the frequency of the mutations in different populations, the team concluded that the A– variant arose in Africa within the past 3840 to 11,760 years, and the Med allele arose between 1600 and 6640 years ago in the Middle East or Mediterranean.

Both mutations then spread rapidly through regions where malaria is endemic, despite the fact that they cause anemia. That shows that the mutations were strongly favored by natural selection, suggesting that malaria suddenly had a severe effect on humans at these times, says Tishkoff.

The dates for the A– variant fit loosely with a well-known hypothesis by geneticist Frank Livingstone of the University of Michigan, Ann Arbor, who proposed in 1958 that sickle cell anemia and malaria took hold when farmers first used iron tools to clear forest and live in dense settlements near mosquito breeding grounds. But Livingstone's dates were just 2500 to 4000 years ago, more recent than Tishkoff's dates. Tishkoff consulted Alison Brooks, an expert on African prehistory at George Washington University in Washington, D.C., who noted that archaeological evidence has been accumulating for a dramatic lifestyle change in Africa starting 12,000 years ago, when a climate shift transformed the Sahara from an arid wasteland into a green savanna with many lakes and ponds. Africans fished and herded animals and for the first time moved into denser communities on the lakeshore—next to the breeding grounds of *Anopheles* mosquitoes. Conditions were perfect for the parasite. Presumably in response to the disease's devastating effect in this environment, the A– mutation arose and spread rapidly—a vivid example of natural selection in action, says Tishkoff.

The Med mutation came later in the Middle East or Mediterranean, perhaps in response to the more recent spread north of the deadliest malaria, *P. falciparum*. Interestingly, the dates for the rapid spread of the Med mutation coincide with the exploration of Greeks and Macedonians, such as Alexander the Great. "It fits beautifully," says Tishkoff. If the dates hold, she says—and at the moment they have large margins of error—"this is one of the few cases where you can tie in genetics, history, and archaeology." **–ANN GIBBONS**

GERMAN RESEARCH MINISTER

Bulmahn Is Bullish on Science Reforms

Edelgard Bulmahn wants to change how the country manages its research institutions, but she's facing vocal opposition from many academics

BERLIN—Ambitious and controversial, Edelgard Bulmahn has been a major force in German science and higher education since becoming research minister in 1998. A member of the "Red-Green" coalition government, Bulmahn has proposed an overhaul of Germany's university rules—seeking merit pay and "junior professorships" that would free young scientists to pursue independent research—that has polarized the academic community (*Science*, 6 April, p. 30). She has also pushed efforts to reverse Germany's brain drain by beefing up fellowship programs and other incentives to attract expatriates and woo international scientists.

But Bulmahn, a political scientist and former member of Parliament, has not restricted herself to academic reforms. She has waded into the debate over embryonic stem cells, emphasizing the use of adult stem cells for now. Bulmahn also is the key negotiator in trying to convince Bavarian state officials to convert a new research reactor to a uranium fuel that could not be diverted by terrorists for making nuclear weapons.

In a 9 April interview with *Science* in her Berlin office, Bulmahn discussed these and other topics in laying out her vision for German research. What follows has been edited for clarity and length.

***Science*:** On becoming minister, you set some ambitious goals to reform the university system and the science system as a whole. In what areas have you made the most progress?

Bulmahn: We have started to modernize our research system to handle today's challenges. ... We need to give our young scientists and scholars more and better opportunities to do their research independently within the framework of their universities or research institutions. ... We haven't finished everything we started, but that is always the case if you want deep reforms. ... Science and research have been priorities of this government. We have increased the budget by 12.5% in the last 2 years, even while the overall federal budget has been decreasing.

***Science*:** More than 3700 professors recently signed a petition complaining about your proposed university reforms, which would allow a performance-oriented salary system, phase out the post-Ph.D. Habilitation requirement to become a professor, and establish "junior professors." How do you respond to their concerns?

Bulmahn: People have become used to this German public-service system after more than 100 years, so of course some people are afraid of these changes. You will always face opposition when you try to change traditional systems.

In their public arguments, opponents have distorted the reform proposals. ... They have used the argument that, in the future, young scientists would get a so-called monthly "starting salary" of DM 8500 [US$4200]. That is not true. The starting salary of a young scientist or young professor would be negotiated by them and the university. ... As a young scientist, you could get much more money, depending on your performance and

Correcting the record. Bulmahn says opponents "have distorted" the government's proposed reforms.

CREDIT: R. KOENIG

on the success of your research.

The opponents also said that the Habilitation (a process for becoming an independent researcher) would be forbidden. ... That is not true. The Habilitation won't be forbidden, but it will no longer be the major factor needed to become a professor. For example, if you have published papers in *Science* or *Nature*, that is a much more reliable measurement of scientific excellence than the Habilitation.

The opponents don't like the junior professorships. They argue that young scientists—people between the ages of about 32 and 35—still need guidance from an older professor. I think they need the older professors as partners, not as their boss who is telling them what to do. That is one of the major discussion points at the moment. A lot of young scientists support these reforms because they think the traditional system works against young scientists.

"[Younger scientists] need the older professors as partners, not as their boss who is telling them what to do."

***Science*:** When do you think the Parliament will take up your proposal?

Bulmahn: This year, and I am very hopeful it will be approved.

***Science*:** Stem cell research is a hot issue now. What role should the government have in overseeing such research?

Bulmahn: Germany has an Embryo Protection Law, one of the first worldwide. [The law prohibits interference with an embryo's development unless it benefits the embryo.] We should keep this law, at least for the moment.

***Science*:** What does the law say about importing embryonic stem cells, which some scientists would like to do?

Bulmahn: It is not expressly forbidden, so it is allowed. The question is whether it should be funded by public money or not. ... This question is being decided by the DFG [basic research granting agency].

I personally think we should emphasize research with adult stem cells, as we already do now, because this is not ethically problematic. It is too early to decide which way may be the most successful. ... My opinion is that we should continue doing experiments with embryonic stem cells from animals and look very carefully at the results.

***Science*:** Will Germany establish a bioethics council?

Bulmahn: The Chancellor [Gerhard Schröder] has proposed creating one. ... We plan to establish this council in May. It will have an advisory role, giving recommendations, but it also will play an important role in the public discussion. Members will include scientists, theologians, philosophers, lawyers, and representatives from important science organizations. The council will make its recommendations to the government.

***Science*:** You are the main federal negotiator with Bavaria about the question of converting the fuel used by the FRM-II research reactor in Garching from highly enriched to medium-enriched uranium, to meet nonproliferation concerns. Do you expect a compromise that will allow it to go on line this fall?

Bulmahn: It depends on the Bavarian government. We are willing to come to such a compromise. And if the Bavarian government accepts the change to medium-enriched uranium, then we can reach a compromise. But we have to set a precise date for the conversion, and that can't be in 10 years.

***Science*:** Twelve years after the fall of the Berlin Wall, there is still a two-tiered system of payment of scientists, with former East Germans being paid less. When will this disparity be phased out?

Bulmahn: It is a problem even in this ministry, where former East Germans working here get paid less. This very much depends on [the German states]. As the federal research minister, I can do nothing about it. What I did ... is to change the salary system and personnel structure for all scientists in the federal government.

I can't change it directly by saying they should get the same salaries as the West Germans. But I will try to change it indirectly.

***Science*:** Are you satisfied with the progress of science in the former East Germany?

Bulmahn: We have made a lot of progress in research, but we need more progress in the application of that research. That is why we started the InnoRegio program to promote the applications of science. ... It is difficult for the researchers to find partners in their regions, so they have to find partners in the western region of Germany.

***Science*:** What has been done to improve the basic research system outside of the universities?

Bulmahn: We had a systematic evaluation of research organizations and institutions. One suggestion was to improve the cooperation between universities and our research organizations. The Genome Research Network [which will channel $175 million over 3 years into universities, Max Planck institutes, and national research centers (*Science*, 6 April, p. 29)] will increase this cooperation. I think that it is absolutely necessary to link those who do the basic research in functional genomics with those who are in the medical field. ... In awarding increases, we concentrated especially in a couple of fields: biotechnology (in which we increased genome research, for example, by more than 400% over the last 2 years) and information and communication technology. Within Europe, Germany now has the highest number of biotech companies. With regard to public funding in the field of genome research, we are now second worldwide, behind only the United States.

***Science*:** The most recent evaluation of the national research centers recommended changing the funding and organizational framework and also extending cooperation with German universities.

Bulmahn: I have been negotiating with the national research centers—transforming the financial and legal framework—for nearly 18 months. We have almost finished the process, and we have agreed to change it to a "program-oriented" funding system, which was recommended by the Science Council. The funding will be by research programs rather than by institutions. The goal is to increase competition among centers in similar research fields and, also, to increase cooperation. In the future, for example, two or three centers can apply together for a common program. ... We will also make it easier for these institutions to spin off new research companies.

***Science*:** Are there any major problems in the relationship between Germany and the United States with regard to science and higher education?

Bulmahn: We have good relations in science and research. But there is one major issue: Germany continues to contribute to the scientific strength of the United States by sending it so many talented researchers. I would like to see more of a two-way street, with more American students coming to study here.

–ROBERT KOENIG AND GRETCHEN VOGEL

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