Prof. Werner Arber
Professor, Nobel laureate in Physiology or Medicine, 1978

Most important awards, prizes and academies

Nobel Prize in Physiology or Medicine (1978). *Academies*: European Molecular Biology Organization (1964); European Academy of Arts, Sciences and Humanities (1981); Foreign Associate of the National Academy of Sciences, USA (1984); Foreign Honorary Member of the American Academy of Arts and Sciences (1984); Academia Europaea (1989); Fellow of the American Academy of Microbiology (1996); Associate Fellow of the Third World Academy of Sciences (TWAS) (1997); President of the International Council of Scientific Unions (ICSU) (1996-1999).

Summary of scientific research

W. Arber's main scientific interests are the mechanisms which promote and which limit the spontaneous variation of genetic information in micro-organisms. In his doctoral dissertation he explained that rare, spontaneous derivatives of the bacterial virus λ have a part of the viral DNA substituted by a segment from the chromosome of the host bacteria. The concept of these hybrid transducing viruses later served others as a model for the design of cloning vectors in recombinant DNA technology. Beginning in 1960, W. Arber explored the molecular basis of host-controlled modification of bacterial viruses. This led to the discovery that this phenomenon acts at the DNA level. Specific enzymes, now known as restriction endonucleases, serve in many bacterial strains

to recognise foreign DNA upon its entry and they subsequently inactivate this DNA by cleavage. An associated DNA methylase protects the cellular DNA from restriction cleavage. Restriction and modification systems thus represent barriers limiting the exchange of genetic material between different micro-organisms, thereby improving genetic stability. Soon after their isolation, restriction enzymes proved to be extremely useful tools for molecular genetic studies, since they provide specific fragmentation of the long DNA filaments, a prerequisite for detailed structural and functional analysis. W. Arber has also intensively studied enzyme-directed processes in the structural rearrangement of genetic material, in particular transposition and site-specific recombination. These processes lead to the recombination of nonhomologous DNA and thus can bring about new gene functions by fusion of previously independent DNA segments. They represent part of the mecha nisms responsible for spontaneous mutagenesis and they are important agents in both vertical and horizontal evolution. On the basis of his long-term experience and taking into account knowledge accumulated over the past fifty years on molecular mechanisms of mutagenesis and of different kinds of recombination of genetic information, particularly in micro-organisms, W. Arber has postulated a theory of molecular evolution, according to which the products of evolution genes carried in the genome are involved either in the generation or in the limitation of genetic variation, without, however, implying a specific direction to biological evolution. Rather, the course of biological evolution results from the casual action of the products of evolution genes on DNA, from the conformational flexibility of the structures of biologically active molecules, from the largely stochastic nature of any interaction affecting genetic stability, and from chance environmental influences, whereby the steadily exerted natural selection limits diversity according to the temporal fitness of the organisms involved. In brief, a multitude of specific molecular mechanisms contribute to overall spontaneous genetic variation. These specific mechanisms can be classified into three major natural strategies of genetic variation, namely, small local changes in the nucleotide sequences, intragenomic rearrangement of DNA segments, and acquisition of a segment of foreign DNA by horizontal gene transfer. These strategies differ in the quality of their contributions to genetic variation and thus to biological evolution. The postulate that the products of specific evolution genes together with intrinsic properties of matter are at the origin of genetic variation which drives biological evolution has interesting philosophical implications. Nature cares actively for biological evolution. The juxtaposition of evolution genes and of the more classical genes acting to the benefit of individual lives implies an intrinsic duality of the genome. These aspects have been discussed by W. Arber in some of his recent publications, as well as the relevance of the acquired knowledge on spontaneous genetic variation for the evaluation of conjectural risks of genetic engineering.

Main publications

Arber, W., Kellenberger, G. and Weigle, J.J., The defectiveness of lambda transducing phage, *Papers on bacterial genetics selected by E.A. Adelberg*, Little, Brown and Co., Boston-Toronto, pp. 224-229 (1960); Arber, W. and Dussoix, D., Host specificity of DNA produced by *Escherichia coli.* 1. Host controlled modification of bacteriophage lambda, *J. Mol. Biol.*, 5, pp.

18-36 (1962); Dussoix, D. and Arber, W., Host specificity of DNA produced by *Escherichia coli.* 2. Control over acceptance of DNA from infecting phage lambda, *J. Mol. Biol.*, 5, pp. 37-49 (1962); Arber, W. and Linn, S., DNA modification and restriction, *Ann. Rev. Biochem.*, 38, pp. 467-500 (1969); Smith, J.D., Arber, W. and Kuehnlein, U., Host specificity of DNA produced by *Escherichia coli*. 14. The role of nucleotide methylation in in vivo B-specific modification, *J. Mol. Biol.*, 63, pp. 1-8 (1972); Arber, W., Iida, S., Juette, H., Caspers, P., Meyer, J. and Haenni, C., Rearrangements of genetic material in *Escherichia coli* as observed on the bacteriophage Pl plasmid, *Cold Spring Harbor Symp. Quant. Biol.*, 43, pp. 1197-1208 (1978); Arber, W., Promotion and limitation of genetic exchange, *Science*, 205, pp. 361-365 (1979); Iida, S., Meyer, J. and Arber, W., Genesis and natural history of IS-mediated transposons, *Cold Spring Harbor Symp. Quant. Biol.*, 45, pp. 27-37 (1981); Iida, S., Meyer, J. and Arber, W., Prokaryotic IS elements, *Mobile genetic elements* (J.A. Shapiro, ed.), Academic Press, Inc., New York, pp. 159-221 (1983); Arber, W., Elements in microbial evolution, *J. Mol. Evol.*, 33, pp. 4-12 (1991); Arber, W., Evolution of prokaryotic genomes, *Gene*, 135, pp. 49-56 (1993); Arber, W., Naas, T. and Blot, M., Generation of genetic diversity by DNA rearrangements in resting bacteria, *FEMS Microbiol. Evol.*, 15, pp. 5-14 (1994); Arber, W., The generation of variation in bacterial genomes, *J. Mol. Evol.*, 40, pp. 7-12 (1995); Arber, W., Involvement of gene products in bacterial evolution, *Molecular strategies in biological evolution* (L.H. Caporale, ed.), Annals New York Academy of Sciences, vol. 870, pp. 36-44 (1999); Arber, W., Genetic variation: molecular mechanisms and impact on microbial evolution, *FEMS Microbiol. Rev.*, 24, pp. 1-7 (2000); Arber, W., Evolution of prokaryotic genomes, Pathogenicity islands and the evolution of pathogenic microbes (J. Hacker and J.B. Kaper, eds.), *Curr. Top. Microbiol. Immunol.,* Vol. 264/I, pp. 1-14 (2002); Arber, W., Molecular evolution: comparison of natural and engineered variations, *Pontif. Acad. Sci. Scr. Varia*, 103, pp. 90-101 (2002); Arber, W., Cultural aspects of the theory of molecular evolution, *Pontif. Acad. Sci. Scr. Varia*, 105, pp. 45-58 (2003); Arber, W., Elements for a theory of molecular evolution, *Gene*, 317, pp. 3-11 (2003); Arber, W., Dual nature of the genome: Genes for the individual life and genes for the evolutionary progress of the population, *IUBMB Life* 57 (4/5), 263-266 (2005); Arber, W., The evolutionary strategy of DNA acquisition as a possible reason for a universal genetic code, *Hist. Phil. Life Sci.* 28, 525-532 (2006); Arber, W., Genetic variation and molecular evolution. In: *Genomics and Genetics*, Vol. 1, R.A. Meyers (Ed.), Wiley-VCH, Weinheim, pp. 385-406 (2007); Arber, W., The impact of science and technology on the civilization. *Biotech. Adv.*, 27, 940-944 (2009); Rech, E.L. and Arber, W., Biodiversity as a source for synthetic domestication of useful specific traits. *Ann. Appl. Biol.*, 162, 141-144 (2013).