This lesson is not about those short, pithy, Anglo-Saxon words we say when we bump our heads or drop something on our feet. It is about the short, pithy, Anglo-Saxon words that cause ambiguity in scientific writing and send Ms. Particular into low-earth orbit.

We’ve already talked about “with” and “only,” but we’ll review them today. And we’ll look at some more problem-causing four-letter words.
With
Don’t use \textit{with} when you mean \textit{having} or \textit{using}

“A single impurity in one-dimensional bosonic systems will be explored, with particular emphasis on accessing a hitherto unobserved phase \textit{with} density-wave correlations.” (???)

Is the author using density-wave correlations as a tool to “access” this new phase, or is the phase characterized by density-wave correlations (unlike other phases, which don’t have such correlations)?

Unless you really mean “along with” or “simultaneously with” or “associated with,” \textbf{don’t} use \textit{with}; use \textit{having} or \textit{using}. 
Only

*Only* is the most commonly misplaced modifier in English

*Only* immediately preceding a verb is usually in the wrong place

> “However, these forms are only obtained at the expense of additional auxiliary symmetries and particles, with the use of nonrenormalizable operators.”

> “For the present slab calculations, we only applied the constant pressure algorithm to the two lattice vectors parallel to the surface, leaving the third unchanged during the simulation.”

> “The remaining forward scattering terms as well as backscattering and Umklaap terms arising from the Coulomb interactions only lead to weak deviations (on the order of a few percent) to the gaps...”

All examples were taken from one issue of a 2013 *Physical Review Letters*.

The third example is also desperately in need of two commas, but where to put them is debatable.

A comma is clearly needed to set off the dependent phrase, “as well as backscattering and Umklaap terms,” but then what do you do with “from the Coulomb interactions”? Does it modify “remaining forward scattering terms” or only the Umklapp terms?

Both edited examples shown below are grammatically correct, but the meaning is different:

> “The remaining forward scattering terms, as well as backscattering and Umklaap terms arising from the Coulomb interactions, lead only to weak deviations...”

> “The remaining forward scattering terms, as well as backscattering and Umklaap terms arising from the Coulomb interactions lead only to weak deviations...”

If the second example is what is meant, the sentence would be much clearer if the modifier (“arising from the Coulomb interactions”) was moved to where it belongs, i.e.,

> “The remaining forward scattering terms, which arise from the Coulomb interactions, as well as backscattering and Umklaap terms, lead only to weak deviations...”
Here’s another example:

“Single photons can represent quantum systems of \( d \) states (qudits) by occupying \( d \) different modes [10–13]. The projection of two such photonic qudits of \( d>2 \) onto a maximally entangled state is impossible without the use of auxiliary photons. This is because only two particles are involved, while the Schmidt number of the projected state is larger than 2 [30].”

Presumably, this *this* means “everything I said in the previous two sentences.”

Ms. Particular (with the approval of the author)* would revise thus:

“Single photons can represent quantum systems of \( d \) states (qudits) by occupying \( d \) different modes [10–13]. The projection of two such photonic qudits of \( d>2 \) onto a maximally entangled state is impossible without the use of auxiliary photons. Because only two particles are involved, additional photons are required when the Schmidt number of the projected state is larger than 2 [30].”

*The author always trumps the editor. Sad but true.
That

Use *that* to define

“Chen et al. [28] have developed a BCS—Bose–Einstein crossover theory of short-coherence-length superconductors *that* exhibit a pseudo-gap, as do BEDT materials.[29]

Use *which* to expand

“The Coffey–Clem theory, *which* generalizes the relation to include thermally assisted flux flow, was tested experimentally.”

What does the following sentence *mean*?

“We have calculated the ground state energy and pairing gap for pure neutron matter in the low-density regime *which* is relevant for the inner crust of neutron stars.”

*That* is used to introduce *restrictive* clauses—subordinate clauses that are integral to understanding the meaning of a sentence.

*Which* is used to introduce *nonrestrictive* clauses—subordinate clauses that introduce additional, interesting, ancillary information that is *not* integral to the meaning.

*Which* clauses are always set off from the rest of the sentence with commas. Think of the commas as handles; they allow you to lift the nonrestrictive clause out of the sentence without changing its meaning.

If you can remove the dependent clause and still have the remaining sentence make sense, it’s a nonrestrictive clause. Introduce it by *which* and set it off with comma-handles.

If the removal of the clause changes the meaning of the sentence or leaves it senseless, it’s a restrictive clause and should be introduced with *that* (no commas).

For a more comprehensive discussion of *which* and *that* (you know you want it), see http://people.physics.illinois.edu/Celia/MsP/WhichisThat.pdf.
Assigning human traits or abilities to animals or inanimate objects is known as anthromorphism and is considered a flaw in scientific writing.

Here is another example of anthromorphism:

“The substrate tells the YBCO how to align during growth.”

What’s going on here is really much more complicated than this simple sentence implies, and good scientific writing should communicate exactly what is happening, not some parable that substitutes for the facts.

While such simplification might be acceptable when writing a popular article for a general audience, it has no place in most scientific writing.
Ones

Busy, anonymous *ones* frequently do all sorts of things in stilted technical writing—avoid this trite construction

Recast the sentence in the passive voice to put the emphasis where it belongs

“Knowing the mass, *one* can use the following relation to calculate the radius:

\[ m = 4\pi \rho \frac{a^3}{3}. \]

“From the mass, the radius is calculated by…”

“This report describes the process by which *one* can create still-frame images…”

“A process to create still-frame images from data files is described…”

Getting rid of the *ones* should make your writing more concise and direct—always a goal in good writing.
Also
Sentences beginning with a marooned also often sound like an afterthought; avoid this construction

Provide a transitional phrase or a simple conjunction (and, but, because) and tie the also sentence to the one preceding it

Attach the also sentence to the one preceding it with a semi-colon if the ideas are closely related

The dark reaction (CO + O₂) does not yield any CO₂ on either of the substrates. Also, in the presence of UV but the absence of O₂, no reaction was observed.

The dark reaction (CO + O₂) did not yield any CO₂ on either of the substrates, and no reaction was observed in the presence of uv light when O₂ was absent.

In the correction, note that the UV in the original is changed to uv (AIP Style Manual), and light is added to clarify. If UV is actually an acronym for something besides ultraviolet, more readers than Ms. Particular may be confused.

The verb tense was also changed in the edit so that both clauses were written in the past tense. Toujours witless consistency!

“In addition,…” is only marginally better than “Also,…” and will be dealt with accordingly.
From

Do not use *from* or *between* before a range—it is meaningless

between 11 and 17, *not* between 11–17
Data

Data is a plural noun and requires a plural verb

“The data shows…” are both wrong
“The data was taken…”

“The data show…”
“The data were taken…”

The singular is datum (but don’t use it; it sounds extremely pretentious).

If you really mean “one data point,” say “one data point.” But beware of basing much of an argument on it.
What is very large to you may be only moderately large to one reader and enormous to somebody else. Don’t expect a reader to divine what’s in your mind and assign the correct size to a qualitative description.

Take Mark Twain’s advice:
“Substitute "damn" every time you’re inclined to write "very;" your editor will delete it and the writing will be just as it should be.”

<table>
<thead>
<tr>
<th>Wimpy</th>
<th>Precise</th>
</tr>
</thead>
<tbody>
<tr>
<td>very small amount</td>
<td>less than 15 μg</td>
</tr>
<tr>
<td>very important</td>
<td>crucial, essential</td>
</tr>
<tr>
<td>very precise</td>
<td>± 5 nm; &lt;10 ppm</td>
</tr>
<tr>
<td>very rapidly</td>
<td>simultaneously, in &lt;2 μs</td>
</tr>
</tbody>
</table>

*Other wimpy qualifiers: rather, little, pretty (meaning “sort of”)*
Less

*Less* is used for quantities that have been measured or calculated

*Fewer* is used to describe quantities that have been counted

“All quantum cryptography schemes to date have a necessary upper limit to the efficiency of the scheme, i.e., (less than/fewer than) 50 percent of the photons sent can contribute to the final key.”

This example has caused a good deal of angst to Ms. Particular, who could argue either way. (Such contrariness comes as no real surprise to people who know Ms. Particular.)

On one hand, the photons were probably initially counted, which would give the nod to *fewer than*. On the other hand, percentages are calculated, not counted, which would argue for *less than*.

Ms. Particular has a preference for *fewer than*, because it sounds better.
Lead

*Lead* is a present-tense verb (*to lead*) or an element (*Pb*)

The past participle of “to lead” is “led” (not to be confused with LED, a light-emitting diode)

“The clues *led* to Colonel Mustard holding the *lead* pipe in the library.”

The “Clue” example will be replaced with a proper physics one in the next edition.
Like

*Like means similar to*

Do not use *like* when you mean *such as* (or e.g.)

“The student will practice each technique on well-known and well-understood materials *
like* lead, aluminum, and silver.”

*Like* excludes; in this example, the student is not practicing on Pb, Al, or Au, she’s practicing on a well-understood material *similar to* Pb, Al, or Au

*Such as* includes
Modifiers that emphasize or intensify the absolute (surely, absolutely, completely) are grammatically correct but should be used judiciously.

Modifiers that indicate less than the absolute (almost, nearly, perhaps, not entirely, in some respects, not quite) are correct but wimpy.
Over

Don’t use over when you mean compared with
“When distilled water was used, sample impurities were reduced by 8 percent over (compared with) the samples prepared with tap water.”

Don’t use over when you mean more than
“Over (More than) half the samples were unusable.”

And it’s ALWAYS “compared with” in science writing.
Science writers should also beware of *factual*, as it has two meanings in English: (1) of or relating to facts, and (2) true.

My analysis might be factual (i.e., an interpretation of facts) and completely erroneous (untrue).
Hope

Be positive to be persuasive; don’t say what you hope to do, say what you will do
“We hope the new frazzlejamber will allow us to increase the sensitivity of our measurements by a factor of 2.”

Get rid of hopefully too

*Hopefully,* this work will lead to some new applications (and make us all a lot of money).

*hopefully* means “full of hope” or “in a hopeful manner”; it does not mean “it is to be hoped” or “we hope”

In the immortal words of Master Yoda, “Do or do not. There is no try.”

And there is no hope in science.
Sometimes, there’s just no way around starting a clause with *there*. (Try it with this sentence.) But many sentences can be improved by eliminating *them thar* preambles and putting the subject at the beginning of the sentence.

The third example demonstrates another truism in writing—phrasing a statement as a positive is usually more concise and always easier for the reader to understand than expressing the same thought as a negative.

Here are two examples:

Although some data supported the hypothesis, it could not be concluded that luminosity scaled linearly with current. (negative, 17 words)

**BETTER:** Data showing linear scaling of luminosity with current were inconclusive. (positive, 10 words)

Arcing under high-current operation could not be avoided without the use of the insulated feedthrough. (negative, 15 words)

**BETTER:** The insulated feedthrough prevented arcing, even during high-current operation. (positive, 9 words)
Due2
Should be used as an adverbial phrase following a to be verb
Other uses blur the distinction between caused by, because of, owing to, and associated with, which have distinct but subtle gradations in the degree of causality
If you cannot substitute attributable to, replace due to
If due to is used to begin a sentence, it is probably wrong as well as inelegant
Writing “due to the fact that” is an egregious abuse of readers’ sensibilities

Editors have a deep and abiding aversion to due to. Scientists should too, because it’s sloppy.
Another due2 example...

“Previous work has shown that tips made from softer magnets, such as nickel or cobalt, significantly enhance spin relaxation rates due to thermal fluctuations of the magnetic moment.”

What’s meant here?

Do the softer magnets affect only some spin relaxation rates (only those caused by thermal fluctuations)?

Or are the thermal fluctuations (a feature of the softer magnets) the cause of the enhanced spin relaxation rates?

Careless writers often use due to as a shorthand to compress complex causal relationships into one easy six-character phrase. Avoid this temptation.