Zellen, also dorthin, wo die Oxydationen stattfinden (FR. MIESCHER[1], O. WARBURG[2]).

5. Es ließ sich zeigen, daß das Thyroxin vom Blut aus zunächst in das Zentralnervensystem – wahrscheinlich in das Zwischenhirn – eindringt (SCHITTENHELM und EISLER[3]) und von dort aus auf dem Wege der peripheren Nerven in das Innere der Zelle gelangt, wo es im sauerstoffarmen Zellbereich Gelegenheit hat, die Gärungsvorgänge zu katalysieren. Diese Nervenwanderung des Thyroxins ließ sich nicht nur unmittelbar am Froschischiadicus nachweisen (MANSFELD und HORVÁTH[4], JANCSÓ und NOVÁK[5]), sondern auch dadurch, daß intravenös injiziertes Thyroxin schon nach 16 Stunden in der Parotis, aber erst nach 24 Stunden in der Leber und nach 46 Stunden im Hoden die Verbrennungen steigert.

In Kenntnis dieser Tatsachen mußte gefragt werden, ob nicht auch am ganzen Tier das Thyroxin vom Blut aus, also ohne Latenzzeit, seine Wirkung entfaltet, falls die Organzellen durch irgendeine Noxe geschädigt sind. Dies zu prüfen schien auch deshalb wichtig, weil man bei einer ganzen Reihe von Krankheiten – so bei Anämien, inkompensierten Herzleiden, Tumoren usw. – eine starke Beschleunigung der Verbrennungen und dementsprechende Abmagerung, ja Kachexie beobachtet, welche ungeklärt ist, aber möglicherweise von dem im Blut zirkulierenden Thyroxin bewirkt wird, welches bei Schädigung der Zellen unmittelbar und ungehemmt an der Zelloberfläche seine Wirkung entfalten mag.

Zur Prüfung dieser Frage hatten wir weiße Ratten teils durch Blutentnahme, teils mittels Phenylhydrazin anämisiert und fortlaufend im Stoffwechselapparat den zeitlichen Verlauf der Thyroxinwirkung geprüft.

Es zeigte sich, daß sobald man die Zahl der Erythrozyten auf etwa die Hälfte – also an der Ratte auf 4–4½ Millionen – reduziert, Thyroxin schon ½–1 Stunde nach seiner Eingabe zu einer mächtigen Beschleunigung der Verbrennungen führt, die bis zu 50% betragen kann, was man am Normaltier niemals vor Ablauf von 24 Stunden beobachtet. Daß es sich in der Tat um eine durch mangelhafte O_2-Versorgung bewirkte Zellschädigung handelt, zeigte die weitere interessante Tatsache, daß ihrer Schilddrüse beraubte Ratten bei dem erwähnten Grad von Anämie das Phänomen der Sofortwirkung des Thyroxins nicht zeigen, da ein Verlust von 50% der Sauerstoffüberträger bei ihrem geringeren O_2-Bedürfnis und ihrer geringeren Empfindlichkeit gegenüber O_2-Mangel (STREULI[6], DURAN[7]) noch keine Zellschädigung bedeutet. Entnimmt man aber diesen schilddrüsenlosen Tieren soviel Blut, daß die Erythrozytenzahl sich auf 2½–3 Millionen vermindert, so sehen wir die gleiche latenzlose Thyroxinwirkung wie am Normaltier.

Von klinischer Seite wurde empfohlen, bei dem schwer kachektischen Zustand Herzkranker durch Verkleinerung der Schilddrüse den Zustand zu bessern. Es ist nicht unwahrscheinlich, daß bei allgemeiner Zellschädigung beobachtete Abmagerung, die mit gesteigerten Verbrennungen einhergeht, Arzneimittel, welche entweder eine Minderproduktion von Thyroxin bewirken, wie das Thiourazil (HUGHES und ASTWOOD[1], GASCHE[2]), oder die die Stoffwechselwirkung des Thyroxins antagonisieren, wie die Thermothyrine (MANSFELD[3]), eine günstige Wendung des kachektischen Zustandes bewirken könnten. Die ausführliche Mitteilung der Versuche erfolgt in den «Hungarica acta physiologica».

G. MANSFELD

Institut für exp. Pathologie und Pharmakologie der Universität Pécs (Ungarn), den 27. März 1946.

Summary

Former investigations have shown, that Thyroxine does not accelerate directly oxidations but the fermentations and that combustions are increased by the breakdown products only. That is why Thyroxine cannot act from the blood, for on the surface of the cells fermentations are stopped by the oxidations because of the Pasteur reaction. Therefore Thyroxine must reach the O_2-poor interior of cells by means of the peripheral nerves. If it is so then in case of the damage of the cells—which is followed as known by the paralysis of the Pasteur reaction—Thyroxine must act directly from the blood without any latency, for then fermentations are no longer stopped at the surface of the cells. The experiments have shown indeed, that if you produce by anemia on white rats a lack of oxygen, Thyroxine increases the oxidations up to 50% already in about 30 minutes which in the case of normal animals cannot be expected before 24 hours. It is probable that in the case of the general damage of cells (serious anemia, uncompensated heart defects, tumors) the noticeable loss in weight and cachexia are conditioned by that Thyroxine which circulates in the blood-stream and they may be cured by remedies such as Thiouracil or Thermothyrine.

[1] FR. MIESCHER, Die histochem. u. physiol. Arb., Bd. 1, S. 95, F.C.V.Vogel, Leipzig 1897.
[2] O. WARBURG, Bioch. Z. *119*, 134 (1921).
[3] SCHITTENHELM und EISLER, Klin. Wschr., 1935 (1927).
[4] G. MANSFELD und HORVÁTH, Pfl. Arch. *235*, 520 (1935).
[5] M. JANCSÓ und E. NOVÁK, Orvosi Hetilap, S. 858 (1935).
[6] STREULI, Bioch. Z. *66* (1918).
[7] DURAN, Bioch. Z. *106*, 254 (1920).

[1] A. M. HUGHES und E. B. ASTWOOD, Endocrinology *34*, 138 (1944).
[2] PAUL GASCHE, Exper. *2*, 24 (1946).
[3] G. MANSFELD, Schweiz. med. Wschr., *72*, 1267 (1942).

Visible Hot Spots on Sliding Surfaces

It has been shown elsewhere[1] that the local temperature at the surface of sliding metals may reach a high value. The temperature may be measured by using the surfaces themselves as a thermometer: that is by placing two different metals in contact so that they form a thermo-couple and measuring the electromotive force generated on sliding. As would be expected, the temperatures reached depend upon the load, speed and thermal conductivity of the metals, but even under comparatively gentle conditions of sliding the temperatures may be high. With the lower melting metals the temperature readily reaches the melting point and does not rise above this. With higher melting metals temperatures of the order of 1000° C are attained. These temperatures are confined to the surface layer and the mass of the metal appears to be cool. Also the temperature fluctuates very violently during sliding. Even if the surfaces are flooded with water or other liquids the temperature is still high. Some recent results obtained with constantan sliding on a flooded steel surface are shown in Figure 1. These measurements were made by Mr. G. K. TUDOR using electrical apparatus developed and

[1] BOWDEN and RIDLER, Proc. Roy. Soc., London, A *154*, 640 (1936).

constructed by Mr. A. E. FERGUSON and R. W. MUNCEY. The magnitude of the temperature rise and the rapid fluctuations in it are apparent.

Visual observation of hot spots. Since the temperature depends upon the thermal conductivity we should expect that these high temperatures would be reached much more readily on non-conducting solids such as glass and quartz and other non-metallic solids. Unfortunately the thermo-couple method cannot be used with these

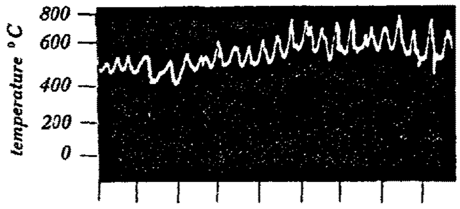

Fig. 1. Surface temperature, constantan slider on flooded steel surface. Load 3·7 kg/msec speed of sliding 600 cm/sec.

solids, but it is possible to show the existence of these hot spots by visual means. If polished surfaces of glass or quartz are used and the apparatus so arranged that a clear image of the rubbing surfaces can be seen, it is found that, when sliding starts, a number of tiny stars of light appear at the interface between the rubbing surfaces. The points of light are reddish in colour at low speeds and become whiter and brighter as the speed or the load is increased. It is clear that they correspond to small hot spots on the surface and their position and distribution over the surface change from instant to instant as the high points in intimate contact move or wear away and new points come into contact. The method is not quantitative, but by making one of the surfaces of metal, and using metals or metallic alloys of different melting point, it is possible to fix approximately the temperature at which hot spots first become visible. Experiment showed that when metals or alloys melting *below* 520° C were slid on glass or quartz no hot spots could be seen even at the highest speeds and loads. With a gold aluminium alloy melting at 570° C, however, and with all metals melting *above* this the hot spots were readily seen. This would fix the temperature at which the hot spots first became visible to the eye, at between 520—570° C [1].

Thermal conductivity k and the incidence of hot spots. A series of experiments was carried out with metals of different thermal conductivity sliding on a glass disc. The sliding speed was kept constant and the load varied until hot spots first became visible. At the same time the coefficient of friction was measured so that the frictional force necessary to give hot spots (at any given speed) could be determined. The results obtained for sliders of constantan ($k = 0{\cdot}05$) steel ($k = 0{\cdot}10$), nickel ($k = 0{\cdot}16$) and tungsten ($k = 0{\cdot}35$) are shown in Figure 2. It will be seen that hot spots occur more readily the lower the thermal conductivity of the slider. For example, at a surface speed of 110 cm/sec a tungsten slider on glass gives visible hot spots when the frictional force is 2600 g/msec, while with the constantan slider hot spots can be seen when the frictional force is only 350 g/msec.

If the surfaces are flooded with a liquid (e.g. with a mixture of glycerine and water) the hot spots still occur and the results for metals of varying thermal conductivity are similar to those given in Figure 2. The main difference is that all the curves are shifted upwards and a higher frictional force (six to seven times as great) is necessary to produce hot spots when the surfaces are flooded. This difference is considerable, but it is clear that the presence of the liquid film is not able to prevent the occurrence of high local temperatures.

Photographic recording of hot spots. Although the occurrence of a transient hot spot is readily observable, the intensity is usually too low to affect a photographic plate. If, however, the slider is run over the same track a number of times the cumulative effect is enough to produce a record. A sensitive photographic plate (Super XX) was held in a frame mounted on the turn table. A glass disc was clamped over it and the metal slider rested on top of this glass disc. A given load was applied, the turn table was rotated at constant speed, and the slider allowed to run for two minutes on the same track. It was then moved in, about a centimeter, towards the centre of the disc and again ran for two minutes. The process was repeated and in this way a series of concentric tracks was obtained of decreasing radii and therefore of decreasing sliding speeds. On developing the photographic plate a number of concentric dark rings appeared (see Figure 3). The innermost visible ring on the plate gave the lowest sliding speed at which the hot spots were recorded. The results obtained with this technique were very similar to those obtained by visual observation of the hot spots. The effect of thermal

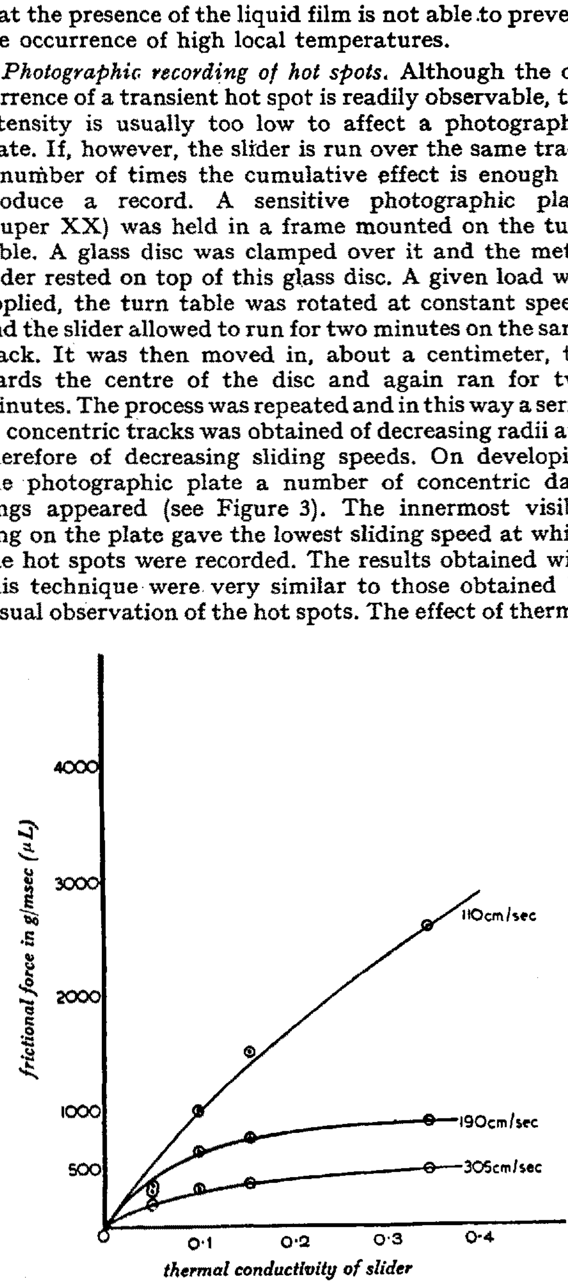

Fig. 2. Frictional force (μL) in g/msec necessary to give visible hot spots with sliders of constantan ($k = 0{\cdot}05$), steel ($k = 0{\cdot}10$), nickel ($k = 0{\cdot}16$) and tungsten ($k = 0{\cdot}35$).

conductivity was the same (the curves obtained closely resembled those given in Figure 2) and the actual values of the minimum loads and speeds necessary to give detectable hot spots were very similar.

For any given combination of surfaces, the incidence of hot spots is determined primarily by the rate of liberation of frictional heat, i.e., by the product $\mu\ Ls$ where μ is the coefficient of friction, L the load between the surfaces, and s the speed of sliding. It is not greatly

[1] The possibility that the points of light are due to some form of triboluminescence other than temperature must be considered, but the evidence is against this.

influenced by the size and shape of the slider. If a large flat slider is used the conditions of load and speed necessary are much the same as for a small curved one. The main difference is that with large flat surfaces the hot spots may be thinly distributed over a wide area instead of being concentrated into a smaller one. This is in harmony with the view[1] that contact between the solids occurs only locally at the summit of the surface irregularities so that the real area of contact is very small and bears little relation to the apparent area of the surfaces. It means that even with light loads the pressure at the points of real contact is high and it is just at these points that the rubbing and the liberation of frictional heat occurs. It is, of course, common knowledge that if surfaces are rubbed hard enough they get hot, but a point brought out by these experiments is that the loads and speeds necessary to give detectable hot spots are very low. For example, with constantan sliding on glass with a load of about 1 kg/m visible hot spots (temp. 520–570° C) can be seen when the sliding speed is as low as one or two feet per second. If the upper slider of metal is replaced by a poor conductor such as quartz ($k = 0{\cdot}0035$), the hot spots appear even more readily.

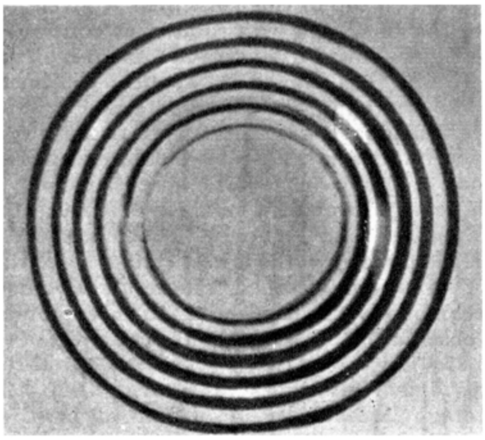

Fig. 3. Photographic hot spot trace of steel slider on glass. Load 1·2 kg/msec. Speed of sliding at innermost visible track 70 cm/sec.

Experiment has shown that these local hot spots are important in a number of physical processes, such as the polishing and surface flow of solids[2], the seizure of metals, the "frictional welding" of plastics and other materials. They also play an important part in the chemical decomposition which accompanies the rubbing of some solids and in the initiation of chemical reactions which are brought about by friction and by impact. An interesting example of this is the initiation of some explosives by friction. Experiments with nitro-glycerine, for example, rubbed between metal surfaces show that the load and speed necessary to cause initiation is determined primarily by the thermal conductivity of the sliding metals. With a poor thermal conductor, such as constantan, initiation occurs more readily than with a good conductor such as tungsten. It is also found that, unless the melting point of the metals exceeds ca. 480° C, explosion of the nitro-glycerine does not occur even at very high loads and speeds. The initiation is apparently brought about by local hot spots on the surface of the rubbing solids.

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Research Group on the Physics and Chemistry of Rubbing Solids, Department of Physical Chemistry, University of Cambridge, March 28, 1946.

Zusammenfassung

In der Berührungsfläche einer an verschiedenen Metallen geriebenen polierten Glas- oder Quarzplatte werden helle, punktförmige Lichtblitze schon bei verhältnismäßig schwachen Reibungseffekten beobachtet. Die lokale Temperatur muß mindestens 550° C betragen. Die Beobachtung deutet auf kleinste Kontaktflächen und ist von Bedeutung für die Kenntnis der Reibungsvorgänge.

[1] BOWDEN and TABOR, Proc. Roy. Soc., London, A. *169*, 391 (1939).
[2] BOWDEN and HUGHES, Proc. Roy. Soc., London, A. *160*, 575 (1937).

Sulfamidés et acides nucléiques

L'action bactériostatique d'un sulfamidé est généralement expliquée à l'aide de la théorie du déplacement de FILDES, qui se justifie lorsque le sulfamidé et la vitamine déplacée présentent une similitude de constitution. Un certain nombre de faits ne cadrent pas avec cette conception.

Partant de la constatation que le sulfamidé détermine une stase, mettant l'organisme dans l'impossibilité de se multiplier, nous avons admis que des constituants essentiels du cytoplasme et du noyau devaient être atteints. En premier lieu, nous avons pensé aux acides nucléiques. Si tel est le cas, les acides nucléiques doivent pouvoir fonctionner comme antisulfamides, ce qui a été démontré chez *Eremothecium Ashbyii*. Cet effet n'est pas dû au nucléotide, mais uniquement aux purines qu'ils contiennent, avant tout à l'adénine. L'effet antisulfamide de cette dernière représente environ le $^1/_{10}$ de celui de l'acide p-aminobenzoïque (PAB), mais peut, dans certains cas, lui être égal[1].

Une préparation d'acide thymonucléique pur (poids moléculaire 500 000 à 1 000 000), due à l'obligeance du Professeur R. SIGNER[2] (Berne) est également active. En présence de 2 mg de cibazol pour 25 cm³ de milieu, 100 γ d'adénine ou 1 mg d'acide thymonucléique restituent une croissance normale (voir figure). Seule une fraction de la macromolécule d'acide thymonucléique, correspondant aux purines, est active.

Un second microorganisme (*Saccharomyces*, souche n° 1) nous permet de confirmer nos premières observations (voir tableau 1).

Tableau 1

adénine	0	0,1	0,5	1	5	10	50 γ
milieu seul	50	53	52	52	52	53	53
milieu + 2 mg cibazol ...	4	5	6	14	16	19	42
milieu + 5 mg cibazol ..	tr.	tr.	4	4	9	17	14

[1] Ces faits ont été exposés le 27 janvier 1946 à l'assemblée de la Société suisse des Physiologistes et des Pharmacologues (Lausanne). Voir W. H. SCHOPFER et M. GUILLOUD, Helv. physiol. acta, *4*, C 24 (1946).
[2] R. SIGNER, T. CASPERSSON und E. HAMMARSTEN, Nature *122* (1938).