KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel for 2012 to **Alvin E. Roth** and **Lloyd S. Shapley** "for the theory of stable allocations and the practice of market design".

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2012

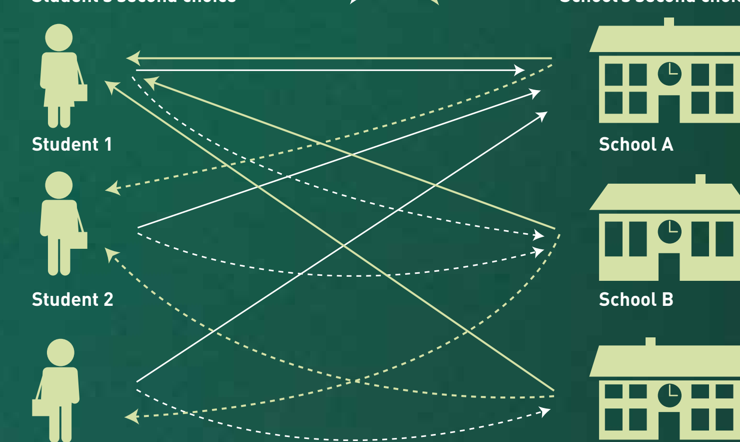
A Perfect Match

This year's prize concerns a central economic problem: how to match different agents with each other as well as possible. For example, students have to be matched with schools, and donors of human organs with patients in need of a transplant. How can such matching be accomplished in an efficient way? What methods are beneficial to what groups?

The prize honors Alvin Roth and Lloyd Shapley who have answered these questions. Lloyd Shapley has studied the foundations of matching theory. A key issue is that of stability. A matching is stable if there are not two agents who would prefer to be matched with each other instead of their assigned counterparts.

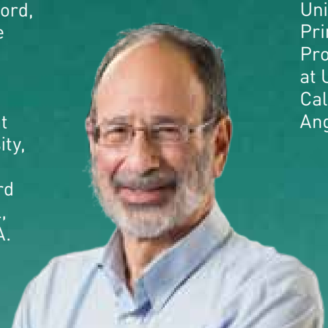
As early as 1962, Shapley together with David Gale developed an algorithm for finding stable matches in two-sided matching problems, such as how to match students and schools. In 1974, Shapley characterized another algorithm for one-sided matching problems, applicable to changing apartments or finding organs for transplant operations.

In the beginning of the 1980s, Alvin Roth addressed a remaining problem: how to prevent people from making strategic choices and instead make them state their true preferences to the centralized clearinghouse. Roth has also studied a variety of matching markets in real life. He found that many algorithms have been used, but those that succeed usually have one thing in common: they satisfy Gale and Shapley's stability criterion. Roth has subsequently constructed new algorithms to better match resident medical doctors to hospitals, workers to jobs, pupils to schools, and kidney donors to patients.



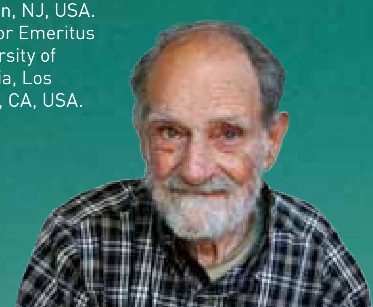
Alvin E. Roth

U.S. citizen. Born 1951 in New York, NY, USA. Ph.D. 1974 from Stanford University, Stanford, CA, USA. George Gund Professor of Economics and Business Administration at Harvard University, Cambridge, MA, USA, and Harvard Business School, Boston, MA, USA.



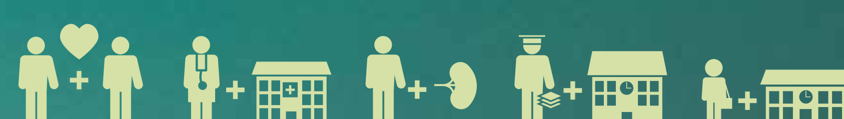
Lloyd S. Shapley

U.S. citizen. Born 1923 in Cambridge, MA, USA. Ph.D. 1953 from Princeton University, Princeton, NJ, USA. Professor Emeritus at University of California, Los Angeles, CA, USA.



Who gets what?

This is a central question in everybody's life: how to find a partner; to find the right kindergarten, school, or college; to get a job. Some of these matching problems are best solved simultaneously by having agents communicate their preferences to a matching office, or clearinghouse. This year's Laureates have developed efficient methods that clearinghouses can apply in order to find stable solutions. For as few as 25 pairs, the possible matchings are already more numerous than all the stars in the universe. The challenge is to find the stable matchings.



The Gale-Shapley algorithm

The algorithm is a method for how to match two types of agents, e.g. students and schools, with each other. First, each student and each school are asked to rank their favorite choices. Second, all schools preliminarily hold on to their favorite applicants, up to the number of seats available. Third, all rejected students apply to their second choice school. This procedure continues until each student is matched to any of the chosen schools that also accepts the student.

Matching schools and students

All students prefer school A, and all schools prefer student 1. How could the three students be allocated to the three schools in a way that is acceptable to all? The Gale-Shapley algorithm can be used to show two possible stable allocations:

- Student 1 goes to school A, student 2 to school B and student 3 to school C (students' second choice).
- Student 1 goes to school A, student 2 to school C and student 3 to school B (schools' second choice).

In reality, of course, the number of students is much larger, and each school can admit more than one student. With larger pools, using the Gale-Shapley algorithm to find the stable allocations requires computer processing.

Matching kidneys and patients

In case of kidney failure, it often happens that a family member wants to donate a kidney to the patient. But the donor's kidney may not be compatible with, for instance, the recipient's blood type. A solution is to organize a kidney exchange, a chain where kidneys for transplant operations are not tied to specific recipients. However, this can cause large logistical problems; with as few as ten couples, there are more than 3.6 million different ways to combine donors and recipients. Today, Roth's algorithms are used to find the best matches, enhancing the welfare of donors as well as recipients.

FURTHER READING! Information on the Prize in Economic Sciences 2012: http://kva.se and http://nobelprize.org. **BLOGG** ● *Market Design* www.marketdesigner. blogspot.se **PRESENTATIONS (VIDEO)** ● **Roth, A. E.** (2007) *What Have We Learned from Market Design*, Rosenthal Memorial Lecture, Boston University: www.youtube.com/watch?v=7qrYC0Ojf-o. ● **Roth, A. E.** (2007) *Market Failure and Market Design*, Google Tech Talks: www.youtube.com/watch?v=4tdOY-HHC7s. **REVIEW ARTICLE** ● **Roth, A. E.** (2008) What have we learned from market design?, *Economic Journal*, 118: 285–310. **BOOKS** ● **Moulin, H.** (1995) *Cooperative Microeconomics*, Princeton University Press. ● **Roth, A. E.** and **Sotomayor, M.** (1990) *Two-sided Matching: a Study in Game-theoretic Modeling and Analysis*, Econometric Society Monograph Series, Cambridge University Press. **SCIENTIFIC ARTICLES** ● **Gale, D.** and **Shapley, L. S.** (1962) College admissions and the stability of marriage, *American Mathematical Monthly*, 69: 9–15. ● **Roth, A.E.** (1984a) The evolution of the labor market for medical interns and residents: A case study in game theory, *Journal of Political Economy*, 92: 991–1016. ● **Roth, A.E.** (1984b) Misrepresentation and stability in the marriage problem, *Journal of Economic Theory*, 34: 383–387. ● **Roth, A.E., Sönmez, T.** and **Ünver, M.U.** (2004) Kidney exchange, *Quarterly Journal of Economics*, 119: 457–88 ● **Serrano, R.** (2009) Cooperative games: core and Shapley value, *Encyclopedia of Complexity and Systems Science*, Edited by R. Meyers, New York: Springer. ● **Shapley, L.S.** and **Scarf, H.** (1974) On cores and indivisibility, *Journal of Mathematical Economics*, 1: 23–37.

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