How to Get Started if You Hate to Write

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Disclaimers:

I am a science writer and technical editor, not a physicist. Don't ask me about the fractional quantum Hall effect in topological insulators.

All of my experience has been in nuclear engineering and physics. I think the ideas I present are broadly applicable to the physical sciences and engineering, but your discipline may have special constraints.

This lecture is based solely on my own opinions, and they are not necessarily shared or endorsed by the the Institute of Physics Saso Carlos or the Department of Physics of the University of Illinois. But they should be.

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One thing I've learned in physics, you have to satisfy both the theorists and the experimentalists…

…so this talk has two parts:

I. **a theory of technical writing**

II. **practical advice for putting together a scientific paper**

First step, throw out most of what you've been taught about "writing"

- Technical writing ain't Shakespeare
- Your purpose is to inform, educate, and persuade—not to entertain
- Write with concrete, quantitative nouns and strong verbs, not adjectives and adverbs
- Use the simplest word
- Write short sentences and control your modifiers

No literary flourishes or discursions

Successful science writing is

Logically constructed—think "linear"

Clearly and succinctly expressed

Precisely and simply worded

Written to inform and persuade

Written with the *reader* in mind

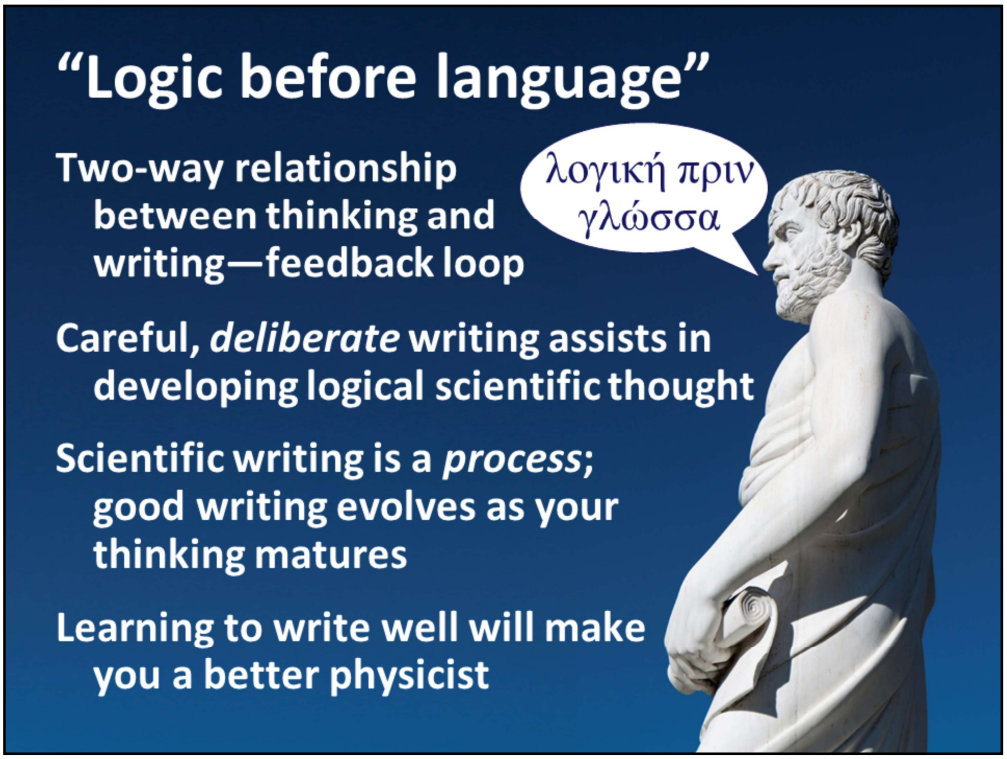
Technical writing is a *craft*, not an art

Like any other craft, you have to learn the techniques

You have to get feed-back from experts

The same skills that make you a good scientist or engineer will make you a good technical writer

- logic
- precision
- the ability to sort out what's important



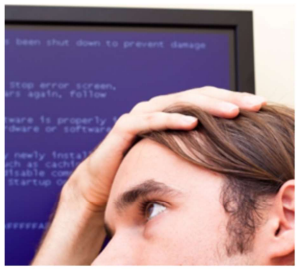
logikḯ prin glṓssa (loyeekee prin glōssuh)

Too often, scientists think of doing research and writing as discrete tasks that have little to do with one another. Today, I'd like you to think of them as a feedback loop, where progress in one informs and drives progress in the other.

From Peter Woodford: "Somehow the discipline of crystallizing a thought into a grammatical sentence with a beginning, a middle, and an end clarifies, sharpens, and delimits the thought.

Learning to write in the style described here will not only make you a better writer, it will also make you a better scientist. It will force you to see holes in your thinking, areas where you've made assumptions, places where you should add references, or data, or further analysis.

Novice writers use the "core dump" method —inefficient and produces poor results



Always start from a plan—always!

1. Promotes thinking
2. Easiest way to get started if you don't like to write
3. Gives you control over length and focus
4. Increases the logical persuasiveness* and coherence of your final paper (or talk)

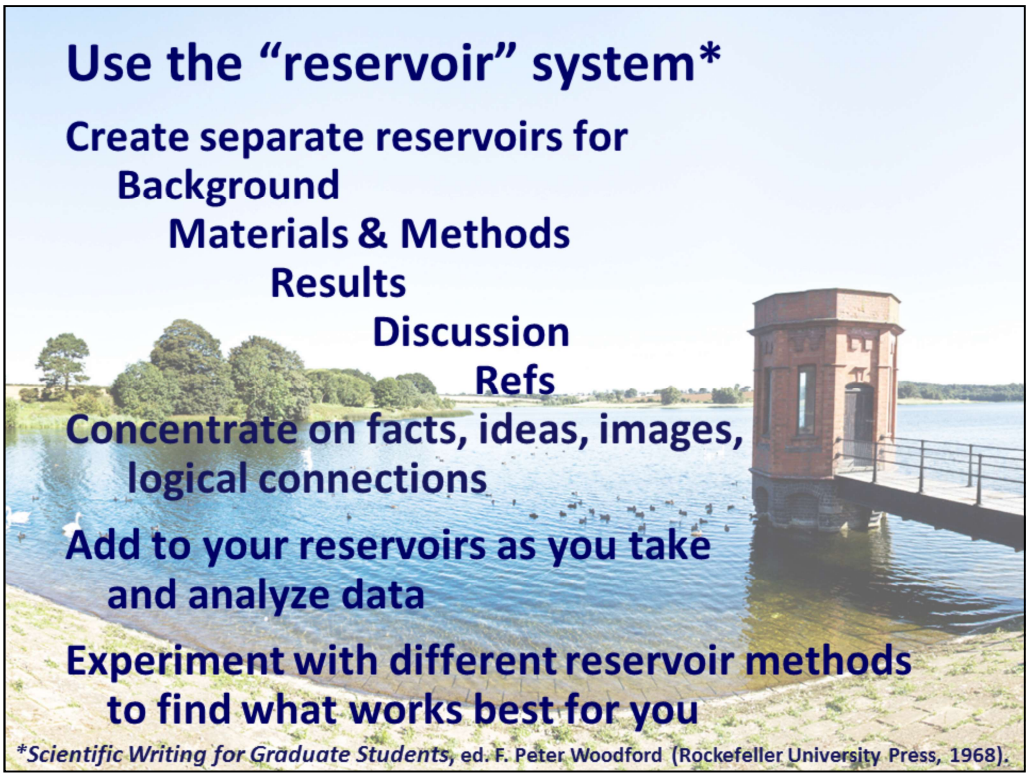
*"Persuasion in Technical Communications," http://people.physics.illinois.edu/Celia/Persuasion.pdf

Novice writers often just word-spew and then try to go back and "fix" what they've written. It's inefficient, time-consuming, and usually produces bad results.

As you are thinking about your paper, consider four questions:

1. What is my *purpose* in writing this document? What's my ultimate goal?
2. Who is going to read it? What do they already know, and what am I going to have to explain? What do *they* want to get out of this paper?
3. What *one thing* do I want the reader to remember? What's the "take-away" message?
4. What are my space/time/page constraints?

At this stage of your writing project, think about what you want to convey to your audience. What are the important points that you want them to understand and remember?



The idea of creating separate holding pens for various parts of a technical document was first articulated, as far as I know, by F. Peter Woodford in *Scientific Writing for Graduate Students: A CBE Manual* (Rockefeller University Press, New York, 1968). Although targeted to graduate students in the life sciences and dated in language (not ***all*** scientists are men!), the fundamentals of Woodford's approach remain sound.

Vernon Booth, a major god in my pantheon (*Communicating in Science: Writing a scientific paper and speaking at scientific meetings*, 2nd ed. [Cambridge University Press, Cambridge, 1993]) also recommends the use of writing reservoirs.

Fill your reservoirs thoughtfully

Is the item really necessary?

To what reservoir does it logically belong?

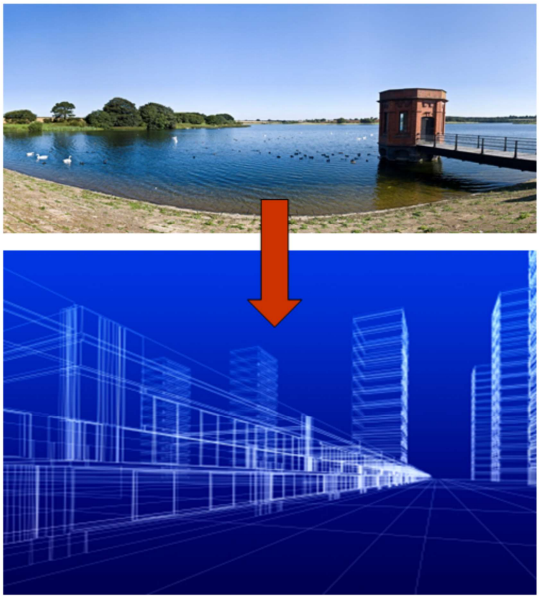
Content for reservoirs:

- Facts, observations, data
- Figures and captions
- Tables
- Analogies
- Ideas and speculations
- Unanswered questions
- Key words
- Felicitous phrases

At this stage, don't worry too much about niceties of language—concentrate on including essentials, eliminating superfluities, and getting things sorted into the right categories.

Now you're ready to start building a coherent narrative

In the next steps, we'll take the content of our reservoirs and make a plan to guide the building of our paper



RULE #1: Never write *anything* without first writing a synopsis and an outline!

"If you don't know where you are going, you might wind up someplace else."

—Yogi Berra

An outline is a tool that enables you to look systematically at how a paper or presentation is organized. Learning to write from an outline is one of the easiest ways to (1) get started and (2) improve the content and coherence of your scientific writing.

Today, we'll look at how to use outlines to get started on any writing project.

Many of the ideas about full-sentence outlining are taken from a course given by Ohio Eminent Scholar and Professor of Physics at The Ohio State University, John W. Wilkins (who is also a Physics Illinois alumnus). His trenchant thinking and incisive writing on communicating in physics are gratefully acknowledged.

For more of Professor Wilkins' excellent advice on technical writing, see his "Brief Guide to Writing and Speaking": http://www.physics.ohio-state.edu/~wilkins/writing/Handouts/brief_writ_speak.html.

Start out with a five-sentence synopsis

What was the goal of your work?

How does it fit into the context of prior work?

What method(s) did you use?

What were your principal results?

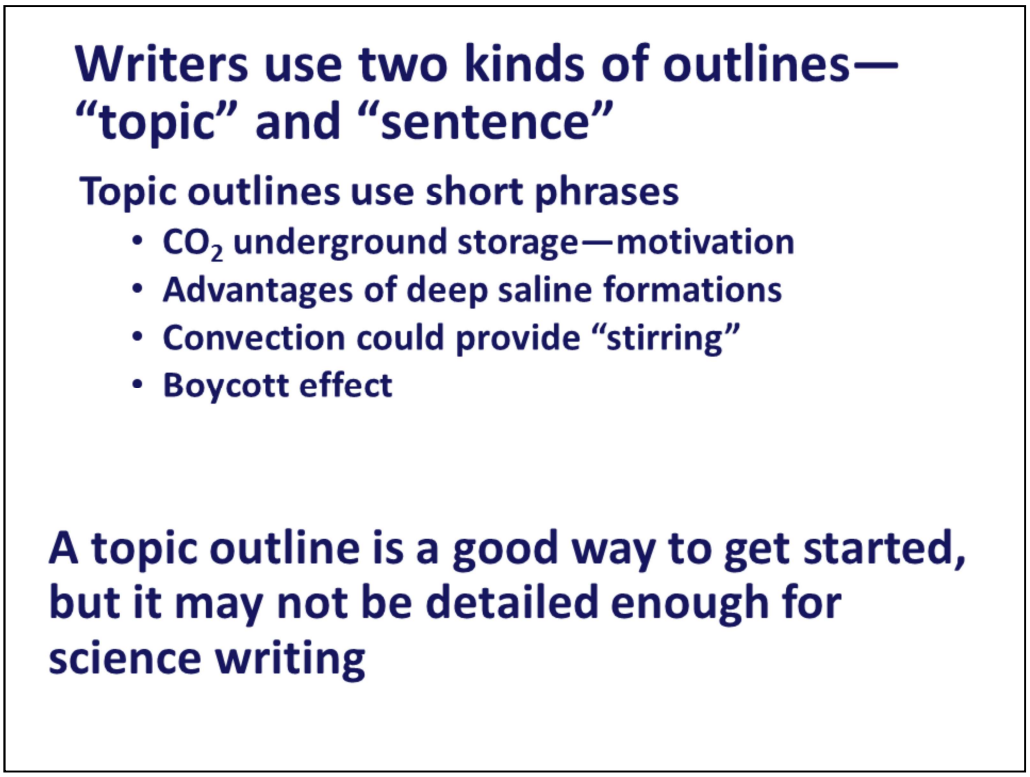
What do you think they mean?

Answer each question in one coherent sentence

Use the synopsis as the starting point for an outline

Writing a synopsis is a good way to get started because it defines the content and scope of your paper.

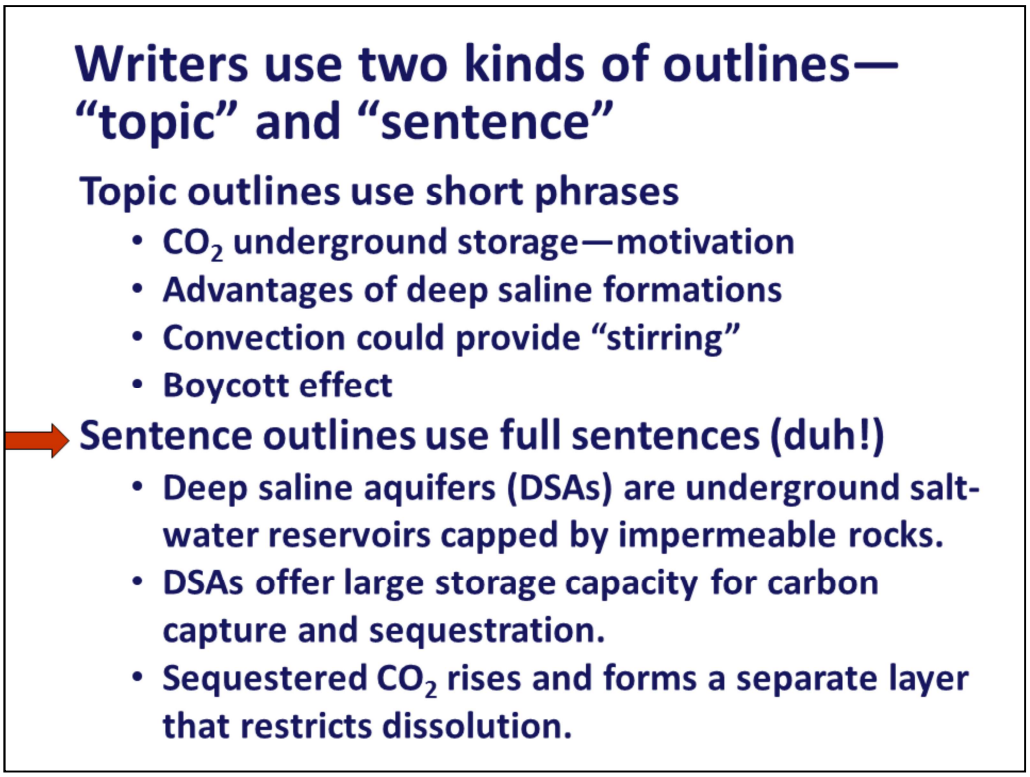
Think of the synopsis as the skeleton—it gives the whole paper its shape and supports your evidence and arguments.



A topic outline consists of short phrases. Here's an example of a topic outline for a paper on carbon sequestration in deep saline formations.

A topic outline may be best for organizing a number of issues or ideas that could be presented in a several different ways, where the order of presentation is not important. Unfortunately, that is not typically the case for science papers.

Topic outlines are fast and easy to write. You might find it helpful to sketch out a topic outline first and then expand it into a full-sentence outline.



Today we'll look at the sentence outline, which is better suited for papers (and talks) that require complex information to be presented in strict logical order.

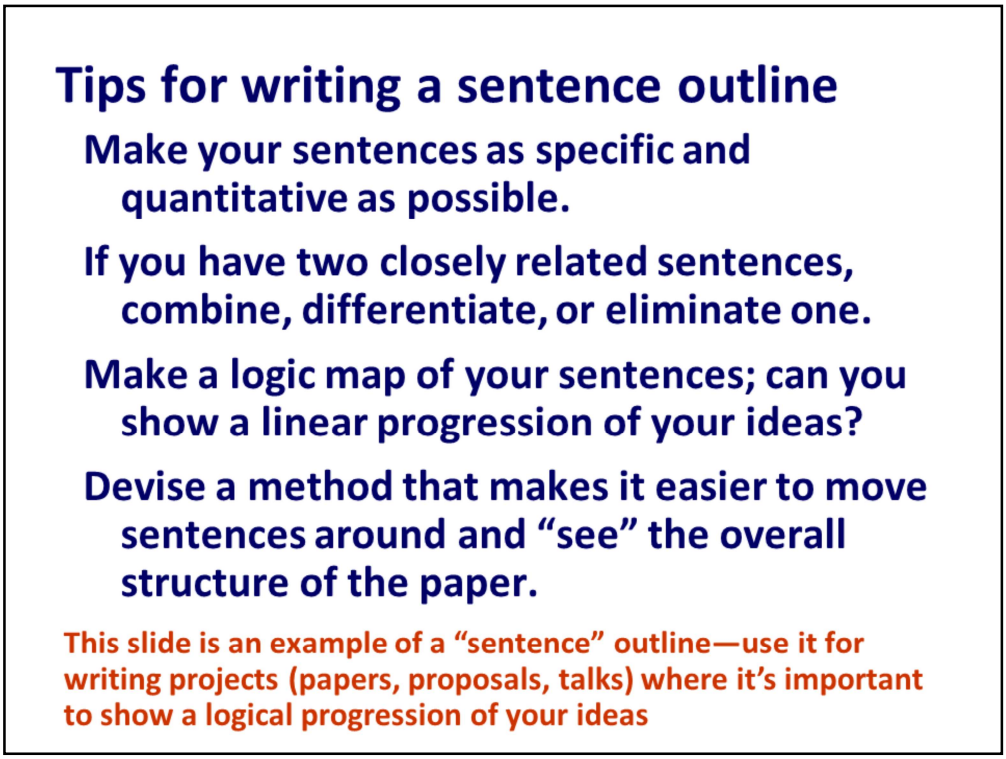
Practice full-sentence outlining

Improved clarity
Improved logical argument
Improved cohesiveness; better transitions
Improved conciseness
Improved control of length
Improved writing efficiency
Improved reader experience

This slide is an example of a "topic" outline—the order that the points are presented in doesn't really matter

Writing a sentence outline will help you as a writer in a variety of ways:

- Your writing will be clearer and more direct. It's unlikely that you'll write a cogent paragraph until you can write a sentence that plainly articulates the point of that paragraph.
- Your arguments will be stronger. A sentence outline shows you the narrative flow of the paper. Are your ideas arranged in the most logical, persuasive way to lead the reader to the conclusions you want him to reach? It's much easier to move sentences around as you are planning a paper than it is whole paragraphs.
- Your paper will be more cohesive, because you'll be more aware of where transitions are needed to move the reader from one idea to the next.
- Your writing will be more concise. A sentence outline will help you spot superfluous material that stands in the way of a straightforward narrative.
- You will get a better idea of the size and scope of your final paper. The length of proposals, journal articles, and conference papers is usually strictly limited. A sentence outline makes it easier to estimate what the final length of your document will be and allows you to make any needed adjustments earlier in the writing process. It's agonizing to make major cuts after you've already gotten something written, and you'll avoid the temptation of leaving digressions in your paper because of pride of authorship.
- You will ultimately save time. The investment in planning and getting organized now will pay off in an easier-to-write, coherent, clear final document.
- Your colleagues will eagerly look forward to hearing your next talk or reading your next paper. Your reviewers will expedite your publications. Funders will shower you with $$$. (Okay, maybe not #3...).



Make your sentences as specific as possible. The purpose of the sentence outline is to help you spot missing or superfluous material. If your sentences are vague and generalized, you'll lose the main advantage of sentence outlining.

If you have two sentences that say about the same thing, eliminate one of them, combine them, or differentiate them.

Ideally in science writing, the narrative should flow logically and incrementally from Point A to Point B to Point C to the conclusions. If your outline does not reveal a logical progression of ideas, move things around until it does.

A word processing document that displays only part of your outline at a time may not be the best way to get an overall look at your paper. Experiment with other methods—index cards dealt out on a big table, Post-It notes stuck on a wall—use your imagination.

Today, we're going to write a paper about the special mirrors built for NASA's Solar Dynamics Observatory

Courtesy NASA

Start by writing down your main points, based on your synopsis*

- The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
- Mirrors image Sun at all seven euv wavelengths.
- The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
- One component of SDO is the AIA, a suite of four telescopes.
- The Sun is the source of all space weather, but its physical processes are poorly understood.

*Write a complete sentence for each point, in any order now—we'll arrange the points logically in the next step

Start by writing down the main points you want to make in the paper. Don't worry about details—just concentrate on the main ideas now.

Next, arrange the points so they provide a logical narrative arc*

*Show a linear progression from premise to conclusions

*No digressions or discursive material

Next, arrange the points in a logical order so they provide a coherent storyline.

Think of this step as creating a map to guide your reader through your talk, paper, or proposal.

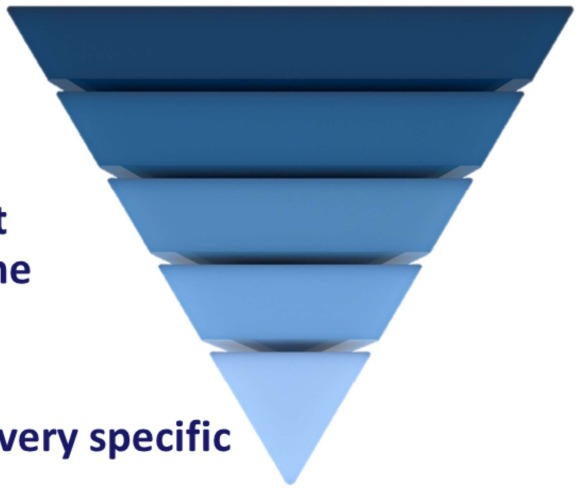
Each one of these points is going to be a signpost along the journey.

A common paradigm in science writing is the "inverted pyramid"

Start broad and general

Add details that define and refine your message

Finish with the very specific main point



Next, arrange the points so they provide a logical narrative

- The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
- Mirrors image Sun at all seven euv wavelengths.
- The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
- One component of SDO is the AIA, a suite of four telescopes.
- The Sun is the source of all space weather, but its physical processes are poorly understood.

Using the inverted-pyramid structure as a guide, we next arrange the points we want to make in a coherent, logical order.

Next, arrange the points so they provide a logical narrative

- The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
- Mirrors image Sun at all seven euv wavelengths.
- The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
- One component of SDO is the AIA, a suite of four telescopes.

1. The Sun is the source of all space weather, but its physical processes are poorly understood.

Start with the “big picture” statement.

Next, arrange the points so they provide a logical narrative

- The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
- Mirrors image Sun at all seven euv wavelengths.

2. The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.

- One component of SDO is the AIA, a suite of four telescopes.

1. The Sun is the source of all space weather, but its physical processes are poorly understood.

Next, arrange the points so they provide a logical narrative

- The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
- Mirrors image Sun at all seven euv wavelengths.

2. The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
3. One component of SDO is the AIA, a suite of four telescopes.
1. The Sun is the source of all space weather, but its physical processes are poorly understood.

Next, arrange the points so they provide a logical narrative

4. The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
   - Mirrors image Sun at all seven euv wavelengths.
2. The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
3. One component of SDO is the AIA, a suite of four telescopes.
1. The Sun is the source of all space weather, but its physical processes are poorly understood.

Next, arrange the points so they provide a logical narrative

4. The atmospheric imaging assembly (AIA) is composed of highly reflective multi-layer mirrors.
5. Mirrors image Sun at all seven euv wavelengths.
2. The NASA Solar Dynamics Observatory (SDO) was launched in 2010 to study the solar corona.
3. One component of SDO is the AIA, a suite of four telescopes.
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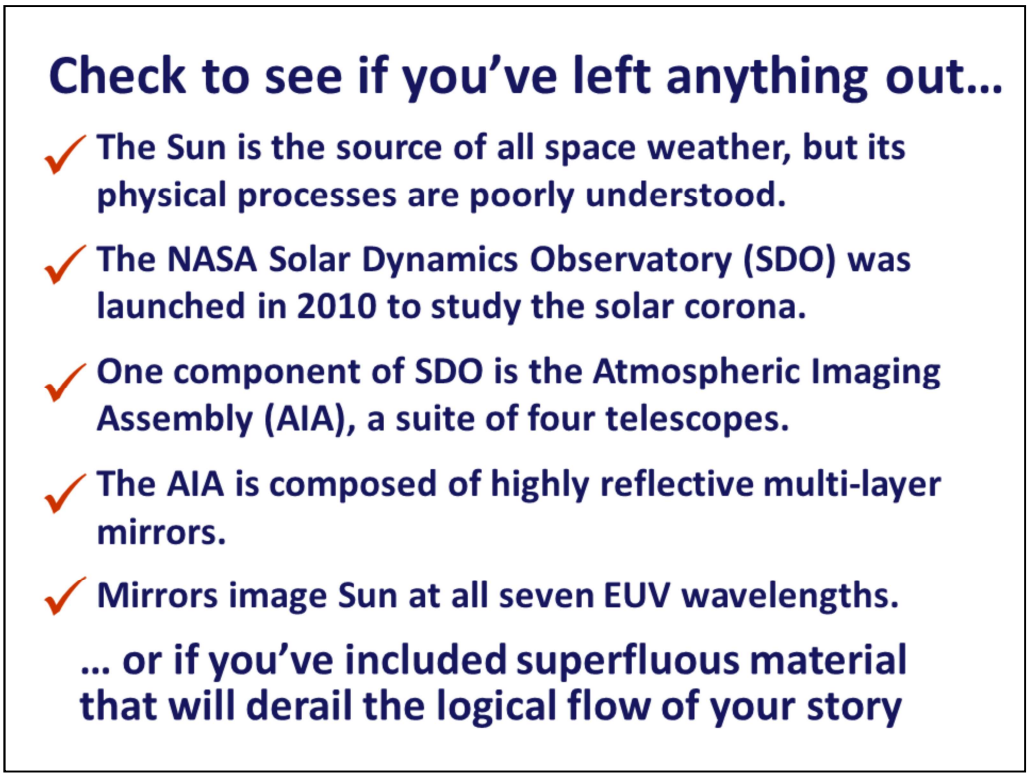


Check to see if you've left anything out, or if you have superfluous statements that lead the reader off the trail that you've laid out for him or her to follow.

Make adjustments (additions or deletions) now. It's much easier to write from a structure than to try to go back after you've already written something and try to impose a logical order on it.

It's also much less painful to cut things now than after you've struggled to get them written and are tempted to leave in superfluous information out of pride of authorship.

NOW you're ready to start writing

Each sentence in your outline becomes the "topic" sentence for a paragraph

The Sun is the source of all space weather, but its physical processes are poorly understood.

<We put a paragraph here>

The Solar Dynamics Observatory was launched by NASA in 2010 to study the solar corona.

Your main points—your topic sentences—provide a framework for your narrative.

The purpose of ***every additional word*** that you put in a paragraph should be to support and explain the topic statement and move the reader logically and incrementally to the next topic statement.

Celia's foolproof, four-step SEES* method to crank out science writing:

1. Put the topic sentence first
2. Explain it
3. Give an example of it
4. Summarize it in a way that leads logically to the next topic sentence

*State → Expand / Explain → Exemplify / Evidence → Summarize

Tip: Use the same construction paradigm for paragraphs, subsections, and sections of your paper

One of the key advantages of this method is its scalability—you can use it for short papers, theses, talks, posters—for any audience.

Do the math: one topic sentence = one paragraph
one figure = one paragraph
four paragraphs = one page

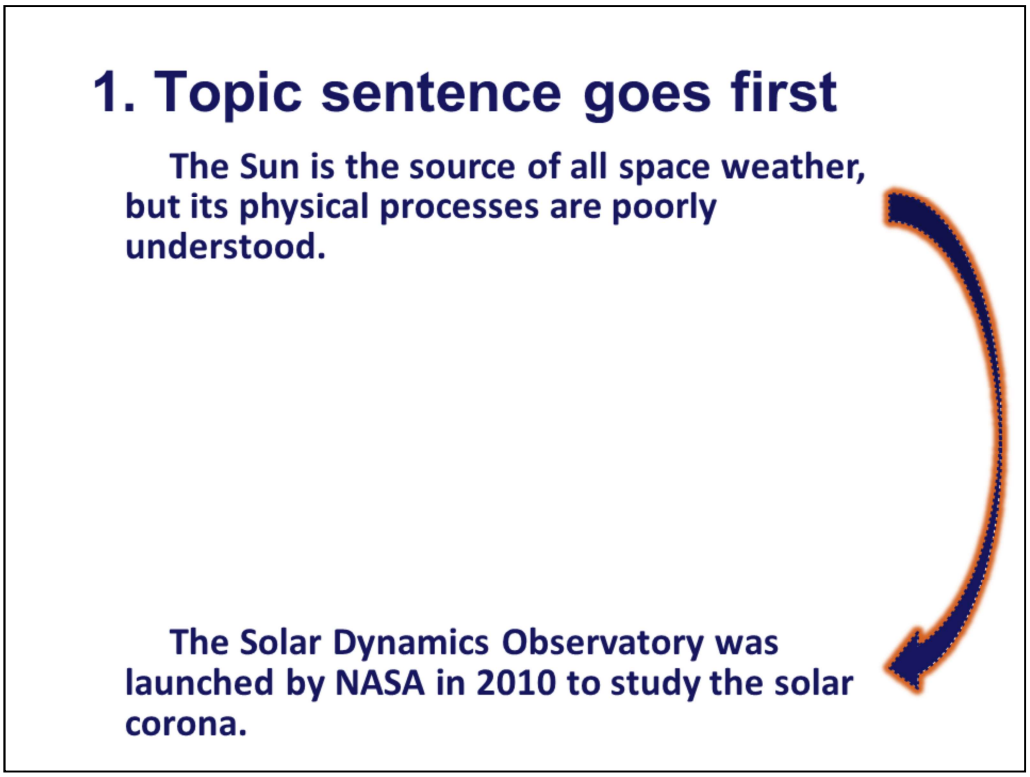
Suppose you're writing a paper for *Science* and you have 21 sentences and three figures. You know right NOW, before you write another word, that you've got too much material for one paper. Make your adjustments now—it's much less painful than trying to cut later.

Use the formula to create logical, coherent paragraphs.

So let's go back to our first two topic sentences from our outline:

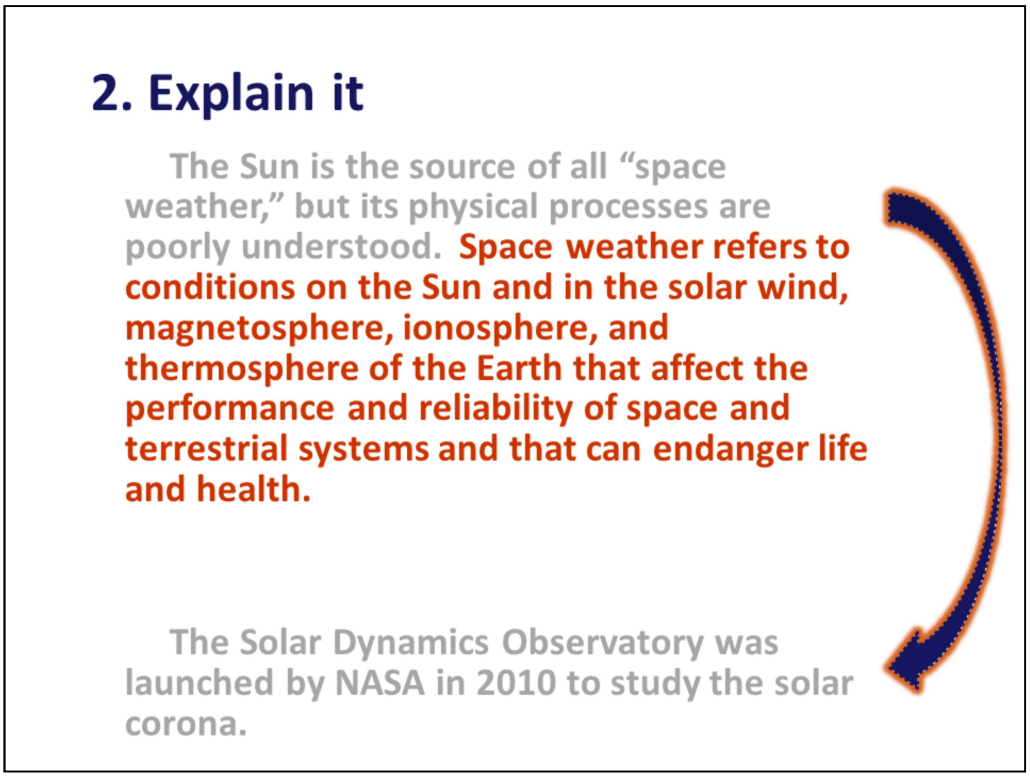
"The Sun is the source of all space weather…"
and
"The Solar Dynamics Observatory was launched by NASA in 2010…"

and run them through the paragraph cranker-outer...



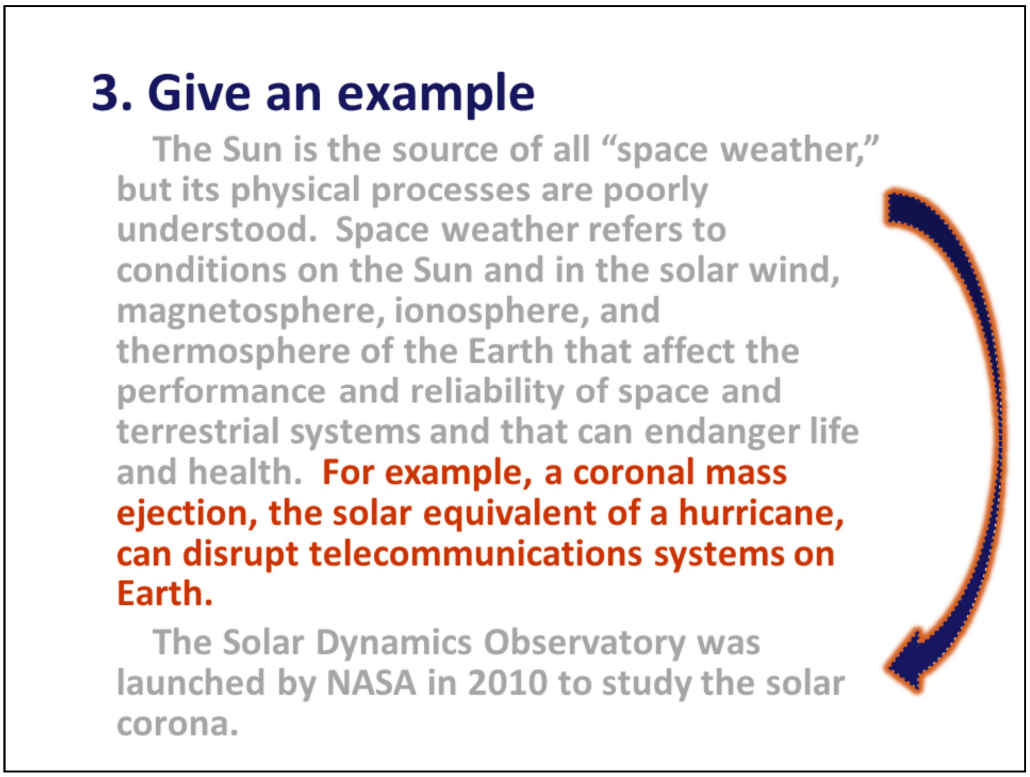
In science writing, the topic sentence is almost always the first sentence of the paragraph. While literary writing might put the topic sentence last, to build suspense, or in the middle, to redirect a reader's attention, put the topic sentence first in your paragraphs to emphasize your important points and reinforce the logical structure of your arguments.

Readers pay the most attention at the beginning of chunks of text. Exploit this natural human tendency by putting your topic sentences in the places where people are most likely to recognize and remember them—as the first sentence of each new paragraph.



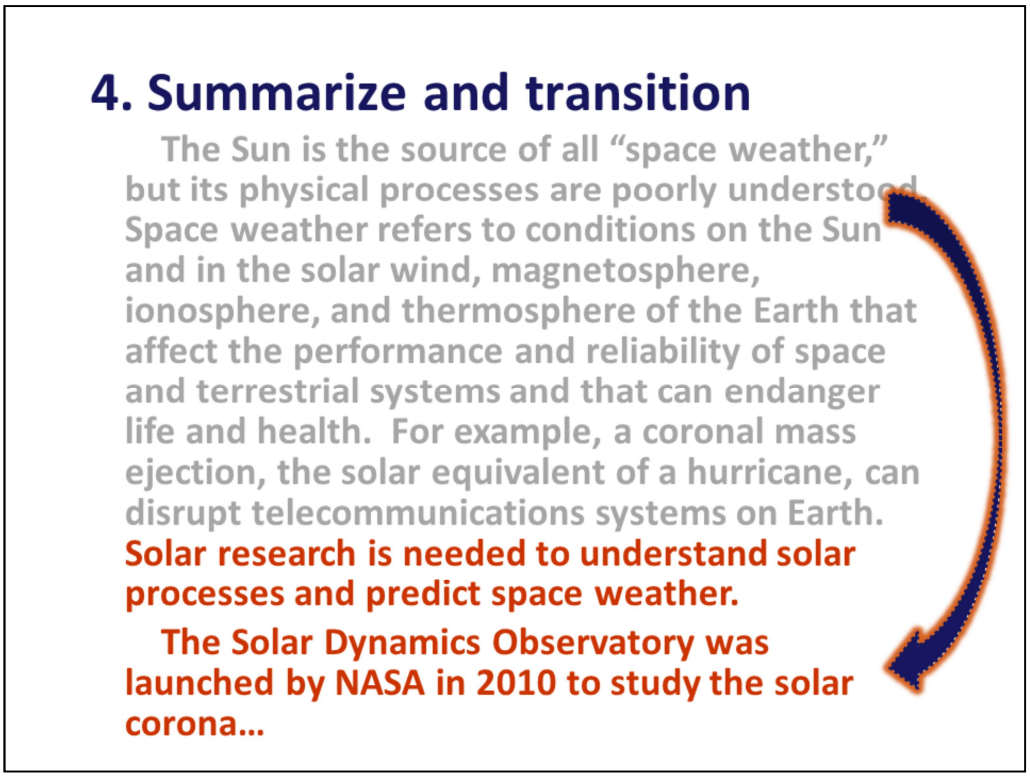
In the next sentence(s), explain, expand on, or provide supporting evidence for the ideas conveyed in the topic sentence.

In the SEES method, this first *E* can stand for three things: explanation, expansion, evidence.



Your explanation will often include illustrative examples. Put them next.

Note how the writer has used a familiar example from terrestrial weather, a hurricane, to explain the unfamiliar concept of "coronal mass ejection."



Finally, add a transitional sentence that sums up this paragraph and leads the reader logically to the next topic sentence.

In this example, the fourth sentence repeats the ideas of "space weather" and "not currently understood" that are introduced in the topic sentence and sets the stage for the next paragraph, which explains what the SDO is, what kind of research it is designed to do, and how it is addressing the problem of space weather. Thus the two paragraphs are linked structurally by the evolution of the ideas and explanations that they present.

Paragraph equation:

$$1\ S_t = 1\ ¶, \qquad [1]$$

where S_t is a topic sentence, and ¶ is a paragraph

Don't put more than one topic sentence in a paragraph

Don't put anything in a paragraph that doesn't support, explain, exemplify, or summarize the topic sentence

Write shorter paragraphs (<8 sentences)

Write from an outline!

No superfluous "stuff" in a paragraph. If it is not directly related to the topic sentence, delete it or move it to its own paragraph.

In fact, no superfluous stuff anywhere!
(q.v. http://people.physics.illinois.edu/Celia/Lectures/Fluff.pdf)

To learn more about the Solar Dynamics Observatory (SDO), see http://sdo.gsfc.nasa.gov/.

To learn more about how the SDO's extreme ultraviolet (euv) telescopes were constructed, see https://str.llnl.gov/JanFeb11/soufli.html.

Start filling your reservoirs and crafting your outline early

Start writing while you're still taking data

Conventional approach is finish the project and then write it up—bad idea

Making the outline will make you see where the holes are and where more (different) data are needed

Much easier to fill in those holes while the project is on-going

Commit to writing incrementally

Commit to writing incrementally; writing should be an integral part of your research work—remember "feedback loop."

Write in increments:

1) Construct a preliminary outline, based on the your initial goals for the project.
2) Write portions of the "results" and "discussion" sections while you're taking and analyzing your data.

Advantages of the incremental method:

You may discover additional data that are needed while the equipment is still set up and the project ongoing.

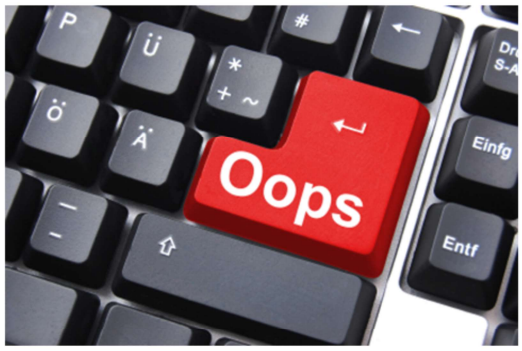
You get a finished paper faster, with more time to revise and edit.

H.B. Michaelson, How to Write and Publish Engineering Reports and Papers (Oryx Press, Phoenix, 1990).

Avoid common beginners' mistakes

Focusing on what took the most time to do

Presenting a chronological history of the work



INSTEAD, focus on the results and conclusions (that's what the reader wants to know)

Some beginning authors think that if they spent 90 percent of their time on some aspect of the experiment, they should devote 90 percent of the paper to that topic.

Readers don't want to know all the things that went wrong, all the components that failed, all the adjustments that had to be made to get the data. They want to know what worked, how it worked, what the results are, and what you think they mean. Remember, a journal is an archive of results, not a cemetery where you bury all your mistakes.

The probability that a first draft will not require revision asymptotically approaches 0.

"Perfection is achieved, not when there is nothing left to add, but when there is nothing left to take away."—Antoine-Marie-Roger de Saint-Exupery

Brevity is a key goal. Use your revisions to clarify and simplify.

Give yourself adequate time to reflect and rewrite.

Revising should incorporate four distinct elements:
1) clarifying the selection and presentation of ideas.
2) organizing the narrative logically and incrementally.
3) using language precisely and concisely.
4) correcting "mechanical" errors that detract from a professional argument.

Ideally, editing should be done in three passes:
1) reading for content (the science).
2) editing for style (organization and language).
3) proofreading for mechanics (spelling, punctuation, grammar, usage).

Writing well is a learned skill—train yourself to recognize good writing; emulate good examples, and practice, practice, practice.

To recap...



Think → Plan → Write

Think first

Commit to writing incrementally—start filling your reservoirs while you're still taking data

Analyze your audience and purpose

Make an outline and follow it

Use the SEES method for paragraphs and sections

Get words on paper/screen

Revise, revise, revise, revise, revise, revise, revise...

FINISH!!!*

*Tip: Don't use too many exclamation points in scientific writing!!
People will think you're a crackpot!!!!

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http://physics.illinois.edu/people/Celia/

NOTES: