"Writing Science", by Joshua Schimel

Chapter 2. Science writing as storytelling

Data → Information → Knowledge → Understanding

Key aspects of effective storytelling: content, structure, and language.

Chapter 3. Making a story sticky

Six factors that make an idea sticky:

- Simple: strip an idea down to its core + use the use the right schema for your audience;
- Unexpected: novel;
- Concrete: at the top of the ladder are the widest abstractions—the simple ideas that motivate science. The bottom are the physical facts—the actual data we collect. Use examples to ground concepts in the concrete;
- Credible;
- Emotional: curiosity and excitement;
- Stories: as you discuss your data and ideas, find units that you can package into coherent modules.

Chapter 4. Story structure

The four core story structures:

- OCAR: Opening (Whom is your story about? Who are the characters? Where does it take place? What do you need to understand about the situation to follow the story? What is the larger problem you are addressing) + Challenge (What do your characters need to accomplish? What specific question do you propose to answer)? + Action (What happens to address the challenge?) + Resolution (How have the characters and their world changed as a result of their action? What did you learn from your work?);

- ABDCE: Action (Start with a dramatic action to immediately engage readers and entice them to keep reading) + Background (Fill readers in on the characters and setting so they can understand the story as it develops) + Development (Follow the action as the story develops to the climax) + Climax (Bring all the threads of the story together and address them) + Ending (What happened to the characters after the climax?);

- LD: this is an ABDCE structure with a more front-loaded story, useful for an audience that is impatient about the resolution. This is known as inverted pyramid or

Lead/Development. In this structure, the lead collapses the opening, challenge, and resolution into a single short section;

- LDR: somewhat in between ABDCE and LD.

So, in summary:

- OCAR: slowest—take your time working into the story;
- ABDCE: faster—get right into action;
- LDR: faster yet—but people will read to the end;
- LD: fastest—the whole story is up front.

Mapping OCAR into IMRaD (Introduction, Materials and Methods, Results, and Discussion):

- Introduction:
    - Opening (This is typically the first paragraph that introduces the larger problem the paper is targeting. What is the context, and what are the characters we are studying)?
    - Background (What information does the reader need to understand the specific work the authors did, why is it important, and what it will contribute to the larger issue? This is an extension of the Opening, as it flashes out introducing the characters)
    - Challenge (What are the specific hypothesis/questions/goals of the current work?)

- Materials and Methods: This begins the action—what did you do?

- Results: This continues the action by describing your findings;

- Discussion: This develops to the climax and the resolution. What did it all mean, and what have you learned? It often ends with a conclusions subsection that is the resolution.

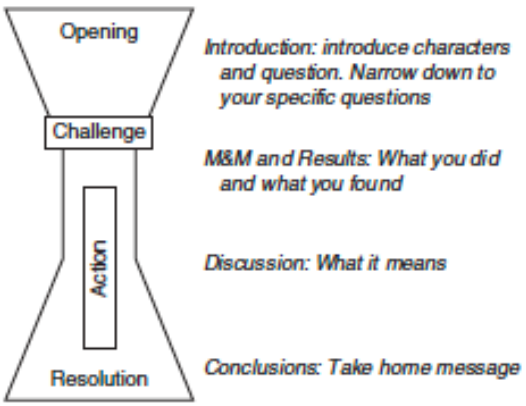

Figure 1. The hourglass structure of a paper. It starts wide with the opening, narrows with the challenge and action, and widens back out again at the resolution.

Chapter 5. The Opening

The goal here is to identify the problem that drives the research, introduce the characters, and target the audience.

Common problems in bad openings: misdirection and no direction. The latter often happens when the opening is used to explain a widely held schema.

Two-step opening for a broader audience:

- Open with an issue that engages the target audience;
- Then, modulate the opening to the schema you want work with;
- This can help for proposals, where the review panels comprise individuals from different disciplines.

How wide should the opening be?

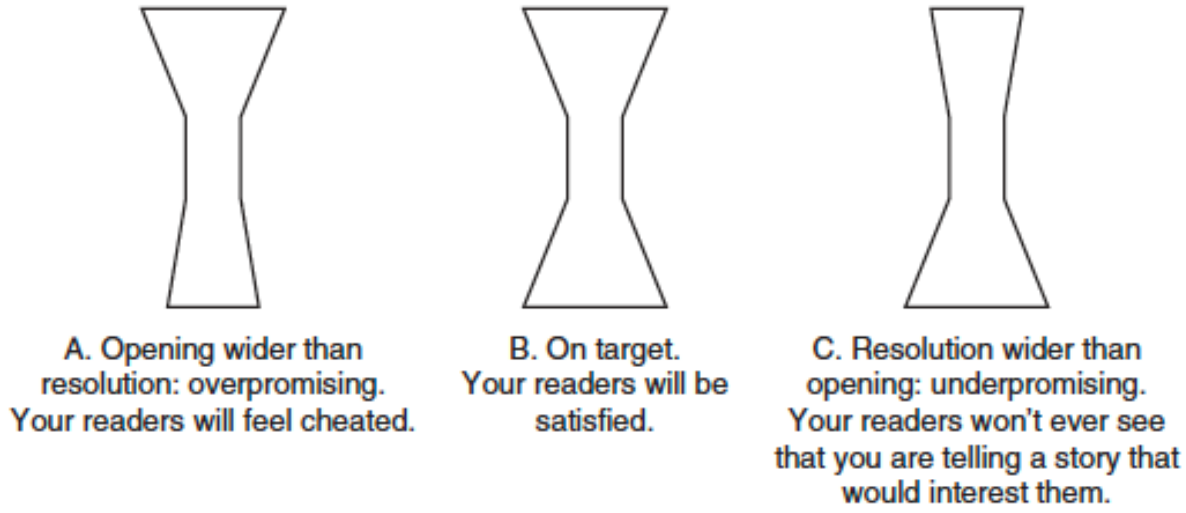

Figure 2. Matching the opening to the resolution.

Chapter 6. The Funnel: Connecting O and C

The main body of the Introduction must connect Opening (the large problem) and Challenge (specific questions). It forms the funnel in the hourglass; it narrows the focus and leads readers from the general to the specific, drawing them along the story and framing in the knowledge gap. This is where you build that to make progress on the large problem, you must answer the specific question.

Bad Introductions:

- Fail to identify the problem → example: "~~little is known~~" vs "sources are not clearly defined";
- Offering a solution before defining the problem.

Introduction vs literature review:

- Literature review builds solid walls (describing knowledge), whereas an Introduction focuses on the hole in the wall (describing ignorance);
- An Introduction focuses on the publications that defined the edges, rather than the core of knowledge;
- On the use of citations: "Smith (2003) found X" vs "X occurs (Smith 2003)" → with the former is the researcher—rather than the research—that we are telling about.

Chapter 7. The Challenge

This starts with the question that drove the research. From the question, we sometimes formulate a hypothesis and we usually state specific objectives, which describe the information we will present. The question is the core of it all.

Question versus Objectives: never assume that the question is obvious. Focusing on the objectives only doesn't engage SUCCESS.

After the question, it is good practice to lay out the research approach. Some papers also provide a brief overview of the Conclusions.

Good challenges: "To learn X, we did Y."

Bad challenges: A challenge is ineffective if it doesn't concretely state the question (or hypothesis) or if it gives the reader the wrong impression about what it is.

Chapter 8. The Action

Methods: To serve the needs of all possible readers, the best way to describe a method is use a Lead/Development (LD) structure, providing an initial overview for all and then the details for those who need them.

Results and Discussion: many papers separate Results and Discussion, while other combine them. However you choose to organize the material, that choice should be grounded in two core principles of writing and science:

- Make the reader's job easy;
- Readers must be able to distinguish what you found from what you think. There are three types of material in the paper:
    - Data → your actual results;
    - Inference → clear and robust interpretation of the data (so obvious that we sometimes treat as data);
    - Interpretation → thoughts, hypothesis, and speculation about what the results may mean for the larger problem you identified.

A couple of suggestions on presenting data:

- Most results call for an LD structure, in which you first frame the major point or patterns and then flash out the details;
- When you tell the story through the lens of statistics, by focusing on the statistical analysis rather than the data, you steal both clarity and power from the story;
- By focusing on the data, being concrete, and showing the whole story, you effectively and honestly present your results and allow the reader to evaluate them, fulfilling core principles of both writing and science.

Discussion: this is where you present your thoughts and interpretations, where you answer the questions you posed in the challenge, and where you show your contribution to the larger problem framed in the opening. It needs to build towards the resolution of the paper, but as a section it should develop a story of its own. Two common strategies:

- OCAR → opening by reminding readers of the challenge and questions, and then working through the resolution;
- LDR → opening the Discussion by framing the Conclusions—what they showed—and then using the rest of the Discussion to support that argument, building to the overall resolution.

Chapter 9. The Resolution

A good resolution steps backward through OCAR: (1) it reiterates the action, (2) answers the questions raised in the challenge, and (3) demonstrates how those answers contribute to the larger problem—bring the story back to the issue the paper opened with.

Concluding with a question: make the question concrete, and be clear about how it grew from your work—you didn't fail to fill in one knowledge gap but identified a new one.

There are different ways to write a bad resolution:

- Weak: authors synopsize their results and tell they are important, but don't clarify why—they don't answer the questions they were asking and don't synthesize their information into knowledge;
- Distracting: conclude with ideas that should be in the Introduction or is already in textbooks and that neither synopsizes nor synthesizes the results. Another way of being distracting is to introduce new information at the end;
- Undermining your Conclusions. E.g., "more research is needed to clarify our findings" …
- How to fix a bad resolution:
    - Synopsize the results;
    - Synthesize those results—show how they answer your question;
    - Show is what this contributes to solving the larger problem.

Note: good resolutions are very important in proposals!

Chapter 10. Internal Structure

Subsections should be written to package complete ideas—that is, form story arcs of their on. Going further, each subsection is built of units finer still (paragraphs, sentences, and clauses within a sentence). Each should tell its own story and form an arc → A story has a hierarchical structure, with small arcs nested within larger ones, ultimately creating the whole. Arc structure is effective because beginnings and ends are power positions.

Use subheads, paragraph breaks, and flag words (e.g., "however" and "consequently") to guide the reader through story arcs and arguments. Individual arcs integrate to form the overall paper: watching your arcs and ensuring they are coherent and connected gives structure and flow to your writing.

Key questions to ask when reviewing a subsection:

- Does it have an OCAR structure?
- Does each unit make a clear single point?
- When several paragraphs together form a section, are the linkages among them clear?
- Has every extraneous thought that breaks the serial arc structure been removed?
- When you introduce a topic, do you resolve that discussion before introducing a new topic?
- Is every major unit of the work defined by either a subhead or clear opening text?

Chapter 11. Paragraphs

Point-first paragraphs:

- The simplest-form of point-first paragraph is the classical TS-D structure—a paragraph has a Topic Sentence that makes a point, which the rest of the paragraph Develops;
- TS-D should dominate your writing;
- An alternative form of point-first paragraph is to use a more extended LD structure in which the lead takes several sentences.

Point-last paragraphs:

- Sometimes, 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;
- With an OCAR structure, 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.

Suggestions:

- Writing should be dominated by point-first paragraphs;
- The complex structures appear at critical story points—openings, resolutions, transitions;
- Long paragraphs benefit from a resolution to tie them together and remind the reader of the point—they lean toward LDR or OCAR.
- The key to writing good paragraphs is to identify (1) who the story is about, (2) your point, and (3) where you should make it

Chapter 12. Sentences

OCAR principles:

- To transform a sentence into a story, you need to see those grammatical units as story units that carry the OCAR functions:
    - Opening: who is the story about → SUBJECT
    - Challenge/action: what happened? → VERB
    - Resolution: what was its outcome? → OBJECT
- The OCAR elements allow us to establish a framework and the place new information into it—allowing readers to process each piece of information in turn.

Opening: The Topic. whatever you put at the beginning of a sentence, readers interpret it 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.

Resolution: The Stress:

- Use the power of the stress by putting key words here—the main message and new ideas or terms;
- Sometimes, there are dangling words after the real stress. To strengthen those 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.

Putting topic and stress together: Shifting information between topic and stress changes how readers interpret it (see Example 12.2).

Subject-verb connection: the longer the gap between actor and action, the duller and more confusing a sentence becomes. The verb (or action) should immediately follow the sentence's subject.

Unburying the stress: some useful suggestions:

- Fix the topic and stress;
- Finish: having unburied both topic and stress, any additional information can be packaged in the middle.

Long sentences: to write a long sentence, you need to use an LD structure: make the key point is a short initial main clause, and then add others that add depth and nuance.

Chapter 13. Flow

Flow within a paragraph:

- Approach 1: all sentences are on the same team—dealing with a coherent theme and working together for a common goal;
    - This may need an LD structure for the paragraph.
- Approach 2: write sentences so the team forms a relay—each passes a baton at the transition, allowing an idea to flow cleanly from start to finish.
    - In this case, do not link topic to topic, as it creates a list of statements about a thing. Link stress-to-topic so as to create a story.

Linking paragraphs within a section: to make them connect, you need to use the same stress-topic, resolution-opening strategies adopted for individual sentences.

Chapter 14. Energizing Writing

Active versus passive voice. The active voice is clear, concise, and direct. It should dominate your writing. So, when to use the passive voice?

- Controlling perspective: being able to shift a sentence's topic between actor and acted-on is critical for developing effective story arcs and flow.
- Hiding the actor: sometimes we don't want to or need to name the actor. The passive voice can do this (e.g., "It has been argued that …").

Fuzzy verbs. Verbs that show action make writing clear. Verbs that mask the action are weak and can be confusing. Fuzzy verbs say that something happened but not what; action verbs show you what.

Table 14.1. FUZZY VERBS VERSUS ACTION VERBS

Fuzzy Verbs (Weak)			
Occur	Facilitate	Conduct	Implement
Affect	Perform		
Action Verbs (Strong)			
Modify	Increase	React	Accelerate
Accomplish	Decrease	Inhibit	Migrate
Create	Invade	Disrupt	

Figure 3. Fuzzy verbs vs. action verbs.

Nominalizations, that is, the process of turning a verb into a noun. Another form of nominalization is converting an adjective into a noun.

Some suggestions:

- Find the action in your sentences, put it in your verbs, and put them early in your sentences;
- Sometimes a passive voice or nominalization will strengthen your writing. Use them wisely.

Chapter 15. Words

Jargon. Let's begin with a couple of definitions:

- Jargon: (A) A term that refers to a schema the reader does not hold. (B) A term for which there is an adequate plain language equivalent.
- Technical term: (A) A term that refers to a schema the reader does hold. (B) A term for which either there is no plain language equivalent or where using it would be confusing.

A general pattern for using technical terms in different places in a sentence:

- Beginning: you assume that every reader knows and understand the term. You run the risk of it appearing to be jargon if they don't;
- End: You define a new term for everyone. You run the risk of appearing ignorant if it is already an accepted schema in the field;
- Middle: You assume that most readers know the term. You are also indicating that the term itself isn't critical to your story. You run the risk of people missing the term.

Emotional weight: Academics take words from three main sources:

- Anglo-Saxon Old English (the peasants' language);
- Norman-French (the nobles');

- Latin (the scholars').

As a guideline, words ending in *–ate* are derived from Latin and sound heavy and full of themselves. Words ending in *–ion* are French. If you are not sure about a word, consult the *Oxford English Dictionary*. It is worth noting that all fuzzy verbs are French or Latin. That is not surprising—common language is concrete, so when scholars reached for fuzzy verbs, they reached for Latin.

Prepositional phrases versus compound nouns: A prepositional phrase, such as "rate of reaction" is made up of an object (reaction) and a modifier (rate) tied together with a preposition (of, in, on, etc.). The alternative is to use an expression such as "reaction rate" in which one noun directly modifies the other: this is a compound noun. Prepositional phrases are usually nasty—longer and clunker than the compound noun. They also have a strange attraction for nominalizations and passive verbs.

So, when to leave a prepositional phrase? Noun trains are worse than prepositional phrases. You can break them up into manageable pieces by using the occasional preposition. One final way you can use prepositional phrases is to control which words lands in a sentence stress' position.

Chapter 16. Condensing

Key targets for condensing:

- Redundancies →
    - Sometimes we use several words where one does all the work that needs doing;
    - Often, we repeat ideas in multiple sentences, in which case collapsing redundancy means collapsing sentences together.

- Obvious →
    - Obvious is kin to redundant, as both encompass words that offer no useful information. The difference is that whereas redundancies duplicate information within a passage, obvious ideas are well known or implied—and so don't need to be said anywhere.

- Modifiers: adjectives and adverbs →
    - Good words don't need modifying: strong, clear nouns and verbs give writing power, a power you can't match by decorating weak words;
    - Good modifiers: some modifiers, rather than amplifying, alter the meaning of their referent. These are powerful (e.g., preliminary results vs. ~~final~~ results).

- Metadiscourse → Some metadiscourse (e.g., "we found that", "we argue that") is necessary to develop the flow of an argument, but it can be obvious or redundant.

- Verbosity → This is the sum of multiple types of filler, creating sentences that rumble on endlessly.

Chapter 17. Putting it all together: real editing

Key steps for a successful editing process:

- Structure: get the structure of the story into shape;
- Clarity: ensure that your ideas are clear and concrete;
- Flow: make the ideas flow, linking one thought to the next;
- Language: make it sound good.

Chapter 18. Dealing with limitations

Deal with limitations as early as possible, get that discussion out of the way, and then get on with developing a strong story. Constrain your conclusions to fit within the limitations, but end with a "yes" → use the "but, yes" strategy.

Depending on the issues, you may need to address limitations in any part of the paper or proposal; as a rule, earlier is better:

- Introduction → in the Introduction, frame the knowledge gap you will actually fill—set up expectations you can deliver on;

- Materials and Methods → When limitations relate to experimental details or analytical methods, discuss them immediately to lay any concerns to rest. You are much better off if you can address readers' concerns as soon as they arise. Doing this is even more vital in proposals.

- Discussion → When constraints go beyond the methodological details, and thus affect how you interpret the data, you must address them in the Discussion. Most of the time, you should avoid the power positions of the Discussion's opening and resolution.

    - In rare occasions, it is necessary to raise constraints in power positions. For example, you may need to do it when experimental approaches are novel or unusual.
    - You should never make limitations *the* Conclusion, but sometimes you may need to mention them *within* the Conclusions. In such cases, you need a tightly defined "but, yes" structure to frame the limitations as quickly as possible and then push on to the conclusions—what you learned.