cannot be isolated from the total sensory history of the animal. The basic question of the origin of the apparently insatiable responding for light, at extremely high rates, will remain unanswered until extensive developmental studies are undertaken (*7*).

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4. A third experimental animal (*M. mulatta*), which was subjected to visual deprivation for a shorter period, showed a similar but less marked elevation of response rates. Testing of this animal was begun after 15 weeks of visual deprivation, when the monkey was 4 months old. Its rate of responding for light (1500 to 2000 responses per hour for weeks 2 to 8 of testing) was significantly higher than that of its normal control of the same age, yet lower than the response rates of the other two experimental animals. It is not known whether the intermediate response rate of this experimental animal is related to the shorter period of visual deprivation or due simply to factors of motor development.
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7. We thank Richard Fugett for his part in caring for the animals. This study was conducted at the University of California, Los Angeles. It was supported by the U.S. Public Health Service (grant B-1883) and by the U.S. Air Force Office of Scientific Research [contract AF 49 (638)-686].

5 December 1962

Growth of the Cellular Slime Mold Polysphondylium pallidum in a Simple Nutrient Medium

A previous attempt to cultivate the slime mold *Dictyostelium discoideum* axenically was successful, but the generation time was too long (16 hours as compared with 3.5 hours in two-membered culture with *Aerobacter aerogenes*) and the stationary-phase cell yield too low (*1*).

Furthermore, the medium was extremely complex and included an undefined lipoprotein fraction from bacteria. A fresh attempt, with the species *Polysphondylium pallidum* (Olive), strain PP-1, has provided a much simpler medium in which exponential growth is achieved, with a cell yield of about 1.5 g (dry weight) of cells per liter.

The constituents of the medium are as follows: lecithin (Glidden Products), 400 to 800 μg/ml; a lipid-free milk powder (Starlac), 0.5 to 2 percent; proteose peptone, 1 percent; and 0.05*M* phosphate at *p*H 6.5 (autoclaved 25 to 30 minutes at 120°C). Aliquots (5 ml) containing an inoculum of 1×10^4 amoebae per milliliter or of spores taken from fruiting bodies were shaken (130 cy/min; 4-cm stroke) in 125-ml erlenmeyer flasks at 23°C. The flasks were covered with aluminum foil to prevent evaporation. Figure 1 shows the kinetic data obtained in three separate subcultures of amoebae. The generation time was 3.7 hours; the yield, 1.6×10^7 cells per milliliter. No lag phase was encountered when the inoculum consisted of amoebae taken from a log-phase culture. Spores and stationary-phase amoebae showed lag phases of varying duration depending on age and physiological state. The milk fraction is not essential; a generation time of about 4.5 hours and a yield of 1.0×10^7 cells per milliliter were obtained when the milk fraction was omitted. Lecithin and at least one of the protein sources are essential. *Polysphondylium pallidum* has been maintained in this medium over the course of seven serial passages (about 100 generations) without loss of rate or yield. Excellent growth and adequate fruiting-body construction are obtained on a corresponding agar medium, in both mass and clonal culture. Two kinds of sterility controls were run. Various dilutions of log-phase cultures were inoculated into nutrient broth, incubated at 30° and 38°C (temperature above the tolerance of the slime-mold amoebae), and plated on lecithin-peptone-milk agar at 24°C. There were no signs of contamination. In any case a yield of 10^7 amoebae per milliliter has been found to require the presence of 10^{10} living bacteria per milliliter (*2*), and contamination at this level would have been detectable by simple microscopic inspection.

Neither *Dictyostelium discoideum* nor *Dictyostelium mucoroides* could be cultivated in the medium described here (*3*).

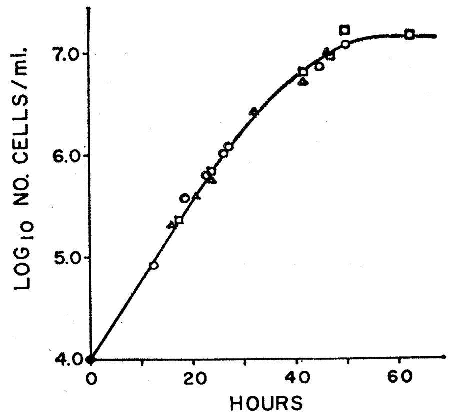

Fig. 1. Kinetic data obtained in three separate subcultures of amoebae.

Note. The successful axenic cultivation of *P. pallidum* was reported in an abstract [H. Hohl and K. B. Raper, "Abstracts of Papers Presented at the Second Annual Meeting of the American Society for Cell Biology" (Nov. 1962)] which appeared after this report had been submitted for publication. The medium used by Hohl and Raper contains bovine embryo extract, bovine serum albumin, Tryptose, dextrose, vitamins, and inorganic salts. The culture used in our study was derived from *P. pallidum*, strain WS-320, obtained from Raper's laboratory in July 1962. This, interestingly enough, is the strain upon which Hohl and Raper have centered their investigations.

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5 December 1962

Two New Forms of Silicon

Drickamer and Minomura (*1*) have observed that at 25°C the electrical resistivity of silicon drops by a factor of about 10^5 upon compression to about 200 kilobars, and the compressed silicon appears to be metallic. They noted that the pressure interval over which the resistivity changes most rapidly depended upon the amount of shear experienced by the silicon; more shear favored more change in resistivity at pressures somewhat lower than 200 kbar.

Because silicon is available in very pure form, the resistance change in silicon was studied as a possible pressure-reference calibration phenomenon. A modified double-opposed-piston pressure apparatus, as described by Bundy (*2*), was used. It was calibrated by reference to the transitions in bismuth, iron, and lead, taken to occur at 88, 131, and 161 kbar, respectively, as reported by Drickamer *et al.* (*3*). The aforementioned sensitivity of silicon to shear was noted, and the resistivity of a piece of high-purity silicon often fell (relative to the value at about 20 kbar, where good electrical contact was made) by a factor of 10^2 or 10^3 at pressures of only 110 or 120 kbar. The resistance tended to drift downward when the press force was held constant for several minutes. At pressures of about 150 to 160 kbar the resistivity was 10^{-5} or 10^{-6} that at 20 kbar, and little further change took place at higher pressures. The resistivity of the compressed silicon then appeared to be in the range 10^{-5} to 10^{-6} ohm-cm—that is, it was similar to that of aluminum. As the pressure was reduced, the resistivity rose only moderately, by a factor of 10 or 100, from its minimum value.

The silicon pieces recovered from such high-pressure experiments had apparent gross resistivities of about 10 ohm-cm (internal cracks from decompression probably raised the apparent resistivity), and their overall resistances increased only slightly upon heating to 100°C. Such silicon is therefore more metallic than ordinary silicon. All the dense silicon prepared so far is in the form of tiny crystals in polycrystalline lumps; no single-crystal studies have been made.

The recovered pieces had densities, as measured by the sink-float method, of about 2.55 g/cm^3. Debye-Scherrer x-ray patterns revealed that the material consisted almost entirely of a new crystalline phase that was body-centered cubic, with a equal to 6.64 ± 0.01 angstroms. For 16 silicon atoms per unit cell the theoretical density then is 2.55 g/cm^3.

Systematic absences and considerations of packing strongly indicate space group Ia3–T_h^7. Furthermore, the set of positions 16(C) (*xxx*, and so on) appeared to be the only possible set. The single x parameter was determined by trial and error to be 0.103 ± 0.001.

The resulting structure consists of a novel arrangement of distorted tetrahedra, wherein the Si-Si distances (2.37 and 2.38 angstroms) are essentially the same as in ordinary silicon of the diamond structure type. A representation of the structure is given in Fig. 1, which shows the tetrahedral surroundings of a contiguous pair of atoms along the body diagonal.

It was found that heating the silicon to temperatures in the range 200° to 1000°C while it was at high pressures slightly reduced the pressures required for the complete transformation to the low-resistivity form. (It is not yet certain whether the form that is recovered is the same form which exists at high pressure.) When the silicon was exposed at 25°C to pressures in the range 110 to 140 kbar—pressures which were usually insufficient to produce the minimum resistivity—the recovered silicon pieces had densities between 2.33 and 2.55 g/cm^3 and exhibited the Debye-Scherrer patterns of both normal and dense silicon.

Thus, the large change in resistivity observed in silicon at high pressures is not labile or reversible but, instead, seems to depend strongly on shear, exposure time, and temperature; it appears then that the change is a sluggish one from one solid form to another. The change is accordingly not a good pressure-reference phenomenon. There is no certain evidence that the silicon was molten at 25°C and at 160 to 200 kbar. The pressure-temperature phase diagram for silicon is under study.

When the dense silicon described was heated in air at about 150°C for 120 minutes its density decreased to 2.41 g/cm^3 and its Debye-Scherrer pattern indicated the presence of another phase. This new phase could be ordinary silicon, to judge from the few weak lines extraneous to the pattern of dense silicon.

However, more extensive heat treatments—at temperatures of 200° to 600°C for periods of between 30 minutes and 3 days—produced patterns (with none of the dense silicon lines, or very few) that could be indexed for a hexagonal cell, with approximate values of a = 3.80 angstroms and c = 6.28, corresponding to a structure related to the wurtzite type in the same way that the structure of ordinary silicon is related to the zincblende type. There is, of course, the coincidence in strong peaks for the hexagonal and the cubic (ordinary silicon) modifications, especially since the lines are broad. To judge from the intensities of the coincident peaks, it appears that there are varying proportions of the two modifications for the different heat treatments, and in some cases the hexagonal form may be the more prevalent. The likelihood that there are stacking faults is quite high but cannot be assessed well from the powder photographs.

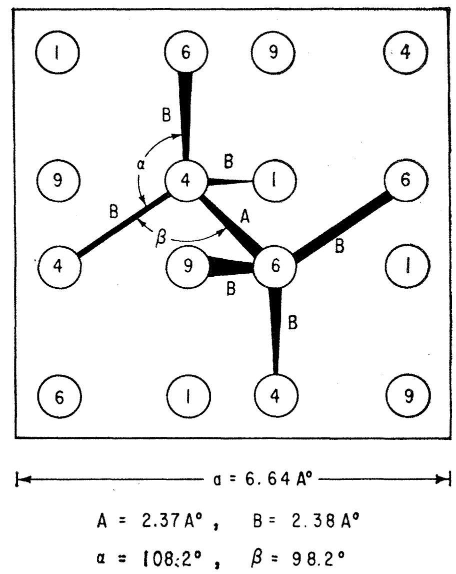

Fig. 1. Projection of the structure of dense silicon on (001). Elevations (in 1/10 *c*) are given by the numbers inside the circles.

Fragments containing large amounts of "wurtzite silicon," like the ordinary silicon starting material, have a density of 2.33 g/cm^3, as measured by the sink-float method, and a high resistivity —for example, 10^4 ohm-cm—which falls sharply with increasing temperature. No large crystals of the "wurtzite silicon" have been prepared (*3*).

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