as compared with animals that had not been heparinized.

(4) It is possible to aspirate the portal vein of an heparinized rabbit and keep the animal alive.

The experience gained from working out the procedure for the removal of adult worms served as a basis for an attempt at applying a similar procedure to animals as a therapeutic measure. Thus, a group of animals infected with *Sch. mansoni* were subjected to portal vein aspiration under operating room technique. Five rabbits and two monkeys were operated on by the author and collaborators.[1] All animals received intravenous amytal anesthesia.

From these preliminary experiments a number of observations have been made and therapeutic possibilities envisioned:

(1) In monkeys with infections that closely simulate *Sch. mansoni* infections in humans, it appears entirely possible to aspirate the portal vein of the heparinized monkey and keep the animal alive.

(2) The lighter the infection in monkeys (and the more closely it approximates the mild human variety), the greater the percentage of recovery of adult worms, as determined by post-mortem examination when the animal was sacrificed following surgery.

(3) If heparin is effective in mobilizing the adult worms and localizing them in the portal vein and liver, it may be possible first to use heparin systemically and then anthelmintics directly into the portal vein to produce a large concentration of the drug where it could have a maximum effect on the offending worms.

Reference

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Radiographs With C^{14}

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Since the discovery of C^{14} (*3*) there has been a temptation to use it to study the distribution of any desired organic substance in a chemical or biological system. To do this it was necessary only to incorporate C^{14} into the organic molecule and then prepare radiographs in the manner originally described by Marie Curie in her classical experiments with radium (*1*).

Unfortunately, the radiation from C^{14} is one of the weakest known. The β-particles emitted have an energy of only 90 kv., and the half-absorption thickness in aluminum is only 2.6 mg./cm.^{2}, or 0.01 mm. In this respect these rays are very similar to the β-rays of actinium, which have a half-thickness of 2.3 mg./cm.^{2} of aluminum and which, because of their weakness, have eluded detection until only recently (*2*). Thus, when C^{14} was available only from cyclotronic sources, it seemed hopeless to attempt to radiograph it. Now that strong sources are available from the Oak Ridge uranium pile, the situation has changed.

[1] Dr. S. B. Beaser, Boston, Massachusetts, and Maj. Richard Upjohn (MC), AUS.

Below we show some C^{14} radiographs obtained in some of our orienting experiments. In all our tests (except the very latest) 35-mm. Eastman "Super XX" film (panchromatic type B) was used. It was developed for 25 minutes at 20° C.

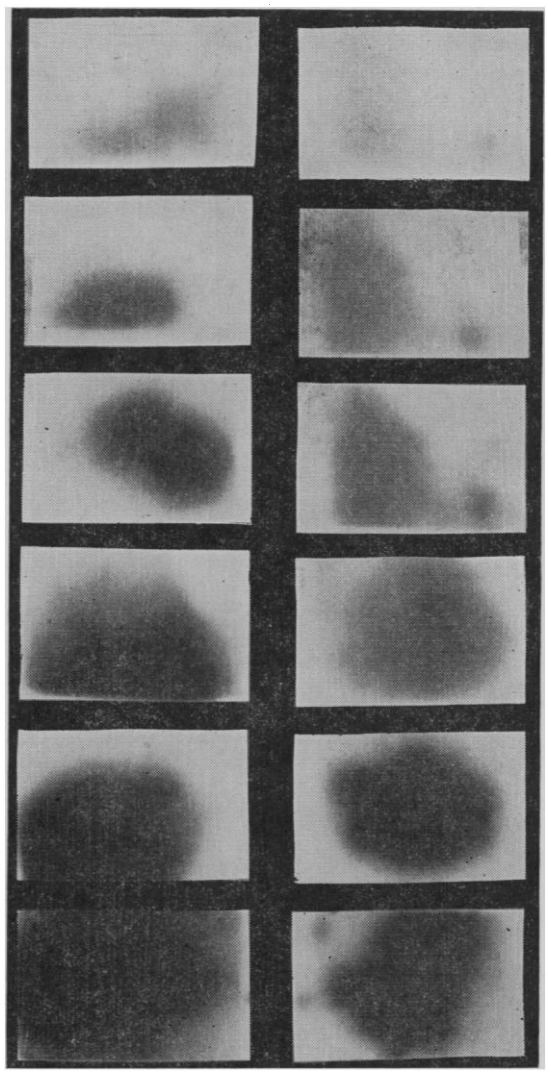

Fig. 1. Direct contact prints made from photographic film exposed to barium-1-radioacetate (left) and 9-radiodibenzanthracene (right).

in a tank, with intermittent agitation, using Eastman developer DK-20. The resolving power under these conditions is about 60 lines/mm.

In the first two series, shown in Fig. 1, about 30 mg. of barium-1-radioacetate and 9-radiodibenzanthracene crystals were placed directly in contact with the emulsion side of the film for varying periods of time. The specific activities of these compounds were, respectively, 266,000 and 3,020 disintegrations/minute and 1 mg. carbon. The time of irradiation, weight of substance, and integrated amount of irradiation are given in Table 1.

By studying Fig. 1 (actually, the original films show much

more contrast), we see, first of all, that even the comparatively weak dibenzanthracene preparation gives a definite effect after 4 hours. Second, we note that the amount of blackening is approximately proportional to time, until we begin to approach saturation.

TABLE 1

No. of radiograph	Barium-1-radioacetate [$Ba(O \cdot C^{14}O \cdot CH_3)_2$]				9-Radiodibenzanthracene [$C_{22}H_{14}$]			
	Time (hrs.)	Wt. (mg.)	Wt. of C (mg.)	Total No. of disintegrations ($\times 10^{-7}$)	Time (hrs.)	Wt. (mg.)	Wt. of C (mg.)	Total No. of disintegrations ($\times 10^{-7}$)
1	1.0	27.8	5.23	8.3	4.0	28.8	27.3	2.0
2	4.0	27.8	5.23	33	16	28.8	27.3	7.9
3	17.5	27.8	5.23	146	66	28.8	27.3	33
4	48	33.6	6.32	484	168	26.8	25.4	77
5	168	34.4	6.47	1,730	401	26.8	25.4	184
6	650	30.0	5.64	5,820	427	28.8	27.3	211

Having thus established the effect and the approximate amount of time and activity required, we proceeded to determine the distribution of sodium acetate solution in a small sweet-potato leaf as it was soaked up through its stem. The stem of the leaf was placed for 4 days in a 0.4 per cent aqueous sodium-1-radioacetate solution with a specific activity of 266,000 disintegrations/minute and 1 mg. C. At the end of that period the total C^{14} activity of the leaf corresponded to 7,250 disintegrations/minute. Film exposures made for 11, 21, 42, and 166 hours are shown in Fig. 2 (left to right).

Even the first exposure, corresponding to only 2 microcurie minutes, shows the distribution of C^{14} in the large and small capillaries very distinctly.

As expected, blank experiments on ordinary barium acetate, dibenzanthracene, and a leaf containing ordinary sodium acetate, for similar periods of time, showed no perceptible effect on the photographic film.

Encouraged by these results, we proceeded to take a radiograph of a leaf which had an extremely small activity—only 225 disintegrations/minute. The actual number of counts per minute in this case equaled only half of the background (20). The leaf, obtained through the courtesy of Dr. Guthrie, of the National Institute of Health, Washington, D. C., was grown in an atmosphere containing $C^{14}O_2$. This was exposed to the film for 20 days. The radiograph showed that the distribution of C^{14} is very even throughout the body of the cells, as one would expect, and very little, if any, is found in the capillaries.

In our most recent experiments, Eastman "No-Screen X-Ray Film" was found to be about five times as sensitive to C^{14} radiation as the Eastman "Super XX" used in the above experiments. The exposure times may consequently be reduced to one-fifth of the time using this film. The film affords the possibility of measuring the penetrating power of a radiation, since it is covered by photographic emulsion on both sides. The weak radiation of C^{14} produces an impression on only one side. This can readily be seen by observing the film by reflected light. A second radiograph may therefore be made on the same film, with an element of more penetrating radiation—for instance, P^{32}.

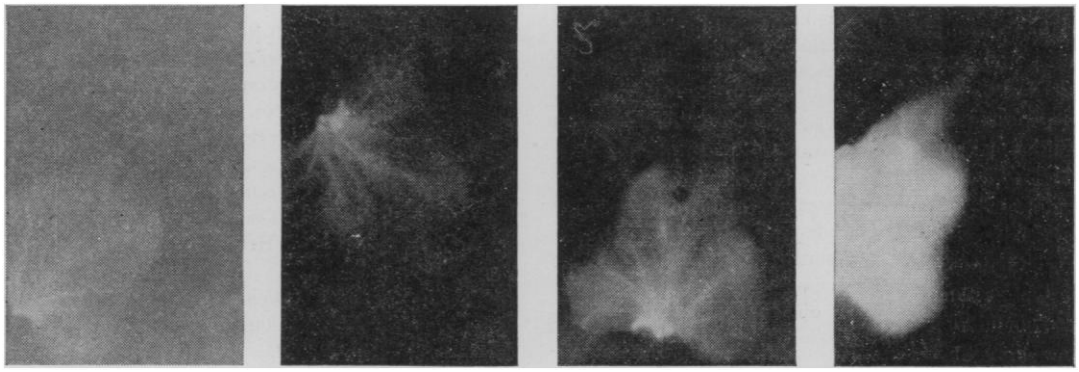

FIG. 2. Direct contact prints made from photographic film exposed to sweet-potato leaf containing C^{14}.

We believe that these results definitely show that present-day films are highly sensitive to C^{14} radiation and indicate the possibilities of the radiographic technique with C^{14} for various biological and chemical studies.

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