SCIENCE COMPETITIONS

Top Young Problem Solvers Vie for Quiet Glory

Once a Soviet-bloc monopoly, the International Mathematics Olympiad now draws competitors from 83 countries worldwide—and counting

FAIRFAX, VIRGINIA—The Patriot Center at George Mason University has never seen an event quite like this one. On a floor usually used for basketball, a regiment of tables stands in formation, each one equipped with a water bottle, a granola bar, and an identifying placard: "Latvia 001" or "Trinidad and Tobago 003." In the center of each table lies a sealed envelope.

Victorious. The Chinese team (shown with leader Yonggao Chen and deputy Shenghong Li) turned in a solid-gold performance at the IMO.

Outside, the competitors are gathering: 83 teams of six youngsters each. Some are clad in ordinary T-shirts and jeans; others are wearing team jackets. "Springboks! Yes!" chants a group of boys from South Africa, borrowing a cheer from their national rugby team.

But the other trappings of a sporting event are missing: There are no vendors, no TV cameras, no frenzied spectators. Once the competitors enter the arena, the exuberance ends and a librarylike hush descends. It's so quiet that you can hear the buzzing of the lights and the pacing of the gray-shirted invigilators.

At 9:00 a.m. on 8 July, the chief invigilator sounds a deafening air horn. The competitors rip open their envelopes, each of which contains three math problems in one, or in some cases two, of 51 different languages. Then all is hushed again. For the next four and a half hours, some of the world's best high school mathematics students will be absorbed in a mental battle for which they have been preparing for months or even years: the 42nd International Mathematics Olympiad (IMO). Then they will do it again tomorrow.

"The IMO is frightening in its difficulty," says John Webb, a former team leader (coach) for South Africa and now the secretary of the IMO's advisory committee. "It is the toughest intellectual challenge you can expect any high school student to face."

The exam consists of six brain-wracking puzzles from four areas of mathematics: algebra, combinatorics, geometry, and number theory. In theory, they require only high school mathematics to solve. But even a professional mathematician would have trouble solving all six problems, let alone doing it in 9 hours. Half of the students in this gym, the best the world has to offer, will score 10 points or fewer out of a possible 42.

For those who excel, the olympiad offers a showcase for their talents and a springboard toward a scientific career. Many IMO medalists have gone on to become top researchers in mathematics or related sciences. Five of the last eight winners of the Fields Medal—often considered the mathematical equivalent of the Nobel Prize—made their first mark at the IMO.

This month's IMO is the first held in the United States for 20 years. In that time the number of participants has doubled, and the budget—$3 million this year, funded largely by contributions from the National Science Foundation and the Akamai Foundation, the charitable arm of a company in Cambridge, Massachusetts, that provides Internet routing services—has ballooned by a factor of 10. (Teams pay their own travel costs to and from the competition, but the host country covers all expenses while they are there.) Yet IMO organizers say there is still room to grow. Even after 42 years, the oldest and largest international academic competition for students of high school age is eager to bring new countries into the mathematical fray.

By 1:30 p.m. on 9 July, the contest is over. Hundreds of teenagers burst forth from the arena doors, some with smiles, very few with tears. Clustering around their coaches, they turn into ordinary kids again, hungry for lunch.

For the U.S. team, a miniature media crush awaits—reporters from CBS, *U.S. News and World Report*, and Technology TV. Half an hour later, as the rest of the team fidgets, 18-year-old Gabriel Carroll of Oakland, California, fields the last question: "So why is mathematics important?"

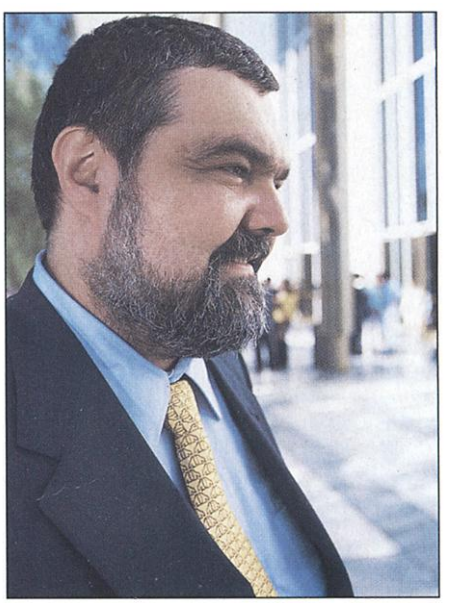
"I don't do mathematics because it's important," Carroll says. "I do it for aesthetic reasons. Math is an art."

Off camera, Titu Andreescu nods approvingly. The U.S. team leader doesn't exactly beam—with eyes that look like the dark hollows in an ancient oak tree, he never beams—but he does say, "Good answer, Gabe."

The coach

A former contestant himself, Andreescu coached the Romanian team from 1981 to 1990. Then he emigrated to the United States, where he started teaching at the Illinois Science and Mathematics Academy in Chicago. Within 3 years, he was coaching again—this time, as a deputy team leader for the United States.

Like a more famous émigré from Romania—Bela Karolyi, the gymnastics coach from the "other" Olympics—Andreescu is known as both a stern taskmaster and a gentle father figure. Every summer, he leads an intensive 4-week training program for the

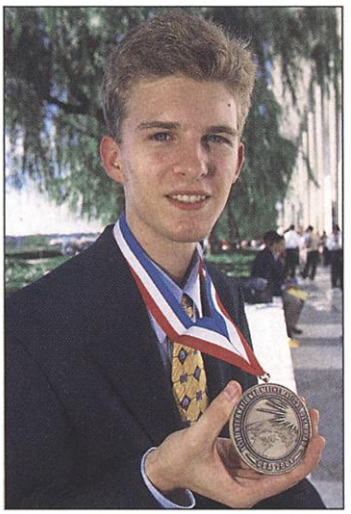


Math guru. Coach Titu Andreescu thinks schools should offer Olympic-style training.

CREDITS: RICK KOZAK

IMO's Golden Boy Makes Perfection Look Easy

Even in the rarefied world of mathematics competitions, Reid Barton is one of a kind. This year, the soft-spoken, unassuming 18-year-old senior from Arlington, Massachusetts, became the first person to win four gold medals in 4 years at the International Mathematics Olympiad (IMO). "Since 10th grade he [has written] proofs like a professional mathematician," says team coach Titu Andreescu. "You could take his solutions to the IMO problems, written in just four and a half hours, and publish them in a book without editing them. It's remarkable."



Shining. Reid Barton's aesthetics of excellence go beyond the IMO.

The son of two environmental engineers, Barton began discovering arithmetic, inventing his own notation, at age 4. In first grade he noticed π on a calculator and asked what it meant. The discovery motivated him to learn the Greek alphabet and start taking lessons in classical Greek at age 7. By second grade, he had finished sixth-grade math, and his grade school teachers said there was nothing more they could offer him. In third grade, he studied game theory with a graduate student tutor, devouring Douglas Hofstadter's *Gödel, Escher, Bach* and Richard Guy and Elwyn Berlekamp's *Winning Ways for Your Mathematical Plays*. The next year it was on to calculus; at age 10, Barton took the Advanced Placement exam, a U.S. standardized college-placement test, and, of course, scored a perfect 5.

Meanwhile, he was accelerating in other subjects as well: chemistry at Tufts University in fifth grade, physics in sixth grade, and in subsequent years Swedish, Finnish, French, and Chinese. "When I took chemistry at Tufts in fifth grade, I was too young to realize how strange it was," he says. "After that I was used to it." Although he has officially been home-schooled since third grade, he still enjoys taking chamber music and orchestra at Buckingham Browne & Nichols School. He listens only to classical music and is a fan of Chopin.

For the last 4 years, Barton has had a part-time job in the laboratory of Charles Leiserson, a computer scientist at the Massachusetts Institute of Technology (MIT). At first he worked on Leiserson's chess-playing program, Cilkchess, which is one of the two or three strongest in the world. In 1999, Leiserson began a 2-year leave of absence to work at Akamai Technologies Inc. in Cambridge, Massachusetts, as director of research, and Barton came with him. Leiserson says that what distinguishes Barton is "his excellent sense of aesthetics. His code is clean, well organized, simple, and easy for other people to modify. It's unusual to find that ability in someone so young."

The day after the IMO ended, Barton hopped on a plane to join the American team at the International Olympiad in Informatics (IOI) in Finland. Last year, he pulled off a similar "double," earning a gold medal at the IOI in Beijing and the IMO in Korea. This year, he scored first in the informatics competition, with 580 points out of a possible 600—55 points ahead of his nearest rival.

This fall Barton will start college at MIT as an undergraduate. He could have gone straight on to graduate school, Leiserson says, but didn't want to miss out on the undergraduate experience. "Reid is a hell of a nice kid," Leiserson says. "He has a very good chance of avoiding burnout issues, which he will start to face as he matures."

–D.M.

top 30 finishers in the USA Mathematical Olympiad, including this year's team members and next year's hopefuls. Based this year at Georgetown University in Washington, D.C., the program features lectures from visiting mathematicians and constant practice—three exams a week under the same conditions as the IMO. Most top countries at the olympiad have similar training programs, lasting from a weekend to a month or more.

The trend toward specialized training appalls some mathematicians. The IMO "should be about inventing things," says Béla Bollobás, who competed for Hungary in the very first olympiad and now teaches at Cambridge University. "If it turns into which of 125 tricks you apply, it's wrong. ... It's against the spirit of mathematics." But Andreescu says his training program does teach real mathematics, and former team members agree. "I think I learned mathematics at a greater rate [at the training camp] than at any other time in my life," says Bjorn Poonen, a silver medalist in 1985 and now a math professor at the University of California, Berkeley.

The benefits of such training need not be limited to IMO participants, Andreescu says. "With $1 million, I could establish a network in the U.S. and train teachers to go back to their communities and do what we do here." Although that kind of expansion may be a long time coming, a smaller but significant one is already under way: Next year, Andreescu's mathematical boot camp will quadruple in size to train about 120 students at new, permanent quarters in Lincoln, Nebraska, thanks to a grant from the Akamai Foundation. "These are exciting times," Andreescu says. "The sky is the limit."

A problem from this year's olympiad

Twenty-one girls and twenty-one boys took part in a mathematical contest
- Each contestant solved at most six problems
- For each girl and each boy, at least one problem was solved by each of them

Prove that there was a problem that was solved by at least three girls and at least three boys.

IMO participants averaged only 0.88 points out of 7 on this problem. Reid Barton's solution will appear on next week's Random Samples page.

Beyond the Cold War

In a sense, the mathematics olympiad itself is another Romanian émigré. The first IMO was held in Romania in 1959. For several years, it was strictly a Soviet-bloc affair, as were the similar scientific competitions it inspired (see sidebar on p. 599). In the late 1960s, however, Western European countries started to join in the IMO. In the détente year of 1974, the United States sent its first team to Erfurt, then in East Germany. Members included Eric Lander, now director of the Whitehead Institute Center for Genome Research in Cambridge, Massachusetts.

"We had a great time hanging out with the Russians," Lander recalls. The two teams bonded over political jokes and lobbed water balloons out of the institute where the competition was held. "The Russians had a sense that they couldn't really get in trouble. The East Germans weren't going to throw the book at them."

Beforehand, some American mathematicians had feared that the United States could not compete with Eastern Europe, with its long tradition of competitions and excellence in math education. "There was a good deal of soul-searching before the United States sent a team," says the IMO's Webb. "It was viewed as totally unacceptable for the U.S. to be at the bottom." But

CREDIT: RICK KOZAK

Science Olympiads Offer a Variety of Arenas for Overachievers

The International Mathematics Olympiad is the oldest and largest scientific olympiad for high school students. But it has distinguished siblings, each with its own quirks. The biology, physics, and chemistry competitions have laboratory components. The International Olympiad in Informatics (IOI, for computer science) is by far the easiest to grade: The students' programs are simply fed into a computer with certain sets of test data, and the results are available within seconds. Some exams, such as those for biology, include multiple-choice questions; others, such as mathematics, do not. The American Chemical Society, which sponsors the U.S. team for the International Chemistry Olympiad, does not let students compete again after they win a gold or silver medal; the corresponding organizations in math, physics, and informatics do allow contestants to go for multiple gold medals.

The United States has never sent a team to the International Biology Olympiad (IBO), a curious absence by a country that devotes so much money to biological and medical research. That situation may change next year. For 3 years Ravi Vikram Shah, a senior at Harvard University, has directed the Harvard Biological Sciences Olympiad, a small high school competition run entirely by undergraduates without faculty help. Next year, Vikram Shah hopes to extend it to a national level and select a team for the IBO. He paid his own way to Brussels, Belgium, to observe this year's IBO and qualify the United States to send a team next year. He reports that he was most impressed by the attitude of the IBO participants. "Rather than mulling over defeat or flaunting [their] success, the groups reveled in their own accomplishment of getting to this level," he says. "In fact, the mentors of countries not receiving a medal seemed more disappointed than the students themselves."

Vikram Shah is getting some help from Elizabeth Wissner-Gross, the mother of a former IOI participant from Long Island, New York. "My younger son was interested in biology and wanted to know why there wasn't a biology olympiad," Wissner-Gross says. For the last year, she has been trying to drum up interest and funding for a USA Biology Olympiad. The first part was easy—more than 100 high school biology teachers have contacted her. The second part has been unsuccessful so far, but Wissner-Gross remains optimistic. "We went to several companies at the beginning of the year, when their budgets were already set," she says. "A number of them said to please come back this fall." She says that the National Institutes of Health has also expressed interest in funding the competition. **–D.M.**

Event	Date and place first held	2001 Location	Number of countries, 2001
International Mathematics Olympiad	1959, Romania	Washington, D.C., U.S.A.	83
International Physics Olympiad	1967, Poland	Antalya, Turkey	65
International Chemistry Olympiad	1968, Czechoslovakia	Mumbai, India	54
International Olympiad in Informatics	1989, Bulgaria	Tampere, Finland	75
International Biology Olympiad	1990, Czechoslovakia	Brussels, Belgium	41

the Americans surprised everyone by finishing second behind Russia and ahead of such traditional powerhouses as Hungary. (There are no official team standings, but in reality everyone is aware of them.)

Casting the net wider

Since then, the roster of IMO competitors has spread far beyond the old Cold War–era rivals. Teams from less developed countries regularly turn in impressive performances. Their formulas for success vary. Vietnam, a perennial top-10 finisher, has special schools in each province from 10th to 12th grades in which students study advanced mathematics along with their regular courses. Colombia, whose team usually finishes first or second among Latin American countries, traces its success to one person: Maria Falk de Losada, who organized the country's first IMO team in 1981 while serving as a Peace Corps volunteer and is still at it 20 years later.

In the world map of the IMO, one giant terra incognita remains. This year's competition included only three teams from African countries: Tunisia, Morocco, and South Africa. As secretary of the IMO's advisory committee, Webb is working to bring more countries from what he calls "the birthplace of mathematics" into the fold.

Webb believes that developing countries need to build from the bottom up—first establishing a sound national infrastructure, then holding a national olympiad, and finally joining the IMO. In this way, although the IMO may serve only a few students, it will indirectly benefit many. "It's the cherry on top of the cake," Webb says. "Most people don't get a bite of the cherry, but they do get a slice of the cake."

Unfortunately, Webb says, not everyone is eager to compete. A team that comes home with no medals, or worse, a string of zeroes, can be a serious embarrassment to its ministry of education. As de Losada says, "countries rule themselves out" rather than risk that kind of humiliation.

Bollobás suggests organizing a two-tiered olympiad, with easier problems for the second "league." But according to Adam McBride of the University of Strathclyde, U.K., the organizer of IMO 2002, that idea stands no chance of getting past the team leaders. No country wants to deny its students a chance to compete on an even footing with China, Russia, and the United States.

A hard act to follow?

When the last paper was graded—at 2:00 in the morning of 12 July—half of the contestants had won gold, silver, or bronze medals. Four students—Liang Xiao and Zhiqiang Zhang of China, and Gabriel Carroll and Reid Barton (see sidebar on p. 597) of the United States—achieved perfect scores. China dominated the unofficial standings, followed by Russia and the United States (tied for second and third), Bulgaria and Korea (tied for fourth and fifth), and Kazakhstan, India, Ukraine, Taiwan, and Vietnam. All six members of China's team won gold medals. Barton won his fourth gold medal in 4 years, a feat believed to be an IMO first.

The next day, in the marble halls of the John F. Kennedy Center for the Performing Arts, Andrew Wiles, the man who proved Fermat's Last Theorem, presented gold medals to 39 contestants. University of Nebraska, Lincoln, mathematician Walter Mientka, organizer of this year's IMO, then symbolically passed the Olympic flag—an interlocking circle and infinity symbol—to McBride, next year's host. McBride confidently predicts that the 2002 olympiad in Glasgow will live up to the high standards set by this one. "We need 50 [graders], and we already have 80 names. The problem-selection committee has absolutely superb people. Assuming we can get money, we're quite confident that we'll put on an excellent show."

–DANA MACKENZIE

Dana Mackenzie is a writer in Santa Cruz, California.