Three disclaimers:

• I am not a scientist—I’m a science writer and technical editor. The author trumps the editor every time. (But you really should listen to us; we have your best interests at heart. We really do.)

• All of my experience has been in nuclear engineering and physics. I think the ideas I’m going to share with you today are applicable to all science and engineering communications, but your mileage may differ.

• The opinions expressed are solely those of the speaker and are not necessarily shared by the University of Illinois. (But they should be.)
Because we think in words, the act of expressing observation in language—of distilling amorphous thoughts into words—is a powerful tool for clarifying your thinking.

Translating your thoughts into words so that you can communicate them to someone else forces you
   to question your assumptions.
   to look for holes.
   to fill in gaps in your thinking.

“The act of composition disciplines the mind; writing is one way to go about thinking, and the practice and habit of writing not only drain the mind, but supply it too.” Strunk and White, The Elements of Style, 3rd ed., p. 70.

“It’s also through writing that we learn to articulate our thoughts clearly; our critical thinking is strengthened and clarified by our expression of it in writing.” J.L. Craig, “Writing strategies for graduate students,” Proc. ASEE Ann. Conf. & Exposition (Nashville, TN, ASEE, 2005).

Antoine Marie Jean-Baptiste Roger, comte de Saint Exupéry, Mort pour la France, was a French aristocrat, writer, poet, and pioneering aviator. He became a laureate of several of France’s highest literary awards and also won the U.S. National Book Award. He is best remembered for his novella The Little Prince (Le Petit Prince) and for his lyrical aviation writings, including Wind, Sand and Stars and Night Flight.
Will Strunk put it another way:
“Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts.”


In 2011, *Time* magazine listed *The Elements of Style* as “one of the 100 best and most influential books written in English since 1923.”

Every person who calls himself or herself a writer should have a copy of Strunk & White within arms-reach.—*cme*

*No promotional consideration was provided by Allyn & Bacon for this heartfelt endorsement.*
Effective editing incorporates four distinct elements

- Clarifying the selection and presentation of ideas, tailored to the audience
- Organizing the narrative logically (refer to last week’s lecture)
- Using language precisely and concisely
- Correcting “mechanical” errors that detract from a professional presentation
Think of the process as zooming in on the manuscript.

In this talk, I’m going to concentrate on Step 2, because that’s where I think I can help you the most.

I have learned that you can talk and talk and talk to physicists, but if you really want to get their attention, show them an equation. Hence the Elliott editing equations given above.

In Eq. 1, $t$ is the time it actually takes to edit a manuscript, $h$ is the number of hours you think any idiot should be able to do it in, and $\varepsilon$ is not necessarily trivial.

Equation 2 is the expression for the time it takes to edit a paper that has multiple authors, where $t$ is the time it actually takes, $h$ is the number of hours you think it should take, $a$ is the number of authors, and $\varepsilon$ is not necessarily trivial.
The first pass is from the macroscopic (section) level—look at the science.

- Are the main points clearly identifiable and given appropriate emphasis?
- Do figures and tables support and enhance the main points?
- Is the narrative coherent—is there a clearly defined progression from background to hypothesis to method to results to conclusions?

**TIP:** Cut and paste the first sentence of each paragraph into a new document. Read it aloud. Does it adequately tell your story? Are there gaps or omissions?

See http://people.physics.illinois.edu/Celia/Lectures/Paragraphs.pdf for tips on how to build effective paragraphs to incorporate an organic, logical structure in your writing.

- Have you supplied sufficient background so that the reader can understand the significance of your work? Have you provided appropriate context through adequate referencing of prior work?
- Have you made your case? Have you justified your assumptions, anticipated reader questions and objections, and supported your arguments?
- Is it clear what you have contributed?
Scientists and engineers tend to be highly skeptical about “miracles.”

Provide transitional statements to tie ideas together.

State assumptions and inferences explicitly and provide supporting detail.

Add authority to your arguments by citing previous work.

Arrange your narrative in a logical structure.
Organize the ms. so that the reader can grasp the main points immediately

Provide a descriptive, memorable title
Include an effective abstract (scientific paper) or executive summary (report) and key words
Preview important points in subheadings
Use graphical highlighting (bold, italic, color) to make your main points pop off the page
Use figures to illustrate and emphasize key concepts
Summarize important points at the end of each section

Tip: remember how scientists read papers

Scientists don’t read papers by starting with the first word of the title and reading all the way to the last word of the references. Most scan a list of titles first and pick out the most likely looking paper. Then they read the abstract, leaf through the paper, read the section headings and look at the figures and captions, skim the conclusions, and then go back and read the whole paper if they’ve decided it’s worth their time.

For some tips on how to write effective titles, see http://people.physics.illinois.edu/Celia/EffectiveTitles.pdf.

For some tips on how to write effective abstracts, see http://people.physics.illinois.edu/Celia/Abstracts.pdf.
Use descriptive headings to guide the reader through the text

“New Mechanisms for Regulating Bone Formation”¹

Section headings:
- Mutations Help Pinpoint Function
- Narrowing Down the Possibilities
- Building Better Bones

Running head: Regulating Bone Growth

Key words: evolutionarily conserved region (ECR),
gene regulation, genome, knockout mice, microscale
computed tomography, osteoblast, osteoclast, osteocyte,
osteoporosis, sclerosteosis, sclerostin (Sost), Van
Buchem’s disease, Wnt signaling


If the journal allows it, replace the generic “Introduction,” “Methods,” “Results,” “Discussion,” “Conclusions” section headings with content-rich, meaningful, memorable phrases that will capture the reader’s attention and provide sign posts to guide him or her through the manuscript.
Provide logical transitions
One section ends with:
“... Improved sensitivity is important because amplifiers and signal processors are nonlinear and thus can mix signals that lie outside the desired band; the mixing generates signals with frequencies that appear as in-band noise.”

Begin the next section with:
“To achieve the improved filter performance, high-quality epitaxial films of YBCO have been...”

The logical connection between the two sections is made clear by repeating the idea of improving performance.

If you’ve following my outlining and paragraph-building advice (http://people.physics.illinois.edu/Celia/SciWriter_Advice.pdf), you’ll already have an organically organized, logical narrative line. Reinforce that underlying structure by using transitional statements to tie paragraphs and sections together.
Include summary statements

“Testing the physics of nuclear isomers”

Problem statement (first page):
“Research in the late 1990s indicated x rays could be used to trigger the release of energy from $^{178}$Hf ... Some estimates suggested that, with accelerated decay, 1 g of 100-percent isomeric $^{178}$Hf could release more energy than the detonation of 200 kg of TNT.”

Summary statement (last page):
“These findings can allay DOE’s concern about potential applications of the purported isomer energy source. X-ray induced decay of the Hf isomer does not present a new concern for national security. It also is not a viable alternative as a stand-alone energy source.”


Provide summary statements at the end of each major section of the paper.

The old speaker’s rule is “Tell them what you’re going to tell them. Tell them. Tell them what you told them.” That advice is just as valid for paper and reports. Take if from a mother—telling somebody something important three times is not overkill.
Next, zoom in to the **mesoscopic** (section) level—look at the **words**.

- Is the language clear and unambiguous?
- Have you defined all acronyms and technical jargon that may be unfamiliar to your audience?
- Have you used the simplest word to unambiguously convey your meaning?
Semantics and syntax control clear communication

“Semantics” is the meaning of words; you must have a vocabulary adequate to describe things precisely

The difference between the right word and the almost-right word is the difference between lightning and lightning bug.
—Mark Twain

But don’t rely on jargon!

Semantics—the indirect relation between words and meaning; note that words have different connotations in different contexts; e.g. “displacement”

• to a physicist—the effect that the wavelength at which a black body radiates the most energy is inversely proportional to its absolute temperature
• to a mechanical engineer—the volume moved by the stroke of a piston
• to a seismologist—a geological fault
• to a marine engineer—the weight of the water displaced by a vessel floating in it
• to a pharmacist—percolation
• to a botanist—abnormality in the position or form of a leaf or organ
• to a psychologist—a defense mechanism in which an emotion is transferred to another, more acceptable object
Subway trains in New York are superconducting?

One way to avoid sloppy syntax is to write shorter sentences. We’ll see how and why in a minute...
Avoid “abstractitis”

“writing that is so abstruse that even the writer does not know what he or she is trying to say” —Sir Ernest Gowers, GCB

1. **Clarify** — replace jargon with accessible terminology; use simple subjects and direct action verbs; de-convolute syntax

2. **Quantify** — replace wimpy, qualitative adjectives with quantitative descriptors

3. **Objectify** — give concrete examples; use analogies

As defined by Ernest Gowers and quoted by Bryan Garner in Garner’s Modern American Usage, abstractitis is writing that is so abstruse that even the writer does not know what he or she is trying to say. Here’s a description of the phenomenon:

“The words ...dance before my eyes in a meaningless procession: cross-reference to cross-reference, exception upon exception—couched in abstract terms that offer no handle to seize hold of—leave in my mind only a confused sense of some vitally important, but successfully concealed, purport, which it is my duty to extract, but which is within my power, if at all, only after the most inordinate expenditure of time.” (Yale L.J. 167, 169 [1947]).

While Gowers in this case was talking about the U.S. Internal Revenue Code, he could easily have been describing many physics papers.

Gowers’ use of a 68-word sentence is a rant for another day.
We’ll look at how to apply each of these editing techniques next.
Write shorter sentences—less than 25 words.

Avoid long strings of nouns used as adjectives—“mean field anisotropic superconducting reverse bias toroid magnet” (or MASRBTM, to its fans)

Follow the “three preposition” rule.* If you have a sentence that contains more than three prepositions, rewrite it before it wanders off to die.

Writing shorter paragraphs will also help your reader follow the logic of your narrative. For more information on how to write strong paragraphs, see http://people.physics.illinois.edu/Celia/Lectures/Paragraphs.pdf.

*With thanks to Stephanie Teich-McGoldrick, who first introduced me to the three-preposition rule.
What’s wrong with this sentence?

“The development of the theory of convection began some 85 years ago with Lord Rayleigh’s analysis of instability in fluids heated from below, but it was not easy for geoscientists to accept that a mechanism applicable to a fluid like water could also be relevant to understanding the behavior of the solid mantle composed of silicates.”

It’s impossible to understand the meaning of this long, convoluted sentence on the first reading. Even if you’re a native English speaker.

Even if you’re a geophysicist.
One of the easiest ways to improve your writing is to write short (<25 words) declarative sentences using active verbs. If you routinely write sentences containing more than 25 words, you likely have long strings of prepositional phrases, weak verbs, misplaced modifiers, and indefinite pronoun references—all leading to difficulty in interpreting your meaning.

Refer to Ms. P on “like,” which is used incorrectly in the example, but that’s a rant for another day. (q.v. http://people.physics.illinois.edu/Celia/MsP/Like.pdf)

*More on the three-preposition rule (3PR) next semester—stay tuned!
Here’s how to fix it:

“Convection theory began some 85 years ago, with Lord Rayleigh’s analysis of instabilities in fluids heated from below. While convection clearly explained the behavior of fluids, geoscientists were reluctant to apply the theory to movement in the Earth’s solid silicate mantle.”

Two sentences of ≈20 words each
Subjects come first
Verbs are verbs
Concise and direct
Keep verbs close to their nouns

Several schemes ranging from minimal computational cost and poor accuracy to high computational cost and high accuracy can be employed.

*Several schemes can be employed, ranging from minimal computational cost and poor accuracy to high computational cost and great accuracy.*

A program to be used in conjunction with a PC data acquisition card was written.

*A program was written for use with a PC data acquisition card.*
Recast *negative expressions*—
a positive is easier to understand
and is usually more concise

*Although some data supported the hypothesis, it could not be concluded that output scaled linearly with current.*

Data were inconclusive to demonstrate linear scaling of output with current.

*Arcing under high-current operation could not be avoided without the use of the insulated feedthrough.*

The insulated feedthrough prevented arcing, even during high-current operation.
Avoid beginning sentences with “There are...”—use the passive voice and plunge right in

“There are several methods to produce thin metal substrates—hot stamping, cold rolling, and cleaving.”

“Thin metal substrates may be produced by several methods—hot stamping, cold rolling, and cleaving.”

This rewrite has the added advantage of putting the important part of the sentence (“thin metal substrates”) first and the examples directly after “methods,” where they belong.

Train yourself to spot “There is...” and “There are...” sentences and rewrite them in the passive voice, which puts the important point first in the sentence (“front loads”).
Make sure *indefinite pronouns* refer to the correct antecedent

Non-commutative geometry is obtained when the latter equation fails and is replaced by another equation, as in the case of the quantum Hall system. The interpretation of this effect in superstrings is startling, however, because *it* is a fundamental theory of spacetime, and *it* means that we cannot think of spacetime in terms of ordinary smooth geometry, as in general relativity.

*or any antecedent...*
Avoid the big A’s—amphibologies and anthropomorphism

Beware of words with multiple meanings
A sintered mixture for the experimental heating rod was prepared from martensitic steel and 5% nickel. *This element* proved to be unsatisfactory.
A subtle but important *point* about the series of *points* generated is that they are not statistically independent.

Don’t give human traits to inanimate objects
The substrate *tells* the YBCO how to align during growth.
The dial *needs* to be set at …
Be sure to use the right word
Alternate or alternative?
Ability, capacity, capability?
Affect or effect?
Principle or principal?
Optimal or optimum?
Biannual or biennial?
Compliment or complement?

Ms. Particular’s Micro-Lectures on Style and Usage (http://people.physics.illinois.edu/Celia/MsP/MsParticular.htm)
Eliminate commonly abused *FLWs*

“only”

The linear relationship in the plots at T ≥ 1340 K only agreed with experimental data when t ≤ 10 ns.

“with”

We show that solitons undergo a strong blueshift in fibers with a dispersion landscape that varies along the direction of propagation.

“etc.”

It is well known that localized magnetic moments and the couplings between them are two indispensable factors to induce long-range spin ordering in solids, exhibiting ferromagnetism (FM), antiferromagnetism (AFM), ferrimagnetism, etc.

*http://people.physics.illinois.edu/Celia/MsP/FLWs.pdf*
No more naked “this”es—just don’t

In some pellet designs, the average ionic charge, Z, and the laser intensity, I, are large enough that the distribution function is predicted to be non-Maxwellian (flat-topped). This has important consequences: reduction of the absorption rate, electron flux, and modification of the continuum x-ray emission rates.

A certain amount of energy is required to cause an electron to spin flip when it is beside another electron. Thus, the energy required is double this and is provided by the incident photons.

“This means that...” i.e., or thus
“Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts.” W. Strunk Jr. and E.B. White, *Elements of Style*, 3rd ed. (Needham Heights, MA, Allyn & Bacon, 1979), p. 23.
Eliminate *unnecessary* words

the results *tend to suggest*
they are *both identical*
estimated to be about 0.75 mg
such as copper, iron, *and etc.*
divided into *two equal halves*
bright yellow *in color and elliptical in shape*
$\Lambda = \lambda/2\theta$, and *vice versa*
given *the fact that* $\tau_a = \sigma q_a \int n(s) \, ds$
were reexamined *in order to confirm the presence*
*It is known that* nanocrystallites can form shear bands

“A phrase such as “*it is interesting to note that*” adds no information and only delays getting to
the point of the sentence.” *Scientific Style and Format*


Replace wordy expressions

due to the fact that
on the order of
in the near future
a very limited number of cases
it appears to be indicated that
in spite of the fact that
subsequent to
at the present time
in consequence of this fact
as compared with
in combination with

because
about
soon
few
apparently
although, despite
after
now
thus
versus
with
Many English words derived from Latin change verbs into the nominative form by adding –tion, –ment, and –ance suffixes to the verbs. Thus act (v.) becomes action (n.), arrange (v.) becomes arrangement (n.), and perform (v.) becomes performance.

An easy way to improve the conciseness and vigor of your writing is to be on the alert for these nouns and change them back into the verbs they came from.
3. Now for proofreading (microscopic scale)

*Editing* concentrates on *ideas* and *expression*

*Proofing* concentrates on *mechanics*—
- Spelling
- Grammar
- Punctuation
- U.S. English usage
- Scientific writing conventions
Proofreading examines the manuscript one word at a time

Acronyms, mathematical symbols, and special characters are defined at first usage

Format and typography are consistent and conform to manuscript preparation rules

Technical writing conventions are observed

Grammar and usage are flawless

Punctuation and spelling are perfect

TIP: Start at the bottom right-hand corner and read backwards and up
Maintain witless consistency throughout the text

**Terminology**—always call the same things by the same names
**Typography**—use of italics and boldface
**Expression of numbers**
**Definitions of symbols or special characters**
**Legends in figures**
**Style of subheadings, captions, table titles**
**Use of color**

If you talk for four pages about a “solar collector” and suddenly introduce a “solar absorber” on Page 5, a careful reader will wonder if something qualitatively different is being described.
Present a professional-looking document

Select an appropriate font and size
Use no more than two font styles
Automatically hyphenate the document to avoid annoying white spaces in justified lines
Position graphics strategically
Select an attractive page layout
Adequate white space
Clean, uncluttered appearance
To recap:

Distill, distill, distill...

Focus on important ideas, logical structure, precise language, “mechanical errors”

Editing should proceed in three steps: content, style, proofreading

Pay attention to transitions and reader cues

Make your own editing checklist and use it

cmelliot@illinois.edu
http://physics.illinois.edu/people/Celia/