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The mathematics of persuasive communication

by Philip Yaffe (phil.yaffe@yahoo.com)

At first glance, mathematics and persuasive communication—writing and public speaking—would seem to have little in common. After all, mathematics is an objective science, while speaking involves voice quality, inflection, eye contact, personality, body language, and other subjective components. However, under the surface they are very similar. Above anything else, the success of an oral presentation depends on the precision of its structure. Mathematics is all about precision. It is therefore not so odd to think that applying some of the concepts of mathematics to oral presentations could make them substantially more effective. The same is true of writing, even though the "speaker" is not physically present.

As they say in the film industry, three key factors go into making a successful movie: the script, the script, and the script. Likewise, three key factors go into making a successful speech: the structure, the structure, and the structure.

Not convinced? Then let's start with something less radical. I think we can all agree that good speaking is related to good writing. If you can write a good text, then you are well on your way to preparing a good oral presentation. Therefore, if you improve your writing, you will also improve your speaking. To simplify matters, the rest of this article will focus on good writing, because in most cases the same ideas apply directly to good speaking.

Know what you are doing

Many commercial companies do not live up to their potential—and sometimes even go bankrupt—because they fail to correctly define the business they are in. Perfume companies, for example, do not sell fragrant liquids, but rather sell love, romance, seductiveness, self-esteem, etc. Bio-food companies do not sell organic produce, but rather sell honesty, purity, nature, etc. Automobile manufacturers do not sell transportation, but rather sell freedom, adventure, spontaneity, prestige, etc. The fact is, each industry, even each individual product, may have to determine what it is truly all about—and there are thousands of them!

Writers are lucky. There are numerous variations to what we do, but there are really only two fundamental types of writing. It is important to recognize this, because not only are they quite different, in some respects they are exactly opposite. So unless we clearly recognize which type of writing we are doing—and how it differs from the other one—we will almost certainly commit serious errors. What are the two types? And how do they differ?

- *Creative writing* includes texts such as short stories, novels, poems, radio plays, stage plays, television scripts, film scripts, etc. The fundamental purpose of creative writing is to amuse and entertain.
- *Expository writing* includes texts such as memos, reports, proposals, training manuals, newsletters, research papers, etc. The fundamental purpose of expository writing is to instruct and inform.

Essential attitude towards expository writing

Because the objectives of creative and expository writing are so different, you must adopt the appropriate attitude towards the type of writing you are doing before striking a key:

- Creative writing attitude: Everyone wants to read want what you are going to write. After

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Editorial: What's in a word?

Geoff Hart (ghart@videotron.ca, geoffhart@mac.com)

In a previous editorial (*the Exchange* 14(1), February 2007) I wondered "what's in a name?" This musing having now fermented on my mental compost heap long enough to become reasonably good intellectual fertilizer, it seems like a reasonable time to return to those musings and take them in a slightly different direction. Specifically: Like all good technical communicators, scientists use words very precisely, to unequivocally communicate specific concepts. In theory, the goal is to present information objectively, free of all the subjective trappings that so bedevil clear communication. In practice, this approach does indeed go a long way towards achieving at least the appearance of objectivity, but that appearance can be deceiving. Consider, for example, how even a seemingly straightforward word such as *species* can vary in its meaning.

The simplest definition—indeed, the one most of us learn in grade school—is that species comprise groups of organisms that can interbreed successfully; that is, they can produce viable offspring capable of perpetuating the species. This is certainly a useful definition both to laymen and to scientists who study plant breeding because it reminds both groups that sunflowers and watermelons are very different species and cannot produce offspring no matter how many storks might intervene. (Of course, that ignores the wonders of modern genetics technology, which allow the transfer of genes between even such seemingly disparate organisms as fireflies and bean plants. More on that in a moment.) This initial attempt at a definition suggests to us that horses and donkeys are also different species, though here the waters grow a bit murkier: even though they can interbreed and produce offspring (mules), their offspring are sterile and cannot themselves reproduce. So possibly they're different species, at least from the perspective of this definition. Yet no one would declare a man and a woman who cannot produce children together different species simply because they are infertile as a couple. Clearly, this definition of *species* needs further work, whether your purpose is to inform the breeding of new organisms—or only to be able to find your beans should you drop them in a dark kitchen.

If you travel a bit farther along the road of scientific knowledge, you'll inevitably encounter the subject of taxonomy, most famously in the form that classifies organisms into the nested boxes of domains, kingdoms, phyla, classes, orders, families, genera, and species. Classical taxonomy, which Linnaeus originated early in the game of defining species (and indeed, early in the game of modern science), worked primarily on the basis of similarities in physical structure, on the very plausible logic that similar structures within a group of organisms probably had similar underpinnings; a rose is a rose, after all, ex-

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Editor: Geoff Hart (ghart@videotron.ca)
Manager: Kathie Gorski (kgorski@execpc.com)
Webmaster: Cory Koeppen (cjoelk@earthlink.net)

901 North Stuart St., Suite 904
Arlington, Virginia
22203-1822 U.S.A.
Tel.: 703-522-4114
Fax: 703-522-2075
Web: www.stc.org

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all, who doesn't want to be amused and entertained?

- Expository writing attitude: No one wants to read what you are going to write. Most people don't like to be instructed and informed. They probably would much prefer to be doing something else.

The importance of recognizing and adopting the "expository writing attitude" cannot be overstated, because it can dramatically change the very nature of what you are writing. Here are a couple of examples.

A. Corporate image brochure

I was once commissioned to write a corporate image brochure. Two things are certain about these expensive, glossy booklets:

- Almost all companies of any size feel compelled to produce them.
- Virtually no one ever reads them.

Starting from the attitude that no one would want to read what I was about to write, I created a brochure that people not only read. They actually called the company to request additional copies to give to friends, clients and professional colleagues!

B. Stagnating product

On another occasion, I was commissioned to develop an advertising campaign to revitalize a product with stagnating sales. Applying the expository writing attitude, I discovered that three of the product's key benefits were not being properly exploited. Why? The manufacturer felt that everything about their product was important, so for years they had been systematically burying these three key benefits under an avalanche of other information of less interest to potential buyers. The new campaign sharply focused on the key benefits; virtually all other information was moved to the background or eliminated. As a result, sales shot up some 40% in the first year.

"The manufacturer felt that everything about their product was important, so for years they had been systematically burying these three key benefits under an avalanche of other information of less interest to potential buyers."

With some nuances, this self-same expository writing attitude can be—and should be—applied to speaking, as well.

Essential approach to expository writing

Because creative writing and expository writing have essentially different objectives and attitudes, they require essentially different approaches:

- The creative writing approach plays with language to generate pleasure. In other words, use your mastery of the language to amuse and entertain.
- The expository writing approach organizes information to generate interest. Clever use of language will never make dull information interesting; however, you can organize the information to make it interesting. Forget about literary pyrotechnics. Concentrate on content.

We are now going to leave the subject of creative writing, because most of what we write, and say, is expository.

What do we mean by "good writing"?

We are now ready to return to the notion of how mathematics applies to good writing, and by extension to good speaking. When someone reads an expository text or listens to an expository speech, they are likely to judge it as good or not good. You probably do this yourself. But what do you actually mean when you say a text or a speech is "good"? After some struggling, most people will usually settle on two criteria: clear and concise.

Mathematics depends on unambiguous definitions; if you are not clear about the problem, you are unlikely to find the solution. So we are going to examine these criteria in some detail in order to establish objective definitions—and even quasi-mathematical formulae—for testing whether a text or a presentation truly is "good".

A. Clarity. How do you know that a text is clear?

If this sounds like a silly question, try to answer it. You will probably do something like this:

Question: What makes this text clear?
Answer: It is easy to understand.
Question: What makes it easy to understand?
Answer: It is simple.
Question: What do you mean by simple?
Answer: It is clear.

You end up going around in a circle. The text is clear because it is easy to understand... because it is simple... because it is clear. "Clear", "easy to understand", and "simple" are synonyms. Al-

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though synonyms may have nuances, they do not have content, so you are still left to your own subjective appreciation of the meanings. But what you think is clear may not be clear to someone else. This is why we give "clear" an objective definition, almost like a mathematical formula. To achieve clarity—i.e., virtually everyone will agree that it is clear—you must do three things:

1. Emphasize what is of key importance.
2. De-emphasize what is of secondary importance.
3. Eliminate what is of no importance.

In short: CL = EDE

Like all mathematical formulae, this one works only if you know how to apply it, which requires judgment. In this case, you must first decide what is of key importance: that is, what are the key ideas you want your readers to take away from your text? This is not always easy to do. It is far simpler to say that everything is of key importance, so you put in everything you have. But there is a dictum that warns: "If everything is important, then nothing is." In other words, unless you first do the work of defining what you really want your readers to know, they won't do it for you. They will get lost in your text and either give up or come out the other end not knowing what it is they have read.

"... you must first decide what is of key importance: that is, what are the key ideas you want your readers to take away from your text? This is not always easy to do. It is far simpler to say that everything is of key importance..."

What about the second element of the formula, de-emphasizing what is of secondary importance? That sounds easy enough. You don't want key information and ideas to get lost in details. If you clearly emphasize what is of key importance—via headlines, italics, underlining, or simply how you organize the information—then whatever is left over is automatically de-emphasized.

Now the only thing left to do is eliminate what is of no importance. But how do you distinguish between what is of secondary importance and what is of no importance? Once again, this requires judgment, which is helped by the following very important test. Secondary importance is anything that supports or elaborates on one or more of the key ideas. If you judge that a piece of information does, in fact, support or elaborate on one or more key ideas, then you keep it. If not, you eliminate it.

B. Conciseness: How do you know that a text is concise?

If this once again sounds like a silly question, let's try to answer it.

Question: What makes this text concise?
Answer: It is short.
Question: What do you mean by short?
Answer: It doesn't have too many words.
Question: How do you know it doesn't have too many words?
Answer: Because it is concise.

So once again we end up going around in a circle. The text is concise because it is short... because it doesn't have too many words... because it is concise. Once again, we have almost a mathematical formula to solve the problem. To achieve conciseness, your text should meet two criteria. It must be as:

1. Long as necessary
2. Short as possible

In short: CO = LS

If you have fulfilled the criteria of "clarity" correctly, you already understand "as long as necessary". It means covering all the ideas of key importance that you have identified, and all the ideas of secondary importance needed to support or elaborate on these key ideas. Note that nothing is said here about the number of words, because it is irrelevant. If it takes 500 words to be "as long as necessary", then 500 words must be used. If it takes 1500 words, then this is all right too. The important point is that everything that should be in the text is fully there.

Then what is meant by "as short as possible"? Once again, this has nothing do to with the number of words. It is useless to say at the beginning, "I must not write more than 300 words on this subject", because 500 words may be the minimum necessary. "As short as possible" means staying as close as you can to the minimum—but not because people prefer short texts; in the abstract the terms "long" and "short" have no meaning. The important point is that all words beyond the minimum tend to reduce clarity.

We should not be rigid about this. If being "as long as necessary" can be done in 500 words and you use 520, this is probably a question of in-

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dividual style. It does no harm. However, if you use 650 words, it is almost certain that the text will not be completely clear—and that the reader will become confused, bored, or lost. In summary, conciseness means saying what needs to be said in the minimum amount of words. Conciseness:

- Aids clarity by ensuring the best structuring of information.
- Holds reader interest by providing maximum information in minimum time.

C. Density

Density is a less familiar concept than clarity and conciseness, but is equally important. In mathematical form, density consists of:

1. Precise information
2. Logically linked

In short: D = PL

"Reader confidence is important in any kind of text, but it is crucial in argumentation. If you are trying to win a point, the last thing you want is the reader to challenge your data..."

Importance of precise information

Suppose you enter a room where there are two other people and say, "It's very hot today." One of those people comes from Helsinki; in his mind he interprets "hot" to mean about 23°C. The other one comes from Khartoum; to him "hot" means 45°C. You are off to a rather bad start, because each one has a totally different idea of what you want to say. But suppose you say, "It's very hot today; the temperature is 28°C." Now there is no room for confusion. They both know quite clearly that it is 28°C outside and that you consider this to be very hot.

Using as much precise information as possible in a text gives the writer two significant advantages:

- Mind control: Let's not be embarrassed by the term "mind control", because this is precisely what the good expository writer wants to achieve. Good writers want the reader's mind to go only where they direct it and nowhere else. Because they can be interpreted in unknown ways, ambiguous terms (so-called "weasel words") such as "hot", "cold", "big", "small", "good", and "bad" allow the reader's mind to escape from the writer's control. An occasional lapse is not critical; however, too many weasel words in a text will inevitably lead to reader confusion, boredom, and disinterest.
- Reader confidence: Using precise information generates confidence, because it tells the reader that the writer really knows what he is talking about. Reader confidence is important in any kind of text, but it is crucial in argumentation. If you are trying to win a point, the last thing you want is the reader to challenge your data, but this is the first reaction imprecise writing will provoke. Precise writing ensures that the discussion will be about the implications of the information—that is, what conclusions should be drawn, not whether the whole thing needs to go back for further investigation.

Importance of logical linking

Precise data (facts) by themselves are insufficient. To be meaningful, data must be organized to create information (i.e., to help the reader understand). There are two important tests to apply when converting data into information:

- Relevance: Is a particular piece of data really needed? As we have seen, unnecessary data damages understanding and ultimately undermines confidence. Therefore, any data that do not either aid understanding or promote confidence should be eliminated.
- Misconceptions: The logical link between data must be made explicit to prevent the reader from coming to false conclusions. For example, a specific situation may be confused for a general one, credit for an achievement may seem to belong to only one person when it really belongs to a group, or a company policy may appear to apply only in very specific circumstances rather than in all circumstances.

To ensure that a logical link is clear, place the two pieces of data as close to each other as possible, preferably right next to each other. When data are widely separated, their logical relationship is masked and the reader is unlikely to make the connection.

What do you want? What do your readers want?

I frequently ask non-professional writers what they are thinking when they sit down at the

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keyboard to compose their text. The answer is usually something like, "How do I want to present my material?" "What tone and style should I use?" "In what order should I put my key ideas?" And so on. However, if you start with the correct attitude, namely that no one wants to read what you write, your first task is none of these. Ahead of anything else, you must find reasons why people should spend their time to read what you write.

In general, you cannot force people to read what they don't want to, even if they are being paid to do so. For example, if you produce a report defining opportunities for increased sales and profits and it is not well written, even people who must read it as part of their job are unlikely to give it their full attention. On the other hand, if they immediately see their own self-interest in reading what you have written, they will do so gladly and with full attention. In fact, you probably couldn't stop them from reading it! There are various methods to generate such a strong desire to read, depending on the type of readers and the type of information. Whatever the most appropriate device, the crucial thing is to recognize the imperative need to use it. Until this need is met, nothing else is of any importance.

Reading is an isolated activity and listening to a speech is a social one. Therefore, although the underlying principles of good writing and good speaking are constant, the way they are applied can be markedly different. *In the 'I' of the Storm: the Simple Secrets of Writing & Speaking (Almost) like a Professional*, my recently published book, clearly explains these differences. It also offers several appendices with cogent examples and pertinent, effective exercises. True to my credo, my book is as long as necessary and as short as possible. In fact, it's only 84 pages long! **Ω**

Philip Yaffe (phil.yaffe@yahoo.com) is a former reporter and feature writer with The Wall Street Journal *and a marketing communication consultant. He currently teaches a course in good writing and good public speaking in Brussels, Belgium.* In the 'I' of the Storm *is available either in a print version or an electronic version from Story Publishers in Ghent, Belgium (www.Storypublishers.be) and from Amazon (www.amazon.com).*

Rechartering update

by Kathie Gorski (kgorski@execpc.com)

Seven SciCom SIG members responded to last month's request for volunteers to work on the SIG's rechartering effort. They include practicing scientists, teachers, industry writers and managers, and independent consultants. They live (mostly) in the US and Europe, and have been members of STC for anywhere from several years to several decades.

The group's inaugural meeting took place last month via conference call. Participants discussed the purpose of rechartering and agreed that their main goal would be to help our SIG leadership determine what it is that the SIG is doing well, what it can improve, and how it can provide more member value. To that end, the team will develop a quick questionnaire, which will go out to all SIG members via email, asking for feedback on those topics and on specific communication tools such as the SIG's newsletter and website. The team will use feedback from the questionnaire to drive the focus of the rechartering effort, the ultimate end-result of which could be a reinvigorated SciCom SIG. **Ω**

Book review: Exploring Medical Language: a Student-directed Approach

LaFleur Brooks, M. 2005. 6th ed. Elsevier Mosby, St. Louis, MO. [ISBN 0-323-02805-5. 768 p., including index. US$52.95 (softcover).]
Previously published in *Technical Communication* 53(3):370–371. August 2006.

by Nicole St. Germaine-Madison (nstgermainemadis@angelo.edu)

Exploring Medical Language: a Student-directed Approach is intended for the student seeking an associate's or bachelor's degree in the medical professions. The intent of the text is to introduce medical terminology and provide associative strategies for learning what the parts of the words (prefixes, roots, and suffixes) mean, therefore enabling students to make sense out of any medical term, new or familiar, that they might encounter. Technical communication practitioners in the

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medical fields would also find this text helpful either for gaining an overview of the basics of medical terminology or as a desk reference.

New to the 6th edition are several beneficial additions. Color photos add detail to the pathology that is under discussion and make the pages more visually stimulating. The new case studies are formatted to look and feel like actual medical reports, thus aiding the student's familiarity with the genres that they will use on the job (or will add the element of familiarity for the practitioner using this book for a reference).

Exploring Medical Language has several notable strengths as a textbook. First, the support for the book is outstanding. A student CD contains an extensive catalog of exercises in a variety of areas for the students (or practitioners) to test their understanding of the terms. These exercises cover even the pronunciation and spelling of the terms, two areas that are usually overlooked in text packages of this type. The text also includes 480 flashcards containing "a word part, combining form, suffix, or prefix on one side and the definition of the word part on the other side" (ix). Last, the book comes with PIN-code access to Mosby's Medical Terminology Online, a resource with even more visual aids and exercises to reinforce the lessons.

Exploring Medical Language is not without its problems, however. The main drawback to the text is a lack of coherence within the chapters. The pages, while visually interesting, can be confusing to read. The number of colored sections, callouts, and boxes creates a visual jumble that is difficult to decipher. Further, the organization of the elements within a chapter can be confusing as well. Concepts are introduced, then guidelines about the concept are presented, then additional information about the concept is presented, and last, some exercises about the concept are presented (in addition to more exercises at the end of the chapter). This pattern repeats throughout each chapter to include as many as five individual concepts.

This constant skipping from task to task in a relatively short chapter makes it difficult to focus on the goal of the chapter as a whole. Instead, one is left with the sense of having learned a few unrelated areas. This pattern of organization does not allow students or new practitioners to pull the information together into a cohesive whole, which is unfortunate because the text generally does an excellent job with providing ways in which to connect the concept to the related pathology.

Fortunately, the benefits outweigh the drawbacks. Overall, the goal of the book ("to ensure your mastery of the language of medicine"; p. vii) is achieved. Aside from the visual clutter, the presentation of the subject matter is very professional and attractive. The exercises provided both within the textbook and the support elements (the CD, flashcards, and Mosby's Medical Terminology Online) focus on more than memorization and enhance not only recall of the definitions of the terms and word parts, but also help readers to connect the terms and parts with the pathology being referred to.

I would recommend this book as a main text in an undergraduate or associate's level medical terminology class, or for technical communication practitioners who would like to either gain a basic mastery of medical terminology or have a comprehensive desk reference. **Ω**

Nicole St. Germaine-Madison (nstgermainemadis@angelo.edu) is a senior member of STC and head of the Professional Writing Program at Angelo State University. Her research interests include technical communication for a Mexican-American audience and technical communication in the health fields.

"What distinguishes us as a species is that we live a life of the brain. We survive by thinking about things. We owe it to our children to prepare them to think about things in as many different ways as possible. One of those ways that is arguably more different than any other—because it's the most difficult—is mathematical thinking. Do you ever need to solve a quadratic equation in your everyday life? I doubt it. I never have. But I don't doubt that having learned how to do it has helped me become a better thinker."
—Keith Devlin, Stanford University

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"It's self-evident that races exist. No one is saying that features are not biologically captured [by race], but that's not all there is. There's much more biology that isn't being captured. What we see is only a small part of our biology."
—Georgia Dunston, geneticist

Book review: How to prepare defense-related scientific and technical reports: guidance for government, academia, and industry

Rice, W. 2007. John Wiley and Sons, Inc., Hoboken, New Jersey. [ISBN-13:978-0471-72509-1, 342 p., including index. US $59.95 (hardcover)]

by Andrea Sutton (andreajsutton@gmail.com)

With over 20 years of governmental technical writing experience, Walter Rice has compiled his extensive knowledge of scientific technical report strategies and governmental guidelines into one solid text. *How to Prepare Defense-Related Scientific and Technical Reports* contains an all-inclusive set of guidelines for report preparation, and there is no need to question for whom the book is written—the author states in the preface that this guide is primarily for those in the Department of Defense community but also for other government agencies that require scientific reports. This book was published to emphasize the need for standardization of government documents and provides "clarification on how to prepare defense-related scientific and technical reports, and provide instructions on how to prepare most classified scientific and technical reports" (xxv).

"The book contains an almost step-by-step guide to the front matter, body text, and back matter of a scientific report, covering every topic from cover page to heading levels to footnote symbols and their use."

This book is comprehensive; it describes the background for the creation, distribution, and preservation of scientific and technical information. Rice provides a history of the technical report, a background on his approach to this subject matter, and his background in providing technical expertise while serving on a committee on scientific and technical reports for the American National Standards Institute (ANSI) and the National Information Standards Organization (NISO).

The chapter contents give an excellent combination on ANSI/NISO technical report guidelines, beginning with formatting: report number formats, preparation of abstracts, and details of publishing requirements. I was also surprised at the amount of detail written about author and non-author responsibilities, report review and distribution, and marking requirements for both classified and non-classified documents.

After an overview of the report and its contents, the book contains an almost step-by-step guide to the front matter, body text, and back matter of a scientific report, covering every topic from cover page to heading levels to footnote symbols and their use. The proper use of font size for headings is not discussed; however, instead of typical changes in font size for headings, these reports use "typographical progression" headings—that is, bold and italic are progressively applied to headlines to distinguish new heading levels versus the standard decimal numbering format found in technical reports.

Much attention was also given to the organization and design of reports, providing not only contextual guidelines for report publication, but also an ample amount of graphic examples for tables, columns, margins, image areas, placement of warning notices, emblems, and other graphical inserts contained in the report. There are detailed descriptions and accompanying illustrations for the orientation of tables and figures, suggestions on portrait or landscape orientation, as well as when to use 8.5"×11" facing pages vs. 17"×11" foldouts. These figures and tables are great for future reference. The formatting illustrations in the text provide helpful guidelines by showing incorrect formatting techniques and correct formatting techniques that reinforce what was stated in the text. If, after reading this book, you want further information, the appendices provide background information on the Defense Technical Information Center, a commentary on tone and style, and a full list of standard government abbreviations, including abbreviations of chemical names, aircraft and spacecraft names, and units of measurement.

And just when I was sure this book only detailed the issues of print publication, Mr. Rice provides a section on the role of the editor in online markups and explains that the print versions are still favored because they provide an easy-reading alternative versus the eye strain of online reading.

How to Prepare Defense-Related Scientific and Technical Reports is a combination how-to book and style guide with information that could very well be applied to any industry. Although the amount of detail is tremendous, this is one of the first books I have read that really provides step-by-step guidance for a professional scientific report with no need to pick and choose portions out of each chapter. The chapter sequence is well-designed and walks you through each aspect of the technical report. Walter Rice has covered everything from cover page to appendix and then gives you more. He provides everything you need to

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write a successful scientific report—all in one book! If you are planning on writing a scientific technical report, I suggest you read this book first. After absorbing the guidelines provided in this book, all you will need are the words. **Ω**

Andrea Sutton (andreajsutton@gmail.com) is a chemist and technical writer for the pharmaceutical industry and a member of STC's Atlanta Chapter. She received her B.S. in Chemistry from Valdosta State University in Valdosta, Georgia, and an M.S. in Information Design and Communication from Southern Polytechnic State University in Marietta, Georgia.

"One variety of mankind does so sensibly pass into the other, that you cannot mark out the limits between them".
—Johann Blumenbach, 1795

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"A curious aspect of the theory of evolution is that everybody thinks he understands it."—Jacques Monod

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"You have to look at a slow sequence of events for a long time before you realize what you're seeing… [But] everybody has moved on to genetics, which involves slicing and dicing organisms. Simply watching them under the microscope is out of fashion."—Elisha Moses, biophysicist, quoted in the January 2002 issue of *Discover*

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"It is of interest to note that while some dolphins are reported to have learned English—up to fifty words used in correct context—no human being has been reported to have learned dolphinese."
—Carl Sagan, astronomer and writer (1934–1996)

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"Where the telescope ends, the microscope begins. Which of the two has the grander view?"—Victor Hugo

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"The most wonderful mystery of life may well be the means by which it has created so much diversity from so little physical matter."—E.O. Wilson

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"Science (done right) questions received wisdom and re-examines common assumptions. It subjects opinions to testing against observed facts, and in the process, it makes the familiar seem strange."—Robert Killheffer

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"... a theorist could explain the outcome of any experiment, as long as he knew it in advance."
—Greg Benford, *Anomalies*

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"Irrationally held truths may be more harmful than reasoned errors."—Thomas H. Huxley

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cept when it's a Rose. Unfortunately, Linneaus new nothing of genetics and evolution, and thus did not know that structural differences might mask closely related organisms nor that structural similarities might mask widely unrelated organisms. The characteristics used by Linnaean taxonomists to classify organisms gradually became increasingly obscure, as can be seen in the debates among paleontologists over the degree to which subtle differences in bone morphology could define whether two bones from our most ancient ancestors belong to the same species, and in the related debates over the consequences for human evolution. Since no one can test whether these differences are truly meaningful (the organisms from which the bones were drawn being long extinct), clearly more information is needed.

What about genetics? *Now* we seem to be on more promising ground. It's clear that the complete set of genes possessed by a group of related organisms (their genome) provides an unmistakable clue to the identity of a species. Organisms that diverged long ago will be more genetically distinct than organisms that diverged more recently, and—returning for a moment to our interbreeding definition of species—organisms whose genes are sufficiently different will be unable to breed because the mixture of genes won't work successfully together. Obscure though genes are, at least in comparison with gross morphological differences such as having wings or fins rather than arms that a Linnaean taxonomist might focus on, this approach has the additional merit of appealing to those of us who still feel that the ability of organisms to breed is the touchstone for whether two organisms belong to the same species; as I noted in my previous editorial, sometimes the public consensus on the meaning of a name can be as important as the scientific reason for choosing that name. Unfortunately, genetics alone can mislead us. A chimpanzee and a human being are commonly said to be 99% identical in terms of our respective genomes, yet nobody would consider us to be the same species. (Even if you don't notice the other obvious differences, the chimp's extra pair of chromosomes is a dead giveaway that things aren't so simple.) As a result, that number is deceiving. Whether you raise that chimpanzee from the moment of birth in its

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original jungle home, or in a modern suburban home, a chimpanzee it will remain—not a human, even if raised with the best intentions and the most sincere efforts to turn our hairy Eliza Doolittle into a proper Englishwoman.

Clearly, genetics alone aren't sufficient to solve the species question without considerable caution: if 99% of the chimp's genes are shared with humans, we have only a 1% chance of choosing the few key genes that distinguish between us if we don't know what we're looking for. And knowing what to look for might not be so easy as it seems. Though some characteristics of an organism such as human blood types are clearly determined by one or a few genes, most complex traits are determined by a moderate to large number of genes that not only interact with each other, but also interact with their environment. Picking a chimp out of a crowd is child's play. But genetically identical organisms can differ radically in appearance under the right circumstances. Rooted cuttings from the same individual plant, for example, may have entirely different phenotypes (e.g., appearances) if they are grown in sufficiently different environments. Worse yet, modern genetic engineering allows us to promiscuously swap genes between organisms located about as far apart on the evolutionary tree as we can imagine. In 100 or 1000 years, will we be able to easily define which species these chimeric organisms truly belong to?

Most egregiously, cultural factors come into play as well. Should one wish to set aside a specific subgroup of humanity for nefarious purposes, it would clearly be useful if you could define that group as a different species. But if the two resulting groups have compatible reproductive organs and are capable of interbreeding, they're clearly the same species. And if they share more of their genomes than chimps and humans—enough so that all the chromosomes match up precisely—they're also clearly the same species. Thus, we must invent a new word that accomplishes the same goals as *species* without failing the test of allowing us to discriminate. The word that solves this problem is *race*, and its definition is every bit as subjective as the most demanding discriminator might wish, since the goal of choosing this word is to seek until we find one or more criteria, no matter how absurd, that allow us to define the other group as different.

This last example sums up the previous examples by revealing how clearly a word definition can fail the test of objectivity: in each case, the seemingly objective word choice is *objective only within a specific context*. For the amateur and professional naturalist alike, the simple Linnaean species taxonomy is all we need to identify that fascinating plant we just touched so we can figure out how to treat the resulting rash. For both amateur and professional plant breeders, knowing that sunflowers and watermelons are different species helps suppress the temptation to grow 6-foot-tall plants whose dangling watermelons relentlessly track the daily course of the sun. For professional gene twiddlers (thankfully, there are as yet few amateurs), being able to define a species based on its genotype allows them to carefully control their studies of the functions of individual genes and how those functions differ among species.

From our perspective as scientific communicators, that's the more useful and interesting insight: not that we humans are inherently subjective beings, but rather that we use words to accomplish specific goals within specific contexts. Understanding that subtle point is what lets us choose the best word for the job. It also (as in my example of *species*) helps us to recognize that words may acquire different connotations in different contexts, and, recognizing those differences, helps us to provide the additional words required to warn readers not to apply the wrong context when they attempt to understand what we're trying to say. **Ω**

"When science tries to resolve its conflicts by adding and subtacting dimensions to the universe like houses on a Monopoly board, we need to look at our dogmas and recognize that the cracks in the system are just the points that let the light shine more directly on the mystery of life."
—Robert Lanza, *A New Theory of the Universe*

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"When people thought the earth was flat, they were wrong. When people thought the earth was spherical, they were wrong. But if you think that thinking the earth is spherical is just as wrong as thinking the earth is flat, then your view is wronger than both of them put together."
—Isaac Asimov, *The Relativity of Wrong*

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Scientific Communication community

STC and our community run an e-mail discussion group that provides a quiet, friendly place to turn for help if you've got any questions concerning scientific communication. To join, point your Web browser to:

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There's no cost to join, and you can expect a very low volume of mail. Of course, the more people who join, the more traffic there'll be, so please join. It's a great way to make the community work for you.

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