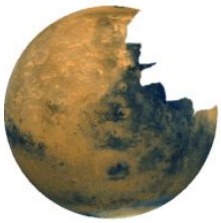

astrobites
THE ASTRO-PH READER'S DIGEST

Astrobites in the Classroom Workshop

Sample Lesson Plans

Supported by the AAS
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AAS 231
January 2018

This packet includes three different types of sample lesson plans that integrate content and principles from Astrobites. Each lesson plan includes step by step instructions, suggestions for adapting the lesson to different class levels across the undergraduate and graduate spectrum, sample student handouts, and a grading rubric.

Visit http://astrobites.org/ for more information about Astrobites.

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This document is available in electronic form here: goo.gl/Q8jAHi
Based on an American Journal of Physics article available here: goo.gl/cAYjqH

This workshop funded by an AAS Education & Professional Development Mini-Grant.

Lesson Plan Type 1:
Periodic Astrobites Reading Assignments

Activity Outline

Students are asked to read an assigned Astrobites article and respond to guided questions that test reading comprehension and conceptual understanding. Students are graded on their responses to the questions, which can be gathered electronically through an online form. The questions are discussed in class to promote greater understanding.

This assignment can be adapted to any course level, including introductory level classes, and is reproducible. It could be done, for example, once per week or once per class period. These readings could be used as pre-lab assignments to connect lab activities to current research, as University of Maryland instructors have done.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading, including identifying connections to course curriculum or previous readings.

- **Conceptual understanding:** Students will strengthen their understanding of course curriculum by integrating information from new readings. They will demonstrate learnings from course content or previous readings by answering guided questions.

- **Literature familiarity:** Over several such assignments, students will develop familiarity with the astronomical literature. They will form an understanding of active disciplines of research and the ability to draw connections to the course curriculum or their own research interests.

B. Instructions

1. **Instructor selects an Astrobites article and formulates 2–4 guided questions.**

   Guided questions are intended to encourage mindful student reading of the assigned article and check student understanding of major concepts. We suggest questions that can be answered by straightforward application of concepts learned in previous lessons to newly-encountered subject matter from the reading, for example applying an understanding of the Doppler effect to describe the observational effect of the orbit of Alpha Centauri on its radial velocity. Questions typically either would not include

calculations, or they would focus only on symbolic manipulation or scaling relations.

2. **Instructor distributes Astrobites article to students along with guided questions in the form of a fillable Google Form.**

   Students submit responses to guided questions. Below we provide a sample Google Form that can be used to gather student responses to questions electronically.

3. **(Optional or extra credit) Students leave a comment on the assigned Astrobite with a question or thought about the article.**

   Astrobites authors track article comments, so students will usually receive a timely response to their comment. All Astrobites authors are practicing scientists (graduate students or recent grads) and so can provide additional subject matter insight or answer questions about the practice of science in their reply.

4. **(Optional or extra credit) Students write a brief essay contrasting the original journal paper to an institutional press release about the same paper.**

   The instructor selects an Astrobites article about a paper that had an associated press release. Students are asked to compare and contrast the scientific findings emphasized in the paper versus the press release, identify the scientific concepts that were explained for non-technical audiences in the press release, and comment on how the uncertainty and significance of the work were presented in the press release. Instructors can use the Astrobite as a resource to provide additional context and perspective for this assignment.

5. **Instructor evaluates responses and scores according to rubric below.**

6. **Instructor reviews guided questions during next class period.**

   One or more students are asked to provide their answers to each question. Instructor guides student discussion towards accurate understanding, as appropriate.

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
  Instructors should:
  - Carefully select articles that are closely related to the current subject matter at hand and that do not introduce new concepts that have not yet been covered in the course.
  - Assign readings less frequently and with several days before due date to promote careful reading.

- Preferentially pose questions that test understanding of course content more so than full reading comprehension.
- Focus on questions with straightforward interpretations and use open-ended questions less frequently.

- **Upper level undergraduate:**
  Instructors should:
  - Give assignments more frequently to encourage students to develop strong familiarity with the literature.
  - Try collecting feedback from students with questions like, “What sentence from the article did you not have enough information to understand?” or “What subject from the article would you like to learn more about in class?” Student responses can be reviewed before the next lesson and used to inform instruction.
  - Reinforce conceptual understanding of physical formulae from the course by using questions that ask students to develop order-of-magnitude arguments that demonstrate consistency with calculations from the paper.
  - Ask students to “update” a relevant section of their textbook by adding information from the current research article, using a short written response to the questionnaire or a brief in-class discussion.
  - Use the questionnaire to ask students to annotate a figure from the paper or a related diagram with a caption and/or axes labels using their own words to demonstrate comprehension.

- **Graduate level:**
  Instructors should:
  - Preferentially assign recent articles covering new results to challenge students to draw connections to current topics without being pulled off course by less relevant content.
  - Preferentially pose questions that invite students to extend beyond the subject matter of the article at hand or apply their understanding to personal research experience.
  - Build student understanding of physical formulae from the course curriculum by posing questions that call on students to reproduce calculations from the paper.
  - Use open-ended question formats to explore student perspectives.
  - Occasionally ask students to go beyond the Astrobites summary by asking questions that direct them towards the source paper.
  - Use this assignment as a launching point to a method 2 or 3 assignment in the same topic area.

D. Materials

Grading Rubric

Score assigned per question:

Score	Completeness	Content
0	Questions not answered or partially answered	Student does not address all questions or demonstrates partial or no understanding of underlying concepts.
1	Question completely or mostly answered	Student demonstrates some understanding of concepts underlying guided questions but may have major factual inaccuracies or logical inconsistency.
2	Question completely answered, with 1–3 sentences	Student demonstrates strong overall understanding of concepts underlying guided questions, though may yet have some factual inaccuracies or logical inconsistency.

Student Handout

See sample Google Form with example questions for distribution to students here: https://goo.gl/j1oMxV

Lesson Plan Type 2:
Student Research Project

Activity Outline

Students are asked to select a research topic and then identify and read several Astrobites articles related to that topic. Students then prepare a written paper or class presentation based on this independent research. In advanced courses, students can be asked to read the source material (original paper), so that the Astrobites article serves as scaffolding to introduce them to that material. A set of optional research tasks asks students to construct an annotated bibliography of their reading and/or a concept graph that links topics from the course curriculum to the modern research. While we suggest modifications to make use of this method at introductory undergraduate through graduate levels, this method is perhaps best suited to the upper-level undergraduate course.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading, including identifying connections to the course curriculum or previous readings.

- **Synthesis:** Students will gain the ability to synthesize concepts and information from a variety of sources into an original work in a presentation or paper format.

- **Interpreting data:** Students will gain the ability to extract information from data visualizations and statistical graphics. Students integrate figures from published research into their projects and use them to support their descriptions or arguments.

B. Instructions

1. **Students select a research topic.**

   The students can select their topic from an instructor-provided list of topics specific to the course curriculum, from the most popular tagged topics within our daily paper summaries category, or from elsewhere.

2. **Students identify 2–4 Astrobites articles related to the topic.**

   (Optional) Utilize the student research to construct an annotated bibliography for the course. Instructors can use a Google Form like the example below to collect a response from each student to document their research on each Astrobite. After the initial

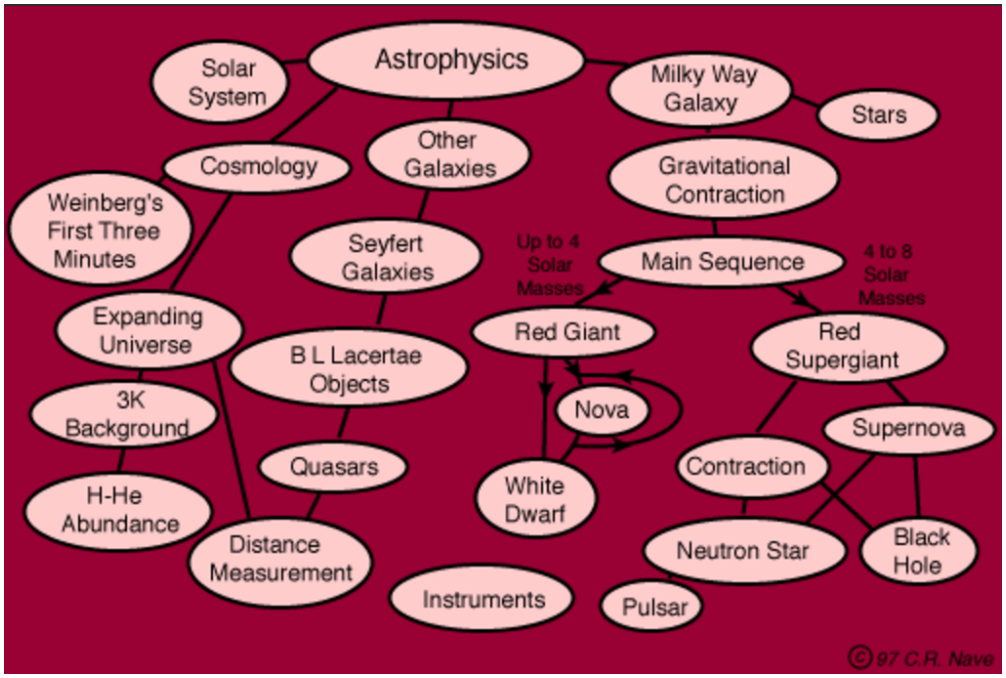
research assignment (Step 2), instructors can then make the filled responses available to all students as a resource to help with the remainder of the project (Steps 3+).

Example Google Form: https://goo.gl/kYTQbT

Example filled responses: https://goo.gl/oTj9cc

3. **(Optional or extra credit) Ask students to construct a concept graph.**

Students write down a list of significant concepts from the curriculums that are prerequisite to understanding the present topic. The list of concepts could be culled, for example, from the table of concepts of their course text. The student then constructs a dependency graph showing how the topics link together. Examples of similar concept graphs are provided by HyperPhysics:



https://goo.gl/V004FK

4. **(Optional or extra credit) Ask students to construct a research timeline.**

Students consult the introductions of the source papers associated with their Astrobites selections. They cross-reference the citations in the sources to reconstruct a sequence of major milestones in research related to their topic.

The Astrophysical Data System (ADS) Bumblebee Author Network tool can also help students. Students can search for a subject, sort in descending order by citation, and then view the author network to get a view of major collaborations and how their contributions impacted the field over time, as in this example: https://goo.gl/8cZSY9

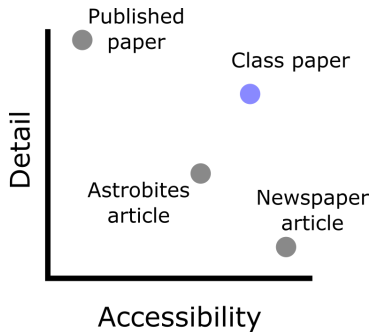
5. **Students complete their project assignment.**

    a. **Student presentation path:** Students are asked to prepare a brief (5–10 min) group or individual presentation about the topic they selected, to deliver in class.

    Instructors encourage students to build skills in interpreting data visualizations by asking them to include and explain one or more figures from the Astrobites source papers in their presentation.

    b. **Student paper path:** Students are asked to prepare a short (4–10 pages) written paper related to the topic they selected.

    The instructor should give guidance as to how the paper should compare to a typical Astrobite or to the published source papers in terms of accessibility (how easy it should be for, for example, someone who has not taken your course to understand) and level of detail. A diagram like the one below can be helpful:



6. **Instructor reviews responses and scores according to rubric below.**

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
    - Since Astrobites articles generally link to several past articles to establish foundational concepts, instructors should encourage students to make use of those links if they have trouble constructing a bibliography through their own searches.
    - For students who may major in or have experience in other disciplines, instructors should ask them to compare the process of astronomical research to

those other fields. What aspects of the research process in astronomy are familiar, or seem surprising?

- **Upper level undergraduate:**
  - Challenge students to dive into the original source articles for each Astrobite. Instructors can use the “annotated bibliography” form to ask students to provide additional information extracted from the source article.

- **Graduate level:**
  - Use the “annotated bibliography” form to invite students to augment the reading from Astrobites with their own knowledge. Instructors can append a question to the form that prompts students to provide additional context that they feel would add understanding to what was presented in the Astrobite.

  - Ask students to criticize the body of research they have investigated. Are there lines of evidence that are more or less rigorous? Are there alternative theories that deserve more or less credence? What are the caveats to the observational, statistical, or theoretical approaches used in the field?

D. Materials

Grading Rubric

(total points: 30)

Score	Scope	Accuracy	Communication
0–3	Total number of sources consulted or project length significantly less than assigned.	Significant factual or conceptual errors presented. An expert in the selected topic would not have agreed with fundamental points made.	Paper / presentation incomplete, not comprehensible, and/or not aligned to course standards. A non-expert would not have learned from it.
4–7	Student integrated fewer sources than expected or did not cover as many aspects of the selected topic as expected.	An expert in the topic may have pointed out a few, minor factual or conceptual errors presented. Student presentation would not have significantly enhanced their peers’ understanding of the selected topic.	Paper / presentation was largely informative for peers in the course, but had some flaws in explanation or depth that inhibited understanding. A non-expert would have learned about some elements of the selected topic.
8–10	Student consulted and integrated at least the expected number of Astrobites articles and other sources. Student	No factual or conceptual errors presented. Student presentation aided their peers’ understanding of the selected	Paper / presentation was strongly coherent, informative, and clearly understood by peers in the course. A non-expert would have

	comprehensively discussed aspects of the selected topic at the level expected for the course.	topic.	learned substantially from it.

Student Handout

Example Google Form for collaborative bibliography (same as above): https://goo.gl/kYTQbT

Lesson Plan Type 3:
Student Writing Assignment

Activity Outline

In this project, designed with upper-level undergraduate or graduate classes in mind, students write their own Astrobites-like article to synthesize and summarize the content of one or more research papers. As the outcome is a set of brief written summaries based on substantial amounts of student research, this assignment helps to build research, literature understanding, and communication skills without subjecting instructors to a high burden in reading long pieces of student work. A sample handout provides guidance as to the form, content, and style of the written pieces.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading, including identifying connections to course curriculum or previous readings.
- **Composition:** Students will gain the ability to synthesize concepts and information from a variety of sources into an original written work.
- **Communication:** Students will gain the ability to convey ideas and knowledge to an audience that may be different in age, training, perspective, or experience than the student.
- **Interpreting data:** Students will gain the ability to extract information from data visualizations and statistical graphics.

B. Instructions

1. **Introductory reading assignment.**

   Students read an introductory source article and associated Astrobite, following, e.g., the approach of method 1. Instructors should select an article with a topic and summarization that they deem appropriate for the course. This serves to introduce students to the summarization style and the level of outside context they should add as authors.

2. **Students select a source article.**

   The instructor can provide a list of research papers tailored to the course curriculum, or

students can be ask to identify their own. Especially for lower-level courses, articles that have previously been the subject of Astrobites posts can be a good fit (see 'Adapting' below).

Students should be given constraints on the source material, such as articles appearing in a certain journal, or on the preprint server the arXiv. Students should submit their selection to the instructor to verify that it is appropriate before they begin drafting their piece

3. **Students write a first draft of their article.**

   See "project description" handout below for an example writing prompt and see the "article template" for an example template.

   The most important choice for the instructor is what audience to direct students to write for. A clear focus in audience should set strong expectations for the content level of the piece. Astrobites articles are written for an undergraduate level audience of physics or astronomy majors. Instructors might ask students to target an audience of their peers or perhaps at one or two levels below their current status.

   As in this example, we recommend setting a fairly narrow word count range and directing students to adhere to it, as this project is meant to help students build experience writing in a concise and clear format. We also recommend asking students to include 1–2 figures from the source paper in their article with captions written in their own words. This will strengthen their ability to understand and convey the significance of graphics and data visualizations in scientific writing.

4. **Students exchange drafts for peer editing.**

   Just as we have all Astrobites articles proofread for content and style by another graduate student in our collaboration, we recommend that students provide peer feedback on their classmates' writing Instructors can provide the peer editing rubric linked below to guide student feedback.

   If possible, instructors are encouraged to hold peer review sessions in class, so instructors can provide oversight and help ensure uniformly thoughtful and constructive feedback. The feedback rubric provided asks peers to force rank areas for improvement and answer guiding questions to encourage constructive critical feedback.

5. **Students submit final drafts of their article.**

6. **Instructor reviews articles and scores according to rubric below.**

7. **(Optional) Submit the article as a guest post to Astrobites.**

   If the target audience for the piece is set by the instructor at or near Astrobites' undergraduate level target, then interested students are welcome to submit their articles to Astrobites for possible publication as a guest post. Students are asked to follow the instructions on our website to submit and clearly label the submission as one associated with a class, mentioning the university, instructor, and course.

   Submissions on recent articles are preferred. Submissions in html or a word processing format (Google Doc, MS Word, OpenDocument) are preferred.

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
  - In place of writing an article, consider having students read and summarize in their own words articles that already have previously written summaries. Students at this level will not likely be able to read and summarize articles directly from the scientific literature on their own. Valuable resources include past Astrobites subject articles or the historical articles from Marcia Bartusiak's Archives of the Universe.
  - Add some structure to the assignment by asking students to focus on a very specific aspect of the article that ties into the course curriculum, such as a particular physical law or discovery.

- **Upper level undergraduate:**
  - Consider asking students to submit their articles in a particular digital format of your choice such as a LaTeXed PDF or html to build technology skills relevant to communication and publication.

- **Graduate level:**
  - For a sense of the commitment involved, consider that the time Astrobites' own graduate students typically spend reading and summarizing an article can vary from 3 to 8 h.
  - Ask students to incorporate salient, related research such as the presentation of a recent colloquium speaker at their institution or the students' or advisors' own work. Optionally or for extra credit, the student can be invited to interview the researcher to add additional context to their writing.

D. Materials

Grading Rubric

(total points: 30)

Score	Scope	Content	Communication
0–3	Article incomplete or significantly different in length than the requirement (shorter or longer). Does not cite other articles or resources beyond the subject.	Article has significant factual inaccuracies.	Article is difficult to understand due to typographical or grammatical issues, or because it is written at a level incongruous with the target audience.
4–7	Article deviates somewhat from length requirement (shorter or longer). Occasionally cites other articles or resources beyond the subject.	Article may have minor factual inaccuracies. Article provides little additional context beyond what was explicitly mentioned in the subject.	The article would be understandable by a member of the target audience, but its value would be impaired by moderate typographical, grammatical, or content level inconsistencies.
8–10	Article in line with word count requirement. Frequently cites other articles or resources beyond the subject.	Article has no factual inaccuracies and provides significant additional context beyond that explicitly mentioned in the subject.	Article is well edited and written clearly. It would be readily understandable by a member of the target audience.

Student Handouts

- Project description: https://goo.gl/qY3qt5
- Article template: https://goo.gl/uuHYOg
- Peer editing rubric: https://goo.gl/KOSIym

Some recent sample astrobites:

- Solar system formation: https://astrobites.org/2016/11/01/modest-chaos-in-the-early-solar-system/
- Stars: https://astrobites.org/2016/11/16/settling-the-proxima-centauri-question/
- Dark matter: https://astrobites.org/2016/12/27/how-one-person-discovered-the-majority-of-the-universe-the-work-of-vera-rubin/
- Compact objects: https://astrobites.org/2016/12/23/ar-sco-the-first-white-dwarf-pulsar/
- Black holes: https://astrobites.org/2016/09/22/black_hole_vs_stars/
- Exoplanets: https://astrobites.org/2016/12/15/the-lowest-mass-planet-with-a-detected-atmosphere/
- High-*z* galaxies: https://astrobites.org/2016/11/08/the-origins-and-fate-of-the-most-distant-galaxy/