Physical English

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For Ginette, Michael, Sean, Peter, Micheon, Danielle, Rachel, Mia, James, Dylan, Christopher, and Liam

Contents

Preface

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Language

1.1 Speech

Our ancestors evolved into their present anatomical form some 200,000 years ago. Some 150,000 years later, or 50,000 years ago, they learned to talk to each other.

Children learn their native language without going to school. They learn by listening to other people talk. Talking face to face is a natural human activity.

Noam Chomsky (linguistics.mit.edu/user/chomsky) created modern linguistics and used language to study consciousness.

1.2 Writing

Reading and writing were invented more recently, probably between 6,000 and 5,000 years ago, possibly in Mesopotamia, now Iraq. Reading is a skill learned at home or in school. It is not a natural act like talking with another person face to face. **So writers should make reading as easy as possible.**

In *Politics and the English Language*, George Orwell (*1984, Animal Farm, Homage to Catalonia, ...*) gave us six rules for writing English:

1. Never use a metaphor, simile, or other figure of speech which you are used to seeing in print.
2. Never use a long word where a short one will do.
3. If it is possible to cut a word out, always cut it out.
4. Never use the passive where you can use the active.
5. Never use a foreign phrase, a scientific word, or a jargon word if you can think of an everyday English equivalent.
6. Break any of these rules sooner than say anything outright barbarous.

Examples of rule 1: Avoid the phrases *send a message* and *going forward* when they aren't needed.

Examples of rule 2: Use *use* instead of *utilize*. Use *many* instead of *multiple*.

Examples of rule 3: Use *then* instead of *at that point in time*; use *now* instead of *at this point in time*. Avoid useless adjectives and adverbs. As Gore Vidal wrote of John Updike, "Might Updike not have allowed one blind noun to slip free of its seeing-eye adjective?"

Examples of rule 5: Use *formulas* instead of *formulae*; use *novas* instead of *novae*; use *supernovas* instead of *supernovae*.

If you follow Orwell's rules, your writing will be easier to read. It will be *tight* and free of extra words and phrases that distract and tire the reader.

Modern research in psychology, as described by Daniel Kahneman in *Thinking, Fast and Slow* (Kahneman, 2011) supports Orwell's rules 2–5. Kahneman writes, "If you care about being thought credible and intelligent, do not use complex language where simpler language will do." See, for example, Daniel Oppenheimer's article, "Consequences of Erudite Vernacular Utilized Irrespective of Necessity: Problems with Using Long Words Needlessly" (Oppenheimer, 2006).

Orwell's rules also make writing easier. When you are about to write a sentence, you may think of several choices of words and phrases. Instead of agonizing over the merits of each choice, you can use Orwell's rules to winnow the list of alternatives, often down to a unique choice.

Writing must be clear. The disastrous charge of the Light Brigade at Balaclava in the Crimean War was made because of a carelessly worded order to "charge for the guns," when what was intended was to haul some British guns into a safer place (Graves and Hodge, 1979, p. 95).

1.3 A higher level

There is a higher level of writing, but I don't have anything much to tell you about that. You can read articles and books by some of the best writers, such as Richard Feynman, Sidney Coleman, Freeman Dyson, Roy Glauber, Steven Weinberg, Edward Witten, and Anthony Zee in the field of physics, Linus Pauling in chemistry, and the several authors of the book *Molecular Biology of the Cell*. And it would not hurt to read Tolstoy, Hemingway, Churchill, Tom Wolfe, F. Scott Fitzgerald, Oscar Wilde, James Joyce, ...

Orwell's rules aren't a recipe for great writing, but violating them can ruin a good story.

1.4 Know your audience

When talking with a friend of yours, you have some idea of what he or she knows and wants to learn from you. The exchange of information in both directions is immediate and effective. When face to face with someone new, you quickly see how the person reacts to what you say. You find out what background is needed and how fast to explain the physics.

But when giving a talk to a group of people you have less feedback and when writing a paper, you have none. So you somehow must learn something about your audience before you prepare your talk and before you write your paper.

If you are giving a talk to a small research group of which you are a member, then you have a good idea what they know, and you can focus on explaining your new results in terms of what you know they know.

But if you are giving a talk to a large audience or are writing an article for an international journal, then you must explain much more.

1.5 Explaining the physics

One way of communicating with a large audience of strangers is to explain the physics from scratch using only the concepts that you are sure they are familiar with. You should explain new ideas and results in terms of the concepts they already know. If you follow Orwell's rules, you will be able to explain the new terms and new ideas succinctly and efficiently.

The key task is to explain the new physics in ways that make it easy for your audience to learn it.

1.6 The ideal talk, the ideal paper

A second reason to know your audience is to find out what they want to learn. If you know your audience, you may know that they want to understand something that you understand. If you explain that to them clearly, they will love you.

1.7 Some tips

Vary the lengths of your sentences. A very short sentence can have a big impact on the reader, especially if it follows a few longer ones.

Use a speller. But if the word is technical, google it.

Use correct grammar. Mistakes distract readers and annoy listeners. Grammatical errors also can lower the level of trust your audience has in you. You can use Google to answer most questions about grammar.

1.8 What's in it for the reader?

Your article is more likely to be read or published if it seems to offer something that would benefit the reader. Thus papers that announce a better measurement of an important observable or the discovery of a new particle get published immediately. Talks with such content are well attended.

Usually our content is less striking. What to do? We must tell the reader or listener why what we have to say is something that they want to know about. We can, for example, review the present state of confusion about an issue and then say how we can clarify it. Some journals of biology and medicine have a highly stylized (and unfortunate) format in which the first paragraphs say that an answer is unknown and in later paragraphs say what answer the authors have discovered.

1.9 General advice

Choose a title that is succinct, informative, and tempting. People love stories. Your paper should tell a story. Its first paragraph should tell the essence of that story and say why it is worth telling. Write clearly and simply. Avoid surplus adjectives and adverbs. Don't hype.

2
Rules

2.1 Latin and Greek

One of Orwell's six rules is to avoid using "a foreign phrase, a scientific word, or a jargon word if you can think of an everyday English equivalent." But sometimes you may need to use a word that the English language has borrowed from Latin or Greek. Don't confuse the singular and plural forms. When in doubt, google the foreign word.

Here are some borrowings from Greek listed with the singular form followed first by the Greek plural when available and then by the English plural when available:

singular	Greek plural	English plural
colon		colons
criterion	criteria	criterions
demon		demons
lexicon	lexica	lexicons
pentagon		pentagons
pentathlon		pentathlons
phenomenon	phenomena	
tetrahedron	tetrahedra	tetrahedrons
zoon	zoa	zoons
crisis	crises	
clitoris	clitorides	clitorises
hypothesis	hypotheses	
thesis	theses	
lemma	lemmata	lemmas
schema	schemata	schemas
stigma	stigmata	
helix	helices	helixes

Here are some borrowings from Latin listed with the singular followed first by the Latin plural when available and then by the English plural when available:

Languages evolve. Meanings change. The rates of change are high for Latin and Greek words and for irregular verbs. Thus in modern English the Latin pair *agendum, agenda* has morphed into the singular word *agenda* meaning a list of things to do. The Latin plural *trivia* is often used in English, but its singular form *trivium* is archaic. The Latin pair *minutia, minutiae* is so often misused that you will be misunderstood if you use it correctly.

Pronunciations also change. Italians pronounce Latin plurals ending in *-ae* so that they rhyme with *May* and *day*. Yet in modern English these words rhyme either with *me* or *I*. Italians pronounce Latin better than we do. These Latin words whose singular forms end in *-a* have English plurals that simply add an *s*, for example, *formula, formulas*. One can avoid confusion by using the unpretentious English plurals *alumnas, formulas, novas, vertebras, supernovas, . . .*

One of the rules of English grammar is that adjectives always are singular; we say "tall trees," not "talls trees." Using the simple English pairs *formula, formulas, supernova, supernovas, . . .* one naturally respects this rule. People who use Latin plurals sometimes use *supernovae* as an adjective, forgetting that they should use *supernova* instead. In the May 2018 issue of APSNEWS, for example, one finds "various CMB calculations of the Hubble constant differ from stellar and supernovae versions by more than 5 percent."

Avoid Latin and Greek whenever you can.

2.2 Irregular verbs

Languages evolve. Usage changes over periods as short as a few years. I like informal speech such as, "Me and him went fishing." Such usage may become standard in 100 years.

But one should avoid rapidly changing usage and outright grammatical mistakes when writing a physics article or talking giving a talk about physics.

The irregular English verbs are slowly changing, so in formal writing and speaking one should either avoid irregular verbs or use them correctly.

singular	Latin plural	English plural
alga	algae	
alumna	alumnae	alumnas
formula	formulae	formulas
larva	larvae	
minutia	minutiae	
nova	novae	novas
persona	personae	personas
vertebra	vertabrae	vertebras
supernova	supernovae	supernovas
alumnus	alumni	
caucus*		caucuses
hiatus	hiati	hiatuses
nucleus	nuclei	
octopus†		octopuses
phallus	phalli	phalluses
prospectus	prospectus	prospectuses
sinus	sinus	sinuses
virus⋆		viruses
addendum	addenda	addendums
aquarium	aquaria	aquariums
bacterium	bacteria	
curriculum	curricula	curriculums
datum	data	
desideratum	desiderata	
gymnasium	gymnasia	gymnasiums
maximum	maxima	maximums
medium	media	
memorandum	memoranda	memorandums
minimum	minima	minimums
moratorium	moratoria	moratoriums
referendum	referenda	referendums
stratum	strata	
trivium	trivia	trivia
analysis	analyses	
basis	bases	
parenthesis	parentheses	
synthesis	syntheses	
genus	genera	
index	indices	indexes

Caucus probably is Algonquian, octopus is Latinized Greek, and the Latin word virus, which means poison, is a mass noun like oxygen or sunlight with no Latin plural.

Table 2.3 *Irregular English verbs*

Base form	Past tense	Past participle
be	was/were	been
begin	began	begun
break	broke	broken
bring	brought	brought
buy	bought	bought
build	built	built
choose	chose	chosen
come	came	come
cost	cost	cost
cut	cut	cut
do	did	done
draw	drew	drawn
drive	drove	driven
eat	ate	eaten
feel	felt	felt
find	found	found
get	got	got
give	gave	given
go	went	gone
have	had	had
hear	heard	heard
hold	held	held
keep	kept	kept
know	knew	known
leave	left	left
lead	led	led
let	let	let
lay	laid	laid
lie	lay	lain
lose	lost	lost
make	made	made
mean	meant	meant
meet	met	met
pay	paid	paid
put	put	put
run	ran	run
say	said	said
see	saw	seen
sell	sold	sold
send	sent	sent
set	set	set
sit	sat	sat
speak	spoke	spoken
spend	spent	spent
stand	stood	stood
take	took	taken
teach	taught	taught
tell	told	told
think	thought	thought
understand	understood	understood
wear	wore	worn
win	won	won
write	wrote	written

3

Examples of mediocre writing and how to fix them

Raw text:

"We want to see established an international order based upon mutual understanding and mutual confidence, and we cannot build such an order unless it conforms to certain principles, which are essential to the establishment of confidence and trust." [Neville Chamberlain]

Graves and Hodge (Graves and Hodge, 1979, p. 103) reduce that repetitious sentence to:

"The international order that we wish to establish must conform to certain principles of mutual understanding and trust."

Raw text:

The goal of this chapter is to develop a sense of the kinds of quantitative data that are being obtained in all fields of biology and the models that must be put forth to greet this data. Like with any useful map, we will argue that any good model has to overlook some of the full complexity and detail of a given biological problem in order to generate an abstraction that is simple enough to be easily grasped by the human mind, as an aid to developing intuition and insight. At the same time, it is critical that useful models make meaningful predictions, so they must include at least some of the realistic details of the biological system. The art of model building lies in striking the proper balance between too little detail and too much. Part of our emphasis on model building centers on the role of having a feeling for the numbers: sizes, shapes, times, and energies associated with biological processes. Here we introduce the style of making numerical estimates that will be used throughout the book.

A first pass at improving this text:

The goal of this chapter is to learn about the kinds of quantitative data that are being measured in biology and the models that can interpret these data. A good model overlooks some of the complexity of the biological system in order to be simple enough to be easily understood. But useful models make predictions, so they must include enough detail to do that. The art of model building lies in striking the proper balance between too little detail and too much. The first step in building a useful model is to learn the sizes, shapes, times, and energies of the biological system. Here we show how to estimate such things.

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Raw text:

This small scale study aims to find patterns and disparities of non-linguists' views on English dialectal differences in the United States. The study itself is influenced by social psychologist Wallace Lambert's study on "matched guise" and Nancy Niedzielski and Dennis Preston's studies on folk linguistics. In Wallace Lambert's 1960s matched guise study-a method measuring language attitudes mentioned in Niedzielski and Preston's work- speech samples were produced by the same person but vary in some domain. An example of this variation is a single person speaking with different accents. Within this study, Lambert presented a bilingual speaker who produced speech samples-one language per sample- in both French and English. "Guise" here references characteristics of a given language. Participants were asked to rate the French Guise and English Guise of the speaker. Participants were unaware that the samples were produced by the same speaker. Studies following this format have had a consistent split of ratings between Status and Solidarity.

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Raw text:

This version addresses a mechanistic, realist worldview. That my present situation, which seems to be "this particular universe right now", leads to multiple futures seems to violate the conservation of mass or energy (actually, energy is not conserved in cosmology). It is good to pick people up where they are at, so this version, aimed at engineers rather than linguist philosophers, starts with established science: In the physicists' empirically established, fundamental descriptions, a universe does not exist in some empty three dimensions called "the only space" as if there is therefore no more space for another universe, perhaps on grounds of that our universe is already infinitely large and so there is no space left for another one. Our cosmos produces its own space; space is "in" it not it in space. More generally speaking: If you start with the assumption that our "universe" is something that exists by itself without physics correlating it with other, different universes, then a universe can exist all by itself by assumption, all by itself from its own inside. So, therefore, by assumption, there is nothing that this world could do to stop any other possible alternative world from existing just like this one does, in its own inside, too! And this obviously also applies to all possible initial conditions and all possible gods and their choices when arranging initial conditions or whatever else you can suggest short of stamping on the ground and shouting "The absoluteness of the absolute is that it is just not relative from a next higher meta-level, praise the one and only, you shall have no one beside him!"

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In 2004, Ferron et al. [165] carried out molecular dynamics simulations relying on EAM interactions. They saw long jumps as well as rebound (recrossing) jumps in self-diffusion on Cu(111) and claimed that at 500 K, 95% of jumps were correlated; at 100K this decreased to 50%. They continued their simulations using the DYNAMO code and atomic interactions derived from EAM potentials [166]. A number of correlated jumps, including atomic long events as well as ballistic transitions were identified at temperatures ranging from 7% to 55% of the melting temperature of copper, with the likelihood of correlations increasing with increasing temperature. Also observed was a linear increase of the characteristic jump length with temperature. The average distance covered by adatoms increased faster than expected for a random walk between nearest-neighbor sites.

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Raw text:

In this paper we will propose a model of Berezin integral as a literal limit of the Riemann sum that corresponds to surface integral. Thus, the fact that Berezin integral coincides with the derivative is a simple consequence of divergence theorem. The fact that Berezin integral doesn't obey the scaling properties expected of ordinary integrals is attributted to the fact that the Berezin integral is claimed to give the expected value only if the volume enclosed by the sphere is $1/D$, where D is the dimension of spacetime (that is sent to infinity at the end) and, therefore, the rescaled surface no longer gives the expected value of the integral. Finally, the Berezin integral can return scalar value due to the richer structure, referred to geometric algebra, that combines the anticommutting wedge product with the Clifford product. While the "finite" part of the integral has wedge product, as always, the product betrween "finite" and "infinitesimal" part is Clifford, which is what ultimately allows for the outcome to be a scalar.

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In this paper we propose a model of Berezin's integral as the Riemann sum of a surface integral. Thus the fact that Berezin's integral is a derivative is due to the divergence theorem. The Berezin integral doesn't obey the scaling properties expected of ordinary integrals because the volume enclosed by the surface is $1/D$, where D is the dimension of spacetime (sent to infinity at the end); therefore, the rescaled surface no longer gives the expected value of the integral. Finally, the Berezin integral can return a scalar value due to the richer structure of a geometric algebra that combines the anticommuting wedge product with the Clifford product. While the "finite" part of the integral has a wedge product, the product of the "finite" and "infinitesimal" parts is Clifford, which makes the outcome a complex number.

Raw text:

Buddhist architecture is defined by the presence of three particular structures; the *stupa* (the cosmic egg), the *vihara* (a monastery), and the *chaitya* (a prayer hall). Images of the Buddha are often times incorporated into the architecture through paintings and reliefs which differentiates it from Hindu caves. The Hindu caves exempted the Buddha for more deity-oriented representations such as Shiva and Ganesh. Unlike Hinduism and Buddhism, there seems to be no cave complexes dedicated entirely to Jainism. Instead, Hindu and Buddhist caves tend to have Jainist elements such as the *Ahimsa*.

To have sacred places carved into mountains is a testament to the mathematical prowess of the ancient Indians that constructed these caves, so much so that the methods the architects used to carve into the face of the cliff sides still baffles historians today. The intensity also speaks to the importance of the earth in the religions of India. These caves and their elements became a house for the supernatural as their careful attention to the way light plays with the inside highlights the importance of certain subjects. The warm tones of the paintings coupled with the round figure which it portrays accentuates the importance of lighting and the shape of the spaces. Although Buddhist architecture slowly lost its individuality as it adopted more Hindu doctrines, the survival of Ajanta speaks to the importance that Buddhism still has in Indian culture, separate of Hinduism.

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What makes a croissant so delectable? Not surprisingly, a croissant owes its wonderful flakiness to the fat which makes it — specifically the fat's stress and strain characteristics, along with its overall structure. Braulio Rodriguez and Alejandro Marangoni of University of Guelph in Ontario, Canada studied exactly this.

They began by analyzing the stress and strain of croissants made with two different kinds of fat, roll-in and all-purpose. With a method that measured the material's response to oscillations, called large amplitude oscillatory shear (LAOS), they plotted the stress by strain. The strain is presumably measured as a percentage of the croissant's final length by the original length, while the stress is the applied pressure to the croissant. In these plots, the all-purpose-fat croissant exhibited a sharp peak in stress at low percentages or strain — suggesting a collapse of the internal structure - whereas the roll-in fat had a subtle peak and overall flat curve - no collapse. Therefore, while roll-in fats do not excel in effects on cardiovascular health, they at least demonstrate better textures for the croissant.

Images of the croissants' structure were made through electron and x-ray scattering. The roll-in croissants had three main substructures. In the first nano-scale, the roll-in fats showed small platelets of the fatty triglyceride molecules and smooth platelet boundaries. In the second larger scale, these platelets created stout cylindrical crystal groups, which then created adhered to each other to create the clusters apparent in the third scale. The all-purpose fats had a similar first nano-scale, though these platelets were larger and had more rigid boundaries. Additionally, the all-purpose fats did not exhibit any complex structure beyond the first scale. Thus, these second and third structures present in roll-in fats could be the supporting factor in the stress-strain plot.

Rodriguez and Marangoni continue to analyze the fat structures of croissants in hope of finding alternative fats for the characteristic texture while avoiding the health risks.

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Special relativity offers incredible benefits to those interested in reaching a distant point in space. The star Betelgeuse is approximated to be 640 light years from earth, and the minimum travel time for anything coming to or from Betelgeuse, from an observer at rest on earth, is 640 years. However, things look quite different from the perspective of the traveler. For a star 640 light years away, using one Rocketdyne F-1 engine (7,700 kN thrust) strapped to some ship about the mass of a car, a system sitting at approximately 10,000 kg passenger included, this journey would take just under 98 days, with an acceleration of 770m/s^2. This is incredible! Has this powerful rocket punched through the universal speed limit? Not by any measure! In fact, the journey has taken quite a long time to oversee from mission control: 640 years and 9 days. Nations have been born and have fallen, two thirds a millennium of human history passed while our explorer sat cozy in its ship for 3 or so months, all to reach a star that is a relatively near neighbor in our galactic neighborhood. Now let's send our explorer to the center of the galaxy, to learn about Sagittarius A* and for the incredible view! Using the midpoint of distance approximations, the center of the galaxy lies about 26,000 light years from earth. With the same acceleration as before, to accelerate at a constant rate until the midpoint of earth and the center is reached before decelerating, the journey takes just over 131 days for our explorer! Back on earth, 26,000 years have passed, more time than four time the length of current recorded human history. This is unfortunate, perhaps if we increase acceleration, say, one thousand-fold, we'll be able to see our friends and family once more. Lucky for our traveler, it only needs to wait four and a half hours to see the core, how exciting! Including time to reach the center, performing a day of experiments, and traveling home. About 52,000 years (and a day) have still passed back home. Humanity as the traveler once knew it is dust. This is the failure of the mechanics of special relativity to provide a reasonable road for galactic, or intergalactic travel to become possible.

A first pass at improving this text:

Special relativity offers incredible benefits to those interested in reaching a distant point in space. The star Betelgeuse is approximately 640 light years from earth, and the minimum travel time for anything coming to or from Betelgeuse, in the rest frame of an observer on Earth, is 640 years. However, in the frame of a traveler in a 10,000 kg spaceship propelled by a Rocketdyne F-1 engine with 7,700 kN of thrust and an acceleration of $770 \mathrm{m/s}^2$, this journey would take just under 98 days. This is incredible! Has this powerful rocket punched through the universal speed limit? Not by any measure! In fact, the journey has taken quite a long time to oversee from mission control: 640 years and 9 days. Nations have been born and have fallen, two thirds a millennium of human history has passed while our explorer sat cozily in a spaceship for 3 or so months, all to reach a star that is a relatively near neighbor in our galactic neighborhood. Now let's send our explorer to the center of the galaxy, to learn about Sagittarius A* and for the incredible view! Using the midpoint of distance approximations, the center of the galaxy lies about 26,000 light years from earth. With the same acceleration as before, to accelerate at a constant rate until the midpoint of earth and the center is reached before decelerating, the journey takes just over 131 days for our explorer! Back on earth, 26,000 years have passed, more time than four time the length of current recorded human history. This is unfortunate, perhaps if we increase acceleration, say, one thousand-fold, we'll be able to see our friends and family once more. Lucky for our traveler, it only needs to wait four and a half hours to see the core, how exciting! Including time to reach the center, performing a day of experiments, and traveling home. Yet about 52,000 years (and a day) still would have passed back home. Humanity as the traveler once knew it is dust. This is the failure of the mechanics of special relativity to provide a reasonable road for galactic or intergalactic travel to become possible.

4

Examples of good writing

add Feynman's stuff.
add ice-cube article on neutrinos from blazar; pdf in 400-18
Goodman & Witten PRD 31(12), 3059, 1985
Drukier, Freese, & Spergel PRD 33(12), 3495, 1986

Infiationary universe: A possible solution to the horizon and fiatness problems
Alan H. Guth
Phys. Rev. 23(2), 347 (1981)

The standard model of hot big-bang cosmology relies on the assumption of initial conditions which are very puzzling in two ways which I will explain below. The purpose of this paper is to suggest a modified scenario which avoids both of these puzzles.

By "standard model, "I refer to an adiabatically expanding radiation-dominated universe described by a Robertson-Walker metric. Details will be given in Sec. II.

Before explaining the puzzles, I would first like to clarify my notion of "initial conditions. " The standard model has a singularity which is conventionally taken to be at time $t = 0$. As $t \to 0$, the temperature $T \to \infty$. Thus, no initial-value problem can be defined at $t = 0$. However, when T is of the order of the Planck mass ($M_P \equiv 1/\sqrt{g} = 1.22 \times 10^{19}$ GeV) or greater, the equations of the standard model are undoubtedly meaningless, since quantum gravitational effects are expected to become essential. Thus, within the scope of our knowledge, it is sensible to begin the hot big-bang scenario at some temperature T_0 which is comfortably below M_P, let us say $T_0 = 10^{17}$ GeV. At this time one can take the description of the universe as a set of initial conditions, and the equations of motion then describe the subsequent evolution. Of course, the equation of state for matter at these temperatures is not really known, but one can make various hypotheses and pursue the consequences.

In the standard model, the initial universe is taken to be homogeneous and isotropic, and filled with a gas of effectively massless particles in thermal equilibrium at temperature T_0. The initial value of the Hubble expansion "constant" H is taken to be H_0, and the model universe is then completely described.

Now I can explain the puzzles. The first is the well-known horizon problem. The initial universe is assumed to be homogeneous, yet it consists of at least $\sim 10^{83}$ separate regions which are causally disconnected (i.e., these regions have not yet had time to communicate with each other via light signals). (The precise assumptions which lead to these numbers will be spelled out in Sec. II.) Thus, one must assume that the forces which created these initial conditions were capable of violating causality.

The second puzzle is the flatness problem. This puzzle seems to be much less celebrated than the first, but it has been stressed by Dicke and Peebles. I feel that it is of comparable importance to the first. It is known that the energy density ρ of the universe today is near the critical value ρ_{cr} (corresponding to the borderline between an open and closed universe).

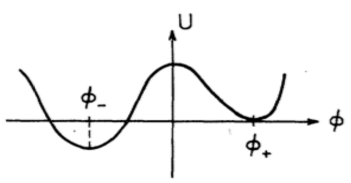
All Possible Symmetries of the S Matrix
Sidney Coleman and Jeffrey Mandula
Phys. Rev. 159(5), 1251 (1967)

Until a few years ago, most physicists believed that the exact or approximate symmetry groups of the world were (locally) isomorphic to direct products of the Poincaré group and compact Lie groups. This world-view changed drastically with the publication of the first papers on $SU(6)$[1]; these raised the dazzling possibility of a relativistic symmetry group which was not simply such a direct product. Unfortunately, all attempts to find such a group came to disastrous ends, and the situation was finally settled by the discovery of a set of theorems[2] which showed that, for a wide class of Lie groups, any group which contained the Poincaré group and admitted supermultiplets containing finite numbers of particles was necessarily a direct product.

Fate of the false vacuum: Semiclassical theory
Sidney Coleman [Phys. Rev. D 15(10), 2929 (1977)]

It is possible for a classical field theory to have two homogeneous stable equilibrium states with different energy densities. In the quantum version of the theory, the state of higher energy density becomes unstable through barrier penetration; it is a false vacuum. . . .
This is the first of two papers developing the quantitative theory of the decay of such false vacuums . . .
The qualitative features of such decay processes have long been understood.[4] They closely parallel the nucleation processes of statistical physics, the crystallization of a supersaturated solution or the boiling of a superheated fluid. Imagine Fig. 1 to be a plot of the free energy of a fluid as a function of density. The false vacuum corresponds to the superheated fluid phase and the true vacuum to the vapor phase. Thermodynamic fluctuations are continually causing bubbles of the vapor phase to materialize in the fluid phase. If the bubble is too small, the gain in volume energy caused by the materialization of the bubble is more than compensated for by the loss in surface energy, and the bubble shrinks to nothing. However, once in a while, a bubble is formed large enough so that it is energetically favorable for the bubble to grow. Once this occurs, the bubble expands until it converts the available fluid to vapor.

An identical picture describes the decay of the false vacuum, with quantum fluctuations replacing thermodynamic ones. Once in a while, a bubble of true vacuum will form large enough so that it is classically energetically favorable for the bubble to grow. Once this happens, the bubble spreads throughout the universe converting false vacuum to true.



Why opposites attract
Y. Aharonov, A. Casher, Sidney Coleman, and S. Nussinov
Phys. Rev. D 46(4), 1877 (1992)

Oppositely electrically or magnetically charged point particles attract at all distances. However, it is not obvious that this is also true for extended objects, like the magnetic monopoles discovered in spontaneously broken gauge theories by 't Hooft [l] and Polyakov [2]. Certainly the long-range part of the force between these objects is attractive, but one might suspect a short-range repulsion when their cores overlap. In this paper we show that this suspicion is groundless: oppositely charged 't Hooft-Polyakov monopoles attract at all distances, just like point particles. The most surprising part of this result is how easy it is to prove.

We stress that our proof is for 't Hooft-Polyakov monopoles as extended objects in classical field theory; we have nothing to say about quantum effects. Also, our proof is for the original 't Hooft-Polyakov monopoles only, the objects that arise in the theory of a triplet of real scalar fields with spontaneously broken SO(3) gauge symmetry. We shall discuss possible generalizations to other cases after we give the proof.

A MODEL OF LEPTONS
Steven Weinberg
PRL 19(21), 1264 (1967)

Leptons interact only with photons, and with the intermediate bosons that presumably mediate weak interactions. What could be more natural than to unite these spin-one bosons into a multiplet of gauge fields? Standing in the way of this synthesis are the obvious differences in the masses of the photon and intermediate meson, and in their couplings. We might hope to understand these differences by imagining that the symmetries relating the weak and electromagnetic interactions are exact symmetries of the Lagrangian but are broken by the vacuum. However, this raises the specter of unwanted massless Goldstone bosons. This note will describe a model in which the symmetry between the electromagnetic and weak interactions is spontaneously broken, but in which the Goldstone bosons are avoided by introducing the photon and the intermediate-boson fields as gauge fields. The model may be renormalizable.

The Quantum Theory of Optical Coherence
Roy J. Glauber
Phys. Rev. 130(6), 2529 (1963)

We are led then to distinguish among various orders of incomplete coherence, according to the number of conditions satisfied. The fields traditionally described as coherent in optics are shown to have only first-order coherence. The fields generated by the optical maser, on the other hand, may have a considerably higher order of coherence. . . .

It would hardly seem that any justification is necessary for discussing the theory of light quanta in quantum theoretical terms.. . .

Coherent and Incoherent States of the Radiation Field
Roy J. Glauber
Phys. Rev. 131(6), 2766 (1963)

Methods are developed for discussing the photon statistics of arbitrary radiation fields in fully quantum-mechanical terms. In order to keep the classical limit of quantum electrodynamics plainly in view, extensive use is made of the coherent states of the field. These states, which reduce the field correlation functions to factorized forms, are shown to offer a convenient basis for the description of fields of all types. Although they are not orthogonal to one another, the coherent states form a complete set. It is shown that any quantum state of the field may be expanded in terms of them in a unique way. Expansions are also developed for arbitrary operators in terms of products of the coherent state vectors. These expansions are discussed as a general method of representing the density operator for the field. A particular form is exhibited for the density operator which makes it possible to carry out many quantum-mechanical calculations by methods resembling those of classical theory. This representation permits clear insights into the essential distinction between the quantum and classical descriptions of the field. It leads, in addition, to a simple formulation of a superposition law for photon fields. Detailed discussions are given of the incoherent fields which are generated by superposing the outputs of many stationary sources. These fields are all shown to have intimately related properties, some of which have been known for the particular case of blackbody radiation.

A birthday toy
I. Bernard Cohen
Einstein Gravity in a Nutshell by A. Zee

At last I was taking my leave. Suddenly Einstein turned and called “Wait. Wait. I must show you my birthday present.” Back in the study I saw Einstein take from the corner of the room what looked like a curtain rod five feet tall, at the top of which was a plastic sphere about four inches in diameter. “You see,” said Einstein, “this is designed as a model to illustrate the equivalence principle. . . . ” A big grin spread across his face and his eyes twinkled with delight as he said, “And now the equivalence principle.” Grasping the gadget in the middle of the long brass curtain rod, he thrust it upwards until the sphere touched the ceiling. “Now I will let it drop,” he said, “and according to the equivalence principle there will be no gravitational force. So the spring will now be strong enough to bring the little ball into the plastic tube.” With that he suddenly let the gadget fall freely and vertically, guiding it with his hand, until the bottom reached the floor. The plastic sphere at the top was now at eye level. Sure enough, the ball rested in the tube.

U.S. v. Internet Research Agency, et al (1:18-cr-32, District of Columbia)
Indictment
Special Counsel Mueller
https://www.justice.gov/file/1035477/download

Use of U.S. Computer Infrastructure

39. To hide their Russian identities and ORGANIZATION affiliation, Defendants and their co-conspirators—particularly POLOZOV and the ORGANIZATION's IT department—purchased space on computer servers located inside the United States in order to set up virtual private networks ("VPNs"). Defendants and their co-conspirators connected from Russia to the U.S.-based infrastructure by way of these VPNs and conducted activity inside the United States—including accessing online social media accounts, opening new accounts, and communicating with real U.S. persons—while masking the Russian origin and control of the activity.

40. Defendants and their co-conspirators also registered and controlled hundreds of web-based email accounts hosted by U.S. email providers under false names so as to appear to be U.S. persons and groups. From these accounts, Defendants and their co-conspirators registered or linked to online social media accounts in order to monitor them; posed as U.S. persons when requesting assistance from real U.S. persons; contacted media outlets in order to promote activities inside the United States; and conducted other operations, such as those set forth below.

Use of Stolen U.S. Identities

41. In or around 2016, Defendants and their co-conspirators also used, possessed, and transferred, without lawful authority, the social security numbers and dates of birth of real U.S. persons without those persons' knowledge or consent. Using these means of identification, Defendants and their co-conspirators opened accounts at PayPal, a digital payment service provider; created false means of identification, including fake driver's licenses; and posted on ORGANIZATION-controlled social media accounts using the identities of these U.S. victims. Defendants and their co-conspirators also obtained, and attempted to obtain, false identification documents to use as proof of identity in connection with maintaining accounts and purchasing advertisements on social media sites.

All Cells Replicate Their Hereditary Information by Templated Polymerization

The mechanisms that make life possible depend on the structure of the double-stranded DNA molecule. Each monomer in a single DNA strand—that is, each **nucleotide**—consists of two parts: a sugar (deoxyribose) with a phosphate group attached to it, and a *base*, which may be either adenine (A), guanine (G), cytosine (C) or thymine (T) (**Figure 1–2**). Each sugar is linked to the next via the phosphate group, creating a polymer chain composed of a repetitive sugar-phosphate backbone with a series of bases protruding from it. The DNA polymer is extended by adding monomers at one end. For a single isolated strand, these can, in principle, be added in any order, because each one links to the next in the same way, through the part of the molecule that is the same for all of them. In the living cell, however, DNA is not synthesized as a free strand in isolation, but on a template formed by a preexisting DNA strand. The bases protruding from the existing strand bind to bases of the strand being synthesized, according to a strict rule defined by the complementary structures of the bases: A binds to T, and C binds to G. This base-pairing holds fresh monomers in place and thereby controls the selection of which one of the four monomers shall be added to the growing strand next. In this way, a double-stranded structure is created, consisting of two exactly complementary sequences of As, Cs, Ts, and Gs. The two strands twist around each other, forming a double helix (Figure 1–2E).

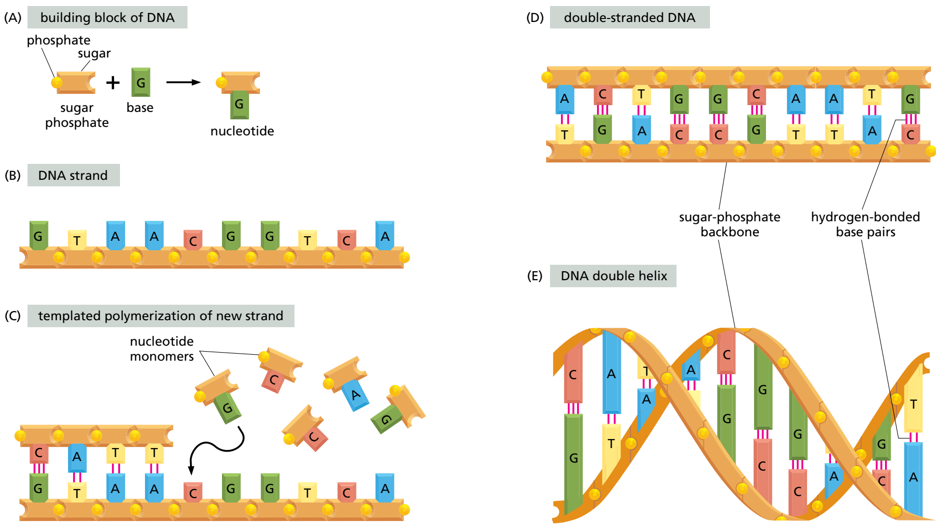


Figure 1–2 DNA and its building blocks. (A) DNA is made from simple subunits, called nucleotides, each consisting of a sugar-phosphate molecule with a nitrogen-containing sidegroup, or base, attached to it. The bases are of four types (adenine, guanine, cytosine, and thymine), corresponding to four distinct nucleotides, labeled A, G, C, and T. (B) A single strand of DNA consists of nucleotides joined together by sugar-phosphate linkages. Note that the individual sugar-phosphate units are asymmetric, giving the backbone of the strand a definite directionality or polarity. This directionality guides the molecular processes by which the information in DNA is interpreted and copied in cells: the information is always "read" in a consistent order, just as written English text is read from left to right. (C) Through templated polymerization, the sequence of nucleotides in an existing DNA strand controls the sequence in which nucleotides are joined together in a new DNA strand; T in one strand pairs with A in the other, and G in one strand with C in the other. The new strand has a nucleotide sequence complementary to that of the old strand, and a backbone with opposite directionality: corresponding to the GTAA... of the original strand, it has ...TTAC. (D) A normal DNA molecule consists of two such complementary strands. The nucleotides within each strand are linked by strong (covalent) chemical bonds; the complementary nucleotides on opposite strands are held together more weakly, by hydrogen bonds. (E) The two strands twist around each other to form a double helix—a robust structure that can accommodate any sequence of nucleotides without altering its basic structure.

Figure 4.1 Page 37 of Molecular Biology of the Cell, 5th edition, by BruceAlberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter.

5

Odds and ends

The indefinite article *a* changes to *an* when it comes immediately before a word that begins with a vowel **sound**. Thus *a lake* but *an ocean*, *an ulcer*. Some vowels sound like consonants: *a universe*, *a university*, *a utopia*, *a Europe*. And some consonants and numbers sound like vowels: *an hour*, *an F*, *an 8*.

Don't confuse *let's*, which means *let us*, with *lets* which means *allows*, as in *Congress lets gun makers get away with murder*.

Don't repeat the verb *is* unnecessarily. It's okay to say, *It depends upon what the meaning of the word is is.* But don't say, *The basic idea is is day follows night.*

Avoid *hopefully*, which means *in a manner full of hope*. It does not mean *I hope*.

Advancement is a process that helps advances happen, as in *The American Association for the Advancement of Science*; it does not mean *advance*.

There is an adverb meaning *in that place*. It cannot be the subject of a sentence. *There are nine justices of the Supreme Court.* The subject is *nine justices*.

How is an adverb. It cannot be the object of the preposition *like*. Thus, never say *how this looks like*, which is Germlish, not English. Say *what this looks like* or *how this looks*.

Where is an adverb. It cannot be the object of the preposition *at*. So ask not *Where are you at?* ask *Where are you?*

The adverbs *farther* and *further* mean almost the same thing; the difference is that *farther* refers to distance while *further* is more abstract.

A compound adjective that precedes the noun it modifies should be hyphenated. Thus, *high-energy physics*.

Some compound nouns should be hyphenated. Thus, *cross-section* avoids the possibility that the section is out of sorts.

Examples of the rules for *who* and *whom*:

- Who made this decision? [who is the subject of the sentence]
- Whom do you think we should support? [whom is the object of the verb support]
- Whom do you think we should support? [whom is the object of the verb support]
- To whom do you wish to speak? [whom is the object of the preposition to]
- The man whom you met yesterday is coming to dinner. [whom is the object of the verb met]
- The children, who had been as good as gold, then suddenly started misbehaving. [who is the subject of the verb had been]
- The people to whom the funds were supposedly directed benefited little from them. [whom is the object of the preposition to]
- The room accommodates 300 students, all of whom are now seated. [whom is the object of the preposition of]
- Congratulations to all the winners, most of whom are reading this blog! [whom is the object of the preposition of]
- *Who* can be used in most places where *whom* is more correct, but it is necessary to write and say *of whom* and never *of who*.]

Use *that* to refer to a thing that is being defined or specified and *which* to refer to something without defining it. Examples of rules for *that* and *which*:

- This is the house that Jack built. [restrictive, no comma]
- A table of contents would have made it easier to use this history book, which also lacks maps. [nonrestrictive, comma]
- They got into the van, which had Ohio plates. [nonrestrictive, comma]
- I was driving the van that had Ohio plates. [restrictive, no comma]

It's okay to split infinitives.

It's okay to end a sentence with a preposition, especially when the alternative would be absurd, as in Churchill's joke, "This is something up with which I will not put."

Use the objective (or accusative) case for the "subject" of an infinitive. Thus write *Now, the task is for President Trump and him to meet …* and not "Now, the task is for President Trump and he to meet …," as U.S. Secretary of State Mike Pompeo did on Fox News Sunday for 13 May 2018.

As Orwell advised, try to avoid meaningless phrases that are spreading like viruses. In particular, avoid ending sentences with "going forward."

I will try to find something about *should* and *ought to*, which are nearly equivalent.

The subjunctive mood is fading out. Among some in England, it is nearly gone. I still use it. I'll try to say more about it.

6

Parts of speech

A noun is a person, place, or thing.

A pronoun is a word that represents a noun in some way. The words *I, me, mine, he, him, his, she, her, hers, . . .* are pronouns. The words *that, which, who, anything, myself* are or can be pronouns.

An article tells us how unique a noun is. The articles are *a, an, the*; they stand before the noun they modify.

An adjective describes a noun or a pronoun. Adjectives may precede their nouns or follow them and a form of the verb *to be*. Adjectives are singular. One says *blue eyes* not *blues eyes*.

A verb is a word that denotes action or a state of being.

An adverb is a word that describes a verb, an adjective, or an adverb.

A conjunction is a word that joins words or sentences (often with the help of a comma). Examples are *and, but, for, or, nor, so, yet*. But other words such as *that* can be conjunctions (He said that she was nice.)

A preposition combines with an article and a noun to form a phrase that describes a verb, noun, pronoun, or adjective.

From the first page of *War and Peace* by Leo Tolstoy:

He was wearing an embroidered court uniform, stockings, shoes, and stars, and had a bright expression on his flat face.

He spoke that refined French in which our grandparents not only spoke but thought, and with those quiet, patronizing intonations which are proper to a significant man who has grown old in society and at court. He went over to Anna Pavlovna, kissed her hand, presenting her with his perfumed and shining bald pate, and settled comfortably on the sofa.

In these three sentences, Tolstoy used only a single adverb.

Verbs have many forms. They can be active (Jack saw Mary in class) or passive (Mary was seen in class). *Be, do, have* are auxilliary verbs. A **participle** is a word formed from a verb, usually by the addition of d, ed, or ing.

A present participle can play the role of a noun. A present participle acting like a noun is a **gerund**. Gerunds take the possessive. Some examples:

- *Rumfeld's handling* of the Iraq war has been criticized.
- *Mary's snoring* drove John mad.
- Harry's favorite activity is *sleeping*.

7
Fixing sentences

Here are some sentences using concepts we discussed last week:
Here are some sentences that involve concepts we discussed last week:

He smiled condescendingly at her, thinking he knew what was best.

Many supernovae bewildered ancient civilizations with their brilliance, which was sometimes even apparent in the morning sky.
Many supernovas bewildered ancient civilizations with their brilliance; some were so bright as to be apparent in the morning sky.

Optics and photonics - one in the same thing, really.
Optics and photonics - one and the same thing, really.

How do you truly measure the beginning of the Universe?
How do you truly measure the beginning of the universe?

He stood at the chalkboard, madly writing and scribbling equations. The students watched- confused, but intrigued.
He stood at the chalkboard, madly writing and scribbling equations. The students watched—confused, but intrigued.

The tea steamed, the laptop keys clicked, but all that night none of their MATLAB codes would work.
The tea steamed, the laptop keys clicked, but all that night none of the MATLAB codes worked.

As they started dinner at the campsite, it began to snow more and more heavily. They worried they would have to go home soon.
As they started dinner at the campsite, it began to snow more and more

heavily. They worried that they would have to go home soon.

The rocket car zipped across the regener lecture hall, ejecting many pounds of CO2 behind it as it went.
The rocket car zipped across Regener lecture hall, ejecting many pounds of CO2 behind it as it went.

Dr. Manjavacas spared those whom registered for physics day. As for the others, their fate was unclear but certainly doomed.
Dr. Manjavacas spared those who registered for Physics Day. The fate of the others was unclear.

how important following some of these rules are in professional scientific papers and articles.
how important it is to follow some of these rules in professional scientific papers and articles.

8
Resources

John Eastwood's *Oxford Guide to English Grammar* is freely available online.

`https://www.uop.edu.jo/download/research/members/`

`oxford_guide_to_english_grammar.pdf`

The Reader Over Your Shoulder by Robert Graves and Alan Hodge has a lot of good advice but is very English.

9
General rules

In their book *The Reader Over Your Shoulder*, Robert Graves and Alan Hodge list and illustrate many general rules that we all ought to follow.

9.1 Principles of Clear Statement I

They call the first set of rules Principles of Clear Statement I:

1. It should always be made clear who is addressing whom, and on the subject of whom.
2. It should always be made clear which of two or more things already mentioned is being discussed.
3. Every unfamiliar subject or concept should be clearly defined; and neither discussed as if the reader knew all about it already nor stylistically disguised.
4. There should never be any doubt left as to where something happened or is expected to happen.
5. There should never be any doubt left as to when.
6. There should never be any doubt left as to how much, or how long.
7. There should never be any doubt left as to how many.

9.2 Principles of Clear Statement II

They call the second set of rules Principles of Clear Statement II:

8. Every word or phrase should be appropriate to its context.
9. No word or phrase should be ambiguous.
10. Every word or phrase should be in its right place in the sentence.
11. No unintentional contrast between two ideas should be allowed to suggest itself.

12. Unless for rhetorical emphasis, or necessary recapitulation, no idea should be presented more than once in the same prose passage.
13. No statement should be self-evident. Graves and Hodge illustrate this rule by their comment on "things that are of inestimable value , but have no price": All things with no price . . . are of inestimable value.
14. No important detail should be omitted from any phrase, sentence or paragraph.
15. No phrase should be allowed to raise expectations that are not fulfilled.
16. No theme should be suddenly abandoned.

9.3 Principles of Clear Statement III

They call the third set of rules Principles of Clear Statement III:

17. Sentences and paragraphs should be linked together logically and intelligibly.
18. Punctuation should be consistent and should denote the quality of connexion, rather than length of pause, between sentences or parts of sentences. Graves and Hodge mention in particular that question marks and exclamation points can appear in the middle of a sentence without ending it. An apostrophe denotes the possessive of a plural noun: *teachers' union*. An apostrophe-s denotes the possessive of a singular noun even when the noun ends in an s: *John's son, Thomas's daughter*. Special rules apply to Latin and Greek names; google them.
19. The order of ideas in a sentence or paragraph should be such that the reader need not rearrange them in his mind. They write that "The natural arrangement of ideas in a critical argument is
    - Statement of problem.
    - Marshalling of evidence, first on main points, then on subsidiary ones—the same sequence kept throughout the argument.
    - Credibility of evidence examined.
    - Statement of possible implications of all evidence not wholly rejected.
    - The weighing of conflicting evidence in the scale of probability.
    - Verdict."

    "They further write that the natural arrangement of ideas in familiar correspondence is:

    - Acknowledgement of previous letter.
    - Comment on the points raised in it, in order of importance—the recipient's interests being given priority.

- New information in order of importance—the recipient's interests being given priority.
- Questions.
- Postscript."

20. No unnecessary idea, phrase or word should be included in a sentence.
21. All antitheses should be true ones. For example, Graves and Hodge would change "Our spirit has not weakened; our spirit has deepened" to "Our spirit has not weakened; our spirit has strengthened."
22. Over-emphasis of the illogical sort tolerated in conversation should be avoided in prose.
23. Ideas should not contradict one another, or otherwise violate logic.
24. The writer should not, without clear warning, change his standpoint in the course of a sentence or paragraph.
25. In each list of people or things all the words used should belong to the same category of ideas.

9.4 The Graces of Prose

Graves and Hodge call their second set of principles The Graces of Prose. The first set is

A Metaphors should not be mated in such a way as to confuse or distract the reader.

B Metaphors should not be piled on top of one another.

C Metaphors should not be used in such close association with unmetaphorical language as to produce absurdity or confusion. For example in a Graham Greene novel, the sentence, "Kay Rimmer sat with her head in her hands and her eyes on the floor," invited the comment "And her teeth on the mantelpiece?" from Graves and Hodge.

D Characteristically poetical expressions should not be used in prose. Except in quotations.

10
Further reading

- Graves, Robert R., and Hodge, Alan, *The Reader Over Your Shoulder*, 1979, 2d edn., Random House.
- Leslie Perelman and Edward Barrett, *The Mayfield Handbook of Technical and Scientific Writing*, 1997, McGraw-Hill, `http://web.mit.edu/course/21/21.guide/`

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