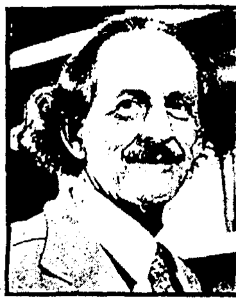

Current Comments®

EUGENE GARFIELD
INSTITUTE FOR SCIENTIFIC INFORMATION®
3501 MARKET ST., PHILADELPHIA, PA 19104

Linus Pauling: An Appreciation of a World Citizen-Scientist and Citation Laureate

Number 34 August 21, 1989

The life and works of Nobel laureate Linus Pauling are examined. Using ISI® data, Pauling's scientific endeavors are reviewed, including a discussion of his most-cited works and his recent research involving quasicrystals. Pauling's comments on a wide range of topics—from the mechanisms of scientific discovery to the notion of scientists as political activists—are also included.

> The world's great men have not commonly been great scholars,
> nor its great scholars great men.
> —Oliver Wendell Holmes[1]

Linus Pauling. For a great number of people—especially scientists—this name brings instant recognition. Pauling is one of the most written-about scientists of this century. Few people can claim to have a paper publication record that spans over 60 years (with well over 700 articles), to have been awarded two Nobel Prizes, or to be in the forefront of research well past the average age accepted for emeritus status. And in spite of his activity, he remains one of the most accessible scientists in my experience.

Many *Current Contents®* (*CC®*) readers are aware of my long-standing fascination with both polymathic scientists and respect for those with a keen sense of social responsibility. Pauling is such a scientist. Among the fields of his scientific expertise are chemistry, biochemistry, genetics, physics, and medicine. His efforts in the cause of world peace are widely recognized. As Pauling approaches his 90th birthday, it is hardly redundant to recognize an individual who has become a legend in his own lifetime.

Citation Laureate

From a citationist's point of view, Pauling has impressive statistics: he has 26 publications that have been cited in 200 or more papers (with 76 other papers having more than 50 cites), while his book *The Nature of the Chemical Bond and the Structure of Molecules and Crystals*[2] is one of the most-cited publications of all time. (Indeed, he wrote a commentary on that *Citation Classic®* that we published in *CC* in 1985.[3]) Earlier this year I discussed the citation record of this classic work in *THE SCIENTIST®*. A reprint of that editorial follows.[4]

Pauling's most-cited works span six decades, with three publications from the 1920s, eight from the 1930s, five from the 1940s, four from the 1950s, four from the 1960s, and two from the 1970s. Table 1 lists his most-cited publications and is taken from the 1945-1988 *Science Citation Index®* (*SCI®*) database. The 1945-1954 *SCI* cumulation was recently published.[5]

Pauling has received many awards, including the Award in Pure Chemistry of the American Chemical Society (ACS) in 1931; the Davy Medal of the Royal Society of London in 1947; the International Lenin Peace Prize of the Soviet government in 1971; the National Medal of Science of the National Science Foundation (NSF) in 1975; the Lomonosov Gold Medal of the Academy of Sciences of the USSR in 1978; the

Table 1: Linus Pauling's publications cited over 200 times in the *SCI*®, 1945-1988. A=number of citations received. B=bibliographic data.

15,318	**Pauling L.** *The nature of the chemical bond and the structure of molecules and crystals: an introduction to modern structural chemistry.* Ithaca, NY: Cornell University Press, 1960. 644 p.
863	**Pauling L, Itano H A, Singer S J & Wells I C.** Sickle cell anemia, a molecular disease. *Science* 110:543-8, 1949.
774	**Pauling L, Corey R B & Branson H R.** The structure of proteins: two hydrogen-bonded helical configurations of the polypeptide chain. *Proc. Nat. Acad. Sci. USA* 37:205-11, 1951.
749	**Pauling L.** Atomic radii and interatomic distances in metals. *J. Amer. Chem. Soc.* 69:542-53, 1947.
561	**Pauling L & Wilson E B.** *Introduction to quantum mechanics with applications to chemistry.* New York: McGraw-Hill, 1935. 468 p.
456	**Pauling L.** The nature of the chemical bond. Application of results obtained from the quantum mechanics and from a theory of paramagnetic susceptibility to the structure of molecules. *J. Amer. Chem. Soc.* 53:1367-400, 1931.
448	**Pauling L.** The theoretical prediction of the physical properties of many-electron atoms and ions: mole refraction, diamagnetic susceptibility, and extension in space. *Proc. Roy. Soc. London Ser. A* 114:181-211, 1927.
399	**Pauling L.** The structure and entropy of ice and of other crystals with some randomness of atomic arrangement. *J. Amer. Chem. Soc.* 57:2680-4, 1935.
397	**Pauling L.** A molecular theory of general anesthesia. *Science* 134:15-21, 1961.
370	**Pauling L.** A theory of the structure and process of formation of antibodies. *J. Amer. Chem. Soc.* 62:2643-57, 1940.
316	**Pauling L.** A resonating-valence-bond theory of metals and intermetallic compounds. *Proc. Roy. Soc. London Ser. A* 196:343-62, 1949.
309	**Pauling L.** The rotational motion of molecules in crystals. *Phys. Rev.* 36:430-43, 1930.
306	**Pauling L & Coryell C D.** The magnetic properties and structures of hemoglobin, oxyhemoglobin and carbonmonoxyhemoglobin. *Proc. Nat. Acad. Sci. USA* 22:210-6, 1936.
288	**Pauling L & Corey R B.** Atomic coordinates and structure factors for two helical configurations of polypeptide chains. *Proc. Nat. Acad. Sci. USA* 37:235-40, 1951.
283	**Pauling L & Corey R B.** Configurations of polypeptide chains with favored orientations around single bonds: two new pleated sheets. *Proc. Nat. Acad. Sci. USA* 37:729-40, 1951.
282	**Cameron E, Pauling L & Leibovitz B.** Ascorbic acid and cancer. *Cancer Res.* 39:663-81, 1979.
276	**Pauling L.** The principles determining the structure of complex ionic crystals. *J. Amer. Chem. Soc.* 51:1010-26, 1929.
262	**Pauling L.** The diamagnetic anisotropy of aromatic molecules. *J. Chem. Phys.* 4:673-7, 1936.
252	**Pauling L.** The nature of the chemical bond. IV. The energy of single bonds and the relative electronegativity of atoms. *J. Amer. Chem. Soc.* 54:3570-82, 1932.
241	**Pauling L.** *Vitamin C and the common cold.* San Francisco, CA: Freeman, 1970. 122 p.
233	**Pauling L.** The nature of the interatomic forces in metals. *Phys. Rev.* 54:899-904, 1938.
225	**Pauling L.** Nature of the iron-oxygen bond in oxyhaemoglobin. *Nature* 203:182-3, 1964.
218	**Zuckerkandl E & Pauling L.** Evolutionary divergence and convergence in proteins. (Bryson V & Vogel H J, eds.) *Evolving genes and proteins.* New York: Academic Press, 1965. p. 97-166.
211	**Pauling L & Corey R B.** Compound helical configurations of polypeptide chains: structure of proteins of the alpha-keratin type. *Nature* 171:59-61, 1953.
206	**Pauling L.** The sizes of ions and the structure of ionic crystals. *J. Amer. Chem. Soc.* 49:765-90, 1927.
204	**Pauling L, Pressman D & Grossberg A L.** The serological properties of simple substances. VII. A quantitative theory of the inhibition by haptens of the precipitation of heterogeneous antisera with antigens, and comparison with experimental results for polyhaptenic simple substances and for azoproteins. *J. Amer. Chem. Soc.* 66:784-92, 1944.

Award in Chemical Sciences of the National Academy of Sciences of the US in 1979; and the Priestley Medal of the ACS in 1984. Recently he received NSF's Vannevar Bush Award.[6]

He has been given honorary doctorates by over 45 institutions, including universities in Chicago, Princeton, New Haven, Cambridge (UK), Oxford, London, Paris, Toulouse, Montpellier, Liège, Melbourne, Delhi, Krakow, Berlin, and Zagreb. Pauling has also been made an honorary member of the academies of science of Austria, Belgium, India, Italy, Norway, Poland, Portugal, Romania, the USSR, Yugoslavia, and other countries.[7]

Pauling cofounded in 1973 the Linus Pauling Institute of Science and Medicine, Palo

Linus Pauling

Alto, California. This nonprofit organization's mission is to improve the quality of human life by prevention of disease and to relieve human suffering through utilization of advanced techniques of chemistry, physics, molecular biology, and medicine. Currently, the institute's research emphasis is on cancer, nutrition, and the aging process.

Pauling on Papers and Published Ideas

Recently, we spoke at length with Pauling, who reflected on his long career as a scientist and scholar. The topics discussed were wide-ranging—covering his life, his works, and his views on science. Excerpts of this conversation are interspersed throughout this essay.[8]

Q: What papers do you feel are your most important works? Your most original? Your most undervalued?

Pauling: Well, I think the most important single paper that I published was the "The nature of the chemical bond" in the *Journal of the American Chemical Society*[9] in March or April of 1931. The most important collection of papers would be the ones that preceded it in 1928[10-13] and followed it dealing with electronegativity scale and resonance of molecules among different electronic structures.[14-16] The one that perhaps hasn't been recognized so greatly for its significance was the one that I published with my students and postdoc fellows in 1949 entitled "Sickle cell anemia, a molecular disease"[17] [cited over 850 times]. It led to the development of the whole field called the hemoglobinemias and, in fact, to many other applications. My paper on the molecular basis of general anesthesia [cited almost 400 times] might be my most original.[18]

Q: On the subject of original ideas and publications, have you ever had any scientific ideas that you thought were so outrageous or unusual that you never mentioned them to anyone?

Pauling: I usually published my "unusual" ideas, and, of course, there have been a few times when I was wrong. But other times I have heard it said, or it was reported to me that it was said, that I have been right so often in the past that I'm probably right now, too—about such ideas as the value of high doses of vitamin C.[19] Perhaps I have had some outrageous ideas, but they were so outrageous that I buried them deeply in my memory. I think my answer is that I tend to publish my ideas even though they are quite unconventional.

On the Process of Scientific Discovery

Pauling's career has been characterized by his capacity for quick insight into new problems, his ability to recognize interrelationships, and the courage to put forward unorthodox ideas. His intuitive guesses, aided by a phenomenal memory of chemical facts, have been referred to by Pauling as the "stochastic method" (from the Greek "apt to divine the truth by conjecture").[20] Pauling talked about his experiences with the process of discovery.

Q: What qualities do you think make great scientists? Is it necessary that scientists think unconventionally for breakthroughs to happen?

Pauling: Well, there are different kinds of great scientists. I think probably an important quality is the ability to recognize problems that might be solved if we worked hard enough at the problem. For example, James Watson felt sure that it was going to be possible to discover the molecular nature of the gene and worked hard at it—even to such an extent that he was fired from the Rockefeller Fellowship that he had. Of course, Einstein has been quoted as saying that, when he was 15 years old, he asked himself what would the world look like if [he] were moving with the velocity of light. To attack that problem he inquired into the nature of equations that had been set up for electromagnetic fields—Maxwell's equations. It was the study of Maxwell's equations that led Einstein to his special theory of relativity. Einstein started thinking about the problem when he was 15; he was 25 when he formulated the special relativity equations. And, of course, I have often worked on a problem for 10 years before finding the solution. And, in one case, I worked on a problem for 40 years—and then one of my students solved it for me.

Q: How long did it take your student to solve the problem?

Pauling: I think he was working pretty steadily on it for perhaps a year. That was Sten Samson, and the problem was the structure of sodium dicadmide: a problem that I mentioned in the second paper that I published, which had the title "The crystal structure of magnesium stannide."[21] That was the first intermetallic compound to have its structure determined. Sodium dicadmide had a very complicated structure—so that was one I worked on for 40 years. Samson solved the problem and published it in 1962[22] [referenced in 13 publications]. In addition to thinking about problems for a long period of time—problems that I think I might be able to solve—I have a very wide knowledge about all fields of science, essentially, and I often applied something I learned in one field of science to a problem in another field of science. My work on anesthesiology is an example; it was crystal structure that led me to solve that problem.

Q: How have your best, or most productive, ideas come to you? Do they come via dreams, concentrated thought, or relaxation?

Pauling: I was one of three people who spoke at a symposium on creativity at the Third World Congress of Psychiatry in Montreal in 1961.... And I said that often my original ideas have come as the result of training my unconscious mind to think about a problem. I gave as an example the one on the theory of general anesthesia. I was in Boston as a member of the scientific advisory board of Massachusetts General Hospital in 1952, and this board was lectured to by the professor of anesthesiology at Harvard—Henry K. Beecher. Beecher said something that I hadn't known, that the noble gas xenon can act as a general anesthetic agent. So I said to my son (who was studying medicine), "How do you think xenon can serve as a general anesthetic agent, since xenon doesn't form any compounds in the human body? It must be some sort of a physical action—I don't understand it." I thought about it day after day for several days; in the evening when I would go to bed, I would lie there and think about the problem.... After a while I stopped that. Then, seven years later, I was reading a scientific paper on crystal structure, and I said to myself, I understand anesthesia. I worked for about a year gathering data, and then I published my paper on "A molecular theory of general anesthesia."[18] So I had trained my unconscious mind to keep this problem in view, and whenever any new thought entered my head, any new piece of information, I would connect it up with that problem to see if there was any connection.... By the way, my talk was published in the proceedings of the Third World Congress of Psychiatry.[23]

On Activism and the Conduct of Science

Despite nearing his 90th birthday, Pauling is still the consummate scientist, and his research activity remains influential worldwide. According to ISI® research-front data, Pauling has been a core author in research fronts consistently for the past five years—5 in 1984, 4 in 1985, 3 in 1986, 7 in 1987, and 10 in 1988. (He has, of course, also been a core author in earlier research fronts, too numerous to mention here.) Table 2 identifies the 1988 research fronts that have Pauling as a core author. One of the fronts, #88-1424, "Quasicrystals," represents a topic that Pauling is presently pursuing.[24,25] According to a recent article in *THE SCIENTIST*, the Linus Pauling Institute is ranked among the top 10 institutions conducting research in this field.[26]

At present, quasicrystal research is in a state of flux. As is normal in ongoing research, there are differing viewpoints, some controversial. And Pauling's view on the existence and properties of quasicrystals is seen as contentious to some. To many people, Pauling's standing viewpoints on many topics—whether scientific or political—are similarly viewed. In the supposedly apolitical atmosphere of science, Pauling advocates activism.

Q: Is controversy useful in scientific research?

Pauling: I doubt it. I would say not—so far as I am concerned—it's the problems themselves that interest me, not whether or not a matter is controversial.

Q: In your view, should scientists become more active politically? Under what circumstances?

Pauling: Well, of course I published many papers, and my book *No More War!*[27] In several of my papers, I talked about science and humanity; science, politics, and physics; and the obligations of scientists. I've said that I believe scientists have the duty of helping their fellow citizens to understand the important problems—the scientific aspects of them. Almost every problem in the world today has some scientific basis or involvement. Sometimes it is hard even for the scientists to understand the problems. I say that scientists should not only help educate and inform their fellow citizens, but also express their own opinions.... I think political activity is very important. A good example was the "Stop the Vietnam War" campaign, which was finally successful. In my own case, it interfered significantly with my scientific work. I thought that the problem of nuclear war was such an important one and that the possibility of wars between the great nations was now being ruled out by the development, construction, and stockpiles of nuclear weapons that I decided...I ought to sacrifice some of my time in order to work in this field [of helping to eliminate nuclear weapons and reduce the risk of war].

Q: Do you think science has entered into an era of playing for public media attention? For example, the idea of cold fusion, which has apparently been disproven.

Pauling: No, I wrote a paper published in *Nature*—a letter to the editor[28]—that I think

Table 2: The 1988 *SCI*® research fronts in which Linus Pauling is a core author. A=number of core papers. B=number of citing papers.

Number	Name	A	B
88-0113	Hydrogen-bonded systems	40	904
88-0465	Ice phase transitions, proton transfers, and dielectric-relaxation spectra	33	306
88-0474	Atomic structure in metals	25	322
88-0931	Mixed-valence coordination clusters	4	24
88-1424	Quasicrystals	57	466
88-1704	Electron spin resonance	12	119
88-3050	Natural bond orbitals	5	63
88-3306	Crystal structure and bonding in transition metals	4	67
88-6699	Chemical hardness and bond dissociation energies	2	12
88-7703	Electronic polarizability of ions	2	27

accounts for the thermal manifestations, the development of heat, and even the explosion. However, there have been several scientific developments or "pseudodevelopments" that have attracted a great deal of attention, partially because of the possible great practical value. One example, of course, is cold fusion. A second example is high-temperature superconductivity. And a third is the so-called icosahedral quasicrystals. In the article in *THE SCIENTIST*, Paul J. Steinhardt [Department of Physics, University of Pennsylvania, Philadelphia] listed about 1,500 papers that have been published [on quasicrystals],[26] and my estimate is that about 1,000 scientists have been working in this field during the last five years....

The reason for the great attention paid to this one aspect of metals science, metals and alloys and crystallography, is...the possibility that there is a new form of matter. And I think all of these people, and the people in industry, especially, said to themselves—and even outright—that, since crystals with a fivefold axis of symmetry had not been known before, and since the electronic and physical properties of metals and alloys are the basis of tremendous industries—airplane industries, lightweight, strong alloys industries, and so on—we ought to look hard at these new kinds of crystals. Steinhardt said that over 100 different compositions of alloys, different intermetallic compounds, have now been shown to form quasicrystals. So there has been great interest, but, of course, no one has succeeded in finding any unusual electronic or physical properties of these substances. That's just what one would expect from my theory of their nature, which is that they're ordinary intermetallic compounds containing icosahedral clusters such as three of my students and I described in 1952,[29] and also the magnesium-aluminum-zinc alloy that we described in 1952[30]—the fact that they are twins doesn't change their electronic properties or physical properties significantly. So this is a forlorn hope that these so-called icosahedral quasicrystals will have unusual electronic or other physical properties.

Reflections on a Life

Today, Pauling is world-renowned; however, his path to get there was at times less than auspicious, due in part to financial hardship as a result of his father's death when Pauling was nine years old. Despite this, as well as his not receiving a high-school diploma, he received his BS in chemical engineering in 1922 from Oregon Agricultural College, Corvallis. To help support himself and his mother, Pauling worked in a dormitory kitchen and graded papers. In 1925 he was awarded a PhD degree from the California Institute of Technology (Caltech), Pasadena, *summa cum laude*.[31] During 1926 and 1927, Pauling visited Europe on a Guggenheim Fellowship, studying quantum mechanics with Arnold Sommerfeld in Munich, Germany; Erwin Schrödinger in Zurich, Switzerland; and Niels Bohr in Copenhagen, Denmark. From there, his scientific career took off.

Q: If you were starting over today, what fields of scientific endeavor would you participate in? Would they be the same as those you have been and are working on?

Pauling: Well, I have been very fortunate in my life. I had some difficulties, of course—financial difficulty—when I was a boy, and there was a question as to whether I would go on to college or not. After some struggle I succeeded in doing that—getting an education. I was very fortunate in going to Caltech in 1922. I think there is no place in the world that I could have gone to that would have been better in preparing me. In general, I had good luck. I was fortunate in that Professor Arthur Amos Noyes of the Chemistry and Chemical Engineering Division at Caltech wrote to me to say that he thought that I should work with Roscoe Dickinson in the field of X-ray crystallography. I don't know why he selected me from among a half-dozen new graduate students that he hadn't seen, to make that suggestion. But he did, and I couldn't have had a better field of work to get going on, with such a powerful technique. I was able to relate to problems I was interested in—the molecular basis of chemistry. I was able to solve problem after problem every few months as a graduate student. And, of course, I was fortunate in being around just as quantum mechanics was being developed.

I arrived in Germany on my Guggenheim Fellowship just about simultaneously with the publication of Schrödinger's first paper on wave mechanics. I arrived at the end of April 1926, and I even had a paper on quantum mechanics published in 1926. And, of course, several in 1927 and 1928 and from then on. Of course, I was fortunate in having married the right person, in having been picked out by the right young woman. I don't think I could have had a better career for myself, and, of course, I didn't really plan it.... I think it was fine that I spent much of my earlier years in mathematics and theoretical physics. My PhD degree—I ran across my diploma a few months ago and noticed that it said "for his research in physical chemistry and mathematical physics." I still think that's a fine basis. There are many physicists who have as good a background in mathematics and physics as I have. I differ from most physicists of a generation or two ago in having had a tremendous background of knowledge in chemistry, too.

Q: Of the Nobel Prizes that you have won, does one have more meaning for you than the other?

Pauling: I was asked that question on the 10th of October 1963 by a reporter—it might have been UPI (this is the same day the Nobel Peace Prize was awarded to me[32]). I have been asked it every once in a while.... And I say, well, I was pleased to have received the Nobel Prize in chemistry in 1954. I wasn't sure I was going to get it because it seemed to me that I hadn't made a single great discovery. I made a lot of small discoveries that all together constituted the formulation of a new kind of chemistry, starting in 1931 [with] my first paper on quantum mechanics and the chemical bond.[15] But I received it, and I had just been enjoying myself—you know, doing chemistry, trying to solve problems—which I still find the most pleasurable activity. So I was pleased that I received the Nobel Prize in chemistry, but I value the Nobel Peace Prize more. I wasn't especially interested in political action or in working for world peace up to 1945. I didn't see any way in which I could do anything that would be significant. I thought that war institutionally was going to be with the human race forever (or at least in my lifetime), but when atomic bombs came along, I thought here—and my wife and I decided too—that I should sacrifice my scientific work. I thought here is the possibility of eliminating war from the world. So, of course, I got into quite a lot of trouble. It was quite an unpleasant period: the McCarthy period. There were times when my passport was taken away from me and I couldn't go to scientific meetings abroad, and Caltech was trying to get rid of me (a place I liked very much). I resisted those efforts. But it wasn't pleasant, so I said that I valued the peace prize more. It showed that working for world peace has become respectable.

* * * * *

My thanks to C.J. Fiscus and Peter Pesavento for their help in the preparation of this essay.

REFERENCES

1. Holmes, Oliver Wendell. *The Oxford dictionary of quotations.* New York: Oxford University Press, 1979. p. 253.
2. **Pauling L.** *The nature of the chemical bond and the structure of molecules and crystals: an introduction to modern structural chemistry.* Ithaca, NY: Cornell University Press, 1960. 644 p.

3. --------------. Citation Classic. Commentary on *The nature of the chemical bond and the structure of molecules and crystals: an introduction to modern structural chemistry.* Ithaca, NY: Cornell University Press, 1939. 429 p. *Current Contents/Engineering, Technology & Applied Sciences* 16(4):16, 28 January 1985 and *Current Contents/Physical, Chemical & Earth Sciences* 25(4):16, 28 January 1985.
4. **Garfield E.** In tribute to Linus Pauling: a citation laureate. *THE SCIENTIST* 3(2):10, 23 January 1989.
5. --------------. The new 1945-1954 *SCI* cumulation provides unique access to the crucial postwar decade of scientific and technological achievement. *Current Contents* (27):3-10, 4 July 1988.
6. NSF award goes to Linus Pauling. *THE SCIENTIST* 3(12):17, 12 June 1989.
7. Biography: Linus Pauling. *Croat. Chem. Acta* 61:C6-8, 1988.
8. **Pauling L.** Personal communication. 27 June 1989.
9. --------------. The nature of the chemical bond. Application of results obtained from the quantum mechanics and from a theory of paramagnetic susceptibility to the structure of molecules. *J. Amer. Chem. Soc.* 53:1367-400, 1931.
10. --------------. Die Abschirmungskonstanten der relativistischen oder Magnetischen Rontgenstrahlendubletts (Shielding constants of relativistic or magnetic X-ray doublets). *Z. Phys.* 40:344-50, 1926.
11. --------------. The shared-electron chemical bond. *Proc. Nat. Acad. Sci. USA* 14:359-62, 1928.
12. --------------. Influence of relative ionic sizes on the properties of ionic compounds. *J. Amer. Chem. Soc.* 50:1036-45, 1928.
13. --------------. Application of the quantum mechanics to the structure of the hydrogen molecule and hydrogen molecule ion and to related problems. *Chem. Rev.* 5:173-213, 1928.
14. --------------. The nature of the chemical bond. II. The one-electron bond and the three-electron bond. *J. Amer. Chem. Soc.* 53:3225-37, 1931.
15. --------------. Quantum mechanics and the chemical bond. *Phys. Rev.* 37:1185-6, 1931.
16. --------------. The nature of the chemical bond. III. The transition from one extreme bond type to another. *J. Amer. Chem. Soc.* 54:988-1003, 1932.
17. **Pauling L, Itano H A, Singer S J & Wells I C.** Sickle cell anemia, a molecular disease. *Science* 110:543-8, 1949.
18. **Pauling L.** A molecular theory of general anesthesia. *Science* 134:15-21, 1961.
19. --------------. The significance of the evidence about ascorbic acid and the common cold. *Proc. Nat. Acad. Sci. USA* 68:2678-81, 1971.
20. Pauling, Linus (Carl). *Encyclopaedia Britannica*. Chicago, IL: Encyclopaedia Britannica, 1985. Vol. 9. p. 210-1.
21. **Pauling L.** The crystal structure of magnesium stannide. *J. Amer. Chem. Soc.* 45:2777-80, 1923.
22. **Samson S.** Crystal structure of $NaCd_2$. *Nature* 195:259-62, 1962.
23. **Rinkel M**, ed. *Specific and nonspecific factors in psychopharmacology: proceedings of the Third World Congress of Psychiatry,* 4-10 June 1961, Montreal, Canada. New York: Philosophical Library, 1963. 174 p.
24. **Pauling L.** Apparent icosahedral symmetry is due to directed multiple twinning of cubic crystals. *Nature* 317:512-4, 1985.
25. Pauling's twinning model. *Mosaic* 18(4):20-1, Winter 1987-88.
26. **Steinhardt P J.** 'Quasicrystal' investigation is mounting. *THE SCIENTIST* 3(11):12; 14; 18, 29 May 1989.
27. **Pauling L.** *No more war!* Westport, CT: Greenwood Press, 1975. 262 p.
28. --------------. Letter to editor. (Explanations of cold fusion.) *Nature* 339(6220):105, 11 May 1989.
29. **Shoemaker D P, Marsh R E, Ewing F J & Pauling L.** Interatomic distances and atomic valences in $NaZn_{13}$. *Acta Crystallogr.* 5:637-44, 1952.
30. **Bergman G, Waugh J L T & Pauling L.** Crystal structure of the intermetallic compound $Mg_{32}(Al, Zn)_{49}$ and related phases. *Nature* 169:1057-8, 1952.
31. Pauling, Linus C. (Wasson T, ed.) *Nobel Prize winners.* New York: Wilson, 1987. p. 798-801.
32. **Pauling L.** *Science and peace: the Nobel Peace Prize lecture.* Washington, DC: Center for the Study of Democratic Institutions, 1964. 15 p.

