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Physiology. — *"Physiological sclerometry"*. By Dr. A. K. M. NOYONS. (Communicated by Prof. H. ZWAARDEMAKER).

(Communicated in the meeting of March 26, 1910).

Already in a former communication [1]) I found an opportunity to draw the attention to the quality of the physiological hardness so little studied, in casu the hardness of the muscles. Then it was pointed out how hardness is a collective idea, comprising and typifying in mineralogy an amount of qualities such as cohesion, elasticity, plasticity, gliding, splitting, and fracture. For physiological purposes it is only the three qualities: elasticity, plasticity and cohesion which naturally come under discussion. Hence the definition of physiological hardness and the method of determining it must be based upon the three above mentioned qualities. Therefore it appears on second thoughts that AUERBACH's [2]) definition of mineralogical hardness cannot unaltered be transferred to the physiological hardness, when he says: "Härte is eine Art von Festigkeit nämlich der Widerstand gegen die Bildung von Unstetigkeiten oder dauernden Deformationen beim Drucke zweier sphärischer Oberflächen gegen einander und kann Eindringungsfestigkeit genannt werden ... Sie ist quantitativ durch den Grenzeinheitsdruck im Mittelpunkte der Druckfläche bestimmt."

Definition and method of determination start from the principle, — which is hardly ever desirable for physiological cases — that the moment at which a permanent deformation appears, is used as a criterion. This permanent deformation is in mineralogy required for the determination of *absolute* hardness. For physiological objects, therefore, we have to look out for another principle.

In the above communication I described a suitable apparatus, by means of which differences of hardness in muscles under different circumstances could be pointed out. The oscillations of a little falling hammer beating a muscle, is under certain premises a measure for the hardness. In judging about the hardness of the object that is to be examined, various data in the photographs may be taken into account:

1. the total number of reverberations;
2. form and height of each reverberation separately;
3. amount of the heights of all reverberations;
4. the process of penetration of the hammer into the object, which is derived from the situation of the lowest points of the sclerometric figure.

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[1]) NOYONS, A. K. M. About the determination of hardness in muscles. Kon. Akad. v. Wetensch. Amsterdam. Proceedings of the meeting of June 12, 1908.

[2]) AUERBACH, FEL. Kanon der Physik. p. 119. Leipzig 1899.

With the aid of the above-mentioned apparatus, for which I choose the name of "ballistic sclerometer" to discriminate it from another apparatus that I am going to describe hereafter, changes of hardness were proved among other in muscles through which passed a galvanic current, in muscles moistened with different isotonic salt-solutions, in m. gastrocnemii excited to tetanus without being capable to contract, lastly with muscles exposed to different temperatures. Also objects of quite different nature and hardness present, at an examination with the ballistic sclerometer, fine differences of hardness. The subjoined figures may throw some light upon this. The objects were examined with a hammer of the same weight, falling constantly from the same height, whilst in the perpendicular position the convex surface of the hammer at rest just touched the surface of the object. Fig. 1 gives the ballistic sclerogram of an *Hirudo medicinalis*, killed by being kept for some hours in ethervapour. Fig. 2 gives an image of the hardness of the m. gastrocnemius of Rana esculenta an hour after its death cut out. Fig. 3 is the ballistic sclerogram of the eye of the hog some hours after death.

Gelatin-plates of the same size and the same thickness but each time of a different concentration, and which at digital touching show quite certain sensoric differences of hardness, may be tapped with the ballistic sclerometer. In accordance with the concentrations we then find differences in the ballistic sclerograms of those plates. The disk-shaped gelatin-plates have an area of 47.3 cM^2 and a thickness of 2.11 cM.

GELATIN-PLATES DETERMINED WITH BALLISTIC SCLEROMETER.

Gelatin-concentration	Transparency [1]	Number of Reverberations	Amount of the heights of all reverberations	Average height of a reverberation
2%	195	25	37 3 cM.	1.49 cM.
3	185	29	44.6	1.53
4	181	31	49	1.60
5	176	34	59 2	1.74
6	168⁵	36	72 4	2.01

[1]) Transparency was determined by examination whether a letter-type $D = 1$ of SNELLEN's optotypes was still to be recognised when viewed through the gelatin-plate and two smoke-glasses.

The figures are nothing but the average product of the numbers of the two smoke-glasses, which every time were wanted by twos from always the same series of smoke-glasses, in order to reach the limit of recognition of the letters.

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Though, as appears among others from the above table, the sclerometric curves denote the mutual differences of hardness very accurately, yet the ballistic method cannot be used to determine the absolute hardness, as it occurs that objects of different structure, which seem to be equally hard by digital touching, make a deviating impression with the ballistic sclerometer. This is because in the ballistic sclerometer it is especially the elasticity of the object that comes to the front. If this is taken into consideration, the method is suitable to the circumstances of the case.

Yet this fact made me look out for another method which was perhaps to show proportionate data at digital touching on the one side and at the sclerometrical examination of the same object on the other.

Mineralogy has at its disposal numbers of methods of a static nature which are not to be used for physiological purposes, so long as one sticks to the permanent deformation as a criterion for hardness. However, another criterion may be used and as a measure for the hardness may be taken the depth of the penetration of a certain object into the object that is to be examined, whilst this penetrating object is charged in a definite way.

This principle somewhat reminds of the principles applied at the determination of hardness in mineralogy according to BRINELL and LUDWIK [1]). In this method we may also speak of absolute hardness, provided the data are every time reduced to the corresponding results arrived at in a material which is considered as unity of hardness. In the static sclerometer the principle is applied as follows. A cone of ebonite hangs by means of a little bar which can move without any incorrect movement, on one arm of a little lever. This same arm of the lever bears a hook in order to hang up different weights, and further a weak iron plate, which by means of an electro-magnet, fed with 4 à 6 volt., can be held fast, so that the cone is prevented from indenting the object. When the current is broken, the cone sinks into the object that is to be examined and the extent of this indenture is indicated by the other arm of the lever magnified 30 times, either by simple reading of the position of the lever along a measuring-lath or by registration on a kymographion or by fixation by means of photography. The registering part of the apparatus with the cone can be moved up and down by means of a metal ring, so that at the determination we first bring about and start from, the condition in which the cone just touches the surface of the object to be examined without any

1) See Dr. VIKT. PÖSCHL, Die Härte der festen Körper. Dresden 1909.

pressure at all. The object itself lies on a firm substratum. In order to be certain that always the same point of the surface is examined this may be marked with colouring matter.

In order to trace whether the form of the indenting object exercises influence upon the degree of indenting I have caused the identure to be brought about by balls of different radii, every time with the same series of weight. When a curve is projected of the size of the indenture, got at different loads, this curve shows, especially at the harder objects, a peculiar course. At the outset the curve has an irregular form, which afterwards passes into a linear course. Now according as the indenture is brought about with balls of greater radii, this linear course shows itself earlier, but at the same time the absolute amount of the indenture is smaller, because the acting force has to spread over a larger surface.

By the analogy of this we should a priori expect that a small plate which might be considered as a ball with an infinitely large radius as penetrating object, must yield a curve, on the whole with a well nigh linear course. Indeed the experiment proves this, provided the condition that the plate has a sufficient size, be satisfied. But as soon as, on the other hand, this size becomes somewhat considerable, so small an indenture is got that the method consequently becomes practically less fit. The subjoined curves obtained from static sclerograms by plotting the depth of the indenture and the corresponding weight, clearly show the influence of the length of the radius of ball or disk. From this it appears that the conus remains the fittest penetrating object, at least in this case, where as an object to be examined was chosen a $\pm$ 5 $^0/_0$ gelatin plate, which, as for its hardness, borders upon the hardness of the M. gastrocnemius of Rana.

The conus may be considered as a little ball with a very small radius. If e. g. the conuspoint is measured under the microscope, it is seen that this point has a certain roundness, for which a radius may be fixed. The indenture got with the conus at a definite weight, but introduced into the system of coordinates as being caused by a ball with 0.4 mM. radius at the same weight, gets a place in accordance with the theoretical plan, on the curve of the conus, which was determined experimentally.

By means of the static sclerometer, with the conus as penetrating object, I have as to their hardness examined gelatin plates of different concentration with the intention, to take as unity of hardness a definite gelatin plate. Gelatin namely is a pretty constant material, easily obtainable for every one (fig. 5). On the whole, if we work with not too large weights, we get regular curves; only the 2 °/₀ gelatin proves not to be able to carry a conus loaded with 100 mgr. Evidently the conus at a given moment destroys the coherence of the gelatin, which manifests itself by the sudden steepness in the curve. At this moment we have reached what in mineralogy is called the 'Grenzeinheitsdruck'.

From the curves may be derived:

1. With how much weight the conus must be loaded in order to make a gelatin plate of a definite concentration undergo an indenture resp. 1 mm., 2 mm., 3 mm. deep.

2. How deep a gelatine plate of a definite concentration is indented at a weight on the conus of resp. 100, 200, 300 and 400 mgr.

In the subjoined tables these amounts have been given.

WEIGHT OF THE CONUS FOR A DEFINITE INDENTURE OF THE GELATIN PLATES.

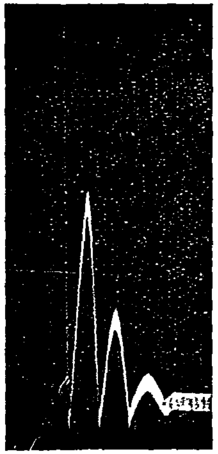
Concentration of the gelatin plate	Weight necessary for 1 mm. indenture	Weight necessary for 2 mm. indenture	Weight necessary for 3 mm. indenture
2%	49 mgrm.	88 mgrm.	101 mgrm.
3	66	131	195
4	105	229	367
5	141	300	487
6	216	439	735
8	337	735	1125

INDENTURE BY A DEFINITE WEIGHT ON THE CONUS.

Concentration of the gelatin plate	Indenture at a weight of 100 gr.	Indenture at a weight of 200 gr.	Indenture at a weight of 300 gr.	Indenture at a weight of 400 gr.	Indenture at a weight of 500 gr.
2%	∞	∞	∞	∞	∞
3	1.53	3 06	4.16	∞	∞
4	0.93	1.78	2.53	3.20	3.83
5	0.72	1.40	2.00	2.56	3.06
6	0.46	0.95	1.40	1.83	2.23
8	0.31	0.63	0.90	1.17	1.41

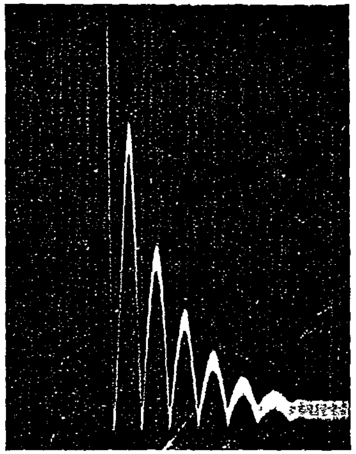
Photographs of the ballistic sclerometer

Fig. 1.



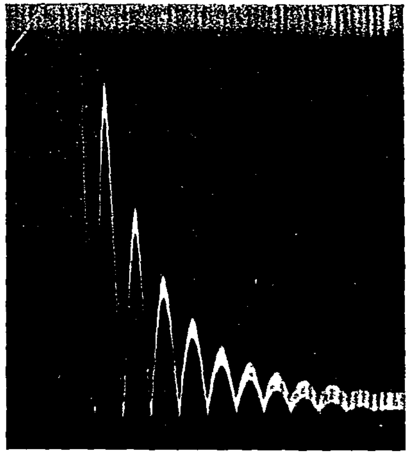
Hirudo medicinalis killed by aether vapour.

Fig. 2.



M. gastrocnemius cut from Rana esculenta.

Fig. 3.

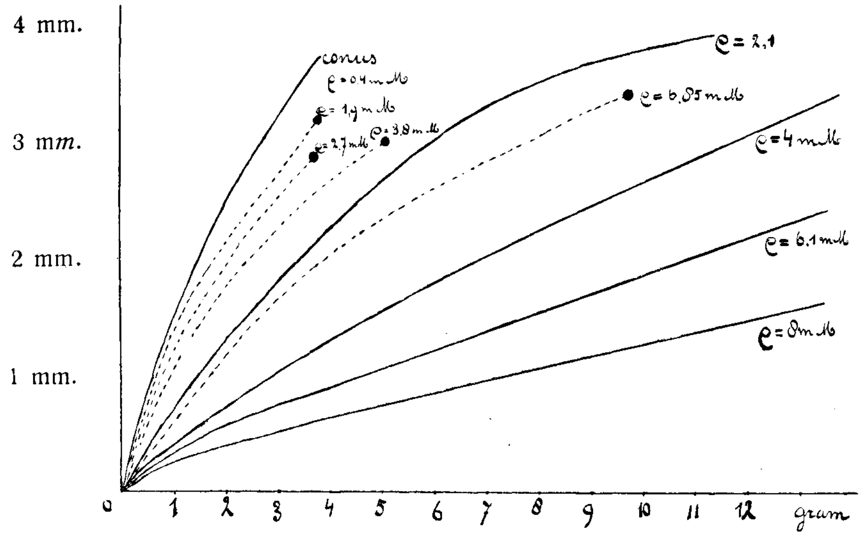


Pig's eye some hours after death.

Fig. 4.

Experiment of the static sclerometer.

5 pCt. gelatineplate with conus, balls and disks, examined as to their hardness.



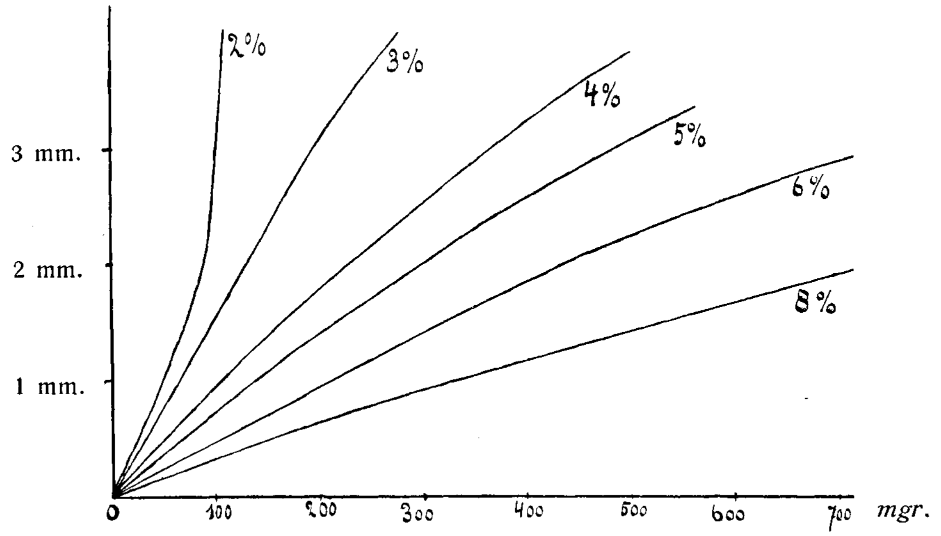
The ordinates render the depth of the indenture.

The abscisses represent the weight of the indenting object.

The curves with solid line show the effect of the conus and the disks; the curves with dotted line show the influence of the balls. Each time the radii of balls and disks have been given.

Fig. 5.

Gelatine plates of different concentration examined as to their hardness with the conus.



The ordinates express the depth of the indenture, the abscisses render the weight of the indenting object.

Lastly we may communicate here the results got by means of the static sclerometer with the three objects, of which the ballistic sclerograms have already been represented.

The Hirudo medicinalis, at a weight on the conus of 94 mgr., showed an indenture of 3.3 mm. and consequently possesses a hardness smaller than a gelatin plate of 2 % gelatin.

The results for the m. gastrocnemius of Rana are found in the following table:

DETERMINATION OF HARDNESS
M. GASTROCNEMIUS OF RANA.

Weight on conus	Dept of indenture	As to its hardness agreeing with gelatin plate of:
75 mgr.	0.78 mM.	3—4 %
94	1.00	3—4
188	1.60	4
282	2.00	4—5
376	2.40	5

From this it may be concluded that the muscle at deeper indentures of the conus, comparatively speaking, gets harder, which may perhaps be attributed to the presence of the many membranes in the muscles. That these differences are, at deeper indentures, no mistakes in the method, probable is made by the fact that at superficial and stronger digital touching also differences in hardness may be perceived.

DETERMINATION OF HARDNESS
OF A PIG'S EYE.

Weight on the conus	Depth of theindenture	In hardness agreeing with a gelatin plate of:
94 mgr.	0.43 mM.	6 %
188	0 80	6—7
376	1.06	6—7
752	2.50	6—7

The determination of hardness happened by making the conus press upon the cupola of the cornea in the pig's eye. At this indenture of the cornea very peculiar optic changes show themselves microscopically under low magnification.

From what precedes it appears that in the hardness of physiological objects we should distinguish well between relative and absolute determination of hardness. This is unmistakably connected with the fact that one of the three qualities which are implied in hardness, viz. elasticity, plasticity, and cohesion, comes to the front. Which part each of these qualities has in definite cases and how they are perhaps to be separated in sclerometry, I hope to show later on.

Chemistry. — *"On the unary tri-molecular pseudo-ternary system acet-, par-, and met-aldehyde".* By Prof. A. Smits and Dr. H. L. de Leeuw. (Communicated by Prof. A. F. Holleman).

(Communicated in the meeting of June 25, 1910).

During the investigation of the system acetaldehyde-alcohol a great quantity of metaldehyde, which deposited in the shape of needles, was formed in one of the mixtures during the cooling without our being able at the first moment to indicate the reason.

This phenomenon, which recalled to our memory the many contradictory accounts which are to be found in the literature about the behaviour of metaldehyde, induced us to undertake the following investigation on the connection between acet-, par-, and met-aldehyde, in which we were fortunate enough to find a solution, which brings unity in the work of many and makes apparent contradictions conform to a perfect harmony.

In 1872 Kekulé and Zincke[1]) found that the formation of metaldehyde from acetaldehyde, just as that of paraldehyde from the same substance, takes place in the presence of certain substances, but that while the formation of paraldehyde takes place at the usual and higher temperatures that of metaldehyde is generally to be observed at lower temperatures. The paper by Kekulé and Zincke cited here is distinguished by the great accuracy of the description of the observed phenomena, and contains a passage, whose meaning has been evidently overlooked by others, as it with great clearness points out the direction in which the solution of the problem is to be found.

The passage in question runs as follows:

"Fügt man zu reinem Aldehyd kleine Mengen von Salzsäure-gas, Chlorkohlenoxyd, Schwefliger Säure oder verdünter Schwefelsäure und kühlt dann sofort, am besten mit einer Kaltemischung ab, so

[1]) Ann. d. Chemie u. Pharm. **162**, 125, (1872).