most potential marrow recipients in Europe and North America lack an HLA-identical sibling, and this has led to the establishment of large registries of potential donors from which unrelated HLA-matched individuals can be selected[6].

The message from Fleischhauer *et al.* is then that HLA typing and assessment of tissue compatibility for bone marrow transplantation will be of the greatest value if all HLA-A, B and C alleles, subtypes included, can be distinguished by routine tissue typing. Moreover the increasing ethnic diversity of North American and European populations underscores the value of a global approach to defining subtypes. Given the inadequacy of the serological typing methods, meeting these goals will require techniques based upon the nucleotide sequences of the alleles themselves. Such DNA-based typing methods are beginning to be used for class II HLA alleles[10], and the results obtained by Fleischhauer *et al.* must surely catalyse their application to class I. □

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Salvador E. Luria (1912–1991)

S. E. Luria, who died on 6 February, brought bacteria and their viruses, the bacteriophages, into the forefront of research on the nature of the gene.

Born in Turin, Italy, Luria initially trained to be a physician and chose radiology for his speciality. After military service he moved to Rome to learn more physics in the circle of Enrico Fermi and Edoardo Amaldi. There Franco Rosetti excited him about radiation biology and the formulations by the German physicist Max Delbrück of the gene as a molecule. Equally importantly, he discovered the existence of bacteriophages and began experiments on them in the laboratory of the bacteriologist Geo Rio. Growing official anti-semitism in Italy necessitated his move to Paris in late 1938 where he continued working on phage under the patronage of the physicist Fernand Holweck, doing experiments that aimed to determine the sizes of phages through measurements of the rate at which they were inactivated by ionizing radiations.

The German conquest of France forced him again to flee, this time to New York City which he reached in September 1940 by boat from Lisbon. At the suggestion of Fermi, Luria approached the Rockefeller Foundation and the fellowship they provided allowed him to resume phage work at the College of Physicians and Surgeons of Columbia University. Soon he was in contact with Delbrück, also by then a refugee from totalitarian tyranny. By the summer of 1941, they had begun joint experiments on *Escherichia coli* and its phages, first at Cold Spring Harbor and later at Vanderbilt to which Delbrück had moved to teach physics.

Initially, they focused on the interference phenomenon which permits only one type of phage to multiply in a given bacteria. In the course of their experiments, they used bacteria variants resistant to specific phages. At that time it was an open question whether these resistant cells arose through gene mutations, since traditional wisdom among bacteriologists was that bacteria lacked chromosomes and a form of heredity similar to that of higher organisms. In particular the English physical chemist Cyril Hinshelwood argued against mutational origins of resistant bacteria, believing that they arose through altered chemical equilibria.

It was Luria who provided the key idea to distinguish between the mendelian and lamarckian explanations. What was needed was a way to show that the phage-resistant variants of *E. coli* existed before they came into contact with phage. In February 1943, soon after his move to Indiana University, he realized that the distribution of resistant bacteria in a series of different cultures should settle the question. If the bacteria were made resistant by contact with phage, the number of resistant bacteria would be very similar in all the cultures. But if they arose by mutations, they should be clustered in families, the size of which reflected the time at which the mutational events occurred during the growth of the cultures. Depending upon when the mutations took place, there could be one, two, four, eight, and so on, resistant cells in each culture tube.

As soon as Luria found his first evidence favouring gene mutations he wrote to Delbrück, who then worked out the appropriate mathematical equations. The resulting Luria–Delbrück manuscript, which appeared late in 1943, changed the face of genetics by making bacteria the obvious organisms for research on the nature of the gene. Experiments could be done in a day instead of weeks, and billions of cells could be examined in searching for mutants and determining mutation rates.

The following year Luria went on to show that phages also spontaneously mutate as they multiply, giving rise to variants every bit as stable as those found in bacteria. Two years later, Delbrück and Alfred Hershey independently provided evidence for genetic recombination in phage, while Joshua Lederberg and Edward Tatum demonstrated genetic recombination in *E. coli*. Thus, within a brief three-year span, the existence of chromosomes within both *E. coli* and its phages was established. For these experiments and Hershey's subsequent demonstration that DNA was the genetic component of phages, Luria, Delbrück and Hershey in 1969 received the Nobel Prize in Medicine and Physiology.

Less appreciated was the key role played by Luria in the 1952 discovery of the host-modification phenomenon in which the host range of a progeny phage can be influenced by the exact strain of bacterium in which it has multiplied. A decade later, Werner Arber went on to show that such behaviour reflects enzymatic attack on unmodified phage DNA and its prevention by methylation.

Luria was an exceptionally talented writer. His scientific papers, textbooks and books for the general public all reflect mastery of his adopted English language. His first popular book, *Life: The Unfinished Experiment* (1973), won the National Book Award, with his autobiography *A Slot Machine, A Broken Test Tube* (1984) lucidly describing his intellectual and humanistic development. I remember him to be a teacher of the first rank. In autumn 1947, after only a few days into his course on viruses, I wanted to do my PhD under his supervision. It was typical of his devotion to his students' future success that he later arranged with John Kendrew for me to go to the Cavendish Laboratory where I was to meet Francis Crick.

Equally important was his skill as an administrator, shown over the 13 years he wisely and compassionately directed MIT's newly formed Cancer Center.

He was a human of passionate political beliefs. From early youth he identified himself with the causes of organized workers as opposed to those of management. As the Vietnam war developed, he became increasingly prominent in the antiwar movement and refused payment of the war-related component of his income taxes. Oppression of any form disturbed him, and there was never any doubt as to where he stood about authoritarian governments or institutions. More recently he worried about society's handling of the human genetic data whose accretion would be greatly accelerated by the human genome project. The possibility of a genetically defined underclass disturbed him, and we disagreed as to whether our societies would find the means to protect the victims of unjust throws of the genetic dice.

Luria knew what science at its best was and strove at all times to maintain high standards in both science and the human behaviour that make it possible. In doing so while young he could offend out-of-date minds or those who were all too self-satisfied with their accomplishments. By the time he died, however, there were few who did not feel better by being in his presence.

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