Where to find and how to train better math and science teachers for U.S. classrooms is discussed: "After all, teachers can exponentially improve the nation's research efforts by training thousands of prospective scientists." "It seems all but improbable that the only martian meteorites to reach Earth came from a single small region on the surface of Mars. Thus, where are the 'missing' martian meteorites that must have also reached Earth...?" And theories of how anterioposterior patterning develops in the limb are compared.

Math and Science Education: Training the Teachers

The growing need for science and math teachers might be met in part by employing recent science Ph.D.s, as Jeffrey Mervis discusses in his News Focus article "How to produce better science and math teachers" (1 Sept., p. 1454). This idea is being tested in Montgomery County, Maryland, public schools in partnership with the National Institutes of Health (NIH). The partnership program has been structured to respond to key recommendations of the National Research Council, which include providing a compressed certification process and the ability of the Ph.D. participants to retain ties to research.

The program was launched at the beginning of this school year. Two postdocs are first-year science teachers while involved in an intense in-service training program that not only provides teacher certification, but also support and mentorship. NIH will provide summer employment so they can keep their research skills current. Also during this academic year, other postdocs who are interested in teaching science or math will be given time away from their NIH duties to shadow teachers and visit classrooms. Thus far, response to the program from recent Ph.D.s, the students, other teachers, and the school administrators has been positive. The number of post-docs inquiring about the program is increasing (*1*), and the program will be expanding.

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References and Notes

1. Inquiries about the program may be faxed to Sandra Shmookler at (301)517-8182.

Mervis presents a well-balanced view of the strengths and weaknesses of recruiting Ph.D.s to teach kindergarten through 12th grade (K–12) math and science in U.S. classrooms. I've been working with K–12 teachers for nearly 20 years in programs supported by the National Science Foundation (NSF) and other agencies, and there is one principle I have learned: Placing math or science specialists into the classroom without appropriate content level for the class or successful teaching and motivational strategies is a recipe for disaster.

What could the federal government do to make such a program to recruit Ph.D.-level scientists for teaching a success? Set up teacher training institutes at a national level, where those selected to train the prospective teachers would be drawn from the nation's best K–12 mentor teachers and award-winning science professors. National fellowships could be offered for postdocs, recent Ph.D.s, or any math/science specialists to learn how to teach, at what level to teach, and how to motivate students to learn science and math. Such fellowships should carry the full prestige of NSF or NIH (like postdoctoral fellowships or R01 research grants) and provide substantial stipends to show prospective teachers that the United States considers K–12 teaching as important as, if not more so than, research. After all, teachers can exponentially improve the nation's research efforts by training thousands of prospective scientists.

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I am a secondary school chemistry and physics teacher with a graduate degree in physical chemistry, and Mervis's article appealed to me in a personal way. He reports that the National Research Council is suggesting a shift in the burden of continuing teacher education from the local school districts to university faculty, but the responsibility does not lie with either of these—it lies with the individual. All professionals, in this case teachers, have the personal responsibility to keep current in their disciplines by reading relevant journals, attending conferences or seminars each year, and networking with colleagues. The only assistance that a teacher really needs is the time and money to pursue the endeavors, and here the employer—not the local school district or university—should be the primary facilitator.

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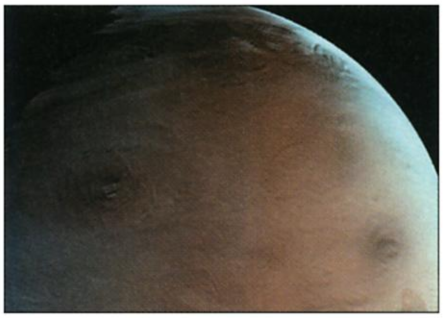
Missing Martian Meteorites

In his Perspective entitled "The latest news from Mars" (*Science*'s Compass, 3 Mar., p. 1601), David W. Mittlefehldt discusses the data on the global surface composition of Mars obtained by the Mars Global Surveyor Spacecraft, which was reported by Bandfield *et al.* in the same issue (Reports, "A global view of martian surface composition from MGS-TES," p. 1626). Mittlefehldt notes that, on the basis of mineral composition, the most promising impact crater launch sites for the SNC meteorites (a group of stony meteorites devoid of chondrules) are in the Tharsis Montes–Olympus Mons region, located in the northern hemisphere.



It seems an unlikely scenario that the Tharsis Montes and Olympus Mons region shown here is the only launch site of martian meteorites.

This raises an interesting puzzle. The region including Tharsis Montes and Olympus Mons (TMOM) covers about 10% of the surface area of Mars. Yet 12 of the 13 SNC meteorites appear likely to have mineralogies associated with this small region of Mars's surface. It seems all but improbable that the only martian meteorites to reach Earth came from a single small region on the surface of Mars. Thus, where are the "missing" martian meteorites that must have also reached Earth but which so far have not been identified?

In addition to the TMOM region, the surface of Mars has two other basic regions: the ancient basaltic highlands, which account for ~60% of the surface area, and the northern andesitic plains, which account for ~30%. Therefore, assuming that all meteorites launched from the surface of Mars have about the same chance of reaching Earth, we should expect that if we have found ~12 SNC meteorites, we also should have found ~36 meteorites of northern plains composition and 72 representatives of the ancient highlands crust.

SNC meteorites are attributed a martian origin on the basis of isotopic anomaly/abundance ratios for chiefly the noble gas elements, although other indicators are taken into account. The initial identification, however, is usually based on the mineralogy of the meteorite. I suggest, therefore, that any meteorites that have a type of mineralogy broadly representative of either the ancient southern highlands or the younger northern plains of Mars be analyzed for noble gas isotope anomaly/abundance ratios to see if they indicate a martian origin. This could be done well ahead of the proposed, but now delayed, Mars sample collection and return mission.

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Response

Taylor has put his finger on a well-known conundrum in martian meteorite studies. Before I launch into that discussion, though, I need to clarify one of Taylor's comments. He indicates that it is on the basis of mineral compositions that the TMOM area is considered a likely site of origin for many of the martian meteorites. In fact, the Thermal Emission Spectrometer data do not reveal a region of Mars that matches the meteorite spectra (see by Bandfield *et al.*'s report). The reason why the TMOM area is a promising source region for the martian meteorites is that it is a young volcanic region thought to be of the right age (*1, 2*).

Now for the conundrum. The cosmic-ray exposure ages of martian meteorites, determined by measuring nuclear transmutations that build up with time, fall into five or six distinct groupings (*3*). Impact-mechanics theorists have suggested that large (several tens of meters) rocks were originally launched off Mars (*4*). The interiors of these large rocks were shielded from cosmic-ray effects, and they were later broken up by collisions in space. This secondary breakup then started the cosmic-ray exposure clocks running, and the measured ages thus are less than the time of launch off Mars. However, more recent modeling indicates that, in fact, the martian meteorites were launched as small bodies, and therefore the cosmic-ray exposure ages of martian meteorites do indicate their launch times from Mars (*5*); that is, there were five or six separate launch events (*3*).

All martian meteorites but one have measured "formation" ages of 1300 million years or less (*1*), determined by radiometric dating. Because the martian meteorites are igneous rocks, these formation ages are generally interpreted to be the times of crystallization from magma. Estimates of the ages of the different geologic terrains on the surface of Mars (*6*), based on the number of craters over the different regions (*7*), indicate that either <16% or <7% of the martian surface is composed of volcanic rock <1300 million years old. As Taylor argues, it is improbable that four out of five (or five out of six) of the impacts on Mars that yielded meteorites occurred on the small fraction of the surface covered by young volcanic rocks.

Taylor suggests that many meteorites from other regions of Mars have simply not been detected in our meteorite collections; however, this is unlikely. All recovered meteorites that are brought to the attention of scientists have a basic characterization done on them, which typically includes a description of the texture and a few analyses of the major minerals; sometimes chemical compositions are determined. These results are listed in the "Meteoritical Bulletin," published in *Meteoritics and Planetary Science*. Meteorites that are unusual in outward appearance typically receive particular attention in this process. Although there may be some meteorites in collections that have not

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received adequate preliminary characterization, it is doubtful that there could be many tens of martian meteorites among them. Only one meteorite, ALH 84001, has a formation age consistent with the presumed age of the southern highlands.

The inescapable conclusion is that one or more of the assumptions that go into the chain of logic outlined above are wrong. Where the error lies is unknown, but either the cosmic-ray exposure ages do not yield the launch times, or the crystallization ages are not the true ages, or a much greater fraction of the martian surface is ≤1300 million years old. This issue was discussed in detail by Nyquist and colleagues, who suggested a possible resolution of the paradox (*1*). However, the solution to this conundrum will most likely require returned bedrock samples from carefully selected terrains on Mars.

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7. The observed crater densities provide relative ages of the various surfaces of Mars. The relative ages are converted to absolute ages by using estimates of the rate of impacts and the size spectrum of impacting bodies to calculate how long it would take to build up the observed crater density. Two different absolute age scales for Mars have been developed from this method, which are the source for the estimates of <16% or <7% for the proportion of Mars's surface composed of young volcanic rock.

Fingering Digit Identity

In commenting on the study by Dahn and Fallon on digit identity in the vertebrate limb (Reports, "Interdigital regulation of digit identity and homeotic transformation by modulated BMP signaling," 21 Jul., p. 438), one developmental biologist told *Science* correspondent Michael Hagmann, "Nobody anticipated that the positional information does not reside within the digit precursors" (News of the Week, "Why chicks aren't all thumbs," 21 Jul., p. 372). In fact, for more than two decades, my colleagues and I have argued that the primary mechanism in the establishment of the limb skeletal pattern is one that establishes arrays of equivalent elements (for example, digits) that are individualized at later stages by means of local interactions. We have supported our arguments by studies of limb bud tissues in vitro and by theoretical models (*1*). In a 1988 minireview (*2*), we noted that a solution to the developmental problem of limb pattern formation would be to "consider the various skeletal elements as equivalent from their inception...[This] places greater emphasis on the similarities between the various skeletal elements than on their differences when considering the mechanisms that first establish them as skeletal elements. If the various elements are eventually to become nonequivalent morphologically, biochemically, or physiologically, these differences could be acquired by local interactions that lead to second order modifications of the original pattern."

One obstacle to understanding the underlying mechanisms of skeletal pattern formation is the notion of "positional information" itself. Positional information has been proposed to be embodied in a molecular gradient that provides an address for each cell in an embryonic field (*3*). As regards the limb, this theory hypothesizes that each skeletal element to be generated requires a distinct cellular