Table 2. Zinc content of human livers (parts per million of wet sample).

	Non-cancerous liver	Portal cirrhosis†	Metastatic carcinoma*		
			Uninvolved liver	Tumor tissue	Lymphatic leukemia‡
	36	33	98	26	135
	26	41	68	16	
	43		101	14	
	34		53	18	
	48				
	39				
Avg.	37.7	37.0	80	18	

* Cases No. 17, 18, 14, 6.
† Carcinoma of the esophagus without hepatic involvement; cases No. 23 and 13.
‡ With hepatic infiltration.

noncancerous liver tissue. This is in agreement with other trace-element studies of tumor tissue.

In one case of acute lymphatic leukemia with hepatic infiltration, the liver revealed a marked increase of iron (301 percent), zinc (258 percent), and chromium (233 percent), and cobalt was present in a concentration of 0.96 ppm, whereas the highest concentration in any of the other livers was 0.05 ppm, and cobalt was not detected in most samples. Molybdenum and manganese were reduced, and tin was moderately increased. Lead and silver were present in measurable amounts, but it is not possible to say whether they are significantly increased, since they were found erratically in other livers. Nickel and aluminum were not detected.

Trace elements are probably linked to protein molecules in most instances and are frequently necessary for the activity of enzymes or enzyme systems. Zinc has been shown to be a component of carbonic anhydrase, possibly of uricase, carnosinase, and perhaps some peptidases. Copper is present in tyrosinase. Molybdenum is believed to be a component of xanthine oxidase (*4*). Many other such linkages exist. An attempt will be made to determine whether a trace-element "profile" or pattern exists for host and cancer tissue. It is yet to be determined whether these elements exist in a combined or ionic state. It is also possible that trace-element levels in blood plasma may give a clue to the levels of these elements in the viscera.

To summarize, 12 trace elements have been studied by a spectrographic method in the livers of six persons dying of noncancerous disease, two persons dying of carcinoma of the esophagus and portal cirrhosis of the liver, four persons dying of gastrointestinal cancer with metastasis to the liver, and one case of acute lymphatic leukemia. A significant increase in zinc occurred in the uninvolved portion of the liver in all cases with metastatic malignancy. Copper was elevated in the liver in two cases with portal cirrhosis and no cancer in the liver, although death was due to cancer of the esophagus. Iron, zinc, chromium, and cobalt were significantly elevated in the liver in one case of acute lymphatic leukemia with hepatic involvement.

References and Notes

1. G. E. Heggen and L. W. Strock, *Anal. Chem.* **25**, 859 (1953).
2. Unpublished data.
3. Tissues in this study were obtained from the department of pathology, Albany Medical College, and were frozen and transported to the Saratoga Springs Commission Laboratory for examination. We are indebted to Dr. Arthur W. Wright and his associates for the histological studies and for their cooperation in obtaining material for study.
4. John R. Totter, *et al.*, *Science* **118**, 555 (1953).

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Heat Death Temperatures and Exposure Times of *Goniobasis livescens*

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There are few useful records of heat death temperatures, because many authors neglected the time factor and the older experimenters paid little attention to individual variation. In a study of the heat death of an organism, the proportion of individuals dying out of those exposed should be determined at each of a series of exposure times and temperatures. In addition to the paucity of satisfactory measurements of heat death temperatures and exposure times, the effect of the rate of heating on these characteristics has been generally overlooked.

Dallinger (*1*) and Jollos (*2*) were able to raise the heat death temperature of protozoans by a process of gradual heating, but the heat acclimatization may have been genetical, resulting from selection, since the experiments extended over considerable periods of time. Huntsman and Sparks (*3*) determined the heat death temperatures of marine animals in which the temperature was raised 1°C every 5 min, but did not rapidly heat any individuals for comparison.

The following experiment was conducted to determine the relationship between temperature and exposure time in the production of heat death, and to determine whether there is a differential in the effects of slow and rapid heating on these factors. Individuals of *Goniobasis livescens* were exposed to temperatures up to 41°C for various periods. The snails ranged in weight from 0.3 to 1.1 g, with an average weight of approximately 0.5 g. They were collected in western Lake Erie during the summer and were subjected to experimental heating within a few hours after their collection, at which time the water in their containers had reached a room temperature of 21° to 28°C.

The temperatures of some of the snails were rapidly raised by submerging them in preheated lake water, whereas the temperatures of the others were slowly

Table 1. Mortality rate of *Goniobasis livescens* to heat exposure per 10 individuals.

Temp (°C)	1 min		5 min		10 min		20 min		30 min		60 min		120 min		180 min		240 min	
	S*	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
41	10																	
40		0		3		5												
39	8	0	9	3	10	4	10		10									
38	8	1	10	1	9	2	10	9	9	9		9						
37	3		5		5	2	6	2	8	7								
36	1	1	2		2	0	1	0	4	4	8	5						
35	1		0		1		0	0	0	1	1	2	2	0				
34	1		1		1		1	0	1	0	1	0	1	1	1	2	0	2
33	1		1				0	0	0	0								
32	1		1		0		1		0	0	0	0						
31	0				0													
30	0				0													
29	0																	

* S represents the slowly heated snails; R represents rapidly heated snails.

raised by increasing the temperature of the water 1°C every 5 min. Both groups were exposed to the ultimate temperature for periods ranging from 1 min to 4 hr. At the end of the exposure period, they were immediately transferred to lake water at room temperature, and individuals that were alive after 3 days were considered to have withstood heat death. Ten snails were tested under each set of conditions, and the numbers that died are shown in Table 1.

The minimum heat death temperature for the majority of individuals is indicated to be approximately 36°C. since most of the snails were killed by 1-hr exposure at this temperature, whereas only a minority were killed by 1-hr exposure at 35°C. The mortality increased with longer exposure at 36°C but not with longer exposure up to 2 hr at 35°C (Table 1). While there was great individual variation, the heat death temperatures for 50 percent of the rapidly heated snails exceeded 40° at 5 min, 40° at 10 min, between 37° and 38° at 20 min, between 36° and 37° at 30 min, and 36° at 60 min. The heat death temperatures for 50 percent of the slowly heated snails were between 37° and 38° at 1 min, 37° at 5 and 10 min, between 36° and 37° at 20 and 30 min, and between 35° and 36° at 60 and 120 min.

The heat death exposure times for 50 percent of the rapidly heated snails were 10 min at 40°, between 10 and 20 min at 39° and 38°, between 20 and 30 min at 37°, and 60 min at 36°. The heat death exposure times for 50 percent of the slowly heated snails were less than 1 min at 38°, 5 to 10 min at 37°, and between 30 and 60 min at 36°. These results indicate that the heat death exposure time decreased with increase of temperature above 36°C and that the heat death temperature decreased with increase of exposure time up to 60 min.

The results indicate that there is a differential in the effects of slow and rapid heating on the heat death temperatures and exposure times, although the differential was the reverse of that expected. Instead of the heat death temperatures and exposure times being greater for the gradually heated snails than for the rapidly heated snails, they were less. We believe that this results from the longer total exposure time to high temperatures of the slowly heated snails. It is evident that a temperature increase of 1°C every 5 min is not sufficiently slow to permit heat acclimatization of *Goniobasis livescens*. At this rate of heating, the temperature is raised before acclimatization to the preceding temperature increment is achieved. The fact that the heat death temperatures and exposure times are effected by the rate of heating indicates that, in a comparison of these characteristics of different organisms, the rates of heating should be given.

References

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Aromatic Biosynthesis. XI. The Aromatization Step in the Synthesis of Phenylalanine*

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A wide variety of benzenoid compounds are produced from nonaromatic materials in the plant and microbial kingdoms. In none of these biosyntheses,

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