Paragraphs

Make the paragraph the unit of composition.
—Strunk and White, *Elements of Style*

Words are to sentences what atoms are to molecules: the basic building blocks that control structure and function. If we extend that analogy, paragraphs become cells: the fundamental unit of life. A cell gains life from its structure, a structure that creates internal cohesion and external connection, allowing it to function as part of a larger organism. So, too, with paragraphs. Hence, Strunk and White’s second principle of composition: “Make the paragraph the unit of composition.”

But how do you make a paragraph a cell, or a unit of composition? What do those terms even mean? Paragraphs tell stories. Not surprisingly, therefore, a paragraph becomes a unit of composition when it tells a complete short story with a coherent structure, a story that fits into and contributes to the larger work. If you string sentences together until you need to come up for air, and then throw in a paragraph break, you will not have a unit of composition.

Grade school teaches that a paragraph has a topic sentence that makes a point, which the rest of the paragraph develops. This topic sentence—development (TS-D) model of paragraph structure is a simplified version of the lead/development (LD) story structure I introduced in chapter 4. It works much of the time
and is a good starting point. However, part of all advanced training is unlearning
the simplifications you were taught in introductory classes. Those classes build
simple schemas to get you started in the field, but to advance you must move
beyond them. Electrons don't orbit around the nucleus like planets around the
sun, single genes don't necessarily code for single proteins, and paragraphs don't
necessarily have a TS-D structure.

You can write a paragraph using any of the story structures discussed in this
book. Each paragraph needs an opening that sets the stage, and each needs to
resolve by making a point, but those don't have to be either a single sentence or the
first sentence. For choosing a structure, the most important decision is whether to
make a point and then develop it, producing an LD structure, or to build to a
conclusion, producing an OCAR or LDR structure. Joseph Williams\(^1\) distinguishes
these as "point-first" versus "point-last" paragraphs.

11.1. POIN T-FI RST PAR AGRAPHS

The simplest form of point-first paragraph is the classical TS-D structure. If a
paper were written with only TS-D paragraphs, you could skip along, reading the
first sentence of each paragraph, and still get its essence. TS-D is simple, clean,
and works well for most jobs. It should dominate your writing. If you go back to
chapter 8 (see examples 8.1 and 8.4), you'll note that this was how I suggested
describing your methods and results. Here are several other simple TS-D
paragraphs.

Example 11.1
A Result: Neither calculation reproduces the experimental strength distribu-
tion. The distribution for GXPF1A is closer to the data, but it pushes the
strength up too high in excitation energy. An even more dramatic increase
occurs for the calculation with KB3G, although the strength integrated up to
7.5 MeV reproduces the experimental value quite well. The summed B(GT)
strength up to Ex = 7.5 MeV (a total of 48 states) for the KB3G interaction is
\(\Sigma B(GT)_{KB3G} = 2.02\) (with a further 10% of that value located at energies up
to 10.3 MeV) compared to the experimental value of 1.95 ± 0.14 up to that
excitation energy. The summed strength up to Ex = 7.5 MeV with the
GXPF1A interaction is \(\Sigma B(GT)_{GXPF1A} = 2.65\). A further 8% of that value is
located at higher excitation energies, fragmented over many weak states.\(^2\)

2. G. W. Hitt, R. G. T. Zegers, S. M. Austin, D. Bazin, A. Gade, D. Galaviz, C. J. Guess, M. Horoi,
   M. E. Howard, W. D. M. Rae, Y. Shimbara, E. E. Smith, and C. Tur, "Gamow-Teller Transitions
to Cu Measured with the Zn(t,He) Reaction," (2009).
Example 11.2

An Argument: We conclude that the increase of the diurnal temperature range [DTR] over the United States during the three-day grounding period of 11–14 September 2001 cannot be attributed to the absence of contrails. While missing contrails may have affected the DTR, their impact is probably too small to detect with a statistical significance. The variations in high cloud cover, including contrails and contrail-induced cirrus clouds, contribute weakly to the changes in the diurnal temperature range, which is governed primarily by lower altitude clouds, winds, and humidity.¹

An alternative form of point-first paragraph is to use a more extended LD structure in which the lead takes several sentences. An example of this is the first paragraph in example 10.2 about nitrogen stoichiometry, in which the lead takes three sentences. The first makes the general argument that organisms have characteristic element ratios, an argument that is sharpened and narrowed to the final clause of the third sentence, which states that these ratios may "predict element mineralization or immobilization during decomposition." That ends the lead with a point the rest of the paragraph expands on.

Another example of an LD paragraph is example 11.3, which comes from a paper about synthesizing complexes between metals and aromatic carbon-60 (C60) structures. This came at the end of the paper's opening, which argued that such complexes are important in nature and that new techniques were becoming available to synthesize them. It makes a critical step in the funnel, narrowing down to the specific problem of synthesizing metal–corannulene ion—molecule complexes.

Example 11.3

Metal-PAH [polycyclic aromatic hydrocarbon] complexes are important as models for surface science and catalysis; PAHs may be used to model finite sections of a carbon surface. There is also evidence that metal-PAH complexes may be constituents of interstellar gas clouds; they have been implicated in the depletion of atomic metal and silicon in the ISM and as contributors to the DIBs [diffuse interstellar bands] and UIB [unidentified infrared bands]. Increasing interest in metal-PAH systems has thus motivated many groups to produce these species in laboratory experiments. Dunbar and co-workers were the first to observe metal-PAH ion complexes in gasphase experiments using FT-ICR mass spectrometry. From these experiments, they determined the binding kinetics of a variety of metal and nonmetal cations with PAHs. Our group has produced a variety of metal and multimetal-PAH sandwich complexes using laser vaporization of film-coated metal samples in a molecular beam cluster source. Competitive binding and photodissociation experiments were successful in determining structural information and

relative bonding strengths of metals with benzene, C60, and coronene. In other experiments, we used a laser desorption time-of-flight mass spectrometer to produce a variety of metal oxide and halide PAH complexes as well as mixed-ligand complexes. Experimental work has stimulated new theoretical studies investigating metal binding sites and bond energies on PAHs. Dunbar, Klippenstein and co-workers and Jena and co-workers have been active in this area.4

I've italicized the sentence that makes the point of this paragraph; it closes the lead and opens the discussion of research groups that have made metal-PAH complexes. The first sentences discussed why they are important, and thus why researchers would want to synthesize them. The following sentences lay out the history of synthesis efforts. Because this is a long paragraph, the authors used several sentences to build to the point, rather than a single topic sentence.

11.2. POINT-LAST PARAGRAPHS

In a point-first paragraph, you make an argument and then flesh it out. Sometimes, however, you need to assemble an argument, pulling threads together to weave them into a conclusion, producing a point-last structure. These may be either LDR or OCAR.

An LDR paragraph opens with an argument and then develops it, similar to an LD paragraph, but then it wraps up with a synthesis: it's strong at both opening and resolution. A good example is the second paragraph of example 10.2 about nitrogen stoichiometry. That paragraph starts with the strong statement that animals and microbes live in a C-rich, N-poor world; it ends with a conclusion as to what that means—N recycling lags behind decomposition—hence LDR.

An additional example of an LDR paragraph is the following (example 11.4), which is about the treatment of post-traumatic stress disorder (PTSD) following battlefield injuries. The authors suggest that using morphine to ease immediate pain might also help reduce later PTSD, because its anti-anxiety effects can prevent the bad memories from consolidating.

Example 11.4
Although much of the research in the field of pharmacotherapy for the secondary prevention of PTSD after trauma is speculative, there is theoretical evidence that early use of anti-anxiety agents can be effective. Pitman and Delahanty argued that pharmacotherapeutic interventions for the prevention of PTSD will be most effective if medication regimens are implemented after exposure to traumatic events. Morgan and colleagues and other

investigators have hypothesized that opiates may interfere with or prevent memory consolidation through a beta-adrenergic mechanism. This theory also lends support to the idea that morphine and other opiates may prove effective in the secondary prevention of PTSD after trauma.\(^5\)

In this paragraph the lead is the general argument that anti-anxiety agents should block PTSD; this point is made in the first sentence. The development is the discussion of the papers by Pitman and Delahanty and by Morgan and colleagues. The resolution is the last sentence, which argues that because morphine is an anti-anxiety agent as well as a potent painkiller, it should limit PTSD.

The other way to craft a point-last paragraph is to use an OCAR structure, in which the opening sentence introduces the issue without framing an argument—it just sets the stage. The last sentence synthesizes the material to make the conclusion. Consider example 11.5.

Example 11.5
If the Great Plains mammoths routinely undertook long-distance migrations, then mammoths at all of the Clovis sites in this study should display similar \(^{87}\text{Sr}/^{86}\text{Sr}\) ratios. However, the Dent mammoths display \(^{87}\text{Sr}/^{86}\text{Sr}\) ratios that are distinct from those of mammoths at Blackwater Draw and Miami, demonstrating that the Dent mammoths belonged to a distinct population. Thus, we conclude that Great Plains mammoths did not routinely migrate between northern Colorado and the southern High Plains, which are separated by about 600 km.\(^6\)

The point of this paragraph is that mammoths did not migrate long distances, which is presented in the closing sentence—hence, point-last. The first sentence poses the question (did they migrate long distances?) and the approach to answering it (Sr isotope ratios). It serves as both opening and challenge, but it doesn't answer the question and so doesn't resolve. It acts as a guide to the story but as a classic OCAR opening, rather than as an LDR lead.

Another excellent example of a point-last OCAR paragraph is example 10.1 about population density and watershed N-export. That paragraph opens by arguing that these might be related. The second sentence poses the challenge, asking whether differences in population density could explain the differences in N-export between north and south. Several more sentences develop the action, leading to the resolution: population density cannot explain the patterns of N-export.


Point-last paragraphs are not terribly common; they might account for 25–30 percent of a paper. Writing is dominated by point-first paragraphs, particularly by TS-D, which is the bread-and-butter paragraph. The complex structures, however, often appear at critical story points—openings, resolutions, and transitions—so you must learn when and how to use them. Additionally, although short paragraphs are usually TS-D, long paragraphs benefit from a resolution to tie them together and remind the reader of the point; they lean toward LDR or OCAR.

I've presented these structures as distinct, but they are not; rather, they form a spectrum from paragraphs with all the power in the first sentence to those with it all in the last—pure TS-D to pure OCAR. Some paragraphs may be hard to classify definitively as TS-D, LD, LDR, or OCAR. Slight shifts in the weighting of a sentence, or of a reader's interpretation, might change how they would define the structure. It's better when the structure is apparent, because if it is unclear, then the point may be, too. It's okay to write point-first paragraphs, and it's okay to write point-last paragraphs, but don't write point-nowhere paragraphs.

11.3. BAD PARAGRAPHS

Because paragraphs tell stories, they can fail for the same reasons that whole stories do. Paragraphs that lack a coherent structure can seem confusing and pointless, as did example 10.3, which illustrated directionless, "stream of consciousness" writing. We fixed that paragraph by breaking it into smaller ones, each of which had a single point; the first paragraph became OCAR and the second TS-D. Anytime you come across a paragraph that seems too long, too rambling, or too incoherent, you need to look for the story arcs and elements, and restructure or break up the paragraph up to highlight them.

As an example, here is a paragraph that is about as bad as it is possible to write (example 11.6). It is about restoring damaged grasslands where phosphorus availability limits plant growth. The researchers did two things: (1) they added compost as fertilizer, and (2) they inoculated a native grass with symbiotic fungi (known as mycorrhizae) to determine whether these treatments would overcome the P-limitation and allow plants to grow well.

Example 11.6:
Adding compost to soil promotes microbial growth, which then increases microbial production of phosphatase enzymes that release plant-available P from organic matter. Bromus carinatus is a native grass that can be used in reestablishing California grasslands. Its success in P-poor systems can be stimulated by inoculation with mycorrhizal fungi. However, the effects of mycorrhizal inoculation of B. carinatus on P uptake have not been assessed.

Not only is the point of this paragraph completely opaque, so is its structure. Is it point-first or point-last? Does it even have a point? There are several threads of argument that seem to weave aimlessly through it. First, P availability is critical
to growing plants and restoring degraded California ecosystems. Second, there are two approaches that may enhance P-uptake by plants: adding compost and inoculating plants with mycorrhizae. Third, *B. carinatus* can be used to reestablish grasslands. Finally, the effects of mycorrhizal inoculation of *B. carinatus* are unknown. Which of these is the point of the paragraph?

The paper intended to connect the first two ideas; the story was about integrating multiple approaches to solve a problem, in this case focusing on increasing P-supply to plants to get them to grow. *B. carinatus* is incidental to that story; it just happens to be a useful species to use. Unfortunately, the authors introduced that point in a way that derailed the paragraph. To the authors, how this all fit together was probably obvious, but it wasn't to a reader. This kind of incoherence frequently results from the curse of knowledge. When authors know too much but write too little, ideas get overcondensed and jumbled.

How do you fix a paragraph like this? The first step is to identify the real story: there are two approaches to restoring degraded grasslands. The second step is to decide whether this needs a point-first or a point-last structure. I argue for a point-first, LD structure. The third step is to pull apart the different threads of this story to clarify their relationships.

Example 11.7

Restoring degraded California grasslands requires adequate supplies of P to support plant growth. Two management approaches have been proposed to achieve this: adding compost and inoculating grasses with mycorrhizal fungi. However, which approach is more effective in enhancing P-uptake and restoration is unclear, and they may work synergistically. Compost not only adds organic P to the soil; it also stimulates microbes that produce phosphatase enzymes and so increases P-release. P uptake by plants, on the other hand, may be stimulated by inoculating them with mycorrhizal fungi.

*Bromus carinatus* is a native grass that may be useful in restoring degraded California grasslands as it grows extensively throughout the state and tolerates harsh conditions. If it can be supplied with adequate P, it establishes well and starts the restoration process. A question, however, is which approach to enhancing P supply will work best with it, or whether both are necessary.

Instead of one dense, cryptic paragraph, I've broken this into two, added explanation, and ensured that each has a clear point and a clear structure: LD and LDR, respectively. Each forms a coherent story within itself, and together they define a direction for the paper. I argue that as a rule, short is better than long (see chapter 16), but you should take the space necessary to frame critical ideas. If you confuse readers, you lose them. If you need to condense, condense elsewhere.

The key to writing good paragraphs, and fixing bad ones, is the same as for other writing problems. Identify (1) who the story is about, (2) your point, and (3) where you should make it. Put the critical pieces of information in the right places, and use the rest of the text to tie them together smoothly.
EXERCISES

11.1. Analyze published papers

Go to the papers you have been analyzing. Choose a selection of paragraphs in the papers; pick the critical points of opening, challenge, resolution, and transitions, as well as a random sampling of body paragraphs. Define their structures: point-first versus point-last. If point-first, are they simple TS-D or more developed LD? If point-last, are they LDR or OCAR? Evaluate where they use each structure—is there a pattern of where the authors use each type of paragraph? Can you determine why they use a particular structure in each case?

11.2. Write a short article

Go back to your short article and analyze the structure of every paragraph: TS-D, LD, LDR, or OCAR? Do they seem appropriate for the particular location and function they serve? If not (or worse, they have no definable structure), rewrite to give them an appropriate and structure.

11.3. Edit

A. Rewrite Example 11.2 about jet contrails and diurnal temperature variation as a point-last, OCAR, paragraph. Does it work as well?
B. Rewrite Example 11.5 about mammoths as a TS-D paragraph. Does it work as well?
A sentence tells a story, just the shortest one possible.

It may seem strange, in a book targeted at high-level scientific writing, to go back to a topic that you probably studied in your first class on writing, possibly when you were six years old. But you can't write strong papers with weak sentences. To polish your writing, you need to go back to basics. That means sentences.

Because a sentence tells a story, basic principles of story structure apply. Readers need to meet the characters (opening), learn what they did (action), and what the outcome was (resolution). However, there are grammatical rules that we must integrate with OCAR principles to write good sentences.

Grammatically, a sentence has a subject, verb, and object. To transform a sentence into a story, however, you need to see those grammatical units as story units that carry out the OCAR functions.

| O | Opening: who is the story about? | = Subject |
| C/A | Challenge/action: what happened | = Verb |
| R | Resolution: what was its outcome? | = Object |
Good sentences present the OCAR elements in the most convenient order possible, establishing a framework and then placing new information into it, allowing readers to process each piece of information in turn. If you give us information out of order, we have to hold it aside until you provide the essential pieces. Imagine helping someone build a house. First you hand them a board, then the nail to pound into it, and only then the hammer to pound it with. If you reverse that order, they'll hang the hammer on their belt and hold the nail in their teeth while they wait for the board to put in place. It's harder that way.

With longer stories, we can choose where to place the emphasis—either in the opening in LD, or in the resolution in OCAR or ABDCE. Most sentences, however, are short enough that you don't have that flexibility. It's in the nature of English that the last word or phrase in a sentence's main clause carries the strongest emotional weight, so simple sentences invariably follow OCAR.

A sentence's condensed form and constrained structure is why Joseph Williams in *Style: Toward Clarity and Grace* defines the terms "topic" and "stress" for the critical opening and resolution positions, terms that are more specific in how they reflect their function in a sentence.

12.1. OPENING: THE TOPIC

In any story, the opening identifies the characters and setting. In a long story, there may be a number of elements to introduce—people, places, concepts, and so on. However, a sentence is more limited and should deal with a more limited suite of characters, frequently just one—it has a single topic.

Whatever you put at the beginning of a sentence, readers interpret as the topic: who or what the sentence is about. Because the topic presents the context for what is to come, it should be a schema or character that readers are familiar with, either because it is common knowledge or because you introduced it earlier. Then you develop the schema by adding new information. If you break that pattern and put new information at the beginning of a sentence, readers may be confused—you're giving them new information but suggesting it's old.

12.2. RESOLUTION: THE STRESS

Endings are always power positions—last words carry the greatest weight. Because of that emphasis, Williams defines the ending of a sentence as the stress. That is why I made "the stress" the last words in the previous sentence—I wanted to emphasize the new term. In a multiclause sentence, the ending of each clause is a minor stress position. Use the power of the stress by putting key words there—the main message and new ideas or terms.

To illustrate the power of the stress position, consider the ending of Winston Churchill's famous "We shall fight them on the beaches" speech. Read it aloud and hear where your voice comes down in emphasis.
Example 12.1

"...and even if, which I do not for a moment believe, this Island or a large part of it were subjugated and starving, then our Empire beyond the seas, armed and guarded by the British Fleet, would carry on the struggle, until, in God's good time, the New World, with all its power and might, steps forth to the rescue and the liberation of the Old.

What words did you find yourself hitting? Was it not the end of each clause? With a big punch on the final words—the sentence's overall stress?

Churchill wrote it this way because he knew the words and ideas he wanted to emphasize, so he put them in stress positions.

12.3. PUTTING TOPIC AND STRESS TOGETHER

Some writers seem to think that if they get the right facts into a sentence, readers will get their point. They are wrong. Shifting information between topic and stress changes how readers interpret it. You must put the right information in the right place if you want readers to get your intended point. Consider the following three sentences; they all contain the same facts, but they tell different stories.

Example 12.2

A. Viruses were not studied in the sea until 1989 yet are its most abundant biological entities.
B. The most abundant biological entities in the sea are viruses, yet they were not studied until 1989.
C. The most abundant biological entities in the sea were not studied until 1989: viruses.

In the first sentence, viruses are "old information" that we're learning something new about. That new story is defined in the stress—viruses are the sea's most abundant biological entities. This expands your understanding of where viruses are important.

Sentences B and C, on the other hand, put "biological entities in the sea" in the topic position. They build on a "sea creature" schema, which is probably about fish, rather than on a "virus" schema. Though these sentences both have sea creatures as their central character, they tell different stories. Sentence B emphasizes when they were first studied—isn't it surprising that it wasn't until 1989? Sentence C emphasizes that the surprising new information is that the most abundant entities are viruses. It tells the opposite story from A, inverting old and new information.

Just putting "viruses," "1989," and "most abundant biological entities in the sea" into a single sentence doesn't create one message—it creates six potential messages (of which I showed three). The difference between these sentences and how you interpret them isn't length or language, but structure—what information
goes where? You must choose which story you want to tell and structure your sentences accordingly.

Recognizing how readers respond to information in different parts of the sentence offers a tool for controlling those responses. Let’s consider another example, one with information that may not be as easy to assimilate.

Example 12.3
Net mineralization represents the nitrogen available to plants because it reflects the difference between microbial nitrogen release and uptake in soil.

Only a minority of you likely knows what “net mineralization” is or have a schema for it. So when I start a sentence with it, the sentence (and ideas) may be challenging. Starting with more familiar concepts makes the sentence easier.

“The amount of nitrogen available for plants is controlled by net mineralization—the difference between microbial nitrogen release and uptake in soil.”

This sentence says effectively the same thing, but it starts with an idea that most people understand—plants need nitrogen. It builds off a widely held schema and educates readers about the role of microbes in controlling plant N. All it took to make the story more tractable was switching the topic. Whereas the first sentence might have seemed opaque, this should seem more transparent.

By shifting the order of the ideas in the sentence, I also buried “net mineralization” in the middle, minimizing the weight on the term itself and letting you slide over it. For people in the field, referring to the term, even in a low-emphasis position, may strengthen the message. If, however, I were writing for people outside the field, who don’t hold the net mineralization schema, I could leave the term out and simplify the sentence to:

“The amount of nitrogen available for plants is controlled by the difference between microbial nitrogen release and uptake in soil”

This sentence says exactly the same to most people—perhaps more, as it is shorter and contains no unfamiliar information to distract.

If I wanted to define “net nitrogen mineralization” and create a schema for it that I could build on, I would move it to the sentence’s overall stress position:

“The amount of nitrogen available for plants is controlled by the balance between microbial nitrogen uptake and release in soil; we define this balance as net N mineralization.”

This emphasizes “net N mineralization” as a new term I want readers to remember. I would write it that way in a textbook. I would not, however, write it that way for a specialist journal—experts wouldn’t need the term defined. For them it’s an established schema. If I wrote the sentence that way for a paper in
Soil Biology & Biochemistry, readers might interpret the writing as that of a novice for whom this *is* new material.

The weighting of words in a sentence follows a consistent order: the stress carries the greatest emphasis, the topic is next, and the middle carries the least. This pattern is described by Roy Peter Clark, in *Writing Tools*, as the 2–3–1 rule of emphasis. Managing this pattern will help you put the right information in the right places; it will guide you in selecting the appropriate topic and stress to write sentences with both clarity and power.

12.4. SUBJECT–VERB CONNECTION

Managing topic and stress is about managing opening and resolution. Writing strong sentences also requires managing the action. Sentences are highly condensed stories; there is no time for a long, gentle opening. Introduce the key characters and then get right to it. The longer the gap between actor and action, the duller and more confusing a sentence becomes. The verb (the action) should immediately follow the sentence’s subject.

As examples of tight subject–verb connection look back to example 12.3 and the first suggested rewrite; each immediately follows the subject with the verb:

“Net mineralization *represents* . . .”

“The amount of nitrogen available for plants *is controlled* . . .”

In the second version, the subject is long (seven words), but the verb (is controlled) immediately follows it.

Example 12.4 offers a case where the authors inserted a phrase into the middle of the sentence, set off with commas, and so disconnected the subject and verb, and as a result made it unnecessarily hard to follow.

Example 12.4

The pooled effect sizes, both with and without adjustment for environmental risk factors, were larger for DNA-based than RNA-based viruses.

The subject is “pooled effect sizes” and the verb is “were,” but those are separated by the discussion of adjusting for environmental risk factors. To reconnect subject and verb, move that parenthetical out of the middle of the sentence.

“The pooled effect sizes were larger for DNA-based than RNA-based viruses, regardless of whether environmental risk factors were adjusted for.”

12.5. MANAGING REAL SENTENCES

The examples I’ve used so far are straightforward, with few extra words or clauses to add information or nuance. To express more complex thoughts, we need to be
able to write more complex sentences, but these often get out of control. Rather than elaborating the message, we end up hiding it, burying it under clutter. The key to writing complex sentences is holding their structure together. Topic, action, and stress need to be well chosen and well placed.

12.5.1. Pick the Right Topic

When we add words or clauses to the beginning of a sentence, we bury the topic and risk that it will be missed or misconstrued. Tightening the structure means picking the right topic. For example, in the following sentence, what is the real topic?

Example 12.5
It has been predicted that the global average temperature will increase at a rate of 0.2°C/decade.

The OCAR structure here is weak because there are two sets of actors and action: (1) someone predicted, and (2) temperature will rise. Why open with the implied nameless people who did the predicting, when the story is almost certainly about global average temperature? Make that the topic:

Global average temperature has been predicted to increase at a rate of 0.2°C/decade.”

This collapses all the action—both the prediction and the increase—into a single short action section, making the sentence clearer. It has a better internal arc structure.

The following is a case where the author only had one potential actor but still managed to bury the sentence’s topic.

Example 12.6
In this study, taking advantage of a well-annotated genome map and effective targeted-mutagenesis techniques, we analyzed the role of Bac17 in pathogenesis by Candida albicans.

Here, the authors added a long incidental qualifying clause to the beginning of the sentence. Since we don’t yet know what is being qualified, we are likely to skim over that material because we don’t have a framework for it. It would be better to move the real topic of this sentence closer to the beginning:

“We analyzed the role of Bac17 in pathogenesis by Candida albicans by taking advantage of a well annotated genome map and effective targeted-mutagenesis techniques.”
12.5.2. Unburying the Stress

Sometimes the problem with a sentence is that there are words dangling after the real stress. To strengthen such sentences, you need to either delete those extra words or move them into the middle of the sentence, thereby shifting the important words into the stress position. For example, the following sentence (example 12.7) ends weakly. How would you strengthen it?

Example 12.7
The number of commercial products containing nanomaterials has risen rapidly; in 2006 there were only 212 while in 2009 there were over 1000 products on the market.

What is the point in this sentence? The first clause makes the argument that nanomaterial use is increasing, whereas the second elaborates that by showing us how much it has increased. The point to emphasize, therefore, should be 1000, rather than “products on the market.” So cut those trailing words; we’ve already said “commercial products,” so we know what the numbers refer to:

“The number of commercial products containing nanomaterials has risen rapidly; in 2006 there were only 212 while in 2009 there were over 1000.”

Example 12.8
Plants can increase their resistance to bacterial pathogens by increasing leaf alkaloid concentrations and by synthesizing tannins to bind to bacterial enzymes within plant tissues.

The dangling words “within plant tissues” are confusing. Does “within” refer to where tannins are synthesized or to where the enzymes are? The message to stress is not where it happens but that tannins bind to bacterial enzymes.

“Plants can increase their resistance to bacterial pathogens by increasing leaf alkaloid concentrations and by synthesizing tannins to bind to bacterial enzymes.”

The following suffers from a buried stress, but this one can’t be solved by deleting the trailing words; the sentence would make no sense if you did that.

Example 12.9
The data did not support our initial hypothesis, as no clear trend in reaction rate with pH was observed.

So what is the problem here? The second clause is supposed to illustrate and support the initial argument. But the important information is the absence of a
trend in reaction rate, so that should be stressed. As written, though, the stress is on "was observed"; the information about reaction rate is buried inside the sentence. Rewrite this to stress the reaction rate response:

"The data did not support our initial hypothesis, as there was no clear trend in reaction rate with pH."

This strengthens the action by focusing on the trend and not on its observation, and improves subject–verb connection, moving the verb to the front of the clause, "as there was."

Possibly the authors thought it important to imply some uncertainty by emphasizing that they didn't observe a trend, rather than to state categorically that there wasn't one. In that case, it would be better to rewrite the sentence this way:

"The data did not support our initial hypothesis, as we did not observe a clear trend in reaction rate with pH."

This puts the important information in the stress and moves the point about observation into the middle of the sentence, the 3-position in the 2–3–1 rule of emphasis. This leaves the qualification in place without making it the point of the sentence.

Many sentences pose even more complex problems. In some, both the topic and stress are buried. That's probably not uncommon in longer sentences, especially those written by developing writers. Example 12.10 offers an example.

Example 12.10
The qualitative agreement between caribou's preference for feeding on young leaves and the trend for protein to decline with leaf age supports the hypothesis that caribou migration is driven by the patterns of leaf-out and maturation spatially and temporally through their home range, rather than by weather.

This is a long, complex, and confusing sentence, but it's a simple idea: caribou migrate to follow the availability of high-quality, nutritious food. We should be able to state a simple idea simply.

Step 1: Fix the topic. Right now the grammatical subject takes 21 words—everything before "supports"; that's way too long and complex. The point is that caribou prefer young leaves, but that is in the middle of the opening clause and is weakly stated. The authors were suggesting that caribou like young leaves because they are protein-rich, but were trying to leave open the possibility that other factors contribute to that preference. They were trying to be careful, but by trying too hard and doing it badly, they ended up being confusing.

To fix this sentence, let's make the topic caribou's food preference: young leaves that are rich in protein. Let's do it in fewer than 20 words: "Caribou prefer to feed on young, protein-rich leaves . . ." This condenses the opening to a simple, nine-word clause that has a one-word topic immediately followed by a verb.
It even leaves causality open; it says that the leaves caribou like are protein-rich, but doesn’t specify that is why they like them. Here, we say more by saying less, using structure instead of words to carry the message. It is easy to write yourself into a corner by over-explaining.

**Step 2: Fix the stress.** In the original version the stress is “weather.” It should be the argument that caribou follow food: “… the spatial and temporal patterns of leaf-out and maturation.”

**Step 3: Finish.** Having unburied both topic and stress, any additional information can be packaged into the middle. The complete sentence now reads:

“Caribou prefer to feed on young, protein-rich leaves, supporting the hypothesis that migration is not driven by weather but by the spatial and temporal patterns of leaf-out and maturation.”

This sentence is now much clearer, and not just because it’s shorter. The topic-action-stress is tighter, giving it a better structure. We got there by following a few simple guidelines:

1. The topic should be short and clear.
2. The main verb should follow it immediately.
3. The key message should come at the stress.

These apply to individual clauses as well as to the sentence as a whole. Remember the hierarchical structure of story arcs. The final sentence of example 12.10 now has three clauses, each of which is tight and clear.

### 12.6. LONG SENTENCES

Most books on writing argue that short sentences are easier to read than long ones. They aren’t wrong, but that is one of the simplifications you should unlearn. The example from Winston Churchill was 141 words long and was neither short nor bad writing—a crime few would dare accuse Churchill of.

Good, clear sentences can be short or long, and the best writers use a mixture of both. The key to writing a good long sentence is holding together the structure, but straight OCAR won’t work. If readers have to wait to the end of the sentence to get the point, they will get lost. To write a good long sentence, you need to use an LD structure: make the key point in a short initial main clause, and then add others that add depth and nuance. This is what Roy Peter Clark describes as a “right opening sentence.” Even though we lean toward short sentences in science writing, it’s a useful skill to be able to craft a clean long one. For example, I fixed the subject–verb connection in example 12.4 by giving it an LD structure—I made the first clause tell the story and added the elaboration in a subordinate clause.

Here’s an example of a right-opening sentence from a paper that reconstructed the historical climate of east Africa by analyzing the past level of Lake Tanganyika.
Example 12.11
At the beginning of the second millennium AD, lake level at Lake Tanganyika fell and remained relatively low during the period from \( \sim 1050 - 1250 \) AD, which corresponds to the timing of the MWP [Medieval Warm Period] in many locales, albeit with a later onset than in some areas.\(^1\)

This sentence is long (more than 40 words), with a complex multiclausal structure, but the story is simple and clear: Lake Tanganyika was low for several hundred years after 1000 A.D. The opening clause sets the stage for the main message, "Lake Tanganyika fell." *Fell* is a powerful verb that immediately follows the subject. From there, the authors added additional clauses that created extra dimensions. The sentence uses a right-opening LD design. It sketches in the main story and then colors in the picture, essentially building and then growing a schema. Although long, this sentence feels simple because its structure works.

Consider what this sentence would look like if we wrote it to put the key action (the lake fell) in the stress of the overall sentence:

*"During the early part of the second millennium AD, from \( \sim 1050 - 1250 \) AD, a period corresponding to the timing of the MWP in many locales, albeit with a later onset than in some, lake level at Lake Tanganyika fell and remained relatively low."*

This is much harder. As readers work their way through this sentence, they are asking themselves "Who’s this story about?" or "What’s the point?" They would have no old-information framework on which to hang the information about timing, and so they would lose the thread. Get to the topic quickly, then to the action, and then add nuance if needed.

Here’s another example of a long sentence that uses the right-opening approach to tell a story about two GTPase proteins.

Example 12.12
We focused on two members of this family: Rab5, which controls transport from the plasma membrane to the early endosome and regulates the dynamics of early endosome fusion, and Rab7, which governs membrane flux into and out of late endosomes.\(^2\)

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This sentence reads easily because the authors structured it carefully. Their first two words are a short subject and an action verb: “We focused.” Then they hit us with critical information in the stress of the opening clause; they focused on “two members of this family.” That clause fully framed the story and the colon suggests that the authors will follow up by describing each member, which they do. First they name Rab5 and then describe it, and then they come back to Rab7 and describe it. This created a sentence with a doubly branched, right-opening structure. That sounds (but doesn’t feel) complicated; it worked because the authors held the structure together when it easily could have fallen apart.

As you can see from the examples, the secret to writing strong sentences is the same as for writing strong papers and paragraphs: make the OCAR elements clear and put them in their right places. Develop story elements into coherent arcs placed in series. Find the topic, make it the subject, and move it toward the beginning of the sentence. Find the action verb and connect it closely to the subject. Find the stress and move it to the end of the main clause. If you have additional material to add, move it to the right so that it modifies, rather than intrudes in, the main story. By doing so, you should be able to take even painfully confusing and complex sentences and make them tight, clear, and easy to read.

EXERCISES

12.1. Evaluate published papers

Pick sentences from several of the paragraphs you analyzed for the exercises in chapter 11. Evaluate what the authors chose to put at the topic and stress positions. Were they good choices? If the authors used more complex sentence structures, did they maintain strong subject–verb connection? If there are sentences that are poorly structured, can you rewrite them to make them clearer?

12.2. Write a short article

Go through every sentence in your article and examine sentence structure. Have you chosen the right topic and stress? Have you ensured tight subject–verb connection? Rewrite them, if necessary, to strengthen them.

12.3. Write new sentences

A. I argued that taking three elements allows you to create six possible stories. Take the elements I used in example 12.2 (viruses, 1989, and biological entities in the sea) and write the three that I did not include.
B. Take the following pieces of information to write three different sentences with three different stories: benzene, cancer, groundwater.
12.4. Revise the following sentences to strengthen them

A. Due to uncertainties resulting from interferences in the X-ray microanalysis, it remains unclear what the crystalline nature of kryptonite is.

B. By reducing diffusion and increasing physiological stress, drought reduces soil microbial activity and causes a build-up of biodegradable C that is rapidly respired upon rewetting.