4. S. I. Askovitz, *Science* 121, 212 (1955).
5. The centroid of two weighted points divides the segment joining the points in proportion to their masses and lies nearer to the "heavier" point. The division of the segment can generally be estimated with a ruler quite readily; or more exact methods may be used, to be found in any textbook on plane geometry.
6. The centroids have been proved to lie on ordinates spaced $\frac{2}{3}s$ apart from each other, where s is the uniform interval between the original x's.

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Interaction Product of Glycine and Dextrose Toxic to Phytophthora fragariae

Because of difficulties in isolating and culturing *Phytophthora fragariae* Hickman, the causal organism of red stele of strawberry, studies were made on the cause of its failure to develop on many media. It was found that potato agar supports growth although potato-dextrose agar does not, so it was concluded that dextrose in some manner was responsible for the lack of growth.

The effect of dextrose in oatmeal and bean agars, the only media reported which satisfactorily support growth of the fungus (*1*), was tested. When oatmeal and Difco lima-bean agars containing 0.1, 0.5, 2.0, and 10.0 percent dextrose were inoculated with *P. fragariae,* growth was retarded in the 0.5-percent dextrose media and completely inhibited in the 2.0- and 10.0-percent dextrose media. Maltose and lactose had the same effect, but the fungus was able to grow in culture media containing up to 20.0 percent sucrose.

These results indicated that inhibition occurred only when reducing sugars were used. The following nine reducing carbohydrates—arabinose, xylose, galactose, levulose, mannose, cellobiose, lactose, maltose, melibiose—and the following 15 nonreducing carbohydrates—sucrose, raffinose, trehalose, melezitose, adonitol, dulcitol, glycerol, inositol, mannitol, sorbitol, corn starch, dextrin, inulin, salicin, and soluble starch—were added to potato agar at a 2.0 percent concentration before autoclaving. *P. fragariae* did not grow on media containing any of the reducing carbohydrates, but did grow in the presence of each of the nonreducing carbohydrates with the exception of glycerol. However, the autoclaved glycerol-potato agar medium gave a positive Benedict test. *P. infestans* grew on oatmeal agar containing 2 percent dextrose, mannose, or galactose, but did not grow when 2 percent maltose, arabinose, levulose, or xylose was added to oatmeal agar.

If dextrose is sterilized by filtration in a Seitz filter or in the autoclave at 20-lb pressure for 20 minutes and then added to sterilized potato or oatmeal agar, *P. fragariae* grows on the media even if they contain as much as 12 percent dextrose. This proves that preheated or unheated dextrose is not in itself responsible for the inhibition.

However, if autoclaved potato agar containing 4 percent dextrose is added to autoclaved oatmeal (or potato) agar in equal proportion, the mixture will not support development of the pathogen.

Although it has been shown (*2*) that glucose reacts with amino acids and thiamine (which is required for the growth of certain species of *Phytophthora, 3*) and thus could make them unavailable, the presence of dextrose would not account for the afore-mentioned result unless dilution by 50 percent of an essential substance causes the inhibition of growth. It can be assumed that the oatmeal agar in the mixture provides the necessary amino acids and vitamins. It seemed more feasible to postulate that a toxic or fungistatic substance was formed through the interaction of the dextrose with constituents of the media during autoclaving. It was known that autoclaved glucose in the presence of phosphate gives considerable conversion to ketoses (*4*).

Proof of the production of a toxic or fungistatic substance through the interaction of an amino acid and a reducing carbohydrate was obtained when it was found that *P. fragariae* would not grow on media to which had been added an autoclaved mixture of glycine and dextrose, but that it would grow on media containing these constituents if they were autoclaved separately before being added. Glycine (0.024 g) and dextrose (2 g) were autoclaved separately and together in 0.5 ml of water and were added to 100 ml of oatmeal agar. When glycine and dextrose were autoclaved together, a browning reaction occurred (*2*).

P. cactorum, P. cambivora, P. cinnamomi, P. megasperma, and *P. parasitica,* which are able to grow on autoclaved media containing 2 percent reducing carbohydrate, were also sensitive to the product of interaction of autoclaved dextrose and glycine. They showed a range of sensitivity, but none were as sensitive as any of the *P. fragariae races* used. However, a species of *Phytophthora* (*5*) that causes loganberry root rot showed the same amount of sensitivity as *P. fragariae.*

Dilution of the glycine-dextrose mixture before autoclaving had a marked effect on the production of toxin. In 10 ml of water, 0.14 g of glycine was required with 2 g of dextrose, whereas if no water was added, only 0.01 g of glycine was required with 2 g of dextrose to produce sufficient toxin to inhibit growth of *P. fragariae.* No toxicity to *P. fragariae* was obtained when sucrose was substituted for dextrose.

When *dl*-alanine, *l*-(-)-leucine, and Bacto asparagine were autoclaved with dextrose, a substance that was toxic to *P. fragariae* was produced. However, the same amount of *l*-cystine and dextrose autoclaved together was nontoxic to *P. fragariae.*

The browning reaction (*2*) occurred when dextrose was autoclaved with glycine, alanine, leucine, and asparagine, but only to a very slight degree when cystine was used. It has been observed that when dextrose is autoclaved with oatmeal, potato, and lima-bean agars, the media become slightly brownish and thus a similar reaction probably occurs.

Because not all the reducing carbohydrates inhibited the growth of *P. infestans,* either different toxins or amounts of toxins are produced. The sensitivity of *Phytophthora* spp. and strains to the product of interaction of glycine and dextrose will aid in showing their relationship (*6*).

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References and Notes

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Mathematics deals exclusively with the relations of concepts to each other without consideration of their relation to experience.—ALBERT EINSTEIN.