Reading Primary Literature

A Practical Guide to Evaluating Research Articles in Biology

阅读初级文献

生物学研究论文评价实用指南

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Section 1: Introduction to the Booklet

第一部分：小册子简介

Primary research articles are an excellent for students of biology. Reading papers opens a doorway into the world of scientific research. As you begin reading articles, you will be challenged to think critically, apply your knowledge, and use the scientific method. The purpose of this booklet is to guide you through this process. It describes the tools and strategies you will need to begin reading articles.

对于生物专业的学生来说，初级研究论文是极好的选择。阅读论文打开了一扇通往科学研究世界的大门。当你开始阅读文章时，你将面临批判性思维、运用知识和使用科学方法的挑战。这本小册子的目的是指导你完成这个过程。它描述了您开始阅读文章所需的工具和策略。

WHAT ARE PRIMARY RESEARCH ARTICLES?

什么是初级研究文章？

Primary research articles, also called research papers or primary literature, are the official documents that scientists use to communicate their research to each other. Research papers describe original findings, including methodology and results. In contrast, documents that synthesize, summarize, or evaluate primary literature are termed secondary sources. Common secondary sources include magazine articles, dictionaries, textbooks, and websites. Magazines written for the general public, such as Discover and Scientific American, publish only secondary articles. Some publications, such as the scientific journals Science and Nature. publish a mixture of primary research papers and secondary reports. Primary papers are always written by scientists, while secondary reports may be written by scientists, journalists, or others. In practice, you'll need to look at each source carefully to determine if it is primary or secondary. Primary sources include a detailed description of the methods and results. They are the first report of original research findings and are written by the scientists who performed the work. This book focuses on primary research articles.

初级研究论文，又称研究论文或初级文献，是科学家用来相互交流研究成果的官方文件。研究论文描述了最初的发现，包括方法和结果。相反，综合、总结或评价主要文献的文献被称为次要文献来源。常见的次要来源包括杂志文章、字典、教科书和网站。为公众撰写的杂志，如《发现》和《科学美国人》，只发表次要文章。一些出版物，如科学期刊《科学与自然》。发表初级研究论文和次要报告的混合体。初级论文通常由科学家撰写，次要报告则可能由科学家、记者或其他人撰写。实际上，您需要仔细查看每个源文件，以确定它是初级的还是次要的。初级来源包括方法和结果的详细描述。它们是最初研究结果的第一份报告，由完成这项工作的科学家撰写。这本书着重于初级研究文章。

You've probably spent hours reading science textbook. They describe accepted scientific facts and concepts, and they are written towards a student audience. In contrast, research articles address areas of emerging knowledge or controversy, and they are written with professional scientists as the intended audience. Research articles represent science in process, while textbooks describe the outcome of that process. Reading research articles requires different strategies than reading textbooks, and you will encounter new challenges as you begin reading them. This booklet will give you the tools to overcome the challenges.

你可能花了几个小时读科学教科书。它们描述了公认的科学事实和概念，并且是写给学生读者的。相比之下，研究文章涉及新兴知识或争议的领域，它们是以专业科学家为预定读者撰写的。研究文章代表了过程中的科学，而教科书则描述了这个过程的结果。阅读研究文章需要不同于阅读教科书的策略，当你开始阅读时，你会遇到新的挑战。这本小册子将为你提供克服挑战的工具。

WHY READ THE PRIMARY LITERATCRE?

为什么要阅读初级文献?

Doing science is a powerful way to learn it. In your laboratory classes, you begin participating in science by performing key experiments and techniques. Reading research articles is another way to become involved in the scientific process. Because evaluating research articles is a central activity of practicing scientists. Think of research papers as a doorway into the scientific world. They present the chance to apply material that you’ve learned through reading textbooks and listening to lecture. They challenge you to think about with scientists as they tackle research problems. They serve as examples for your own scientific writing. And they encourage you to critically analyze new scientific ideas.

参与科学是一种强大的学习方法。在实验课上，你通过执行关键的实验和技术开始参与科学。阅读研究论文是参与科学过程的另一种方式。因为科研论文评审是实践工作者的一项核心活动。把研究论文看作是通往科学世界的一扇门。他们提供了一个机会来应用你阅读课本和听讲座所学到的知识。当科学家们解决研究问题时，他们会挑战你去和他们一起思考。它们可以作为你自己科学写作的例子。他们鼓励你批判性地分析新的科学观点。

Try to approach reading research article as a challenge rather than a chore. While the primary literature may appear dry, under the surface you will find drama and controversy. Research scientists constantly face mysteries because they work at the edge of our knowledge. So research articles can be like detective novels, in which scientists carefully gather the clues and evidence needed to solve scientific problems. Further, like a good detective novel the course of science often has entertaining twists and surprises. Finally, the research literature reflects upon the scientists themselves. It documents how their tools, priorities, and practices change over time and how they cooperate and compete with each other. Recognize the personal side of science; it will add useful context to the research article you read.

试着把阅读研究文章当作一种挑战，而不是一件琐事。虽然初级文献可能显得枯燥，但在表面之下，你会发现戏剧和争议。研究科学家不断地面对谜团，因为他们在我们知识的边缘工作。因此，研究文章可以像侦探小说一样，让科学家仔细收集解决科学问题所需的线索和证据。此外，就像一本好的侦探小说一样，科学课程经常有有趣的曲折和惊喜。最后，研究文献让科学家进行了自身反思。它记录了他们的工具、优先级和实践如何随着时间的推移而变化，以及他们如何相互合作和竞争。认识到科学的个人方面；它将为你阅读的研究文章增加有用的内容。

Learning to read research articles has obvious benefits if you plan to pursue a research career in biology. But the brief exposure to the primary literature afforded by this booklet will be beneficial even if you never again read a primary literature article. As a child, I took up the trumpet and learned to play the “Star War Theme” loud enough to drive our Irish Setter under the kitchen table. However I never became especially skilled, and I can’t play a note today. Yet my battle with the trumpet continue to enrich my adult life by enhancing my appreciation and understanding of music. In the same way, learning to read primary literature open the door towards comprehending and evaluating all sorts of scientific information. Learn to read research articles and you will become a more confident and effective judge of scientific information, a remarkably useful skill in today’ world.

如果你打算从事生物学方面的研究工作，学习阅读研究文章有明显的好处。即使你从来没有读过初级文献的文章，但这本小册子所提供的对初级文献的简短接触将是有益的。当我还是个孩子的时候，我拿起小号，学着把“星球大战”的主题曲，声音足够大以致把我们的爱尔兰谍犬吓的躲到到厨房桌子下面。但是我并没有变成熟练的专家，今天我也不能演奏一个音符。然而，我与小号的斗争提高了我对音乐的欣赏和理解，继续丰富了我的成年生活。同样，学习阅读初级文献也为理解和评价各种科学信息打开了大门。学会阅读研究文章，你将对科学信息形成一个更加自信和有效的判断，这是一个在当今世界非常有用的技能。

HOW TO USE THIS BOOKLET

如何使用这本小册子

Learning to read primary research articles is a lot like learning other demanding activities For example, imagine that you’ve been handed a fishing rod and a tackle. Without any advice, trying to catch fish using these tools will be hard. Some tips and advice from an expert will greatly ease your way. But instruction alone won’t make you a competent angler. You'll need to go stand by the water and practice baiting a hook, casting a line, and landing a fish. So it is with reading research articles; both instruction and practice are needed.

学习阅读主要的研究文章很像学习其他高要求的活动，例如，想象给了你一根钓竿和一个钓具。如果没有任何建议，试图用这些工具捕鱼将是困难的。一些专家的提示和建议会让你轻松很多。但仅仅指导并不能让你成为一个称职的钓鱼者。你需要站在水边，练习给鱼钩上饵、抛线和钓鱼。阅读研究论文也是如此；既需要指导，也需要实践。

This booklet is the instruction manual you'll need to quickly become a talented reader of research articles. The sections cover how to find articles, the structure of research articles, and the four main parts of an article: the Introduction, Materials and, Methods, Results, and Discussion. In addition to studying this booklet, you’ll also need to struggle with research articles yourself. The end-of-section exercises will prompt that practice; they ask you to critically read a paper by applying the section’s advice. Depending on your course and instructor, you might choose your own article using the instructions in section 2 or your instructor might assign one.

这本小册子是指导手册，你需要迅速成为一个研究文章的天才读者。这些章节包括如何查找文章，研究文章的结构，以及文章的四个主要部分：引言，材料和方法，结果和讨论。除了学习这本小册子，你还需要自己努力研究文章。课后练习将促进这一练习；它们要求你运用该节的建议批判性地阅读一篇论文。根据您的课程和讲师，您可以使用第2节中的说明选择自己的文章，或者您的讲师可以指定一篇文章。

As you begin your journey into the primary literature of biology, there will inevitably be obstacles and frustrations. But I hope you will also find satisfaction in overcoming the challenges and participating in the process of science.

当你开始你的生物学初级文献阅读之旅时，不可避免地会遇到障碍和挫折。但我希望你们也能在克服挑战和参与科学进程中找到满足感。

Section 2: Finding Research Articles

第2部分：查找研究文章

The major journals in biomedicine now publish online. More than a million scientific articles are available free on the Internet, and many more can be accessed for a fee. Along with this availability comes challenges. Scientists need to find relevant information amidst a mountain of data and then intelligently analyze the information. This section describes the first step: locating and accessing research articles. The details will be specific to your institution and subdiscipline, so we will focus on general strategies and free online databases. You should also learn about the specific resources available on your campus.

生物医学的主要期刊现在在网上出版。互联网上有100多万篇免费的科学文章，而且更多的文章可以付费阅读。随之而来的是挑战。科学家需要在海量的数据中找到相关信息，然后对信息进行智能分析。本节描述第一步：查找和访问研究文章。具体细节将具体到您的机构和子学科，所以我们将集中在一般策略和免费在线数据库。您还应该了解校园中可用的特定资源。

The strategies you employ will depend on the purpose of your search. Are you trying to develop a topic for a research paper? Scanning the table of contents of a prestigious journal might give you some ideas about current hot research areas. You might also look at secondary sources such as textbooks and magazine for ideas. If you've already selected a general topic area, but need to find article within that topic, then you might decide to search databases of research article. Or perhaps you've already found an interesting article and now need to read some related articles to put it in context. In this case, you might look at the sources it cites and also search databases.

你采用的策略将取决于你搜索的目的。你想为一篇研究论文制定一个主题吗？浏览一本著名期刊的目录可能会让你对一些关于当前热门研究领域有所了解。你也可以从课本和杂志等二级资源中寻找灵感。如果你已经选择了一个通用的主题领域，但是需要在该主题中找到文章，那么你可以决定搜索研究文章的数据库。或者你已经找到了一篇有趣的文章，现在需要把它作为背景来阅读一些相关的文章。在这种情况下，您可以查看它引用的源文件，还可以搜索数据库。

WINDOW-SHOPPING: BROWSING JOURNALS

橱窗购物：浏览期刊

Suppose you wish to browse journals to develop topic ideas. Where can you find journals? One place is your school's library, which has hard copies of many journals. Having the paper journal in your hands can be particularly useful when you are browsing for interesting topics. Of course, many journals are also available online. If you already know which journal you want to browse, a simple strategy is to locate its homepage with an Internet search engine. Online journals have straightforward interface that allow you to browse or search for articles.

假设您希望浏览期刊以发展主题思想。在哪里可以找到期刊呢？一个地方是你们学校的图书馆，那里有许多期刊的打印件。当你浏览有趣的主题时，手中拿着纸质杂志尤其有用。当然，许多期刊也可以在网上找到。如果你已经知道你想浏览哪本杂志，一个简单的策略就是用互联网搜索引擎找到它的主页。在线期刊有一个简单的界面，允许你浏览或搜索文章。

Another way to access online journals is through a website that catalogs and organizes them. For example, you will find many important journals in biomedicine at the Highwire Press site hosted by Stanford University Libraries (www.highwire.org) . Excellent instructions for using the site are available on its homepage. You can see a list of journals, choose one that matches your interests, and browse the tables of contents of recent issues. For many journals, access available about a year after publication. A useful feature of the Highwire site is a listing of journals with free online access.

访问在线期刊的另一种方式是访问对其进行分类和组织的网站。例如，你可以在斯坦福大学图书馆主办的Highwire出版社网站上（www.highwire.org）找到许多重要的生物医学期刊。网站主页上提供了使用该网站的极好说明。您可以查看期刊列表，选择一个与您的兴趣相匹配的杂志，然后浏览最近一期的目录。对于许多期刊，发表一年后就可以访问。Highwire网站的一个有用功能是列出可以免费在线访问的期刊列表。

Almost 1000 scientific journals are hosted on Highwire. How can you decide which journals are the most relevant to your topic? Which are the most reliable? Which are the most prestigious? One strategy is to look in the references section of your class textbook to see which journals are cited; these are likely to be relevant to your course and highly regarded. As you begin to find research articles, you can also check their Reference Cited sections; again, the journals that are regularly cited are the most useful and prestigious. Journal rankings also exist. One widely used measure, the **impact factor**, measures how many times the articles published in a journal are cited by other articles. Finally, you can ask your course instructor or librarian. Widely read and cited journals that publish research in biology include: Science, Nature, Cell, Development, Genetics, Proceedings of the National Academies of Science (PNAS), Journal of Biological Chemistry, Journal of Clinical Investigation, Journal of Experimental Biology, American Journal of Physiology, Neuron, Journal of Bacteriology, and Public Library of Science (PLoS) Biology. This is a partial list; there are many other outstanding journals.

Highwire上有近1000种科学期刊。你如何决定哪些期刊与你的主题最相关？哪个最可靠？哪一个最有声望？一个策略是在你的课堂教科书的参考资料部分，看看引用了哪些期刊；这些期刊可能与你的课程相关，并且受到高度重视。当你开始查找研究文章时，你也可以查看他们的参考引用部分；同样，经常被引用的期刊是最有用和最有声望的。期刊排名也存在。一个广泛使用的指标，即影响因子，用来衡量在期刊上发表的文章被其他文章引用的次数。最后，你可以问问你的课程老师或图书管理员。广泛阅读和引用的发表生物学研究的期刊包括：科学，自然，细胞，发展，遗传学，美国国家科学院院刊（PNAS），生物化学杂志，临床研究杂志，实验生物学杂志，美国生理学杂志，神经元，细菌学杂志，和公共科学图书馆（PLoS）生物学。这只是部分列表；还有许多其他优秀期刊。

Another useful website is BioMed Central (www.biomedcentral.com). which publishes more than 150 journals, including general titles such as BMC Biology and Journal of Biology and specialized titles such as BMC Physiology and BMC Microbiology. Articles published in BioMed Central are **open-access**, meaning that they can be freely accessed and distributed. You can search all of the BioMed Central journals or browse particular titles.

另一个有用的网站是BioMed Central（www.biomedcentral.com）。出版各类期刊150余种，包括BMC生物学、生物学杂志等综合类期刊和BMC生理学、BMC微生物学等专业期刊。在BioMed Central上发表的文章是开放获取的，这意味着它们可以自由访问和分发。你可以搜索所有的生物医学中心期刊或浏览特定的标题。

Online articles are usually available in two formats: full-text and PDF. PDF files, which are viewable using the Adobe Reader®, faithfully represent the article as It appears in the print journal. Access the PDF version if you wish to print the article. In contrast the full-text version of an article does not attempt to represent the actual printed article; Instead full-text versions use html format and therefore may include special features not available in the printed article. For example, links may enable you to navigate easily throughout the article, to access supporting documents such as supplemental data, and to go to full-text version of other articles.

在线文章通常有两种格式：全文和pdf。可使用Adobe Reader®查看的PDF文件如实地表示在印刷期刊中出现的文章。如果要打印文章，请访问pdf版本。相反，文章的全文版本并不试图表示实际打印的文章；全文版本使用HTML格式，因此可能包含打印文章中没有的特殊功能。例如，链接可以使您轻松浏览整篇文章，访问支持文档（如补充数据），并转到其他文章的全文版本。

Suppose you have chosen to work with a particular article. The html version of your article can be an entry point into an interconnected web of references. You may find links to other articles, including those by the same authors, those that your article cites, and those that cite your article. In contrast to the printed version of an article. The html version can be updated, so that links can be included to sources that were published after the original paper. For example, you can’t identify papers that refer to your article by looking at the printed version, but the html version may contain this information. Locating such sources can be valuable since they may offer commentary on your article. The Science Citation Index, which is available at many institutions, is another tool that enable you to identify sources that cite a particular article.

假设您选择了处理特定的文章。你的文章的html版本可以是进入一个相互连接的参考资料网的入口点。你可以找到其他文章的链接，包括同一作者的文章，你的文章引用的那些文章，以及所引用你文章的那些文章。与文章的印刷版本相反，html版本可以更新，这样链接就可以包含到原始论文之后发布的源文件中。例如，您无法通过查看打印版本来识别引用您文章的论文，但HTML版本可能包含此信息。找到这样的信息来源是很有价值的，因为它们可以为你的文章提供评论。科学引文索引（Science Citiation Index）在许多机构都有，它是另一个工具，使您能够识别引用特定文章的来源。

NEEDLE IN A HAYSTACK: SEARCHING DATABASES

大海捞针：搜索数据库

Suppose you have developed a research topic and need to find relevant primary sources. Or maybe you have found a single journal article and need to find additional articles on the same topic. In both cases, searching a research article database will be an effective approach. Several databases may be available on your campus; choose the one best suited to your topic. Although details will vary slightly from one to the next, the general principles will be the same, and most databases contain helpful instructions to get you started.

假设您已经制定了一个研究主题，并且需要找到相关的主要来源。或者你已经找到一篇期刊文章，需要找到关于同一主题的其他文章。在这两种情况下，搜索研究文章数据库将是一种有效的方法。你的校园中可能有多个数据库可用；请选择最适合你的主题的数据库。尽管每个数据库的详细信息会略有不同，但基本原则是相同的，而且大多数数据库都包含有帮助您入门的说明。

As an example, we'll discuss the freely available PUBMED site, which is part of an interconnected collection of databases operated by the National Center for Biotechnology Information (NCBI, www.ncbi.nlm.nih.gov). PUBMED allows users to search articles in almost 5,000 journals in medicine and related fields. In total over 15 million citations are included. Given the huge number of citations in PUBMED, separating useful articles from all of the rest can be tricky. Good searches will be comprehensive, meaning they will return all or most of the article on a particular topic, and will also be well focused, meaning they will return a reasonable number of articles with few irrelevant articles.

作为一个例子，我们将讨论免费提供的PUBMED站点，它是由国家生物技术信息中心（NCBI，www.ncbi.nlm.nih.gov）运营互联集合数据库的一部分。PUBMED允许用户在医学和相关领域的近5000种期刊上搜索文章。总共超过1500万条引文。鉴于PUBMED中引用的文章数量巨大，将有用的文章与其他所有文章分开可能会很棘手。好的搜索将是全面的，这意味着它们将返回关于某个特定主题的所有或大部分文章，好的搜索也是重点突出的，这意味着它们将返回数量合理的文章，而很少有不相关的文章。

The choice of **search terms** is obviously crucial to an effective search. You can find search terms on the first page of research articles; look for a list of terms below the Abstract. You might also pick up useful terms in secondary sources or by browsing article titles. Scientists often use specialized word with precise meanings, so it also helps to know some of the scientific vocabulary. For example, while the general public says "heart attack," a scientist may say '' sudden cardiac death," “myocardial infarction," "heart failure," "cardiac ischemia '' or “ventricular fibrillation,” with each of these phrases having a somewhat different meaning. Searches using different terms will return different sets of articles. Knowing exactly which terms to use can be difficult to determine, and some trial and error may be needed. Don't be afraid to start searching with a term that might be imperfect. Searches are free and fast, and better search terms can often be gleaned from the citations returned by an initial search.

搜索词的选择显然对有效搜索至关重要。你可以在研究文章的第一页找到搜索词；查看摘要下面的术语列表。您还可以在辅助资源或浏览文章标题中找到有用的术语。科学家们经常使用具有精确含义的专门词汇，所以了解一些科学词汇也有帮助。例如，当大众说“心脏病发作”时，科学家可能会说“心源性猝死”、“心肌梗死”、“心力衰竭”、“心肌缺血”或“心室颤动”，每一个短语都有不同的含义。使用不同术语的搜索将返回不同的文章集。确切地知道使用哪些术语可能很难确定，而且可能需要一些尝试和错误。不要害怕用一个可能不完美的词开始搜索。搜索是免费和快速的，更好的搜索词通常可以从最初搜索返回的引文中收集到。

Because scientists may use various terms for the same concept, many databases include a controlled subject vocabulary. In PUBMED, these terms are called the Medical Subject Heading (MeSH). You can find MeSH words by searching the MeSH database on the NCBI site. For example, searching for “cardiac ischemia” returns two MeSH terms: “myocardial ischemia” and “coronart arteriosclerosis”. The term that best matches your interest can be used as a search term, leading to a comprehensive and well-focused search.

由于科学家可能会对同一概念使用不同的术语，许多数据库都包含一个受控制的主题词汇表。在PUBMED中，这些术语称为医学主题标题（MeSH）。您可以通过在NCBI站点上搜索MeSH数据库来查找MeSH单词。例如，搜索“心脏缺血”返回两个MeSH词：“心肌缺血”和“冠状动脉硬化”。最符合您兴趣的术语可以用作搜索术语，从而实现全面、重点突出的搜索。

Once you’ve identified some useful search terms, a good strategy is to start with general searches and then try to focus. Preliminary searches may yield an unmanageable number of articles. For example, PUBMED returns about 250,000 articles for search term “hypertension” and 200,000 articles for “diet.” Combining terms using AND will focus the search. About 10,000 articles are returned for “diet AND hypertension,” a lot less than either term alone but still probably too many to sift through. The search can be further narrowed using the LIMT function, which enables you to select features such as publication data range, language, subject (animal or human), subject age, and online availability of the full-text article. You can also restrict your search to only article titles or abstracts to narrow the search further.

一旦你确定了一些有用的搜索词，一个好的策略就是从一般搜索开始，然后尝试集中精力。初步搜索可能会产生无法管理的项目数。例如，PUBME为搜索词“高血压”返回了大约250000篇文章，为“饮食”返回了200000篇文章。结合使用“AND”将集中搜索。大约有10000篇关于“饮食AND高血压”的文章被返回，比单独的两个术语都要少很多，但可能还是太多而无法筛选。使用LIMT功能可以进一步缩小搜索范围，该功能使您能够选择诸如出版物数据范围、语言、主题（动物或人类）、主题年龄和全文文章的在线可用性等功能。您还可以将搜索限制为仅搜索文章标题或摘要，以进一步缩小搜索范围。

Using the operator OR between terms will return all the citations that contain either term and thus can be useful for generating a comprehensive citation list. For example, if you wish to make a complete search about athletics, you might combine "athletics" with "sports" using OR. Searching "athletics OR sport " will return more articles than using either term alone. The NOT operator is also handy. Placing NOT before a search term eliminates all articles containing the term, thereby reducing the number of articles returned. Suppose you find that a major portion of the literature on sports and athletics deal with badminton, a sport that does not interest you. NOT could eliminate articles about badminton, thus returning a more reasonable total number of articles.

使用运算符“OR”在术语之间使用将返回包含任一术语的所有引文，因此对于生成综合引文列表非常有用。例如，如果您希望对athletics进行完整的搜索，可以使用OR将“athletics”与“sports”结合起来。搜索“athletics OR sport”将比单独使用这两个词返回更多的文章。NOT运算符也很方便。在搜索项之前放置NOT会删除包含该项的所有文章，从而减少返回的文章数。假设你发现关于sports和athletics的文献中有很大一部分是关于羽毛球（badminton）的，而羽毛球（badminton）是一项你不感兴趣的运动。NOT可以排除关于羽毛球的文章，从而返回更合理的文章总数。

Searches that return between 10 and 100 articles are good starting points. You can scan the titles for articles that match your interest. Both Highwire and PUBMED mark free access articles with special icons, so you can easily identify them. However, be careful not to let free availability be a major search criterion. You may have access to many articles not listed in these databases as free. Your library may subscribe to the journal either in paper or online, or you may be able to obtain the article through an interlibrary loan. Check with a librarian at your institution for more information.

搜索返回10到100篇文章是很好的起点。你可以扫描标题，找到符合你兴趣的文章。Highwire和PUBMED都提供了带有特殊图标的免费访问文章，因此您可以轻松识别它们。但是，请注意不要让免费可用性成为主要的搜索标准。您可以免费访问这些数据库中没有列出的许多文章。你的图书馆可以通过纸质或在线订阅这本杂志，或者你可以通过馆际互借获得这篇文章。向你所在机构的图书管理员咨询更多信息。

SECTION 2 EXERCISES

第二节 练习

These exercises will help you locate and access research article:

这些练习将帮助您查找和访问研究文章：

1. Visit your library or access an online database. Identify several journals in your area of study that publish primary research articles. Browse the table of contents of these journals and scan some of the articles. List two or three differences among the journals you've found.

1. 访问您的图书馆或访问在线数据库。在你的研究领域中找出几本发表主要研究论文的期刊。浏览这些期刊的目录并浏览其中一些文章。列出两到三个你发现的期刊的不同之处。

2. Locate the journals Nature (www.nature.com) and Science ([www.sciencemag.org](http://www.sciencemag.org)), again either online or at the library. Browse through an issue of one of these journals and identify primary and secondary articles. Write down the titles, authors, journal, year, volume, and page numbers of three primary and three secondary articles.

2. 找到自然杂志（www.nature.com）和科学杂志（www.sciencemag.org），无论是在线还是在图书馆。浏览其中一种期刊的一期，并确定主要和次要文章。写下三篇主要和三篇次要文章的标题、作者、期刊、年份、卷和页码。

3. Develop a list of three research topics., that interest you, using your textbook, popular magazine articles, Internet news sites, and other secondary sources.

3. 利用你的教科书、流行杂志文章、互联网新闻网站和其他二级资料，列出三个你感兴趣的研究主题。

4. Develop a list of three current research topics, by browsing through the table of contents of recent journal issue. Look for topics that are explored in several recent articles.

4. 通过浏览最近一期期刊的目录，列出当前的三个研究主题。寻找最近几篇文章中探讨的主题。

5. Choose one of the research topics from question three or four and develop a list of five search terms that could be used search for research articles on the topic.

5. 问题3或问题4中选择一个研究主题，并列出五个可用于搜索该主题研究文章的搜索词。

6. Using an appropriate database, identify five primary research articles on your topic.

6. 使用适当的数据库，确定五篇关于你的主题的初级研究文章。

7. Pick one of the articles from question six. Develop a list of at least five research articles that would help you understand the chosen article. Look for articles cited by the chosen article, articles that cite it, and other articles by the same authors. Also, search appropriate databases to find additional related articles.

从问题6中选择一篇文章。列出至少五篇研究文章，帮助你理解所选文章。查找所选文章所引用的文章、引用该文章的文章以及同一作者的其他文章。此外，搜索适当的数据库以查找其他相关文章。

Section 3: The Anatomy of a Paper

第三节：论文的解剖

Most biology research papers contain the following sections: Citation, Abstract, Introduction, Materials and Methods, Results, Discussion, Acknowledgments, and References. In this section, we first consider the ways that you can use the Citation, Abstract, Acknowledgments and References sections. Subsequent sections will be devoted to the Introduction, Materials and Methods, Result, and Discussion.

大多数生物学研究论文包括以下几个部分：引文、摘要、引言、材料和方法、结果、讨论、致谢和参考文献。在本节中，我们首先考虑如何使用引文、摘要、致谢和参考文献部分。后面的部分将专门介绍引言、材料和方法、结果和讨论。

FORMATTING MATTERS

格式问题

Research articles share a common format; material is presented in discrete sections arranged in a particular order. For instance, the Materials and Methods section, which describes exactly how the work was done, usually precedes the Results section, which portrays the data. This format is not only convenient for readers and writers; it also enables research to be judged according to the standards of the scientific community.

研究文章有一个共同的格式；材料是按特定顺序排列的离散部分。例如，Materials和Methods部分通常位于Results部分之前，Results部分描述的是数据，它准确地描述了工作是如何完成的。这种格式不仅方便读者和作者，而且可以根据科学界的标准来评判研究。

The format of research papers can help you maintain a critical stance. Because each aspect of the study is described in a separate section. You can independently assess different aspects of a study. For example, original data are presented entirely in the Results, while interpretation of data is mainly confined to the Discussion. You can exploit this separation by closely analyzing the data in the Results before considering interpretations in the Discussion.

研究论文的格式可以帮助你保持批判性的立场。因为研究的每个方面都在一个单独的部分中进行描述。你可以独立评估研究的不同方面。例如，原始数据完全呈现在结果中，而对数据的解释主要局限于讨论。在讨论中考虑解释之前，可以通过仔细分析结果中的数据来利用这种分离。

The format of papers also allows you to quickly access information. To make the most of this, try to approach a paper with specific objectives. You may want to use the Introduction as background information about a new topic. You may focus on the Materials and Methods if you wish to find techniques to use in your own research project. You may want to compare the study’s Results with those of another study. Or you may be interested in how a famous scientist synthesizes new research in the Discussion. Make yourself familiar with the format of papers; it will allow you to go directly to the desired information.

论文的格式也允许你快速获取信息。为了充分利用这一点，试着写一篇有明确目标的论文。您可能想要使用介绍作为关于新主题的背景信息。如果你想在自己的研究项目中找到可以使用的技术，你可以专注于“材料”和“方法”。你可能想把这项研究的结果与另一项研究的结果进行比较。或者你可能对一位著名科学家如何在讨论中综合新研究感兴趣。熟悉论文的格式；它将允许您直接访问所需的信息。

Journals vary in their formatting. Sometimes the Materials and Methods are at the end of the article rather than following the Introduction. Sometimes the Results and Discussion are combined into a single section. Sometimes, most notably in the very influential Nature and Science, the text is not divided into separate sections. However, if you are familiar with the standard format of papers, you can adjust to these modified formats. Look for writing that corresponds to each of the sections of a standard article.

期刊的格式各不相同。有时材料和方法在文章的末尾，而不是在介绍之后。有时，结果和讨论被合并成一个单独的部分。有时，尤其是在影响深远的《自然》和《科学》中，文章并没有被分成单独的章节。然而，如果你熟悉论文的标准格式，你可以调整这些修改过的格式。寻找与标准文章的每个部分相对应的文章。

The format of papers is not only helpful to readers; it may also impact the scientific process. Scientists need to communicate their findings effectively in research articles, so they may anticipate the paper they plan to write while they are collecting data. In this way, the demands placed on authors by the format of papers can influence the way they conduct their studies. This influence is overwhelmingly positive, because the format of papers is consistent with the methodological standards of the scientific community. If you are conducting independent research, you may find it useful to think about how you will present your work before you perform your studies. Will you be able to make a convincing case to other scientist?

论文的格式不仅对读者有帮助，而且可能影响科学过程。科学家们需要在研究文章中有效地传达他们的发现，这样他们就可以在收集数据的同时预测他们计划撰写的论文。这样，论文格式对作者的要求会影响他们进行研究的方式。这种影响是绝对积极的，因为论文的格式符合科学界的方法标准。如果你正在进行独立研究，你可能会发现在你进行研究之前，考虑一下你将如何展示你的作品是有用的。你能向其他科学家提出令人信服的理由吗？

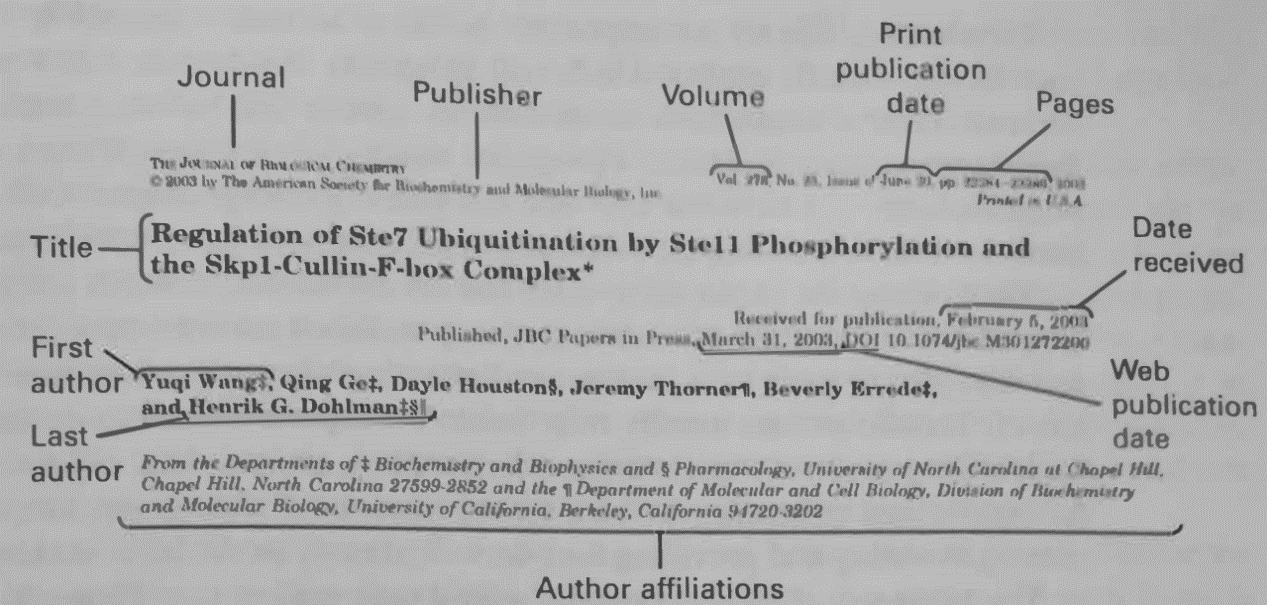


FIGURE 1. The header of a scientific paper. In this example, a Web publication date is given rather than a paper acceptance date. Adapted with permission from the American Society for Biochemistry and Molecular Biology.

图1。科学论文的标题。在本例中，给出的是Web发布日期，而不是纸张接受日期。经美国生物化学和分子生物学学会许可改编。

CITATION

引文

Basic citation information is given at the top of an article’s first page: the title authors, institutional affiliations, journal, volume, pages, and publication data (Figure 1). Don’t skip this information; it can be surprisingly useful. The journal name, volume, and page numbers form a unique “address” and can be used to identify a particular article. You can often find the journal’s Publisher on the first page. Some journals are published by scientific societies, for example the American Physiological Society or the American society of Microbiologists. Others are produced by commercial publishers. While journals produced by societies and companies can both be reliable, it helps to know what organization is behind the journal. Also scrutinize the title, which usually the species studied, the experimental approach, and perhaps a brief indication of the results obtained. Reading articles titles carefully can save you time; you can often decide whether you wish to read any further.

基本的引用信息在文章第一页的顶部给出：标题、作者、机构附属机构、期刊、卷、页和出版数据（图1）。不要跳过这些信息；它可能非常有用。期刊名称、卷和页码形成唯一的“地址”，并可用于标识特定的文章。你经常可以在第一页找到杂志的出版商。一些期刊是由科学协会出版的，例如美国生理学会或美国微生物学家学会。其他的是由商业出版商制作的。虽然社会和公司生产的期刊都是可靠的，但了解期刊背后的组织是有帮助的。还要仔细检查标题，这通常是研究的种类，实验方法，也许是获得的结果的简要指示。仔细阅读文章标题可以节省您的时间；您可以经常决定是否希望继续阅读。

Authors: The Research Team

作者：研究团队

The stereotype of the lonely scientist working in the solitary confinement of a laboratory stands in direct contrast to the collaborative, interdisciplinary world of modem science. Most modern research articles have multiple authors，reflecting this collaborative model. Let's look at the personnel in a typical research group and explore how they are represented in an author list.

孤独的科学家独自在实验室里工作的刻板印象，与现代科学的协作、跨学科世界形成了直接的对比。大多数现代研究文章都有多个作者，反映了这种协作模式。让我们看看典型研究小组中的人员，并探究他们在作者列表中是如何表示的。

Scientists work in diverse research groups that ordinarily include people of different ages, backgrounds, and educations. The boss is the principal investigator (PI), an established scientist who usually has a PhD or MD. PIs determine research priorities, write grants, hire personnel, present findings at conferences, convene lab meetings, and revise manuscripts. They are ultimately responsible for the work done in their lab. Research groups contain other scientists who have finished their education. Postdoctoral fellows (“post-docs” for short) have recently received a PhD or MD, but have not yet established their own research program. They are experienced, free from other responsibilities, highly motivated, and often the most productive members of a research group. Groups may also include senior research scientists who are well past the post-doc portion of their career and have a long-term position. Finally, collaborators may join a research group for a particular project. Collaborators may come from across the hall or form across the globe, and many laboratory groups are distinctly multinational.

科学家在不同的研究小组工作，通常包括不同年龄、背景和受教育程度的人。老板是首席研究员（PI），一位公认的科学家，通常拥有博士或医学博士学位。首席研究员决定研究的优先顺序，撰写拨款，雇用人员，在会议上提出研究结果，召开实验室会议，并修改手稿。他们最终要对实验室的工作负责。研究小组包括其他完成学业的科学家。博士后研究员（简称“博士后”）最近获得了博士或医学博士学位，但尚未建立自己的研究计划。他们经验丰富，没有其他职责，积极性很高，通常是研究小组中最有效率的成员。研究小组也可能包括资深的研究科学家，他们已经过了他们职业生涯中的博士后阶段，并且拥有一个长期的职位。最后，合作者可以加入特定项目的研究小组。合作者可能来自大会堂的另一端，也可能来自全球各地，许多实验室团队明显是跨国的。

Graduate students are important members of many research groups. They each have a specific project which will culminate in a written thesis and an oral defense. Their research both contributes to science and fulfills a requirement of their degree program. Master’s programs usually last one or two years while PhD programs may last between four and six years. Undergraduate students sometimes work in labs during the summer or part time during the school year.

研究生是许多研究小组的重要成员。他们每个人都有一个具体的项目，最终会有一篇书面论文和口头答辩。他们的研究既有助于科学，又满足了他们的学位课程的要求。硕士课程通常持续一到两年，而博士课程可能持续四到六年。本科生有时在暑期或学年兼职在实验室工作。

Technicians are employed by a lab and are not working towards a degree. Some are permanent members of a research group while others are recent college graduates who plan to work for a year or two before applying to graduate or professional school. Technicians are usually responsible for aspects of the day-to-day work of the lab. They perform experiments, order supplies, analyze data, and train students. An experienced technician can be a central member of a lab group, keeping the lab running smoothly and providing long-term continuity to the lab's workings.

技术人员受雇于实验室，并不是为了获得学位而工作。有些人是研究小组的永久成员，而另一些人是应届大学毕业生，他们计划工作一两年，然后再申请研究生或职业学校。技术人员通常负责实验室日常工作的各个方面。他们进行实验，订购供应品，分析数据，培训学生。经验丰富的技术人员可以成为实验室小组的核心成员，保持实验室的平稳运行，并为实验室的工作提供长期的连续性。

The sequence of authors contains useful information (see Figure 1). The first author is usually the scientist who did the most work on a project, often a senior scientist, post-doc, or graduate student. The PI is often listed as the last author and is also sometimes called the senior author. The first and last authors get a major portion of the credit for the study. Middle authors may have contributed in any number of ways, for example, by providing technical help or by reading and editing the manuscript. They get considerably less credit than first and last authors. If you wish to track down similar studies, focus your attention on the first and last authors, who are most likely to have done additional work on the topic.

作者序列包含有用的信息（参见图1）。第一作者通常是在一个项目上做得最多的科学家，通常是资深科学家、博士后或研究生。PI通常被列为最后一位作者，有时也被称为资深作者。第一位和最后一位作者付出了这项研究的大部分功劳。中间作者可能以各种方式做出了贡献，例如通过提供技术帮助或阅读和编辑手稿。他们获得的荣誉比第一个和最后一个作者少得多。如果你想追踪类似的研究，把你的注意力集中在第一个和最后一个作者身上，他们很可能在这个话题上做了额外的工作。

Who is included as an author? Scientific ethics require that only those who have made an intellectual contribution to the work be listed. It is unethical to omit someone who has significantly contributed to a project or to include someone who has not had a substantive role. In the end, each author is responsible for the content of the paper. When technicians or undergraduates have made an intellectual contribution to the project, they are listed as authors. Otherwise, they might be thanked in the Acknowledgments.

谁是作者？科学伦理学要求只有那些对这项工作作出了智力贡献的人才能被列入名单。忽略对项目有重大贡献的人，或包括没有实质性作用的人，是不道德的。最后，每位作者对论文的内容负责。当技术人员或本科生对项目做出了智力贡献时，他们被列为作者。否则，他们可能会在致谢中得到感谢。

Consider the institutional affiliations of the authors. Are all of the authors from the same institution or is this a multi-institutional collaboration? What sorts of institutions are involved? Major research universities? Drug manufacturers? Liberal arts colleges? Are the authors associated with basic science departments (i.e., Cell Biology, Biochemistry, Physiology) or are they associated with clinical departments (i.e., Internal Medicine, Nephrology, Oncology)? The institutional affiliations can tell you about the authors’ perspectives.

考虑作者的机构隶属关系。所有的作者都来自同一个机构还是这是一个多机构的合作？涉及哪些机构？主要研究型大学？药品制造商？文科学院？作者是与基础科学部门（即细胞生物学、生物化学、生理学）相关还是与临床部门（即内科、肾病学、肿瘤学）相关？机构隶属关系可以告诉你作者的观点。

Publication Dates：Peer Review

出版日期：同行评审

On the first page of an articles, you may find several dates, including the date the article was received by the journal, the date it was accepted for publication, and the print publication date (see Figure 1). Article are sometimes posted on the Internet shortly after acceptance, and in such case the date of first Internet publication may be given rather the acceptance date. Why are these delays between receipt, acceptance, and publication? What happens in these interims? Let’s look at the process of drafting, submitting, and revising a manuscript.

在一篇文章的第一页上，您可能会找到几个日期，包括期刊收到文章的日期、接受发表文章的日期以及打印发布日期(参见图1)。文章有时在接受后不久在互联网上发布，在这种情况下，可以给出第一次互联网发布的日期而不是接受日期。为什么在接收、验收和发布之间会出现这些延迟？在这些中间阶段发生了什么？让我们看一看手稿的起草、提交和修改的过程。

One scientist often writes a first draft of a research paper. After this initial effort, however, the process is usually distinctly collaborative. The draft will typically be read by several members of a research group, often resulting in substantial revisions. The manuscript may also be read by scientists outside the immediate research group, who can provide an objective perspective. After this initial "friendly" review, a manuscript may be ready to be sent to a journal. Choosing the appropriate journal is an important decision for authors. Authors seek to publish their work in prestigious, widely read journals. However, the review process can be lengthy, so it is risky to end an article to a top-notch journal where acceptance may be uncertain.

一位科学家经常写一篇研究论文的初稿。然而，在最初的努力之后，这个过程通常是明显的协作性的。该草案通常会由一个研究小组的几个成员阅读，通常会导致实质性的修订。手稿也可以由直接研究小组以外的科学家阅读，他们可以提供客观的观点。在最初的“友好”评论之后，一份手稿可能已经准备好发送到一本杂志。选择合适的期刊是作者的一个重要决定。作者们试图将他们的作品发表在著名的、广为阅读的期刊上。然而，评审过程可能会很长，因此将一篇文章结尾放在一本一流的杂志上是有风险的，因为该杂志的接受程度可能不确定。

Submitted articles are first considered by an editor who assesses whether the manuscript is within the scope of the journal. If so, the editor will send it out to two or more anonymous reviewers. This process is called peer review, because the reviewers are the authors' peers: other research scientists with expertise in the study's topic. They critically read the manuscript and inform the editor of its suitability for publication. They may also be asked to rate the priority or importance of the manuscript. Reviewers also write a set of comments for the authors; these will be essential to the authors if they are asked to revise and resubmit. The final decision about publication is in the hands of the editor. The editor may simply reject the manuscript, accept it without revisions, ask for minor revisions, or require major issues to be addressed before resubmission.

提交的文章首先由编辑考虑，他会评估稿件内容是否在期刊的范围内。如果是这样，编辑将把它发送给两个或更多的匿名审阅者。这个过程被称为同行评审，因为评审人员是作者的同行：在研究主题方面具有专业知识的其他研究科学家。他们仔细地阅读了手稿，并告知编辑它是否适合出版。他们也可能被要求为手稿的优先级或重要性打分。评审员还为作者写一组评论；如果要求作者修改和重新提交，这些评论对作者来说是必不可少的。出版的最终决定权在编辑手中。编辑可以简单地拒绝稿件，接受原稿而不作修改，要求小修改，要求进行小的修改，或者要求在重新提交之前解决重大问题。

Although you will not find any direct evidence of the peer review process in most papers, remember that each primary research has been evaluated by other scientists before publication. One clue to the peer review process is the delay between submission and acceptance (or Internet publication) dates. If the article was accepted shortly after submission, it could mean that the reviews examined it carefully and found it flawless. Or they might have looked at it quickly and missed an important issue. If there was a long delay, the authors might have been asked to make substantial revisions, perhaps even to supply additional data. On the other hand, a reviewer might simply have been late in submitting comments. Take note of the length of the delay between submission and acceptance, but don’t put too much emphasis on it.

尽管你在大多数论文中找不到任何关于同行评审过程的直接证据，但请记住，在发表之前，每一项初步研究都经过了其他科学家的评估。同行评审过程的一个线索是提交和接受（或互联网出版）日期之间的延迟。如果这篇文章在提交后不久就被接受，这可能意味着审查人员对它进行了仔细审查，发现它毫无瑕疵。或者他们可能很快就看了，错过了一个重要的问题。如果出现长时间的延迟，作者可能会被要求做出实质性的修改，甚至可能提供额外的数据。另一方面，评论者可能只是迟交评论。注意提交和接受之间的延迟时间，但不要过分强调它。

Once a manuscript is accepted, it will be some time before the article is finally printed. Before publication in print, authors receive a formatted version of the article. They can respond to editorial changes, check for small errors, and answer questions from the publisher. Because the review and publication process can be lengthy, scientists find it helpful when the submission, acceptance, and publication dates are printed on the paper. Scientists get credit by publishing original findings. When multiple groups publish on the same topic, submission and acceptance dates can help resolve disagreements about who published first.You can use these dates to help understand what the authors knew when they submitted an article. For example, an article submitted in October 2002 and published August 2003 could not reasonably be expected to consider information that was published in June 2003.

稿件一旦被接受，就要过一段时间才能最终印刷出来。在出版之前，作者会收到文章的格式化版本。他们可以对编辑更改做出响应，检查小错误，并回答出版商的问题。由于审查和出版过程可能会很长，科学家发现，当提交、接受和出版日期印在纸上时，这是有帮助的。科学家们通过发表最初的发现而获得赞誉。当多个组在同一主题上发布时，提交和接受日期可以帮助解决关于谁先发布的分歧。您可以使用这些日期来帮助了解作者在提交文章时所知道的内容。例如，在2002年10月提交并于2003年8月发表的一篇文章不能合理地考虑2003年6月发表的信息。

Peer review is a good way of evaluating the scientific value of papers before they published. Errors are corrected, interpretations are refined, and explanations are deepened. Work that fails to meet basic standards isn’t published. But Peer review isn't perfect. Mistakes sometimes slip past reviewers, so don't be surprised if you find something in a paper that might be incorrect. Also, peer review isn’t designed to uncover scientific fraud. In the rare cases where scientists intentionally misrepresent their work, peer reviewers are usually not in a position to detect the fraud. The system thus relies on the honesty of authors, and breaching this trust is considered to be an ethical lapse of the highest order. Fortunately, fraud is often exposed through other mechanisms, either by whistleblowers who have firsthand know ledge of the misconduct or as a consequence of other scientists failing to replicate key findings.

同行评议是评价论文发表前科学价值的一种好方法。纠正错误，细化解释，深化解释。不符合基本标准的作品不会出版。但同行评议并不完美。错误有时会从审稿人面前溜走，所以如果你在论文中发现了可能不正确的地方，不要惊讶。此外，同行评议并不是为了揭露科学欺诈。在极少数情况下，科学家故意歪曲他们的工作，同行评论员通常无法发现欺诈。因此，这一制度依赖于作者的诚实，违反这种信任被认为是最高级别的道德过失。幸运的是，欺诈往往通过其他机制暴露出来，要么是由对不当行为有直接了解的告密者揭发，要么是由于其他科学家未能复制关键发现的结果。

ABSTRACT

摘要

Abstracts are succinct summaries of research papers. They usually include statements of the study' s purpose, experimental approach, key results, and conclusions. Each of the sections of a scientific paper is condensed into a few sentences in the Abstract. They are typically limited to less than 250 words, so each word must be carefully chosen.

摘要是研究论文的简明总结。它们通常包括研究目的、实验方法、关键结果和结论的陈述。在摘要中，一篇科学论文的每一节都被浓缩成几句话。它们通常被限制在250个单词以内，因此每个单词都必须仔细选择。

Apart from the title, Abstracts are the most widely distributed portion papers. They are freely available in online databases. Take the time to read Abstract closely. It will introduce you to the study's core methods, finding. conclusions, and help focus your further reading. Some Abstracts will be difficult to read. When an entire research study is condensed into a single paragraph writing must become quite dense. In some cases, it might be best to skim the Abstract and proceed to the other sections, where you will find more explanation. Don't quit reading an article just because the Abstract is too difficult. Given the rest of the paper a chance. Finally, resist the temptation to use the Abstract as a substitute for reading the full article. You won't find enough detail to make an informed judgment. Scientists don't cite an article solely based on the Abstract.

除标题外，摘要是分布最广的部分论文。它们可以在线数据库中免费获得。花时间仔细阅读摘要。它将向您介绍该研究的核心方法，即发现。结论，并帮助你更深入的阅读。有些摘要很难阅读。当整个研究性学习被浓缩成一个段落时，写作必须变得相当密集。在某些情况下，最好是略读摘要，然后转到其他部分，在那里您会找到更多的解释。不要因为摘要太难就放弃阅读一篇文章。给剩下的报纸一个机会。最后，抵制使用摘要作为阅读全文的替代品的诱惑。你找不到足够的细节来做出明智的判断。科学家不会仅仅引用一篇基于摘要的文章。

When scientists attend meeting, they frequently present their finding in short oral sessions or as posters. Such presentations are often accompanied by an Abstract, which is distributed to meeting attendees and sometimes published in a special journal issue. These Abstracts are similar to those that accompany a full-text scientific paper. But they are not supported by full-text papers, and they do not always receive critical peer review by other scientists. Thus, meeting abstracts may be less reliable documents than Abstracts of full-length papers. Much of the work presented at meetings will eventually be incorporated into peer-reviewed research articles, and meetings are an important way for scientists to get feedback on their work prior to publication.

当科学家参加会议时，他们经常在简短的口头会议或海报上展示他们的发现。这样的报告通常附有摘要，摘要会分发给与会者，有时会发表在一期特别的期刊上。这些摘要与全文科学论文的摘要相似。但是他们没有全文论文的支持，他们也不总是得到其他科学家的批评性同行评议。因此，会议摘要可能不如全文摘要可靠。会议上提出的许多工作最终将纳入同行评议的研究文章，会议是科学家在发表之前获得工作反馈的重要途径。

ACKNOWLEDGMENTS

致谢

In the Acknowledgments, authors thank the people or institutions that have contribute to the work. Scientists acknowledge those who have given valuable feedback, either by reading a draft of the manuscript or by commenting on a preliminary presentation of the work. You can sometimes get a good sense for the pre-publication feedback that scientists received by seeing who they thank in the Acknowledgments. Authors may also acknowledge technical assistance and gifts of equipment, supplies, or reagents.

在致谢中，作者感谢为工作做出贡献的人或机构。科学家们通过阅读手稿草稿或对工作的初步介绍进行评论，对那些提供了宝贵反馈的人表示感谢。有时，你可以通过看到他们在致谢信中感谢的人，对科学家在发表前收到的反馈有一个很好的理解。作者也可以承认技术援助和设备、用品或试剂的馈赠。

Research funding sources are noted in the Acknowledgments. Numerous sources of money are available to scientists, including the home institution, government agencies such as the National Science Foundation and the National Institutes of Health, industry groups such as pharmaceutical companies, and private research foundations such as the American Heart Association. Scientists apply for funding through grant applications that describe their past accomplishments and the proposed studies. These applications are evaluated by panels of scientists. Check the Acknowledgments to see how a study was funded. Since competition for grant monies can be extraordinarily competitive, funded projects have passed a rigorous peer review. Consider also whether the funding source could bias outcomes. Would you feel differently about a study funded by a pharmaceutical company compared to one funded by the government? Perhaps it would depend on the purpose of the research? Finally, post-docs and graduate students may receive fellowships to fund their studies. When these are noted in the Acknowledgments, it can help you identify which authors are students and post-docs.

致谢中注明了研究经费来源。科学家有许多资金来源，包括家庭机构、政府机构（如国家科学基金会和国家卫生研究院）、行业团体（如制药公司）和私人研究基金会（如美国心脏协会）。科学家通过描述他们过去的成就和拟进行研究的拨款申请来申请资助。科学家小组对这些应用程序进行了评估。查看致谢，看看研究是如何资助的。由于赠款的竞争非常激烈，资助项目通过了严格的同行审查。还要考虑资金来源是否会影响结果。一项由制药公司资助的研究与由政府资助的研究相比，你会有不同的感受吗？也许这取决于研究的目的？最后，博士后和研究生可以获得奖学金来资助他们的研究。当这些在致谢中注明时，它可以帮助您确定哪些作者是学生和博士后。

Some journals ask authors to disclose possible conflicts of interest, usually in the Acknowledgements or in a separate statement at the end of the article. For example, scientists might have a financial interest in a company whose business is related to the study. Check to see if any of the authors have a direct financial stake in the outcome of the study; this might influence the wat you evaluate the article.

一些期刊要求作者披露可能的利益冲突，通常是在致谢或在文章结尾的单独声明中。例如，科学家可能对一家与研究相关的公司有经济利益。检查是否有作者在研究结果中有直接的经济利益；这可能会影响你对文章的评价。

REFERENCES

参考文献

The References section is sometimes called the Reference Cited or Literature Cited. It includes only those articles cited in the text of the paper. By citing other studies, scientists acknowledge the work of others and position their own work within a larger body of scientific literature.

参考文献部分有时被称为参考文献引用或文献引用。它仅包括论文正文中引用的那些文章。通过引用其他研究，科学家认可了他人的工作，并将自己的工作置于更大的科学文献中。

The References can be an excellent source for finding further reading on a topic. You may wish to analyze the kind of sources used in a paper. Have the authors previously published on this topic? Do they mainly cite their own works? Have the authors considered other recent studies? Have they read the older, classic literature on a topic? Have they considered the work of scientists outside their immediate field? Answers to some of these questions may be found with a quick look at the References, and if you wish to pursue the matter further you can read some of the cited articles.

这些参考资料可以成为进一步阅读某一主题的极好来源。你可能想分析一篇论文中使用的来源。作者以前发表过关于这个话题的文章吗？他们主要引用自己的作品吗？作者考虑过其他最近的研究吗？他们读过关于某个主题的古老的经典文学作品吗？他们是否考虑过他们直接领域之外的科学家的工作？对其中一些问题的回答可以通过快速查看参考文献找到，如果你想进一步研究这个问题，你可以阅读一些被引用的文章。

THE EXTENDED RESEARCH TEAM

扩展研究团队

We have seen in this section that science is very much a team activity. The research team extends even beyond the list of authors to include other scientists from within and outside a research group. Members of a research team who are not author often give feedback by reading drafts of the manuscript. They may also share opinions during lab meetings, which are regular meetings of research groups. Results and interpretations are usually given a rigorous challenge at these meetings; scientists evaluate their own findings critically before sharing them with other research groups.

我们在这一节中看到，科学在很大程度上是一种团队活动。这个研究小组甚至超出了作者的范围，包括了来自研究小组内外的其他科学家。非作者的研究小组成员通常通过阅读手稿草稿来提供反馈。他们也可以在实验室会议（研究小组的定期会议）上分享意见。在这些会议上，结果和解释通常会受到严格的挑战；科学家在与其他研究小组分享他们的发现之前，会对他们自己的发现进行批判性的评估。

Scientists outside the research group contribute to the work by reviewing manuscripts, assessing grant proposals, and offering technical help. They also comment on conference presentations and research seminars. Academic departments regularly invite speakers, often from outside their own institution, to present seminars. Speakers present their new findings and often receive questions and useful feedback. The audience learns about new research, often before it is published. Keep these inputs from other scientists in mind when reading a paper. By the time a paper has been published, the opinions of many scientists have been incorporated.

研究小组以外的科学家通过审阅手稿，评估拨款建议，并提供技术帮助，为这项工作做出贡献。他们还对会议报告和研究研讨会发表评论。学术部门定期邀请演讲者，通常来自本机构以外的人，出席研讨会。演讲者提出他们的新发现，并经常收到问题和有用的反馈。观众了解新的研究，通常是在它发表之前。在阅读论文时，请记住来自其他科学家的这些输入。到论文发表的时候，许多科学家的意见已经被采纳了。

SECTION 3 EXERCISES

第三节 练习

Using a research article as an example, complete the following exercises:

以一篇研究文章为例，完成以下练习：

1. In one or two sentences, restate the title of the paper in a way that would be understandable to a member of the general public without a scientific background.

1. 用一两句话重述论文的题目，使没有科学背景的普通公众能够理解。

2. Who are the authors of the paper? What kind of institutions are they from? What kind of departments are they in? Do the institutional or departmental affiliations of the authors offer any insight into their perspective or possible biases? Can you identify the PI? Are any of the authors students?

2. 这篇论文的作者是谁?他们来自什么样的机构?他们属于什么部门？作者的机构或部门从属关系是否对他们的观点或可能的偏见提供了一些见解？你能认出来PI吗？作者中有学生吗？

3. When was the paper published? How long were the delays between submission and acceptance and publication?

3. 这篇论文是什么时候发表的？从提交到接受和发表之间有多长时间的延迟？

4 Read the paper’s Abstract. Summarize the main point of the study in two or three sentences.

4. 阅读论文摘要。用两三句话概括研究的要点。

5. Can you determine how the study was funded? If so, does the source of funding influence you opinion of the work?

5. 你能确定这项研究的资金来源吗？如果是，资金来源是否影响你对工作的看法？

6. Were any other scientists consulted in this project? Did the authors get feedback from other scientists prior to publication?

6. 在这个项目中有没有咨询过其他科学家?作者在发表之前是否得到了其他科学家的反馈？

7. Examine the References. Do the authors cite themselves? Are some other authors cited frequently? Are recent works cited? Do the authors cited ant older papers to provide an historical perspective? Do you see any sources that might help you understand the paper better?

7. 检查参考文献。作者们引用了他们自己的吗？其他一些作者经常被引用吗？最近的作品被引用了吗？作者是否引用了一些较老的论文来提供历史观点？你有没有看到任何资料可以帮助你更好地理解这篇论文？

Section 4: The Introduction

第四部分：引言

The Introduction contain background information and a description of the study’s purpose. Authors describe a research problem, explain prior work, and indicate where controversy exists. They describe why their work is important and how it seeks to extend knowledge. You can use the Introduction to learn about previous studies in a research field and to understand the study’s purpose.

引言包括背景资料和研究目的的描述。作者描述一个研究问题，解释先前的工作，并指出存在争议的地方。他们描述了为什么他们的工作是重要的，以及如何寻求扩展知识。你可以通过引言来了解研究领域中以前的研究，并了解研究的目的。

UNDERSTANDING THE JARGON

理解行业术语

Suppose you encounter an Introduction that is littered with unfamiliar technical language. It helps to know that scientists have valid reasons for employing specialized terminology. Scientific words or phrases can condense a large body of shared knowledge. For example, when cell biologists say "tyrosine kinase," they mean "a member of a class of enzymes that catalyzes the addition of a phosphate group to the amino acid tyrosine in certain proteins thereby affecting their function." Writing this every time would be cumbersome, so the technical language serves an important role. Taking the time to learn the specialized vocabulary may be time-consuming, but it's a necessity if you hope to appreciate the paper's scientific concepts.

假设您遇到了一篇充斥着不熟悉的技术语言的介绍。了解科学家使用专业术语的正当理由是有帮助的。科学词汇或短语可以浓缩大量的共享知识。例如，当细胞生物学家说“酪氨酸激酶”时，他们的意思是“一种酶的成员，对某些蛋白质中的氨基酸酪氨酸加上磷酸基进行催化，从而影响其功能。”每次都写这个会很麻烦，所以技术语言扮演着重要的角色。花时间学习专业词汇可能很费时，但如果你希望欣赏文章的科学概念，这是必要的。

To comprehend a paper's specialized terminology you may need to consult additional sources. Secondary sources, including textbooks, review articles, websites, and dictionaries, are useful tools for understanding scientific terminology and concepts. Some secondary sources are written specifically for nonscientist, and are easier to understand than research articles. However, because secondary sources are so varied, it’s necessary to carefully evaluate the credibility of each source. Also, secondary sources must never substitute for careful reading of primary research papers. Scientists always consult primary sources on questions of central importance to their own work.

要理解一篇论文的专业术语，您可能需要参考其他来源。二级资源，包括教科书、评论文章、网站和词典，是理解科学术语和概念的有用工具。一些二级资源是专门为非科学家编写的，比研究文章更容易理解。然而，由于二手资料来源千差万别，有必要仔细评估每个资料来源的可信度。此外，二手资料绝不能取代仔细阅读初级研究论文。科学家们总是在对他们自己的工作至关重要的问题上查阅第一手资料。

To master the terminology in a paper, note the most commonly used technical terms in the Introduction and then find definitions for then, using a biological, scientific, or medical dictionary. Such dictionaries can be found online and in the reference section libraries. While looking for challenging terminology, pay particular attention to abbreviations and acronyms. These are often used extensively and can make an article seem incomprehensible. Abbreviations are sometimes defined in a list on the article’s first page. Take the time to become familiar with each abbreviation.

要掌握论文中的术语，请注意引言中最常用的技术术语，然后使用生物、科学或医学词典查找其定义。这样的词典可以在网上和参考资料部分的库中找到。在寻找较难的术语时，请特别注意缩写和首字母缩略词。它们经常被广泛使用，会使文章看起来难以理解。缩略语有时在文章第一页的列表中定义。花点时间熟悉每个缩写。

Defining terms is a good start, but to fully understand the concept behind each term you may need to go beyond dictionaries and consult other sources. Books, including textbooks, can be a good tool. You probably know that as knowledge in biology has grown, textbooks have lengthened accordingly. Fortunately, using texts to understand the primary literature does not require a cover-to-cover read. Instead, you can identify topics in the table of contents or index, and read only the relevant section. Encyclopedias and magazine articles can be used in similar fashion.

定义术语是一个很好的开始，但是要完全理解每个术语背后的概念，您可能不仅仅需要查阅词典还要查阅其他来源。书籍，包括教科书，可以是一个很好的工具。你可能知道，随着生物学知识的增长，教科书也相应地加长了。幸运的是，使用文本来理解初级文献并不需要来逐一阅读。相反，您可以在目录或索引中标识主题，并只读取相关部分。百科全书和杂志上的文章也可以以类似的方式阅读。

Review articles offer more specialized and focused background reading. They are often found in the same journals that publish primary research articles, but their focus is summarizing and synthesizing the findings of many studies rather than presenting new results. Reviews are written as communications to practicing scientists, and thus may be more difficult to understand than textbooks or magazine articles. However, they can provide an authoritative overview of a research field and usually have comprehensive references lists that can be a good source of further reading.

评论类文章提供更专业和重点背景阅读。它们经常出现在发表初级研究文章的同一期刊上，但它们的重点是总结和综合许多研究的结果，而不是提出新的结果。评论是写给实践科学家的，因此可能比教科书或杂志文章更难理解。然而，他们可以提供一个研究领域的权威概述，通常有全面的参考书目，可以作为进一步阅读的良好来源。

Information on the Internet can be both current and convenient to access. However, the quality of Internet sites is variable; some are trustworthy, others are not. Thus, evaluating the reliability of Internet sites is essential. Here are six elements that should be considered when evaluating websites:

互联网上的信息既可以是最新的，也可以是方便访问的。然而，互联网网站的质量是可变的；有些是值得信赖的，有些则不是。因此，评估互联网网站的可靠性是至关重要的。以下是评估网站时应考虑的六个因素：

1. Author. Who is the source of the information? Is there a single author or an organization? What are the author's qualifications? Is the site affiliated with the government, an educational institution, a private foundation, or a company?

1. 作者。信息的来源是谁？一个作者还是一个组织？作者的资历是什么？该网站是否隶属于政府、教育机构、私人基金会或公司？

2. Scope. What is the intended audience of the site? What body of information is covered? How does the scope relate to the author’s expertise?

2. 范围。网站的目标受众是什么？涵盖了哪些信息？范围与作者的专业知识有什么关系？

3. Timeliness. When was the information posted? How often is the site updated?

3. 及时性。信息是什么时候发布的？网站多久更新一次？

4. Presentation. Are there misspellings or grammatical error. Are there broken links?

4. 演示。是否有拼写错误或语法错误。是否有断开的链接?

5. Mission. Does the site have an obvious agenda? Is there any obvious bias?

5. 任务。这个网站有明显的议程吗？有什么明显的偏见吗？

6. Review. Has information on the site been peer reviewed? Is there a mechanism for comments, feedback, or criticism?

6. 审查。网站上的信息是否经过同行评审?是否有一种机制用于评论、反馈或批评?

Among the most highly reliable websites are those developed by universities and colleges government health and science agencies, professional scientific societies, and private research foundations. However, even websites hosted by reputable organizations should be critically evaluated. In fact, it is best to make a habit of assessing the reliability of every secondary source: with minor modification, the previous guidelines can be used for printed sources.

最可靠的网站包括由大学和学院、政府卫生和科学机构、专业科学协会和私人研究基金会开发的网站。然而，即使是由信誉良好的组织主办的网站也应该受到严格的评估。事实上，最好养成评估每一个二次源可靠性的习惯：只要稍加修改，以前的指南就可以用于印刷源。

OBSERVATIONS, EXPLANATIONS, EXPERIMENTS

观察、解释、实验

Scientific studies are rooted in previous work, yet seek to expand the boundaries of existing knowledge. A key aspect of the Introduction is describing the study’s purpose within the context of prior studies. Appreciating this function of the Introduction requires an understanding of the different sorts of activities that make up scientific methodology. Scientists make observations, propose explanations, and test explanations. Although these processes are interconnected, studies do not necessarily address all three of them. In reading the Introduction, you should identify the main purpose of the study and ask question appropriate to the purpose.

科学研究植根于以往的工作，并寻求扩大现有知识的界限。引言的一个关键方面是在先前研究的背景下描述研究的目的。理解引言的这一功能需要理解构成科学方法论的各种活动。科学家进行观察，提出解释，并测试解释。尽管这些过程是相互关联的，但研究并不一定涉及所有这三个过程。在阅读引言时，你应该确定研究的主要目的，并提出与目的相适应的问题。

A mam goal of biological inquiry is to develop accurate explanations of the natural world. Scientists explore areas where our existing explanation are incomplete. A first step in new research is to collect as many relevant facts as possible. To learn about the observations made by others, scientist read the primary literature and communicate with their colleagues. They also make their own observations, often aided by specialized equipment such a microscope. Look for evidence of observations in the Introduction. How does previous work form the basis for the current study? What aspects of the research area are incompletely understood? What new observations led the scientists to undertake the work?

生物学研究的主要目标是对自然世界的准确解释。科学家们探索我们现有的解释不完整的领域。新研究的第一步是收集尽可能多的相关事实。为了了解其他人的观察结果，科学家阅读了原始文献并与他们的同事交流。他们还进行自己的观察，通常借助于显微镜这样的专门设备。在引言中寻找观察的证据。以前的工作如何构成当前研究的基础？对研究领域的哪些方面还不完全了解？什么新的观察结果使科学家们承担了这项工作？

Some studies are mainly observational; for example their purpose might be to sequence a bacterial genome or to survey the species in a region of rainforest. In such cases, ask yourself whether the Introduction justifies the collection of new information. How do the new observations improve upon previous ones? Will the new data set be more complete or detailed? Is some new observational tool or technique available? Will the new data lead to new explanations or revision of current ones?

一些研究主要是观察性的；例如，它们的目的可能是对细菌基因组进行测序，或是调查雨林地区的物种。在这种情况下，问问你自己，介绍是否有理由收集新的信息。新的观测结果如何改进以前的观测结果？新的数据集是更完整还是更详细？有新的观测工具或技术吗？新的数据会导致新的解释还是对现有的解释进行修正？

In some instances, specific research questions arise from observations. Suppose you observe that a bird is capable of unusually fast flight. What questions arise from this observation? One type of question asks how the bird achieves rapid flight. What anatomical, physiological, and biochemical properties contribute to its speed? Another type of question asks why the bird flies fast. Is the function to avoid predators, attack prey, migrate quickly, or some combination? New questions also arise when observations contradict expectations. Scientists recently found blood vessels in a Tyrannosaurus rex skeleton, countering the conventional wisdom that dinosaur soft tissue is not preserved and leading to a whole new set of questions about dinosaur evolution, anatomy, and physiology.

在某些情况下，具体的研究问题产生于观察。假设你观察到一只鸟能飞得非常快。从这个观察中产生了什么问题？有一类问题问鸟是如何实现快速飞行的。什么解剖，生理和生化特性有助于它的速度？另一类问题是为什么鸟飞得很快。是躲避捕食者，攻击猎物，快速迁徙，还是某种组合？当观察结果与预期相矛盾时，也会出现新的问题。科学家们最近在霸王龙的骨骼中发现了血管，这与传统观念相反，传统观念认为恐龙的软组织没有被保存下来，这导致了一系列关于恐龙进化、解剖学和生理学的新问题。

Choosing which questions to pursue is crucial decision for scientists. Scientists may share a new research idea with other members of their research group. They will assess the scientific merits od the project. How important will the result be? Will a key research problem be resolved? They will consider how likely it is to succeed. Are there major technical hurdles to be overcome? Does the group have the time and money to pursue the project? Will it be possible to get funding? Finally, they will evaluate practical issues. Is another research group pursuing a similar project? Would the project help a student move towards completion of degree? Will someone need spend weekends taking care of animals or cell lines? In the end, both scientific and practical factors influence whether a project is pursued.

选择要研究的问题对科学家来说是至关重要的决定。科学家可能会与他们研究小组的其他成员分享一个新的研究想法。他们将评估这个项目的科学价值。结果会有多重要？一个关键的研究问题会得到解决吗？他们会考虑成功的可能性。是否存在需要克服的主要技术障碍？这个小组有时间和金钱来执行这个项目吗？有可能得到资金吗？最后，他们将评估实际问题。另一个研究小组也在进行类似的项目吗？这个项目能帮助学生完成学位吗？有人需要在周末照顾动物或细胞株吗？最后，科学因素和实践因素共同影响着项目的实施。

When scientists decide to tackle a research question, they carefully gather relevant observations and then propose an explanation. Scientific explanations take the form of theories and hypotheses. All scientific explanations are subject to revision, but theories are generally well-established explanations, while hypotheses are usually tentative explanations that have not been fully tested. Also, theories have broader implications than hypotheses, which tend to have a narrower focus.

当科学家决定解决一个研究问题时，他们会仔细收集相关的观察结果，然后提出一个解释。科学解释采取理论和假设的形式。所有的科学解释都会被修正，但理论通常是公认的解释，而假设通常是未经充分检验的试探性解释。此外，理论比假设具有更广泛的含义，假设往往具有更窄的焦点。

The chief purpose of some papers is to synthesize observations and evidence into a new theory. If so, consider whether the authors justify the need for it. What biological area does the theory address? Are there existing theories that cover the same area? What are the inadequacies of existing theories? Also examine the strategy for developing a new theory. Why is this paper's approach better than that of previous workers? What experimental data or observations form the basis for the theory? What strategy or logic will be used to develop it? Will a mathematical model be constructed? Is there a plan to test the accuracy of the theory against the available evidence?

一些论文的主要目的是把观察和证据综合成一种新的理论。如果是的话，考虑一下作者是否证明有必要这样做。这个理论涉及哪些生物学领域？现有的理论是否涵盖同一领域？现有理论有哪些不足之处？并探讨了发展新理论的策略。为什么本文的方法比以前的工人好？什么样的实验数据或观察结果构成了这个理论的基础？什么样的策略或逻辑将被用来发展它？会建立一个数学模型吗？有没有计划根据现有证据来检验这一理论的准确性？

Single studies rarely attempt to test entire theories; more commonly studies test specific hypotheses. Hypotheses are tentative explanations. They are based on evidence accumulated through experiments and observations, and they are influenced by the prevailing theories. Good hypotheses lead to specific predictions that can either be contradicted or supported by experiments. When scientists repeatedly obtain experimental results inconsistent with the predictions of a hypothesis, then it must be discarded or substantially revised. When experimental results are consistent with predictions of a hypothesis, it gains support and can be tested further. Those that withstand rigorous and repeated testing become well accepted.

单一的研究很少试图测试整个理论；更普遍的研究是测试特定的假设。假设是试探性的解释。它们是建立在实验和观察积累的证据基础上的，并受到当时流行理论的影响。好的假设会导致特定的预测，这些预测可能会与实验相矛盾，也可能得到实验的支持。当科学家反复获得与某一假设的预测不一致的实验结果时，就必须放弃或对其进行实质性的修正。当实验结果与一个假设的预测一致时，它得到了支持，可以进一步检验。那些经得起严格和反复测试的产品被广泛接受。

Hypotheses are often stated towards the end of the Introduction. They may be stated explicitly: "We hypothesized that drug X lowers blood pressure by dilating blood vessels." Sometimes they are stated without using the term hypothesis: “We tested whether drug X lowers blood pressure by dilating blood vessels." Or they might be stated as competing possibilities: “One possibility is that drug X lowers blood pressure by dilating blood vessels. However, it is also possible that it lowers blood pressure by causing increased urinary output."

通常在引言的末尾陈述假设。他们可以明确地说：“我们假设药物X通过扩张血管来降低血压。”有时他们在陈述时没有使用术语假设：“我们测试了药物X是否通过扩张血管来降低血压。”或者，它们可能被说成是相互竞争的可能性：“一种可能性是药物X通过扩张血管来降低血压。然而，也有可能它通过增加尿量来降低血压。”

Carefully consider the hypothesis. The Introduction should relate it to previous research. Have the authors made a convincing case for the importance of testing the hypothesis? Does it follow logically from prior research results? Also assess the relationship between the hypothesis and the theory. Is the hypothesis so central to the theory that its rejection would be a challenge to theory itself? Or does the hypothesis deal with a peripheral aspect of the main theory? If the Introduction contains an outline of how the authors plan to test predictions of the hypothesis, think about the relationship between the experimental strategy and the hypothesis. Does the strategy constitute a rigorous test of the hypothesis? Is it possible to imagine a finding that would contradict predictions of the hypothesis?

仔细考虑这个假设。引言应将其与先前的研究联系起来。作者是否为检验假设的重要性提出了令人信服的理由？它是否符合先前研究结果的逻辑？还评估了假设和理论之间的关系。假设在理论中如此核心，以至于它的拒绝将是对理论本身的挑战吗？或者这个假设处理的是主要理论的外围方面？如果引言包含作者计划如何测试假说预测的大纲，请考虑实验策略和假说之间的关系。该策略是否构成了对假设的严格检验？有没有可能想象一个与假说的预测相矛盾的发现？

SCIENCE AS A CYCLICAL PROCESS

科学是一个循环过程

Observation: explanation, and experiments form an interconnected cycle (Figure2). Observations and experimental results make up the accumulated evidence that is synthesized into explanations. including theories and hypotheses. These explanations are tested by experiments and also motivate new observations. So the accumulated evidence guides the theories and hypotheses that scientists propose. In turn, theories and hypotheses guide the experiments scientists perform and the observations they make. As this cycle proceeds, evidence accumulates and theories become increasingly refined.

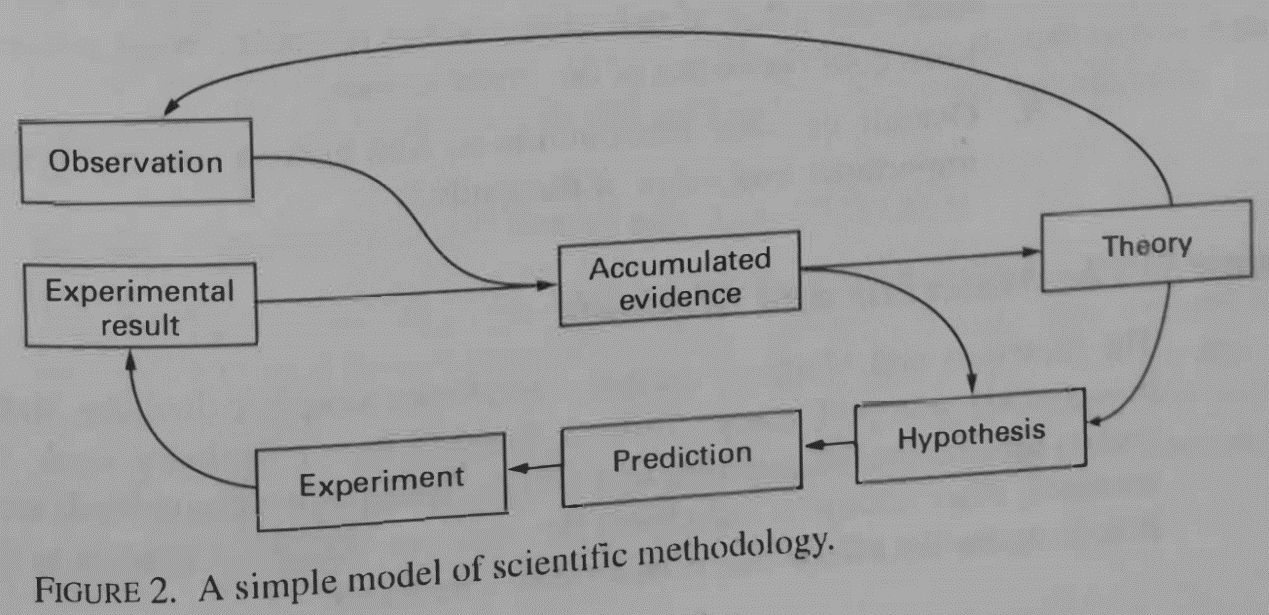
观察：解释和实验形成一个相互联系的循环（图2）。观察和实验结果构成了合成解释的累积证据。包括理论和假设。这些解释经过实验验证，也激发了新的观察。因此，积累的证据指导了科学家提出的理论和假设。反过来，理论和假设指导科学家进行的实验和他们进行的观察。随着这一循环的进行，证据不断积累，理论也日益完善。

Reasoning in science is sometimes from general to specific and Sometimes from specific to general. Development of theories moves from specific observations and results to general explanations with far-reaching implications. In Contrast, testing of theories moves from the general to the specific as the reasoning, proceeds from broad theoretical frameworks to more specific hypotheses and finally to even more specific predictions about experimental results.

科学中的推理有时从一般到具体，有时从具体到一般。理论的发展从具体的观察和结果转向具有深远影响的一般解释。与此相反，理论的检验随着推理从一般到具体，从广泛的理论框架到更具体的假设，最后到对实验结果更具体的预测。

You will occasionally read a paper that does not fit neatly into the framework we've discussed. Scientists draw on diverse tactics, and they may apply more than one strategy in a study. So, use this section as a guide towards understanding the Introduction, but don't be surprised to find creative approaches that defy this simple framework. And remember that consensus in science comes from the accumulated findings of many studies, so it is always wise to assess how each study relate to other research.

您偶尔会阅读一篇不完全符合我们所讨论的框架的论文。科学家们利用不同的策略，他们可能在一项研究中应用不止一种策略。因此，使用这一节作为理解引言的指南，但不要惊讶于发现与这个简单框架背道而驰的创造性方法。请记住，科学上的共识来自于许多研究的累积发现，因此评估每项研究与其他研究的关系总是明确的。



SECTION 4 EXERCISES

第四节 练习

Using a research article as an example, complete the following exercises:

以一篇研究文章为例，完成以下练习:

1. Read the Introduction section of the paper. What is its main research area?

1. 阅读论文的引言部分。它的主要研究领域是什么？

2. List the 10 most important terms used in the Introduction and give a definition for each term.

2. 列出引言中使用的10个最重要的术语，并给出每个术语的定义。

3.Identtify two or three key previous studies that are described in the Introduction. Describe this previous work in your own words.

3. 找出介绍中描述的两个或三个以前的关键研究。用你自己的话描述一下之前的工作。

4. Are there areas of controversy in the research area? If so, what are they?

4. 在研究领域是否存在争议？如果有，它们是什么？

5. What new research question does the paper address? Why is this research question important? How does it extend previous work?

5. 这篇论文提出了什么新的研究问题？为什么这个研究问题很重要？如何扩展以前的工作？

6. Does the paper test a hypothesis? If not, go to question 7. If so, restate in your own words the study's hypothesis. How does the hypothesis relate to the main theory? If the hypothesis is rejected, will the main theory be challenged? What predictions of the hypothesis are tested in the study? Describe a finding that would contradict the hypothesis and one that would support it.

6. 论文是否验证了一个假设?如果没有，转到问题7。如果是这样，请用你自己的话重申这项研究的假设。假设与主要理论有什么关系？如果假设被拒绝，主要理论会受到挑战吗？在这项研究中，该假说的哪些预测得到了验证？描述一个与假设相矛盾的发现和一个支持假设的发现。

7. Does the paper aim to develop a new theory or refine an existing one? If not, go to question 8. If so, is there an existing theory that addresses the research question? What are the shortcomings of the existing theory? What information, experimental or observational, is available to guide development of a new or refined theory? What approach does the paper take towards the refinement or development of theory?

7. 这篇论文的目的是发展一个新的理论还是完善一个现有的理论？如果没有，转到问题8。如果是的话，有没有一个现有的理论来解决这个研究问题？现有理论有哪些不足之处？什么样的信息，实验的或观察的，可以用来指导一个新的或完善的理论的发展？论文对理论的完善和发展采取了什么样的方法？

8. Does the paper aim to collect a new set of observations? If not, go to question 9. If so, describe the new set of observations. How will they extend previous observations? Has a new technique or technology made collection of new observations possible? What new explanations could arise out of the observations?

8. 这篇论文的目的是收集一组新的观察结果吗？如果没有，转到问题9。如果是，请描述新的观察结果集。他们将如何扩展先前的观察？新技术或新技术是否使收集新的观察结果成为可能？从这些观察中可以得到什么新的解释？

9. Overall, does the Introduction section make a convincing case for the importance and value of the study?

9. 总的来说，导言部分是否为研究的重要性和价值提供了令人信服的理由？

Section 5: The Materials and Methods

第五节：材料与方法

The Materials and Methods section sometimes simply called the Methods, tells how a study was performed. Authors describe the preliminary work, the experimental details, and the experimental design. When a study’s methods are well documented, other scientists can repeat the experiments. We’ll discuss in this section how to assess the effectiveness of a study’s methods.

“材料和方法”部分有时简称为“方法”，讲述了研究是如何进行的。作者描述了初步工作，实验细节和实验设计。当一项研究的方法被很好地记录下来时，其他科学家可以重复这些实验。我们将在本节中讨论如何评估研究方法的有效性。

PRELIMINARY WORK AND APPROVALS

前期工作和审批

Scientists often conduct preliminary studies before they do the work reported in a paper. They may need to troubleshoot equipment or develop new methodologies. Preliminary experiments may be needed to optimize procedures. Patience, determination, and problem-solving skills are prerequisites for success during these early stages of a research project. If the authors discuss optimization of techniques or development of new procedures in the Materials and Methods, extensive work may have preceded the reported experiments.

科学家们经常在做论文中报告的工作之前进行初步研究。他们可能需要排除设备故障或开发新方法。可能需要进行初步实验以优化程序。在研究项目的早期阶段，耐心、决心和解决问题的能力是成功的先决条件。如果作者在材料和方法上讨论技术优化或新程序的开发，在报告的实验之前可能已经做了大量的工作。

Scientists need permission before starting some studies. If a study involves vertebrate animals or human subjects, scientists must apply to a review board. These boards are usually composed of other scientists, ethicists, and members of the general public. Review boards that evaluate human studies asses the balance between benefits and risks. In assessing benefits the board considers whether the study will produce important findings. Are there general societal benefits? Will the subjects directly benefit, such as in a study that tests a disease treatment? Is the experiment well designed? Has the work already been done? In assessing risks. the board considers the chance of physical or psychological harm to the subjects. Will the researchers undertake every reasonable measure to minimize ham? Will subjects be completely informed of the study's procedures and risks and then asked to give their informed consent? Will subjects be unfairly coerced into participating, for example through unreasonable financial incentives or by the implication that participation is a condition of employment?

科学家在开始一些研究之前需要得到许可。如果一项研究涉及脊椎动物或人类对象，科学家必须向审查委员会提出申请。这些委员会通常由其他科学家、伦理学家和普通公众组成。评估人类研究的审查委员会评估利益和风险之间的平衡。在评估效益时，委员会考虑这项研究是否会产生重要的发现。有一般的社会效益吗？受试者是否会直接受益，例如在一项测试疾病治疗的研究中？这个实验设计得好吗？工作已经完成了吗？在评估风险时。委员会考虑对受试者身体或心理伤害的可能性。研究人员会采取一切合理的措施来减少火腿吗？受试者是否会被完全告知研究的程序和风险，然后被要求给予知情同意？会否不公平地强迫受试者参与，例如透过不合理的经济诱因，或暗示参与是一项就业条件？

The review boards that assess animal studies are usually distinct from those that assess human studies. However, they consider many of the same factors. Animal review boards also ask whether the scientists have considered alternate models that would reduce the number of animals used. For example, could tissue culture replace some of the animal studies? If a study was approved by a review board, this is usually stated in the paper, often in the first few paragraphs of the Materials and Methods. Look for evidence of such review, especially if you have questions about the treatment of animals or human subjects. Other aspects of a study may also require approval, for example use of controlled drugs or radioactive materials. Again, look for evidence of such approvals in the Materials and Methods.

评估动物研究的评审委员会通常不同于评估人类研究的评审委员会。然而，他们考虑了许多相同的因素。动物审查委员会还询问科学家们是否考虑过可以减少使用动物数量的替代模型。例如，组织培养能代替一些动物实验吗？如果一项研究得到了审查委员会的批准，这通常会在文件中说明，通常在材料和方法的前几段中说明。寻找这类审查的证据，特别是如果你对动物或人类受试者的治疗有疑问的话。研究的其他方面也可能需要批准，例如使用管制药物或放射性材料。再次，在材料和方法中寻找此类批准的证据。

NUTS AND BOLTS: EXPERIMENTAL DETAILS

螺母和螺栓：实验细节

The Materials and Methods is often packed with technical terminology and methodological detail, sometimes making it difficult to read. How can you handle this dense information? One strategy is to evaluate the variables that were assessed, measured, manipulated, or controlled. In most studies, you will find three separate types of variables: dependent variables, independent variables, and controlled variables.

材料和方法往往充满了技术术语和方法细节，有时使其难以阅读。你如何处理这些密集的信息?一种策略是评估被评估、测量、操纵或控制的变量。在大多数研究中，你会发现三种不同类型的变量：因变量、自变量和控制变量。

Dependent Variables

因变量

Dependent variables change in response to other variables. The purpose of many experiments is to characterize dependent variables and how they change under different conditions. For example, In a study of volume regulation in fish Cell，cell volume is the dependent variable. Experiments might examine how it changes in response to other variables, such as the osmolarity of the surrounding fluid. Take care to identify the dependent variables, because these are often the study's focus.

因变量随着其他变量的变化而变化。许多实验的目的是描述因变量及其在不同条件下的变化。例如，在鱼类细胞体积调节的研究中，细胞体积是因变量。实验可能会研究它是如何随着其他变量的变化而变化的，比如周围流体的渗透压。注意确定因变量，因为这些往往是研究的重点。

Measurement of dependent variables may require sophisticated techniques. Be sure that you understand the key techniques used in a paper. You can't evaluate the results if you don't know how they were obtained. Some techniques involve a number of steps. Suppose for example a study examines changes in gene expression during cell volume regulation. A first step would be to isolate RNA, a process which includes several centrifugation and incubation steps. Relying only on the text of the Materials and Methods, you might find it difficult to see how each part of a multi-step procedure fits together. To better understand a technique, try to draw a flowchart that outlines its steps. Figure 3 shows how such a flowchart might look for a standard RNA isolation procedure. When you depict a technique this way, the methodological details as well as the overall strategy become apparent. Basic procedures may not be described in the Materials and Methods because the authors assume the audience is familiar with them. In such cases, you may need to consult secondary Sources to learn more.

因变量的测量可能需要复杂的技术。请务必了解论文中使用的关键技术。如果你不知道它们是如何获得的，你就不能评估结果。有些技术涉及多个步骤。例如，假设一项研究检查了细胞体积调节过程中基因表达的变化。第一步是分离RNA，这个过程包括几个离心和孵化步骤。仅依靠材料和方法的文本，您可能会发现很难看到多步骤程序的每个部分是如何组合在一起的。为了更好地理解一项技术，请尝试绘制概述其步骤的流程图。图3显示了这样的流程图如何寻找标准RNA分离程序。当您以这种方式描述一项技术时，方法细节以及整体策略就变得明显了。基本程序可能不会在材料和方法中描述，因为作者假设观众熟悉它们。在这种情况下，您可能需要咨询二级资源以了解更多信息。

Independent Variables

自变量

Independent variables potentially influence the dependent variable. In some cases they are directly manipulated by the experimenter. Other times they are measured but not manipulated. Let's consider again a study of cell volume regulation. Osmolarity of the fluid outside cells is an independent variable because it is predicted to affect cell volume. Osmolarity can be manipulated, for example, by placing cells into solutions of different solute concentration. Suppose, however. we were interested in whether or not cell volume regulation is different in the cell of marine versus freshwater fish. In this case, the independent variable is the habitat of the fish. Although we may be unable to change this variable, we could still examine its effect by studying fish collected from different habitats. Some studies test multiple independent variables; be sure to identify all of them.

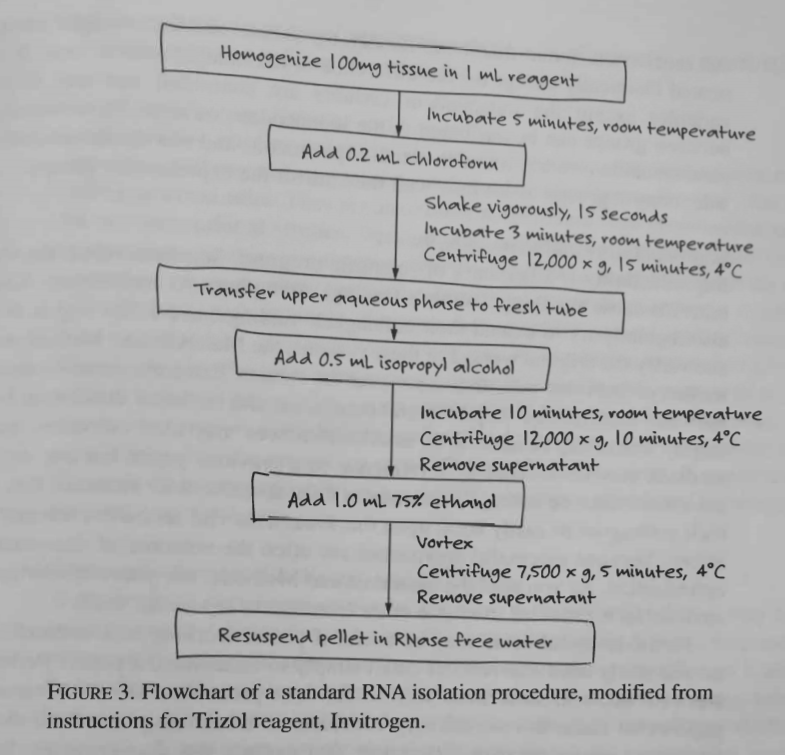
自变量潜在地影响因变量。在某些情况下，它们是由实验者直接操纵的。其他时候，它们是测量的，但不是操纵的。让我们再次考虑细胞体积调节的研究。细胞外液体的渗透压是一个自变量，因为它被预测会影响细胞体积。例如，可以通过将细胞放入不同溶质浓度的溶液中来操纵渗透压。但是假设。我们感兴趣的是在海洋鱼类和淡水鱼的细胞中细胞体积调节是否不同。在这种情况下，自变量是鱼的栖息地。虽然我们可能无法改变这个变量，但我们仍然可以通过研究从不同栖息地收集的鱼类来检查其影响。一些研究测试多个自变量；一定要识别所有这些变量。

Controlled Variables

控制变量

A difficulty in many studies is that numerous factors other than those under investigation could affect the outcome. For this reason, scientists seeking to measure the influence of independent variables strive to control other variables; these are called controlled variables. For example, studying the effect of osmolarity on cell volume requires that other factors such as temperature and pH, are held constant. Variables can sometimes be controlled through experimental design. Imagine that a difference was detected between cell volume regulation of a marine compared to a freshwater fish. Can this difference be attributed to the different habitat or is it due to some other difference between the two species? Studying a single species. such as salmon, that migrates between marine and freshwater environments would make species a controlled variable. Scientists seek to control as many variables as they can, because doing so enables them to draw stronger conclusions. Look closely at the Materials and Methods to see which variables the investigators have controlled. Consider whether there are other variables that could have influenced the results but were not controlled.

许多研究中的一个困难是，除正在调查的因素外，许多因素都可能影响结果。由于这个原因，寻求测量自变量影响的科学家努力控制其他变量；这些被称为受控变量。例如，研究渗透压对细胞体积的影响需要温度和pH等其他因素保持恒定。有时可以通过实验设计来控制变量。想象一下，与淡水鱼相比，检测到海洋细胞体积调节之间的差异。这种差异可以归因于不同的栖息地，还是由于两个物种之间的其他一些差异？研究一个单一的物种。例如鲑鱼，在海洋和淡水环境之间迁徙将使物种成为可控变量。科学家试图控制尽可能多的变量，因为这样做可以让他们得出更有力的结论。仔细查看材料和方法，看看研究人员控制了哪些变量。考虑是否还有其他可能影响结果但未被控制的变量。



Controls

控制

Many experimental designs use control groups. Don't confuse these with controlled variables; they're not exactly the same. Control groups usually receive a treatment where the independent variable is unchanged from the normal or ordinary value. They can therefore serve as a comparison for the experimental groups that receive a different treatment. Ideally, the control and experimental groups are treated identically except tor the difference in the independent variable. If so, all variables except the independent variable are controlled and any difference between groups can be attributed to the independent variable. Unfortunately, this ideal situation is rarely found in actual experiments, and you should carefully consider control groups to see how well they mirror the experimental groups.

许多实验设计使用对照组。不要把它们与受控变量混淆，它们并不完全相同。对照组通常接受自变量与正常值或正常值无变化的治疗。因此，它们可以作为接受不同治疗的实验组的比较。理想情况下，除了自变量的差异外，对照组和实验组被同等对待。如果是这样，除了自变量之外的所有变量都是受控的，并且组之间的任何差异都可以归因于自变量。不幸的是，这种理想的情况在实际的实验中很少发现，你应该仔细考虑对照组，看看他们对实验组的反应有多好。

Reproducibility and Repeatability

重现性和可重复性

Reproducibility is a hallmark of scientific progress. Scientists repeat the work of others because verifying a study’s findings strengthens its conclusions. Scientists also regularly try to extend their colleagues' findings, and a first step is to repeat and verify the original work. For these reasons, the Materials and Methods must be written so that other scientists can repeat the studies. Extensive detail is required to meet this requirement. Experimental conditions and technical detail must be thoroughly described, because even small differences may alter outcomes. Standard methods may be covered by a reference to a Previous paper, but any deviations from them must be noted. When authors fully describe their methods, they enable their colleagues to easily build upon the Work. This can save other scientists huge efforts, because successful approaches are often the outcome of time-consuming optimization. As you read the Materials and Methods, ask yourself whether sufficient detail is provided to enable other scientists to repeat the study.

重复性是科学进步的一个标志。科学家重复其他人的工作，因为验证一项研究的发现可以强化其结论。科学家也经常尝试扩展他们同事的发现，第一步是重复和验证原来的工作。由于这些原因，必须编写材料和方法，以便其他科学家能够重复这些研究。需要大量的细节来满足这一要求。必须彻底描述实验条件和技术细节，因为即使很小的差异也可能改变结果。标准方法可以参考以前的文章，但必须注意任何偏离标准方法的地方。当作者完整地描述他们的方法时，他们使他们的同事能够轻松地在工作的基础上进行构建。这可以节省其他科学家的巨大努力，因为成功的方法通常是耗时优化的结果。当你阅读材料和方法时，问问自己是否提供了足够的细节来让其他科学家重复这项研究。

Methodological detail may be useful if you're working in a research lab, but do you really need that level of detail simply to understand a paper? Perhaps not. But you will still sometimes need to consider procedural details. Consider two papers that come to contradictory conclusions. Examining how each study was performed might uncover differences that explain the discrepancies. You may also need to refer to the Materials and Methods as you assess the Results. Suppose a paper reports that “women who ate a high-carbohydrate diet ran 15% longer than those who ate a normal diet.” You would want to know many methodological details before interpreting this result. How many women were tested? What were their ages? Were they trained athletes? How were they selected to participate in the study? What was the composition of the diet? How fast did the women run? The Materials and Methods section should supply these details. One way to use the Materials and Methods is to consult it for details that are necessary to interpret the Results.

如果你在一个研究实验室工作，方法细节可能是有用的，但是你真的需要那样的细节来理解一篇论文吗？也许不是。但有时仍需要考虑程序细节。考虑两篇得出矛盾结论的论文。研究每项研究是如何进行的，可能会发现解释差异的差异。在评估结果时，您可能还需要参考资料和方法。假设有一篇论文报道说“吃高碳水化合物饮食的女性比吃正常饮食的女性要多跑15%，”在解释这个结果之前，你需要知道很多方法的细节。有多少女性接受了测试？他们几岁了？他们训练过运动员吗？他们是如何被选中参加这项研究的？饮食的成分是什么？这些女人跑得有多快？材料和方法科应提供这些细节。使用这些材料和方法的一种方法是查阅它，了解解释结果所需的详细信息。

THE BIG PICTURE: EXPERIMENTAL DESIGN

全局：实验设计

Convincing findings arise when a study's design is well matched to its purpose. As we’ll see below, different purposes call for different experimental approaches. In reading the Materials and Methods. one of your main tasks is to assess the experimental design’s effectiveness. Correlative studies are most appropriate for describing the patterns in nature. Causative studies are most effective at establishing the causal factors that explain those patterns.

当一项研究的设计与目的很好地匹配时，就会产生令人信服的结果。我们将在下面看到，不同的目的需要不同的实验方法。在阅读材料和方法上。你的主要任务之一是评估实验设计的有效性。相关研究最适合描述自然界的模式。因果关系研究在确定解释这些模式的因果因素方面最为有效。

Correlative Studies: Patterns and Connections

相关研究：模式与联系

In correlative studies, scientists do not manipulate independent variables, but instead exploit preexising variation in them. For this reason. they are often called retrospective studies. They are also sometimes referred to as cross-sectional studies or observational studies. Because correlative studies can investigate multiple independent variables simultaneously without artificial manipulation of the conditions. they are an excellent means for identifying connections between variables.

在相关研究中，科学家并不操纵自变量，而是利用自变量中的前置变异。因为这个原因。它们通常被称为回顾性研究。它们有时也被称为横向研究或观察研究。因为相关研究可以同时研究多个自变量，而无需人为操纵条件。它们是识别变量之间联系的一种很好的方法。

Let's look at an example. Suppose that scientists suspect that an insecticide, used on vegetables, causes cancer in humans. A Correlative approach would be to identify people who have been exposed to the insecticide and compare their cancer rates lo a control group. Cancer rate is the dependent variable in this Study, while insecticide exposure is the independent variable. If cancer rates are the same in both populations, then the insecticide probably does not cause cancer. If cancer rates are higher in the exposed population, a correlation has been established between cancer rate and insecticide exposure.

让我们看一个例子。假设科学家怀疑一种用于蔬菜的杀虫剂会导致人类癌症。一个相关的方法是确定接触过杀虫剂的人，并将他们的癌症发病率与对照组进行比较。本研究以癌症发生率为因变量，以杀虫剂暴露量为自变量。如果两种人群的癌症发病率相同，那么这种杀虫剂可能不会致癌。如果暴露人群中的癌症发病率较高，则癌症发病率与杀虫剂暴露之间存在相关性。

Correlative Studies: Challenges and Limitations

相关研究：挑战与局限

A challenge in correlative studies is that many independent variables may be correlated with the dependent variable. For example. family history. diet, exercise, and smoking all might affect cancer rates. Interpretation is complicated if multiple factors are different between the control and experimental groups. Thus, scientists attempt to match the groups, so that variables other than those being studied are the same. If scientists can't match the groups, they measure variables known to influence the dependent variable and use statistical techniques to account for the differences. In assessing a correlative study, consider whether the investigators have accounted for all the variables that could influence the outcome.

相关研究的一个挑战是许多自变量可能与因变量相关。例如。家族史。饮食、运动和吸烟都可能影响癌症发病率。如果对照组和实验组之间存在多个因素的差异，那么解释就很复杂。因此，科学家们试图将这些组进行匹配，使被研究的变量以外的变量是相同的。如果科学家不能匹配这些组，他们会测量已知影响因变量的变量，并使用统计技术来解释这些差异。在评估相关研究时，考虑研究者是否考虑了所有可能影响结果的变量。

Correlative studies cannot demonstrate causation; they can only suggest it. One issue is that cause and effect can be confused. Consider a study that demonstrates a correlation between exercise and healthy heart function. One possibility is that exercise causes improvements in heart function. But it is also possible that people with healthy hearts are more likely to exercise; in this case, a healthy heart contributes to high levels of physical activity rather than the reverse. Another issue is that independent variables may be correlated with changes in a dependent variable even they’re not causative. In the insecticide example, consider the possibility that other cancer risk factors are present in the part of the country where the insecticide was used. If so, the insecticide could be associated with cancer risk only because it is correlated with a causative factor, not because it is a Cause itself. Correlative and causative studies are often used together. Correlative studies can point out possible causes. which can then be investigated in causative studies.

相关的研究不能证明因果关系，只能提出因果关系。一个问题是因果关系可能会混淆。考虑一项研究，证明运动与健康的心脏功能之间存在相关性。一种可能性是运动可以改善心脏功能。但也有可能心脏健康的人更容易锻炼；在这种情况下，健康的心脏有助于高水平的体力活动，而不是相反。另一个问题是自变量可能与因变量的变化相关，即使它们不是因果关系。在杀虫剂的例子中，考虑在使用杀虫剂的国家部分存在其他癌症危险因素的可能性。如果是这样，杀虫剂可能与癌症风险有关，只是因为它与一个致病因素有关，而不是因为它本身是一个原因。相关研究和因果关系研究经常一起使用。相关研究可以指出可能的原因。然后可以在因果关系研究中进行研究。

Causative Studies: Between-Groups Design

因果关系研究：组间设计

In causative studies, scientists manipulate an independent variable and measure the effect on a dependent variable. In a between-groups design, experimental groups receive a treatment while a separate control group does not. For example, in Figure 4A, the experimental group exercises and the control group does not. The effect of the experimental treatment can be determined by comparing post-treatment measurements in the control and experimental groups. Random assignment of subjects into groups minimizes the chance that they differ in factors other than the manipulated independent variable. Measurements on experimental and control groups can be made at the same time under identical conditions, ensuring that variables other than those under study are held constant. However, because separate individuals are assigned to control and experimental groups, between groups designs do not control for interindividual variability. When such variability is high, the groups are more likely to differ from each other prior to the treatment and it can be difficult to differentiate between preexisting differences and those due to the treatment.

在因果关系研究中，科学家操纵一个自变量，并测量它对因变量的影响。在组间设计中，实验组接受治疗，而单独的对照组不接受治疗。例如，在图4A中，实验组运动，而对照组不运动。实验处理的效果可以通过比较对照组和实验组处理后的测量值来确定。将受试者随机分组，可以最大限度地减少除被操纵的自变量外，其他因素的差异。在相同的条件下，可以同时对实验组和对照组进行测量，以确保研究对象以外的变量保持不变。然而，由于单独的个体被分配到控制组和实验组，组与组之间的设计不能控制个体间的可变性。当这种变异性很高时，这些群体在治疗前更有可能彼此不同，很难区分先前存在的差异和治疗后的差异。

Causative Studies: Repeated-Measures Design

因果关系研究：重复测量设计

Repeated-measures designs control for differences among individuals by studying the same subjects after exposure to different treatments. A simple repeated measures design is to make measurements before and after a treatment (Figure 4B). The treatment effect can then be expressed as the difference between the before and after measurements in the same individual, controlling for interindividual variability. This makes it easier to detect differences, allowing smaller sample sizes to be used. Note that in the before-and-after design, time-related variables are not controlled since the treatment effect is always measured after the control. This can be a problem when the variables are influenced by the time of day or when making an initial measurement affects later measurements.

重复测量通过研究相同受试者在接受不同治疗后的差异来设计个体间差异的控制。一个简单的重复测量设计是在处理前后进行测量（图4B）。治疗效果可以表示为同一个体测量前后的差异，控制个体间的差异。这使得检测差异更容易，允许使用更小的样本量。注意，在前后设计中，时间相关的变量不受控制，因为处理效果总是在控制后测量。当变量受到一天中时间的影响，或者当初始测量影响到以后的测量时，这就会成为一个问题。

A cross-over repeated-measures design addresses these issues. Cross-over designs are similar to between-groups designs, except that the same individuals undergo both the control and experimental treatments on separate occasions. Treatments can be matched so that only the studied variables differ. To control for effects due to the order of treatment, subjects can be randomly assigned to receive the experimental or control treatment first. Figure 4A would depict a cross-over design if the same subjects performed the control and exercise treatments on separate day.

交叉重复测量设计解决了这些问题。交叉设计与组间设计相似，只是同一个体在不同的场合同时接受对照和实验治疗。处理方法可以匹配，因此只有研究的变量不同。为了控制治疗顺序的影响，可以随机分配受试者先接受实验治疗或对照治疗。如果同一受试者在单独的一天进行对照和运动治疗，图4a将描绘交叉设计。

Model Systems

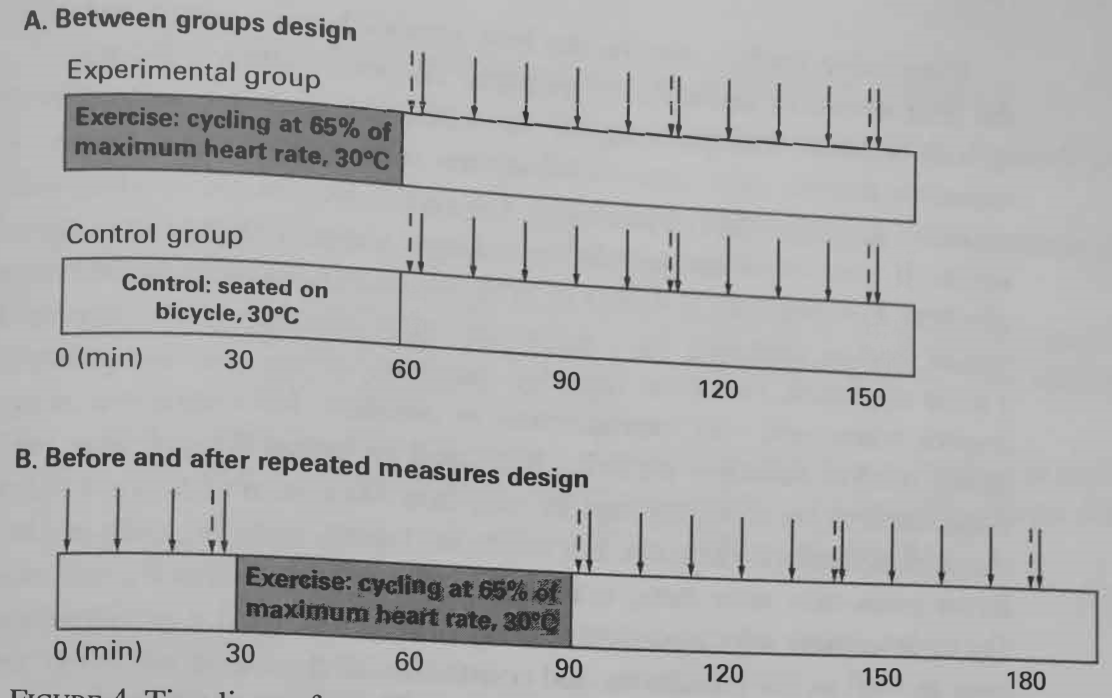
模型系统

Causative studies often employ model systems. Models are alternative experimental systems that save time and money and allow experiments that would otherwise be impossible. A laboratory animal might be used instead of humans, or tissue culture might be used in place of a living animal. However, care must be taken in extrapolating from the model. Scientists choose model systems with great care, balancing their advantages and disadvantages. If a study uses a model system, you should consider whether it makes the experiments easier to perform and also assess how well it represents the system it replaces.

因果关系研究通常采用模型系统。模型是可供选择的实验系统，可以节省时间和金钱，并允许在其他情况下不可能进行的实验。可以用实验动物代替人类，也可以用组织培养代替活体动物。但是，在从模型推断时必须小心。科学家小心翼翼地选择模型系统，平衡它们的优缺点。如果一项研究使用了一个模型系统，你应该考虑它是否使实验更容易进行，并评估它代表它所取代的系统的程度。

Let's return to the example of insecticide and cancer risk. Conducting a causative study of insecticide use and cancer risk in humans may be impossible; exposing humans to a suspected carcinogen is clearly unethical. Instead, suppose that carcinogenicity could be assessed by applying the insecticide to cultured cells and assessing their production of a cancer marker. In this case, you would want to assess whether findings in these tissue culture experiments are applicable to insecticide exposure in humans. For example, is it possible that the insecticide is broken down when ingested by a human but is not when applied to cultured cells?

让我们回到杀虫剂和癌症风险的例子。对人类使用杀虫剂和癌症风险进行因果关系研究可能是不可能的；让人类接触可疑的致癌物显然是不道德的。相反，假设可以通过将杀虫剂应用于培养细胞并评估其癌症标记物的产生来评估致癌性。在这种情况下，您需要评估这些组织培养实验中的发现是否适用于人类接触杀虫剂。例如，杀虫剂是否有可能在被人体摄入时被分解，但在应用于培养细胞时却没有分解？



FGURE 4. Timelines of two different experimental designs. Solid arrows represent blood pressure measurements; dotted arrows represent blood samples. Panel A shows a between- groups design if separate subjects form the control and experimental groups. The same timelines would depict a cross-over repeated-measures design if the same subjects received control and experimental treatments on different occasions. Panel B shows a before-and-after design.

FGURE 4。两种不同实验设计的时间表。实心箭头表示血压测量值；虚线箭头表示血液样本。如果单独的受试者组成对照组和实验组，则面板A显示组间设计。如果相同的受试者在不同的场合接受控制和实验治疗，同样的时间线将描述交叉重复测量设计。面板B显示设计前后的A。

Evaluating Experimental Design

实验设计评价

The Materials and Methods may not explicitly state what type of study was conducted or which groups are the controls. Sometimes. you can make sense out of the experimental design by diagramming it. Draw a timeline for each experimental group and indicate treatments and measurements on it (Figure 4). The study design and control groups should become obvious. Combine this with technique flowcharts (Figure 3), and you'll have a complete visual representation of the study.

材料和方法可能没有明确说明进行了哪种类型的研究或哪些组是对照组。有时。你可以用图表说明实验设计的意义。为每个实验组画一个时间线，并在上面标明治疗和测量（图4）。研究设计和对照组应该变得明显。将其与技术流程图（图3）结合起来，您将获得研究的完整可视化表示。

Correlative studies may be the best approach when investigators seek to study the interactions of multiple independent variables, when it is important to study a system without manipulating it, or when the purpose is to identify possible causative factors. Also, correlative studies may be the only option if manipulating variables is impossible or unethical. Causative studies are needed to establish causation. If interindividual variability is large, a repeated-measures approach is usually best. For example, it dishes of cells varied considerably in their control level of cancer marker, sampling them before and after exposure to the insecticide would be a good approach. However, repeated-measures designs are not possible in circumstances when only one measurement is possible, for example if measurement of cancer marker damaged the cells. Repeated-measures designs also don't work well if the subjects are changing rapidly over time because it is then possible that they’ve changed between treatments. For example, rapidly growing cells might display different properties over time, making comparisons on separate occasions difficult. Try to determine why a particular study design was used. Consider the study's purpose as well as the limitations and constraints of the experimental system.

当研究人员试图研究多个自变量之间的相互作用时，当研究一个系统而不进行操作是很重要的，或者当目的是确定可能的原因因素时，相关研究可能是最好的方法。此外，如果操纵变量是不可能的或不道德的，相关研究可能是唯一的选择。需要因果关系研究来确定因果关系。如果个体间的可变性很大，那么重复测量方法通常是最好的。例如，培养皿中的细胞在控制癌症标记物的水平上有很大的差异，在接触杀虫剂之前和之后取样将是一个很好的方法。然而，重复测量设计在只有一种测量方法的情况下是不可能的，例如，如果癌症标记物的测量破坏了细胞。如果随着时间的推移，研究对象发生了迅速的变化，重复测量的设计也不能很好地发挥作用，因为在不同的治疗之间，它们可能发生了变化。例如，随着时间的推移，快速生长的细胞可能会显示出不同的特性，使得在不同的场合进行比较变得困难。尝试确定为什么使用特定的研究设计。考虑研究的目的以及实验系统的局限性和约束。

Critically consider the controls in causative studies. What would be an appropriate control treatment in the experiment of insecticide exposure in tissue culture cells? To decide we must know how the experimental treatment was performed. Exposing cells to insecticide might include preparing a solution of insecticide in solvent, pipetting the insecticide solution onto the cells, and then mixing by gentle shaking. A good control would match everything except the insecticide exposure, for example by pipetting a solution containing the same solvent without insecticide onto the cells. Check to see whether there are differences between the experimental and control groups other than the studied variables.

批判性地考虑原因研究中的控制。在组织培养细胞暴露于杀虫剂的实验中，什么是合适的对照处理？要决定我们必须知道实验治疗是如何进行的。将细胞暴露于杀虫剂中可能包括在溶剂中制备杀虫剂溶液，用管道将杀虫剂溶液滴到细胞上，然后通过轻微摇动混合。一种好的控制方法是除了接触杀虫剂以外的所有方法都相匹配，例如将含有相同溶剂但不含杀虫剂的溶液用管道注入细胞。检查除研究变量外，实验组和对照组之间是否存在差异。

SECTION 5 EXERCISES

第五节 练习

Using a research article as an example, complete the following exercise:

以一篇研究文章为例，完成以下练习：

1. Was preliminary work done before the reported experiments were performed? How does the preliminary work relate to the reported experiments?

1. 在所报告的实验进行之前是否进行了初步工作？初步工作与报告的实验有什么关系？

1. Did the authors obtain approvals from animal or human review boards or other regulatory agencies? Do you have questions or concerns about treatment of human or animal subjects?

2.作者是否获得动物或人类审查委员会或其他监管机构的批准？你对人类或动物受试者的治疗有疑问或担忧吗？

1. List the variables studied. Differentiate between independent, dependent, and controlled variables.

3.列出所研究的变量。区分独立变量、因变量和受控变量。

1. How do the authors measure the dependent variables? Were the independent variables manipulated by the investigators? How were other variables controlled? Did the investigators fail to control any important variables?

4.作者如何测量因变量？调查人员是否操纵了自变量？其他变量是如何控制的？调查人员是否未能控制任何重要的变量？

1. Chose a key technique and draw a flowchart to depict it.

5.选择关键技术并绘制流程图进行描述。

1. Do the Materials and Methods provide enough detail for another scientist to repeat the work?

6.材料和方法是否为另一位科学家重复这项工作提供了足够的细节？

1. Draw a timeline depicting the experimental design. Indicate the timing of measurements and treatments.

7.绘制描述实验设计的时间线。指出测量和治疗的时间。

1. Was a model system used in the study? If so. what experimental advantages does it have over the system it replaces? How well does it mimic the system it replaces?

8.研究中是否使用了模型系统？如果是这样的话。与它所取代的系统相比，它有什么实验优势？它能很好地模仿它所取代的系统吗？

1. Describe the overall study design. Classify it as Correlative or causative. If it is causative, is it a repeated measures or a between-groups design? Does the design fit well with the Study's main purpose?

9.描述总体研究设计。将其归类为相关或因果关系。如果是因果关系，是重复测量还是组间设计？设计是否符合研究的主要目的？

Section 6: The Results

第6节：结果

The Results, together with the Materials and Methods. are the core of a study. New observations, data, and findings are presented in the Results. In this section, we discuss strategies to help you assess the primary data.

结果，以及材料和方法。是研究的核心。新的观察、数据和发现在结果中呈现。在本节中，我们将讨论帮助您评估主要数据的策略。

Scientists collect data in many forms, including numerical output from instruments and visual information such as photographs and micrographs. Unprocessed data must be recorded in a timely, accurate, and lasting form. Human memory is not always trustworthy, and thus the most reliable records are made immediately. Scientists keep a lab or field notebook where they record their methods and data. You can view the Results section as a translation of unprocessed data from the notebook into a succinct and easily understood form. Rarely does this mean sharing all the data in exactly the form they were collected. Data are analyzed, Sorted, and synthesized before they are presented. The notebook is also important as physical proof that the work was actually performed. In the rare case of an accusation of research fraud, it becomes an important piece of evidence.

科学家以多种形式收集数据，包括来自仪器的数字输出和可视信息，如照片和显微照片。未处理的数据必须以及时、准确和持久的形式记录。人类的记忆并不总是可信的，因此最可靠的记录是立即做出的。科学家们有一个实验室或野外笔记本，在那里他们记录他们的方法和数据。您可以将结果部分视为将笔记本中的未处理数据转换为简洁且易于理解的形式。这很少意味着以完全相同的形式共享所有数据。数据在呈现之前进行分析、排序和合成。笔记本作为实际完成工作的实物证明也很重要。在罕见的研究欺诈指控的情况下，它成为了一项重要的证据。

DEALING WITH VARIABILITY: STATISTICS

处理可变性：统计学

In this section, we discuss basic statistical principles needed to assess biological studies. When reading articles, you may need to consult a statistical manual for more information about specific statistical tests (see Resources, p.43).

在本节中，我们将讨论评估生物学研究所需的基本统计原则。阅读文章时，您可能需要查阅统计手册，以获得有关特定统计测试的更多信息（请参阅参考资料，第43页）。

Variability is ubiquitous in measurements of biological systems. Technical variability, or measurement error, arises any time a measurement is made. No technique is perfect, and variability is introduced when measurements deviate unpredictably from actual values. Scientists always seek to minimize technical variability because it complicates data interpretation, but it can never be completely eliminated. Biological variability refers to real differences between individuals. Because biological variability represents actual differences, there's no way to completely eliminate. In fact, scientists sometimes want to study it because it plays a key role m processes such as natural selection. Although biological variability can't be eliminated, careful experimental design can minimize its influence. For example, when studying animals. matching factors such as age, weight, and sex can reduce biological variability.

变异性在生物系统的测量中是无处不在的。任何时候进行测量时，都会出现技术可变性或测量误差。没有一种技术是完美的，当测量结果与实际值发生不可预测的偏差时，就会引入可变性。科学家总是寻求将技术变异性降到最低，因为它使数据解释变得复杂，但它永远不可能完全消除。生物变异性是指个体之间的真实差异。因为生物变异性代表了实际的差异，所以没有办法完全消除。事实上，科学家有时想要研究它，因为它在自然选择等过程中起着关键作用。虽然生物变异性无法消除，但仔细的实验设计可以将其影响降到最低。例如，当研究动物时。年龄、体重和性别等配对因素可以降低生物变异性。

Due to variability, biologists need to make multiple measurements to fully characterize a system. These measurements constitute a data set. Sometimes an entire data set is shown in a paper. If the heart rate of six cyclists has been measured. they might all be presented in a table. More commonly. data sets are summarized. Sometimes, data sets are presented graphically, as histograms or frequency distributions. Some distributions are symmetrical (Figure 5A). Normal distributions are a specific type of symmetrical distribution that form a characteristic bell-shaped curve. Many statistical tests assume a normal distribution, a condition not always met in biological data sets. Nonsymmetrical distributions can have various shapes. For example, they may be skewed in one direction (Figure 5B). Distributions may also be unimodal, having a single peak (Figures 5A and 5B), or multimodal, having more than one peak. In evaluating data, try to get a sense of the way the values are distributed. Unfortunately, this can be difficult to assess in many papers, because the needed data are often not provided.

由于变异性，生物学家需要进行多次测量以充分描述一个系统。这些测量值构成一个数据集。有时一张纸上会显示整个数据集。如果已经测量了六个骑自行车的人的心率。它们可能都摆在桌子上。更普遍。对数据集进行了总结。有时，数据集以直方图或频率分布的形式呈现。一些分布是对称的（图5a）。正态分布是一种特殊的对称分布类型，它形成了一条典型的钟形曲线。许多统计检验假设正态分布，这在生物数据集中并不总是满足。非对称分布可以有各种形状。例如，它们可能在一个方向上倾斜（图5b）。分布也可以是单峰分布（图5a和5b），或者多峰分布，具有多个峰值。在评估数据时，尝试了解值的分布方式。不幸的是，这在许多论文中很难评估，因为通常没有提供所需的数据。

Descriptive Statistics: Central Tendency and Variability

描述性统计：中心趋势与变异性

Data sets can also be summarized by describing two features: central tendency and variability. Central tendency describes the typical or representative value. Means, the arithmetic average of the most common way of representing central tendency. They work particularly well with symmetrical data sets. Medians are the middle value when the points are arranged from highest to lowest; modes are the most common value in a data set. Medians and modes can be useful with nonsymmetrical data sets, such as those that are skewed in one direction. In these data sets， the most extreme outlying values can have a disproportionate effect on the mean, pulling it away from the central tendency. Most papers in biology summarize data using means. Be aware that means are only a partial representation of a data set. The shape of the distribution and the amount of variability are also important.

数据集也可以通过描述两个特征来总结:集中趋势和可变性。集中趋势描述典型的或有代表性的值。均值，表示集中趋势最常用的算术平均方法。它们在对称数据集上工作得特别好。中值是点由高到低排列时的中间值;模式是数据集中最常见的值。中值和模式对于非对称数据集非常有用，比如那些向一个方向倾斜的数据集。在这些数据集中，最极端的边缘值会对平均值产生不成比例的影响，使其偏离中心趋势。大多数生物学论文都是用方法来总结数据的。请注意，平均值只是数据集的部分表示。分布的形状和可变性也很重要。

Two common measures of variability are the range, the minimum and maximum values, and the standard deviation. which represents an adjusted average distance between individual data points and the mean. A large standard deviation indicates high variability, meaning the data are more spread out compared to a data set with a small standard deviation. For a normal distribution, about 68% of the values are within one standard deviation of the mean, while about 95% of the values are within two standard deviations. Values are often report as a measure of the central tendency ± a measure of variability; for instance mean ± standard deviation. In assessing results consider the magnitude of the variability in the context of the central tendency. For example, a standard deviation of 1 second may be irrelevant when comparing a mean difference of several hours, but crucial when evaluating a mean difference of a few seconds.

两种常见的可变性度量是范围、最小值和最大值以及标准偏差。它表示单个数据点与平均值之间经过调整的平均距离。较大的标准差表示高可变性，这意味着与标准差较小的数据集相比，数据更分散。对于正态分布，约68%的值在平均值的一个标准差内，而约95%的值在两个标准差内。数值通常被报告为中心趋势的测量值±可变性的测量值；例如平均值±标准偏差。在评估结果时，考虑中心趋势背景下的变化幅度。例如，当比较几个小时的平均差时，1秒的标准差可能是不相关的，但当评估几秒的平均差时，标准差是至关重要的。

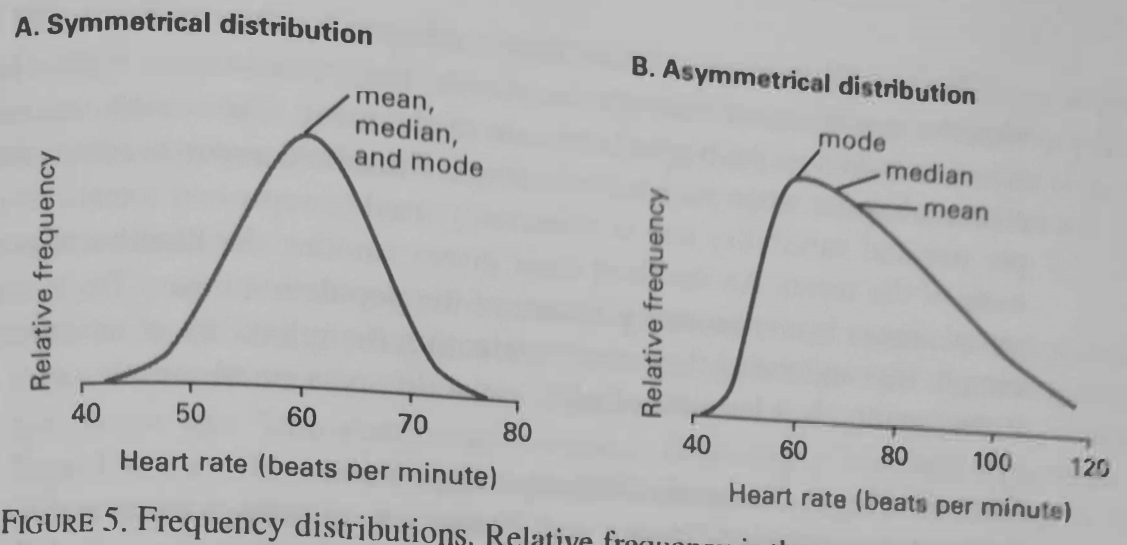


FIGURE 5. Frequency distributions. Relative frequency is the proportion of all the values in a data set that fall into a particular range. Panel A shows a symmetrical distribution. Panel B shows an asymmetrical distribution with a positive skew.

图5。频率分布。相对频率是数据集中属于特定范围的所有值的比例。面板A显示对称分布。面板B显示了正偏斜的不对称分布。

Inferential Statistics: From a Sample to a Population

推论统计：从样本到总体

It's often desirable to generalize from a studied group, the sample, to a broader group, the population. For example, scientists are probably not just interested in how one particular flask of Escherichia coli responds to altered glucose concentration; more likely they hope their findings will apply to other cultures of E. coli as well. Inferential statistics enable scientists to generalize from a specific sample to a wider population. Uncertainty always exists in this process, and inferential statistical approaches therefore lead to statements of probabilities rather than certainties.

人们通常希望从一个被研究的群体，样本，推广到一个更广泛的群体，人口。例如，科学家可能不仅仅对一瓶大肠杆菌对葡萄糖浓度变化的反应感兴趣；他们更希望他们的发现也适用于其他大肠杆菌培养物。推论统计使科学家能够从一个特定的样本推广到更广泛的人群。不确定性总是存在于这一过程中，因此推理统计方法导致的是概率陈述而不是确定性。

If you want to know the mean heart rate of women at your college, one approach would be to study every woman on campus. If this was impractical, an alternate approach would be to study a properly selected sample and then generalize to the broader population. If heart rate Was measured in 10 women, the mean of this sample would be an estimate of the population's mean. Repeating the measurement with ten different women would probably return a slightly different mean. The results in most papers reflect a similar scenario; some individuals are sampled as representatives of a larger population. A crucial step in assessing such results is determining how accurately the sample reflects the population. First determine what population the scientists are interested in, and then assess how well the sample represents this population, For example, a sample of varsity athletes would probably not be representative of the heart rates of the general campus population, while a random sample of enrolled students would be more representative.

如果你想知道大学里女性的平均心率，一种方法是研究校园里的每一位女性。如果这是不切实际的，另一种方法是研究一个适当选择的样本，然后推广到更广泛的人群。如果对10名女性进行心率测量，这个样本的平均值将是对人群平均值的估计。对十个不同的女性重复测量可能会得到稍微不同的平均值。大多数论文的结果反映了类似的情况；一些个体被抽样作为更大群体的代表。评估这些结果的一个关键步骤是确定样本反映人口的准确性。首先确定科学家感兴趣的人群，然后评估样本代表该人群的程度，例如，大学运动员的样本可能不能代表一般校园人群的心率，而随机抽样的在校生更具代表性。

The reliability of an estimate is also affected by the variability and the sample size, the number of individuals measured. When variability is high, a large sample size is required to get a good estimate of the mean. Conversely, a smaller sample size is adequate when variability is lower. Standard error accounts for both sample size and variability and is commonly used to represent uncertainty in an estimate of the mean. As standard error grows smaller. the likelihood grows that the sample mean is an accurate estimate of the population mean. Try to consider both sample size and variability when evaluating the reliability of an estimate. If there is uncertainty, is it because of high variability or a small sample size?

估计的可靠性也受到变异性、样本量、被测个体数量的影响。当变异性较大时，需要较大的样本量来获得对平均值的良好估计。相反，当变异性较低时，较小的样本量就足够了。标准误差同时考虑了样本量和变异性，通常用于表示均值估计的不确定性。随着标准误差的减小。样本均值是总体均值的准确估计的可能性增大。在评估评估评估的可靠性时，尝试同时考虑样本量和可变性。如果存在不确定性，是因为变异性大还是样本量小？

Statistical Tests: Null and Alternative Hypotheses.

统计检验：零假设和替代假设。

Suppose you sampled 20 men and 20 Women on your campus and found a difference in heart rates between Sexes. One possibility is that a real difference exists between men and women on campus. Another is that the measured difference occurred by chance as a result of sampling only part of variable populations; for example. the sample of women might have inadvertently included several women with higher than average heart rates. Inferential statistics can help distinguish between these possibilities by determining the probability that a difference in sample means is due to a true difference in the population.

假设你在你的校园里对20名男性和20名女性进行了抽样调查，发现男女之间的心率存在差异。一种可能性是，在校园里男女之间确实存在着差异。另一种是，测量的差异是偶然发生的，因为抽样仅是可变总体的一部分；例如。女性样本可能无意中包括了几个心率高于平均水平的女性。通过确定样本均值的差异是由总体的真实差异引起的概率，推断统计可以帮助区分这些可能性。

Many statistical tests differentiate between a null hypothesis and an alternative hypothesis. These hypotheses are constructed so that only one can be true. For example, if the null hypothesis states there is no difference between treatments, the alternative hypothesis states that there is a difference. The alternative hypothesis is the one that requires strong support in order to be accepted. To establish a rigorous test of the alternative hypothesis, statistical tests begin with the assumption that the null hypothesis is true. The alternative hypothesis gains support only when the null hypothesis is rejected. The bottom line is that the alternative hypothesis is rigorously tested while the null hypothesis is not.

许多统计检验区分零假设和替代假设。这些假设被构造成只有一个是正确的。例如，如果零假设声明处理之间没有差异，则替代假设声明存在差异。另一种假说是需要强有力的支持才能被接受的假说。为了建立替代假设的严格检验，统计检验从假设零假设为真开始。只有当零假设被拒绝时，替代假设才能获得支持。底线是，替代假设经过严格测试，而零假设则没有。

Statistical hypotheses are only valid when they are developed before data are collected or examined. It's always possible to develop a hypothesis that fits a particular data set after it is collected, but when this is done the hypothesis has not been rigorously tested. Assessing whether a hypothesis was developed before or after conducting the experiments can be difficult. One clue is whether It was mentioned in an earlier paper.

统计假设只有在数据收集或检查之前提出时才有效。在收集了特定的数据集之后，总是有可能开发出一个适合该数据集的假设，但是当这样做时，该假设并没有经过严格的测试。评估一个假设是在进行实验之前还是之后提出的可能很困难。一个线索是它是否在早先的一篇论文中提到过。

The alternative hypothesis usually states the interesting result: that there is an effect, difference, or correlation. Consequently. the null hypothesis usually states that there is no effect, no difference, or no correlation. Since the alternative hypothesis is rigorously tested, an interesting result is only accepted when there is strong support for it. Suppose we are interested in determining whether there is a difference between the heart rates of men and women. The null hypothesis would be that there is no difference, and the alternative hypothesis would be that there is a difference. If the null hypothesis is rejected, a difference between men and women would be strongly supported. Papers often state only the alternative hypothesis, but you need to understand both the null and alternative hypotheses to assess statistical tests. If the statistical hypotheses are not explicitly stated, try to determine them yourself.

另一种假设通常陈述有趣的结果：有一种效果、差异或关联。因此。零假设通常表示没有影响、没有差异或没有相关性。由于另一种假设是经过严格检验的，只有在有强有力的支持时，一个有趣的结果才被接受。假设我们有兴趣确定男女心率之间是否存在差异。无效假设是没有区别，而另一种假设是有区别。如果无效假设被否定，男女之间的差异将得到有力支持。论文通常只陈述替代假设，但是你需要同时理解零假设和替代假设来评估统计测试。如果统计假设没有明确说明，那就试着自己确定它们。

Positive Results

阳性反应

Rejection of the null hypothesis is a positive result, because the alternative hypothesis is strongly supported. However, statistical tests do not reject null hypotheses with absolute certainty. There always remains the possibility that a null hypothesis has been mistakenly rejected. Rejecting a true null hypothesis is a Type I error. Also called a false-positive error. Biologists are willing to accept only a low possibility of making such errors, because they can lead to the erroneous acceptance of the interesting result described by the alternative hypothesis.

拒绝零假设是一个积极的结果，因为替代假设得到了强有力的支持。然而，统计检验不能绝对肯定地拒绝零假设。始终存在着一种可能性，即零假设被错误地拒绝了。拒绝真正的零假设是I型错误。也称为误报错误。生物学家只愿意接受犯这种错误的低可能性，因为它们可能导致错误地接受另一种假设所描述的有趣的结果。

Inferential statistics assess the probability that a false-positive error will be committed. Many statistical tests return a number called a p-value. Findings are labeled as statistically significant when the p-value is less than a preestablished significance level. A typical significance level in biology studies is 0.05; this means that the null hypothesis will be rejected if there is less than a 5% chance of doing so mistakenly. When considering statistically significant results, always assess the probability that an error has been made. If p-values are reported, they directly indicate the likelihood of making a false-positive error. Very low p-values indicate that the null hypothesis can be rejected with high certainty. In other words, as p-values decrease, the chance of making a false-positive error also decreases.

推断统计评估误报发生的概率。许多统计测试返回一个称为p值的数字。当p值小于预先确定的显著性水平时，发现被标记为具有统计学意义。生物学研究中典型的显著性水平是0.05；这意味着，如果错误地这样做的可能性小于5%，那么无效假设将被拒绝。在考虑具有统计意义的结果时，始终要评估出错的概率。如果报告了p值，则它们直接表示产生误报的可能性。很低的p值表明零假设可以被高确定性地拒绝。换言之，随着p值的减小，产生假阳性错误的可能性也减小。

Also consider the significance levels used in a study. A low significance level ensures a small chance of committing a false-positive error. For example, a low significance level might be warranted when testing a risky drug treatment in an experimental animal, because a very high likelihood of effectiveness might be needed prior to human testing. On the other hand, less certainty might be acceptable in preliminary studies with high variability or lower sample sizes.

还要考虑研究中使用的显著性水平。低显著性水平确保了犯假阳性错误的可能性很小。例如，当在实验动物身上测试一种有风险的药物治疗时，低显著性水平可能是必要的，因为在进行人体测试之前，可能需要非常高的有效性可能性。另一方面，在高变异性或样本量较低的初步研究中，不确定性可能是可以接受的。

Because each study has some probability of making a false-positive error, such errors i nevitably slip into the published literature. Thus, some of the statistically significant findings reported in papers are false-positive results. Reproducing findings is an antidote to this problem. Statistical significance is unlikely to arise erroneously in several experiments, especially if they are done with different conditions or methodologies.

因为每项研究都有可能出现假阳性错误，这样的错误不可避免会出现在已发表的文献中。因此，在论文中报告的一些具有统计意义的发现是假阳性结果。重现发现是解决这个问题的解毒剂。统计学上的显著性不太可能在几个实验中错误地出现，特别是当它们使用不同的条件或方法时。

Negative Results

阴性结果

Negative results arise when the null hypothesis is not rejected; in such cases the alternative hypothesis is not supported. As with Positive results. it is always possible that a negative result is mistaken. Failing to reject a false null hypothesis leads to a Type II error. also called a false-negative error. ln this case an alternative Hypothesis that should have been accepted is not. In contrast to a false-positive error, the probability that a false-negative error has occurred usually cannot be determined. Therefore, when the null hypothesis is not rejected, it is not appropriate to accept it or to reject the alternative hypothesis. In fact, the evidence may even favor the alternative hypothesis. For example, in the case of a p-value of 0.06 in a study where the threshold is set at 0.05, the null hypothesis would not be rejected. Also, a failure to reject the null hypothesis might occur because the experimental design was flawed or the sample size was too small. Consider the possibility of false-negative results when differences are found to be not statistically Significant.

当零假设不被拒绝时，就会产生否定的结果;在这种情况下，不支持备择假设。就像积极的结果一样。消极的结果总是有可能是错误的。拒绝错误的零假设会导致II类错误。也称为假阴性错误。在这种情况下，一个本应被接受的替代假设没有被接受。与假正误差相反，假负误差发生的概率通常无法确定。因此，当零假设不被拒绝时，接受它或拒绝备择假设都是不合适的。事实上，证据甚至可能支持备择假设。例如，在一个阈值为0.05的研究中，当p值为0.06时，零假设不会被拒绝。此外，由于实验设计有缺陷或样本量太小，可能会出现拒绝零假设的失败。当发现差异没有统计学意义时，考虑假阴性结果的可能性。

Negative results can be hard to publish. Convincingly demonstrating no difference between treatments or no connection between Variables is difficult. Also, findings of no effect generally don't generate the same excitement as positive results. But there are good reasons to publish well-designed studies that produce negative results. One reason is that it saves other scientists from repeating the same study; another is that finding no effect might have important bioloegical implications. Ruling out one cause might strengthen the case for another.

负面结果很难发表。很难令人信服地证明治疗之间没有差异或变量之间没有联系。而且，没有效果的发现通常不会产生与阳性结果相同的兴奋。但是，有很好的理由发表设计良好的研究报告，这些研究会产生负面结果。一个原因是它避免了其他科学家重复相同的研究；另一个原因是，发现没有影响可能具有重要的生物学意义。排除一个原因可能会加强另一个原因的理由。

Biological Relevance

生物相关性

A finding of statistical significance does not necessarily imply that a result is biologically meaningful. Suppose that two species have a statistically significant difference in mean body temperature: 37.1 °C for one species and 37.2°C for the other. Does a 0.1 °C difference in body temperature have any important biological implications? Conversely, further study of a biologically interesting difference, such as a 3 °C difference in body temperature between species, might be worthwhile even without proof of statistical significance. Remember that false-negative results are possible. Statistical significance might arise with experimental refinements or increased sample sizes. As you assess the results, look carefully at the magnitude of differences. Are there large differences that fail to reach statistical significance? Do statistically significant differences vary enough for there to be biological consequences?

具有统计学意义的发现并不一定意味着一个结果在生物学上是有意义的。假设两种动物的平均体温差异有统计学意义:一种动物的平均体温为37.1℃，另一种动物的平均体温为37.2℃。体温相差0.1℃有什么重要的生物学意义吗?相反，即使没有统计上的显著性证据，进一步研究生物学上有趣的差异，例如物种间的体温差异3℃，也可能是值得的。记住，假阴性结果是可能的。统计显著性可能随着实验的细化或样本量的增加而增加。在评估结果时，请仔细查看差异的大小。是否存在未达到统计显著性的较大差异?统计上的显著差异是否足以导致生物学上的后果?

VISUALIZING RESULTS: TABLES AND GRAPHS

可视化结果：表和图

Results can be presented as pictures, graphs, tables, or as statements in the text. Consider how data are presented; this gives you a sense of which results the authors wish to emphasize. Tables can concisely present large data sets, but it’s tough to emphasize particular findings using a table. Presenting data in graphs takes a bit more space than in tables, but graphs are more effective in illustrating differences. The most important findings are ordinarily presented in graphs and tables, because these attract the most attention from readers. Key findings are also emphasized in the Results text. We’ll focus below on graphs; you can apply a similar approach to reading tables.

结果可以显示为图片、图表、表格或文本中的语句。考虑数据是如何呈现的；这让您了解作者希望强调哪些结果。表可以简洁地表示大型数据集，但使用表很难强调特定的结果。用图表表示数据比用表格表示要占用更多的空间，但图表在说明差异方面更有效。最重要的发现通常以图表的形式呈现，因为它们最吸引读者的注意。结果文本也强调了主要的调查结果。下面我们将重点讨论图表；您可以使用类似的方法来阅读表格。

Graphs

图

Take your time assessing graphs, because they consolidate large amounts of information. A graph's purpose can be discerned by determining the dependent and independent variables and reading the figure legend. Independent variables are ordinarily shown on the x-axis, and dependent variables are plotted on the y-axis.

花点时间评估图表，因为它们整合了大量信息。通过确定因变量和自变量并读取图形图例，可以识别图形的用途。自变量通常显示在x轴上，而因变量则绘制在y轴上。

Imagine that investigators have identified a new species of bacteria from a hot spring and have tested its growth rate at two different temperatures (Figure 6). In this graph, specific growth rate is the dependent variable, temperature is the independent variable, and comparison of growth rates at two temperatures is the purpose. Consider how the purpose of the experiment plotted on a graph relates to the study's overall purpose. For example, why is the comparison of growth rates shown in Figure 6 important? You may need to return to the Introduction for a reminder of the study s goals.

想象一下，研究人员从一个温泉中发现了一种新的细菌，并在两种不同的温度下测试了其生长速度（图6）。在这个图中，比生长率是因变量，温度是自变量，比较两种温度下的生长率是目的。考虑在图表上绘制的实验目的如何与研究的总体目的相关。例如，为什么图6所示的增长率比较很重要？您可能需要返回到导言部分，以提醒您学习的目标。

Examine the graph's units and axis scale. First, determine the unit of measurement, which is often given in parentheses after the axis label. Notice that specific growth rate in Figure 6 is expressed as h-1. What does this unit mean? How was growth rate measured? What experimental conditions were used? You will find answers to some questions in the figure legend, but you may also need to check the Materials and Methods. Also assess what range of values was measured by looking at the y-axis scale. In Figure 6, specific growth rates range from about 0.02 h-1 to 0.04 h-1. Are these high or low growth rates? You may need to compare values to those from other figures or even other papers in order to get a sense of what the reported numbers mean.

检查图形的单位和轴比例尺。首先，确定测量单位，通常在轴标签后的括号中给出。注意，图6中的具体增长率表示为H-1。这个单位是什么意思？增长率是如何衡量的？使用了什么实验条件？您将在图图例中找到一些问题的答案，但您可能还需要检查资料和方法。还可以通过查看y轴刻度来评估测量值的范围。在图6中，比生长率从0.02h-1到0.04h-1不等。这些增长率是高还是低？您可能需要将数值与其他数字或其他论文中的数值进行比较，以便了解所报告的数字的含义。

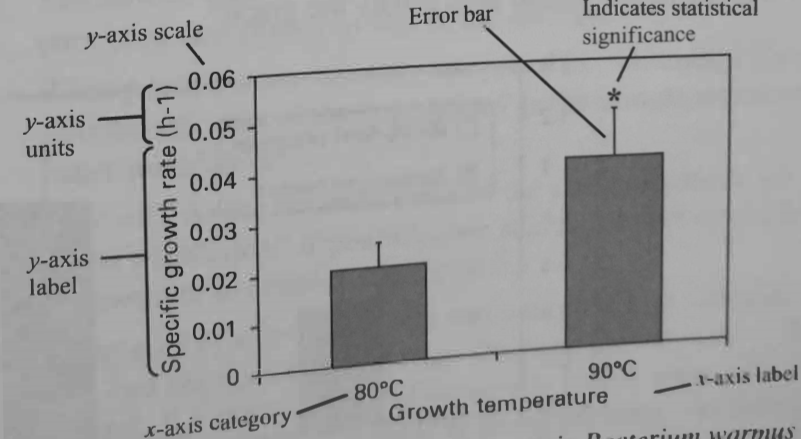


FIGURE 6. Growth rale of the fictional hot springs bacteria Bacterium warms measured at 80℃ and 90℃. Bars represent means土standard error. *n*= 12 for each species. Significant differences between treatments (p <0.05. Student’s *t*-test) are indicated by a (\*).

图6。在80℃和90℃条件下测定了温泉细菌的生长速率。Bars代表意味着土标准差。n= 12对于每个物种。治疗组间差异有统计学意义(p <0.05)。学生的t检验)由a(\*)表示。

Once you understand the purpose and methods behind a graph, try to discern the major patterns in the data. What are the major trends? Arc the differences between treatments large or small? Consider measures of variability, which are often given as error bars projecting above and/or below data points. How variable are the data? Is the variability consistent across treatments? Do any data points fail to follow the overall trend? Read the figure legend closely; it often gives important information such as the sample size (often abbreviated as *n*), the type of variability shown in the error bars, and how the data were statistically evaluated. In Figure 6, the sample size was 12, the error bars depict standard error, statistical difference; were evaluated with a Student's *t*-test, and the significance level was set at 0.05. Sometimes statistically significant findings are indicated by marks on the graph. Read the figure legend to learn how these marks are used. In Figure 6, the \* symbol above the 90°C bar is used to show that the difference in growth rates at the two temperatures is statistically significant.

一旦理解了图背后的目的和方法，就要尝试识别数据中的主要模式。主要趋势是什么？治疗方法的差别是大是小？考虑可变性的度量，这些度量通常以数据点上方和/或下方的误差条的形式给出。数据有多变量？治疗前后的变异性是否一致？是否有任何数据点未能遵循总体趋势？仔细阅读图表图例；它通常提供重要信息，如样本大小（通常缩写为n）、误差栏中显示的变异类型以及数据的统计评估方式。在图6中，样本量为12，误差条描述标准误差，统计差异；用学生t检验进行评估，显著性水平设为0.05。有时统计上有意义的发现可以用图表上的标记来表示。阅读图形图例了解如何使用这些标记。在图6中，90°C条上方的\*符号表示两种温度下的生长速率差异具有统计学意义。

Evaluating Data

评估数据

As you evaluate the results, consider how they've been presented. Let's suppose growth rates of a second hot springs bacterial species were also measured. The graph in Figure 7 emphasizes the difference between the species. The effect of temperature on Bacterium hottus is also apparent. But notice that the effect of temperature on Bacterium warmus, which was evident in Figure 6, is now difficult to discern in Figure 7 because the y-axis scale has been changed to accommodate the higher growth rates of Bacterium hottus. The bottom line is that a graph can emphasize or camouflage different aspects of the data. When reading a graph. ask yourself how the data are presented. Are certain differences highlighted? Are others obscured? Does the presentation reflect the authors' opinions about the data? Do you see interesting patterns that are downplayed in the authors' presentation? Does the figure legend help clarify the graph?

在评估结果时，请考虑它们是如何呈现的。假设第二个温泉细菌的生长速度也被测量了。图7中的图表强调了物种之间的差异。温度对热菌的影响也很明显。但请注意，温度对Warmus细菌的影响（如图6所示）现在很难在图7中识别，因为Y轴刻度已更改以适应Hottus细菌的较高生长速率。归根结底，图形可以强调或伪装数据的不同方面。当读图表时。问问你自己数据是如何呈现的。是否强调了某些差异？其他人被蒙蔽了吗？报告是否反映了作者对数据的看法？你有没有看到作者在演讲中轻描淡写的有趣模式？图形图例是否有助于澄清图形？

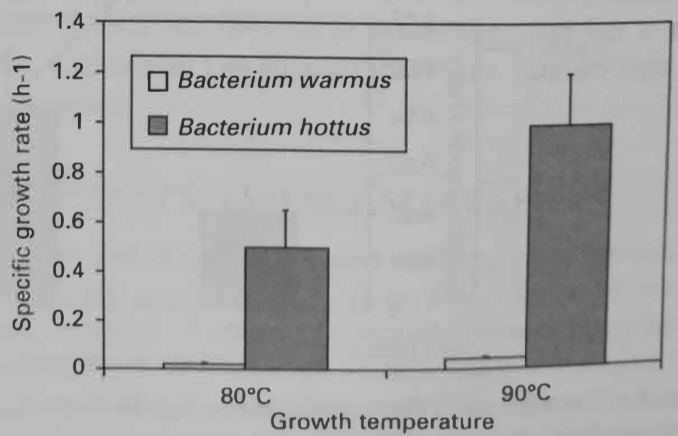


FIGURE 7. Growth rates of two fictional hot springs bacteria measured at 80℃ and 90℃. Bars represent means ± standard error. *n* = 12 for each treatment.

图7。两种虚构的温泉细菌在80℃和90℃下的生长速率。Bars表示平均值±标准差。每次治疗n=12。

Ty to evaluate the numerical data without being influenced by how they are presented. One method is to examine the graphs and tables for major trends before reading the Results text. Another strategy is to read the Results section text first, picking out the main statements the authors make about their data. Then, check to see if the numerical data in the tables or graphs support these statements. The key is to develop your understanding of the study's findings and then compare it to what the authors say. If there' s a discrepancy. you might have identified a shortcoming in the authors' analysis. On the other hand, you might also have misunderstood the authors, so check your analysis carefully.

在不受数据呈现方式影响的情况下对数值数据进行评估。一种方法是在阅读结果文本之前检查图表的主要趋势。另一个策略是先阅读结果部分的文本，挑选出作者对数据的主要陈述。然后，检查表或图中的数字数据是否支持这些语句。关键是发展你对研究结果的理解，然后将其与作者所说的进行比较。如果有出入。你可能在作者的分析中发现了一个缺点。另一方面，你也可能误解了作者，所以仔细检查你的分析。

Why go through all the trouble to evaluate the primary data yourself? Why not simply read the Results and accept what the authors say? The answer is that only after evaluating the primary data can you critically assess the study and its conclusions. Just as you can’t intelligently review a movie or a book unless you've read it yourself, you can't critically assess a scientific study without personally evaluating its Core component: the data.

为什么要费尽周折亲自评估主要数据？为什么不简单地阅读结果并接受作者所说的呢？答案是，只有在评估了主要数据之后，你才能批判性地评估研究及其结论。正如你不能明智地评论一部电影或一本书，除非你自己读过，你不能批判性地评估一项科学研究，而不亲自评估其核心组成部分：数据。

SECTION 6 EXERCISES

第六节练习

Using a research article as an example, complete the following exercises:

以一篇研究文章为例，完成以下练习：

1. How are the data presented in the paper? In pictures, graphs, tables, or text?

1.论文中的数据是如何呈现的？以图片、图表、表格或文本的形式？

1. Choose a key table or graph and use it to answer the following questions. What are the main trends in the data? Are the differences between treatments large or small? How is variability depicted? How variable are the data? How are the data distributed? How is central tendency presented?

2. 选择一个关键表格或图表，并使用它来回答以下问题。数据的主要趋势是什么?治疗之间的差异是大还是小?如何描述可变性？数据有多变量？数据是如何分布的?集中趋势是如何呈现的?

1. Summarize each table or graph in the paper in a few sentences. Compare your description to that of the authors.

3.用几句话总结论文中的每个表格或图表。将你的描述与作者的描述进行比较。

1. What population is the study interested in examining? Does the study sample only part of the population? Is the sample representative of the entire population?

4.研究对哪些人群感兴趣？这项研究是否只对部分人群进行了抽样？样本是否代表整个人群？

1. How well do the measurements of the sample estimate the properties of the population? If possible, use standard errors or another statistical measure to support your answer.

5. 样本的测量值如何估计总体的性质?如果可能的话，使用标准误差或其他统计方法来支持你的答案。

1. Choose a key experiment that was analyzed with statistics. State the null and alternative hypotheses. Describe the outcome of the statistical test. If a statistical significance was found, what is the likelihood that a false positive occurred? If no significance was found, can you assess the possibility of a false negative?

6.选择用统计学方法分析的关键实验。陈述零假设和替代假设。描述统计测试的结果。如果发现统计学意义，发生假阳性的可能性有多大？如果没有发现显著性，你能评估假阴性的可能性吗？

1. Are the findings biologically relevant? Are there any findings that didn't reach statistical significance but might be worth further study?

7. 这些发现在生物学上相关吗?是否有未达到统计学意义但值得进一步研究的发现?

Section 7: The Discussion

第七部分：讨论

The Discussion is an opportunity for authors to explain what their findings mean, to illuminate the key conclusions, and to address potential criticisms. Information is drawn from many different sources, and opinion may mingle with objective fact. Your task is to sort through this information and come to your own conclusions about the study. Be prepared to consult other writings as you read the Discussion. Because it synthesizes information from the rest of the study, you may need to refer back to the Introduction, Materials and Methods, and Results. Since it connects the study to previous work, you may need to consult other research articles.

讨论为作者提供了一个机会来解释他们的发现意味着什么，阐明关键结论，并解决潜在的批评。信息来自许多不同的来源，意见可能与客观事实相混合。你的任务是整理这些信息，得出你自己对这项研究的结论。阅读讨论时，准备查阅其他文章。因为它综合了研究其他部分的信息，所以您可能需要参考介绍、材料和方法以及结果。由于它将研究与之前的工作联系起来，您可能需要参考其他研究文章。

INTERPRETATION: FINDING MEANING

解释：找到意义

The Materials and Methods and Results mostly report factual information. While superficial interpretation may be found in the Results, in-depth interpretation is usually confined to the Discussion. Interpretation differs from simple reporting of experimental results because it involves describing the meaning of the data. Evaluating how well the study fulfills its purpose is a form of interpretation. Authors may describe whether a useful data set was collected, whether the findings support or contradict the hypothesis, or whether a new theory was developed. Another type of interpretation is the synthesis of a study's different findings. Authors may state whether all the study's findings are consistent, whether any results contradict the others, or whether more reliable conclusions can be made when a set of experiments is considered as a whole. Interpretation also includes describing the strengths and weaknesses of a study. Authors may address the shortcomings of their methodologies and the limitations of their conclusions.

材料、方法和结果大多反映事实信息。虽然在结果中可以找到肤浅的解释，但深入的解释通常仅限于讨论。解释不同于简单的实验结果报告，因为它涉及到描述数据的意义。评价这项研究如何达到目的是一种解释。作者可以描述是否收集了有用的数据集，研究结果是否支持或反驳了假设，或者是否开发了新的理论。另一种解释是综合研究的不同发现。作者可以说明所有研究结果是否一致，是否有任何结果与其他结果相矛盾，或者当一组实验被视为一个整体时，是否可以得出更可靠的结论。解释还包括描述研究的优缺点。作者可以讨论他们的方法的缺点和结论的局限性。

Critically reading a paper requires that you completely understand the author interpretations, and then compare them to your own. This may seem like a daunting task. Is it even possible to question the interpretations of the authors? Aren't they in a much better position to make interpretations than you? Although you will generally have no basis to question the actual data, you will be able to evaluate interpretations of the data. If the authors have presented their method and results clearly, you have access to all the information that is necessary for developing interpretations. Furthermore, it is possible to arrive at different interpretation than the authors. For example, you may approach the paper from a different perspective, you may have new information that has become available since the author wrote the article, or you may be more objective in assessing the experimental design and results. A strength of the scientific process is that scientists vigorously challenge each other's interpretations. As you begin developing your own interpretations and assessing those of others, you become an actual participant in the scientific process.

批判性地阅读一篇论文要求你完全理解作者的解释，然后把它们与你自己的比较。这似乎是一项艰巨的任务。甚至有可能质疑作者的解释吗？他们不是比你解释得更好吗？虽然你一般不会质疑实际数据，但你将能够评估数据的解释。如果作者已经清楚地展示了他们的方法和结果，那么你就可以获得开发解释所需的所有信息。此外，有可能得出不同的解释比作者。例如，你可以从不同的角度来看待这篇论文，你可以从作者写这篇文章以来获得新的信息，或者你可以更客观地评估实验设计和结果。科学过程的一个力量是科学家们强烈地挑战彼此的解释。当你开始开发你自己的解释和评估别人的时候，你就成为了科学过程中的实际参与者。

How can you develop your own interpretations? Here's where the hard work you've done assessing the Introduction, Materials and Methods, and Results pays off. Before you read the Discussion, review the other sections with the aim of developing your interpretations. Write these down. Then read the Discussion to see how the authors interpret their findings. You may come across interpretations that didn't occur to you. In these cases, consider whether you agree with the authors, referring if necessary back to the other sections. Developing and assessing interpretations takes practice. You won't be an expert on your first try, but you'll improve with time.

如何形成自己的解释？这就是你在评估介绍、材料和方法以及结果方面所做的艰苦工作的回报。在阅读讨论之前，复习其他章节，目的是发展你的解释。把这些写下来。然后阅读讨论，看看作者如何解释他们的发现。你可能会遇到一些你没有想到的解释。在这种情况下，考虑是否同意作者的意见，必要时再参考其他章节。开发和评估解释需要实践。你不会是第一次尝试的专家，但你会随着时间的推移而进步。

CONNECTIONS: RELATIONSHIP TO OTHER WORK

联系：与其他工作的关系

The Discussion compares the study to previous research, placing the Work into the context of a broader research field. This is a key activity, since consensus in science usually emerges from many studies considered together. Authors may discuss how their findings contradict other studies, how previous work supports their conclusions, and how their work extends the knowledge within a field.

讨论部分将这项研究与以往的研究进行了比较，将这项工作置于一个更广泛的研究领域中。这是一项关键的活动，因为科学中的共识通常来自于将许多研究放在一起考虑。作者可以讨论他们的发现如何与其他研究相矛盾，以前的工作如何支持他们的结论，以及他们的工作如何在一个领域内扩展知识。

Reading the Discussion can be complicated because authors interpret not only their work. but also others' work. Keep track of this as you read by looking for cues that indicate what is being discussed. Previous work is usually identified with a citation: “Physical activity level has been found to be correlated with blood pressure (Smith, et al, 2003).” Or, “Smith and colleagues (2003) found that physical activity level was correlated with blood pressure.” Also consider whether a previous study is simply being summarized, as is the case in the examples above, or whether the authors are interpreting or criticizing the study. “Because Smith and colleagues (2003) studied only 10 college-aged males, care must be taken in applying their results to other populations” is an interpretation. Be careful about accepting criticisms of previous work. In fairness to Smith and colleagues, you should check their paper before judging it.

阅读讨论会很复杂，因为作者不仅解释他们的作品。还有其他人的工作。当你阅读的时候，通过寻找暗示正在讨论什么的线索来跟踪它。以前的研究通常会被引用：“发现体力活动水平与血压相关（Smith，et al，2003）。”或者，“Smith和同事（2003）发现体力活动水平与血压相关。”还要考虑以前的研究研究只是简单的总结，就像上面的例子一样，或者作者是在解释还是批评研究。“因为史密斯和他的同事（2003年）只研究了10名大学年龄的男性，所以在将他们的研究结果应用于其他人群时必须小心”是一种解释。注意不要接受对以前工作的批评。为了对史密斯和同事们公平起见，你应该在评判之前检查他们的论文。

Previous work is often used to support a study's conclusions. The strongest claims can be made when studies by different investigators are consistent. Claims are particularly strengthened when studies using different approaches come to the same conclusion, because it is unlikely that several approaches are flawed. Assess how the study relates to other work. Are the study's conclusions consistent with prior Work? Does it use a different approach than previous work? Does the study come to a new conclusion, or is it another piece of evidence supporting a wellstudied theory? Does it strengthen a previously shaky conclusion? Authors also describe whether their study conflicts with prior work. Assess such contradictions carefully. Were the previous studies somehow flawed? What differences in methodology may have led to the contradictory results? Why might the new study be more reliable? Here again you may need to consult some of the previous studies to get their perspective.

以前的工作经常被用来支持研究的结论。当不同研究者的研究结果一致时，可以提出最有力的主张。当使用不同方法的研究得出相同的结论时，主张尤其得到加强，因为不太可能有几种方法存在缺陷。评估研究与其他工作的关系。这项研究的结论与之前的研究是否一致？它使用的方法与以前的工作不同吗？这项研究是得出了一个新的结论，还是另一个证据支持了一个经过充分研究的理论？这是否强化了一个先前不稳定的结论？作者还描述了他们的研究是否与先前的工作相冲突。仔细评估这些矛盾。以前的研究有缺陷吗？哪些方法上的差异可能导致了矛盾的结果？为什么新的研究会更可靠？在这里，你可能需要参考一些以前的研究，以获得他们的观点。

EXPLANATIONS AND IMPLICATIONS

解释和意义

Scientists have the opportunity to explain their results in the Discussion. For example, when a study demonstrates a cause-and-effect relationship, scientists seek to explain the mechanism that connects cause and effect. Suppose a study finds that exercise lowers blood pressure. This conclusion will be strengthened if we have a plausible explanation of how exercise causes a reduction in blood pressure. Sometimes the study itself gives possible clues to the mechanism. Other times mechanisms can be proposed based on previous studies. Look for mechanistic explanations in the Discussion. Do the authors give convincing explanations for their findings? Do their data suggest mechanisms? Are other mechanisms possible?

科学家可以在讨论中解释他们的结果。例如，当一项研究表明因果关系时，科学家试图解释因果关系的机制。假设一项研究发现运动可以降低血压。如果我们对运动如何导致血压下降有一个合理的解释，这个结论将会得到加强。有时这项研究本身就为这一机制提供了可能的线索。其他时间机制可以在先前研究的基础上提出。在讨论中寻找机械解释。作者是否对他们的发现给出了令人信服的解释？他们的数据是否暗示了机制？其他机制可能吗？

Some studies are specifically aimed at identifying mechanisms. In such cases you should assess how convincingly the mechanism has been established. Even when a mechanism is clearly demonstrated, a new set of mechanistic questions often arises. As studies accumulate, explanations become more detailed and accurate. The Discussion should give you a sense of this process. How sophisticated are the current mechanistic explanations? Are they well refined or are they general and approximate? Is there more than one competing explanation?

一些研究的具体目的是确定机制。在这种情况下，你应该评估该机制建立得有多令人信服。即使当一种机制被清楚地演示出来，也常常会出现一组新的机械论问题。随着研究的积累，解释变得更加详细和准确。讨论应该让您了解这个过程。目前的机械论解释有多复杂?它们是很精细的，还是一般的和近似的?是否存在不止一种相互矛盾的解释?

Authors usually describe the significance of their work toward the end of the Discussion. Studies can have scientific significance, practical applications, or both. A study might suggest a new set of research questions, put forward a new theory, or resolve a long-standing controversy. It might support the effectiveness of a new drug, improve a manufacturing process, or aid in the development of a new technology. Examine carefully any claims of significance in the Discussion. Are they justified by the information presented in the paper? Are the implication direct and immediate, or are they tentative and speculative? Sometimes authors describe future work in the Discussion. This can be a clue to the significance of a study. Important work usually leads to exciting new questions to explore.

作者通常在讨论结束时描述他们工作的重要性。研究可以有科学意义，实际应用，或者两者兼而有之。一项研究可能会提出一系列新的研究问题，提出一个新的理论，或者解决一个长期存在的争议。它可能会支持一种新药的有效性，改善制造过程，或有助于开发一种新技术。仔细检查讨论中任何重要的主张。他们的理由是论文中的信息吗？暗示是直接的和直接的，还是暂时的和推测的？有时作者在讨论中描述未来的工作。这可以作为研究意义的线索。重要的工作通常会激发令人兴奋的新问题去探索。

SECTION 7 EXERCISES

第七节：联系

Using a research article as an example, complete the following exercises:

以一篇研究文章为例，完成以下练习：

1. How do the authors interpret their findings? Which results do they consider to be most important? Do they claim to support or contradict a hypothesis? Do they synthesize their individual findings into a coherent story?

1.作者如何解释他们的发现？他们认为哪些结果最重要？他们声称支持或反驳一个假设吗？他们是否将自己的发现综合成一个连贯的故事？

1. Do the authors address weaknesses of their methods or findings? Do they address possible criticisms?

2.作者是否指出了他们的方法或发现的弱点？他们是否处理了可能的批评？

1. How does your interpretation of the study compare to the authors’?

3.你对这项研究的解释与作者相比如何？

1. Describe how the study connects to previous research in the field. Is it supported by prior Work? Does it contradict any previous conclusions?

4.描述该研究如何与该领域先前的研究相联系。是否有前期工作支持？它是否与先前的结论相矛盾？

1. Do the authors propose an explanation for their findings? Is a plausible mechanism proposed? Is there any evidence to support the proposed mechanism?

5.作者是否对他们的发现提出了解释？是否提出了合理的机制？是否有证据支持拟议的机制？

1. What are the implications of the study on the research field? Does it suggest new work that needs to be done? What are the next steps that need to be accomplished?

6.这项研究对研究领域有何意义？它是否暗示了需要做的新工作？接下来需要完成哪些步骤？

1. What is your overall opinion of the Study?

7.你对这项研究的总体看法是什么？

Section 8: Putting it All Together

第8节：整合

We’ve covered lots of specific aspects about reading research articles. Let's think about the themes that have emerged. Here are 10 tips to guide your reading of the primary literature:

关于阅读研究文章，我们已经讨论了很多具体的方面。让我们想想已经出现的主题。这里有10个窍门来指导你阅读初级文献：

1. Focus On methods and results. Try not to be influenced by the way the study is presented, but rather focus your analysis on the experimental design, techniques, and data.

1.注重方法和结果。尽量不受研究方法的影响，而应将您的分析重点放在实验设计、技术和数据上。

1. Be a skeptic. Ask yourself how strongly the authors’ interpretations and conclusions are supported by the evidence.

2.持怀疑态度。问问自己作者的解释和结论有多有力地得到证据的支持。

1. Be fair. Scientific research is difficult, and scientists operate under many constraints. Don't expect studies to be perfect.

3.公平点。科学研究是困难的，科学家的工作受到许多限制。不要期望学习是完美的。

1. Read nonlinearly. Exploit the format of research articles to quickly access the information you need. Don't feel compelled to read every line start to finish. Skim the paper to understand its overall approach. Refer to previous sections as necessary.

4.非线性阅读。利用研究文章的格式快速访问所需信息。不要强迫自己从头到尾读每一行。略读这篇论文，了解它的整体方法。如有必要，请参阅前面的章节。

1. Consider the big picture. Assess where the study fits into the cycle of science, and how it relates to previous research.

5. 大局观。评估这项研究在科学环节中的位置，以及它与先前研究的关系。

1. Consult other Sources. Writers of research articles assume their audience has basic knowledge of the area. Consult secondary sources to get the needed background.

6.咨询其他来源。研究文章的作者假定他们的读者对这个领域有基本的了解。咨询二级来源以获得所需的背景资料。

7. Take your time. Research articles condense entire studies into a few printed pages. It probably took the authors years to conceive, perform, and publish their work. Be patient and persistent when reading articles.

7.慢慢来。研究论文将整个研究压缩成几页印刷品。作者可能花了数年的时间构思、表演和出版他们的作品。阅读文章要有耐心和毅力。

1. Accept uncertainty. Research articles deal with emerging knowledge and controversial issues. Don’t expect to find absolute answers to every question. Each paper is a step in an ongoing process.

8.接受不确定性。研究文章涉及新出现的知识和有争议的问题。不要指望每个问题都能找到绝对的答案。每一篇论文都是一个持续过程中的一个步骤。

1. Expect to be challenged. If you’re not an expert in an area, there might be aspects of a paper you can’t understand fully. That's OK; you can still learn from those parts of a paper that you can comprehend.

9. 期待挑战。如果你不是某个领域的专家，你可能无法完全理解一篇论文的某些方面。没关系；你仍然可以从你能理解的文章中学习。

1. Relax and enjoy; Perhaps this is the hardest advice to follow, especially when you’re confronted with a complicated paper. But try to approach an article like a puzzle. It's going to take time and effort to make progress, but there's real satisfaction in doing so.

10.放松并享受；也许这是最难遵循的建议，尤其是当你面对复杂的论文时。但是试着像拼图一样接近一篇文章。要取得进步需要时间和精力，但这样做确实令人满意。

Resources for Students and Educators

供学生和教育工作者使用的资源

WEBSITES

网站

Research articles can be found at the following sites:

研究文章可以在以下站点找到：

BioMed Central ([www.biornedcentral.com](http://www.biornedcentral.com)).

Highwire Press ([www.highwire.org](http://www.highwire.org)).

National Center for Biotechnology Information (www.ncbi.nih.gov).

BOOKS

书籍

The following books focus on the scientific method:

以下书籍侧重于科学方法：

Carey, S.S. (2004). A beginner's guide to scientific method. Belmont, CA: Wadsworth/Thomson.

Gauch Jr., H. G. (2003). Scientific method in practice. Cambridge: Cambridge University Press.

Giere, R. N. (1991). Understanding scientific reasoning. Fort Worth: Holt, Rinehart, and Winston.

Kitcher, P. (1993). The advancement of science: science without legend, objectivity without illusions. New York: Oxford University Press.

Kuhn, T. S. (1970). The structure of scientific revolutions. International Encyclopedia of Unified Science, volume 2, number 2. Chicago: Univer ity of Chicago Press.

Popper, K. (1959). The logic of scientific discovery. New York: Harper and Row.

Wilson, E. B. (1952). An introduction to scientific research. New York: McGraw-Hill.

The following books focus on reading and writing:

以下书籍侧重于阅读和写作：

Adler, M. J. & van Doren, C. (1972). How to read a book. New York: Simon and Schuster.

Allay, M. (1996). The craft of scientific writing. New York: Springer.

Day, R. (1998). How to write and publish a scientific paper. Phoenix, AZ: Oryx Press.

Gralf, G., & Birkenstein, C. (2005). They say/l say: The moves that matter in academic writing. New York: W. W. Norton.

McMillan, V. E. (2001). Writing papers in the biological sciences. Boston. MA: Bedford Books.

Pechenik, J. A. (2004). A short guide 10 writing about biology. New York: Pearson/Longman.

The following books focus on experimental design and statistics:

以下书籍侧重于实验设计和统计：

Ambrose. H. W. and K. P. Ambrose. (2002). Handbook of biological investigation. Knoxville, TN: Hunter Textbooks.

Barnard, C. Gilbert, F., & McGregor, P. (1993). Asking questions in biology: design, analysis, and presentation in practical work. New York: Longman Scientific & Technical.

Gould, J. L. & Gould, G. F. (2002). Biostats basics: A student handbook. NewYork: W.H. Freeman and Company.

Heath, D. (1995). An introduction to experimental design and statistics for biology. London: UCL Press.

Quinn, G. P. & Keough, M. J. (2002). Experimental design and data analysis for biologists. New York: Cambridge University Press.

Sokal, R. R. (2005). Biometry. New York: W.H. Freeman and Company.

Zar. J. H. (2006). Biostatistical analysis. Upper Saddle River, NJ: Prentice Hall.

ARTICLES ABOUT READING PAPERS

关于阅读论文的文章

Gillen, C. M. (2006). Criticism and interpretation: Teaching the persuasive aspects of research articles. CBE Life Science Education5, 3438.

Levine, E. (2001). Reading your way to scientific literacy. Journal of College Science Teaching 31, 122 -125.

Muench, S. B. (2000). Choosing primary literature in biology to achieve specific educational goals. Journal of College Science Teaching, 29, 255 260.

Mulnix, A. (2003). Investigations of protein structure and function using the Scientific literature: An assignment for an undergraduate cell physiology course. Cell Biology Education, 2, 248255.

Pall, M. L. (2000). The value of scientific peer-reviewed literature in a general education science course. The American Biology Teacher, 62, 256 258.

Russell, J. S., Martin, L, Curtin, D., Penhale, S. and Trueblood, N. A. (2004). Nonscience majors gain valuable insight studying clinical trials literature: an evidence-based medicine library assignment. Advances in Physiology Education 28, 188 -194.

Smith, G. R. (2001). Guided literature explorations. Journal of College Science Teaching, 30, 465- 469.

Woodhull-McNeal, A. (1989). Teaching introductory science as inquiry. College Teaching, 37,3 -7.

EXAMPLE RESEARCH ARTICLES

研究文章示例

Bricelj. V. M., Connell, L, Konoki, K.. MacQuarie, S. P. Scheuer. T. Catterall. W.A., et al. (2005). Sodium channel mutation leading to Saxitoxin resistance in clams increases risk of PSP Nature, 434: 763-767.

Carrier D. R, Deban, S. M., & Otterstrom, J., (2002). The face that sank the Essex: Potential function of the spermaceti organ in aggression. Journal of Experimental Biology, 205, 1755- 1763.

Fleischmann, R. D., Alland, D., Eisen, J. A., Carpenter, L, White, O., Peterson, J., et al. (2002). Whole genome comparison of Mycobacterium tuberculosis clinical and laboratory strains. Journal of Bacteriology 184:5479 5490.

Pai, R. Tarnawski, A. S., & Tran, T, (2004). Deoxycholic acid activates β-catenin signaling pathway and increases colon cell cancer growth and invasiveness. Molecular Biology of the Cell 15:2156- 2163.

Rabbani, M. A., Maruyama, K., Abe, H., Khan, M. A, Katsura, K., Ito, Y, et al. (2003). Monitoring expression profiles of rice genes under cold, drought, and high- salinity stresses and abscisic acid application using cDNA microarray and RNA gel-blot analyses. Plant Physiology 133:1755- -1767.

Rao, P. K, Kumar, R. M, Farkhondeh, M., Baskerville, S., & Lodish, H. F. (2006). Myogenic factors that regulate expression of muscle-specific microRNAs. PNAS 103:8721-8726.

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