tio across the picture. Since Ganymede is expected to have weak coloration (*1*) the red and blue images (or corresponding restorations in these colors) should strongly correlate spatially. So, therefore, should the artificial green with both the red and the blue. Now, in a composite, correlated features come through strongly, while uncorrelated or weakly correlated features do not. By the hypothesis of weak color effect, the latter should tend to be artifacts anyhow. The upshot, then, is that the ratio of true to false details in the Ganymede pictures should be enhanced by the color superposition. A corollary, however, is that any strong color (departure from the gray range) is suspect.

Color versions of the restorations were produced in a similar manner. At each pixel, an amount of green was generated equal to the arithmetic average of the red and blue intensities there. Before this step, the red and blue pictures were equalized in total light intensity. The effect of the green addition, then, is to produce an equal-energy white color where red and blue are equal. The philosophy here is that, if red and blue are equal, and nothing is known about green, the simplest assumption to make about green is that it equals both the red and the blue value, thereby producing a net color that is a shade of gray (the most unbiased or conservative choice of "color" in these circumstances).

In this manner, the linear restorations in Figs. 4c and 5c were used to produce the color output in the middle image on the cover; and the maximum entropy restorations in Figs. 4b and 5b were used to produce the color output in the bottom image. As before, the maximum entropy picture exhibits more detail than does the linear one.

Summary

Restored pictures of Ganymede have been produced that have some identifiably reliable features and some identifiable artifacts. The latter arise from artifacts in parts of the red image data. Among the presumably reliable features are some mare-like objects (perhaps with some internal structure), and a few rather large, bright rings. Whether the latter are ice, or arise from near-specular reflection from smooth surface features, is left for future investigation.

One of the restoring methods used, maximum entropy, has been shown to be applicable to moderately extended images. In view of its short time requirements (30 seconds per picture), the method should be applicable to moderately larger images, for example with twice the given number of data points.

References and Notes

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5. If the output restoration is denoted $\hat{o}(x,y)$, its entropy H is defined as

$$H = -\int\int \hat{o}(x,y)\ln\hat{o}(x,y)dxdy$$

This H is maximized, subject to the input image data as constraints.
6. An identical calculation for Pioneer 11 data on Ganymede gave a correlation coefficient of .91. By comparison, Pioneer 11 data suffer little, if any, artifact detail. (However, they were sampled more coarsely than the Pioneer 10 data, and so are less appropriate to restore.)
7. S. Wernecke, abstract of paper presented at the meeting on image processing for 2-D and 3-D Reconstruction from Projections, Stanford University, Stanford, California, 4 to 7 August 1975.
8. The authors gratefully acknowledge the assistance provided by members of the Pioneer Imagery Photo-Polarimeter team of the University of Arizona, and personnel of the Pioneer Project Office of NASA-Ames Research Center In addition, we thank D. Wells of Kitt Peak National Observatory for his strong encouragement and for permitting access to the Comtal display equipment at his facility. This work was supported in part by NASA contract NAS2-6265 and by Air Force contract F33659-72-C-0605.

NEWS AND COMMENT

Blind Medical Student: Overcoming Preconceptions

David Hartman probably would have done very well for himself anyway, but, owing to a combination of circumstances, people, and his own character, he is emerging as perhaps a very significant individual.

Hartman, 26, is the first blind person to have been admitted to an American medical school in almost a century. He is now a senior at Temple University School of Medicine in Philadelphia and will graduate in May. He has completed, with only minor deviations, all the courses required of his sighted colleagues. He plans to be a psychiatrist, with special emphasis on the physical and psychological rehabilitation of handicapped people.

Doctors who continue their practice after becoming blind are not unknown; Hartman even knows of a couple who continued their medical training after losing their sight. But starting from scratch without any vision is another matter, and there are few medical schools that will even consider letting in such a student. The last time it happened was reportedly in 1878, when Robert H. Babcock entered Chicago Medical College. Babcock learned anatomy by touch and went on to write books about heart and lung diseases.

While Hartman's success has helped fracture some preconceptions about the limitations of the blind, it by no means presages a deluge of blind entrants to medical school. "David is a unique person," says M. Prince Brigham, assistant dean for admissions at Temple. "For every David Hartman there are thousands [of talented blind people] who would find medical school so utterly and maddeningly frustrating" they would never make it. "He has . . . ego strength—a self-awareness sufficient to allow him to withstand some of the disappointments he faces." It all boils down, says Brigham, to his being "extremely mature."

Hartman says that some people to whom he reveals his calling conjure up visions of carnage in the operating room—which would seem to reflect a belief that anyone who is blind would have to be some sort of magician or superman to keep up. But Hartman, as he himself insists, is no genius. He is, however, well organized, realistic, determined, and intelligent. He has a kind and thoughtful presence, quite doctorly, and an appealing chuckle that gives one the impression he feels secure in his control over his life.

He has a fairly well developed philosophy, one of the major tenets of which is that everyone is handicapped in some way, usually less obviously so but often no less. Think, for example, "of a guy who just can't relate to people going into psychiatry."

Hartman emphasizes that his career really is a team effort, starting with a family determined to foster his independence and keep his horizons open. His teachers at college fully supported his ambitions. He is now teamed up with his wife Sheryl, whom he married in 1973 and who plans a teaching career once she gets her doctorate in educational psychology.

Hartman was born in Havertown, Pennsylvania, with congenitally deformed lenses. At the age of 8, what with added complications of glaucoma and detached retinas, he became totally blind. He spent 5 years in a school for the blind and then went on to Haverford High School and Gettysburg College, where—his determination to go into medicine already formed—he majored in biology. He successfully completed the lab work, substituting touch for sight, and graduated with slightly less than an A average. "He achieved the impossible at Gettysburg," says Brigham, so it did not seem irrational to give him the opportunity to continue doing so at Temple.

Temple, as it turned out, was the only medical school where this attitude prevailed. Hartman, ever the thorough planner, started probing medical schools during his junior year at college. He applied to ten of them his senior year and was interviewed at Temple, Pennsylvania Medical College, Harvard, and Yale. The others said they really didn't think it would be feasible to admit him, which hurt—"I felt my grade point averages and performance warranted at least an interview. They could have given me that courtesy." He was invited for an informal talk with a group of doctors at Yale, all of whom, he says, were very skeptical. "I walked out of there just ready to kill someone." Others who interviewed him grilled him extensively, particularly on how he planned to get through histology (microscopic study of tissues) and anatomy. Hartman had all his answers ready: he was quite capable of learning enough anatomy and he didn't, after all, plan to be a surgeon; as for histology, he made the case that a conceptual grasp of the field was adequate for his purposes. Temple, according to medical school dean Roger Sevey, took the added step of bringing Hartman's application through the executive faculty (its policy-making group) "to make sure the faculty was committed to seeing this young man through." Once committed, the school decided to treat him as much as possible according to prevailing standards; they therefore did not elicit a promise that he would stick to psychiatry.

Hartman, whose father is a banker, is paying his own way, but Temple officials say he would have been eligible for financial aid like any other student. He was accepted on an experimental basis, as number 181 in the usual entering class of 180, which circumvented any dispute over whether he was occupying a place that might have gone to someone with a better chance of graduating. Other than that, no special arrangements were

Judging a Handicapped Applicant

What to do about a handicapped applicant can be an agonizing question for conscientious admissions officers, particularly in medical school which probably offers the most physically and emotionally stressful educational environment anywhere.

A fundamental question is: What is a handicap? Deafness, blindness, or total paralysis raise obvious problems. But there are a host of diseases, conditions, or circumstances whose impacts on an individual's projected performance are very difficult to evaluate. What allowances should be made, for example, for a person with epilepsy, with juvenile diabetes, with ulcerative colitis, with arrested Hodgkin's disease, with a history of depression? When is age a handicap? Is overt homosexuality a drawback?

Prince Brigham of Temple medical school approaches the matter by posing two questions: How much will the handicap interfere with the person's performance as a physician? Are physical and academic facilities sufficient to handle the handicap? He remembers reluctantly having to discourage the medical aspirations of an achondroplastic dwarf because she was so short, and her fingers so stubby, she would not have been able to manage even routine duties.

Schools can be forgiven for turning away a student with serious medical problems when equally qualified sturdy individuals are clamoring for admission. But where is the line drawn between turning down a poor risk and denying a highly motivated individual the opportunity to prove he can surmount his problems? Frances Drew, associate dean for student affairs at the University of Pittsburgh Medical School, cites the example of a woman with ulcerative colitis who applied to 12 medical schools. She revealed her condition to six of them and was turned down. She was accepted by the other six. The rejections were understandable, particularly in view of the fact that colitis is usually associated with emotional problems. Nonetheless, the woman got through school and got her health under control with the help of an operation. Since it is clear that the woman's applications were rejected because of a factor that proved not be relevant to her performance, some people say she has the basis for a suit against the schools that turned her down. So far, though, *Science* has not heard of any such suits.

Although handicapped people suffer from other people's preconceptions the same way as women and minority people have, the problem is different. As Brigham says, "The handicapped really do need to be outstanding." And those who apply to medical school generally are, for, according to Drew, "The thing about these people is they are amazingly tough and gutsy to begin with or they wouldn't even have applied."

There are signs that handicapped people with a good chance of succeeding will be given more consideration in the future. The Association of American Medical Colleges (AAMC), which puts out the Medical College Admissions Test, is reevaluating the whole medical school admissions process. James Angel, director of the AAMC's admissions assessment program, says the purpose of the changes will be to put more emphasis on an applicant's personal qualities and ability to learn, and less on sheer ability to retain facts. The AAMC intends to replace the exam now in use, and to develop a systematic means of assessing an applicant's total personality. The organization also wants to train admissions officers in more sensitive and sophisticated methods of evaluating applicants. Angel says the purpose of the exercise has more to do with such things as eliminating racial bias than helping the handicapped. In fact, he hadn't given the latter much thought until *Science* called, and now he intends to include it in his spring discussions with admissions officers.—C.H.

made—Temple decided to play the whole thing by ear. None of the regular curriculum requirements were waived, although he has been excused from such things as x-ray reading.

The first 2 years were harrowing, complete with the night sweats common to beginning medical students. Lab work has required the development of various shortcuts and considerable help from fellow students and professors. With gross anatomy, Hartman found "I could touch almost everything"—he eschewed the rubber gloves worn by his classmates, so his probings were a race to learn the necessary before his fingertips became numb from formaldehyde. Histology required some finessing—most of his learning was conceptual, but he learned the shape of various nerve and cell formations with the aid of three-dimensional models and simple diagrams his teachers embossed on transparent paper with a ballpoint pen or stylus. He closely follows others through lab work. Once in physiology lab, he was invited to feel the artery pulsating in the throat of an unconscious dog with a tracheotomy. He didn't even have to see it for the experience to make him pass out. But he subsequently attacked the problem by performing a tracheotomy himself.

Having once had sight, Hartman is able to visualize a great deal, which gives him a significant advantage over a person born blind. His main problem is time. The first year was manageable, he says, but the second was "unbelievable" because of the prodigious amount of reading required. Hartman's original technique was to tape-record all his lectures, play them over at home, and record summaries of them, which he then filed away. Replaying and summarizing a 1-hour lecture took about 2 hours. Finding himself swamped, Hartman, with the assistance of Brigham, developed the technique of whispering summaries of what was going on in lectures rather than taping them all. He has also switched to transforming his notes to Braille for easier accessibility. To get through his reading material he has relied on taped books—Recordings for the Blind has been of invaluable help, having put two 2000-page textbooks, on anatomy and surgery, on tape for him—and on fellow students who spend many hours a week, sometimes refusing pay, reading to him and explaining diagrams.

Hartman faced new kinds of challenges in his third year, which was devoted mainly to six 6-week clinical rotations in psychiatry, obstetrics and gynecology (where he helped deliver a baby), pediatrics (where he worried that he might drop a baby), general medicine, and surgery. With the last he spent a few hours a week assisting in the operating room, and most of the time in pre- and postoperative care. This year—"the only one where I have felt confident of graduating"—has been devoted to more clinical rotations, this time of his own selection, with the exception of 3 weeks in the emergency room. Things worked out all right there too, since most of the emergencies were medical rather than surgical. Hartman is confident of his ability to take histories and perform physical examinations—the only things he needs help with are ear, eye, and mouth inspections, and skin rashes; for the latter he relies on the patient's description. He laments the theft of a special blood pressure gauge which enabled him to read pressure the same way he tells time on his watch—flipping up the cover and feeling the needle and raised bumps for the numbers. Hartman feels competent to handle most diagnostic problems since there is "very seldom a single subtle abnormality" that blindness would prevent him from perceiving. "The unconscious patient is a problem," he concedes, since there isn't much to work with and inspection of the pupils is important.

Hartman has had to overcome reservations on the part of the clinical faculty, says Sevey—"a few on the clinical faculty have been unable to look beyond the fact of his blindness to the person . . . but most, even if initially skeptical, have become his advocate." Beryl Lawn, an internist he has worked with (and who, by the way, was trained at Temple after an accident that rendered her paraplegic), says that patients, with a few exceptions, have no problems with Hartman. In fact, she says, "they remark particularly on his patience and empathy." Some don't believe he is blind. For public appearances he dons a pair of $900 plastic eye caps that give him a direct and realistic gaze. Not all is sweetness and light, of course. Hartman says he asked one patient who struck him as particularly depressed if anything could be done to cheer him up. "Yeah, get lost," said the man. Hartman took this in stride, but the incident points up one overriding concern of the handicapped, particularly those who are blind or deaf, namely, How do I stack up? Lacking visual reference points that everyone else takes for granted, such a person must rely heavily on continuous feedback from every available source. With patients, there is always that uncomfortable fear that he might not be doing them any good, or that he is the only one benefitting from the encounter.

Hartman, who takes his exams orally, dictating answers to a professor, has given considerable thought to how he is evaluated. Students who scoff at grade systems probably haven't thought much about how important it is for a handicapped person to feel his grades reflect both an appraisal of him in relation to his capabilities and in relation to the achievements of his peers. "You've got to know where you fit in." Too much emphasis on the former makes the grades meaningless in the real world; too much on the latter is unrealistic and unfair.

Hartman and his wife live in a small apartment in Phildelphia. He helps around the house and, despite all the work,

Photo by Townsend H. Wentz, Jr.

David Hartman, right, with Neil Pratt, assistant professor of anatomy at Temple University.

they find time to see friends and go to basketball and ice hockey games together. She takes the car to school and he takes the bus, moving around with the aid of a collapsible white cane. Sheri reads aloud for them both as well as for him—currently they are plowing through *The Cancer Ward*. Hartman studies in a small den crowded with dozens of volumes of a Braille medical dictionary and many stacks of tapes identified with Braille tabs. He has a Braille typewriter and an Opticon, an expensive newly developed instrument about the size of a small cassette tape recorder that translates printed words, through a lighted sensor, into little upraised brushes that give the shape of each letter. Hartman finds the Opticon of limited use because it is very slow going, but is thinking about better applications for it—such as reading electrocardiograms.

After years of arduous work and planning and "wondering how crazy I really was" to choose a medical career, the future is looking pretty good.

Although Hartman sees himself as "pretty much average in medical school" he is in the top 20 percent of his class. Asked why it took so long for a blind student to be admitted to medical school, he attributes it partly to society's increased interest in opportunity for all, partly to the change in medical education that permits a person to specialize early. Extensive knowledge about everything is no longer required and "they don't need that all-American completely physically healthy individual." Temple also deserves considerable credit. It was founded at the turn of the century with the aim of bringing a medical education to the working man and others to whom it was not usually available. Sevey says its admissions committee is the hardest working committee at the school, and Beryl Lawn says the people there are exceptionally nice, making a special effort "to take the whole person into account." Says Sheri Hartman, "If Temple hadn't been willing to take the risk, he'd be just another blind person in psychology."

Hartman, who's always planning and has fallback positions for everything, has his next 5 or 6 years tentatively mapped out. He wants to do two residencies, one in rehabilitative medicine, the other in psychiatry. His plan is to do 1 year in the former field ("I want to be sharp on physical diagnosis"), then take 2 or 3 years in psychiatry and return to rehabilitation, the idea being that you can't do rehabilitation in a psychiatric residency, but you can apply psychiatric training to a rehabilitation residency. So far he doesn't know much about psychiatry, having avoided it in the interests of getting as much physical medicine as possible under his belt. He hypothesizes, though, that people who are nervous about psychiatrists might feel more relaxed with him because they won't feel they are being psyched out at first glance.

Hartman sees himself as working in a hospital setting but is also interested in doing family therapy (which he says is particularly important for disabled people) and in improving services for the poor. He is also interested in developing new techniques for evaluating the effectiveness of therapy.

His career will obviously include education of the nonhandicapped as well, whose ability to relate to handicapped people is often hampered by preconceptions about their limitations. Hartman believes that he could very possibly be an internist if he chose, and he thinks some way might even be found in the future for a blind person to go into surgery. "I don't think anybody knows a blind or disabled person's limitations," says he. "There is no way a sighted person can tell me what I can or cannot do."

—CONSTANCE HOLDEN

Scientists and Bureaucrats: A Clash of Cultures on FDA Advisory Panel

When scientist meets bureaucrat, the experience can be frustrating to both.

Consider, for example, the recent 2-day meeting of the Toxicology Advisory Committee of the Food and Drug Administration (FDA). This group of distinguished scientists—drawn primarily from the universities and government health agencies—has been grappling with the problem of determining the safety of the controversial color additive, Red Dye No. 2. It operates amid a swirl of conflicting interests and in full view of the public, thanks to recent laws that require much advisory committee business to be conducted in open session, where petty irritations and clashing egos lie exposed to all.

The committee was appointed late last year to give the harassed FDA greater expertise on issues involving the safety of chemicals in foods, drugs, cosmetics, and medical devices. It is considered one of the agency's most important advisory bodies—one of only two such committees chaired by a high FDA official.*

On 8 and 9 March the committee members assembled at FDA offices in Rockville, Maryland, to consider the safety of both Red No. 2 and its successor, Red No. 40. They heard presentations by FDA officials, debated the significance of experimental findings, and tried to reach a consensus on key issues. But they were plainly irritated at the conditions under which they were forced to operate. They complained repeatedly about having to debate complicated scientific issues at a public meeting—one that was jammed to the point of overheating by a crowd of bureaucrats, industry representatives, reporters, and a lone consumer advocate. Their chief fear was that offhand remarks might be taken "out of context." Nor did they appear mollified when an FDA official assured them: "The audience may be out there, but that doesn't stop the monkeys in the zoo from playing."

But mostly they railed against what they perceived as heavy-handed manipulation of the discussions by FDA officials who had certain questions they wanted answered—questions that did not always strike the committee members as sensible or appropriate. At one point the committee refused to take a yes-or-no vote on an issue it considered too com-

*The committee is currently chaired by Mark Novitch, the FDA's acting associate commissioner for science, and includes Thomas B. Clarkson, Wake Forest University; Thomas W. Clarkson, University of Rochester; W. Gary Flamm, National Cancer Institute; David W. Gaylor, FDA's National Center for Toxicological Research; Eloise R. Giblett, King County Central Blood Bank, Seattle; Bert N. LaDu, University of Michigan; H. George Mandell, George Washington University; Sheldon D. Murphy, Harvard University; Edward A. Smuckler, University of Washington; Robert A. Squire, National Cancer Institute; Thomas R. Tephly, University of Iowa; and James G. Wilson, Children's Hospital Research Foundation, Cincinnati. Not all members attended the recent meeting, which was chaired by John Jennings, the FDA's associate commissioner for medical affairs.