acid rather than methoxylated pectin appears to be the preferred substrate for the crude bacterial enzyme. To avoid commitment at the present time concerning the relationship with fungal pectin-*trans*-eliminase, we shall refer to this enzyme as bacterial (or *Erwinia*, or *Bacillus*) polygalacturonic-*trans*-eliminase.

Culture filtrates of *E. carotovora*, grown on a shaker in a synthetic medium with polygalacturonic acid as the sole carbon source, exhibited maximum polygalacturonic-*trans*-eliminase activity when the culture entered the stationary phase of growth, that is, after approximately 15 hours at 30°C. There was a loss of enzyme activity on incubation of cultures beyond 16 hours. Although good growth was obtained in glucose, filtrates prepared from such glucose-grown cultures failed to show polygalacturonic-*trans*-eliminase activity. The enzyme system is stable for periods up to 1 month when stored at *p*H 8.0 at 4°C. Using *tris*-HCl buffer in the range of *p*H 6.8 to 8.5 and glycine-NaOH buffer at *p*H 8.8 and 9.3, bacterial polygalacturonic-*trans*-eliminase activity was observed to be optimal at *p*H 8.5. Under the conditions of our assay method, an optimum temperature of 50°C was recorded for the reaction. An absolute requirement for calcium could be demonstrated in the dialyzed enzyme preparations (Fig. 1). Added $CaCl_2$, up to 0.001*M*, increased the rate of the reaction; higher concentrations of $CaCl_2$ resulted in precipitation of the substrate with a consequent decrease in the reaction rate. The addition of $3 \times 10^{-5}M$ ethylenediaminetetraacetic acid (Versene) completely inhibited the reaction; upon addition of 0.001*M* $CaCl_2$ almost all the original activity was restored. At the time our first statement (*4*) on bacterial polygalacturonic-*trans*-eliminase was submitted, most of our work had been based upon pectin as substrate. Subsequent investigation revealed that the polygalacturonic-*trans*-eliminase of *E. carotovora* acts very much more readily on polygalacturonate than on methoxylated pectin. (Observed in a typical experiment: with pectin as substrate, the optical density at 235 mμ was 0.03 at 2 minutes, 0.045 at 6 minutes, 0.08 at 15 minutes, and 0.09 at 20 minutes; with polygalacturonate as substrate, the optical density at 230 mμ was 0.10 at 1 minute, 0.32 at 4 minutes, and 0.57 at 7 minutes.) It is not yet clear whether the attack on pectin was preceded by the action of pectin esterase which was present in the crude enzyme preparation.

Under the conditions we employed, prolonged incubation of the crude bacterial enzyme with polygalacturonic acid resulted in two major degradation products, one substance with R_F value corresponding to digalacturonic acid and one compound with R_F value between that of mono- and digalacturonic acid. This latter material is the unsaturated dimer, based upon the observed ultraviolet absorption and specific reaction with thiobarbiturate. Chemical characterization of this material is under way, as is further purification of the enzyme systems.

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28 September 1961

Newton and Spectral Lines

The apparatus used by Isaac Newton in his premier investigations into the nature of color during the years 1668–1672 differs in no important respect from a modern prism spectroscope. According to his *Opticks*, Newton used a prism, an opening in his shutter, and a lens to focus the image of the opening on the prism, and onto a screen on the wall. He experimented with various shapes for the opening; at first, he used a round ¼-inch hole. However, the spectrum produced by this method was too narrow and he says (*1*, p. 70):

> Yet, instead of the Circular Hole, F., 'tis better to substitute an Oblong Hole shaped like a long Parallelogram, with its Length parallel to the Prism ABC. For if this Hole be an Inch or two long, and but a tenth or a twentieth Part of an Inch broad, or narrower; the Light of the Image . . . will be as simple as before, or simpler, and the Image will become much broader, and therefore more fit to have Experiments tried on its light than before.

He used a variety of prisms, including ones made both of solid glass and of glass plates filled with rainwater, which he saturated with "Saccharum Saturni" (lead acetate) to increase the refractive index. Although he complained in a number of instances about the poor quality of the glass in his solid prisms, he seems to have found a few fairly good specimens whose defects were sufficiently localized so that he could mask them with black paper (*1*, p. 88):

> I took another Prism of clear white Glass; but the Spectrum of Colours which this Prism made had long white Streams of faint Light shooting out from both ends of the Colours, which made me conclude that something was amiss; and viewing the Prism I found two or three little Bubbles in the glass, which refracted the Light irregularly. Wherefore I covered that part of the glass with black Paper, and letting the Light pass through another Part of it which was free from such Bubbles, the Spectrum of Colours became free of those irregular Streams of Light, and was now such as I desired.

He used lenses of focal length 6, 8, 10, or 12 feet, and of sufficiently high quality "as may serve for optical uses." He thus had a spectroscope in nearly modern form, and with it generated solar spectra nearly 10 inches in length. With such an instrument Newton should have obtained both the dispersion and resolution necessary to produce distinguishable absorption lines in the solar spectrum.

Why, then, did he not report the presence of spectral lines? Were the lines really not visible, or did he observe but not report them, and if so, why?

H. Kayser, in the introduction to his *Handbuch der Spectroscopie* (*2*), discusses these questions and suggests that Newton did not see the lines because of internal inhomogeneities and surface imperfections of his prisms. More recently, R. C. Lord (*3*) has concluded after careful calculations that the visibility of the *d* lines would be borderline and thinks that Newton's failure might be ascribed to his use of a slit that was too wide.

The answers to these questions should, in part, be provided by experiment.

Accordingly, we reconstructed a Newtonian spectroscope and duplicated, as nearly as possible, his first experiments with the spectrum. Using slit widths of 0.8 to 1.5 mm (according to his nebulous "a twentieth part of an inch or narrower") and a 60° glass prism, we observed blurred but definite solar absorption lines at the positions of the Fraunhofer *E* (iron), *b* (magnesium), *F* (hydrogen), *g* and possibly *H* (calcium) lines.

Further experiments were made with a lead acetate solution–filled "prismatick vessel" made from ordinary glass and having prism angles of 55°, 55°, and 70°. The *E*, *F*, and *g* lines were observed with the use of this crude prism.

In most of these experiments optical imperfections in the system caused random lines and spots to appear in the continuum on the screen. These lines and spots were, however, readily traceable to their sources because they changed position with respect to the fixed colors when slight shifts in the position of the elements of the optical train were made. Only the absorption lines maintained a constant position with respect to the colors.

It should be noted that the absorption lines, as we observed them, were visible only when the optical parts of the experimental system were aligned so as to provide maximum dispersion and resolution of the spectrum produced. This was not surprising, in view of the crudeness of the apparatus. Since conditions requisite for the best viewing of either colors *or* lines are necessarily identical and since Newton's primary interest during this stage of his investigations was the nature of color, it was assumed that his experiments were carried out under conditions as near optimum as the situation would permit. This assumption is supported by Newton's general attitude toward the attainment of optical excellence (*1*, p. 72):

> The lens also ought to be Good, such as may serve for optical Uses, and the Prism ought to have a large Angle. . . Being made from Glass free from Bubbles and Veins, with its sides not a little convex or concave. . . but truly Plane, and its Polish truly elaborate, as in working optick-glasses.

With the probability that Newton *did* see the lines, there arises the question: Why didn't he mention them? It seems unlikely that a skilled observer of Newton's stature could have failed to note their presence, and his silence on this matter must be presumed to be due to other causes. Possibly he ascribed the lines to optical imperfections in his spectroscope, or perhaps he was so engrossed in the major aspect of his studies—the nature of color—that he dismissed the lineation as a secondary phenomenon. Perhaps he considered the lines to be interference phenomena with which he was familiar:

> I placed another Knife by this so that their edges might be parallel and look towards one another, and that the beams of light might fall upon both the Knives, and some part of it pass between their edges. . . . as the Knives approached one another. . . . Fringes began to appear . . . on either side of the direct light.

Perhaps the explanation for his silence on the subject of spectral lines can be found in the psychology of the man himself. Newton was by nature suspicious, introverted, and sensitive. He was reticent in the extreme in releasing information about his studies and was determined that his scientific works should include nothing but observations. In addition, he was beset by critics, notably Robert Hooke, and it is probably not coincidental that the *Opticks* was published in 1704—the year following Hooke's death. In this context, it is not unreasonable to speculate that spectral lines were first observed by Newton, but since he was not able to defend or even consistently reproduce them, he simply refused to mention the fact of their presence.

There are other possibilities, perhaps more consistent with Newton's reputation as an impartial and accurate observer of what he saw. He may have assumed that the lines were the natural boundaries of the colors, as did Wollaston some 130 years later. He may have been so beset with optical imperfections, despite his attempts to achieve excellence, that the lines were either unnoticeable in the welter of other marks in the spectrum, or obscured by them entirely. *Opticks* certainly gives reason to believe that he eventually achieved a fair degree of clarity in his results, but this by no means rules out the possibility that the majority of his experiments were beset with problems. The body of *Opticks* deals with successes, not failures.

Finally there is the remote possibility that he simply overlooked the lines in the excitement and novelty of the more vivid and reproducible phenomena which he saw and attempted to understand.

We have no way of knowing that Newton actually saw the lines. In duplicating his experiments, our results indicate that they would have been visible, and rather vividly so, under some circumstances. According to *Opticks*, many of Newton's experiments were apparently carried out under such circumstances. We can only say, "We saw the lines," and wonder why Sir Isaac Newton failed to achieve the distinction of being the founder of the science of spectroanalysis, in addition to his other achievements (*4*).

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Laterality of Verbal Intelligence in the Brain

Abstract. Patients with left-hemisphere epilepsy and their speech mechanism abnormally located in the right cerebral hemisphere are more similar in their verbal ability to ordinary patients with right-hemisphere epilepsy than to those with left-hemisphere epilepsy.

Commonly the cerebral mechanism for speech is localized in the left hemisphere. This report is on the intelligence of nine patients found to be the reverse of normal: when sodium amytal was injected into the carotid arteries their speech was disorganized on the right side.

The apparent reason for their reversed localization was that they had suffered damage to the left hemisphere early in life. They were epileptic patients being considered for possible neurosurgery on the left hemisphere to relieve them of their seizures, and the "amytal aphasia test" (*1*) was part of the diagnostic procedure. Usually a right-handed patient who shows epileptiform activity near the left temporal leads on the electroencephalogram (EEG) will also have postictal dysphasia. That is, after a seizure the patient will often have difficulty in naming objects although able to speak, for example, "This is a, er . . . I know what