

How, why, what happened next: an introduction to scientific writing

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Introduction

Scientific writing and writing about science, does not come naturally to most people but it is a skill, some would say an art, that can be learnt. From deciding on your audience through to checking the proofs, this article will cover the fundamentals of an Animal Technologist's first ventures in scientific reporting.

Scientific writing takes many forms, from posters, reports, articles and formal scientific papers amongst others and all have a different format and purpose. All are distinctive in style which needs to be **precise, succinct and logical**.

What is the difference between scientific writing and writing about science?

Scientific writing involves writing for scientists and technologists who can be expected to have some familiarity with the topic under discussion (although some may be novices). Writing about science is concerned with explaining science to a non-science/technology audience. Most of this article is dedicated to scientific writing but Animal Technologists do have to write for the general public from time to time so it is sensible to start with that.

Writing about science

In my experience this is science journalism, you do not necessarily need to be a journalist but you do need to understand how publications work and know your subject inside out and back to front. There is nothing worse than to read something in the popular press that is inaccurate and patronising. The style of writing required is usually Informal but may be formal.

The aim is to explain science in terms a lay person will understand – something that many scientists find difficult (you only have to listen to or read some of the reporting of the COVID-19 pandemic to appreciate this).

The Institute of Animal Technology (IAT) regularly produces communications in the category of writing about science. This was particularly important at the height of the animal rights campaign, there were many articles in the press, magazines, etc., for and against the use of animals in medical research. Many from the anti-vivisection lobby repeated ill-informed ideas about how animals were used and the degree of suffering animals underwent, which meant that it became vital to be able to explain to the general public what animal research meant for animals and people, particularly to children and young people. Resources were provided to teachers in an attempt to redress the balance, an example of this was the IAT bespoke website called Medical Micky which not only explained about research but also provided animal care articles. The information included in Medical Micky was provided by Animal Technologists – producing it was a massive learning curve for those involved as not only did they have to understand their subject but also understand how to write clearly in non-technical language and to be politically correct e.g. not to refer to mum and dad, as a reader may be a member of a single parent family or where the family includes same sex parents.

Scientific writing

Writing for a scientific audience usually comes at the end of an extensive period of study, experimental work and thought which starts with an idea or observation. It is important to discuss the idea with more experienced colleagues as they can provide advice on how to proceed and they may know if the idea has been tried before.

Planning the Study

At an early stage it is important to carry out a literature search for reports of closely related studies already published. A good source of these articles is PubMed, a free to use database that contains 32 million citations (references) for biomedical literature mainly from MEDLINE (a more detailed database), life science journals and online books. The citations may include links to the full text content from PubMed Central and publisher websites. People working in scientific institutes will probably have access to other databases and library resources who will be able to obtain any articles that are required. Scientific literature is being published all the time so it is important to keep checking for articles throughout the study and to keep accurate records of them to include in the reference section of your written report.

After reviewing the literature the study itself can be planned. All experimental studies will take time and most will cost money so permission will need to be gained to go further. This process will be helped if a detailed proposal is submitted stating the aim of the study, why it is necessary, how it will be carried out and benefits that will accrue from it.

Before planning the study it is necessary to read the PREPARE guidelines (Planning Research and Experimental Procedures on Animals: Recommendations for Excellence (see submissions at www.atwjournal.com).¹ This will ensure the study will be meaningful and avoid animals being wasted. It will also help when writing the report as following the guidelines will ensure all the required data for the various elements of the paper have been collected.

As well as the PREPARE guidelines¹ it is useful to read the NC3Rs Animal Research Reporting on in Vivo Experiments (ARRIVE) guidelines (<https://arriveguidelines.org>).² Although these are more relevant to writing the report it is good practice to be aware of them at the planning stage to ensure all relevant information needed for the report is recorded during the study.

Accurate records of the study must be kept, including details of what does not work as well as that what does. Notes of observations should be kept as the project proceeds and results must be recorded accurately so that statistics can be carried out and tables, graphs, charts, etc., can be produced.

It is important to back up computer data in at least two different places every day so that if something unforeseen happens the data is safe and efforts have not been wasted – this is the voice of experience writing!

Starting to Write the Report

Usually each journal will have its own set of Instructions to Authors (see www.atwjournal.com) and articles

generally have to conform to these instructions. However not all papers will contain every element of the instructions for example some ATW papers do not relate to experimental situations for example those about management, health and safety etc., so possibly will have no method or results section. If in doubt the editor should be contacted for guidance.

As has been said before being familiar with the ARRIVE guidelines is important.² Adherence to these guidelines ensures transparent and thorough reporting. This enables readers and reviewers to scrutinise the research adequately, evaluate its methodological rigour and reproduce the methods or findings. The guidelines contain a useful checklist for ensuring all the elements of accurate reporting of studies are included. When writing a manuscript, the checklist can be used as an *aide memoire* to ensure that the manuscript contains all relevant information.

Being familiar with the journal the article will be published in will make the writing process easier. In the IAT Journal *Animal Technology and Welfare* (ATW) papers, articles and posters that have won prizes are good guides as to what is expected. The scientific report about identifying mice from the team at the Royal Veterinary College, which was a winner of the Marjorie Whittingham Journal Article Prize (2019) is recommended.³

Divisions in a scientific paper

Abstract/Summary

Although published papers usually start with an abstract it is in fact written last. They should be relatively short, around one or two paragraphs and should provide a brief outline of what the paper is about without regurgitating chunks of the paper. At the end of the abstract you should provide key words, usually a maximum of 6, which can be used by someone searching for papers on a particular subject or species. For example, key words for a paper on comparison of environmental enrichment in mice might be Mice, Environmental Enrichment, Bedding, Refinement, Welfare.

Formal paper abstracts in ATW are translated into 4 European languages enabling non-English speakers (particularly Animal Technologists) to decide if a paper is of interest and if to go for a full translation.

Why = Background/Introduction

An introduction is a way of familiarising the reader with you work. For example, why was study undertaken and what you hoped to achieve – this can be varied, to answer a question, establishing a condition observed etc. Lerner, N. (2007) considers that the content of an introduction varies according to its purpose and the

audience.⁵ Avoid giving unnecessary background or repeating yourself. One of the common failures of an introduction is that it fails to focus on a clear research question or hypothesis.

State which legislation you were working under if appropriate e.g. this work was carried out under the Animals (Scientific Procedures) Act 1986 (ASPA). When study was conducted and general time frame. Do not forget to reference as you go.

How = Method

The Method section gives the experimental design, basically what you did and used. The method section should include animals used, source strain, age number, sex, etc., cages, cage furniture and diet fed. Timing of observations, precautions taken, etc. Give names of sources of equipment, etc.

“The key to a successful Methods section is to include the right amount of detail – too much, and it begins to sound like a laboratory manual; too little, and no one can repeat what was done.” Successful Scientific Writing, 2nd ed.⁵

Provide enough detail for readers to be able to reproduce the work in their own facility.

Results

Use graphs to explain the data collected and state statistical method used (if used) e.g. Student t, ANNOVA, etc. Ask for help before you start the study as you need a statistically viable number of animals and to collect the correct type of data.

Include **Observations** – anything unexpected or went wrong – this is sometimes more helpful than what worked and allows other studies to avoid the pitfalls you encountered

Discussion/conclusion

Fundamentally what you have decided your results mean. Include suggestions for future work and recommendations as to how you think the study could have been improved pointing out any shortcomings. It is an opportunity to compare the results you achieved with those you expected, including consideration of unexpected results and how you might test these explanations.

Acknowledgements

This is where you can thank the team that helped you with the work. Only need names (given and family unless they prefer initials).

References/ Bibliography

Check the referencing method the journal uses – Harvard

or Vancouver are the usual systems. ATW uses the Vancouver system i.e numeric in order of appearance. References to sources such as guidelines should include the date accessed as these may change in future versions and readers will then know which version was used.

Proofreading

Make corrections as you go and add words that your computer does not recognise to its internal dictionary first making sure that they are spelt correctly. It will save you a lot of work in the long run.

Read through the paper several times, preferably with a day in between what you think is the final draft and what will be the final draft. Read it out loud at least once, ask someone else to read it and then ask someone with experience to read it again, make any corrections and do not forget to save them and give the file a version number. Authors with a great deal of experience still follow this rule, this particular article has been read by at least 3 other people all of whom either have experience in either writing papers and articles or proof-reading.

So far, we have been concerned with preparing scientific papers which report experimental studies. The next part deals with short communications featured in ATW.

Tech-2-Tech articles

These articles lend themselves to a more relaxed style of writing and are often produced from presentations for college courses, in house meetings, etc., and of course Congress posters/workshops. They are a good introduction to publishing for first time authors but not exclusively so. Subjects covered are often about practical aspects such as new systems of cage cleaning, husbandry of unusual species, observations of characteristics of strains particularly adverse effects in GA animals, challenges presented by a new role, etc. They tend to be very visual with lots of photos or graphics. Presentations can be converted into a Tech-2-Tech article as long as the notes of the narrative that accompanies the slides are kept. Usually Tech-2-Tech articles are relatively short and as a guideline are not more than 2600 words (3 pages in ATW) including pictures/graphics (each one equals 250 words) and references. However, there are no hard and fast rules as to length – submit a manuscript, it can always be edited or a longer article published.

A good example of a Tech-2-Tech article is the study on cryopreservation in Zebrafish which won the AS-ET Tech-2-Tech prize.⁴

General rules of scientific writing

1. **Before you start writing you must obtain permission of your employer who will probably require you to go through an internal approval.** There is nothing worse than to spend time writing to find out bosses will not let you publish. Similarly if you are reporting on a finding of someone else's study you must check with them that it is OK to publish as you may find that they are intending to use some of the data in their own paper and many journals insist that material has not been published before and is therefore original research. Most journals will require you to sign that you have authority to publish.
2. Read the Instructions to Authors before you start writing – use the ARRIVE guideline checklist or possibly develop your own including the required elements so that you do not unintentionally omit something important.²
3. Check referencing method stated in Instructions. ATW uses the Vancouver system which is numeric – citations are numbered in the order they appear in the text.
4. Set proofing language to English (UK) but some international journals will specify the language papers must use e.g. English (USA).
5. Turn on spell check but when changing spellings check that the word is being used in the correct context and double check technical language.
6. Usually report in the past tense if appropriate but not always – you may be writing about some proposed changes, etc. Use formal English grammar and punctuation. If using acronyms then the full name must be given at least once, the first time it is used with the acronym in brackets immediately afterwards e.g. Institute of Animal Technology (IAT).
7. Latin terms such as *in vivo* or a species name e.g. *Homo sapien* and foreign language words are usually written in italics.
8. If you use someone else's photograph/quote, etc., you must check about copyright and ask the copyright owner for permission to use it – they will generally say yes if you acknowledge their ownership. This is usually given in brackets after the legend. To make life easier for authors using material published in ATW, copyright is held by the IAT and anybody wanting to use it can contact the Editor and we will say yes or no – we always protect the author and will refuse permission if we feel the use of something is not appropriate. Copyright in the UK usually lapses 70 years after the death of the author so you can use a quote from a classical author such as Keats but not one by Ted Hughes unless you contacted the copyright owner. Also, product names may be Trademarked or have a registered mark in which case the symbols, superscript TM or R in a circle, that must follow the word e.g. TM ® the first time it is used.

9. If you lack confidence about using English grammar obtain a copy of a good book on English grammar and punctuation – an Editor will help but if the English is very poor your manuscript may be sent back to you. Editors can usually recognise authors with conditons such as Dyslexia, Dyspraxia, etc., and we will help correct any errors if we can but there is no excuse for laziness.

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I must also thank all the past editors of the IAT Journal *Animal Technology and Welfare* who have over the last 70 years continued to produce an official publication for the Institute. I have learnt so much both as an Animal Technologist and as an Editor - even things I was not aware that I had learnt!

References

- 1 **PREPARE guidelines** <https://norecopa.no/prepare>
- 2 **ARRIVE guidelines** <https://arriveguidelines.org>
- 3 **Mazlan, N., Lopez-Salesanky, N. Burn, C., and Wells, D. (2014).** Mouse identification methods and potential welfare issues: a survey of current practices in the UK. *Animal Technology and Welfare Vol 13.1 pp1-10.*
- 4 **Mantzorou, D., Berriman, T., Havelange, W., Glover, J., Berry, S., Correia de Silva, B.(2019).** Sperm cryopreservation and *in vitro* fertilisation in Zebrafish facilities at King's College London. *Animal Technology and Welfare Vol 18.3 pp194-198*
- 5 **Lerner, N. Ogren-Balkama.** A Guide to Scientific Writing Neal Lerner Marilee Ogren-Balkama Massachusetts Institute of Technology. [Microsoft Word - Guide to Scientific Writing.doc \(mit.edu\)](#)
- 6 **Matthews, J.R., Bowen, J.M., Matthews, R.W. (2000). 2nd edition.** Successful Scientific Writing: A step-by-step guide for the biological and medical sciences. *Cambridge University Press.*