Chemically Speaking
A Dictionary of Quotations

Selected and Arranged by

Carl C. Gaither
and
Alma E. Cavazos-Gaither

Illustrated by Andrew Slocombe

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This book is dedicated to the members of the Cavazos family who are serving in the military:

Matthew Cavazos, MS3, US Navy
Maurice Moore, II, HMSN, US Navy
Alphonso Cavazos, SPC, US Army
Timothy Donovan, SGT, US Army
Carlos Villanueva, SA, US Navy
James R. Bentley, PFC, US Army Reserves.

We also dedicate the book to the men and women of the US Navy Reserves and especially to the US Navy Reservists who drill at Navy and Marine Corps Reserve Center, Waco, Texas.

Carl C. Gaither
Alma E. Cavazos-Gaither

I love thee, Mary, and thou lovest me—
Our mutual flame is like th' affinity
That doth exist between two simple bodies:
I am Potassium and thine Oxygen.
'Tis little that the holy marriage vow
Shall shortly make us one. That unity
Is, after all, but metaphysical.
Oh, would that I, my Mary, were an acid,
A living acid; thou an alkali
Endow'd with human sense, that, brought together,
We both might coalesce into one salt,
One homogeneous crystal. Oh, that thou
Wert Carbon, and myself were Hydrogen;
We would unite to form olefiant gas,
Or common coal, or naphtha—would to heaven
That I were Phosphorus, and thou wert Lime!
And we of Lime composed a Phosphuret.
I'd be content to be a Sulphuric Acid,
So that thou might be Soda. In that case
We should be Glauber's Salt. Wert thou Magnesia
Instead we'd form the salt that's named from Epsom.
Our happy union should that compound form,
Nitrate of Potash—otherwise Salpetre.
And thus our several natures sweetly blent,
We'd live and love together, until death
Should decompose the fleshly tertium quid,
Leaving our souls to all eternity
Amalgamated. Sweet, thy name is Briggs
And mine is Johnson. Wherefore should not we
Agree to form a Johnsonate of Briggs?

Unknown
The Chemist to His Love
In Sara and John E. Brewton and John Brewton Blackburn
Of Quarks, Quasars, and Other Quirks (pp. 44–5)

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No prefatory remarks can so clearly indicate the scope of this book as its Table of Contents, to which the reader is referred. Such a table is a skeleton of the subject matter presented, but it does not describe the flesh which this bare framework carries.

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EXPERIMENT

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TRIAL AND ERROR

PREFACE

There are many reasons why a book of quotations is compiled. We undertook the labor of compiling our books in order to accurately record the words and wisdom of the authors. Robert W. Shaunon has written about the need for the need of accuracy in the following quotation.

Perhaps the reader may ask, of what consequence is it whether the author's exact language is preserved or not, provided we have his thought? The answer is, that inaccurate quotation is a sin against truth. It may appear in any particular instance to be a trifle, but perfection consists in small things, and perfection is no trifle.

The Canadian Magazine
Misquotation (p. 473)
October 1898

We have extracted and written on the following pages a great number of hints which we have found in the books we have reviewed.

Frequently, great quotations get lost as time passes. Even more frequently, the sources of these quotations are lost because the books sit upon shelves acquiring dust. Robert Christy wrote

The compiler does not venture to claim for his work either completeness or perfection; he hopes, however, that it may be found, what he has conscientiously endeavored to make it, useful and instructive.

Proverbs Maxims and Phrases of All Ages
Preface (p. i)

Toward this end we have compiled the hints and ideas from a great quantity of books for you, the reader, to enjoy and use in your daily activities.

"Dictionaries are like watches; the worst is better than none, and the best cannot be expected to go quite true". Thus Doctor Samuel Johnson wrote in the preface of his *Dictionary*. All of the contents of this book have been compiled from widely scattered sources. They are presented in this book for the first time in a form that is readily accessible for pleasure or for reference. Although there are doubtless errors in the quotations and in the citations, and there is certainly much omission, we have sought to ease the reader's need to undertake long searches of the literature in chemistry, physics, mathematics, literature, and philosophy.

We found an interesting quote attributed to Alfonso de Cartagena in Richard Allen's *Star Names: Their Lore and Meaning* (p. 486):

Unto those Three Things which the Ancients held impossible, there should be added this Fourth, to find a Book Printed without erratas.

Toward this end we respond with William Kitchiner's insight:

That this book has its fault, no one can doubt,
Although the Author could not find them out.
The faults you find, good Reader, please to mend,
Your comments to the Author kindly send.

The Economy of the Eyes
The Second Part

Chemically Speaking is a book of quotations. It has, for the first time, brought together in one easily accessible form the best expressed thoughts that are especially illuminating and pertinent to the discipline of chemistry. Some of the quotations are profound, others are wise, some are witty, and some are frivolous. Quotations from the most famous men and women to the unknown are here. You may not find all the quoted 'jewels' that exist, but we are certain that you will find a great number of them here. We believe that Benjamin Franklin was correct when he said that "Nothing gives an author so much pleasure as to find his work respectfully quoted…".

Chemically Speaking is also an aid for the individual who loves to quote—and to quote correctly. "Always verify your quotations" was advice given to Dean John William Bourgen, then fellow of Oriel College, by Dr Martin Joseph Routh. That advice was given over 150 years ago and today it is still true. Frequently, books on quotations will have subtle changes to the quotation, changes to punctuation, slight changes to the wording, even misleading information in the attribution, so that the compiler will know if someone used a quotation from 'his' book. We attempted to verify each and every one of the quotations in this book to insure that they are correct.

The attributions give the fullest possible information that we could find to help you pinpoint the quotation in its appropriate context or discover more quotations in the original source. Judicial opinions and speeches include, when possible, the date of the opinion or speech. We assure the reader that not one of the quotations in this book was created by us.

In summary, *Chemically Speaking* is a book that has many uses. You can:

Identify the author of a quotation.
Identify the source of the quotation.
Check the precise wording of a quotation.
Discover what an individual has said on a subject.
Find sayings by other individuals on the same subject.

How to Use This Book

A quotation for a given subject may be found by looking for that subject in the alphabetical arrangement of the book itself. To illustrate, if a quotation on bubbles is wanted, you will find four quotations listed under the heading 'Bubble'. The arrangement of quotations in this book under each subject heading constitutes a collective composition that incorporates the sayings of a range of people.

The next method for finding information in the book is through the index. Lord Campbell wrote in the *Lives of the Chief Justices of England*:

So essential did I consider an index to be to every book, that I proposed to bring a bill into Parliament to deprive an author who publishes a book without an index of the privilege of copyright, and, moreover, to subject him for his offence to a pecuniary penalty.

Volume III
Preface

We have provided a SUBJECT BY AUTHOR INDEX and an AUTHOR BY SUBJECT INDEX to help you in finding a quote of interest.

To find all the quotations pertaining to a subject and the individuals quoted use the SUBJECT BY AUTHOR INDEX. This index will help guide you to the specific statement that is sought. A brief extract of each quotation is included in this index.

If you recall the name appearing in the attribution or if you wish to read all of an individual author's contributions that are included in this book then you will want to use the AUTHOR BY SUBJECT INDEX. Here the authors are listed alphabetically along with their quotations.

Thanks
It is never superfluous to say thanks where thanks are due. Firstly, we want to thank Jim Revill of IOP Publishing who has assisted us so very much with our books. Next, a most substantial debt of gratitude is extended to the following libraries for allowing us to use their resources: The Jesse H. Jones Library and the Moody Memorial Library, Baylor University; the main library of the University of Mary-Hardin Baylor; the main library of the Central Texas College; the Perry-Castañeda Library, the Undergraduate Library, the Engineering Library, the Law Library, the Physics–Math–Astronomy Library, and the Humanities Research Center, all of the University of Texas at Austin.

Samuel Johnson has written:

The greatest part of writer's time is spent in reading, in order to write: a man will turn over half a library to make one book.

In James Bosewell
Life of Johnson
Volume I
6 April 1775 (p. 581)

We are sure that Joe Gonzalez, Matt Pomeroy, Chris Braun, Ken McFarland, Craig McDonald, Kathryn Kenefik, Brian Camp, Robert Clontz, and Gabriel Acurado of the Perry-Castañeda Library certainly must believe that Johnson's statement is true since they had to put up with us when we were checking out the hundreds of books. Finally, we wish to thank our daughter Marilynn for her assistance in finding the books we needed when we were at the libraries.

A great amount of work goes into the preparation of any book. When the book is finished there is then time for the editors and authors to enjoy what they have written. It is hoped that this book will stimulate your imagination and interests in matters about nature and this hope has been eloquently expressed by Helen Hill:

If what we have within our book
Can to the reader pleasure lend,
We have accomplished what we wished,
Our means have gained our end.

In Llewellyn Nathaniel Edwards
A Record of History and Evolution of Early American Bridges (p. xii)

In closing we wish to leave you with these words from Jerry Flack.

Let us give students ideas worthy of their contemplation. The erudition found in quotations down through the ages is grist for the thinking of today's youth.

Teaching K-8
Quotations in the Classroom (p. 60)
Volume 24, Number 3, November/December 1993

Carl Gaither
Alma Cavazos-Gaither
28 February 2002

ABSTRACTION

Bohm, David
All is process. That is to say "there is '*no thing*' in the universe." Things, objects, entities, are abstractions of what is relatively constant from a process of movement and transformation. They are like the shapes that children like to see in the clouds.

In C.H. Waddington (ed.)
Towards a Theoretical Biology
Volume 2
Further Remarks on Order (p. 42)

Boole, George
Of the many forms of false culture, a premature converse with abstractions is perhaps the most likely to prove fatal to the growth of a masculine vigor of intellect.

A Treatise on Differential Equations
Preface (p. vi)

Devlin, Keith
The increased abstraction in mathematics that took place during the early part of this century was paralleled by a similar trend in the arts. In both cases, the increased level of abstraction demands greater effort on the part of anyone who wants to understand the work.

Mathematics: The Science of Patterns
Chapter 2 (p. 55)

Whitehead, Alfred North
It is this union of passionate interest in the detailed facts with equal devotion to abstract generalisation which forms the novelty in our present society…This balance of mind has now become part of the tradition which infects cultivated thought. It is the salt which keeps life sweet.

Science and the Modern World
Chapter I (p. 4)

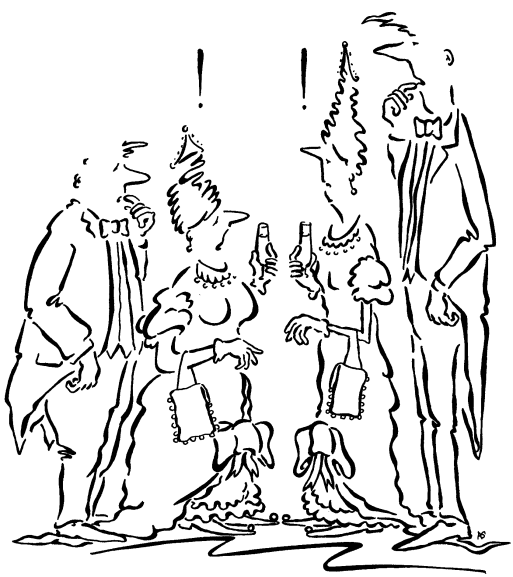
ACCIDENT

Gregg, Alan
One wonders whether the rare ability to be completely attentive to, and to profit by, nature's slightest deviation from the conduct expected of her is not the secret of the best research minds and one that explains why some men turn to most remarkably good advantage seemingly trivial accidents. Behind such attention lies an unremitting sensitivity…

The Furtherance of Medical Research
Chapter III (p. 98)

Lessing, Gotthold Ephraim
Nothing under the sun is coincidence.

Emilia Galotti
Act V, Scene 3



ACCURACY

Fresenius, C.R.
Knowledge and ability must be combined with ambition as well as with a sense of honesty and a severe conscience. Every analyst occasionally has doubts about the accuracy of his results, and also there are times when he knows his results to be incorrect. Sometimes a few drops of the solution were spilt, or some other slight mistake made. In those cases it requires a strong conscience to repeat the analysis and not to make a rough estimate of the loss or apply a correction. Anyone not having sufficient will-power to do this is unsuited to analysis no matter how great his technical ability or knowledge. A chemist who would not take an oath guaranteeing the authenticity, as well as the accuracy of his work, should never publish his results, for if he were to do so then the result would be detrimental, not only to himself, but to the whole of science.

In Ferenc. Szabadváry
History of Analytical Chemistry
Chapter VII (p. 176)

Jevons, William Stanley
Numerical precision is the soul of science…

The Principles of Science
Book III
Chapter XIII (p. 273)

Kolthoff, I.M.
Sandell, E.B.
Anyone who has acquired sufficient skill to make an exact analysis satisfactorily can adapt himself to the performance of a less accurate one—but the reverse is not true.

Textbook of Quantitative Inorganic Analysis
Introduction (p. 4)

ACID

Huheey, James E.
In a very real sense, we can make an acid be anything we wish—the differences between the various acid–base concepts are not concerned with which is "right" but which is *most convenient to use in a particular situation*.

Inorganic Chemistry: Principles of Structure and Reactivity
Chapter 6 (p. 207)

Unknown
Add acid to watuh
Just as you oughta.

Source unknown

ADSORPTION

Matthews, Albert
Adsorption. . . is a physico-chemical term meaning the concentration of substances at phase-boundaries in heterogeneous systems. Dressing can be called a process of adsorption. Every morning when we dress, clothing which has been distributed throughout our environment—dispersed in the surrounding phase—concentrates itself at the surface of our bodies. At night the process is reversed. We might go on to express these events by a curve or isotherm, showing how the quantity adsorbed is a function of the amount in the room, how it usually proceeds to an equilibrium, how it is greater at low than at high temperatures, that it is reversible and not accompanied by chemical change in the clothes, that it is specific in that certain clothes are adsorbed with greater avidity than others, that certain adsorbents (people) adsorb with greater avidity than others, or more so, and finally we could prove that the clothing moved into the surface film in virtue of the second law of thermodynamics and in consonance with the principle of Willard Gibbs.

In Joseph Needham
The Sceptical Biologist
The Sceptical Biologist, IV (p. 33)

AESTHETIC

Bernstein, Jeremy
In science as in the arts, sound aesthetic judgments are usually arrived at only in retrospect. A really new art form or scientific idea is almost certain at first to appear ugly. The obviously beautiful, in both science and the arts, is more often than not an extension of the familiar. It is sometimes only with the passage of time that a really new idea begins to seem beautiful.

Experiencing Science
Chapter I (p. 3)

Chesterton, G.K.
. . . aesthetics never do anything but what they are told.

Lunacy and Letters
The Love of Lead (p. 160)

du Noüy, Pierre Lecomte
Whenever there is no objective confirmation, our attitude toward certain theories depends, in the last resort, on aesthetic considerations, disturbing as this may seem.

The Road to Reason
Chapter I (fn 4, p. 30)

Sullivan, J.W.N.
. . . since the primary object of the scientific theory is to express the harmonies which are found to exist in nature, we see at once that these theories must have an aesthetic value. The measure of the success of a scientific theory is, in fact, a measure of its aesthetic value, since it is a measure of the extent to which it has introduced harmony in what was before chaos.

The Athenaeum
The Justification of the Scientific Method (p. 275)
Number 4644, 2 May 1919

Thomson, George P.
One can always make a theory, many theories, to account for known facts, occasionally even to predict new ones. The test is aesthetic.

The Inspiration of Science
Chapter II (p. 17)

AFFINITY

Whewell, William
Attractions take place between bodies, Affinities between the particles of a body. The former may be compared to the alliances of states, the latter to the ties of family.

The Philosophy of the Inductive Sciences
Volume II
Aphorisms
Aphorisms Concerning Ideas, LXXV (p. 458)

AGE

Barrie, J.M.
I'm not young enough to know everything.

The Admirable Crichton
Act I (p. 16)

Davy, Sir Humphry
The advance in years brings indifference, and at the same time strength and steadiness. The young sapling is moved by every breeze; shoots forth its leaves vigorously when favoured by dew and sunshine; but is often severely injured, if not destroyed, by frost. In the mature tree, as the heartwood is covered by many coatings of sapwood, it becomes compressed and harder; but though it loses its vitality, it contributes to the strength of the vegetable.

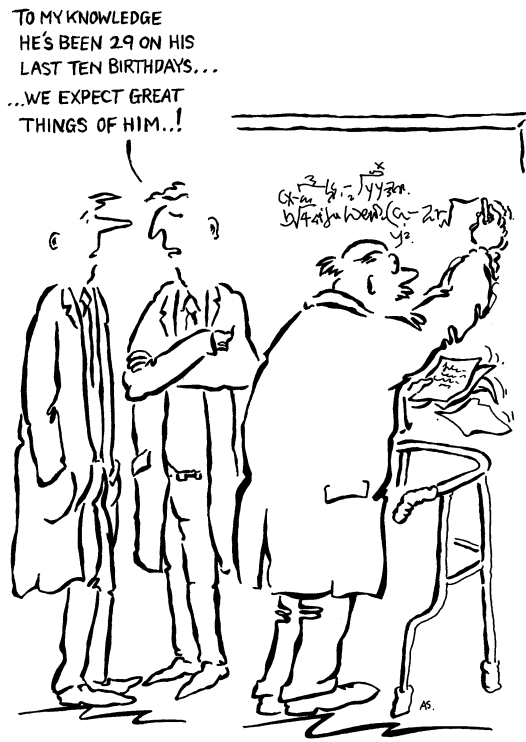
The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter IV (p. 214)

Dirac, P.A.M.
Age is, of course, a fever chill
that every physicist must fear.
He's better dead than living still
When once he's past his thirtieth year.

In Robert Jungk
Brighter Than a Thousand Suns
Chapter 2 (fn, p. 27)

Einstein, Albert
A person who has not made his great contribution to science before the age of thirty will never do so.

In S. Brodetsky
Nature
Newton: Scientist and Man (p. 699)
Volume 150, Number 3815, 12 December 1942



A person who has not made his great contribution to science before the age of thirty will never do so.
Albert Einstein – (See p. 9)

Priestley, Joseph
It may be my fate to be a kind of *comet*, or flaming *meteor* in science, in the regions of which (like enough to a meteor) I made my appearance very lately, and very unexpectedly; and therefore, like a meteor, it may be my destiny to move very swiftly, burn away with great heat and violence and become as suddenly extinct.

Philosophical Empiricism
Section V (p. 67)

. . . it may be my destiny to move very swiftly, burn away with great heat and violence and become as suddenly extinct.
Joseph Priestley – (See p. 10)

Unknown
A man's age can be measured by the degree of pain he feels as he comes in contact with a new idea.

Source unknown

AIR

Boyle, Robert
The generality of men are so accustomed to judge of things by their senses that, because the air is invisible, they ascribe but little to it, and think it but one remove from nothing.

In Sir W. Ramsay
The Gases of the Atmosphere
Chapter I (p. 10)

Fourcroy, Antoine-François
The atmosphere is a vast laboratory, in which nature operates immense analyses, solutions, precipitations, and combinations: it is a grand

receiver, in which all the attenuated and volatilized productions of terrestrial bodies are received, mingled, agitated, combined, and separated.

The Philosophy of Chemistry
Chapter III (p. 15)

Ramsay, Sir William
To tell the story of the development of men's ideas regarding the nature of atmospheric air is in great part to write a history of chemistry and physics.

The Gases of the Atmosphere
Chapter I (p. 1)

ALCHEMY

Kircher, Athanasius
. . . alchemy is a science, not yet known but which may become known.

In Bernard Jaffe
Crucibles: The Story of Chemistry
Chapter XVI (p. 331)

Lacinio, Giano
[Alchemy]. . . the key to all good things, the Art of Arts, the science of sciences.

The New Pearl of Great Price
The Third Distinction (pp. 138–9)

Mersenne
We can take pride in the fact that there is no science as certain as ours because it teaches by experience which is the mother, the source and the universal cause of all knowledge: and it is for the lack of this that Aristotle and the other philosophers have wondrously failed in their philosophy. . .

In Allen G. Debus
The French Paracelsians
Chapter 3 (p. 72)

Milton, John
If by fire
Of sooty coal th' empiric alchymist
Can turn, or holds it possible to turn,
Metals of drossiest ore to perfect gold.

Paradise Lost
Book V, L. 439–42

Norton, Thomas
Maistrie ful mervelous & Archymastrie
Is the tyncture of holey Alchymye,

A wonderful science, secrete philosophie,
A singuler grace & gyfte of almyghtie,
which neuir was fownde bi labour of mann,
But it bi teching, or by reuelacion bigan.

Ordinal of Alchemy
Capitulum I, L. 181–6

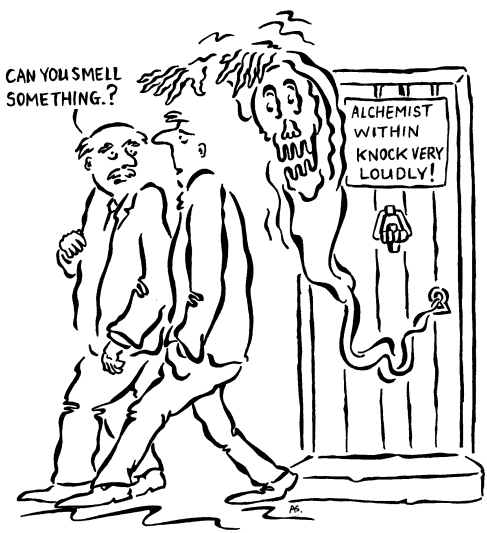
Paracelsus
The great virtues that lie hidden in nature would never have been revealed if alchemy had not uncovered them and made them visible. Take a tree, for example; a man sees it in the winter, but he does not know what it is, he does not know what it conceals within itself, until summer comes and discloses the buds, the flowers, the fruit…Similarly the virtues in things remain concealed to man, unless the alchemist disclose them, as the summer reveals the nature of the tree.

In Jolande Jacobi (ed.)
Paracelsus: Selected Writings
Chapter III (p. 218)

Pratchett, Terry
The explosion removed the windows, the door and most of the chimney.

It was the sort of thing you expected in the Street of Alchemists. The neighbours *preferred* explosions, which were at least identifiable and soon over. They were better than the smells, which crept up on you.

Moving Pictures (p. 15)



Most alchemists were nervous, in any case; it came from not knowing what the crucible of bubbling stuff they were experimenting with was going to do next.

Moving Pictures (p. 25)

Proverb, Spanish
It is approved alchemy to have an income and spend nothing.

In Robert Christy
Proverbs, Maxims and Phrases of All Ages
Alchemy (p. 21)

Sendivogius, Micheel
A Prince without People is unhappy; so is an Alchymist without Sulphur and Mercury.

A New Light of Alchymy
Of Sulphur (p. 145)

Shakespeare, William
You are an alchemist; make gold of that.

Timon of Athens
Act V, scene i, L. 117

AMBITION

Gay-Lussac
I have not chosen a career which will lead me to a great fortune, but that is not my principal ambition.

In Maurice Grosland
Gay-Lussac: Scientist and Bourgeois
Chapter I (p. 1)

ANALOGY

Chargaff, Erwin
When a science approaches the frontiers of its knowledge, it seeks refuge in allegory or in analogy.

Essays on Nucleic Acids
Chapter 8 (p. 119)

Davy, Sir Humphry
The substitution of analogy for fact is the bane of chemical philosophy; the legitimate use of analogy is to connect facts together and to guide to new experiments.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 14 (p. 200)

Emerson, Ralph Waldo
…science is nothing but the finding of analogy, identity, in the most remote parts.

The Works of Ralph Waldo Emerson
Volume IV
The American Scholar (p. 62)

Johnson-Laird, P.N.
A scientific problem can be illuminated by the discovery of a profound analogy, and a mundane problem can be solved in a similar way.

The Computer and the Mind
Chapter 14 (p. 266)

Latham, Peter
It is safest and best to fill up the gaps of our knowledge from analogy.

In William B. Bean
Aphorisms from Latham (p. 37)

Lichtenberg, Georg Christoph
The way to determine the secret workings of Nature is from analogous cases where one has caught her in the act.

In J.P. Stern
Lichtenberg: A Doctrine of Scattered Occasions
Further Excerpts from Lichtenberg's Notebooks (p. 293)

Maxwell, James Clerk
In order to obtain physical ideas without adopting a physical theory we must make ourselves familiar with the existence of physical analogies. By a physical analogy I mean that partial similarity between the laws of one science and those of another which makes each of them illustrate the other. Thus all the mathematical sciences are founded on relations between physical laws and laws of numbers, so that the aim of exact science is to reduce the problems of nature to the determination of quantities by operations with numbers. Passing from the most universal analogies to a very partial one we find the same resemblance in mathematical form between two different phenomena giving rise to a physical theory of light.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume I
On Faraday's Lines of Force (p. 156)

Pasteur, Louis
The arguments…by which you support my theories, are most ingenious, but not founded on demonstrated facts; analogy is no proof.

In R. Vallery-Radot
The Life of Pasteur
Chapter VIII (p. 223)

Strindberg, August
Two times two—is two, and I can prove that by analogy, the highest of all forms of proof. Listen! Listen now. One times one is one, so two times two must be two. For what applies to one must apply to the other.

A Dream Play
Section 12, The School (p. 42)

ANALYSIS

Berzelius, Jöns Jakob
Beginning chemists…should not fail to train themselves in quantitative analysis, for although it is nothing but manual work, one should remember that until one has mastered such work one lacks the skill to perform an accurate experiment of a more advanced sort. One must have such a habit of weighing carefully, of pouring from one vessel into another without spilling and without allowing the last drop to run over the edge, and of observing a large number of small details which, if overlooked, often spoil several weeks of careful work, that no distraction, no unforeseen circumstance can spoil the result; and before this habit is acquired, one must several times have had the annoyance of spoiling one's experiment through carelessness or thoughtlessness. If such an accident occurs, one should, as a matter of principle, always repeat the experiment at once rather than try to improve the result by a probable correction.

In J. Erik Jorpes
Jac. Berzelius (p. 41)

Blanshard, Brand
A mind with muscles so flabby that it sickens under a little gymnastics, is one whose creations we can afford to lose. And the fact seems to be that analysis, if not indulged to excess, is an aid, not a hindrance, to appreciation.

The Nature of Thought
Volume I
Chapter VI, Section 17 (p. 239)

Emerson, Ralph Waldo
The great gifts are not got by analysis.

The Works of Ralph Waldo Emerson
Volume I
Essays
Second Series
Experience (p. 270)

Hillerbrand, W.F.
Lundell, G.E.F.
A distinction should be noted between the analysis of pure substances and the analysis of mixtures. The determination of an element in its pure compounds by volumetric or gravimetric procedures is a mechanical operation which bears the same relation to the analysis of mixtures that finger exercises do to the playing of a piano. Training along such lines is necessary. It should be understood, however, that it is only a beginning. Too often the training of the student stops at this point. If he pursues the subject no further, he carries away an entirely erroneous conception of the analyst's task and of the accuracy that he should obtain. The test of an analyst is his ability to choose the proper line of attack for the analysis of the material in hand, to modify existing methods of analysis or devise new ones if necessary, to carry the analysis through, and to put the proper interpretation on the result that is obtained.

Applied Inorganic Analysis
Chapter I, Section I (p. 2)

Huxley, Thomas
In ultimate analysis everything is incomprehensible, and the whole object of science is simply to reduce the fundamental incomprehensibilities to the smallest possible number.

Collected Essays
Volume II
Darwiniana
Mr Darwin's Critics (p. 165)

Lampadius, W.A.
For work in all natural sciences persistency is needed, but especially in analytical chemistry. At the beginning of my analytical work many analyses were wrong, because I could not wait until the reagent dissolved the mineral, or until the filtration, washing or similar operations were finished according to their order. Those who cannot wait weeks and months for the results, should never begin analytical work.

In Ferenc. Szabadváry
History of Analytical Chemistry
Chapter VIII (p. 199)

Newton, Sir Isaac
As in mathematicks, so in natural philosophy, the investigation of difficult things by the method of analysis, ought ever to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by

induction, and admitting of no objections against the conclusions but such as are taken from experiments, or other certain truths.

Opticks
Book III, Part I (p. 543)

Poe, Edgar Allan
. . . analytical power should not be confounded with simple ingenuity; for while the analyst is necessarily ingenious, the ingenious man is often remarkably incapable of analysis.

Complete Tales and Poems of Edgar Allan Poe
The Murders in the Rue Morgue (p. 143)

von Goethe, Johann Wolfgang
An age that specializes exclusively in analysis and is, as it were, afraid of synthesis is not on the right path. For only both of them together, like breathing, in and out, make up the life of science.

Wisdom and Experience
Science and Philosophy (p. 122)

Wilson, E. Bright
Observations are useless until they have been interpreted. The analysis of experimental data therefore forms a critical stage in every scientific inquiry—a stage which has been responsible for most of the failures and fallacies of the past.

An Introduction to Scientific Research
Chapter 8 (p. 169)

ANALYST

Blair, Andrew Alexander
The speed and faculty with which results may be obtained, and often the accuracy of these results, are dependent upon various mechanical appliances as well as upon the skill of the analyst.

The Chemical Analysis of Iron
Apparatus (p. 11)

Nalimov, V.V.
The existence of a multitude of new physico-chemical methods of analysis, side by side with the classical methods of chemical analysis, urgently raises the question of finding out rational criteria for comparing the results obtained by various analytical methods. The development and introduction of new analytical methods take place considerably faster than their standardization…It is already evident that an analyst must be as thoroughly familiar with the methods of modern mathematical statistics as the geodesist is with the method of least squares.

The Application of Mathematical Statistics to Chemical Analysis
Preface (pp. vii–viii)

Winkler, Clemens
The truly successful performance of researches in inorganic chemistry is possible only to one who is not only a theoretical chemist but also an accomplished analyst and moreover, not merely a practically trained, mechanical worker, but a thinking, creative artist.

In Mary Elvira Weeks
Discovery of the Elements (p. 399)

ANSWER

Atkins, Peter W.
Yet the stern and stony eye of science seeks answers that are not grounded in the fundamentality of purpose...

New Scientist
Will Science Ever Fail? (p. 32)
Volume 135, Number 1833, 8 August 1992

Carroll, Lewis
His answer trickled through my head,
Like water through a sieve.

Alice's Adventure in Wonderland and Through the Looking-Glass
Through the Looking-Glass
It's My Own Invention (p. 126)

Hawking, Stephen W.
There may be ultimate answers, but if there are, I would be sorry if we were to find them. For my *own* sake I would like very much to find them, but their discovery would leave nothing for those coming after me to seek. Each generation builds on the advances of the previous generation, and this is as it should be. As human beings, we need the quest.

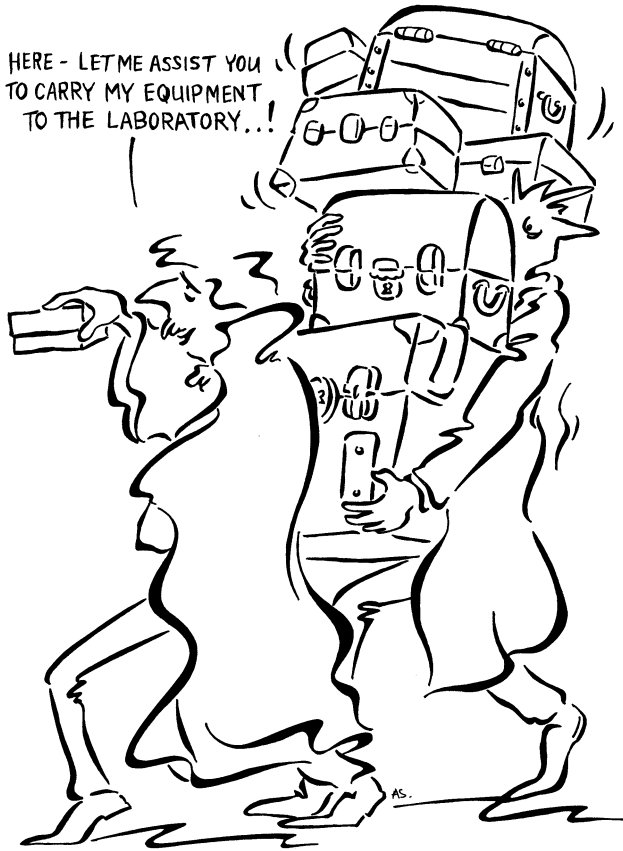
In J.L. Wilhelm
Quest
A Singular Man (p. 39)
April 1979

APPARATUS

Davy, Sir Humphry

The apparatus essential to the modern chemical philosopher is much less bulky and expensive than that used by the ancients. An air pump, an electrical machine, a voltaic battery (all of which may be upon a small scale), a blow-pipe apparatus, a bellows and forge, a mercurial and water gas apparatus, cups and basins of platinum and glass, and the common reagents of chemistry, are what are required. All the implements absolutely necessary may be carried in a small trunk; and some of the best and most refined researches of modern chemists have been made by means of an apparatus which might with ease be contained in a small travelling carriage, and the expense of which is only a few pounds.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue the Fifth (pp. 364–5)



. . . All the implements absolutely necessary may be carried in a small trunk; and some of the best and most refined researches of modern chemists have been made by means of an apparatus which might with ease be contained in a small travelling carriage. . .

Sir Humphrey Davy – (See p. 25)

APPROXIMATE

Emerson, Ralph Waldo
We live in a system of approximations. Every end is prospective of some other end, which is also temporary; a round and final success nowhere. We are encamped in nature, not domesticated.

The Works of Ralph Waldo Emerson
Volume I
Essays
Second Series
Nature (p. 360)

ATOM

Atkins, Peter W.
. . . one or two atoms can convert a fuel to a poison, change a color, render an inedible substance edible, or replace a pungent odor with a fragrant one. That changing a single atom can have such consequences is the wonder of the chemical world.

Molecules (p. 2)

One of the wonders of this world is that objects so small can have such consequences: Any visible lump of matter—even the merest speck—contains more atoms than there are stars in our galaxy.

Molecules (p. 4)

Each new atom brings something of the personality of its element to the molecule, and this conspiracy of atoms results in a molecule with properties that are richer than those of each atom alone.

Molecules (p. 13)

Benchley, Robert
. . . the atom is composed of little pieces of old pocket lint.

Benchley Lost and Found
Atom Boy (p. 80)

Bentley, Richard
. . . the *fortuitous or casual concourse of atoms*. . .

The Works of Richard Bentley, D.D.
Volume III
Sermon VII (p. 147)

...the atom is composed of little pieces of old pocket lint.
Robert Benchley – (See p. 28)

Berthelot, Marcellin
I do not want chemistry to degenerate into a religion; I do not want the chemist to believe in the existence of atoms as the Christian believes in the existence of Christ in the communion wafer.

Berichte der Deutschen Chemischen Gesellschaft
In C. Graebe
Marcellin Berthelot (p. 4855)
Volume 41, 1908

Bridges, Robert Seymour
From universal mind the first born atoms draw their function, whose rich chemistry the plants transmute to make organic life...

Poetical Works of Robert Bridges
Testament of Beauty

Butler, Samuel
Some things can teach much to some things and little to others; some can be taught much by some things and little by others; some can neither be

taught much nor teach much. All depends upon the kind of company into which an atom has got. If it has got into bad hands it will have to part company with them before it can get into better. But all atoms being immortal go on learning and unlearning, combining and separating, appointing, disappointing, and being disappointed for ever and ever.

In Geoffrey Keynes and Brian Hill (eds.)
Samuel Butler's Notebooks
Immortality of Atoms and Teaching (p. 126)

We shall never get people whose time is money to take much interest in atoms.

In Geoffrey Keynes and Brian Hill (eds.)
Samuel Butler's Notebooks
Atoms (p. 133)

The puzzle which puzzles every atom is the same which puzzles ourselves—a conflict of duties—our duty towards ourselves, and our duty as members of a body politic. It is swayed by its sense of being a separate thing—of having a life to itself which nothing can share; it is also swayed by the feeling that in spite of this it is only part of an individuality which is greater than itself and which absorbs it.

In Geoffrey Keynes and Brian Hill (eds.)
Samuel Butler's Notebooks
Unity and Separateness (p. 143)

The element of free-will, spontaneity, individuality, so omnipresent, so essential, yet so unreasonable and so inconsistent with the other element not less omnipresent and not less essential, I mean necessity—this element of free-will which comes from the unseen kingdom within which the writs of our thoughts run not, must be carried down to the most tenuous atoms, whose action is supposed most purely chemical and mechanical; it can never be held as absolutely eliminated, for if it be so held there is no getting it back again, and that it exists even in the lowest forms of life cannot be disputed. Its existence is one of the proofs of the existence of an unseen world, and a means whereby we know the little that we know at all.

In Geoffrey Keynes and Brian Hill (eds.)
Samuel Butler's Notebooks
Free-Will in Atoms (p. 197)

Cavendish, Margaret
. . . nothing can be less than atoms.

Poems and Fancies
The Bell in St Paul's Churchyard

Close, Frank
Marten, Michael
Sutton, Christine

Take a deep breath! You have just inhaled oxygen atoms that have already been breathed by every person who ever lived. At some time or other your body has contained atoms that were once part of Moses or Isaac Newton. The oxygen mixes with carbon atoms in your lungs and you exhale carbon dioxide molecules. Chemistry is at work. Plants will rearrange these atoms, converting carbon dioxide back to oxygen, and at some future date our descendants will breathe some in.

If atoms could speak, what a tale they would tell.

The Particle Explosion
Chapter 1 (p. 7)

Atoms are the complex end-products of creation. Their basic constituents were created within the first seconds of the Big Bang. Several thousand years elapsed before these particles combined to make atoms. The cold conditions where atoms exist today are far removed from the intense heat

of the Big Bang. So to learn about our origins we have to see within the atoms, and study the seeds of matter.

The Particle Explosion
Chapter 1 (p. 7)

Cole, A.D.
. . . an atom is a world in itself. . . How has the indivisible unit evolved into the complex microcosm we now imagine?

Science
Recent Evidence for the Existence of the Nucleus Atom (p. 73)
N.S. Volume XLI, Number 1046
Friday, 15 January 1915

Dalton, John
These observations have tacitly led to the conclusion which seems universally adopted, that all bodies of sensible magnitude, whether liquid or solid, are constituted of a vast number of extremely small particles, or atoms of matter. . .

A New System of Chemical Philosophy
Volume I
Part 1, Chapter II (p. 141)

Darrow, Karl K.
One of the things which distinguishes ours from all earlier generations is this, that WE HAVE SEEN OUR ATOMS.

The Renaissance of Physics
Chapter VI (p. 107)

Darwin, Erasmus
Dull atheist, could a giddy dance
Of atoms lawlessly hurl'd
Construct so wonderful, so wise,
So harmonised a world?

In Paul H. Barrett and R.B. Freeman (eds.)
The Works of Charles Darwin
Volume 29
Erasmus Darwin
Preface (p. 44)

Davies, Paul
. . . the rules of clockwork might apply to familiar objects such as snooker balls, but when it comes to atoms, the rules are those of roulette.

God and the New Physics
Chapter 8 (p. 102)

Democritus

[Atoms] have all sorts of shapes and appearances and different sizes…Some are rough, some hook-shaped, some concave, some convex and some have other innumerable variations.

In Samuel Sambursky
The Physical World of the Greeks
Chapter V (pp. 110–11)

The atoms are at war with one another as they move along in the void owing to their dissimilarity and their other differences, and as they move they collide and are interlaced in a manner which makes them touch and be near to one another, but they never really produce any single existence out of them: for it is quite absurd to suppose that two or more things could ever become one.

In Cyril Bailey
The Greek Atomists and Epicurus
Chapter III, Section 3 (p. 136)

Douglas, A. Vibert

You cannot solve the riddles of the stars without invoking the aid of the atom, nor can you fully comprehend the atom without the aid of the stars. On the uplifting wings of imagination the astrophysicist roams the universe from atom to atom, from star to star, from star to atom, from atom to star. Impelled by curiosity regarding the natural universe, encouraged by the evidences for his faith in the reality of cosmic harmony, he presses on and on—a sweet and a fitting thing it is to toil for the Truth.

The Atlantic Monthly
From Atoms to Stars (p. 165)
Volume 144, August 1929

Dryden, John

From harmony, from heav'nly harmony
This universal frame began:
When Nature underneath a heap
of jarring atoms lay,
And could not heave her head…

The Poetical Works of Dryden
A Song for St Cecilia's Day
L. 4–8

The airy atoms did in plagues conspire…

The Poetical Works of Dryden
Britannia Rediviva
L. 154

To be the child of chance, and not of care,
No atoms casually together hurl'd.

The Poetical Works of Dryden
To my Honor'd Friend Sir Robert Howard
L. 31–2

So many huddled atoms make a play…

The Poetical Works of Dryden
Prologue and Epilogue to the University of Oxford
L. 31

May, tho' our atoms should resolve by chance…

The Poetical Works of Dryden
Lucretius
L. 19

For then our atoms, which in order lay,
Are scatter'd from their heap, and puff'd away…

The Poetical Works of Dryden
Lucretius
L. 119–20

Eddington, Sir Arthur Stanley
The atom is as porous as the solar system.

The Nature of the Physical World
Chapter I (p. 1)

Emerson, Ralph Waldo
The intellect sees that every atom carries the whole of Nature…

The Works of Ralph Waldo Emerson
Volume III
The Conduct of Life
Illusions (p. 211)

You cannot detach an atom from its holdings, or strip off from it the electricity, gravitation, chemic affinity, or the relation to light and heat, and leave the atom bare.

The Works of Ralph Waldo Emerson
Volume III
Society and Solitude
Farming (p. 303)

For the world was built in order,
And the atoms march in tune;
Rhyme the pipe, and Time the warder

Cannot forget the sun, the moon.

The Works of Ralph Waldo Emerson
Volume V
Poems
Monadnock, L. 245–8 (p. 134)

Faraday, Michael
But I must confess I am jealous of the term *atom*; for though it is very easy to talk of atoms, it is very difficult to form a clear idea of their nature, especially when compound bodies are under consideration.

Experimental Researches in Electricity
Volume I
Series VII, Section 869 (p. 256)

Feynman, Richard
Leighton, R.B
Sands, M.
If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, if you wish to call it that) that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.

The Feynman Lectures in Physics
Volume I
(pp. 1–2)

Everything is made of atoms. That is the key hypothesis.

The Feynman Lectures in Physics
Volume I
(pp. 1–8)

. . . if all of this, all the life of a stream of water, can be nothing but a pile of atoms, how much more is possible?

The Feynman Lectures in Physics
Volume I
(pp. 1–9)

The behavior of things on a very tiny scale is simply different. An atom does not behave like a weight hanging on a spring and oscillating. An atom does not behave like a miniature representation of the solar system with little planets going around orbits. Nor does it appear to be somewhat

like a cloud or fog of some sort surrounding the nucleus. It behaves like nothing you have ever seen before.

The Character of Physical Law
Chapter 6 (p. 128)

Gassendi, Pierre
As letters are the elements of writing and from letters are formed first syllables, and then successively words, phrases, and speeches, so also atoms are the elements of all things. From the atoms the smallest molecules are joined together first, and then successively somewhat bigger ones, still bigger ones, the finest and the coarsest bodies, and finally the biggest bodies.

In Walter Charleton
Physiologia Epicuro-Gassendo-Charltoniana; or,
A fabrick of science natural, upon the hypothesis of atoms
founded by Epicurus, repaired by Petrus Gassendus, augmented by Walter Charleton
Animadversions (p. 108)

Hall, John
If that this thing we call the world
By chance on atoms was begot
Which through in ceaseless motion whirled
Yet weary not
How doth it prove
Thou art so fair and I in love.

In John D. Barrow
The World within the World (p. 162)

Harrow, Benjamin
If the constituent atoms in a tumbler of water could all be labeled for later identification, and the water were then mixed with all the water in the world, and if, after thorough mixing, the tumbler were again filled, it would contain two thousand of the original atoms.

In Bernard Jaffe
New World of Chemistry (p. 56)

Heisenberg, Werner
…atoms are neither things nor objects…atoms are parts of observational situations…

Physics and Beyond
Chapter 10 (p. 123)

Higgins, Bryan
…the atoms of each element are globular or nearly so; and that the spiral, spicular and other figures ascribed to these atoms, are fictitious,

unnecessary, and are inconsistent with the uniformity of nature, and are repugnant to experience.

In D.S.L. Cardwell (ed.)
John Dalton & the Progress of Science
Quoted in B.B. Kelham
Atomic Speculation in the Late Eighteenth Century (p. 112)

Huxley, Aldous
Atoms, or perhaps it would be more accurate to say those aspects of the atom which scientists chose to consider, are immeasurably less complicated than men.

Proper Studies
Introduction (p. vii)

Kekulé, F. August
The question of whether atoms exist or not has but little significance from a chemical point of view: its discussion belongs rather to metaphysics. In chemistry we have only to decide whether the assumption of atoms is an hypothesis adapted to the explanation of chemical phenomena. More especially have we to consider the question whether a further development of the atomic hypothesis promises to advance our knowledge of the mechanism of chemical phenomena…

Should the progress of science lead to a theory of the constitution of chemical atoms—important as such a knowledge might be for the general philosophy of matter—it would make but little alteration in chemistry itself. The chemical atoms will always remain the chemical unit…

In Ida Freund
The Study of Chemical Composition
Chapter XIX (p. 624)

Lamarck, Jean-Baptiste
The most important discoveries of the laws, methods and progress of Nature have nearly always sprung from the examination of the smaller objects which she contains.

In James R. Newman
The World of Mathematics
Volume 2 (p. 842)

Mann, Thomas
For the molecule was composed of atoms, and the atom was nowhere near large enough even to be spoken of as extraordinarily small. It was so small, such a tiny, early transitional mass, a coagulation of the unsubstantial, of the not-yet-substantial and yet substance-like, of energy, that it was scarcely possible yet—or, if it had been, was now no longer

possible—to think of it as material, but rather as mean and border-line between the material and immaterial.

The Magic Mountain
Chapter V
Research (p. 283)

Maxwell, James Clerk
An atom is a body which cannot be cut in two.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Molecules (p. 361)

[Atoms]... the imperishable foundation-stones of the universe.

In James Jeans
The Mysterious Universe
Chapter III (p. 64)

At quite uncertain times and places,
The atoms left their heavenly path,
And by fortuitous embraces,
Engendered all that being hath.

In Lewis Campbell and William Garnett
The Life of James Clerk Maxwell
Molecular Evolution (p. 637)

How freely he scatters his atoms before the beginning of years;
How he clothes them with force as a garment, those small

incompressible spheres!

In Lewis Campbell and William Garnett
The Life of James Clerk Maxwell
British Association, 1874 (p. 639)

At any rate the atoms are a very tough lot, and can stand a great deal of knocking about…

In Lewis Campbell and William Garnett
The Life of James Clerk Maxwell
Correspondence (p. 391)

In the very beginning of science,
the parsons, who managed things then,
Being handy with hammer and chisel,
made gods in the likeness of men;
Till Commerce arose and at length
some men of exceptional power
Supplanted both demons and gods by
the atoms, which last to this hour.

In John D. Barrow
The World within the World (p. 168)

Nabokov, Vladimir
But the individual atom is free: it pulsates as it wants, in low or high gear; it decides itself when to absorb and when to radiate energy.

Bend Sinister (p. 159)

Pallister, William
Each atom is a tiny universe
In which electrons in orbit rehearse
The motions of the planets round the sun,
In miniature the actions there begun.
It particles revolve so far apart
The solar system might have taught the art.

Poems of Science
Men and the Stars
Within the Atom

Pope, Alexander
See plastic nature working to this end,
The single atoms each to other tend,
Attract, attracted to, the next place

Form'd and impell'd its neighbor to embrace.

The Complete Poetical Works of Pope
An Essay on Man
Epistle III, L. 9–12

Ramsay, Sir William
So the atoms in turn, we now clearly discern,
Fly to bits with the utmost facility;
They wend on their way, and, in splitting, display
An absolute lack of stability.

Industrial and Engineering Chemistry: News Edition.
The Death-Knell of the Atom (p. 18)
Volume 8, Number 18, 20 January 1930

Robb, Alfred Arthur
All preconceived notions he sets at defiance
By means of some neat and ingenious appliance
By which he discovers a new law of science
Which no one had ever suspected before.
All the chemists went off into fits,
Some of them thought they were losing their wits,
When quite without warning
(Their theories scorning)
The atom one morning
He broke into bits.

In Cecilia Payne-Gaposchkin
Introduction to Astronomy
On J.J. Thomson (p. 341)

What's in an atom, the innermost substratum
That's the problem he is working at today.

In Cecilia Payne-Gaposchkin
Introduction to Astronomy
On Rutherford (p. 341)

A Corpuscle once did oscillate so quickly to and fro,
He always raised disturbances wherever he did go.
He struggled hard for freedom against a powerful foe—
An atom—who wouldn't let him go.

The American Physics Teacher
The Revolution of the Corpuscle (p. 180)
Volume 17, Number 3, June 1939

Robert, Cecil
What the atom of each element is, whether it is a movement, or a thing, or a vortex, or a point having inertia, whether there is any limit to its

divisibility, and, if so, how that limit is imposed, whether the long list of elements is final, or whether any of them have any common origin, all these questions remain surrounded by a darkness as profound as ever.

In Alan A. Gromestein
The Roots of Things
Chapter 10 (p. 261)

Roscoe, H.E.
Atoms are round bits of wood invented by Mr Dalton.

In William H. Brock
The Norton History of Chemistry
Chapter 4 (p. 128)

Rutherford, Ernest
The atom will always be a sink of energy and never a reservoir.

In Ritchie Calder
Profile of Science
Chapter 1 (p. 22)

Smith, Angus
We believe in atoms, because Nature seems to use them, and we break them up continuously because we do not know where to stop. There are various methods of spanning the distance from nothing to something.

In Ida Freund
The Study of Chemical Composition
Chapter XI (p. 301)

Smith, Sydney
Let onion atoms lurk within the bowl…

The Wit and Wisdom of Sydney Smith
Recipe for a Salad (p. 429)

Soddy, Frederick
Yet the atom, for all that, is not Nature's unit, but ours.

Matter and Energy
Chapter V (p. 143)

Stedman, Edmund Clarence
White orbs like angels pass
  Before the triple glass,
That men may scan the record of each flame,—
    Of spectral line and line
    The legendary divine,—
Finding their mould the same, and aye the same,

The atoms that we knew before
Of which ourselves are made,—dust, and no more.

The Atlantic Monthly
Poems of Occasion
Corda Concordia (p. 181)
Volume 48, Issue 286, 1881

Thomson, William (Lord Kelvin)
The idea of an atom has been so constantly associated with incredible assumptions of infinite strength, absolute rigidity, mystical actions at a distance and indivisibility, that chemists and many other reasonable naturalists of modern times, losing all patience with it, have dismissed it to the realms of metaphysics, and made it smaller than "anything we can conceive".

Nature
On the Size of Atoms (p. 551)
Volume 1, 31 March 1870

Tyndall, John
Take your dead hydrogen atoms, your dead nitrogen-atoms, your dead phosphorus-atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless, observe them running together and forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion are to arise?

Address Delivered Before the British Association Assembled at Belfast (p. 37)
Report of the 44th Meeting
August 1874

Unknown
When they broke open molecules, they found they were filled with atoms. But when they broke open atoms, they found they were filled with explosions.

Source unknown

To split the mighty atom
All mankind was intent.
Now any day the atom may
Return the compliment.

Source unknown

Vaihinger, Hans
The opponents of the atom are generally content to point to its contradictions and reject it as unfruitful for science. A rash form of caution, for without the atom science falls.

The Philosophy of 'As if'
Chapter XV (pp. 70–1)

von Lindermann, Louis Ferdinand
. . . the oxygen atom has the shape of a ring, and the sulphur atom, the shape of a clot.

Quoted by L.I. Ponomarev
The Quantum Dice
Chapter 3 (p. 40)

Walker, Kenneth
. . . we first described billiard balls in terms of atoms and then described atoms in terms of billiard balls, a description that brought us no nearer to a true understanding of the ultimate nature of either billiard balls or atoms.

Meaning and Purpose
Chapter XIV (p. 153)

Wallace, Robert C.
It is almost with a sense of shock that we realize that the essence of physics and chemistry alike lies in the arrangements within the atom.

Canadian Historical Review
Cooperation in the Natural and Human Sciences (p. 374)
Volume XIV, Number 4, December 1933

Whitman, Walt
For every atom belongs to me as good as belongs to you.

Complete Poetry and Collected Prose
Song of Myself
I

Wordsworth, William
To let a creed, built in the heart of
things,
Dissolve before a twinkling atom!

The Poetical Works of William Wordsworth
The Borderers
Act III, L. 1220–1

Wysong, R.L.
A well known principle in physics is the Heisenberg principle of uncertainty. The principle basically argues that the movement of electrons and atoms is a random process. If the atom is governed by random processes, how could there be biochemical bias? If the law of the atom is randomness how can we cite the atom as the source of order?

The Creation–Evolution Controversy
Chapter 7 (p. 126)

ATOMIC WEIGHT

Richards, Theodore W.
If our inconceivably ancient Universe even had any beginning, the conditions determining that beginning must even now be engraved in the atomic weights. They are the hieroglyphics which tell in a language of their own the story of the birth or evolution of all matter, and the Periodic Table containing the classification of the elements is the Rosetta Stone, which may enable us to interpret them. Until, however, these hieroglyphics are clearly visible in their true form, we cannot hope for an interpretation.

In Nobel Foundation
Nobel Lecture
Chemistry 1901–1921
6 December 1919 (p. 282)

Unknown
The atomic weight of silver is 107.8. After all, everybody knows the atomic weight of the Lone Ranger's horse.

Source unknown

The atomic weight of silver is 107.8. After all, everybody knows the atomic weight of the Lone Ranger's horse.
Unknown – (See p. 45)

AUTHORITY

Andreski, Stanislav
So long as authority inspires awe, confusion and absurdity enhance conservative tendencies in society. Firstly, because clear and logical thinking leads to a cumulation of knowledge (of which the progress of the natural sciences provides the best example) and the advance of knowledge sooner or later undermines the traditional order. Confused thinking, on the other hand, leads nowhere in particular and can be indulged indefinitely without producing any impact upon the world.

Social Sciences as Sorcery
Chapter 7 (p. 90)

Browne, Sir Thomas
. . . the mortallest enemy unto Knowledge, and that which hath done the greatest execution upon truth, hath been a peremptory adhesion unto Authority, and more especially, the establishing of our belief upon the dictates of Antiquity.

The Works of Sir Thomas Browne
Volume I
Pseudodoxia Epidemica
Chapter VI (p. 152)

AVERAGE

Maxwell, James Clerk

The data of the statistical method as applied to molecular science are the sums of large numbers of molecular quantities. In studying the relations between quantities of this kind, we meet with a new kind of regularity, the regularity of averages, which we can depend upon for all practical purposes, but which can make no claim to the character of absolute precision which belongs to the laws of abstract dynamics… molecular science teaches us that our experiments can never give us anything more than statistical information, and that no law deduced from them can pretend to absolute precision.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Molecules (pp. 373–4)

BALANCE

Chargaff, Erwin
A balance that does not tremble cannot weigh.

Heraclitean Fire
Part III
The Trembling of the Balance (p. 179)

Johnston, James Finlay Weir
. . . the first object one notices is a glass case standing on a table. It is the balance. How much light this fragile, simple instrument has shed on the natural sciences! How many phenomena it has explained! How many hidden truths it has revealed! Who could enumerate the discussions it has ended, the hypotheses it has destroyed! Who, in former times, would have believed that the determination of abstract truths and the development of the laws of nature would depend on the oscillations of this moving beam!

In Mary Elvira Weeks
Discovery of the Elements
Chapter 12 (pp. 533–4)

von Liebig, Justus
For all great discoveries chemists are indebted to the "balance"—that incomparable instrument which gives permanence to every observation, dispels all ambiguity, establishes truth, detects error, and guides us in the true path of inductive science.

Familiar Letters on Chemistry
Letter I (p. 6)

BEAUTY

Aristotle
Now since the good and the beautiful are different... those who assert that the mathematical sciences say nothing of the beautiful or the good are in error. For these sciences say and prove a great deal about them; if they do not expressly mention them, but prove attributes which are their results or definitions, it is not true that they tell us nothing about them. The chief forms of beauty are order and symmetry and definiteness, which the mathematical sciences demonstrate in a special degree.

Metaphysics
Book XIII, Chapter 3, 1078^{a} [30]

Boltzmann, Ludwig
Certain methods have frequently yielded the most beautiful results, and many persons have been tempted to believe that the development of science to the end of all time would consist in the systematic and unremitting application of them. But suddenly they begin to show indications of impotency, and all efforts are then bent upon discovering new and antagonistic methods. Then there usually arises a conflict between the adherents of the old method and those of the new. The point of view of the former is characterised by its opponents as antiquated and obsolete; whilst its upholders in their turn look down with scorn upon the innovators as perverters of true classical science.

The Monist
The Recent Development of Method in Theoretical Physics (p. 229)
Volume 11, 1901

Dirac, P.A.M.
The researcher worker, in his efforts to express the fundamental laws of Nature in mathematical form, should strive mainly for mathematical beauty. He should still take simplicity into consideration in a subordinate way to beauty.... It often happens that the requirements of simplicity

and of beauty are the same, but where they clash the latter must take precedence.

Proceedings of the Royal Society (Edinburgh)
The Relation between Mathematics and Physics (p. 124)
Volume LIX, 25 February 1939

Shaftesbury, Anthony Ashley Cooper
There is no one who, by the least progress of science or learning, has come to know barely the principles of mathematics, but has found, that in the exercise of his mind on the discoveries he there makes, though merely of speculative truths, he receives a pleasure and delight superior to that of sense. When we have thoroughly searched into the nature of this contemplative delight, we shall find it of a kind which relates not in the least to any private interest of the creature, nor has for its object any self-good or advantage of the private system.

Characteristics of Men, Manners, Opinions, Times, etc.
Volume I
Treatise IV
An Inquiry Concerning Virtue or Mercy
Book II, Part II, Section I (p. 296)

BIOCHEMISTRY

Chantrenne, H.
Biochemistry is no longer the chemistry of death and decay; it is the chemistry of the living cell, with its essential irreversible, oriented processes admirably organized and controlled.

In Nathan O. Kaplan and Eugene P. Kennedy (eds.)
Current Aspects of Biochemical Energetics
For the 25th Anniversary of $\sim$ P (p. 37)

Chargaff, Erwin
. . . biochemistry is helpless before life, having to kill the organism before investigating it. Biochemistry is, in fact, much more successful in practicing the second part of its composite name than in following the prefix.

Perspectives in Biology and Medicine
Triviality in Science: A Brief Meditation on Fashions (p. 333)
Volume 19, Number 3, Spring 1976

Darling, David
Every human being, and every human mind, has roots that extend indefinitely far back through time. The genes that regulate all aspects of our physical development, including the prenatal fabrication of our brains, were in existence long before we or our parents were born. Those genes, in turn, evolved, step by step, from more primitive genetic material that can trace its ancestry back to the first biochemical reactions on Earth. And we do not have to stop there. We can carry the search for the ultimate origin of ourselves back still further-back to the very beginning of the universe.

Equations of Eternity
Chapter 2 (p. 22)

Deutscher, Murray
To dialyze, or not to dialyze—that is the question:—

Whether 'tis better for the protein to suffer
The wear and tear of defective Visking
Or to take the chances against a sea of buffers
By chromatography instead?

Perspectives in Biology and Medicine
Biochemist's Soliloquy (p. 277)
Volume VIII, Number 2, Winter 1965

Fruton, Joseph S.
Simmonds, Sophia
The ultimate goal of biochemistry is to describe the phenomena that distinguish the "living" from the "non-living" in the language of chemistry and physics.

General Biochemistry
Chapter 1 (p. 1)

Hopkins, Frederick Gowland
The task of the biochemist wishing to get to the heart of his problem is exceptional in that he must study systems in which the organization of chemical events counts for more, and is carried far beyond, such simpler coordinations as may be found in non-living systems. He would be overbold were he to claim at present that such high organization can depend alone upon adjusted concentrations and ordered structural distributions among specialized colloidal catalysts, but he is justified, I think, in feeling sure that such factors contribute to that organization in a significant sense. The biochemist, when he aims at describing living systems in his own language, comes in contact with philosophical thought.... His may not be the last word in the description of life, but without his help the last word will never be said.

In Joseph Needham and Ernest Baldwin (eds.)
Hopkins & Biochemistry
Problems of Specificity in Biochemical Catalysis
33rd Robert Boyle Lecture, 1931 (p. 223)

Rose, Steven
Biochemists are different from organic and natural-product chemists in a number of important ways. *First*, for us the structure, sequence and molecular properties of substances derived from living organisms are not of great interest in their own right, but only insofar as they may be seen as providing information which casts light on the biological role of the substance.... *Second*,...we are likely to be less interested in the properties

of 'pure' molecules in isolation, and more concerned with the ways in which they are involved in complex interactions with other molecules.

Trends in Biochemical Sciences
Reflections on Reductionism (p. 161)
Volume 13, May 1988

van Bergeijk, W.A.
Biology implies biochemistry, but not the other way around.

In George Gaylord Simpson
Biology and Man (p. 19)

BOOK

Carroll, Lewis
And what is the use of a book, thought Alice, without pictures or conversations.

Alice's Adventure in Wonderland and Through the Looking-Glass
Alice's Adventures in Wonderland
Down the Rabbit-Hole

French, John
There is a glut of chemical books, but a scarcity of chemical truths.

Art of Distillation
To the Reader

Lemery, Nicolas
My Lord, the Treatise I now offer you, is not writ after the usual way of ordinary Chymists, it has none of the bombastik Expressions nor ridiculous Pretences, none of the Melancholick dreams and wretched Enthusiasms, none of the palpable Falsities, and even Impossibilites, wherewith the common rate of Chymical Books has been stuff'd hitherto.

A Course of Chemistry
Dedication

Smee, Alfred
In former times, when the means of communicating knowledge were limited to the manual labour of writing every separate copy of a work, those who entered into such a difficult task were deservedly recognized as benefactors to mankind; but in these days, when the faculty of printing allows such unlimited multiplication of books, that useful knowledge is lost amongst the mass of volumes produced, an apology is required by every writer who adds to the difficulty of learning, by increasing the quantity of books from which knowledge is to be selected.

The Sources of Physical Science
Preface (p. v)

Steinbeck, John
Ricketts, Edward
The design of a book is the pattern of reality controlled and shaped by the mind of the writer. This is completely understood about poetry and fiction, but is too seldom realized about books of fact.

The Sea of Cortez
Introduction (p. 1)

BUBBLE

Lawrence, D.H.
But the pressure was too great. He would have to find something to make good the equilibrium. Something must come with him into the hollow void of death in his soul, fill it up, and so equalise the pressure within to the pressure without. For day by day he felt more and more like a bubble…

Women in Love
Chapter XXIV (p. 308)

Maxwell, James Clerk
On an Etruscan vase in the Louvre figures of children are seen blowing bubbles. Those children probably enjoyed their occupation just as modern children do. Our admiration of the beautiful and delicate forms, growing and developing themselves, the feeling that it is our breath that is turning dirty soap-suds into spheres of splendor, the fear lest by an irreverent touch we may cause the gorgeous vision to vanish with a sputter of soapy water in our eyes, our wistful gaze as we watch the perfect bubble when it sails away from the pipe's mouth to join, somewhere in the sky, all the other beautiful things that have vanished before it,…

Nature
Plateau on Soap-Bubbles (p. 119)
Volume 10, Number 242, 18 June 1874

Mukaiyama, Teruaki
Vigorous evolution of gas, quick coloration to brown, and the formation of precipitates; there hidden, was the treasure of possibility in the bubbles of foam on the surface, which were observed in the reaction vessel in a corner of our small laboratory! For organic chemists, facing such an unpredictable phenomenon is not uncommon. In flasks, that which can be predicted by thought or discussion with co-workers often happens.

Challenges in Synthetic Organic Chemistry
Prologue (p. 1)

CALCULATION

Austen, Jane
. . . if the first calculation is wrong, we make a second better. . .

Mansfield Park
Chapter V (p. 34)

Bolton, Henry C.
In his calculations the chemist relies on the supposed chemical relations of the invisible, intangible, and immeasurable particles he calls atoms. These relations have been determined by others in whom he has confidence, and the accuracy of these constants has to be accepted on faith.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 8 (p. 115)

Gay-Lussac
To be in a position to discover the laws which link phenomena together, it is important to make use of the very powerful instrument of calculation ("le calcul") by means of which one may more easily grasp the relations between bodies.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 62)

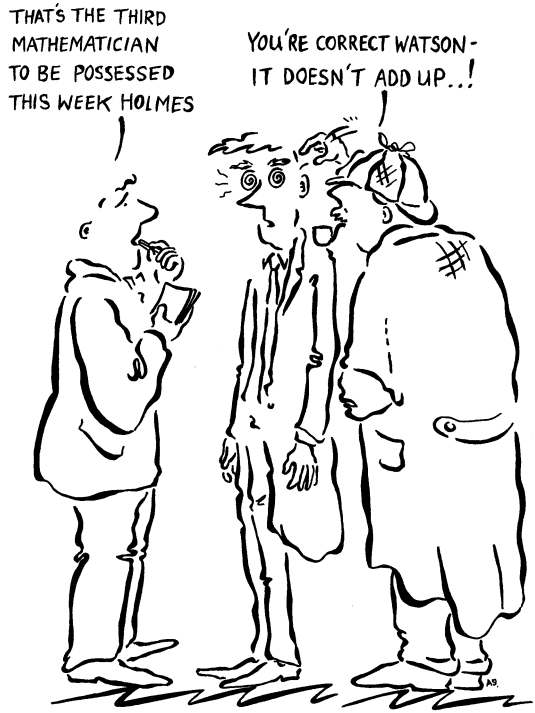
Gromestein, Alan A.
If anyone proposes a relation $y = f(x)$ as a "law of nature" which "exactly" expresses the relation between x and y you need only ask:

How do you know that the relation is not, rather, $y = f(x) \times [1 + g(x)]$, where $g(x)$ is so close to zero as to be unnoticeable under all the conditions in which the relation has as yet been tested, but which becomes large under novel conditions.

The Roots of Things
Chapter 10 (p. 264)

Huxley, Aldous
The demon of calculation possesses the mind.

Along the Road
Part II
Views of Holland (p. 105)



CANDLE

Faraday, Michael
There is no law under which any part of this universe is governed which does not come into play and is touched upon in these phenomena. There is no better, there is no more open door by which you can enter into the study of natural philosophy, than by considering the physical phenomena of a candle.

The Chemical History of a Candle (p. 1)

CAUSE AND EFFECT

Boole, George
So to apprehend in all particular instances the relation of cause and effect, as to connect the two extremes in thought according to the order in which they are connected in nature (for the *modus operandi* is, and must ever be, unknown to us), is the final object of science.

An Investigation of the Law of Thought
Chapter XX (p. 320)

de Cervantes, Miguel
. . . the cause being removed, the effect might cease. . .

Don Quixote
Part I, Chapter 7 (p. 17)

Levins, R.
Lewontin, R.C.
Lines of causality run from part to whole, from atom to molecule, from molecule to organism, from organism to collectivity. As in society, so in all of nature, the part is ontologically prior to the whole.

The Dialectical Biologist
Introduction (p. 2)

Mach, Ernst
In speaking of cause and effect we arbitrarily give relief to those elements to whose connection we have to attend in the reproduction of a fact in the respect in which it is important to us. There is no cause nor effect in nature; nature has but an individual existence; nature simply *is*. Recurrences of like cases in which A is always connected with B, that is, like results under like circumstances, that is again, the essence of the connection of cause and effect, exist but in the abstraction which we perform for the purpose of mentally reproducing the facts.

The Science of Mechanics
Formal Development (pp. 580–1)

Meredith, Owen
To all facts there are laws,
The effect has its cause, and I mount to the cause.

Lucile
Part II, Canto III, Stanza vii

Thompson, Francis
All things by immortal power,
Near or far
Hiddenly
To each other linked are,
That thou canst not stir a flower
Without troubling of a star…

Complete Poetical Works of Francis Thompson
The Mistress of Vision
Stanza XXII

Thoreau, Henry David
Our last deed, like the young of the land crab, winds its way to the sea of cause and effect as soon as born, and makes a drop there to eternity.

Journal
Volume 1: 1837–1844
14 March 1838 (p. 38)

CENTRAL LIMIT THEOREM

Massey, William A.
When you are listening to corn pop, are you hearing the Central Limit Theorem?

Chance News
Correspondence with J. Laurie Snell
9 January 1996

CHANCE

Born, Max
…the conception of chance enters into the very first steps of scientific activity, in virtue of the fact that no observation is absolutely correct. I think chance is a more fundamental conception than causality; for whether in a concrete case a cause–effect relationship holds or not can only be judged by applying the laws of chance to the observations.

Natural Philosophy of Cause and Chance
Chapter VI (p. 47)

Bridgman, P. W.
"Chance" has no meaning except in the setting of order.

The Nature of Physical Theory
Chapter IX (p. 123)

Conrad, Joseph
And if you ask me how, wherefore, for what reason? I will answer you: Why, by chance! By the merest chance, as things do happen, lucky and unlucky, terrible or tender, important or unimportant; and even things which are neither, things so completely neutral in character that you would wonder why they do happen at all if you didn't know that they, too, carry in their insignificance the seeds of further incalculable chances.

Chance: A Tale in Two Parts
Chapter IV (p. 106)

da Costa, J. Chalmers
Even in the tangled threads of what we call "Chance," there is order, and there was law in the tangling. We don't happen to see the order and know the law, but both are there.

The Trials and Triumphs of the Surgeon
Stepping Stones and Stumbling Blocks (p. 235)

du Noüy, Pierre Lecomte
The laws of chance have rendered, and will continue to render, immense services to science. It is inconceivable that we could do without them, but they only express an admirable, subjective interpretation of certain inorganic phenomena and of their evolution. They are not a true explanation of objective reality.

Human Destiny
Chapter 3 (p. 37)

Merz, John Theodore
The study of this blind chance in theory and practice is one of the greatest scientific performances of the nineteenth century.

A History of European Thought in the Nineteenth Century
Volume II (p. 624)

Selye, Hans
Chance is a lady who smiles only upon those who know how to appreciate her artful charms; those connoisseurs she rarely neglects—the secret of the game is art appreciation.

From Dreams to Discovery
Chapter 3 (p. 92)

CHAOS

Adams, Henry
Chaos often breeds life, when order breeds habit.

The Education of Henry Adams
Chapter XVI (p. 232)

Devaney, Robert L.
It has been said that the three great developments in twentieth century science are relativity, quantum mechanics, and chaos. That strikes me the same as saying that the three great developments in twentieth century engineering are the airplane, the computer, and the pop-top aluminum can. Chaos and fractals are not even twentieth century ideas: chaos was first observed by Poincaré and fractals were familiar to Cantor a century ago, although neither man had the computer at his disposal to show the rest of the world the beauty he was seeing.

College Mathematics Journal
Introduction: Special Issue on Dynamical Systems (p. 2)
Volume 22, Number 1, January 1991

Figenbaum, Mitchell
What will prove altogether remarkable is that some very simple schemes to produce erratic numbers behave *identically* to some of the erratic aspects of natural phenomena.

Los Alamos Science
Universal Behavior in Nonlinear Systems (p. 4)
Summer 1980

Milton, John
In the Beginning, how the Heav'ns and Earth rose out of *Chaos*...

Paradise Lost
Book I, L. 9–10

...where eldest Night
And *Chaos*, Ancestors of Nature, hold

Eternal *Anarchie*, amidst the noise
Of endless wars.

Paradise Lost
Book II, L. 894–7

CHEMICAL

Berthelot, Marcellin
The domain in which chemical synthesis exercises its creative power is vaster than that of nature herself.

In Philip Ball
Designing the Molecular World (p. 13)

Berzelius, Jöns Jakob
The devil may write chemical textbooks…because every few years the whole thing changes.

In Bernard Jaffe
Crucibles: The Story of Chemistry
Chapter IX (p. 116)

It is easier to write an abbreviated word than to draw a figure. The chemical signs ought to be letters for the greater ease of writing and not to disfigure a printed book. I *shall therefore take for the chemical sign the initial letter of the Latin name of each chemical element*, thus, C, H, N, O, S, and P. If the first letter be common to two metals, I shall use both the initial letter and another letter they have not in common…

In Bernard Jaffe
New World of Chemistry
Chapter 6 (p. 66)

Callen, Charles Lane
"Does accident often play a part in chemical discoveries?" I inquired. "At times it does, but not as rule," Dr Stine replied. "Even when it does, the circumstance is not, strictly speaking, accidental…the chemist invariably has to put in some mighty hard work in order to bring about fortunate accidents."

The American Magazine
If the Chemist Stepped Out of Your Life (p. 189)
May 1926

Cook, Joseph
Oh, sing a song of phosphates,
Fibrine in a line,
Four-and-twenty follicles
In the van of time.

When the phosphorescence
Evoluted brain,
Superstition ended,
Men began to reign.

In Sara and John E. Brewton and John Brewton Blackburn
Of Quarks, Quasars, and Other Quirks
Boston Nursery Rhymes
Rhyme for a Chemical Baby (p. 41)

Davy, Sir Humphry
Whilst chemical pursuits exalt the understanding, they do not depress the imagination or weaken genuine feeling; whilst they give the mind habits of accuracy, by obliging it to attend to facts, they likewise extend its analogies; and, though conversant with the minute forms of things, they have for their ultimate end the great and magnificent objects of nature.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (pp. 361–2)

[The chemical philosopher's mind] should always be awake to devotional feeling, and in contemplating the variety and the beauty of the external world, and developing its scientific wonders, he will always refer to that infinite wisdom through whose beneficence he is permitted to enjoy knowledge; and, in becoming wiser, he will become better, he will rise at once in the scale of intellectual and moral existence, his increased sagacity will be subservient to a more exalted faith, and in proportion as the veil becomes thinner through which he sees the causes of things, he will admire more the brightness of the divine light by which they are rendered visible.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (p. 367)

The foundations of chemical philosophy are observation, experiment, and analogy. By observation, facts are distinctly and minutely impressed on the mind. By analogy, similar facts are connected. By experiment, new facts are discovered; and, in the progression of knowledge, observation,

guided by analogy, lends to experiment, and analogy confirmed by experiment, becomes scientific truth.

Elements of Chemical Philosophy
Part I, Volume I
Introduction (p. 2)

Editorial
Our chemical heritage—the record of our achievements and our shortcomings—has a vital role to play in developing a more adequate public understanding of science. The past must be preserved, deployed, and made known. We all—whether Chief Executive officers, chemical scientists, school teachers, or representatives of the media—need a better understanding of the human dimensions of the chemical sciences. Chemical history, our chemical heritage, can help inform our decision making. A positive view of the past chemical achievements will lend a modest but firm realism to our plans for the future.

Beckman Center for the History of Science
Volume 9, Spring 1992

Emerson, Ralph Waldo
'Tis a superstition to insist on a special diet. All is made at last of the same chemical atoms.

The Works of Ralph Waldo Emerson
Volume III
Conduct of Life
Culture (p. 101)

Fischer, Emil
To use a picture, I will say that enzyme and glucoside must join one another as lock and key, in order to be able to exert a chemical effect.

Berichte der Deutschen Chemischen Gesellschaft
Volume 27, 1894 (p. 2992)

Frederick the Great
Is it not true that the doctrine of attraction and gravity has done nothing but astonish our imagination? Is it not true that all the chemical discoveries have done only the same?

Letter to Jean le Rond D'Alembert
7 January 1768

Hearn, Lafcadio
I feel like a white granular mass of amorphous crystals—my formula appears to be isomeric with Spasmotoxin. My aurochloride precipitates into beautiful prismatic needles. My Platinochloride develops octohedron crystals,—with a fine blue florescence. My physiological action is not indifferent. One millionth of a grain injected under the skin of a frog produces instantaneous death accompanied by an orange blossom odor.

In Elizabeth Bisland
The Life and Letters of Lafcadio Hearn
Volume I
Letter to George M. Gould, 1889 (p. 462)

Hinshelwood, Sir Cyril N.
Nobody, I suppose, could devote many years to the study of chemical kinetics without being deeply conscious of the fascination of time and change: this is something that goes outside science into poetry; but science, subject to the rigid necessity of always seeking closer approximations to the truth, itself contains many poetical elements.

In The Nobel Foundation
Nobel Lectures
Chemistry 1942–62
Nobel Lecture
11 December 1967 (p. 474)

Hoffmann, Roald
The chemical article is an artistic creation.... It is not a laboratory notebook, and one knows that that notebook in turn is only a partially reliable guide to what took place. It is a more or less (one wishes more)

carefully constructed, man- or woman-made text.... If one is lucky, it creates an emotional or aesthetic response in its readers.

Angewandte Chemie International Edition English
Under the Surface of the Chemical Article (p. 1597)
Volume 27, Number 12, 1988

Kekulé, F. August
Fifty years ago, the stream of chemical progress had divided into two branches. The one flowed, chiefly on French soil, through luxuriant flower-decked plains, and those who followed it, with Laurent and Dumas at their head, could reap, during the whole voyage, almost without effort, an abundant harvest. The other followed the course indicated by an old and approved guide-post set up by the great Swedish chemist, Berzelius; it led for the most part through broken boulders, and only later did it again reach fertile country. At length, as the two branches had again approached much nearer to one another, they were separated by a thick growth of misunderstandings, so that those who were sailing along the one side neither saw those on the other, nor understood their speech.

In O.T. Bentfey
Journal of Chemical Education
August Kekulé and the Birth of The Structural Theory of Organic Chemistry in 1858 (p. 21)
Volume 35, Number 1, January 1958

Lavoisier, Antoine
The principal object of chemical experiments is to decompose natural bodies, so as separately to examine the different substances which enter into their composition. By consulting chemical systems, it will be found that this science of chemical analysis has made rapid progress in our own times.... Thus, as chemistry advances towards perfection, by dividing and subdividing, it is impossible to say where it is to end; and these things we at present suppose simple may soon be found quite otherwise. All we dare venture to affirm of any substance is that it must be considered as simple in the present state of our knowledge, and so far as chemical analysis has hitherto been able to show.

Elements of Chemistry
Part II
Section 1 (pp. 54, 55)

...one day the precision of the data might be brought to such perfection that the mathematician in his study would be able to calculate any

phenomenon of chemical combination in the same way…as he calculates the movement of the heavenly bodies.

Memories de l'Académie Royale des Sciences
1782 [Published 1785] (p. 534)
Mémoire sur l'affomoté du principe oxygène

Lehn, Jean-Marie
The essence of chemical science thus finds its full expression in the words of *Leonardo da Vinci*: "Where nature finishes producing its own species, man begins, using natural things and in harmony with this very nature, to create an infinity of species."

Angewandte Chemie International Edition English
Perspectives in Supermolecular Chemistry (p. 1317)
Volume 29, Number 11, 1990

Moncrief, J. William
What are mortals made of?
By analization
I've tried all the nation,
Defined each gradation,
And prov'd every station,
With Sir Humphry's best
New chemical test,
And found what mortals are made of.

Analization
Source unknown

Ostwald, Wilhelm
Thus there was for him nothing small or great in Nature. Every phenomenon embraced for him an endless diversity of factors, and in the yellow flame of an ordinary alcohol lamp whose wick was sprinkled with salt, he saw the possibility of accomplishing the chemical analysis of the most distant stars.

In Mary Elvira Weeks
Discovery of the Elements (p. 363)

Peirce, Charles Sanders
A chemical compound might be expected to be quite as much like a proposition as like an algebraic invariant.

Monist
The Logic of Relations (p. 169)
Volume 7, 1896

Shoemaker, Sydney
If what I want when I drink fine wine is information about its chemical properties, why don't I just read the label?

In Daniel C. Dennett
Consciousness Explained
Chapter 12 (p. 383)

Stephenson, Thomas
Johnny, feeling like a bore, drank some H_2SO_4;
So his father, an M.D., gave him $CaCO_3$.
Johnny's neutralized, it's true, but he's full of CO_2.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
Chemical Cantos (p. 10)
Volume 7, Number 13, 10 July 1929

Maudie was delighted when she found a lump of KCN.
"Daddy's fond of sweets," said she, as she dropped it in his tea.
Father drank it; that is how Maud's mamma's a widow now.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
Chemical Cantos (p. 10)
Volume 7, Number 13, 10 July 1929

Tommy, eager to explore, found some $CuSO_4$.
"Nice rock candy," Tommy cried as he jammed a lump inside.
Doctor pumped him out, it's true, but Tommy still feels rather blue.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
Chemical Cantos (p. 10)
Volume 7, Number 13, 10 July 1929

Bobbie, in his careless glee, mixed some I with NH_3.
When the stuff was dry and thick, Bobbie hit it with a brick.
Robert's now in heaven they say; at least he seemed to go that way.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
Chemical Cantos (p. 10)
Volume 7, Number 13, 10 July 1929

Stockridge, Frank P.
Life is a chemical reaction; death is the cessation of that reaction; living matter, from the microscopic yeast-spore to humanity itself, is merely the result of certain accidental groupings of otherwise inert matter, and *life*

can actually be created by repeating in the laboratory nature's own methods and processes!

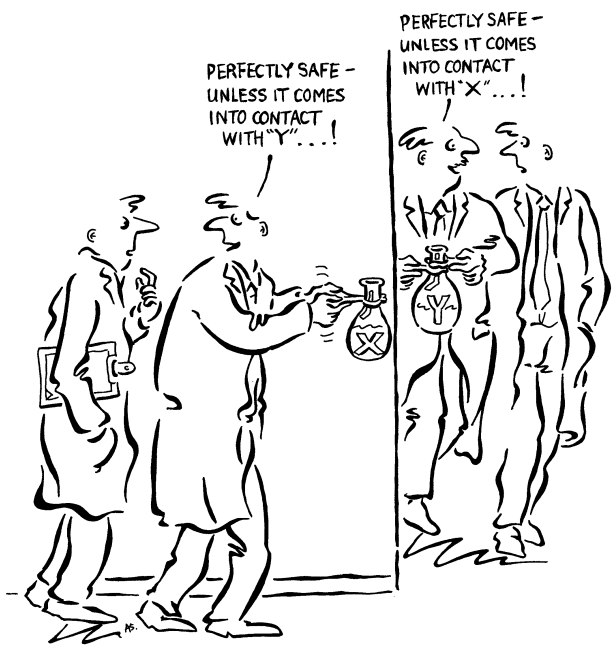
Cosmopolitan
Creating Life in the Laboratory (p. 774)
Volume 52, Number 6, May 1912

Süskind, Patrick
. . . There's jasmine! Alcohol there! Bergamont there! Grenouille went on crowing, and at each name he pointed to a different spot in the room, although it was so dark that at best you could only surmise the shadows of the cupboards filled with bottles.

Perfume: The Story of a Murder
Chapter 14 (p. 75)

Teeple, John E.
The manufacturer of chemicals has all the griefs of a maker of shoes, or bolts and nuts, or ready-to-wear clothes, and has just one more grief in addition—i.e., troubles occurring in chemical transformations.

The Journal of Industrial and Engineering Chemistry
Is the Practice of Chemistry a Profession, a Trade, or a Tool? (p. 666)
Volume 17, Number 7, July 1925



Unknown
Chemical: A substance that:
1. An organic chemist turns into a foul odor;
2. an analytical chemist turns into a procedure;
3. a physical chemist turns into a straight line;
4. a biochemist turns into a helix;
5. a chemical engineer turns into a profit.

Source unknown

Attention, Folks! This way! See the chemical Wonders!

Over here we have Nellie, Nellie NaOH. She's the girl with a powerful base and has she got it? Yousah folks! She's got valence, she's got weight, not only weight but atomic weight. Our Nellie's quite a mixer. She gets in your hair, she gets on your hands, she gets all over your lab. apron. Think of it, folks, all of Nellie for the small price of a fifteen dollar breakage fee.

And over here we have no one but the villain of the chem lab. Is he tough? Is he rugged? Is he biting in action? Yousah! Introducing no one else but good old Nitric Acid. Step up, folks, and he'll eat his way right into your hearts; and folks, you should see him when he meets Nellie. He spouts, he burns, he fumes, and his molecular weight goes up and down.

On this side, folks, we have Nellie's fiancé, Aluminum Hydroxide. He's very temperamental and when he gets sore he goes acidic and basic by turns. It's colossal, he's colloidal, in fact he's amphoteric, and as for the girls—he ionizes them.

The next in our happy family is Nellie's brother, Aggie, Aggie NO_2. He's our acrobat and trapeze artist. Watch him jump from the top of a 50-cc Burette into a small beaker of KCl without raising a splash or a ripple. Folks, a perfect titration.

And we have much more. If you want to see all come inside the lab. And for the small price of a dime, one dime, one-tenth of a dollar, one-half your refund at the end of the course, you can see not only Nellie, not only Nitric, but such artists as Atomical brothers on the Valence Rings and many more of our widely known stars.

Step right in, folks, and see all and be entertained by the music of H_2 and his SO_4 radicals.

Industrial and Engineering Chemistry: News Edition
Step Right In (p. 419)
Volume 12, Number 22, 20 November 1934

There are different sorts of alcohol. Plain alcohol is the parent of all the alcohol family, and going on down from the parent we get ethyl alcohol, which is the potable or consumable part of the alcohol family. Then we get

butyl alcohol, depending upon the content. Then we get methyl alcohol, and finally we get wood alcohol, and they are all traceable back to the parent of the whole alcohol family.

Congressional Record
19 May 1936 (p. 7697)

Winkler, Clemens
The world of chemical reaction is like a stage, on which scene after scene is ceaselessly played. The actors on it are the elements.

In Mary Elvira Weeks
Discovery of the Elements
Chapter 1 (p. 2)

Wittgenstein, Ludwig
Getting hold of the difficulty *deep down* is what is hard.

Because if it is grasped near the surface it simply remains the difficulty it was. It has to be pulled out by the roots; and that involves our beginning to think about these things in a new way. The change is as decisive as, for

example, that from the alchemical to the chemical way of thinking. The new way of thinking is what is so hard to establish.

Culture and Value (p. 48e)

CHEMICAL AFFINITIES

Berthollet, C.L.
A theory of chemical affinities solidly established, and serving as a basis for the explanation of all chemical questions, ought to be a collection of, or contain, all the principles from which the causes of chemical phenomena can proceed, in every possible variety of circumstances; because observation has proved, that all these phenomena are only the various effects of that affinity, to which all the various chemical powers of bodies may be attributed.

Researches into the Laws of Chemical Affinity
Researches
Article I (pp. 1–2)

Macquer, Pierre Joseph
. . . perhaps time, experience, the increase of chemical knowledge, lastly, the zeal of persons skilled in mathematics and chemistry, will hereafter throw much more light upon these subjects, of which now we have but confused notions. However, I cannot but consider them as the true key of the most hidden phenomena of chemistry, and consequently of all natural philosophy.

In D.S.L. Cardwell (ed)
John Dalton & the Progress of Science
Quoted by Arnold Thackeray
Quantified Chemistry—the Newtonian Dream (p. 102)

CHEMICAL ENGINEER

Davis, George E.
Chemical Engineering must not be confounded with either Applied Chemistry or with Chemical Technology, as the three studies are distinct. Chemical Engineering runs through the whole range of manufacturing chemistry, while Applied Chemistry simply touches the fringes of it and does not deal with the engineering difficulties even in the slightest degree, while Chemical Technology results from the fusion of the studies of Applied Chemistry and Chemical Engineering, and becomes specialised as the history and details of certain manufactured products.

A Handbook of Chemical Engineering
Volume I
Chapter I (p. 4)

Pigford, Robert L.
The chemical engineer…needs to understand chemistry, physics, and mathematics in approximately equal proportion in order that he, apparently better than those from other backgrounds, can assemble and evaluate whatever knowledge is required to "bring things together."

Chemical & Engineering News
Chemical Engineering Technology: The Past 100 Years (p. 190)
Volume 54, Number 15, 6 April 1976

Whitney, W.R.
Chemistry was the plaything of magicians, monks and pure-science teachers centuries before chemical engineering became a comprehensible term.

Science
The Stimulation of Research in Pure Science which has Resulted from the Needs of Engineers and of Industry (p. 288)
Volume LXV, 1927

CHEMICAL LIMERICKS

Olcoott, H.S.
A promising chemist named Wood,
With research in explosive made good.
A thunderous clap!
The unfortunate chap
Became spots and some fumes in the hood.

Industrial and Engineering Chemistry: News Edition
Volume 13, Number 11, 10 June 1935 (p. 256)

Unknown
There was an old man from Calcutta
Who smeared his tonsils with butta!
It changed his snore
From a terrible roar
To a soft oleaginous mutta.

Industrial and Engineering Chemistry: News Edition
Volume 13, Number 10, 20 May 1935 (p. 237)

There was a wise chemist from Nyes,
Whose job was to make some new dyes.
They weren't very stable,
Now his friends aren't able
To tell if he flies or he fries.

Industrial and Engineering Chemistry: News Edition
Volume 13, Number 21, 10 November 1935 (p. 432)

A professor at lecture was showing
A group of reactions without knowing
That someone had arranged
To have his chemicals changed.
Now the search for the professor is still going.

Industrial and Engineering Chemistry: News Edition
Volume 13, Number 23, 10 December 1935 (p. 472)

CHEMICAL MNEMONICS

Clark, Louis W.
For Remembering the Activity Series of the Metals:
"Kentuckians never can manage alcohol magnanimously, zealots claim. Firewater nightly stirs pugnacious humans, cancels bonds of sanctity, hideously, agitating potential anarchy."
The first letter of each word is the initial letter in the symbol of the elements as they ordinarily occur in the activity table.

For Remembering the Lanthanum Series, or Rare Earth Elements
"Ladies can't put nickels properly in slot-machines. Every girl tries daily, however, every time you look."

Journal of Chemical Education
More Mnemonics (p. 110)
Volume 33, Number 3, March 1956

For the transitional elements:
Period Four: "Saint Thomas very carefully made five completely new copies of zarathustra."

Period Five: "Your xylophone needs more tuning. Remember Robert played arpeggios clandestinely."

Period Six (Exclusive of the Lanthanide Series): "H.T. Walker read Oglethorpe's inimitable 'Principles of Agriculture and Horticulture'."

Journal of Chemical Education
More Mnemonics (p. 110)
Volume 36, Number 2, February 1959

Cwalina, G.E.
For dicarboxylic acid:
Oxford Makes Such Glittering Advances Picking Subtle Aztec Sedatives.

Chemical and Engineering News
Mnemonics (p. 1473)
Volume 27, Number 20, 16 May 1946

Malik, Jim G.
The Lanthanum Series (Rare Earths)
Let's collect pleasingly novel pansies since every good type does have extra fine young leaves.

Journal of Chemical Education (p. 329)
Volume 33, Number 7, July 1956

Unknown
For the Actinide Elements:
Ah, to Please U, New Powers Arise. Come, be Caressed, Enjoy Fully Man's Nobility.

Journal of Chemical Education (p. 357)
Volume 35, Number 7, July 1958

CHEMIST

Armstrong, Henry Edward
The fact is, there has been a split of chemistry into two schools since the intrusion of the Arrhenic faith, rather it should be said, the addition of a new class of worker into our profession—people without knowledge of the laboratory arts and with sufficient mathematics at their command to be led astray by curvilinear agreements; without the ability to criticise, still less of giving any chemical interpretation.

The fact is, the physical chemists never use their eyes and are most lamentably lacking in chemical culture. It is essential to cast out from our midst, root and branch, this physical element and return to our laboratories.

Chemistry and Industry
Ionomonia in Extremis (p. 917)
Volume 14, 1936

Atkins, Peter W.
Chemists currently strive to achieve the fine control exercised by nature. To do so, they stir, pour, heat, and distil, just as they have done ever since their intellectual ancestors vainly sought a reaction that would produce gold from lead. These crude processes seem to be ways of bending matter to our will and forcing it to undergo specific change. Modern chemists, though, use these techniques to direct reactions more precisely and rationally than alchemists, cooks, and Faraday's contemporaries. They may seek to build complex molecules, and to do so proceed by stealth and subtlety… They have found ways to emulate (and sometimes improve on) nature by mixing, stirring, and heating in such a way that they do not break asunder what they have already joined—even though they cannot manipulate the atoms directly.

Atoms, Electrons, and Change (p. 11)

Ball, Philip
Geologists brave the awesome fury of volcanoes and earthquakes; oceanographers plumb the hidden depths of the world. What do chemists do? Well, they make paint, among other things.

Designing the Molecular World
Introduction (p. 4)

Becher, J.J.
The chymists are a strange class of mortals impelled by an almost insane impulse to seek their pleasure among smoke and vapour, soot and flame, poisons and poverty; yet among all these evils I seem to live so sweetly, that may I die if I would change places with the Persian King.

In H.E. Howe (ed.)
Chemistry in Industry
Volume I
frontispiece

Black, Joseph

. . . the chemist studies the effects produced by heat and by mixture, in all bodies, or mixtures of bodies, natural or artificial, and studies them with a view to the improvement of arts, and the knowledge of nature.

Lectures on the Elements of Chemistry
Volume I
Lectures on Chemistry
Definitions (11, 14?)
Volume II (p. 415)

Bogert, Marston Taylor

Practically everything you eat, taste, wear, smell and see has resulted in some way from the ingenuity of chemists.

The American Magazine
The New Marvels of Chemistry in Your Everyday Life (p. 19)
September 1921

Boyle, Robert

And indeed, I fear that the chief Reason why Chymists have written so obscurely of their three Principles, may be, That not having Clear and Distinct Notions of them themselves, they cannot write otherwise than Confusedly of what they but Confusedly Apprehend:. . .

The Sceptical Chymist
The Fourth Part (pp. 202–3)

. . . me thinks the Chymists, in their searches after truth, are not unlike the Navigator of Solomons Tarshish Fleet, who brought home from their long and tedious Voyages, not only Gold, and Silver, and Ivory, but Apes and Peacocks too; For so the Writings of several. . . of your Hermetick Philosophers present us, together with divers Substantial and noble Experiments, Theories, which either like Peacock feathers make a great shew, but are neither solid nor useful; or else like Apes, if they have some appearance of being rational, are blemish'd with some absurdity or other, that when they are Attentively consider'd, makes them appear Ridiculous.

The Sceptical Chymist
The Conclusion (pp. 429–30)

Bridges, Robert Seymour

. . . 'twas no unique, ultimately separable thing,
as is a chemic element; far rather our moods,
influences and spiritual affections are like
those many organic substances which, tho' to sense
wholly dissimilar and incomparable in kind,
are yet all combinations of the same simples,

and even in like proportions differently disposed;
so that whether it be starch, oil, sugar, or alcohol
'tis ever our old customers, carbon and hydrogen,
pirouetting with oxygen in their morris antics;
the chemist booketh all of them as CHO,...

Poetical Works of Robert Bridges
The Testament of Beauty
Book III, L. 928–38

Browning, Robert
Once I saw a chemist take a pinch of powder
—Simple dust it seemed—and half unstop a phial.
—Outdropped harmless dew.

The Complete Poetic and Pragmatic Works of Robert Browning
Two Camels, L. 109–11

Bullock, J. Lloyd
There is a further use in thus becoming a good practical chemist; it will enable you to be the counselor of the agriculturalist, of the manufacturer, of the physician—to spread the love and practice of chemistry.

The Chemist
A Lecture on the State of Pharmacy in England and Its Importance to the Public (p. 282)
Volume 5, 1844

Coleridge, Samuel T.
The eyeless Chemist heard the process rise,
The stormy Chalice bubbled up in sighs;...

The Complete Poetical Works of Samuel Coleridge
Kisses, L. 11–12

Collins, Wilkie
Mind, they say, rules the world. But what rules the mind? The body. The body (follow me closely here) lies at the mercy of the most omnipotent of all potentates—the Chemist. Give me—Fosco—chemistry; and when Shakespeare has conceived Hamlet, and sits down to execute the conception—with a few grains of powder dropped into his daily food, I will reduce his mind, by the action of his body, till his pen pours out the most abject drivel that has ever degraded paper. Under similar circumstances, revive me the illustrious Newton. I guarantee that, when he sees the apple fall, he shall eat it, instead of discovering the principle of gravitation. Nero's dinner shall transform Nero into the mildest of me before he has done digesting it; and the morning draught of Alexander the Great shall make Alexander run for his life, at the first sight of the

enemy, the same afternoon. On my sacred word of honor, it is lucky for society that modern chemists are, by incomprehensible good fortune, the most harmless of mankind. The mass are worthy fathers of families who keep shops. The few are philosophers besotted with admiration for the sound of their own lecturing voices; visionaries who waste their lives on fantastic impossibilities; or quacks whose ambition soars no higher than our corns. Thus Society escapes; and the illimitable power of chemistry remains the slave of the most superficial and the most insignificant ends.

The Woman in White
The Third Epoch
The Count's Narrative (p. 513)

Corey, E.J.
The synthetic chemist is more than a logician and strategist; he is an explorer strongly influenced to speculate, to imagine, and even to create. These added elements provide the touch of artistry which can hardly be included in a cataloguing of the basic principles of Synthesis, but they are very real and extremely important.

Pure and Applied Chemistry
General Methods for the Construction of Complex Molecules (p. 30)
Volume 14, 1967

Crookes, William
Chemists do not usually stutter. It would be very awkward if they did, seeing that they have at times to get out such words as methylethylamylophenylium.

In William H. Brock
The Norton History of Chemistry
Introduction (p. xxvi)

It is the chemist who must come to the rescue of the threatened communities. It is through the laboratory that starvation may ultimately be turned to plenty.

Reports of the British Association for the Advancement of Science
1898 (p. 4)

Curie, Eve
By definition, a chemist only believes in the existence of a new substance when he has seen the substance, touched it, weighed and examined it, confronted it with acids, bottled it, and when he has determined its "atomic weight."

Madame Curie
Chapter XIII (p. 165)

Davy, Sir Humphry

A steady hand and a quick eye are most useful auxiliaries; but there have been very few great chemists who have preserved these advantages throughout life; for the business of the laboratory is often a service of danger and the elements, like the refractory spirits of romance, through the obedient slave of the magician, yet sometimes escape the influence of his talisman and endanger his person. Both the hands and the eyes of others however may sometimes advantageously made use of.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (pp. 365)

Dibdin, Charles

Thee, wond'rous chemist! who canst make, at will,
Wash-balls from dew-drops; and canst blooms distil;
With blooms and dews, Dame Nature's self canst pose,
And brew, like spiders, poison from the rose!

Mirth and Metre
The Age
A Satire
An Argument, L. 262–5

Dickens, Charles

. . . like a gloomy Analytical Chemist; always seeming to say, after 'Chablis, Sir?'—'You wouldn't if you knew what it was made of.'

Our Mutual Friend
Book the First
Chapter II (p. 10)

Dryden, John

A man so various, that he seem'd to be
Not one, but all mankind's epitome:
Stiff in opinions, always in the wrong;
Was everything by starts, and nothing long;
But, in the course of one revolving moon,
Was chymist, fiddler, statesman, and buffoon. . .

In Bernard N. Schilling
Dryden and the Consecutive Myth
Absalom and Achitopherl
Part 1, L. 545–50

Emerson, Ralph Waldo
Nature is a rag-merchant, who works up every shred and ort and end into new creations; like a good chemist whom I found, the other day, in his laboratory, converting his old shirts into pure white sugar.

The Works of Ralph Waldo Emerson
Volume III
Conduct of Life
Considerations by the Way (p. 172)

Farrell, Hugh
The chemist is revolutionizing industry. He is developing new products and new ideas every hour of every day. As a result of his work, flourishing industries are being scrapped overnight. There is no industry—not one—that is not in danger of waking up tomorrow and finding that the chemist has made a discovery that might revolutionize it.

In Bernard Jaffe
New World of Chemistry (p. 495)

Frost, Robert
Even while we talk some chemist at Columbia
Is stealthily contriving wool from jute…

The Poetry of Robert Frost
Build Soil

Fuller, Buckminster
Nature has made certain things which we call natural, and everything else is 'man-made', ergo artificial. But what one learns in chemistry is that Nature wrote all the rules of structuring; man does not invent chemical structuring rules; he only discovers the rules. All the chemist can do is find out what Nature permits, and any substances that are thus developed or discovered are inherently natural.

The Buckminster Fuller Reader (p. 318)

Girtanner, Christopher
Every chemist, every artist will make gold, kitchen utensils will be of silver, and even gold, which will contribute more than anything else to prolonge life, poisoned at present by the oxyards of copper, lead, and iron, which we daily swallow with our food.

Philosophical Magazine
Volume VI
Memoir on Azot, and on the Question,
Whether it be a simple or a compound Body (p. 353)
May 1800

Grosser, Arthur E.
When we decode a cookbook, every one of us is a practicing chemist. Cooking is really the oldest, most basic application of physical and chemical forces to natural materials.

New York Times
29 May 1984

Herbert, George
The subtle chymick can devest
And strip the creature naked, till he finde
The callow principles within their nest:
There he imparts to them his minde,
Admitted to their bed-chamber before
They appeare trim and drest
To ordinate suitours at the doore.

The Temple
The Church
Vanity, L. 15–21 (p. 126)

Hoffmann, Roald
I had written three pages
on how insects are such good chemists, citing
the silkworm sex attractant, and the bombardier beetle,
spraying out hot hydrogen peroxide when threatened.

Gaps and Verges
Evolution (p. 3)

Holmes, Harry N.
The chemist deals with a very material world, even though philosophers assure him that he doesn't really know matter, that he only perceives its attributes or properties. However, he is not to be argued out of his dinner by mere words.

Out of the Test Tube
Chapter II (p. 24)

Ihde, Aaron J.
The person who is merely trained to carry out analyses or syntheses can do his job quite satisfactorily without knowing any history of chemistry. On the other hand, the chemist who is in a position where he has significant responsibility for the planning of investigations needs to know something about the past history of chemical investigation and the development

of chemical thought. Without such knowledge, he is merely a chemical technologist.

Journal of Chemical Education
Let's Teach History of Chemistry to Chemists! (p. 687)
Volume 48, Number 10, October 1971

Lehn, Jean-Marie
Like the artist, the chemist engraves into matter the products of creative imagination. The stone, the sounds, the words do not contain the works that the sculptor, the composer, the writer express from them. Similarly, the chemist creates original molecules, new materials and novel properties from the elements provided by nature, indeed entire new worlds, that did not exist before they were shaped at the hands of the chemist, like matter is shaped by the hands of the artist, as so powerfully rendered by August Rodin.

Supramolecular Chemistry (p. 206)

Levi, Primo
I thought of another moral, more down to earth and concrete, and I believe that every militant chemist can confirm it: that one must distrust the almost-the-same (sodium is almost the same as potassium, but with sodium nothing would have happened), the practically identical, the approximate, all surrogates, and all patchwork. The differences can be small, but they can lead to radically different consequences, like a railroad's switch points: the chemist's trade consists in good part of being aware of these differences, knowing them close up and foreseeing their effects. And not only the chemist's trade.

The Periodic Table
Potassium (p. 60)

We chemists…are here for this—to make mistakes and to correct ourselves, to stand the blows and hand them out. We must never feel disarmed: nature is immense and complex, but it is not impermeable to the intelligence; we must circle around it, pierce and probe it, looking for the opening or making it.

The Periodic Table
Nickel (p. 75)

The trade of chemist (fortified, in my case, by the experience of Auschwitz), teaches you to overcome, indeed to ignore, certain revulsions that are neither necessary or congenital: matter is matter, neither noble nor vile, infinitely transformable, and its proximate origin is of no importance whatsoever. Nitrogen is nitrogen, it passes miraculously from the air into plants, from these into animals, and from animals into us; when its

function in our body is exhausted, we eliminate it, but it still remains nitrogen, aseptic, innocent.

The Periodic Table
Nitrogen (pp. 180–1)

. . . to see if I could convey to the layman the strong and bitter flavor of our trade, which is only a particular instance, a more strenuous version of the business of living. I told him that it did not seem fair to me that the world should know everything about how the doctor, prostitute, sailor, assassin, countess, ancient Roman, conspirator, and Polynesian lives and nothing about how we transformers of matter live. . .

The Periodic Table
Silver (p. 203)

Lewis, Gilbert N.
A detective with his murder mystery, a chemist seeking the structure of a new compound; use little of the formal and logical modes of reasoning. Through a series of intuitions, surmises, fancies, they stumble upon the right explanation, and have a knack of seizing it when it once comes within reach.

The Anatomy of Science
Chapter I (p. 6)

Mayo, Charles H.
The philosophic view of bacteria is to consider them necessary to life as the minute chemists of the air, the water, and the soil.

Annals of Surgery
Stone in the Kidney
Volume 7, 1920

Minsk, Louis M.
Here's to the chemist—a most extraordinary guy.
Who does lots of things, he doesn't know why.
The number of errors he throws down the sink,
Leads one to believe he seldom does think.
His words are so blunt, his manner so rough
Five minutes with him is more than enough.
But don't pity him, he leads a great life,
Rather pity the woman he chose for a wife.
God bless her and keep her and please make her brave
To share with her husband all cares slight and grave.
But, too, make her thankful—to this hark and list,

She might have done worse—with some physicist.

Industrial and Engineering Chemistry: News Edition
Ode to a Chemist and His Wife (p. 531)
Volume 15, Number 22, 10 December 1937

Mukaiyama, Teruaki
In studies of new synthetic reactions, a detailed study of the observed phenomenon will provide you with a hint that could be a 'seed' to open an entirely new area of promising development. To cherish the 'seed' that is picked up by your own hands, and to let its roots spread deep into the soil, will surely lead you to further interesting possibilities. Chemists should always bear in mind that to realize their goals they need to practice their bench work daily. It will surely make your dreams come true.

Challenges in Synthetic Organic Chemistry
Chapter 13 (pp. 210–11)

Nickon, Alex
Silversmith, Ernest F.
Organic chemists need to keep a great many facts and concepts in their heads. Not surprisingly, therefore, they sometimes name compounds after head coverings, protecting, as it were, this storehouse of knowledge.

Organic Chemistry: The Name Game
Chapter 2 (p. 20)

Chemists spend a good deal of time inside buildings, so it is natural for them to relate the shapes of molecules to the ubiquitous structures.

Organic Chemistry: The Name Game
Chapter 4 (p. 50)

Ostwald, Wilhelm
All those sticky, mucilaginous, resinous, tarry masses which refuse to crystallize, and which are the abomination of the normal organic chemist; those substances which he carefully sets toward the back of his cupboard and marks "not fit for further use," just these are the substances which are the delight of the colloid chemist.

An Introduction to Theoretical and Applied Colloid Chemistry: The World of Neglected Dimensions
Fourth Lecture (p. 134)

Playfair, John
The chemist, indeed, is flattered more than any one else with the hopes of discovering in what the essence of matter consists; and Nature, while she keeps the astronomer and the mechanician at a great distance, seems to admit him to a more intimate acquaintance with her secrets. The vast powers which he has acquired over matter, the astonishing

transformations which he effects, his success in analysing almost all bodies, and in reproducing so many, seem to promise that he shall one day discover the essence of a substance which he has so thoroughly subdued.

Transactions of the Royal Society of Edinburgh
Biographical Account of the Late James Hutton (p. 74)
Volume 5, 1805

Pope, Alexander
The starving chemist in his golden views
Supremely blest.

The Complete Poetical Works of Pope
An Essay on Man
Epistle II, L. 260–1

Richet, Charles
A chemist cannot find, already in his mind, the laws and the phenomena which govern matter.

The Natural History of a Savant
Chapter XI (p. 126)

Sidgwick, N.V.
The chemist…must resist the temptation to make his own physics; if he does it will be bad physics—just as the physicist has sometimes been tempted to make his own chemistry, and then it was bad chemistry.

In Joseph Needham and Ernest Baldwin
Hopkins & Biochemistry (p. 204)

Standen, Anthony
Chemists are, on the whole, like physicists, only 'less so'. They don't make quite the same wonderful mistakes, and much what they do is an art, related to cooking, instead of a true science. They have their moments, and their sources of legitimate pride. They don't split atoms, as the physicists do. They join them together, and a very praiseworthy activity that is.

Science Is A Sacred Cow
Chapter III (pp. 77–8)

Sully-Prudhomme
Surrounded by beakers, by strange coils,
By ovens and flasks with twisted necks,
The chemist, fathoming the whims of attractions,
Artfully imposes on them their precise meetings.

In Helen Plotz
Imagination's Other Place
The Naked World

Thompson, D'Arcy W.
The learned chemist is still a learned man; in love and knowledge of the arts the chemists are hardly beaten by the scholars.

Science and the Classics
Chapter I (p. 4)

Turgenev, Ivan
"A good chemist is twenty times as useful as any poet," broke in Bazarov.

Fathers and Sons
Chapter VI (p. 28)

Unknown
A chemist, a physicist, and a geologist were walking along a beach when the physicist suddenly said that he wanted to measure the depth of the sea, and then he jumped into the sea. The geologist said that he wanted to see the seabed and he followed suit. The chemist waited for a while for them to reappear and then concluded, physicists and geologists are soluble in sea water.

Source unknown

The Chemist's rule: Never take more than three data points. There will always be some kind of graph paper on which they fall in a straight line.
The Chemist's rule, first corollary: if you have only one kind of graph paper, never take more than two data points.

Source unknown

To the optimist, the glass is half full.
To the pessimist, the glass is half empty.
To the chemist, the glass is twice as big as it needs to be.

Comprehending Chemists
Source unknown

Got a problem? Ask Chemists! They have all the solutions.

Source unknown

It's amino world without chemists.

Source unknown

As I was spinnin' into the moat 'longside o' the northwest door,
I seed a man workin' below me like I never had seen before.
He was nickin' a tube on a two-foot rule, and I sez to 'im "Oo are you?"
Sez 'e "I'm a chemist, a physical chemist, and mathematician too!"
Now 'is work begins by Gawd knows when, and 'is work is never through;
'E isn't a messy organicman nor one of the black-board crew,

'E's a kind of giddy harumfrodite—chemist and physicist too.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
The Physical Chemist (p. 14)
Volume 7, Number 24, 20 December 1929

A mathematical physicist may be able to predict which way an electron will jump. But nobody seems to be able to guess which way a chemist will move under proper excitation.

Industrial and Engineering Chemistry: News Edition
Chemistry Went South (p. 5)
Volume 8, Number 8, 20 April 1930

von Liebig, Justus

The loveliest theories are being overthrown by these damned experiments; it is no fun being a chemist any more.

In William H. Brock
Justus von Liebig
Letter to J.J. Berzelius, 22 July 1834 (p. 72)

CHEMISTRY

Aldersey-Williams, Hugh
Chemistry is the science of molecules, and it is a messy science.

The Most Beautiful Molecule
Chapter 1 (p. 14)

Armstrong, Henry Edward
Prof. W.L. Bragg asserts that "In sodium chloride there appear to be no molecules represented by NaCl. The equality in numbers of sodium and chlorine atoms is arrived at by a chessboard pattern of these atoms; it is a result of geometry and not of a pairing-off of these atoms."

Chemistry is neither chess nor geometry, whatever X-ray physics may be…It were time the chemists took charge of chemistry once more and protected neophytes against the worship of false gods; at least taught them to ask for something more than chessboard evidence.

Nature
Poor Common Salt (p. 478)
Volume 120, Number 3022, 1927

Arnheim, Rudolph
Just as a chemist "isolates" a substance from contaminations that distort his view of its nature and effects, so the work of art purifies significant appearance. It presents abstract themes in their generality, but not reduced to diagrams.

Visual Thinking
Chapter 14 (p. 273)

Asimov, Isaac
Beginning students of chemistry often think of the science as a mere collection of disconnected data to be memorized by brute force. Not at all! Just look at it properly and everything hangs together and makes sense.

Of course, getting the hang of the proper look isn't always easy.

From Earth to Heaven
To Tell A Chemist (p. 113)

Atkins, Peter W.
Chemistry stands at the pivot of science. On the one hand it deals with biology and provides explanations for the processes of life. On the other hand it mingles with physics and finds explanations for chemical phenomena in the fundamental processes and particles of the universe. Chemistry links the familiar with the fundamental.

Molecule (p. 2)

Austin, Alfred
Only the chemistry of love can make
Two atoms one.

Prince Lucifer
Act IV, scene V, L. 64–5

Bailar, John C., Jr.
Moeller, Therald
Kleinberg, Jacob
Guss, Cyrus O.
Castellion, Mary E.
Metz, Clyde
Look around you. That's how chemistry began—in the limitless curiosity of human beings about their surroundings.

Chemistry
Chapter 1 (p. 1)

Balzac, Honoré de
You are dressed so coquettishly to talk about chemistry.

The Quest of the Absolute (p. 73)

Modern chemistry is... much, and yet little. Much has been accomplished, for chemistry has learned to shrink before no difficulties; little, because what has been accomplished is as nothing compared with what remains to do.

The Quest of the Absolute (p. 76)

Bartlett, Elisha
Let chemistry push her researches into the remotest accessible recesses of the living economy, and let her claim, for her own, every process,

every act, every transformation, over which she can establish a legitimate jurisdiction.

An Essay on the Philosophy of Medical Science
Part II, Chapter 15

Bartow, Edward
. . . chemistry is dependent on other sciences in the building of what we might call The House of Chemistry. . . The House of Chemistry, or perhaps we should call it the Mansion, Castle, or Palace of Chemistry, cannot stand alone. Can we not imagine that it is built on the rocks of geology and mineralogy?. . . This mansion is built in the garden of agriculture. Its foundation is in the healing art of medicine. . . Physics is the window, where physical instruments shed light on the intricacies of the composition of matter. . . Astronomy is the upper story, from which chemistry looks out on the universe, and studies the composition of the stars. History is the walls, which bind the various parts together, and includes chemistry and the sciences in one homogeneous system.

Industrial and Engineering Chemistry
President's Address
Progress in Sanitation (p. 385)
Volume 14, Number 19, 10 October 1936

Beguinus, Jean
Chymistry is the Art of dissolving natural mixed bodies, and of coagulating the same when dissolved, and of reducing into salubrious, safe, and grateful medicaments.

Tyrocinium Chymicum: Chemical Essays Acquired from Nature & Manual Experience
Book One, Chapter I (p. 1)

Bent, H.A.
Chemistry is, indeed, the central subject in a modern academic curriculum. It stands between the traditional humanities on the one hand and modern physics on the other hand.

Chemical and Engineering News
Comments (p. 44)
12 March 1984

Bernal, John Desmond
Chemistry, far more than physics, was the dominant science of the nineteenth century. This is so, in spite of the fact that the major physical discoveries found their development and application in the steam engine at the beginning and electric power at the end of the century. With chemistry, however, there was a far larger number of new processes that could be turned more immediately to profitable use, and this afforded

directly and indirectly for the training and employment of an ever-increasing number of chemists. Indeed from the beginning of the century and increasingly till its end the chemists were the most numerous of the newly differentiated groups of scientists.

Science and Industry in the Nineteenth Century
Chapter III (p. 70)

…the old chemistry was largely a matter of memory, a set of cookery recipes that had, for no apparent reason but to worry the student, to be learnt by heart.

In H.N. Parton
Science is Human
Science and the Liberal Arts (p. 17)

Berthelot, Marcellin
Chemistry creates its objects.

In Jean-Marie Lehn
Supramolecular Chemistry (p. 206)

Biggs, Noah
I praise God who hath been so bountiful to me, as to call me to the practise of *Chymistry* out of the dregs of other Professions: Since *Chymistry* hath *principles* not drawn from fallacious reasonings, but such as are known by nature, & conspicuously by fire; and she prepareth the *Intellect* to penetrate, not the upper deck or *surface* of things, but the deep hold, the *concentrick* and *hidden* things of nature, and maketh an investigation into the *America* of nature…

The Vanity of the Craft of Physick (p. 57)

Boerhaave, Herman
Chemistry is an art which teaches the manner of performing certain physical operations, whereby bodies cognizable to the senses, or capable of being rendered cognizable, and of being contained in vessels, are so changed by means of proper instruments, as to produce certain determined effects and at the same time discover the causes thereof; for the service of various arts.

Elements of Chemistry (p. 19)

But if anyone shall still retain a doubt of the worth and abilities of chymistry, to reward those who cultivate it: let him consider the practice and procedure of the happiest philosopher the world ever yet cou'd boast, the great Sir *Isaac Newton*: who, when he demonstrates the laws, the actions, and the powers of bodies, from a consideration of their effects, always produces chymical experiments for his vouchers; and when, to

solve other phenomena, he makes use of these powers, his refuge is to chymistry.

In Arnold Thackray
Atoms and Power
Chapter 2 (p. 8)

Boyle, Robert
For I observed, that of late Chymistry begins, as indeed it deserves, to be cultivated by Learned Men who before dispis'd it, and to be pretended to by many who never cultivated, that they may be thought not to ignore it…

The Sceptical Chymist
A Preface Introductory (p. A2)

Bridges, Robert Seymour
From Universal Mind the first-born atoms draw
their function, whose rich chemistry the plants transmute
to make organic life, whereon animals feed
to fashion sight and sense and give service to man,
who sprung from them is conscient in his last degree
of ministry unto God, the Universal Mind,
whither all effect returneth whence it first began.

Poetical Works of Robert Bridges
The Testament Of Beauty
Book IV, L. 116–22

Buchanan, Robert Williams
He read the great stone Book whereon is writ
The riddle of the world from age to age;
Knew the fair marvels of the Zodiac,
The stars and their processions; had by heart
The elemental truths of chemistry…
And zealously, within a mental maze,
As dense as that which covered Rosamond,
His teacher guarded him against the creeds.

The Complete Poetical Works of Robert Buchanan
Volume II
Justinian; Or, The New Creed

Byron, Lord George Gordon
No chemistry for them unfolds her gasses,
No metaphysics are let loose in lectures,
No circulating library amasses
Religious novels, moral tales, and strictures

Upon the living manners, as they pass us;
No exhibition glares with annual pictures;
They stare not on the stars from out their attics,
Nor deal (thank God for that!) in mathematics.

Beppo: A Venetian Story
LXXVIII (p. 40)

Cady, Varian
I think that I shall never see
A test as hard as Chemistry,
A test that makes you stir and squirm
And wonder if you'll pass this term,
A test that makes you tear your hair
And wish you were not sitting there,
A test that turns your hair to snow
Because it asks what you don't know.
Tests are flunked by fools like me
Especially when in Chemistry.

Industrial and Engineering Chemistry: News Edition
(Chemis)TREES (p. 419)
Volume 12, Number 22, 20 November 1934

Caglioti, Luciano
Chemistry…is one of the broadest branches of science, if for no other reason that, when we think about it, everything is chemistry.

The Two Faces of Chemistry (p. xv)

Chemistry has invaded our lives, has provided us with new foods and new materials, has replaced wood and metal with less expensive products, has enabled low-income classes to acquire things that otherwise would have been inaccessible.

The Two Faces of Chemistry (p. xv)

Chakrabarti, Chuni L.
Analytical chemistry, like Cleopatra's beauty, is of infinite variety.

Journal of Chemical Education
Provocative Opinion (p. 58)
Volume 47, Number 1, January 1970

Chaptal, Jean-Antoine-Claude
How immense is the empire of chemistry! It embraces in its studies all the phenomena which nature presents to our view, in the infinite variety

of her productions, and all the processes of the arts for which we are indebted to human ingenuity.

Chemistry Applied to Arts and Manufactures
Book I (pp. 2–3)

Collingwood, Robbin George
Egregious blunder! A beginner in physics or chemistry does not know what matter is, and if he thinks he does it is the duty of his teacher to disabuse him; but he knows what physics or chemistry is; it is the stuff in this red text-book, or the stuff old So-and-So teaches, or the stuff we have on Tuesday mornings.

The New Leviathan
Part 1, Chapter 1, Aphorism I.42

Couper, Archibald Scott
The end of chemistry *is its theory*. The guide in chemical research *is a theory*.

Proceedings of the Royal Society of Edinburgh
Life and Chemical Works of Archibald S. Couper
Appendix III (p. 240)
On a New Chemical Theory
Volume 29, 1908–9)

Cullen, William
Chemistry is the art of separating mixt bodies into their constituent parts & of combining different bodies or the parts of bodies into new mixts for the purposes of philosophy & arts, that is, for the purposes of philosophy by explaining the composition of bodies, the nature of mixture & the properties of bodies thereon depending, & for the purposes of arts by producing several artificial substances more suitable to the intention of various arts than any natural productions are.

In A.L. Donovan
Philosophical Chemistry in the Scottish Enlightenment
Chapter 6 (p. 98)

Davy, Sir Humphry
Chemistry relates to those operations by which the intimate nature of bodies is changed, or by which they acquire new properties. This definition will not only apply to the effects of mixture, but to the phenomena of electricity, and in short to all the changes which do not merely depend upon the motion or division of masses of matter.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (p. 363)

It may be said of modern chemistry, that its beginning is pleasure, its progress knowledge and its object truth and utility.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (p. 365)

. . . at no very distant period the whole science [chemistry] will be capable of elucidation by mathematical principles.

Elements of Chemical Philosophy
Part I, Volume I
Introduction (pp. 59–60)

de Unamuno, Miguel
. . . chemistry ought to be not for chemists alone.

The Tragic Sense of Life
Chapter XII (p. 356)

du Fresnoy, Nicholas Langlet
It is necessary to note that there are two kinds of chemistry; the one wise and reasonable, even necessary for the extraction of useful remedies from all things in nature. . . : the other is that foolish and senseless chemistry which is nevertheless the older of the two. . . The first has been given the name of *Chemistry*, and the second that of *Alchemy*.

In Allen G. Debus
The French Paracelsians
Chapter 6 (p. 203)

Duffy, Carol Ann
The words you spoke were frenzied prayers to chemistry;. . .

From the Other Country
Dream of a Lost Friend, L. 9

Dumas, Jean-Baptiste
In chemistry, our theories are crutches; to show that they are valid, they must be used to walk. . . A theory established with the help of twenty facts must explain thirty, and lead to the discovery of ten more.

Leçons de Philosophie Chimique (p. 60)

Duncan, Robert
Chemistry having its equations beyond our range of inequation.

Bending the Bow
Orders, Passages 24

Edgeworth, Maria

…chemistry is a science particularly suited to women, suited to their talents and their situation. Chemistry is not a science of parade, it affords occupation and infinite variety; it demands no bodily strength, it can be pursued in retirement, it applies immediately to useful and domestic purposes; and whilst the ingenuity of the most intensive mind may be exercised, there is no danger of inflaming the imagination; the judgement is improved, the mind is intent upon realities, the knowledge that is acquired is exact, and the pleasure of the pursuit is a sufficient reward for the labour.

Letters for Literary Ladies
Answer to the Preceding Letter (pp. 39–40)

Emerson, Ralph Waldo

'Tis a short sight to limit our faith in laws to those of gravity, of chemistry, of botany, and so forth.

The Works of Ralph Waldo Emerson
Volume III
The Conduct of Life
Worship (p. 144)

Chemistry began by saying it would change the baser metals into gold. By not doing that it has done much greater things.

Journals of Ralph Waldo Emerson
Volume II (p. 288)

Esar, Evan

Sex appeal is a matter of chemistry, but you don't have to be a chemist to find the formula.

20,000 Quips & Quotes (p. 128)

One of the first things a boy learns with a chemistry set is that he'll never get another one.

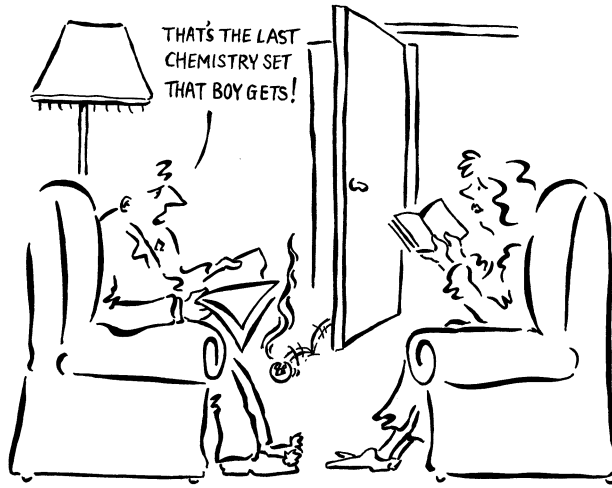
20,000 Quips & Quotes (p. 128)

Faraday, Michael

Chemistry is necessarily an experimental science: for as facts are the data from which its conclusions are drawn, and the evidence by which its principles are supported, a constant appeal to them is necessary… Hence the importance of multiplying facts by every means in our power whilst engaged in the pursuit of this science.

Chemical Manipulation
Introduction (p. i)

It is the great beauty of our science, CHEMISTRY, that advancement in it, whether in a degree great or small, instead of exhausting the subjects



One of the first things a boy learns with a chemistry set is that he'll never get another one.
Evan Esar – (See p. 106)

of research, opens the doors to further and more abundant knowledge, overflowing with beauty and utility, to those who will be at the easy personal pains of understanding its experimental investigation.

Experimental Researches in Electricity
Volume I
Series VII, Section 871 (p. 257)

Farber, Eduard
The evolution of chemistry is a drama written and enacted by the great chemists.

Great Chemists
Preface (p. ix)

Flory, Paul J.
. . . to hold that all chemistry follows deductively from physics and dismiss the matter therewith is to overlook the central role of science in erecting constructs for representation of physical reality in terms rational to the human mind. . . to present chemistry as a deductive science is to conceal the historical foundations and conceptual framework of the science of molecules and molecular behavior. This viewpoint could conceivably lead

ultimately to denial of the rightful existence of chemistry as a separate discipline.

Chemical Engineering News
The Science of Molecules (p. 25)
Volume 52, Number 30, 1974

Fourcroy, Antoine-François
The general truths in any science are continually multiplied, as its perfection advances, and its means of investigation are improved. Such has been the fortune of chemistry.

Elements of Chemistry and Natural History
Volume I
Advertisement (p. 1)

Fownes, George
The Science of Chemistry has for its object the study of the nature and the properties of all the materials which enter into the composition or structure of the earth, the sea, and the air…The highest efforts of Chemistry are constantly directed to the discovery of the general laws or rules which regulate the formation of chemical compounds, and determine the action of one substance upon another. These laws are deduced from careful observation and comparison of the properties and relations of vast numbers of individual substances;—and by this method alone. The science is entirely experimental, and all its conclusions the result of skilful and systematic experimental investigations.

A Manual of Elementary Chemistry, Theoretical and Practical
Introduction (p. 25)

Friedman, Bernard S.
In recent years it has become clear that chemists and other scientists must—indeed they have no choice—be concerned with the social implications of their work.

Chemical Engineering News
The President's Message (p. 2)
Volume 52, Number 1, 7 January 1974

Glaser, Christopher
They that have any true knowledge of this Noble Art [chemistry], are without doubt fully persuaded of the usefulness of it; for it is the key which alone can unlock to all Naturalists the door of Nature's secrets; by reducing things to their first principles; by giving of them new forms; and by imitating Nature in all its productions and Physical alterations.

The Compleat Chymist
Chapter II (p. 3)

Halbach, Mary Jayne
I think that I shall never see
A study as muddled as chemistry,
A study hidden in pondrous books,
Where only a chemist ever looks!
A study written in secret code—
Just numerous equations by the load!
Chemistry was and is and will be—
But I'll never know what it means to me!

Industrial and Engineering Chemistry: News Edition
Sentiment of a Would-Be Chemistry Student (p. 257)
Volume 10, Number 20, 20 October 1932

Haldane, J.B.S.
The main objection to religious myths is that, once made, they are so difficult to destroy. Chemistry is not haunted by the phlogiston theory as Christianity is haunted by the theory of a God with a craving for bloody sacrifices. But it is also a fact that while serious attempts are constantly being made to verify scientific myths, religious myths, at least under Christianity and Islam, have become matters of faith which it is more or less impious to doubt, and which we must not attempt to verify by empirical means. Chemists believe that when a chemical reaction occurs, the weights of the reactants are unchanged. If this is not very nearly true, most of chemical theory is nonsense. But experiments are constantly being made to disprove it…Chemists welcome such experiments and do not regard them as impious or even futile.

Possible Worlds and Other Papers
Science and Theology as Art-Forms (p. 243)

Hendrick, Ellwood
I used to think theology was rather rough on doubt,
But chemistry, with ions, beats theology all out.
So you'd better get your Bible down before you're well begun,
For you're going to need to exercise the art of faith, my son.

Journal of Chemical Education
Editor's Outlook (p. 365)
Volume 22, Number 8, August 1945

Hinshelwood, Sir Cyril N.
What the Society is and must continue above all else to be is a fellowship of those who share the love of chemistry, that most splendid child of intellect and art. Chemistry provides not only a mental discipline, but an adventure and an aesthetic experience. Its followers seek to know the hidden causes which underlie the transformations of our changing world,

to learn the essence of the rose's colour, the lilac's fragrance, and the oak's tenacity, and to understand the secret paths by which the sunlight and the air create these wonders.

Journal of the Chemical Society of London
Centenary Celebration of the Chemical Society
1947 (p. 1277)

Hoffer, Eric
The chemistry of dissatisfaction is as the chemistry of some marvelously potent tar. In it are the building stones of explosives, stimulants, poisons, opiates, perfumes and stenches.

The Passionate State of Mind
Number 14

Hofmann, A.W.
. . . organic chemistry before Kekulé spread his wings. . . was like a merrily splashing torrent; there were so many stones in the water that one could still cross it without getting wet. Today, the torrent has become a deep and massive stream; the eye can hardly see the opposite bank, and proud, richly loaded fleets rock gently on its broad surface.

In W.H. Brock, O.T. Benfey and S. Stark
Journal of Chemical Education
Hofmann's Benzen Tree at the Kekulé Festivities (p. 887)
Volume 68, Number 11, November 1991

Horne, R.A.
If you bemoan technological compartmentalization, take hope! Consider environmental chemistry. Man is a chemical mote aswim in a chemical soup. All the changes about him, all the changes within him are chemical. Everything he sees and touches, everything he does, and the effect of what he does are chemical. If there is anything in the real world that does not fit under the rubric of environmental chemistry, then I am at a loss to find it.

The Chemistry of Our Environment
Preface (p. vii)

Huxley, Thomas
Nothing can be more incorrect than the assumption one sometimes meets with, that physics has one method, chemistry another, and biology a third.

Collected Essays
Volume I
Methods and Results
The Progress of Science (p. 60)

Janssen, Johannes
Chemistry is the true and living anatomy…

History of the German People at the Close of the Middle Ages
Volume XIV
Chapter VI (p. 5)

Kant, Immanuel
…chemistry can become nothing more than a systematic art or experimental doctrine, but never a science proper…

Metaphysical Foundations of Natural Science
Preface (p. 7)

Klaproth, Martin Heinrich
No science has ever made more rapid progress in a shorter time than chemistry.

In Mary Elvira Weeks
Discovery of the Elements (p. 316)

Knight, David
Chemistry can thus be seen as a kind of scientific cookery, its ideas only of interest to those involved in it and perhaps their wives, biographers or psychiatrists…

Ideas in Chemistry: A History of the Science
Chapter 1 (p. 1)

Now that God has given us chemistry let us enjoy it.

Ideas in Chemistry: A History of the Science
Chapter 1 (p. 12)

Chemistry seems in our day more a business of questions difficult to answer than of questions difficult to ask.

Ideas in Chemistry: A History of the Science
Chapter 13 (p. 171)

Kornberg, A.
Life, after all, is only chemistry, in fact, a small example of chemistry observed on a single, mundane planet.

International Journal of Quantum Chemistry
Understanding Life as Chemistry (p. 125)
Volume 53, 1995

Kunckel, Johann
Chemistry is without contradiction one of the most useful arts and it would be no exaggeration to call it the mother or the instructress of other arts; she alone can teach us to interpret the Sacred Scriptures;

she alone teaches us the work of God; and it is thanks to her that we understand the Creation and the material world; Physics and medicine are her dependents; and again, she serves as the foundation for the science of animals and vegetables.

In Allen G. Debus
The Chemical Philosophy
Volume II
Chapter 7 (pp. 464 & 467)

Le Fèvre, Nicholas
Chymistry is the true Key of Nature.

In Allen G. Debus
The French Paracelsians
Chapter 4 (p. 126)

. . . Chymistry is nothing else but the Art and Knowledge of Nature it self; that it is by her means we examine the Principles out of which natural bodies do consist and are compounded; and by her are discovered unto us the causes and sources of their generations and corruptions, and of all the changes and alterations to which they are liable:. . . [Further] it is known, that the ancient Sages have taken from Chymistry, the occasions and true motives of reasoning upon natural things, and that their monuments and writings do testifie this Art to be of no fresher date than Nature it self.

A Compleat Body of Chymistry
The Preface (p. 1)

Le Gallienne, R.
Perfume would seem to be one of the elements, one of the original secrets of the universe. How it gets into flowers, and certain uncouth creatures, as for instance, ambergris in the whale, or civet in the civet cat of Abyssinia, or musk once more in the Florida alligator, is a hidden process of the divine chemistry, and why it affects us as it does no philosopher has yet explained. Literally, it belongs to those invisible powers whose influence is incalculable, and as yet unknowable.

The Romance of Perfume (p. 6)

Le Noble, William J.
It may sound like a lot of work to keep up with organic chemistry, and it is; however, those who haven't the time to do it become subject to decay in the ability to teach and contribute to the Science—a sort of first-order process the half-life of which can't be much more than a year or so.

Highlights of Organic Chemistry
Chapter 3 (p. 112)

Lemery, Nicolas
Chymistry is an Art that teaches how to separate the different substances which are found in Mixt Bodies…

A Course of Chemistry
Of Chemistry in General (p. 1)

Levi, Primo
This was found pretty soon, drawing on good inorganic chemistry, that distant Cartesian island, a lost paradise, for us organic chemists, bunglers, "students of gunk"…

The Periodic Table
Chromium (p. 157)

…for me chemistry represented an indefinite cloud of future potentialities which enveloped my life to come in black volutes torn by fiery flashes, like those which had hidden Mount Sinai. Like Moses, from that cloud I expected my law, the principle of order in me, around me, and in the world…I would watch the buds swell in spring, the mica glint in the granite, my own hands, and I would say to myself: "I will understand this, too, I will understand everything."

The Periodic Table
Hydrogen (pp. 22–3)

Lewes, G.H.
Physics treat of Masses acting at sensible distances. Chemistry treats of Molecules acting at insensible distances.

Comte's Philosophy of the Sciences
Section XI (p. 113)

Libby, Willard F.
Chemistry is increasingly important to the peaceful atom. In fact, in the next few years, the chemist may be the most important contributor.

Address
Manufacturing Chemists' Association, Inc.
25 November 1998, New York

Lichtenberg, Georg Christoph
He who understands nothing but chemistry doesn't even understand chemistry.

In Philip Ball
Designing the Molecular World (p. 3)

Little, Arthur D.
Chemistry is a creative science…and the first chapter of its Book of Genesis is not yet written.

In David H. Killeffer
Chemical Engineering
Chapter 10 (p. 130)

Loos, Anita
There's nothing colder than chemistry.

Kiss Hollywood Good-By
Chapter 21 (p. 193)

Lytton, Edward Robert Bulwer, 1st Earl of Lytton
Chemistry, Soldier, trust me, is a science
Which now-a-days we sceptred students need
To study more than your rough art of war

Chronicles and Characters
Volume 2
The Duke's Laboratory, L. 234–6

"Friend, I believe in miracles," said he,
"And I believe in chemistry as well;…"

Glenaveril; Or, The Metamorphoses
A Poem in Six Books
Book The Fourth
Canto ii. John Steel, Stanza LVIII

Mackenzie, Colin
The Science of Chemistry is the knowledge of the relations of those phenomena, or changes, which take place in the sensible qualities of bodies, as results of the action of one species of matter on another.

One Thousand Experiments in Chemistry
Introduction (p. v)

Mann, Thomas
Soon or late, division must yield "units" which, even though in composition, were not organized, and which mediated between life and absence of life; molecular groups, which represented the transition between vitalized organization and mere chemistry.

The Magic Mountain
Chapter V
Research (p. 283)

Marple, Howard A.
Christmas Spirit is a neutral chemical that builds new compounds and rejuvenates old. It is a reversible compound, for Christmas Spirit returns to its original state, ready to begin anew.

It has an affinity for good, and attacks the bad. Large or small quantities of it can be handled, depending on the capacity of the mind that dispenses it.

Let us analyze the chemical and physical properties of Christmas Spirit as we do any chemical, element, or compound. It has, at times, an odor of frankincense and myrrh, the odor of evergreen or of burning tapers. This depends on the place and the heat of reaction. On mixing, it has a tinkling, joyful sound, full taste of all good things.

Its energy is unbounding, dividing itself a million times, it becomes more powerful, creating in most all it meets a feeling of light-heartedness; in some, a wistful sadness. More often it is like new wine—it refreshes, stimulates. Makes happiness and smiles, increasing generosity and good nature.

The world is its laboratory, and all those that inhabit this planet may use and enjoy its benefits. Its wave length covers the entire scale of the spectrum. It is a force that cannot be measured in meters or tons and can be transmitted with the speed of light to extreme corners of the earth, using an ether wave as medium.

Christmas Spirit is the Universal Solvent or Alkahest sought by the alchemists of old. "If it were found," they reasoned "there would be no vessel strong enough to hold it." Is it not true with Christmas Spirit?

Right administered, it pervades the innermost recesses of the stoniest hearts, and adds new life to drooping, discouraged spirits.

Christmas Spirit is the elixir of life that materially influences the chemistry of all human life.

Industrial and Engineering Chemistry: News Edition
The Chemistry of Christmas (p. 3)
Volume 7, Number 23, 10 December 1929

Mayo, William J.
Life is largely a matter of chemistry.

Industrial and Engineering Chemistry
The Advancement of Learning in Medicine Through Biochemistry (p. 460)
Volume 20, Number 5, May 1928

Melville, Harry W.
In physical chemistry, as in other sciences, progress usually occurs by a series of rather discontinuous steps separated by periods of consolidation. Thus certain topics and branches of a subject become popular fields of activity once the pioneering work has defined the field of endeavour. Thereafter papers flow in ever-increasing numbers.

In Faraday Society
Transactions of the Faraday Society
High Polymers (p. 565)
Volume 49, 1953

Mencken, H.L.
It is now quite lawful for a Catholic woman to avoid pregnancy by a resort to mathematics, though she is still forbidden to resort to physics or chemistry…

Minority Report: H.L. Mencken's Notebooks
Sample 62

Mendeléeff, D.I.
In sciences like chemistry, which treat of ideas as well as of the substances of nature, experience demonstrates at every step that the work of the past has availed much, and that without it it would be impossible to advance 'into the ocean of the unknown.'

Principles of Chemistry
Volume I
Preface (p. vii)

Mittasch, Alwyn
Chemistry without catalysis, would be a sword without a handle, a light without brilliance, a bell without sound.

Journal of Chemical Education
In Ralph E. Oster
Alwin Mittasch (p. 532)
Volume 25, Number 10, October 1948

Muir, M.M. Pattison
The more I try to understand chemistry, the more I am convinced that the methods, achievements, and aims of the science can be realized only by him who has followed the gradual development of chemical ideas.

A History of Chemical Theories and Laws
Preface (p. v)

The purpose of chemistry seems to have changed much from time to time. At one time chemistry might have been called a theory of life, and at another time a department of metallurgy: at one time a study

of combustion, and at another time an aid to medicine, at one time an attempt to define a single word, the word *element*, and at another time the quest for the unchanging basis of all phenomena. Chemistry has appeared to be sometimes a handicraft, sometimes a philosophy, sometimes a mystery, and sometimes a science.

A History of Chemical Theories and Laws
Introduction (p. vii)

Chemistry is a universal science: it was founded by many whose memories are forgotten. The foundations of chemistry are laid deep in the experiences, the hopes, the visions of mankind.

A History of Chemical Theories and Laws
Part I, Chapter I (p. 1)

Newman, Joseph S.
Thus man, in essence, seems to be
A problem based on chemistry.

Poems for Penguins
Biochemistry

Osler, Sir William
Professional chemists look askance at physiological chemistry, and physiological chemists criticize pretty sharply the work of some clinical chemists, but there can be no doubt of the value to the physicians of a very thorough training in methods and ways of organic chemistry.

Aequanimitas
Internal Medicine as a Vocation (p. 137)

Packe, Christopher
The Art of Chymistry, [*Honoured Sir*] although in its speculations most Noble and Delectable to a Philosophic Mind, and in its Practice highly Inservient, and Beneficial to Mankind; yet hath it not escaped Obloquies, the false Imputations of Detractors, and Caluminiators, who either through Ignorance, Idleness, or Envoy (or all of the cojoined) have made a false Representation of this most Noble Art to the World, and endeavored to set Mankind at the greatest distance from that which is its highest interest to court.

In Johann Glauber
The Works of the Highly Experienced and Famous Chymist, John Rudolph Glauber
To The Honoured, and Truly Learned, Edmond Dickenson, M.D.

Pallister, William
This is the quest for you and me,
Are men twigs on the chemis-tree?

When X is life, and time is T,
Sp is space, and vast force is E,
When Y is thought, dimension D:
Does X = $C_{500}H_{100}O_{250}N_{250}S_{50}$ + P?

Poems of Science
Protoplasm (p. 75)

Pauling, Linus
There is more to chemistry than an understanding of general principles. The chemist is also, perhaps even more, interested in the characteristics of individual substances—that is, of individual molecules.

In Mary Jo Nye
Before Big Science
Chapter 6 (p. 188)

Chemistry is wonderful! I feel sorry for people who don't know anything about chemistry. They are missing an important source of happiness.

In Barbara Marinacci (ed.)
Linus Pauling in His Own Words
Chapter 2 (p. 43)

…every aspect of the world today—even politics and international relations—is affected by chemistry.

Chemical and Engineering News
Chemistry and the World of Tomorrow (p. 54)
Volume 62, Number 16, April 1984

Plummer, Andrew
Chemistry is an art that has furnished the world with a great number of useful facts, and has thereby contributed to the improvement of many arts; but these facts lie scattered in many different books, involved in obscure terms, mixed with many falsehoods, and joined to a great deal of false philosophy; so that it is no great wonder that chemistry has not been so much studied as might have been expected with regard to so useful a branch of knowledge, and that many professors are themselves but very superficially acquainted with it.

In A.L. Donovan
Philosophical Chemistry in the Scottish Enlightenment
Chapter 3 (p. 39)

Popper, Karl R.
Physics and chemistry are not very different, and there seems to be no great difference in the kind of things to which they apply, except that chemistry, as it is usually understood, becomes inapplicable, at very high temperatures and also, perhaps, at very low ones. It therefore would not be very surprising if the hopes, held for a long time, that chemistry

can be reduced to physics, were to come true, as indeed they seem to be doing…by a reduction I mean, of course, that all the findings of chemistry can be fully explained by (that is to say, deduced from) the principles of physics.

Objective Knowledge: An Evolutionary Approach
Chapter 8 (p. 290)

Prelog, V.
Chemistry takes a unique position among the natural sciences for it deals not only with material from natural sources but creates the major parts of its objects by synthesis. In this respect, as stated many years ago by Marcellin Berteholt, chemistry resembles the arts; the potential of its creativity is terrifying.

Science
Chirality in Chemistry (p. 18)
Volume 193, Number 4247, 2 July 1976

Primas, Hans
The most important task of contemporary theoretical chemistry is to stimulate the mutual understanding of the various branches of chemistry and its neighboring sciences.

Chemistry, Quantum Mechanics and Reductionism
Chapter 1
Section 1.2 (p. 2)

Protheroe, Chester F.
I sing to you of chemistry,
Of test tubes and of stinks;
Of things that burn and those that don't,
And those that clog up sinks;

Of hydrogen and oxygen,
The water that they make,
And hydrogen peroxide—
Unstable—do not shake;

Of chemical equations,
Of valence and other joys:
How are your mathematics?
Oh, bright-faced girls and boys!

Chemistry
Reader's Column (p. 42)
Volume 40, Number 3, March 1967

Prout, William
Chemistry forms the connecting link between that kind of knowledge which is founded on quantity, and those kinds of knowledge which rest solely on experience. Now so far as the logic of quantity is applicable, so far are we certain of our conclusions. But when this logic cannot be applied, our conclusions are no longer such as must be, but are only for the most part such as may be.

In Ida Freund
The Study of Chemical Composition
Chapter XIX (p. 592)

Richards, Ellen H.
. . . some sort of false logic has crept into our schools, for the people whom I have seen doing housework or cooking know nothing of botany or chemistry, and the people who know botany and chemistry do not cook or sweep. The conclusion seems to be, if one knows chemistry she must not cook or do housework.

In Carolyn Louisa Hunt
Life of Ellen H. Richards
Chapter 10

Richards, Theodore W.
Chemistry has not grown spontaneously to its present state; it is a product of human mentality. The science which we know today is but an echo of the eternal and incomprehensible 'music of the spheres' as heard and recorded by the minds of individual men.

In Bernard Jaffe
New World of Chemistry (p. vi)

Richet, Charles
If the progress of chemistry consisted only in producing still more noxious gases capable of destroying a regiment in a few minutes, then chemistry would be an accursed science.

The Natural History of a Savant
Chapter XIII (pp. 143–4)

Sarton, George
. . . any branch of science may be completely revolutionized at any time by a discovery necessitating a radically new approach to the subject. Chemistry to-day is essentially different from chemistry in the eighteenth century. The fundamental notions are different, the methods are different, the scope is indescribably larger, and the contents are infinitely more varied. We may safely assume that the chemistry of the twenty-fifth

century will be as unlike that of the present as that, in turn, is unlike that of the fifteenth century.

The Study of the History of Science (pp. 7–8)

Scheele, Carl Wilhelm

It is the object and chief business of chemistry to skillfully separate substances into their constituents, to discover their properties, and to compound them in different ways. How difficult it is, however, to carry out such operations with the greatest accuracy, can only be unknown to one who either has never undertaken this occupation, or at least has not done so with sufficient attention.

The Discovery of Oxygen
Part II
Chemical Treatise on Air and Fire
Section 1

Shaw, George Bernard

Not love: we know better than that. Let's call it chemistry... Well, you're attracting me irresistibly—chemically.

You Never Can Tell
Act II (p. 70)

In the arts of life man invents nothing; but in the arts of death he outdoes Nature herself, and produces by chemistry and machinery all the slaughter of plague, pestilence and famine.

Man and Superman
Act 3 (pp. 83–4)

Shelley, Mary

Chemistry is that branch of natural philosophy in which the greatest improvements have been made and may be made—but I have not neglected the other branches of science. A man would make but a very sorry chemist if he attended to that department of human knowledge alone. If your wish is to become really a man of science and not merely a petty experimenter, I should advise you to apply to every branch of natural philosophy, including mathematics.

The Novels and Selected Works of Mary Shelley
Volume 1
Frankenstein
Volume I
Chapter II (p. 33)

Shulman, Max
Organic chemistry is the study of organs; inorganic chemistry is the study of the insides of organs.

In Evan Esar
20,000 Quips & Quotes

Smith, Betty
Francie came away from her first chemistry lecture in a glow. In one hour she found out that everything was made up of atoms which were in continual motion. She grasped the idea that nothing was ever lost or destroyed. Even if something was burned up or rot away, it did not disappear from the face of the earth; it changed into something else—gases, liquids, and powders. Everything, decided Francie after that first lecture, was vibrant with life and there was no death in chemistry. She was puzzled as to why learned people didn't adopt chemistry as a religion

A Tree Grows in Brooklyn
Chapter XLIX (p. 389)

Teeple, John E.
Chemistry is a science, a branch of knowledge, and there is no law to prevent anyone who has the least bit of chemical information—such, for instance, as the chemical symbol for water—from calling himself a chemist.

The Journal of Industrial and Engineering Chemistry
Is the Practice of Chemistry a Profession, a Trade, or a Tool? (p. 665)
Volume 17, Number 7, July 1925

Thomson, J.A.
CHEMISTRY is mainly the science of the different kinds of matter, their transformations, affinities, and interactions. It is *par excellence* the science of molecules and atoms.

Introduction to Science
Chapter IV (p. 106)

Thomson, Thomas
Chemistry is a science, the object of which is to ascertain the ingredients that enter into the composition of bodies, to examine the nature of these ingredients, the manner in which they combine, and the properties resulting from their combination.

A New System of Chemistry
Definition (p. 1)

Chemistry, unlike other sciences, sprang originally from delusions and superstition, and was at its commencement exactly on a level with magic and astrology.

The History of Chemistry
Introduction (p. 1)

Thoreau, Henry David
Verily, chemistry is not a splitting of hairs when you have got half a dozen raw Irishmen in the laboratory.

Cape Cod
Chapter 10 (p. 172)

Unknown
1. *Physical Chemistry*: The pitiful attempt to apply $y = mx + b$ to everything in the universe.
2. *Organic Chemistry*: The practice of transmuting vile substances into publications.
3. *Inorganic Chemistry*: That which is left over after the organic, analytical, and physical chemists get through picking over the periodic table.
4. *Chemical Engineering*: The practice of doing for a profit what an organic chemist only does for fun.

Classification of Chemistry

Chemistry is physics without thought; mathematics is physics without purpose.

Source unknown

Physics is the taking of very accurate measurements on impure and poorly defined materials. Chemistry is characterized by sloppy measurements on very pure materials. Thus Physical Chemistry is sloppy measurements on impure materials.

Source unknown

I pledge allegiance to the chart of the Periodic Table of Elements, and to the Atomic Theory for which it stands. One concept, under Mendeléev, for observations and experimentation for all.

Chemistry Pledge
Source unknown

Love is a matter of chemistry, but sex is a matter of physics.

Source unknown

A microchemist is a man who does microanalysis or microsynthesis. He studies microreactions in microtest-tubes. He collects microprecipitates on microfilters and weighs them on a microbalance, or makes microtitrations

with microburets, and records the results in a micronotebook. Then he writes *Macro*papers for the microjournals.

Industrial and Engineering Chemistry: News Edition
A Microtreatise on Microchemistry (p. 312)
Volume 13, Number 14, 20 July 1935

A chemistry professor was very strict about attendance, and despised tardiness. Every student caught arriving to class late (especially those interrupting his lecture) was quickly reprimanded in front of the whole class. Students were quick to comment on the professor's genetics. Well, one day a student entered through the front doors of the lecture hall, while the prof was writing notes on the chalkboard. The professor caught the student out of the corner of his eye (this acute sense of peripheral vision, further supported the rumours of his evolution), and turned to face the student. He demanded, "What do you think you're doing?". Being a science student, one naturally thinks quickly, so the student snapped up and replied, "I came down from the back to get a better look at the board". The prof smiled.

Source unknown

van Helmont, Jean Baptiste
I praise my bountiful God, who hath called me into the Art of the fire, out of the dregs of other professions. For truly, Chymistry…prepares the understanding to pierce the secrets of nature, and causeth a further searching out in nature, than all other Sciences being put together: and it pierceth even unto the utmost depths of real truth…

Oriatrike or Physick Refined
Chapter LIX (p. 462)

van 't Hoff, J.H.
This is physical chemistry, formerly a colony, now a great, free land.

In Diana Kormos Barkan
Walther Nernst and the Transition to Modern Physical Science
Chapter I (p. 1)

von Meyer, Ernst
The main problem of chemistry, the investigation of the true composition of compounds, necessarily carries along with itself the constant endeavour to elaborate and perfect the means employed for arriving at this end.

A History of Chemistry from Earliest Times to the Present Day
Chapter VI (p. 358)

von Schelling, F.W.J.
Chemistry itself is a science which advances securely upon the beaten path of experience, even when it does not turn back to first principles. But a science which in itself is so rich, and which has lately made such great progress towards *system* surely deserves to be led back to such principles.

Ideas for a Philosophy of Nature
Chapter 8 (p. 237)

Wells, H.G.
He was a practical electrician but fond of whiskey, a heavy, red-haired brute with irregular teeth. He doubted the existence of the Deity but accepted Carnot's cycle, and he had read Shakespeare and found him weak in chemistry.

The Door in the Wall, and Other Stories
Lord of the Dynamos
Chapter 7

Werner, Alfred
Chemistry must become the astronomy of the molecular world.

In George B. Kauffman
Alfred Werner: Founder of Coordination Chemistry (p. iii)

Whewell, William
. . . the common operations of chemistry give rise in almost every instance to products which bear no resemblance to the materials employed. . . it is an utter mistake to expect that the qualities of the elements shall be still discoverable, in an unaltered form in the compound.

The Philosophy of the Inductive Sciences
Volume I
Part I, Book VI (p. 379)

Wiley, Harvey W.
There is no branch of our science which is to be crowned king and leader. Chemistry is a pure democracy, and all are equal therein.

The Journal of the American Chemical Society
Address of Welcome to the World's Chemical Congress (p. 304)
Volume XV, Number 6, June 1893

CHEMISTRY AND LIFE

Berrill, N.J.
Life can be thought of as water kept at the right temperature in the right atmosphere in the right light for a long enough period of time.

You and the Universe
Chapter 15 (p. 117)

Huxley, Thomas
Looking back through the prodigious vista of the past, I find no record of the commencement of life, and therefore I am devoid of any means of forming a definite conclusion as to the conditions of its appearance. Belief, in the scientific sense of the word, is a serious matter, and needs strong foundations. To say, therefore, in the admitted absence of evidence, that I have any belief as to the mode in which existing forms of life originated, would be using words in a wrong sense. But expectation is permissible where belief is not; and if it were given to me to look beyond the abyss of geologically recorded time to the still more remote period when the Earth was passing through physical and chemical conditions which it can no more see again than a man can recall his infancy, I should expect to be a witness of the evolution of living protoplasm from not-living matter.

Collected Essays
Volume VIII
Discourses: Biological and Geological
Biogenesis and Abiogenesis (p. 256)

Keosian, J.
The materialist theory of the origin of life from inanimate beginnings recognizes the role of chance in the interactions of matter in the universe, but views the overall developments as in no way accidental; on the

contrary it is looked upon as inevitable, almost inexorable, outcome of the emergence and operation of natural laws.

In D.L. Rohlfing and A.I. Oparin (eds.)
Molecular Evolution: Prebiological and Biological
The Origin of Life Problem—A Brief Critique (p. 14)

Oparin, A.I.
It has now become quite clear that the origin of life was not the result of some "happy chance" as was thought till quite recently, but a necessary stage in the evolution of matter. The origin of life is an inalienable part of the general process of the development of the universe and, in particular, the development of the earth.

In R. Buvet and C. Ponnamperuma (eds.)
Chemical Evolution and the Origin of Life
Problem of the Origin of Life: Present State and Prospects (pp. 3–4)

CHEMISTRY AND MEDICINE

Berzelius, Jöns Jakob
Of all the sciences contributing to medicine, chemistry is the primary one, and, apart from the general light it throws on the entire art of healing, it will soon bestow on some of its branches a perfection such as one never could have anticipated.

In J. Erik Jorpes
Jac. Berzelius (p. 7)

Janssen, Johannes
. . . the doctor must be a chemist also, and medicine and chemistry cannot be separated from each other.

History of the German People at the Close of the Middle Ages
Volume XIV
Chapter VI (p. 7)

Latham, Peter Mere
Sagacious observers and experimenters have, in these later days, gone nigh to show that there is a chemistry within us which is cooperative with life; that in making good its work, it gives to our bodies the materials of their health; and that doing its work faultily, it suffers noxious things to form, which become the elements of their diseases.

In William B. Bean
Aphorisms from Latham (p. 89)

Chemical experiment and clinical observation, leading each other by the hand, proceed together, and arrive at the seminal principal of the disease.

In William B. Bean
Aphorisms from Latham (p. 93)

Osler, Sir William
. . . the physician without physiology and chemistry flounders along in an aimless fashion, never able to gain any accurate conception of disease,

practising a sort of popgun pharmacy, hitting now the malady and again the patient, he himself not knowing which.

Aequanimitas
Teaching and Thinking
II (p. 121)

CHEMISTRY SONGS

Alexander, Jerome
It's not easy to be a chemist,
It's a long way to go,
Qualitative, quantitative,
Must be accurate, you know.
Precipitation, then in filtration,
Colloids make me tear my hair—
It's a long, hard road to be a chemist,
But my heart lies there.

Industrial and Engineering Chemistry: News Edition
I'm Going to be a Chemist (p. 239)
Sung to the tune *It's a Long, Long Way to Tipperary*
Volume 13, Number 10, 20 May 1935

Crowther, Greg
FEMALE VOICE: MALE VOICE:

You don't wash my glassware;
You don't cite my papers.

You hardly ever bother
To reorder safety gloves
When we're out of my size.

I remember when…
You helped me make the figures
For the first draft of my thesis.
Now I'm nothing
But a footnote in your life.

Yeah, my lab was your lab,
And your lab was mine.

Now you go on sabbatical
And leave me behind…
And you don't wash my glassware anymore.

It used to be so easy;

We'd write our grants together.
But our funding has run out,
My dear,
And I guess our love has, too.

Baby, I remember
All the things you taught me.

I learned how to theorize,
And I learned how to recant.

Well, I learned to accept
All those vicious peer reviews.

But I just can't accept

No, I just can't accept

A rejection from you.

A rejection from you.
You don't wash my glassware anymore.

Sung to the tune *You Don't Bring Me Flowers*

Mamas don't let your babies grow up to be chemists.
Don't let 'em teach or go or work at the Hutch;
Make 'em be bankers and lawyers and such.
Mamas don't let your babies grow up to be chemists.
With every involvement, they end up in solvent,
Smelling bad and inhaling too much.

Sung to the tune *Mamas Don't Let Your Babies Grow Up To Be Cowboys*

I love the lab!
The days fly by in here!
I love the lab!
I'm spending more time here each year!

The more I'm in lab,
The more I'm filled with glee,
And the more the glee,
The more I'm a merrier me!
It's true!
The more I'm a merrier me!

I Love The Lab
Sung to the song *I Love To Laugh* from the movie *Mary Poppins*

Gucker, Frank T., Jr.
I am the very pattern of a modern Doctor Chemical;
I send to all the journals my remarks and views polemical.
I've studied mathematics till I think in terms vectorial
And scorn the plodding soul who seeks for molecules pictorial.
The calculus is food for babes; I love a complex var-i-able
And state a simple law in terms the layman thinks are terr-i-able.

I can talk of relativity and space-time for a month or more
And integrate elliptically to terms the $(n+1)$th or more—
And yet my hand and mind are seized with palsey and paralysis
When I essay that dreadful task—a chemical analysis.

Industrial and Engineering Chemistry: News Edition
The Modern Doctor Chemical (p. 312)
Sung to the tune Modern Major-General
Volume 10, Number 34, 20 December 1932

CLASSROOM EMANATIONS

Unknown
A gas is a dry liquid.

A Salt is a substance which has been naturalized.

A calorie is the amount of pressure required to push 1 gm of water 1 °C.

Molecules bump together and cause the molecular hypothesis.

The phlogiston theory is a theory that used to be believed by chemists and people.

A catalyst is a substance which felicitates a chemical change but does not change itself.

Pure substances are those which do not contain any organic or inorganic matter.

A moral solution is one which contains one g.m.w. per liter.

Nascent atoms are equipped with arms, with which they can combine with other atoms.

The difference between a physical and a chemical change is that a chemical change evaporates and a physical change remains the same

Ozone is made by passing a spark plug through the air.

Sulfurated hydrogen is a gas of pugnacious odor.

Journal of Chemical Education
Classroom Emanations (p. 611)
Volume 2, Number 7, July 1925

Nitrous oxide is called laughing gas because it is used by dentists.

Organic chemistry is a big chapter in inorganic chemistry.

Red phosphorus is used for matches so that people who are in the habit of chewing matches will not suffer.

Galvanized iron is iron which is used for making galvanometers.

The absorption of water from the air by Calcium Chloride is called desecration.

Gunpowder is mixed thoroughly so as to fool the ingredients into thinking they are a compound.

Normality factor is that factor which when added in the correct amount, produces, or tends to produce, equilibrium in a solution.

An example of "reduction" is when water is boiled down it is reduced to a smaller amount after a bit.

A solution is a combination of homegenial bodies which are suspended relatively far apart.

Temporary and permanent hardness of water signifies whether the water is in the form of snow or ice.

Journal of Chemical Education
Class-Room Chemical Emanations
Volume 3, Number 1, January 1926

COMMANDMENTS

Unknown

1. Thou shalt be pipe fitter, electrician, glass blower, leadburner, welder, office boy, carpenter and lab devil, for the sake of thy process.
2. Thou shalt not take the name of thy superintendent, or thy assistant superintendent, or even thy third assistant superintendent in vain.
3. Six days shalt thou labor with thy process and on the seventh thou shalt labor also. For the Sunday was made for chemists.
4. Thou shalt keep thy process running on Election Day, Fourth of July, Thanksgiving, Christmas, and on Columbus Day. For the welfare of thy plant, thou shalt know no holiday whatever.
5. Thou shalt run thy process without residues, either those that pollute with stenches the air above or those that may be poured into rivers, or those that accumulate as ungodly wastes up on the face of the earth.
6. Thou shalt endeavor by thermodynamics, relativity, soft soap bulldozing, profanity and chemistry, to keep thy efficiencies high, yea a hundred per cent is acceptable.
7. Thou shalt not covet new equipment, or assistants or foremen. For all these things are an abomination in the sight of thy employers.
8. Thou shalt swap tobacco with thy workmen. For their sake thou shalt speak Scotch, Polish, Italian, Bohemian, Low Dutch, and Irish with facility.
9. Thou shalt turn out a product of unexcelled purity. For the sales department knows best.
10. Thou shalt not covet great rewards. Thou shalt accept humbly the honorarium meted out to you. May thy troubles be few, thy spiritual reward large, and may thy days belong with thy process.

Industrial and Engineering Chemistry: News Edition
The Ten Commandments of an Industrial Chemist (p. 6)
Volume 7, Number 20, 20 October 1929

COMMON SENSE

Bronowski, Jacob
The world makes sense all right; it makes common sense... But common sense is not what we put into the world. It is what we find there.

The Common Sense of Science
Chapter V (p. 78)

Davy, Sir Humphry
In the progress of an art, from its rudest to its more perfect state, the whole process depends upon experiment. Science is in fact nothing more than the refinement of common sense making use of facts already known to acquire new facts.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (p. 355)

Henderson, L.J.
It is a strange irony that the principles of science should seem to deny the necessary conviction of common sense.

The Order of Nature
Chapter V (p. 92)

Hoyle, Fred
A common sense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature.

In Geoffrey Burbidge (ed.)
Annual Review of Astronomy and Astrophysics
The Universe: Past and Present Reflections (p. 16)
Volume 20, 1982

Russell, Bertrand

It used to be supposed by empiricists that the justification of such inference rests upon induction. Unfortunately, it can be proved that induction by simple enumeration, if conducted without regard to common sense, leads very much more often to error than the truth. And if a principle needs common sense before it can be safely used, it is not the sort of principle that can satisfy a logician. We must, therefore, look for a principle other than induction if we are to accept the broad outlines of science, and of common sense in so far as it is not refutable. This is a very large problem.

My Philosophical Development
Chapter 1 (p. 11)

Thoreau, Henry David

There is absolutely no common sense; it is common nonsense.

The Writings of Henry David Thoreau
Volume 4
Paradise (To Be) Regained (p. 298)

COMMUNICATION

Carroll, Lewis
Take care of the sense and the sounds will take care of themselves.

Alice's Adventure in Wonderland and Through the Looking-Glass
Alice's Adventures in Wonderland
The Mock Turtle's Story (p. 96)

Lemke, J.
True Dialogue occurs when teachers ask questions to which they do not presume to already know the "correct answer."

Talking Science: Language, Learning and Values
Chapter 3 (p. 55)

Pool, Ithiel de Sola
Computing and communication are becoming one...

Technologies Without Boundaries: On Telecommunications in a Global Age
Part I
Chapter I (p. 8)

Priestley, Joseph
When for the sake of a little more reputation, men can keep brooding over a new fact, in the discovery of which they might, possibly, have very little real merit, till they think they can astonish the world with a system as *complete* as it is *new*, and give mankind a high idea of their judgment and penetration; they are justly punished for their ingratitude to the fountain of all knowledge, and for their want of a genuine love of science and of mankind, in finding their boasted discoveries anticipated, and the field of honest fame pre-occupied, by men, who, from a natural ardour of mind engage in philosophical pursuits, with an ingenious simplicity immediately communicate to others whatever occurs to them in their inquiries.

Experiments and Observations on Different Kinds of Air
Volume I
The Preface (pp. xvii–xviii)

Schrödinger, Erwin
If you cannot—in the long run—tell everyone what you have been doing, your doing has been worthless.

Science and Humanism (pp. 8–9)

COMPOUND

Fittag, R.
We are now forced to increase the number of compounds, not merely in order to prepare new substances, but to discover natural laws.

In W. Mansfield Clark
The Determination of Hydrogen Ions (p. 67)

Proust, J.L.
We must recognize an invisible hand which holds the balance in the formation of compounds. A compound is a substance to which Nature assigns fixed ratios, it is, in short, a being which Nature never creates other than balance in hand, *pondere et mensurd*.

Annales de Chimie
Volume 32, (p. 26)

von Baeyer, Adolf
I have never stuck stubbornly to a particular point of view if it could no longer be reconciled with the facts. . . I went for a ride, so to speak, through a pleasant countryside among the compounds and enjoyed the view. One day it looked this way, and perhaps the next day it looked different. So why should one stick stubbornly to one particular point of view.

In Richard Willstätter
From My Life
Chapter 6 (p. 141)

CONCEPT

Chargaff, Erwin
Great concepts require great names.

Essays on Nucleic Acids
Chapter 11 (p. 183)

The initial incommunicability of truth, scientific or otherwise, shows that we think in grooves, and that it is painful for us to be torn away from the womblike security of accepted concepts.

Heraclitean Fire
Part II
The Exquisiteness of Minute Differences (p. 86)

Reynolds, William C.
Perkins, Harry C.
Concepts form the basis for any science. These are ideas, usually somewhat vague (especially when first encountered), which often defy really adequate definition. The meaning of a new concept can seldom be grasped from reading a one-paragraph discussion. There must be time to become accustomed to the concept, to interrogate it with prior knowledge, and to associate it with personal experience. Inability to work with details of a new subject can often be traced to inadequate understanding of its basic concepts.

Engineering Thermodynamics (p. 4)

Tansley, A.G.
We must never conceal from ourselves that our concepts are creations of the human mind which we impose on the facts of nature, that they are derived from incomplete knowledge, and therefore will never *exactly* fit the facts, and will require constant revision as knowledge increases.

Journal of Ecology
The Classification of Vegetation and the Concept of Development (p. 120)
Volume 8, Number 2, June 1920

CONFUSION

Lovelace, Augusta Ada
. . . at the moment I am in a charming state of confusion.

In Dorothy Stein
Ada: A Life and a Legacy
Chapter 3 (p. 107)

Moore, Marianne
Unconfusion submits
its confusion to proof; it's
not a Herod's oath that cannot change.

Collected Poems
The Mind is an Enchanting Thing (p. 134)

Ritchie, A.D.
If you are in the very thickest fog you are not confused because you see nothing to confuse you. But as the fog gradually disperses you catch sight indistinctly of a bit of something here and another bit of something there; you are not quite sure what each is or how it fits in with the rest. Then you are confused until it is clear enough to see everything.

Memoirs and Proceedings of the Manchester Literary & Philosophical Society
The Atomic Theory (p. 180)
Volume 86, Number 8, 1943–45

COSMOCHEMISTRY

Frost, Robert
Say something to us we can learn
By heart and when alone repeat.
Say something! And it says, "I burn."
But say with what degree of heat.
Talk Fahrenheit, Talk Centigrade.
Use language we can comprehend.
Tell us what elements you blend.

The Poetry of Robert Frost
Take Something Like a Star, L. 9–15

Fuller, Buckminster
Universe has no pollution.
All the chemistries of the Universe are essential
To its comprehensive self regulation.

In John S. Lewis
Physics and Chemistry of the Solar System
Chapter II (p. 43)

Marcet, Jane
Nature also has her laboratory, which is the universe, and there she is incessantly employed in chemical operations.

Conversations on Chemistry
Conversation I (p. 2)

CREATIVITY

Glegg, Gordon L.
Disciplined thinking focuses inspiration rather than blinkers it.

The Design of Design
Introduction (p. 1)

Lipscomb, William N.
For me, the creative process, first of all, requires a good nine hours of sleep a night. Second, it must not be pushed by the need to produce practical applications.

New York Times
7 December 1977

Lowell, James Russell
In creating, the only hard thing's to begin.

A Fable for the Critics (p. 28)

Stein, Gertrude
Picasso said once that he who created a thing is forced to make it ugly. In the effort to create the intensity and the struggle to create this intensity, the result always produces a certain ugliness; those who follow can make of this thing a beautiful thing because they know what they are doing, the thing having already been invented, but the inventor because he does not know he is going to invent inevitably the thing he makes must have its ugliness.

Picasso (p. 9)

Unknown
If you are going to be creative, you are going to be wrong a lot.

Source unknown

In creating, the only hard thing's to begin.
James Russell Lowell – (See p. 144)

CRITICISM

Darwin, Charles
Whenever I have found out that I have blundered, or that my work has been imperfect, and when I have been contemptuously criticized, and even when I have been overpraised, so that I have felt mortified, it has been my greatest comfort to say hundreds of time to myself that "I have worked as hard and as well as I could, and no man can do more than this".

In F. Darwin
The Life and Letters of Charles Darwin
Volume I
Chapter II, Autobiography (p. 89)

CRYSTAL

Hearn, Lafcadio
I feel like a white granular mass of amorphous crystals—my formula appears to be isomeric with Spasmotoxin. My aurochloride precipitates into beautiful prismatic needles. My Platinochloride develops octohedron crystals,—with fine blue florescence. My physiological action is not indifferent. One millionth of a grain injected under the skin of a frog produced instantaneous death accompanied by an orange blossom odor.

In Elizabeth Bisland
The Life and Letters of Lafcadio Hearn
Volume I
Letter to George M. Gould, 1889 (p. 462)

Lonsdale, Dame Kathleen
. . . a crystal is like a class of children arranged for drill, but standing at ease, so that while the class as a whole has regularity both in time and space, each individual child is a little fidgety!

Crystals and X-Rays
Chapter I

Mann, Thomas
I shall never forget the sight. The vessel of crystallization was three-quarters full of slightly muddy water—that is, dilute water-glass—and from the sandy bottom there strove upwards a grotesque little landscape of variously colored growths: a confused vegetation of blue, green, and brown shoots which reminded one of algae, mushrooms, attached polyps, also moss, then mussels, fruit pods, little trees or twigs from trees, here, and there of limbs. It was the most remarkable sight I ever saw, and remarkable not so much for its profoundly melancholy nature. For when Father Leverkühn asked us what we thought of it and we timidly answered him that they might be plants: "No," he replied, "they are not, they only act that way. But do not think the less of them. Precisely

because they do, because they try as hard as they can, they are worthy of all respect."

Doktor Faustus
Chapter III (p. 19)

Shaw, George Bernard
Tyndall declared that he saw in Matter the promise and potency of all forms of life, and with his Irish graphic lucidity made a picture of a world of magnetic atoms, each atom with a positive and a negative pole, arranging itself by attraction and repulsion in orderly crystalline structure. Such a picture is dangerously fascinating to thinkers oppressed by the bloody disorders of the living world. Craving for purer subjects of thought, they find in the contemplation of crystals and magnets a happiness more dramatic and less childish than the happiness found by mathematicians in abstract numbers, because they see in the crystals beauty and movement without the corrupting appetites of fleshly vitality.

Back to Methuselah
Preface
The Poetry and Purity of Materialism (p. lxii)

CRYSTALLOGRAPHY

Leclerc, Georges Comte de Buffon
. . . all the work of the crystallographers serves only to demonstrate that there is only variety everywhere they suppose uniformity. . . that in nature there is nothing absolute, nothing perfectly regular.

Histoire Naturelle des Mineraux
Volume III (p. 433)

Pauling, Linus
I miss the old days, when nearly every problem in X-ray crystallography was a puzzle that could be solved only by much thinking.

In Philip Ball
Designing the Molecular World (p. 111)

CURIOSITY

Einstein, Albert
It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wrack and ruin without fail.

Autobiographical Notes (p. 17)

von Goethe, Johann Wolfgang
The desire of knowledge is first stimulated in us when remarkable phenomena attract our attention. In order that this attention be continued, it is necessary that we should feel some interest in exercising it, and thus by degrees we become better acquainted with the object of our curiosity.

Goethe's Theory of Colour
Introduction (p. xxxvii)

Whitney, W.R.
The valuable attributes of research men are conscious ignorance and active curiosity.

Science
The Stimulation of Research in Pure Science which has Resulted from the Needs of Engineers and of Industry (p. 285)
Volume LXV, 1927

DATA

Margenau, Henry
Data have an ephermeralness, a rhapsodic spontaneity, a nakedness so utterly at variance with the orderly instincts that pervade our being and with the given unity of our own experience as to be unfit for use in the building of reality. The constructs, on the other hand, are foot-loose, subjective, and altogether too fertile with logical implications to serve in their indiscriminate totality as material for the real world. They do, however, contain the solid logical substance which a stable reality must contain.

The Nature of Physical Reality
Chapter 21 (pp. 448–9)

DEFINITION

Davy, Sir Humphry
There is nothing more difficult than a good definition, for it is scarcely possible to express, in a few words, the abstracted view of an infinite variety of facts.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (pp. 362–3)

Freudenthal, Hans
Fundamental definitions do not arise at the start but at the end of the exploration, because in order to define a thing you must know what it is and what it is good for.

In A.G. Howson (ed.)
Developments in Mathematical Education
What Groups Mean in Mathematics and What They Should Mean in Mathematical Education (p. 107)

DEMONSTRATION

Shakespeare, William
And this may help to thicken other proofs
That do demonstrate thinly.

Othello
Act III, scene iii, L. 430–1

Twain, Mark
Nothing ever satisfies her but demonstration; untested theories are not in her line, and she won't have them.

The Diaries of Adam and Eve
Eve's Diary
Friday (p. 75)

DIFFERENCE

Foster, Sir Michael
Man, unscientific man... is often content with 'the nearly' and 'the almost.' Nature never is. It is not her way to call the same things which differ, though the difference may be measured by less than the thousandth of a milligramme or of a millimetre, or by any other like standard of minutemess. And the man who, carrying the ways of the world into the domain of science, thinks that he may treat Nature's differences in any other way than she treats them herself, will find that she resents his conduct; if he in carelessness or in disdain overlooks the minute difference which she holds out to him as a signal to guide him in his search, the projecting tip, as it were, of some buried treasure, he is bound to go astray, and, the more strenuously he struggles on, the farther will he find himself from his true goal.

In J.A. Thomson
Introduction to Science
Chapter I (p. 18)

Heisenberg, Werner
It is probably true quite generally that in the history of human thinking the most fruitful developments frequently takes place at those points where two different lines of thought meet. These lines may have roots in quite different parts of human culture, in different times or different cultural environments or different religious traditions; hence if they actually meet, that is, if they are at least so much related to each other that a real interaction can take place, then one may hope that new and interesting developments may follow.

Physics and Philosophy
Chapter XI (p. 187)

Levi, Primo
I thought of another moral... and I believe that every militant chemist can confirm it: that one must distrust the almost-the-same (sodium is almost

the same as potassium), but with sodium nothing would have happened), the practically identical, the approximate, the or-even, all surrogates, and all patchwork. The differences can be small, but they can lead to radically different consequences, like a railroad's switch points; the chemist's trade consists in good part in being aware of these differences, knowing them close up, and foreseeing their effects. And not only the chemist's trade.

The Periodic Table
Potassium (p. 60)

DISCOVERY

Baldwin, James M.
We do not scatter our thoughts as widely as possible in order to increase the chances of getting a true one; on the contrary, we call the man who produces the most thought-variations a 'scatter-brain,' and expect nothing inventive from him…we succeed in thinking well by thinking hard; we get the valuable thought-variations by concentrating attention upon the body of related knowledge which we already have; we discover new relations among the data of experience by running over and over the links and couplings of the apperceptive systems with which our minds are already filled;…

The Psychological Review
On Selective Thinking (p. 4)
Volume 5, Number 1, 1898

Barth, John
"My project", he told us, "is to learn where to go by discovering where I am by reviewing where I've been—where we'va *all* been…"

Chimera
Dunyazadiad (p. 10)

Bolyai, John
Mathematical discoveries, like springtime violets in the woods, have their season which no human can hasten or retard.

Mathematics Teacher
In Israel Kleiner
Thinking the Unthinkable:
The Story of Complex Numbers (with a Moral) (p. 590)
Volume 81, Number 7, October 1988

Calder, Ritchie
The genealogy of scientific discovery is important because every scientist inherits so much from his predecessors. Science is evolutionary,

depending upon the inter-marriage of ideas. The family tree of a major scientific discovery is usually more impressively international than that of the most august royal house.

Profiles of Science
Chapter 2 (p. 32)

Chekhov, Anton
Vershinin: Isn't it the case that in their own time the discoveries of Copernicus, or Columbus if you like, seemed superfluous and ridiculous; whereas, the empty scribblings of some crank or other seemed to be the ultimate truth?

The Three Sisters
Act I (p. 36)

Davy, Sir Humphry
The greatest use of practical science is discovery.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter III (p. 154)

de Morgan, August
Modern discoveries have not been made by large collections of facts, with subsequent discussion, separation, and resulting deduction of a truth thus rendered perceptible. A few facts have suggested an *hypothesis*, which means a *supposition*, proper to explain them. The necessary results of this supposition are worked out, and then, and not till then, other facts are examined to see if their ulterior results are found in nature.

A Budget of Paradoxes
Volume I
Basis of Modern Discovery (pp. 85–6)

Gay-Lussac
If one were not animated with the desire to discover laws, they would often escape the most enlightened attention.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 43)

A discovery is the product of a previous discovery and in its turn it will give rise to a further discover.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 4 (p. 71)

Henry, Joseph
The seeds of great discoveries are constantly floating around us, but they only take root in minds well prepared to receive them.

In Walter B. Cannon
The Way of an Investigator, a Scientist's Experience in Medical Research
Chapter VI (p. 76)

Holton, G.
And yet, on looking into the history of science, one is overwhelmed by evidences that all too often there is no regular procedure, no logical system of discovery, no simple, continuous development. The process of discovery has been as varied as the temperament of the scientist.

Thematic Origins of Scientific Thought
Chapter 11 (pp. 384–5)

Kekulé, F. August
During my stay in Ghent I resided in elegant bachelor quarters in the main thoroughfare. My study, however, faced a narrow side-alley and no daylight penetrated it. For the chemist who spends his day in the laboratory this mattered little. I was sitting writing at my textbook but the work did not progress; my thoughts were elsewhere. I turned my chair to the fire and dozed. Again the atoms were gamboling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of the kind, could now distinguish larger structures of manifold conformation: long rows, sometimes more closely fitted together all twining and twisting in snake-like motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightening I awoke; and this time also I spent the rest of the night in working out the consequences of the hypothesis.

Journal of Chemical Education
In O. Theodore Denfey
August Kekulé and the Birth of the Structural Theory
of Organic Chemistry in 1858 (p. 22)
Volume 35, Number 1, January 1958

Leibniz, Gottfried Whilhem
The art of discovering the causes of phenomena, or true hypothesis, is like the art of decyphering, in which an ingenious conjecture often greatly shortens the road.

New Essays Concerning Human Understanding
Book IV, Chapter XII (p. 526)

Lonergan, Bernard J.F.
Discovery is new beginning. It is the origin of new rules that supplement, or even supplant, the old. Genius is creative. It is genius precisely because it disregards established routines, because it originates the novelties that will be the routines of the future. Were there rules for discovery, then discoveries would be mere conclusions.

Insight
Chapter I (p. 4)

Merton, R.K.
The discovery is not true
If true, it is not new
If both new and true, it is not significant.

On Theoretical Sociology, Five Essays, Old and New
Chapter I (p. 21)

Reichenbach, Hans
The act of discovery escapes logical analysis; there are no logical rules in terms of which a "discovery machine" could be constructed that would take over the creative function of the genius. But it is not the logician's task to account for scientific discoveries; all he can do is to analyze the relation between given facts and a theory presented to him with the claim that it explains these facts. In other words, logic is concerned with the context of justification.

The Rise of Scientific Philosophy
Chapter 14 (p. 231)

Rutherford, Ernest
It is not in the nature of things for any one man to make a sudden violent discovery; science goes step by step and every man depends on the work of his predecessors. When you hear of a sudden unexpected discovery—a bolt from the blue, as it were—you can always be sure that it has grown up by the influence of one man on another, and it is the mutual influence which makes the enormous possibility of scientific advance. Scientists are not dependent on the ideas of a single man, but on the combined wisdom of thousands of men, all thinking of the same problem and each doing his little bit to add to the great structure of knowledge which is gradually being erected.

In S. Chandrasekhar
Truth and Beauty
Chapter 1 (p. 14)

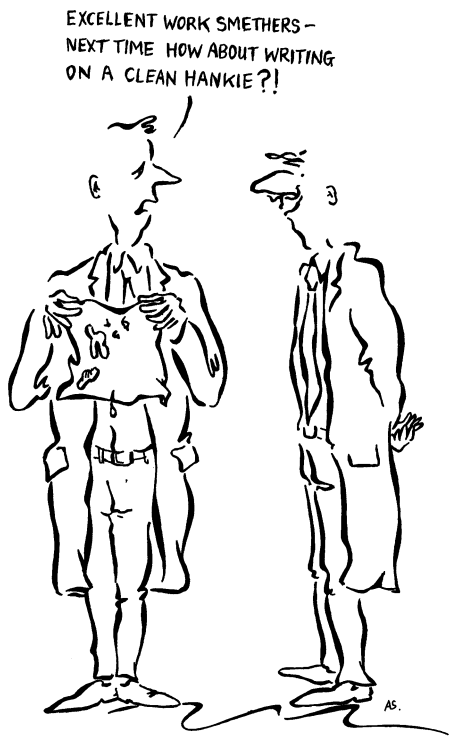
Taton, René
Every great discovery has produced some sort of intellectual scandal, has been opposed by current, and always badly informed, opinions on the

basic nature of scientific problems, and also by the majority of scientists of the time holding outdated theories, and incapable of renouncing some of their most solidly ingrained ideas.

Reason and Chance in Scientific Discovery
Chapter XI (p. 147)

Unknown
All scientific discoveries are first recorded on napkins or tablecloths. Keep supplies of them handy at all times.

Source unknown



Nothing can be more puerile than the complaints sometimes made by certain cultivators of a science, that it is very difficult to make discoveries now that the soil has been exhausted, whereas they were so easily made when the ground was first broken. It is an error begotten by ignorance out of indolence. The first discovery did not drop upon the expectant idler who, with placid equanimity waited for the goods the gods might send, but was heavily obtained by patient, systematic, and intelligent labour; and, beyond all question, the same labour of the same mind which made the first discoveries in the new science, would now succeed in making

many more, trampled though the field may be by the restless feet of those unmethodical inquirers who, running to and fro, anxiously exclaim, "Who will show us any good thing?"

Journal of Mental Science
Psychological Inquiries (p. 212)
1862

von Liebig, Justus
Theories lead to experiments and investigations and he who investigates will scarcely ever fail of being rewarded by discoveries. It may be, indeed, the theory sought to be established is entirely unfounded in nature; but while searching in a right spirit for one thing, the inquirer may be rewarded by finding others far more valuable than those which he sought.

Familiar Letters on Chemistry
Letter IV (pp. 33–4)

DISORDER

Ziman, John M.
'Disorder' is not mere chaos; it implies defective *order*:...

Models of Disorder
Chapter 1 (p. 1)

DISTILL

Levi, Primo
Distilling is beautiful. First of all, because it is a slow, philosophic, and silent occupation, which keeps you busy but gives you time to think of other things, somewhat like riding a bike. Then, because it involves a metamorphosis from liquid to vapor (invisible), and from this once again to liquid; but in this double journey, up and down, purity is attained, an ambiguous and fascinating condition, which starts with chemistry and goes very far. And finally, when you set about distilling, you acquire the consciousness of repeating a ritual consecrated by the centuries, almost a religious act, in which from imperfect material you obtain the essence, the *usia*, the spirit, and in the first place alcohol, which gladdens the spirit and warms the heart.

The Periodic Table
Potassium (pp. 57–8)

Shakespeare, William
Hast thou not learned me how to make perfumes? Distil? Preserve?

Cymbeline
Act I, scene v, L. 13

ELECTRON

Benchley, Robert
The protons are positive and the electrons are negative, and, of the two, I am sure that the electrons are nicer.

Benchley Lost And Found
Atom Boy! (p. 81)

Birkeland, Kristian
Space is filled with electrons and flying electric ions of all kinds.

In Eric J. Lerner
The Big Bang Never Happened (p. 169)

Davisson, Clinton
We think we understand the regular reflection of light and x-rays—and we should understand the reflections of electrons as well if electrons were only waves instead of particles.... It is rather as if one were to see a rabbit climbing a tree, and were to say, "well that is rather a strange thing for a rabbit to be doing, but after all there is really nothing to get excited about. Cats climb trees—so that if the rabbit were only a cat, we would understand its behavior perfectly."

Quoted by Anthony French and Edwin Taylor in
An Introduction to Quantum Physics (p. 54)

Dingle, H.
He thought he saw electrons swift
  Their charge and mass combine.
He looked again and saw it was
  The cosmic sounding line.
The population then, said he,
  Must be 10^{79}.

In Sir Arthur Eddington
The Expanding Universe
The Universe and the Atom
Section IV (p. 113)

Eddington, Sir Arthur Stanley
An electron could never decide how large it ought to be unless there existed some length independent of itself for it to compare itself with.

Mathematical Theory of Relativity
Chapter V (p. 155)

Fournier d'Albe, E.E.
We may therefore, without in the least interfering with the efficiency of the electron…imagine it to be a veritable microcosm, a world in which life might not very materially differ from life on our earth.

The Electron Theory
Chapter XVI (p. 288)

Glashow, Sheldon L.
Much as a pitched baseball is given a spin about its axis, so also does the electron spin about. However, the microscopic quantum mechanical electron behaves very differently from a baseball. Baseballs can be old, new, clean, dirty, and can differ from one another in myriad ways. On the other hand, all electrons are absolutely identical to one another. There is a subtler difference as well. Baseballs may spin rapidly, slowly, or in the case of a knuckleball, not at all. Every electron in the universe (about 10^{80} of them!) is spinning at exactly the same rate. The magnitude of electron spin is an intrinsic and immutable characteristic of the electron. Only the axis about which the electron spins can be changed.

Interactions
Chapter 3 (p. 56)

Jeans, Sir James
The electrons may now be pictured as octopus-like structures with tentacles or 'tubes of force' sticking out from it in every direction.

Physics and Philosophy
Chapter IV (p. 122)

The hard sphere…has always a definite position in space; the electron apparently has not. A hard sphere takes up a very definite amount of room; an electron—well it is probably as meaningless to discuss how much room an electron takes up as it is to discuss how much room a fear, an anxiety, or an uncertainty takes up.

In Lincoln Barnett
The Universe and Dr Einstein
Chapter 3 (p. 22)

Lewis, Gilbert N.
…since all electrons are alike, and presumably leave no trail behind them, we cannot say that atom A loses an electron to atom B and atom C to atom

D, but only that atoms A and C have each lost an electron and atoms B and D have each gained one.

Journal of the American Chemical Society
Valence and Tau Tomerism (p. 1452)
Volume 35, 1913

Millikan, Robert Andrews
The word "electron" was first suggested in 1891 by Dr G. Johnstone Stoney as a name for the "natural unit of electricity," namely, that quantity of electricity which must pass though a solution in order to liberate at one of the electrodes one atom of hydrogen or one atom of any univalent substance.

The Electron
Chapter II (p. 25)

Indeed, nothing more beautifully simplifying has ever happened in the history of science than the whole series of discoveries culminating about 1914 which finally brought practically universal acceptance of the theory that the material world contains but two fundamental entities, namely, positive and negative electrons, exactly alike in charge, but differing widely in mass, the positive electron—now usually called a proton—being 1850 times heavier than the negative, now usually called simply the electron.

Time, Matter and Values
Chapter II (p. 46)

Shaw, George Bernard
. . . why the men who believe in electrons should regard themselves as less credulous than the men who believed in angels is not apparent to me.

In Homer D. Swander
Man and the Gods: Three Tragedies
Saint Joan
Preface (p. 133)

Standen, Anthony
. . . nothing will do for Mr Average Citizen but to stuff himself full of electrons, protons, neutrons, neutrinos, genes, chromosomes, glands, hormones, potassium, chloride, high-octane gasoline, ultrasonic vibrations, and the theory of relativity.

Science is a Sacred Cow
Chapter I (pp. 26–7)

Sullivan, J.W.N.
The electron is not, for example, an enduring something that can be tracked through time. Its mathematical description does not involve that

degree of definiteness. Any picture we form of the atom errs, as it were, by excess of solidity. The mathematical symbols refer to entities more indefinite than our pictorial imagination, limited as it is by experience of "gross matter," can construct.

The Bases of Modern Science
Chapter XI (pp. 252–3)

Thomson, George P.
One may picture the free electron. . . as something like a gossamer spider floating through the air at the center of a number of radiating filaments which control its flight as the air wafts them about, or as they are caught by solid objects.

In Bernard Jaffe
Crucibles: The Story of Chemistry
Chapter XVI (p. 254)

The goddess of learning is fabled to have sprung full-grown from the brain of Zeus, but it is seldom that a scientific conception is born in its final form, or owns a single parent. More often it is the product of a series of minds, each in turn modifying the ideas of those that came before, and providing material for those that come after. The electron is no exception.

In the Nobel Foundation
Nobel Lectures
Physics
1922–1941
Nobel Lecture, 7 June 1938 (p. 397)

An electron is like an able guerrilla leader who occupies a wide area with rumors of his presence, but when he strikes, he strikes with his whole force.

Nature
Electron Optics (p. 82)
Volume 129, Number 3246, 16 January 1932

Unknown
There was a jolly electron—alternately bound and free—
Who toiled and spun from morn to night, no snark so lithe as he. . .

Jolly Electron
In Bernard Jaffe
Crucibles: The Story of Chemistry
Chapter XIV (p. 215)

There were many electrons like this one in flight,
But obeying Coulomb, they made small approach and then
Rapidly went apart. And the reason was that only
At rest could they repel one another,
But never attract!

In V. Grigoryev and G. Myakishev
The Forces of Nature
Chapter 7
The Song of the Electron (p. 239)

ELEMENT

Boyle, Robert
…I now mean by elements…certain Primitive and Simple, or perfectly unmingled bodies; which not being made of any other bodies, or of one another, are the Ingredients of which all those call'd perfectly mixt Bodies are immediately compounded, and into which they are ultimately resolved…

The Sceptical Chymist
The Sixth Part (p. 350)

It seems not absurd to conceive that at the first Production of mixed Bodies, the Universal Matter whereof they among other Parts of the Universe consisted, was actually divided into little Particles of several sizes and shapes variously mov'd.

The Sceptical Chymist
The First Part
Proposition I (p. 37)

Browne, B.P.
Every chemical element is regarded as having a distinct nature of its own, which nature, moreover, determines all its activities.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 7 (p. 96)

Cowper, William
Some say that in the origin of things
When all creation started into birth,
The infant elements receiv'd a law
From which they swerve not since

The Task: A Poem in Six Books
Book 6 (p. 241)

Crookes, Sir William
The elements perplex us in our researches, baffle us in our speculations and haunt us in our very dreams. They stretch like an unknown sea before us, mocking, mystifying, and murmuring strange revelations and possibilities.

In C. Baskerville
Science
The Elements: Verified and Unverified (p. 93)
New Series, Volume 19, Number 472, 15 January 1904

Crowson, David
Physicists at Harwell have discovered the heaviest element known to science, named Administratum. The new element has no protons or electrons, and has an atomic number of zero. However, it does have one neutron, eight assistant neutrons, ten executive neutrons, 35 vice neutrons and 258 assistant vice neutrons.

Administratum has an atomic mass of $311\frac{1}{2}$, since the neutron is only detectable half of the time. Its 312 particles are held together by a force which involves the continuous exchange of meson-like particles, called morons.

Since it has no electrons, Administratum is completely inert. Nevertheless, its presence can be detected because it impedes every reaction with which it comes into contact. One experiment, which should have lasted only a few days, is still running after $2\frac{1}{2}$ years due to the addition of just one milligramme of Administratum.

It is weakly active, and has a normal half-life of approximately six months. After this time, it does not actually decay, but undergoes a metamorphosis in which assistant neutrons, executive neutrons, vice neutrons and assistant vice neutrons exchange places. This almost invariably leads to an increase in atomic weight, hence it is self-sustaining.

Although it occurs widely, Administratum tends to concentrate around large corporations, research laboratories and government departments. It can especially be found in recently re-organized sites, and there is reason to believe that it is heavily involved in the processes of deforestation and global warming.

It should be remembered that Administratum is known to be toxic at all concentrations, and can easily destroy any productive reactions where it is allowed to accumulate. Numerous attempts have been made to determine how Administratum can be controlled to prevent irreversible damage, but results to date are not promising.

Quotation found on the Internet

Davidson, John
Fleet Street was once a silence in the ether.
The carbon, iron, copper, silicon,
Zinc, aluminum vapours, metalloids,
Constituents of the skeleton and shell
Of Fleet Street—of the woodwork, metalwork,
Brickwork, electric apparatus, drains
And printing-presses, conduits, pavement, road—
Were at the first unelemented space,
Imponderable tension in the dark
Consummate matter of eternity.

Fleet Street (p. 3)

Einstein, Albert
All matter of the universe is made up of *elementary particles* of only a few kinds. It is like seeing in one town buildings of different sizes, construction and architecture, but from shack to sky-scraper only very few different kinds of bricks were used, the same in all buildings. So all known elements of our material world, from hydrogen the lightest, to uranium the heaviest, are built of the same kinds of bricks, that is, the same kinds of elementary particles. The heaviest elements, the most complicated buildings, are unstable and they disintegrate or, as we say, are radioactive. Some of the bricks, that is, the elementary particles of which radioactive atoms are constructed, are sometimes thrown out with a very great velocity approaching that of light. An atom of an element, say radium, according to our present views,... is a complicated structure, and radioactive disintegration is one of the phenomena in which the composition of atoms from still simpler bricks, the elementary particles, is revealed.

The Evolution of Physics
Field Relativity (pp. 206–7)

Emerson, Ralph Waldo
The four-quarters of the globe are no longer Europe, Asia, Africa and America, but Carbon, Oxygen, Hydrogen, and Nitrogen.

The Works of Ralph Waldo Emerson
Volume III
Farming (p. 303)

Empedocles of Acragas
...I shall tell you of a double process. At one time it increased so to be a single One out of Many; at another time it grew apart so as to be Many out of One—Fire and Water and Earth and the boundless height of Air,... these

things alone exist, and running through one another they become different things at different times, and are ever continuously the same.

In Kathleen Freeman
Ancilla to the Pre-Socratic Philosophers
Section 31. Empedocles of Acragas, 17 (pp. 53–4)

Heisenberg, Werner
I am convinced that the spectrum of all chemical elements can be obtained…from quantum theory in a unique manner without physics by boneheaded calculation.

In Keith Hannabuss
An Introduction to Quantum Theory
Letter to Pascual Jordan
28 July 1926 (p. 235)

Keats, John
To watch the abysm-birth of elements.

The Poetical Works of John Keats
Endymion
Book III, L. 28

Lavoisier, Antoine
All that can be said upon the number and nature of elements is, in my opinion, confined to discussions entirely of a metaphysical nature…if, by the term *elements*, we mean to express those simple and indivisible atoms of which matter is composed, it is extremely probable we know nothing at all about them; but if we apply the term *elements*, or *principles of bodies*, to express our idea of the last point which analysis is capable of reaching, we must admit, as elements, all the substances into which we are capable, by any means, to reduce bodies by decomposition.

Elements of Chemistry
Preface (p. 3)

Moissan, H.
The search for an element is always captivating.

In Mary Elvira Weeks
Discovery of the Elements (p. 438)

Montague, James J.
The fact that Raphael was a whizz
At graphic composition
Was not at all because of his
Inordinate ambition.
Success, despite its practiced eye,

Would doubtless have defied him,
His greatness was created by
The elements inside him.

Industrial and Engineering Chemistry: News Edition
What's the Use of Worrying? (p. 257)
Volume 10, Number 20, 20 October 1932

Pallister, William
Within the atom is a whirling world,
A complex system in a vortex hurled:
Electrons charged with forces negative
Revolve around the protons positive
In varied spheres, in varied numbers, too,
Yet with a maximum of ninety-two
Designs, known as the elements to you
And proved by spectrum study to be true.

Poems of Science
Men and the Stars
Within the Atom (p. 51)

Unknown
When hydrogen played oxygen,
And the game had just begun,
Hydrogen racked up two fast points
But oxygen had none.
Then oxygen scored a single goal,
And thus it did remain
Hydrogen 2 and oxygen 1
Called off because of rain.

Quoted in John D. Barrow and Frank J. Tipler
The Anthropic Cosmological Principle
The Anthropic Principle and Biochemistry (p. 541)

Winkler, Clemens
The world of chemical reactions is like a stage, on which scene after scene is ceaselessly played. The actors on it are the elements.

In Mary Elvira Weeks
Discovery of the Elements (p. 1)

ALUMINUM

Verne, Jules
"Aluminum!" cried his three colleagues in chorus.

"Unquestionably, my friends. This valuable metal possesses the whiteness of silver, the indestructibility of gold, the tenacity of iron, the fusibility of copper, the lightness of glass. It is easily wrought, it is very widely distributed, forming the base of most of the rocks, is three times lighter than iron, and seems to have been created for the express purpose of furnishing us with the material for our projectile."

From the Earth to the Moon
Chapter VII (p. 40)

ANTIMONY

Renaudot, Eusèbe
We, the undersigned Doctors of medicine of the Faculty of Paris, certify to all to whom it may concern, that the qualities of antimony are recognized by us to be very useful for the cure of a number of illnesses. We certify this on the basis of long usage and continued experience. Further we declare that this remedy which has for so long been charged with having a poisonous malignity has many rare virtues and that a physician can successfully employ it to combat a great number of diseases provided that he uses it with a prudence and discretion.

Allen G. Debus
The French Paracelsians
Chapter 3 (p. 97)

Valentinus, Basilius
But antimony, like mercury, can best be compared to a round circle without end,...and the more one investigates it, by suitable means, the more one discovers in it and learns from it; it cannot be mastered, in short, by one person alone because of the shortness of human life.

In Mary Elvira Weeks
Discovery of the Elements
Chapter 3 (p. 95)

ARGON

Strutt, John William
Indeed, I have seen some indications that the anomalous properties of argon are brought as a kind of accusation against us. But we had the very best intentions in the matter. The facts were too much for us, and all that we can do now is apologize for ourselves and for the gas.

Life of John William Strutt, Third Baron Raleigh
The Discovery of Argon (p. 222)

ARSENIC

Valentinus, Basilius
For smelter fumes have I been named.
I am an evil, poisonous smoke…
But when from poison I am freed,
Through art and sleight of hand,
Then can I cure both man and beast,
From dire disease ofttimes direct them;
But prepare me correctly, and take great care
That you faithfully keep watchful guard over me;
For else am I poison, and poison remain,
That pierces the heart of many a one.

In Mary Elvira Weeks
Discovery of the Elements (p. 92)

CARBON

Darwin, Erasmus
Hence sable coal his massy couch extends;
And stars of gold that sparkle pyrite blends;
Hence dull-eyed naphtha pours his pitchy streams,
And jet uncolour'd drinks the solar beams…

The Botanical Garden
Part I, Canto II, L. 349–52

Eiseley, Loren
Somewhere, somehow, sometime, in the mysterious chemistry of carbon, the long march toward the talking animal had begun.

The Immense Journey
The Secret of Life (p. 198)

Jeans, Sir James
…life exists in the universe only because the carbon atom possesses certain exceptional properties.

The Mysterious Universe
Chapter I (p. 9)

Prout, William
…it is perhaps difficult to say what is most wonderful; but we have often thought, that the Deity has displayed a greater stretch of power, in accommodating to such an extraordinary variety of changes, a material so unpromising and so refractory as charcoal, and in finally uniting it with

the human mind, than was requisite for the creation of the human mind itself.

Chemistry, Meteorology, and the Function of Digestion
Considered with Reference to Natural Theology
Book III, Chapter I (pp. 442–3)

GOLD

Exodus 39:3
And they did beat the gold into thin plates, and cut it into wires…

The Bible

Jonson, Ben
Aye, for 'twere absurd to think
That Nature in the Earth bred gold,
Perfect in the instant.

The Alchemist
Act II, Scene 3, L. 139–41

HYDROGEN

Dalton, John
No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen.

New System of Chemical Philosophy
Volume I
Part 1, Chapter III (p. 212)

IODINE

Pallister, William
When you insist on living far inland
And do not get your fish-food from the sea;
When you forsake the ocean and the sand
And ceases to feed the fish you used to be;
Perhaps you do not fully understand,
If you disclaim your race,
You'll get a funny-face.

So satisfy your iodine demand.

Poems of Science
De Ipsa Natura
Iodine (p. 221)

LEAD

Chesterton, G.K.
Lead is the humblest of the metals; it is always put where it is invisible—and where it is indispensable. It is put on the keels of boats, where nobody can see it and everybody relies on it. It is put in the shrouds of the sea-sunken dead, whom we desire to see no more.

Lunacy and Letters
The Love of Lead (pp. 158–9)

MERCURY

Darwin, Erasmus
On vermeil beds in Idria's mighty caves
The living silver rolls its ponderous waves.

The Botanic Garden
Canto II, L. 405–6

Flaubert, Gustauv
Mercury. Kills the patient with the disease.

Dictionary of Accepted Ideas

NITROGEN

Crookes, Sir William
The fixation of nitrogen is vital to the progress of civilized humanity, and unless we can class it among the certainties to come, the great Caucasian race will cease to be the foremost in the world, and will be squeezed out by the races to whom wheaten bread is not the staff of life.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 23 (p. 421)

Slossen, E.E.
For nitrogen plays a double role in human economy. It appears like Brahma in two aspects, Vishnu the Preserver and Siva the Destroyer.

In Bernard Jaffe
New World of Chemistry (p. 225)

OXYGEN

Darwin, Erasmus
When air's pure essence joins the vital flood,
And with phosphoric acid dyes the blood,
Your virgin trains the transient heat dispart,
And lead the soft combustion round the heart...

The Botanic Garden
Part I, Canto I, L. 3339–402

Fridovitch, Irwin
Oxygen is toxic! We, whose lives depend upon a continual supply of oxygen, do not easily comprehend its toxicity. Our apparent comfort at the ambient level of oxygen is due to elaborate defenses against its very considerable toxicity.

BioScience
Oxygen is Toxic (p. 462)
Volume 27, Number 7, July 1977

Hoffmann, Roald
Carried by blood, carrying
electrons, life-empowering
oxygen. Elsewhere, in engines
It's sucked into carburetor

trains, there to mix with branched
heptanes, octanes, another kind
of feedstock. Sparked, it burns
things in controlled explosions,

a human specialty. And what
thermochemistry says should end
in greening CO_2 and steam, in
incomplete combustion partly

goes to CO, carbon monoxide.
This odorless diatomic tres-
passer sweeps into bronchia, brashly
binding 200 times better

than O_2. A free ride on deoxyhemo-
globin down arteries, right past
cells that long for other, can't
wait too long before shutdown.

Gaps and Verges
Jerry-Built Forever (p. 29)

Traube, Moritz
Truly, the history of oxygen is the history of life!

In W. Coleman
Biology in the Nineteenth Century: Problems of Form, Function, and Transformation
Chapter VI (p. 135)

PHOSPHORUS

Darwin, Erasmus
Or mark the shining letters Kunckel's name
In the pale phosphor's self-consuming flame.

The Botanical Garden
Part I, Canto I, L. 231–2

RADIUM

Curie, Marie
Radium is not to enrich any one. It is an element; it is for all people.

Pierre Curie
Introduction (p. 24)

Horton, F.
A radium atom was dying,
  And just ere it burst up for aye,
Corpuscles, which round it were flying,
  These last dying words heard to say…
    Oh, I am a radium atom

The American Physics Teacher
The Radium Atom (p. 181)
Volume 7, Number 3, June 1939

SODIUM

Glashow, Sheldon L.
That is why the stove's flame turns yellow when the soup boils over. The table salt in the soup contains sodium, whose dominant spectral lines are bright yellow.

Interactions
Chapter 3 (p. 50)

SULFUR

Duchesne
For as a man can never make a good closing mortar, of water and sand onely, without the mixture of lime, which bindeth the other two together like oile and glue: so Sulphur as the oily substance, is the mediator of Salt and Mercurie, and coupleth them both together: neither doth it only couple them to death, but it also represse and contemperate the acrimonie of Salt, and the sharpnesse of Mercurie, which is found to bee very much therein.

In Allen G. Debus
The French Paracelsians
Chapter 3 (p. 55)

Masini, Count Vincenzo
Within the rocks, among the thorns,
Between the cliffs, sulfur takes root;
For gold, silver, copper, iron, and sulfur
Likewise are plants.

In Mary Elvira Weeks
Discovery of the Elements
Chapter I (p. 55)

TITANIUM

Klaproth, Martin Heinrich
Whenever no name can be found for a new fossil which indicates its peculiar and characteristic properties (in which situation I find myself at present), I think it best to choose such a denomination as means nothing of itself, and thus can give no rise to any erroneous ideas. In consequence of this, as I did in the case of uranium, I shall borrow the name for this metallic substance from mythology, and in particular from the Titians, the first sons of the earth. I therefore call this new metallic genus TITANIUM.

Analytical Essays towards Promoting the Chemical Knowledge of Mineral Substances
Chapter XIV (p. 210)

URANIUM

Einstein, Albert
Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element

uranium may be turned into a new and important source of energy in the immediate future.

Letter to F.D. Roosevelt
2 August 1939

Klaproth, Martin Heinrich
The number of known metals had been increased by one—from 17 to 18. . . A few years ago we thrilled to hear of the discovery of the final planet by Sir William Herschel. He called the new member of our solar system Uranus. I propose to borrow from the honor of that great discovery and call this new element Uranium.

In Lennard Bickel
The Deadly Element, The Story of Uranium (p. 21)

ZINC

Levi, Primo
Zinc, Zinck, zinco: they make tubs out of it for laundry, it is gray and its salts are colorless, it is not toxic, nor does it produce striking chromatic reactions; in short, it is a boring metal.

The Periodic Table
Zinc (p. 33)

ENERGY

Aston, Francis W.
Should the research worker of the future discover some means of releasing this energy in a form which could be employed, the human race will have at its command powers beyond the dreams of science fiction; but the remote possibility must always be considered that the energy once liberated will be completely uncontrollable and by its intense violence detonate all neighboring substances. In this event the whole of the hydrogen on the earth might be transformed at once and the success of the experiment published at large to the universe as a new star.

In the Nobel Foundation
Nobel Lectures: Chemistry
1922–1941
Mass Spectra and Isotopes
Nobel Lecture, 12 December 1922 (p. 20)

Blake, William
Energy is eternal delight.

The Prophetic Writings of William Blake
The Marriage of Heaven and Hell
The Voice of the Devil
#3

Energy is the only life…
and Reason is the bound or outward circumference of Energy.

The Prophetic Writings of William Blake
The Marriage of Heaven and Hell
The Voice of the Devil
#2

Huxley, Julian
Energy. I am energy. Sublime and meaningless Energy.
I stream in floods across the empty ocean
Of space, where island-universes float,

Each like a little lonely boat.

The Captive Shrew
Matter, Energy, Time and Space (p. 65)

Steele, Joel Dorman
The sunbeam comes to the earth as simply motion of ether-waves, yet it is the grand source of beauty and power. Its heat, light, and chemical energy work everywhere the wonder of life and motion. In the growing plant, the burning coal, the flying bird, the glaring lightning, the blooming flower, the rushing engine, the roaring cataract, the pattering rain—we see only varied manifestations of this one protean energy which we receive from the sun.

Popular Physics
Chapter VII (p. 188)

Tyndall, John
This law generalises the aphorism of Solomon, that there is nothing new under the sun, by teaching us to detect everywhere, under its infinite variety of appearances, the same primeval force. To nature, nothing can be added; from nature nothing can be taken away; the sum of her energies is constant…Waves may change to ripples and ripples to waves,—magnitude may be substituted for number, and number for magnitude,—asteroids may aggregate to suns, suns may resolve themselves into florae and faunae, and florae and faunae melt in air,—the flux of power is eternally the same. It rolls in music throughout the ages, and all terrestrial energy,—the manifestations of life as well as the display of phenomena, are but the modulations of its rhythm.

In Henry Adams
The Degradation of the Democratic Dogma
A Letter to American Teachers of History
Chapter I (pp. 144–5)

Unknown
America's number one energy crisis is Monday morning.

Source unknown

ENERGY STATE

Free, E.E.
Imagine a series of race tracks one inside the other. Imagine these tracks are separated by high board fences. Put a race horse in the outermost track and instruct him to run around it until when he happens to feel like it, he has to jump the inside fence into the next track, run around it for a while, and then jump into the next fence, and so on until he reaches the innermost track of all. If, then you watch this procedure from the field outside the outermost fence, you will not see the horse at all as long as he is running in a single track. The fences hide him. But whenever he jumps from one track into the next, you will see him for an instant as he goes over.

In Bernard Jaffe
Crucibles: The Story of Chemistry
Chapter XVI (pp. 244–5)

ENZYME

Shaw, William H.R.
The light of the firefly's tiny torch at dusk
Destroy and build great structures in the realm
Of molecules while we with prying eyes
And puny instruments attempt to watch,
To marvel, and—perhaps—to understand.

The Journal of Chemical Education
The Kinetics of Enzyme Catalyzed Reactions
The Enzymes (p. 22)
Volume 34, Number 1, January 1951

ERROR

Baker, Henry
Remember that Truth alone is the Matter that you are in search after; and if you have been mistaken, let not Vanity seduce you to persist in your Mistake.

The Microscope Made Easy
Part I
Chapter XV (p. 62)

Davy, Sir Humphry
Experimental science hardly ever affords us more than approximations to truth; and whenever many agents are concerned we are in great danger of being mistaken.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter II (pp. 69–70)

d'Holbach, Baron
All the errors of man are errors of physics.

Système de la nature ou des lois du monde physique et du monde moral (p. 19)

Girtanner, Christopher
Let us not be attached to systems, but to truth; and when Nature speaks, let us listen to her voice in preference to that of a Stahl or a Lavoissier, a Descartes or a Newton. Whatever may be the result of our experiments, we shall profit by them: as we run the risqué of losing nothing but error, let us hasten to subject ourselves to that loss.

Philosophical Magazine
Volume VI
Memoir on Azot, and on the Question,
Whether it be a simple or a compound Body (p. 337)
May 1800

Koyré, Alexandre

What good is it then to spend time on error? Isn't the important thing the final success, the discovery, and not the tortuous paths that one followed and on which one could have gotten lost?... What is important for posterity is in fact the discovery or invention. Nonetheless (at least for the historian–philosopher) it is the dead end, the error... which are sometimes as important as the successes. They can, maybe, be even more important. They are... instructive by permitting us, sometimes, to grasp and to comprehend the secret paths of thought.

Etudes Galiléennes (p. 77)

von Goethe, Johann Wolfgang

Error is to truth as sleep is to waking. As though refreshed, one returns from erring to the path of truth.

Wisdom and Experience
Science and Philosophy (p. 126)

ETHICS

Poincaré, Henri
Ethics and science have their own domains, which touch but do not interpenetrate. The one shows us to what goal we should aspire, the other, given the goal, teaches us how to attain it... There can no more be immoral science than there can be scientific morals.

The Foundation of Science
The Value of Science
Introduction (p. 206)

EXPERIENCE

Beveridge, W.I.B.
The rare genius with a flair for research will not benefit from instruction in the methods of research, but most would-be research workers are not geniuses, and some guidance as to how to go about research should help them to become productive earlier than they would if left to find these things out for themselves by the wasteful method of personal experience.

The Art of Scientific Investigation
Preface (pp. x–xi)

Braithwaite, Richard B.
The peaks of science may appear to be floating in the clouds, but their foundations are in the hard facts of experience.

Scientific Explanation
Chapter XI (p. 354)

da Vinci, Leonardo
The interpreter of the wonders of nature is experience. It never misleads us, only our grasp can do it with us. Until we can establish a general rule, we must accept the help of experience. Although nature begins with the cause, and with the experiment, we must do it inversely, we must discover the cause with experiments.

In Ferenc. Szabadváry
History of Analytical Chemistry
Chapter III (pp. 21–2)

Deming, William Edwards
Experience without theory teaches nothing.

Out of the Crisis
Chapter 11 (p. 317)

Hertz, Heinrich

…that which is gained from experience can again be annulled by experience.

The Principles of Mechanics, Presented in New Form
Introduction (p. 9)

EXPERIMENT

Chargaff, Erwin
Never say no to an experiment.

Voices in the Labyrinth
Chapter 7
Section II (p. 81)

Dalton, John
. . . those who are conversant in practical chemistry, know that not more than one new experiment in five is fit to be reported to the public; the rest are found, upon due reflection, to be some way or other defective, and are useful only as they shew the sources of error, and the means of avoiding it.

A New System of Chemical Philosophy
Volume I
Part 2, Preface

Davy, John
Appearances in these things are most deceptive: in the theatre experiments are made for illustration, and are generally of a simple kind, and easily comprehended, and the minds of the audience are prepared by the lecturer to follow and understand them. In the laboratory, on the contrary, this aid is wanting when most necessary; and, in consequence, operations. . . of a very accurate kind, and carried on with a perfect design, may appear confused to the uninstructed, or to the uninitiated.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter V (pp. 259–60)

Duhem, Pierre
Unlike the reduction to absurdity employed by geometers, experimental contradiction does not have the power to transform a physical hypothesis

into an indisputable truth; in order to confer this power on it, it would be necessary to enumerate completely the various hypotheses which may cover a determinate group of phenomena; but the physicist is never sure he has exhausted all the imaginable assumptions. The truth of a physical theory is not decided by heads or tails.

The Aim and Structure of Physical Theory
Chapter VI (p. 190)

Dumas, Jean-Baptiste

The art of observation and that of experimentation are very distinct. In the first case, the fact may either proceed from logical reasons or be mere good fortune; it is sufficient to have some penetration and the sense of truth in order to profit by it. But the art of experimentation leads from the first to the last link of the chain, without hesitation and without a blank, making successive use of Reason, which suggests an alternative, and of Experience, which decides on it, until, starting from a faint glimmer, the full blaze of light is reached.

In R. Vallery-Radot
The Life of Pasteur
Chapter VI (p. 122)

Faraday, Michael

Let the imagination go, guiding it by judgment and principle but holding it in and directing it by *experiment*.

In L. Pearce Williams
Michael Faraday: A Biography (p. 467)

Nothing is too wonderful to be true, if it be consistent with the laws of nature, and in such things as these, experiment is the best test of such consistency.

Faraday's Diary
19 March 1849
Entry 10,040

As an experimentalist, I feel bound to let experiment guide me into any train of thought which it may justify; being satisfied that experiment, like analysis, must lead to strict truth if rightly interpreted; and believing also that it is in its nature far more suggestive of new trains of thought and new conditions of natural power.

In Silvanus P. Thompson
Michael Faraday: His Life and Work
Chapter VI (p. 242)

Gay-Lussac
One cannot repeat experiments too often when the problem is one of determining a relationship.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 70)

Giddings, F.H.
In scientific experimentation we control everything that happens. We determine when it shall occur and where. We arrange circumstances and surroundings, atmosphere and temperatures; possible ways of getting in and possible ways of getting out. We take something that has been in, or put in something that has been out, and see what happens.

The Scientific Study of Human Society
Chapter III (p. 55)

Jevons, William Stanley
When we merely note and record the phenomena which occur around us in the ordinary course of nature we are said to *observe*. When we change the course of nature by the intervention of our will and muscular powers, and thus produce unusual combinations and conditions of phenomena, we are said to *experiment*. Sir John Herschel has justly remarked that we might properly call these two modes of experience *passive and active observation*. . . [A]n experiment differs from a mere observation in the fact that we more or less influence the character of the events which we observe.

Principles of Science
Book III
Chapter XVIII (p. 400)

Maxwell, James Clerk
An Experiment, like every other event which takes place, is a natural phenomenon; but in a Scientific Experiment the circumstances are so arranged that the relations between a particular set of phenomena may be studied to the best advantage. In designing an Experiment the agents and phenomena to be studied are marked off from all others and regarded as the Field of Investigation.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
General Considerations Concerning Scientific Apparatus
I. Experiments (p. 505)

Snyder, Solomon
Of course, if you can predict the consequences of your own experiments before they commence, your research is very likely to be *boring*.

Brainstorming
Chapter 10 (p. 195)

Twain, Mark
Some things you *can't* find out; but you will never know you can't by guessing and supposing: no, you have to be patient and go on experimenting until you find out that you can't find out. And it is delightful to have it that way, it makes the world so interesting. If there wasn't anything to find out, it would be dull. Even trying to find out and not finding out is just as interesting as trying to find out and finding out, and I don't know but more so.

The Diaries of Adam and Eve
Eve's Diary
Friday (p. 87)

Unknown
It is all very well to theorize, but it is what we learn from experiment that really counts.

Source unknown

Experiments should be reproducible—they should all fail in the same way.

Source unknown

EXPERIMENTER

Brillouin, L.
Perfect logic and faultless deduction make a pleasant theoretical structure, but it may be right or wrong; The experimenter is the only one to decide, and he is always right.

Scientific Uncertainty and Information
Chapter III (p. 38)

Deutsch, Martin
It is of course the ambition of every experimenter… to make a discovery, to sail safely between the Scylla of intellectual prejudice which makes us reject evidence not really integrated without preconceived notions, and the Charybdis of irrelevance which has swallowed many working days spent in pursuit of instrumental artifice.

Daedalus
Evidence (pp. 97–8)
Fall 1958

EXPLAIN

Jerome, Fred
Explain, explain, explain—but without resentment.

In Barbara Gastel
Presenting Science to the Public
Chapter 2 (p. 24)

Scriven, Michael
. . . whatever an explanation *actually* does, in order to be called an explanation at all it must be *capable* of making clear something not previously clear, i.e. of increasing or producing understanding of something. The difference between explaining and "merely" informing. . . does not, I shall argue, consist in explaining being something "more than" or even something intrinsically different from informing or describing, but in its being the appropriate piece of informing or describing, the appropriateness being a matter of *its relation to a particular context*.

In H. Feigl and G. Maxwell (eds.)
Minnesota Studies in the Philosophy of Science
Volume III
Scientific Explanation, Space and Time
Explanations, Predictions, and Laws (pp. 175–6)

EXPOSITION

Hardy, Thomas
. . . there is no scorn more profound, or on the whole more justifiable, than that of the men who make for the men who explain. Exposition, criticism, appreciation, is work for second-rate minds.

A Mathematician's Apology
Chapter I (p. 61)

FACT

Abbott, Edwin A.
From dreams I proceed to facts.

Flatland
Chapter 15 (p. 77)

Adams, Henry
The facts seemed certain, or at least as certain as other facts; all they needed was explanation.

The Education of Henry Adams
Chapter XXIX (p. 404)

Aristotle
. . . with a true view all the data harmonize, but with a false one the facts soon clash.

The Nicomachean Ethics
Book I, Chapter VIII, 1098^{b} [10]

Barry, Frederick
Facts are, to begin with, *coercive*.

The Scientific Habit of Thought
Chapter II (p. 92)

Bernard, Claude
If the facts used as a basis for reasoning are ill-established or erroneous, everything will crumble or be falsified; and it is thus that errors in scientific theories most often originate in errors of fact.

An Introduction to the Study of Experimental Medicine
Part I, Chapter I, Section III (p. 13)

Facts are neither great or small in themselves.

An Introduction to the Study of Experimental Medicine
Part I, Chapter II, Section II (p. 34)

A fact is nothing in itself, it has value only through the idea connected with it or through the proof it supplies.

An Introduction to the Study of Experimental Medicine
Part I, Chapter II, Section VII (p. 53)

Bohm, David
…it is important to note that facts are not to be considered as if they were independently existent objects that we might find or pick up in the laboratory…[I]n a certain sense, we 'make' the fact. That is to say, beginning with immediate perception of an actual situation, we develop the fact by giving it further order, form and structure with the aid of our theoretical concepts.

Wholeness and the Implicate Order
Chapter 6 (p. 142)

Carlyle, Thomas
I grow daily to honor Facts more and more; and Theory less and less. A Fact it seems to me is a great thing; a Sentence printed if not by God, then at least by the Devil…

In Joseph Slater (ed.)
The Correspondence of Emerson and Carlyle
Letter to R.W. Emerson
29 April 1836 (pp. 146–7)

Carroll, Lewis
First accumulate a mass of Facts: and *then* construct a Theory.

The Complete Works of Lewis Carroll
Sylvie and Bruno
Queer Street, Number Forty

The Theory hardly rose to the dignity of a Working Hypothesis. Clearly more Facts were needed.

The Complete Works of Lewis Carroll
Sylvie and Bruno
Queer Street, Number Forty

Chesterton, G.K.
The moment you step into the world of facts, you step into a world of limits.

Orthodoxy
The Suicide of Thought (p. 71)

Churchill, Winston
A balloon goes up quite easily for a certain distance, but after a certain distance it refuses to go up any further, because the air is too rarefied to

float it and sustain it. And, therefore, I would say, let us examine the concrete facts.

In F.B. Czarnomski
The Wisdom of Winston Churchill (p. 133)
Speech
St Andrew's Hall, Glasgow
11 October 1906

You must look at facts because they look at you.

In F.B. Czarnomski
The Wisdom of Winston Churchill (p. 132)
Speech
Commons
7 May 1925

I like the martial and commanding air with which the Right Hon. Gentleman treats facts. He stands no nonsense from them.

In F.B. Czarnomski
The Wisdom of Winston Churchill (p. 132)
Speech
Commons
19 February 1909

Coleridge, Samuel T.
Facts you know, are not truths; they are not conclusions; they are not even premises, but in the nature and parts of premises. The truth depends on, and is only arrived at by, a legitimate deduction from *all* the facts which are truly material.

Coleridge's Table-Talk
27 December 1831 (p. 107)

Crothers, Samuel McChord
The trouble with facts is that there are so many of them.

The Gentle Reader
That History Should Be Readable (p. 183)

Dickens, Charles
"Fact, fact, fact!" said the gentleman. And "Fact, fact, fact!" repeated Thomas Gradgrind. "You are to be in all things regulated and governed," said the gentleman, "by fact. We hope to have, before long, a board of fact, composed of commissioners of fact, who will force the people to be a people of fact, and of nothing but fact. You must discard the word Fancy altogether. You have nothing to do with it."

Hard Times
Chapter II (p. 8)

Dobzhansky, Theodosius
Science and religion deal with different aspects of existence. If one dares to overschematize for the sake of clarity, one may say that these are the aspect of fact and the aspect of meaning.

The Biology of Ultimate Concern
Chapter 5 (p. 96)

Dunne, Finlay Peter
There's always wan encouragin' thing about th' sad scientific facts that come out ivry week in th' pa-apers. They're usually not thrue.

Mr Dooley, on Making a Will
On the Descent of Man (p. 90)

Feyerabend, Paul K.
Facts contain ideological components, older views, natural interpretations, which have vanished from sight or perhaps never were formulated in an explicit manner. These components are highly suspicious, first because of their age, because of their archaic origin, and, secondly, because their very nature protects them from critical examination and always has protected them from such an examination.

In R.G. Colodny
The Nature and Function of Scientific Theories
Problems of Empiricism
Part II (p. 310)

No theory ever agrees with all the facts *in its domain, yet it is not always the theory that is to blame. Facts are constituted by older ideologies, and a clash between facts and theories may be proof of progress.*

Against Method
Chapter 5 (p. 39)

Gay-Lussac
In the natural sciences and especially in chemistry generalisations should result from the detailed knowledge of each fact, they should not precede it. It is really only after having acquired this knowledge that we can be assured whether they have something in common…

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 67)

A fact is not novel if it has an analogue which could have some interest. A fact which does not fit in with a series of known facts is a fact which deserves particular attention. If the mind had to retain all individual facts, it could not manage and science would not exist; but when these facts can be connected by general laws and by theories, when a large number of

these facts can be represented by a single one, one can remember them more easily, one can generalise one's ideas, one can compare one general fact with another general fact and discoveries can succeed each other. It is only when laws can be introduced into a science that it assumes the true character of science.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 70)

Greenstein, Jesse L.
Knowing how hard it is to collect a fact, you understand why most people want to have some fun analyzing it.

Fortune
Great American Scientists: The Astronomer (p. 149)
Volume 61, Number 5, May 1960

Haldane, J.B.S.
...you must constantly be returning from the unfamiliar facts of science to the familiar facts of everyday experience...I think that popular science can be of real value by emphasizing the unity of human knowledge and endeavour, at their best. This fact is hardly stressed at all in the ordinary teaching of science, and good popular science should correct this fault, both by showing how science is created by technology and creates it, and by showing the relation between scientific and other forms of thought.

In J. Maynard Smith (ed.)
On Being the Right Size and Other Essays
How To Write A Popular Scientific Article (pp. 155, 158)

Heinlein, Robert A.
What are the facts? Again and again and again—what are the *facts*? Shun wishful thinking, ignore divine revelation, forget what "the stars foretell," avoid opinion, care not what the neighbors think, never mind the unguessable "verdict of history"—what are the facts, and to how many decimal places? You pilot always into an unknown future; facts are your single clue. Get the facts!

Time Enough for Love
Intermission (p. 264)

Huxley, Aldous
Facts do not cease to exist because they are ignored.

Proper Studies
A Note on Dogma (p. 205)

Facts are ventriloquists' dummies. Sitting on a wise man's knee they may be made to utter words of wisdom; elsewhere they say nothing or talk nonsense…

Time Must Have a Stop
Chapter XXX (p. 301)

Huxley, Julian
To speculate without facts is to attempt to enter a house of which one has not the key, by wandering aimlessly round and round, searching the walls and now and then peeping through the windows. Facts are the key.

Essays in Popular Science
Heredity
I, The Behavior of the Chromosomes (pp. 1–2)

Langer, Susanne
Our world "divides into facts" because we so divide it.

Philosophy in a New Key
Chapter X (p. 273)

Latham, Peter Mere
Bear in mind then, that abstractions are *not facts*; and next bear in mind that *opinions* are not facts.

In William B. Bean
Aphorisms from Latham (p. 36)

Lavoisier, Antoine
We must trust to nothing but facts: these are presented to us by nature and cannot deceive. We ought, in every instance, to submit our reasoning to the test of experiment and never to search for truth but by the natural road of experiment and observation.

Elements of Chemistry
Preface (p. 2)

Mach, Ernst
After the repeated survey of a field has afforded opportunity for the interposition of advantageous accidents, has rendered all the traits that suit with the mood or the dominant thought more vivid, and has gradually relegated to the background all things that are inappropriate, making their future appearance impossible; then from the teeming, swelling host of fancies which a free and highflown imagination calls forth, suddenly that particular form arises to the light which harmonizes perfectly with the ruling idea, mood, or design. Then it is that which has resulted slowly as the result of a gradual selection, appears as if it were the outcome of a deliberate act of creation. Thus are to be explained the statements of Newton, Mozart, Richard Wagner, and others, when they say that thoughts, melodies, and harmonies had poured in upon them, and that they had simply retained the right ones.

The Monist
On the Part Played by Accident in Invention and Discovery (p. 174)
Volume 6, Number 2, January 1896

Pearson, Karl
The smallest group of facts, if properly classified and logically dealt with, will form a stone which has its proper place in the great building of knowledge, wholly independent of the individual workman who has shaped it.

The Grammar of Science
Part I
Introductory, Section 5 (p. 17)

Pirandello, Luigi
Producer. Let's get to the point, let's get to the point. This is all chat.
Father. Right then! But a fact is like a sack—it won't stand up if it's empty. To make it stand up, first you have to put in it all the reasons and feelings that caused it in the first place.

Six Characters in Search of an Author
Act I (p. 21)

Siegel, Eli
Facts are always whispering, uttering, and shouting advice.

Damned Welcome
Aesthetic Realism Maxims
Part 2, #387 (p. 152)

Twain, Mark
. . . always dress a fact in tights, never in an ulster. . .

Life on the Mississippi
Chapter XXXIV (p. 253)

The mere knowledge of a fact is pale; but when you come to realize your fact, it takes on color. It is all the difference between hearing of a man being stabbed to the heart, and seeing it done.

A Connecticut Yankee in King Arthur's Court
Chapter VI (p. 42)

How empty is theory in the presence of fact!

A Connecticut Yankee in King Arthur's Court
Chapter XLIII (p. 437)

For a forgotten fact is news when it comes again.

Following the Equator
Chapter LVIII (p. 546)

Tyndall, John
. . . the brightest flashes in the world of thought are incomplete until they have been proved to have their counterparts in the world of facts.

Fragments of Science
Part II
Chapter III (p. 411)

Whewell, William
. . . in order that the facts obtained by observation and experiment may be capable of being used in furtherance of our exact and solid knowledge, they must be apprehended and analysed according to some Conception which, applied for this purpose, give distinct and definite results, such as can be steadily taken hold of and reasoned from;. . .

Philosophy of the Inductive Sciences
Volume II
Book XI, Chapter III (p. 39)

Wright, Chauncey
True science deals with nothing but questions of facts...

In James Bradley Thayer
Letters of Chauncey Wright with some Account of His Life
Letter to F.E. Abbot of 13 August 1867
(p. 113)

FAITH

Eddington, Sir Arthur Stanley

Reasoning leads us from premises to conclusion; it cannot start without premises…[W]e…must believe that we have an inner sense of values which guides us as to what is to be heeded, otherwise we cannot start on our survey even of the physical world…At the very beginning there is something which might be described as an act of faith—a belief that what our eyes have to show us is significant.

Science and the Unseen World
Chapter VI (pp. 73–4)

Planck, Max

Science demands also the believing spirit. Anybody who has been seriously engaged in scientific work of any kind realizes that over the entrance to the gates of the temple of science are written the words: *Ye must have faith*. It is the quality which the scientist cannot dispense with.

Where is Science Going?
Epilogue (p. 214)

FERMENTATION

Ripley, George
True *Firmentation* few Workers understand,
That secret therefore I will expound to thee,
I travailed truly through manie a Land,
Ere ever I might finde any that would tell it mee:
Yet as God would, evermore blessed behee,
At the last I came to the knowledge thereof perfite,
Take heede therefore what I thereof doe write.

The Compound of Alchymy

FILTER

Aristotle
Make a vessel of wax and put it in the sea, fastening its mouth in such a way as to prevent any water getting in. Then the water that percolates through the wax sides of the vessel is sweet, the earthy stuff, the admixture of which makes the water salt, being separated off as it were by a filter.

Meteorology
Book II, Chapter 3, 359^{a} [35]

FIRE

Dickinson, Emily
Fire exists the first in light,
And then consolidates—
Only the chemist can disclose
Into what carbonates.

The Complete Poems of Emily Dickinson
1063

FLUOROCHEMISTRY

de Ment, Jack

With the increasing number of researches and publications devoted to the applications of fluorescence to chemistry, a need is rapidly arising to identify this new branch of science as distinct and apart from related and often confused fields.

Therefore, it seems expedient to propose the name *fluorochemistry* as descriptive of this branch of science. The term fluorochemistry is in order with other terms created to identify highly specialized fields which are still within the boundaries of chemistry and/or physics, eg., photochemistry, physical optics, and so on.

Science
Discussion (p. 407)
Volume 95, Number 2468, 17 April 1942

FORCE

Henry, John
. . . had Newton *not* been steeped in alchemical and other magical learning, he would never have proposed forces of attraction and repulsion between bodies as the major feature of his physical system.

In John Fauvel, Raymond Flood, Michael Shortland and Robin Wilson (eds.)
Let Newton Be!
Chapter 6 (p. 144)

FORECAST

Heilbroner, Robert
Rather than projecting the shadow of Tomorrow's unknowable realities, I propose to ask whether it is *imaginable*—I stress this crucial word—to exercise effective control over the future-shaping forces of Today. This rescues us from the impossible attempt to predict the shape of Tomorrow, and leaves us with the somewhat less futile effort of inquiring into the possibilities of changing or controlling the trends of the present... Can this intrusion of science and technology be bounded, confined to its needed applications, and kept from sucking the life out of our engagement with nature and with one another? I find that difficult to imagine.

Visions of the Future: The Distant Past, Yesterday, Today, Tomorrow
Chapter 5 (pp. 95, 99)

FORMULA

Coleridge, Samuel T.
. . . from the time of Kepler to that of Newton, and from Newton to Hartley, not only all things in external nature, but the subtlest mysteries of life and organization, and even of the intellect and moral being, were conjured within the magic circle of mathematical formulae.

The Theory of Life
On the Definitions of Life Hitherto Received (p. 375)

de Jouvenel, Betrand
It is utterly implausible that a mathematical formula should make the future known to us, and those who think it can would once have believed in witchcraft.

The Art of Conjecture
Chapter 15 (p. 173)

Hofmann, A.W.
. . . symbolic formulae. . . would deserve to rank among the chemist's most powerful instruments of *research*.

Introduction to Modern Chemistry
Lecture V (p. 87)

Huxley, Thomas
. . . as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulae will not get a definite result out of loose data.

Lay Sermons: Addresses and Reviews
Chapter XI (p. 249)

FRACTAL

Krantz, Steven

There is not even a universally accepted definition of the term "fractal". It seems that if one does not prove theorems (as, evidently, fractal geometers do not), then one does not need definitions. One notable difference between fractal geometry and calculus is that fractal geometry has not solved any problems. It is not even clear that it has created any new ones.

The Mathematical Intelligencer
Fractal Geometry (pp. 13–14)
Volume 11, Number 4, Fall 1989

GAS

Boltzmann, Ludwig
In my opinion it would be a great tragedy for science if the theory of gases were temporarily thrown into oblivion because of a momentary hostile attitude toward it, as for example was the wave theory because of Newton's authority.
I am conscious of being only one individual struggling weakly against the stream of time. But it still remains in my power to contribute in such a way that, when the theory of gases is again revived, not too much will have to be rediscovered.

Lectures on Gas Theory
Part II
Foreword to Part II (p. 216)

Emerson, Ralph Waldo
A man does not tie his shoe without recognizing laws which bind the farthest regions of nature: moon, planet, gas, crystal, are concrete geometry and numbers.

The Works of Ralph Waldo Emerson
Volume I
Essays
Second Series
Nature (p. 356)

Maxwell, James Clerk
So many of the properties of matter, especially when in the gaseous form, can be deduced from the hypothesis that their minute parts are in rapid motion, the velocity increasing with the temperature, that the precise nature of this motion becomes a subject of rational curiosity. Daniel Bernoulli, Herapath, Joule, Krönig, Clausius, etc. have shewn that the relations between pressure, temperature, and density in a perfect gas can be explained by supposing the particles to move with uniform velocity in

A man does not tie his shoe without recognizing laws which bind the farthest regions of nature: moon, planet, gas, crystal, are concrete geometry and numbers.
Ralph Waldo Emerson – (See p. 216)

straight lines, striking against the sides of the containing vessel and thus producing pressure.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume I
Illustrations of the Dynamical Theory of Gases (p. 377)

Unknown
Sir James Dewar
Is cleverer than you are
None of you asses
Can condense gases.

In Abraham Pais
Inward Bound
Chapter 7 (p. 137)

When you smell an odorless gas, it is probably carbon dioxide.

Source unknown

GENERALITY

Emerson, Ralph Waldo
Generalization is always a new influx of divinity into the mind. Hence the thrill that attends it.

The Works of Ralph Waldo Emerson
Volume I
First Essays
Circles (p. 198)

Gay-Lussac
In the natural sciences, and particularly in chemistry, generalities must come after the detailed knowledge of each fact and not before it. It is really only after having acquired this knowledge that one may see if the facts have anything in common... and only after that is it permissible to consider them in a general manner.

Annales de Chimie et de Physique
Volume 11, 1819 (p. 297)

Rayleigh, Lord
Science is nothing without generalisations... The suggestion of a new idea, or the detection of a law, supersedes much that had previously been a burden upon the memory, and by introducing order and coherence facilitates the retention of the remainder in an available form.

In William C. McC. Lewis
A System of Physical Chemistry
Volume I (p. iv)

GENIUS

Bromberger, Sylvain
A clear mark of scientific genius is the ability to see certain well known facts as departures from general rules…and the germane ability to ask why—questions that occur to no one else.

In K. Colodny (ed.)
Mind and Cosmos
Why-Questions (p. 103)

Egler, Frank E.
Genius knows no method, tho it leaves a spoor-method for drones to follow.

The Way of Science
Methodology and Logic (p. 44)

GEOCHEMISTRY

Hartwell
In bygone geologic ages—
Approximated by our sages—
Died the mammoth, kith and kin,
Just potential parafin.

On their anaërobic shoulders
Lay the ocean, glacial boulders,
Without the faintest notion when
They would turn to kerogen.

The ocean tossed about in pain,
Dried up—its bottom land again.
And here and there we find the signs
Which indicate the anticlines.

On hydrocarbon chains and branches
Chemists cast their valence glances,
Found long straight chain and naphthene ring.
O perfect crude—of thee I sing.

Industrial and Engineering Chemistry: News Edition
Organic Chemistry in Verse (p. 312)
Volume 10, Number 24, 20 December 1932

GLASSWARE

Cullinane, N.M.
My sweet pipet,
Can I forget
The day we met—pipet?
The day was drear and wet, how wet!
Your price was half a dollar net,
But shall I ever repay the debt, Pipet?
I think of what you held for me,
E'en though 'twas only 10 cc.,
(or 20 as the case may be),
And how in vain I tried to check
The water running down your neck—pipet.

Industrial and Engineering Chemistry: News Edition
Ode to a Pipet (p. 394)
Volume 13, Number 19, 10 October 1935

Epp, Erik
If a piece of glassware can fall it will do so.

Glass isn't as sturdy as it looks.

If glassware can fall in two directions, it will fall in such a way as to create the most damage.

The above damage will also be done in such a way as to cause the most injury to your person.

The probability of a piece of glassware breaking is directly proportional to its price, its cleanliness and its necessity for the current lab.

The probability of a piece of glassware breaking is inversely proportional to the quantity available for use.

The probability of a piece of glassware falling is directly proportional to its height above the floor.

If a piece of glass may fall it will fall just out of reach.

If two pieces of glass may break, the most expensive one will.

The one moment you turn away is the one moment the glassware decides to fall.

The probability of a piece of glassware falling is inversely proportional to the amount of time until the lab is complete.

The number of glass shards to clean up is inversely proportional to the lab time remaining.

Laws of Laboratory Glassware
Erik's Chemistry, http://eppe.tripod.com/

Smith, Miles
Boundy, Cather
Now if by chance we are missing a flask
We go to our neighbor, and timidly ask,
"Can you give us the low down—who stole our glass?"
With innocent surprise or utter dismay
He tells us that he has not seen it today.
So we give up our search, but the suspicion is strong
That our chemical neighbor has done us the wrong.

Industrial and Engineering Chemistry: News Edition
Our Poet's Corner
A Wail of Analytiker Men
Volume 8, Number 2, 20 January 1930

GOD

Scripps, Edwin W.
[Scientists are] so blamed wise and so packed full of knowledge… that they cannot comprehend why God has made nearly all the rest of mankind so infernally stupid.

In Dorothy Nelkin
Selling Science: How the Press Covers Science and Technology
Chapter 6 (p. 81)

Steele, Joel Dorman
God has no idlers in his world. Each atom has its use. There is not an extra particle in the entire universe.

A Fourteen Weeks Course in Chemistry
Inorganic Chemistry
Oxygen (p. 27)

GRAPH

Unknown
Never take more than three data points. There will always be some kind of graph paper on which they fall in a straight line.

Source unknown
The Chemist's Rule

If you have only one kind of graph paper, never take more than two data points.

Source unknown
The Chemist's Rule, First Corollary

GUESS

Bronowski, Jacob
There never was a great scientist who did not make bold guesses, and there never was a bold man whose guesses were not sometimes wild.

Science and Human Values
The Sense of Human Dignity (p. 82)

Feynman, Richard
In general we look for a new law by the following process. First we guess it. Then we compute the consequences of the guess to see what would be implied if this law that we guessed is right. Then we compare the results of the computation to nature, with experiment or experience, compare it directly with observation, to see if it works. If it disagrees with experiment it's wrong. In that simple statement is the key to science. It does not make any difference how beautiful your guess is. It does not make any difference how smart you are, who made the guess, or what his name is—if it disagrees with experiment it's wrong. That is all there is to it.

The Character of Physical Law
Chapter 7 (p. 156)

HEAT

Fourier, Joseph
. . . a very extensive class of phenomena exists, not produced by mechanical forces, but resulting simply from the presence and accumulation of heat. This part of natural philosophy cannot be connected with dynamical theories, it has principles peculiar to itself, and is founded on a method similar to that of other exact sciences.

The Analytical Theory of Heat (p. 23)

HISTORY

Geikie, Archibald
While eagerly pressing forward in the search after the secrets of Nature, we are apt to keep the eye too constantly fixed on the way that has to be traveled, and to lose sight and remembrance of the paths already trodden.

The Founders of Geology
Lecture I (p. 1)

Macquer, Pierre Joseph
As the History of any Science ought to relate the labours, the discoveries, and the errors of the cultivators of that Science; and to shew the obstacles which they have been obliged to surmount, and the mistaken paths into which they have sometimes been misled; it cannot therefore fail of being very useful to persons engaged in the same pursuits.

A Dictionary of Chemistry
Volume I
A Preliminary Discourse Concerning the Origin and Progress of Chemistry (p. 1)

HYPOTHESIS

Amundson, Ronald
It is commonly held that scientists do not generate hypotheses *randomly*, but rather with *the goal in mind* of solving some scientific problem. Now, if a purposively generated hypothesis has a greater chance of scientific success than a randomly generated one (a supposition we must fervently hope is true) then Condition 2 fails fully to be met. There are degrees here, of course. Perhaps "insightful" hypotheses are only *slightly* more likely than random ones to be successful, and only a tiny bit of the success of science is to be explained by the insights of scientists. Selection would in this case retain much of its force. But if "insightful" hypotheses are *much* more likely to be successful, selection is *much* eroded.

In K. Hahlweg and C.A. Hooker (eds.)
Issues in Evolutionary Epistemology
The Trials and Tribulations of Selectionist Explanations (p. 427)

Bruner, Jerome Seymour
The shrewd guess, the fertile hypothesis, the courageous leap to a tentative conclusion—these are the most valuable coin of the thinker at work whatever his line of work.

The Process of Education
Introduction (p. 14)

Cort, David
But suspicion is a thing very few people can entertain without letting the hypothesis turn, in their minds, into fact…

Social Astonishments
ONE
Believing in Books (p. 27)

Davis, W.M.
The sensible facts are discoverable by our senses, the insensible facts by our thoughts. The invention of hypotheses is therefore nothing more than

a mental effort to bring insensible facts into causal relation with sensible facts, and such an effort of correlation is praiseworthy even if it is daring.

In H. Shapley, H. Wright, and S. Rapport (eds.)
Readings in the Physical Sciences
The Reasonableness of Science (p. 22)

du Noüy, Pierre Lecomte
The man of science who cannot formulate a hypothesis is only an accountant of phenomena.

The Road to Reason
Chapter IV (p. 77)

Friedman, Milton
The construction of hypotheses is a creative act of inspiration, intuition, invention; its essence is the vision of something new in familiar material.

Essays in Positive Economics
Part I
Introduction (p. 43)

Huxley, Thomas
Any one who has studied the history of science knows that almost every great step therein has been made by the 'anticipation of Nature,' that is, by the invention of hypothesis, which, though *verifiable*, often had very little foundation to start with; and, not unfrequently, in spite of a long career of usefulness, turned out to be *wholly erroneous* in the long run.

Collected Essays
Volume I
Method and Results
The Progress of Science (p. 62)

Plato
…I think that you should go a step further, and consider not only the consequences which flow from a given hypothesis; but also the consequences which flow from denying the hypothesis…

Parmenides
[135]

Poynting, John Henry
The hypotheses of science are continually changing. Old hypotheses break down and new ones take their place. But the classification of known phenomena which a hypothesis has suggested, and the new discoveries of phenomena to which it has led, remain as positive and permanent

additions to natural knowledge when the hypothesis itself has vanished from thought.

Collected Scientific Papers
Part VII, Article 69 (p. 741)

Sagan, Carl
Spin more than one hypothesis. If there's something to be explained, think of all the different ways in which it *could* be explained. Then think of tests by which you might systematically disprove each of the alternatives. What survives, the hypothesis that resists disproof in this Darwinian selection among "multipleworking hypotheses," has a much better chance of being the right answer than if you had simply run with the first idea that caught your fancy.

The Demon-Haunted World: Science as a Candle in the Dark
Chapter 12 (p. 210)

Unknown
Q: What is the difference between a hypothesis and a theory?
A: Think of a hypothesis as a card. A theory is a house made of hypotheses.

Source unknown

Verworn, M.
. . . without hypothesis there can be no progress in knowledge.

Irritability
Chapter IX (p. 259)

von Goethe, Johann Wolfgang
No hypothesis can lay claim to any value unless it assembles many phenomena under one concept.

Wisdom And Experience
Science and Philosophy (p. 115)

IDEA

Acton, Lord
Ideas have a radiation and development, an ancestry and posterity of their own, in which men play the part of godfathers and godmothers more than that of legitimate parents.

In Gertrude Himmelfarb
Darwin and The Darwinian Revolution
Chapter XVIII (p. 380)

Aristotle
The same ideas, one must believe, recur in men's minds not once or twice but again and again.

On the Heavens
Book I, Chapter 3, 270^{b} [20]

Collins, Wilkie
Habits of literary composition are perfectly familiar to me. One of the rarest of all the intellectual accomplishments that a man can possess, is the grand faculty of arranging his ideas. Immense privilege! I possess it. Do you?

The Woman in White
The Third Epoch
The Story Concluded by Walter Hartright

Dirac, P.A.M.
...it is a general rule that the originator of a new idea is not the most suitable person to develop it because his fears of something going wrong are really too strong and prevent his looking at the method from a purely detached point of view in the way that he ought to.

The Development of Quantum Theory (p. 24)

Drexler, K.E.
Because of our superficial self-awareness, we often wonder where an idea in our heads came from. Some people imagine that these thoughts and

feelings come directly from agencies outside their own minds; they incline towards a belief in haunted heads.

Engines of Creation
Chapter 5 (p. 67)

Duckworth, Eleanor
The having of wonderful ideas is what I consider to be the essence of intellectual development.

Harvard Educational Review
The Having of Wonderful Ideas (p. 218)
May 1972

Wonderful ideas cannot spring out of nothing. They build on a foundation of other ideas.

Harvard Educational Review
The Having of Wonderful Ideas (pp. 222–3)
May 1972

Wonderful ideas build on other wonderful ideas. They are not had without content…

Harvard Educational Review
The Having of Wonderful Ideas (p. 224)
May 1972

Eisenschiml, Otto
Fine ideas, unless put into words, are like water in a jug which has no outlet.

The Art of Worldly Wisdom
Part 9 (p. 112)

Eliot, T.S.
Between the idea
And the reality
Between the notion
And the act
Falls the shadow.

Collected Poems 1909–1935
The Hollow Men
V

Feyerabend, Paul K.
There is no idea, however ancient and absurd that is not capable of improving our knowledge.

Against Method
Chapter 4 (p. 47)

Harrison, Edward R.
Ideas, once born, seemingly have a life of their own. Like germs they breed, spread, mutate, and catch their invaded victims by surprise. When and where an idea originated is often unknown, and many a person believes the idea, as recounted by him, springs unprompted from the recesses of his own mind. A thought drifts as light as thistledown, and sensitive minds responding to its novel vibrations 'independently' discover the new idea.

Masks of the Universe
Chapter 6 (p. 87)

Henderson, John R.
Almost anybody can have an idea. Ideas are the small change of science: it is conviction—zany, indestructible belief—that is the real pot of gold.

Guy's Hospital Gazette
Who Discovered Insulin?
Volume 85, 1971

Krantz, David L.
Wiggins, Lynda
Scientific ideas compete in an open marketplace. Each offers the possibility of a plausible solution to what might be a potentially significant problem. In its promise, an idea will attract other scientists—fellow explorers who will articulate, criticize, and ultimately determine the idea's actuality. While these explorers can breathe life into an idea, their absence or defection leads to its death. Ideas without recruits become like Bishop Berkeley's proverbial unheard falling tree.

Human Development
Personal and Impersonal Channels of Recruitment
in the Growth of Theory (p. 133)
Volume 16, 1973

Mencken, H.L.
…the proof of an idea is not to be sought in the soundness of the man fathering it, but in the soundness of the idea itself. One asks of a pudding, not if the cook who offers it is a good woman, but if the pudding itself is good.

The Philosophy of Friedrich Nietzsche
Nietzsche the Prophet
Chapter II (p. 271)

Oliver, Mary
A fact: one picks it up and reads it, and puts it down, and there is an end to it. But an idea! That one may pick up, and reflect upon, and oppose, and expand, and so pass a delightful altogether.

Blue Pastures
Pen and Paper and a Breath of Air (p. 57)

Peirce, Charles Sanders
It is terrible to see how a single unclear idea, a single formula without meaning, lurking in a young man's head, will sometimes act like an obstruction of inert matter in an artery, hindering the nutrition of the brain, and condemning its victim to pine away in the fullness of his intellectual vigor and in the midst of intellectual plenty.

Chance, Love, and Logic
Second Paper, section I (p. 37)

Polanyi, Michael
A vital judgment practiced in science is the assessment of *plausibility*. Only plausible ideas are taken up, discussed and tested by scientists. Such a decision may later be proved right, but at the time that it is made, the assessment of plausibility is based on a broad exercise of intuition guided by many subtle indications, and *thus it is altogether undemonstrable*. *It is tacit*.

Knowing and Being
The Growth of Science in Society (p. 76)

Priest, Graham
Historians of ideas soon learn—to their dismay—that their subject appears to be mathematically dense: between any two people who wrote on the matter there appears to be another.

Beyond the Limits of Thought
Chapter 1 (p. 6)

Stinton, D.
One should never have too much reverence for ideas, no matter whose they are. Ideas are meant to be kicked around, stood upon their heads, and looked at backwards through mirrors. It is only in this way that they can grow up in the way that they should, without excessive self-importance. The ideas of one man are the food for thought of another.

The Anatomy of the Aeroplane
Preface (p. ix)

Whitehead, Alfred North
If you have had your attention directed to the novelties in thought in your own lifetime, you will have observed that almost all really new ideas have a certain aspect of foolishness when they are first produced.

Science and the Modern World
Chapter III (p. 70)

Wilson, Edward O.
Keep in mind that new ideas are commonplace, and almost always wrong. Most flashes of insight lead nowhere; statistically, they have a half-life of hours or maybe days. Most experiments to follow up the surviving insights are tedious and consume large amounts of time, only to yield negative or (worse!) ambiguous results.

American Scientist
Scientists, Scholars, Knaves and Fools (p. 6)
Volume 86, January–February 1998

IGNORANCE

Harrison, Edward R.
Consider the unlearned, unaware of their ignorance, who think they know everything! As knowledge increases, ignorance decreases, but this kind of ignorance—unlearned ignorance—is no more than the lack of knowledge. With knowledge comes awareness of ignorance—learned ignorance—and the more we know, the more aware we become of what we do not know.

Masks of the Universe
Chapter 17 (p. 273)

Holmes, Oliver Wendell
Our task is only that of sending out a few pickets under the starry flag of science to the edge of that dark domain where the ensigns of the obstinate rebel, Ignorance, are flying undisputed.

Medical Essays 1842–1882
Chapter IV (p. 212)

Huxley, Thomas
The chess-board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of nature. The player on the other side is hidden from us. We know that his play is always fair, just, and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance.

Collected Essays
Volume III
Science and Education
A Liberal Education (p. 82)

James, William
Our science is a drop, our ignorance a sea. Whatever else be certain, this at least is certain—that the world of our present natural knowledge

is enveloped in a larger world of *some* sort whose residual properties we at present can frame no positive idea.

The Will to Believe
Is Life Worth Living?
Section IV (p. 54)

Lodge, Sir Oliver
In regions where our ignorance is great, occasional guesses are permissible.

Philosophical Magazine
On the Supposed Weight and Ultimate Fate of Radiation (p. 549)
Volume 41, Number 244, 1921

Pratchett, Terry
But then... it used to be so simple, once upon a time. Because the universe was full of ignorance all around and the scientist panned through it like a prospector crouched over a mountain stream, looking for the gold of knowledge among the gravel of unreason, the sand of uncertainty and the little whiskery eight-legged swimming things of superstition. Occasionally he would straighten up and say things like "Hurrah, I've discovered Boyle's Third Law." And everyone knew where they stood. But the trouble was that ignorance became more interesting, especially big fascinating ignorance about huge and important things like matter and creation, and people stopped patiently building their little houses of rational sticks in the chaos of the universe and started getting interested in the chaos itself—partly because it was a lot easier to be an expert on chaos, but mostly because it made really good patterns that you could put on a t-shirt.

Witches Abroad (p. 7)

Walker, Kenneth
And how small is the sum of our actual knowledge. With regards to all the more important things, to the questions which concern us more nearly, it amounts to little beyond a consciousness of our own ignorance.

Meaning and Purpose
Chapter XV (p. 168)

Watts, Alan W.
The greater the scientist, the more he is impressed with his ignorance of reality, and the more he realizes that his laws and labels, descriptions and definitions, are the products of his own thought.

The Wisdom of Insecurity
Chapter IX (p. 149)

IMAGINATION

Bacon, Francis
We are not…to imagine or suppose, but to *discover*, what Nature does or may be made to do.

In Henry Hobhouse
Seeds of Change, Five Plants That Transformed Mankind
Quinine and the White Man's Burden (p. 14)

Darwin, Charles
The value of the products of our imagination depends, of course, on the number, accuracy, and clearness of our impressions, on our judgment and taste in selecting or rejecting the involuntary combinations, and to a certain extent on our power of voluntary combining them…

The Descent of Man
Chapter III (p. 292)

Doyle, Sir Arthur Conan
It is, I admit, mere imagination; but how often is imagination the mother of truth?

The Valley of Fear
Part I, Chapter 6 (p. 118)

Faraday, Michael
…in the pursuit of physical science, the imagination should be taught to present the subject investigated in all possible and even impossible views…

Experimental Researches in Chemistry and Physics
On Mental Education (p. 480)

Leslie, Sir John
The gift of a lively fancy is an important requisite for every physical observer.

Elements of Natural Philosophy
Introduction (p. xiii)

Mitchell, Maria
We especially need imagination in science. It is not all mathematics nor all logic, it is somewhat beauty and poetry.

In Helen Wright
Sweeper in the Sky
Chapter 9 (p. 164)

Montgomery, Lucy Maud
Isn't it splendid to think of all the things there are to find out about? It just makes me feel glad to be live—it's such an interesting world. It wouldn't be half so interesting if we know all about everything, would it? There'd be no scope for imagination then, would there?

Anne of Green Gables
Chapter II (p. 19)

Payne-Gaposchkin, Cecilia
To realize one's limitations marks the awakening of intellectual integrity, without which imagination, integrity and assiduity are barren.

An Autobiography and Other Recollections
Chapter 7 (p. 123)

Raymo, C.
Science is not a collection of facts, nor is science something that happens in the laboratory. Science is something that happens in the head; it is a flight of imagination beyond the constraints of ordinary imagination.

The Virgin and the Mousetrap
Chapter 1 (p. 3)

Reid, Thomas
It is genius, and not the want of it, that adulterates philosophy, and fills it with error and false theory. A creative imagination disdains the mean offices of digging for a foundation, of removing rubbish, and carrying materials; leaving these servile employments to the drudges in science, it plans a design, and raises a fabric. Invention supplies materials where they are wanting, and fancy adds colouring and every befitting ornament. The work pleases the eye, and wants nothing but solidity and a good foundation.

The Works of Thomas Reid
Volume I
An Inquiry into the Human Mind
Chapter I, Section ii (p. 99)

Serling, Rod
There is a fifth dimension beyond those known to man. It is a dimension vast as space and timeless as infinity. It is the middle ground between light

and shadow, between the pit of his fears and the summit of his knowledge. This is the dimension of imagination. It is an area called the Twilight Zone.

Twilight Zone
Television series
Preamble

Shaw, George Bernard
Stupidity has all the knowledge, and Imagination all the intelligence.

Man and Superman
Act III (p. 83)

IMPOSSIBLE

Aristotle
In framing an ideal we may assume what we wish, but should avoid impossibilities.

Politics
Book II, Chapter 6, 1265^{a} [15]

Cromer, Alan
Belief in impossibility is the starting point for logic, deductive mathematics, and natural science. It can originate in a mind that has freed itself from belief in its own omnipotence.

Uncommon Sense
Chapter 4 (p. 78)

Matthew 19:21
With men this is impossible, but with God all things are possible.

The Bible

IMPROBABLE

Dawkins, Richard
To "tame" chance means to break down the very improbable into less improbable small components arranged in series. No matter how improbable it is that an X could have arisen from Y in a single step, it is always possible to conceive of a series of infinitesimal graded intermediates between them. However improbable a large scale change may be, smaller changes are less improbable. And provided we postulate a sufficiently large series of sufficiently finely graded intermediates, we shall be able to derive anything from anything else, without astronomical improbabilities.

The Blind Watchmaker
Chapter 11 (pp. 317–18)

INDEPENDENCE

Koerner, Jon
The problem is that, in many cases for many systems, there may simply be no such thing as a truly independent variable. Out here in the real world, the phrase "independent" may often be oxymoronic. The very notion of independence reflects the world of Platonic idealism, a pure world populated by separate discrete *things* each with its essence, floating suspended in a sea of laws, rules governing the relations between these autonomous entities.

Nontriviality of Nonlinear Dynamics in Psychology of Learning
Doctoral Dissertation
University of Minnesota
1989 (p. 118)

INFERENCE

Doyle, Sir Arthur Conan
…it is not really difficult to construct a series of inferences, each dependent upon its predecessor and each simple in itself. If, after doing so, one simply knocks out all the central inferences and presents one's audience with the starting-point and the conclusion, one may produce a startling, though possibly a meretricious, effect.

The Complete Original Illustrated Sherlock Holmes
The Adventure of the Dancing Men (p. 479)

Priestley, Joseph
I can only repeat, that it is not my opinions, on which I would be understood to lay any stress. Let the new facts, from which I deduce them, be considered as my discoveries, and let other persons draw better inferences from them if they can.

In F.W. Gibbs
Joseph Priestley: Adventurer in Science and Champion of Truth
Chapter 9 (p. 117)

INFORMATION

Dretske, Fred I.
Beauty is in the eye of the beholder, and information is in the head of the receiver.

Knowledge and the Flow of Information
Preface (p. vii)

Eliot, T.S.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

The Rock
Part I (p. 7)

Herschel, J.F.W.
…the sparks of information from time to time struck out, instead of glimmering for a moment, and dying away in oblivion, began to accumulate into a genial glow, and the flame was at length kindled which was speedily to acquire the strength and rapid spread of a conflagration.

A Preliminary Discourse on the Study of Natural Philosophy
Chapter VI (p. 348)

Lee, Stan
Negative information is that which, immediately upon acquiring, causes the recipient to know less than he did before.

Dunn's Conundrum
Trash Report: #85-10-9 (p. 156)

Mailer, Norman
The only thing of which I could be certain was that everyone had information to offer, spoke in a voice that was full of authority, and contradicted what the last fellow had said.

Ancient Evenings
Part IV, Chapter 7 (p. 312)

Twain, Mark

I think it is best to put up with information the way you get it; and seem satisfied with it, and surprised at it, and grateful for it, and say, "My word!" and never let on. It was a wide space; I could tell you how wide, in chains and perches and furlongs and things, but that would not help you any. Those things sound well, but they are shadowy and indefinite, like troy weight and avoirdupois; nobody knows what they mean. When you buy a pound of a drug and the man asks you which you want, troy or avoirdupois, it is best to say "Yes," and shift the subject.

Following the Equator
Chapter XXIII (pp. 224–5)

INORGANIC

Shulman, Max
Organic chemistry is the study of organs; inorganic chemistry is the study of the insides of organs.

In Evan Esar
20,000 Quips & Quotes (p. 127)

INSTRUMENT

Bacon, Francis
The unassisted hand and the understanding left to itself possess but little power. Effects are produced by the means of instruments and helps, which the understanding requires no less than the hand; and as instruments either promote or regulate the motion of the hand, so those that are applied to the mind prompt or protect the understanding.

Novum Organum
Aphorism II

Beveridge, W.I.B.
Elaborate apparatus plays an important part in the science of to-day, but I sometimes wonder if we are not inclined to forget that the most important instrument in research must always be the mind of man.

The Art of Scientific Investigation
Preface (p. ix)

Bridgman, P.W.
Not only do we use instruments to give us fineness of detail inaccessible to direct sense perception, but we also use them to extend qualitatively the range of our senses into regions where our senses no longer operate…

The Way Things Are
Chapter V (p. 149)

Egler, Frank E.
Dazed with this brightness of our technology, I wonder if some are not inclined to forget that the most important instrument in science must always be the mind of man.

The Way of Science
Methodology and Instrumentation (p. 59)

Eisenhart, Churchill
Of wonders of science and feats of design

Has many a scribe writ the praise;
And if I now mention the subject again
It's distinctily a relative phase.
For while science and gadgets are fine in their ways
One worries at times 'bout their clutch,
Especially when science, design, and math'matics
Combine to get us in Dutch.

Science
Operational Aspects of Instrument Design (p. 343)
Volume 110, 7 October 1949

Kuhn, Thomas
...scientists see new and different things when looking with familiar instruments in places they have looked before...It is as elementary prototypes for these transformations of the scientist's world that the familiar demonstrations of a switch in visual gestalt prove so suggestive. What were ducks in the scientist's world before the revolution are rabbits afterwards.

The Structure of Scientific Revolutions
Chapter X (p. 111)

Lavoisier, Antoine
As the usefulness and accuracy of chemistry depend entirely upon the determination of the weights of the ingredients and products, too much precision cannot be employed in this part of the subject; and for this purpose, we must be provided with good instruments.

Elements of Chemistry in a New Systematic Order
Part III, Chapter I (p. 88)

In the present advanced state of chemistry, very expensive and complicated instruments are become indispensably necessary for ascertaining the analysis and synthesis of bodies with the requisite precision as to quantity and proportion; it is certainly proper to endeavor to simplify these, and to render them less costly; but this ought by no means to be attempted at the expense of their conveniency of application, and much less of their accuracy.

Elements of Chemistry in a New Systematic Order
Part III, Chapter II, Section II (p. 94)

von Goethe, Johann Wolfgang
Ye instruments, ye surely jeer at me,
With handle, wheel and cogs and cylinder.
I stood beside the gate, ye were to be the key.
True, intricate your ward, but no bolts do ye stir.
Inscrutable upon a sunlit day,

Her veil will Nature never let you steal,
And what she will not to your mind reveal,
You will not wrest from her with levers and with screws.

Faust
The First Part
Night, L. 668–75

Whitehead, Alfred North
The reason why we are on a higher imaginative level is not because we have finer imagination, but because we have better instruments.

Science and the Modern World (p. 167)

ION

Hendrick, Ellwood
I used to think theology
Was rather rough on doubt,
But chemistry with ions beats
Theology all out.

In James Kendall
Journal of Chemical Education
The Present Status of the Ionization Theory
Volume 2, Number 5, May 1925 (p. 376)

Kunin, Robert
Myers, Robert J.
A recent interpretation of the miracle supposedly performed by Moses as he led the Israelites safely through the wilderness suggests the possibility of the application of ion exchange. In order to make the 'bitter' water at Matah potable during their journey, Moses found a tree 'which when he had cast it into the waters, the waters were made sweet'. It has been suggested that the oxidized cellulose of the tree entered into an exchange reaction with the bitter electrolytes of the water, rendering the water potable.

Ion Exchange Resins
Chapter 1 (p. 1)

KNOWLEDGE

Aristotle

Yet it does not appear to be true in all cases that correlatives come into existence simultaneously. The object of knowledge would appear to exist before knowledge itself for it is usually the case that we acquire knowledge of objects already existing; it may be difficult, if not impossible, to find a branch of knowledge the beginning of the existence of which was contemporaneous with that of its object.

Categories
Chapter 7, 7^{b} [20]

All men by nature desire to know.

Metaphysics
Book I, Chapter I, 980^{a}

. . . knowledge is the object of our enquiry and men do not think they know a thing till they have grasped the 'why' of it.

Physics
Book II, Chapter 2, 194^{b} [15]

. . . knowledge of any kind is a thing to be honored and prized. . .

On the Soul
Book I, Chapter I, 402^{a}

Bloor, David

All knowledge, the sociologist could say, is conjectural and theoretical. Nothing is absolute and final. Therefore all knowledge is relative to the local situation of the thinkers who produce it: the ideas and conjectures that they are capable of producing: the problems that bother them; the interplay of assumptions and criticism in their milieu; their purposes and aims; the experiences they have and the standards and meanings they apply.

Knowledge and Social Imagery
Chapter 8 (pp. 142–3)

Like many features of a landscape, knowledge looks different from different angles. Approach it from an unexpected route, glimpse it from an unusual vantage point, and at first it may not be recognizable.

Knowledge and Social Imagery
Chapter 8 (p. 144)

Boulding, Kenneth E.
The carbon atom, for instance, knows how to join with four hydrogen atoms or with two oxygen atoms. It also mysteriously enough knows how to join with one oxygen atom to form carbon monoxide. It is little more than a figure of speech, however, to regard this ability as knowledge.

The Image
Chapter 3 (p. 33)

Byron, Lord George Gordon
. . . knowledge is not happiness, and science
But an exchange of ignorance for that
Which is another kind of ignorance.

The Complete Poetical Works of Byron
Manfred (p. 489)

Chargaff, Erwin
Illuminated darkness is not light.

Heraclitean Fire
Part II
In the Light of Darkness (p. 109)

Coleridge, Mary
The fruits of the tree of Knowledge are various; he must be strong indeed who can digest all of them.

Gathered Leaves (pp. 8–9)

Collingwood, Robin George
Questioning is the cutting edge of knowledge; assertion is the dead weight behind the edge that gives it driving force.

Speculum Mentis
Chapter III, Section 5 (p. 78)

da Vinci, Leonardo
The acquisition of any knowledge whatever is always useful to the intellect, because it will be able to banish the useless things and retain

those which are good. For nothing can be either loved or hated unless it is first known.

In Edward McCurdy
The Notebooks of Leonardo da Vinci
Volume I
Aphorisms (p. 88)

All our knowledge originates in opinions.

In Edward McCurdy
Leonardo da Vinci's Note-Books
How in all Travels One May Learn (p. 53)

Dumal, Rene
You cannot stay on the summit forever; you have to come down again…So why bother in the first place? Just this: What is above knows what is below, but what is below does not know what is above. In climbing, take careful note of the difficulties along your way; for as you go up, you can observe them. Coming down, you will no longer see them, but you will know they are there if you have observed them well.

There is an art of finding one's direction in the lower regions by the memory of what one saw higher up. When one can no longer see, one can at least still know.

Mount Analogue
Editor's Note (p. 110)

Keep your eye fixed on the way to the top, but don't forget to look right in front of you. The last step depends on the first. Don't think you've arrived just because you see the summit. Watch your footing, be sure of the next step, but don't let that distract you from the *highest goal*. The first step depends on the last.

Mount Analogue
Editor's Note (p. 111)

Einstein, Albert
Yet it is equally clear that knowledge of what *is*, does not open the door directly to what *should be*.

Out of My Later Years
Science and Religion
Section I (p. 22)

Fabing, Harold
Marr, Ray
Knowledge is a process of piling up facts; wisdom lies in their simplification.

Fischerisms (p. 2)

Feynman, Richard
A great deal more can be known than can be proved.

Chicago Tribune
318:4, Section 7, 14 November 1993

Fleck, Ludwik
Certainty, simplicity, vividness originate in popular knowledge. That is where the expert obtains his faith in this triad as the ideal of knowledge. Therein lies the general epistemological significance of popular science.

Genesis and Development of a Scientific Fact
Chapter 4, Section 4 (p. 115)

Foster, Sir Michael
What we know and what we think is not a new fountain gushing fresh from the barren rock of the unknown at the stroke of the rod of our own intellect, it is a stream which flows by us and through us, fed by the far-off rivulets of long ago.

Lectures on the History of Physiology
Lecture I (p. 1)

Gibran, Kahlil
No man can reveal to you aught but that which already lies half asleep in the dawning of your knowledge.

The Prophet
On Teaching (p. 56)

Perplexity is the beginning of knowledge.

The Voice of the Master
Youth and Hope (p. 87)

Gore, George
New knowledge is not like a cistern, soon emptied, but is a fountain of almost unlimited power and duration…

The Art of Scientific Discovery
Part I
Chapter III (p. 27)

Hall, A.R.
…the grain of real knowledge is concealed in a vast deal of esoteric chaff.

The Scientific Revolution, 1500–1800
Chapter XI (p. 307)

Harris, Sydney J.
Our current annoyance at the long hair affected by young men is both trivial and parochial; what matters is the amount of substance inside the head, not outside.

Chemistry
Volume 40, Number 3, March 1967 (p. 2)

Harrison, Edward R.
. . . the first law of knowledge is the conservation of ignorance. Take any subject, no matter how simple; have you noticed, after study and thought, how the more we know of that subject the more aware we become of what we do not know? For some outlandish reason greater knowledge leads unavoidably to an awareness of greater ignorance. Learned ignorance (awareness of ignorance) replaces unlearned ignorance (unawareness of ignorance), and total ignorance as a consequence remains unchanged. Learned ignorance always increases with knowledge. (This is the second law of knowledge.) Happy is the person who knowing nothing thinks he knows everything!. . .

Quarterly Journal of the Royal Astronomical Society
A Twinkle in the Eye of the Universe (p. 423)
Volume 25, Number 4, December 1984

Holmes, Oliver Wendell
It is the province of knowledge to speak and it is the privilege of wisdom to listen.

The Poet at the Breakfast Table
Chapter 10 (p. 310)

The best part of our knowledge is that which teaches us where knowledge leaves off and ignorance begins.

Medical Essays 1842–1882
Border Lines in Medical Science (p. 211)

The traveler who would not drink of the Nile until he had tracked it to its parent lakes, would be like to die of thirst; and the medical practitioner who would not use the results of many laborers in other departments without sharing their special toils, would find life far too short and art immeasurably too long.

Medical Essays 1842–1882
Scholastic and Bedside Teaching (p. 274)

Huxley, Thomas
Indeed, if a little knowledge is dangerous, where is the man who has so much as to be out of danger?

Collected Essays
Volume III
Science and Education
On Elementary Instruction in Physiology (p. 300)

Kettering, Charles F.
We have only begun to knock a few chips from the great quarry of knowledge that has been given us to dig out and use. We know almost nothing about everything. That is why, with all conviction, I say that the future is boundless.

In James Kip Finch
Engineering and Western Civilization (p. 306)

Lichtenberg, Georg Christoph
I made the journey to knowledge like dogs who go for walks with their masters, a hundred times forward and backward over the same territory; and when I arrived I was tired.

Lichtenberg: Aphorisms & Letters
Aphorisms (p. 58)

Middendorf, W.H.
Brown, G.T., Jr.
A full storehouse of knowledge is a necessary but not sufficient condition for invention. To this, one must add an organized method of attack.

Electrical Engineering
Orderly Creative Inventing (p. 867)
October 1957

Morgan, Charles
. . . as knowledge increases, wonder deepens. . .

The Fountain
The Bond
Chapter 10 (p. 383)

Myrdal, Gunnar
All ignorance, like all knowledge, tends thus to be opportunist.

Objectivity in Social Research
Chapter III (p. 19)

Popper, Karl R.
From the amoeba to Einstein, the growth of knowledge is always the same: we try to solve our problems, and to obtain, by a process of elimination, something approaching adequacy in our tentative solutions.

Objective Knowledge: An Evolutionary Approach
Chapter 7 (p. 261)

Robinson, James Harvey
Of all human ambitions an open mind eagerly expectant of new discoveries and ready to remold convictions in the light of added knowledge and dispelled ignorances and misapprehensions, is the noblest, the rarest and the most difficult to achieve.

The Humanizing of Knowledge
Chapter V (p. 61)

Shelley, Mary
Oh what a strange nature is knowledge! It clings to the mind, when it has once seized on it, like a lichen on the rock.

The Novels and Selected Works of Mary Shelley
Volume 1
Frankenstein
Volume II
Chapter V (p. 90)

Snyder, Carl H.
. . . the difference between "magic" and "science" is knowledge.

The Extraordinary Chemistry of Ordinary Things
Preface (p. vii)

Swift, Jonathan
Erect your schemes with as much method and skill as you please; yet if the materials be. . . spun out of your own entrails. . . the edifice will conclude at last in cobwebs. . . As for us the ancients, we are content with the bee to pretend to nothing of our own, beyond our wings and our voice, that is to say, our flights and our language. For the rest, whatever we have got, has been by infinite labour and search, and ranging through every corner of nature.

Gulliver's Travels, The Tale of a Tub, Battle of the Books, etc.
The Battle of the Books (p. 554)

Szent-Györgyi, Albert
Knowledge is a sacred cow, and my problem will be how we can milk her while keeping clear of her horns.

Science
Teaching and the Expanding Knowledge (p. 1278)
Volume 146, Number 3649, 4 December 1964

Tennyson, Alfred Lord
Knowledge comes, but wisdom lingers…

In Charles W. Eliot (ed.)
The Harvard Classics
English Poetry in Three Volumes
Volume III
Locksley Hall, L. 141

To follow knowledge, like a sinking star,
Beyond the utmost bound of human thought.

In Charles W. Eliot (ed.)
The Harvard Classics
English Poetry in Three Volumes
Volume III
Ulysses, L. 32–3

Unknown
Right now I'm having amnesia and deja vu at the same time. I think I've forgotten this before.

Source unknown

Whitehead, Alfred North
The consequences of a plethora of half-digested theoretical knowledge are deplorable.

The Aims of Education
Chapter I (p. 9)

Knowledge does not keep any better than fish.

The Aims of Education
Chapter VII
Section III (p. 147)

Wilson, Edward O.
New knowledge is not science until it is made social. The scientific culture can be defined as new verifiable knowledge secured and distributed with fair credit meticulously given.

Naturalist
The Forms of Things Unknown (p. 210)

LABORATORY

Armitage, Simon
I am very bothered when I think
of the bad things I have done in my life.
Not least that time in the chemistry lab
when I held a pair of scissors by the blades
and played the handles
in the naked lilac flame of the Bunsen burner,
then called your name, and handed them over.

Book of Matches
I Am Very Bothered When I Think, L. 1–7

Ciardi, John
To the laboratory then I went. What little right men they were exactly! Magicians of the microsecond precisely wired to what they cared to ask no questions of but such as their computers clicked and hummed.

It was a white-mocked, glass, and lightened Hell. And there Saint Particle the Septic sat lost in his horn-rimmed thoughts. A gentlest pose. But in the frame of one lens as I passed I saw an ogre's eye leap from his face.

Saturday Review
Fragment
30 April 1966

Curie, Marie
I am among those who think that science has great beauty. A scientist in his laboratory is not only a technician: he is also a child placed before natural phenomena which impress him like a fairy tale.

In Sharon Bertsch McGrayne
Nobel Prize Women in Science: Their Lives, Struggles, and Momentous Discoveries
Chapter 11

Drake, Daniel
The laboratory is not more necessary for the study of chemistry, or a garden of plants for the study of botany, than a hospital for the study of practical medicine and surgery.

Introductory lecture
Medical College of Ohio, 1849

Fischer, Martin H.
A laboratory is only a place where one may better set up and control conditions.

In Howard Fabing and Ray Marr
Fischerisms

All the world is a laboratory to the inquiring mind.

In Howard Fabing and Ray Marr
Fischerisms

Henry, William
A chemical laboratory, though extremely useful, and even essential, to all who embark extensively in the practice of chemistry, either as an art, or as a branch of liberal knowledge, is by no means required for the performance of those simple experiments, which furnish the evidence of the fundamental truths of science. A room that is well lighted, easily ventilated, and destitute of any valuable furniture, is all that is absolutely necessary for the purpose.

The Elements of Experimental Chemistry
Volume I
Part I
Chapter I (p. 27)

Jones, Thomas P.
Nature has the universe for her laboratory, in which she is continually employed in chemical operations, producing effects as interesting, as wonderful, and equally necessary with those which belong to Natural Philosophy.

New Conversations on Chemistry
Conversation I (p. 14)

Lagen, Doug
The lab is my jeopardy, I cannot breathe.
It eateth my clothes with strong acids.
It destroyeth my soles.
It leadeth me into the paths of science for its own sake.
Yea, though I walk through the welter of stink and smells, I will fear not chemical, for it is oneness.

It provideth me a bench in the presence of fluorine.
It loadeth my day with toil.
My beaker runneth over.
Surely bad tastes and odors shall follow me all the days of my life, and I shall dwell in the house of science forever.

Chemistry
The Lab (p. 27)
June 1976

Lamb, J.C.
If you can make the vilest stinks invented
And work in them from morn till late at night,
Or with your lot be perfectly contented
When you are asked to fool with dynamite;
If you can still remain quite calm and placid
When plant officials effervesce and fret,
Or being told to test a fuming acid
Can suck it through a 1-cc pipet:
⋮
If you can subjugate all thoughts of pleasure
And still retain a meed of self-esteem;
If you can give your few short hours of leisure
To keeping up with every modern theme;
If you donate your every waking minute
And seek your sole reward in duty done,
Yours is the Lab. And everything that's in it,
And what is more, you're welcome to it, Son.

Industrial and Engineering Chemistry: News Edition
If (p. 152)
Volume 10, Number 11, 10 June 1932

Pasteur, Louis
…I implore you, take some interest in those sacred dwellings meaningly described as *laboratories*. Ask that they may be multiplied and completed. They are the temples of the future, of riches and of comfort. There humanity grows greater, better, stronger; there she can learn to read the works of Nature works of progress and universal harmony, while humanity's own works are too often those of barbarism, of fanaticism and of destruction.

In R. Vallery-Radot
The Life of Pasteur
Chapter VI (p. 152)

Soddy, Frederick

Laboratories are necessary, and though an artist without a studio or an evangelist without a church might conceivably find under the blue dome of heaven a substitute, a scientific man without a laboratory is a misnomer.

In Bernard Jaffe
New World of Chemistry (p. 44)

Unknown

1. When you don't know what you're doing, do it neatly.
2. Experiments must be reproducible. They should fail the same way each time.
3. First draw your curves, then plot your data.
4. Experience is directly proportional to equipment ruined.
5. A record of data is essential. It shows you were working.
6. To study a subject best, understand it thoroughly before you start.
7. To do a lab really well, have your report done well in advance.
8. If you can't get the answer in the usual manner, start at the answer and derive the question.
9. If that doesn't work, start at both ends and try to find a common middle.
10. In case of doubt, make it sound convincing.
11. Do not believe in miracles—rely on them.
12. Team work is essential. It allows you to blame someone else.
13. All unmarked beakers contain fast-acting, extremely toxic poisons.
14. Any delicate and expensive piece of glassware will break before any use can be made of it.

Source unknown
Rules Of The Lab

LANGUAGE

Barthes, Roland
As far as science is concerned language is simply an instrument, which it profits it to make as transparent and neutral as possible: it is subordinate to the matter of science (workings, hypotheses, results) which, so it is said, exists outside language and precedes it. On the one hand and *first* there is the content of the scientific message, which is everything; on the other hand and *next*, the verbal form responsible for expressing that content, which is nothing.

In Michael Lane (ed.)
Structuralism: A Reader
Science versus Literature (p. 411)

Davy, Sir Humphry
In natural science there is one language universally intelligible,—the language of facts; it belongs to nature, and it is permanent as the objects of nature; it is the same to the citizen of Paris and of London.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter III (p. 148)

Lavoisier, Antoine
It is time to rid chemistry of obstacles of every kind which retard its progress and to introduce in it a true spirit of analysis; we have proved sufficiently that this reform must be brought about by perfecting the language.

In Baron Louis Bernard Guyton de Morveau
Méthode de nomenclature chimique (p. 16)

Locke, David
It is commonly said, especially by boosters of science, that its language is international and is mutually comprehensible around the world. But, of

course, the facts are otherwise... Take the names for certain of the standard chemical elements. In German these were built up from vernacular roots, in English from classical roots—thus, *Wasserstoff*, "hydrogen"; *Saauerstoff*, "oxygen." As it happens oxygen was given its name by Lavoisier (*oxygène*, roughly "acid maker") on the mistaken notion that it was an essential ingredient of acids. In English, the *oxy-* root has for all practical purposes lost any connection with acidity; it is used only to indicate the presence of oxygen. But in German the word for acid is *Säure*, and the spurious connection of oxygen, *Sauerstoff*, with acids is constantly maintained; it is as though in English one always said "acidogen" for "oxygen." German chemists, of course, are not fooled by its name into thinking that oxygen behaves differently than it does... But surely, the associations, the connotations, the idea of the kind of thing is dealing with, is different in the two cases.

Science as Writing
Chapter 3 (p. 61)

Muir, M.M. Pattison
... to write a full description of the origin, growth and misadventures of the language of chemistry is to write a history of science.

A History of Chemical Theories and Laws (p. 189)

Stoppard, Tom
If there is any point in using language at all it is that a word is taken to stand for a particular fact or idea and not for other facts or ideas.

Travesties
Act I (p. 22)

Walker, Ruth A.
Johnston, Helen
Equations are the language of the chemist.

The Language of Chemistry
Preface (p. viii)

LAW

Brouwer, L.E.J.
It is well to notice in this connection that a natural law in the statement of which measurable magnitudes occur can only be understood to hold in nature with a certain degree of approximation; indeed natural laws as a rule are not proof against sufficient refinement of the measuring tools.

Bulletin of the American Mathematical Society
Intuitionism and Formalism (p. 82)
Volume 20, November 1913

Dirac, P.A.M.
The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the application of these laws leads to equations much too complicated to be soluble.

Proceedings of the Royal Society of London
Quantum Mechanics of Many-Electron Systems (p. 714)
Volume 123, Number 792, 6 April 1929

Dumas, Jean-Baptiste
Everything must give way to the laws of Nature, and he alone who has mastered those laws can control her processes. But the mastery cannot be obtained with a struggle. The fable of Proteus is a true picture of the combat between man, eager for knowledge, and the stubborn guardian, charged with the protection of the secrets of destiny. Proteus changed himself into a thousand shapes before speaking, and yielded only to the hero who, far from being moved by his transformations, bound him with bands of ever increasing strength. Such is Nature herself, her answers are always truthful, but like the ancient shepherd of Neptune's flocks, before allowing Truth to shine forth, she arrays herself in the garments of error, or hides herself behind the phantoms of illusion, and will only assume

her proper shape under the determined assaults of a resolute disciple of Science.

In Faraday Lectures
Lectures Delivered before the Chemical Society
The First Faraday Lecture (p. 4)

Faraday, Michael
How wonderful it is to me the simplicity of nature when we rightly interpret her laws and how different the convictions which they produce on the mind in comparison with the uncertain conclusions which hypothesis or even theory present.

The Correspondence of Michael Faraday
Volume 2
Faraday to Svanberg
16 August 1850 (p. 430)

Fisher, H.A.L.
The fact of progress is written plain and large on the page of history; but progress is not a law of nature.

A History of Europe
Volume I
Preface (p. vii)

Frazer, J. George
We must remember that at bottom the generalisations of science or, in common parlance, the laws of nature are merely hypotheses devised to explain that ever-shifting phantasmagoria of thought which we dignify with the high-sounding names of the world and the universe.

The Golden Bough: A Study in Magic and Religion
Volume I, abridged edition
Chapter LXIX (p. 712)

Fuller, Buckminster
Dil, Anwar
If nature permits a formulation
It is natural.
If nature's laws of behavior
Do not permit formulation
The latter does not occur.
Whatever can be done
Is natural
No matter how grotesque, boring,
Unfamiliar, or unprecedented.
In the same way

Nature never "fails."
Nature complies with her own laws.
Nature is the law.
When man lacks understanding
Of nature's laws
And a man-contrived structure
Buckles unexpectedly,
It does not fail.
It only demonstrates that man
Did not understand
Nature's laws and behaviors.
Nothing failed.
Man's knowledge or estimating
Was inadequate.

Humans in Universe
Appendix I (p. 191)

Hawking, Stephen W.
…there are grounds for cautious optimism that we may now be near the end of the search for the ultimate laws of nature.

A Brief History of Time
Chapter 10 (p. 156)

Jevons, William Stanley
'It is the glory of God,' said Solomon, 'to conceal a thing, but the glory of a king to search it out.' The laws of nature are the invaluable secrets which God has hidden, and it is the kingly prerogative of the philosopher to search them out by industry and sagacity.

Principles of Science
Book I
Chapter VII (p. 126)

Meyerson, Émile
…we only attain laws by violating nature, by isolating more or less artificially a phenomenon from the whole, by checking those influences which would have *falsified* the observation. Thus the law cannot directly express reality. The phenomenon as it is envisaged by it, the "pure" phenomenon, is rarely observed without our intervention, and even with this it remains imperfect, disturbed by accessory phenomena…Doubtless, if nature were not ordered, if it did not present us with similar objects, capable of furnishing generalized concepts, we could not formulate laws…

Identity & Reality
Chapter I (pp. 31 & 32)

Oersted, Hans Christian
Added to this we already see numerous indications of a future, in which the chemical and mechanical laws of nature will be more intimately united.

In short, the natural laws of chemistry, as well as those of mechanics, are laws of Reason, and both are so intimately connected, that they must be viewed as a unity of Reason.

The Soul in Nature: with Supplementary Contributions
All Existence a Dominion of Reason (p. 104)

Oppenheimer, J. Robert
The scientist is not responsible for the laws of nature, but it is a scientist's job to find out how these laws operate. It is the scientist's job to find ways in which these laws can serve the human will. However, it is not the scientist's job to determine whether a hydrogen bomb should be used. This responsibility rests with the American people and their chosen representatives.

In Lewis Wolpert and Alison Richards
A Passion for Science
Chapter I (p. 9)

Unknown
Unnamed Law: If it happens, it must be possible.

Source unknown

von Helmholtz, Hermann
A law of nature, however, is not a mere logical conception that we have adopted as a kind of *memoria technicai* to enable us to more readily remember facts. We of the present day have already sufficient insight to know that the laws of nature are not things which we can evolve by any speculative method. On the contrary, we have to *discover* them in the facts; we have to test them by repeated observation or experiment, in constantly new cases, under ever-varying circumstances; and in proportion only as they hold good under a constantly increasing change of conditions, in a constantly increasing number of cases with greater delicacy in the means of observation, does our confidence in their trustworthiness rise.

Popular Lectures on Scientific Subjects
Aim and Progress of Physical Science (p. 370)

LEARN

Bryson, Lyman
No man. . . can choose to do what he never heard of doing or never thought of doing. In this sense, the ultimate measure of freedom is knowledge and we learn in order to be free.

Science and Freedom
What is Freedom
Section II (p. 13)

Dennett, Daniel
. . . we often learn more from bold mistakes than from cautious equivocation.

Consciousness Explained
Preface (p. xi)

Garrett, A.B.
Learning is motivated by *intent* and understanding by *visualization*.

Journal of Chemical Education
Vizualization: A Step to Understanding (p. 544)
Volume 25, Number 10, October 1948

Hemingway, Ernest
There are some things which cannot be learned quickly, and time, which is all we have, must be paid heavily for their acquiring. They are the very simplest things. . .

Death in the Afternoon
Chapter 16 (p. 192)

Hoffmann, Banesh
If you have read thus far, there is no dignified way of escape left to you. You have paid your fare, and climbed to the highest peak of the roller-coaster. You have therefore let yourself in for the inevitable consequences. It is no use trying to back out. You had warning in the preface of what

to expect, and if contemplation of the heights there described makes you giddy and apprehensive, I cannot accept responsibility. The going will be rough, but I can promise you excitement aplenty. So hold tight to your seat and hope for the best. We are about to push off into vertiginous space.

The Strange Story of the Quantum
A Warning to the Reader (p. 70)

Pythagoras
The learning of many things does not teach intelligence…

In G.S Kirk and J.E. Raven
The Presocratic Philosophers
Fragment 260 (p. 218)

Russell, Bertrand
William James used to preach the "will to believe." For my part, I should wish to preach the "will to doubt."…What is wanted is not the will to believe, but the wish to find out, which is the exact opposite.

Sceptical Essays
Chapter XII (pp. 154, 157)

Shakespeare, William
…and children
Have lost, or do not learn for want of time,
The sciences that should become our country…

The Life of King Henry Fifth
Act V, Scene ii, L. 56–8

Wheeler, John Archibald
…how can anyone learn anything new who does not find it a shock.

A Journey into Gravity and Spacetime
Chapter 3 (p. 39)

LIFE

Czapek, Frederick
Life is, therefore, quite inseparable from chemical reactions, and on the whole what we call life is nothing else but a complex of innumerable chemical reactions in the living substance which we call protoplasm.

Chemical Phenomena in Life
Chapter VI (p. 63)

Oparin, A.I.
Life—the word is so easy to understand yet so enigmatic for any thoughtful person.

Life: Its Nature, Origin, and Development
Chapter I (p. 1)

LITERATURE

Horton, P.G.
The literature,
The chemical literature,—
When in doubt look it up in the literature.
Every question man can raise, every phrase of every phase of that question is on record in the literature;
Thrashed out threadbare pro and con
In the literature.
Did the universe at large once carry a positive charge?
Why aren't holes in macaroni square?
From Avogadro's number to the analysis of cucumber, if you're interested you'll find it, for it's there
In the literature.
In *Journal* this or *zeitschrift* that, *Comptes rendus* or *Zentralblatt*,
In the literature.

Industrial and Chemical Engineering Chemistry: News Edition
The Chemical Literature (p. 336)
Volume 11, Number 22, 20 November 1933

Tyndall, John
It has been said that science divorces itself from literature. The statement, like so many others, arises from a lack of knowledge. A glance at the less technical writings of its leaders—of its Helmholtz, its Huxley, and its Du Bois-Reymond—would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigor of literary style? Science desires no isolation, but freely combines with every effort toward the bettering of man's estate. Single-handed and supported not with outward sympathy, but with inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands…The world embraces not only a Newton, but a Shakespeare; not only a Boyle, but a Raphael; not only a Kant, but a Beethoven; not only a Darwin, but a Carlyle. Not in each

of these, but in all, is human nature whole. They are not opposed, but supplementary; not mutually exclusive, but reconcilable.

Address
Delivered before the British Association assembled at Belfast, 1874

LITTLE WILLIE

Unknown
Little Willie, good as pie,
Fed the cat on alkali.
Now the process, with yields first-rate,
Produces potassium pussiate.

Little Willie, hard as rocks,
Put fulminate in Daddy's socks.
Now Daddy really wants to know
How long it takes to grow a toe.

Little Willie, tried and true,
Fed his sis on methylene blue.
Now Sister has a perplexed look
Whene'er she sees a babbling brook.

Little Willie, happy and free,
Took a breath of H_3P.
Now Willie belches rings of smoke,
And thinks it's quite a parlor joke.

Little Willie, calm and placid,
Boiled his ma in nitric acid.
Now Mother dear is just a plastic,
Transparent, clear; but non-elastic.

Little Willie, full of glee,
Put radium in Grandma's tea.
Now Grandpa thinks it a lark
To see her glowing in the dark.

Little Willie, I hate to tell,
Soaked his dad in HCl.
Now the chemist at his sink
Wonders what made all the stink.

Little Willie, so and so,
Put H_2S in our H_2O.
Now this was not so bad at all,
For we drink naught but alcohol.

We had a little Willy,
Now Willy is no more,
For what he thought was H_2O
Was H_2SO_4

Source unknown

Little Willie from his mirror
Licked the mercury right off,
Thinking, in his childish error,
It would cure the whooping cough.

At the funeral his mother
Brightly said to Mrs Brown:
Twas a chilly day for Willie
When the mercury went down!

In Arnold Silcock
Verse and Worse
Little Willie (pp. 240–1)

MAGIC

Porta, John Baptista
There are two sorts of Magick: the one is infamous, and unhappie, because it hath to do with foul spirits, and consists of Inchantments and wicked Curiosity; and this is called Sorcery; an art which all learned and good men detest; neither is it able to yield any truth of Reason or Nature, but stands merely upon fancies and imaginations, such as vanish presently away and leave nothing behind them…The other Magick is natural; which all excellent wise men do admit and embrace, and worship with great applause; neither is there anything more highly esteemed, or better thought of by men of learning…I think that Magick is nothing else but the survey of the whole course of Nature.

Natural Magick
The First Book of Natural Magick
Chapter II (pp. 1–2)

MATHEMATICS

Bloor, David
. . . mathematics like morality is designed to meet the requirements of men, who hold a great deal in common in their physiology and in their physical environment.

Knowledge and Social Imagery
Chapter 6 (p. 97)

Bruner, Jerome Seymour
If we are not to live in embarrassed dread in the century ahead, we will have to understand the mathematical ideas that lie behind the scientific advances that are shaping the modern world.

Arithmetic Teacher
In Kenneth J. Travers
Through Clouds of Failure Into Orbit (p. 591)
Volume 15, Number 7, November 1968

Crick, Francis Harry Compton
Mathematics cares neither for science nor for engineering (except as a source of problems) but only about the relationship between abstract entities.

What Mad Pursuit
Epilogue: My Later Years (p. 160)

Davies, Paul
The belief that the underlying order of the world can be expressed in mathematical form lies at the very heart of science. So deep does this belief run that a branch of science is considered not to be properly understood until it can be cast in mathematics.

The Mind of God
Chapter 6 (p. 140)

Frankland, A.
. . . I am convinced that the future progress of chemistry as an exact science depends very much upon the alliance with mathematics. . .

American Journal of Mathematics
Extract of a Letter of Dr Frankland to Mr Sylvester (p. 349)
Volume 1, Number 4, 1878

Klein, F.
The ordinary mathematical treatment of any applied science substitutes exact axioms for the approximate results of experience, and deduces from these axioms the rigid mathematical conclusions. In applying this method it must not be forgotten that the mathematical developments transcending the limits of exactness of the science are of no practical value. It follows that a large portion of abstract mathematics remains without finding any practical application, the amount of mathematics that can be usefully employed in any science being in proportion to the degree of accuracy attained in the science. Thus, while the astronomer can put to use a wide range of mathematical theory, the chemist is only just beginning to apply the first derivative, i.e. the rate of change at which certain processes are going on; for second derivatives he does not seem to have found any use as yet.

Lectures on Mathematics
Lecture VI (p. 47)

MATTER

Bicknell, Alexander
So when we view a castle-wall
Rent by a ponderous cannon ball,
We must conclude from your new rules
(Our reas'ning fathers being fools),
That 'tis not solid brick or stone
Which solid iron has o'erthrown;
But that a Nothing did attract,
And had not strength to counteract,
By its repulsive force the thing,
(The *Thing* your pardon Sir, the *Nothing*).

The Putrid Soul. A poetical epistle to Joseph Priestley on his Disquisitions Relating to Matter and Spirit (pp. 8–10)

Bohm, David
Matter is like a small ripple on this tremendous ocean of energy, having some relative stability and being manifest.

In René Weber
Dialogues with Scientists and Sages
The Implicate Order and the Super-Implicate Order (p. 28)

Čapek, Milič
This concept [matter] has hardly changed from the times of Leucippus to the beginning of the twentieth century: an impenetrable *something*, which fills completely certain regions of space and which persists through time even when it changes its location.

The Philosophical Impact of Contemporary Physics (p. 54)

Cornforth, John W.
. . . the business of chemists is matter. . .

Australian Journal of Chemistry
Scientists as Citizens (p. 268)
Volume 46, 1993

Dyson, Freeman J.
We have learned that matter is weird stuff. It is weird enough, so that it does not limit God's freedom to make it do what he pleases.

Infinite in All Directions
Chapter 1 (p. 8)

Einstein, Albert
Living matter and clarity are opposites—they run away from one another.

In Max Born
The Born–Einstein Letters
Letter to Mrs Born
15 January 1927 (p. 95)

Frost, Robert
It was in a state
Matter was begun—
And in fact complete,
One and yet discrete
To conflict and pair.
Everything was there,
Every single thing
Waiting was to bring,
Clear from hydrogen
All the way to men.

The Poetry of Robert Frost
A Never Naught Song, L. 8–16

Heaviside, Oliver
Even if we resolve all matter into one kind, that kind will need explaining, and so on for ever and ever deeper and deeper into the pit at whose bottom truth lies, without ever reaching it, for the pit is bottomless.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 10 (p. 133)

Herbert, Nick
The world is one substance. As satisfying as this discovery may be to philosophers, it is profoundly distressing to physicists as long as they do not understand the nature of that substance. For if quantumstuff is all there is and you don't understand quantumstuff, your ignorance is complete.

Quantum Reality
Chapter 3 (p. 40)

Kant, Immanuel
Give me matter and I will construct a world out of it!

In W. Hastie (ed.)
Kant's Cosmogony
Preface (p. 29)

Kline, Morris
…where is the good, old-fashioned, solid matter that obeys precise, compelling mathematical laws? The stone that Dr Johnson once kicked to demonstrate the reality of matter has become dissipated in a diffuse distribution of mathematical probabilities.

Mathematics in Western Culture
Chapter XXIV (p. 382)

Levi, Primo
…conquering matter is to understand it, and understanding matter is necessary to understanding the universe and ourselves: and that therefore Mendeléev's Periodic Table, which just during those weeks we were learning to unravel, was poetry…

The Periodic Table
Iron (p. 41)

Newton, Sir Isaac
The quantity of matter is the measure of the same, arising from its density and bulk conjointly.

Mathematical Principles of Natural Philosophy
Definitions, Definition I (p. 5)

…it seems probable to me that God in the beginning formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them; and that these primitive particles being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break in pieces; no ordinary power being able to divide what God himself made one in the first creation.

Opticks
Book II, Part I (very near the end)

Poe, Edgar Allan
…matter *exists* only as attraction and repulsion—that attraction and repulsion *are* matter.

Eureka: A Prose Poem
L. 28 (p. 37)

Rorty, Richard
[When] we tell our Whiggish stories about how our ancestors gradually crawled up the mountain on whose (possibly false) summit we stand, we need to keep some things constant throughout the story. The forces of nature and the small bits of matter, as conceived by current physical theory, are good choices for this role.

Philosophy and the Mirror of Nature
Chapter VII (p. 344)

Russell, Bertrand
"Matter" is a convenient formula for describing what happens where it isn't.

An Outline of Philosophy
Chapter XV (p. 165)

Shakespeare, William
What stuff 'tis made of, whereof it is born,
I am to learn.

The Merchant of Venice
Act I, Scene 1, L. 4–5

Shelley, Percy Bysshe
I change but I cannot die.

The Complete Poetical Works of Shelley
The Cloud
l. 76

Tait, Peter
Only sheer ignorance could assert that there is any limit to the amount of information which human beings may in time acquire of the constitution of matter. However far we may manage to go, there will still appear before us something further to be assailed. The small separate particles of a gas are each, no doubt less complex in structure than the whole visible universe, but the comparison is a comparison of two infinities.

Lectures on Some Recent Advances in Physical Science
Lecture XII (pp. 288–9)

Teilhard De Chardin, Pierre
We do not get what we call matter as a result of the simple aggregation and juxtaposition of atoms. For that, a mysterious identity must absorb and cement them, an influence at which our mind rebels in bewilderment at first, but which in the end must perforce accept.

The Phenomenon of Man
Chapter I
Section B (p. 42)

Thomson, J.J.
From the point of view of the physicist, a theory of matter is a policy rather than a creed; its object is to connect or co-ordinate apparently diverse phenomena, and above all to suggest, stimulate and direct experiment. It ought to furnish a compass which, if followed, will lead the observer further and further into previously unexplored regions.

The Corpuscular Theory of Matter
Chapter I (p. 1)

Walker, Kenneth
Science is the product of the intellect and its language is the language of matter.

Meaning and Purpose
Chapter IX (p. 89)

Whitehead, Alfred North
Thus, to a really learned man, matter exists in test tubes, animals in cages, art in museums, religion in churches, knowledge in libraries.

Essays in Science and Philosophy
Part III
Harvard: The Future
Section IV (p. 215)

MEASUREMENT

Born, Max

…nobody will object to an ardent experimentalist boasting of his measurements and rather looking down on the "paper and ink" physics of his theoretical friend, who on his part is proud of his lofty ideas and despises the dirty fingers of the other.

Experiment and Theory in Physics (p. 1)

The problem of physics is how the actual phenomena, as observed with the help of our sense organs aided by instruments, can be reduced to simple notions which are suited for precise measurement and used for the formulation of quantitative laws.

Experiment and Theory in Physics (pp. 8–9)

Gibran, Kahlil

If it were not for our conception of weights and measures we would stand in awe of the firefly as we do before the sun.

Sand and Foam (p. 52)

Hales, Stephen

…we are assured that the all-wise Creator has observed the most exact proportions, of *number, weight and measure*, in the make of all things; the most likely way therefore, to get any insight into the nature of those parts of the creation, which come within our observation, must in all reason be to number, weigh and measure.

Vegetable Staticks
The Introduction (p. xxxi)

Kelvin, Lord

Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards

of accurate measurement and patient long contained labour in the minute sifting of numerical results.

Report of the British Association for the Advancement of Science
Volume 41, xci, 1871

Lewis, Gilbert N.
I have no patience with attempts to identify science with measurement, which is but one of its tools, or with any definition of the scientist which would exclude a Darwin, a Pasteur, or a Kekulé.

The Anatomy of Science
Chapter I (p. 6)

Russell, Bertrand
. . . measurement demands some one–one relation between the numbers and magnitudes in question—a relation which may be direct or indirect, important or trivial, according to circumstances.

The Principles of Mathematics
Chapter XXI (p. 176)

Singer, Charles
Galileo showed men of science that weighing and measuring are worthwhile. Newton convinced a large proportion of them that weighing and measuring are the only investigations that are worthwhile.

A Short History of Medicine
Chapter V, Section 1 (p. 138)

Standen, Anthony
If the idols of scientists were piled on top of one another in the manner of a totem pole the topmost would be a grinning fetish called Measurement.

Science is a Sacred Cow
Chapter III (p. 82)

Weaver, Warren
With the extremely small or the extremely large, with inconceivably brief or extended phenomena, science has a difficult time. It is by no means clear that our present concepts or even our existing language is suitable for these ranges.

Science and Imagination
Chapter 2 (p. 50)

Whitehead, Alfred North
Search for measurable elements among your phenomena, and then search for relations between these measures of physical quantities.

Science and the Modern World
Chapter III (p. 66)

MECHANICS

Einstein, Albert
Just now I am teaching the foundations of poor deceased mechanics, which is so beautiful. What will her successor look like? With that question I torment myself incessantly.

In Keith Hannabuss
An Introduction to Quantum Theory
Letter to Heinrich Zangger
14 November 1911 (p. 246)

Jevons, William Stanley
The principles of mechanics. . . seem comparatively simple and obvious as explained to us in books of instruction. But the early philosophers did not possess such books; they had only the Book of Nature in which is set forth, not the laws, but the results of the laws, and it was only after the most patient and skilful investigation, and after hundreds of mistakes, that those laws were ascertained.

Lessons in Logic (p. 204)

von Helmholtz, Hermann
. . . the ultimate aim of physical science must be to demonstrate the movements which are the real causes of all other phenomena and discover the motive powers on which they all depend; in other words, to merge itself into mechanics.

Popular Lectures on Scientific Subjects
The Aim and Progress of Physical Science (p. 375)

METAL

Daniel 2:32–3
This image's head was of fine gold, his breast and his arms of silver, his belly and his thighs of brass,
His legs of iron, his feet part of iron and part of clay.

The Bible

Daniel 5:4
They drank wine, and praised the gods of gold, and of silver, of brass, of iron, of wood, and of stone.

The Bible

Flaubert, Gustauv
Bronze. Metal of the classic centuries.

Dictionary of Ideas

Henry, William
The metals are not presented immediately to the hand of man, like the objects of the animal and vegetable kingdoms, but, they are, for the most part, buried in darkness, in the bowels of the earth, where they are so much disguised, by combination and mixture with other substances, that they often appear entirely unlike themselves.

The Elements of Experimental Chemistry
Volume II
Notes (p. 389)

Isaiah 60:17
For brass I will bring gold, and for iron I will bring silver, and for wood brass, and for stones iron…

The Bible

Numbers 31:22–3
Only the gold, and the silver, the brass, the iron, the tin, and the lead,
Every thing that may abide the fire, ye shall make it go through the fire…

The Bible

METAPHOR

Davy, Sir Humphry
…the tropes and metaphors of the speaker were like the brilliant wild flowers in a field of corn, very pretty, but which did very much hurt to the corn.

The Collected Works of Sir Humphry Davy
Volume IX
Consolations in Travel
Dialogue V (p. 366)

Harré, Rom
Metaphor and simile are the characteristic tropes of scientific thought, not formal validity of argument.

Varieties of Realism
Part I (p. 7)

McLuhan, Marshall
McLuhan, Eric
…all words are metaphor…

The Laws of Media: The New Science
Chapter 3 (p. 120)

METAPHYSICS

von Mises, Richard
There is no field that will *always* remain the special province of metaphysics and into which scientific research can never carry any light; there are no "eternally unexplorable" areas.

Positivism: A Study in Human Understanding
Chapter 21 (p. 273)

METHOD

Bernard, Claude
. . . good methods can teach us to develop and use to better purpose the faculties with which nature has endowed us, while poor methods may prevent us from turning them to good account. Thus the genius of inventiveness, so precious in the sciences, may be diminished or even smothered by a poor method, while a good method may increase and develop it.

An Introduction to the Study of Experimental Medicine
Part I, Chapter II, Section II (p. 35)

Bridgman, P.W.
The scientific method, as far as it is a method, is nothing more than doing one's damnedest with one's mind, no holds barred.

Reflections of a Physicist
Chapter 21 (p. 351)

Carroll, Lewis
The method employed I would gladly explain,
While I have it so clear in my head,
If I had but the time and you had but the brain—
But much yet remains to be said.

The Complete Writings of Lewis Carroll
The Hunting of the Snark
Fit the Fifth
The Beaver's Lesson

Egler, Frank E.
I would sooner trust a good mind without a method, than a good method without a mind.

The Way of Science
Methodology of Science (p. 36)

Gay-Lussac
We are convinced that exactitude in experiments is less the outcome of faithful observation of the divisions of an instrument than of exactitude of method.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 3 (p. 70)

Hertz, Heinrich
For the moment, I am blundering without precise method. I repeat old experiments in this field and demonstrate others which pass through my head…I hope that, among the hundred remarkable phenomena which I come across, some light will shine from one or another.

In René Taton
Reason and Chance in Scientific Discovery
Chapter III (p. 41)

Lonergan, Bernard J.F.
It is in the measure that special methods acknowledge their common core in transcendental method, that norms common to all the sciences will be acknowledged, that a secure basis will be attained for tackling interdisciplinary problems, and that the sciences will be mobilized within a higher unity of vocabulary, thought and orientation, in which they will be able to make their quite significant contribution to the solution of fundamental problems.

Method in Theology
Chapter 1 (p. 23)

Maxwell, James Clerk
Nature is a journal of science, and one of the severest tests of a scientific mind is to discern the limits of the legitimate application of scientific methods.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Paradoxical Philosophy (p. 759)

Medawar, Peter
Ask a scientist what he conceives the scientific method to be, and he will adopt an expression that is at once solemn and shifty-eyed: solemn, because he feels he ought to declare an opinion; shifty-eyed because he is wondering how to conceal the fact that he has no opinion to declare.

Pluto's Republic
Induction and Intuition in Scientific Thought (p. 80)

Russell, Bertrand
Whatever knowledge is attainable, must be attained by scientific methods; and what science cannot discover, mankind cannot know.

Religion and Science
Science and Ethics (p. 243)

Sagan, Carl
The method of science, as stodgy and grumpy as it may seem, is far more important than the findings of science.

The Demon-Haunted World
Chapter 1 (p. 22)

Sullivan, J.W.N.
To judge from the history of science, the scientific method is excellent as a means of obtaining plausible conclusions which are always wrong, but hardly as a means of reaching the truth.

The Athenaeum
The Justification of the Scientific Method (p. 275)
Number 4644, 2 May 1919

Walker, Kenneth
To understand the true function of science and to be able to evaluate its theories it will first be necessary to have a very clear idea of the method by which it works.

Meaning and Purpose
Chapter II (p. 16)

Wilson, E. Bright
A method is a dangerous thing unless its underlying philosophy is understood, and none more dangerous than the statistical. Our aim should be, with care, to avoid in the main erroneous conclusions. In a mathematical or strictly logical discipline the care is one of technique; but in a natural science and in statistics the care must extend not only over the technique but to the matter of judgment, as is necessarily the case in coming to conclusions upon any problem of real life where the complications are great. Over-attention to technique may actually blind one to the dangers that lurk about on every side—like the gambler who ruins himself with his system carefully elaborated to beat the game. In the long run it is only clear thinking, experienced feelings and a patient poise, not automatic systems and methods, that win the strongholds of science…

Science
The Statistical Significance of Experimental Data (p. 94)
Volume 58, Number 1493, 10 August 1923

MICROSCOPE

Lichtenberg, Georg Christoph
Microscopes should be invented for every kind of investigation and, where that is impossible, experiments should be conducted on a large scale. This is the only direct road to new discovery.

In J.P. Stern
Lichtenberg: A Doctrine of Scattered Occasions
Further Excerpts from Lichtenberg's Notebooks (p. 294)

MODEL

Ball, John
To make progress in understanding all this, we probably need to begin with simplified (oversimplified?) models and ignore the critics' tirade that the real world is more complex. The real world is *always* more complex, which has the advantage that we shan't run out of work.

Ethology and Sociobiology
Memes as Replicators
Volume 5, Number 3, 1984 (p. 159)

Chargaff, Erwin
Models—in contrast to those who sat for Renoir—improve with age.

Heraclitean Fire
Part III
Science as an Obsession (p. 171)

Deutsch, K.
Men think in terms of models.

Philosophy of Science
Mechanism, Organism and Society
Volume 18, Number 3, July 1951 (p. 230)

Eddington, Sir Arthur Stanley
Our model of nature should not be like a building—a handsome structure for the populace to admire, until in the course of time someone takes away a corner-stone and the edifice comes toppling down. It should be like an engine with movable parts. We need not fix the position of any one lever—that is to be adjusted from time to time as the latest observations indicate. The aim of the theorist is to know the train of wheels which the lever sets in motion—that binding of the parts which is the soul of the engine.

Observatory
The Internal Constitution of the Stars (p. 357)
Volume 43, 1920

Morrison, Foster
Much of the technical literature is difficult to read, even for scientists and engineers. Even the best books tend to dwell on the mathematical models and don't give the slightest hint what to do if one is lucky enough to have some data.

The Art of Modeling Dynamic Systems: Forecasting for Chaos, Randomness, & Determinism
Preface (p. vii)

Poynting, John Henry
...while the building of Nature is growing spontaneously from within, the model of it, which we seek to construct in our descriptive science, can only be constructed by means of scaffolding from without, a scaffolding of hypotheses. While in the real building all is continuous, in our model there are detached parts which must be connected with the rest by temporary ladders and passages, or which must be supported till we can see how to fill in the understructure. To give the hypotheses equal validity with facts is to confuse the temporary scaffolding with the building itself.

Collected Scientific Papers
Part VII
Article 52 (p. 607)

Walker, Marshall
Scientists have learned by humiliating experience that their model is not reality.

The Nature of Scientific Thought
Chapter XIV (p. 158)

MOLECULE

Aldersey-Williams, Hugh
A molecule is a messy thing. It has a gangling skeleton whose bones are chemical bonds and whose joints are its component atoms.

The Most Beautiful Molecule
Chapter 1 (p. 11)

Barrow, Gordon M.
The chemist must learn to live in, and to feel at home in, the world of molecules. It is not enough that he knows the chemical constitution and chemical reactions of the materials around him. To be really effective and successful, he must also develop an intimacy with the molecular world. He must fit himself into the molecular scale of things. He must put that first drummed-in chemical fact that molecules are small in the very back of his mind and replace it by a consciousness that molecules are real, intricate, structural arrangements of atoms in space.

The Structure of Molecules
Introduction (p. 1)

Bierce, Ambrose
MOLECULE, n. The ultimate, indivisible unit of matter. It is distinguished from the corpuscle, also the ultimate, indivisible unit of matter, by a closer resemblance to the atom, also the ultimate, indivisible unit of matter…

The Devil's Dictionary

Crick, Francis Harry Compton
Almost all aspects of life are engineered at the molecular level, and without understanding molecules we can only have a very sketchy understanding of life itself.

What Mad Pursuit
Chapter 5 (p. 61)

Dawkins, Richard

[Molecules of living things] are put together in much more complicated patterns than the molecules of nonliving things, and this putting together is done following programs, sets of instructions for how to develop, which the organisms carry around inside themselves. Maybe they do vibrate and throb and pulsate with 'irritability', and glow with 'living' warmth, but these properties all emerge incidentally. What lies at the heart of every living thing is not a fire, not warm breath, not a 'spark of life'. It is information, words, instructions. If you want a metaphor, don't think of fire and sparks and breath. Think, instead, of a billion discrete, digital characters carved in tablets of crystal. If you want to understand life, don't think about vibrant, throbbing gels and oozes, think about information technology.

The Blind Watchmaker
Chapter 5 (p. 112)

Hoffmann, Roald

It's a wild dance floor there at the molecular level.

In Philip Ball
Designing the Molecular World (p. 83)

Men (and women) are not as different from molecules as they think.

The Metamict State
Men and Molecules (p. 43)

Kropotkin, Peter

The molecule becomes a particle of the universe on a microscopic scale—a microcosmos which lives the same life.

Nineteenth Century
Recent Science (p. 252)
Volume 34, August 1893

Maxwell, James Clerk

As long as we have to deal with only two molecules, and have all the data given us, we can calculate the result of their encounter; but when we have to deal with millions of molecules, each of which has millions of encounters in a second, the complexity of the problem seems to shut out all hope of a legitimate solution.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Molecules (p. 373)

[Molecular science is] one of those branches of study which deal with things invisible and imperceptible by our senses, and which cannot be subjected to direct experiment.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Molecules (p. 361)

…molecular science teaches us that our experiments can never give us anything more than statistical information, and that no law deduced from them can pretend to absolute precision. But when we pass from the contemplation of our experiments to that of the molecules themselves, we leave the world of chance and change, and enter a region where everything is certain and immutable.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
Molecules (p. 374)

Montague, James J.
Though men may boast of brain or brawn
And maids of soft attractions,
Such qualities depend upon
Their chemical reactions.
When Daniel, placid and serene,
Defied a den of lions,
He owed his calm, unflinching mien
To molecules and ions.

Industrial and Engineering Chemistry: News Edition
What's the Use of Worrying? (p. 257)
Volume 10, Number 20, 20 October 1932

Morrison, Jim
Love hides in molecular structures.

Absolutely Live
Love Hides
Sung by The Doors
July 1969

Newman, Joseph S.
Quite recently… to be exact,
Within a billion years, in fact…
Some time before the glacial drift
Had given the planet's face a lift,
A group of shameless molecules

Broke all the inorganic rules
And (C.I.O. epitomized!)
Spontaneously organized.

Poems for Penguins
Biology

There's none to say how carbon first
Conceived its ocy-hydric thirst—
How nitrogen, in right proportion,
And sulphur joined the strange consortion—
But close upon the tenuous verge
Where shadows end, does life emerge,
And from these elemental five
Sprang proteid molecules alive!

Poems for Penguins
Biochemistry

Weinberg, Robert A.
Can—and should—life be described in terms of molecules? For many, such description seems to diminish the beauty of Nature. For others of us, the wonder and beauty of nature are nowhere more manifest than in the submicroscopic plan of life…

Scientific American
The Molecules of Life (p. 57)
Volume 253, Number 4, October 1985

Weiss, Paul
…there is no phenomenon in a living system that is *not* molecular, but there is none that is *only* molecular, either.

Within the Gates of Science and Beyond
The Living System: Determinism Stratified (p. 270)

MOTION

Steele, Joel Dorman
Rest is nowhere. The winds that come and go, the ocean that uneasily throbs along the shore, the earth that revolves about the sun, the light that darts through space—all tell of a universal law of Nature. The solidest body hides within it inconceivable velocities. Even the molecules of garnet and iron have their orbits as do the stars, and move as ceaselessly.

Popular Physics
Chapter II (p. 19)

Thomson, Thomas
Substances may either be examined in a state of rest, or as acting upon each other and producing changes on each other. The knowledge derived from the first of these views, is called *Natural History*; that which we obtain by the second, is distinguished by the name Science. But bodies cannot act upon each other without producing motion, and the motions produced by such actions are of two kinds; either so great as to be visible to our senses, and capable of being measured by the space passed over; or so small as not to be distinguishable by our senses, except by the effects produced. The phenomena connected with the first of these kinds of motions constitute what is called *Natural Philosophy* or *Mechanical Philosophy* in this country, and on the Continent, *Physics*. The phenomena connected with the imperceptible motions belong to the science called *Chemistry*.

History of the Royal Society from its Institution to the End of the Eighteenth Century
Book III (p. 311)

MYSTERY

Burroughs, John
. . . after science has done its best the mystery is as great as ever, and the imagination and the emotions have just as free a field as before.

Indoor Studies
Science and Literature (pp. 51–2)

Einstein, Albert
The most beautiful experience we can have is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science. Whoever does not know it and can no longer wonder, no longer marvel, is as good as dead, and his eyes are dimmed.

Ideas and Opinions
The World As I See It (p. 11)

Feynman, Richard
With more knowledge comes a deeper, more wonderful mystery, luring one on to penetrate deeper still. Never concerned that the answer may prove disappointing, with pleasure and confidence we turn over each new stone to find unimagined strangeness leading on to more wonderful questions and mysteries—certainly a grand adventure.

What do You Care What Other People Think?
Epilogue
The Value of Science (p. 243)

Margenau, Henry
I recognize no subjects and no facts which are alleged to be forever closed to inquiry or understanding: a mystery is but a challenge.

Open Vistas
Chapter III
Section 3 (p. 76)

Unknown
"Give me the facts," said My Lord Judge, "thy conclusions are but the guess-work of imagination; which puzzle the brain, and tend not to solve this mystery".

In Colin Mackenzie
One Thousand Experiments in Chemistry
On cover page

NAÏVETE

Harish-Chandra
I have often pondered over the roles of knowledge or experience, on the one hand, and imagination or intuition, on the other, in the process of discovery. I believe that there is a certain fundamental conflict between the two, and knowledge, by advocating caution, tends to inhibit the flight of imagination. Therefore, a certain naïvete, unburdened by conventional wisdom, can sometimes be a positive asset.

Biographical Memoirs of Fellows of the Royal Society
In R. Langlands
Harish-Chandra (p. 206)
Volume 31, 1985

NAME

Carroll, Lewis
"My *name* is Alice…"
"It's a stupid name enough!" Humpty Dumpty interrupted impatiently. "What does it mean?"
"*Must* a name mean something?" Alice asked doubtfully.
"Of course it must," Humpty Dumpty said with a short laugh; "*my* name means the shape I am…With a name like yours, you might be any shape, almost."

Alice's Adventure in Wonderland and Through the Looking-Glass
Through the Looking-Glass
Humpty Dumpty (pp. 82–3)

Doyle, Sir Arthur Conan
Man, it's Witchcraft! Where in the name of all that is wonderful did you get those names?

The Valley of Fear
Part I, Chapter I (pp. 26–7)

Le Fèvre, Nicaise
This Principle, as well as the others, hath received several names; for it is called Oil, Natural Fire, Light, Vital Fire, Balsom of Life and of Sulphur, and besides, many other appellations have been given by the Sons of Art, which we will not fill up this Section: According to our usual custom, we will content our selves, with examining the nature of the thing, leaving the niceties of Names to the over-curious.

A Compleat Body of Chymistry
Part I
Chapter III, Section IV (p. 25

Unknown
2,6-Dichlorotolerate
Ethyl decapitate

Copper keystoneate
Polyvinvyl fluortile
Appropriatic acid
Hydrofurious acid
Tetraphallic myriskit acid
Arsenic hydroxyexterminate
Isosliptic triptoepain
Tetrabromoseltzer
p-natalsuccinate
Ultrasonic lactone
2,4-sixonote-hoodoo we appreciate
o-pedic methoxysuicide
Vinylasbestos fluoride
Formyl invitation amide
1,2,3-trimethyl tricycle

Chemtech
What's In A Name? (p. 608)
Volume 8, Number 10, October 1978

NATURE

Chargaff, Erwin
We manipulate nature as if we were stuffing an Alsatian goose. We create new forms of energy; we make new elements; we kill crops; we wash brains. I can hear them in the dark sharpening their lasers.

Columbia Forum
The Paradox of Biochemistry (p. 18)
Volume XII, Number 2, Summer 1969

Davy, Sir Humphry
Oh, most magnificent and noble Nature!
Have I not worshipped thee with such a love
As never a mortal man before displayed?
Adored thee in thy majesty of visible creation,
And searched into thy hidden and mysterious ways
As Poet, as Philosopher, as Sage?

In J. Davy
Fragmentary Remains (p. 14)

Dumas, Jean-Baptiste
In the study of Nature conjecture must be entirely put aside, and vague hypothesis carefully guarded against. The study of Nature begins with facts, ascends to laws, and raises itself, as far as the limits of man's intellect will permit, to the knowledge of causes, by the threefold means of observation, experiment and logical deduction.

In Faraday Lectures
Lectures Delivered before the Chemical Society
The First Faraday Lecture (p. 2)

Irwin, Keith Gordon
It is nature, of course, that is the great chemist. Every growing plant is a marvelous chemical factory, every living thing a brilliant shifter of atoms from one bewildering compound to another. And down in the depths

of the earth enormous forces operate to create the minerals that someday may be close to the earth's surface.

The Romance of Chemistry
Foreword (p. xi)

Kant, Immanuel
. . . in every doctrine of nature only so much science proper is to be found as there is a priori cognition in it, a doctrine of nature will contain only so much science proper as there is applied mathematics in it.

Metaphysical Foundations of Natural Science
Preface (p. 7)

Manning, Richard
Now I take this thought as necessary to humble our science, to understand that everything we know was taught us by nature, but nature gave us brains evolved to their niche, so they are limited in their understanding. All that we know we have learned from nature, but we do not know all that nature knows.

Grassland
Chapter 12 (p. 263)

Morrison, A. Cressy
Although nature, the great chemist, has provided man with the prototypes and methods by which he has attempted, with considerable success, to conquer his environment, her motives and objectives have seldom been man's. The beautiful silks with which man bedecks himself and his womankind,. . . were created for far different purposes than those to which man has put them.

Man in a Chemical World
Chapter 2 (p. 13)

Priestley, Joseph
I view with rapture the glorious face of nature, and I admire its wonderful constitution, the laws of which are daily unfolding themselves to our view.

In F.W. Gibbs
Joseph Priestley: Adventurer in Science and Champion of Truth
Chapter 10 (p. 168)

Richet, Charles
Nature guards her secrets jealously; it is necessary to lay violent siege to her for a long time to discover a single one of them, however small it be.

The Savant
Chapter XIII (p. 149)

Schachtel, Ernest
…nature is to man whatever name he wants to give her. He will perceive nature according to the names he gives to her, according to the relation and perspective he chooses.

Metamorphosis
Chapter 8 (p. 202)

Steele, Joel Dorman
In Nature all is common, and no use is base. She keeps no selected elements done up in gilt papers for sensitive people.

A Fourteen Weeks Course in Chemistry
Conclusion (p. 223)

Weyl, Hermann
Allow me to express now, and for all, my deep respect for the work of the experimenter and his fight to wring significant facts from an inflexible Nature, who says so distinctly "No" and so indistinctly "Yes" to our theories.

The Theory of Groups and Quantum Mechanics
Introduction (p. xx)

Whitehead, Alfred North
…nature gets credit which in truth should be reserved for ourselves: the rose for its scent: the nightingale for his song: and the sun for his radiance. The poets are entirely mistaken. They should address their lyrics to themselves, and should turn them into odes of self-congratulation on the excellence of the human mind. Nature is a dull affair, soundless, scentless, colorless; merely the hurrying of material, endlessly, meaninglessly.

Science and the Modern World
Chapter III (p. 80)

NOMENCLATURE

Lavoisier, Antoine
The impossibility of separating the nomenclature of a science from the science itself is owing to this, that every branch of physical science must consist of three things: the series of facts which are the objects of the science, the ideas which represent these facts, and the words by which these ideas are expressed. Like three impressions of the same seal, the word ought to produce the idea, and the idea to be a picture of the fact. And, as ideas are preserved and communicated by means of words, it necessarily follows that we cannot improve the language of any science without at the same time improving the science itself; neither can we, on the other hand, improve a science without improving the language or nomenclature which belongs to it.

Elements of Chemistry
Preface (p. 1)

NOTATION

Brough, J.C.
Though Frankland's notation commands admiration,
As something exceedingly clever,
And Mr Kay Shuttleworth praises its subtle worth,
I give it up sadly for ever:
Its brackets and braces, and dashes and spaces,
And letters decreased and augmented
Are grimly suggestive of Lunes to make restive
A chemical printer demented.
I've tried hard, but vainly, to realize plainly
Those bonds of atomic connexion
Which Crum Brown's clear vision discerns with precision
Projecting in every direction.

In C.A. Russell
The History of Valency
Chapter V (p. 106)

NULL HYPOTHESIS

Dunnette, Marvin D.
. . . most of us still remain content to build our theoretical castles on the quicksand of merely rejecting the null hypothesis.

American Psychologist
Fads, Fashions, and Folderol in Psychology (p. 345)
Volume 21, Number 4, April 1966

Tukey, John W.
The worst, i.e., most dangerous, feature of 'accepting the null hypothesis' is the giving up of explicit uncertainty. . . Mathematics can sometimes be put in such black-and-white terms, but our knowledge or belief about the external world never can.

Statistical Science
The Philosophy of Multiple Comparisons (pp. 100–1)
Volume 6, Number 1, February 1991

NUMBERS

Boethius
. . . the science of numbers ought to be preferred as an acquisition before all others, because of its necessity and because of the great secrets and other mysteries which there are in the properties of numbers. All sciences partake of it, and it has need of none.

In J. Fauvel and J. Gray
The History of Mathematics: A Reader
Chapter 7
Section 7.B2 (p. 247)

Gibran, Kahlil
And he who is versed in the science of numbers can tell of the regions of weight and measures, but he cannot conduct you thither.
For the vision of one man lends not its wings to another man.

The Prophet
On Teaching (pp. 56–7)

Hamming, Richard
The purpose of computing is insight, not numbers.

In R.W. Lucky
Silicon Dreams
Chapter 6 (p. 275)

Jacobi, Karl
The God that reigns in Olympus is Number Eternal.

In T. Dantzig
Number: The Language of Science
Chapter 10 (p. 179)

OBSERVATION

Baker, Henry
Beware of determining and declaring your Opinion suddenly on any Object; for Imagination often gets the Start of Judgement, and makes People believe they see Things, which better Observations will convince them could not possibly be seen: Therefore assert nothing till after repeated Experiments and Examinations in all Lights and in all Positions.

The Microscope Made Easy
Part I
Chapter XV (p. 62)

Bernard, Claude
Observation, then, is what shows facts; experiment is what teaches about facts and gives experience in relation to anything.

An Introduction to the Study of Experimental Medicine
Part I, Chapter I (p. 11)

Davy, Sir Humphry
The grandest as well as the most correct views are those that have been gained by minute observation, and by the application of all the more precise and accurate methods of science.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter III (p. 153)

du Noüy, Pierre Lecomte
. . . I said that an observed fact only becomes a scientific fact when all the observers are in unanimous agreement.

The Road to Reason
Chapter I (pp. 29–30)

Gaililei, Galileo
It is not in ancient tomes, but in close observations and personal consecration that a grain of truth may be found. It is so very easy to seek the significance of things in the papers of this or that man rather than in the works of nature which, ever alive and active, are constantly before our eyes.

In Helen Wright
Palomar: The World's Largest Telescope
Origin of the Telescope (p. 9)

Hanson, N.R.
. . . there is more to seeing than what meets the eyeball.

Patterns of Discovery
Chapter I (p. 7)

Hinshelwood, Sir Cyril N.
Again and again, the key to a great discovery has been an unexpected observation. . .

Nature
Science and Scientists (p. 1057)
Volume 207, Number 5001, 4 September 1965

Langer, Susanne
The men in the laboratory. . . cannot be said to observe the actual objects of their curiosity at all. . . The sense data on which the propositions of modern science rest are, for the most part, little photographic spots and blurs, or inky curved lines on paper. . . What is directly observable is only a sign of the "physical fact"; it requires interpretation to yield scientific propositions.

Philosophy in a New Key
Chapter I (p. 20)

Wells, H.G.
. . . nothing destroys the powers of general observation quite so much as a life of experimental science.

The Food of the Gods
Chapter 2 (p. 25)

Zinsser, Hans
The scientist takes off from the manifold observations of predecessors, and shows his intelligence, if any, by his ability to discriminate between the important and the negligible, by selecting here and there the significant stepping-stones that will lead across the difficulties to new understanding. The one who places the last stone and steps across the terra firma of

accomplished discovery gets all the credit. Only the initiated know and honor those whose patient integrity and devotion to exact observation have made the last step possible.

As I Remember Him: the Biography of R.S.
Chapter XX (p. 332)

OCCAM'S RAZOR

Aristotle
When the consequences of either assumption are the same, we should always assume that things are finite rather than infinite in number, since in things constituted by nature that which is finite and that which is better ought, if possible, to be present rather than the reverse…

Physics
Book VIII Chapter 7, 259^{a} [5]

OPINION

Browne, Sir Thomas
Where we desire to be informed, 'tis good to contest with men above ourselves; but, to confirm and establish our opinions, 'tis best to argue with judgements below our own, that the frequent spoils and victories over their reasons may settle in ourselves an esteem and confirmed opinion of our own.

In Charles Sayle (ed.)
The Works of Sir Thomas Browne
Volume I
Religio Medici
The First Part
Section 6 (p. 12)

Crum, H.A.
Let us also remember that plants vary and opinions vary. One man's fish is another man's poison. One man's moss is another man's mess.

The Bryologist
Traditional Make-Do Taxonomy (p. 22)
Volume 88, 1985

Joubert, Joseph
Our opinions are clouds between us and the clear skies of truth.

Pensées and Letters of Joseph Joubert
X (p. 83)

Milton, John
. . . opinion in good men is but knowledge in the making.

Areopagitica (p. 406)

Young, Thomas
The object of the present dissertation is not so much to propose any opinions which are absolutely new, as to refer some theories, which have

been already advanced, to their original inventors, to support them by additional evidence, and to apply them to a great number of diversified facts, which have hitherto been buried in obscurity. Nor is it absolutely necessary in this instance to produce a single new experiment; for of experiments there is already an ample store.

Philosophical Transactions of the Royal Society
On the Theory of Light and Colours (p. 12)
Volume 92, 1802

ORDER

Anaxagoras
Mind orders all things.

In Jean-Henri Fabre
The Glow-Worm and other Beetles (p. 234)

Birkhoff, Garrett
. . . there is hidden order in Nature, to be found only by patient search.

Hydrodynamics: A Study in Logic, Fact, and Similitude
Conclusion (p. 179)

Huxley, Thomas
. . . the man of science knows that here, as everywhere, perfect order is manifested; that there is not a curve of the waves, not a note in the howling chorus, not a rainbow glint on a bubble which is other than a necessary consequence of the ascertained laws of nature; and that with sufficient knowledge of the conditions competent physico-mathematical skill could account for, and indeed predict, every one of those 'chance' events.

In F. Darwin
The Life and Letters of Charles Darwin
Volume I (pp. 553–5)

Oppenheimer, J. Robert
We cannot make much progress without a faith that in this bewildering field of human experience, which is so new and so much more complicated than we thought even five years ago, there is a unique and necessary order: not an order that we can tell a priori, not an order that we can see without experience, but an order which means that the parts fit into a whole and that the whole requires the parts.

The Constitution of Matter (p. 37)

Pope, Alexander
Where order in variety we see,
And where, though all things differ, all agree.

The Complete Poetical Works of Pope
Windsor Forest, L. 15–16

Shakespeare, William
The heavens themselves, the planets, and this centre,
Observe degree, priority, and place,
Insisture, course, proportion, season, form,
Office, and custom, in all line of order.

Troilius and Cressida
Act I, Scene iii, L. 85–8

ORGANIC

Berzelius, Jöns Jakob
We have reached a point where we are beginning to see a theory of organic compounds; but if, instead of letting this develop as our experience grows, we want to base it on isolated facts, considered without regard for their relations with the general system of our knowledge, and by giving explanations which do not harmonise with the principles of the science, and if, moreover, we want to conclude that this lack of agreement must lead us to reject as erroneous principles which are already well established on other grounds, then we shall never succeed in finding the truth.

Annals de Chemie et de Physique
Volume 71, 1839

Brown, Sara
To all who love Organic's ways I sing:
Consider ye the Saccharides at eventide!
While softly flows the gentle Alanine
Along the banks of Furfuraldehyde.

What tho dark Ester of the Iodides
And Ethyl, that ethereal one whom Aryl chose,
These Catalyzers of my heart, disdained my song—
Let me lonely with old Erythrose—

I swear my soul was stirred with bonds unknown,
As ever was the soul of Palmitin
When by the Halides of the mighty Phosphorus
I gazed the night on golden Stearin.

Industrial and Engineering Chemistry: News Edition
The Beauty of Organic Names (p. 229)
Volume 11, Number 15, 10 August 1933

Cram, Donald J.
Cram, Jane M.
No other profession is endowed with such a rich landscape, draws inspiration from so many fields of science, exercises the hand and mind in so many different ways, offers such opportunities to employ creative instincts, and mixes ideas, theory, and experiment on a daily basis. Hurrah for the science of organic chemistry, and for the joy it brings those who play the research game.

Container Molecules and Their Guests
Preface (p. vi)

Holmes, Oliver Wendell
Drops of deliquenscence glistened on his forehead,
Whitened round his feet the dust of efflorescence,
'Till one Monday morning when the flow suspended,
There was no De Sauty.

Nothing but a cloud of elements organic,
C. O. H. N. Ferrum, Chlor. Flu. Sil. Potassa,
Calc. Sod. Phosph. Mag. Sulphur, Mang. (?) Alumin. (?)
Cuprum (?)
Such as man is made of.

The Professor at the Breakfast Table
Chapter I
De Sauty (p. 33)

Hopkins, Frederick Gowland
A very distinguished organic chemist long since dead, said to me in the late eighties: "The chemistry of the living? That is the chemistry of protoplasm; that is superchemistry; seek, my young friend, for other ambitions".

In Joseph Needham and Ernest Baldwin (eds.)
Hopkins & Biochemistry
Report of the British Association
Some Chemical Aspects of Life
1933 (p. 245)

Kekulé, F. August
We define organic chemistry as the chemistry of carbon compounds. In doing this, we see no opposition between organic and inorganic compounds. What has been known for a long time as organic chemistry and which more usefully may be called the chemistry of carbon compounds, is rather only a special section of pure chemistry which is dealt with separately because the large number and special importance of carbon compounds seems to make a special field of study necessary…It

must be emphasized that organic chemistry does not deal with the study of the chemical processes in the organs of plants and animals.

Lehrbuch der Organischen Chemie
Volume I (p. 10)

Thompson, D'Arcy W.
The mysteries of organic chemistry are great, and the differences between its processes or reactions as they are carried out in the organism and in the laboratory are many; the actions, catalytic and other, which go on in the living cell are of extraordinary complexity. But the contention that they are different in kind from ordinary chemical operations,... would seem to be no longer tenable.

On Growth and Form
Volume II
Chapter IX (p. 652)

Thudichum, J.L.W.
Organic chemistry is the child of medicine, and however far it may go on its way, with its most important achievements, it always returns to its parent.

Journal of the Royal Society of Arts
On the Discoveries and Philosophy of Leibig
Volume 24, 1876 (p. 141)

Ure, Andrew
All the elementary principles of organic nature may be considered as deriving the peculiar delicacy of their chemical equilibrium, and the consequent facility with which it may be subverted and new modeled, to the multitude of atoms grouped together in a compound. On this view, none of them should be expected to consist of a single atom of each component.

Philosophical Transactions of the Royal Society
On the Ultimate Analysis of Vegetable and Animal Substances
Volume 112, 1822 (pp. 468–9)

Unknown
Don't panic, it's organic!

Source unknown

Wöhler, F.
The organic chemistry of our day can drive anyone mad. It seems to me to be a virgin forest full of wonderful things, a vast jungle with no way out, without an end, where one dares not penetrate.

In O.A. Reutov
Fundamentals of Theoretical Organic Chemistry
Chapter 1 (p. 1)

Organic chemistry just now is enough to drive one mad. It gives one the impression of a primeval, tropical forest full of the most remarkable things, a monstrous and boundless thicket, with no way of escape, into which one may well dread to enter.

Letter to Berzelius
28 January 1835

Wöhler, F.
von Liebig, Justus
When in the dark province of organic nature, we succeed in finding a light point, appearing to be one of those inlets whereby we may attain to the examination and investigation of this province, then we have reason to congratulate ourselves, although conscious that the object before us is unexhausted.

The American Journal of Science and Arts
Researches Respecting the Radical of Benzoic Acid (p. 261)
Volume 26, Number 2, 1834

OUTLIER

Unknown
I'm not an outlier; I just haven't found my distribution yet.

Source unknown

PARADOX

Falletta, Nicholas
A paradox is truth standing on its head to attract attention.

The Paradoxicon (p. xvii)

Gilbert, William
Sullivan, Arthur
How quaint the ways of paradox!
At common sense she gaily mocks!

The Complete Plays of Gilbert and Sullivan
Pirates of Penzance
Act II (p. 168)

Shaw, George Bernard
Paradoxes are the only truths.

Misalliance (p. 142)

Thomson, William (Lord Kelvin)
Paradoxes have no place in science. Their removal is the substitution of true for false statements and thoughts.

In Silvanus Thompson
The Life of Lord Kelvin
Volume II
Chapter XXV (p. 1125)

PERIODIC LAW

Atkins, Peter W.
The periodic table is arguably the most important concept in chemistry, both in principle and in practice. It is the everyday support for students, it suggests new avenues of research to professionals, and it provides a succinct organization of the whole of chemistry. It is a remarkable demonstration of the fact that the chemical elements are not a random clutter of entities but instead display trends and lie together in families... Anyone who seeks to be familiar with a scientist's-eye view of the world must be aware of the general form of the periodic table, for it is a part of scientific culture.

The Periodic Kingdom
Preface (pp. vii–viii)

Bolton, Henry C.
The periodic law has given to chemistry that prophetic power long regarded as the peculiar dignity of its sister science, astronomy.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 9 (p. 122)

Mendeléeff, D.I.
I shall endeavor to show, as briefly as possible, in how far the periodic law contributes to enlarge our range of vision. Before the promulgation of this law the chemical elements were mere fragmentary, incidental facts in Nature; there was no special reason to expect the discovery of new elements, and the new ones which were discovered from time to time appeared to be possessed of quite novel properties. The law of periodicity first enabled us to perceive undiscovered elements at a distance which formerly was inaccessible to chemical vision...

Journal of the Chemical Society
The Periodic Law of the Chemical Elements (p. 648)
Volume 55 1889

I shall not form any hypothesis, either here nor further on to explain the nature of the periodic law. For first of all, the law itself is too simple; and secondly, this new subject has been too little studied yet, in its diverse parts for us to form any hypothesis.

In Bernadette Bensaude-Vincent
British Journal for the History of Science
Part I
Mendeléev's Periodic System (p. 7)
Volume 19, Number 61, March 1986

Sanderson, R.T.
Students may readily be bewildered by the apparently fundamental lack of agreement among various periodic tables, and some may even acquire reasonable doubt as to whether chemists actually know what they are doing.

Journal of Chemical Education
One More Periodic Table (p. 481)
Volume 31, 1954

PHILOSOPHY

Bell, R.P.
The exact verbal definition of qualitative concepts is more often the province of philosophy than of physical science.

The Proton in Chemistry
Chapter II (p. 7)

Donne, John
And new Philosophy calls all in doubt,
The Element of fire is quite put out;
The Sun is lost, and th' earth, and no man's wit
Can well direct him where to looke for it.
And freely men confess that this world's spent,
When in the Planets and the Firmament
They seeke so many new; they see that this
Is crumbled out again to his Atomies.

The Complete Poems of John Donne
An Anatomy of the World
The First Anniversary, L. 205–12

Jones, Steve
This is the essence of science. Even though I do not understand quantum mechanics or the nerve cell membrane, I trust those who do. Most scientists are quite ignorant about most sciences but all use a shared grammar that allows them to recognize their craft when they see it. The motto of the Royal Society of London is '*Nullius in verba*': trust not in words. Observation and experiment are what count, not opinion and introspection. Few working scientists have much respect for those who try to interpret nature in metaphysical terms. For most wearers of white coats, philosophy is to science as pornography is to sex: it is cheaper, easier, and

some people seem, bafflingly, to prefer it. Outside of psychology it plays almost no part in the functions of the research machine.

The New York Review of Books
The Set Within the Skull (p. 13)
6 November 1997

Mach, Ernst
…every philosopher has his own private view of science, and every scientist his private philosophy.

Knowledge and Error
Chapter I (p. 3)

Meredith, Patrick
Hence a true philosophy of science must be a philosophy of scientists and laboratories as well as one of waves, particles and symbols.

Instruments of Communication
Chapter 2, Section 5 (p. 40)

Russell, Bertrand
…science is what you more or less know and philosophy is what you do not know.

Logic and Knowledge
The Philosophy of Logical Atomism (p. 281)

Shapere, D.
…philosophy of science…is immune to the vicissitudes of science—the coming and going of particular theories; for those changes have to do with content of science, whereas the philosopher is concerned with its structure—not with specific theories, but with the meaning of "theory" itself.

Philosophical Problems of Natural Science
Introduction (p. 9)

PHYSICAL SCIENCE

Huxley, Thomas
When simple curiosity passes into the love of knowledge as such, and the gratification of the aesthetic sense of the beauty of completeness and accuracy seems more desirable than the easy indolence of ignorance; when the finding out of the causes of things becomes a source of joy, and he is counted happy who is successful in the search, common knowledge of Nature passes into what our forefathers called Natural History, from whence there is but a step to that which used to be termed Natural Philosophy, and now passes by the name of Physical Science.

The Crayfish
Chapter I (p. 3)

PLAGERISM

John of Salisbury
Why does he fetch us up words and deeds of the ancients?
We are wise from ourselves, our youth has taught itself,
our company does not resume the doctrines of the ancients.
We do not accept this burden of following the words
Of those whom Greece has and Rome venerates.
I am a resident of the Petit-Pont, a new projector in arts,
for I boast that former discoveries are my own:
What the old men have taught and dear youth does not know,
I swear to have been discoveries of my own

In John van Laarhoven (ed.)
Entheticus Maior and Minor
Volume 1
Part I
Section B, Bad Speech, L. 44–52

POLLUTION

Ames, Bruce
We are living in a sea of chemicals that have not been tested for mutagenicity or carcinogenicity.

New Scientist
In Roger Lewin
Cancer Hazards in the Environment (p. 168)
Volume 69, Number 984, 22 January 1976

Carson, Rachel
These sprays, dusts, and aerosols are now applied almost universally to farms, gardens, forests, and homes—nonselective chemicals that have the power to kill every insect, the "good" and the "bad," to still the song of birds and the leaping of fish in the streams, to coat the leaves with a deadly film, and to linger on in soil—all this though the intended target may be only a few weeds or insects. Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called "insecticides," but "biocides."

Silent Spring
Chapter 2 (pp. 7–8)

As crude a weapon as a cave man's club, the chemical barrage has been hurled against the fabric of life.

Silent Spring
Chapter 17 (p. 297)

For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death.

Silent Spring
Chapter 3 (p. 15)

Hammer, P.C.
. . . the filling of minds with technical concepts without establishing their relationships is a form of pollution.

Cybernetics
Mind Pollution
Volume 14, 1971

Peacock, Thomas Love
. . . they have poisoned the Thames, and killed the fish in the river. A little further development of the same wisdom and science will complete the poisoning of the air, and kill the dwellers on the banks.

Gryll Grange
Chapter I (p. 11)

POSTULATE

Russell, Bertrand
The method of "postulating" what we want has many advantages; they are the same as the advantages of theft over honest toil.

Introduction to Mathematical Philosophy
Chapter VII (p 71)

PRAYER

Ayres, C.E.
I believe in atoms, molecules, and electrons, matter of heaven and earth, and electrical energy its only form. I believe in modern science, conceived by Copernicus and borne out by Newton, which suffered under the Inquisition, was persecuted and anathematized, but rose to be the right hand of civilization as a consequence of the fact that it rules the quick and the dead. I believe in the National Research Council, the communion of scientists, the publication of discoveries, the control of nature, and progress everlasting. Amen.

Science: The False Messiah
Chapter X (p. 129)

Conoley, Gillian
. . . I had only prayer, prayer and science.

American Poetry Review
Beckon (p. 9)
Volume 25, Number 2, March–April 1996

Southgate, Theresa
I am like a chemical compound in Your Laboratory of Life, O Lord, a compound from which the element Perfection has not yet been isolated, a compound in which the properties of the element Perfection are disguised by combination with earthly vanities. Take me then, O Lord, analyze me according to my good and evil constituents and isolate the pure element Perfection, as a chemist analyzes and separates from a substance all foreign matter. Analyze me that I may learn to know myself and that I may emerge a pure element, worthy to be included in the group of elements already freed from the bonds of their earthly life.

First, grind me in the mortar of childish whims, that I may emerge a composite sample of Your Likeness. Weigh me on the balance of Your generosity and decide how great a sample I shall be in Your Laboratory of Life. Then, ignite me in the furnace of Your love, that the carbon

dioxide of earthly vanities be driven off. Cool me with the balm of Your mercy. Dissolve me in Your grace and filter me through the fine mesh of earthly trials so that imperfections may be banished. Precipitate my evil tendencies with the strong precipitant of Your justice and isolate them from Your compound. Precipitate the gelatinous silicate of earthly attachments which draw me from You. Imprison me in Your love with the mordant of sacrifice. Digest me in the length of my life, that my good deeds will grow and that self-satisfaction shall not be occluded with them. Blast out any impurities that may be introduced and finally, seal me forever, a pure substance in the container of your Eternal Happiness.

Journal of Chemical Education
A Chemist's Prayer (p. 507)
Volume 23, Number 10, October 1946

Unknown
Lord, I fall upon my knees
And pray that all my syntheses
May no longer be inferior,
To those conducted by bacteria.

Source unknown

Wheelock, John
Oh, Lord, we thank Thee for the Oxygen Gas; we thank Thee for the Hydrogen Gas; and for all the gases. We thank Thee for the Cerebrum; we thank Thee for the Cerebellum; and for the Medulla Oblongata. Amen!

Apocraphyl

PRECISION

Davy, Sir Humphry
Simplicity and precision ought to be the characteristics of a scientific nomenclature: words should signify things, or the analogies of things, and not opinions.

Elements of Chemical Philosophy
Volume IV
Introduction (p. 32)

Herschel, J.F.W.
[Precision] is the very soul of science; and its attainment afford the only criterion, or at least the best, of the truth of theories, and the correctness of experiments.

A Preliminary Discourse on the Study of Natural Philosophy
Chapter IV (p. 122)

PREDICTION

Kluckhohn, Clyde

…it is one thing to be able to make some useful predictions as to what is likely to happen…It is quite another thing to interfere, willfully to introduce new complications into an already tortuous social maze.

Mirror for Man
Chapter X (p. 263)

PROBABILITY

Born, Max
As far as I can see, the only foundation of the doctrine of probability, which (though not satisfactory for a mind devoted to the 'absolute') seems at least not more mysterious than science as a whole, is the empirical attitude: The laws of probability are valid just as any other physical law in virtue of the agreement of their consequences with experience.

Experiment and Theory in Physics (pp. 26–7)

Doyle, Sir Arthur Conan
"We are coming now rather into the region of guesswork," said Dr Mortimer.
"Say, rather, into the region where we balance probabilities and choose the most likely. It is the scientific use of the imagination, but we have always some material basis on which to start our speculation."

The Complete Sherlock Holmes
Volume 2
The Hound of the Baskervilles
Chapter 4 (p. 687)

Huygens, Christian
We know nothing very certainly, but everything only probably, and the probability has degrees that are widely different.

Oeuvres Complètes de Christian Huygens
Volume VII (p. 298)

Kosko, Bart
Which is easier to believe in, probability or God? ... The ultimate fraud is the scientific atheist who believes in probability.

Fuzzy Thinking
Chapter 3 (p. 50)

Peirce, Charles Sanders

The relative probability of this or that arrangement of Nature is something which we should have a right to talk about if universes were as plenty as blackberries, if we could put a quantity of them in a bag, shake them well up, draw out a sample, and examine them to see what proportion of them had one arrangement and what proportion another. But, even in that case, a higher universe would contain us, in regard to whose arrangements the conception of probability could have no applicability.

Popular Science Monthly
The Probability of Induction (p. 714)
Volume 12, April 1878

Schiller, F.C.S.

...it is better to be satisfied with probabilities than to demand impossibilities and starve.

In Charles Singer (ed.)
Studies in the History and Method of Science
Volume I
Scientific Discovery and Logical Proof (p. 272)

PROBLEM

du Preez, Peter
The reason for the rapid advance of the problem-solving capacity of natural sciences is that scientists are trained to introduce theoretical variations, to test them empirically, and to preserve and propagate those innovations which survive whatever tests have been proposed.

A Science of Mind: The Quest for Psychological Reality
Chapter 7 (p. 123)

Heisenberg, Werner
…only those revolutions in science will prove fruitful and beneficial whose investigators try to change as little as possible and limit themselves to the solution of a particular and clearly defined problem. Any attempt to make a clean sweep of everything or to change things arbitrarily leads to utter confusion.

Physics and Beyond
Chapter 12 (p. 148)

Hoyle, Fred
It is almost a matter of principle that in any difficult unsolved problem the right method of attack has not been found; failure to solve important problems is rarely due to the inadequacy in the handling of technical details.

Man in the Universe
Chapter 2 (p. 20)

Lewis, Gilbert N.
Indeed it seems hardly likely that much progress can be made in the solution of the difficult problems relating to chemical combination by assigning in advance definite laws of force between the positive and

negative constituents of an atom, and then on the basis of these laws building up mechanical models of the atom.

Journal of the American Chemical Society
The Atom and the Molecule (p. 773)
Volume 38, Number 1, April 1916

Mach, Ernst
Every real problem can and will be solved in due course without supernatural divination, entirely by accurate observation and close, searching thought.

Popular Scientific Lectures
Sensations of Orientation (p. 308)

Margenau, Henry
It is in fact obvious that science should be pressed to say all it can about any problem which is at all susceptible to scientific treatment.

The Nature of Physical Reality
Chapter 2 (p. 12)

Nehru, P.
It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people.

Proceedings of the National Institute of Science of India
Speech (p. 564)
Volume 27, 1960

Oppenheimer, J. Robert
...we probably have no very good idea today of the range of problems that will be accessible to science.

The Flying Trapeze
Space and Time (p. 2)

Popper, Karl R.
...science should be visualized as *progressing from problem to problem*—to problems of ever increasing depth...Problems crop up especially when we are disappointed in our expectations, or when our theories involve us in difficulties, in contradictions; and these may arise either within a theory, or between two different theories, or as the result of a clash between our theories and our observations...Thus science starts from problems, and not from observations; though observations may give rise to a problem,

especially if they are *unexpected*; that is to say, if they clash with our expectations or theories.

Conjectures and Refutations
Chapter 10 (p. 222)

…I think there is only one way to science—or to philosophy, for that matter: to meet a problem, to see its beauty and fall in love with it; to get married to it, and to live with it happily, till death do ye part—unless you should meet another and even more fascinating problem, or unless, indeed, you should obtain a solution. But even if you do obtain a solution, you may then discover, to your delight, the existence of a whole family of enchanting though perhaps difficult problem children for whose welfare you may work, with a purpose, to the end of your days.

Realism and the Aim of Science
Preface, 1956 (p. 8)

Porter, George
To solve a problem is to create new problems, new knowledge immediately reveals new areas of ignorance, and the need for new experiments.

In The Nobel Foundation
Nobel Lectures
Chemistry 1963–1970
Nobel Lecture
11 December 1967 (p. 261)

Russell, Bertrand
I am sorry that I have had to leave so many problems unsolved. I always have to make this apology, but the world really is rather puzzling and I cannot help it.

In John G. Slater (ed.)
The Collected Papers of Bertrand Russell
Volume 8
The Philosophy of Logical Atomism
Lecture V (p. 211)

Shaw, George Bernard
My business tonight will be very largely to raise difficulties. That is all the use I am really in this world.

The New York Times
Shaw Expounds Socialism as World Panacea
12 December 1926

Religion is always right. Religion solves every problem and thereby abolishes problems from the Universe. Religion gives us certainty, stability, peace and the absolute. It protects us against progress which

we all dread. Science is the very opposite. Science is always wrong. It never solves a problem without raising ten more problems.

In B. Patch
Thirty Years with G.B.S.
Chapter 12 (p. 235)

Simon, Herbert A.
The more difficult and novel the problem, the greater is likely to be the amount of trial and error required to find a solution. At the same time, the trial and error is not completely random or blind; it is, in fact, rather highly selective. The new expressions that are obtained by transforming given ones are examined to see whether they represent progress toward the goal. Indications of progress spur further search in the same direction; lack of progress signals the abandonment of a line of search. Problem solving requires selective trial and error.

The Sciences of the Artificial
Chapter 4 (pp. 95–6)

...human problem solving, from the most blundering to the most insightful, involves nothing more than varying mixtures of trial and error and selectivity.

The Sciences of the Artificial
Chapter 4 (p. 97)

Unknown
Math problems? Call 1-800-$[(15y)(16i)^3]$-$[\cos(xy)/2.778x]$.

Problems worthy of attack, prove their worth by fighting back.

Source unknown

Hubby: You always carry my photo in your handbag to the office. Why?
Wife: When there is a problem, no matter how insurmountable, I look at your picture and the problem disappears.
Hubby: You see, how miraculous and powerful I am for you.
Wife: Yes, I see your picture and say to myself, "What other problem can there be greater than this one?"

Source unknown

Wilson, E. Bright
Many scientists owe their greatness not to their skill in solving problems but to their wisdom in choosing them.

An Introduction to Scientific Research
Chapter 1 (p. 1)

PROGRESS

Bush, Vannevar
Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for the exploration of the unknown.

Science: The Endless Frontier
Chapter 1 (p. 7)

Foster, Sir Michael
The path [of progress in science] may not always be in a straight line; there may be swerving to this side and to that; ideas may seem to return again and again to the same point of the intellectual compass; but it will always be found that they have reached a higher level…Moreover, science is not fashioned as is a house, by putting brick to brick, that which is once put remaining as it was put to the end. The growth of science is that of a living being. As is the embryo, phases follows phase, and each member or body puts on in succession different appearances, though all the while the same member, so a scientific conception of one age seems to differ from that of a following age…

Annual Report of the Smithsonian Institution for 1899
The Growth of Science in the Nineteenth Century

Garrod, Archibald
In these days of rapid scientific progress there is a tendency to accept the facts of nature, as at present known, without glancing back at the slow and difficult stages by which the knowledge of these facts has been arrived at. Yet such a retrospect is by no means unprofitable, since it warns us that hasty generalizations upon insufficient data retard rather than advance the progress of knowledge, and that the theories of the day must not be accepted as necessarily expressing absolute truths.

In Alexander G. Bearn
Archibald Garrod and the Individuality of Man
Chapter 3 (p. 25)

Kuhn, Thomas
Does a field make progress because it is a science, or is it a science because it makes progress?

The Structure of Scientific Revolutions
Chapter XIII (p. 162)

Larmor, J.
New ideas emerge dimly into intuition, come into consciousness from nobody knows where, and become the material on which the mind operates, forming them gradually into a consistent doctrine, which can be welded onto existing domains of knowledge. But this process is never complete: a crude connection can always be pointed to by a logician as an indication of the imperfection of human constructions.

In Henri Poincaré
Science and Hypothesis
Preface

Lodge, Sir Oliver
The present is an epoch of astounding activity in physical science. Progress is a thing of months and weeks, almost of days. The long line of isolated ripples of past discovery seem blending into a mighty wave, on the crest of which one begins to discern some oncoming magnificent generalization. The suspense is becoming feverish, at times almost painful. One feels like a boy who has been long strumming on the silent keyboard of a deserted organ, into the chest of which an unseen power begins to blow a vivifying breath.

Modern Views of Electricity
Lecture III
The Discharge of a Leyden Jar (pp. 382–3)

Nisbet, R.L.
Simply stated, *the idea of progress holds that mankind has advanced in the past—from some aboriginal condition of primitiveness, barbarism, or even nullity—is now advancing, and will continue to advance through the foreseeable future*... the idea of progress is a synthesis of the past and a prophecy of the future. It is inseparable from a sense of time flowing in unilinear fashion... the idea represents "an appraisal both of the historic process in general and of the predominant trend which is manifested in it." The consequence of this awareness of historical process... is widespread belief "in a tendency inherent in nature or man to pass through a regular sequence of stages of development in the past, the present and the future, the latter stages being—with perhaps occasional retardations or

regressions—superior to the earlier"... Advance from the inferior to the superior must seem as real and certain as anything in the laws of nature.

History of the Idea of Progress
Introduction (pp. 4–5)

Priestley, Joseph
The history of science cannot but animate us in our attempts to advance still further, and suggest methods and experiments to assist in our further progress.

In John G. McEvoy
British Journal of the History of Science
Electricity, Knowledge, and the Nature of Progress in Priestley's Thought
Volume 12, 1979 (p. 6)

Sarton, George
The saints of to-day are not necessarily more saintly than those of a thousand years ago; our artists are not necessarily greater than those of early Greece; they are likely to be inferior; and, of course, our men of science are not necessarily more intelligent than those of old; yet one thing is certain, their knowledge is at once more extensive and more accurate. The acquisition and systemization of positive knowledge is the only human activity that is truly cumulative and progressive.

Introduction to the History of Science
Volume I
Introductory Chapter (p. 3)

The history of science is the only history which can illustrate the progress of mankind. In fact, progress has no definite and unquestionable meaning in fields other than the fields of science.

The Study of History of Science (p. 5)

Serres, Michel
But, irresistibly, I cannot help thinking that this idea is the equivalent of those ancient diagrams we laugh at today, which place the Earth at the center of everything, or our galaxy at the middle of the universe, to satisfy our narcissism. Just as in space we situate ourselves at the center, at the navel of things in the universe, so for time, through progress, we never cease to be at the summit, on the cutting edge, at the state-of-the-art of development. It follows that we are always right, for the simple, banal, and naive reason that we are living in the present moment. The curve traced by the idea of progress thus seems to me to sketch or project into time the vanity and fatuousness expressed spatially by that central

position. Instead of inhabiting the heart or the middle of the world, we are sojourning at the summit, the height, the best of truth.

Conversations on Science, Culture, and Time
Second Conversation
Method (pp. 48–9)

Shaw, George Bernard
Sir Patrick: Lord! Yes. Modern science is a wonderful thing. Look at your great discovery! Look at all the great discoveries! Where are they leading to? Why, right back to my poor dear old father's ideas and discoveries. He's been dead now over forty years. Oh, it's very interesting.
Ridgeton: Well, there's nothing like progress, is there?

The Doctor's Dilemma
Act I (p. 11)

von Liebig, Justus
To resolve an enigma, we must have a perfectly clear conception of the problem. There are many ways to the highest pinnacle of a mountain; but those only can hope to reach it who keep the summit constantly in view. All our labour and all our efforts, if we strive to attain it through a morass, only serve to cover it more completely with mud; our progress is impeded by difficulties of our own creation, and at last even the greatest strength must give way when so absolutely wasted.

Animal Chemistry
Part II
The Metamorphosis of Tissues (p. 125)

Walker, Kenneth
We travel through life with so much mental luggage that it is advisable occasionally to pause and take stock of it in order that we may get rid of those ideas which impede our progress.

Meaning and Purpose
Chapter I (p. 14)

PROPOSITION

Keyser, Cassius J.
If he contend, as sometimes he will contend, that he has defined all his terms and proved all his propositions, then either he is a performer of logical miracles or he is an ass; and, as you know, logical miracles are impossible.

Mathematical Philosophy

Russell, Bertrand
The belief or unconscious conviction that all propositions are of the subject–predicate form—in other words, that every fact consists in some thing having some quality—has rendered most philosophers incapable of giving any account of the world of science and daily life.

Our Knowledge of the External World
Lecture II (pp. 54–5)

Shaw, George Bernard
My method for examining any proposition is to take its two extremes, both of them impracticable; make a scale between them; and try to determine at what point on the scale it can best be put into practice. A mother who has to determine the temperature of her baby's bath has two fixed limits to work between. The baby must not be boiled and must not be frozen.

Everybody's Political What's What?
Chapter 20 (p. 162)

PUBLICATION

Agnew, Neil McK.
Pyke, Sandra W.
. . . perhaps the most deceptive myth of all is that the Ph.D. represents the last hurdle in some kind of knowledge race. A student who has just cleared the jump should enjoy this illusion while it lasts. The science game now shifts to a new ground with new rules. Your rating first depends on getting some articles out; then, once you've demonstrated that you can publish, your rating depends on whether you are publishing in respectable journals; then your rating depends on whether you have a good book out; and then. . .

The Science Game
Chapter 12 (p. 146)

Buckle, H.T.
The publications of our scientific institutions, and of our scientific authors, overflow with minute and countless details, which perplex the judgment, and which no memory can retain. In vain do we demand that they should be generalized, and reduced into order. Instead of that, the heap continues to swell. We want ideas, and we get more facts. We hear constantly what nature is doing, but we rarely hear what man is thinking.

History of Civilization in England
Volume II
Chapter VI (p. 396)

Elder, Joseph
Publication is the end-product of research. Research without publication is sterile.

Science
Jargon—Good and Bad (p. 536)
Volume 119, Number 3095, 23 April 1954

Hudson, Jeffrey
There's this desert prison. . . with an old prisoner, resigned to his life, and a young one just arrived. The younger one talks constantly of escape, and, after a few months, he makes a break. He's gone a week, and then he's brought back by the guards. He's half dead, crazy with hunger and thirst. He describes how awful it was to the old prisoner. The endless stretches of sand, no oasis, no sign of life anywhere. The old prisoner listens for a while, then says. "Yep. I know. I tried to escape myself, twenty years ago." The young prisoner says "You did? Why didn't you tell me, all these months I was planning my escape? Why didn't you let me know it was impossible?" And the old prisoner shrugs, and says, "So who publishes negative results?"

A Case of Need
Tuesday, 11 October
Nine (p. 121)

Nelkin, Dorothy
. . . too often science in the press is more a subject for consumption than for public scrutiny, more a source of entertainment than of information. Too often science is presented as an arcane activity outside and above the sphere of normal human understanding, and therefore beyond our control. Too often the coverage is promotional and uncritical, encouraging apathy, a sense of impotence, and the ubiquitous tendency to defer to expertise.

Selling Science: How the Press Covers Science and Technology
Chapter 10 (p. 173)

Ziman, John M.
The referee is the lynchpin about which the whole business of Science is pivoted.

Public Knowledge: An Essay Concerning the Social Dimension of Science
Chapter 6 (p. 111)

PURITY

Nilson, Lars Fredrik
On the purity of substances depends the perfection of the whole.

In Mary Elvira Weeks
Discovery of the Elements (p. 407)

PURPOSE

Lewis, Gilbert N.
Randall, Merle

There are ancient cathedrals which, apart from their consecrated purposes, inspire solemnity and awe. Even the curious visitor speaks of serious things, with hushed voice, and as each whisper reverberates through the vaulted nave, the returning echo seems to bear a message of mystery. The labor of generations of architects and artisans has been forgotten, the scaffolding erected for their toil has long since been removed, their mistakes have been erased, or have become hidden by the dust of centuries. Seeing only the perfection of the completed whole, we are impressed as by some superhuman agency. But sometimes we enter such an edifice that is still partly under construction; then the sound of hammers, the reek of tobacco, the trivial jests bandied from workman to workman, enable us to realize that these great structures are but the result of giving ordinary human effort a direction and purpose.

Thermodynamics
Preface (p. v)

QUESTION

Boltzmann, Ludwig

. . . the scientist asks not what are the currently most important questions, but "which are at present solvable?" or sometimes merely "in which can we make some small but genuine advance?" As long as the alchemists merely sought the philosopher's stone and aimed at finding the art of making gold, all their endeavors were fruitless; it was only when people restricted themselves to seemingly less valuable questions that they created chemistry. Thus natural science appears completely to lose from sight the large and general questions.

In Brian McGuinness (ed.)
Theoretical Physics and Philosophical Problems
The Second Law of Thermodynamics (pp. 13–14)

. . . but all the more splendid is the success when, groping in the thicket of special questions, we suddenly find a small opening that allows a hitherto undreamt of outlook on the whole.

In Brian McGuinness (ed.)
Theoretical Physics and Philosophical Problems
The Second Law of Thermodynamics (p. 14)

Chargaff, Erwin

Science is wonderfully equipped to answer the question "How?" But it gets terribly confused when you ask it the question "Why?"

Voices in the Labyrinth
Chapter 1 (p. 8)

Gore, George

The area of scientific discovery enlarges rapidly as we advance; every scientific truth now known yields many questions yet to be answered. To some of these questions it is possible to obtain answers at the present

time, others may only be decided when other parts of science are more developed.

The Art of Scientific Discovery
Part I
Chapter III (p. 27)

Huxley, Elspeth
The best way to find things out…is not to ask questions at all. If you fire off a question, it is like firing of a gun; bang it goes, and everything takes flight and runs for shelter. But if you sit quite still and pretend not to be looking, all the little facts will come and peck round your feet, situations will venture forth from thickets, and intentions will creep out and sun themselves on a stone; and if you are very patient you will see and understand a great deal more than a man with a gun.

The Flame Trees of Thika
Chapter 28 (p. 272)

Peirce, Charles Sanders
Who would have said, a few years ago, that we could ever know of what substances stars are made of whose light may have been longer in reaching us than the human race existed? Who can be sure of what we shall now know in a few hundred years? Who can guess what would be the result of continuing the pursuit of science for ten thousand years, with the activity of the last hundred? And if it were to go on for a million, or a billion, or any number of years you please, how is it possible to say that there is any question which might not ultimately be solved.

Values in a Universe of Chance
How to make Ideas Clear (p. 134)

Unknown
There is an important question that must be asked when approaching any difficult project for the first time, and that question is, "Why bother?"

Source unknown

Walker, Kenneth
We must accept the fact that the scientist can only answer a few of the questions we ask him and never the question of "Why?"

Meaning and Purpose
Chapter VIII (p. 80)

Weisskopf, Viktor
It was absolutely marvelous working for Pauli. You could ask him anything. There was no worry that he would think a particular question was stupid, since he thought *all* questions were stupid.

American Journal of Physics
Working for Pauli (p. 422)
Volume 45, Number 5, May 1977

RADICAL

Mark, Herman F.
The concept of "free radicals" was not known in 1920—well perhaps in politics, but not in chemistry.

From Small Organic Molecules to Large
Chemistry Study in Vienna (p. 15)

von Liebig, Justus
Dumas, Jean-Baptiste
. . . in inorganic chemistry the radicals are simple; in organic chemistry they are compounds—that is the sole difference.

In William H. Brock
Justus von Liebig
Chapter 3 (p. 81)

RANDOM

Szent-Györgyi, A.
The usual answer to this question is that there was plenty of time to try everything. I could never accept this answer. Random shuttling of bricks will never build a castle or a Greek temple, however long the available time. A random process can build meaningful structures only if there is some kind of selection between meaningful and non-sense mutations.

Molecular Evolution: Prebiological and Biological
The Evolutionary Paradox and Biological Stability (p. 111)

REACTION

Baudrimont, A.E.
A chemical reaction cannot take place without a movement of the atoms. Consequently a reaction…cannot and will never be able to indicate the arrangement of the atoms in a combination…For a reaction, by establishing a molecular movement, destroys the preceding arrangements of the atoms. Therefore, being able to extract a compound substance from a combination does not mean that this compound already existed in this combination.

Isis
In S.C. Kapoor
The Origins of Laurent's Organic Classification (p. 493)
Volume 60, 1969

Hoffmann, Roald
there was no question that the reaction worked
but transient colors were seen
in the slurry of sodium methoxide in dichloromethane
and we got a whole lot of products
for which we can't sort out the kinetics
the next slide will show
the most important part
very rapidly
within two minutes
and I forgot to say on further warming
we get in fact the keytone…

The Metamict State
Next Slide Please (p. 51)

Lippmann, Walter
The reaction of one chemical element to another chemical element is always correct, is never misled by misinformation, by untruth, and by illusion.

Essays in the Public Philosophy
Chapter VIII (p. 92)

Mukaiyama, Teruaki
Vigorous evolution of gas, quick coloration to brown, and the formation of precipitates; there, hidden, was the treasure of possibility in the bubbles of foam on the surface, which were observed in the reaction vessel in a corner of our small laboratory! For organic chemists, facing such an unpredictable phenomenon is not uncommon. In flasks, that which can never be predicted by thought or discussion with co-workers often happens.

Challenges in Synthetic Organic Chemistry
Prologue (p. 1)

REASON

Bernard, Claude
Reasoning will always be correct when applied to accurate notions and precise facts; but it can lead only to error when the notions or facts on which it rests were originally tainted with error or inaccuracy.

An Introduction to the Study of Experimental Medicine (p. 2)

Beveridge, W.I.B.
Every experience and history teach us that in the biological and medical sciences reason seldom can progress far from the facts without going astray.

The Art of Scientific Investigation
Chapter 7 (p. 81)

A useful habit for scientists to develop is that of not trusting ideas based on reason only…Practically all reasoning is influenced by feelings, prejudice and past experience, albeit often subconsciously.

The Art of Scientific Investigation
Chapter 7 (p. 87)

The role of reason in research is not so much in exploring the frontiers of knowledge as in developing the findings of the explorers.

The Art of Scientific Investigation
Chapter 7 (p. 91)

Bryant, William Cullen
…I would make
Reason my guide,…

The Poems by William Cullen Bryant
Conjunction of Jupiter and Venus

Cicero
Reasoning is the mistress and queen of all things.

Tusculanarum Disputationum
Book II, Chapter 21

Joos, Georg
As soon as we inquire into the *reasons* for the phenomena, we enter the domain of theory, which…connects the observed phenomena and traces them back to a single "pure" phenomena, thus bringing about a logical arrangement of an enormous amount of observational material.

Theoretical Physics
Introduction (p. 1)

Kant, Immanuel
Human reason, in one sphere of its cognition, is called upon to consider questions, which it cannot decline, as they are presented by its won nature, but which it cannot answer, as they transcend every faculty of the mind.

The Critique of Pure Reason
Preface to First Edition (p. 1)

Pope, Alexander
What can we reason but from what we know?

The Complete Poetical Works of Pope
An Essay on Man
Epistle I, L. 18

Romanoff, Alexis
Reasoning goes beyond the analysis of facts.

Encyclopedia of Thoughts
Aphorisms 1973

von Goethe, Johann Wolfgang
Reason is applied to what is developing, practical understanding to what is developed. The former does not ask, What is the Purpose? and the latter does not ask, What is the source? Reason takes pleasure in development; practical understanding tries to hold things fast so that it can use them.

Scientific Studies
Volume 12
Chapter VIII (p. 308)

Whitehead, Alfred North
The art of reasoning consists in getting hold of the subject at the right end, of seizing on the few general ideas that illuminate the whole, and of persistently organizing all subsidiary facts round them. Nobody can be a good reasoner unless by constant practice he has realized the importance of getting hold of the big ideas and hanging on to them like grim death.

In W.W. Sawyer
Prelude to Mathematics (p. 183)
Presidential Address to the London Branch of the Mathematical Association, 1914

RESEARCH

Agnew, Neil McK.
Pyke, Sandra W.
Research is like a love affair. The ingredients include: (1) your image of the girl; (2) the real girl as she would appear if you…had access to all information about her; and (3) the bits, pieces, or samples of information you have, some of it clear, some of it vague, some of it twisted by memory or biased senses…Changing a once-loved picture is a very painful process, and we know the degrees to which a lover will go to ignore, twist, and blink away negative data…

The Science Game
Leaping to Conclusions (p. 128)

Barrie, Sir James Matthew
…those hateful persons called Original Researchers…

My Lady Nicotine
Chapter XIII (p. 85)

Beveridge, W.I.B.
People in most other walks of life can allow themselves the indulgence of fixed ideas and prejudices which make thinking so much easier,…but the research worker must try to keep his mind malleable and avoid holding set ideas in science. We have to strive to keep our mind receptive and to examine suggestions made by others fairly and on their own merits, seeking arguments for as well as against them. We must be critical, certainly, but beware lest ideas be rejected because an automatic reaction causes us to see only the arguments against them. We tend especially to resist ideas competing with our own.

The Art of Scientific Thinking
Chapter 7 (p. 86)

Anyone with an alertness of mind will encounter in the course of an investigation numerous interesting side issues that might be pursued. It is a physical impossibility to follow up all of these. The majority are not

worth following, a few will reward investigation and the occasional one provides the opportunity of a lifetime. How to distinguish the promising clues is the very essence of the art of research.

The Art of Scientific Thinking
Chapter 3 (p. 35)

Carrel, Alexis
In researches dealing with physics, and chemistry, and also with physiology, one always attempts to isolate relatively simple systems, and to determine their exact conditions.

Man The Unknown
Chapter 2, Section 5 (p. 50)

Day, R.A.
The goal of scientific research is publication. Scientists, starting as graduate students, are measured primarily not by their innate knowledge of either broad or narrow scientific subjects, and certainly not by their wit or charm; they are measured, and become known (or remain unknown), by their *publications*.

How to Write & Publish A Scientific Paper
Preface (p. ix)

Dr Gil
There! Little Research, don't you cry—
You'll be a paper by and by.
Three observations—half a page of notes,
Will bring prostration to seven other blokes.

Industrial and Engineering Chemistry: News Edition
The Professor Sings to His Brain Child (p. 149)
Volume 11, Number 9, 19 May 1933

Gregg, Alan
Research has been defined as a guerrilla warfare on the unknown. In the rigorous uncertainties of such campaigns the investigator must be prepared to swap horses in mid-stream and to discard some very dear items of accumulated baggage of belief or personal pride, whenever intellectual honesty calls for such sacrifices.

The Furtherance of Medical Research
Chapter III (pp. 87–8)

Heisenberg, Werner
…the subject matter of research is no longer nature in itself, but nature subjected to human questioning…

In Aldous Huxley
Literature and Science
Chapter 25 (p. 76)

Hubble, Edwin
Research men attempt to satisfy their curiosity, and are accustomed to use any reasonable means that may assist them toward the receding goal. One of the few universal characteristics is a healthy skepticism toward unverified speculations. These are regarded as topics for conversation until tests can be devised. Only then do to they attain the dignity of subjects for investigation.

The Realm of the Nebulae
Introduction (p. 6)

Kropotkin, Peter
…all great researches, all discoveries revolutionizing science, have been made outside academies and universities, whether by men rich enough to remain independent, like Darwin and Lyell, or by men who undermined their health by working in poverty, and often in great straits, losing endless time for want of a laboratory, and unable to procure the instruments or books necessary to continue their researches, but persevering against hope, and often dying before they had reached the end in view. Their name is legion.

The Conquest of Bread
Chapter IX, Section IV (p. 103)

Mach, Ernst
…scientific research is somewhat like unraveling complicated tangles of strings, in which luck is almost as vital as skill and accurate observation.

Knowledge and Error
Chapter I (p. 10)

Medawar, Peter
If politics is the art of the possible, research is surely the art of the soluble.

New Statesman
The Act of Creation
Volume 19, June 1964

Perutz, Max
. . . research consists of formulation of imaginative hypotheses that are open to falsification by experiment.

Is Science Necessary?
How to Become a Scientist (p. 199)

Platt, Sir Robert
The conventional picture of the research worker is that of a rather austere man in a white coat with a background of complicated glassware. My idea of a research worker, on the other hand, is a man who brushes his teeth on the left side of his mouth only so as to use the other side as a control and see if tooth-brushing has any effect on the incidence of caries.

British Medical Journal
Volume 1, 1953 (p. 577)

Robinson, James Harvey
Research is mainly looking for things that are not there and attempting processes that will not occur.

The Humanizing of Knowledge
Chapter II (p. 32)

Sarewitz, Daniel
A lone scientist, frizzy-haired and bespectacled—the absent-minded, benevolent genius lost in thought; or perhaps the dedicated experimentalist clad in a white coat and laboring madly among the condensers, Van de Graaf generators, computers, and even electrode-covered cadavers: These are typical public images of scientific research.

Frontiers of Illusion
Chapter 3 (p. 31)

Scalera, Mario
There is no practical purpose here. There is simply man's insatiable curiosity, his abhorrence of the unknown—the desire to see, in the confusing phenomena of nature, the law, the order, that underlies them. This kind of urge has its own reward. . . the reward that comes to a man who suddenly sees order shaping out of chaos—this is what we call fundamental research.

Chemical and Engineering News
An Industrial Research Director Views Fundamental Research
21 April 1958 (p. 85)

Smith, Theobald
Research is fundamentally a state of mind involving continual re-examination of the doctrines and axioms upon which current thought and

action are based. It is therefore critical of existing practices. Research is not necessarily confined to the laboratory although it is usually associated with an elaborate technique and complex instruments and apparatuses which require a laboratory housing. This is controlled research which endeavors to pick out of the web of nature's activities some single strand and trace it towards its origin and its terminus and determine its relation to other strands. The older type of research involving observation and study of the entire fabric... largely with the help of the unaided senses... has had its day, but backed by the experience and keen observant mind it even now occasionally triumphs over the narrow controlled research of the laboratory. It is the kind used by Darwin and other early biologists in establishing on a broad, comparative basis, the evolution of plant and animal life.

American Journal of the Medical Sciences
The Influence of Research in Bringing into Closer Relationship
the Practice of Medicine and Public Health Activities (p. 19)
December 1929

Unknown
Do not follow where the path may lead. Go instead where there is no path and leave a trail.

Source unknown

When you don't know what you are doing, do it neatly.

Experience is directly proportional to the quantity of equipment ruined or destroyed.

Past experience is always correct, and should never be misled by present facts.

In case of doubt, make it sound convincing.

Don't believe in miracles, rely on them.

Teamwork is essential, it allows you to blame someone else.

Record of data is essential, it indicates you have been doing something.

No matter what result is anticipated, someone will always fit the facts to it.

No matter what happens, there is always someone that believes it happened according to his or her pet theory.

The probability of an event occurring is inversely proportional to its desirability.

The quantity which when added to, subtracted from, divided into, or multiplied by the results obtained experimentally to give the correct result, is known as a constant.

Experiments must be reproducible, they should fail in the same way. If any experiment works you must be using the wrong equipment.

An experiment may be considered successful if no more than half the data must be discarded to obtain the results required.

For neatness always draw the curves first and afterwards plot the data.

If an experiment is a complete failure it can always be used as a bad example.

Guide to Research
Source Unknown

von Liebig, Justus
We were the first pioneers in unknown regions, and the difficulties in the way of keeping on the right path were sometimes insuperable. Now, when the paths of research are beaten roads, it is a much easier matter; but all the wonderful discoveries which recent times have brought forth were then our own dreams, whose realization we surely and without doubt anticipated.

Annual Report of the Smithsonian Institution
Autobiography (p. 267)
1891

Weber, Robert L.
Much of the misunderstanding of scientists and how they work is due to the standard format of articles in scientific journals. With their terse accounts of successful experiments and well-supported conclusions they show little of the untidy nature of research at the frontiers of knowledge.

A Random Walk in Science
Introduction (p. xv)

Wittig, Georg
Chemical research and mountaineering have much in common. If the goal or the summit is to be reached, both initiative and determination as well as perseverance are required. But after the hard work it is a great joy to be at the goal or the peak with its splendid panorama.

In Tore Frängsmyr (ed.)
Nobel Lectures
Chemistry 1971–1980
Nobel Lecture of Peter Mitchell
8 December 1978 (p. 368)

RESULTS

Alighieri, Dante
Great flame follows a little spark. . .

The Divine Comedy of Dante Alighieri
Paradise
Canto I, L. 34

Gauss, Karl
I have had my results for a long time; but I do not yet know how I am to arrive at them.

Attributed
In Leonard Nelson
Socratic Method and Critical Philosophy
Chapter IV (p. 89)

Gay-Lussac
I only present these conclusions with the greatest reserve, knowing myself how I have still to vary my experiments and how easy it is to err in the interpretation of results.

In Maurice Grossland
Gay-Lussac: Scientist and Bourgeois
Chapter 4 (p. 87)

RUST

Chaucer, Geoffrey
. . . if gold ruste, what shal iren do?

The Canterbury Tales
Prologue
The Parson, L. 500

Tennyson, Alfred Lord
How dull it is to pause, to make an end,
To rust unburnish'd, not to shine in use.

In Charles W. Eliot (ed.)
The Harvard Classics
English Poetry in Three Volumes
Volume III
Ulysses, L. 22–3

Kreutzberg, E.C.
Rust and corrosion mean an enormous loss to Americans, greater than that caused by fire and flood combined, a loss of at least one billion dollars a year. Rust is a skin disease. Corrosion is an infectious internal disease like tuberculosis.

Iron Trade Review
Nickel–Chromium Steels More Widely Used
Volume 86, Number 16, 17 April 1930

SALT

Boerhaave, Herman
Whosoever is not acquainted with the taste of Salts will never arrive at the knowledge of our *Arcana*.

Elements of Chemistry
Volume I, Part II (p. 438)

Darwin, Erasmus
Hence with diffusive salt old Ocean steeps
His emerald shallows, and his sapphire deeps.
Oft in wide lakes, around their warmer brim
In hollow pyramids the crystals swim;
Or, fused by earth-born fires, in cubic blocks
Shoot their white forms, and harden into rocks.

The Botanic Garden
Part 1
Canto II, L. 120–5
(pp. 29–30)

SCIENCE

Abbey, Edward
That which today calls itself science gives us more and more information, an indigestible glut of information, and less and less understanding.

Down the River
Part I
Down the River with Henry Thoreau
7 November 1980 (p. 29)

Apothegm, French
Le scepticisme est le vrai flambeau de la science.
[Doubt is the true torch of science.]

In John Epps
The Life of John Walker, M.D.
Chapter IV (p. 101)

Bacon, Francis
. . . the real and legitimate goal of the sciences, is the endowment of human life with new inventions and riches.

Novum Organum
Aphorisms
81

Balard, Antoine-Jérôme
Science appears to have as its mission not merely the satisfaction of man's need of learning and understanding everything, which characterizes the noblest of our faculties; it has another aim, doubtless less brilliant but perhaps more moral, I would almost say more sacred, which consists in coordinating the forces of nature to increase production and make men more nearly equal by the universality of comfort.

In Mary Elvira Weeks
Discovery of the Elements (p. 438)

Barrow, John
The goal of science is to make sense of the diversity of Nature.

Theories of Everything
Chapter 1
Algorithmic Compressibility (p. 10)

Barzun, Jacques
It is not clear to anyone, least of all the practitioners, how science and technology in their headlong course do or should influence ethics and law, education and government, art and social philosophy, religion and life of the affections. Yet science is an all-pervasive energy, for it is at once a mode of thought, a source of strong emotion, and a faith as fanatical as any in history.

Science: The Glorious Entertainment
To the Reader (p. 3)

Bateson, G.
Science *probes*; it does not prove.

Mind and Nature. A Necessary Unity
Chapter II, Section 1 (p. 32)

Bernal, John Desmond
. . . it is not possible in any published book to speak freely and precisely about the way science is run. The law of liable, reasons of State, and still more the unwritten code of the scientific fraternity itself forbid particular examples being held up alike for praise or blame.

The Social Function of Science
Preface (p. xv)

Black, Joseph
. . . if science be the discovery of the laws of nature, the knowledge of those laws will enable us to foresee what will be the result of any process, and must point out to us, in all cases, the means, and the best means, for producing any desired chemical effect: and here does our science repay, with a liberality unparalleled in any other science, all her former obligations to the arts of life. From them did she borrow the many facts which excited her to speculate; and her occupation has at last enabled her to repay her debts with large interest, while she has grown rich in knowledge almost beyond hope.

Lectures on the Elements Chemistry
Volume I
Lectures on Chemistry
Definitions (p. 20)

Calder, Ritchie
Science is a river which the explorer may encounter at any point along its course. He can follow it either to its source or to its delta or both.

Profile of Science
Introduction (p. 13)

Chargaff, Erwin
In science you don't ask why, you ask how much.

Voices in the Labyrinth
Ouroboros (p. 128)

The sciences are extremely pedigree-conscious, and the road to the top of Mount Olympus is paved with letters of recommendation, friendly whispers at meetings, telephone calls at night.

Heraclitean Fire
Part I
No Hercules, No Crossroads (p. 32)

Compton, Karl Taylor
Science is not a technique or a body of knowledge, though it uses both. It is rather an attitude of inquiry, or observation and reasoning, with respect to the world. It can be developed, not by memorizing facts or juggling formulas to get an answer, but only by actual practice of scientific observation and reasoning.

A Scientist Speaks (p. 44)

Davis, Kenneth S.
In our time it has become all too easy to regard science as a vast impersonal force—a kind of Frankenstein's monster that, escaping human control, has forcibly seized us and carries us at terrifying speeds in directions we have not chosen towards ends unknown.

The Cautionary Scientist
Introduction (p. 7)

Davy, Sir Humphry
There is now before us a boundless prospect of novelty in science; a country unexplored, but noble and fertile in aspect; a land of promise in philosophy.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter III (p. 117)

Science, unlike literature, is independent of taste or caprice.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter IV (p. 216)

Del Rio, A.M.
It is impossible that he who has once imbibed a taste for science can ever abandon it.

Annals of Philosophy
Analysis of an Alloy of Gold, Rhodium from the Parting House at Mexico
Volume 10, October 1825

de Unamuno, Miguel
Science is a cemetery of dead ideas, even though live ideas are born out of it.

The Tragic Sense of Life
Chapter 5 (p. 100)

Dyson, Freeman J.
It used to be said, before the recent era of revolutionary discoveries, that science was organized common sense. In the modern era it would be more accurate to define science as organized unpredictability.

From Eros to Gaia
Chapter 6 (p. 68)

Franklin, Benjamin
The rapid progress true Science now makes occasions my regretting sometimes that I was born so soon. It is impossible to imagine the heights to which may be carried, in a thousand years, the power of man over matter. O that moral Science were in as fair a way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call *humanity*.

Letter to Joseph Priestley
8 February 1780
In Linus Pauling
College Chemistry
Chapter 1 (p. 3)

Freund, Ida
The object of all the Natural Sciences is the acquisition of knowledge concerning the natural objects surrounding us, as we apprehend them by our senses; of the changes occurring in these objects, together with the laws governing these changes; and of the more proximate or

more ultimate causes to the operation of which are due the individual phenomena and the general laws comprising these.

The Study of Chemical Composition
Introduction (p. 1)

Garrod, Archibald
Science is not, as so many seem to think, something apart, which has to do with telescopes, retorts, and test tubes, and especially with nasty smells, but it is a way of searching out by observation, trial, and classification; whether the phenomenon investigated be the outcome of human activities, or of the more direct workings of nature's laws. Its methods admit of nothing untidy or slipshod, its keynote is accuracy and its goal is truth.

In Alexander G. Bearn
Archibald Garrod and the Individuality of Man
Chapter 8 (p. 97)

Gluckman, Max
Science is cumulative. The apprentice in this generation can outdo his master of the last.

Politics, Law and Ritual in Tribal Society
Chapter VII (p. 303)

Gortner, Ross Aiken
Science will stagnate only when all will agree that only one interpretation can be drawn from a given series of data.

Selected Topics in Colloid Chemistry
Preface (p. vii)

Guye, Charles Eugene
. . . it is because we do not possess 'Science' that we have 'sciences.'

Physico-Chemical Evolution (p. 8)

Haggard, H.W.
There is another class of explorers whose exploits are rarely heralded by the waving of flags, to whom few monuments are erected, and whose names find small place in world history. They are the explorers in science. They change no maps, but they change our ways of living.

In Bernard Jaffe
New World of Chemistry (p. 113)

Heidel, W.A.
It is an unwarranted assumption that ancient science differed in principle at any point from that of to-day.

In Julius W. Friend and James Feibleman
What Science Really Means
Chapter II (p. 26)

Heinlein, Robert A.
The difference between science and the fuzzy subjects is that science requires reasoning, while those other subjects merely require scholarship.

Time Enough for Love
Second Intermission (p. 366)

Huxley, Aldous
Science is a matter of disinterested observation, unprejudiced insight and experimentation, patient ratiocination within some system of logically correlated concepts.

Literature and Science
Chapter 23 (pp. 68–9)

Jones, Rufus M.
Science has not closed, and will never close the soul's east window of divine surprise.

A Preface to Christian Faith in a New Age
Chapter II, Section IV (pp. 55–6)

Kipling, Rudyard
There are times when Science does not satisfy.

With the Night Mail (p. 24)

Knight, David
Most science is a very ordinary human activity not so very far removed from painting by numbers.

Ideas in Chemistry: A History of the Science
Introduction (p. 6)

Kubie, L.S.
The unique honor of science is the humility and honesty with which it constantly corrects its own errors. It is this which makes it the greatest among the so-called humanities.

Daedalus
The Fostering of Creative Scientific Productivity (p. 305)
Volume 91, Number 2, Spring 1962

Matsen, F. Albert
. . . *science* [is defined] as a set of observations and theories about observations.

Journal of Chemical Education
The Role of Theory in Chemistry (p. 365)
Volume 62, Number 5, May 1985

Mendeléeff, D.I.
While science is pursuing a steady onward movement, it is convenient from time to time to cast a glance back on the route already traversed, and especially to consider the new conceptions which aim at discovering the general meaning of the stock of facts accumulated from day to day in our laboratories.

In Faraday Lectures
Lectures Delivered before the Chemical Society
The Periodic Law of the Chemical Elements (p. 160)

What has been sown for the field of science will grow up for the people's welfare.

Principles of Chemistry
Introduction

Meredith, George
Science is notoriously of slow movement.

The Ordeal of Richard Feverel
XLIV (p. 518)

Muller, Herbert J.
. . . men of science, men given to 'realism,' are likely to make a clean sweep of old interests and sentiments as so much rubbish. They regard religion as superstition, metaphysics as moonshine, art as primitive pastime, and all ritual as monkey-business.

Science and Criticism
Chapter I (p. 6)

Newton, Roger G.
Science is not holy scripture, nor do its practitioners consider themselves priests protecting a glittering grail, forever unchanging and pure. What drives scientists on is the thirst to *understand* more and to *use* nature, to build rather than to exploit a comprehensible universe.

What Makes Nature Tick?
Epilogue (p. 234)

Ortega y Gasset, Jose
. . . experimental science has progressed thanks in great part to the work of men astoundingly mediocre, and even less than mediocre. That is to say, modern science, the root and symbol of our actual civilisation, finds a place for the intellectually commonplace man and allows him to work therein with success. . . A fair amount of the things that have to be done in physics or in biology is mechanical work of the mind which can be done by anyone or almost anyone. For the purpose of innumerable investigations it is possible to divide science into small sections, to enclose oneself in one of these, and leave out of consideration all the rest.

The Revolt of the Masses
Chapter 12 (p. 110, 111)

Ostwald, Wilhelm
The more perfect the theoretical evolution of the sciences becomes, the greater will be the scope of their explanations or the same time the greater their practical importance.

The Journal of the American Chemical Society
On Chemical Energy (p. 430)
Volume XV, Number 8, August 1893

Perl, Martin
I was following an old idea in science: 'If you can't understand a phenomenon, look for more examples of that phenomenon.'

The Science Teacher
Electron, Muon, and Tau Heavy Lepton—
Are These the Truly Elementary Particles? (pp. 18–19)
Volume 47, Number 9, December 1980

Pirsig, Robert M.
Science values static patterns.

Lila. An Inquiry Into Morals
Chapter 11 (p. 142)

Poe, Edgar Allan
Science! True daughter of Old Time thou art!
Who altered all things with thy peering eye.

The Raven and Other Poems
Sonnet—To Science

Popper, Karl R.
. . . it is the aim of science to find *satisfactory explanations* of whatever strikes us as being in need of explanation.

Objective Knowledge: An Evolutionary Approach
Chapter 5 (p. 191)

The empirical basis of objective science has thus nothing "absolute" about it. Science does not rest upon rock-bottom. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or "given" base; and when we cease our attempts to drive our piles into a deeper layer, it is not because we have reached firm ground. We simply stop when we are satisfied that they are firm enough to carry the structure, at least for the time being.

The Logic of Scientific Discovery
Chapter 5, Section 30 (p. 111)

Priestley, Joseph
. . . a successful pursuit of science makes a man the benefactor of all mankind and of every age.

Experiments and Observations on Different Kinds of Air
Volume I
The Preface (p. xxvii)

Richards, Theodore W.
Every student of Science, even if he cannot start his journey where his predecessors left off, can at least travel their beaten track more quickly than they could while they were clearing the way: and so before his race is run he comes to virgin forest and becomes himself a pioneer.

In Nobel Foundation
Nobel Lectures
Chemistry
1901–1921
Nobel Lecture
6 December 1919 (p. 280)

Richet, Charles
No one has the right to encumber science with premature assertions.

The Savant
Chapter X (p. 122)

To neglect science is to exclude fair hope, to condemn ourselves to live a uniform monotonous existence.

The Savant
Chapter XIII (p. 147)

Russell, Bertrand
Science, ever since the time of the Arabs, has had two functions: (1) to enable us to *know* things, and (2) to enable us to *do* things.

The Impact of Science on Society
Chapter II (p. 18)

Seifriz, William
So let me give full credit to the young and enthusiastic research workers, full of high-energy phosphate bonds. What I deplore is their attitude of mind. Science has become tough and the students learn to accept it that way.

Science
A New University (p. 89)
Volume 120, Number 3107, 16 July 1954

Simon, Herbert A.
The central task of a natural science is to make the wonderful commonplace: to show that complexity, correctly viewed, is only a mask for simplicity; to find pattern hidden in apparent chaos.

The Sciences of the Artificial
Chapter I (p. 1)

Teller, Edward
Teller, Wendy
Talley, Wilson
If there ever was a misnomer, it is "exact science." Science has always been full of mistakes. The present day is no exception. And our mistakes are good mistakes; they require a genius to correct them. Of course, we do not see our own mistakes.

Conversations on the Dark Secrets of Physics
Chapter 3 (p. 37)

Thoreau, Henry David
There is a chasm between knowledge and ignorance which the arches of science can never span.

The Writings of Henry David Thoreau
Volume I
A Week on the Concord and Merrimack Rivers (p. 125)

von Liebig, Justus
Thus the progress of science is, like the development of nature's works, gradual and expansive. After the buds and branches spring forth the leaves and blossoms, after the blossoms the fruit.

Familiar Letters On Chemistry
Letter I (p. 10)

Weinberg, Steven
It is simply a logical fallacy to go from the observation that science is a social process to the conclusion that the final product, our scientific theories, is what it is because of the social and historical forces acting in

this process. A party of mountain climbers may argue over the best path to the peak, and these arguments may be conditioned by the history and social structure of the expedition, but in the end either they find a good path to the peak or they do not, and when they get there they know it. (No one would give a book about mountain climbing the title *Constructing Everest*)... It certainly feels to me that we are discovering something real in physics, something that is what it is without any regard to the social and historical conditions that allowed us to discover it.

Dreams of a Final Theory
Chapter VII (p. 188)

Whitehead, Alfred North
Science therefore is nothing but a confident expectation that relevant thoughts will occasionally occur.

An Enquiry Concerning the Principles of Natural Knowledge
Part I
Chapter I (p. 10)

SCIENTIFIC

Dingle, H.
Success in scientific theory is won, not by rigid adherence to the rules of logic, but by bold speculation which dares even to break those rules if by that means new regions of interest may be opened up.

Through Science to Philosophy
Chapter XV (p. 346)

Garrod, Archibald
Nevertheless, scientific method is not the same as the scientific spirit. The scientific spirit does not rest content with applying that which is already known, but is a restless spirit, ever pressing forward towards the regions of the unknown, and endeavouring to lay under contribution for the special purpose in hand the knowledge acquired in all portions of the wide field of exact science. Lastly, it acts as a check, as well as a stimulus, sifting the value of the evidence, and rejecting that which is worthless, and restraining too eager flights of the imagination and too hasty conclusions.

In Alexander G. Bearn
Archibald Garrod and the Individuality of Man
Chapter 7 (p. 82)

Gore, George
A scientific investigator should possess the power of correctly interpreting effects; of detecting fallacy when in the guise of truth, and of recognizing truth when intermixed with error.

The Art of Scientific Investigation
Chapter XLIX (p. 447)

Knickerbocker, William Skinkle
. . . the scientific attitude of mind produces many of the virtues which in old-fashioned courses in ethics were taught as objectively as a problem in geometry. Patience, endurance, humility, teachableness, honesty, accuracy—without these it is impossible for a scientist to work. And the

history of science is as inspiring in its human values as are the legends of the saints. Contemplate the heroism of a Galileo, the patience of a Darwin, the humility of a Pasteur; a modern eleventh chapter of *Hebrews* might be written listing the names of all those men of faith who by quiet work, unremitting in their zeal, one by one discovered facts which made man's lot easier and happier in what was otherwise to him a hostile and unhappy universe.

Classics of Modern Science
Preface (p. vii)

Large, E.C.

There were two age-old tendencies toward stagnation in scientific thought which those of youthful spirit had always to resist. One was the human weakness of accepting the uncorroborated say-so of eminent authorities, and the other was the human stupidity of regarding natural science as something divisible into watertight compartments. Of course it was contended that such compartments labeled Chemistry, Mycology, Bacteriology, etcetera, were never really fish-tanks for myopic specialists to swim about in, but merely convenient *de*partments in one splendid and sunlit edifice of science, separated at the most by glass walls, decorated with the flags of all nations, and provided with innumerable intercommunicating doors. If so many stacks of old scientific papers got piled up on each side of the glass partitions that in the end no one could see though them, that was certainly regrettable; and if some of the doors were locked for periods ranging from a decade to a century, well, that also was a pity—but who wanted to work in a draught?

The Advance of the Fungi
Chapter XXIII (p. 317)

Medawar, Peter

…it is high time that laymen abandoned the misleading belief that scientific enquiry is a cold dispassionate enterprise, bleached of imaginative qualities, and that a scientist is a man who turns the handle of a machine of discovery; for at every level of endeavor scientific research is a passionate undertaking and the Promotion of Natural Knowledge depends above all on a *sortie* into what can be imagined but is not yet known.

The Times Literary Supplement [London]
Imagination and Hypothesis (p. 850)
25 October 1963

. . . scientific reasoning is a kind of dialogue between the possible and the actual, what might be and what is in fact the case. . .

Induction and Intuition in Scientific Thought
Chapter III, Section 1 (p. 48)

Schrödinger, Erwin

Our age is possessed by a strong surge towards the criticism of traditional customs and opinions. A new spirit is arising which is unwilling to accept anything on authority, which does not so much permit as demand independent, rational thought on every subject, and which refrains from hampering any attack based upon such thought, even though it be directed against things which formerly were considered to be as sacrosanct as you please. In my opinion this spirit is the common cause underlying the crisis in every science today. Its results can only be advantageous: no scientific structure falls entirely into ruin: what is worth preserving preserves itself and requires no protection.

Science and the Human Temperament
Chapter I (p. 38)

SCIENTIST

Abbey, Edward
Any good poet, in our age at least, must begin with the scientific view of the world; and any scientist worth listening to must be something of a poet, must possess the ability to communicate to the rest of us his sense of love and wonder at what his work discovers.

The Journey Home
Chapter 8 (p. 87)

Cornforth, John W.
Scientists do not believe; they check.

Australian Journal of Chemistry
Scientists as Citizens (p. 266)
Volume 46, 1993

Gelernter, David
Scientists nowadays rarely know how to read seriously. They are accustomed to strip-mining a paper to get the facts out and then moving on, not to mollycoddling the thing in search of nuances; there probably aren't any.

In John Brokman and Katinka Matson (eds.)
How Things Are: A Science Tool-Kit for the Mind
Study Talmud (p. 213)

Gibran, Kahlil
A scientist without imagination is a butcher with dull knives and outworn scales.

Sand and Foam (p. 46)

Medawar, Peter
Among scientists are collectors, classifiers and compulsive tidiers-up; many are detectives by temperament and many are explorers, some are

artists and others artisans. There are poet-scientists and philosopher-scientists and even a few mystics…and most people who are in fact scientists could easily have been something else instead.

The Art of the Soluble
Hypothesis and Imagination (p. 132)

Mencken, H.L.
The Scientist: The value the world sets upon motives is often grossly unjust and inaccurate. Consider, for example, two of them: mere insatiable curiosity and the desire to do good. The latter is put high above the former, and yet it is the former that moves one of the most useful men the human race has yet produced: the scientific investigator. What actually urges him on is not some brummagem idea of Service, but a boundless, almost pathological thirst to penetrate the unknown, to uncover the secret, to find out what has not been found out before. His prototype is not the liberator releasing slaves, the good Samaritan lifting up the fallen, but a dog sniffing tremendously at an infinite series of rat-holes.

Smart Set
August 1919 (pp. 60–1)

Poincaré, Henri
The scientist should not waste his time on the achievement of practical goals. He will surely reach such goals, but this must be marginal with respect to his principal activity. He should never forget that the specific object he is investigating is part of a whole which is infinitely greater than this object; love for this whole and an interest in it should constitute the only motives of the actions of the scientist. Science has marvelous applications, but a science in which applications were the only aim would no longer be science but only a kitchen. There is no science other than disinterested science.

In Stefan Amsterdamski
Between History and Method
Chapter V (p. 94)

Richet, Charles
Probably the chief characteristic of true savants—whether they be archaeologists, mathematicians, chemists, astronomers, or physicists—, is that they do not endeavor to apply their work in practice.

The Savant
Chapter I (p. 4)

Sabin, Albert
No matter how good you are, you cannot be a scientist unless you learn to live with frustration.

New Scientist
I Ask Only for a Place to Work… (pp. 491–2)
Volume 57, Number 835, 1 March 1973

Snow, C.P.
I believe the intellectual life of the whole of western society is increasingly being split into two polar groups…Literary intellectuals at one pole—at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension—sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding.

The Two Cultures and a Second Look
Chapter I (pp. 11–12)

Standen, Anthony
When a white-robed scientist, momentarily looking away from his microscope or cyclotron, makes some pronouncement for the general public, he may not be understood but at least he is certain to be believed…Scientists are exalted beings who stand at the very topmost pinnacle of popular prestige, for they have the monopoly of the formula "It has been scientifically proved…", which appears to rule out all possibility of disagreement.

Thus the world is divided into Scientists, who practice the art of infallibility, and non-scientists, sometimes contemptuously called "laymen", who are taken in by it.

Science is a Sacred Cow
Chapter I (p. 13)

Twain, Mark
…the scientist. He will spend thirty years in building up a mountain range of facts with the intent to prove a certain theory; then he is so happy in his achievement that as a rule he overlooks the main chief fact of all—that his accumulation proves an entirely different thing.

The Complete Works of Mark Twain
What is Man?
The Bee (p. 283)

Weinberg, Alvin Martin
The traditional working scientists are at the bottom rung—each one knows almost everything about almost nothing; as one progresses toward

the top of the ladder, the subject matter becomes more abstract until one finally reaches the philosopher at the top who knows almost nothing about almost everything.

Reflections on Big Science
Chapter II (p. 47)

Wilson, Edward O.
The ideal scientist thinks like a poet and works like a bookkeeper, and I suppose that if gifted with a full quiver, he also writes like a journalist. As a painter stands before canvas or a novelist recycles old emotion with eyes closed, he searches his imagination for subjects as much as for conclusions, for questions as much as for answers.

American Scientist
Scientists, Scholars, Knaves and Fools (p. 7)
Volume 86, January–February 1998

Scientists, I believe, are divided into two categories: those who do science in order to be a success in life, and those who become a success in life in order to do science.

Naturalist
The Forms of Things Unknown (p. 210)

Young, J.Z.
. . . in his laboratory he does not spend much of his time thinking about scientific laws at all. He is busy with other things, trying to get some piece of apparatus to work, finding a way of measuring something more exactly,. . . You may feel that he hardly knows himself what law he is trying to prove. He is continually observing, but his work is a feeling out into the dark, as it were. When pressed to say what he is doing he may present a picture of uncertainty or doubt, even of actual confusion.

Doubt and Certainty in Science
First Lecture (p. 2)

SILVER TREES

Darwin, Erasmus
So the learn'd alchemist exulting sees
Rise in his bright matrass Diana's trees;
Drop after drop, with just delay, he pours
The red-fumed acid on Potosi's ores;
With sudden flash the fierce bullitions rise,
And wide in air the gas phlogistic flies;
Slow shoot, at length, in many a brilliant mass
Metallic roots across the netted glass;
Branch after branch extended their silver stems,
But into gold, and blossoms into gems.

The Botanic Garden
Canto IV, L. 581–90

SIMPLICITY

Davy, Sir Humphry
Complexity almost always belongs to the early epochs of every science; and the grandest results are usually obtained by the most simple means.

The Collected Works of Sir Humphry Davy
Volume IV
Elements of Chemical Philosophy
Introduction (p. 41)

The more the phenomena of the universe are studied, the more distinct their connection appears, the more simple their causes, the more magnificent their design, and the more wonderful the wisdom and power of their Author.

The Collected Works of Sir Humphry Davy
Volume IV
Elements of Chemical Philosophy
Introduction (p. 42)

de Saint Exupéry, Antoine
Have you ever thought…about whatever man builds, that all of man's industrial efforts, all his calculations and computations, all the nights spent over working draughts and blueprints, invariably culminate in the production of a thing whose sole and guiding principle is the ultimate principle of simplicity?…In any thing at all, perfection is finally attained, not when there is no longer anything to add, but when there is no longer anything to take away.

Wind, Sand and Stars
Chapter 3 (pp. 65, 66)

du Noüy, Pierre Lecomte
The complex is not always profound; but the profound is not necessarily simple.

The Road to Reason
Chapter V (p. 115)

Emerson, Ralph Waldo
Nothing is more simple than greatness; indeed, to be simple is to be great.

The Works of Ralph Waldo Emerson
Volume IV
Literary Ethics (p. 114)

Fuller, Thomas
Generally nature hangs out a sign of simplicity in the face of a fool.

The Holy and Profane States
Of Natural Fools
Maxim I (p. 171)

Gibran, Kahlil
The obvious is that which is never seen until someone expresses it simply.

Sand and Foam (p. 54)

Grimaux, L.E.
Gerhardt, C.
The chemist must always compare the results of his experiments with those which precede them; for it is by this comparison alone that little by little we arrive at general laws, and consequently at the simplification of science.

In Russell McCormmach (ed.)
Historical Studies in the Physical Sciences
Sixth Annual Volume
In John Hedley Brooke
Laurent, Gerhatdt, and the Philosophy of Chemistry (p. 424)

Hoagland, Mahlon
It is often the scientist's experience that he senses the nearness of truth when such connections are envisioned. A connection is a step toward simplification, unification. Simplicity is indeed often the sign of truth and a criterion of beauty.

Toward the Habit of Truth
Preface (p. xxiii)

Hoffer, Eric
It is not at all simple to understand the simple.

The Passionate State of Mind
Number 230

Hoffmann, Hans
The ability to simplify means to eliminate the unnecessary so that the necessary may speak.

In Bradley Efron and Robert J. Tibshirani
An Introduction to the Bootstrap
Preface (p. xiv)

Kadanoff, L.P.
…all the richness of structure observed in the natural world is not a consequence of the complexity of physical law, but instead arises from the many-times repeated application of quite simple laws.

Physics Today
Complex Structures from Simple Systems (p. 8)
Volume 44, Number 3, March 1991

Oppenheimer, J. Robert
The point is to simplify and to order knowledge. The profession I'm part of has as its whole function the rendering of the physical world understandable and beautiful. Otherwise, you have only tables and statistics.

Look
With Oppenheimer on an Autumn Day (p. 63)
Volume 30, Number 26, 27 December 1966

Percy, Walker
It is not merely the truth of science that makes it beautiful, but its simplicity.

Signposts in a Strange Land
From Fact to Fiction (p. 187)

Slobodkin, Lawrence B.
The awkward richness of possibilities seems to shatter any possible coherent theory of simplicity…

Simplicity and Complexity in Games of the Intellect
Chapter 10 (p. 204)

Thoreau, Henry David
Simplify. Simplify.

The Writings of Henry David Thoreau
Volume 2
Walden (p. 102)

SOLID

Updike, John
Textbooks & Heaven only are Ideal;
Solidity is an imperfect state.
Within the cracked and dislocated Real
Nonstiochiometric crystals dominate.
Stray Atoms sully and precipitate;
Strange holes, *excitons*, wander loose; because
Of Dangling Bonds, a chemical Substrate
Corrodes and catalyzes—surface Flaws
Help Expitaxial Growth to fix absorptive claws.

Midpoint and Other Poems
The Dance of the Solids
Stanza 9

SOLUBLE

Unknown
A chemist, a physicist, and a geologist were walking along a beach when the physicist suddenly said that he wanted to measure the depth of the sea, and then he jumped into the sea. The geologist said that he wanted to see the seabed and he followed suit. The chemist waited for a while for them to reappear and then concluded, "Physicists and geologists are soluble in sea water."

Source unknown

SOLUTION

Unknown
A super-saturated solution is one that holds more than it can hold.

Source unknown

To most people solutions mean finding the answers but to chemists solutions are things that are still all mixed up…

Source unknown

Witt, Otto N.
In the strictly scientific sense of the word insolubility does not exist, and even those substances characterized by the most obstinate resistance to the solvent action of water may properly be designated as extraordinarily difficult of solution, not as insoluble.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 13 (p. 177)

SPECULATION

Eddington, Sir Arthur Stanley
If we are not content with the dull accumulation of experimental facts, if we make any deductions or generalizations, if we seek for any theory to guide us, some degree of speculation cannot be avoided. Some will prefer to take the interpretation which seems to be most immediately indicated and at once adopted as an hypothesis; others will rather seek to explore and classify the widest possibilities which are not definitely inconsistent with the facts. Either choice has its dangers: the first may be too narrow a view and lead progress into a cul-de-sac; the second may be so broad that it is useless as a guide and diverges indefinitely from experimental knowledge.

Observatory
The Internal Constitution of the Stars (p. 356)
Volume 43, 1920

STATISTICAL

Chatfield, Christopher
Most statisticians are all too familiar with conversations which start:
Q: What is the purpose of your analysis?
A: I want to do a significance test.
Q: No, I mean what is the overall objective?
A (with puzzled look): I want to know if my results are significant.
And so on…

Statistical Science
Avoiding Statistical Pitfalls (p. 242)
Volume 6, Number 3, August 1991

Deming, William Edwards
We admit with Sir Winston Churchill that it sometimes pays to admit the obvious: we do not perform an experiment to find out if two varieties of wheat or two drugs are equal. We know in advance without spending a dollar on an experiment that they are not equal. The difference between two treatments or between two areas or two groups of people, will show up as 'significantly different' if the experiment be conducted through a sufficient number of trials, even though the difference be so small that it is of no scientific or economic consequence.

Likewise tests of whether the data of a survey or an experiment fit some particular curve is of no scientific or economic consequence…With enough data no curve will fit the results of an experiment. The question that one faces in using any curve or any relationship is this: how robust are the conclusions? Would some other curve make safer predictions? Statistical significance of B/A thus conveys no knowledge, no basis for action.

American Statistician
On Probability as a Basis for Action (p. 148)
Volume 29, Number 4, November 1975

Schmidt, Frank L.
If we were clairvoyant and could enter the mind of a typical researcher we might eavesdrop on the following thoughts:

Significance tests have been repeatedly criticized by methodological specialists, but I find them very useful in interpreting my research data, and I have no intention of giving them up. If my findings are not significant, then I know that they probably just occurred by chance and that the true difference is probably zero. If the result is significant, then I know I have a reliable finding. The *p* values from the significance tests tell me whether the relationships in my data are large enough to be important or not. I can also determine from the *p* value what the chances are that these findings would replicate if I conducted a new study. These are very valuable things for a researcher to know. I wish the critics of significance testing would recognize this fact.

Every one of these thoughts about the benefits of significance testing is false. I ask the reader to ponder this question: does this describe your thoughts about the significance test?

Psychological Methods
Statistical Significance Testing and Cumulative Knowledge in Psychology:
Implications for Training of Researchers (p. 126)
Volume 1, Number 2, 1996

STATISTICIAN

Hooke, R.
It is commonly believed that anyone who tabulates numbers is a statistician. This is like believing that anyone who owns a scalpel is a surgeon.

How to Tell the Liars from the Statisticians
Chapter 1 (p. l)

STATISTICS

Balchin, Nigel
"*Organic chemist*!" said Tilley expressively. "Probably knows no statistics whatever."

The Small Back Room (p. 136)

Efron, Bradley
Tibshirani, Robert J.
Statistics is a subject of amazingly many users and surprisingly few effective practitioners.

An Introduction to the Bootstrap
Preface (p. xiv)

Shaw, George Bernard
Even trained statisticians often fail to appreciate the extent to which statistics are vitiated by the unrecorded assumptions of their interpreters.

The Doctor's Dilemma
Preface
Statistical Illusions (p. lxiv)

Spengler, Oswald
Statistics belong, like chronology, to the domain of the organic, to fluctuating Life, to Destiny and Incident, and not to the world of laws and timeless causality.

The Decline of the West
Chapter X (p. 218)

Twain, Mark
Sometimes, half a dozen figures will reveal, as with a lighting-flash, the importance of a subject which ten thousand labored words with the same purpose in view, had left at last but dim and uncertain.

Life on the Mississippi
Chapter XXVIII (p. 209)

SYMBOL

Brodie, Sir Benjamin
A symbol, however, should be something more than a convenient and compendious expression of facts. It is, in the strictest sense, an instrument for the discovery of facts, and is of value mainly with reference to this end, by its adaptation to which it is to be judged.

Philosophical Transactions
The Calculus of Chemical Operations (p. 857)
Volume 156, 1866

Butler, James Newton
Bobrow, Daniel Gureasko
"When I use a symbol, it means just what I choose it to mean—neither more nor less." "The question is, whether you can make symbols mean so many different things?" "The question is, which is to be master—that's all."

The Calculus of Chemistry
Chapter 2 (p. 7)

Goldstein, Herbert
It has been remarked in a jocular vein that if H stands for the Hamiltonian, K must stand for the Kamiltonian!

Classical Mechanics
Canonical Transformations (p. 380)

Truesdell, Clifford
There is nothing that can be said by mathematical symbols and relations which cannot also be said by words. The converse, however, is false. Much that can and is said by words cannot successfully be put into equations, because it is nonsense.

Six Lectures on Modern Natural Philosophy
Lecture III (p. 35)

SYMMETRY

Aristotle
A nose which varies from the ideal of straightness to a hook or snub may still be of good shape and agreeable to the eye.

Politics
Book V, Chapter 9, 1309^{b} [20]

Blake, William
Tyger, Tyger, burning bright
In the forest of the night,
What immortal hand or eye
Could frame thy fearful symmetry?

The Complete Writings of William Blake
Songs of Innocence and of Experience
The Tyger

Borges, Jorge Luis
. . . reality favors symmetry.

In Richard Burgin
Conversations with Jorge Luis Borges
Chapter VI (p. 109)

Carroll, Lewis
You boil it in saw dust: you salt it in glue:
You condense it with locust and tape:
Still keeping one principal object in view—
To preserve its symmetrical shape.

The Complete Writings of Lewis Carroll
The Hunting of the Snark
Fit the Fifth
The Beaver's Lesson

Perhaps Looking-glass milk isn't good to drink...

Alice's Adventures in Wonderland and Through the Looking-Glass
Through the Looking-Glass
Looking-Glass House (pp. 7–8)

Feynman, Richard
Leighton, R.B
Sands, M.

Why is nature so nearly symmetrical? No one has any idea why. The only thing we might suggest is something like this: There is a gate in Japan, a gate in Neiko, which is sometimes called by the Japanese the most beautiful gate in all Japan; it was built in a time when there was great influence from Chinese art. The gate is very elaborate, with lots of gables and beautiful carvings and lots of columns and dragon heads and princes carved into the pillars, and so on. But when one looks closely he sees that in the elaborate and complex design along one of the pillars, one of the small design elements is carved upside down; otherwise the thing is completely symmetrical. If one asks why this is, the story is that it was carved upside down so that the gods will not be jealous of the perfection of man. So they purposely put the error in there, so that the gods would not be jealous and get angry with human beings.

We might like to turn the idea around and think that the true explanation of the near symmetry of nature is this: that God made the laws only nearly symmetrical so that we should not be jealous of His perfection!

The Feynman Lectures on Physics
Volume I
52–9 (pp. 52–12)

Herbert, George

My body is all symmetry,
Full of proportions, one limb to another,
And all to all the world besides:
Each part may call the farthest, brother:
For head with foot hath private smity,
And both with moon and tides.

The Works of George Herbert
The Temple
Man

Mackay, Charles

Truth... and if mine eyes
Can bear its blaze, and trace its symmetries,
Measure its distance, and its advent wait,

I am no prophet—I but calculate.

The Poetical Works of Charles Mackay
The Prospects of the Future

Newman, James
Symmetry establishes a ridiculous and wonderful cousinship between objects, phenomena, and theories outwardly unrelated: terrestrial magnetism, women's veils, polarized light, natural selection, the theory of groups, invariants and transformations, the work habits of bees in the hive, the structure of space, vase designs, quantum physics, scarabs, flower petals, X-ray interference patterns, cell division in sea urchins, equilibrium positions in crystals, Romanesque cathedrals, snowflakes, music, the theory of relativity.

The World of Mathematics
Volume 1
Commentary on Symmetry (p. 670)

Pascal, Blaise
Those who make antitheses by forcing words are like those who make false windows for symmetry.

Pensées
Section I, 27

Symmetry is what we see at a glance…

Pensées
Section I, 28

Updike, John

When you look	kool uoy nehW
into a mirror	rorrim a otni
it is not	ton si ti
yourself you see,	,ees uoy flesruoy
but a kind	dnik a tub
of apish error	rorre hsipa fo
posed in fearful	lufraef ni desop
symmetry	yrtemmys

Telephone Poles and Other Poems
Mirror

Valéry, Paul
The universe is built on a plan the profound symmetry of which is somehow present in the inner structure of our intellect.

In Jefferson Hane Weaver
The World of Physics
Volume II (p. 521)

When you look into a mirror it is not yourself you see, but a kind of apish error posed in fearful symmetry
John Updike – (See p. 407)

Weyl, Hermann
Symmetry, as wide or as narrow as you may define its meaning, is one idea by which man through the ages has tried to comprehend and create order, beauty, and perfection.

Symmetry
Bilateral Symmetry (p. 5)

Symmetry is a vast subject, significant in art and nature. Mathematics lies at its root, and it would be hard to find a better one on which to demonstrate the working of the mathematical intellect.

Symmetry
Crystals: The General Mathematical Idea of Symmetry (p. 145)

Yang, Chen N.
Nature seems to take advantage of the simple mathematical representations of the symmetry laws. When one pauses to consider the elegance and the beautiful perfection of the mathematical reasoning involved and contrast it with the complex and far-reaching physical consequences, a deep sense of respect for the power of the symmetry laws never fails to develop.

In Heinz R. Pagels
The Cosmic Code (p. 289)

Zee, Anthony

Pick your favorite group: write down the Yang–Mills theory with your groups as its local symmetry group; assign quark fields, lepton fields, and Higgs fields to suitable representations; let the symmetry be broken spontaneously. Now watch to see what the symmetry breaks down to…That, essentially, is all there is to it. Anyone can play. To win, one merely has to hit on the choice used by the Greatest Player of all time. The prize? Fame and glory, plus a trip to Stockholm.

Fearful Symmetry
Chapter 14 (pp. 253–4)

SYNTHESIS

Berthelot, Mercelin
The domain in which chemical synthesis exercises its creative power is vaster than that of nature itself.

In Bernard Jaffe
Chemistry Creates a New World (p. xiv)

Dalton, John
Chemical analysis and synthesis go no farther than the separation of particles one from another, and their reunion. No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen.

A New System of Chemical Philosophy
Volume I
Part 1, Chapter III (p. 212)

Seebach, D.
No matter what the narrow goal of any particular project, whether the work involved is groundbreaking or of a more routine nature, synthesis and analysis are crucial to every chemist's activities.

Angewandte Chemie International Edition
Organic Synthesis—Where Now? (p. 1321)
Volume 29, 1990

Unknown
There's hardly a thing a man can name
Of beauty or use in life's small game,
But you can extract in alembro or jar,
From the physical basis of black coal tar:
Oil and ointment, and wax and wine,
And the lovely colours called aniline:

You can make anything, from salve to a star
(If only you know how), from black coal tar.

In Roald Hoffmann
The Same and Not the Same
Chapter 20 (p. 98)

von Goethe, Johann Wolfgang
"Affinities begin really to interest only when they bring about separations."
"What!... is that miserable word, which unhappily we hear so often now-a-days—in the world; is that to be found in nature's lessons too?"
"Most certainly," answered Edward; "the title with which chemists were supposed to be most honorably distinguished was, artists of separation."
"It is not so any more," replied Charlotte; "and it is well that it is not. It is a higher art, and it is a higher merit, to unite. An artist of union is what we should welcome in every province of the universe".

Elective Affinities
Chapter IV (p. 35)

Woodward, Robert
The structure known, but not yet accessible by synthesis, is to the chemist what the unclimbed mountain, the uncharted sea, the untilled field, the unreached planet, are to other men... The unique challenge which chemical synthesis provides for the creative imagination and the skilled hands ensures that it will endure as long as men write books, paint pictures, and fashion things which are beautiful, or practical, or both.

In William H. Brock
The Norton History of Chemistry
Chapter 16 (p. 633)

The synthesis of substances occurring in Nature, perhaps in greater measure than activities in any other area of organic chemistry, provides a measure of the condition and power of the science. For synthetic objectives are seldom if ever taken by chance, nor will the most painstaking, or inspired, purely observational activities suffice. Synthesis must always be carried out by plan, and the synthetic frontier can be defined only in terms of the degree to which realistic planning is possible, utilizing all of the intellectual and physical tools available. It can scarcely be gainsaid that the successful outcome of a synthesis of more than thirty stages provides a test of unparalleled rigor of the predictive capacity of the science, and of the degree of its understanding of its portion of the environment.

In A.R. Todd (ed.)
Perspectives in Organic Chemistry
Synthesis (p. 155)

TEACHING

Akenside, Mark
. . . the green retreats of Academus. . .

The Poems of Pleasure
The Pleasures of the Imagination
Book I, L. 591 (p. 67)

Berrill, N.J.
A great teacher is not simply one who imparts knowledge to his students but is one who awakens their interest in the subject and makes them eager to pursue it for themselves. An outstanding teacher is a spark plug, not a fuel line.

In B.W. Rossiter
Journal of Chemical Education
Volume 49, 1972

Boerhaave, Herman
As you have put your selves under my care, to instruct you in the knowledge of Chemistry, I shall think it my duty to endeavour as much as possible to answer your expectations.

Elements of Chemistry
Volume I
The Design (p. 1)

Colton, Charles Caleb
Examinations are formidable, even to the best prepared, for the greatest fool may ask more than the wisest man can answer.

Lacon (p. 170)

Darwin, Charles
I am inclined to give up the attempt as hopeless. Those who do not understand, it seems cannot be made to understand.

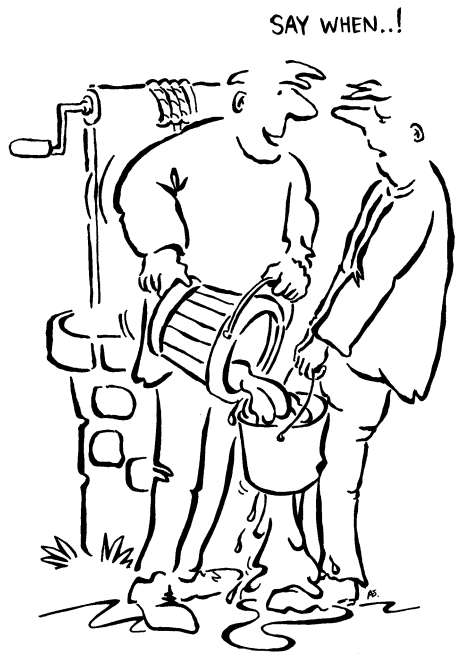
In F. Darwin
The Life and Letters of Charles Darwin
Volume II
Darwin to Hooker
5 June 1860 (p. 110)

Ehrensvärd, Gösta Carl Henrik
. . . consciousness will always be one dimension above comprehensibility.

Man on Another World
Chapter X (p. 151)

Eldridge, Paul
What difference does it make how often we lower and raise the bucket into the well if the bucket has no bottom?

Maxims for a Modern Man
Number 484



Faraday, Michael
A lecturer should appear easy and collected, undaunted and unconcerned, his thoughts about him and his mind clear for the contemplation

and description of his subject. His action should be slow, easy and natural consisting principally in changes of posture of the body, in order to avoid the air of stiffness or sameness that would otherwise be unavoidable.

In J.M. Thomas
Michael Faraday—and the Royal Institution
Chapter 3 (p. 18)

The most prominent requisite to a lecturer, though perhaps not really the most important, is a good delivery; for though to all true philosophers science and nature will have charms innumerably in every dress, yet I am sorry to say that the generality of mankind cannot accompany us one short hour unless the path is strewed with flowers.

In J.M. Thomas
Michael Faraday—and the Royal Institution
Chapter 5 (p. 97)

…a truly popular lecture cannot teach, and a lecture that truly teaches cannot be popular.

In J.M. Thomas
Michael Faraday—and the Royal Institution
Chapter 8 (p. 192)

Feyerabend, Paul K.
A good teacher will not just make people *accept* a form of life, he will also provide them with means of *seeing it in perspective* and perhaps of even *rejecting* it.

In Gerard Radnitzky and Gunnar Andersson
The Structure and Development of Science
Dialogue on Method (p. 86)

Huxley, Aldous
Ram it in, ram it in!
Children's heads are hollow.
Ram it in, ram it in!
Still there's more to follow.

Proper Studies
Education (p. 111)

Huxley, Thomas
Therefore, the great business of the scientific teacher is, to imprint the fundamental, irrefragable facts of his science, not only by words upon the mind, but by sensible impressions upon the eye, and ear, and touch of the student, in so complete a manner, that every term used, or law enunciated, should afterwards call up vivid images of the particular

structural, or other, facts which furnished the demonstration of the law, or the illustration of the term.

Lay Sermons, Addresses, and Reviews
On the Study of Zoology (p. 112)

Rollins, Mavis M.
Our Father, we praise You for the privilege of new beginnings. Thank You for letting us peek into Your creation and explore Your handiwork. Thank You for the secrets You share with Science Teachers and Students.

Enable us to walk with integrity into the opportunities You lay before us. As we work out of our humanity, teach us to admire the accomplishments of others without envying their acclaim, to follow the example of leaders without belittling their discoveries, to praise the ingenuity of the creative without distracting them with flattery, to lead the learner without manipulating the mind, and to grow wise through reflection, experience and service.

Keep our hearts fresh and our minds open to the possibilities of growth through which You may choose to stretch us.

Help us to handle Your insight with wisdom so that we can honor You in all our ways, for we recognize that we abide in Your kingdom, under Your power, for Your glory. Amen.

Source unknown
A Prayer for Science Teachers

Romanoff, Alexis
True teaching is a grave profession—
Demands most thoughtful, wise discretion.

Encyclopedia of Thoughts
Couplets

Schufle, J.A.
The teaching of chemistry has for too long been a process in which facts are transmitted from the notebook of the professor into the notebook of the student without going through the heads of either.

The Texas Journal of Science
The Use of Case Histories in the Teaching of History of Science (p. 101)
Volume 21, Number 1, October 1969

Truesdell, Clifford
Formerly, the beginner was taught to crawl through the underbrush, never lifting his eyes to the trees; today he is often made to focus on the curvature of the universe, missing even the earth.

Six Lectures on Modern Natural Philosophy
Lecture I (p. 22)

Unknown
Nil carborundum illegitimi.
[Don't let the bastards grind you down.]

Source Unknown

Fallacia plurium interrogationum.
[The fallacy of many questions.]

Source Unknown

It is not needful in the present day to discourage thinkers, they are not too numerous.

Westminster Review
Exclusion of Opinion (p. 49)
Volume 29, 1838

You may feel that this is a little unclear but in fact I am lecturing it extremely well.

Mathematical and Scientific Quotations from Cambridge
The Internet

Weinberg, Alvin Martin
Very typically a field that was once fashionable eventually ceases to command the interest of the scientists in that field and becomes the concerns of scientists in another field. Nuclear chemistry is a good example of this trend: it began as nuclear physics, was taken over by the chemists, and now, insofar as nuclear properties of radionuclides are important for technology, parts of nuclear chemistry are being taken over by engineers. This tendency for fashions in science to come and go greatly complicates the teaching of science. For, as science proliferates, the discrepancy tends to widen between the older, consolidated body of scientific knowledge and the parts of science that excite the active researcher.

Reflections on Big Science
Chapter II (p. 46)

Wells, H.G.
No man can be a good teacher when his subject becomes inexplicable.

Experiment in Autobiography
Chapter 5, Section 2 (p. 176)

Wright, Charles R.A.

. . . in teaching the science of chemistry it is preferable, first, to enumerate the facts in language independent of any hypothesis, and then to enunciate the various hypotheses that have been and are held, showing how far each is in accordance or contradiction with the observed facts; rather than to mix up from the outset one particular hypothesis with the facts, so as finally to impress on the mind the manifestly erroneous conclusion that the facts have no existence apart from the hypothesis that more or less clearly explains them.

The Athenaeum
Atoms (p. 468)
Number 2398, 11 October 1873

TERMINOLOGY

Dancoff, S.M.
When you set out in a new field and choose a terminology you have the choice of using old, familiar words in new meanings or else you can make up new words for the new meanings. If you use old words you make the theory look homey and inviting, but you run the risk of confusing the issue every time the old word is used. If you use new words you make the thing look excessively highbrow and frighten off any who might be interested.

Bulletin of the Atomic Scientists
Does the Neutrino Really Exist? (p. 139)
Volume VIII, Number 5, June 1952

THEORIST

Crick, Francis Harry Compton
Theorists almost always become too fond of their own ideas, often simply by living with them too long. It is difficult to believe that one's cherished theory, which really works rather nicely in some respects, may be completely false.

What Mad Pursuit
Chapter 13 (p. 141)

Truesdell, Clifford
Noll, Walter
The task of the theorist is to bring order into the chaos of the phenomena of nature, to invent a language by which a class of these phenomena can be described efficiently and simply.

The Non-Linear Field Theories of Mechanics
Volume III
Introduction
Section 2 (p. 4)

THEORY

Bernard, Claude
A theory is merely a scientific idea controlled by experiment.

An Introduction to the Study of Experimental Medicine
Part I, Chapter I (p. 26)

Bigelow, S. Lawrence
Without theory there can be no imagination; without imagination there can be no originality, no advance.

An Introduction to the Study of Experimental Medicine
Section I
Chapter I (p. 26)

Our laws summarize our knowledge, our theories summarize our beliefs. . . Laws codify established facts, they are history; theories contain the possibilities of the future. Theories may be considered as knowledge in the state of flux.

Theoretical and Physical Chemistry
Section I
Chapter II (pp. 15–16)

Born, Max
A theory, to be of any real use to us, must satisfy two tests. In the first place, it must not make use of any ideas which are not confirmed by experiment. Special assumptions must not be dragged in merely to meet some particular difficulty. In the second place, the theory must not only explain all the facts known already, but must also enable us to foresee other facts which were not known before and can be tested by further experiment.

The Restless Universe
Chapter I (pp. 5-6)

Bridgman, P.W.
Every new theory as it arises believes in the flush of youth that it has the long-sought goal; it sees no limits to its applicability, and believes that at long last it is the fortunate to achieve the "right" answer.

The Nature of Physical Theory
Chapter X (p. 136)

Couper, Archibald Scott
The end of chemistry *is its theory*. The guide in chemical research *is a theory*. It is therefore of the greatest importance to ascertain whether the theories at present adopted by chemists are adequate to the explanation of chemical phenomena, or are at least based upon the true principles which ought to regulate scientific research.

The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science
Volume 16, Number 4, 1858

Davy, Sir Humphry
Theories ought to be made for time, and be considered capable of improvement.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter II (p. 70)

Einstein, Albert
Physical theory has two ardent desires, to gather up as far as possible all pertinent phenomena and their connections, and to help us not only to know *how* Nature is and *how* her transactions are carried through, but also to reach as far as possible the perhaps utopian and seemingly arrogant aim of knowing *why* Nature is *thus and not otherwise*. Here lies the highest satisfaction of a scientific person.

In G. Holton
Thematic Origins of Scientific Thought
Chapter 8 (p. 242)

Einstein, Albert
Infield, Leopold
There are no eternal theories in science. It always happens that some of the facts predicted by a theory are disproved by experiment. Every theory has its period of gradual development and triumph, after which it may experience a rapid decline.

The Evolution of Physics
The Decline of the Mechanical View (p. 77)

Feynman, Richard
Another thing I must point out is that you cannot prove a vague theory wrong…Also, if the process of computing the consequences is indefinite, then with a little skill any experimental result can be made to look like the expected consequences.

Science
In Gary Taubes
The (Political) Science of Salt (p. 403)
Volume 281, Number 5379, 14 August 1998

Goodman, Nicholas P.
…there are no deep theorems—only theorems that we have not understood very well.

The Mathematical Intelligencer
Reflections on Bishops Philosophy of Mathematics (p. 63)
Volume 5, Number 3, 1983

Gould, Stephen Jay
I would say usually, theories act as straitjackets to channel observations toward their support, and to forestall data that might refute them. Such theories cannot be rejected from within, for we will not conceptualize the disapproving observations.

Dinosaur in a Haystack
Chapter 12 (p. 151)

Kuhn, Thomas
…no theory ever solves all the puzzles with which it is confronted at a given time; nor are the solutions already achieved often perfect.

The Structure of Scientific Revolutions
Chapter XII (p. 146)

One often hears that successive theories grow ever closer to, or approximate more and more closely to, the truth. Apparently generalizations like that refer not to the puzzle—solutions and the concrete predictions derived from a theory but rather to its ontology, to the match, that is, between the entities with which the theory populates nature and what is "really there."

The Structure of Scientific Revolutions
Postscript—1969 (p. 206)

Lewontin, R.C.
Theory generally should not be an attempt to say how the world is. Rather, it is an attempt to construct the logical relations that arise from various assumptions about the world.

In E. Mayr and W.B. Provine (eds.)
The Evolutionary Synthesis
Part 1
Chapter 1
Theoretical Population Genetics in the Evolutionary Synthesis (p. 65)

Matthew, William Diller
Many a false theory gets crystallized by time and absorbed into the body of scientific doctrine through lack of adequate criticism when it is formulated.

Climate and Evolution
Supplementary Note (p. 159)

Mayes, Harlan Jr.
Theory, glamorous mother of the drudge experiment.

In Eric M. Rogers
Physics for the Inquiring Mind
Chapter 40 (p. 648)

Newell, A.
Working with theories is not like skeet shooting, where theories are lofted up and *bang*, they are shot down with a falsification bullet, and that's the end of that theory. Theories are more like graduate students—once admitted you try hard to avoid flunking them out, it being much better for them and for the world if they can become long-term contributors to society.

Unified Theories of Cognition
Introduction (p. 14)

Nietzsche, Friedrich
It is certainly not the least charm of a theory that it is refutable...

Beyond Good and Evil
Chapter I, 18

Popper, Karl R.
Theories are nets cast to catch what we call 'the world': to rationalize, to explain, and to master it. We endeavor to make the mesh ever finer and finer.

The Logic of Scientific Discovery
Chapter III, Section 11 (p. 59)

Reiser, Anton
Our experience and observations alone never lead to finalities. Theory, however, creates reliable roads over which we may pursue our journeys through the world of observations.

In Bernard Jaffee
New World of Chemistry (p. 133)

Shaw, George Bernard
The weakness of the man who, when his theory works out into a flagrant contradiction of the facts, concludes "So much the worse for the facts: let them be altered," instead of "So much the worse for my theory."

Liberty
New York
A Degenerate's View of Nordau
27 July 1895

Turner, Michael S.
...If all you have are observations, that's botany. If all you have is theory, that's philosophy.

Scientific American
In John Hogan
Universal Truths (p. 117)
Volume 266, Number 4, October 1990

Twain, Mark
...the trouble about arguments is, they ain't nothing but *theories*, after all, and theories don't prove nothing, they only give you a place to rest on, a spell, when you are tuckered out butting around and around trying to find out something there ain't no way to find out...There's another trouble about theories: there's always a hole in them somewheres, sure, if you look close enough.

The Complete Novels of Mark Twain
Tom Sawyer Abroad
Chapter 9 (p. 269)

Unknown
Theory is when you know how it works but it still doesn't. Practice is when it works but you don't know why. In this Department [Chemistry], theory and practice are joined together: nothing works and no one knows why!

Source unknown

Theories are like toothbrushes: Everyone uses only his own.

Source unknown

von Neumann, John A.
It must be emphasized that it is not a question of accepting the correct theory and rejecting the false one.

It is a matter of accepting that theory which shows greater formal adaptability for a correct extension. This is a formalistic esthetic criterion, with a highly opportunistic flavor.

Collected Works
Volume VI
Method in the Physical Sciences (p. 498)

Waddington, C.H.
A scientific theory cannot remain a mere structure within the world of logic, but must have implications for action and that in two different ways. In the first place, it must involve the consequences that if you do so and so, such and such results will follow. That is to say it must give, or at least offer the possibility of controlling the process; and secondly—and this is a point not so often mentioned by those who discuss the nature of scientific theories—its value is quite dependent on its power of suggesting the next step in scientific advance.

The Nature of Life
Chapter 1 (pp. 11–12)

Wisdom, John O.
Sometimes [the word theory] is used for a hypothesis, sometimes for a confirmed hypothesis; sometimes for a train of thought; sometimes for a wild guess at some fact, or for a reasoned claim of what some fact is—or even for a philosophical speculation.

Foundations of Inference in Natural Sciences
Chapter III (p. 33)

Woodbridge, Frederick
It is a theory of nature, that system of things which allows a plant to grow, an animal to graze, and a man to think, fully as much as it allows the sun to be eclipsed or bodies to be in motion or at rest.

Aristotle's Vision of Nature
Chapter III (p. 49)

Woodger, J.H.
Theoretical statements, it is clear, cannot be verified because we can never know whether they are true. All we can do is to go on testing their consequences until an observation record turns up which contradicts them. Then we have the choice of two courses: we can say that the

theoretical statement is false and reject it; or we can assume that we have been mistaken in our observation and retain the theoretical statement.

Biology and Language
Lecture II (p. 57)

Wurtz, Charles Adolphe
The triumph of a theory is to embrace the greatest number and the greatest variety of facts.

A History of Chemical Theory from the Age of Lavoisier to the Present Time
Lavoisier
I (p. 7)

THERMODYNAMICS

Bridgman, P.W.
It must be admitted, I think, that the laws of thermodynamics have a different feel from most of the other laws of physics. There is something more palpably verbal about them—they smell more of their human origin. The guiding motif is strange to most of physics: namely, a capitalizing of the universal failure of human beings to construct perpetual motion machines of either the first or the second kind. Why should we expect nature to be interested either positively or negatively in the purposes of human beings, particularly purposes of such unblushingly economic tinge?

The Nature of Thermodynamics
Chapter I (pp. 3-4)

Feynman, Richard
Leighton, R.B
Sands, M.
In doing a problem involving a given mass of some substance, the condition of the substance at any moment can be described by telling what its temperature is and what its volume is. If we know the temperature and volume of a substance, and that the pressure is some function of the temperature and the volume, then we know the internal energy. One could say, "I do not want to do it that way. Tell me the temperature and the pressure and I will tell you the volume. I can think of the volume as a function of temperature and pressure, and the internal energy as a function of temperature and pressure, and so on." That is why thermodynamics is hard, because everyone uses a different approach. If we could only sit down once and decide on our variables, and stick to them, it would be fairly easy.

The Feynman Lectures on Physics
Volume I
44–5 (pp. 44–9)

Lewis, Gilbert N.
Randall, Merle
The fascination of a growing science lies in the work of the pioneers at the very borderland of the unknown, but to reach this frontier one must pass over well traveled roads; of these one of the safest and surest is the broad highway of thermodynamics.

Thermodynamics (p. x)

THOUGHT

Byron, Lord George Gordon
The power of Thought,—the magic of the Mind!

The Complete Poetical Works of Byron
The Corsair
Canto I, Stanza 8

Carlyle, Thomas
Thought once awakened does not again slumber.

Sartor Resartus, On Heroes, Hero-Worship and the Heroic in History
Lecture I (p. 258)

Hobbes, Thomas
From desire ariseth the thought of some means we have seen produce the like of that which we aim at; and from the thought of that, the thought of means to that mean; and so continually, till we come to some beginning within our own power.

Leviathan
Chapter III (p. 53)

Holmes, Oliver Wendell
A thought is often original, though you have uttered it a hundred times.

The Autocrat of the Breakfast Table
Chapter I (p. 6)

Ludmerer, Kenneth M.
Critical thinking, in short, offers the way to keep science and technology in harness.

Learning to Heal: the Development of American Medical Education
Chapter 14 (p. 280)

Shakespeare, William
Flout 'em and scout 'em
And scout 'em and flout 'em;
Thought is free

The Tempest
Act III, Scene ii, L. 130–3

Unknown
Pain is inevitable, suffering is optional.

Source unknown

TRIAL AND ERROR

Born, Max
No, we are in a jungle and find our way by trial and error, building our road *behind* us as we proceed. We do not *find* signposts at crossroads, but our own scouts *erect* them, to help the rest.

Experiment and Theory in Physics (p. 44)

TRUTH

Bacon, Francis
. . . man always believes more readily that which he prefers.

Novum Organum
Aphorism 49

Becker, Ernest
The man of knowledge in our time is bowed under a burden he never imagined he would ever have: the overproduction of truth that cannot be consumed. For centuries man lived in the belief that truth was slim and elusive and that once he found it the troubles of mankind would be over. And here we are in the closing of the 20th century, choking on truth.

The Denial of Death
Preface (p. x)

Brown, George Spencer
To arrive at the simplest truth, as Newton knew and practiced, requires *years of contemplation*. Not activity. Not reasoning. Not calculating. Not busy behaviour of any kind. Not reading. Not talking. Not making an effort. Not thinking. Simply *bearing in mind* what it is one needs to know. And yet those with the courage to tread this path to real discovery are not only offered practically no guidance on how to do so, they are actively discouraged and have to set about it in secret, pretending meanwhile to be diligently engaged in the frantic diversions and to conform with the deadening personal opinions which are continually being thrust upon them.

Laws of Form
Appendix 1 (p. 110)

Bush, Vannevar
It is a great truth of science that every ending is a beginning, that each question answered leads to new problems to solve, that each opportunity grasped and utilized engenders fresh and greater opportunities.

In Helen Wright
Palomar, the World's Largest Telescope
Dedication of the Hale Telescope (p. 183)

Calvin, Melvin
The true student will seek evidence to establish fact rather than confirm his own concept of truth, for truth exists whether it is discovered or not.

Chemical Evolution
Chapter 11 (p. 252)

Chandler, Raymond
There are two kinds of truth: the truth that lights the way and the truth that warms the heart. The first of these is science, and the second is art. Neither is independent of the other or more important than the other. Without art science would be as useless as a pair of high forceps in the hands of a plumber. Without science art would become a crude mess of folklore and emotional quackery. The truth of art keeps science from becoming inhuman, and the truth of science keeps art from becoming ridiculous.

The Notebooks of Raymond Chandler
Great Thoughts
19 February 1938 (p. 7)

Chargaff, Erwin
. . . I prefer the search for the truth to its possession.

Serious Questions
Knowledge Industry (p. 111)

Descartes, René
. . . we must believe that all the sciences are so inter-connected, that it is much easier to study them all together than to isolate one from all the others. If, therefore, anyone wishes to search out the truth of things in serious earnest, he ought not to select one special science; for all the sciences are conjoined with each other and interdependent. . .

Rules for the Direction of the Mind
Rule 1 (p. 1)

Dumas, Jean-Baptiste
Truth is so beautiful that it deserves every effort a man can bestow to attain it; it is so fruitful that it carries along with it its own recompose. By

keeping the end in view, without occupying ourselves with particulars, we find the ordinary details of prosperity and riches fall into their proper places.

In Faraday Lectures
Lectures Delivered before the Chemical Society
The First Faraday Lecture (p. 3)

Eddington, Sir Arthur Stanley
An addition to knowledge is won at the expense of an addition to ignorance. It is hard to empty the well of Truth with a leaky bucket.

The Nature of the Physical World
Chapter X (p. 229)

Fourcroy, Antoine-François
The general truths in any science are continually multiplied, as its perfection advances, and as its means of investigation are improved.

Elements of Chemistry and Natural History
Volume I
Advertisement (p. 1)

Kepler, Johannes
The very truth, and the nature of things, though repudiated and ordered into exile, sneaked in again through the back door, to be received by me under an unwonted guise.

New Astronomy
Part IV, Chapter 58 (p. 575)

Lee, Oliver Justin
The truth to a scientist is not the vague metaphysical concept about which philosophers talk and write so much and know so little. *To him truth is that body of statements and conclusions about any set of features and phenomena in nature which represent most accurately all the best observations he can make and which conform most closely to all findings in adjacent or related phases and fields of investigations*. He may and does often wonder what the so-called *ultimate truth* may be, but he does not worry about it. He knows that *a priori pure thinking* will never reveal it so far as knowledge of the physical universe is concerned, and that observation and deduction alone in the manner of science will ever do it.

Measuring Our Universe from the Inner Atom to Outer Space
Chapter 14 (pp. 149–50)

Medawar, Peter
The truth is *not* in nature waiting to declare itself, and we cannot know *a priori* which observations are relevant and which are not;

every discovery, every enlargement of the understanding begins as an imaginative preconception of what the truth might be. This imaginative preconception—a "hypothesis"—arises by a process as easy or as difficult to understand as any other creative act of mind; it is a brainwave, an inspired guess, the product of a blaze of insight. It comes, anyway, from within and cannot be arrived at by the exercise of any known calculus of discovery.

Advice to a Young Scientist
Chapter 11 (p. 84)

Mendeléeff, Maria
Refrain from illusions, insist on work, and not on words, patiently search divine and scientific truth.

In Benjamin Harrow
Eminent Chemists of Our Time
Dmitri Ivanowitch Mendeléeff (p. 22)

Orlans, Harold
A profession which seeks the truth must consider whether silence about motives and restraint in expression serve, on balance, to enhance or suppress it.

Policy Sciences
Neutrality and Advocacy in Policy Research (pp. 107–19)
Volume 6, 1975

Poe, Edgar Allan
Truth is not always in a well. In fact, as regards the more important knowledge, I do believe that she is invariably superficial. The depth lies in the valleys where we seek her, and not upon the mountain-tops where she is found.

Complete Tales and Poems of Edgar Allan Poe
The Murders in the Rue Morgue (p. 153)

Priestley, Joseph
When I. . . compare my last discoveries relating to the constitution of the atmosphere with the first, I see the closest and easiest connexion in the world between them, so as to wonder that I should not have been led immediately from the one to the other. That this was not the case, I attribute to the force of prejudice, which unknown to ourselves, biases not only our *judgments*, properly so called, but even the perception of our senses: for we may take a maxim so strongly for granted, that the plainest evidence of sense will not entirely change, and often hardly modify our persuasions; and the more ingenious a man is, the more effectually he

is entangled in his errors; for his ingenuity only helping him to deceive himself, by evading the force of truth.

In F.W. Gibbs
Joseph Priestley: Adventurer in Science and Champion of Truth
Chapter 9 (p. 119)

Raymo, C.
Science is not a smorgasbord of truths from which we can pick and choose.

The Virgin and the Mousetrap
Chapter 16 (p. 144)

Scientific truths are tentative and partial, and subject to continual revision and refinement, but as we tinker with truth in science—amending here, augmenting there—we always keep our ear attuned to the timbre of the web.

The Virgin and the Mousetrap
Chapter 16 (p. 145)

Richet, Charles
Truth, the goddess, the sovereign, the all-powerful, who will freeze with terror those who jeer at her!

The Savant
Chapter II (p. 23)

. . . if you would discover a new truth, do not seek to know what use will be made of it.

The Natural History of a Savant
Chapter XII (p. 133)

Russell, Bertrand
Science thus encourages abandonment of the search for absolute truth, and the substitution of what may be called "technical" truth, which belongs to any theory that can be successfully employed in inventions or in predicting the future. "Technical" truth is a matter of degree: a theory from which more successful inventions and predictions spring is truer than one which gives rise to fewer.

Religion and Science
Grounds of Conflict (p. 15)

Sattler, R.
Modern philosophy of science has gone far beyond the naïve belief that science reveals the truth. Even if it could, we would have no means of proving it. Certainty seems unattainable. All scientific statements remain

open to doubt. . . We cannot reach the absolute at least as far as science is concerned; we have to content ourselves with the relative.

Biophilosophy
Chapter 1 (p. 41)

Sendivogius, Micheel
There is abundance of knowledge, yet but little Truth known. The generality of our knowledge is as Castles in the Air, or groundless fancies.

A New Light of Alchymy
To the Reader

Shaw, George Bernard
Ridgeon: The buried truth germinates and breaks through to the light.

The Doctor's Dilemma
Act V (p. 114)

Shepherd, Linda Jean
. . . the "truth" has many faces, depending upon the perspective of the observer.

Lifting the Veil
Chapter 6 (p. 153)

Weinberg, Steven
We search for universal truths about nature, and, when we find them, we show that they can be deduced from deeper truths.

Dreams of a Final Theory
Prologue (p. 6)

Weyl, Hermann
We are not very pleased when we are forced to accept a mathematical truth by virtue of a complicated chain of formal conclusions and computations, which we traverse blindly, link by link, feeling our way by touch. We want first an overview of the aim and of the road; we want to understand the *idea* of the proof, the deeper context.

The American Mathematical Monthly
In Abe Shenitzer
Part II. Topology and Abstract Algebra as
Two Roads of Mathematical Comprehension (p. 646)
Volume 102, Number 7, August–September 1995

UNCERTAINTY

Ziman, John M.
Many philosophers have now sadly come to the conclusion that there is no ultimate procedure which will wring the last drops of uncertainty from what scientists call their knowledge.

Public Knowledge: An Essay Concerning the Social Dimension of Science
Chapter 1 (p. 5)

UNDERSTAND

Arnott, Neil
…no man can understand a subject of which he does not carry a distinct outline in his mind…

Elements of Physics, or, Natural Philosophy, General and Medical
Synopsis (p. 4)

Barbour, Julian
…the higher we climb, the more comprehensive the view. Each new vantage point yields a better understanding of the interconnection of things. What is more, gradual accumulation of understanding is punctuated by sudden and startling enlargements of the horizon, as when we reach the brow of a hill and see things never conceived of in the ascent. Once we have found our bearings in the new landscape, our path to the most recently attained summit is laid bare and takes its honourable place in the new world.

The End of Time
Part 1
Chapter 1 (p. 13)

Berkeley, George
Philonous: I am not for imposing any sense on your words: you are at liberty to explain them as you please. Only, I beseech you, make me understand something by them.

Three Dialogues between Hylas and Philonous
First Dialogue (p. 40)

Bush, Vannevar
The enthusiasm, the exuberance, that properly accompanies the great achievements of science, the thrill of at last beginning to understand nature and the universe about us, in all their awesome magnificence,

continues to lead many men all over the world, especially young men, on to this new materialism.

Science is Not Enough
Chapter II (pp. 19–20)

Chu, Steven
You want to try to put something that you learn in your own language, so that it's no longer something that's merely memorized but something you transfer from your head to your gut—you simplify it and put it in your own language to the point where it seems almost obvious and intuitive. It's only when you understand your science in this very obvious, intuitive way that you have a chance of thinking of something new.

American Scientist
Interview (p. 25)
Volume 86, January–February 1998

Cortázar, Julio
It had been some time since Gregorovius had given up the illusion of understanding things, but at any rate, he still wanted misunderstanding to have some sort of order, some reason about them.

Hopscotch
Chapter 31 (p. 179)

Eco, Umberto
Adso: "But how does it happen," I said with admiration, "that you were able to solve the mystery of the library looking at it from the outside, and you were unable to solve it when you were inside?"
William of Baskerville: "Thus God knows the world, because He conceived it in His mind, as if from the outside, before it was created, and we do not know its rule, because we live inside it, having found it already made."

The Name of the Rose
Vespers (p. 218)

Feynman, Richard
What I cannot create I do not understand.

In James Gleick
Genius
Epilogue (p. 437)

Galilei, Galileo
The vain presumption of understanding everything can have no other basis than never understanding anything. For anyone who had experienced just once the perfect understanding of one single thing, and

had truly tasted how knowledge is accomplished, would recognize that infinity of other truths of which he understands nothing.

Dialogue Concerning The Two Chief World Systems
First Day (p. 101)

Heisenberg, Werner
. . . as facts and knowledge accumulate, the claim of the scientist to an understanding of the world in a certain sense diminishes.

Wandlungen in der Grundlagen der Naturwissenschaft
Zur Geschichte der physikalischen Naturerklärung (p. 28)

Whenever we proceed from the known into the unknown we may hope to understand, but we may have to learn at the same time a new meaning of the word "understanding".

Physics and Philosophy
Chapter XI (p. 201)

Hoffmann, Roald
In principle one could go ahead and calculate each molecule. . . However . . . even if the results were in excellent agreement with experiment, the resultant predictability would not necessarily imply understanding. True understanding implies a knowledge of the various physical factors, the mix of different physical mechanisms, that go into making an observable.

Accounts of Chemical Research
Interaction of Orbitals through Space and through Bonds (p. 2)
Volume 4, Number 1 1971

Le Guin, Ursula K.
If the human creatures will not understand Relativity, very well; but they must understand Relatedness.

The Wind's Twelve Quarters
Direction of the Road (p. 274)

Lec, Stanislaw
Some like to understand what they believe in. Others like to believe in what they understand.

Unkempt Thoughts
Chapter I

Swift, Jonathan
. . . where I am not understood, it shall be concluded, that something very useful and profound is couched underneath. . .

Gulliver's Travels, The Tale of A Tub, Battle of the Books, Etc.
Tale of a Tub
The Preface (p. 403)

Wittgenstein, Ludwig
Telling someone something he does not understand is pointless, even if you add that he will not be able to understand it.

Culture and Value (p. 7e)

UNEXPECTED

Heraclitus
If one does not expect the unexpected one will not find it out, since it is not to be searched out, and difficult to compass.

In G.S Kirk and J.E. Raven
The Presocratic Philosophers
Fragment 213 (p. 195)

Raymo, C.
Delight in the unexpected is part of the lifeblood of science. Almost alone among belief systems, science welcomes the disturbingly new.

The Virgin and the Mousetrap
Chapter 15 (p. 138)

UNKNOWN

Chargaff, Erwin
I have always oscillated between the brightness of reality and the darkness of the unknowable.

Heraclitean Fire
Part I
The Silence of the Heavens (p. 55)

Hinshelwood, Sir Cyril N.
. . . as the chart of the unknown becomes filled in, judgment of the most profitable course to follow itself changes. Mysterious inlets may prove dead ends or may open into vast seas.

Supplement to Nature
Science and Scientists (p. 1057)
Volume 207, Number 5001, 4 September 1965

Pinter, Harold
In other words, apart from the known and the unknown, what else is there?

The Homecoming
Act 2 (p. 52)

Service, Robert
Let us probe the silent places, let us seek what luck betides us;
Let us journey to a lonely land I know.
There's a whisper on the night-wind, there's a star agleam to guide us,
And the Wild is calling, calling. . . let us go.

The Complete Poems of Robert Service
The Call of the Wild
Stanza 5

VACUUM

Marquis, Don
he i said is afraid of a vacuum what is
there in a vacuum to make one afraid
said the flea there is nothing in it
I said and that is what makes one
afraid to contemplate it a person
can t think of a place with nothing at
all in it without going nutty and if he
tries to think that nothing is
something after all he gets nuttier…

the lives and times of archy & mehitabel
the merry flea

Pascal, Blaise
Because… you have believed from childhood that a box was empty when you saw nothing in it, you have believed in the possibility of a vacuum.

Pensées
Section II, 82

…I had always held that the vacuum was not a thing impossible in nature and that she did not flee it with such horror as many imagine.

Scientific Treatises
New Experiments Concerning the Vacuum (p. 359)

Whitehead, Alfred North
You cannot have first space and then things to put into it, any more than you can have first a grin and then a Cheshire cat to fit on to it.

In Sir Arthur Eddington
New Pathways in Science (p. 48)

Williams, Tennessee
. . . a vacuum is a hell of a lot better than some of the stuff that nature replaces it with.

Cat on a Hot Tin Roof
Act 2

VISION

Douglas, A. Vibert

To every investigator there come moments when his thought is baffled, when the limits of experimental possibility seem to have been reached and he faces a barrier which defies his curiosity. Then it is that imagination, like a glorious greyhound, comes bounding along, leaps the barrier, and a vision is flashed before the mind—a vision no doubt that is partly false, but a vision that may be partly true. It stirs up new ideas in the thoughts of the investigator, it fires him with a fresh enthusiasm and his curiosity spurs him on to further endeavors.

The Atlantic Monthly
From Atoms to Stars (p. 158)
Volume 144, August 1929

VOLUME

Avogadro, Amedeo
M. Gay-Lussac has shown in an interesting Memoir that gases always unite in a very simple proportion by volume, and that when the results of the union is a gas, its volume also is very simply related to those (volumes) of its components. But the proportions of weight of substances in compounds only seem to depend on the relative number of molecules which combine, and on the number of compound molecules which result. It must then be admitted that very simple relations also exist between the volumes of gaseous substances and the numbers of simple or compound molecules which form from them. The first hypothesis to present itself in this connection, and apparently even the only admissible one, is the supposition that the number of integral molecules in any gas is always the same for equal volumes, or always proportional to the volumes.

Journal de Physique de Chimie d'histoire Naturelle et des Artes
Volume 73, 1811

Shenstone, W.A.
Avogadro's hypothesis affords a bridge by which we can pass from large volumes of gases, which we can handle, to the minuter molecules, which individually are invisible and intangible.

In Joseph William Mellor
Mellor's Modern Inorganic Chemistry
Chapter 5 (p. 73)

WATER

Burke, Edmund
Water, when simple is insipid, inodorous, colourless, and smooth; it is found, when *not cold*, to be a great resolver of spasms and lubricator of the fibers; this power it probably owes to its smoothness.

An Essay on The Sublime and Beautiful
Part IV, Section XXI (p. 166)

Davy, Sir Humphry
. . . I have come to [the] conclusion. . . that water is the basis of all the gases, and that oxygen, hydrogen, nitrogen, ammonia, nitrous acid e&c., are merely electrical forms of water. . .

Fragmentary Remains
Letter to T.A. Knight (p. 129)

Esar, Evan
A beautiful blonde is chemically three-fourths water, but what lovely surface tension.

20,000 Quips & Quotes (p. 127)

Lawrence, D.H.
Water is H_2O, hydrogen two parts, oxygen one,
but there is also a third thing, that makes water
and nobody knows what that is.

The atom locks up two energies
but it is a third thing present which makes it an atom.

Pansies
The Third Thing

Le Fèvre, Nicaise
That insipid liquor which commonly is called Water, hath by the Chymists the name of Phlegm given unto it, when it is separated from all other Mixture…

A Compleat Body of Chymistry
Part I
Chapter III, Section II (p. 22)

Overstreet, H.A.
Water, however, is not simply the sum of hydrogen and oxygen. It is something qualitatively new, something that cannot be found by the most searching examination of the gas, hydrogen, nor of the gas, oxygen. No amount of previous knowledge of the atomic structure of hydrogen and oxygen could, apparently, give a knowledge of this peculiar fluid that results from combining the two gasses.

The Enduring Quest
Chapter IV (p. 59)

Russell, Bertrand
A drop of water is not immortal; it can be resolved into oxygen and hydrogen. If, therefore, a drop of water were to maintain that it had a quality of aqueousness which would survive its dissolution we should be inclined to be sceptical.

What I Believe (p. 6)

Unknown
H_2O is hot water, and CO_2 is cold water.

Source unknown

Water is composed of two gins, Oxygin and Hydrogin. Oxygin is pure gin. Hydrogin is gin and water.

Source unknown

WISDOM

Berrill, N.J.
Wisdom, the highest product of the human mind, comes late; the young are rarely wise and are not expected to be.

Man's Emerging Mind
Chapter 1 (p. 14)

Collingwood, Robbin George
A man ceases to be a beginner in any given science and becomes a master in that science when he has learned that *this expected reversal is never going to happen* and that he is going to be a beginner all his life.

The New Leviathan
Part 1, Chapter 1, Aphorism I.45

Ecclesiastes 1:13
And I gave my heart to seek and search out by wisdom concerning all things that are done under heaven. This sore task has God given to the sons of man to be exercised herewith.

The Bible

Ecclesiastes 1:18
For in much wisdom is much grief and he that increaseth knowledge increases sorrow.

The Bible

Eisenschiml, Otto
Learn as much as you can, but remember that wisdom is more than a mere accumulation of facts. No one hires a man because he knows the encyclopedia by heart.

The Art of Worldly Wisdom
Part 9 (p. 108)

Wisdom, if inarticulate, is as impotent as loud-mouthed stupidity.

The Art of Worldly Wisdom
Part 9 (p. 112)

WORD

Matthew 24:35
Heaven and earth shall pass away, but my words shall not pass away.

The Bible

Maxwell, James Clerk
. . . when a physical phenomenon can be completely described as a change in the configuration and motion of a material system, the dynamical explanation of that phenomenon is said to be complete. We cannot conceive any further explanation to be either necessary, desirable, or possible, for as soon as we know what is meant by the words *configuration*, *mass* and *force*, we see that the ideas which they represent are so elementary that they cannot be explained by means of anything else.

In W.D. Niven (ed.)
The Scientific Papers of James Clerk Maxwell
Volume II
On the Dynamical Evidence of the Molecular Constitution of Bodies (p. 418)

Popper, Karl R.
The relationship between a theory (or a statement) and the words used in its formulation is in several ways analogous to that between written words and the letters used in writing them down.

In Paul Arthur Schlipp (ed.)
The Philosophy of Karl Popper
Volume 1
Book I
Part 1
Autobiography of Karl Popper
Section 7 (p. 15)

Schuster, A.
Scientific controversies constantly resolve themselves into differences about the meaning of words.

In C.K. Ogden and I.A. Richards
The Meaning of Meaning (p. xxiv)

Shakespeare, William
Thy reason, man?
Troth, sir, I can yield you none without words; and words are grown so false, I am loath to prove reason with them.

Twelfth Night
Act III, Scene i

Whewell, William
I am always glad to hear of the progress of your researches, and never the less so because they require the fabrication of a new word or two. Such a coinage has always taken place at the great epochs of discovery; like the medals that are struck at the beginning of a new reign:—or rather like the change of currency produced by the accession of a new sovereign; for their value and influence consists in their coming into common circulation.

In Silvanius P. Thompson
Michael Faraday: His Life and Work
Chapter IV
Letter from Whewell to Faraday
14 October 1837 (p. 163)

WORK

Davy, Sir Humphry
The most important part of the history of a man of science is necessarily recorded in his works.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter I (p. 1)

The works of scientific men are like the atoms of gold, of sapphire and diamonds, that exist in a mountain; they form no perceptible part of the mass of the mountain; they are neglected and unknown when it is entire; they are covered with vegetable mould, and by forests. But when time has sapped its foundation—when its fragments are scattered abroad by the elements, and its decayed materials carried down by rivers, then they glitter, and are found; then their immortality is known, and they are employed to ornament the diadems of emperors and the sceptures of kings.

The Collected Works of Sir Humphry Davy
Volume I
Memories of the Life of Sir Humphry Davy
Chapter IV (p. 218)

Editor
No man is truly equal to his work until he is superior to it.

Journal of Chemical Education
Editor's Outlook (p. 66)
Volume 10, Number 2, February 1933

WRITING

Chargaff, Erwin
...Scientists, like little fishes, swim in schools. When we open one of our scientific journals these days, we find a very uneven distribution of topics. Some important fields are almost entirely neglected, others seem to explode into bursts of unbelievable mediocrity. Really valuable contributions in the fields most in vogue at present probably are just as scarce as those dealing with the stepchildren of present-day biochemistry. But not all disciplines make it so easy to call each mush a "homogenate", each soup a "partially purified extract", and so to speak—when you have nothing whatever—of a "system". There is a real danger that our science may suffocate in its own excrements.

Essays on Nucleic Acids
Chapter 10 (p. 162)

Dariot, Claude
I will try to write the truth without any mixture or disguise, the method of preparation of each [substance I describe] according to the way I made it myself and experimented with it.

In Allen G. Debus
The French Paracelsians
Chapter 2 (p. 41)

Feynman, Richard
We have a habit in writing articles published in scientific journals to make the work as finished as possible, to cover all the tracks, to not worry about the blind alleys or describe how you had the wrong idea first, and so on. So there isn't any place to publish, in a dignified manner what you actually did in order to do the work...

In the Nobel Foundation
Nobel Lectures
Physics
1963–1970
Nobel Lecture, 11 December 1965

Gebremedhin, Tesfa G.
Tweeten, Luther G.
Avoid digressing into diatribes and areas, especially controversial issues, not central to your research. You may never complete a scientific crusade if you stop to lop off the head of an innocent peasant on the way…

Remember that the review process has a big random element…Be philosophical—remember that sometimes you will be unfairly rejected and at other times undeservedly accepted. Write enough articles so that it averages out!…

Carefully read the editor's rejection. It may in fact be a request for resubmission after major changes. The editor doesn't want to appear generous because that would encourage you to resubmit a poorly revised manuscript, and he would feel obligated to accept it. A little humor helps: A politician says "yes" if he means maybe, "maybe" if he means no, and if he says "no" he's not a politician. An editor says "no" if he means maybe, "maybe" if he means yes, and if he says "yes" he's not an editor…

Reviewers may be defensive about a manuscript that provides too large a deviation from received wisdom and perhaps even threatens the reigning paradigm. If you are brilliant enough to come up with such material, it may be wise to publish it in less shocking increments or in a book.

Research Methods and Communication in the Social Sciences
Chapter 4 (pp. 99, 100, 101)

Moog, Florence
Good writing, after all, is just clear thinking. Anyone who can think well enough to make advances in any learned field ought to be able to write about his work. I am, of course, aware that many research papers submitted to scientific journals are, from a literary standpoint, putrid; but usually such essays are scientifically not very fragrant either.

Science
Can Scientists Write for the General Public (p. 567)
Volume 119, Number 3095, 23 April 1954

Oersted, Hans Christian
So much is certain: that nothing is better adapted to form a mind which is capable of great development, than living and participating in great scientific revolutions. I would therefore counsel all those whom the period they live in has not naturally presented with this advantage, to procure it artificially for themselves, by reading the writings of those periods in which the sciences have suffered great changes. To pursue the writings of the most opposite systems, and to extract their hidden truth, to answer questions raised by these opposite systems, to transfer the chief theories of the one system into the other, is an exercise which cannot be sufficiently

recommended to the student. He would certainly be rewarded for this labour, by becoming as independent as possible of the narrow opinions of his age.

The Soul in Nature: with Supplementary Contributions
Observations on the History of Chemistry: A Lecture 1805–1807 (p. 322)

Unknown

1. Shun and avoid the employment of unnecessary, excessive extra words.
2. Make certain all sentences are full and complete. If possible.
3. At all costs, avoid clichés as you would the plague.
4. Take pain's to spell and, pucntuate correctly.

V. BE Consistent.

6. Don't approximate. Always be more or less precise.
7. Sedulously eschew obfuscatory hyperverbosity or prolixity.
8. Avoid pointless repetition, don't repeat yourself unnecessarily.
9. Observe, in all written expression, it is, of the foremost qualification—; if not, certainly not or less than—at least definitely secondary then, the importance, of whenever possibly trying, so that when, except where it cannot be avoided and/or in further necessary development it becomes imperative to omit, yet, remember without fail (for this must not be underestimated) to be brief and clear. This is vital.

11. Always try to remember th e extreme importance of being accurate nea t and careful.

Rules for Chemistry Writers
Source unknown

X-RAYS

Polanyi, Michael
One of the greatest and most surprising discoveries of our own age, that of the diffraction of X-rays by crystals (in 1912) was made by a mathematician, Max von Laue, by the sheer power of believing more concretely than anyone else in the accepted theory of crystals and X-rays.

Personal Knowledge
Chapter 9 (p. 277)

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Now let us come to those references to authors which other books have, and you want for yours. The remedy for this is very simple: You have only to look out for some book that quotes them all, from A to Z as you say yourself, and then insert the very same alphabet in your book, and though the imposition may be plain to see, because you have so little need to borrow from them, that is no matter; there will probably be some simple enough to believe that you have made use of them all in this plain, artless story of yours. At any rate, if it answers no other purpose, this long catalogue of authors will serve to give a surprising look of authority to your book.

de Cervantes, Miguel
The History of Don Quixote de la Mancha
Preface (p. xiii)

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