Na-Anions.	NO_3.	Cl.	SO_4.	Acetate.
Viscosity (*a*) ..	1·76	1·81	1·85	1·93
(*b*) ..	1·53	1·62	1·7	1·79

Controls :	Alkaline gelatine	2·10
	Acid „	2·13
	Neutral „	1·75

These anions decrease the internal friction of acid and alkaline gelatine in the descending order—

NO_3. Cl. SO_4. Acetate.

The order is not reversed with the change of reaction, as is the case with the order of influence of ions on surface tension (*vide* later).

The decreasing effect of the anions on viscosity is much greater in the acid than in the alkaline gelatine.

The viscosity of acid and alkaline gelatine is much higher than of the neutral colloid.

C.—SURFACE TENSION OF SERUM.*

I.

Surface tension or surface pressure is a force acting on the surface of every liquid and solid. It has the tendency of making the surface as small as possible, and therefore produces the globular form of a drop of liquid.

The surface pressure is the cause of capillary attraction and capillary depression, because it is higher on a convex, and less on a concave meniscus compared with the plane surface.

A certain relation exists between surface energies and chemical energies, hence if the surface tension of a liquid chemical compound is known, its molecular weight can be calculated. Forces of curved surfaces also influence the osmotical equilibrium, for instance, if we put a tube in a salt solution, the wall of which is easily permeable for the solvent and the dissolved body, the concentration of the latter one is always higher on the concave side of the surface, viz., in the tube (Kaufler†). Applying this theory to the organisms, the salt concentration in the cells is always higher than in the interstitial liquid, or the osmotical equilibrium for instance, between red blood cells and plasma, is not the same as it would be *ceteris paribus* in vitro with a plane separating surface.

On every surface of either liquids or solids, condensations of the neighbouring substances take place. This is called *adsorption* or *absorption*. Every absorption is dependent on the decrease of the surface tension of the absorbens by the absorbed substance (Gibbs‡).

Coal dust, powdered platinum or palladium absorb enormous quantities of gas; they also absorb dissolved bodies out of a solution. The absorbed quantity is naturally absolutely greater the larger the total absorbent surface. The importance of these facts for physiology is evident if we remember the enormous total surface the cells of the organism have, and that it is, for instance, for the total number of erythrocytes of a human being about 2800 square metres.

The eminent role of surface energies for heterogeneous systems, such as colloids, is elucidated by the fact that 1 c.c. of a substance which as a cubus has a surface of 6 square cm., if split up in particles of 0·1μ diameter would have a total surface of 60·000 square metres.§

* Appeared in the *Transvaal Medical Journal*, August, 1908.
† Kaiserl. Akad. d. Wissenschaften Wien, math. nat. klasse. *43*, 686, 1902.
‡ Transact., Connecticut Academy. *3*, 108, 343.
§ *Wolfgang Ostwald*, Zeitschrift fur Chemie und Industrie der Kolloide, *1*, 291, 1907.

Since we know that the *immune substances* and the *enzymes* are *colloidal* we understand that the visible and measurable part of their respective reactions is more like an absorption than a chemical reaction.

If we now take a physiological colloidal system in view, we have to distinguish

(*a*) surface tension on the surface of the whole system (in vitro) towards air; phases: *liquid-gas* (the liquid itself is a pluriphasic system);

(*b*) surface tension of each colloid particle towards the medium; phases: "*solid*"-*liquid* (the liquid is a salt solution, monophasic system).

What are the consequences of this physical arrangement?

Ad. a. Colloid particles are condensed in the surface, so to say, absorbed by it, whereby the surface tension decreases to a certain minimum. The result is that the density of the system with regard to colloid particles is higher in the surface than in the interior of the liquid. It has to be borne in mind that this is the case not only in the systems liquid-air, but also in liquid-solid, that is to say, anywhere in the organism where the body fluids are in contact with cell walls. The degree of condensation is dependent—amongst other factors—on the substances on both sides of the surface, and upon the radius of its curve.

Condensation of colloid particles which follows a decrease of surface tension takes place in

(1) *Haemo- and bacteriolysis*; absorption of lysines and anti-bodies on the curved surface of the blood and microbe-cell respectively.

(2) *Phagocytosis*; the leucocytes condense microbes or other particles on their surface. This absorption is perhaps the last phase of a chemotactic process.

(3) *Action of enzymes*; the enzymes are colloid particles and absorb crystalloids and colloids on their surface. The condensation, i.e. increase of concentration is the main cause of the acceleration of the reaction.

The ability of some colloids—for instance, proteids—of superficial condensation to such a degree that *membranes* are formed causes a still more pronounced separation of colloid-complexes, viz., isolation and individualisation of each complex, each cell.

The condensed surface already influences the passage of crystalloid molecules and ions. But the membrane completely acts as a typical separator and regulator for the transition of substances from one to the other side of the surface wherein it is localised. The surface tensions, or more precisely, the difference of surface tensions of two systems in contact with each other, creates the conditions for the formation of membranes (*Devaux*,* *Ramsden*,† *Metkalf*‡). *The membranes dominate and regulate the entrance into and exit from the cells and thus influence the protoplasmic metabolism by their semi-permeability or elective permeability* (*Zangger*§).

* Procés verbaux des sciences Bordeaux, 1903-4.
† Proc. Royal Soc. *72*, 156, 1903.
‡ Zeitschr. Physik. Chemie. *52*, 1, 1905.
§ Ergebnisse d. Physiologie v. Asher-Spiro. *7*, 99, 1908.

Ad. b. Also on the surface of each particle condensations must take place. Crystalloid molecules and ions of the medium especially are absorbed and thus influence the properties of the surfaces of the particles.

On the other hand the properties of the entire system will be dependent on the peculiarities of the single globules, namely:

(1) *The internal friction* of a colloid solution is (besides the internal friction of the medium) undoubtedly influenced by the surface, the volume, and the degree of imbibition of the particles.*

(2) *The surface tension* of the system itself, as an expression of the concentration of the particles and their tendency to condense in the surface, will be affected as soon as this tendency is altered as a consequence of changes of the properties of the particles. As a matter of fact it is possible to give a colloidal solution another surface tension by the addition of electrolytes or non-electrolytes, which certainly are partially absorbed by the globules.

II. *Experiments.*

The following table shows the results of 108 examinations of surface tension of various horse sera in ascending order.

I examined (1) normal horses, (2) horses suffering from horse-sickness, (3) horses immune and hyperimmunised against horse-sickness (immune= passed through an attack of horse-sickness; hyperimmunisation=infusion of about 10 litres of blood from a highly sick into an immune horse), (4) serum horses, that is to say, hyperimmunised horses from which regularly large quantities of blood had been drawn in certain intervals (generally 6 litres at a time).

We see that the majority of values of surface tension range between 5·9 and 6·1, a large number between 5·7 and 5·9, and 6·1 and 6·2 respectively, and only a few below 5·7 and above 6·2.

Surface Tension of Horse Sera.

Date of Examination.	Number of Horse.	Remarks.	Surface Tension, 37°.
1908.			
May 12 ..	2901	Hyperimmunised; last bleeding eight days ago ..	4·87
June 20 ..	3411	Horse-sickness; climax	4·98
June 20 ..	3372	Horse-sickness; climax	5·10
June 22 ..	3084	Serum horse; last bleeding four days ago	5·23
June 22 ..	3663	Normal	5·37
July 2 ..	3146	Hyperimmunised six days ago	5·44
June 13 ..	1972	„ twenty days ago	5·44
„ 22 ..	3064	Serum horse; last bleeding four days ago	5·46
„ 24 ..	3685	Normal	5·49
„ 23 ..	3646	„	5·49
April 27 ..	3506	Normal	5·54
May 18 ..	3541	„ strangulated for three minutes	5·56

* Compare *Pauli and Handovsky*, Hofmeister's Beitrage. 11, 415, 1908.

Surface Tension of Horse Sera.—(Continued.)

Date of Examination.	Number of Horse.	REMARKS.	Surface Tension, 37°.
1908.			
June 27 ..	3146	Hyperimmunised the day before; immediately before the second hyperimmunisation	5·57
May 18 ..	3541	Normal; strangulated ten minutes	5·66
June 20 ..	3608	Horse-sickness; climax seventeenth day	5·67
„ 22 ..	3033	Serum horse; last bleeding four days ago	5·67
July 2 ..	3076	„ „ five weeks ago	5·68
June 1 ..	3505	Horse-sickness; climax tenth day	5·69
„ 24 ..	3517	„ „ ninth day	5·69
May 3 ..	3049	Serum horse; immediately before bleeding	5·69
June 15 ..	3632	Normal	5·70
„ 3 ..	3591	„	5·72
April 30 ..	3364	„	5·73
June 20 ..	2903	Serum horse; last bleeding two days ago	5·75
„ 27 ..	3146	Hyperimmunised immediately after second hyperimmunisation	5·75
April 27 ..	3302	Horse-sickness begins; reaction ninth day	5·76
„ 27 ..	3465	„ „ „ „	5·76
June 23 ..	3637	Normal	5·76
„ 20 ..	3091	Serum horse; last bleeding two days ago	5·77
„ 27 ..	3119	Hyperimmunised day before; immediately before second hyperimmunisation	5·78
„ 15 ..	3625	Normal	5·78
„ 4 ..	3427	Horse-sickness; climax thirteenth day	5·79
„ 20 ..	2270	Serum horse; bled two days ago	5·79
June 23 ..	3638	Normal	5·80
May 4 ..	3512	„	5·81
June 27 ..	3119	Immediately after second hyperimmunisation	5·81
„ 26 ..	3079	Immune against horse-sickness	5·82
„ 23 ..	3647	Normal	5·82
April 27 ..	3447	Immune	5·83
June 13 ..	3451	Hyperimmunised	5·83
„ 29 ..	1288	„	5·83
July 2 ..	3119	„ six days ago	5·85
June 22 ..	3670	Normal	5·85
„ 24 ..	3675	„	5·87
April 27 ..	3499	Horse-sickness; climax ninth day	5·87
June 1 ..	3546	„ „ tenth day	5·87
„ 22 ..	3668	Normal	5·89
May 11 ..	3524	Normal	5·90
June 12 ..	3302	Horse-sickness; climax fourteenth day	5·91
„ 13 ..	1293	Hyperimmunised	5·91
July 1 ..	1288	„ one day after first bleeding	5·92
June 2 ..	3589	Normal	5·92
„ 1 ..	3551	Horse-sickness; climax	5·92
„ 17 ..	1288	Hyperimmunised; bled six days ago	5·93
April 28 ..	3507	Normal	5·93
June 17 ..	3449	Immune	5·94
„ 27 ..	1162	Hyperimmunised	5·94
„ 27 ..	3685	Normal	5·95
May 11 ..	3474	Horse-sickness; climax nineteenth day	5·95
May 18 ..	3538	Normal; strangulated for ten minutes	5·96
April 30 ..	3451	Horse-sickness; climax tenth day	5·96
May 11 ..	3457	„ „ fifth day..	5·97
„ 11 ..	3445	„ „ ninth day	5·97
„ 18 ..	3538	Normal; strangulated for six minutes	5·98

Surface Tension of Horse Sera.—(Continued.)

Date of Examination.	Number of Horse.	Remarks.	Surface Tension, 37°.
1908.			
June 15 ..	3623	Normal	5·98
„ 2 ..	3590	„	5·98
May 18 ..	3538	„ strangulated for three minutes	5·99
„ 3 ..	3510	„	5·99
June 17 ..	1085	Hyperimmunised; first bleeding six days ago ..	5·99
June 3 ..	3473	Horse-sickness; climax fourteenth day	6·00
„ 24 ..	3682	Normal	6·00
„ 3 ..	3506	„	6·01
„ 29 ..	1672	Serum horse; bled two months ago	6·02
„ 3 ..	3490	Horse-sickness	6·02
July 1 ..	1660	Serum horse; last bleeding day previous	6·03
June 20 ..	3172	„ „ „ two days previous ..	6·03
July 1 ..	1672	„ „ „ day previous	6·04
May 18 ..	3541	Normal	6·04
June 15 ..	3636	„	6·06
April 28 ..	3504	„	6·06
„ 28 ..	3342	„	6·06
June 3 ..	3607	„	6·07
„ 3 ..	3555	Horse-sickness	6·07
„ 17 ..	3408	Immune horse-sickness	6·07
„ 29 ..	1660	Serum horse; last bleeding four weeks ago	6·08
„ 1 ..	3264	Horse-sickness; climax	6·09
„ 1 ..	3588	Normal	6·09
„ 1 ..	3587	„	6·09
May 3 ..	3511	„	6·10
April 4 ..	3340	„	6·10
June 3 ..	3590	„	6·11
„ 15 ..	3630	„	6·11
„ 13 ..	3584	Horse-sickness, end; eighth day	6·11
May 18 ..	3538	Normal	6·12
June 30 ..	1972	Serum horse; last bleeding twelve days ago	6·13
„ 30 ..	1293	„ „ „ „	6·14
„ 1 ..	3424	Horse-sickness; climax	6·14
May 13 ..	3524	Normal	6·14
June 15 ..	3635	„	6·16
April 30 ..	3317	„	6·17
„ 30 ..	3362	Horse-sickness; climax	6·17
May 4 ..	2901	Hyperimmunised; bled thirteen days ago	6·19
June 9 ..	1288	Hyperimmunised	6·21
April 28 ..	3314	Normal	6·24
June 17 ..	3411	Immune	6·27
„ 1 ..	3591	Normal	6·27
„ 17 ..	1660	Hyperimmunised; first bleeding six days previous ..	6·28
June 3 ..	3589	Normal	6·45

The surface tension at 37° * of *normal* horse-serum varies from 5·37 to 6·45. The average from 42 examinations on 36 horses being *5·95*, the variations are 9·75 per cent. below and 8·4 per cent. above the average =18·15 per cent. total variation. The average surface tension of the sera of 23 different horses suffering from *horse-sickness* is *5·85*, that is to say, 1·68 per cent. lower than the average normal surface tension. But the

* The surface tension of water at this temperature is *7·132*. Hence the surface tension of serum is lower than that of water, but the viscosity is higher.

variations are in somewhat wider limits, namely, between 4·98 to 6·17 =20·34 per cent. Horses with a very strong attack of horse-sickness, when circulation and respiration are highly altered, generally show a subnormal value of surface tension of serum. I am inclined to attribute this phenomenon merely to the stasis of the blood in the jugular vein and accumulation of CO_2, because it was possible to reproduce a decrease of surface tension of serum by artificial strangulation of the vein, as the following examples demonstrate :—

		Surface tension of Serum at 37°.	Viscosity of Serum at 23°.
18/5/08—1.—	Horse 3541, normal	6·04	1·96
	Three minutes' strangulation	5·56	2·08
	Ten minutes' strangulation	5·66	2·16
18/5/08—2.—	Horse 3538, normal	6·12	—
	Three minutes' strangulation	5·99	—
	Six minutes' strangulation	5·98	—
	Ten minutes' strangulation	5·96	—
		Surface tension of Blood at 37°.	Viscosity of Blood at 25°.
16/1/08—3.—	Horse 3256, normal	5·62	3·95
	A fifteen minutes' gallop and five minutes' strangulation	5·42	5·55

At the same time the viscosity of serum and blood increases*, and a combination of both methods therefore gives very valuable prognostical indications, especially when the examinations are made several times on different dates.

It is a well-known fact that by accumulation of carbonic acids, the microbicide properties of serum increase, a fact which is the base of the hyperaemia treatment by artificial stasis of the blood. At present it is not possible to define the role of the decreased surface tension in the destruction of microbes, but there is no doubt that the absolute value of surface tension of the blood liquid on one side and of the microbe on the other, or rather the difference of both, has an influence on the structure of the membrane of the bacillus and on the condensation (absorption) of the blood anti-bodies on its surface.

We are not permitted to say that the decrease of surface tension alone is the cause of the increase of destructive properties of a serum, as the following experiment shows :—

Serum Mule 3417.	Surface Tension.	Viscosity.
Normal	6·04	1·88
Heated for half an hour at 56°	5·85	1·9

The heating process is followed by a synchronical decrease of the surface tension and loss of the microbicide properties of the serum, for the alexines are destroyed. In this case the decrease of surface tension is rather a symptom of physical-chemical alterations of the serum colloids.

The influences of infusion (hyperimmunisation) and bleedings on the surface tension are shown by the following table :—

		Surface tension immediately before infusion of 5 litres of blood.	after
27/6/08.	Horse 3146	5·57	5·75
	„ 3119	5·78	5·81

* Compare *W. Frei*, on Viscosity of Blood. *Transvaal Medical Journal*, April, 1908.

			Surface tension immediately before bleeding.	Surface tension two hours after bleeding (6 litres).
18/6/08.	Horse	1293	5·79	5·89
	,,	1972	5·79	5·75
			1 day before.	1 day after.
29/6/08.	Horse	1288	5·83	5·92
1/7/08.	,,	1660	6·08	6·03
	,,	1672	6·02	6·04

The surface tension of serum is increased after *infusion,* whilst the viscosity is lower. That points to a decrease of serum-proteids. This is not easy to understand, because an increase in concentration had to be expected. But we must not forget that the figures only refer to serum of blood from the jugular vein, and that we have no indications about the blood which is probably accumulated in the distended capillaries of the intestines.* (Results of other transfusion experiments.)

In three instances *loss of blood* has a diminishing influence on the surface tension of the serum. The viscosity is also decreased. Both facts are probably due to the diffusion of water or intercellular liquid without, or with but very little, colloid substances into the blood vessels in order to keep the blood pressure at a normal height. The experiments are not yet numerous enough to draw definite conclusions.

After having observed that neutralisation of serum causes a considerable decrease of surface tension, the following experiments were made to study the influence of the concentration of the hydroxylion on the surface tension and viscosity :—

		Surface tension.	Viscosity.
11/5/08—1.—	Serum horse 3524, normal	6·14	1·90
	5 c.c. Serum + 5 drops nKOH ..	6·14	1·83
	5 c.c. Serum + 5 drops n H_2SO_4 (acid reaction. Opalescent gelatinons) ..	5·31	5·4
	Increase of OH concentration does not alter the surface tension, but causes a slight decrease of the viscosity. Change of reaction decreases the surface tension and considerably increases the viscosity.		
2/6/08—2.—	Serum horse 3590, normal	5·98	2·12
	4 c.c. Serum + 4 drops n Na OH ..	5·79	2·13
	4 c.c. Serum + 1 drops $\frac{n}{2}H_2SO_4$ (alkaline reaction)	5·92	2·33
	4 c.c. Serum + 2 drops $\frac{n}{2}$ H_2SO_4 (acid reaction)	4·94	2·57
	Increase and decrease of the OH concentration causes a diminution of surface tension (whilst the viscosity always becomes higher). The actual degree of alkalinity is the optimal one.		

* Compare *Tigerstedt*, Ergebnisse d. Physiologie. *6*, 303, 1907.

		Surface tension.	Viscosity.
2/6/08—3.	—Serum horse 3589, normal	5·92	—
	5 c.c. Serum + 2 drops n Na OH ..	6·01	—
	5 c.c. Serum + 5 drops n Na OH ..	6·09	—
	7 c.c. Serum + 2 drops $\frac{n}{2}$ H_2SO_4 (very slight alkaline reaction)	6·00	—
	Increase and decrease of the number of OH ions causes an increase in surface tension. The actual concentration corresponds to a minimum of surface tension.		
23/6/08—4.	—Serum horse 3647, normal	5·82	1·83
	5 c.c. Serum + 2 drops nKOH ..	5·93	1·85
	5 c.c. Serum + 4 drops nKOH ..	5·85	1·88
	5 c.c. Serum + 2 drops $\frac{n}{2}$ H_2SO_4 (very slight alkaline reaction)	5·07	1·95

The optimal OH concentration is somewhat higher than the actual one

Conclusions.—The natural concentration of OH ions in normal horse serum is not always the optimal one for the maximum surface tension.

The alkalinity gives the surface tension a certain height which would not exist in a neutral or acid serum.

It follows from the experiments of *Buglia* * (who studied the influence of H concentration on cattle serum) that the surface tension shows two maxima, one of them coinciding with the natural OH concentration of serum, the other being immediately before the neutral zone at a lower degree of alkalinity.

Although the correlations between surface tension and *phagocytosis* have not been experimentally studied, we can safely say that a relation exists between (*a*) alkalinity, (*b*) surface tension of serum, and (*c*) intensity of phagocytosis, for it has been observed that the phagocytosis is a maximum at an optimal concentration of OH ions (not proportional) which is present in the serum.†

We know that there is an optimal OH concentration (or two optima) for the surface tension of serum, and it is interesting to find similar phenomena in a simple colloid, namely gelatine combined with various quantities of alkali.

30/5/08. Temperature =37° 0·75 per cent. gelatine.

Concentration of Na OH.	Surface tension.
%	
0	6·29
0·013	6·48
0·063	*6·63*
0·125	6·36
0·25	*6·58*
0·5	6·48
0·75	6·45
1·0	6·33

* Biochem. Zeitschrift. *11*, 311, 1908.

† *Hamburger* and *Hekma.* Bioch. Zeitschrift *9*, 273, 1908.

There are two optima, at the concentrations 0·063 and 0·25 respectively. The curve resembles *Buglia's*.

Another function of the hydroxylion, where an optimal concentration is also required, is the stabilisation of negative colloids (metal sols, *Bredig*).

It has yet to be found whether the points of greatest stability and greatest surface tension of a colloidal solution are coincident.*

Guided by the idea that the serum is a system of colloids with various electrolytes and non-electrolytes, and especially in order to obtain an idea of the effect of electrolytes, I commenced to study the influence of single ions on gelatine, and obtained the following results :—

I. 7/5/08.—One per cent. gelatine + Cl-kations in $\frac{n}{9}$ concentration.

	Surface tension 37°.	Viscosity at 25°.
Gelatine (control)	5·97	2·33
Gelatine + Na Cl	6·20	3·9
Gelatine + K Cl	6·29	2·15
Gelatine + Mg Cl_2	6·19	2·7
Gelatine + Ca Cl_2	6·34	3·35

The kations Na K, Mg Ca, with Cl as anion in $\frac{n}{9}$ concentration *increase* the surface tension of 1 per cent. neutral reacting gelatine in the descending order Ca K, Na Mg. *Whatmough* composed the order Ca Na, K Mg as increasing the capillarity of water. The viscosity increased in the order Na Ca, Mg K. (K decreases.)

II. 18/4/08.—One per cent. gelatine + Na-anions in $\frac{n}{5}$ concentration.

	Surface tension at 37°.
Gelatine (control)	6·24
,, + Na Cl	6·58
,, + Na_2 CO_3	6·63
,, + Na_2 SO_4	6·67
,, + Na NO_3	6·47

Natrium anions in $\frac{n}{5}$ concentration *increase* the surface tension of 1 per cent. neutral gelatine in the descending order SO_4, CO_3, Cl, NO_3.

The same order of ions was stated to *increase* the surface tension of pure water, for Na in the same descending order SO_4, Cl, NO_3 (*Whatmough*†), and also the internal friction of H_2O in the descending order SO_4, Cl, NO_3 for several kations (*Wagner*‡).

III. 20/5/09.—5 c.c. 1 per cent. gelatine + 1 drop $\frac{n}{2}$ H_2 SO_4 + Na-anions in $\frac{n}{6}$ concentration.

* OH ion stabilises (disseminates) negative colloids and increases their surface tension, that means it prevents the particles from condensing in the surface. Also other anions especially citrate, oxalate, acetate, picrate have a stabilising effect. Citrate disseminates Ba SO_4 suspension (*Gengou*) and protracts the haemolysis by cobra venom (*Gengou*) ; that would be, it prevents the particles of the colloidal venom from condensing on the surface of the blood corpuscle.

† Zeitschrift Physik. Chemie. *39*, 129, 1902.

‡ Zeitschrift Physik. Chemie. *5*, 31, 1890.

	Surface tension 37°.	Viscosity at 23°.
Gelatine (neutral control ..	6·30	1·75
,, (sour control) ..	6·14	2·13
,, $+Na\ Cl$	6·05	1·62
,, $+Na_2\ SO_4$	6·16	1·7
,, $+Na\ NO_3$	6·31	1·53
,, $+Na\ C_2H_3O_2$ ..	6·38	1·79

VI. 20/5/08.—One per cent. gelatine + 1 drop nKOH + Na-anions in $\frac{n}{6}$ concentration.

	Surface tension 37°.	Viscosity at 23°.
Gelatine (control neutral) ..	6·30	1·75
,, (control alkaline) ..	6·53	2·1
,, $+Na_2CO_3$	6·47	1·83
,, $+Na\ NO_3$	6·48	1·76
,, $+Na_2SO_4$	6·51	1·85
,, $+Na\ Cl$	6·53	1·81
,, $+Na\ C_2H_3O_2$ ..	6·57	1·93

The Na-anions Cl, (CO_3), NO_3, SO_4, acetate in $\frac{n}{6}$ concentration *decrease* the surface tension of 1 per cent. alkaline gelatine (except acetate) in the descending order (CO_3), NO_3, SO_4, Cl, whilst these ions *increase* the surface tension of acid gelatine in the same descending order Acet., NO_3, SO_4, Cl. (Cl decreases.) The order of influence of these ions is reversed as soon as the reaction is changed.

The differences of the effects of these anions are much greater in an acid than in an alkaline medium. In analogy to serum, the surface tension of alkaline gelatine is higher, of acid gelatine lower than of the neutrally reacting colloid.

The internal friction of acid and alkaline gelatine is *decreased* in the ascending order Acet., SO_4, Cl, NO_3, that is to say by the same ions which *increase* the viscosity of water in the ascending order NO_3, Cl, SO_4.

RÉSUMÉ.

The surface tension is a factor of enormous biological importance, especially for the phenomena of haemo- and bacteriolysis, phagocytosis and enzyme reactions.

The surface tension of serum of horses suffering from horse-sickness is subnormal.

Infusion of homogeneous blood and considerable loss of blood have an influence on the surface tension of horse serum.

The alkalinity of the serum guarantees a certain height and probably stability of the value of surface tension, but this latter one increases not proportionally with an increase of the hydroxylion-concentration; there is a certain optimum (perhaps two optima), and when this is surpassed the tension decreases again.

The anions SO_4, Cl, NO_3 increase the surface tension of neutral gelatine in exactly the same the kations Na, K, Mg Ca nearly in the same order in which the capillarity of water is increased by them.

The order of influence of the Na-anions NO_3, Cl, SO_4 on gelatine is reversed as soon as the reaction is changed. The degree of influence of these ions is much higher in the acid than in the alkaline gelatine.

The surface tension of neutral gelatine (and neutral serum) is increased by the OH and decreased by the H-ion.

D.—ELECTRIC CONDUCTIVITY.

In a homogeneous system the electric conductivity is an expression of the number of free ions and thus of the degree of dissociation, and of the velocity of the ions.

In heterogeneous systems with electrolytes the resistance for the passage of the electric current is greater than it would be *ceteris paribus* in the electrolyt solution without suspended globules, for the latter

(*a*) absorb on their surface a certain number of ions and thus simply reduce the number of carriers of electricity;

(*b*) are mechanical obstacles for the migration of the remaining free ions.

Therefore the result of examination of the serum conductivity is dependent on

(*a*) number and kind of serum ions;

(*b*) quantity and actual state of serum colloids.

That is to say on two factors which are in competition with each other.

It was found that the conductivity of milk is considerably increased by elimination of the colloidal casein * (coagulation by means of the specific enzyme).

Similarly the colloidal ferrihydroxyde decreases the conductivity of NH_4Cl.†

The following experiments were carried out to study quantitatively the influence of various organic colloids in different concentrations on the conductivity of the same electrolyte, that is to say, the influence of albumine, globuline, gelatine, and saponine on the ions Na and OH. Albumine and globuline are colloidal components of serum wherein also both ions are present.

(1) *Albumine.*

Serum diluted with dist. H_2O in the proportion of 1 : 10. The globulines precipitate; the clear remaining liquid is boiled after addition of a small quantity of $(NH_4)_2\ SO_4$. The coagulum obtained is washed several times by means of dist. H_2O and centrifugal power until the liquid has a conductivity of $0{\cdot}75 \times 10^{-4}$. From the dried deposits a 4 per cent. stock solution is made with $\frac{n}{2}$-Na OH.

9/12/07. T=37°.

Concentration of Albumine. %	Conductivity $\times 10^{-4}$.	Differences, absolute.	Difference in percentages. %
$0 \cdot \left(\frac{n}{2}\text{ Na OH}\right)$	1097		
0·5	1056	41	3·7
1·0	1015	41	3·9
1·5	977	38	3·7
2·0	942	35	3·7
2·5	905	37	3·9
3·0	870	35	3·9
3·5	837	33	3·8
4·0	802	35	4·2

* *Schnorf*, Thesis, Zürich, 1904.

† *Dumanski*, Zeitsche, f. Chemie und Indust., I. Kolloide, *1*, 281, 1907.