it amounts to observing that $x = at + b$ can always be reduced to $x =$ constant by a linear transformation for which $dt^2 - dx^2$ is invariant.

Then in the coordinate system for which the geodesic P_1P_2 is $x =$ constant, the space-time interval ds is a pure time interval dt (since $dx = 0$). The elapsed proper time is

$$\int_{t_1}^{t_2} dt = t_2 - t_1$$

The concept of the same place at two different times *is* meaningful in this reference frame; P_1 and P_2 are the same place at two different times. Now for any other arc joining P_1 and P_2, say $x = x(t)$, with

$$\left|\frac{dx}{dt}\right| < 1$$

(the latter condition makes the arc a possible path of a particle), the proper time is given by

$$ds = \sqrt{dt^2 - dx^2} = \sqrt{1 - (dx/dt)^2}\, dt < dt$$

$$s_2 - s_1 = \int_{P_1}^{P_2} ds < \int_{t_1}^{t_2} dt$$

—that is, the proper time is largest for a geodesic.

Exactly the same proof, for the case slope of $P_1P_2 < 1$, gives $t = ax + b$, $|a| < 1$ (or $t =$ constant in an inertial system whose x-axis is parallel to P_1P_2), and shows that the distance between two points is longest along a geodesic. This is the Lorentz contraction: an object measures longest in its rest system.

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Serological Procedure for the Detection of Antibodies to Penicillin

Abstract. A hemagglutination technique for demonstrating antibodies to penicillin in sera from penicillin-allergic subjects is described. Erythrocytes coupled to penicillin T by means of bis-diazotized-benzidine constitute the "antigen" used to measure the antipenicillin antibody. The hemagglutination reaction is highly specific, as indicated by hemagglutination-inhibition studies. The clinical significance of these antibodies remains to be elucidated.

The antigenic property of penicillin is recognized by such in vivo methods as the skin scratch and intradermal tests and the conjunctival test. However, little is known of the nature of the antibody to penicillin. It has been demonstrated by passive transfer techniques (*1*), and recently an in vitro demonstration of circulating antibody has been reported by Ley *et al.* (*2*). Watson and his colleagues (*3*) describe an attempt to characterize the penicillin antibody by electrophoretic studies in starch gels.

Table 1. Hemagglutination* titers of sera from penicillin-sensitive subjects.

Patient's serum	Serum dilutions (in NRS 1:100)						
	1:4	1:8	1:16	1:32	1:64	1:128	1:256
JH-2	4+	4+	4+	4+	3+	±	0
DMP-2	4+	3+	2+	±	0	0	0
BV-1	2+	2+	2+	0	0	0	0
AV-2	0	0	0	0	0	0	0

* Erythrocytes sensitized with penicillin T by means of BDB.

This paper reports a new serological technique for detecting antibodies to penicillin. The principle of coupling the antibiotic to the erythrocyte by means of bis-diazotized-benzidine (BDB) is used to prepare the "antigen" (*4*). The bis-diazotized-benzidine provides a stable bond between the penicillin and the red cell. Hemagglutination occurs when cells sensitized in this fashion are mixed with the serum from certain individuals who are hypersensitive to the drug. The pattern of agglutination obtained resembles that seen in the virus hemagglutination test (*5*).

Successful coupling of penicillin to erythrocytes has been accomplished with penicillins T (*p*-aminobenzyl penicillin) and V (phenoxymethyl penicillin). Rabbit, sheep, or human group O, Rh-negative erythrocytes may be used. If erythrocytes of heterologous species are employed, absorption procedures are carried out to eliminate nonspecific agglutination. After preliminary experiments, the human red cell was selected as a matter of convenience.

It is essential to determine the optimal ratio of BDB to penicillin for the sensitization of the erythrocytes. This is accomplished by a "checkerboard" titration of a known positive antipenicillin serum and a negative serum with (i) erythrocytes exposed to a constant amount of penicillin and varying volumes of a 15-fold dilution of BDB and (ii) erythrocytes exposed to varying amounts of penicillin and a constant volume of the diluted BDB. That combination of the two reagents producing the highest titer with the positive serum and no reactions with the negative serum and in the controls is used for the performance of the test proper.

The sensitized erythrocytes are washed once in 1-percent normal rabbit serum in a phosphate buffer of *p*H 7.3 (NRS 1:100). The same medium (NRS 1:100) has to be used to prepare the 2-percent erythrocyte suspension, as the sensitized cells are unstable in saline. For the same reason NRS 1:100 is also used to prepare the twofold dilutions of the test sera.

The reaction between the serum and the sensitized erythrocytes is allowed to take place at room temperature. The results of the hemagglutination may be read in 3 to 5 hours, and observation may be repeated after overnight incubation on the bench.

Nine of 20 sera from persons with reported allergic manifestations to penicillin have produced positive hemagglutination reactions with titers from 1:4 to 1:64. Representative titrations are shown in Table 1.

Hemagglutination-inhibition experiments with decreasing concentrations of penicillin solutions and a constant dilution of a serum known to produce a 4+ reaction indicate that this technique is highly specific and sensitive. Eight units of penicillin V and four units of penicillins G and T completely prevented agglutination of erythrocytes linked to penicillin T. Moreover, the cross reactions exhibited by the hemagglutination-inhibition test appear to lend support to the assumption that the penicillin molecule per se, rather than the side chain, is primarily concerned in eliciting antibody formation.

The clinical significance of the antibody to penicillin is being investigated (*6*).

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References and Notes

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