antigens, complement allotyping and additional enzyme markers would clarify the point.

Although in the face of the evidence presented one tends to think of tissue typing at birth (to predict the occurrence of autoimmune disease) or perhaps even before one goes to the computer dating service, there are practical scientific reasons for being cautious. For example, Uno *et al.* selected only 15 of the 30 families studied for inclusion without saying how or why this selection was made. Second, IgG allotype frequencies are very different in Caucasoid and Japanese populations. Third, Graves' disease is very strongly associated with B8/DR3 in Caucasoids but with DR5 and DR8 in Japanese populations. A study of Japanese families living in America might show whether these differences are due to a different environmental factor interacting with different IgG or HLA haplotypes in the two populations or to putative susceptibility genes going with different allotypes in the two populations.

Theoretically the reasons for expecting HLA and immunoglobulin-gene linked associations with immune response in general and autoimmune disease in particular are overwhelming: HLA-DR antigens (or antigens in the same chromosome area) are necessary for antigen handling and presentation by a lymphoid cell subset; markers in this region (by analogy with the mouse) are important for interaction of T cells during a response; immunoglobulin genes are also involved in T-cell recognition and control; HLA-A,-B and -C antigens are important at the effector arm of the cellular response; and finally, C2, C4, Bf and immunoglobulin are involved at the effector arm of the humoral response. Thus, HLA and immunoglobulin genes are active throughout the immune response from recognition to control and it is slight differences in an individual allele's ability to function, or more exactly a summation of slight differences, which we are measuring as disease susceptibility. Theoretically therefore we expect that use of HLA and immunoglobulin allotyping data together with other genetic markers and environmental factors should allow autoimmune diseases to be predicted exactly. However, there is still a considerable amount of analysis of both HLA-region genes and IgG-region genes to be done in order to achieve this goal in the general population.

In Japanese families, the occurrence of Graves' disease can be exactly predicted on the basis of HLA and immunoglobulin allotypes, but it is too early to start wearing "Are you my HLA type?" badges outside Japan. Nevertheless, elimination of autoimmune diseases by genetic counselling is now much closer to being realized: if two independent susceptibility genes are necessary for disease onset, then it is possible to ensure that the genes will not occur together in the next generation. □

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Positronium and positronium ions

from T.C. Griffith

POSITRONS and positronium, the bound state of an electron and a positron, have in recent years been used in a rapidly increasing range of experiments in atomic physics, solid-state and surface physics and positronium chemistry. Positronium has also played an important part in fundamental experiments designed to check the validity of certain aspects of the theory of quantum electrodynamics (QED). It is therefore pertinent that the recent detection of a new entity, the positronium negative ion, Ps^- ($e^-e^+e^-$), initially predicted to exist as a bound state by Wheeler[1] in 1946, should be greeted as an important historical landmark which could greatly extend the activities of positron physicists. The careful experiment performed by Allen Mills[2] at the Bell Laboratories, New Jersey clearly demonstrates that Ps^- can be produced in the laboratory under controlled conditions.

Ps^- is the analogue of H^- ions produced by slow proton bombardment of thin foils and the method used by Mills incorporates the same ideas. In his experiment, a nearly monoenergetic beam of low-energy positrons, guided by a longitudinal magnetic field, strikes a thin film of carbon in ultra-high-vacuum conditions. The energy of the positrons is adjusted such that the beam is partially transmitted and application of a suitable potential to a grid located at the exit side of the carbon film will reflect the transmitted positrons back to the carbon whilst accelerating the weak beam of Ps^- into a field-free drift region beyond the grid. A lithium-drifted germanium detector is used to measure the energy spectrum of the resulting annihilation photons and a γ-ray peak is found whose energy depends on the accelerating potential applied to the grid. It was demonstrated that this peak can be attributed to a Doppler-shifted annihilation γ resulting from the 2γ decay of Ps^-.

As well as being of interest in its own right, Ps^- is also important because it might be used to produce beams of positronium of well defined energies. This could be achieved by accelerating the Ps^- to a given energy and then photoionizing it to give positronium which could, perhaps, be used in scattering experiments. Another suggested application is to use the annihilation of Ps^- in flight to provide a tunable source of γ rays of precisely known relative energy shift. The intrinsic properties of the Ps^- such as its lifetime ($\sim$ 2 nanoseconds), its 2γ angular correlation, its ($1\gamma/2\gamma$) branching ratio, its magnetic moment and measurement of its photoionization cross-section are obvious candidates for extensive studies.

The glamour of detecting the Ps^- ions should not be allowed to overshadow the deeper significance of this experiment. The major triumph underlying this work is the dramatic technical advances associated with the production of intense beams of slow positrons of well defined energies achieved at Bell Laboratories and at Brandeis University by Karl Canter and co-workers[3]. Technology has now reached such a level that within a few years low-energy positron beams of intensities of 10^9 positrons per second, or even several orders of magnitude higher, can be envisaged. Positron emitters created *in situ* in a nuclear reactor followed by carefully designed moderators and beam transport systems may be used for this purpose. If allowed to strike clean metal surfaces under ultra-high-vacuum conditions these positrons can be converted, with almost 100 per cent efficiency, into low-energy positronium atoms. We might therefore expect intense and highly localized sources of positronium atoms which can be used to study the excited states of positronium using laser beams in experiments, similar to those performed for atomic hydrogen, that will provide further high-precision tests of QED.

Even more exotic possibilities exist. Quantum chromodynamics predict that orthopositronium can decay into a new elementary particle, the axion, and a γ ray. The axion must have a mass of less than 1 MeV for this to be possible and if this were the case, then an intense positronium source from a low-energy positron beam could well find application in a search for the axion. □

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