Editorial

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In recent years the use of chimeric virus-like particles (VLPs) as vaccines and gene carriers has taken increasing importance in both basic and applied research. We therefore considered it pertinent to organize a special workshop to enable researchers in the field to share and compare data and to discuss new projects and perspectives in the development of VLPs.

The workshop 'Chimeric Virus-Like Particles as Vaccines' was held from May 17 to 19, 1995 in the Charité Medical School of the Humboldt University in Berlin, Germany. The Charité Hospital was founded in 1710 and became part of the Berlin University in 1810. Many great scientists worked there, among them Rudolf Virchow, Hermann von Helmholtz, Otto von Warburg, Robert Koch, Emil von Behring, Paul Ehrlich. Some of the origins of virus research can also be found there. Two examples should be mentioned: Friedrich Loeffler – who later, during his stay in Greifswald, became one of the founders of modern virology – was a coworker of Robert Koch in Berlin. Moreover, the development of the electron microscope and its use in virus research was closely connected with the Charité. In the joint laboratory of the First Medical Clinic and the Siemens & Halske Company, viruses were rendered visible for the first time; some of the data were published in 1940 by Helmut Ruska, Ernst Ruska and Bodo von Borries in the *Archiv für die Gesamte Virus-forschung* (which is currently named *Archives of Virology*). The present Institute of Medical Virology was founded in 1958. At that time it was one of the first virological institutions at a German University. The surroundings of the historical Charité Hospital presented a special atmosphere which the participants greatly enjoyed during the workshop.

It was a primary objective of the organizers to bring together colleagues who are investigating structural aspects in virology and those who are interested in the development of VLPs as future vaccines. Accordingly, the program was divided into the following parts: structure and morphogenesis of viral capsids (and envelopes), potential applications of VLPs (vaccines, diagnostics, gene therapy), investigation of particular carriers (HBcAg, HBsAg, Ty, HIV-Gag, other systems), and further developments (gene transfer, transgenic plants, DNA vaccination). Detailed knowledge about the structure of viral components and their assembly forms a necessary basis for the development of VLPs (see Bruss et al., Borisova et al, Kattenbeck et al, Wagner et al., Roy). The X-ray structure of certain viruses, capsids and capsid proteins has been elucidated. Examples are the VP7 protein of blue-tongue virus (see Roy), and the phages MS2

and fr. In other cases, indications of possible insertion sites can be deduced from immunological and cryoelectron-micro-scopic data (see Borisova et al., Roy).

Because of their spatial structure VLPs induce a higher humoral immunity than denatured particles (see Schirmbeck et al., Jagadish et al., Roy). They are also able to induce a MHC class I-restricted cytolytic T lymphocytes (CTL) immune response (Schirmbeck et al.). Currently, antigens of various infectious agents are synthesized as VLPs in heterologous expression systems; they should be useful as diagnostics and future vaccines (for example, in the case of human papillomavirus infections, see Sapp et al., Kirnbauer; bluetongue virus infections, Roy). Prevailing carriers allowing the exposition of foreign antigens are the yeast retrotransposon Ty protein pi, the

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hepatitis B virus core antigen (HBcAg) after expression in *Escherichia coli* or *Salmonella* (Borisova et al., Schödel et al.), bluetongue virus core expressed in insect cells (Roy) and HIV gag proteins expressed in insect and mammalian cells (Wagner et al.). The main advantage of the virus epi-tope presentation on VLPs consists in a higher humoral immunogenicity of the peptide epitope (see Schödel et al., Borisova et al.). Chimeric VLPs are able to induce both epitope-specific B and/or T cell responses (Wagner et al., Schödel et al., Borisova et al., Roy) and can be applied without adjuvant in some cases (Wagner et al., Jagadish et al.). Furthermore, they cannot replicate and are noninfectious.

Some additional carriers of foreign epitopes were developed, among them plant viruses and their proteins (Porta et al., Jagadish et al.). Another attempt to develop chimeric vaccines is the construction of chimeric viruses (which carry the foreign epitopes on their surface) as in the case of rhinovirus-based constructs (Ferstandig Arnold et al.). During the workshop new strategies for the construction of VLPs were also presented on the basis of Q β phage (Kozlovska et al.) and HIV (Tobin et al.).

The results of VLP production by* transgenic plants open new perspectives in the development of new vaccines which may even be applied orally. In gene therapy, packaging of the desired DNA into VLPs could enable cell targeting and enhance the efficacy of gene transfer. The DNA vaccination by injection of naked recombinant plasmid DNA has opened a new direction in modern vaccine development (see Whalen). It was shown that DNA vaccination by an HBsAg-expressing plasmid leads to strong induction of humoral and CTL immune responses in an animal model (Schirmbeck et al.).

The workshop created an environment for many discussions and ideas that should result in new collaborations and projects of the participants. The final discussion at the end of the workshop again summarized the significance of the VLP strategy for development of new vaccines and carriers in gene therapy.

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