Methodological Guide to Writing a Scientific Article in IMRAD Format

IMRAD (Introduction, Materials and Methods, Results, and Discussion) is an international standard for the structure of scientific articles, especially common in the natural sciences and biomedicine. Since the early 1970s, IMRAD has become the “gold standard” for reporting research, formalized by ANSI and recommended by the ICMJE (Vancouver guidelines) for biomedical journals. Today, the vast majority of international journals require this structure for original research articles. Even domestic (local) journals have adapted: the IMRAD format is now mandatory almost everywhere (even in fields where it was not previously used) to meet the requirements of scientific databases.

IMRAD provides a clear and logical presentation of material: each part of the article answers a specific set of questions, and together they lead the reader from the problem statement to the conclusions. Below is a detailed guide on preparing all sections of an article in IMRAD format, with attention to the specifics of scientific and applied biotechnology. The guide includes style advice, common mistakes, additional sections of an article, and features of preparing a manuscript for publication.

Introduction: The Significance of the IMRAD Format

This section explains why the IMRAD format is needed, when it is applied, and which journals require it. IMRAD is used primarily for original research articles that present results of empirical studies (experiments, observations). Its goal is to standardize the structure of an article, which makes reading and peer review easier: the reader knows exactly where to find the description of methods, where the results are, etc. This format turns a dry report of work done into a coherent scientific argument, increasing the clarity and persuasiveness of the presentation.

When IMRAD is used: in virtually all scientific disciplines, especially in applied fields. In biotechnology (as part of the biomedical sciences), the IMRAD format is used for articles describing experiments, development of new biotechnological processes, obtained biological data, and so on. It has become universal: originally arising in the natural science community in the USA, the format is now accepted worldwide, including in theoretical works, thanks to its convenient logic.

Journal requirements: If you plan to publish, be sure to check the “Instructions for Authors” section of your target journal. Nearly all journals indexed in international databases (Scopus, Web of Science, etc.) expect authors to follow the IMRAD structure. Many explicitly state this in their guidelines; for example, the ICMJE Uniform Requirements for Manuscripts stipulate the presence of Introduction, Methods, Results, and Discussion sections. Specialized biotechnology journals (for example, *Applied Microbiology and Biotechnology*, *Biotechnology Letters*, etc.) are no exception. Thus, adhering to the IMRAD format is a guarantee that your work will be correctly perceived by editors and reviewers.

Note: The IMRAD structure is usually required for original research articles. Reviews, short communications, or technical reports may have other formats. However, knowing IMRAD is useful even in those cases—it disciplines your writing. In this guide, we assume you are preparing an original research article (original paper).

Main Sections of an IMRAD Article

Below are recommendations for each of the four main IMRAD sections: Introduction, Materials and Methods, Results, and Discussion. For each section, we describe its purpose, approximate length, language features, typical author mistakes, and provide a fragment of successful text as an example.

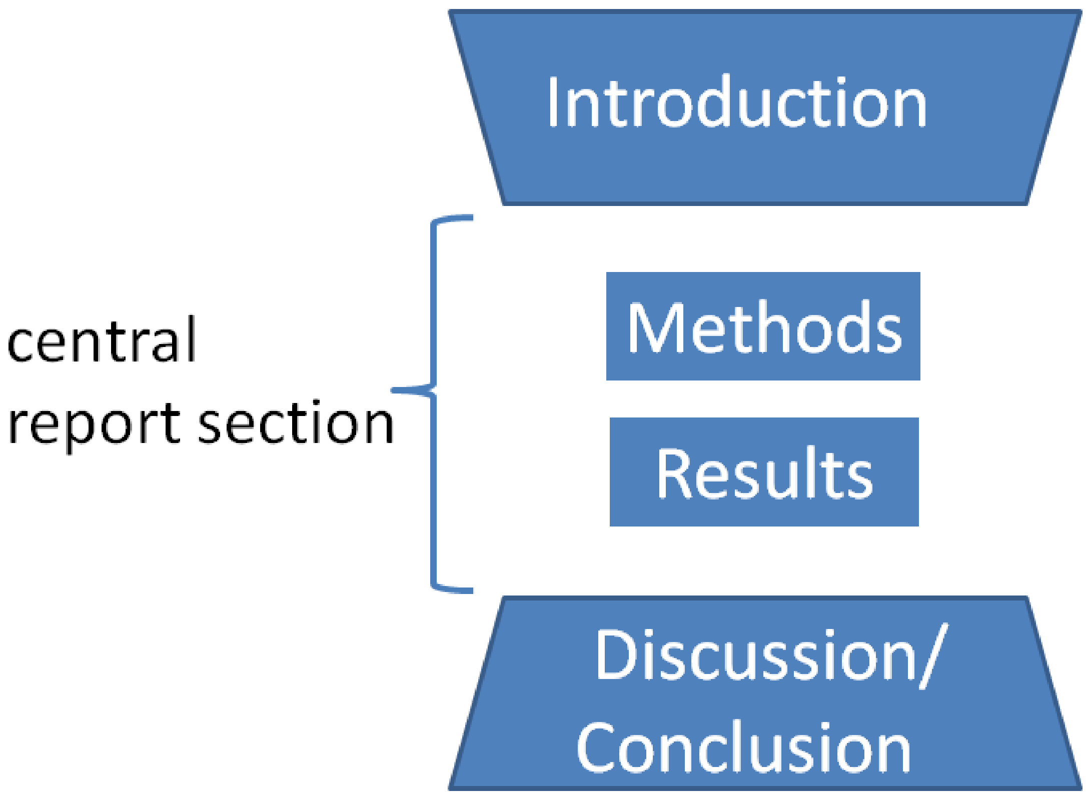

Figure 1. The "wineglass" model illustrating the IMRAD structure. At the top, the wide opening (Introduction) covers the general context and problem statement; the middle narrows (Materials and Methods, Results), focusing on the specific study; at the bottom, the base widens again (Discussion), returning to broader scientific questions and the significance of the findings. The symmetrical shape reflects that the questions raised in the Introduction find their counterparts in the Discussion (in reverse order), and the change in width shows the transition from general to specific and back again.

Section "Introduction" (Introduction)

Purpose of the section: The Introduction answers the question "Why was the study conducted?" It establishes the relevance of the problem, the place of your work among previous research, and formulates the aim (hypothesis) of the study. A good Introduction draws attention to the importance of the research and immediately makes clear why the results might be interesting to the reader. In other words, the Introduction needs to indicate the background of the study (what is already known on the topic, what gaps or contradictions exist) and the specific question or problem you address. It is also customary to briefly explain key terms, abbreviations, and niche concepts to prepare the reader for the text that follows.

Recommended length: The introduction should be relatively short yet substantive. Typically, it is 1–2 pages or around ~500 words (many journals recommend not exceeding this length). To stay within the optimal volume, avoid fluff and repetition: do not duplicate in the Introduction what has already been stated in the abstract or will be discussed in detail later. It is sufficient to outline the problem and its relevance, briefly review the literature, and state the purpose of your research. Remember that a detailed literature review belongs in the Discussion or in a separate review article; the Introduction only needs the minimum context necessary to understand the goal of the work.

Style features: The Introduction is written in an academic, formal style, without overly complex sentences. Various verb tenses are acceptable, depending on context. For example, the aim of the study is often stated in the past tense ("The aim of the present work was...") because the research has been completed. General facts and current knowledge on the topic can be given in the present tense ("Antibiotic resistance **is** a serious problem..."), however, describing what previous authors have done is usually given in the past or present perfect ("Previous studies **showed**..." or "it **has been shown** that..."). The Introduction is written mostly without personal pronouns: avoid referring to the paper in the first person ("we investigated...") – it's better to use a neutral construction: "it was investigated..." or "an analysis was conducted...". However, there is no strict taboo on first person (if the journal does not forbid it, you can write "In this work, we investigated..."). The style should be logical, moving from the general problem statement to the specific niche of your work (the funnel principle). It is important to maintain an objective tone, without subjective evaluations or promotional claims.

Typical mistakes in the Introduction:

Lack of a clear motivation. The author does not explain why the research problem is important. The reader should understand the relevance of the topic from the first paragraphs (for example, by using problem statistics or identifying a knowledge gap). Otherwise, the Introduction loses its meaning. Remember: *"The Introduction should emphasize the importance of the study and define its place among similar works"*. If the significance is not clear, the reader will not be interested in your results.

Weak literature review. A common rookie mistake is either not citing previous works at all, or citing them arbitrarily. You should analyze at least a few key publications on the topic to show that you are familiar with the state of the field. The review should lead toward your research question. It's not enough to write a single phrase "The problem is understudied" – you need to briefly show what has been done and what is still missing. For example, emphasize that the literature lacks a solution to the specific problem you focus on. Ideally, the Introduction should mention 20–30 sources, including international ones, especially from the last 5–10 years, to demonstrate the relevance and global context of the research.

No clear aim or objectives. At the end of the Introduction, the reader expects to see the formulated aim of the study (and/or the hypothesis) and, if necessary, the main tasks the author set to achieve that aim. A mistake would be a vague or missing statement of purpose. The formulation of the aim should flow directly from the preceding review: after stating what is lacking in the science, it should logically follow: *"In view of this, the aim of the present work was…"*.

Unnecessary details and discussions. Beginners sometimes overload the Introduction with methodological details, an in-depth discussion of their results, or general musings off-topic. Remember that the Introduction is not the place for results or conclusions, and not even for detailed methodology. Everything in its place: experiment details go in Methods, interpretation goes in Discussion. If you remove any paragraph from the Introduction that isn't directly related to justifying the study's purpose, the text will only improve.

Duplication of the abstract. The Introduction should not repeat the abstract verbatim. The abstract is a brief summary of the entire work, whereas the Introduction is the beginning of the main text, which should delve deeper into the topic. Avoid starting the Introduction with phrases like "In this article, we consider…" as already stated in the abstract. It's better to jump straight into the essence of the scientific problem.

Example of an Introduction fragment:

"The spread of antibiotic-resistant bacteria is a serious challenge to modern medicine. In particular, *Staphylococcus aureus* strains with multiple resistance cause thousands of hospital infections each year. A substantial body of research has accumulated in the global literature on the search for new antibacterial agents; however, an effective solution to the problem of S. aureus resistance has not yet been proposed. The present study is aimed at developing a fundamentally new enzyme preparation active against resistant strains."

Why is this a good example? It starts with a general problem (antibiotic resistance), supports it with specifics (the example of *S. aureus*), points out the absence of a solution (a gap in knowledge), and formulates the aim of the study. The text is concise (~90 words), without unnecessary details, and immediately demonstrates the importance of the work.

Section "Materials and Methods" (Materials and Methods)

Purpose of the section: Materials and Methods answer the question "What was done and how?". Here the author describes how the study was conducted, including the research subject(s), materials used, equipment, and methods of experiment and data analysis. Essentially, the Methods section is an instruction for reproducing your experiment: the reader (and especially the reviewer) needs to understand whether the results can be trusted and whether one could replicate your experiment if needed. In applied biotechnology, the Methods section is extremely important, since the correctness of the methodology determines the reproducibility of results and the possibility of implementing your developments in practice.

Content of the section: Describe the sequence of the study, justify the choice of methods and materials, and provide sufficient quantitative details. Often the easiest way is to present methods in chronological order (in the sequence the experiments were carried out). Alternatively, if the study is multi-component, the section can be divided into subsections (e.g., "Cell Cultivation," "Analytical Methods," "Statistical Analysis"). Be sure to list all key techniques, instruments, and software used to obtain and process the data. If in your work you developed a new method, describe it in maximum detail. If you used a well-established method, there is no need to describe it from scratch – just briefly mention it and give a reference to a source or standard where it is described. For example: *"DNA was extracted by the phenol-chloroform method according to the standard protocol [ISO 12345:2019]."* – this is enough so as not to clutter the text with well-known details. It is important to note any specifics: any modifications of standard techniques or non-standard parameters should be described and explained (including why they were made). If the experiment required special equipment, provide the make and model of instruments and the supplier of reagents (especially for critical ones), as well as the conditions of the experiment (temperature, incubation time, reagent concentrations, etc.). Don't forget the statistical methods for data processing (tests of significance, number of replicates, criteria for significance) – these are usually stated at the end of the Methods section.

Writing style: As a rule, use the past tense, because you are describing steps that have already been carried out. For example, "the cells were cultivated at 37 °C for 24 hours." Both active voice ("We cultivated the cells…") and passive voice ("The cells were cultivated…") are acceptable; there are no strict requirements, although many English-language journals today encourage active voice. In Russian scientific style, impersonal constructions are often used ("conducted analysis," "comparison was made"). The key is to stick to a consistent style throughout the text. Write precisely and clearly: avoid ambiguities. It's better to split one overly complex compound sentence into two or three simple sentences than to risk misunderstanding. Do not overload the text with numerical data – detailed results will appear in the next section. Here you can limit yourself to describing what was measured and by what methods, and then provide the specific numbers in the Results section.

Typical mistakes in the Methods section:

Not enough detail for reproducibility. For example, the author mentions "the microbial culture was grown on nutrient medium," but does not specify the medium composition, incubation temperature, or duration of cultivation. Or says "enzyme activity was measured by a standard method," without clarifying which method and providing a reference. The reader should not have to guess how exactly you worked – otherwise your results may be doubted. **Rule:** any competent specialist, after reading your Methods section, should be able to **repeat** the experiment given the same equipment. If some information is critical for reproducibility, include it or provide a reference.

Unnecessary (excessive) details. The opposite situation: the author writes out trivial things in excessive detail. For example, a step-by-step description of preparing a buffer solution using a basic recipe, listing every step of an obvious procedure, or characteristics of equipment that do not affect the results (the color of test tubes, the operating system version of a computer, etc.). Novices tend to think that the more they write, the better. In fact, you need to strike a balance: include all essential details and omit what is obvious to specialists. Mentioning "extra" details distracts from and dilutes important information.

Lack of references for methods or standards. In applied biotechnology, standard protocols (e.g. GOST, ISO, methodological guidelines) and previously published methods are widely used. A typical mistake is to describe a method as if it were one's own, without citing the original source. This can look like appropriation of someone else's method and raise red flags with reviewers. **Advice:** if a method is not your own invention, always cite the source (literature or standard). Example: *"Protein content was determined by the Bradford method"*

– this is sufficient to give credit to the original author of the method and inform the reader where to find details. The same applies to instruments: specify the manufacturer and model, especially if results depend on it (e.g., Illumina NextSeq 550 sequencer, Thermo Scientific NanoDrop 2000 spectrophotometer, etc.).

Mixing results into the experimental description. Methods are about procedures, not their outcomes. However, sometimes authors start inserting phrases like "...and it was found that..." into this section. This should be avoided: any data and observations belong in the Results section. In Methods you can mention what was measured, but not what was **found**. If it is absolutely necessary to provide some monitored value (for example, "the temperature during the reaction did not exceed 50 °C"), this is acceptable, but then make it clear that it is a condition, not a result.

Unstructured, chaotic description. A lack of logical order in describing methods makes reading difficult. A common mistake is listing methods in a random sequence. It's better to group related procedures: for example, first the methods of obtaining samples, then the methods of analysis, then the methods of processing results. Also avoid long blocks of text: break the section into paragraphs by topic, use subheadings if the section is lengthy.

Neglecting ethical standards. This is especially relevant for biotechnological research: if you worked with laboratory animals, human samples, or pathogenic microorganisms of groups II–IV, you **must** include information about ethics committee approval, licenses or permits (if applicable). Failure to mention required ethical approvals where obviously needed is considered a serious omission and can lead to rejection. For example: *"The study on laboratory animals was conducted in accordance with the provisions of the European Convention ETS123, and the protocol was approved by the local ethics committee (Protocol No. ...)."*

Example fragment of the "Materials and Methods" section:

"The *E. coli* BL21(DE3) bacterial strain was used for expression of recombinant protein X. Cultures were grown in Luria-Bertani medium at 37 °C until an optical density of OD_{600} ~0.6 was reached. Induction of target protein synthesis was carried out by adding isopropyl-β-D-thiogalactopyranoside (IPTG) to a final concentration of 0.5 mM, after which the culture was incubated for 4 h. For protein purification, nickel-affinity chromatography was applied according to the manufacturer's standard protocol (GE Healthcare). The eluted fractions were dialyzed against buffer (20 mM Tris-HCl, pH 8.0) and analyzed by SDS-PAGE."

Why is this a good example? It describes the main steps of the experiment in order: choice of strain, cultivation conditions, induction, protein purification, analysis. Key parameters are given (temperature, IPTG concentration, incubation time), and a standard technique (affinity chromatography) is referenced by citing the manufacturer's protocol instead of providing excessive detail. The text is precise and contains no results (there are no statements about the **effectiveness** of the purification – that will come in the Results section). The style is neutral, in the past tense.

Section "Results" (Results)

Purpose of the section: The Results answer the question "What was obtained?". Here the author presents the new data obtained in the course of the study – observations, measurements, experimental facts. The Results section is the key part of the article: it contains the scientific novelty and value for which the entire paper was written. The preceding sections (Introduction, Methods) create the background and toolkit, but the value of the article is determined by the Results. Therefore, you should approach its preparation especially carefully.

Structure and content: It is best to present results in a logical order, following the same sequence as the research objectives. Break the section into subsections if it helps the reader. For example, you might sequentially describe: (1) characteristics of the obtained data (e.g., properties of initial samples, validation of the experiment), (2) main observations/effects, (3) additional analyses or checks, if any. Each paragraph should carry a message. It is not good practice to simply list numbers or facts – try to immediately highlight what significant finding they indicate. However, remember the fine line: interpretations and generalizations belong in the Discussion. In the Results section you state facts, but refrain from extensive explanation of causes. For example, it is appropriate to write: *"Enzyme activity increased 2-fold at pH 6.0 compared to pH 7.5 (Table 2)."* But a phrase like "This is due to increased stability of the enzyme at acidic pH" should be saved for the Discussion, otherwise you are starting to analyze rather than just report the result.

When presenting results, use visual materials: tables, graphs, charts, figures. In biotechnological works, one often includes microphotographs, spectra, electrophoresis gels, etc. – all of these are considered illustrations of results. There is an unwritten rule: results that can be given in a quantitative or graphical form are better presented as such. A graph or table will often convey information more clearly than a paragraph of text. However, avoid duplication: do not provide the same data in both a table and a figure and also extensively in the text. Choose the optimal way: if the trend or relationship is important – use a graph; if exact numerical values are needed – use a table. In the text, highlight the key numbers or trends, referring to the table/figure. For example: *"Enzyme activity increased from 20 to 50 U with a temperature increase from 20 °C to 40 °C (Fig. 3)."* Here, the details of the curve or all 10 intermediate values need not be listed – that's what Figure 3 is for. All tables and figures should be numbered and captioned (title + explanation of what is shown). In the article text, be sure to reference each of them at least once (at minimum one reference per table or figure) – otherwise it's unclear why they are needed.

Data processing: If you have numerical results, ensure that units of measurement are indicated, and where appropriate, include errors, confidence intervals, or p-values of statistical tests. For example: "12.7±0.3 mg/mL," "growth phase lasted 8±1 hours," "differences are statistically significant, $p < 0.05$." For graphs, label the axes with quantities and units; for micrographs, include scale bars. Do not embellish the data: zero or negative results are still results, and they should be reported honestly if they are important for completeness. Novice authors sometimes hide "unsuccessful" results, but experts will usually notice gaps. It's better to report: "At concentrations above X, no effect was observed" – and then provide an explanation in the Discussion – than to omit it and raise questions.

Sequence of presentation: Present the results such that the reader can establish a cause-and-effect chain. Poor style is to jump chaotically from one set of data to another. Good style is to first show the validity of your data (e.g., control experiments), then the main results, then any supporting or secondary observations. All results needed for the subsequent discussion should be presented here; otherwise, there will be nothing to discuss. At the same time, you should not describe every raw datum – aggregate and select, group them, make summary tables. If there is an overwhelming amount of data (e.g., hundreds of measurements), do not try to cram it all into the main article – that's what Appendices or Supplementary Materials are for (see below).

Typical mistakes in the Results section:

Lack of focus and clarity. If the Results section turns into a dry list of numbers without explanation, the reader will struggle to grasp the point. For example: "The product concentration was 1.2 mg/mL (experiment 1), 0.5 mg/mL (experiment 2), 0.8 mg/mL (experiment 3)...". This text is hard to follow. It is much better to group and interpret: "In all three experiments, production of the target product was observed, with the highest concentration achieved in experiment 1 – 1.2 mg/mL, which is 2.4 times higher than in experiment 2." Here we have a conclusion (that experiment 1 was best) and the numbers to support it. **Tip:** try to accompany each set of results with a brief statement of what they show. But (!) do not confuse this with explaining the reasons – only state the trend or comparison.

Disproportionately long presentation. Another mistake is an overly lengthy, cumbersome Results section. If you obtained many different data, perhaps not all need to be included in the article. Focus on the key results that answer the posed questions. Secondary graphs or tables can be moved to Supplementary Materials. Also common is a situation where the Results section is overloaded with repetitive information. For example, the text, a table, and a graph all convey the same thing. Optimize: either keep text + graph, or text + table. A frequent problem is duplication of data in text and table: if a table is provided, there's no need to list every number from it in the text, just summarize the main point. Remember the principle: illustrative materials are usually used in the Results section; do not duplicate the same information in multiple formats.

Mixing with Discussion. Perhaps the most common mistake is when authors begin discussing the results too early. For example: "When the temperature increased, product yield dropped to 20% (Fig. 5). This is likely due to enzyme denaturation." The last sentence is already interpretation, which belongs in the Discussion. In the Results section, it's better to limit yourself to: "...dropped to 20%. Thus, a suppression of product yield was observed with increasing temperature (Fig. 5)." That is, record the phenomenon, but do not delve into explaining it. Discipline yourself: as soon as you feel the urge to write "this is due to...", save that thought for the next section.

Careless or incorrect data presentation. This includes technical blunders: missing labels on graph axes, illegible numbers on figures, improper rounding of values (e.g., giving excessive precision that the method doesn't support), discrepancies between text and figures (the text says one thing but the graph shows another). These errors are common among beginners. **Advice:** carefully double-check all visual materials: do the labels match the content, are there typos in numbers, are units and symbols properly formatted? Ideally, each figure and table should be understandable on its own – at least the main symbols should be explained in the caption or a note.

Omitted results. Sometimes in trying to be concise, authors relegate too many important findings to the Discussion. As a result, the Results section is missing pieces – for example, a mention of a control experiment or a numerical value that is later referenced. This complicates reading: the reviewer has to hunt through the text to find the actual data. **Rule:** everything discussed in the Discussion must be presented (at least by reference to a figure/table) in the Results section. If you want to discuss, say, the correlation between two parameters, ensure that either a correlation graph or a corresponding data table is provided in Results. If you plan to discuss that "at 50 °C the effect disappeared," make sure that the Results section indeed states that no effect was observed above that temperature.

Example fragment of the "Results" section:

"Analysis of recombinant protein X expression showed that at 0.5 mM IPTG induction, the target protein accounted for ~40% of total cellular protein (Fig. 4). On the electrophoresis gel (Fig. 5), a prominent band of ~25 kDa is visible in induced samples and absent in controls (no IPTG), corresponding to the expected size of protein X. The yield of purified product after affinity chromatography was 15±2 mg per liter of culture with ~95% purity (Table 1). Thus, the obtained protein X was isolated with high yield and purity."

Why is this a good example? It sequentially presents the key results: the expression level of the protein, evidence of its presence on a gel, and the quantitative yield upon purification. References are used to figures (a graph and a gel image) and a table with numerical data, and the text is not overburdened with numbers: only the most important ones are given. Note that the final sentence provides a brief interim summary ("the protein was obtained with high yield") – this is acceptable as a short conclusion drawn from the figures. Importantly, there are no explanations *why* such results were obtained – only statements. Everything is written in the past tense ("showed," "was visible," "was isolated"), which is logical for a completed experiment.

Section "Discussion" (Discussion)

Purpose of the section: The Discussion answers the questions "What do all these results mean?" and "Why are they important?". Here the author interprets the findings, relates them to the research objectives and previously known data, and discusses the scientific and practical value of the work. Simply put, if the Results section provided the reader with the "facts," the Discussion should help them understand how those facts advance scientific knowledge. Often it is the Discussion that distinguishes a publication in a good journal from a mere technical report: editors and reviewers want to see that the author can critically evaluate their data and place them in a broad context.

Connection with the Introduction: A good approach is to view the Discussion as a mirror reflection of the Introduction (in terms of content). In the Introduction, you posed questions and outlined hypotheses – in the Discussion you need to provide answers or commentary on them. If certain unresolved issues were mentioned in the Introduction, make sure that you revisit them in the Discussion. The most common mistake is inconsistency between the Introduction's statements and the Discussion. For example, an author might state at the beginning that the goal was to develop a new method X, but in the Discussion suddenly talk about general biological aspects, forgetting to evaluate whether method X succeeded. The Discussion must directly relate to the aims and objectives stated at the beginning of the work.

If the goal was achieved – say so and provide evidence; if not – discuss why and what to do next.

Structure of the Discussion: You need not follow a rigid scheme, but it typically includes several components: **1. Summary of main results** – start by briefly recapping what you found (especially if the Results section is large). Sometimes the first paragraph of the Discussion explicitly restates the principal findings of the work in simple terms. This helps set the tone. **2. Interpretation and explanation** – next, explain why you obtained such results and how they align with expectations. Here it is appropriate to discuss mechanisms, reasons behind phenomena, whether hypotheses are confirmed or refuted. You can refer to figures or tables, but by this point the reader is usually already familiar with them. **3. Comparison with literature** – a very important part: compare your results with those of other studies. Show whether your findings support or contradict previous work. If there are discrepancies, try to find an explanation (differences in methods, experimental conditions, etc.). Always cite sources when discussing others' data. A good practice is a sentence like: *"Our results are consistent with the data of Ivanov and Petrov , who also showed an increase in product yield at pH 6.0. However, Smith et al. (2020) reported the opposite trend, which may be due to the use of a different strain."* Such comparison demonstrates your engagement with the scientific discourse. **4. Evaluation of significance and limitations** – explain what's new or important about your results for science or practice. Perhaps your method is more efficient, or you observed an effect for the first time – highlight that. Simultaneously, acknowledge the limitations: no study is perfect. For example, a small sample size, absence of certain tests, or narrow experimental conditions – show that you are aware of these. This adds honesty to your work. **5. Perspectives and recommendations** – usually at the end of the Discussion (or in a separate **Conclusion** section) you mention how the results can be used and what should be studied next. For example: *"The obtained data can form the basis of a technology for biosynthesis of substance Y; a promising direction for further research is optimization of the process at bioreactor scale."*

Writing style: Here you have more freedom in tense usage. It can be convenient to describe **your** results in the past tense ("it was found that...") or in the present if you consider them established facts at the time of discussion ("our experiments show that..."). Widely accepted scientific facts and literature data are often given in the present tense to emphasize their generality: for example, "E. coli-based catalysts **are used** for insulin production since 1982." But these are not strict rules – the main thing is that the text is consistent and clear. The tone of the Discussion should be academically confident but not baseless. Every assertion should either follow from your results or be supported by a literature citation. Using the first person ("in our study, we found...") is acceptable, though many prefer an impersonal style. Avoid overly emotional statements – phrases like "we were the first in the world to achieve an incredible result." Even if it is a major achievement, describe it neutrally: "for the first time, data on ... were obtained."

Typical mistakes in the Discussion:

Repeating results instead of discussing them. It's bad if the Discussion consists of the same sentences as the Results, just rephrased. The Discussion is not a repeat but an interpretation. Novices tend either to mix these parts or to be afraid to voice their opinion and end up just listing the numbers again. You need to go further: **why** did you get those results?

What do they mean in the context of the problem? Don't be afraid to articulate conclusions and hypotheses.

Straying from the research objectives. As noted, a big mistake is when the Discussion goes off on a tangent and doesn't address the questions posed in the Introduction. For example, an author might discuss general biological principles but say nothing about whether they accomplished the task stated at the beginning. **Advice:** re-read your Introduction and the questions raised there. Make sure that in the Discussion each of them is answered (even if the answer is "the question remains open and requires further study" – which is an honest acknowledgment of the work's limitations). The Discussion should logically correspond to the set objectives and hypotheses.

Overly bold claims not supported by data. Sometimes authors, inspired by their results, make overly broad statements. For example, after obtaining data in cell culture, they immediately claim to have a "new effective treatment for a disease." Such a conclusion is not justified by the experiment – applying it to actual treatment is far off. Ensure that your conclusions match the scope of your study. Avoid phrases like "it has been proven that..." – most likely, your work only *showed* something under certain conditions. It's also best to avoid words like "obviously" or "undoubtedly" – they can provoke skepticism. Better to say: "the results **indicate** that ...", "it is **possible** that ...".

Ignoring alternative explanations and negative results. When discussing your data, try to consider contradictory points as well. If something doesn't fit your hypothesis, don't hide it. For example: *"Interestingly, at 50 °C the activity unexpectedly increased, although we had assumed the opposite. A possible reason might be ...."* This shows your scientific honesty. Be critical of your own data: including analysis of conflicting results is an important aspect of scientific rigor. Similarly, if there are publications with results different from yours, be sure to mention them and suggest why things turned out differently (different systems, conditions, etc.). The ability to address counterarguments is the mark of a mature author.

Lack of references to literature. A discussion with no mention of other studies looks odd – it's as if you don't know where to place your results. Cite other authors' work that supports or contradicts your conclusions. Just don't overload the discussion with others' data – they should serve as background for interpreting **your** results, not lead off on a separate tangent. And remember: when mentioning others' results, you must cite the source, otherwise it will look like you're appropriating ideas.

Weak ending. At the end of the Discussion (or in the Conclusion), the reader expects clear conclusions. A common mistake is to end the Discussion with a vague statement like "Our study yielded a lot of interesting data." This says nothing. Much better is: "Thus, the stated goal was achieved: method X was developed, which increased product yield by 30%. It was shown that...". Conclusions should be specific and linked to the objectives. If this is missing, reviewers often comment that "the article does not provide clear conclusions" – a serious shortcoming.

Example fragment of the "Discussion" section:

"The data obtained **support** the working hypothesis of a stimulatory effect of calcium ions on antibiotic production. In the presence of Ca^{2+}, biosynthetic activity increased by an average of 25% compared to the control (Table 2), which is consistent with the results of previous studies.

For instance, Ivanov et al. (2018) reported a similar rise in antibiotic synthesis under the influence of Ca^{2+} in *Streptomyces* cultures. Our results complement their finding by demonstrating that the effect is shown in an industrial producer strain, not only under laboratory conditions. At the same time, an unexpected outcome was the decrease in production upon addition of magnesium ions – previously Folmer et al. (2019) observed the opposite trend. The possible explanation for the discrepancy lies in the use of different microbial species and fermentation conditions. Overall, the approach we developed proved effective for enhancing biosynthesis of the target compound, however it requires further study: in particular, the long-term influence of the ions on the culture and the economic optimization of the process need to be evaluated."

Analysis of the example: In this fragment, the author interprets the results (the role of Ca^{2+}), compares them with literature (citing Ivanov et al. and Folmer et al.), noting both agreements and discrepancies with previous works and offering explanations. Notice that part of the text is in the present tense ("support the hypothesis," "is consistent with results," "Folmer observed") – this is normal in a Discussion, emphasizing the currency and generality of scientific knowledge. In the end, the author gives a summarizing conclusion (the method is effective) and points out a limitation/future perspective (additional aspects need study), which gives the section a sense of closure and smoothly transitions to the conclusion.

Additional Sections of a Scientific Article

Aside from the main IMRAD sections, a full research article includes a number of additional sections. Their purpose is to provide the reader with all necessary information about the work: from the title and a brief summary to the list of sources. Let's consider the main ones and the specifics of preparing them.

Article Title (Title)

Role of the title: The title is the first thing a potential reader (or reviewer) sees. It should succinctly and accurately reflect the essence of the study – the subject and the main result or idea. A good title immediately lets the reader know what the article is about and attracts the right audience. Moreover, in the age of electronic libraries, the title functions as a search query: other researchers will find your work by key words from it.

How to craft a title:

Keep it concise – roughly no more than 10–12 words. Remove generic terms and empty phrases (such as "Study on...", "Some aspects of..."). Instead, be specific from the start: use "Method for Increasing Vitamin B12 Production using..." rather than "On the question of increasing the yield of useful substances."

Reflect the aim and main result. The reader should catch the main message from the title. For example: "A New Biosensor for Rapid Detection of Pesticides in Water" – it's clear what was done (a biosensor was developed) and for what (detecting pesticides). In contrast, a title like "Detection of Some Contaminants" is too vague.

Avoid jargon and abbreviations (unless an abbreviation is extremely well-known in your field, like PCR, DNA, etc.). The title should be understandable to the broadest possible range of specialists. Ideally, do not use highly specialized terms that aren't widely known. For instance, instead of "Application of method X for...", it's better to state the essence of method X in plain words.

Avoid subjective claims. Do not include evaluative words in the title such as "effective method," "unique strain," "significant influence." Let readers judge those from the text. The title should be a neutral description. Ideally, it reads like a statement of fact. For example, "Biological treatment of wastewater by method Y using strain Z" – neutral and clear.

Title capitalization and punctuation: In English, either sentence case or Title Case is used (depending on journal style). In Russian, titles are usually written with only the first word capitalized (and proper nouns) and without a period at the end. Check the journal's requirements.

Example of a good title: *"Transgenic Yeasts as a Biofactory: Enhancing Insulin Synthesis by 40% through Promoter Activation."* – This identifies the object (transgenic yeasts), the essence of the work (biofactory for insulin, promoter activation), and the result (40% increase in synthesis). The title is informative and will attract specialists in biotechnology and medical biology.

Example of a poor title: *"Research of Some Methods in Biotechnology."* – Too general, unclear what was done; such a title won't attract readers and won't show up in targeted search queries.

Abstract (Abstract)

Role of the abstract: The abstract is a brief summary of the article, usually 150–250 words (about 5–10 sentences). From the abstract, a reader (or a database search engine) decides whether it's worth reading the entire article. A good abstract gives a condensed essence of the work: what was done, how, and what was found. Keep in mind that the abstract is often freely available even if the article is behind a paywall, so it should be self-contained and informative.

What to include in the abstract: Most journals require the abstract to contain the following elements:

Background: 1–2 sentences of context and the problem (why the research was done).

Objective: Clearly state the goal or hypothesis of the work.

Methods: 1–2 sentences about the methods or approach used (without details).

Results: 1–3 sentences on the most important results – include specific numbers or qualitative outcomes.

Conclusion/Significance: 1 sentence about the main conclusion and the significance of the results.

Some journals request a **structured abstract** with subheadings (Background, Methods, Results, Conclusions), but in most applied journals it is written as a single paragraph. Avoid using complex terminology in the abstract and spell out all abbreviations, since it will be read by people from various fields. Do not include citations, figures, or reference numbers in the abstract – the abstract needs to stand alone. The style should be objective, with no “we” and no evaluative adjectives. For example, instead of “very good results were obtained,” state specifically what was obtained.

Typical mistakes in the abstract:

Too vague or broad. For example: “The influence of various factors on the object was studied. Results of interest were obtained.” – such an abstract communicates nothing. The reader learns neither the essence of the work nor the specific findings.

Overly detailed abstract. The opposite problem – trying to stuff every detail into the abstract, including secondary results, methodological nuances, and too many numbers. The text becomes overloaded and hard to read. Remember: the abstract is not a substitute for the article, but an advertisement for its content. You need to pick the most important points.

Mismatch with the article content. Sometimes the abstract is written hastily before finalizing the article, and it no longer accurately reflects the text. Make sure that all main results mentioned in the abstract actually appear in the article, and conversely that the article’s key conclusions are reflected in the abstract.

Violating length requirements. If the journal requires “Abstract ≤ 200 words” (~1500 characters), don’t submit a 300-word abstract. They are strict about this.

Example of an abstract:

“Background: Antibiotic resistance in pathogens necessitates the search for new therapeutic approaches. Objective: In this study, a recombinant enzyme with bactericidal activity against Staphylococcus aureus *was created and tested. Methods: The enzyme’s gene was inserted into a producer strain; the purified preparation was tested* in vitro *on resistant isolates. Results: The new enzyme inhibited the growth of all tested* S. aureus *strains, reducing the optical density of cultures by 70±5% compared to control. Conclusion: The recombinant enzyme is promising as a basis for anti-staphylococcal therapy.”*

(This abstract is structured for clarity here, but it could also be written as one coherent paragraph. It clearly shows the problem, the aim, the general method, a concrete result, and the main conclusion.)

Keywords (Keywords)

What they are: A small set of words or phrases (usually 5–7) that characterize the main topics of the work. Keywords are chosen by the authors and listed immediately after the abstract. They are used for indexing the article in bibliographic databases and help interested researchers find your work.

How to choose keywords:

Think like a search engine: What terms would a researcher input who might benefit from your article? For example, if the paper is about plastic biodegradation by bacteria, keywords could be: biodegradation, plastic, microorganisms, enzymes, environmental biotechnology.

Be specific: Don't use terms that are too broad ("biotechnology" by itself is too general). It's better to be specific: "plant biotechnology," "recombinant proteins," "CRISPR-Cas9," etc..

Don't duplicate words from the title. Usually, the article title is already indexed. Keywords should complement with additional terms. However, if the title is very specific, you can repeat some important terms.

Formatting: keywords are usually separated by commas; each starts with a lowercase letter (unless it's a proper noun). Check the *Instructions for Authors*: sometimes they require a specific number or format (e.g., alphabetical order).

Example: For an article titled "Immobilization of Lipase on Nanoparticles for Biodiesel Synthesis," possible keywords: *nanobiocatalysis; lipase; biodiesel; enzyme immobilization; transesterification.*

Conclusion (Conclusions)

What it is: A section that briefly summarizes the outcomes of the study. Often, a separate Conclusion section is not needed because the final part of the Discussion serves this purpose. However, some journals **do** require a separate **Conclusions** section – check the guidelines. In applied research, a Conclusion helps emphasize practical takeaways.

Content of the conclusion:

Brief conclusions relative to the aim: Write 2–3 sentences about what you achieved. A logical link to the Introduction is essential: your conclusions must directly answer the questions and objectives posed at the outset. If the Introduction's goal was "to develop method X," then in the Conclusion: "method X was developed, characterized by…".

Significance: Mention why the obtained results are important for science or practice (without rehashing the entire Discussion). For example: "For the first time, … were obtained, which opens new possibilities for …".

Perspectives: Often the last sentence gives a recommendation for what to do next. This could be advice for practitioners (e.g., implement the method) or future research direction (e.g., test on an industrial scale, explore a broader context, etc.).

Style: Extremely concise and clear. Essentially, the Conclusion is the answer to the reader's question: "So, what did we learn?" It's advisable to avoid new references in the Conclusion (all key literature should have been cited earlier). Also, do not introduce new data or discussion points – only conclusions drawn from what was presented. It's recommended to write conclusions in a bullet-point list (numbered or bulleted) if allowed; otherwise, as a short paragraph.

Typical mistakes:

Trivial or missing conclusions. It's bad to end the article abruptly or with generic statements ("In this work, such-and-such was studied" – without highlighting the result). The reader will be left with a sense of incompleteness.

Contradiction between conclusions and data. Sometimes authors overstate in the conclusions things that are not fully supported by the results. This must be avoided – reviewers will spot it. Every stated conclusion must flow from the facts in the Results section.

Excessive length. The Conclusion is not the place to *repeat* the entire Discussion. No need to reiterate every result. Just summarize the most important points.

Example of a conclusion:

"Conclusions: 1) A new method for enzyme immobilization was proposed, resulting in a 25% increase in lipase activity. 2) It was demonstrated that the immobilized lipase retains stability for 30 days of continuous process, surpassing known systems. 3) The developed technology can be applied in biodiesel production and adapted for other biocatalytic processes. Further research should focus on scaling up the process and testing on industrial raw material samples."

Acknowledgments (Acknowledgments)

Purpose: A section to express gratitude to people or organizations who helped with the work but are not authors. This section also often includes information about funding (grants, programs), if there isn't a separate **Funding** section.

Whom to acknowledge: Scientific supervisors, consultants, technicians, colleagues who gave advice, organizations that provided materials or equipment, and sometimes reviewers (if they significantly improved the article). Always acknowledge sponsors and grantors: usually phrased as: "This research was supported by RFBR grant No... / [Name of Program] Grant No....". Often journals require specifying funding sources explicitly, sometimes with a standard wording. If the research was done without targeted funding, it's common to write: "This research received no external funding".

Style: Very brief, in a polite formal tone. For example: "The authors thank I.I. Ivanov for assistance with the experiments, A.A. Petrova for valuable advice in discussing the results. We express special gratitude to the Biosensor Lab of IBCh RAS for providing equipment." All names are usually given in full (at least initials and last name). Separate multiple acknowledgments with commas or semicolons, in one paragraph. Avoid overly emotional language (this is not the place for "invaluable help" – just say "for help"). Mentioning family, friends, or "for moral support" is not customary in scientific articles (acceptable in theses, but not in research papers).

Common error: Forgetting to mention funding when it existed – this can lead to issues with the sponsor or journal. Always check grant conditions: often they require an acknowledgment in a specific form.

References (Literature Cited)

Purpose: A complete bibliographic list of all sources cited in the text of the article. This is fundamental to scientific ethics: every idea, fact, or method borrowed from someone else's work must be referenced. The reference list allows readers to find details on the cited works and demonstrates your familiarity with the field.

Formatting the list:

Citation style: Different journals require different formats. In the natural sciences, common formats are: **numeric style** (Vancouver, where references are numbered in the order of appearance in the text and formatted according to a standard, e.g., GOST or APA/Vancouver style); or **author–date style** (Harvard, where the text cites "(Ivanov, 2020)" and the list is alphabetized by authors). **Important:** strictly follow the journal's format – this is a frequent point of contention during technical checks. If a template or sample is provided – follow it. Use bibliography managers (EndNote, Zotero, Mendeley) or Word's built-in tools to format the list; it makes the task easier.

Completeness of information: Each reference entry should include: author(s), title of the work, source (journal or book name), publication details (year, volume, issue, page range) and DOI (if available). For electronic sources – URL and access date. For standards – standard number and year. Check each source for typos in names, numbers. A common mistake is an inaccurate reference list (and it immediately stands out to editors).

Quantity and recency: In applied biotechnology articles, usually 20–40 sources are cited. Ensure that a significant portion (e.g., ≥50%) are recent (from the last ~10 years). Avoid excessive self-citation (no more than 10–15% of references to your own work, otherwise it may look like you're trying to inflate citation metrics). Strive to cite primary sources (original research articles) rather than review papers or second-hand summaries, especially for key facts. Also include international sources – citing only local or regional publications can lower credibility (it suggests you haven't considered the global context).

No "extra" references: Do not include literature that is not cited in the text (the list should not contain items "for general background" – only what's actually referenced). Conversely, ensure that every mention of others' data in the text has a corresponding entry in the list.

Citation ethics: Make sure that each idea or result taken from someone else's work is directly accompanied by a citation. Paraphrasing still requires a source! Plagiarism is unacceptable. If you quote a short phrase verbatim from another author (which is rarely done in research articles), put it in quotes and cite the source. But it's generally better to paraphrase in your own words with credit to the author.

Example formatting (numeric style, according to GOST R 7.0.5–2008):

Ivanov I.I., Petrov P.P. Biotechnology of oil-degrading bacteria // *Applied Biochemistry and Microbiology*. – 2018. – V. 54, No. 3. – P. 250–257. DOI: 10.1134/S0003683818030056.

Sidorov A.B., Nikolaeva T.N. Application of lipase in biodiesel production // *Biotekhnologiya* (Biotechnology). – 2020. – Vol. 36, No. 7. – P. 15–22.

World Health Organization. 2019. *Global report on antibiotic resistance*. URL: http://www.who.int/antimicrobial-resistance/en/ (accessed 12.05.2025).

(Note: The example shows a mixed English and Russian list formatted per GOST: for English sources – journal names in English; for Russian – in Russian. No square brackets around numbers in text because GOST uses superscript or inline numbers.)

Again, the exact format depends on the journal – always check their requirements or sample articles. Some journals require the reference list in two languages (original language list and a transliterated/translated References list) – as is the case in certain Russian journals. This is for international database indexing, and it's usually stated in the Instructions.

Common errors:

Inconsistent formatting (different styles mixed in one list).

Spelling mistakes in authors' names (especially when transliterating Russian names to English – follow the BSI/ISO standard).

Inappropriate sources (e.g., citing textbooks, popular articles, or sources not directly relevant to the topic – such sources are frowned upon).

Citing inaccessible or unchecked sources (e.g., personal websites without reliability). Use peer-reviewed sources whenever possible: articles from scientific journals, patents, standards, dissertations. Avoid citing unpublished data or personal communications – if absolutely necessary, these are usually indicated in the text as *(unpublished data)* but it's better to avoid them.

Appendices (Appendices / Supplementary Materials)

What they are: Additional materials that are outside the main text. In the article itself, they can appear as Appendices at the end (with titles like "Appendix A", "Appendix 1", etc.) or be provided separately as supplementary files on the journal's website. In applied research, appendices often include large data tables, extra graphs, apparatus schematics, photos of experimental setups, raw data, calculations, large code fragments, etc.

When to use them: If there is information important for completeness of the description but too bulky or distracting for the main text, put it in an appendix. For example, if you conducted 10 similar experiments – in the article it may suffice to describe 2–3 key ones, and the rest of the graphs can go to Supplementary Materials. Or say you have a table of 100 values – in the text you present averages, and the full table goes in an appendix for readers who want details.

Formatting: Each appendix is labeled with a letter or number and given a title. In the article text, there should be references like: "...described in Appendix A" or "(see Supplementary Materials, Fig. S1)." Without such cues, a reader might not realize supplementary information exists. If an appendix is submitted as a separate file, name it clearly (e.g., "Supplementary_Table1.xlsx").

Example: *Appendix 1. Schematic of the bioreactor experimental setup (with an optional description).* Or: *Appendix A. Additional tables of results from series B.*

Pitfalls:

Putting key results in an appendix. Do not place essential findings without which the main text is unclear into an appendix. All primary data must be in the article; appendices are only for supporting details.

Improper referencing of appendices. Ensure all appendices are cited in the main text, otherwise readers might overlook them.

Excessive supplementary material. Don't turn your article into a monograph with a dozen appendices. If you feel you have too much supplementary material, perhaps it should be condensed or published separately (e.g., on a lab website, referenced by a link in the article).

Specific Considerations for Applied Biotechnology Articles

Below are some specific aspects characteristic of publications in the field of applied biotechnology. These tips will help account for industry-specific details and requirements when preparing your article.

Example Topics and Directions in Applied Biotechnology

Applied biotechnology covers a wide range of research aimed at practical use of biological systems and processes. Here are a few examples of topics that are common and well-suited to the IMRAD format:

Biocatalysis and Enzyme Technologies: e.g., development of improved enzymes for industrial synthesis, enzyme immobilization on carriers for reuse, biocatalytic production of pharmaceutical substances.

Genetic and Metabolic Engineering of Microorganisms: creating recombinant producer strains (for insulin, vitamins, biofuel), optimizing metabolic pathways to increase the yield of a target product.

Biomedicine and Biopharmaceuticals: new biotechnological methods of treatment and diagnosis – gene therapy, cell-based producers for antibodies, vaccines, CRISPR editing for disease models.

Agrobiotechnology: transgenic plants with enhanced traits (pest resistance, enriched nutritional content), biopreparations for plant protection (bio-pesticides, bio-fertilizers).

Environmental Biotechnology: bioremediation (clean-up of contaminated soils and water using microorganisms), waste processing by biological methods (composting, biogas production), biosensors for environmental monitoring.

Nanobiotechnology and New Materials: biosynthesis of nanoparticles by microorganisms, creation of biodegradable polymers, tissue engineering (growing artificial organs or tissues).

Bioanalytics and Instrumentation: development of biosensors, lab-on-a-chip systems, microfluidic devices for medical diagnostics or product quality control.

All these topics lend themselves to the IMRAD format, since they involve a specific goal (to create/improve something) and experiments that yield measurable results. When describing applied work, it is especially important to emphasize the practical significance: for example, if your biotechnological development was successful, note that it can improve production efficiency or solve an environmental problem.

Presenting Experimental Data: Tables and Graphs

Biotechnology research usually involves significant amounts of experimental data: analytical measurements, cultivation parameters, product characteristics, etc. Proper data presentation is key to ensuring that readers and reviewers appreciate your contribution. Here's a checklist for working with data in an article:

Choose the format of presentation: Decide which data to present in the text, which in tables, and which as graphs or figures. As a rule:

Tables are convenient for comparing specific numbers or characteristics of multiple objects, e.g., parameters of several strains or conditions. A table is well-perceived when exact values need to be shown. Don't make tables overly large: if there are more than 6–8 columns or hundreds of cells, consider moving it to an appendix.

Graphs/Charts are good for displaying relationships, trends, dynamics of changes, or distributions. In biotech, common graphs include "product concentration vs time," "activity vs pH," bar charts comparing variants, growth curves, etc. Graphs provide visual immediacy: you can see the trend at a glance.

Illustrations (images): microscopic photographs, equipment schematics, electrophoresis gel results, spectra – all of these are best included as figures. They add "life" to the article and are often necessary as proof (for instance, a gel with protein bands is direct evidence of expression).

Formatting tables: Use clear column headings, including units of measurement directly in the heading (e.g., "Optical density, OD_{600} units"). Minimize the use of abbreviations, or include a note with their definitions below the table. Tables are usually formatted without vertical lines, using only horizontal separators (depends on journal style). Each table should have a title (e.g., "Table 1. Product yield at various temperatures") and, if needed, footnotes explaining specific cells.

Formatting figures: Ensure that all details are visible and readable. The font size on graph axes, legends, labels on micrographs – make sure they are large enough to remain clear when printed. Color graphs should use contrasting colors or different line styles/markers for black-and-white print – verify this (or label curves directly). The figure caption should explain what is shown, without needing to read the main text. For example: *"Fig. 2. Dependence of* E. coli *cell growth rate on glucose concentration: 1 – strain A, 2 – strain B. It can be seen that above 5% glucose, strain A's growth rate decreases…"*. A caption can be 2–3 sentences if necessary to clarify details. In scientific journals, it's common for figure captions to contain enough information to understand the figure in isolation.

Follow domain standards for data presentation: If there are industry standards for how to format, for example, DNA sequences or chemical nomenclature, adhere to them (e.g., nucleotide sequences grouped in 10s, gene diagrams shown as arrows, mutations named per HGVS nomenclature, etc.). This demonstrates professionalism.

Units and notation: Use SI units if possible (grams, meters, moles). In biology, non-SI units are often used (e.g., % for concentration, rpm for centrifuge speed) – those are fine, but be consistent. If you state a mass in μg, don't switch to mg elsewhere without need. Always specify temperature with °C, time clearly (seconds, minutes, hours, or provide context). Don't forget control groups or reference points: often tables include a "Control" column for comparison – this improves clarity.

Statistical significance: In applied experiments, it's necessary to indicate how reliable your data are. Provide standard deviations or standard errors of the mean (SD or SEM) for numerical values if there were replicates. For example: 5.3±0.2 kg. If you compare variants, you can add significance markers (asterisks * for $p<0.05$, etc.), but explain them in a caption or note. You might explicitly state: "data are presented as mean ± standard deviation, $n=5$." This signals to the reviewer that you handled statistics properly.

Volume of data: If you have extremely large datasets (genomic sequences, transcriptomic arrays), present only summaries in the paper (e.g., "150 differentially expressed genes were identified; see Supplementary Table S1 for the full list") – and upload the full dataset as Supplementary Materials or to a public repository (GenBank, GEO, etc.). Many journals now encourage open deposition of raw data – it enhances trust and citations, as other researchers can use your data.

Citing Methods and Standards

In biotechnology, it's important to properly cite methodological sources and standards you used. This is not only about respecting intellectual property, but also about the credibility of your work. Here are some tips:

Citing methodologies: If you mention that you used "such-and-such method" or "analysis was performed according to…", you must accompany it with a reference to a publication where the method is described, or to a standard/patent. For example: *"Protease activity was determined by the azo-casein method (Ward, 1988)"* or *"…according to GOST 34100.3–2017."* Without a reference, it's unclear what method you mean, and a reviewer might think you're unfairly presenting it as your own.

Standards and regulations: In applied work, official standards may be used (ISO, GOST, ASTM, etc.) – whether for test methods or quality requirements. Provide the standard number and year. For example: *"…according to international standard ISO 21527-1:2008."* In the reference list, give the full description: "ISO 21527-1:2008 Microbiology of food and animal feeding stuffs…". If a standard is national, give its details in the original language.

Referencing equipment/reagents: Generally, brand names don't go in the reference list, but you can mention them in parentheses in the text. For example: *"used a QIAprep kit (Qiagen, Germany)"*. These are not bibliographic references, just informative mentions, and should not be listed in References. But if you refer to technical documentation or a method sheet, you can cite it as a source (e.g., *"Technical Manual of XYZ Kit, Catalog No…, Company"*).

Patents: If your work is based on a patented method or you compare with one, be sure to cite the patent. Patents are listed in References with their number, country, and year. For example: *"Pat. US 8,123,456 B2, USA, 2012."*

Software tools: For reproducibility, note the versions of any software or libraries used. If you used, say, R for analysis, you needn't cite the manual in the text, but you can: *"data were analyzed in R v4.0 (R Core Team, 2020)"* – and include a reference to the R project website or the paper about R.

Bioinformatics and databases: If you performed, for example, sequence alignment using BLAST – cite the classic paper by Altschul et al., 1990 (the foundational BLAST paper). If you submitted sequences to GenBank – provide their accession numbers.

Why all this? *Such citations show the expert that you worked diligently and relied on recognized methods*. Moreover, during peer review, you might be asked for more detail on a method – and having a reference will fend off unnecessary scrutiny (the editor will see the method is standard and described in the cited source).

Preparing the Manuscript for Submission: Meeting Journal Requirements

When all parts of the article are written, an equally important stage follows – preparing for submission to a journal. Even excellent research can be rejected at the technical check stage if the manuscript is not formatted according to the guidelines. To avoid this, follow this algorithm:

Carefully study the "Instructions for Authors" of the chosen journal. Find the Author Guidelines on the journal's website. Pay attention to:

Length limits: maximum words, pages, figures, allowed number of tables. If your article exceeds the limits – shorten it beforehand.

Required structure: Sometimes journals ask for additional sections, for example "Conclusions" or "Implications," or they might combine Results and Discussion. Follow exactly the structure specified. If something isn't needed – leave it out (e.g., some journals do not require a separate Conclusion).

Reference and citation format: Numeric or author-year? In order of citation or alphabetical? Do they use *et al.* for more than 3 authors? These nuances matter. It's best to format correctly from the start. Using a bibliographic manager with the journal's style can be very helpful.

File formats: Do they require figures as separate files (usually yes, in high resolution) and in what format (JPEG, TIFF, EPS)? Minimum resolution (typically 300 dpi for photos, 600 dpi for line graphs)? Should tables remain in the text or be uploaded separately? Prepare everything according to requirements.

Language and affiliations: If the article is in Russian, often they require the title, abstract, keywords in English (and vice versa for English articles). Check if that's required. Also check how to list author information (full names, positions, ORCID, etc.) – usually on a separate title page.

Other sections: Some journals require sections like "Author Contributions," "Conflict of Interest," "Funding" to be listed separately. Don't miss these. For example: *"Conflict of interest – The authors declare no conflict of interest."* – a standard line.

Template or example article: Many journals (especially Russian ones) offer a downloadable Word template, with styles, font sizes, numbering, etc., already set. This can greatly simplify things – use the template by copying your text into it.

Edit language and style. Before submission, ensure the text is written clearly and correctly. Remove any colloquialisms, slang, or overly emotional expressions. If writing in Russian, make sure you follow the norms of scientific Russian (for example, avoid overuse of abbreviations like "etc." – better to spell things out or say "and others"). For English manuscripts – it's highly recommended to have it proofread by a native speaker or a professional editor. Grammatical errors and typos can create a negative impression even if the science is great. Use spell check, but don't rely on it entirely – proofread carefully yourself. A good practice is to give the text to a colleague for feedback.

Check figure and table references: Verify that numbering is consistent, and that every table/figure is mentioned in the text. Do the same for references: citation numbers should ascend in order, with no gaps or duplicates (e.g., no missing numbers or repeating the same number for different sources).

Ensure consistency: Check that units and notations are consistent throughout (e.g., don't switch between "mL" and "ml." with a period, or "deg C" and "°C" – pick one style). Same with terminology – if you initially write *E. coli*, don't later refer to it as "colon bacillus" interchangeably. Everything that can be standardized should be.

Prepare supporting documents: Usually, along with the article, you need to submit accompanying forms – a cover letter to the editor, often a conflict of interest disclosure, copyright transfer, author information form, etc. Treat the cover letter seriously: briefly present your work, explain why it suits the journal, and possibly suggest potential reviewers. The letter should be polite and to the point.

Final self-check – Author's Checklist:

Are all sections present (Introduction, Methods, ... References)?

Do the title and abstract match in both languages (if a translation is required)?

Are table/figure numbers and references all correct and in order?

Have units of measurement been included for all data?

Are all necessary citations provided, and are there no stray "[?]" or "Error! Bookmark not defined" artifacts (these sometimes appear if you used automatic referencing and then broke links)?

Are margins, fonts, and line spacing according to guidelines (e.g., many journals want 1.5 spacing, 12 pt Times New Roman, 2 cm margins)?

If English translations of table and figure captions are required – have they been added?

Are the authors' names and affiliations written exactly as needed (e.g., initials, full organization names in both languages, email addresses)?

Plagiarism check: Run your text through a plagiarism checker yourself, especially if you heavily cited Russian sources. Properly cited text isn't considered plagiarism, but large verbatim blocks even with citations can flag. Paraphrase key points in your own words. Ensure there's no unquoted copying from other works – editors and reviewers are very sensitive to this.

Tip: After making all revisions, set the article aside for a day or two, then proofread again with fresh eyes or have a colleague read it. Often, small issues become apparent after a short break, and you can fix them before submission. This increases the chances of success.

Finally, ensure you chose the right journal in terms of scope and level. Your article should fit the journal's stated scope and be of interest to its readership. Check the journal's impact factor or national indexing (if relevant) and other requirements (e.g., for thesis credit). Don't hesitate to cite articles from the same journal – this shows you are familiar with their publications.

Conclusion

Preparing a scientific article in IMRAD format is a challenging task, especially for a novice author. However, by following the structural requirements and the advice outlined in this guide, you will significantly improve the quality of your manuscript. A clear structure, logical presentation, attention to detail in formatting, and adherence to the journal's instructions are the ingredients for a successful scientific publication. In the field of applied biotechnology, where research is often aimed at solving concrete problems, it is crucial to convincingly demonstrate the novelty and practical significance of your results. A well-written article will not only pass expert evaluation but also attract the interest of colleagues, garner citations, and contribute to the advancement of your scientific career.

Remember the principles of scientific ethics: adhere to norms of authorship (list only those who made substantial contributions), cite sources diligently, and do not fabricate or embellish data. Each article you publish is a contribution to the treasury of world knowledge, so approach its writing with responsibility and creativity.

We wish you success in preparing your article! May it be accepted for publication and become a notable step forward in the development of applied biotechnology.

Useful Resources for Further Work:

(Books) Gastel B., Day R. *How to Write and Publish a Scientific Paper*. 8th ed. Cambridge University Press, 2016.

(Guidelines) Kozhukhova N.I. *Methodological instructions for preparing and writing scientific articles in IMRAD structure*. Tambov, 2024.

(Online course) Academic Writing for Scientists – section "IMRaD Structure."

(Sample template) Elsevier Journal Template (available on Elsevier's website).

(Young scientist's blog) Kochetkov A. "IMRAD structure of a scientific article: tips and mistakes" – available on the NaukaPlus website.