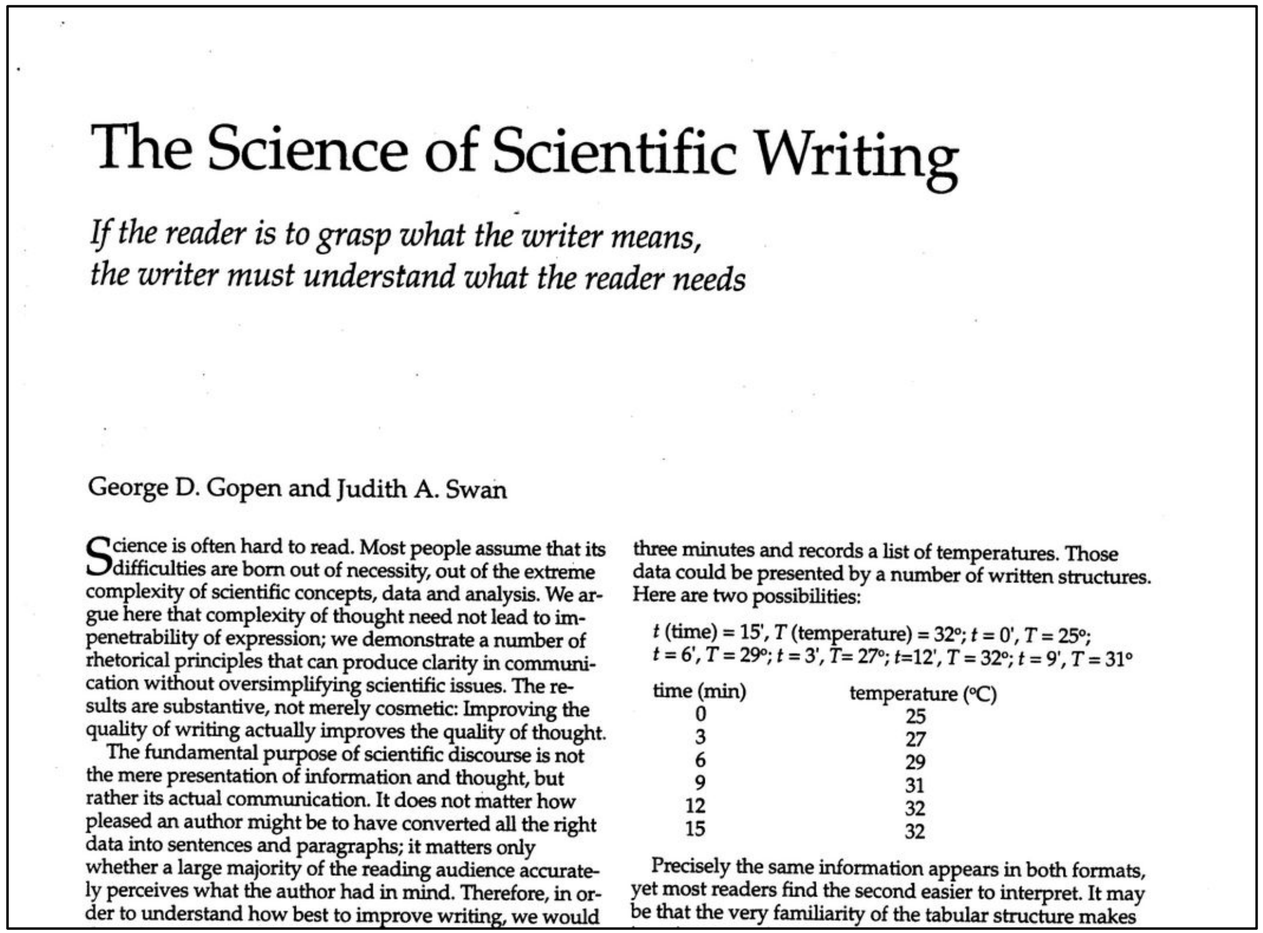
Communicating Ideas: Writing

4/18/25

“The fundamental purpose of scientific discourse is not the mere presentation of information and thought, but rather its actual communication.

–Gopen and Swan (1990)



The Science of Scientific Writing

If the reader is to grasp what the writer means,
the writer must understand what the reader needs

George D. Gopen and Judith A. Swan

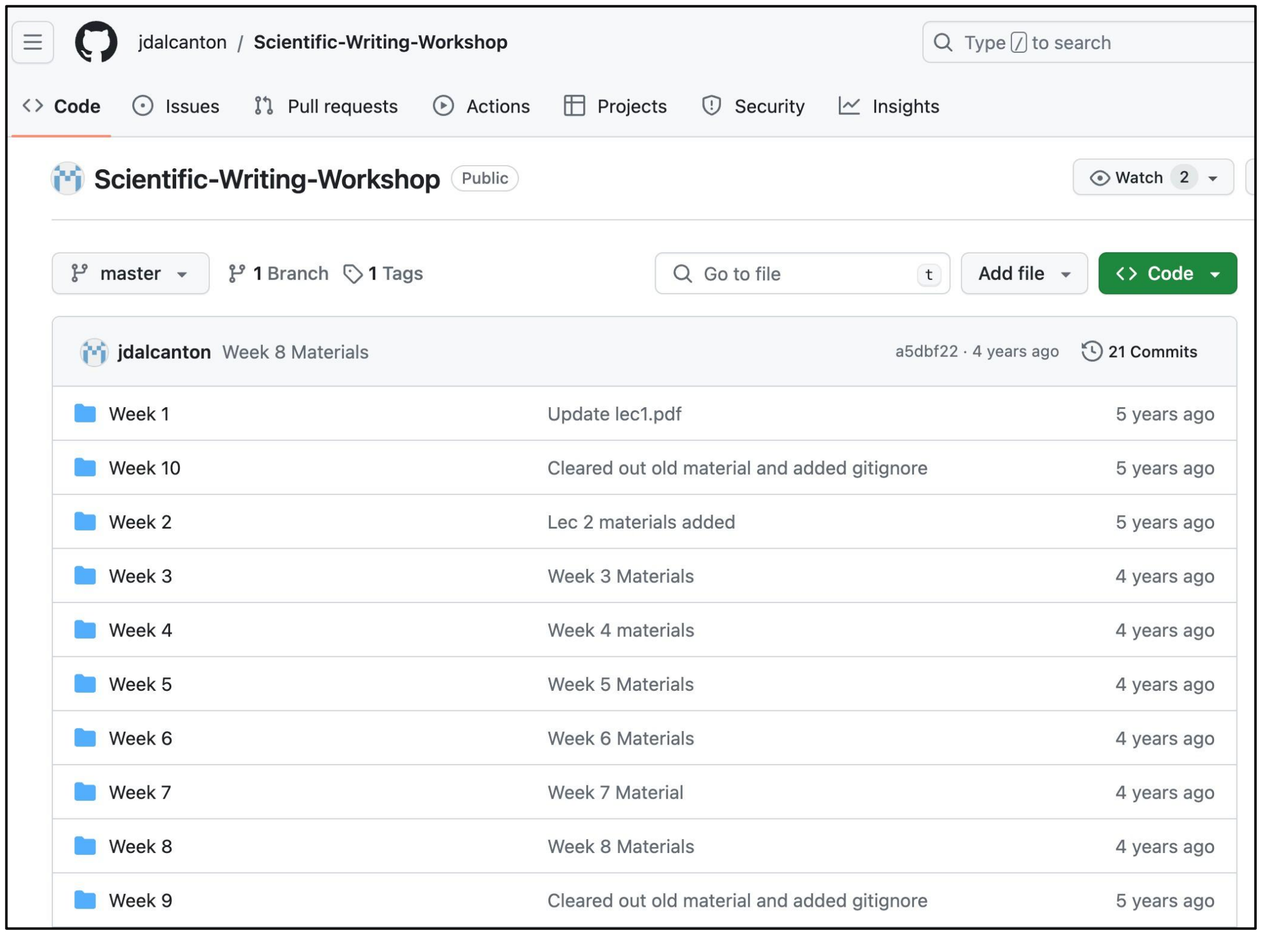
Science is often hard to read. Most people assume that its difficulties are born out of necessity, out of the extreme complexity of scientific concepts, data and analysis. We argue here that complexity of thought need not lead to impenetrability of expression; we demonstrate a number of rhetorical principles that can produce clarity in communication without oversimplifying scientific issues. The results are substantive, not merely cosmetic: Improving the quality of writing actually improves the quality of thought.

The fundamental purpose of scientific discourse is not the mere presentation of information and thought, but rather its actual communication. It does not matter how pleased an author might be to have converted all the right data into sentences and paragraphs; it matters only whether a large majority of the reading audience accurately perceives what the author had in mind. Therefore, in order to understand how best to improve writing, we would three minutes and records a list of temperatures. Those data could be presented by a number of written structures. Here are two possibilities:

t (time) = 15', T (temperature) = 32°; t = 0', T = 25°;
t = 6', T = 29°; t = 3', T = 27°; t=12', T = 32°; t = 9', T = 31°

time (min)	temperature (°C)
0	25
3	27
6	29
9	31
12	32
15	32

Precisely the same information appears in both formats, yet most readers find the second easier to interpret. It may be that the very familiarity of the tabular structure makes



Gopen and Swan, 1990

https://github.com/jdalcanton/Scientific-Writing-Workshop

How is writing the same as giving presentations?

- The goals are the same. Convince the audience that:
  - What you have done is correct
  - What you have done is important

How is writing different from giving presentations?

- “Performance” is not a factor
- No improvisation
- Not as contained in length
- No opportunity for questions

Why?

Good writing makes your science more effective

- Papers are understood
- Your ideas enter public discussion
- Your proposals are accepted

Why?

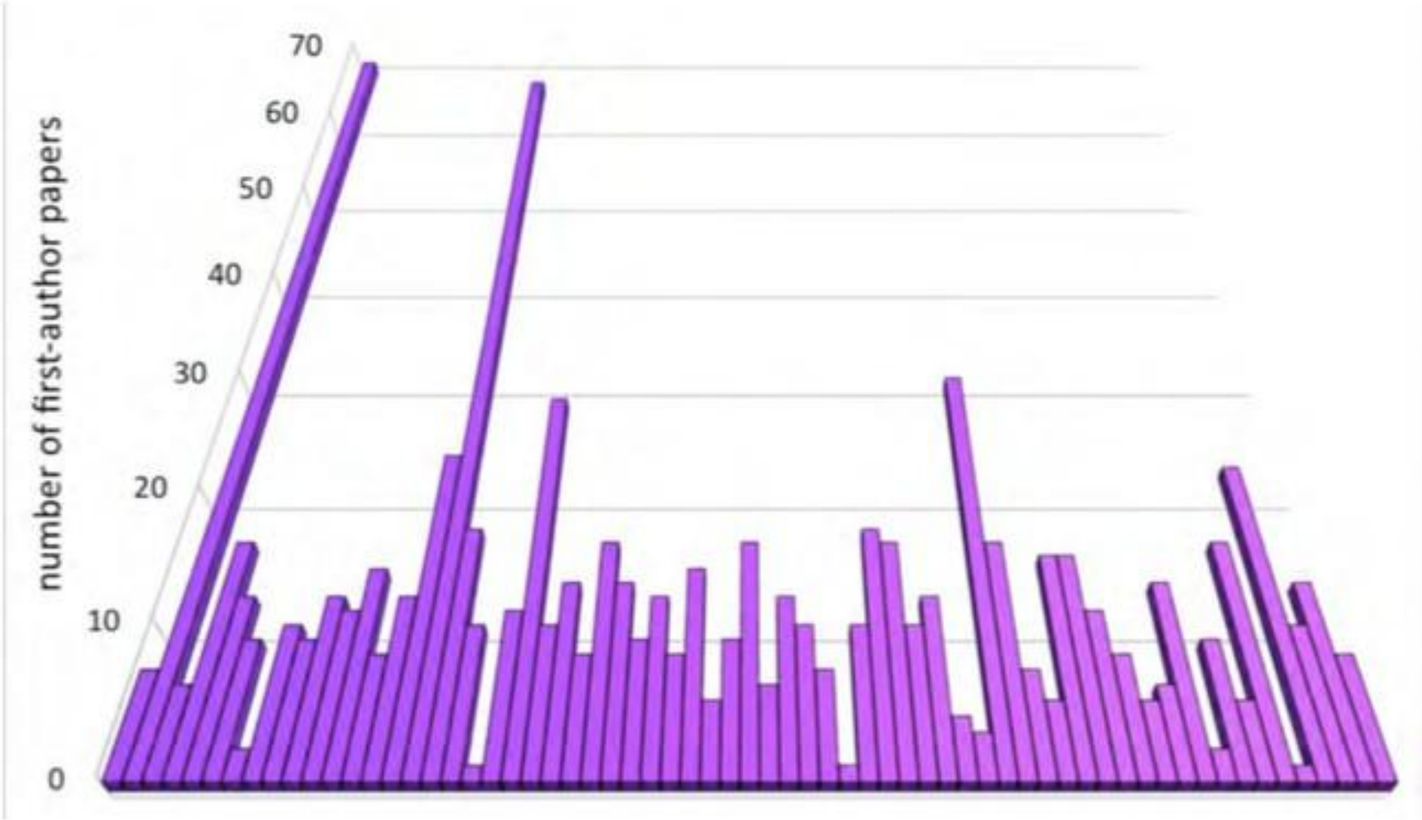
Productive, good writing is rewarded

- Influence
- Resources
- Jobs
- Reputation

of first-author papers of 65 hires into tenure track positions in 2011

Astronomers who got a tenure-track or similar position last year typically had 10 first-author publications in peer-reviewed journals, and some people had many more than that.

Advice: Evidence of scientific leadership is important. It's fine to be part of a large team, but your publication record must also demonstrate your capacity to lead research projects.



Why?

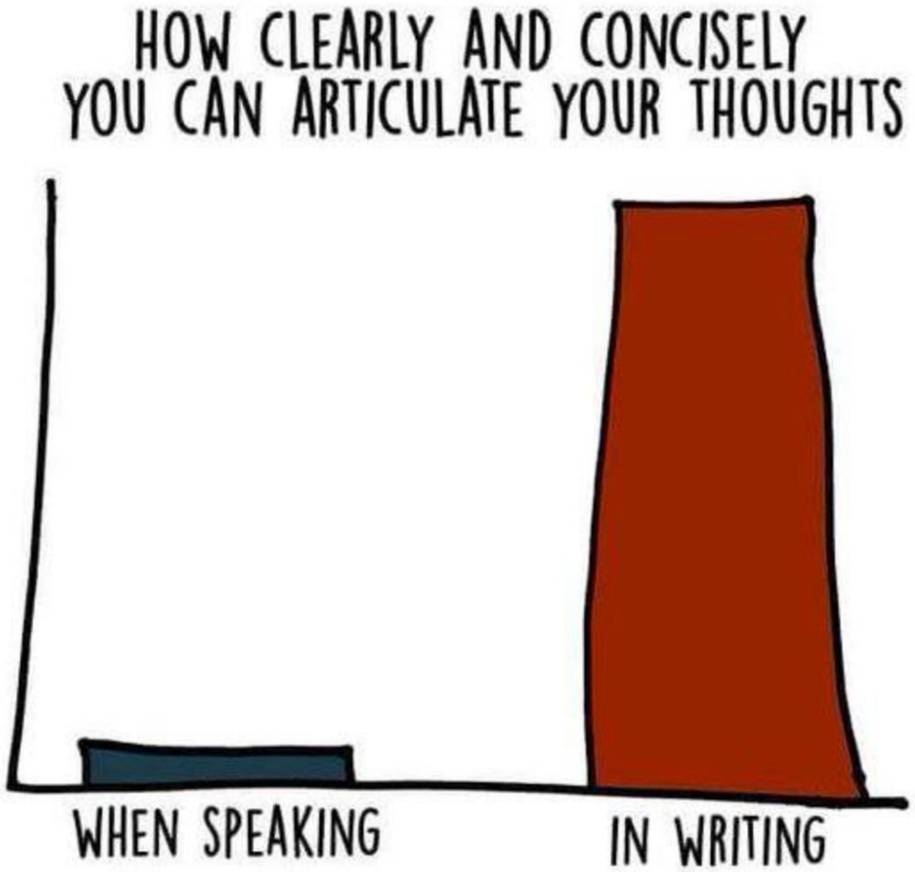
Writing is finishing.

Finishing = free to pursue new science.

Why?

Efficient writing leaves more time for the fun stuff

Telling people your result is never as rigorous as writing it.



Why is writing weighted so heavily?

Writing *is* science

Writing *is* science

https://xkcd.com/568

Writing *is* science

Greg Wilson
@gvwilson

Follow

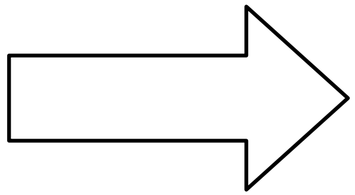
"Writing is nature's way of showing us how sloppy our thinking is." - Leslie Lamport (as true of code as it is of prose)

How less experienced scientists think about writing

Do Science

- Calculations
- Code
- Make Plots

80%



Write Paper

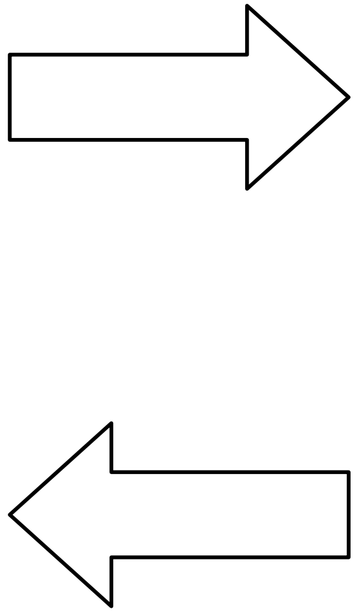
- Write words

20%

How it actually works

"Science"

- Calculations
- Code
- Make Plots



"Write"

- Analyze
- Question
- Evaluate
- Reference
- Feedback
- Write words
- Edit

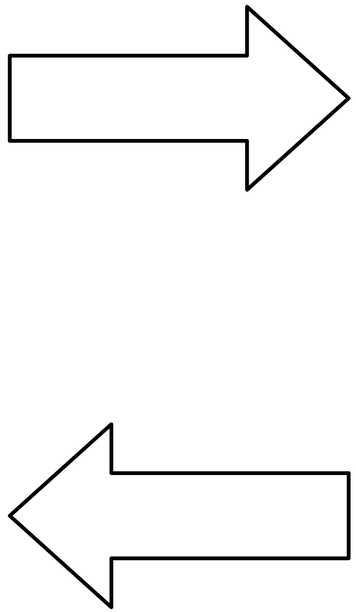
<50%

>50%

You don't really *know*, until you write

"Science"

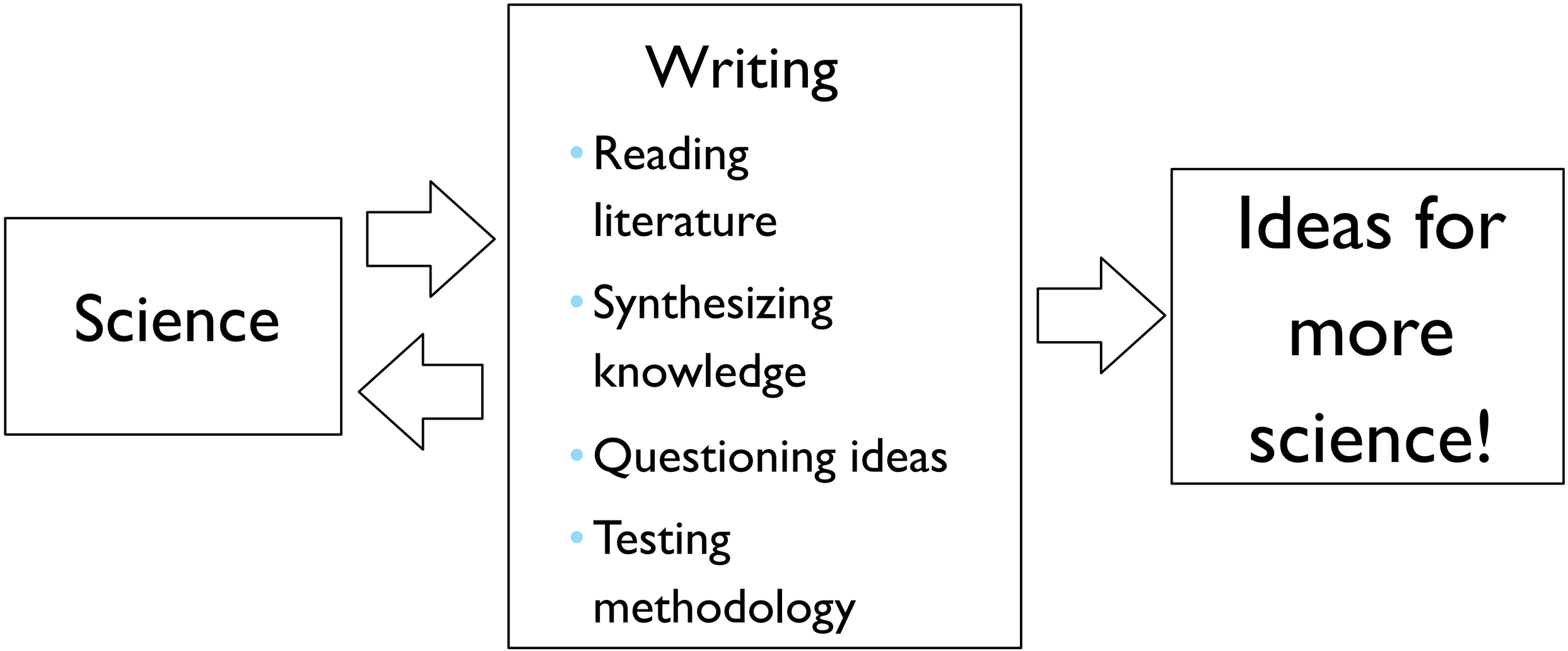
- Calculations
- Code
- Make Plots



"Write"

- Analyze
- Question
- Evaluate
- Reference
- Feedback
- Write words
- Edit

Writing inspires broad thinking



“The act of writing makes you decide what you think is true*”

- Valuable
- Necessary
- *Scaaaaaaaary*

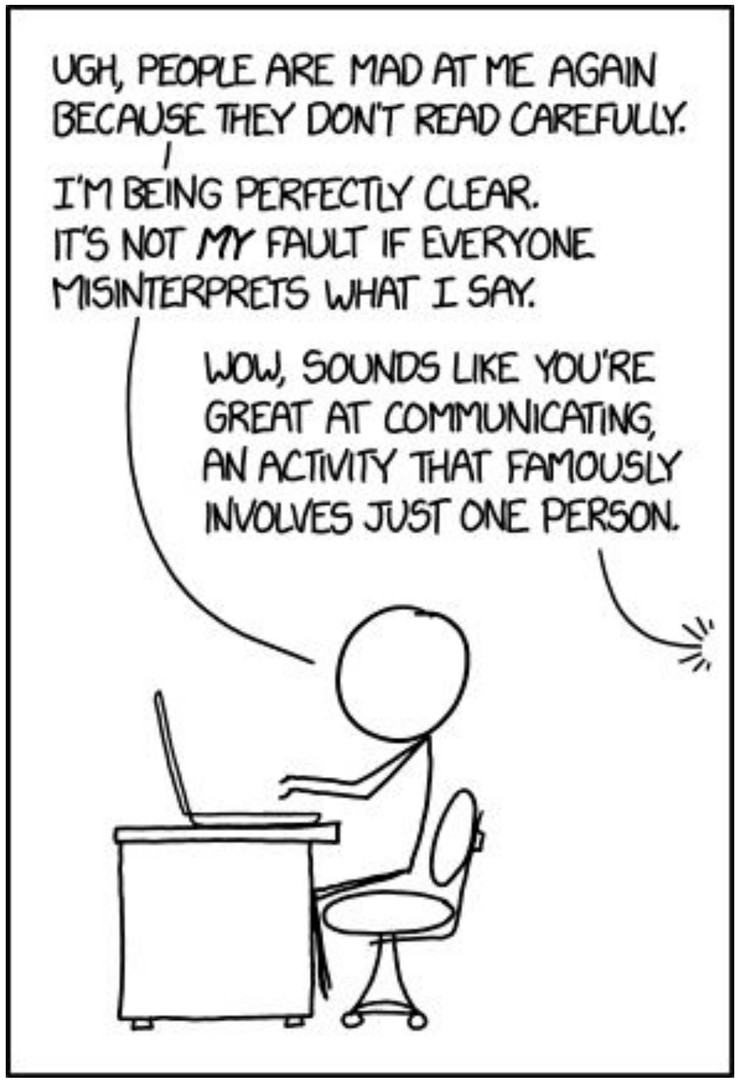
*Kate McIntyre

“The fundamental purpose of scientific discourse is not the mere presentation of information and thought, but rather its actual communication.

…

It matters only whether a large majority of the [audience] accurately perceives what the [scientist] had in mind.”

–Gopen and Swan (1990)



https://xkcd.com/1984

“Science is often hard to read. Most people assume that its difficulties are born out of necessity, out of the extreme complexity of the scientific concepts, data and analysis.”

–Gopen and Swan (1990)

“It matters only whether a large majority of the readers accurately perceives what the author had in mind. …
Therefore, in order to understand how to improve writing, we would do well to understand better how readers go about reading”

–Gopen and Swan
(1990)

What do readers do?

- They interpret!

On the right are three different ways of presenting the same information. Which one is best for the English reader?

t (time) = 15', T (temperature) = 32°; t = 0', T = 25°;
t = 6', T = 29°; t = 3', T = 27°; t = 12', T = 32°; t = 9', T = 31°

time (min)	temperature (°C)
0	25
3	27
6	29
9	31
12	32
15	32

temperature (°C)	time (min)
25	0
27	3
29	6
31	9
32	12
32	15

Information is interpreted more easily and more uniformly if it is placed where most readers expect to find it

What are readers' expectations?

- Subject-verb separation
  - Bad Example: "Kate, who spent several years at NASA where she acquired most of her research experience and led one of the key programs on the new JWST telescope, discovered a new exoplanet last year."

What are readers' expectations?

- Subject-verb separation
- The emphasis of a sentence/paragraph lies at/near the end
  - *"We tend to take a 'mental breath' as we begin to read each new sentence … As we recognize that the sentence is drawing its conclusion, we begin to exhale that mental breath. The exhalation produces a sense of emphasis. Moreover, we delight in being rewarded at the end of a labor with something that makes the ongoing effort worthwhile."* - Gopen and Swan (1990)
  - Bad Example: "Kate discovered a new exoplanet last year, after she had spent several years acquiring research experience at NASA, where she led one of the key programs on the new JWST telescope."

What are readers' expectations?

- Subject-verb separation
- The emphasis of a sentence/paragraph lies at/near the end
- The topic of a sentence lies at the beginning
  - Good example: "NASA hired Kate several years ago and she spent several years there honing her research skills and leading a program on the new JWST telescope before discovering a new exoplanet."

What are readers' expectations?

- Subject-verb separation
- The emphasis of a sentence/paragraph lies at/near the end
- The topic of a sentence lies at the beginning
- Sentences are connected with logical flow
  - In general, beginnings of sentences connect back to "old information" and the emphasis at the end of a sentence presents "new information", which then becomes old information at the beginning of the next sentence

Making sentences better

often means

“Making sentences simpler*”

*simpler = efficient. “What is the most straightforward way to convey this thought?”

Note: this approach is characteristic of writing in American English, which dominates style for written scientific communication

“A writer’s personal style is the sum of all the structural choices that person tends to make when facing the challenge of creating discourse.

…

But for the very reason that writers tend to be consistent in making such choices, they can learn to improve their writing style; they can permanently reverse those habitual structural decisions that mislead or burden readers.”

–Gopen and Swan
(1990)

How to write an abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words "**here we show**" or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

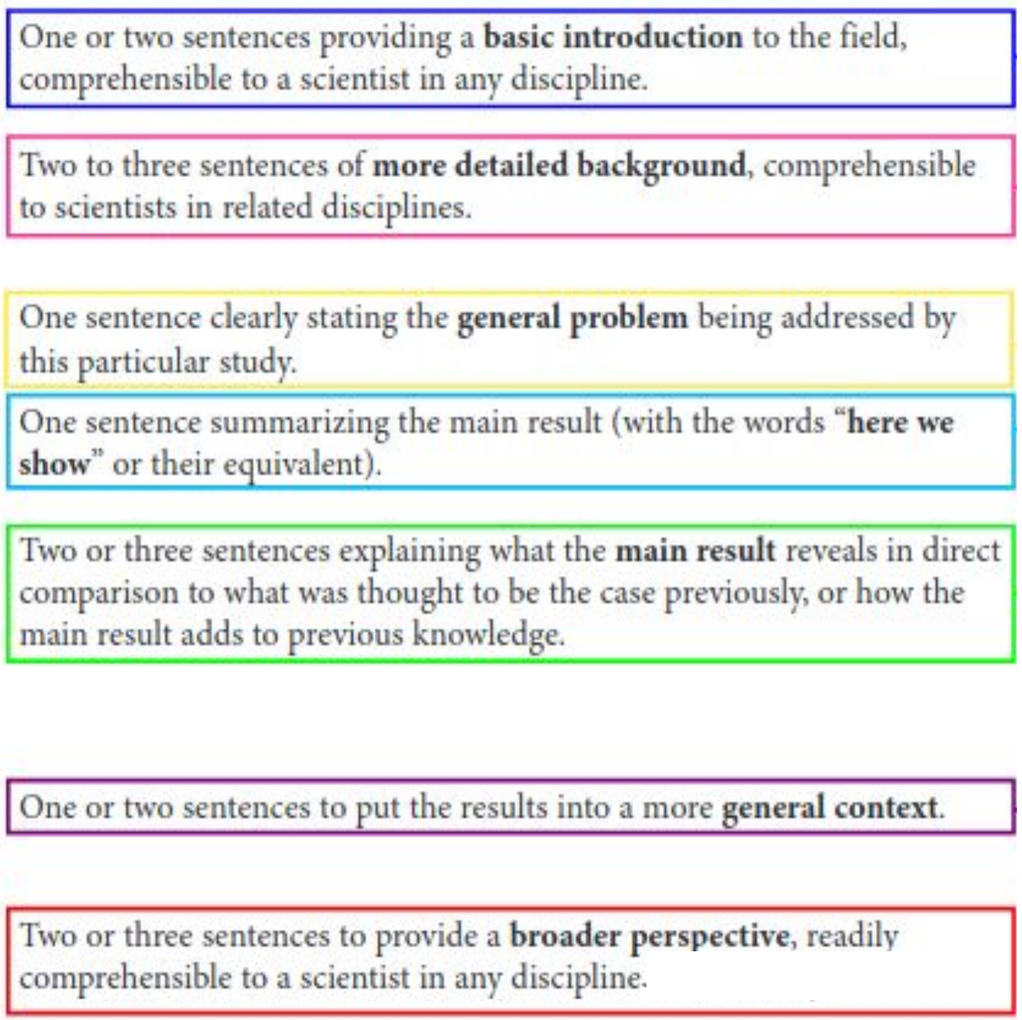
One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Centaurs are small bodies orbiting between Jupiter and Neptune and behave as an intermediate population between trans-Neptunian-belt objects and Jupiter-family comets. As such, their surface composition and evolutionary processes are key to understanding the Solar System's history. However, the mechanisms driving their transformation and the impact of thermal processing on their surfaces remain open questions. Here we examined the surface properties of five Centaurs using the James Webb Space Telescope near-infrared spectrograph reflectance spectra (0.6-5.3 μm). They exhibit considerable diversity in surface composition. Our analysis indicates that Centaurs can be split into two main categories, which is also observed for trans-Neptunian objects: one group has surfaces composed of refractory materials with some water ice, whereas the other is dominated by carbon-based materials. Additionally, two of the five objects have primarily refractory surfaces with minimal volatiles, suggesting a high concentration of primitive, comet-like dust. We suggest that the observed Centaur surfaces reflect their transitional states, as they are shifting from being ice-rich bodies to progressively becoming more dominated by non-volatile materials as they approach the Sun. Such thermal processing may have changed the surface properties of other similar Solar System bodies, like comets, Jupiter trojans and D-type asteroids.

Taken from *Nature Astronomy* **9**, 245–251 (2025)

How to write an abstract (small project edition)



1. 1 sentence to set the stage/introduce general topic/stimulate interest
2. 1-2 sentences to motivate this specific project
3. 1-2 sentence on what you actually did
4. 1-2 sentence describing main results (if available)
5. 1 sentence tying it back to the big picture or reiterating the importance/impact of this project

Source: Leslie Rogers

Your first goal is a *first* draft

Not a complete draft.
Not a polished draft.
Not a perfect draft.

Your first goal is a *first* draft

"I'm writing a first draft and reminding myself that I'm simply shoveling sand into a box so that later I can build castles."

— Shannon Hale

What if I don’t know what I have to say?

There is *always* something you know how to say, so write that.

- What you did.
- Figure captions.
- Describing a plot in the text.
- Where the data came from.

What if I don’t know what I have to say?

Make a plan to use the remaining 7 hours of the day to learn something new to say tomorrow.

- “Calculate the error bar.”
- “Fit the function”.
- “Compare to Paper X’s results.”
- “Test if Y is true”
- “Read up on Topic Y”

When you stop writing…

…*always* have a plan for what you want to write in the next session*.

*And write it down in bold-face/color in the document. Future You will thank you.

Why can’t I write?

http://www.phdcomics.com/comics.php?f=1733

“Why can’t I write?”

You’re not good at it yet.

No one likes to do things they suck at.

“Why can’t I write?”

You don’t know what to say.

“Why can’t I write?”

You don’t know how to say what you want to say.

“Why can’t I write?”

You *thought* you knew how to say what you want to say, but it’s not actually working.

“Why can’t I write?”

You are not prioritizing time to write.

How do I jump start writing?

Set realistic, achievable goals.

Prioritize time to write.

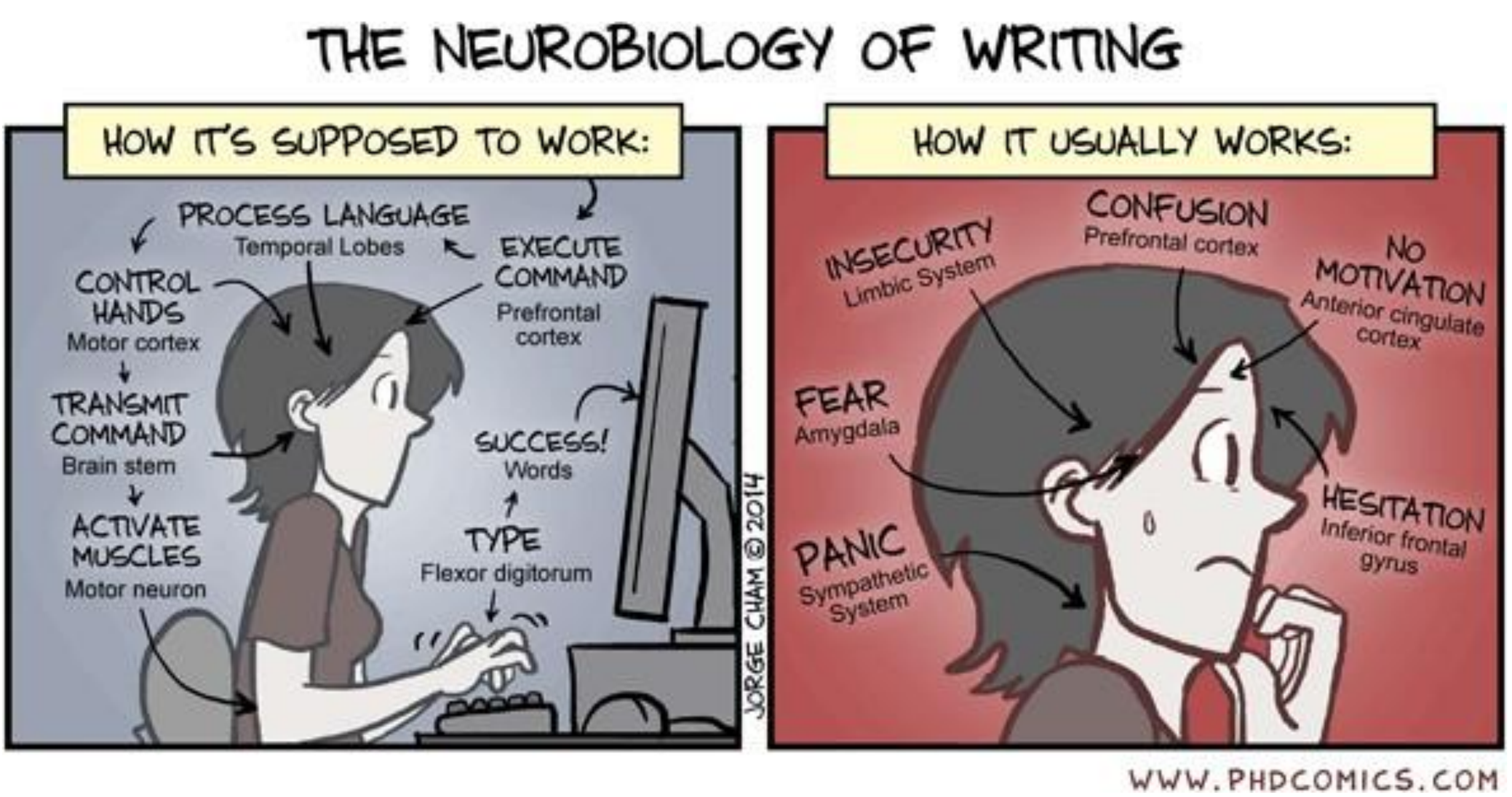
Fact:

If writing is hard for you, you will always avoid it, and it will never get done, and you will always feel bad.

Schedule it so it happens.

“Why can’t I write?”

Emotions.



http://www.phdcomics.com/comics.php?f=1733

Schedule it so it happens.

At what time of day & at what location are you:

Most effective at writing?

Least likely to be interrupted?

Least likely to freak out?

Schedule it so it happens.

Schedule no more than a 1 hour chunk, and don't aim to write more than ~200 words*.

*If you do write more, great! Ride that train! But don't set a goal that sets you up to feel bad.

"You can always edit a bad page. You can't edit a blank page."

— Jodi Picoult