1. Use of "atomic mass" rather than "atomic weight"
2. Calorimetry
3. Molecular theory of gases (collisions and energy relationships)
4. Rates of effusion and kinetic energy of molecules
5. Separation of isotopes by gaseous effusion
6. Paramagnetism (by comparing electron-spin to the "left-hand rule" of solenoids)
7. Ionization energy and the shielding effect
8. Metal deposition versus amperage and time
9. Quantum mechanics and the wave nature of the electrons in the atom

Most high schools separate chemistry and physics into their respective courses, as do lower-level courses in college. Beyond that, the separation disappears somewhat, such as in physical chemistry and chemical physics. This is especially relevant in research areas such as electrochemistry, semiconductors, and superconductivity, to mention just a few. It would seem to be to our benefit as teachers to use as much physics as possible in our lower-level chemistry courses. I have found that teaching physics principles to students is a significant help to them in the understanding of chemical principles and seeing the relationships between the disciplines.

Literature Cited

1. DeBoer, G. E. *A History of Ideas in Science Education*; Teachers College Press, Columbia University: New York, 1991.
2. The National Center for Improving Science Education, *The High Stakes of High School Science*; The Network: Andover, MA, 1991.
3. Whitley, R. *Problems in Interdisciplinary Studies*; Jurkovich, R.; Paelinck, J. H. P., Eds.; Gower: Brookfield, VT, 1984.
4. Lide, D. R., Ed. *CRC Handbook of Chemistry and Physics*, 72nd ed.; Chemical Rubber: Boston, MA, 1991–1992.
5. Bohr, N. *Phil. Mag. J. Sci.* July 1913, 26.
6. French, A. P.; Kennedy, P. J. *Niels Bohr, a Centenary Volume;* Harvard University: Cambridge, MA, 1985.
7. Hendry, J. *The Creation of Quantum Mechanics and the Bohr–Pauli Dialogue*; D. Reidel: Boston, MA, 1984.

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New Literature Suggests that We Don't Have To Teach Everything in the Textbook

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Science Curricula

What to include and what to leave out of the chemistry curriculum, with a good conscience, is a difficult decision for most teachers. As chemistry textbooks get bigger, teachers feel pressure to include more and more content. This situation also is fueled by the uncertainty of the standardized tests that students will take.

There are several routes to deciding what currently is being taught or should be taught. How can a teacher decide what should be taught?

Determining What to Teach

- One can do a content analysis of textbooks to identify what is available.
- One can look at standardized tests or teachers' exams to identify what is being tested.
- One could consult expert panels to identify what is recommended.

In many classrooms today, students are exposed to a vast array of scientific facts and terms. Students are thought of as being successful in science if they can recite the given information. Students often are given little time to analyze, to interpret, or to discuss their ideas, conceptions, or misconceptions about scientific information. Rowe states that high school science texts average between seven and 10 new concepts, terms, or symbols per page. Thus, in a school year of 180 days, and in class periods of approximately 55 minutes each, 20 concepts would have to be covered per period, an average of one every two minutes. Too many concepts and too much vocabulary, studied in too little depth also leads to teacher and student frustration (*1*). The purpose of this article is to summarize four recent documents that identify what is deemed essential in chemistry at grades 8 and 12 and to identify areas of agreement and disagreement among the sources. These documents represent panels of expert thinking. Teachers familiar with the content of these reports can make informed decisions on possible deletions and defend such curricular decisions with confidence. If a topic appears in none of the documents, teachers should be prepared to defend their inclusion on an in-depth level of study.

Documents Selected

Benchmarks for Science Literacy Project 2061. With the help of six school district teams and several hundred reviewers, this document was derived from Science for All Americans. Benchmarks are statements of what all students should know or be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12. The benchmarks are intended to be used as a resource for curriculum development (*2*).

1994 National Assessment of Educational Progress, commonly called "The Nation's Report Card," is a national representation of what students know and can do in reading, mathematics, science, and history for grades 8 and 12. In 1988, The National Assessment Governing Board was created by Congress to set guidelines for the NAEP. The Board selects the subject areas to be assessed. The NAGB uses teachers, scholars, business representatives, policy-makers, measurement specialists, and members of the public to recommend a national consensus. This consensus is reflected in the item specification process. The NAEP is conducted on a national representative sampling basis. The assessment evaluates "developmentally appropriate,

Summary of Documents

	8th Grade	12th Grade
Properties of Matter	Sources vary in specificity, but all except 2061—three sources address directly Observation of physical and chemical (color, temperature, production of new product) SSC, NSES Conservation of matter— NAEP, 2061, NSES Properties of matter and its changes—All sources Kinetic Theory—SSC, NAEP	Qualitative and quantitative understanding of the law of conservation of matter—NAEP, NSES Physical properties for all states of matter—2061, NAEP Synthesis of new materials—2061, NAEP
Structure of Matter	Atomic structure (no infrastructure)—All sources Simple molecular models—2061	Subatomic structure—All sources Kinetic Theory—NAEP Physical versus chemical versus nuclear change—2061, NAEP, NSES Electron configuration and resulting properties—2061, NSES, NAEP Use of 3-D models—2061, NSES, SSC Quantum theory—SSC Radioactivity—isotopes—2061, NSES, SSC
Solutions	Properties of solutions—SSC, NAEP (solubility versus temperature)	Solubility, solubility equilibrium—SSC, NSES Acid–Bases—SSC, 2061, NAEP
Energy & Phase Change (Physical Change)	Forms of energy—All Sources Conservation of energy—All Sources Energy transformations—2061, NAEP, NSES Digestion of food—2061 Alternative forms SSC, 2061, NAEP Phase changes— SSC, 2061, NAEP How mixtures are separated—NAEP	Forms of Energy—Descriptions to include electromagnetic, nuclear, and chemical—All Sources Consequences of energy dependencies—2061 Energy change—nuclear change—NSES, 2061, NAEP (Atomic level) Alternative sources—All sources
Nature of Chemical Change	Conservation of matter—2061, NAEP, NSES Observation of rate of change—SSC Word equations—SSC, 2061 Description of a chemical change—NAEP, SSC, 2061 Elements, compounds, mixtures—2061, NAEP Observation of endo/exothermic—SSC	Reaction Rate—2061, NSES, SSC Chemical reactions (written)—2061, NSES, SSC Complete mole concept—SSC Complete stoichiometry—SSC, NAEP System equilibrium—2061, NSES, SSC Types of reactions—SSC, NSES Bonding—2061, SSC
Technology	Environmental impact—NAEP, 2061	Resource management—NAEP, 2061 Technology is interdisciplinary—2061, NAEP Environmental and social impact—NAEP, 2061
Historical Perspectives	History of the elements—2061 Important contributions—2061 Lavoisier, Curies	Scientific universe formation—2061 Important contributors—2061 Implication of scientific finds on society—2061

SSC–*Science, Scope & Coordination;* NAEP–*National Assessment of Educational Progress;* NSES–*National Science Education Standards;* 2061–*Benchmark for Science Literacy*

complex, integrative tasks that test students' conceptual understanding as well as their mastery of the principles of scientific investigation and/or their practical reasoning capabilities" (*3*).

National Science Education Standards is the initial result of a grant awarded to the National Research Council that convened and coordinated a process that led to national science education standards K–4, 5–8, and 9–12. Representatives from the groups below have been involved and continue to participate in the drafting of curriculum and the assessment of standards. Items cited in this article are from the prototype draft from February 1993 (*4*).

- National Science Teachers Association
- American Association for the Advancement of Science
- American Association of Physics Teachers
- American Chemical Society
- Council of State Science Supervisors
- Earth Science Education Coalition
- National Association of Biology Teachers

Scope, Sequence, and Coordination of Secondary School Science. This document was prepared by the National Science Teachers Association with funding from the National Science Foundation. It was created as a guide to curriculum designers. Those who participated in the development include scientists, science supervisors, and teachers. This document provides a framework for the organization of science with a sequencing of topics that are grade appropriate. Guidelines are given for grades 6–8, 9–10, and 11–12. Its spiral curriculum from grade 6 through grade 12 allows every student to experience each science discipline every year. The framework allows for flexibility so that alterations in the sequence can be postponed to later grades instead of being dropped (5).

Organization of Data

Because the documents are not strictly parallel, the topical organization was selected from *Scope*, "Sequence and Coordination of Secondary School Science". The table is an edited compilation of results. These results are representative of what students in grades 8 and 12 should know in the area of chemistry.

Discussion of Results

Common themes throughout the documents for the 8th-grade level point to observations being made with very basic understanding. All sources call for the basic study of atomic structure, observation of energy types and transfer, symbolic or word equations, kinetic theory, properties of matter, and acid–base description. All sources also suggest deferral of atomic infrastructure, chemical equations, and stoichiometry to the high school level.

Common to all documents for the senior year are the in-depth study of the basics given at the 8th-grade level. They also include acid–base equations, systems equilibrium, 3-D models, stoichiometry, nuclear energy, and quantum theory. The senior level calls for the students to interpret the implications of modern technology on our environment and society. The importance of historical perspectives is discussed by several documents. No document recommends memorizing all chemical symbols or the periodic table for any student at any level.

Below are areas that were recommended by only a specific document. This is a short list and reflects differences in the philosophical orientation of the document creators (2, 3).

- Recycling and disposal of artificial products (NAEP)
- Specific chemical changes in fossil fuel usage (NAEP)
- Stars are made up of elements (AAAS)
- Toxic substances (AAAS)
- Mutations due to radiation or chemicals (AAAS)
- Ozone pollutant/protectant (AAAS)

Reflection

An experienced chemistry teacher knows what areas are difficult for a first-year chemistry student. Teachers sometimes do not know what is relevant or what their students really need to know. Selvaratnam cites that students often memorize and are sometimes required to memorize many items of knowledge that need not really be memorized (6). The sources cited in this paper repeatedly use the following terms: "reason", "interaction", "describe", "explain", and "predict". Rarely is the term "memorize" used as an objective. These four sources point to a more specific curriculum that allows for in-depth understanding of basic chemical principles that are related to the students' daily experiences.

New technologies have brought with them a tremendous increase in vocabulary. As educators, we must recognize when to include this information in our curriculum. For example, in all of the documents cited, deferral of any details of atomic structure to the high school level is preferred. The vocabulary of internal atomic structure has crept down to grade 5 textbooks or lower and is regarded as inappropriate.

Science curriculum must include the teaching of process skills, skills that teach our students to search for, to locate, and to interpret new terms and concepts. Educators must give them the basis upon which to build.

Teachers must first decide what foundation of information to use with their students.

Literature Cited

1. Rowe, M. B. *The Third Sourcebook for Science Supervisors*; Moltz, L. L.; Madrazo, G. M., Eds.; National Science Teachers Association: Washington, DC, 1993; p 25.
2. American Association for the Advancement of Science. *Benchmarks for Scientific Literacy*; Oxford University: New York, 1994.
3. *NAEP Science Frameworks for the 1994 National Assessment of Educational Progress*; Council of Chief Schools Officers for the National Assessment Governing Board: Washington, DC, Prepublication draft.
4. National Research Council. Draft—*National Science Education Standards*; National Academy: Washington, DC, 1994.
5. National Teachers Association. *Scope, Sequence and Coordination of Secondary School Science: The Content Core*; Washington, DC, 1992.
6. Selvaratnam, M. *J. Chem. Educ.* **1993**, *10*, 825.