefs and to help students develop a clearer understanding of the differences between a lab report (a genre for students learning chemistry) and a journal article (a genre for expert chemists), without actually asking them to produce close approximations of the latter. Instead, we engage students in simple assignments designed to raise their awareness of these differences. Such increased awareness can serve as a right-of-passage and foster a sense of belonging to the discipline. Knowing, for example, that the Experimental section (akin to the Methods section in an applied linguistics journal article) comes at the end of an organic chemistry journal article (not after the Introduction), that nuclear magnetic resonance (NMR) data are presented in the Experimental section in prose (not as spectra, that is, as graphic displays, in the Results section), and that chemicals are written in lower case (not capitalized) enhances a student's right to membership as an organic chemist. Awareness of these conventions is akin to knowing a secret password or handshake for entrance into a club or organization.

In the sections that follow, we provide an overview of the read–and–notice module and give examples of tasks assigned to increase students' awareness of disciplinary conventions. Although the examples are all specific to organic chemistry, the approach can be easily adapted to other disciplines, including other areas within chemistry. We begin by describing a pre-assessment task (which students complete again later as a post-assessment task) and then describe 10 read–and–notice assignments.

4.1 Pre-assessment Task

The module begins with a pre-assessment task. Students are asked to answer 15 multiple-choice questions designed to assess what they already know about writing conventions in organic chemistry. Upon completion of the task, students are told only how many questions they answered correctly; they do not see the correct answers, nor do they see the questions that they answered incorrectly. At the end of the semester, students repeat the task as a post-assessment. Only the post-assessment is graded (the equivalent of one homework assignment).

It is worth noting that when we piloted our materials, the pre-assessment task was completed by three students enrolled in an organic chemistry lecture and lab; they all ultimately received A grades in each course. All three scored below 20% on the pre-assessment task, confirming our assumption that students are not likely to have learned these conventions in other courses or through the writing of lab reports.

4.2 Read–and–Notice Assignments

Following the pre-assessment task are 10 read–and–notice assignments that are designed to be completed by students online. The sequence of assignments is outlined in the course syllabus (see Table 1 in the Appendix). The assignments center around excerpts from three different chemistry journals: two are published by the American Chemical Society (ACS), *The Journal of Organic Chemistry* (*JOC*) and *Organic Letters* (*Org. Lett.*); the third, *Tetrahedron,* is published by Elsevier. We intentionally used different publishers and genre types (research articles and letters) to help students recognize that conventions vary across journals. The articles that were selected from the three chemistry journals addressed content parallel to the lab experiments in the organic chemistry lab; the experiments involve "named" reactions in organic synthesis, specifically the Diels-Alder, Wittig, Friedel-Crafts, and Grignard reactions. The selected articles each refer to one of these reactions, enticing perhaps the more motivated student to explore the articles for the science, too! We assumed, while selecting articles for the read–and–notice assignments, that very few students, in their second year of university study, will have read anything from these journals (or other peer-reviewed journals). Thus, it is our intention, with these low-stake read–and–notice tasks, to offer a gentle introduction to the professional literature and corresponding disciplinary conventions.

In the sections that follow, we describe read–and–notice tasks that can be adapted by ESP practitioners working in other disciplinary contexts. In the examples provided, we use italics to share correct answers with our readers; these answers are not provided to students. Also, standard chemistry language is used in the examples (e.g., MW for molecular weight and mp for melting point); these terms are not spelled out because it is assumed that students know them. At various points, "Your thoughts?" questions are embedded into the tasks to help students reflect on what they have learned. Students are expected to share their thoughts (in writing) to receive credit, although the content of their responses is not graded. At other points in the read–and–notice module, students encounter "Did You Know?" questions. These questions too require student responses, for which students are given credit for correct or incorrect answers.

Assignment 1: Sections of a Journal Article In the first task, students are asked to browse three journal articles and list by name, or number in the correct order, the major headings used in each article. By means of this task, students learn that *Org. Lett*. has no headings in the main body of the paper, whereas both *JOC* and *Tetrahedron* place the Experimental section after the Conclusions (a common practice among organic chemists). To further raise students' awareness, the first Did You Know? task asks students to respond *true* or *false* to the following assertions:

- It is not the scientist's responsibility to format references so that they adhere to the journal's guidelines. This is done by the journal's editorial staff. (*false*)
- If a submitted manuscript exceeds the word limit, it may be returned unread. (*true*)

- Many journals charge scientists to publish their work, although ACS does not. (*true*)
- *JOC* editors and peer reviewers judge articles primarily on the quality of the science. Problems with grammar, spelling, formatting, etc. are corrected by editors. (*false*)

In line with the approach used in *Write Like a Chemist*, the remaining activities are grouped by major sections of a journal article. We begin with the Experimental section (four tasks), and continue with Results and Discussion (three tasks), Introduction (one task), and References (one task). We follow this sequence not because it reflects the order of sections in a chemistry journal article, but because the Experimental section includes the information most familiar to students. It is also the section many chemists write first, when preparing a manuscript for publication.

Assignments 2–5: Experimental Section The read–and–notice tasks associated with the Experimental section of a journal article center on disciplinary conventions associated with (a) using capitalization and abbreviations, (b) describing materials, (c) describing methods (or procedures), and (d) presenting NMR data. Examples A1–A4 (in Appendix) illustrate the types of questions incorporated into these tasks. For most tasks, students are given feedback for correct and incorrect answers. Correct feedback is used to reinforce the key concept (e.g., Right! Chemicals are not capitalized unless they are named after a person); hints are given for incorrect responses (e.g., Check the article again. What do you notice about the capitalization of chemical names?).

Assignments 6–8: Results and Discussion Section To raise students' consciousness about disciplinary conventions in Results and Discussion sections of journal articles, read–and–notice tasks focus on tables and on the use of prose to communicate findings (results) and interpretation (discussion). We begin with a task that requires students to interpret a table from *JOC*. Our goal is to raise students' awareness about how the results of multiple reactions can be reported concisely in a single table (12 reactions are summarized in the *JOC* table that is provided). We also prompt them to think about how the authors organized the table. We lead students to discover that the authors conducted the reaction 12 times (and probably dozens of times more that are not reported), each with a slightly different ligand. A reaction included above the table illustrates the structures of the various ligands, each with a unique label. We contrast the *JOC* table with a table in their lab manual, which describes the results of only one reaction. In a "Did You Know?" question, we ask students to think generally about how authors report their results—in chronological order or in a way that leads readers logically to the conclusions of the work, with the latter being correct. In the second task, students are shown two tables—one that is correctly formatted (from *Tetrahedron*) and one that is not. Students are asked to select (from a list) attributes that are wrong in the incorrect table (e.g., inclusion of gridlines, bolded headings).

In a task centered on the prose of the Results and Discussion section, students are asked to distinguish between the purpose of a Results section (to present results) and a Discussion section (to interpret results), even though these two sections are most often combined in organic chemistry journals. In a follow-up task (Example A5), students are asked to select which sentences convey “results” (presentation of findings) and which convey “discussion” (interpretation of findings).

Assignment 9: Introduction Section To raise students’ consciousness about the characteristics of journal article Introductions, we focus largely on organization and authors’ “moves” (following the seminal works of Swales 1990, 2004). We begin with a multiple-choice question (ungraded) that asks students to select the sentence that is most likely the opening sentence of an Introduction (Example A6). We expect that many students will select (incorrectly) a sentence in which the authors introduce the work presented in the paper (e.g., In this paper, we. ..) rather than a sentence that broadly introduces the research area. Students are then presented with seven excerpts from an Introduction (in correct order) and asked to match each excerpt with its purpose (Example A7). In a follow-up activity, students are given an abbreviated list of purposes in scrambled order and asked to order them correctly (Example A8). Lastly, they are asked to answer the first question again (Example A6), but this time students’ responses are scored.

Assignment 10: References and Citations To raise students’ awareness about in-text and end-of-text attribution conventions**,** students are introduced to the format followed by *JOC*, which is nearly identical to the formats used in *Org. Lett.* and *Tetrahedron*. To increase students’ attention to detail, we ask them to identify the one correctly formatted reference in a list of eight references (Example A9). In a follow-up matching exercise, students are asked to identify the mistakes made in the other seven references (e.g., spaces should be used between initials in authors’ names; semicolons (not commas) should be used to separate authors’ names; page numbers should be inclusive; all authors’ names should be listed). For in-text citations, we begin by asking students to identify which rules are correct for citations, using an excerpt from *JOC* for guidance (Example A10). The feedback given for incorrect answers helps students identify the correct rules (e.g., the feedback tells them that direct quotations should be avoided in chemistry writing). A follow-up exercise instructs them in the correct use of et al. (Example A11).

5 Conclusion

In this chapter, we have described two approaches to ESP instruction: the pre-production *read-and-notice* approach and the *read-analyze and write* approach. The two approaches, sequenced one after the other, can help students transition from general academic English to the language and genres of their chosen areas of study. By means of the pre-production approach, students develop observational skills that help them notice, compare, and contrast disciplinary conventions. These skills prepare them for a later stage that involves an iterative series of read-analyze and write tasks centered around valued disciplinary genres. To illustrate both approaches, we provided examples from our experiences developing materials for and teaching ESP in a chemistry context. Parallels certainly exist in other ESP contexts.

Whether students are transitioning to the genres of, for example, architecture, biology, engineering, hotel-restaurant management, or law, they will all arrive at a point in their studies when they need access to disciplinary genres. ESP practitioners who want to ease the transition can adapt the approaches introduced here to meet their students' needs. Central to both approaches is the need for ESP practitioners to (a) identify the genres valued in the target disciplines; (b) analyze them to determine the linguistic, non-linguistic, and organizational features that characterize them (see also Quero and Coxhead, chapter "Using a Corpus-Based Approach to Select Medical Vocabulary for an ESP Course: The Case for High-Frequency Vocabulary" in this volume; Farhady, Tavassoli, and Irani, chapter "Selecting Corpus-Based Grammatical Structures for ESP/EAP Materials" in this volume); (c) select examples of authentic texts that are accessible to students in terms of disciplinary content; and (d) develop scaffolded instructional materials that guide students in developing observational skills (with the read-and-notice approach) and then engage students in more rigorous read-analyze and write tasks. The two approaches, when adapted to different academic disciplines, equip students with the language, genre-analytic, and writing skills needed for entrée into their chosen disciplines. Interdisciplinary collaboration—between ESP and disciplinary specialists—is a particularly effective way to achieve these aims.

Appendix

Table 1 Organic chemistry lab experiments and associated read–and–notice assignments

Experiment #	Lab experiment	Online read–and–notice assignments
	Safety orientation, check-in	
1	Column chromatography	Pre-assessment
2 (pt 1)	^{1}H NMR processing	1. Sections of a journal article
2 (pt 2)	^{1}H NMR interpretation	2. Experimental: abbreviations and capitalization
3	$NaBH_4$ reductions	3. Experimental: describing materials
4	Literature search	4. Experimental: describing procedures
5	Grignard reaction	5. Experimental: describing NMR data
6	Wittig reaction	6. Results: tables (part 1)
7	Aldol reaction	7. Results: tables (part 2)
8	Friedel-Crafts reaction	8. Results and Discussion: present and interpret data
9	Diels-Alder reaction	9. Introduction: organization
10 (pt 1)	Luminol synthesis	10. References and Citations
10 (pt 2)	Luminol chemiluminescence	Post-assessment
	Final exam, check-out	

Adapted from the syllabus for an organic chemistry lab

Example A1: Experimental Section (Capitalization)
Which of the following sentences use capitalization correctly? Use your lab manual and the *JOC* article as guides.

- High-purity CH_4 was used as the carrier gas. (*correct*)
- The more polar solvent was ethanol. (*correct*)
- Thin-layer chromatography (TLC) was used to separate a mixture of ferrocene and acetylferrocene. (*correct*)
- The eluent was collected in an erlenmeyer flask. (*incorrect – Erlenmeyer is capitalized because it is named after a person*)
- The gases used were Oxygen, Nitrogen, and Helium. (*incorrect, written-out names of elements or compounds are in lowercase*)

Example A2: Experimental Section (Abbreviations)
Chemists are expected to use standard abbreviations in their writing. To practice this skill, fill in the following blanks with the correct abbreviation using the attached list of abbreviations from *JOC*. Be sure to capitalize and punctuate correctly.

aueous ________ *(aq)*
concentrated ________ *(concd)*
compound ________ *(compd)*
gas chromatography _________ *(GC)*
hour(s) ________ *(h)*
literature value ________ (*lit.*)
room temperature _____ *(rt)*
temperature ________ *(temp)*
thin-layer chromatography ________ *(TLC)*
volume ________ (vol)
weight ________ (wt)

Example A3: Experimental Section (Describing Materials)
In this exercise, we compare how materials are described in lab manuals and journal articles.

(1) Consider the Materials section of the Diels-Alder reaction in your lab manual. Which statements are TRUE about the ways in which materials are described? Select all that are correct. *(Correct answers are A, B, C, and F)*

(continued)

A. Physical properties of the reagents used, such as MW and mp, are listed in a table.
B. The amounts of reagents used are listed in a table.
C. Hazards associated with each reagent are listed in a table.
D. Physical properties and hazards of potential products are listed in a table.
E. The expected amount of each potential product is listed in a table.
F. The equipment you will use is reported in a bulleted list, for example:

- 25 mL roundbottom flask
- 250 mL beaker
- Büchner funnel

(2) Now let's examine how materials are described in an organic journal article. Browse through the following excerpt from *JOC* (adapted from Colomer et al. 2016).

Materials and Methods. Reagents and solvents were handled using standard syringe techniques. All reactions were carried out under an argon atmosphere. Diisopropylamine (i-Pr_2NH) was purified by distillation from CaH_2. Aldehydes were purified by distillation and stored over Na_2SO_4. Anhydrous solvents were purified by filtration on a solvent purification system (SPS). Crude products were purified by flash chromatography on 230–400 mesh silica gel with distilled solvents. Analytical TLC was carried out on silica gel plates with detection by UV light or 10% phosphomolybdic acid solution in ethanol. All reagents were commercial products. Through this section, the volume of solvents is reported in mL/mmol of starting material.

Which of the following sentences are TRUE in the *JOC* excerpt above? Select all that apply. (*Correct answers are A, D, F, and G.*)

A. Unlike the lab manual, chemical information about compounds is not listed in Tables.
B. A list of chemicals is included but in sentence format, for example: The following chemicals were used: (1) anhydrous ethanol, (2) THF, (3) Na_2SO_4, and (4) diisopropylamine (*i*-Pr_2NH).
C. Instead of tables, physical properties (e.g., mp, MW) are reported in the text.
D. Purification procedures are briefly described.
E. Vendor information is included (e.g., Sigma Aldrich).
F. The entire section is written in full sentences (no bulleted lists or fragments).
G. The section is largely written in past tense.

Example A4: Experimental Section (Describing Procedures)
This activity has four questions.

(1) Refer to the Grignard reaction in your lab manual. Go to Procedure, Preparing the Grignard Reagent. The procedure is described in 15 numbered steps. What verbs are used at the start of the first five steps? (*The answers are Pack, Obtain, Assemble, Remove, and Weigh.*)

(2) Journal articles describe procedures quite differently than lab manuals. Here are three key differences:

- Steps are not numbered or listed. Everything is written in prose (full sentences).
- Imperatives (verbs such as Weigh, Add, Stir, Combine) are not used.
- Sentences are written primarily in the past tense.

With that in mind, compare these two sentences:

Lab manual:	1. Stir the mixture at 0 °C for 20 min.
Journal article:	The mixture was stirred at 0 °C for 20 min.

Using the example above, rewrite the following sentence for a journal article. Type your answer in the box provided. Be sure capitalization, units, punctuation, and spelling are correct. (You can copy and paste as needed.) (*Answer: The mixture was refluxed at 140 °C for 10 min.*)

Lab manual:	4. Reflux the mixture at 140 °C for 10 min.
Journal article:	________________________________

(3) Consider the following six-step procedure from a lab manual:

1. Obtain 15 mL of ethanol and place it in a 125 mL Erlenmeyer flask.
2. Obtain 20 mL of 2.5 M sodium hydroxide and add it to the Erlenmeyer flask.
3. Obtain approximately 2.0 mL of benzaldehyde and place it in a small vial or test tube.
4. Obtain approximately 1.0 mL of acetone and add it to the benzaldehyde in a vial or a test tube.
5. Using a Pasteur pipet, add the benzaldehyde/acetone mixture slowly (a drop or two at a time, over a period of 5 min) to the ethanol/sodium hydroxide mixture.
6. Allow the reaction to stir at room temperature for 30 min.

In a journal article, these steps would be condensed to no more than two sentences! We have provided an example below; however, some information is missing. Using the lab manual excerpt, fill in the blanks in the journal article excerpt. Your answer must be an exact match and use capitalization, abbreviations, spelling, and punctuation correctly. Note how the authors use parentheses to achieve conciseness.

(continued)

Benzaldehyde (____) in ____ (1.0 mL) was added dropwise over 5 min to a mixture of ____ (15 mL) and ___ (20 mL, 2.5 M). The reaction was ____ at room temperature for 30 min.

Answer: Benzaldehyde *(2.0 mL)* in *acetone* *(1.0 mL)* was added dropwise over 5 min to a mixture of *ethanol* (15 mL) and *sodium hydroxide* (20 mL, 2.5 M). The reaction was *stirred* at room temperature for 30 min.

(4) Your thoughts? What key differences did you notice between how procedures are described in a lab manual versus a journal article? Why do you think these differences exist?

Example A5: Results and Discussion Section (Present and Interpret Data)

In exercise A4, you learned that in the Results section, results are shared, and in the Discussion section, results are interpreted. However, because these two sections are combined, results and interpretative remarks are often intertwined. Nonetheless, it is usually possible to distinguish the two. Here are some guidelines:

In the Results, authors highlight the results presented in tables (without repeating them) by

- Calling out the table in the text (e.g., "As shown in Table 1")
- Describing the results in the table (without repeating the values)
- Summarizing important findings

In the Discussion section, authors

- Interpret their results (often using phrases such as "The results indicated" or "The results suggested")
- Compare their findings to others' works
- Propose mechanisms to explain their results

Below we present excerpts from a *JOC* Results and Discussion section (adapted from Wang et al. 2016). Determine which excerpt is a Result (R) and which is a Discussion (D).

1. As shown in Table 1, the desired product could be obtained in moderate yield (68–78%) with varying levels of enantioselective excesses. *(R)*
2. The results indicate that the rate-determining step of the dinuclear zinc catalytic asymmetric reaction may change when the substrate bears a strong electron-withdrawing group. *(D)*

(continued)

3. To our surprise, when Trost's ProPenol dinuclear zinc catalyst **7a** was examined under the same condition, the enantiomeric excess of the product was up to 97% (Table 1, entry 2). *(R)*
4. Among the ligands screened for the Friedel-Crafts reaction, $\mathbf{L}_1$ afforded the best results in terms of yield and enantioselectivity (Table 1, entry 2). *(R)*
5. These results suggest that THF not only serves as the reaction media but also acts as a weak catalytic auxiliary in the reaction. *(D)*
6. In further investigation, we used **7a** as the catalyst for the Friedel-Crafts alkylation process and various reaction conditions were examined (Table 2). *(R)*
7. When the temperature was raised to 40 °C, ee dropped to 86% (Table 2, entry 7). *(R)*
8. Therefore, the optimal conditions for the enantioselective Friedel−Crafts reaction were as follows: 10 mol% ligand $\mathbf{L}_1$, 20 mol% $ZnEt_2$, 2 equiv. of indole **8a** to imine **9** in THF at room temperature for 12 h. *(R)*
9. In accordance with the report by Wang,[11] when N-methylindole **8w** was examined in the catalytic system, no reaction was observed. *(D)*
10. A plausible mechanism for the Friedel−Crafts alkylation process is proposed on the basis of Ding's X-ray analysis of the zinc complex and our observed results (Scheme 4).[8,9,11] *(D)*

Example A6: Introduction (Opening Sentence)

Consider the following three sentences from an Introduction in *JOC* (adapted from Lakshmi and Ravikanth 2013). Which sentence do you think is the first sentence of the Introduction (the opening sentence of the paper)? Your answer will not be graded, but please let us know what you think! We will ask you this question again at the end of the activity. Note: citation numbers have been replaced with "#" to make this more challenging.

A. Recently, we reported on 3,5-diformyl BODIPYs and demonstrated their use as a pH sensor,[#] cyanide sensor,[#] and in other applications.[#]
B. In this paper, we report the synthesis of conjugated BODIPYs by carrying out a reaction between formyl BODIPYs and alkyl or aryl ylides under the Wittig reaction conditions.
C. Among the numerous classes of highly fluorescent dyes, conjugated BODIPY is known to be a versatile and robust fluorophore due to its novel characteristic features and numerous useful applications. (*Correct answer*)

(continued)

Example A7: Introduction (Purposes)

The following excerpts are from a *JOC* Introduction (adapted from Wang et al. 2016). They are in the correct order (that is, the order in which they appeared in the actual article); however, some sentences have been omitted. Your task is to determine the purpose of each excerpt. The purposes are listed below in scrambled order. Match each excerpt with its correct purpose. Each purpose is used only once.

(*Answers*: 1 = E, 2 = B, 3 = D, 4 = G, 5 = A, 6 = C, 7 = F)

1. _____ Optically active nonproteinogenic amino acids have captivated chemists for their biological activities and chemical transformations.[1] (paragraph 1, sentence 1)
2. _____ 3-Indolylglycine derivatives can be used as important synthetic intermediates and building blocks in natural and man-made products.[2] (paragraph 1, sentence 2)
3. _____ Several strategies have been reported for their stereoselective synthesis, including asymmetric catalysis,[3] use of chiral auxiliaries,[4] enzymatic resolution,[5] and dynamic kinetic resolution.[6] Among these methods, asymmetric catalysis is the most significant and effective approach to prepare these compounds because only a limited quantity of the chirality controlling element is used. (paragraph 1, sentences 3 and 4)
4. _____ Wanner et al. developed chiral phosphoric acids 1 and 2 catalytic process for the synthesis of 2-nitrophenylsulfenyl-protected (S)-indolylglycine and triphenylmethylsulfenyl-protected (R)-indolylglycine (Fig. 1).[3a] The enantioselective Friedel−Crafts reaction of indoles with ethyl glyoxylate imines utilizing chiral phosphoric acid 3 was described by Kang and co-workers.[3b] (paragraph 1, sentences 5 and 6)
5. _____ Dinuclear zinc catalysts have also shown excellent performance on asymmetric Friedel−Crafts alkylation reactions … (For example,) Wang et al. reported the Friedel−Crafts amidoalkylation of indoles with aryl aldimines catalyzed by **7a**, affording 3-indolyl methanamine derivatives.[11] However, only aryl aldimines were tested in their work. (last paragraph, first sentence)
6. _____ Herein, we report the dinuclear zinc catalyst system for asymmetric Friedel−Crafts alkylation reaction between indoles and ethyl glyoxylate imine. (last paragraph, next to last sentence)
7. _____ What's more, the products are 3-indolyl α-amino esters. In the presence of 10 mol% catalyst, a series of 3-indolylglycine derivatives were synthesized in moderate to good yields and excellent ee (up to >99%) under mild conditions. (last paragraph, last sentence)

Purposes (in scrambled order)

A. Identify a gap (or gaps) (i.e., shortcomings) in previous works, suggesting the need for further research.

(continued)

B. Highlight the importance of the research area.
C. Introduce the current work (i.e., the work presented in the article) as a way to fill gaps left in others' works.
D. Provide essential background information (previous accomplishments in this area).
E. Introduce the general research area.
F. Preview key findings of the current work.
G. Highlight and cite previous works in the research area.

Example A8: Introduction (Scrambled Purposes)
Consider the purposes of the Introduction again, this time reduced from seven to four. Based on your answers to the previous question, arrange these purposes in their correct order. *(Answer: 3, 1, 4, 2)*

1. Provide background information and cite others' works.
2. Introduce the current work (that will fill the gap).
3. Identify the general research area and its importance.
4. Identify a gap in the research area (work that still needs to be done).

Example A9: References
JOC, *Org. Lett.*, and *Tetrahedron* all recommend similar guidelines. Here are three examples of a reference format used in *JOC* (from Kumar et al. 2017):

(1) Koelle, P.; Noeth, H. *Chem. Rev.* **1985,** *85,* 399–418.
(2) Piers, W. E.; Bourke, S. C.; Conroy, K. D. *Angew. Chem., Int. Ed.* **2005,** *44,* 5016–5036.
(3) Hayashi, Y.; Rohde, J. J.; Corey, E. J. *J. Am. Chem. Soc.* **1996,** *118*, 5502–5503.

Examine the three *JOC* references above, paying careful attention to detail (e.g., spacing and punctuation). Below we have listed eight references (adapted from Georgiou et al. 2017), but only one matches the *JOC* format above. Which one is it? Note the differences are quite subtle! Assume that all articles are at least three pages in length. *(Answer: reference 5)*

(1) Pelly SCA; Govender S; Fernandes MA; Schmalz H-G; de Koning C. *J. Org. Chem.* **2007**, *72,* 2857–2861.
(2) Habib A. M., Masuda S., McCloud T. *J. Org. Chem.* **1987**, *52,* 412–415.

(continued)

(3) La Forge F. B.; Haller H. L.; Smith L. E. *Chem. Rev*. **1933**, 181.
(4) Pastine S. J.; Sames D. Concise Synthesis of the Chemopreventitive Agent (±)-Deguelin. *Org Lett.* **2003**, *5,* 4053–4055.
(5) Akselsen O. W.; Skattebol L.; Hansen T. V. *Tetrahedron Lett*. **2009,** *50,* 6339–6342.
(6) Büchi G.; Crombie L.; Godin P. J.; Kaltenbronn J. S.; Whiting D. A. *J. Am. Chem. Soc.* **1961**, 2843–2848.
(7) Undeani G. O. et al. *Cancer Res.* **1997**, *57,* 3424–3428.
(8) Alonso, Rafael; Campos, Pedro. J.; Garcia, Barabara; Rodriguez, Miguel A. *Org. Lett.* **2006**, *8,* 3521–3526.

Example A10: Citations

Immediately below the following *JOC* excerpt (adapted from Lakshmi and Ravikanth 2013), we list 10 rules regarding in-text citations. Some are correct and some are incorrect. Using the *JOC* excerpt for guidance, which rules are correct for *JOC*? There is more than one correct answer. *(Answer: 2, 3, 5, 6, 10)*

JOC excerpt (from the Introduction)

Among the numerous classes of highly fluorescent dyes, 4,4-difluoro-4-bora-3a,4a–diaza-s-indacene (BODIPY) is known to be a versatile and robust fluorophore due to its novel characteristic features and numerous useful applications. The novel features of BODIPY include robustness against light and chemicals, relatively high molar absorption coefficients and fluorescence quantum yields, negligible triplet formation, narrow emission bandwidths with high peak intensities, good solubility, resistance toward self-aggregation in solution,[1] excitation/emission wavelengths in the visible spectral region (>500 nm), and fluorescence lifetimes in the nanosecond range.[2] BODIPY dyes have been shown to be promising for a variety of applications including use as biological labels,[1,3] electroluminescent devices, tunable laser dyes,[4] potential candidates for solid-state solar concentrators,[5] fluorescent switches[6] and fluorophores in sensors, and potential photosensitizers in photodynamic therapy of cancer.[1,7] Moreover, the spectroscopic and photophysical properties of BODIPYs can be fine-tuned by attachment of ancillary residues at the appropriate positions of the BODIPY core[8] by carrying out various synthetic reactions on BODIPYs. The various synthetic strategies available for the modification of the BODIPY core are electrophilic substitution,[9] condensation reactions,[10] substitution of the fluorine atoms,[11] direct substitution of the hydrogen atoms,[12] and transition-metal catalyzed reactions through the use of halogenated systems.[13–17]

(continued)

Which of the following rules are correct? There is more than one correct answer.

____1. Citations are placed only at the end of a sentence.
____2. Citations can be placed in a sentence.
____3. Citations are placed after commas, not before.
____4. At the end of the sentence, citations are placed before the period.
____5. A work should be cited each time it is referenced, not just the first time.
____6. Two citations that are not sequential are separated by a comma.
____7. The authors' names must be included in the sentence that cites their work.
____8. Only one work should be cited in a sentence.
____9. Direct quotes (where an author is cited word-for-word rather than paraphrased) are common in chemistry writing.
____10. Citations are numbered in numerical order (1, 2, 3, …).

Example A11: Use of et al.
Although most citations omit the names of the authors (for conciseness), authors' names are occasionally included. In such instances, et al. (meaning "and others") is used if the cited work has at least three authors. For one or two authors, the last names of the authors are written out. Consider the following examples (adapted from Wong and Wong 2007):

> Inoue et al.[3] achieved *anti*- and *syn*-aldol products of carboxylic esters using combinations of a boron triflate and an amine.
>
> Ohkouchi et al.[17] have shown that the silver(I) carboxylate-BINAP catalyst coordinated to the nucleophile in Mukaiyama aldol reactions; the activated complex then attacked the aldehyde to afford the aldol adduct.
>
> Solid-state characterization of a trichlorotitanium aldolate has been reported by Cozzi and Floriani.[13]

Using the sentences above for guidance, correct the following citations if necessary. Copy and paste the underlined passage into the box (correct or incorrect), then edit the citation if necessary. (*Correct answers are shown in italics.*)

(1) <u>Rurack, Kollmannsberger, and Daub</u>[20] extended pyrroles from 2-formyl pyrroles using Wittig conditions.

Rurack et al.[20] synthesized

(continued)

(2) Wong and Thurman[4] ab initio calculations to investigate the mechanism of the metal chloride-promoted Mukaiyama aldol reaction between trihydrosilyl enol ether and formaldehyde.

Wong and Thurman[4] employed (correct as is)

(3) When Yanai, Yoshino, Takahashi et al.[15] used $Tf_2CHCH_2CHTf_2$, the Mukaiyama aldol reaction of R-substituted cyclohexanones with 2-silyloxyfurans gave the aldol products in excellent yield without loss of diastereoselectivity.

When Yanai et al.[15] used

(4) In particular, Mühlthau et al.[11] have reported a highly diastereoselective Friedel–Crafts alkylation of 1-arylalkanoles via the formation of chiral benzylic carbocations.

Mühlthau et al.[11] have reported

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