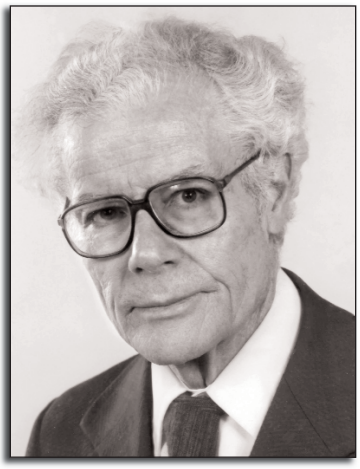
David Turnbull (1915–2007)—In Memoriam

David Turnbull passed away at his home in Cambridge, Massachusetts, on April 28, 2007, at the age of 92. A physical chemist by training, he laid the foundations of the quantitative study of the kinetics of phase transformations in condensed matter. He has been associated with the Materials Research Society from its inception. The Society's interdisciplinary charter resonated with the breadth of his scientific interests. He was a regular speaker and participant in the early symposia on laser- and ion-beam–induced phase transformations. Following his retirement in 1985, his friends established a fund at MRS to endow the David Turnbull Lectureship.



David Turnbull

In 1979, Turnbull received the third Von Hippel Award, the Society's oldest and highest honor, following awards to von Hippel himself and to William Baker of Bell Laboratories. On that occasion, Turnbull remarked, "It is not clear that I belong in this progression. I feel that I am in a position like that of a certain Linus. I'm sure you all know two famous persons named Linus, but you may not have heard of the Linus I am referring to. He was [...] the first Bishop of Rome following the Apostles Peter and Paul." That he was being characteristically modest becomes clear when one re-reads, almost thirty years later, his remarkably prescient acceptance speech on "Directions in Materials Science."[1]

Turnbull is best known for his formulation, in the late 1940s, of the classical theory of crystal nucleation from the melt, which he tested quantitatively in a series of experiments on undercooled liquid metal droplets. His measurements of the homogeneous crystal nucleation frequency in emulsified droplets of mercury[2] remain models of their kind. His qualitatively most spectacular result was that simple monatomic liquids, like copper or silver, could be undercooled to at least 80% of their absolute melting point. This demonstrated that the structure of liquids is fundamentally different from that of crystals, and it was the basis of F.C. Frank's proposal that the short range order in simple liquids has a polytetrahedral character, which favors the formation of (non-crystallographic) icosahedral clusters.

From undercooling to universal glass formation was a logical step: Turnbull predicted that all liquids could be cooled to the glassy state if their viscosity rose sufficiently sharply with the falling temperature. There was empirical evidence of such a rise, for which he developed, with Morrel Cohen, the now widely used free-volume model based on the probability of density fluctuations.[3] Confirmation came in 1959, when Pol Duwez discovered an amorphous phase in a splat-quenched Au-Si alloy—precisely at the eutectic composition predicted by Turnbull as most favorable for glass formation.

That these rapidly quenched amorphous metals were true glasses, like the well-known silicate or organic glasses, was proved by Turnbull and his associates by demonstrating that they exhibited the characteristic features of a glass transition: a discontinuity in the coefficient of thermal expansion and in the specific heat, and a rapid decrease of the viscosity upon heating. Turnbull's deep understanding of crystal nucleation also led him to the insight that it should be possible to bring alloys with a low liquidus and a high glass transition temperature into the glassy state at very low cooling rates if heterogeneous nucleants were eliminated, for example by fluxing. Together with Lindsay Greer and their students, he demonstrated this in 1982 on $Pd_{40}Ni_{40}P_{20}$, the first bulk metallic glass.[4]

Although Turnbull may be best known for his work on nucleation and glass formation, he has made many other key contributions to materials science. In the area of diffusion, he made, with R.E. Hoffman, the first measurements of short-circuit diffusion along grain boundaries and dislocations and, with F.C. Frank, he identified the interstitial mechanism for fast diffusion of noble metals in semiconductors. He extended the latter work to a broad study of fast diffusion of noble metals in polyvalent hosts. He maintained an interest in understanding the attachment of atoms from the liquid or amorphous phase to a growing crystal surface, especially under conditions of high pressure or large undercooling. He also made some of the early contributions to the analysis of grain growth and recrystallization.

David Turnbull was born in 1915 on a farm near Kewanee, Illinois. He obtained his BSc degree at Monmouth College in 1936 and his PhD degree in physical chemistry at the University of Illinois in Urbana in 1939. Between 1939 and 1946, he was a member of the faculty at the Case Institute of Technology. From 1946 until 1962, he was on the staff of the General Electric Research Laboratory in Schenectady, N.Y., where he was for a while the head of the Chemical Metallurgy section. In 1962 he became Gordon McKay Professor of Applied Physics at Harvard University, where he became emeritus in 1985. He was a member of the National Academy of Sciences. Besides the Von Hippel Award, he received the Japan Prize, the Acta Metallurgica Gold Medal, the New Materials Prize of the American Physical Society, the Franklin Medal, the Hume-Rothery Award

David Turnbull (bottom left) greets students and Turnbull Lecturers at the 2006 Materials Research Society Fall Meeting in Boston.

of TMS-AIME, and many other honors. For many years he was co-editor, with Frederick Seitz and Henry Ehrenreich, of the well-known Solid State Physics Series.[5]

But even more than for his distinguished scientific career, David Turnbull will be remembered as a uncommonly wise and generous human being, who recognized and brought out the best in everyone. This made him, in spite of his understated style, a highly effective teacher and advisor to generations of students and associates. It is therefore fitting that his eponymous Lectureship at MRS recognizes both research and teaching "as exemplified by the life work of David Turnbull." An unforgettable example, indeed.

FRANS SPAEPEN
Harvard University

References

1. D. Turnbull, "Laser and Electron Beam Processing of Materials," in *Materials Research Society Symposia Proceedings*, (Academic Press, New York, 1980), p. 1.

2. D. Turnbull, *J. Chem. Phys*. **20**, 411 (1952).

3. M.H. Cohen and D. Turbull, *J. Chem. Phys.* **31**, 1164 (1959).

4. A.J. Drehman, A.L. Greer, and D. Turnbull, *Appl. Phys. Lett*. **41**, 716 (1982); H.W. Kui, A.L. Greer, and D. Turnbull, *Appl. Phys. Lett*. **45**, 615 (1984).

5. D. Turnbull, Autobiography, www.mrs.org/Turnbull.

MRS Members Participate in Congressional Visits Day

Members and staff of the Materials Research Society recently participated in the 2007 Science, Engineering & Technology (SET) Congressional Visits Day on May 1–2. This event, held annually, brings several hundred scientists, engineers, researchers, educators, and technology executives to Washington, DC to advocate for legislation important to the science community. This year's core message was the importance of competitiveness and innovation policies to sustaining U.S. technological leadership and in developing a skilled, creative, and effective workforce.

Participants first attended an orientation session at the American Association for the Advancement of Science (AAAS) on May 1, sponsored by SET. Speakers included Sharon Hays, Associate Director for Science, Office of Science & Technology Policy; Kei Koizumi, Director, R&D Budget Policy Program, AAAS; Chuck Atkins, Chief of Staff, House Committee on Science and Technology; Kathryn Clay, Professional Staff, Senate Committee on Energy and Natural Resources; and Bill Leinweber, Executive Vice President, Research!America.

This session was followed by a reception and awards ceremony at the Russell Senate Building, during which the George E. Brown Jr. SET Leadership Award was presented to Representative Nancy Pelosi (D-Calif.), Speaker of the House of Representatives and Senator Lamar Alexander (R-Tenn.), U.S. Senate Committee on Appropriations. This award is presented annually to individuals who have served as active leaders in the determination of Science/Engineering/Technology (SET) policy and have demonstrated strong public advocacy in support of a role for the federal government in research and who have taken specific actions to advance SET public policy.

That evening, MRS members held a separate orientation session to form MRS teams for the next day's Congressional Visits and to review background materials and issues to focus the MRS message.

Members of the Materials Research Society participated in the 2007 Science, Engineering & Technology Congressional Visits Day on May 1–2 to encourage their legislators to support the physical sciences.

On May 2, a group of 31 MRS members visited the offices of their representatives and senators to discuss relevant issues, and the effects and importance of these issues in their own Congressional district/state, as well as to the country as a whole. Members of Congress were encouraged to support the Administration's budget request for the American Competitiveness Initiative regarding the National Science Foundation (NSF), the Department of Energy (DOE) Office of Science, and the National Institute of Standards and Technology, aimed at doubling these appropriations over the next 10 years. Congressional members were also encouraged to increase support for Federal investments in research and development (R&D), with an emphasis on appropriations for science and technology in NSF, DOE, and the Department of Defense (DoD). They were also induced to support the Innovation bills that were being considered by the House and Senate at that time and to maintain the U.S. innovative edge by investing in basic research and education.

Although the SET Congressional Visits Day is held only once a year, MRS members are encouraged to visit their representatives and senators both in Washington and in their home districts to advocate for support for the physical sciences. For interested members, MRS can provide information on the current issues and pending legislation. For more information, contact Kathy D'Biagio at dbiagio@mrs.org.