How to Get Started if You Hate to Write

Part II—Writing Paragraphs

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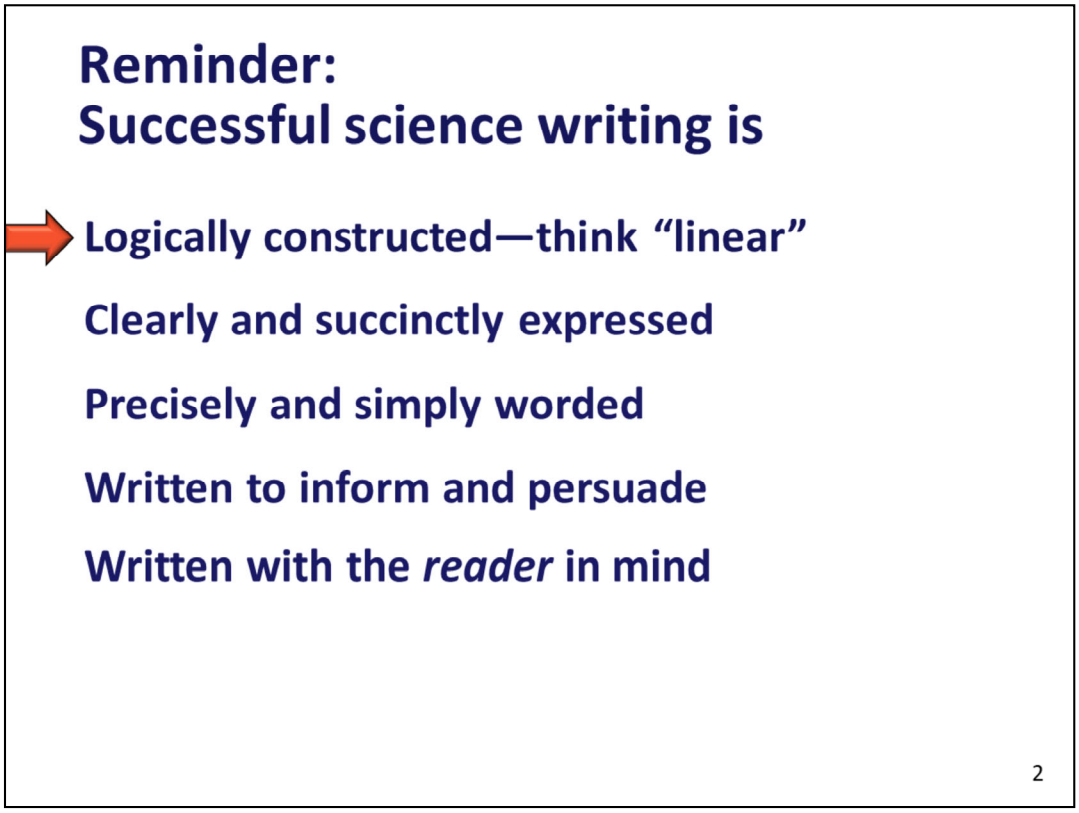
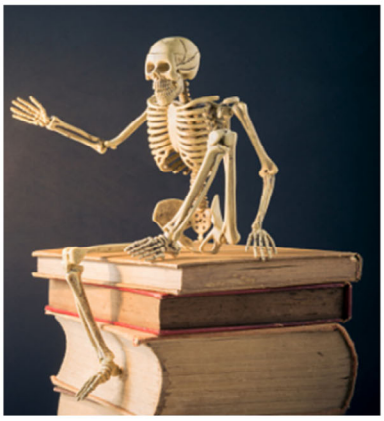


Any piece of scientific writing must present a coherent, cohesive, persuasive logical argument—that's axiomatic.

First, write your five-sentence synopsis

1. Goal
2. Context
3. Method
4. Results
5. Conclusions



One coherent sentence for each part

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Next, make an outline…

To avoid the novice writer's "core dump" method…

…and the cognitive paralysis induced by a blank piece of paper or a blank screen

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The "standard model" of physics writing—

- four kinds of sentences and
- two flavors of paragraphs

Four kinds of sentences:

Topic—states a primary idea
Supporting—explains, expands on, illustrates, gives evidence for the topic sentence
Concluding—summarizes preceding sentences
Limiting—expresses opposing or contrasting ideas

Two flavors of paragraphs:

Direct—states main idea in the first sentence and then expands on it
Pivoting—states a contrary or limiting idea first, then states the topic sentence

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Good resource for writing paragraphs:

"Write with purpose: what do you want your paragraph to do?"
https://libguides.newcastle.edu.au/ld.php?content_id=39162655

Direct paragraph style—topic sentence is the first sentence in the paragraph

- Followed by supporting sentences that explain, give examples or evidence, or expand the topic sentence
- Use the direct paragraph style to:
  - Explain an idea
  - Define a concept
  - Describe a thing or process
  - Classify parts of a whole
  - Make an argument
- Use the direct paragraph style for most scientific writing

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The pivoting paragraph begins with a *limiting* sentence or a rhetorical question

The topic sentence comes next, followed by supporting sentences

Presents a contrasting or negative idea or a question *before* the main idea is introduced

Is effective for comparing and contrasting ideas

Use a pivoting paragraph to:

- Set up a logical argument
- Emphasize positive aspects of the main idea
- Anticipate reader's questions or objections and answer them

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Whichever paragraph style you use, always end a paragraph with a sentence that—

Reminds the reader of the topic sentence

Summarizes it in a way that leads logically to the topic sentence in the next paragraph

Landau's Fermi liquid theory successfully describes the behavior of interacting fermionic particles for a wide range of materials, such as electrons in simple metals and liquid helium-3[1]. In some metals, Fermi liquid theory fails when strong correlations or fluctuations are present[2]. Also known as bad, or strange, metals, these states present anomalous properties such as resistance that does not follow the Fermi liquid prediction T^2, sometimes scaling as T instead or exhibiting more complex phenomena[2,3]. The resistivity of bad metals also does not saturate[4,5] as temperature is increased into the regime where the Mott–Ioffe–Regel (MIR) limit is violated and the apparent meanfreepath is shorter than the interatomic spacing[4,6]. This lack of saturation implies that quasiparticles are absent (e.g., refs. 7–9. for an overview), as does the lack of particle-like excitations in photoemission spectroscopy[10].

Understanding the origin of bad-metal behavior is a key problem in condensed matter physics, which may be important to resolving questions related to high-temperature superconductivity[11] and Mott quantum criticality[12]. This problem has been studied using ...

W. Xu, W.R. McGehee, W.N. Morong, and B. DeMarco, "Bad-metal relaxation dynamics in a Fermi lattice gas," *Nature Communications* **10**, 1588 (2019).

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Today, we're going to write the introduction (#1 of the synopsis) for a paper about the special mirrors built for NASA's Solar Dynamics Observatory (SDO)

Courtesy NASA

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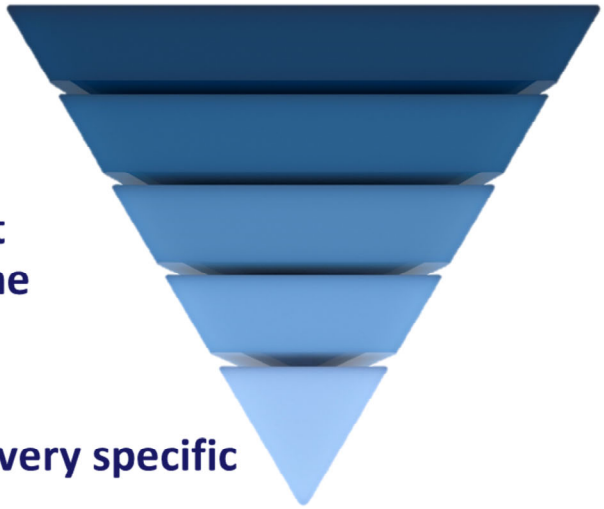
A common paradigm in science writing is the "inverted pyramid"

Start broad and general

Add details that define and refine your message

Finish with the very specific takeaway point



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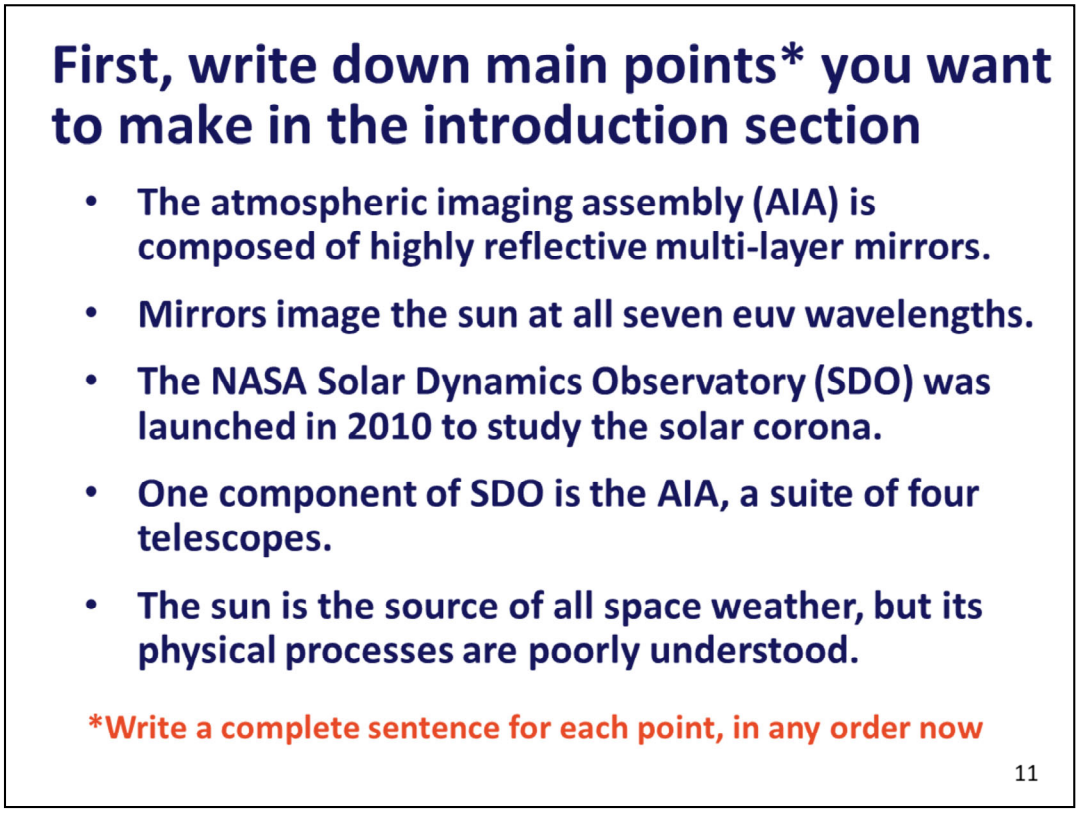

Start by writing down the main points you want to make in the paper. Don't worry about details—just concentrate on the main ideas now.

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

*Show a linear progression of ideas from premise to conclusions

*No digressions or discursive material

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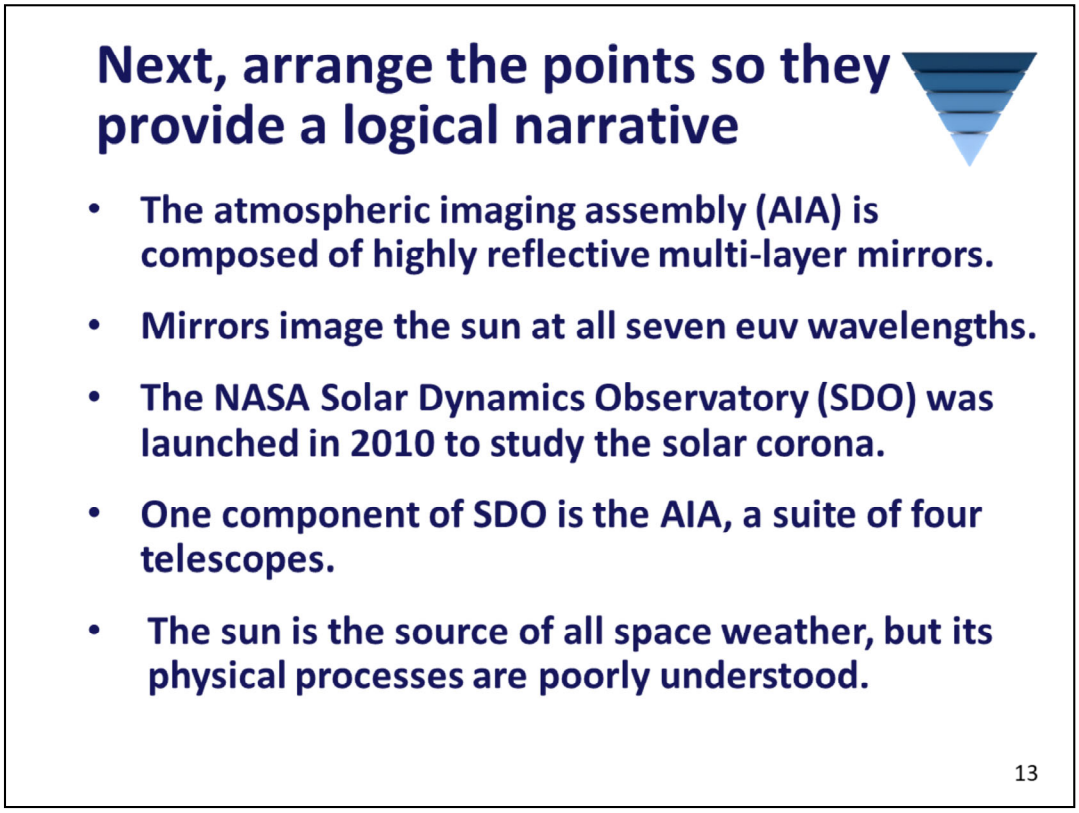
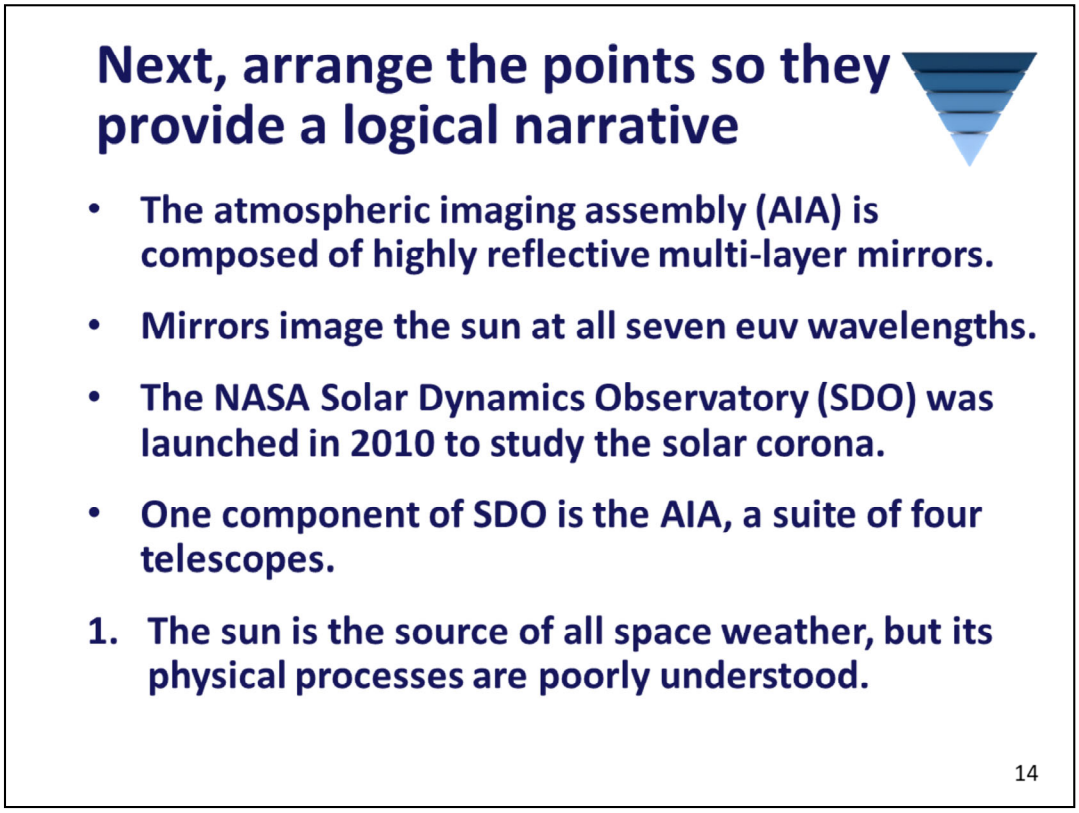
Next, arrange the points in a logical order so they provide a coherent storyline.

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

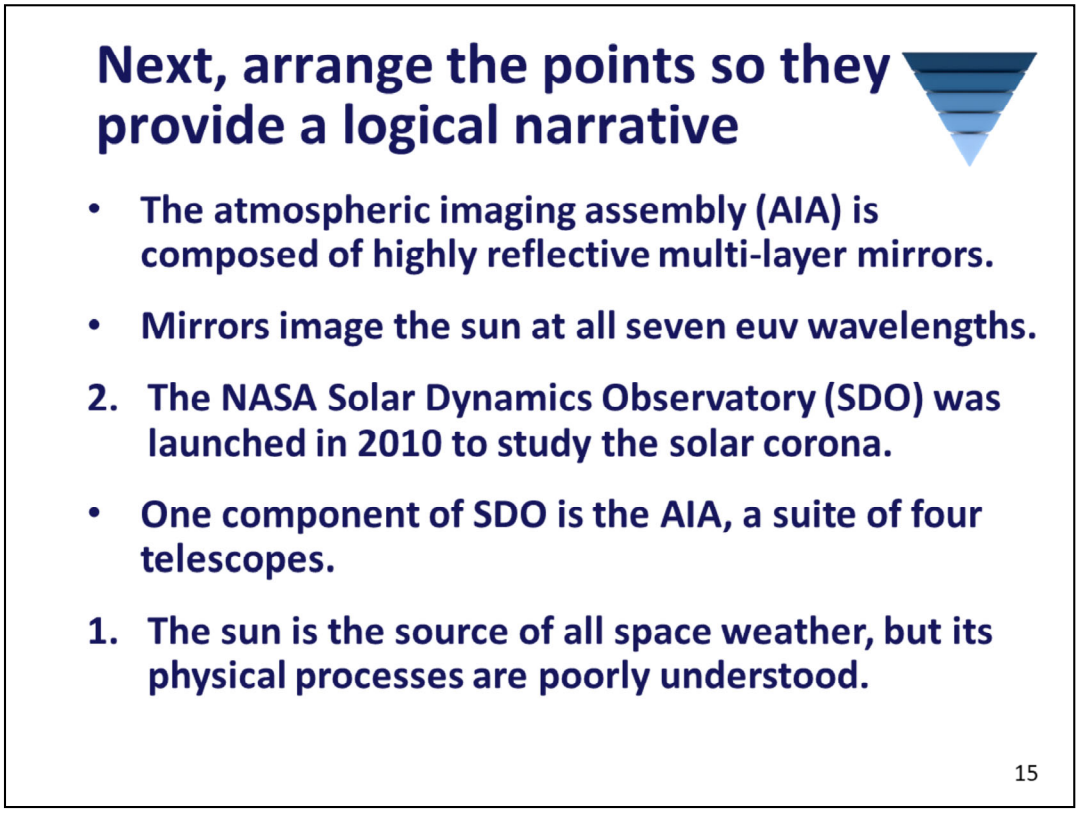
Each one of these points is going to be a signpost along the journey.



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



Start with the “big picture” statement.



Continue to define and refine your message.

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 the 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.

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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 the 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.

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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 the 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.

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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* (and only now)**
you're ready to start writing…

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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.

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Your main points provide a framework for your narrative. They become the topic sentence of a paragraph.

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, expand, give evidence for it
3. Give an example of it
4. Summarize it in a way that leads logically to the next topic sentence

*State → Explain (Expand, Evidence) → Exemplify → Summarize

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

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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

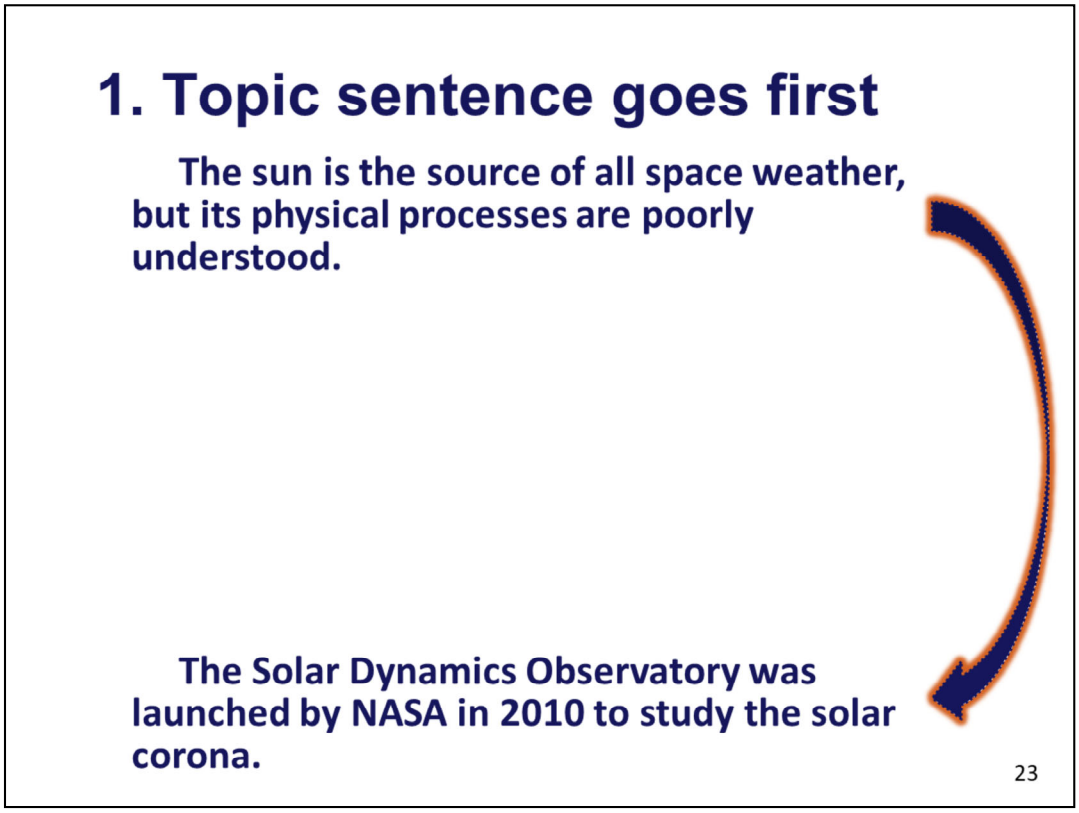
Suppose you're writing a paper for *PRL* and you have 21 sentences and three figures. You know right NOW, before you write another word, that you've got too much material for one *PRL*. Make your adjustments now—it's much less painful than trying to cut later.

Use the formula to create logical, coherent paragraphs.

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

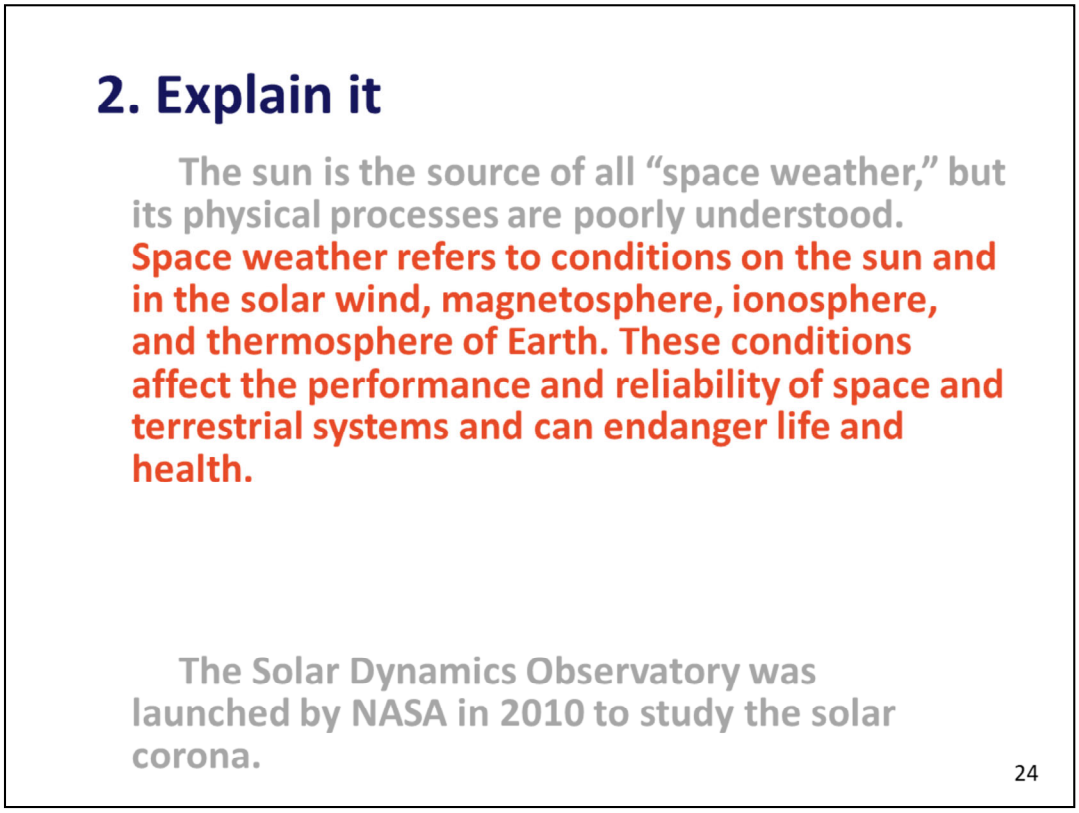
"The Sun is the source of all space weather…"
and
"The Solar Dynamics Observatory was launched by NASA in 2010…"

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



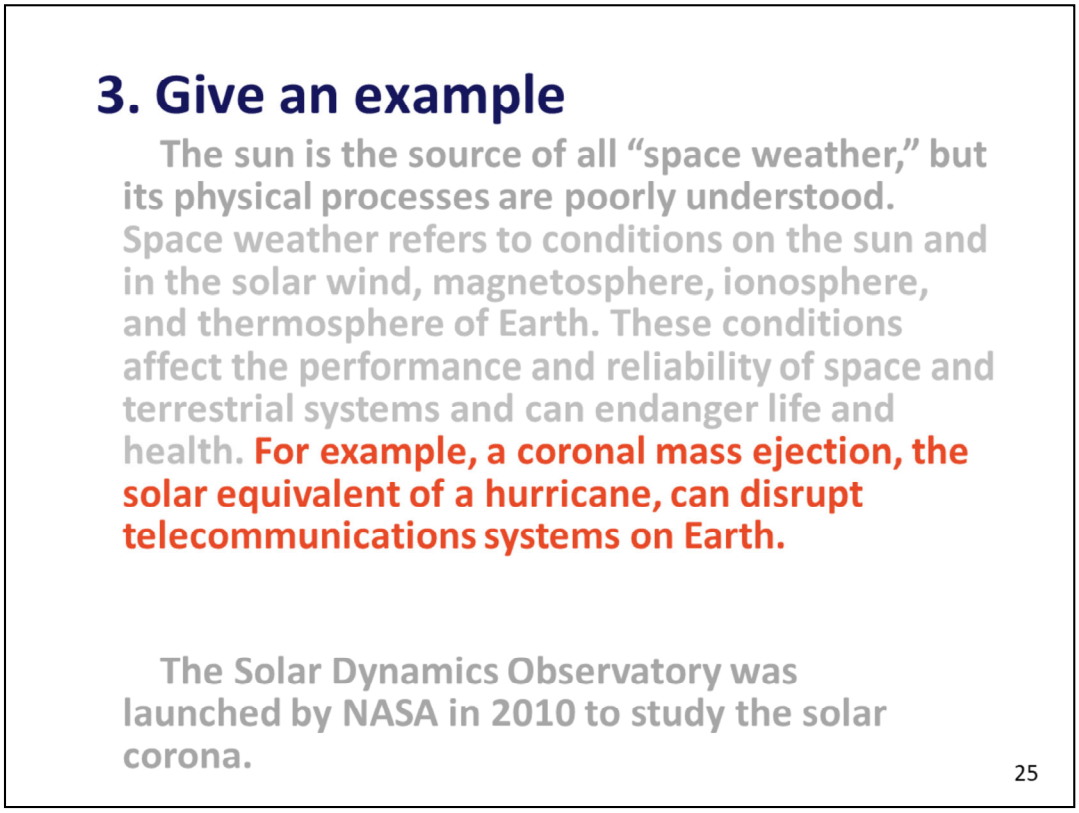
In science writing, the topic sentence is almost always the first sentence of the paragraph. While literary writing might put the topic sentence last, to build suspense, or in the middle, to redirect a reader's attention, put the topic sentence first in your paragraphs to emphasize your important points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



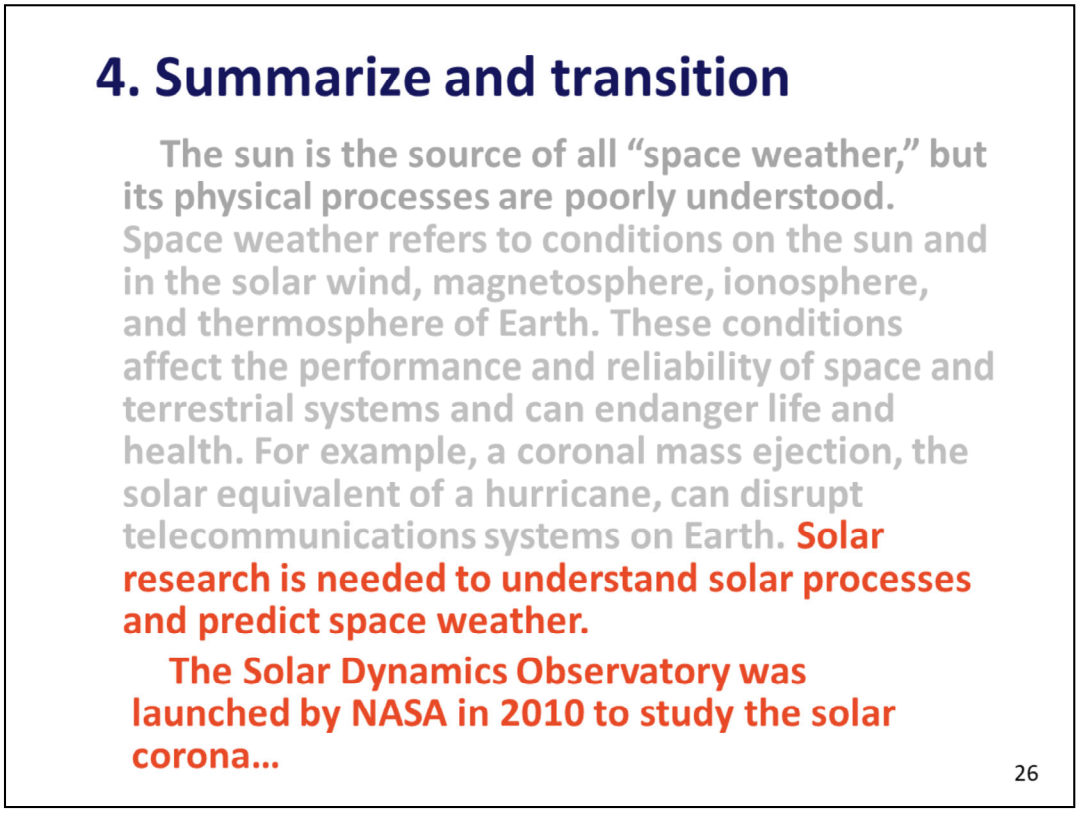
In the next sentence(s), explain, expand on, or provide supporting evidence for the ideas conveyed in the topic sentence.

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 reinforce the idea of space ***weather*** and 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.***

Elliott paragraph equation:

$$1\ S_t = 1\ ¶, \qquad [1]$$

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

N.B. Only *one* topic sentence per paragraph

If you have more than one S_t in a paragraph, break up the paragraph!

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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 recap:

Paragraph equation:

$$1\ S_t = 1\ ¶, \qquad [1]$$

Finish thinking before you start writing!

Only 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)!

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Notes: