steel notoriously lacking in "toughness." The cleavage traverse here is relatively flat and uninterrupted across the entire grain; the grain is relatively larger than the preceding, thereby reducing the factor of grain-boundary hindrance; and crystallographic markings, particularly at

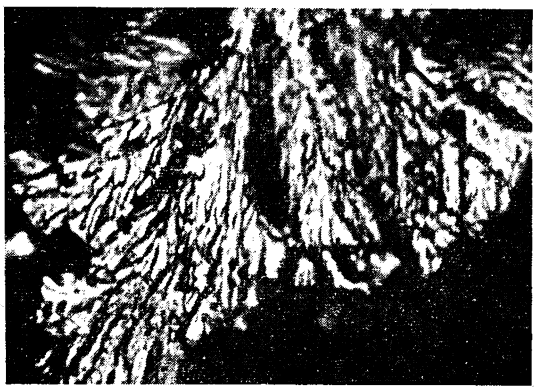

FIG. 3. *Pattern of "toughness."* Standard unalloyed Steel Q from Navy tests, known to be relatively tough for steel of its class (× 1,250).

90°, are in strong evidence. This is accordingly a pattern of cleavability, or weakness—specifically, a low resistance to notch-impact.

Transferring attention now to unalloyed steel, one finds in Figs. 3 and 4 the fractographs of two of the standardized mild steels widely studied with respect to their serviceability for ship-plate. In Fig. 3, Steel Q, which contains 0.22% carbon, 1.13% manganese, and 0.05% silicon, shows a "toughness" pattern suggestive of that shown in Fig. 1. In this case the "toughness"

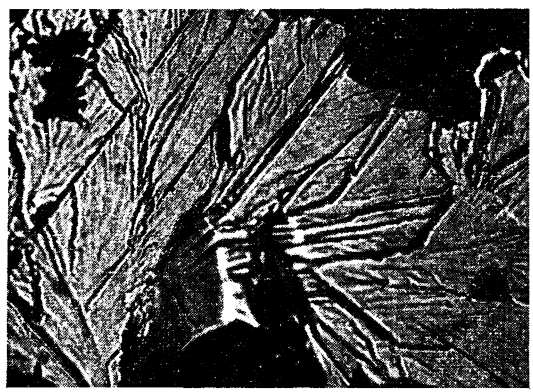

FIG. 4. *Pattern of weakness.* Standard unalloyed Steel E from Navy tests, similar in composition to Steel Q, but known to lack toughness (× 975).

has also been similarly derived, by heat treating in a manner to produce martensite.

In conformity with the information in the fractograph, mechanical testing of this steel in other laboratories has proved it to be "tough" relative to other steels of its kind. A relatively low temperature is required for transition from a tough fracture to a brittle one.

A fractograph of the standard Steel E (Fig. 4) shows a decidedly different pattern, more in keeping with the pattern in Fig. 2. It is similar in composition to Steel Q, except for a manganese content of only 0.33%; but it differs considerably in structure in that its condition is "as-rolled"—hence, not martensitic. The cleavage traverse is flat, expansive, and but little interrupted, and crystallographic markings are much in evidence. In conformity with this fractographic indication of inferior cleavage characteristics, Steel E is known to compare poorly with Steel Q, experiencing transition from tough to brittle cleavage at such relatively high temperatures that it prohibits recommendation for the types of service in question.

These patterns, of course, are strictly comparable only among materials of a defined class. Other fundamental factors—specifically, alloy content—greatly influence strength and toughness; and a pattern for mild steel cannot be compared directly with one for an alloy steel, as a rating of toughness, without taking into account the fundamental difference in atomic cohesion. As will be shown in a report soon to be issued, an alloy steel with an unfavorable cleavage pattern may still show greater toughness than an unalloyed steel with a favorable pattern, simply because the atomic matrix of the alloy steel is more strongly coherent.

Perhaps the principal importance of the evidence stands in its demonstration of an active structural factor within the individual grain which impedes cleavage in one case much more strongly than it does in another, and which therefore accounts for subtle differences, not previously understood, among structural materials of a given class.

Reference

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Deposition of Protein in the Liver Following Intravenous Injection of an Amino Acid Mixture (Hydrolyzed Protein) and Glucose[1]

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Although tissue protein is normally synthesized from food protein, there has been no demonstration by direct *in situ* study that this is possible with an amino acid mixture injected intravenously as the sole source of protein food. Chemical and histological evidence was reported from this laboratory (*2*) that protein is deposited in the cytoplasm of protein-depleted hepatic cells by the administration of a high protein diet by mouth. Evidence is presented herewith to show that the same

[1] Aided by a grant from the Commonwealth Fund.

is true when all the food is administered intravenously, the nitrogenous nourishment consisting of an amino acid mixture.

Six experiments were carried out on adult dogs weighing about 10 kg and in good nutritional condition. A control period of protein deprivation was carried out for 2 weeks by giving a 20% solution of sucrose by mouth in amount to supply 50 cal/kg of body weight/day. All animals drank this solution without difficulty. Each animal received an adequate amount of vitamins in capsule form each day.

TABLE 1

Dog	Date	Procedure and intake	Body wt (kg)	Hepatic nitrogen (% of wet wt)	Wt of liver (gm/kg of initial body wt)
A 8	Mar. 24	Control depletion	10.9	...	...
	Apr. 6	Biopsy	9.8	2.72	...
	Apr. 12	Autopsy (glucose alone)	9.3	2.75	31.2
A13	Apr. 13	Control depletion	9.1	...	...
	Apr. 27	Biopsy	8.2	2.96	...
	May 3	Autopsy (glucose alone)	7.5	2.84	32.9
A 9	Mar. 24	Control depletion	7.7	...	...
	Apr. 6	Biopsy	6.8	2.26	...
	Apr. 12	Autopsy (sucrose alone)	6.6	2.42	29.6
A10	Mar. 31	Control depletion	9.1	...	...
	Apr. 13	Biopsy	8.2	2.59	...
	Apr. 19	Autopsy (glucose + amino acid mixture)	8.7	3.12	35.1
A11	Mar. 31	Control depletion	10.4	...	...
	Apr. 13	Biopsy	9.8	2.73	...
	Apr. 19	Autopsy (glucose + amino acid mixture)	9.5	3.17	37.1
A14	Apr. 20	Control depletion	8.9	...	...
	May 4	Biopsy	8.2	2.58	...
	May 10	Autopsy (glucose + amino acid mixture)	8.2	2.91	38.6

At the end of this 2-week period the liver was biopsied under Nembutal anesthesia, a portion being used for microscopic study and the rest analyzed for its nitrogen content. Half, or 3, of the animals were maintained during the following week on carbohydrate alone, two of them by the injection of 10% glucose intravenously and one by 10% sucrose by mouth. The dose was 100 cc/kg of body weight/day. The other 3 animals received intravenously the same amount of solution, which contained, however, 5% of an amino acid mixture in 5% glucose. The amino acid mixture was a protein hydrolysate containing about 30% peptides and was made by the enzymic digestion of casein by pork pancreas (Amigen). The dogs given the amino acid mixture received 5 gm or 600 mg of nitrogen/kg/day. All intravenous injections were given at the same rate of 16 cc/kg/hr. Salt was added to the glucose solution so that the electrolyte intake was similar in the two groups.

At the end of the experiment all animals were sacrificed 2 hrs following the last injection. The entire liver was carefully removed and weighed, sections were studied microscopically, and the nitrogen concentration measured. All animals were weighed at the start and at intervals during the experiment. Nitrogen determinations were made by the traditional macro-Kjeldahl procedure on a wet sample of the liver. Microscopic sections were carefully cut at 8 μ and stained with hematoxylin and eosin.

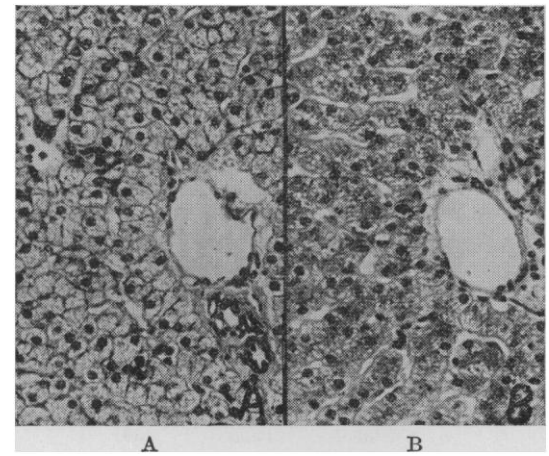

FIG. 1. Photomicrograph (×240) of the liver surrounding a central vein; specimen obtained at autopsy at end of experiment: A—control dog receiving intravenous glucose only, B—experimental dog receiving intravenous glucose plus an amino acid mixture (Amigen). Note in A the vacuolated cells and completely obliterated sinusoids, which is characteristic of the protein-deficient liver. (Nitrogen content, 2.42 gm %.) In B, by contrast, note the well-stained cytoplasm and normal sinusoids characteristic of the liver in a normal, well-fed animal. (Nitrogen content, 3.17 mg %.)

As shown in Table 1, all animals lost weight during the control period of 2 weeks of protein deprivation. The 3 dogs that received only carbohydrate during the third week continued to lose weight, whereas the 3 dogs that received intravenous protein hydrolysate either maintained their weight or showed a slight gain. The nitrogen content of the liver in the dogs on a carbohydrate intake alone, during the third week, changed very little (+0.02%), as shown by comparing the analysis of the biopsy specimen with that obtained at autopsy. By contrast, all of the animals receiving the protein hydrolysate showed an increase averaging +0.43%. The weight of the liver at death also showed a difference between the two experimental groups. The livers of the group receiving carbohydrate alone weighed 29.6, 31.2, and 32.9 gm/kg of initial body weight. The comparable figures in the 3 dogs receiving intravenous protein hydrolysate were 35.1, 37.1, and 38.6. The average difference was 31.2 as compared with 36.9.

Microscopic sections of the biopsied liver at the end of the control period in all 6 experiments showed the vacuolated, clear cytoplasm (*1, 2*) which is characteristic of protein depletion in the presence of an adequate carbohydrate intake. At the end of the experimental period, however, there was a definite difference in the appearance of the liver of the animals receiving intravenous glucose alone as compared with those receiving glucose and

hydrolyzed protein. The difference is shown in one typical experiment illustrated in Fig. 1. The presence of stainable cytoplasm in the liver of the animal receiving hydrolyzed protein is striking and is similar to previous studies in which this same change was observed following the ingestion of protein nourishment by mouth (*2*).

It would seem, from the observations reported here, that the intravenous injection of an amino acid mixture (hydrolyzed protein) leads to a deposition of tissue protein in the liver.

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Radical Reactions With Certain Nitrogen Compounds: The Conversion of Benzene (Toluene, etc.) in Other Compounds at Low Temperature

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The conversion of benzene with nitrosyl, NOH, radical and air or oxygen (H_2O_2) into *o*-nitrosophenol has been reported upon by the writer in several papers (*2–6*). The very short-lived radical, NOH, is stabilized in the following paramagnetic copper complex $[Cu^{I}(\overset{+}{N}O)]$ (*5*). The unpaired electron is on the nitrogen atom. Using the so-called L solution (Cu metal + $NH_2OH \cdot HCl$ + air), one can easily demonstrate that even frozen solid benzene is converted into *o*-nitrosophenol or into its red copper salt (B reaction). New reactions with iron nitric oxide complexes are reported here, and the results help in understanding the conversion of benzene into *o*-nitrosophenol at 0° C.

The best-known nitroso iron complexes are the nitroprussides. It has been known for a long time (*7*) that aqueous solutions of sodium nitroprusside become blue on standing in daylight, with the formation of Prussian blue compounds. The reaction is not very sensitive, and in weak daylight it may take hours before the solution becomes blue. Nitroprusside solutions were considered less light sensitive than ferrocyanide or pentacyano carbon monoxide solutions. The writer found, however, that nitroprusside solutions are just as light sensitive as ferrocyanide solutions. Even on winter days, nitric oxide, NO, is split off from the complex immediately (indicated by a positive Griess-reaction), but no color change takes place as in ferrocyanide solutions (pale yellow $\underset{\text{dark}}{\overset{\text{light}}{\leftrightarrows}}$ intensive yellow). The writer found new color reactions with which one can demonstrate that nitroprusside solutions are decomposed even in daylight and at 0° temperature.

Dilute methyl alcoholic solution of nitroprusside, to which a very small amount of iron carbonyl, $Fe(CO)_5$, is added in the darkroom, gives a pale yellowish solution which, on standing, is unchanged in the dark but which changes color in a few seconds in daylight and becomes black in a few minutes—at the same time bubbles of CO are visible. The nitric oxide split off in daylight attaches itself immediately to the iron carbonyl complex, and black compounds are formed.

If a small amount of cupferron is dissolved in a dilute nitroprusside solution (darkroom), the pale yellowish-red solution remains entirely unchanged in the dark. If, however, it is exposed to daylight, a bluish tint appears in a few seconds, and usually in 1 min the solution is deep violet-blue. The violet-blue compound is

$$\left[Fe^{II}\begin{matrix}ONC_6H_5\\(NC)_5\end{matrix}\right] \equiv .$$

A mixture of nitroprusside, H_2O_2, and sodium azide (NaN_3) made in the darkroom becomes pale blue in daylight in a few seconds and deep violet in a few minutes. The same mixture in the darkroom remains unchanged for hours. The violet compound is ferri-aquo salt

$$\left[Fe^{III}\begin{matrix}H_2O\\(NC)_5\end{matrix}\right] = .$$

If thiourea is added to a nitroprusside solution in the darkroom, the solution retains its pale yellowish-red color for weeks and months. The mixture, however, becomes blue in the daylight in a few seconds, deep blue in a minute or so. If the nitroprusside solution without thiourea is exposed to light only for a few minutes, the illuminated solution which has not changed at all to the eye becomes immediately blue on adding thiourea. The light reaction with thiourea differs entirely in its mechanism from the other three reactions just described, in which NO is split off in the course of the reaction. In the thiourea reaction NO remains in the complex and the thiourea molecule attaches itself to the NO, thus forming a deep blue sulfur and nitrogen-containing complex. Since the color change does not take place in the dark at all, light must have changed NO in the original nitroprusside and made it reactive. This assumption is supported by an interesting light reaction, namely, the conversion of benzene into *o*-nitrosophenol in daylight at low temperature by short exposure of an H_2O_2-containing nitroprusside solution covered with benzene.

All solutions for this experiment were made in the darkroom. Five gm of sodium nitroprusside was dissolved in 100 cc of water and 2 cc of Perhydrol added. The ruby-red solution was put in an Erlenmeyer flask with ground-glass stopper and covered with 50 cc of benzene. The well-shaken mixture remains entirely unchanged in the dark for weeks or months. If, however, the Erlenmeyer flask is exposed to winter sunlight (outside air temperature was −15° C) for 5–10 min, the benzene becomes a beautiful green color. The aqueous part remains unchanged in color. The green benzene