Research Paper Organization and Content

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Published research papers observe certain norms of format and language. Formatting details such as type size and font, margins, and how to cite sources, are regulated by each publisher. Other characteristics such as overall organization reflect not only the requirements of the publisher, but the expectations of the community: A reader expects to find a general summary in the Abstract, background and motivation in the Introduction, what was done in Materials and Methods, results in Results, and analysis of results in Discussion. The reader might read the Abstract, flip to the Discussion to learn more about the results, read some of the figure captions, and then decide whether or not to read the entire paper.

All writers observe the norms outlined above. In addition, a skillful writer carefully chooses words and grammatical structure to guide the reader through what may be difficult material. For example, the skillful writer keeps in mind that the reader does not necessarily see the logical connections between sentences within a section. The writer takes pains to make sure that these connections are clear.

The following analysis describes the basic sections of a research paper or lab report. We examine examples from published papers and see how the authors were able to use careful language to help the reader follow the discussion. Following that discussion, Sections 5 and 6 contain pointers to keep in mind when writing a technical report. Graphic elements such as figures and tables are discussed in Section 5, and a summary of writing guidelines is presented in Section 6.

Knowing what to expect in each section of the paper can help you, the reader, interpret technical papers. Knowing what is expected can also help you as you write your own technical papers.

1 The Abstract

The Abstract is

- Short: typically 200 words or less (editors' limits range from 50 words to 250 words)
- Directed to a more general audience than the rest of the paper
- Carefully crafted to contain the following five points in an organized, easy-to-read fashion:

    1 Statement of broad problem/background (usually without citations)
    2 Scientific hypothesis or goal of this experiment/study stated in general terms
    3 Methods for this study: specific numbers if it's possible to state them briefly
    4 Results: Specific data if possible, with some analysis
    5 Discussion: Hypothesis/hypotheses proven? Disproven? Desired procedure or mechanism developed successfully? Generalizations?

Here are the Abstracts from two published papers: One which addresses all five points, and one which addresses only the last three. Such a 'truncated' abstract is the norm in some journals. In both examples, note how underlined words in the passages help the reader follow the flow of ideas. Note also the careful choice of wording to indicate how strong an assertion the author is making.

Abstract: Paper One

C.K. Stein, T. W. Glover, J. L. Palmer, and B. L. Glisson, " Direct correlation between FRA3B expression and cigarette smoking", *Genes, Chromosomes and Cancer* 34:333-340, 2002. Used with permission of the first author.

1 Introductory background information: broad picture	Cytogenetic deletions and/or loss of heterozygosity (LOH) of the short arm of chromosome 3, often with a break at 3p14, are well documented in lung tumors.
2 Intro to the hypothesis under investigation	The coincidence of a chromosomal fragile site, FRA3B, at a common chromosomal breakpoint in lung cancer has suggested that fragility at this site may predispose to breakage that could contribute to multistep carcinogenesis. This idea is supported by the more recent finding that FRA3B maps within the FHIT (fragile histadine triad) gene, and that aberrant transcripts and genomic deletions of FHIT/FRA3B occur in a variety of tumors including lung tumors.
3 This study: methods	To determine whether some individuals have increased fragility of FRA3B that might increase the risk for breakage or deletion in 3p14.2, fragile site expression was examined in smokers, nonsmokers, and small cell lung cancer (SCLC) patients.
4 Results	The data clearly show that active smokers exhibit a significantly higher frequency of fragile site expression, including FRA3B, compared to that of nonsmokers and patients diagnosed with SCLC who have stopped smoking.
5 Discussion	These results suggest that active tobacco exposure increases chromosome fragile site expression, and that this fragility is transient and reversible. The data support the hypothesis that exposure to tobacco carcinogens increases the potential for chromosome breakage at fragile sites.

Abstract: Paper Two

Lima, R. Wada, S., Takeda, M., Tsubota, K., Yamaguchi, T. (2007, January 16). In vitro confocal micro-PIV measurements of blood flow in a square microchannel: The effect of the haematocrit on instantaneous velocity profiles. *Journal of Biomechanics, 40,* 2752 – 2757

1 Broad picture	(Missing in this shortened abstract. Note the extra-detailed title, however.)
2 Hypothesis under investigation	
3 This study: methods	A confocal microparticle image velocimetry (micro-PIV) system was used to obtain detailed information on the velocity profiles for the flow of pure water (PW) and in vitro blood (haematocrit up to 17%) in a 100-μm-square microchannel.
4 Results	The averaged ensemble velocity profiles were found to be markedly parabolic for all the working fluids studied. When comparing the instantaneous velocity profiles of the three fluids, our results indicated that the profile shape depended on the haematocrit.
5 Discussion	Our confocal micro-PIV measurements demonstrate that the root mean square (RMS) values increase with the haematocrit implying that it is important to consider the information provided by the instantaneous velocity fields, even at low *Re*. The present study also examines the potential effect of the RBCs on the accuracy of the instantaneous velocity measurements.

2 The Introduction

The purpose of the Introduction is to prepare the reader to understand the rest of the paper. A common mistake made by student writers is to think of the Introduction as a compendium of everything known about the subject – or at least everything the writer has learned on the subject. The Introduction is not the place to show that you did a lot of research (some of which led to dead ends). Instead, think of it as a concise statement of the motivation for the particular study reported in this paper. The Introduction should move from background to open questions to attempted solutions. At every step, the writer highlights how attempted solutions have been limited, and what questions remain open. By the end of the Introduction, the reader should have certain questions in mind and should be interested in knowing how the writer's work answers them. Most Introductions end with a brief statement of how the questions were addressed, and of how the rest of the paper is organized.

The Introduction will contain many references to the work of others. Note how they are woven into the discussion in this example, from Paper Two.

Introduction: Paper Two (In this and later examples, material in square brackets [ ] summarizes material cut from the original.)

The velocity profiles of blood flow in vivo and in vitro have been measured using several techniques, including double-slit photometry (Gaehtgens et al., 1979/ Baker and Wayland, 1974), video microscopy and image analysis (Bugliarello and Hayden, 1963; Tangelder et al., 1986; Parthasrathi et al., 1999), laser-Doppler anemometry [more sources], and particle-measuring methods [more sources]. Nevertheless, **no general consensus yet exists concerning the actual velocity profile in microvessels**. While some studies have reported parabolic profiles [more references], others have suggested blunt profiles [more references]….	*General topic of the report* *Velocity profiles **have been measured:** verb time is not past; verbs use passivevoice*[χ]. *Citations occur in the text.* *The open question and motivation for this study is introduced here.*
Due to its outstanding spatial filtering technique and multiple point light illumination system, **confocal microparticle image velocimetry (micro-PIV)** has become accepted as a reliable method….Very recently, we demonstrated the ability of confocal micro-PIV to measure both homogeneous and nonhomogenous fluids (Lima et al., 2006a).	*New topic = new paragraph* *Introduction of the proposed method* *It is clear when the authors are reporting background information, and when they have moved to specifics about their own research:* • *Switch to past time is introduced with 'very recently'.* • *Subject = <u>we</u>.*
The present study compared the instantaneous and ensemble velocities profiles of pure water and blood flow in vitro. The velocity profiles of both pure water and in vitro blood with two different haematocrits (9 and 17% Hct) were acquired in the centre plane of a 100-μm square microchannel.	*Could be clearer: What was the motivation for the choices made? What did they expect to find? Adding that information would make past tense more appropriate. The last sentence could be moved to the Materials and Methods section.*

Possible rewrite of the last paragraph of the Introduction:

> …Very recently, we demonstrated the ability of confocal micro-PIV to measure both homogeneous and nonhomogenous fluids (Lima et al., 2006a).
>
> **In order to measure the actual velocity profile in microvessels using confocal micro-PIV,** we compared the instantaneous and ensemble velocity profiles of pure water and blood flow in vitro.

3 The Experimental Methods section

In a published paper, a section called Materials and Methods or Experimental Methods gives the steps taken by the authors/investigators. (Often this section is presented as an appendix in published papers.) Past tense is the norm. Passive voice[χ] is common; however, use of active voice and *we/our* is appropriate when it clarifies the process, as in this example from the Materials and Methods section of Paper Two:

> In this study, we used a 100-mm-square borosilicate glass microchannel fabricated by Vitrocom (Mountain Lakes, NJ, USA), which was mounted on a glass slide immersed in glycerol that had the same refractive index. A square microchannel was selected to minimise possible refraction of the laser beam at the walls of the microchannel.

Note that the authors do not simply present the step in their procedure with no comment. Instead, they state the reasons for the steps taken: "A square microchannel was selected to minimize possible refraction…."

In the following example (from the same paper), the authors explain the motivation for their next step. The authors use 'we' to neatly connect the 'in order' phrase to the rest of the sentence:

> In order to obtain adequate quality images for processing with the PIV software (PivView; PivTec GmbH, Göttingen, Germany), we captured images with a resolution of 640X480 pixels and 12-bit greyscale, at a rate of 200 frames/s, with an exposure time of 4995 ms, and a time interval (Δt) of 5 and 10 ms between two images. All the PIV measurements were performed for a period of approximately 0.5 s in order to obtain both instantaneous and ensemble averaged velocities.

More about passive voice[χ]. Passive voice is common in technical writing. Some writers mistakenly think that they must never say 'we' or 'I' in a formal paper, and that the only other choice is to use passive voice. This is not true, and use of passive often creates cloudy or flabby sentences. Let's try putting one of the active ('we' = agent) sentences from the previous passage into passive:

> In this study, a 100-mm-square borosilicate glass microchannel fabricated by Vitrocom…, which was mounted on a glass slide immersed in glycerol that had the same refractive index, was used.

The resulting sentence is nearly impossible to follow! The 'we' sentence is much clearer. However, it is quite possible to reword the original sentence to leave out 'we', while still maintaining active voice:

> This study used a 100-mm-square borosilicate glass microchannel fabricated by Vitrocom…, which was mounted on a glass slide immersed in glycerol that had the same refractive index.

Which is clearer: the original, or this revision? Can a **study** 'use' anything, or must the agent be animate? (Some prefer 'utilize' if the agent is 'this study.') Which passage is more suitable for technical writing? Opinions may differ, but surely all will agree that either the first or the last version is preferable to the passive-voice version.

A final note: All three versions of this sentence use passive voice in modifying phrases (fabricated by Vitrocom / which was mounted / a glass slide immersed in glycerol). Passive voice is very useful for allowing the smooth combining of phrases into one sentence, and for keeping the focus on the procedure.

4 The Results/Discussion section(s)

Whether this is one section or two, the purpose is to present the results of the experiment or study and to draw appropriate conclusions from the results. If a paper presents results for several experiments, probably the results and discussion of each experiment will be presented together. Such a paper will probably have a separate **Conclusions** section to provide a summary of the entire paper.

In any paper, the report of the results includes relevant graphics (charts, graphs, and tables) with salient points noted in the text. Any graphics presented relate to the stated purpose of the report.

The **Discussion** section, with the **Conclusions** section if that is separate, answers these questions:

1. What was the purpose of the study? Was it to validate a certain hypothesis, and if so, what was that hypothesis?
2. What is the significance of the results? (The answer to this question will include an interpretive summary of the results.)
3. How do the results fit with data from other sources? (Sources are cited in the Discussion and are listed in References at the end of the paper.)
4. What qualifications need to be applied to these results? (This includes conclusions about the effectiveness of lab technique, experiment construction, sample size, further study needed, and the like.)

The **Discussion** section will lose clarity if passive voice$^{\chi}$ is overused. Inexperienced writers frequently produce awkward or incomprehensible sentences by trying to avoid saying 'we' in the Discussion. Let's take a clear sentence (from Paper Two) which uses 'we', and try removing 'we' from it. First, the original:

> Comparing the ensemble velocity profiles of all fluids (see **Fig. 1**), we observed small deviations (<5%) for both Δt = 5 and 10 ms, especially in the central region of the velocity profile.

Eliminating ‘we’ produces this:

> Comparing the ensemble velocity profiles of all fluids (See Fig.1), small deviations…were observed, especially in the central region of the velocity profile.

The problem with the new sentence is that the reader expects the subject of the introductory phrase (implied ‘we’) to be the subject of the sentence. However, the subject of the sentence turns out to be ‘small deviations.’ The reader has to think, not just about the technical content of the passage, but about the wording and grammar. Good writers avoid letting the wording and grammar interfere with the meaning and flow of ideas.

Here is an alternative way to word the passage without ‘we’ or passive voice:

> A comparison of the ensemble velocity profiles of all fluids (See Fig. 1) revealed small deviations…, especially in the central region of the velocity profile.

Which is clearer: the original, or this version? The choice here is more between two styles, and less between two degrees of clarity.

Here is an analysis of Paper Two, a paper which has a combined Results/Discussion section followed by a Conclusions section.

Paper Two: Results and discussion

3. Results and discussion *3.1. Ensemble velocity profiles* Most previous studies have determined the velocity profiles of flowing blood by measuring the time-averaged velocity field. **Figs. 1(a) and (b)** show the averaged velocity of 100 (Δt = 5 ms) and 50 (Δt =10 ms) ensemble PIV images, respectively. These images were recorded at the same time period of approximately 0.5 s. **Fig. 1** also compares the PIV measurements with an analytical solution for steady flow through a long, straight, rigid square microchannel (see **Lima et al., 2006a** for more details).	***Heading*** *and Subheadings guide the reader by dividing the results/discussion section into subsections.* *Justification for use of the technique employed in this study (“most previous studies…”)* *Discussion of results includes reference to graphics:* ***present tense*** *Information about how data were recorded:* ***past tense****. (Also passive)* *Reference to figures: “Fig. 1”, “Figs. 1(a) and (b)”. The word ‘Fig(ure)’ is capitalized when it is part of the name of a particular figure.*

Comparing the ensemble velocity profiles of all fluids (see **Fig. 1**), we observed small deviations (<5%) for both Δt = 5 and 10 ms, especially in the central region of the velocity profile. Using the *t*-test analysis we found no significant difference between the working fluids and the analytical solution at 98% confidence interval. Hence, these results imply that the ensemble-averaged velocity profiles of in vitro blood with haematocrits up to 17% flowing within a 100-mm square microchannel do not change significantly from a parabolic shape. These results agree with Baker and Wayland (1974) and Sugii et al. (2005). [Further analysis of ensemble-averaged velocity profiles for both Δt = 5 and 10 ms] These results suggest that for both cases it is possible to obtain reliable ensemble-averaged velocity profiles for all the working fluids used in this study.	*Discussion of results* *Authors use 'we' for clarity* *Description of analytical process* *Degree of certainty:* *"These results **imply…"*** *(Comparison with results of other studies)* *"These results **agree with (those of) Baker….*** *These results **suggest** that …**it is possible** to obtain reliable …profiles….*

In Paper Two, the summary elements of the paper are presented in a final section called **Conclusions.**

4. Conclusions In this study, we determined both ensemble and instantaneous velocity profiles for in vitro blood (haematocrit up to 17%) flowing through a 100-µm-square microchannel. Although the ensemble velocity profiles were markedly parabolic, some fluctuations in the instantaneous velocity profiles were found to be closely related to the increase in the haematocrit. The present study shows clearly that the RMS values increase with the haematocrit implying that the presence of RBCs within the plasma flow strongly influences the measurements of the instantaneous velocity fields. The possible reasons for the RMS increase are the motion and interaction of RBCs and the light scattered and absorbed from the RBCs. This latter cause seems to be more predominant at Hct = 17%. As a result, for 17% Hct improvements on the signal-to-noise ratio are required to further enhance the measurement performance of the instantaneous velocities.	*Summary, related to the stated goal of the study* *Interpretation of results* *Strength of assertion:* ***The present study shows clearly that…*** *Strength of interpretation:* ***implying that…*** *More discussion, including limitations of this study and need for further study.*

For comparison, here is the **Discussion section of Paper One.** This paper has a separate Results section and no separate Conclusion. Note the clear progression from summary of the motivation

and purpose of the study, through a discussion which evaluates the findings and compares them to the findings of other studies, to a statement of limitations of the study, and finally, a statement of conclusions to be drawn from it.

Paper One: Discussion

The preponderance of lung tumors with LOH or cytogenetic deletions and rearrangements of the short arm of chromosome 3 has led to the speculation that expression of the most common fragile site, FRA3B, might be associated with some of these events. This is supported by [certain findings.] To consider this from a different perspective, our study examined patterns of fragile site expression and demonstrated that active cigarette smokers have increased expression of fragile sites including FRA3B.	*Summary of the motivation and hypothesis of the study*
….The present study is the first to compare the levels of fragile site expression in nonsmokers (no cigarette smoke exposure), smokers (current exposure), and lung cancer patients who have stopped smoking (past exposure). The data show a statistically significant increase in general fragile site expression as well as FRA3B expression in smokers compared to that of nonsmoking controls and lung cancer patients (Table 1).	*Significance of results* *Hypothesis validated*
Our findings confirm earlier studies that compared smokers with nonsmokers (Kao-Shan et al., [1987]; Ban et al., [1995]) and are consistent with the studies comparing lung cancer patients with healthy individuals (Porfirio et al., [1989]; Egeli et al., [1997]) when smoking exposure is factored in.	*Relationship of results to those of earlier studies / hypotheses*
However, this analysis adds a new dimension. By concurrently examining fragile site expression in smokers, nonsmokers, and nonsmoking SCLC patients, we were able to demonstrate two significant points. It is *active* tobacco exposure that is important for increased chromosomal fragility and, second, the increase in chromosome fragility is transient and reversible. This is established by the finding that it is the active smokers who exhibit the highest expression of chromosomal fragile sites, but former smokers (i.e., patients diagnosed with SCLC who have stopped smoking) have fragile site expression that is no higher than that of a nonsmoker. These data agree with biochemical analyses showing that chemical compounds	*New dimension of this analysis explained.* *Note 'It is' and italics to emphasize contrasting information.* *Corroborating data added.*

associated with smoking are present in the peripheral circulation of heavy smokers, and that there is a reduction in the level of these substances over time after the individual stops smoking (Mooney et al., [1995]).	
It is important to note that, in this study, significant levels of fragile site expression were seen only in the cells that had been cultured either in low folic acid or with the addition of aphidicolin. In vitro, common fragile sites are usually not expressed unless they are induced by these or other agents that disrupt DNA replication and/or synthesis. In vivo, breakage at fragile sites appears to be affected by environmental factors that produce DNA damage (Yunis et al., [1987]).	*Limitations of the study*
The current data suggest that in vivo fragile site expression may be influenced by a combination of tobacco exposure and other factors associated with tumor formation, such as abnormalities of DNA replication or repair during tumorigenesis….	*Strength of conclusion: the current data suggest…*

5 Graphic Elements (figures, tables, and graphs)

In a technical report, photos, graphs, tables, and the like can clarify the message. Make sure such graphic elements actually move the message forward: Choose them carefully, and design them carefully to convey the most information.

Here is a brief list of guidelines for including graphic elements in a report.

1. **Only include graphics that serve a purpose.**
   - If you include a graphic, the graphic should have a message. **Explain the message in the caption** (as well as in the text of your report; see Guideline 3).
   - Skip graphics that don't illustrate a specific message that is part of the report.

2. **Label the graphic with a title and a descriptive caption.**
   - Typically, Figures have captions below the figure, and tables have a title above the table.
   - Use **descriptive** titles or captions ('Table 1: CO2 emissions by state for the years 1990 – 2000' or'Fig. 1: National Levels of Six Principal Pollutants, 1990 – 2006'). Note: The IEEE Style Guide says to always write 'Fig.' even if it's the first word of a sentence. Other style guides will differ.
   - Label axes; give units of measure.
   - If the graphic comes from another source, give source information at the bottom of the graphic.

3. Refer to each graphic in the text of the paper using the number assigned to the graphic, rather than the vague expression 'in the figure below.'

Examples:

- The number of balls retrieved by the various Lego vehicles varied widely, from 0 to 13 (see Fig. 1).
- The data in Fig. 2 demonstrate that those teams using mostly red Legos had a distinct advantage over those using only white or grey Legos.

4. Put the graphic close to the in-text reference. Graphics only go at the end of a report if (a) the report is long and the graphic is cited multiple times on widely-separated pages; or (b) if the report will go to multiple audiences, and not all audiences will want the same information.

5. Present data ethically.

- Don't leave out data or fudge numbers to make your results look better. (Account for anomalous data points in your discussion.)
- Use a scale that presents data accurately and ethically. Don't make differences look larger or smaller than they are.

6. Make the graphic easy to read.

- Don't try to make too many points in one graphic. You may need to present the same data in more than one graphic if you have more than one point to make using the same data.
- Eliminate **unnecessary** details if they distract from the point you want to make.
- Make sure the graphic is legible (type is clear enough, lines can be distinguished from one another, etc.).
- Avoid making the reader turn the page to view the graphic.

6 Summary writing guidelines for all sections of a paper or lab report

1. Choose a logical order in which to present your information. Clearly indicate the relationship of one idea to another by careful choice of logical connectors.

2. Carefully word your discussion to indicate the degree of certainty of your results or your interpretation of them. This does not mean you should hedge your bets by inserting "I think" or "In my opinion" in front of assertions. On the other hand, don't make statements you can't support.

3. Accurately and appropriately cite sources in your text. Each citation must be linked to an item in the List of References at the end of the report.

4. Use *we/our* sparingly. However, this does not mean you need to resort to awkward or unclear use of the passive voice[χ]. Choose an active-voice subject other than *I/we* as in these examples:

- **A comparison of the results** shows a statistically significant increase ….
- **This analysis** indicates a need for….
- **These data** agree….

Passive allows focus on processes and is appropriate in these examples:

- Significant levels of disease were seen in the cells from Source 1…
- The current structure is modeled on that of insects, in that the front legs are used both for locomotion and for carrying objects.

We/our may be the most efficient way to refer to the agent or connect parts of the sentence:

- [By] concurrently examining fragile site expression in smokers, nonsmokers, and nonsmoking SCLC patients, **we were able to** demonstrate two significant points.
- **Our findings confirm earlier studies** that compared smokers with nonsmokers… (*Possible rewording*: *These* findings confirm earlier studies….)
- Very recently, **we demonstrated** the ability of confocal micro-PIV to measure both homogeneous and nonhomogenous fluids (Lima et al., 2006a).

5. Make sure your sentence structure is clear. Avoid leading the reader astray with misplaced modifiers, or introductory modifying phrases that don't modify what the reader expects them to, like this one:

☒ After recording the images, they were digitized and transferred to a computer for evaluation….

This sentence momentarily misleads the reader, who expects that the understood subject (*we)* of the modifying phrase will be the same as the subject of the sentence. However, the subject of the sentence is *they.* The following improved sentence keeps the focus on the images and the process, while avoiding the confusion of the first sentence:

→ After the images were recorded, they were digitized and transferred to a computer for evaluation….

The following example momentarily misleads the reader:

☒ A legged robot is less prone to tip over and more reliable.

Simply adding 'is' to the second part of the sentence corrects the problem and keeps the reader from having to back-track:

→ A legged robot is less prone to tip over and is more reliable.

Avoid writing sentences which can be misinterpreted, such as this one:

☒ Our lab works with biologically-inspired robots more than their lab.

Does the author mean, "more than we work with their lab", or "more than their lab works with biologically-inspired robots?"

6. Cut redundancy. An example of redundant wording is the use of 'such as' and 'etc.' (or even worse, 'and etc.') in the same sentence. 'Such as' means 'here are some examples from a longer list.' *Et cetera* (etc.) means 'and so forth.' Choose one expression, not both. Also remember that 'etc.' is confusing if the reader has no way of finishing the list, as in this example:

☒ The developments made so far in the study of legged robots have dealt mostly with the issues of leg co-ordination, gait control, stability, incorporation of various types of sensors, etc.

Better wording would be this:

→ The developments made so far in the study of legged robots have included improvements in leg co-ordination, gait control, and stability, as well as the incorporation of various types of sensors.

7. Cut initialisms and acronyms. Both are shorthand terms consisting of only the first letters of a group of words. They are called *acronyms* when pronounced as one word, as in MOSFET, or *initialisms* when each letter is pronounced as a word, as in CEO or LED. These expressions are frequently confusing to the reader. Even if you've identified the expression somewhere in Section 1, the reader may have forgotten what those letters stood for by Section 3. Reduce use of acronyms and initialisms to a minimum. If there's a chance that the reader will not know the meaning, explain the expression the first time you use it. Provide a table of important expressions used.

[χ] **Passive voice** refers to a sentence structure in which the grammatical subject of the sentence *receives* the action rather than *doing* the action. On the other hand, if the grammatical subject is also the doer of the action (the agent), the sentence is in **active voice**. Here is a sentence in active voice:

Frank Furness designed the Fine Arts Library.

In this sentence, the grammatical subject, Frank Furness, is also the agent. Here is the same content expressed in a sentence in passive voice:

The Fine Arts Library was designed by Frank Furness.

This time, the grammatical subject, the Fine Arts Library, is the **receiver** of the action.

The passive-voice construction consists of a form of the BE verb (am, are, was, were, etc.) plus a past participle naming the action (designed, done, broken, etc.)

Passive voice is useful for connecting sentences or for putting the focus on the process or product rather than on the agent. However, it must not be overused. See Sections 3, 4, and 6 for more details.

Note that not all sentences containing a form of BE are passive-voice sentences. Here are two examples where the BE verb functions as an [=] sign, connecting a topic and a comment:

- This study **is** the first to compare fragile-site expression in both smokers and non-smokers.
- The goal **was** to validate results from the short-term study by extending the study to a period of twenty years.

There is no hidden action in those two example sentences. However, in many cases, a sentence would be improved if BE + a noun phrase were changed to an action verb:

☒ The difference between these measured pK_a values and the literature values was 4.72% for pK_{a1} and 6.12% for $pK_{a2.}$

→ The measured pK_a values differed from the literature values by 4.72% for pK_{a1}, and 6.12% for $pK_{a2.}$