



Have you ever considered why we write in paragraphs? Understanding the point of having paragraphs will help you write better ones.

Paragraphs form the superstructure for narrative explanations; each paragraph contains one key point that informs or persuades the reader of the central concept being conveyed in that chunk of text.

In this lecture, we'll look at how to construct effective paragraphs to support the internal logical arguments of your scientific articles.

Note in the background of this slide how the arrangement of the white lines moves your eye to the right center of the page (right above the first "l" in "Elliott").

In just the same way, by carefully constructing your paragraphs—the building blocks of expository writing—you create a logical structure for your argument and lead the reader directly to the conclusions you want him or her to reach.

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.

Start by writing down the main points you want to make

Write one complete sentence for each point:

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

Today we're going to look at how we might organize a paper on the multi-layer mirrors built for NASA's Solar Dynamics Observatory.

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

Write down those important points as you think of them, in no particular order at this time. We'll arrange them in a logical order later.

As you are deciding about these points, consider three main 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 article?
3. What are my space/time/page constraints?

Next, arrange the points in order so they tell a logical story

Think of this step as creating a map to guide your reader through your narrative

- **The Sun is the source of all space weather, but its physical processes are poorly understood.**
- **The Solar Dynamics Observatory was launched by NASA in 2010 to study the solar corona and its effects on space weather.**
- **Heart of SDO is the AIA, a suite of four scopes.**
- **The telescopes are composed of highly reflective multi-layer mirrors.**
- **Mirrors image Sun at all seven EUV wavelengths.**

Good writing starts with good structure.

Get in the habit of writing from an outline*—at minimum, a list of the points that you want to make or the questions that you want to answer.

Once you've decided on the main points, arrange them so that each point is related to and builds on the point that comes before it in the narrative. This arrangement is now the bare-bones outline for your paper or talk.


I recommend writing out your main points in full sentences and making them as explicit as possible. It's hard to see the logical structure of a piece of writing if you start with vague, generic statements.

*my recommendations for outlining:

<http://people.physics.illinois.edu/Celia/Lectures/Outlines.pdf>


**Each sentence 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 inevitably to the next topic statement.

Celia's foolproof, four-step 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**

...how to this method witlessly

Use the formula to create logical, coherent paragraphs.

So let's go back to our first two topic sentences from Slide 2...

"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...

1. Topic sentence goes first

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

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



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.

2. Explain it

The Sun is the source of all “space weather,” but its physical processes are poorly understood. Space weather refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere of the Earth that affect the performance and reliability of space and terrestrial systems and that can endanger life and health.

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



In the second sentence(s), explain, expand on, or give evidence for the ideas conveyed in the topic sentence.

3. Give an example

The Sun is the source of all “space weather,” but its physical processes are poorly understood. Space weather refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere of the Earth that affect the performance and reliability of space and terrestrial systems and that can endanger life and health. For example, a coronal mass ejection, the solar equivalent of a hurricane, can disrupt telecommunications systems on Earth.

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



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

4. Summarize and transition

The Sun is the source of all “space weather,” but its physical processes are poorly understood. Space weather refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere of the Earth that affect the performance and reliability of space and terrestrial systems and that can endanger life and health. For example, a coronal mass ejection, the solar equivalent of a hurricane, can disrupt telecommunications systems on Earth. **Solar research is needed to understand solar processes and predict space weather.**

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

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 and what kind of research it is designed to do. Thus the two paragraphs are linked structurally by the evolution of the ideas and explanations that they present.

Paragraph equation:

$$1 S_T = 1 P, \quad [1]$$

where S_T is a topic sentence and P 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!

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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 general, writing shorter paragraphs will increase the clarity and conciseness of your writing and make your arguments easier to follow.

Trying to write without an outline is like trying to build a skyscraper without a blueprint, foundation, tape, or level. If you think you can go back and “fix” it later, you probably can, but it's going to be painful, expensive, and time-consuming. It's always faster, cheaper, and ultimately easier to plan first.

For more practical advice about how to write a paragraph, see <https://owl.english.purdue.edu/owl/resource/606/01/>.

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>.