Science Research Writing

For Non-Native Speakers of English

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Unit 5 ✏ Writing the Abstract

5.1 Structure

The structure and content of the Abstract have changed in recent decades. Before on-line publication databases such as the Science Citation Index, the Abstract was printed at the top of a research article and its function was mainly to encourage the reader to continue reading the article and to facilitate that reading by providing a brief preview. The reader and the writer didn't consider the Abstract of a research article as an independent unit because it was not normally read without reference to the article itself.

The Internet has influenced the way that science research is communicated and the way that scientists access published research. Abstract databases allow scientists to search and scan the scientific literature and then decide which research articles they want to read in detail. Some readers simply want to know what is going on in their research area and may not be interested in the details; others may want to know details but are only interested in research articles which are directly relevant to their own research. However, if readers are going to actually read your research article, the Abstract now needs to persuade them to obtain a copy of it, not just encourage them to keep reading a paper they have already accessed.

Abstracts compete for attention in on-line databases. Many more people will read the title than the Abstract, and many more will read the Abstract than the whole paper. This means that however 'good' and well-written the Abstract is, it needs to have independent validity. It should make sense as a standalone, self-contained description of the research article, and readers should be able to understand the key points and results of the research even if they never see the whole article. The Abstract, in this sense, is a representation of the research article.

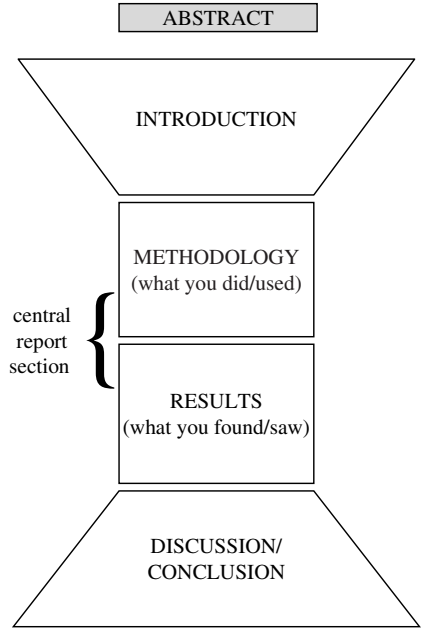

Fig. 1. The shape of a research article or thesis.

Why does the unit on Abstracts come at the end of this book rather than at the beginning?

In the first place, the style and the length of the Abstract depend on where you plan to submit it and that decision may be taken late in — or even after — the writing process. However, the most important reason for putting this unit on Abstracts at the end of the book is that you are in a better position to create an Abstract after you have finished writing the other sections of your paper. The content of the Abstract is derived from the rest of the article, not the other way around. Although you should not simply cut and paste whole sentences from the body of the article, the Abstract does not contain material which is not already in the paper. This means that you don't need to create completely new sentences; once you have decided what should go in the Abstract you can select material, including parts of sentences and phrases, from the relevant sections of the paper and adapt or modify them to meet the demands of an Abstract. This also means that the Abstract is easier to write than the rest of the paper!

Does every Abstract follow the same model?

No, and the title of the Abstract reflects this. Some are called Summary, some are called Background, some are called Abstract and others have no title at all. Most Abstracts are results-focused and there are basic similarities in all Abstracts, but there are two quite distinct models. The first model is similar to a summary, and is very structured. It deals with all the main subsections of the research article and can even have subtitles such as Background/Method/Results/Conclusions. The second model is more common, and focuses primarily on one or two aspect of the study, usually — but not always — the method and the results. Both models will be discussed here. Note that the models for an Abstract described here are appropriate for articles, papers, theses *etc.* Abstracts for conferences may not follow either of these models.

How do I know which model to choose?

This decision is based on the type of research you have done and the Guide for Authors of the journal where you want to publish your research. The decision is normally determined by the journal rather than the author. If the choice is yours, then generally speaking, the more narrow and specified your research topic, the less likely you are to use the summary format. This is because in a narrow research field, most readers already know the background. The word limit set by each journal also has a significant effect on the structure and therefore also on the content of the Abstract.

So as you can see, when we come to ask our three questions:

- How do I start the Abstract? What type of sentence should I begin with?
- What type of information should be in the Abstract, and in what order?
- How do I end this section?

You already know a lot about what the Abstract should include and in what order.

Here are examples of both models. Remember that Model 2 Abstracts are more common than Model 1.

Start by reading the Abstract below, which is an example of a structured Abstract using the summary format (Model 1). The title of the

paper is: **Physical properties of petroleum reservoir fluids derived from acoustic measurements**. Don't worry if you have difficulty understanding terms such as *bubble point*. Just try to get a general understanding at this stage and familiarise yourself with the structure.

MODEL 1

> ***Abstract:*** *The speed of sound in a fluid is determined by, and therefore an indicator of, the thermodynamic properties of that fluid. The aim of this study was to investigate the use of an ultrasonic cell to determine crude oil properties, in particular oil density. An ultrasonic cell was constructed to measure the speed of sound and tested in a crude oil sample. The speed of sound was measured at temperatures between 260 and 411 K at pressures up to 75 MPs. The measurements were shown to lead to an accurate determination of the bubble point of the oil. This indicates that there is a possibility of obtaining fluid density from sound speed measurements and suggests that it is possible to measure sound absorption with an ultrasonic cell to determine oil viscosity.*

Now look at an example of the second, more common, type of Abstract. The title of this paper is: **Effect of polymer coatings on drug release**.

MODEL 2

> ***Abstract:*** *This study investigated the use of a novel water-soluble polymer blend as a coating to control drug release. It was found that using a blend of methylcellulose and a water-soluble copolymer significantly slowed the release rate of ibuprofen compounds in vitro and allowed for a more consistent release rate of 10–20% per hour.*

5.2 Grammar and Writing Skills

Because the Abstract is derived from the rest of the article, most of the grammar and writing skills have already been covered in previous units. The use of VERB TENSE, however, is very important in the Abstract. This section also deals with the LENGTH and LANGUAGE of the Abstract.

5.2.1 Verb tense

Verb tense is especially important in the Abstract because the strict word limit means that you may need to omit phrases that tell the reader whose work you are referring to, or what you think about your results. In this case, these can be achieved by careful and accurate use of verb tense.

Remember that the tense you use in a sentence may be grammatically correct — and therefore no editor or proofreader will notice it or draw your attention to it — but if you have not chosen the appropriate tense the sentence will not mean what you wanted it to mean and it will not have the effect you hoped it would have.

The **gap/problem** is normally in the Present Simple tense:

The main problem, however, is…
We examine why these models have difficulty with…
However, this assumption is not valid when…
This is complicated by…
However, this assessment cannot be based solely on…
Although it is known theoretically that…

When you are referring to **what the paper itself does** or **what is actually in the paper itself**, use the Present Simple tense, for example:

This paper presents a new methodology for…
In this paper we apply…
This study reports an improved design for…
In this paper we extend an existing approach to…
We consider a novel system of…
The implications for learning algorithms are discussed…
New numerical results are presented here for…

When you are referring to your **methodology,** or what you did during the research period, it is common to use the Past Simple tense, for example:

Two catalysts were examined in order to…
Samples were prepared for electron microscopy using…
A crystalliser was constructed using…
The effect of pH was investigated by means of…
The data obtained were evaluated using…
A permeameter was used to investigate…

It is also possible to use the Present Simple tense to talk about your **methodology**, especially when you are referring to calculations or equations which can be found in the paper itself:

Numerical examples are analysed in detail…
The calculated wavelengths are compared to…
Several models are created using…
The accuracy is evaluated by…
A detailed comparison is made between…
The method is illustrated on blends of homopolymers…

Results can be expressed in either the Present Simple tense, for example:

We find that oxygen reduction may occur up to 20 microns from the interface…
The model consistently underpredicts…
The ratio shifts towards…
We show that this theory also applies to…
The most accurate readings are obtained from…
We find that this does not vary…
These examples illustrate that overpotential is better described in terms of…

Or, more commonly, in the Past Simple tense, for example:

The Y-type was found to produce…
The hydrocarbons showed a marked increase in…

No dilation was observed…
This was consistent with…
Organised fibers were found after 6 weeks…
These profiles were affected by…
This finding correlated with…

but be aware that the sentence may use two different tenses. Even if the first part of the sentence is in the Past Simple tense (*We found/It was found etc.*) you can decide to put the finding/result itself or the implication of the result in the Present Simple tense if you believe it is strong enough to be considered as a fact or truth:

The experiments demonstrated there are two matrices…
It was found that proteins are produced from…
The results demonstrated that the morphology is different…
This image suggested that there is a direct relationship between…

Some of the reasons behind that choice are discussed in the unit on Introductions (Section 1.2.1) and the unit on Results (Section 3.4.2). In addition to the reasons given there, it is worth noting that the Abstract tends to present the contents of the paper in fairly direct way, not only because of the word limits imposed by editors, but also to engage the attention of the reader. This influences the decision to use the Present Simple for the results or the implications, even though those implications may have been stated in the Past Simple in the article itself.

Achievements can be expressed in the Present Perfect tense, as in the Discussion/Conclusion:

We have obtained accurate quantitative LIF measurements…
This investigation has revealed that…
We have devised a strategy which allows…
We have demonstrated the feasibility of this approach by…
A novel material has been produced which…
Three-dimensional FE predictions have confirmed that…
Considerable insight has been gained concerning…

and also in the Present Simple tense:

This process can successfully be combined with…
The framework described here is both simple and universal…
The value of our approach lies in…
This provides a powerful tool for…
This novel film is mechanically robust and is able to…
The algorithm presented here ensures that…

Applications are normally stated in the Present Simple tense:

This process is suitable for the production of…
This framework can be used to evaluate…
This approach can be applied to…
This demonstrates potential for general applicability to…
These profiles may serve as a predictor for…
This framework can be used to evaluate…

5.2.2 Length

The Abstract usually has a strict word limit. Most are between 80–150 words and are written as a single paragraph. Even longer Abstracts (150–250 words) are usually written as a single paragraph. Don't submit an Abstract that is over the word limit or it may be cut by an editor in a way that does not represent your work appropriately.

For your first draft, don't worry too much about the word limit. Once you have decided which of the two Abstract models you will use, start by including whatever you think is important, and then gradually remove words, phrases and even sentences that are not essential.

5.2.3 Language

Think of the search phrases and keywords that people looking for your work might use. Make sure that those exact words or phrases appear in your Abstract, so that they will turn up at the top of a search result listing.

The Abstract is sometimes written in a slightly less technical way than the article itself in order to attract a wider audience. This may mean that some of your readers do not know a particular technical term or acronym

that you want to include. To solve this problem, you can use the acronym, abbreviation or technical term in the Abstract but you should first say what it means or stands for. For example:

Granules of hydroxyapatite (HA) were implanted.

5.3 Writing Task: Build a Model

5.3.1 Building a model

You are now ready to build a model of the Abstract by writing a short description of **what the writer is doing in each sentence** in the space provided below. This should be very easy, because all the components of the Abstract have occurred in previous subsections. As before, the Key is on the next page.

GUIDELINES

This time you will need to build two models, to cover the two types of Abstracts. You should only need to spend 10–20 minutes on this task, because the sentence types are familiar to you from previous units. Don't forget that your models are only useful if they can be transferred to other Abstracts, so don't include content words or you won't be able to use the models to generate your own Abstract.

Remember that one way to find out what the writer is doing in a sentence, rather than what s/he is saying, is to imagine that your computer has accidentally deleted it. What changes for you, as a reader, when it disappears? If you press another key on the computer and the sentence comes back, how does that affect the way you respond to the information?

As mentioned in previous sections, another way to figure out what the writer is doing is to look at the grammar and vocabulary clues. What is the tense of the main verb? What is that tense normally used for? Is it the same tense as in the previous sentence? If not, why has the writer changed the tense? What words has the writer chosen to use?

This time, you may find that you produce perfect models, but you will still probably modify them — especially the second type — when you compare them to the way Abstracts are written in your target articles.

MODEL 1

Physical properties of crude oil from acoustic measurements ***Abstract*** **1** *The speed of sound in a fluid is determined by, and therefore an indicator of, the thermodynamic properties of that fluid.* **2** *The aim of this study was to investigate the use of an ultrasonic cell to determine crude oil properties, in particular oil density.* **3** *An ultrasonic cell was constructed to measure the speed of sound and tested in a crude oil sample.* **4** *The speed of sound was measured at temperatures between 260 and 411 K at pressures up to 75 MPs.* **5** *The measurements were shown to lead to an accurate determination of the bubble point of the oil.* **6** *This indicates that there is a possibility of obtaining fluid density from sound speed measurements and suggests that it is possible to measure sound absorption with an ultrasonic cell to determine oil viscosity.*	**In this sentence, the writer:** 1_____ 2_____ 3_____ 4_____ 5_____ 6_____

5.3.2 Key

In Sentence 1 '*The speed of sound in a fluid is determined by, and therefore an indicator of, the thermodynamic properties of that fluid.*' **the writer provides background factual information**.

How do I know what kind of background information to provide?

The background information that is found at the start of this type of Abstract is usually derived from the first sentences of the Introduction.

In this particular Abstract, the information provides a factual background. Other types of background may also be appropriate; for example, if your field of study is wastewater treatment or air pollution, then it may be useful to mention the political background.

How much background information should I give?

In some journals, this type of Abstract has subtitles, *i.e.* Background/Method/Results/Conclusions; if so, the number of words is usually distributed fairly evenly among the different parts, but if not, the distribution is left to the writer and the proportion of the Abstract taken by each part varies considerably. If you feel that a lot of background is *necessary to understand the Abstract itself,* combine the relevant points and summarise them in as few words as possible. The focus of an Abstract is more likely to be on the methodology or the results, so limit background information to one or two sentences.

Can I use research references in the Abstract?

Research background may be necessary, although it is rare to include actual research references. However, if your article follows directly from an existing published paper or is a major advance or contradiction of a specific work or theory, you should cite the relevant paper in the Abstract.

In Sentence 2 '*The aim of this study was to investigate the use of an ultrasonic cell to determine crude oil properties, in particular oil density.*' **the writer combines the method, the general aim and the specific aim of the study in one sentence**.

Try to combine sentences in a way that shortens the total length of the Abstract. You can reduce the number of words by combining the background information and the aim, or what this paper does and what was found, so that the sentence serves more than one purpose. Sentences such as *In order to determine x we did y* combine the aim and the method in one sentence.

In Sentences 3 and 4 '*An ultrasonic cell was constructed to measure the speed of sound and tested in a crude oil sample.* **4** *The speed of sound was measured at temperatures between 260 and 411 K at pressures up to 75 MPs.*' **the writer summarises the methodology and provides details**.

How much detail should I give?

It depends on how important the details are. In this case the methodology is the main focus of the study; the aim of the study was *to investigate the use of an ultrasonic cell* (Sentence 2). If the important contribution of your work really is in the details of the methodology, you can and should provide those details in the Abstract and you can even give those details numerically. It is quite common to find sentences which give temperatures, pressures, times, quantities thicknesses and even light-absorption data. However, in many other cases the focus of the study — and therefore of the Abstract — is not on the methodology, in which case it is given in summary form and details are reserved for the Results.

In Sentence 5 '*The measurements were shown to lead to an accurate determination of the bubble point of the oil.*' **the writer indicates the achievement of the study**.

One of the central functions of the Abstract is to emphasise new and important achievements of the study. Almost all Abstracts also include positive language at this point (*an accurate determination*) to demonstrate the value of the work.

In Sentence 6 '*This indicates that there is a possibility of obtaining fluid density from sound speed measurements and suggests that it is possible to measure sound absorption with an ultrasonic cell to determine oil viscosity.*' **the writer presents the implications of the study**.

Another important function of the Abstract is to show how the implications of the study contribute to knowledge and information in this area, and this can be derived from the aim of the study or the gap or problem the study addressed (*The aim of this study was to investigate the use of an ultrasonic cell to determine crude oil properties, in particular oil density*).

Many types of implications can be mentioned; for example, there may be implications for associated problems or for previous studies in the light of your findings.

These implications seem rather soft — is language like 'possible' really appropriate here?

It's certainly true that phrases such as *It may therefore be the case that* and other phrases that you saw in Section 3.2.4 are not common here. Results, implications and achievements are often stated quite strongly, which encourages the reader to read the rest of the article favourably and accept the conclusions. It's also true that qualifications and discussions of implications, including possible restrictions and constraints, can be left to the article itself. However, what you report in the Abstract should be consistent with what you report in the paper, and if your work represents an early stage in a breakthrough or the implications of your work are still not firm, it is appropriate to communicate this by including modal verbs (*could/might/may*) or words such as *possible.*

What do I do if there were problems with my study — do I mention those in the Abstract?

If they are really important, yes, and if so, you even briefly say what they were. It is better not to say that something *will be discussed*. The Abstract should provide/summarise the exact details of your findings. Important implications, data and findings are included, NOT left out. This includes problems, if (*but only if*) they were important, and directions for future work. Both are relatively rare in the Abstract.

MODEL 2

Effect of polymer coatings on drug release ***Abstract*** **1** *This paper reports the use of a novel water-soluble polymer blend as a coating to control drug release.* **2** *It was found that using a blend of methylcellulose and a water-soluble copolymer significantly slowed the release rate of ibuprofen compounds in vitro and allowed for a more consistent release rate of 10–20% per hour.*	**In this sentence, the writer:** 1_____ 2_____

In Sentence 1 '*This paper reports the use of a novel water-soluble polymer blend as a coating to control drug release.*' **the writer combines what the paper does** (*This paper reports*), **the method or materials used** (*water-soluble polymer blend*), **the contribution (***novel***) and the aim of the study (***to control drug release***).**

This shows why it is not a good idea just to copy sentences from the research article itself. The word limit in the Abstract means that you may not have space to write one sentence describing the method you used and another stating the aim of your study; you need to find a way of combining such elements. Look at these combinations:

GAP/ACHIEVEMENT

> *In contrast to traditional approaches to water distribution planning based on cost, the model proposed here allows issues such as quality of supply to be considered.*

ACHIEVEMENT/METHOD

A substantial increase in catalyst productivity was achieved by nanofiltration-coupled catalysis.

PROBLEM/METHOD

In order to select the optimum strategy in an environment with multiple objectives, a decision-aid tool for optimal life-cycle assessment was used.

In Sentence 2 '*It was found that using a blend of methylcellulose and a water-soluble copolymer significantly slowed the release rate of ibuprofen compounds in vitro and allowed for a more consistent release rate of 10–20% per hour.*' **the writer refers to the method in more detail and provides numerical details of the results**.

Even when an Abstract is short it must still do almost as much work as the paper, and it should still inform potential readers whether the article is suitable for their needs. If the reader cannot decide whether to read the paper without knowing whether you used simulation, analytic models, prototype construction, or analysis of field data, you should include that. If the value and relevance of your work is that you did many experiments with various parameters rather than a single case study, you should include that information. If, as in this case, the value of the work is *a more consistent release rate of 10–20% per hour* then this should be included in the Abstract.

How much detail of the results should I give?

The results are probably the most important component of this type of Abstract, and you should be specific and give details of key results. Avoid vague words such as *small* or *better*. If you provide 'naked numbers' try and include quantitative language such as ***only*** *38%* or ***as high as*** *15%* so that the numbers cannot be misinterpreted. In this case, the writer does not simply refer to *a more consistent release rate*, the actual numerical result (*a more consistent release rate of* ***10-20% per hour***) is included. For the same reason, you should not use unclear terms such as *various methods were used* when you describe your methodology.

5.3.3 The models

Here are the sentence descriptions we have collected:

MODEL 1

In Sentence 1	**the writer provides background factual information.**
In Sentence 2	**the writer combines the method, the general aim and the specific aim of the study in one sentence.**
In Sentences 3 and 4	**the writer summarises the methodology and provides details.**
In Sentence 5	**the writer indicates the achievement of the study.**
In Sentence 6	**the writer presents the implications of the study.**

MODEL 2

In Sentence 1	**the writer combines what the paper does, the method or materials used, the contribution and the aim of the study.**
In Sentence 2	**the writer refers to the method in more detail and provides numerical details of the results.**

Rather than construct two different models, the model description given in the box below will include both types of Abstracts. We can streamline the sentence types we have collected so that the model has five basic components.

The more structured type, Model 1, typically includes the first four components in the box below in approximately the order presented; in this type of Abstract, each component tends to occur separately. These structured Abstracts occasionally include the fifth component, LIMITATIONS and/or FUTURE WORK.

Model 2 selects just two or three of the components and tends to combine components in a single sentence where possible. The components generally include RESULTS and/or ACHIEVEMENTS and frequently METHODOLOGY, but this depends on the research area and the level of specificity. A wider research focus may require BACKGROUND or AIM in the Abstract. In Model 2, the order of components is very

flexible indeed — the only pattern that is generally followed is that METHODOLOGY tends to come before RESULTS.

1	BACKGROUND AIM PROBLEM WHAT THE PAPER DOES
2	METHODOLOGY/MATERIALS
3	RESULTS ACHIEVEMENT/CONTRIBUTION IMPLICATIONS
4	APPLICATIONS
5	LIMITATIONS FUTURE WORK

5.3.4 Testing the models

The next step is to look at the way this model works in some real Abstracts. Here are two Abstracts from real research articles. Read them through, and mark the model components (1, 2, 3, 4 or 5) wherever you think you see them. For example, if you think the first sentence corresponds to number 1 in the model, write 1 next to it, *etc*.

Effects of H_2O on structure of acid-catalysed SiO_2 sol-gel films

Abstract

Thin silica films were deposited on silicon wafers by the sol-gel technique, using spin coating. The sols were prepared by HCl catalysis of tetraethylorthosilicate (TEOS) diluted in ethanol, using

different molar ratios, *R,* of H_2O:TEOS. The films were then baked at various temperatures, and characterised using ellipsometry, profilometry, optical scattering and infrared spectroscopy. It was found that the thickness, shrinkage, porosity and pore sizes all decrease with increasing *R*. it was also found that high water levels yield films of higher homogeneity and finer texture, and less tensile stress.

Limitations of charge-transfer models for mixed-conducting oxygen electrodes

Abstract

A framework is presented for defining charge-transfer and non-charge-transfer processes in solid state electrochemical systems. We examine why charge-transfer models have difficulty modelling non-charge-transfer effects, and walk through several examples including the ALS model for oxygen reduction on a porous mixed-conducting oxygen electrode. These examples illustrate that electrode 'overpotential' is often better described in terms of macroscopic thermodynamic gradients of chemical species. In the case of a porous mixed conducting oxygen electrode, oxygen reduction is limited by chemical reaction and diffusion, and may occur up to 20 microns from the electrochemical (charge-transfer) interface.

OPTIMIZATION AND SENSITIVITY ANALYSIS FOR MULTIRESPONSE PARAMETER ESTIMATION IN SYSTEMS OF ORDINARY DIFFERENTIAL EQUATIONS

Abstract

Methodology for the simultaneous solution of ordinary differential equations (ODEs) and associated parametric sensitivity equations using the Decoupled Direct Method (DDM) is presented with respect to its applicability to multiresponse parameter estimation for systems described by nonlinear ordinary differential equations.

The DDM is extended to provide second order sensitivity coefficients and incorporated in multiresponse parameter estimation algorithms utilizing a modified Newton scheme as well as a hybrid Newton/Gauss–Newton optimization algorithm. Significant improvements in performance are observed with use of both the second order sensitivities and hybrid optimization method. In this work, our extension of the DDM to evaluate second order sensitivities and development of new hybrid estimation techniques provide ways to minimize the well-known drawbacks normally associated with second-order optimization methods and expand the possibility of realizing their benefits, particularly for multiresponse parameter estimation in systems of ODEs.

Semi-continuous nanofiltration-coupled Heck reactions as a new approach to improve productivity of homogeneous catalysts

Abstract

Substantial increase in homogeneous catalyst productivity for a well known Heck coupling was achieved by nanofiltration-coupled catalysis. The use of nanofiltration membranes enabled catalyst separation and allowed subsequent catalyst recycle and reuse. This new technique demonstrated potential for general applicability to homogeneously catalysed organic syntheses.

Ras isoforms vary in their ability to activate Raf-1 and phosphoinositide 3-kinase

Ha-, N-, and Ki-Ras are ubiquitously expressed in mammalian cells and can all interact with the same set of effector proteins. We show here, however, that *in vivo* there are marked quantitative differences in the ability of Ki- and Ha-Ras to activate Raf-1 and phosphoinositide 3-kinase. Thus, Ki-Ras both recruits Raf-1 to the plasma membrane more efficiently than Ha-Ras and is a more potent activator of membrane-recruited Raf-1 than Ha-Ras. In contrast, Ha-Ras is a more potent activator of phosphoinositide

> 3-kinase than Ki-Ras. Interestingly, the ability of Ha-Ras to recruit Raf-1 to the plasma membrane is significantly increased when the Ha-Ras hypervariable region is shortened so that the spacing of the Ha-Ras GTPase domains from the inner surface of the plasma membrane mimics that of Ki-Ras. Importantly, these data show for the first time that the activation of different Ras isoforms can have distinct biochemical consequences for the cell. The mutation of specific Ras isoforms in different human tumors can, therefore, also be rationalized.

Now do the same in your target articles. We hope you obtain good confirmation of the model and have found the answers to the questions at the beginning of this section:

- How do I start this section? What type of sentence should I begin with?
- What type of information should be in this section, and in what order?
- How do I end this section?

5.4 Vocabulary

You already have most of the information you need to write this section of your paper because you can find the words/phrases you need in the other units of this book. However, because the Abstract needs to be understood by a wider range of people than the article itself, the Abstract tends to use simpler, more conventional language where possible. We will therefore look at the most common vocabulary in each part of the model.

The vocabulary lists in this section are taken from over 600 Abstracts in different fields, all of which were written by native speakers and published in science journals. Only words/phrases which appear frequently in this set of research articles have been included; this means that the vocabulary lists contain words and phrases which are considered normal and acceptable by both writers and editors.

In the next section we will look at typical vocabulary for all the areas of the model.

5.4.1 Vocabulary task

Look through the Abstracts in this unit and in each of your target articles. Underline or highlight all the words and phrases that you think could be used in each part of the model. You should recognise them from previous sections without too much trouble.

A full list of useful language can be found on the following pages and of course in the relevant sections in previous units. This list includes all the words and phrases you have highlighted from the Abstracts in this unit, along with others which you may have seen in your target articles.

5.4.2 Vocabulary for the Abstract

1. BACKGROUND

You can find more in Unit 1, Section 1.4.2, as well as examples of how these are used.

a number of studies exist(s) frequently generally is a common technique is/are assumed to is/are based on is/are determined by is/are influenced by is/are related to it has recently been shown that	it is known that it is widely accepted that occur(s) often popular produce(s) recent research recent studies recently recently-developed

AIM

You can find more in Unit 1, Section 1.4.2 and Unit 2, Section 2.4.2, as well as examples of how these are used.

in order to our approach the aim of this study to compare	to examine to investigate to study with the aim of

PROBLEM

You can find more in Unit 1, Section 1.4.2, as well as examples of how these are used.

(an) alternative approach	impractical
a need for	inaccurate
although	inconvenient
complicated	it should be possible to
desirable	limited
difficulty	not able to
disadvantage	problem
drawback	require
essential	risk
expensive	time-consuming
however	unsuccessful

WHAT THE PAPER DOES

In this study/paper/investigation we *or* We	This study/paper/investigation
address	considers
analyse	describes
argue	examines
compare	extends
consider	includes
describe	presents
discuss	reports
emphasise	reviews
examine	
extend	
introduce	
present	
propose	
review	
show	

Note: It is also possible to use many of these verbs with *it* or, i.e. *In this paper* ***it*** *is shown/argued that…* or in the passive, i.e. *A framework* ***is presented****…*

2. METHODOLOGY/MATERIALS

You can find more in Unit 2, Section 2.4.2, as well as examples of how these are used.

was/were assembled	was/were modelled
was/were calculated	was/were performed
was/were constructed	was/were recorded
was/were evaluated	was/were studied
was/were formulated	was/were treated
was/were measured	was/were used

3. RESULTS

You can find more in Unit 3, Section 3.4.2, as well as examples of how these are used.

caused	was/were achieved
decreased	was/were found
had no effect	was/were identical
increased	was/were observed
it was noted/observed that…	was/were obtained
occurred	was/were present
produced	was/were unaffected (by)
resulted in	yielded
was identified	

ACHIEVEMENT/CONTRIBUTION

You can find more in Unit 4, Section 4.4.2, as well as examples of how these are used.

accurate	achieve
better	allow
consistent	demonstrate
effective	ensure
enhanced	guarantee
exact	obtain
improved	validate
new	
novel	
significant	compare well with
simple	for the first time
suitable	in good agreement
superior	

IMPLICATIONS

You can find more in Unit 3, Section 3.4.2, as well as examples of how these are used, but remember not to use the weaker forms such as *seem to suggest* or *tend to be related to* in the Abstract.

The evidence/These results…	it is thought that
	we conclude that
indicate(s) that	we suggest that
mean(s) that	
suggest(s) that	can
	may

4. APPLICATIONS

You can find more in Unit 4, Section 4.4.2, as well as examples of how these are used.

applicability	make it possible to
can be applied	potential use
can be used	relevant for/in

5. LIMITATIONS and FUTURE WORK

Limitations and future work are rarely mentioned in an Abstract and then only briefly. You can find more in Unit 2, Section 2.4.2, Unit 3, Section 3.4.2, and Unit 4, Section 4.4.2, as well as examples of how these are used

a preliminary attempt not significant slightly	future directions future work

5.5 Writing an Abstract

In the next task, you will bring together and use all the information in this unit. You will write an Abstract according to the model using the grammar and vocabulary you have learned, so make sure that you have both the model (Section 5.3.3) and the vocabulary (Section 5.4) in front of you.

In this unit you have seen the two models of Abstracts and the vocabulary conventionally used has been collected. Remember that when you write, your sentence patterns should also be conventional, so use the sentence patterns of the Abstracts in this unit and in your target articles as models for the sentence patterns in your writing.

Choose one of the models, follow it exactly this time, and in future, use it to check your Abstract so that you can be sure that you have done what your readers expect you to do in this section.

Although model answers are provided in the Key, you should try to have your own answer checked by a native speaker of English if possible, to make sure that you are using the vocabulary correctly.

5.5.1 Write an Abstract

Write an Abstract for the same research that was used in Unit 4, Section 4.5.1 to write the Discussion/Conclusion. It's reprinted here in full, including the model Discussion from the Key at the end of Unit 4.

> *Imagine that you and your team have designed a machine which can remove chewing gum from floors and pavements by treating the gum chemically to transform it into powder and then using vacuum suction to remove it.*

In the Introduction, you began by saying that chewing-gum removal is a significant environmental problem. You then provided factual information about the composition of chewing gum[1,2] and the way in which it sticks to the floor.[6] After that, you looked at existing chewing-gum removal machines[3,4] and noted that research has shown that they are unable to use suction to remove gum without damaging the floor surface.[10] You referred to Gumbo *et al*., who claimed that it was possible to use chemicals to dissolve chewing gum.[5] At the end of the Introduction you announced that you and your research team had designed a chewing gum removal machine (CGRM), which you call GumGone. GumGone sprays a non-toxic chemical onto the gum which transforms it to white powder. The machine can then remove the gum using suction without damaging the floor surface.

In the Methodology you described the design and construction of the machine. You compared your CGRM, GumGone, to two existing machines, Gumsucker[3] and Vacu-Gum.[4] You then gave details of a set of trials which you conducted to test the efficiency of the new CGRM and a further set of trials which showed the effect on the floor surface of gum removal.

In the Results section, you showed results of these trials. You compared the performance of GumGone with Gumsucker and Vacu-Gum. Your results were very good, and they can be seen in the tables below.

Table 1: Gum removal as a percentage of total sample

	Gumsucker	Vacu-gum	GumGone
Wooden floor	77	73	80
Stone floor	78	78	82
Carpeted floor	56	44	79

Table 2: Floor damage/staining

	Gumsucker	Vacu-gum	GumGone
Wooden floor	minimal	minimal	none
Stone floor	significant	some	none
Carpeted floor	significant	significant	minimal

Discussion

Gum removal technology has traditionally faced the problem of achieving effective gum removal with minimal damage to floor surfaces. Existing CGRMs such as Gumsucker and Vacu-Gum use steam heat and steam injection respectively to remove gum and although both are fairly effective, the resulting staining and damage to floor surfaces, particularly carpeted floors, is often significant.[10]

In this study the design and manufacture of a novel CGRM, GumGone, is presented. GumGone reduces the gum to a dry powder using a non-toxic chemical spray and then vacuums the residue, leaving virtually no stain. In trials, GumGone removed a high percentage of gum from all floor surfaces without causing floor damage. The floor surfaces tested included carpeted floors, suggesting that this technology is likely to have considerable commercial use.

Percentage removal levels achieved using GumGone were consistently higher than for existing CGRMs on all types of floor surface. This was particularly noticeable in the case of carpeted floor, where 79% of gum was removed from a 400 m^2 area, as opposed to a maximum of 56% with existing machines. This represents a dramatic increase in the percentage amount of gum removed. Our results confirm the theory of Gumbo *et al.* that chemicals can be used to dissolve gum into dry powder and make it suitable for vacuuming.[5]

The greatest advantage over existing CGRMs, however, lies in the combination of the two technologies in a single machine. By reducing the delay period between gum treatment and gum removal, the GumGone system resulted in negligible staining of floor surfaces. This represents a new approach which removes the need for stain treatment or surface repair following gum removal.

As noted earlier, only one wattage level (400 watts of vacuum suction power) was available in the GumGone prototype. Further work is needed to determine the power level at which gum removal is maximised and floor damage remains negligible.

5.5.2 Key

Here are the sample answers. When you read them, think about which part of the model is represented in each sentence.

MODEL 1

Abstract

The fats and resins in chewing gum contribute to elasticity, bulk and texture but also increase staining. The aim of this study was to design a gum removal machine able to remove gum chemically with no stain residue. A machine, GumGone, was designed and constructed, which injected non-ionic detergent into gum deposits using a power spray and then immediately vacuumed the resulting powder. It was found that 1 μl of detergent achieved effective, stain-free removal over a 300 m^2 area. Performance was superior to existing systems and suggests that the delay between treatment and removal is a significant factor in staining.

MODEL 2

Abstract

This paper reports the design of a gum removal machine, GumGone, which combines non-ionic detergent treatment with immediate vacuum removal to minimise stain residue. Tests were conducted over a 300 m^2 area and removal levels of between 79% to 80% were achieved. Residual staining levels were superior to existing systems.

5.6 Creating a Title

In Section 5.5 it was stated that *Many more people will read the title than the Abstract, and many more will read the Abstract than the whole paper.* This is because the title, like the Abstract, tells readers whether or not the research article will be useful for them. A good title will attract readers and,

more importantly, will attract the appropriate readers. The reverse is also true: if the title is poor the research article may not reach the appropriate audience.

I don't know how to start constructing a title.

Start by looking at your research aim or the question you were trying to answer. Try and turn the question or problem into a title. For example,

What is the difference between x and y?

becomes

A comparison of x and y
and
How does x affect y?

becomes

The effect of x on y

What is a good title?

The title should predict and describe the content of the paper as accurately as possible. If your paper is a case study, the title should reflect this:

Crack propagation in a pressurised pipe

If it is a more general survey the title should indicate this:

Crack initiation in pressurised pipes

The title should include key words that make the paper retrievable easily on search engines. It does not necessarily have to be a sentence but it should nevertheless make sense. Notice that titles of research articles don't normally use title case; they are generally written in sentence case.

There are some grammar issues that are worth noting. When you use key words in constructing the title, be careful about creating complex compound nouns. The conciseness of a compound noun is very tempting for non-native writers and English has a high level of tolerance for such

nouns, but make sure that the compound noun can be understood without ambiguity. Note that the noun on the right-hand side of a compound noun is the 'real' noun and any noun or nouns to the left of it have adjectival function in the sense that they modify the right-hand noun. Also note that the relationship between the nouns that make up a compound noun may include options you had not considered:

- *an oil* ***can is a can*** *which may contain oil ….or it may be empty, but its normal use is to contain oil*
- *an oil can* ***opener is an opener*** *for cans which may contain oil*
- *an oil can opener repair* ***man is a man*** *who is able to repair cans which may contain oil*
- *an oil can opener repair man training* ***programme is a programme*** *to train men to repair openers for cans which may contain oil*
- *an oil can opener repair man training programme funding* ***problem is a problem*** *with the funding for the training programme to train men to repair openers for cans which may contain oil*

Another aspect of grammar that often causes problems — and not only in the title — is the use of prepositions such as *by, with, on, in, for*. Prepositions are not simply a type of glue to hold words together; they have a profound effect on meaning, and in the title this effect is particularly significant. The preposition *with,* for example, may mean either *using* or *having*. Evidence *for* something is evidence that tends to support or confirm that it is present or that it exists. Evidence *of* something is an actual observable sign of its presence or existence.

Filtering of code phase measures ***from*** *dual-frequency gps receivers*

is different from

Filtering of code phase measures ***in*** *dual-frequency gps receivers*

and

Sensory components controlling bacterial nitrogen assimilation

is much clearer than

Sensory components in bacterial nitrogen assimilation

Since this is such a complex area and the risk of an error in the title is so significant, it is advisable to avoid preposition-heavy structures and/or to get your title checked by a native-speaker colleague before submitting the paper for publication.

Good titles are usually concise, so it is not common to begin with phrases such as *A study of…* or *An investigation into…* They are also written in very formal English, so the use of a question mark is not common.

What can I do to make sure that readers accurately estimate the value of my paper?

If the results obtained in the study represent a significant achievement, the title may simply state the results:

> *Ras isoforms vary in their ability to activate raf-1 and phosphoinositide 3-kinase*

However, in most cases, the title is not the right place to indicate either the value of the paper or its limitations. State your title neutrally; words like *reliable* are not common, nor are modal verbs such as *may/might/could*. Be careful not to set up expectations which are not fulfilled in the paper itself; for example, if your study does not refer to all substrates/systems/reactions *etc.*, the title should specify which substrates/systems/reactions it does refer to.