vestigation of the possible incorporation of Mn^{54} into living systems that are subjected to fallout from thermonuclear explosions.

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26 July 1957

Gibberellin-Stimulated Cambial Activity in Stems of Apricot Spur Shoots

Sachs and Lang (*1*) found that gibberellin increased the number of cell divisions in the subapical region of the shoot of *Hyoscyamus niger*. To our knowledge this is the only report to date of gibberellin stimulating cell division. In this paper, evidence is presented that gibberellin can increase the cell division rate in the cambial zone under certain circumstances. It may be significant that the cambial zone, like the subapical region of a shoot, is normally conditioned for mitotic activity.

In investigations by one of us (J.C.C.) of various macroscopic effects of gibberellin on the growth of the vegetative and reproductive structures of the apricot (*2*), considerable growth in diameter of stems of spur shoots and of branches 1 year old or older was noted. This growth caused longitudinal splitting of the bark. By contrast, stems of the long shoots formed in the current season showed no apparent growth in diameter. Scaffold branches of trees of *Prunus armeniaca* cv. Royal had been sprayed on April 10 with a 1000 mg/lit solution of a gibberellin (*3*) containing 0.05 percent Tween 20. For studies of the microscopic aspects of the gibberellin-induced increase in stem diameter, segments of stems of three typical spurs from control and from treated branches were fixed 5 weeks after treatment in formalin-acetic acid-alcohol. Sections were cut at 40 μ on a freezing microtome and were stained with safranin and fast green. Transverse sections were taken at a distance of 3/16 to ¼ in. below the terminal bud, and longitudinal ones from segments below that region.

From casual inspection of the sections it was obvious that xylem development had been greatly stimulated by the treatment (Fig. 1), whereas phloem development appeared to be unaffected. In transections of treated and control spurs, ocular micrometer measurements were made of radial diameters of the secondary xylem, arbitrarily distinguished as the predominantly small-celled xylem outside the series of large vessels which are presumably of primary origin. Because of tangential stretching and radial compression of phloem in treated spurs, the radial thickness of that tissue was not measured. The numbers of cells per radial row were counted in both vertical and horizontal systems of the secondary xylem and also in those systems of all the phloem between the primary phloem fibers and the cambium; the position of the cambium was determined on an arbitrary basis. Since the vascular tissue cylinders are wider in the vicinity of leaf traces, all counts and measurements were made on the side of the stem opposite that in which the three traces to the nearest leaf appeared. For each treated or control spur, one radial measurement and one count of cells in the vertical systems of xylem and phloem were made in each of ten nonserial sections. In the case of numbers of xylem and phloem ray cells in radial sequence, two counts were made in each of ten sections. Ray cell constitution may be a better indication of previous mitotic activity of the cambium, since intrusive growth commonly found in xylem of the vertical system (*4*) would exaggerate the actual numbers of cells counted in transections, and since ray cell initials in the apricot apparently do not undergo as many divisions, if they undergo any, as the initials of the vertical systems, as evidenced by the greater radial diameters of the ray cells. The mean values for the measurement and cell count data are given in Table 1. Deviations from means of cell counts were inevitably high (the greatest was 31 percent) where the means were less than 10, but dropped to less than 10 percent where the means were greatest.

Table 1. Xylem and phloem development in stems of spur shoots from apricot branches sprayed with gibberellin and from control branches.

Shoot	Secondary xylem: Radial diam. (μ)	Secondary xylem: Mean No. of cells along radial diam., Vertical system	Secondary xylem: Mean No. of cells along radial diam., Horizontal system	Phloem: Mean No. of cells along radial diam., Vertical system	Phloem: Mean No. of cells along radial diam., Horizontal system
		Controls			
A	144	16.4	9.9	20.1	6.4
B	133	13.2	10.6	19.2	6.0
C	164	18.9	12.8	18.1	7.3
		Treated shoots			
A	605	60.1	37.8	19.4	7.8
B	999	91.3	55.7	20.3	8.1
C	863	80.2	52.2	18.4	7.9

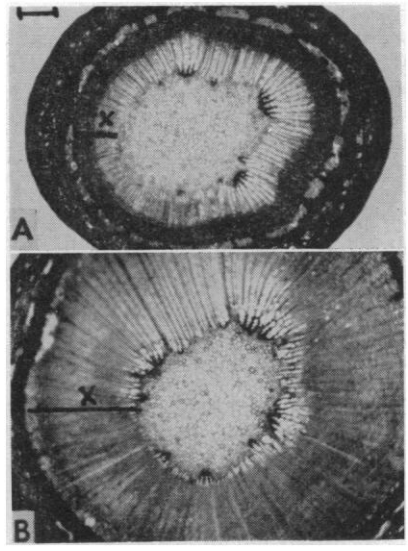

Fig. 1. Transections of stems of spur shoots of apricot showing xylem development in a spur from a control branch (*A*) and in one from a branch sprayed with gibberellin (*B*). *X*, xylem. The scale line at the upper left represents 120 μ.

Larger numbers of cell counts per sample might have changed the means by a point or two but would scarcely have shifted them to different orders of magnitude.

The great discrepancy between treated and control spurs in the radial diameters and numbers of cells along the radius of their xylem cylinders shows indirectly that gibberellin stimulated considerable division in cells of the cambial zone. Particularly significant is the increase in numbers of cells along the xylem rays. This rules out the possibility that increase in diameter of the secondary xylem resulted largely or exclusively from greater elongation and intrusive growth of cells of the vertical system. Indeed, the similarity of ratios of mean numbers of cells of the vertical system to corresponding means for the rays (1.7, 1.2, and 1.5 for the three controls; 1.6, 1.6, and 1.5 for the three treated spurs) suggests that there may have been no essential difference in intrusive growth between treated and control samples. The data from cell counts in the phloem show that gibberellin had little or no effect on stimulating addition of new cells to that tissue. It would be tempting to consider that gibberellin might have influenced differentiation indirectly by affecting the polarity of cambial divisions. However, the emphasis on initiation of xylem rather than phloem elements could be merely an exaggeration of the particular phase of the natural growth pattern affecting all spurs at the time of gibberellin treatment (*5*). Perhaps treatment at a different date would stimulate phloem development commensurate with xylem development.

The occurrence of considerable gibberellin-stimulated cell division in the cambial zone in the current season's growth of apricot spur shoots but not in that of the long shoots would appear to be connected with differences in the growth phases of the two types of shoot. At the time of treatment the terminal buds of the long shoots were still active, whereas those of the spurs had already entered their rest phase. Application of gibberellin stimulated longitudinal growth of long shoots and in no way interfered with their lateral bud and shoot development. However, it not only failed to break the rest of buds on spur shoots but actually retarded bud development, as is indicated by the smaller size of buds on treated spurs than on those of controls.

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29 July 1957

Tidal Overmixing in Estuaries

The eddies and currents which move salt water from the ocean into coastal estuaries and then mix the salt water with the outflowing fresh river water are important in determining the concentration pattern and movement of all suspended and dissolved materials in the estuary. Concentrations of salt, pollutants, oxygen, plankton, nutrients, and silt are in part controlled by the pattern of motion.

Salt water moves upstream against the river flow by processes ranging from the advection of a pure salt-water wedge flowing in on the bottom of deep estuaries to eddy diffusion associated with tidal currents in shallow water (*1*). The purpose of this report (*2*) is to discuss one of the processes of eddy diffusion that is due to tidal currents in the Coos Bay and river estuary on the Oregon coast; the discussion may be applicable to similar estuaries in other regions.

The Coos Estuary would be classed (*1*) as a positive, vertically homogeneous estuary with the principal movement of salt water upstream being caused by tidal eddy diffusion. The salt content is nearly constant with depth everywhere in the estuary, and it increases linearly from the fresh river water at the head of the estuary to full sea water at the mouth. The estuary is cut through low, coastal mountains and might be called a mountainous coast estuary. Although much of its area is composed of shallow tide flats, its average width is less than 1 mile. A narrow channel with mean depths of 7 to 10 m extends inland for 15 miles. The tides are the characteristic mixed tides of the West Coast, with a mean range of 1.6 m and a maximum range of 3.1 m. At times, the surface currents exceed 6 knots.

Higher high water is usually followed by lower low water, lower high water, and higher low water, in that order. From observations of salinity, which are discussed later, it can be inferred that the tidal excursion is greater at the surface than along the bottom, where bottom friction tends to retard the tidal currents. Right after low water, the whole estuary is nearly vertically homogeneous, having the same salt content from the surface to the bottom in any given position. During flood tide, the surface water moves upstream more rapidly than the bottom water. This causes an unstable salinity and density inversion, with more salt, more dense water on the surface than on the bottom. The heavier water sinks and the lighter water rises, causing mixing throughout the water column all the way from the surface to the bottom. This instability should appear during flood and high water.

During ebb, the surface water again out-distances the bottom water, but stability which may be observed during ebb and at low water is set up. Ebb currents are combined with river flow to give maximum velocities. These in turn bring about some turbulent vertical mixing during flow over the relatively shallow bottom. This tends to inhibit the formation of strong vertical stability.

Seven hundred and eighty-nine sets of surface and bottom salinity and temperature observations were examined statistically (3156 observations in all) in order to determine how often, and to what degree, the above pattern was followed in the Coos Estuary. Data were available from five stations on the estuary. Figure 1 shows typical salinity data for higher high water and lower low water for 2 days during 1931. Note that salinity inversions were present at all stations at higher high water during both days.

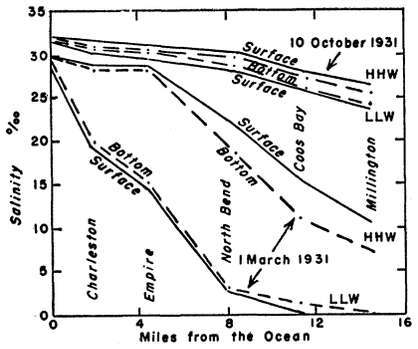

Fig. 1. The observed surface and bottom salinity distribution in the Coos Estuary on 1 March and 10 October 1931. Data for higher high water (HHW) and lower low water (LLW) are given. The place names are the locations where observations were made.

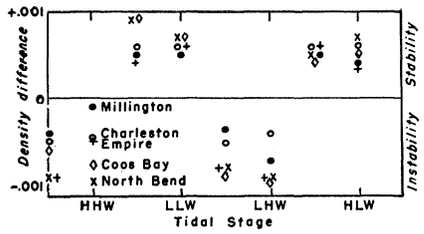

Fig. 2. Median density differences between the surface and the bottom water for five different stations at eight different tidal stages. Mean depths at station locations were Charlestown, 4.5 m; Empire, 4.5 m; North Bend, 8.2 m; Coos Bay, 7.5 m; and Millington, 3.9 m.

The available data had been taken at bi-weekly intervals of time over a 3-year period. Each station was visited from three to five times on any given day of sampling. All observations were made at the time of a high or a low water at the location of the station or at a time half way between a high and low water or a low and high water.

All temperature and salinity data were next converted to density, ρ. In each case, the relative density between the surface and bottom was desired, so that no correction was made for pressure. The density of the surface water was then subtracted from the density of the bottom sample to give a $\Delta\rho$ for each pair of observations. Positive values of $\Delta\rho$ indicate stability, while negative values indicate instability. The data for each station were then grouped into eight groups, according to the stage of the tide at the time the observations were made (higher high water, between higher high water and lower low water, lower low water, and so forth). The algebraic median values of each of the 40 groups of data were determined and plotted (Fig. 2). According to the above hypothesis, $\Delta\rho$ should be negative, indicating instability during both floods and high waters; $\rho\Delta$ should be positive during ebbs and low waters, indicating stability. The median values plotted on Fig. 2 have the expected sign in all cases. Of the 789 individual density differences, 87 percent have the expected sign, 3 percent were zero, and only 10 percent have the opposite sign from that expected.

It is clear that the process described, which we will call "tidal overmixing," must be of importance in the Coos Estuary and similar estuaries. The process of