Effective Science Writing

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About Me

Teaching

- Advanced Mathematics

Research

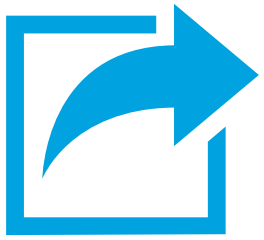
- Dye chemistry
- Computational chemistry
- Physical chemistry
- Co-authored > 80 peer-reviewed research papers

Liu Xiaogang

Writing

- English is my second language → I am not an expert, perhaps a bit more experienced than students.
- English is the second language of many scientists → Simple writing can be effective.
- Writing has no fixed rules → We only provide guidelines.
- There are many ways to write well, and infinite ways to write badly! → Learn good tips & avoid pitfalls

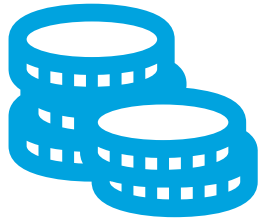
Importance to Your Career



Share your research vision and findings with different audiences

Fast-tracks your career advancement

Achieves recognition of your contributions



Secures funding to support your research efforts

Helps form new collaborations with colleagues

The Importance of Writing Good Papers

Your research does not exist, if you do not publish papers!

Your paper does not exist, if no one reads it!

Three Paths of Academic Writing

Manuscripts

- Technical
- Fellow scientists are primary audience

Our focus today!

Grants

- Technical
- Funding agencies and fellow scientists are primary audiences

Public-facing

- Non-technical
- General public are primary audience, *e.g., news, social media, interviews, press releases*

Outline

What is a paper?

What is the structure of paper?

Three key elements for writing good papers

General advice for writing good papers

What is a Paper?

"A paper is an organized description of hypotheses, data and conclusion, intended to instruct the reader".

Whitesides, *Adv. Mater.* **2004**, *16*, 1375-1377

The goal of scientific writing is persuasion.

- Teach your results to readers
- Convince *skeptical* reviewers (and the scientific community) that you are right!

Scientific writing is not archiving your results.

- Imagine that you are giving a class to readers, and you want to make the class engaging…

The Structure of a Scientific Manuscript

1

Information about manuscript

***Title**, authors and affiliations, **abstract**, keywords, and table of contents graphic*

2

Introduction

Introduce the field, share context, explain the gap, and outline the planned approach, significance

3

Materials and methods

Detail process in sufficient detail that it can be repeated in a separate lab

4

Results and discussion

Describe experiments and report findings, explain meaning of data

5

Conclusion and additional info

Acknowledgment, data and safety statements, COI, supporting information and references

Title: The Abstract of the Abstract

Two types of title:

- Eye-catching (News and Views)
- Descriptive (Research papers)

Pick up the type according to:

- The journals/magazines
- The target audience
- The nature of the article

Ionic glue

Tobias Kraus

News & Views | 06 Sept 2021

Made with manganese

Katja Heinze

News & Views | 06 Sept 2021

Ethylene/ethane separation in a stable hydrogen-bonded organic framework through a gating mechanism

Yisi Yang, Libo Li ... Banglin Chen

Article | 08 Jul 2021

Electrostatic co-assembly of nanoparticles with oppositely charged small molecules into static and dynamic superstructures

Tong Bian, Andrea Gardin ... Rafal Klajn

Article | 06 Sept 2021

Fig 1. Titles of the Sep 2021 issue of *Nature Chemistry*

Abstract: The summary of the entire manuscript

Components of the Abstract

- The **context** of the research
- The **gap/problem** we are facing
- The description of your **methods** and **key results** (be specific)
- The **impact** of your work

Writing tips:

- Write it at the end
- Present tense (ACS Style)
- <150 words (in most cases)

Specific labeling of biomolecules with bright fluorophores is the keystone of fluorescence microscopy. Genetically encoded self-labeling tag proteins can be coupled to synthetic dyes inside living cells, resulting in brighter reporters than fluorescent proteins. Intracellular labeling using these techniques requires cell-permeable fluorescent ligands, however, limiting utility to a small number of classic fluorophores. Here we describe a simple structural modification that improves the brightness and photostability of dyes while preserving spectral properties and cell permeability. Inspired by molecular modeling, we replaced the N,N-dimethylamino substituents in tetramethylrhodamine with four-membered azetidine rings. This addition of two carbon atoms doubles the quantum efficiency and improves the photon yield of the dye in applications ranging from in vitro single-molecule measurements to super-resolution imaging. The novel substitution is generalizable, yielding a palette of chemical dyes with improved quantum efficiencies that spans the UV and visible range.

Nature Methods, **2015**, *12*, 244–250

Introduction: The background of the story

Components of the Introduction

Paragraph 1:

- The first sentence sets up the **topic**.
- Why is it **important**?

Paragraph 2:

- **Background**: What has been done?
  - Give credits to other people
- What is still **missing**?

Paragraph 3:

- What did we do?
- The **impact**/who should care?

Rapid evolution of fluorescence imaging techniques in recent years demands fluorophores with enhanced **brightness and photostability**. This evolution, particularly in biomolecular labeling and super-resolution imaging techniques, has facilitated fluorescence imaging with single-molecule precision in numerous biological and biomedical studies. However, many existing fluorophores lack sufficient **brightness and photostability** for single-molecule and live-cell imaging. Rational molecular engineering of fluorophores, *based on a deep understanding of their working mechanism*, is thus crucial and imperative to yield novel fluorophores with superior **brightness and photostability.**

Someone did this. Someone did that. However, some key thing (**brightness and photostability**) is still missing. Solving this key thing can save the entire world.

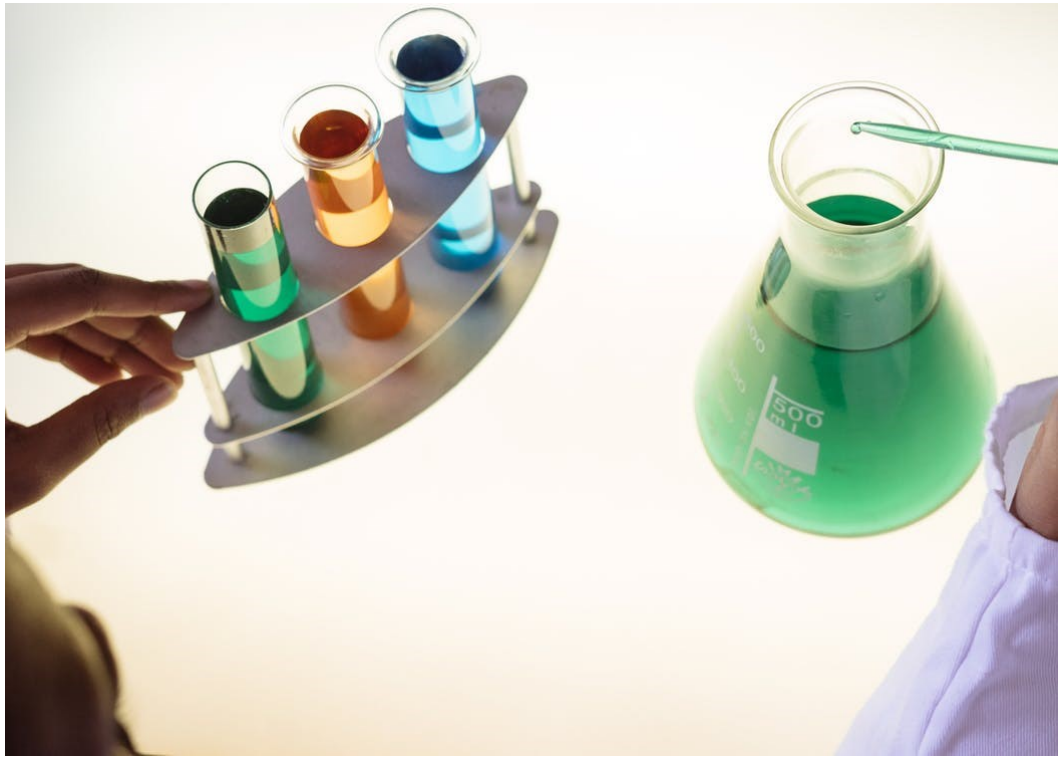
In this manuscript, we (almost) saved the world by doing…

JACS **2016**, *138*, 6960-6963

Materials and Methods: Details to Reproduce the Work

Writing Tips:

- Offer sufficient details
- Move it to the Supporting Information, if possible
- Organize them into different sections
  - Make it easy to look up information



Results and Discussions

Components of the Results and Discussion:

- Results and discussion are usually combined.
- What did you obtain from your experiments?
- What do those data mean?
- How do the data support your hypothesis/argument?

Writing tips:

- Write it like a **story**
  - Develop a hypothesis with brief and valid reasons, but without sufficient details/evidence.
  - Produce evidence along the way to support that hypothesis.
  - Follow the story/logic; do not follow the actual orders of doing experiments.
- Use **declarative** section headings
  - "Selectivity Test" (**X**)
  - "Probe XX demonstrates good selectivity towards copper ions" (√)
- Craft your **figures/tables** to minimize the use of text.

Conclusion

It is different from the abstract

- Conclusion is a section of the paper
- Abstract is a summary of the entire paper (which includes the conclusion).

What conclusion can be drawn from the study?

(Optional) What is the limitation of this manuscript?

- Write it in a positive way
- “By addressing this solubility issues, this fluorophore will become highly useful for bioimaging……”.

What is the significance of the work?

Why does the restaurant food taste better than home-cooked food?

Why are some papers written better than others?

Three Tips: From cooking appetizing food to writing good papers

Three ingredients to cook good food:

Garlic

Shallots

Butter

Anthony Bourdain, *Kitchen Confidential*

Three elements to write good papers:

Logic

Structure

Coherence

Logic: The “Soul” of Your Paper

- **The objective of the paper is persuasion.**
  - Are you addressing an important question?
  - Are you aware of the milestone works in this field?
  - Have you critically analyzed the gap/challenges of this field?
  - Has your work made substantial progress?
  - Is your conclusion well supported by data?

Logic: Focus on the Introduction Section

- The introduction is the most difficult section to write in a paper.
- The introduction often reflects the authors' taste and determines if a paper will be accepted.

- The introduction section typically has three paragraphs.

Paragraph 1: Establish a **topic**; show that this topic is **important**!

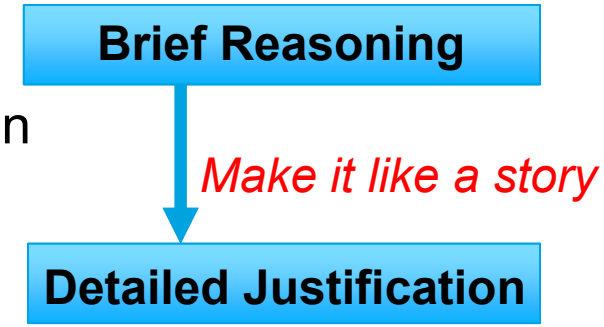
Paragraph 2: Background
(a) Review the literature.
(b) Conclude that one key thing is still missing.
- This key thing is the topic of this paper.
- End this paragraph by emphasizing the impact of solving this key thing.

Paragraph 3: Summarize what you have done (in solving this key thing).

Logic: Focus on the Background section

- Cite *important* references
  - To make friends and give credit to others
  - To share the same “experiences” with your readers and reviewers.
  - Typical features: (1) high-impact journals; (2) high citations; (3) reputable groups.
- Summarize the references
  - Be precise, succinct, and relevant
  - Be systematic
    - “On the **theoretical** side… Accordingly, various **experimental** strategies have been applied….”
    - “The current methods can be broadly **classified** into three categories.”
  - **Identify the gap/what key thing is still missing** ➔ Your contributions

Logic: Focus on the Results and Discussion



Does your paper have an explicit hypothesis (or claim)?

- This statement typically appears at the beginning of Results and Discussion
- **A good paper usually comes with the hypothesis/claim**

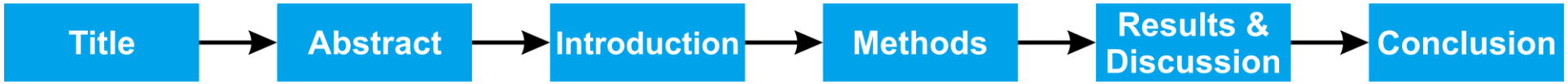
Do your results support this hypothesis (or claim)?

- The rest section is developed to validate this hypothesis/claim.
- **Foresee all possible questions and address them!**
- What does the raw data say? Can it be interpreted in different ways, and if so, why is your interpretation correct?
- What level of confidence does the raw data provide? (statistically)
- Are there different experiments that can be done to answer your claim?
- Is your conclusion supported by established theories or does it stand aside from those ideas?

Structure: The “Backbone” of Your Paper

A paper has a layered structure.

The order that a paper appears

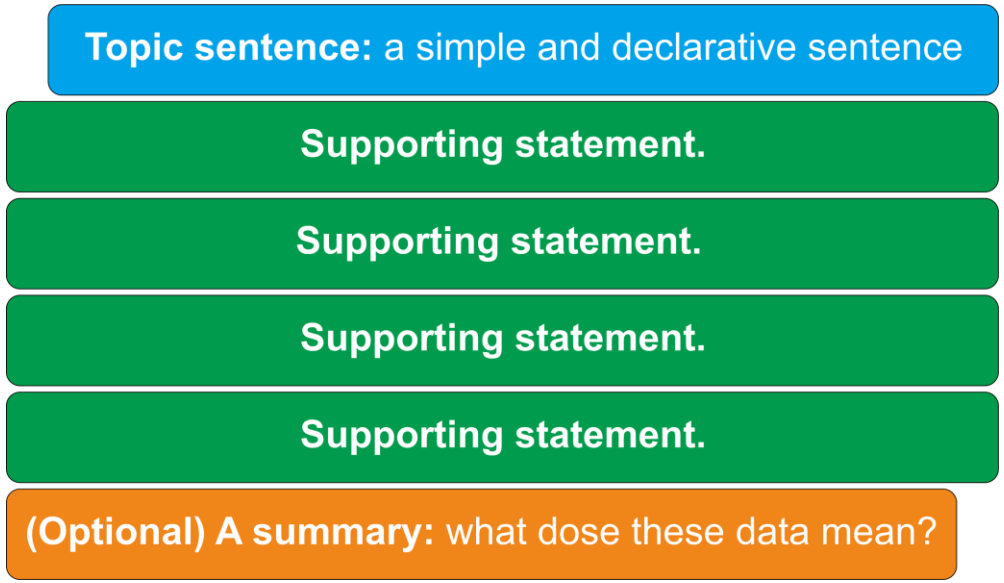


The order that we read a paper

Ensure that your writing is structured and easy to index.

Structure: How to organize a paragraph?

- **The structure of a paragraph**



Examples:

Our calculations also showed that the state-crossing to the nonemissive ET state is accompanied by the rotation of the substituted meso-phenyl ring in BODIPYs. Accordingly, restricting such rotations (i.e., in high-viscosity solvents) should recover the fluorescence. Hence, we measured the viscosity dependence of the emission intensities in B4−B6. As we increased solvent viscosity by raising the volume ratio of glycerol in the ethanol/glycerol mixture, we noticed a considerable enhancement of fluorescence intensities in B4−B6, by 7– 11 times (Figure 3c). These results are in good agreement with our theoretical calculations.

JACS, **2020**, *142*, 6777-6785.

Structure: How to organize a paragraph and a section?

- **The structure of a paragraph**

Topic sentence: a simple and declarative sentence — Context

Supporting statement.

Supporting statement. — Results & Discussion

Supporting statement.

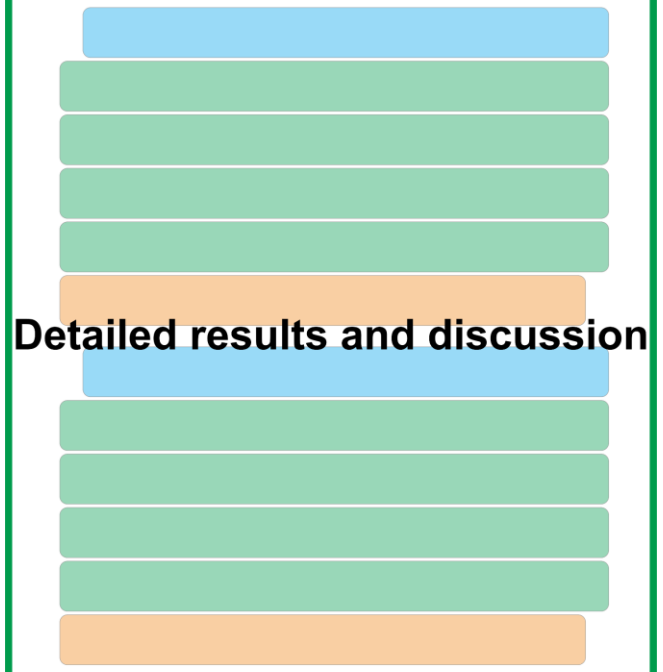
Supporting statement.

(Optional) A summary: what dose these data mean? — Conclusion

The structure of a section:

A simple and declarative section heading

A preamble paragraph.



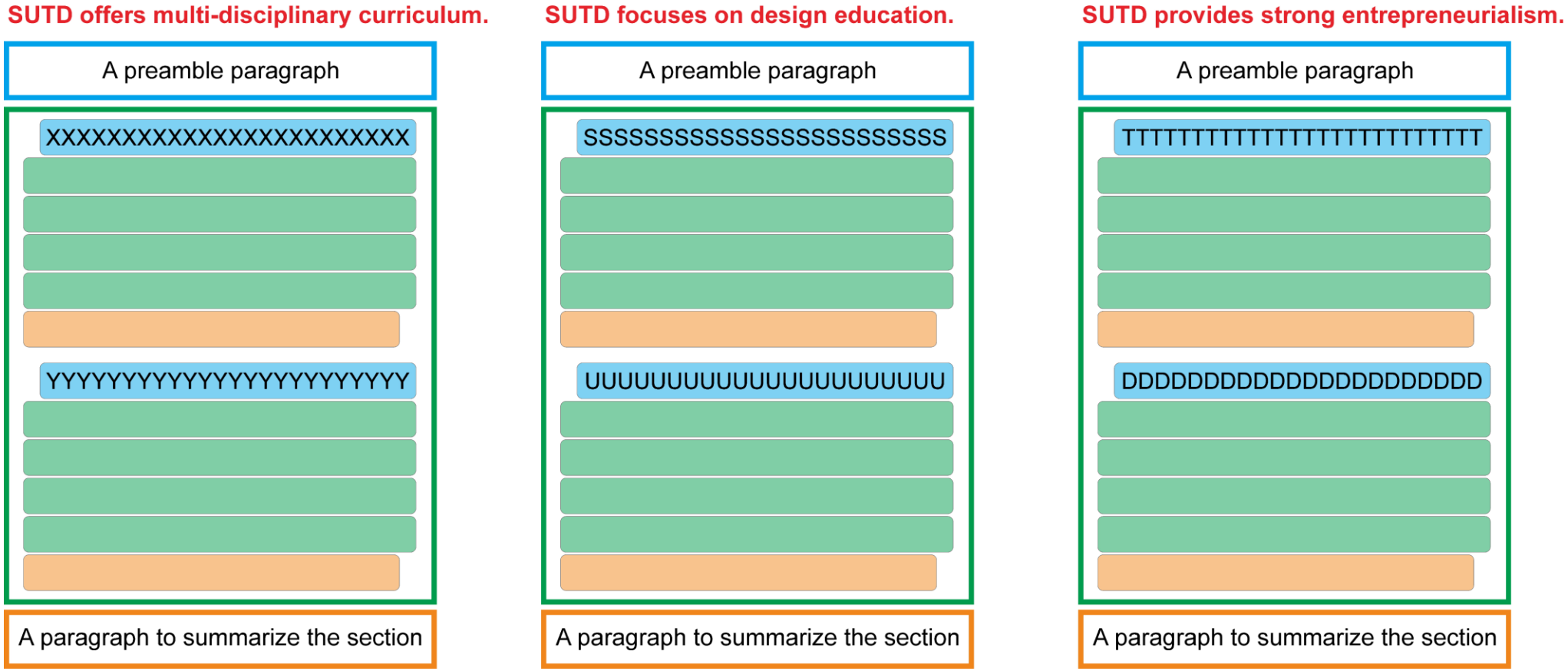
A paragraph to summarize this section.

Structure: The overall view of Results and Discussion

Declarative headings give an overall view of the argument.

Topical sentences provide the outline of the evidence.

The summary is optional, especially for short sections.



- **Organize the sections according to their importance and logic, not the order of doing experiments.**
- **Provide a clear and layered structure to make a reader's life easier.**

Structure: Pay attention to graphics

A picture is worth one thousand words

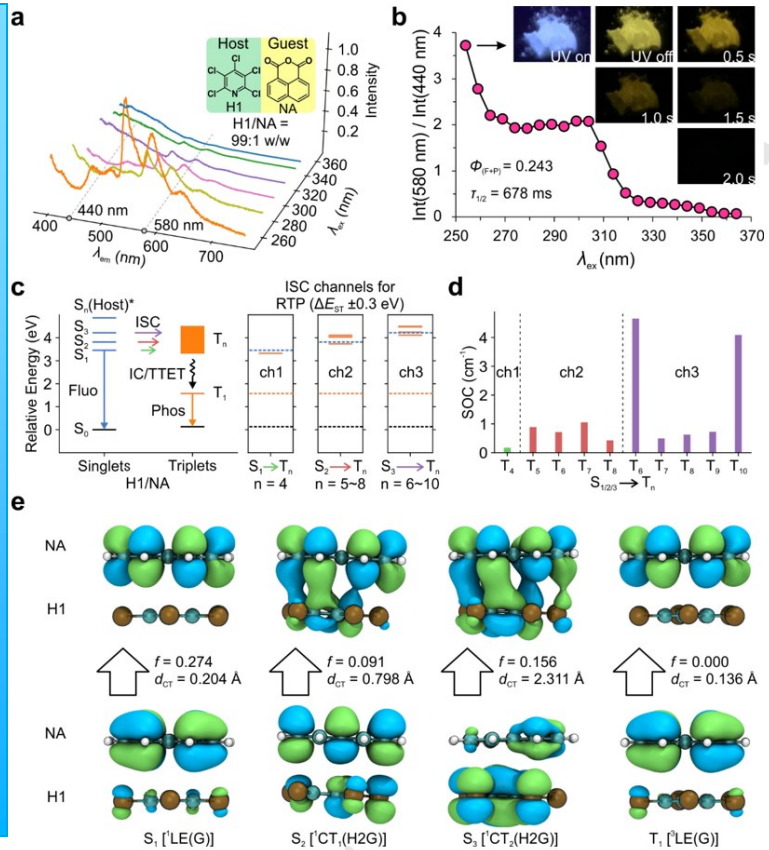
The order we read a paper

Guidelines from the Fluorescence Research Group

1. Use professional software.
   - CorelDraw, Adobe Illustrator, MatLab, Python…
2. Use the TIF format.
   - TIF preserves the size of the picture when embedded in Microsoft Word.
3. Make a good choice of colors.
4. Use the “Arial” font.
5. Calculate the font size.
   - The font size of the text in the figure: ~7-8 after the scaling
   - The font size of the figure subtitle [a, b, c, etc.]: ~14-16 after the scaling
   - Ensure consistency of text sizes in all figures.
6. Check the requirements on figure sizes and make full use of space (especially width).

Structure: Pay attention to graphics

NOT IN USE



WASTED SPACE

Figure 1. (a) Excitation-emission matrix (EEM) of H1/NA. (b) Ratio plot between phosphorescence intensity (580 nm) and fluorescence intensity (440 nm) derived from EEM plot at various excitation wavelengths with emission pictures of the compound before and after turning off 254 nm excitation light source. (c) The relative energy of H1/HA and the ISC channels for RTP calculated at the CAM-B3LYP/Def2-SVP level in chloroform. (d) The corresponding SOC matrix element of various ISC channels for RTP. (e) The corresponding hole and electron NTOs of S_1, S_2, S_3, and T_1. The S_n energy level was estimated from the H1 monomer calculated at the CAM-B3LYP/Def2-SVP level in chloroform.

revision

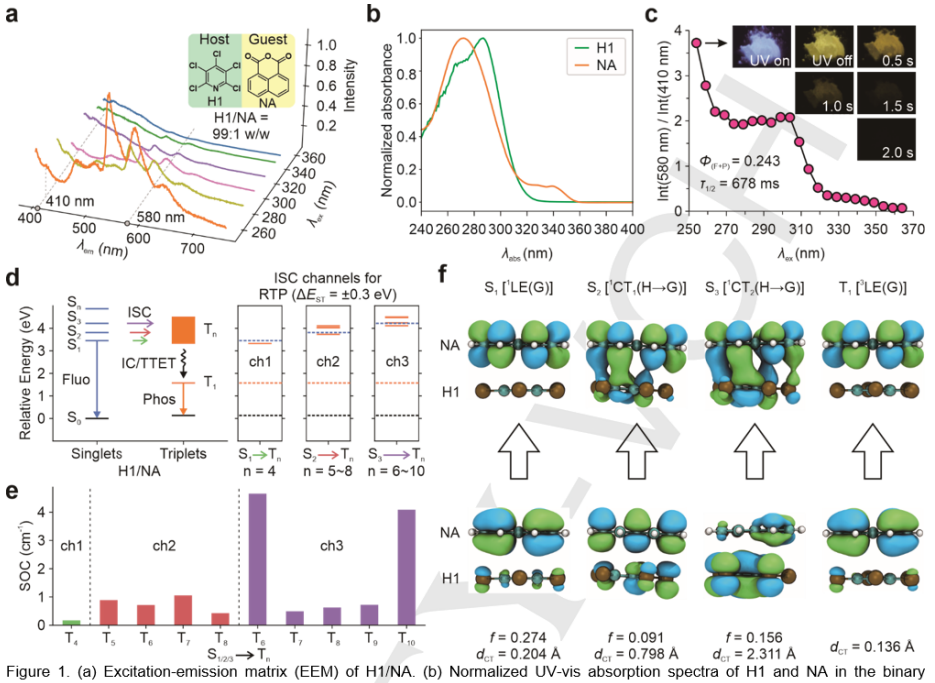


Figure 1. (a) Excitation-emission matrix (EEM) of H1/NA. (b) Normalized UV-vis absorption spectra of H1 and NA in the binary mixture of ethanol and 1-propanol (v:v = 80:20). (c) Ratio plot between phosphorescence intensity (580 nm) and fluorescence intensity (410 nm) derived from EEM plot at various excitation wavelengths with emission pictures of the compound before and after turning off 254 nm excitation light. d) The relative energy of H1/HA and the ISC channels for RTP calculated at the CAM-B3LYP/Def2-SVP level in chloroform. (e) The corresponding SOC matrix element of various ISC channels for RTP. (f) The corresponding hole and electron NTOs of S_1, S_2, S_3, and T_1. The S_n energy level was estimated from the H1 monomer calculated at the CAM-B3LYP/Def2-SVP level in chloroform.

Coherence: The "Muscle" of Your Paper

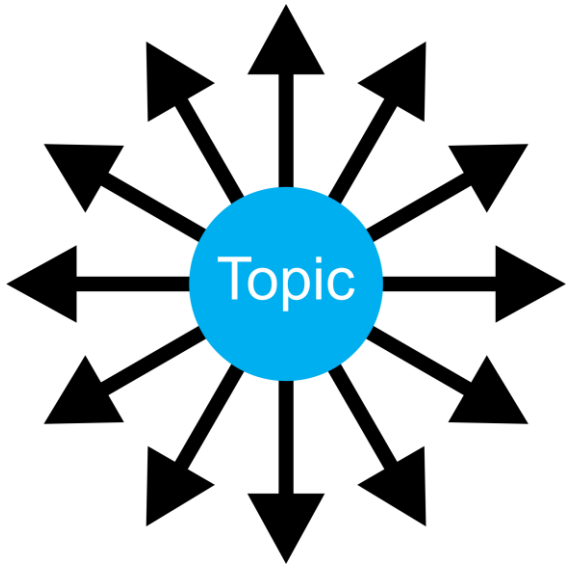
An Example:

The Singapore University of Technology and Design is established to advance knowledge and nurture technically-grounded leaders and innovators to serve societal needs, with a focus on Design, through an integrated multi-disciplinary curriculum and multi-disciplinary research.

We "read" a picture as a whole – two-dimensional view

We "read" texts line by line – one-dimensional view

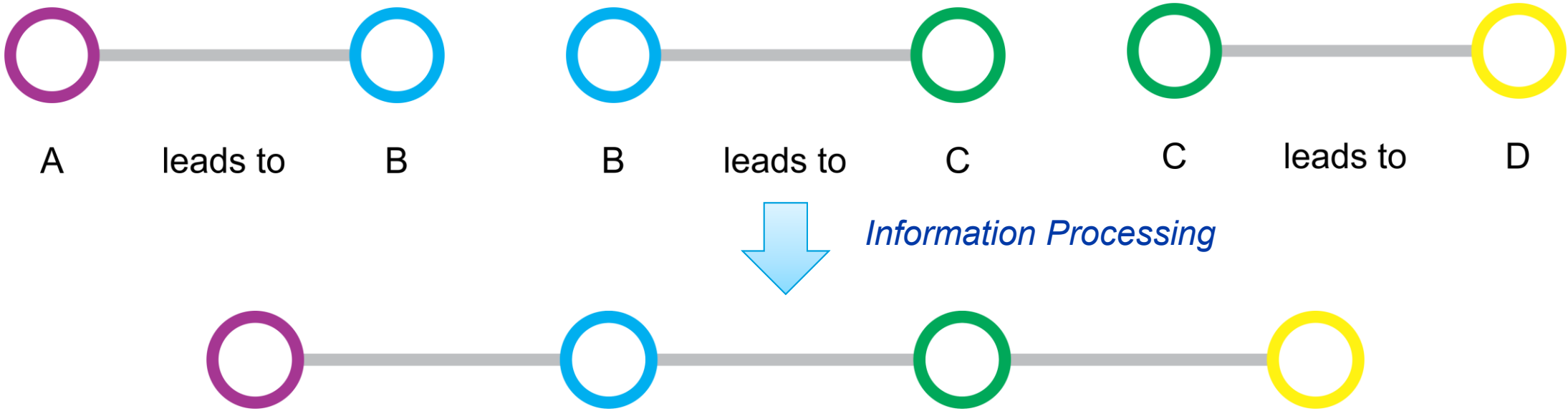
(1) Start sentences with the same topic



"The ***Journal of the American Chemical Society (JACS)***, founded in 1879, is the flagship journal of the American Chemical Society and the world's preeminent journal in all of chemistry and interfacing areas of science. **This periodical** is devoted to the publication of fundamental research papers and publishes approximately 19,000 pages of Articles, Communications, and Perspectives a year. Published weekly, ***JACS*** provides research essential to the field of chemistry."

About JACS, https://pubs.acs.org/page/jacsat/about.html

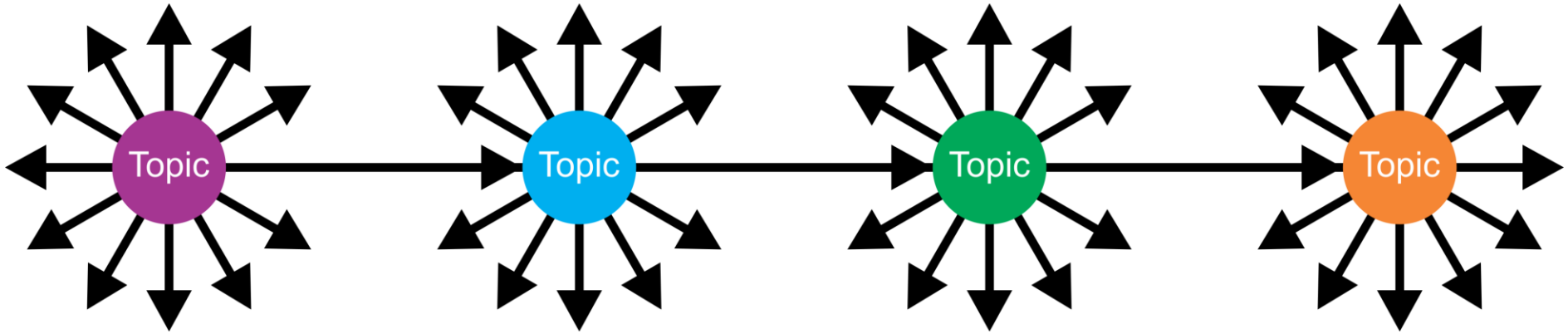
(2) Connect the previous “end” with the next “start”



“Scientists had previously believed that there were just two types of catalysts: metals and enzymes. Enzymes contain hundreds of amino acids or proteins, but the winners were able to demonstrate that a single organic molecule can act as a catalyst.”

CNN News (https://edition.cnn.com/2021/10/06/world/nobel-prize-chemistry-winner-scn-2021/index.html)

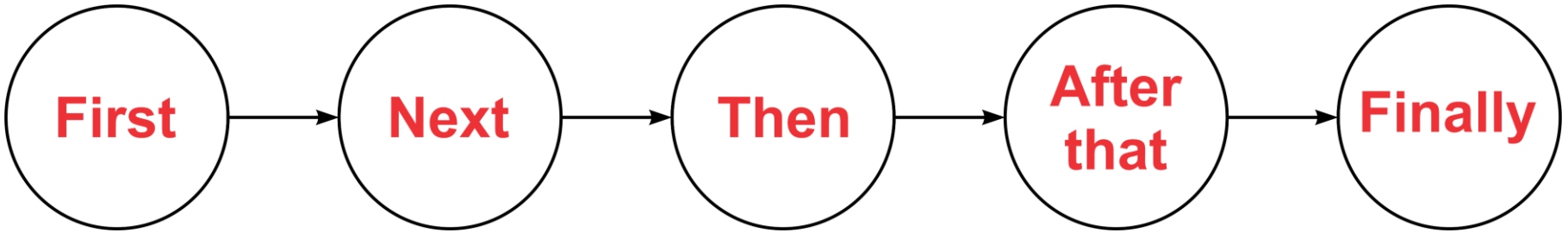
(3) Combine the previous two methods in a flexible way



*"**Chemistry** has long-benefited from the use of **models** to interpret patterns in data (from the Eyring equation in chemical kinetics, the scales of electronegativity to describe chemical stability and reactivity, to the ligand-field approaches that connect molecular structure and spectroscopy). **Such models** are typically in the form of reproducible closed-form equations and remain relevant over the course of decades. However, **the rules of chemistry** are often limited to specific classes of systems (for example, electron counting for polyhedral boranes) and conditions (for example, thermodynamic equilibrium or a steady state)"*

Artrith *et al.*, *Nature Chemistry*, **2021**, *13*, 505–508

(4) Use sequencers in English



These sequences are useful when:

- Discussing your experimental procedures;
- Describing your journey of investigations.

General Advice on

How to write a paper?

Writing tip: Start your writing with an outline

- **Purpose: (1) Plan your research. (2) Seek agreement between you and your supervisor.**
- **What to include in the outline:**
  - **1. Title;**
  - **2. Authors;**
  - **3. Introduction:** (1) what is the objective? (2) why the objective is important? (3) Background. (4) what is the gap? (5) what do we do? (6) what is the implication?
  - **4. Results and Discussion**
    - Use section heading
    - For example, (1) Molecular Design Strategy; (2) Quantum Chemical Simulations; (3) Experimental Validation; (4) Bioimaging Applications.
    - Do not follow the historical order of experiments. Follow the story/logic of your paper.
  - **5. Conclusion**
  - Prepare **graphics and tables**; insert them into the outline. Include detailed **captions**.
- **You may start with your one/two sentences of conclusion, and write the rest to make this point.**
- **Use a minimal amount of text.**

Writing tip: The first draft – Just write it.

- Write down whatever is in your mind.
- Do not expect to be perfect; revisions will come later.
- The speed matters; just complete it first!

- If you think too much, you may not even complete one paragraph in one day!
- Nobody will read your first draft!

Writing tip: Revision…Revision….Revision…

- You will need to revise the manuscript many times.
- Break long sentences into multiple short sentences.
- Modify your structures, logic, and coherence.
- Use software to check out grammar mistakes.
  - **Grammarly** (The free version is sufficient).

- Seek feedback from colleagues and revise your paper accordingly.
- Wait for one day or several days to relook at the paper again (at least once)
- Read your final manuscript on paper (NOT on a screen) at least once.

Writing tip: Deletion…Deletion….Deletion…

- Be succinct and relevant.
  - Writing a short paper is equivalent to saving readers' time.

First version: "The mechanical switch OX … represents an efficient mechanophore with versatile functionalization, rapid ring-closure kinetics and diverse regioisomeric mechanosensitive modes." (19 words)

Second version: "The mechanical switch OX … represents an efficient mechanophore with versatile functionalization and rapid ring-closure kinetics." (15 words)

JACS **2021**, DOI: 10.1021/jacs.1c05923.

Note: The regioisomeric property in not used in the paper, so this phrase is deleted.

- Delete "as shown below"; just do it.
- Delete "we will first do this; then do that."; just do it.
- Make use of the Supporting Information to deposit information and shrink the main text.

Writing tip: Some Points of Styles

- **Avoid using nouns as adjectives:**
  - *Not:* "the fluorophore quantum yield"
  - *But:* "the quantum yield of the fluorophore"
  - "Quantum yield" is fine.
- **"This" should be followed by a noun – to be explicit:**
  - *Not:* "This is a reliable method, as shown by XXX."
  - *But:* "This method is reliable, as shown by XXX"
- **Mind the order of wording – reduce the interruptions to brains:**
  - *NOT:* "As shown in Figure 1a, A possesses a higher quantum yield than B"
  - *But:* "A possesses a higher quantum yield than B, as shown in Figure 1a"
  - *Even better:* "A possesses a higher quantum yield than B (Figure 1a)"

Writing tip: Some Points of Styles

- **Mind the tense:**
  - Abstract should be in the present tense (ACS Style).
  - Describe all experiments in the past tense.
  - Use the present tense as much as possible.
- **Use the active voice whenever possible:**
  - *Not:* "It is demonstrated that this polymer has considerable potential in force sensing."
  - *But:* "We demonstrate that this polymer has considerable potential in force sensing."
  - *Probably better*: "This polymer has considerable potential in force sensing."
- **Complete the comparison**
  - *NOT:* "SUTD is relatively small."
  - *But:* "SUTD is smaller than NTU."

Writing tip: Some Points of Styles

- **Abbreviations**
  - Have you defined the abbreviations?
  - It only takes 5 seconds!
- **The curse of knowledge**
  - “The SLEET model suggests fluorophore XX is prone to photo-induced electron transfer.”
  - Do you know the SLEET model?
  - Elaborate on the SLEET model, before you use it.
- **The invisible spaces**
  - Do a search of double whitespace characters and replace them with a single whitespace character (when appropriate).

Writing tip: Some Points of Styles

- **Common phrases to avoid**
  - Replace "*in order to*" with "*to*"
  - Avoid using "*One one hand… ; one the other hand…*"; "*however*" will do.
  - Do not say "*As a rule of thumb*", use "*In general*".
  - Do not say "*home-made*", use "*developed in-house*".
- **Pay attention to citation styles**
  - Use software (such as EndNote) to manage citation styles
  - Download citations from the publisher's website (instead of Google Scholar) whenever possible.
  - Keep the Endnote citations within the documents. Only replace the reference list with "pure texts".
  - Check all references carefully— are abbreviations, page numbers, year, DOI all complete, and correct?

Useful References

- G. M. Whitesides, “Whitesides’ Group: Writing a Paper”, *Adv. Mater.* **2004**, *16*, 1375-1377
- D. A. Weitz, “Weitzlab Guide to Good Paper Writing”, available online
- D. J. Lipomi, “Style Guides and the Garlic, Shallots, and Butter of Scientific Writing”, *Chem. Mater.* **2021**, *33*, 3865-3867
- *Grammarly* (software)

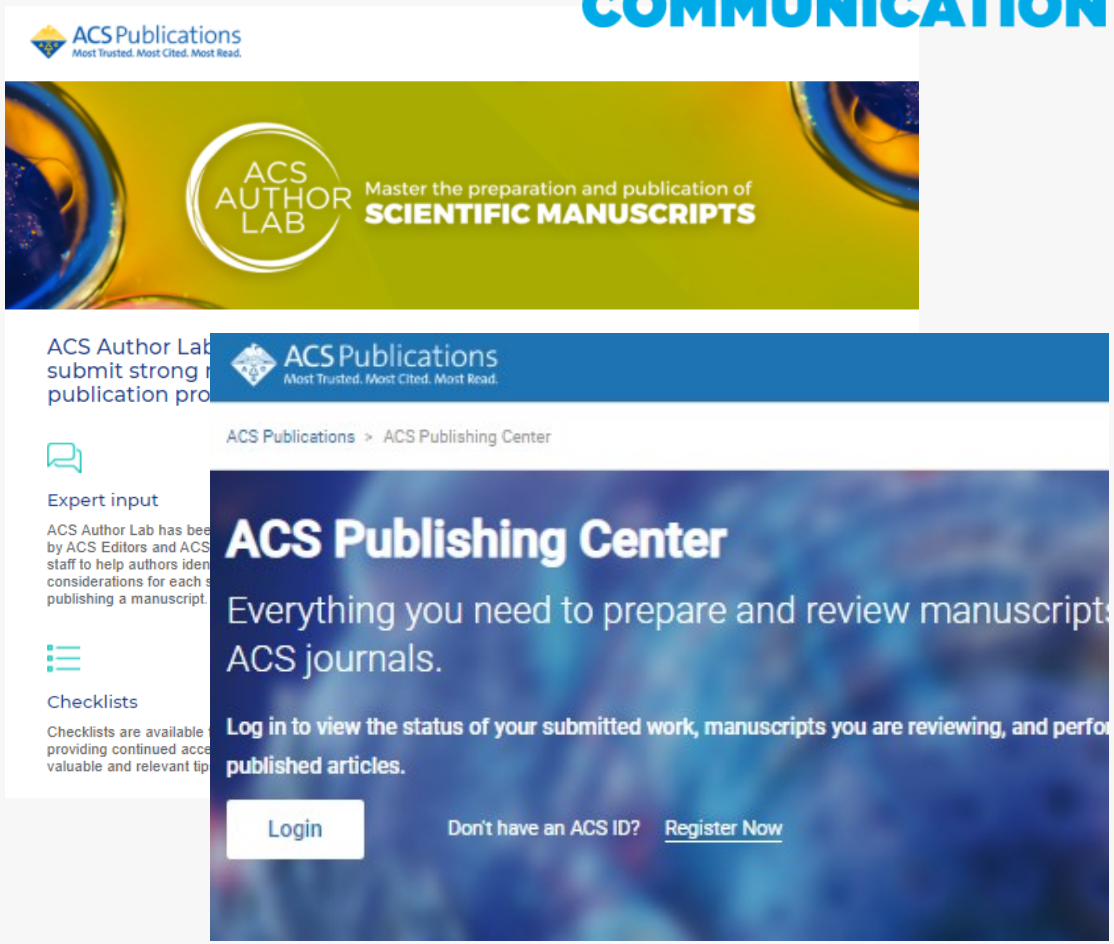
Additional Key Resources

Where can I find journal guidelines and templates for submission?
publish.acs.org/publish/

Where can I read more?
Mastering the Art of Scientific Publication
pubs.acs.org/page/vi/art_of_scientific_publication.html

ACS Guide to Scholarly Communication Online
pubs.acs.org/doi/book/10.1021/acsguide

What else can I do?
Take the 7 courses in the new ACS Author Lab
connect.acspubs.org/author-lab



Conclusion

What is a paper?

- Organized description for persuasion and instruction.
- Highly structured organization for indexing and accessing information.

Three key elements for writing good papers

- Logic – the “soul” of a paper
- Structure – the “backbone” of a paper
- Coherence – the “muscle” of a paper

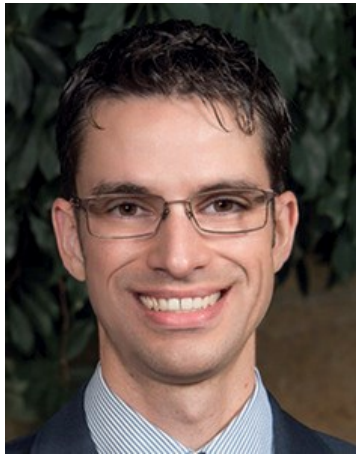
General advice for writing good papers

- Develop an outline
- Finish the first draft as quickly as possible
- Revise and delete texts to write a short, structured and persuasive paper

Acknowledgement

George Whitesides

David Weitz



Darren Liponi

Davin Tan

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

FRG

Questions

Thank You