It is, therefore, possible to distinguish by means of physical-chemical methods whether a horse is suffering from piroplasmosis or horse-sickness.

This task would be greatly facilitated for laboratory use by taking a physical-chemical "description" of every horse.

Ad (*b*).—A doubtless pure case of horse-sickness after infusion is only 3124. In such cases we would have to distinguish

(1) among symptoms merely due to the infusion of a great quantity of homologous blood ;

(2) among symptoms caused by the horse-sickness virus.

The symptoms under (2) are so pronounced and the duration of the attack so short that those mentioned under (1) have no chance to emphasise themselves.

The volume of blood corpuscles increases by accumulation of CO_2 in the jugular blood continually until the lethal exitus occurs caused by heart affection. (Heart form of horse-sickness.)

Specific gravity and viscosity of serum decrease on account of a loss of non-electrolytes (and perhaps colloids), as the dropping of osmotic pressure and the increase of conductivity prove.

Ad (*c*).—These horses show symptoms of horse-sickness and piroplasmosis together, more or less distinctly those of one or the other disease.

The slight decrease of the blood values in 2903, for instance, speaks for horse-sickness, for it follows a temperature reaction. The exacerbations of the depression of freezing point in 3091, however, are more signs of piroplasmosis. The increases of the blood values of 2915, 2917, and 2904 are caused by the horse-sickness virus, the dropping of the same, and of the conductivity of serum in 2915 is due to the influence of piroplasms. The declinations of specific gravity and surface tension of serum in 2915 are like those found in horse-sickness.

Three horses 2904, 2917, and 3124 died, evidently of horse-sickness. The physical-chemical symptoms, *which indicate the fatal end* a short time before death, are in all horses the following :—

(1) Sudden increase of volume of corpuscles, viscosity, and specific gravity of the blood.

(2) Sudden decrease of the specific gravity of serum.

These symptoms of death are just the reverse in horse 2915 which succumbed to piroplasmosis.

(*g*) PIROPLASMOSIS.

The principle of piroplasmosis is destruction of red blood cells, that is to say, haemolysis, caused by endoglobular parasites. The consequence is anaemia or, better, oligocytaemia. Therefore we have to distinguish among the clinical symptoms of a piroplasmatic infection :

Primary symptoms.

(1) Symptoms directly due to the piroplasms (haemolysis, fever).

(2) Symptoms due to the pathologically increased process of haemolysis, i.e. the consequences of blood destruction. (Alterations of osmotic pressure, icterus haemoglobinuria.)

Secondary symptoms.

(3) Symptoms which are merely consequences of the deficiency of erythrocytes. (Poverty, acceleration of pulse, and respiration.)

(4) Symptoms of re-convalescence, reappearance of young red blood cells (poikilocytosis).

As the clinical symptoms are only the consequences of physical and chemical processes within the blood and tissues, we expected alterations in the physical-chemical state of the serum, for instance, of its osmotic pressure and conductivity, as a consequence of the diffusion of electrolytes, and eventually colloids from the dead erythrocytes into the blood liquid and perhaps of secretions and excretions of the piroplasms themselves. Subsequently the urine altered, for the elimination of abnormal blood constituents partially takes place through the kidneys. At least secondary affections of the latter were expected to signalise themselves also by abnormal physical-chemical peculiarities of their excretion.

From the horses 2840, 2841, 2847, and 2848 we obtained the following indications :—

(1) Temperature.

(2) Results of microscopical and clinical observations.

(3) Number and volume of erythrocytes.

(4) Conductivity of serum at 25°.

(5) Depression of freezing point = osmotic pressure of serum.

(6) Conductivity of urine at 25°.

(7) Depression of freezing point = osmotic pressure of urine.

The examinations were made day by day for about five weeks, that is to say, from a few days before infection, continuing throughout the whole attack almost to complete restitution of the animals.

Horse 2840.

Date.	Temperature.		Red Blood Corpuscles.		Serum.		Morning Urine.			Afternoon Urine.			Results of Microscopical Examinations.	Pulse.
	Morning.	Evening.	Number.	Volume.	Conductivity.	Depression of Freezing Point.	Conductivity.	Colour.	Depression of Freezing Point.	Conductivity.	Colour.	Depression of Freezing Point.		
				%										
June 27	—	—	—	—	113·3	0·556	—	—	—	—	—	—	—	—
„ 29	—	—	—	—	116·3	0·558	—	—	—	—	—	—	—	—
July 1	98·2	100·2	—	—	113·8	0·597	—	—	—	—	—	—	—	—
„ 2	100·2	100·2	—	—	113·9	0·544	—	—	—	—	—	—	—	—
„ 3	99·2	100·4	—	—	115·3	0·578	145	—	0·321	—	—	—	Inj. subc. 5 c.c. blood of DE 2564	—
„ 4	100·2	101·0	—	—	109·9	0·998	—	—	—	—	—	—	—	—
„ 5	99·6	100·0	—	—	114·3	0·778	39	—	—	—	—	—	—	—
„ 6	100·2	99·6	—	—	117·0	0·653	208	—	2·437	—	—	—	—	—
„ 7	100·0	100·4	—	—	—	—	—	—	—	—	—	—	—	—
„ 8	99·2	100·6	—	37	116·1	0·551	348	Yellow, clear	2·365	—	—	—	—	—
„ 9	100·2	100·8	7,700,000	36	115·4	0·564	—	—	—	—	—	—	—	—
„ 10	100·2	100·2	—	37	114·2	0·566	259	Clear	2·055	287	Clear	2·001	—	—
„ 11	98·4	101·0	9,000,000	39	110·8	0·550	380	„	2·410	135	„	0·795	—	—
„ 12	99·2	101·4	—	34	112·4	0·666	—	—	—	256	Normal	2·341	Mic. exam.: Negative	—
„ 13	100·0	103·4	8,100,000	36	113·1	0·540	—	—	—	—	—	—	„ „	—
„ 14	101·0	101·6	—	—	111·8	0·798	242	Brownish, clear	2·668	—	—	0·789	*Piropl. equi*, rare	34
„ 15	99·0	101·0	7,100,000	37	114·0	0·511	?	Reddish	2·755	—	—	—	„ „ „	32
„ 16	99·2	100·4	5,600,000	34	111·7	0·522	—	—	—	265	Normal	2·815	„ „ „	34
„ 17	99·6	100·4	6,900,000	34	115·5	—	270	Yellow, cloudy	3·393	329	„	—	Mic. exam.: Negative	36
„ 18	99·8	99·0	6,300,000	33	111·7	0·519	—	—	—	290	Clear	2·754	„ „	36

,,	19	99·2	100·2	7,300,000	33	111·3	0·512	246	Clear	2·122	—	—	—	,, ,,		32
,,	20	103·0	105·2	7,300,000	33	108·2		222	Normal	1·548	114	Normal	—	—		—
								81	Normal	—	81	Light yellow	0·508	Mic. exam. :	Negative	46
,,	21	102·0	101·2	—	—	110·9	0·529	23	Clear	0·875	—	—	—	Conjunctiva	yellow	—
								133	Dark yellow, cloudy	—	21	Clear	—	Mic. exam. :	Negative	40
,,	22	99·4	100·6	5,900,000	33	109·2	0·521	20	Clear	1·637	—	—	—	—		—
,,	23	100·0	100·0	—	30	110·5	0·561	297	Normal	2·091	64	Dark yellow	—	Mic. exam. :	Negative	30
,,	24	99·2	99·4	6,400,000	34	116·3	0·567	347	,,	2·302	243	Slight cloudy	—	,,	,,	40
								202	Yellow, clear	—	362	Dark yellow, clear	—	,,	,,	34
,,	25	98·0	101·0	—	34	111·0	0·525	98	Light yellow, clear	1·089	—	—	—	—		—
,,	26	98·6	98·8	6,300,000	32	107·7	0·523	150	Normal	1·111	—	—	—	Mic. exam. :	Negative	—
,,	27	97·8	99·2	—	32	111·7	0·580	170	Dark yellow	1·348	—	—	—	,,	,,	—
,,	28	98·0	98·8	—	—	114·1	0·572	281	,,	2·123	96	Clear	—	,,	,,	—
,,	29	98·2	99·2	6,800,000	31	111·8	0·520	—	—	—	—	—	—	,,	,,	—
,,	30	98·8	99·6	—	—	114·2	0·525	—	—	—	—	—	—	,,	,,	—
,,	31	98·6	99·2	7,400,000	34	113·9	0·559	—	—	—	306	Normal	2·141	—		—
											344	Dark yellow	1·973	—		—
Aug.	1	98·8	99·2	—	—	114·1	0·587	252	Dark yellow, clear	1·556	128	Clear	—	—		—
,,	2	98·2	99·0	7,500,000	34	112·9	0·517	—	—	—	250	Normal	1·617	—		—
,,	3	99·0	99·0	—	—	113·8	0·540	—	—	—	337	,,	2·545	—		—
,,	4	—	—	—	—	114·0	0·581	—	—	—	—	—	—	—		—

Discussion.

The incubation period with regard to the *temperature reaction* is nine days. The fever shows two periods, namely: the first, lasting for four days; the second and more pronounced, which starts after an interval of four days, and endures only three days.

Piroplasma equi is observed the eleventh, twelfth, and thirteenth day (after injection), that is to say, at the end of the first fever period and the beginning of the feverless interval.

Number and volume of red blood corpuscles also show two periods of decrease and re-increase. The first decrease starts about the same time when the temperature rises. The first minimum coincides with the beginning of the feverless interval. The days of the most intensive destruction of corpuscles are therefore those where the parasites are present. The second minimum lies at the end of the second fever reaction. Then the number of erythrocytes increases slowly and is thirty days after injection almost normal again.

The reason that the curves of number and volume of blood corpuscles are not going absolutely parallel are, first of all, the technical errors made, especially in counting, then the poikilocytosis; different sizes of erythrocytes, of course, do not affect the result of counting.

The conductivity of serum oscillates between 108 and 117 $\times$ 10^{-4}. The normal value averaged from five examinations before injection amounts to 114·5 $\times$ 10^{-4}. The very minimum of conductivity = 107·7 on the twenty-third day lies, therefore, about 6 per cent. below the normal value, while the total variation of conductivity during the disease amounts to 8·1 per cent.

Two periods of low values of conductivity may be noticed, both coinciding with the fever periods: first from the eighth to the thirteenth day; second from the seventeenth to the twentieth day; then again, a deep precipitation occurs on the twenty-third day, probably corresponding with a third reaction. After that the conductivity "recovers" very quickly and is already normal again the twenty-fifth day.

I want to draw attention to a phenomenon which is almost typical for piroplasmosis, and which never has been observed in horse-sickness; I mean a remarkable decrease of the conductivity of the serum the first or second day after infection, whereafter conductivity returns at once to normal height, at which it remains for the next days of the incubation period.

In horse 2840 this sudden decrease of conductivity seems to be produced by an increase of the non-electrolytes, because the depression of freezing point shows a corresponding rise, and it is well known that non-electrolytes depress the electrolytic dissociation.

The cryoscopy of serum indicates an enormous depression of the freezing point the first day = — 0·998°, corresponding with an osmotic pressure of about twelve atmospheres at 0° or $12\,(1 + \frac{3}{2}\frac{7}{7}\frac{7}{8})$ = about fourteen atmospheres at 37°, while the normal depression is — 0·577° according with an osmotic pressure of about eight atmospheres at 37°. The depression returns then to the normal the fifth day. After another increase coinciding with the second part of the first temperature reaction and subsequently with the first period of low conductivity and considerable destruction of blood corpuscles, the depression remains subnormal for eight days, and varies after that from — 0·52° to — 0·58°, almost parallel to increases and decreases of the conductivity. The low value of conductivity and depression of freezing point from the seventeenth to the nineteenth day points to considerable diminution of serum electrolytes.

The conductivity of urine goes, with a few exceptions, parallel with that of serum, that is to say (as the blood for serum was taken in the morning), the more or less electrolytes the serum contains, the more or less of them respectively are eliminated by the kidneys; but it must not be forgotten that dilution of the same amount of electrolytes in a great quantity of urine-water might misrepresent a minus of electrolytes.

Notwithstanding the examinations of urine being started after the infection, I am inclined to consider the first three values of the conductivity as subnormal as a direct consequence of the injection, according to the synchronical changes in serum. The normal conductivity of urine would be about 250×10^{-4}, hence it is much higher than that of serum, and the limits of variations are enormously wide. $(20 - 230 \times 10^{-4}.)$

The concentration of electrolytes in the urine, of course, has to vary on account of their comparatively constant concentration in the serum. In analogy to the appearances of the serum, the conductivity of urine shows periods, the second of which contains the lowest values (seventeenth, eighteenth and nineteenth day), that is just during the second periods of breaking down of blood corpuscles.

The depression of freezing point of urine, going parallel with the conductivity, proves that the osmotically active components of urine are mostly electrolytes. The variations of the osmotic pressure of urine are considerable, namely, according to the variations of depression of freezing point from $-0{\cdot}32°$ to $-3{\cdot}4°$. P = from 4·4 to 46·6 atmospheres at 37°.

HORSE 2841.

Date.	Temperature.		Red Blood Corpuscles.		Serum.		Morning Urine.			Afternoon Urine.			Results of Microscopical Examinations.	Pulse.
	Morning.	Evening.	Number.	Volume.	Conductivity at 25×10^4	Depression of Freezing Point.	Conductivity at 25×10^4	Colour.	Depression of Freezing Point.	Conductivity at 25×10^4	Colour.	Depression of Freezing Point.		
				%										
June 27	—	—	—	—	112·9	0·548	386	—	2·205	—	—	—	—	—
,, 29	—	—	—	—	115·7	0·550	341	—	2·212	—	—	—	—	—
July 1	97·4	100·2	—	—	115·5	0·563	246	—	—	—	—	—	—	—
,, 2	98·0	101·0	—	—	114·2	0·583	245	—	2·194	—	—	—	—	—
,, 3	100·2	100·4	—	—	115·3	0·552	—	—	—	—	—	—	Inj. subc. 5 c.c. blood of DF 2494	—
,, 4	100·0	101·8	—	—	115·0	0·937	—	—	—	—	—	—	—	—
,, 5	100·0	101·4	—	—	111·8	0·520	—	—	—	—	—	—	—	—
,, 6	101·0	99·4	—	—	117·3	0·545	150	—	1·966	—	—	—	—	—
,, 7	99·4	101·2	—	—	—	—	—	—	—	—	—	—	—	—
,, 8	99·8	100·6	9,200,000	40	115·9	0·579	—	—	—	—	—	—	—	—
,, 9	100·0	101·2	—	40	115·8	0·577	—	—	—	—	—	—	—	—
,, 10	99·4	101·2	9,500,000	40	113·2	0·553	—	—	—	—	—	—	—	—
,, 11	100·8	100·2	—	36	113·7	0·780	—	—	—	229	Clear	1·678	—	—
,, 12	100·2	102·6	8,900,000	37	113·4	0·750	296	—	2·579	129	Greenish yellow brown	—	Mic. exam.: Negative	—
							298	Normal	—	—	—	—	—	—
,, 13	101·0	100·2	7,400,000	38	116·3	0·865	300	—	2·349	—	—	—	*Piropl. equi* rare	—
,, 14	100·0	102·2	—	—	113·6	0·757	—	—	—	268	Normal	2·713	,, ,, ,,	—
								Brown	2·789	—	—	—	,, ,, present	44
,, 15	98·8	104·0	8,900,000	36	110·1	0·526	235							
							221	Yellow, cloudy	—	—	—	—	Mucosa orange	—
,, 16	101·0	102·6	6,400,000	30	111·0	0·505	136	Red brown, clear	2·647	87	Clear	1·096	*Piropl. equi* present	46
,, 17	103·0	103·6	6,400,000	31	114·5		251	,,	—	224	Red brown, clear	2·715	,, ,, rare	62

,, 18	100·8	100·0	6,500,000	26	113·2	0·518	261	Brown, clear	2·971	143	Brown, clear	2·207	,, ,, ,,	44
,, 19	100·0	102·0	5,000,000	24	113·0		250	Light brown	2·374	—	—	—	,, ,, ,,	44
							287	Red brown	—	—	—	—	—	—
,, 20	100·0	100·2	5,900,000	26	110·9	0·548	185	Normal	—	103	Red brown	0·937	,, ,, ,,	40
,, 21	100·0	100·0	—	—	116·2	0·578	297	Red brown	2·387	40	Light yellow, clear	—	Conjunctiva pale	—
							47	Yellow, clear	—	—	—	—	—	—
							27	,,	—	—	—	—	—	—
,, 22	100·6	103·4	5,600,000	23	112·5	0·525	275	Dark yellow	2·136	151	Dark yellow	—	Mic. exam.: Negative	48
,, 23	100·8	100·4	6,700,000	29	113·3	0·552	290	,,	2·623	180	Dark yellow, clear	—	,, ,,	44
,, 24	100·0	101·0	—	28	118·9	0·603	354	,,	2·449	430	Normal	—	*Piropl. equi* rare	44
							318	Normal	—	—	—	—	—	—
,, 25	100·2	102·0	4,800,000	21	111·6	0·531	130	Dark yellow, clear	2·192	181	Clear	—	,, ,, very rare	—
,, 26	100·0	101·0	—	20	111·5	0·511	210	,,	2·321	134	Normal	—	Mic. exam.: Negative	—
,, 27	99·8	99·6	5,200,000	23	113·5	0·536	258	,,	2·254	143	,,	—	,, ,,	—
,, 28	99·2	101·2	—	—	116·4	0·569	301	—	2·158	—	—	—	—	—
,, 29	99·2	101·0	—	28	113·4	0·676	—	—	—	—	—	—	Mic. exam.: Negative	—
,, 30	99·6	101·0	7,500,000	29	117·8	0·542	375	Normal	2·512	419	Normal, thick	—	—	—
,, 31	100·0	100·2	—	—	113·0	0·928	—	—	—	310	Dark yellow	2·382	—	—
Aug. 1	100·2	100·4	5,400,000	27	116·0	0·537	—	—	—	300	,,	2·408	—	—
,, 2	100·2	100·4	—	31	114·7	0·747	203	Normal	1·286	178	Normal	—	—	—
,, 3	100·0	100·4	6,000,000	28	114·8	0·541	297	,,	2·536	—	—	—	—	—
,, 4	—	—	—	—	115·0	0·538	—	—	—	—	—	—	—	—

The temperature reaction starts the ninth day, shows a first fever period of about six days, and after an interval of four days, a second period of two days. A slight elevation on the twenty-second day might perhaps be a third reaction.

Piroplasms are observed from the tenth to the eighteenth day, and a second time the twenty-first and twenty-second days, that is to say, in the periods of the greatest destruction of erythrocytes. The parasites are apparently not present the nineteenth and twentieth days and, therefore, the number of erythrocytes increases.

The destruction of blood corpuscles sets in about four days after the first rise of temperature and is most intensive from the twelfth to the sixteenth day; then a slight re-creation takes place, followed by a second breaking down from the twenty-first to twenty-third day. There is even a third minimum, the twenty-ninth day.

The loss of blood cells in this case is more considerable than in 2840.

The conductivity of serum, the normal average of which is 114 ·7, i.e. the same as in horse 2840, varies during the attack about 7 ·7 per cent., and the lowest value on the twelfth day lies only 4 per cent. below the normal average.

Compared with the degree of haemolysis, the alterations of the conductivity are small. There is a precipitation on the second day, this time corresponding with an absolute decrease of the osmotic concentration (if we take the drepression of freezing point into consideration).

A slight decrease of the conductivity on the seventh, eighth, and ninth days has to be attributed to an increase of non-electrolytes (see depression of freezing point). Then follows an absolute diminution of ions (twelfth and thirteenth days) at the beginning of the blood destruction, and the minimum of conductivity coincides with the maximum of temperature elevation. With the re-increase of the number of erythrocytes (nineteenth and twentieth days) also the ion concentration of the serum becomes greater, and reaches a remarkably high value the twenty-first day.

The subsequent onset of haemolysis is again accompanied by a decrease of conductivity. A similar phenomenon can be observed in horses 2840 and 2847.

The depression of freezing point of serum after the already-mentioned jump (*vide* horse 2840) the first day, indicates a considerable increase of the osmotic pressure from the eighth to the eleventh day, that is to say, an alteration which comes in before noteworthy destructions of blood corpuscles and before the temperature rose. That this increase of the osmotic concentration is chiefly due to electrolytes is proved by the parallelism of the curves of conductivity and depression of freezing point. The subnormal value of the depression on the following days is synchronical with, and the consequence of the enormous haemolysis taking place during this time.

From the seventeenth to the twenty-fifth day there are many parallelisms between the conductivity and the crycoscopical results of serum and urine, which demonstrate the predominance of the electrolytes on the osmotic pressure of serum and prove again the regulative function of the kidneys with regard to the stability of the osmotic concentration of serum.

The conductivity of the urine which is before injection 292 × 10^{-4}, varies during the disease between 27 and 430 × 10^{-4}, or 138 per cent.; like in horse 2840, the greatest alterations occur during the second half of the disease when there are especially two high values, the twenty-first and twenty-seventh days (both immediately before a sudden destruction of erythrocytes, or better, coinciding with a period of restitution of blood cells).

The depression of the freezing point of the urine amounts before the injection to — 2·2° and varies during the attack of the disease between — 0·94° and — 2·97°. The alterations correspond only in the first phase of the disease almost with those of the conductivity; afterwards the value of the depression of freezing point remains rather constant, thus showing how the concentrations of non-electrolytes (urea ?) can vary and accomplish each other at the same time to a certain stabile osmotic pressure.

Horse 2847.

Date.	Temperature. F.		Red Blood Corpuscles.		Serum.		Morning Urine.			Afternoon Urine.			Results of Microscopical Examinations.	Pulse.
	Morning.	Evening.	Number.	Volume.	Conductivity at 25×10^{-4}	Depression of Freezing Point.	Conductivity at 25×10^{-4}	Colour.	Depression of Freezing Point.	Conductivity at 25×10^{-4}	Colour.	Depression of Freezing Point.		
1907.				%										
June 27	—	—	—	—	111·0	0·570	—	—	—	—	—	—	—	—
„ 29	—	—	—	—	113·7	0·539	—	—	—	—	—	—	—	—
July 1	99·4	100·6	—	—	113·2	0·570	351	—	2·509	—	—	—	—	—
„ 2	99·2	101·6	—	—	113·0	0·590	—	—	—	—	—	—	—	—
„ 3	99·4	99·4	—	—	115·8	0·577	362	—	2·598	—	—	—	Inj. subc. 5 c.c. blood of HF 2707	—
„ 4	99·8	101·6	—	—	113·3	0·520	—	—	—	—	—	—	—	—
„ 5	99·2	100·0	—	—	109·1	0·630	277	—	2·477	—	—	—	—	—
„ 6	99·8	100·6	—	—	116·5	0·602	—	—	—	—	—	—	—	—
„ 7	100·0	100·2	—	—	—	—	368	Clear	2·352	—	—	—	—	—
„ 8	99·6	100·6	—	42	115·0	0·629	376	Cloudy	2·795	324	Normal	2·942	—	—
„ 9	99·8	102·6	8,400,000	43	113·7	0·732	343	—	2·807	—	—	—	—	—
„ 10	100·2	102·8	8,800,000	42	114·1	—	330	Clear	2·402	—	—	—	—	—
							319	—	—	—	—	—	—	—
„ 11	100·0	101·2	9,300,000	42	108·0	0·524	372	—	2·752	100	—	—	*Piropl. equi* rare	—
„ 12	101·2	102·6	7,800,000	36	109·4	0·523	254	—	2·563	117	—	—	„ „ „	—
„ 13	100·0	102·6	9,500,000	33	—	0·579	—	—	—	243	Normal	1·983	„ „ „	—
„ 14	102·2	103·0	5,500,000	37	113·1	0·738	—	—	—	—	—	—	„ „ „	—
„ 15	99·6	103·4	5,800,000	35	106·9	1·312	119	Light yellow, cloudy	1·461	68	Clear	1·014	„ „ „	54
							112	Light brown	—	—	—	—	—	—
„ 16	100·4	102·6	5,800,000	33	109·7		40	Light yellow	1·762	—	—	—	*Piropl. equi* rare	48
„ 17	101·8	102·6	6,800,000	34	111·6	0.530	—	—	—	—	—	—	„ „ „	46
„ 18	100·0	103·0	6,400,000	34	109·4		—	—	—	287	Clear	—	„ „ „	50
„ 19	101·0	101·0	5,800,000	31	108·4	0·560	235	Normal	2·767	282	Normal	1·786	Mic. exam. : Negative	48
							113	Brown, clear	—	—	—	—	—	—
„ 20	101·0	102·0	5,600,000	32	110·2	0·575	12	Clear	1·817	64	Dark yellow, clear	—	Mic. exam. : Negative	42

„	21	100·8	102·0	—	—	113·4	0·534	—	—	—	165	„ thick	2·225	„ „	—
								305	Normal	—	14	Clear	—	—	—
„	22	100·6	101·8	6,000,000	35	111·0	0·529	79	Yellow, cloudy	0·548	126	Dark yellow	—	Mic. exam. : Negative	38
„	23	100·0	101·2	—	36	111·3	0·571	230	Normal	1·881	270	Normal	—	„ „	40
„	24	99·2	101·2	6,400,000	32	113·4	0·607	361	Normal	2·531	56	Clear	—	„ „	46
								224	„	—	—	—	—	—	—
„	25	99·6	101·0	—	30	110·7	0·572	228	„	1·550	241	Normal	—	*Piropl. equi* very rare	38
								204	Brown	—	—	—	—	—	—
„	26	101·2	100·2	7,000,000	33	111·2	0·556	70	Light yellow, clear	2·375	156	Dark yellow, clear	—	Mic. exam. : Negative	—
								297	Dark yellow	—	—	—	—	—	—
								27	Clear	—	—	—	—	—	—
„	27	99·8	101·4	—	33	111·8	0·543	75	Normal	2·318	211	Normal	—	Mic. exam. : Negative	—
„	28	99·4	101·4	—	—	114·8	0·588	286	Normal	2·467	—	—	—	„ „	—
„	29	99·8	101·2	7,500,000	36	112·4	0·563	300	„	2·648	—	—	—	—	—
„	30	100·4	101·6	—	—	—	0·526	195	„	1·325	331	Dark yellow	—	Mic. exam. : Negative	—
„	31	100·2	100·6	7,300,000	38	111·6	0·551	128	Clear	—	178	Normal	0·743	—	—
Aug.	1	101·0	101·4	—	—	113·1	0·568	293	Brown yellow	2·266	273	„	—	—	—
„	2	100·0	101·4	6,600,000	35	113·0	0·525	386	Normal	2·337	—	—	—	Mic. exam. : Negative	—
„	3	100·0	101·8	—	—	112·2	0·577	237	„	2·525	—	—	—	—	—
„	4	—	—	—	—	112·6	0·512	—	—	—	—	—	—	—	—

This horse (and 2848) is injected with virus from a horse foal; the *fever* begins already the sixth day. The temperature reaction lasts without interval fifteen days; it is not very pronounced, and the fever not high.

The appearance of *piroplasms*, however, is periodical; first they are seen from the eighth to the fifteenth, and secondly on the twenty-second day; hence the parasites are earlier present in the blood than in the former horses, accordingly the *destruction of erythrocytes* emphasises itself rapidly, and the first minimum of volume occurs on the tenth day. Three other minima fall on the sixteenth, twenty-second, and thirtieth day respectively.

The loss of blood corpuscles is less than in horse 2841, though there were four periods of destruction.

The conductivity of serum varies during the disease between 106 ·8 and 116 ·5 $\times$ 10^{-4} = 8 ·5 per cent. (normal 113 ·3), and the minimum lies 5 ·7 per cent. below the normal average. The conductivity falls considerably from the seventh to eighth day, then it exacerbates three times within twenty-four hours and rises again within two or three days to a somewhat higher value until it reaches, in steps, the normal.

Similarly to horse 2841, the conductivity "recovers" later, while the haemolysis continues, but still each decrease of the number of blood corpuscles causes a "relapse" of conductivity.

The depression of freezing point indicates the date of injection with a slight decrease, immediately followed by a slight increase. The beginning of the temperature reaction is marked by a rather high osmotic pressure of the serum of about ten atmospheres; the decrease both of conductivity and the number of erythrocytes is accompanied by a subnormal osmotic pressure—about seven atmospheres—after which the latter rises within three days to the enormous height of eighteen atmospheres. As this maximum almost coincides with the minimum of conductivity, it is due to accumulation of non-electrolytes in the blood.

The conductivity of the urine amounts normally to about 356 $\times$ 10^{-4}, and oscillates during the sickness from 12 to 386. It alters in the same sense with the depression of freezing point of urine. A remarkable decrease takes place on the eighth day, i.e. as soon as the haemolysis sets in.

The depression of freezing point of urine, chiefly caused by ions, shows a very low value of osmotic pressure on the twelfth day, when the osmotic pressure of serum is very high, while its ion concentration is low; that means very little electrolytes are put out with the urine and also very little non-electrolytes, though the concentration of the latter in the serum is supernormal.

Altogether the osmotic pressure shows—besides the already mentioned—two other periods of decrease which reach their minima the nineteenth and twenty-eighth day respectively.

Horse 2848.

Date.	Temperature.		Red Blood Corpuscles.		Serum.		Morning Urine.			Afternoon Urine.			Results of Microscopical Examinations.	Pulse.
	Morning.	Evening.	Number.	Volume.	Conductivity at 25×10^{-4}.	Depression of Freezing Point.	Conductivity at 25×10^{-4}.	Colour.	Depression of Freezing Point.	Conductivity at 25×10^{-4}.	Colour.	Depression of Freezing Point.		
				%										
June 27	—	—	—	—	119·2	0·590	—	—	—	—	—	—	—	—
„ 29	—	—	—	—	116·8	—	317	—	2·469	—	—	—	—	—
July 1	99·4	99·8	—	—	117·8	0·557	240	—	2·478	—	—	2·360	—	—
„ 2	99·4	99·6	—	—	116·0	0·548	243	—	2·118	—	—	—	—	—
„ 3	100·0	99·0	—	—	—	—	292	—	2·310	—	—	—	Inj. subc. 3 c.c. blood of HF 2786	—
„ 4	100·0	100·4	—	—	117·5	0·549	241	—	2·197	—	—	—	—	—
„ 5	99·6	100·4	—	—	115·8	0·572	—	—	—	—	—	—	—	—
„ 6	99·8	100·4	—	—	118·8	0·574	279	—	2·572	270	—	2·572	—	—
„ 7	100·8	99·0	—	—	—	—	—	—	—	—	—	—	—	—
„ 8	98·6	100·4	8,700,000	36	118·7	0·654	—	—	—	—	—	—	—	—
„ 9	100·0	101·6	—	33	118·4	0·734	—	—	—	—	—	—	—	—
„ 10	100·2	103·0	9,400,000	35	114·0	0·792	—	—	—	271	—	2·144	—	—
„ 11	103·8	102·2	8,700,000	33	112·5	0·729	—	—	—	280	—	2·116	—	—
„ 12	101·8	103·0	8,200,000	32	112·7	0·550	277	Cloudy	2·301	154	—	—	Mic. exam. : Negative	—
„ 13	102·0	104·8	6,700,000	31	114·4	1·307	218	Clear	1·715	—	—	—	*Piropl. equi* rare	—
„ 14	104·6	105·6	8,300,000	32	114·0	0·600	224	„	1·991	203	Dark yellow, clear	1·585	„ „ present	58
„ 15	103·0	102·0	6,600,000	30	110·0	0·533	—	—	—	85	Brown, clear	1·479	„ „ fairly frequent	56
„ 16	101·0	103·6	5,300,000	24	110·0	0·503	—	—	—	90	Red brown, clear	1·794	*Piropl. equi* present	58
„ 17	103·6	102·6	4,000,000	19	115·8	0·561	194	Red brown, clear	2·562	169	Normal	—	„ „ rare	66
							309	Normal	—	—	—	—	Conjunctiva orange	—
„ 18	100·4	101·0	6,000,000	24	112·6	0·626	161	Brown, clear	1·997	—	—	—	*Piropl. equi* rare	46
„ 19	100·0	102·0	6,800,000	31	113·1	0·517	—	—	—	99	Brownish	2·037	„ „ „	44
„ 20	101·0	104·8	5,800,000	24	110·8	0·499	170	Brownish	2·434	—	—	—	„ „ „	48

HORSE 2848—(*continued*).

Date.	TEMPERATURE.		RED BLOOD CORPUSCLES.		SERUM.		MORNING URINE.			AFTERNOON URINE.			RESULTS OF MICROSCOPICAL EXAMINATIONS.	Pulse.
	Morning.	Evening.	Number.	Volume.	Conductivity at 77×10^{-4}	Depression of Freezing Point.	Conductivity at 77×10^{-4}	Colour.	Depression of Freezing Point.	Conductivity at 77×10^{-4}	Colour.	Depression of Freezing Point.		
				%										
July 21	105·0	103·6	—	—	112·2	0·522	—	—	—	132	Red brown	1·632	*Piropl. equi* rare Poikyl.	48
										157	Clear	—	Conjunctiva yellow	—
„ 22	103·4	103·0	3,500,000	17	110·9	0·581	143	Dark brown	—	179	Brown, clear	0·527	Poikylocytosis	58
„ 23	101·0	103·8	5,700,000	20	110·3	0·530	44	Dark yellow, clear	0·591	41	„	—	„	48
„ 24	101·2	102·0	—	19	114·1	0·563	—	—	—	162	Red brown	2·003	„	46
„ 25	99·4	101·2	4,800,000	20	112·8	0·600	164	Red brown, clear	1·536	94	Dark yellow, clear	—	„	40
							136	Red brown	—	—	—	—	—	—
„ 26	99·6	100·6	—	20	112·8	0·516	74	Clear	1·315	—	—	—	Poikylocytosis	—
„ 27	99·8	100·2	4,300,000	18	112·5	0·560	—	—	—	105	Brown	1·112	Mic. exam.: Negative	—
„ 28	99·0	100·0	—	—	114·2	0·608	215	Brownish, clear	2·026	—	—	—	—	—
„ 29	99·0	100·0	—	21	113·6	0·584	—	—	—	—	—	—	Mic. exam.: Negative	—
„ 30	99·6	100·6	5,500,000	25	116·5	0·542	—	—	—	252	Red brown	2·273	—	—
„ 31	100·0	100·4	—	—	115·4	0·541	338	Normal, thick	2·187	—	—	—	—	—
Aug. 1	100·0	100·6	5,400,000	23	115·1	0·527	—	—	—	270	Cloudy	2·394	—	—
„ 2	99·4	101·2	—	20	116·0	0·600	—	—	—	—	—	—	Mic. exam.: Negative	—
„ 3	99·8	100·0	6,500,000	23	115·5	0·537	—	—	—	332	Dark yellow	2·264	—	—
„ 4	—	—	—	—	115·2	0·526	—	—	—	—	—	—	—	—

The temperature reaction sets in on the sixth day, and shows two distinct periods of very high fever without an interval of normal temperature.

The parasites are observed from the tenth to the eighteenth day, i.e. only during the first half of the sickness, not in the second part, where there is a very high fever. Therefore the intensity of fever seems not always to be proportional to a great number of piroplasms, but they are frequent in the first part of the sickness and subsequently the *erythrocytes* suffer greatly. Their destruction begins two days after the temperature rises. It is first very slight, but then most intensive from the twelfth to the fourteenth day. A considerable reincrease of their number follows, in spite of the fact that parasites are still present. Three other periods of breaking down occur with intervals of four to five days respectively.

The recovery of the blood corpuscles is very slow and their number is, at the end of the examination time, still far from being normal.

The conductivity of serum, the average of which before the injection is 117×10^{-4}, reaches its minimum in two steps, on the seventh and twelfth day. After that the conductivity makes three attempts to get normal, but recedes each time.

The osmotic pressure of the serum begins to increase the fifth day, returns to normal, and then makes an enormous jump before the haemolysis is remarkable, and—as in horses 2840 and 2841—before conductivity has arrived at the lowest value. As the depression of freezing point shows, the osmotic pressure then oscillates periodically between $-0{\cdot}5$ and $-0{\cdot}6$.

Conductivity and osmotic pressure of urine both decrease more in the second part of the attack, both going up and down parallel with one another and the conductivity specially with the conductivity of serum, the reason of which phenomena I have already explained. The alterations of the ion concentration take place more continually and not so abruptly as in other cases.

The physical-chemical examinations on the following two horses 2961 and 2975 are made on a larger scale.

The investigations embraced :

(1) Temperature of the body.
(2) Results of microscopical and clinical examinations.
(3) Volume of erythrocytes.
(4) Conductivity of serum at 37°.
(5) Depression of freezing point of serum.
(6) Specific gravity of serum at 37°.
(7) Coefficient of thermical expansion of serum.
(8) Capillary attraction of serum in blotting paper.
(9) Quantity of serum globulines.
(10) Quantity of negative serum albumines.
(11) Quantity of daily urine.
(12) Conductivity of urine at 37°.
(13) Depression of freezing point of urine.
(14) Specific gravity of urine at 37°.
(15) Capillary attraction of urine in blotting paper.
(16) Alkalinity of urine.
(17) Quantity of water drunk daily by the animal.

After it was known that conductivity and osmotic pressure, i.e. the electrolyte and non-electrolyte concentration in serum and urine change during piroplasmosis, we expected also alterations of the specific gravity, because this is also, among other factors, dependent on the salts, and as the latter influence the surface tension, the capillary attraction should show variations as well.

The method of measuring the capillarity was that of *Goppelsroeder*, namely, stripes of blotting paper are immersed in serum or urine always to a constant depth ; the height from the level of the liquid to the upper margin of the wetted paper gives the indication of the capillarity.

This method gives not very accurate results, because the experiments were not made at constant temperatures.

The specific gravity of serum was measured twice at 25° and 37° respectively and (Pycnometer method) it was possible to calculate the *coefficient of thermic expansion* with the formula given by Kolhrausch*—

$$E = 3b \frac{p}{p^1} + \frac{1}{t^1 - t} \times \frac{p - p^1}{p^1}$$

[t—lower ; t^1—higher temperature ; p—the weight of the liquid at t ; p^1—weight of the previously at t^1 heated (pycnometer full), and then at t cooled (and contracted) liquid ; $3b$—cubic expansion coefficient of glass.]

As the expansion coefficient of water and watery solutions increases with the pressure whereunder the liquid is† and as surface pressure and internal pressure (*Tammann*) and probably imbibition pressure have principally the same effect as internal pressure, I thought that there could be some relation between coefficient of expansion and capillarity. Experience did not prove this expectation. The coefficient of expansion rather seems to go parallel with the specific gravity and adversely proportionate to the conductivity, but it shows alterations on the days of the climax.

There cannot be any doubt that the serum colloids undergo certain structural or quantitative alterations during any disease, especially in form of antibodies and their combinations with the respective antigenes.

In order to obtain the *serum globulines*, 10 c.c. of serum were dialysed against 500 c.c. of distilled water during forty-eight hours at a temperature of 1–5°. By this process the globulines precipitated ; they were separated by centrefugalisation, dried and weighed.

The quantity of negative *serum albumines* was indicated by the quantity of (positive) colloidal ferri-hydroxyd [Fe $(OH)_3$] which was necessary to produce in 2 c.c. of the (clear) residual dialysator-liquid a maximal precipitation.

The number of drops necessary for that is contained in the first column, while the second column gives the number of drops (always the same pipette used) wanted for the complete redissolution of the precipitate.

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* Lehrbuch & Prakt. Physik, 10th ed. 177, 1905.

† *Chwolson*, Lehrbuch der Physik, I.

Date.	Temperature.		Serum.						Negative Serum Albumines. Number of Drops of Fe (OH), which completely		Serum Capillarity.	Urine Capillarity.	Daily Drinking Water. (Litres).		
	Morning.	Evening.	Volume of Red Blood Corpuscles.	Depression of Freezing Point.	Conductivity $\times 10^4$	Specific Gravity at 98·6.	Coefficient Thermal Expansion.	Globulines, mgr. pro. 10 c.c. Serum.	Precipitates.	Redissolves.			10 a.m.	5 p.m.	Total.
1907.			%								mm.	mm.			
Aug. 7	—	100·6	—	0·558	140·0	—	—	—	—	—	—	—	—	—	—
„ 8	100·4	101·4	—	0·551	141·7	—	—	—	—	—	61	84	—	—	—
„ 9	98·6	100·2	—	0·564	144·9	—	—	—	—	—	47	96	—	—	—
„ 10	99·8	101·2	—	0·606	143·6	—	—	—	—	—	61	81	—	—	—
„ 11	100·6	100·2	—	0·642	141·9	—	—	—	—	—	52	67	—	—	—
„ 12	99·8	100·6	—	0·631	143·5	1·0317	0·00029	—	—	—	44	75	—	—	—
„ 13	100·2	101·8	—	0·639	146·5	1·0322	0·00030	—	—	—	51	114	—	—	—
„ 14	101·0	101·0	—	0·534	138·9	1·0305	0·00031	12	—	—	50	65	—	—	—
„ 15	99·8	101·6	—	0·554	137·7	1·0293	0·00030	—	—	—	54	65	—	—	—
„ 16	100·0	101·0	—	0·559	143·2	1·0306	0·00026	12·5	—	—	45	67	20	1·5	21·5
„ 17	100·0	101·0	—	0·546	137·7	1·0311	0·00030	10·5	—	—	51	74	3·5	0	3·5
„ 18	99·8	101·4	—	0·558	139·3	1·0313	0·00030	—	2	4	51	60	16	3·5	19·5
„ 19	101·2	101·0	—	0·555	139·9	1·0299	0·00030	10	2	4	51	68	13·5	2	15·5
„ 20	99·6	101·4	—	0·546	139·5	1·0305	0·00030	14	2	3	50	62	12	1	13
„ 21	101·0	102·4	28	0·537	137·9	1·0311	0·00030	17	1	3	46	73	12·5	1	13·5
„ 22	103·0	104·0	26	0·561	140·3	1·0308	0·00030	17	1	2	46	82	18·5	1·5	20
„ 23	101·4	103·0	27	0·581	134·8	1·0320	0·00030	13	3	4	54	70	6	11·5	17·5
„ 24	103·0	105·6	25	0·510	136·0	1·0311	0·00029	11	2	4	66	60	18·5	6	24·5
„ 25	103·0	103·8	20	0·527	132·1	1·0309	0·00030	3·5	3	4	52	—	21·5	3	24·5
„ 26	102·2	102·6	18	0·527	128·8	1·0315	0·00031	18	2	3	52	56	17·5	5	22·5
„ 27	100·6	102·4	19	0·540	128·5	1·0312	0·00031	25	2	3	43	51	18	2	20
„ 28	100·0	101·8	23	0·550	135·6	1·0303	0·00030	22	2	3	43	88	20·5	4	24·5
„ 29	101·0	103·2	23	0·540	136·7	1·0296	0·00029	28	2	3	49	69	17	2·5	19·5
„ 30	102·8	101·2	25	0·556	138·7	1·0302	0·00028	29	2	3	58	98	22·5	1	23·5
„ 31	100·4	101·4	22	0·527	137·9	1·0288	—	9·5	1	2	61	114	21·5	4	25·5
Sept. 1	99·6	100·0	24	0·548	140·4	1·0280	0·00030	11	2	4	62	111	14·5	1	15·5
„ 2	99·6	100·8	25	0·550	139·6	1·0288	0·00030	8·5	3	5	62	183	5	13·5	18·5
„ 3	99·8	101·2	25	0·547	139·0	1·0294	0·00030	42	1	3	63	158	9·5	6·5	16
„ 4	100·0	103·0	23	0·548	139·1	1·0299	0·00030	14·5	2	3	55	103	11·5	4	15·5
„ 5	102·2	105·4	21	0·535	136·4	1·0298	0·00030	74·5	1	2	51	101	13	3·5	16·5
„ 6	104·4	106·2	21	0·529	136·7	1·0283	0·00032	27	2	4	63	113	12	6·5	18·5
„ 7	105·6	106·4	25	0·538	136·4	1·0281	0·00031	17·5	2	3	65	67	13·5	4·5	18·0
„ 8	104·6	—	45	0·528	138·9	1·0244	0·00031	28·5	2	4	—	—	0	—	—

HORSE 2961—(*continued*).

Date.	Urine. Daily Quantity.	Depression of Freezing Point.	Conductivity × 10⁴.	Specific Gravity.	Alkalinity.	Urine Colour.	Results of Microscopical Examinations.	Pulse.	Clinical Observations.
1907.									
Aug. 7	—	—	—	—	—	—	—	—	—
„ 8	—	2·231	327	1·031	—	Normal	—	—	—
„ 9	—	2·625	350	1·037	—	„ thick	—	—	—
„ 10	—	2·680	342	1·040	—	„ „	—	—	—
„ 11	—	2·716	243	1·038	—	„ „	—	—	—
„ 12	—	2·747	307	1·038	—	„ „	—	—	—
„ 13	—	2·306	242	1·030	—	„ „	—	—	—
„ 14	—	2·615	261	1·035	—	„ „	—	—	—
„ 15	—	2·536	233	1·031	—	„ „	—	—	Inj. subc. 3 c.c. def. blood of HF 2786.
„ 16	—	1·139	219	1·011	—	Clear	—	—	—
„ 17	10·6	1·088	178	1·011	—	Normal	—	—	—
„ 18	4·0	1·300	208	1·017	—	Muddy	—	—	—
„ 19	7·8	1·583	315	1·022	1·8	Normal	—	—	—
„ 20	5·4	1·519	297	1·020	1·5	„	—	—	—
„ 21	4·1	1·434	265	1·019	1·8	„	Mic. exam.: Negative ..	—	—
„ 22	3·9	1·255	217	1·015	1·6	„	„ „ ..	—	—
„ 23	9·3	1·520	255	1·019	1·8	Dark yellow	„ „ ..	46	—
„ 24	16·5	0·996	—	—	—	„	*Piropl. equi* rare	42	—
„ 25	15·0	0·904	174	1·009	0·9	Normal	„ „ „	70	Conj. yellow,
„ 26	18·1	0·745	108	1·006	0·4	Clear	„ „ very rare ..	70	„ „
„ 27	12·4	0·785	82	1·006	1·0	Normal	Mic. exam.: Negative ..	50	„ „ Gmelin reac. negative.
„ 28	9·1	0·945	150	1·011	1·5	„	*Piropl. equi* rare	40	„ „ „ „ „
„ 29	15·5	0·811	165	1·007	1·7	„	„ „ „	48	Gmelin reaction negative
„ 30	10·0	1·178	250	1·012	3·1	„	„ „ „	58	—
„ 31	5·8	1·274	—	1·015	3·6	„	Mic. exam.: Negative ..	58	—
Sept. 1	6·5	1·168	300	1·013	4·3	„	„ „ „	44	Normal.
„ 2	5·4	1·385	325	—	2·3	„	—	42	—
„ 3	5·7	1·458	416	1·017	3·6	„	—	—	—
„ 4	2·4	1·944	457	1·023	3·1	Dark yellow	—	—	—
„ 5	9·5	1·638	393	1·021	3·2	Normal	Mic. exam.: Negative ..	64	—
„ 6	7·1	1·348	353	1·013	4·7	„	*Piropl. equi* rare	90	—
„ 7	—	1·376	360	1·011	5·4	„	„ „ „	72	Dikkop.
„ 8	—	—	—	—	—	—	„ „ „	—	Died of horse-sickness.

The temperature rises the fifth day and shows two elevations, the first of which is the higher one. Two days after the end of the piroplasmosis the fever again sets in on account of accidental horse-sickness infection, of which the horse dies on 8th September, 1907. Like in other cases, the *parasites* are visible periodically and appear again in the horse-sickness. A phenomenon which can be observed sometimes is the breaking down of piroplasmosis immunity by an attack of horse-sickness, whereafter the animal dies of the super-position of both diseases.

The destruction of erythrocytes takes place principally in the same manner as in the foregoing horses. Clinical symptoms of *icterus* coincide with the minimal volume of the red blood cells and partially with their re-increase in number.

The osmotic concentration of serum does not increase, but rather shows only a subnormal value at the time when it has to be expected supernormal. It decreases a second time during the horse-sickness, but it is not possible to distinguish which of the diseases is the cause of this phenomenon.

The conductivity, adversely to previous cases, shows a considerable increase the first day ; then, as a rule, it goes up and down with the osmotic concentration, thus proving that the latter is chiefly due to ions, but the minimum of depression of freezing point is earlier than that of conductivity ; that means at the end of the intensive destruction of globules there is a slight increase of non-electrolytes.

Comparing the *specific gravity*, which—perhaps after previous decrease—has a slight tendency to increase, with the synchronic decrease of conductivity and number of erythrocytes and with the osmotic concentration, we must admit that the dead globules leave colloidal residues in the blood liquid whereby the resistance for the electric current, or better, for the migration of ions, is increased and an absorption of ions on these colloids takes place. Subsequently conductivity and osmotic pressure must be subnormal, while the specific gravity can increase. This idea finds a still better confirmation by the enormous divergency of the curves of conductivity and specific gravity after having passed their minimum and maximum respectively, and further, by the parallelism of the conductivity with the number of corpuscles and the depression of freezing point. The pathological colloids disappear, the serum recovers and regains the normal quantity of ions, and the blood receives a fresh supply of erythrocytes from the hematopoetic organs.

The coefficient of expansion first shows a declination the day after injection, it increases then at the same time when conductivity decreases, reaches its maximum when the conductivity is minimal, returns to the normal like the latter, and increases again at the horse-sickness attack.

The height of capillary attraction undergoes no great alterations. There is a high value on the ninth day coinciding with the minimum of depression of freezing point and the highest fever ; afterwards the capillarity becomes subnormal, increases again, and a final declination indicates the new attack. While the alterations of the capillarity have almost the same sense as those of the conductivity, the quantitative behaviour of the globulines is just reversed. This is absolutely in accordance with the experience of physical-chemistry, namely, that hydrophile colloids have the tendency to condense in surfaces and thus decrease the surface tension. At the same time we see that the colloids I mentioned above, which originate from the red globules and cause the decrease of the ion concentration and conductivity, must be to a great deal globulines.

The considerable loss of blood corpuscles—the residues of which are at least partially eliminated by liver, kidney, and spleen—involves an increase of the quantity of blood liquid in order to keep the blood pressure constant. This is—besides others (fever)—a reason for the increase of the quantity of water taken daily by the animal. This quantity increases from the second day, not continually, but with interruptions. At the same time a slight increase of the specific gravity of serum takes place, also with interruptions; that is to say, the dilutive tendency of the increased amount of liquid taken by the animal is not able to paralyse the factors which make the specific gravity higher, but on some exceptional days the latter factors are overcome by the former one, and the result is an ephemeral dilution of the serum.

But a dilution of the serum with regard to the osmotic concentration takes place all the same, as the depression of the freezing point proves. The increase of the specific gravity must be, as I said, put down to colloids.

Polyuria is a well-known symptom of piroplasmosis. In this experiment the daily quantity of urine increases roughly with the increase of the quantity of drinking water. Naturally the quantity of drinking water is always greater than the quantity of urine, but the proportions are very variable, even 15 : 1 has been observed. Therefore it is possible that the greatest quantity of body liquid is not put out with the urine. The main organs which come into consideration for the excretion of water are: (1) kidneys; (2) lungs; (3) skin; (4) intestines. A small amount is lost as secretion of the lacrimal and salivary glands (and in special cases, considerable quantities of liquid leave the body in form of milk and uterine liquids).

The greater the quantity of urine, the more diluted it is, as can be seen by the comparison of its specific gravity, conductivity, and osmotic concentration with the total quantity. The conductivity decreases much more than the osmotic pressure; that means there is specially a loss of ions more than of non-electrolytes.

It is interesting to see that at the end of the disease the conductivity is higher than normal; the depression of freezing point, however, is still subnormal. The ions are quicker regenerated than the non-electrolytes.

The capillarity of the urine goes down very slightly with the decrease of the specific gravity and then increases to supernormal height. The method permits of saying that the surface tension of urine is greater and varies much more than that of serum.

The alkalinity or the concentration of OH ions seems to decrease like that of other ions.

Horse 2961 died two hours after the blood was taken—8th September, 1907. The following are the *symptoms before death*:—The volume of blood corpuscles is enormously increased, the relative quantity of blood liquid is therefore diminished. The specific gravity of serum is very low and the conductivity slightly increased; the serum is watery, and has lost a great deal of its colloidal components.

Horse 2975.

Date.	Temperature. F.		Volume of Red Blood Corpuscles.	Serum.				
	Morning.	Evening.		Depression of Freezing Point.	Conductivity $\times 10^{-4}$	Specific Gravity.	Coefficient Thermal Expansion.	Globulines.
			%					
Aug. 7	—	100·2	—	0·555	150·2	—	—	—
„ 8	99·4	100·0	—	0·557	150·0	—	—	—
„ 9	98·8	100·6	—	0·545	150·3	—	—	—
„ 10	99·0	100·4	—	0·627	150·7	—	—	—
„ 11	100·2	100·4	—	0·632	148·5	—	—	—
„ 12	100·2	100·6	—	0·611	149·8	—	—	—
„ 13	99·6	101·0	—	0·596	150·0	1·0253	0·00031	—
„ 14	100·0	100·6	—	0·646	147·6	1·0259	0·00029	22
„ 15	100·2	101·8	—	0·622	145·7	1·0256	0·00029	—
„ 16	101·0	101·0	—	0·543	149·8	1·0261	0·00029	—
„ 17	100·4	104·2	—	0·549	144·7	1·0258	0·00030	—
„ 18	101·8	101·0	—	0·547	143·7	1·0255	0·00029	7
„ 19	100·4	103·0	—	0·626	145·0	1·0257	0·00030	12
„ 20	99·8	101·8	32	0·715	144·5	1·0263	0·00031	—
„ 21	100·0	101·0	30	0·540	145·6	1·0257	0·00030	16·5
„ 22	100·4	103·8	28	0·575	148·7	1·0267	0·00031	12
„ 23	102·2	103·0	30	0·538	142·7	1·0268	0·00030	19·5
„ 24	100·6	103·6	29	0·508	141·7	1·0275	0·00031	11·5
„ 25	100·4	102·2	28	0·558	137·7	1·0275	0·00030	2
„ 26	103·0	104·4	31	0·546	135·0	—	—	18·5
„ 27	101·2	101·6	26	0·532	134·2	1·0283	0·00032	4·5
„ 28	100·4	102·0	25	0·532	140·7	1·0266	0·00030	10·5
„ 29	100·6	104·6	26	0·528	138·0	1·0267	0·00029	23
„ 30	101·8	101·6	24	0·524	140·7	1·0251	0·00029	35·5
„ 31	100·6	101·0	28	0·533	146·6	1·0264	0·00029	45·5
Sept. 1	98·8	100·4	27	0·541	144·7	1·0266	0·00029	7·5
„ 2	99·2	101·0	26	0·548	144·2	1·0260	0·00029	18
„ 3	99·6	100·6	25	0·566	146·0	1·0259	0·00029	17·5
„ 4	99·8	102·0	24	0·539	145·5	1·0258	0·00030	15·5
„ 5	100·2	103·6	23	0·538	145·3	1·0255	0·00031	19·5
„ 6	100·8	103·4	22	0·550	146·6	1·0254	—	15·5
„ 7	103·2	106·4	20	0·539	142·2	1·0256	0·00028	7·5
„ 8	104·6	106·4	27	0·547	141·2	1·0265	0·00031	20·5
„ 9	103·0	102·6	25	0·538	144·2	1·0253	0·00031	23·5
„ 10	101·0	103·6	23	0·541	143·1	1·0249	0·00030	23
„ 11	101·0	101·6	23	0·532	143·8	1·0249	0·00028	30·5
„ 12	100·6	101·4	26	0·565	145·1	1·0266	0·00031	24
„ 13	100·0	100·8	24	0·582	146·0	—	—	16·5
„ 14	100·6	100·6	24	0·562	145·7	1·0275	0·00031	38·5
„ 15	100·0	100·6	23	0·573	146·3	1·0266	0·00031	37
„ 16	99·6	100·2	23	0·558	146·0	1·0272	—	81·5
„ 17	99·0	106·4?	25	0·575	147·0	—	0·00031	29
„ 18	100·2	101·4	22	0·578	147·0	1·0265	0·00031	31
„ 19	99·8	100·6	22	0·553	—	1·0263	0·00030	24·5
„ 20	100·0	100·6	25	0·561	145·6	—	—	37
„ 21	99·6	100·4	—	0·583	—	—	—	—
„ 25	—	—	25	0·543	148·7	—	—	—

HORSE 2975—(*continued*).

Date.	Negative Serum Albumines. Number of Drops of $Fe(OH)_3$ which completely		Serum Capillarity.	Urine Capillarity.	Daily Drinking Water (Litres).		
	Precipitates.	Redissolves.			10 a.m.	5 p.m.	Total.
August 7 ..	—	—	—	—	—	—	—
„ 8 ..	—	—	—	—	—	—	—
„ 9 ..	—	—	73	71	—	—	—
„ 10 ..	—	—	67	82	—	—	—
„ 11 ..	—	—	59	55	—	—	—
„ 12 ..	—	—	66	73	—	—	—
„ 13 ..	—	—	66	67	—	—	—
„ 14 ..	—	—	67	120	—	—	—
„ 15 ..	—	—	56	56	—	—	—
„ 16 ..	—	—	54	80	13	5·5	18·5
„ 17 ..	—	—	73	61	4·5	0·5	5
„ 18 ..	2	4	63	60	2	2	4
„ 19 ..	2	3	58	86	10	3	13
„ 20 ..	1	2	63	79	7	4	11
„ 21 ..	2	3	51	79	4	4·5	8·5
„ 22 ..	3	4	55	120	15	4	19
„ 23 ..	2	3	68	113	5	4	9
„ 24 ..	2	4	69	77	4·5	2	6·5
„ 25 ..	3	5 ?	67	108	4·5	3	7·5
„ 26 ..	2	4	58	91	5	5	10
„ 27 ..	4	?	50	116	6	3	9
„ 28 ..	2	4	50	94	13·5	3	16·5
„ 29 ..	2	4	53	71	5·5	2·5	8
„ 30 ..	1	3	62	71	6·5	1	7·5
„ 31 ..	1	3	69	94	23	1	24
Sept. 1 ..	3	6 ?	61	115	10	0·5	10·5
„ 2 ..	2	4	67	149	4	6	10
„ 3 ..	2	3	67	151	10	7	17
„ 4 ..	2	3	59	141	5	5	10
„ 5 ..	2	4	54	88	6·5	4	10·5
„ 6 ..	2	3	73	94	12·5	3	15·5
„ 7 ..	3	5	74	111	3·5	3	6·5
„ 8 ..	2	3	55	80	6·5	2	8·5
„ 9 ..	1	3	61	75	7·5	12·5	20
„ 10 ..	2	4	78	90	11·5	9·5	21
„ 11 ..	1	3	63	92	12·5	10·5	23
„ 12 ..	2	4	61	91	13	5	18
„ 13 ..	3	4	62	108	17	3·5	20·5
„ 14 ..	1	3	75	106	10·5	3	13·5
„ 15 ..	2	4	60	110	—	—	—
„ 16 ..	2	4	67	141	5	7	12
„ 17 ..	2	3	55	152	6	1	7
„ 18 ..	2	3	81	160	11	7·5	18·5
„ 19 ..	2	3	—	174	2	5	7
„ 20 ..	2	4	89	170	4	3	7
„ 21 ..	—	—	—	—	—	—	—
„ 25 ..	—	—	—	—	—	—	—

HORSE 2975—(*continued*).

Date.	URINE.					
	Daily Quantity.	Depression of Freezing Point.	Conductivity at $\times 10^4$	Specific Gravity.	Alkalinity.	Coolur.
August 7	—	—	—	—	—	—
„ 8	—	—	432	—	—	—
„ 9	—	3·000	460	1·044	—	Normal, thick
„ 10	—	2·796	345	1·041	—	„ „
„ 11	—	2·642	280	1·038	—	„ „
„ 12	—	2·864	306	—	—	—
„ 13	—	2·792	331	1·041	—	Normal, thick
„ 14	—	2·635	354	1·037	—	„ „
„ 15	—	2·223	220	1·029	—	„ „
„ 16	2·3	1·852	400	1·021	—	Normal
„ 17	3·3	2·417	381	1·033	—	Dark yellow
„ 18	3·0	2·450	309	1·036	—	„ thick
„ 19	2·4	2·148	332	1·031	2·7	Normal
„ 20	1·0	2·469	438	1·035	2·2	Dark yellow
„ 21	2·4	2·726	475	1·040	2·8	„
„ 22	3·6	2·980	508	1·042	4·0	„ thick
„ 23	1·8	2·714	546	1·035	5·5	Brown yellow
„ 24	2·7	3·025	—	—	—	Dark yellow, thick
„ 25	3·4	3·403	588	1·047	7·7	Brown yellow
„ 26	9·7	1·304	306	1·013	2·5	Normal
„ 27	2·8	2·483	368	1·034	4·8	Dark yellow
„ 28	2·0	2·830	422	1·038	6·3	Brown
„ 29	2·7	2·901	375	1·038	5·4	„
„ 30	1·8	2·396	270	1·033	4·3	Dark yellow
„ 31	4·5	2·058	436	1·025	7·2	„
Sept. 1	2·4	1·795	475	1·020	7·9	Brown yellow
„ 2	1·0	2·588	580	—	5·8	Dark yellow
„ 3	1·3	2·629	566	1·036	7·2	Normal
„ 4	4·0	2·194	465	1·029	3·6	„ thick
„ 5	1·3	2·655	694	1·031	10·1	Dark yellow
„ 6	2·7	2·976	703	1·042	10·8	Brown yellow
„ 7	3·8	2·831	670	1·036	7·2	Dark yellow
„ 8	3·0	2·475	537	1·031	7·2	„
„ 9	3·8	1·733	321	1·023	4·3	Brown
„ 10	3·0	2·114	304	1·036	2·5	Brown yellow
„ 11	0·1	2·119	540	1·027	5·0	Dark yellow
„ 12	2·0	2·445	616	1·034	6·1	Normal
„ 13	1·7	2·733	596	1·045	7·2	Dark yellow
„ 14	2·7	2·578	587	1·040	7·2	Normal
„ 15	2·8	2·953	618	1·050	6·1	„ thick
„ 16	2·0	2·749	540	1·045	6·1	„
„ 17	3·4	2·520	550	1·036	5·0	„
„ 18	2·5	2·850	521	1·042	7·2	„
„ 19	2·2	2·751	518	1·044	5·4	Dark yellow
„ 20	—	2·590	470	—	4·5	—
„ 21	—	—	—	—	—	—
„ 25	—	—	—	—	—	—

HORSE 2975—(*continued*).

Date.	Results of Microscopical Examinations.	Pulse.	Clinical Observations.
Aug. 7 ..	—	—	—
,, 8 ..	—	—	—
,, 9 ..	—	—	—
,, 10 ..	—	—	—
,, 11 ..	—	—	—
,, 12 ..	—	—	—
,, 13 ..	—	—	—
,, 14 ..	—	—	—
,, 15 ..	—	—	Inj. subc. 3 c.c. def. blood DF 2564.
,, 16 ..	—	—	—
,, 17 ..	—	—	—
,, 18 ..	—	—	—
,, 19 ..	—	—	—
,, 20 ..	—	—	—
,, 21 ..	—	—	—
,, 22 ..	—	—	—
,, 23 ..	—	46	—
,, 24 ..	—	40	—
,, 25 ..	*Piropl. equi* present	36	Conj. yellow.
,, 26 ..	,, ,, ,, ...	56	,, ,,
,, 27 ..	Mic. exam. : Negative ..	42	,, ,, Gmelin reac. positive.
,, 28 ..	*Piropl. equi* rare	38	,, ,, ,, ,, negative. ,, ,, positive.
,, 29 ..	,, ,, ,, ...	50	,, ,, ,, ,, positive.
,, 30 ..	,, ,, ,, ...	46	—
,, 31 ..	—	48	—
Sept. 1 ..	—	44	Normal.
,, 2 ..	—	—	—
,, 3 ..	—	44	—
,, 4 ..	—	—	—
,, 5 ..	—	50	—
,, 6 ..	Mic. exam. : Negative ..	50	—
,, 7 ..	,, ,, ..	56	—
,, 8 ..	,, ,, ..	52	—
,, 9 ..	,, ,, ..	—	—
,, 10 ..	,, ,, ..	—	—
,, 11 ..	,, ,, ..	—	—
,, 12 ..	—	—	—
,, 13 ..	—	—	—
,, 14 ..	—	—	—
,, 15 ..	—	—	—
,, 16 ..	—	—	—
,, 17 ..	—	—	—
,, 18 ..	—	—	—
,, 19 ..	—	—	—
,, 20 ..	—	—	—
,, 21 ..	—	—	—
,, 25 ..	—	—	—

The pure piroplasmosis *fever reaction* is irregular and the incubation time seems to be very short. Also this horse had an attack of horse-sickness, after having almost recovered from piroplasmosis.

Piroplasms are not frequent and are only seen for two days at the end of the first temperature reaction.

The dissolution of blood corpuscles occurs rather slowly, and—as is the rule—in steps, according to the periods of the disease. A third decrease during the horse-sickness shows that the latter is accompanied again by a piroplasmotic attack.

The osmotic pressure of serum first increases, then decreases, and remains subnormal until the end of the horse-sickness attack, with an interruption after the end of the pure piroplasmosis. Osmotic concentration and conductivity do not entirely go parallel. With regard to them and the specific gravity of the serum, the same applies, as I said, on 2961.

The coefficient of expansion shows similar alterations like in 2961.

The capillarity has two low zones, the second of which—in analogy to 2961—coincides with the minimum of conductivity and, of course, with the maximum of the expansion coefficient.

The relation between the capillarity and the *quantity of globulines* is not so distinct, like in horse 2961, and only existing during the horse-sickness reaction.

The quantity of *drinking water* differs considerably from day to day. During the piroplasmosis it is great when the conductivity of serum is high, that is to say, the organism tries to compensate excesses in the concentration of ions even when they are not exaggerated.

Polyuria cannot be observed this time, and the alterations of the urine quantity are comparatively small. The behaviour of *specific gravity, osmotic concentration, conductivity, alkalinity and capillarity* of the urine is very similar to that in horse 2961, except that, according to the absence of polyuria, the osmotic concentration and specific gravity do not decrease ; conductivity and alkalinity rather increase during the horse-sickness infection ; at the same time, the number of erythrocytes is at its lowest.

Of horses 3248 and 3260 we examined :—

(1) Temperature of the body.
(2) Microscopical and clinical symptoms.
(3) Volume of erythrocytes.
(4) Viscosity of blood at 37°.
(5) Surface tension of blood at 37°.
(6) Specific gravity of blood at 37°.
(7) Conductivity of serum at 37°.
(8) Viscosity of serum at 25°.
(9) Specific gravity of serum at 37°.

And of horses 3249 and 3253, besides (1)—(9) :—

(10) Quantity of daily urine (filtered and not filtered).
(11) Conductivity of daily urine at 37°.
(12) Viscosity of daily urine (filtered).
(13) Surface tension of daily urine (filtered) at 37°.
(14) Specific gravity of daily urine (filtered and not filtered) at 37°
(15) Alkalinity (filtered).
(16) Quantity of drinking water.

The surface tension is obtained by measuring the height which the blood or serum goes up at 37° in a freshly drown capillary, the diameter of which at the meniscus is determined by means of an ocular-micrometer. The surface tension is calculated by means of the formula :—

$$\text{Surface tension} = \frac{1}{2}\, r\, h\, s. \quad (\textit{Kohlrausch.})$$

HORSE 3248.

Date.	TEMPERATURE. F.		Volume of Red Blood Corpuscles.	BLOOD.			SERUM.				RESULTS OF MICROSCOPICAL EXAMINATIONS.
	Morning.	Evening.		Specific Gravity.	Viscosity.	Surface Tension.	Specific Gravity.	Viscosity.	Surface Tension.	Conductivity $\times 10^4$	
1908.			%								
Jan. 16	100·2	101·4	39	1·0578	3·46	—	1·0280	1·82	5·78	156·9	—
„ 17	101·4	100·6	—	—	3·94	—	1·0285	1·80	5·46	159·0	Inj. subc. 1 c.c. fresh blood of DF 2926.
„ 18	100·8	101·4	38	—	3·60	—	1·0266	1·80	5·76	143·8	—
„ 19	101·4	101·8	36	—	3·72	—	1·0261	1·65	5·20	151·0	—
„ 20	100·0	102·0	34	1·0517	3·50	5·26	1·0276	1·72	5·50	160·0	—
„ 21	100·6	100·6	35	1·0516	3·60	5·52	1·0260	1·75	5·58	142·3	—
„ 22	100·8	101·0	32	1·0482	2·86	5·68	1·0252	1·48	4·90	149·0	—
„ 23	100·6	101·4	34	1·0488	2·76	5·48	1·0253	1·63	4·82	149·7	—
„ 24	100·4	100·4	30	1·0490	3·12	5·50	1·0258	1·65	5·70	155·3	—
„ 25	100·4	100·8	27	1·0484	2·84	5·82	1·0252	1·55	5·38	150·8	—
„ 26	100·4	101·4	28	1·0470	2·88	5·80	1·0253	1·61	5·42	153·8	—
„ 27	102·0	102·0	32	1·0456	3·34	5·38	1·0256	1·53	4·86	151·3	Mic. exam.: Negative.
„ 28	101·0	100·8	25	1·0471	2·76	5·28	1·0256	1·62	5·46	151·6	„ „
„ 29	100·6	101·6	34	1·0460	3·00	5·50	1·0252	1·55	5·28	148·2	*Piropl. equi* very rare.
„ 30	101·2	101·0	27	1·0442	2·66	5·78	1·0251	1·60	5·20	152·0	„ „ rare.
„ 31	100·2	101·0	26	1·0424	2·46	5·36	1·0251	1·63	5·84	150·8	„ „ „ 1 rosette.
Feb. 1	101·0	101·2	23	1·0429	2·34	5·46	1·0251	1·55	5·34	153·5	„ „ „ 1 „
„ 2	100·0	101·0	20	1·0412	2·36	5·22	1·0251	1·60	5·92	154·0	„ „ very rare.
„ 3	100·4	100·8	20	1·0421	2·62	5·70	1·0254	1·61	5·56	154·8	Mic. exam.: Negative.
„ 4	100·0	101·0	24	1·0440	2·62	4·62	1·0259	1·64	5·70	157·8	„ „
„ 5	100·6	101·6	26	1·0438	2·46	5·50	1·0257	1·60	5·34	152·6	„ „
„ 6	100·0	101·0	28	1·0462	2·79	5·28	1·0263	1·72	5·90	157·0	„ „
„ 7	101·2	100·0	27	1·0467	3·14	5·38	1·0266	1·70	5·78	157·5	„ „
„ 8	100·6	101·0	25	1·0449	2·90	5·26	1·0260	1·72	5·50	157·0	„ „
„ 9	100·6	102·6	26	1·0438	2·74	4·92	1·0249	1·63	5·48	151·0	„ „
„ 10-15	—	—	—	—	—	—	—	—	—	—	—

The temperature reaction, starting the ninth day, is slight. *Piroplasms* are seen from the twelfth to sixteenth days ; they are rare, but in spite of that, the destruction of blood cells, beginning on the third day and showing two periods, is most abundant from the twelfth to the sixteenth day, which time would correspond with the second period of destruction.

The internal friction and *specific gravity* of the blood, as they are dominated especially by the number of blood corpuscles, also show three periods of decrease, which go almost parallel with the blood cell destruction. That these three values are not accurately going parallel is caused (1) by factors which influence only the plasma and not (or less) the corpuscles, or which influence the specific gravity in a positive and the viscosity in a negative sense, for instance, salts ; (2) by methodological and experimental errors, for instance, the specific gravity always was taken at 37°, the viscosity has been calculated for 37°, but the volume of blood corpuscles was obtained at the room temperatures. On the other hand, differences in the flow of the blood through the metal tube due to irregularities in its size and position may influence the results.

There is a specially distinct declination of specific gravity and viscosity on the fifth day, i.e. long before any clinical symptoms appear. The *surface tension* of blood does not show remarkable alterations. *The viscosity of serum* falls on the second, and again the fifth day, like the viscosity of blood ; but the minimum of the former takes place much earlier. There are many parallels with the *surface tension*. This is subnormal during the disease, but reaches the normal state again before the internal friction does.

Adversely to horse 2975, the *specific gravity* of these four horses decreases during the attack ; that means loss of colloidal or crystalloid components of serum, or of both together. In analogy to the previous six cases we should expect that the osmotic concentration decreases, and as the experiments on these four horses show also the ion concentration falls. The difference is that the conductivity alters rather early in these horses and that its alterations during the most intensive haemolysis are comparatively unimportant. As the colloidal serum components are chiefly responsible for the internal friction, we must admit that in cases of piroplasmosis, where we find a subnormal serum viscosity, loss of albuminoid substances of serum has taken place. Hence we understand that in such cases the conductivity is not considerably decreased, for these very colloids are obstacles to the migration of ions. It is remarkable that from the nineteenth day, all the methods indicate a tendency of recovery, but a few days afterwards there is a general relapse.

Horse 3260.

Date.	Temperature. F.		Volume of Red Blood Corpuscles.	Blood.			Serum.				Results of Microscopical Examinations.
	Morning.	Evening.		Specific Gravity.	Viscosity.	Surface Tension.	Specific Gravity.	Viscosity.	Surface Tension.	Conductivity $\times 10^4$	
			%								
Jan. 16	100·0	100·4	37	1·0594	3·96	—	1·0282	1·90	5·58	157·6	—
„ 17	100·0	100·0	—	—	4·52	—	1·0276	1·95	5·54	152·4	Inj. subc. 1 c.c. fresh blood of DF 2926.
„ 18	100·6	100·6	33	—	3·50	—	1·0251	1·70	5·62	145·7	—
„ 19	100·6	101·6	36	—	3·72	—	1·0258	1·70	5·82	146·2	—
„ 20	100·0	100·6	32	1·0513	3·56	5·44	1·0252	1·70	5·64	148·5	—
„ 21	100·2	101·2	32	1·0487	3·80	5·24	1·0245	—	5·76	148·3	—
„ 22	100·2	101·0	32	1·0510	3·14	5·28	1·0256	1·62	4·88	153·3	—
„ 23	101·0	101·6	32	1·0513	3·02	5·08	1·0254	1·65	4·92	151·8	—
„ 24	100·4	101·0	31	1·0513	3·20	4·94	1·0252	1·66	5·32	157·6	—
„ 25	101·2	102·4	30	1·0508	3·24	5·64	1·0251	1·65	5·42	151·3	—
„ 26	101·8	101·4	28	1·0486	2·98	4·54	1·0253	1·68	5·42	152·0	Mic. exam.: Negative.
„ 27	100·2	100·0	34	1·0498	3·28	5·34	1·0254	1·70	5·48	152·7	*Piropl. equi* rare.
„ 28	100·4	102·0	31	1·0484	2·80	5·60	1·0255	1·78	5·28	153·0	„ „ fairly frequent.
„ 29	100·6	100·6	27	1·0438	2·66	5·38	1·0245	1·62	5·66	147·5	„ „ rare.
„ 30	99·6	101·6	28	1·0484	3·36	4·94	1·0262	1·65	5·64	155·0	Mic. exam.: Negative.
„ 31	100·6	100·2	29	1·0469	2·92	5·48	1·0255	1·68	5·20	152·7	„ „
Feb. 1	100·2	101·4	31	1·0480	3·00	5·40	1·0252	—	5·42	152·1	„ „
„ 2	100·0	101·0	33	1·0509	3·16	4·84	1·0264	1·64	5·06	154·9	„ „
„ 3	100·2	101·0	29	1·0494	—	5·40	1·0260	1·65	5·38	157·2	„ „
„ 4	100·0	100·8	26	1·0478	2·80	5·24	1·0256	1·65	5·64	150·2	„ „
„ 5	100·0	102·0	32	1·0456	2·74	5·58	1·0247	1·50	5·62	153·8	„ „
„ 6	100·2	101·0	36	1·0477	2·74	5·48	1·0257	1·70	4·64	155·0	*Piropl. equi* rare.
„ 7	99·2	100·8	28	1·0459	2·96	5·76	1·0257	1·72	5·62	157·3	Mic. exam.: Negative.
„ 8	100·6	100·2	27	1·0451	2·82	4·60	1·0254	1·65	5·38	153·8	„ „
„ 9	100·6	102·4	29	1·0450	3·00	5·40	1·0253	1·70	5·58	153·3	„ „
Feb. 20	—	—	27	1·0432	—	—	1·0241	—	—	146·2	—
„ 25	—	—	29	1·0456	—	—	1·0245	—	—	151·1	—
Mar. 2	—	—	32	1·0471	—	—	1·0253	—	—	152·1	—
„ 11	—	—	31	1·0473	—	—	1·0253	—	—	148·8	—

The temperature reaction is irregular and slight, as in the previous horse. *Piroplasms* are seen several times, viz., the tenth, twelfth, and the twentieth day.

The destruction of blood corpuscles is not very intensive, but periods are recognisable. Minima of the volume of corpuscles, viscosity, and specific gravity of the blood are noted on the twelfth and twenty-second, and of specific gravity and viscosity also on the nineteenth day.

The behaviour of *viscosity, specific gravity, conductivity, and surface tension* of serum is similar to that in horse 3248 ; surface tension and specific gravity show alterations in opposite sense to each other, and with the latter the internal friction goes up and down ; the surface tension very often is high when the viscosity is low and vice versa, except from the fourth to the tenth day. The explanation for these phenomena can only be given when the influence of each serum component—crystalloidal, as well as colloidal—on the internal friction and surface tension have thoroughly been studied.

Horse 3249.

Date.	Temperature. F.		Volume of Red Blood Corpuscles.	Blood.			Serum.				Urine.					
	Morning.	Evening.		Specific Gravity.	Viscosity.	Surface Tension.	Specific Gravity.	Viscosity.	Surface Tension.	Conductivity × 10	Daily Quantity.	Specific Gravity.	Filtered Specific Gravity.	Conductivity × 10^{-4}.	Filtered Conductivity × 10^{-4}.	Filtered Alkalinity.
			%													
Jan. 16	100·4	100·0	37	1·0605	4·32	—	1·0290	1·87	5·08	156·5	—	—	—	—	—	—
,, 17	100·2	100·4	—	—	4·66	—	1·0296	1·95	5·56	157·3	—	—	—	—	—	—
,, 18	99·6	102·4	46	—	4·68	—	1·0282	1·81	5·36	149·2	—	—	—	—	—	—
,, 19	99·6	100·8	36	—	3·60	—	1·0256	1·70	5·68	148·5	3·7	1·029	—	391	—	5·4
,, 20	100·4	101·2	34	1·0513	3·36	5·58	1·0260	1·70	5·54	146·8	5·0	1·014	—	405	—	5·1
,, 21	100·0	100·4	32	1·0497	3·32	5·60	1·0257	1·80	4·74	148·2	5·2	1·011	—	358	—	4·1
,, 22	100·2	101·8	35	1·0519	3·32	5·74	1·0261	1·65	5·12	149·2	2·0	1·044	—	736	—	9·5
,, 23	100·0	101·4	36	1·0533	3·32	5·44	1·0262	1·68	5·24	151·0	10·3	1·017	—	434	—	4·5
,, 24	100·6	100·6	33	1·0526	3·48	4·64	1·0268	1·75	5·58	153·3	3·0	1·041	1·033	669	650	5·8
,, 25	100·2	100·6	37	1·0557	3·82	5·74	1·0262	1·68	5·76	152·0	3·7	1·032	1·029	636	617	7·3
,, 26	100·6	100·4	38	1·0556	3·84	5·46	1·0265	1·75	5·66	150·7	2·6	1·044	1·038	784	758	8·7
,, 27	100·2	101·0	39	1·0529	3·74	5·50	1·0264	1·69	5·50	151·1	3·6	1·039	1·035	694	660	8·9
,, 28	100·6	102·8	36	1·0509	3·26	5·72	1·0261	1·62	5·24	150·3	7·0	1·021	1·018	519	511	5·3
,, 29	100·6	101·8	41	1·0527	3·68	5·56	1·0266	1·70	5·36	147·3	4·5	1·019	1·017	454	453	6·0
,, 30	100·4	100·8	41	1·0545	4·14	5·44	1·0272	1·75	6·40	148·3	3·6	1·024	1·021	515	501	6·7
,, 31	100·6	100·8	32	1·0493	3·38	5·50	1·0264	1·70	5·00	150·3	5·4	1·019	1·017	410	405	4·4
Feb. 1	101·0	100·6	34	1·0509	3·28	5·50	1·0266	1·70	5·46	149·5	3·6	1·029	1·025	610	576	8·1
,, 2	100·0	100·8	33	1·0510	3·20	5·50	1·0263	1·68	5·22	150·7	3·9	1·028	1·026	680	674	7·2
,, 3	100·2	100·8	32	1·0505	3·80	5·52	1·0263	1·63	5·60	148·7	8·8	1·014	1·012	362	360	4·1
,, 4	100·6	104·0	28	1·0499	3·16	5·60	1·0267	1·70	5·74	150·6	9·3	1·020	1·017	509	493	6·0
,, 5	103·6	103·4	30	1·0480	3·00	5·36	1·0266	1·70	5·64	146·2	5·6	1·017	1·015	469	462	6·3
,, 6	102·4	103·0	26	1·0448	2·62	5·56	1·0255	1·72	5·32	149·5	4·1	1·032	1·028	485	462	7·2
,, 7	103·6	103·6	21	1·0434	2·86	5·50	1·0254	1·72	5·36	146·2	7·8	1·020	1·018	527	508	7·4
,, 8	102·2	102·2	18	1·0412	2·78	5·56	1·0250	1·95	5·46	148·8	11·0	1·012	1·010	402	397	4·9
,, 9	100·4	101·6	21	1·0427	2·82	5·44	1·0248	1·75	5·38	150·7	8·5	1·010	1·007	350	339	4·3
,, 10	100·0	101·6	26	1·0466	3·56	5·10	1·0256	1·78	4·92	149·6	3·6 ?	1·020	1·017	531	522	5·4
,, 11	100·6	100·6	26	1·0472	3·26	4·98	1·0257	1·70	5·06	148·8	6·2	1·018	1·015	482	477	4·8
,, 12	100·6	100·6	24	1·0454	2·82	4·00	1·0250	1·68	4·42	150·2	6·8	1·023	1·020	538	534	5·9
,, 13	—	—	20	1·0426	2·64	5·80	1·0253	1·70	—	151·4	5·3	1·023	1·019	536	530	5·2

Date.	Urine—(*continued*).					Drinking Water. (Litres.)			Urine—Colour.		Results of Microscopical Examinations.
	Solids (Sp. Gr. — 1) × Quantity.	Filtered (Sp. Gr. — 1) × Quantity.	Filtered Surf. Tens.	Filtered Viscosity.	Room Temperature 12 noon. F.	10 a.m.	5 p.m.	Total.	Not Filtered.	Filtered.	
					°						
Jan. 16	—	—	—	—	—	—	—	—	—	—	Inj. subc. 1 c.c. fresh blood of DF 2926.
„ 17	—	—	—	—	—	—	—	—	—	—	—
„ 18	—	—	—	—	—	—	—	—	—	—	—
„ 19	108	—	6·34	1·20	90	—	—	—	Normal	Light brown	—
„ 20	70	—	6·54	1·14	88	13	2	15	„	„	—
„ 21	58	—	6·62	1·10	90	10	4	14	„	„	—
„ 22	88	—	7·06	1·30	76	3	3·5	6·5	„ thick	Red brown	—
„ 23	176	—	6·28	1·10	76	12	3	15	„	Red	—
„ 24	124	100	6·00	1·20	83	20	6	26	„ thick	„	—
„ 25	118	108	6·30	1·18	83	21·5	5	26·5	„	Reddish	—
„ 26	114	98	6·06	1·27	83	12	2	14	„ thick	Red	—
„ 27	140	126	6·28	—	76	5·5	3·5	9	„	„	Mic. Exam.: Negative.
„ 28	148	126	6·48	1·10	83	18	5·5	23·5	„	Red brown	*Piropl. equi* rare.
„ 29	86	76	6·32	1·12	83	4·5	2	6·5	„	Reddish brown	„ „ „
„ 30	86	76	6·34	1·16	86	10	3·5	13·5	„	Red	„ „ „
„ 31	102	92	6·44	1·11	86	14	4	18	„	Yellow brown	„ „ very rare.
Feb. 1	104	90	6·28	1·20	74	4·5	5·5	10	„	Dark red	„ „ „
„ 2	110	102	6·18	1·13	77	13	4	17	„	Red brown	„ „ „
„ 3	124	106	6·92	1·05	81	12·5	4·5	17	„	Yellow brown	„ „ „
„ 4	186	158	6·20	1·11	85	2·5	5	7·5	„	„	„ „ fairly frequent.
„ 5	96	84	6·28	1·11	76	10	3	13	„	„	„ „ „ „
„ 6	132	118	6·30	1·20	77	9	4·5	13·5	„ thick	Red	„ „ frequent.
„ 7	156	140	6·56	1·10	81	11·5	3	14·5	„	Light brown red	„ „ rare.
„ 8	132	110	6·82	1·12	85	13·5	3	16·5	„	Light brown	Mic. Exam.: Negative.
„ 9	86	60	6·72	1·10	85	5·5	6	11·5	„	Brown	„ „
„ 10	72	62	6·40	1·20	88	14·5	7	21·5	„	„	*Piropl. equi* very rare.
„ 11	112	94	6·64	1·12	86	12	6·5	18·5	„	Dark yellow	Mic. Exam.: Negative.
„ 12	156	136	6·08	1·15	86	12	5	17	„	Yellow brown	„ „
„ 13	122	100	6·38	1·18	86	11	4	15	„	Yellow	—

There is a very distinct *temperature reaction*, which seems to be the third, starting on the eighteenth day ; though *piroplasms* are present from the eleventh to the twenty-fourth day (except two days). Two long periods of haemolysis are distinguishable ; the first starting the second day—a very slight one ; the second from the thirteenth to the twenty-second day, during which considerable loss of erythrocytes takes place. This loss corresponds with the number of parasites.

Notwithstanding a strong temperature reaction, as compared with other cases, *specific gravity and viscosity* of blood behave in the same way as 3248 and 3260 and corresponds to the volume of globules. *Viscosity and specific gravity* of serum both fall on the second day, a phenomenon which has to be attributed to a diminution of serum—colloids and ions. (Compare Conductivity.) From the fourth to the eleventh day, specific gravity, surface tension, and conductivity all increase first and then decrease, but only a little, so that the final values are still higher than the first ones. The viscosity increases and decreases similarly, but the decrease is more intensive. These phenomena have to be explained by alterations of the concentration of ions which influence surface tension, viscosity, and conductivity similarly, according to their physical-chemical properties, and the specific gravity by their absolute quantity. The intensive haemolysis, beginning the fourteenth day causes also other physical conditions in the serum. Surface tension and viscosity alter reversely. Their curves, first convergent, diverge towards the end of our examination. This would point to an increase of colloidal substances, but as the specific gravity decreases, there must be a special kind of ions influencing viscosity and surface tension in reverse directions. In all probability it is a diminution of the OH ion concentration which produces the phenomeneon, for we know from numerous experiments that in piroplasmosis the alkalinity of serum is subnormal, and on the other hand, it has been demonstrated that loss of OH ions can cause a decrease of surface tension and an increase of the viscosity at the same time. (Compare chapter on Surface Tension.)

The daily quantity of urine does not show remarkable alterations—except on the sixth day—until the destruction of blood corpuscles begins, then it increases and is highest when the volume of erythrocytes is lowest. The greater the quantity of urine, the lower its *specific gravity*. As the latter is almost exclusively due to crystalloids, and among these the proportion of electrolytes remains almost constant in this case, the conductivity decreases and increases with the specific gravity.

The concentration of the hydroxyl ions is going parallel with that of the other ions. Surface tension and viscosity of the urine are altering in reverse sense, the more crystalloids are dissolved in the urine the higher the viscosity, the lower the surface tension. Certain ions influencing surface tension in a negative, viscosity in a positive, sense must have partially disappeared. As a consequence we should expect in this special case during the destruction of blood cells : the greater the urine quantity, the smaller the viscosity the greater the surface tension ; but, unfortunately, we have no normal values for comparison. By multiplying S — 1 (specific gravity of urine minus specific gravity of H_2O) with the total quantity of urine, we obtain with some approximation the weight of the dry residuals of the urine. In this way we see that the greater the quantity of urine, the more solid substances are put out in it, or perhaps, more precisely, the more solids the organism has to eliminate through the kidneys, the more water is required for this process. As a matter of fact, the quantity of urine and the amount of solid substances in it are likewise increased in the periods of the most intensive haemolysis.

Horse 3253.

Date.	Temperature. F.		Blood.				Serum.				Urine.					
	Morning.	Evening.	Volume of Red Blood Corpuscles.	Specific Gravity.	Viscosity.	Surface Tension.	Specific Gravity.	Viscosity.	Surface Tension.	Conductivity $\times 10^{-4}$.	Daily Quantity.	Specific Gravity.	Filtered Specific Gravity.	Conductivity $\times 10^{-4}$.	Filtered Conductivity $\times 10^{-4}$.	Filtered Alkalinity.
			%													
Jan. 16	100·6	101·8	34	1·0566	4·14	—	1·0297	1·90	5·16	155·7	—	—	—	—	—	—
,, 17	99·6	100·6	—	—	3·64	—	1·0280	1·77	5·24	149·5	—	—	—	—	—	—
,, 18	99·8	101·0	40	—	4·16	—	1·0281	1·98	5·76	149·0	—	—	—	—	—	—
,, 19	100·6	101·8	31	—	3·40	—	1·0266	1·75	5·72	149·6	3·0	1·028	—	569	—	6·5
,, 20	101·0	101·2	34	1·0528	3·74	5·36	1·0274	1·85	5·34	146·4	9·3	1·013	—	396	—	4·3
,, 21	101·0	100·8	30	1·0492	3·40	5·36	1·0265	1·78	4·54	148·9	6·0	1·011	—	341	—	3·9
,, 22	100·4	101·0	33	1·0513	3·22	4·82	1·0268	1·70	9·60	149·6	4·9	1·022	—	441	—	5·5
,, 23	100·6	100·6	34	1·0527	3·36	4·82	1·0270	1·70	4·40	151·3	5·2	1·016	—	415	—	3·8
,, 24	100·6	101·8	30	1·0495	3·10	5·66	1·0261	1·63	4·54	153·1	3·8	1·029	1·026	600	582	5·5
,, 25	100·6	101·4	31	1·0501	3·24	5·56	1·0260	1·65	5·40	152·0	4·5	1·039	1·035	709	665	6·3
,, 26	102·4	102·6	30	1·0480	2·98	5·58	1·0260	1·68	5·22	149·0	12·0	1·018	1·015	470	462	4·6
,, 27	100·6	99·8	27	1·0473	2·82	4·80	1·0262	1·70	5·56	148·8	4·8	1·030	1·025	556	535	6·2
,, 28	99·8	102·0	30	1·0501	3·30	5·38	1·0268	1·68	4·88	152·5	7·2	1·015	1·013	386	384	4·4
,, 29	101·6	102·0	27	1·0458	2·94	5·78	1·0255	1·62	5·50	146·1	10·2	1·013	1·012	383	379	4·2
,, 30	100·6	100·6	22	1·0427	2·66	5·62	1·0259	1·66	5·50	148·5	7·8	1·016	1·014	389	385	4·9
,, 31	100·6	100·8	23	1·0439	2·64	5·44	1·0264	1·70	5·16	150·0	5·8	1·018	1·015	396	391	3·9
Feb. 1	101·0	101·2	25	1·0441	2·60	5·54	1·0262	1·66	5·16	148·8	6·7	1·014	1·012	383	378	3·5
,, 2	100·6	103·8	27	1·0464	2·90	5·50	1·0271	1·70	5·52	150·0	7·5	1·024	1·022	537	507	4·9
,, 3	105·0	101·0	22	1·0453	2·80	5·58	1·0270	1·70	5·40	145·8	12·0	1·008	1·005	251	248	2·7
,, 4	100·0	101·2	27	1·0491	3·16	5·46	1·0273	1·70	5·50	145·4	11·2	1·011	1·010	319	309	3·4
,, 5	101·0	101·6	25	1·0462	3·10	5·34	1·0273	1·62	5·38	147·7	10·6	1·012	1·011	333	320	3·5
,, 6	100·6	101·6	24	1·0434	2·52	5·10	1·0265	1·80	5·72	146·7	7·7	1·015	1·014	392	369	4·6
,, 7	100·4	100·8	23	1·0455	2·86	5·96	1·0271	1·82	5·38	147·4	9·1	1·012	1·011	338	322	3·6
,, 8	99·6	101·0	23	1·0445	2·64	5·42	1·0270	1·83	4·96	146·0	4·5	1·008	1·007	315	312	3·5
,, 9	99·6	101·4	27	1·0486	3·38	5·12	1·0287	1·90	5·50	149·6	5·1	1·024	1·022	493	451	5·5
,, 10	100·4	101·4	27	1·0472	3·16	5·50	1·0283	1·90	5·26	150·8	8·3	1·015	1·014	338	327	3·0
,, 11	99·8	101·4	25	1·0464	3·02	5·86	1·0272	1·95	5·40	150·0	6·1	1·020	1·019	471	459	4·4
,, 12	99·4	100·2	27	1·0468	3·00	5·36	1·0278	1·80	5·50	151·1	10·0	1·014	1·013	374	366	3·7
,, 13	100·0	101·0	26	1·0473	2·96	5·18	1·0276	1·80	—	146·5	7·8	1·012	1·010	330	321	2·8
,, 19	—	—	29	1·0483	—	—	1·0269	—	—	152·7	—	—	—	—	—	—
,, 24	—	—	34	1·0552	—	—	1·0303	—	—	157·0	—	—	—	—	—	—
March 4	—	—	30	1·0492	—	—	1·0265	—	—	151·6	—	—	—	—	—	—
,, 10	—	—	31	1·0498	—	—	1·0269	—	—	152·1	—	—	—	—	—	—

Date.	Urine—(*continued*). Solids (Sp. Gr.—1) × Quantity.	Filtered (Sp. Gr.—1) × Quantity.	Filtered Surf. Tens.	Filtered Viscosity.	Room Temperature 12 noon.	Drinking Water. (Litres.) 10 a.m.	5 p.m.	Total.	Urine—Colour. Not Filtered.	Filtered.	Results of Microscopical Examinations.
					°						
Jan. 16	—	—	—	—	—	—	—	—	—	—	—
„ 17	—	—	—	—	—	—	—	—	—	—	Inj. subc. 1 c.c. fresh blood of DF 2926.
„ 18	—	—	—	—	—	—	—	—	—	—	—
„ 19	84	—	7·22	1·20	90	—	—	—	Normal	Light brown	—
„ 20	120	—	6·66	1·13	88	20	14	34	„	„	—
„ 21	66	—	7·16	1·12	90	16	4	20	„	„	—
„ 22	108	—	6·82	1·15	76	14·5	5·5	20	„	Light red brown	—
„ 23	84	—	7·14	1·13	76	18	5	23	„	Light brown	—
„ 24	110	100	6·88	1·20	83	17·5	11·5	29	„	Light red	—
„ 25	176	158	6·26	1·20	83	19·5	10	29·5	„	„	—
„ 26	216	180	6·74	1·10	83	12	3	15	„	„	Mic. exam.: Negative.
„ 27	144	120	7·26	—	76	5	5·5	10·5	„	Light brown	*Pirop. equi* very rare.
„ 28	108	94	7·24	1·10	83	21	5	26	„	Yellow brown	„ „ fairly frequent; 1 rosette.
„ 29	134	122	4·78	1·12	83	7	4	11	„	„	„ „ „ „
„ 30	126	110	6·54	1·19	86	13	2	15	„	„	„ „ rare.
„ 31	104	88	6·64	1·15	86	12	3	15	„	„	„ „ very rare.
Feb. 1	94	80	6·96	1·11	74	4·5	5	9·5	„ thick	Light yellow brown	„ „ „
„ 2	180	166	7·50	1·10	77	6·5	4	10·5	„	Yellow	„ „ „ 1 rosette.
„ 3	96	60	7·60	1·00	81	4·5	6·5	11	„	„	„ „ „ 2 rosettes.
„ 4	124	112	6·68	1·10	85	9	5·5	14·5	„	„	„ „ rare; 1 rosette.
„ 5	128	118	7·40	1·05	76	14	3	17	„	„	„ „ „
„ 6	116	108	7·26	—	77	7	6	13	„	„	„ „ „
„ 7	110	100	7·08	1·15	81	5·5	6	11·5	„	„	„ „ very rare.
„ 8	36	32	6·56	1·15	85	5	4	9	„	Light brown	Mic. exam.: Negative.
„ 9	122	112	7·42	1·23	85	6	2·5	8·5	„	Brown	*Pirop. equi* very rare.
„ 10	126	116	7·00	1·17	88	13·5	7·5	21	„	Yellow	„ „ „
„ 11	122	116	6·26	1·15	86	9	6·5	15·5	„	Brown	Mic. exam.: Negative.
„ 12	140	130	7·20	1·12	86	11·5	12·5	24	„	Yellow	„ „ „
„ 13	94	78	7·16	1·16	86	10	5·5	12·5	„	Dark yellow brown	—
„ 19	—	—	—	—	—	—	—	—	—	—	—
„ 24	—	—	—	—	—	—	—	—	—	—	—
March 3	—	—	—	—	—	—	—	—	—	—	—
„ 10	—	—	—	—	—	—	—	—	—	—	—

The *temperature reaction* is very irregular and indistinct. The temperature is abnormal from the third to the twenty-second day. *Piroplasms* can be observed from the tenth to the twenty-fourth day. At the same time occurs the decrease of the number of erythrocytes in two periods, which also find expression in the specific gravity and internal friction of the blood.

Viscosity, specific gravity, surface tension, and conductivity of serum show many similarities with the respective values of 3249. The former two decrease very soon after injection, pass their minima the twelfth day, i.e. in the first period of blood cell destruction, and then the viscosity begins to recover while the specific gravity passes again through a minimum at the second onset of haemolysis. The rapid re-increase of the viscosity, however, might be partially caused by the second haemolysis. The *surface tension*, low for four days, finds itself within normal limits the eighth day. Like in horse 3249, the *conductivity* has a slight declination on the third day and increases slightly after that, which is the expression of the increase of certain ions, influencing viscosity and surface tension equally and at the same time. But these ions, or a part of them, disappear when the destruction of globules sets in, or others increase in concentration and the above-mentioned deductions do not hold good, for instance, for the nineteenth day, when the ion concentration is evidently low, the surface tension normal, and the viscosity very small. As in several other instances, the conductivity is also in this horse decreased by the destruction of blood corpuscles. Evident relation exists between *quantity* and, of course, of the *specific gravity* and *conductivity of urine* on one hand and the conductivity of serum on the other; again an expression of the tendency of the serum to keep the ion concentration constant. Adversely to horses 3249 and 2961, the quantity of urine is small on the twenty-second day, where there is the lowest amount of erythrocytes, it is high when the body temperature is high; but conductivity and specific gravity behave like in the above-mentioned horses. In 3249 and 3253 we can distinguish two great periods of the physical-chemical symptoms of the blood and the serum, the second of which shows more intensive alterations than the first with regard to blood. The limit lies in 3249 about on the thirteenth, in 3253 on the eleventh day. Among the symptoms of the urine there are three periods, the last of which is the most distinct as a consequence of its coincidence with the severest haemolysis.

The amount of *solids in the urine* is greatest on the ninth day, when the greatest quantity of urine is passed, afterwards—adversely to the previous horse—the solids become quantitatively higher or lower with the specific gravity.

The *viscosity of the urine* is lowest when fever and quantity of urine are highest. It increases when the number of blood corpuscles decreases, and decreases when the destruction stops, and it is in this way somewhat independent of the specific gravity. This is probably due to the appearance of colloidal substances in the urine (perhaps bile components).

Results and Conclusions.

The well-known *periodicity* of clinical symptoms in piroplasmotic infections emphasises itself also in the physical properties of blood, serum, and urine. One of the main factors of the periodical appearance, increase and decrease of the symptoms, is undoubtedly based on the life-cycle of the piroplasms. They generally show two periods of appearance. There are, however, more periods of decrease of the number of blood corpuscles, i.e. of haemolysis, mostly two to four. This latter fact finds the explanation in the processes of blood destruction and regeneration, because haemolysis caused by injection of haemolytic serum is not continuous, but broken by days of reconvalescence.

A better relation exists between the periods of the temperature elevations with the appearance of parasites. But the intensity of the fever is not at all proportional to the number of piroplasms.

The great dependence of internal friction and specific gravity of the blood upon the number of erythrocytes involves a similarity of the periods of viscosity, specific gravity, and volume of red blood corpuscles.

Once realised that piroplasms, being endoglobular parasites, kill blood corpuscles, that is to say, cause haemolysis, there are several questions arising; with regard to their whereabouts in the body of the host, and the manner in which these parasites enter the blood corpuscles, our investigations give no indications. With regard to the question as to the influence of the piroplasms on the protoplasm of the blood corpuscles, my former experiments in connection with haemolysis* lead to the conclusion that with all probability also the piroplasmotic haemolysis is in principle a membrane-reaction, permeabilisation of the outer layer of the erythrocyt for haemoglobin, caused by certain metabolic products, secretions or excretions of the parasitic protoplasm, whereafter the haemoglobin diffuses into the interglobular liquid and is no more able to act as an oxygen carrier.

Concerning the place where the destruction of the globule happens, two possibilities have to be considered:

(1) Haemolysis takes place in the blood stream.
(2) Infected and moribund blood corpuscles are retained in glands (liver, spleen), and completely decay there.

Supposing the destruction takes place entirely in the circulating blood, red stained serum should be expected, but as a matter of fact, this was comparatively rarely the case, and then only when haemoglobinuria and oliguria were observed. (Compare 3249.)

The explanation for the presence of haemoglobin in these cases has to be looked for in secondary renal affections. Therefore I consider the main place of haemolysis in piroplasmosis not to be the circulating system, but certain glands, with greatest likelihood, liver and spleen.

As I am only to refer within these pages about my own experiments, I limit the description of processes of destruction of blood corpuscles and the further decomposition of the various components, studied specially by human medical scientists† in the following sketch. For more particulars on the subject, see my article "Haemolysis in practical veterinary science in South Africa."‡

From this table we can see what substances temporarily can be mixed with the serum, and which cause partially the secondary physical-chemical symptoms of piroplasmosis—the sequels of haemolysis. These substances are—

Components of the stroma—colloids, electrolytes, non-electrolytes.
Haemoglobin.
Bile pigments.
Bile acids, or better, their salts.

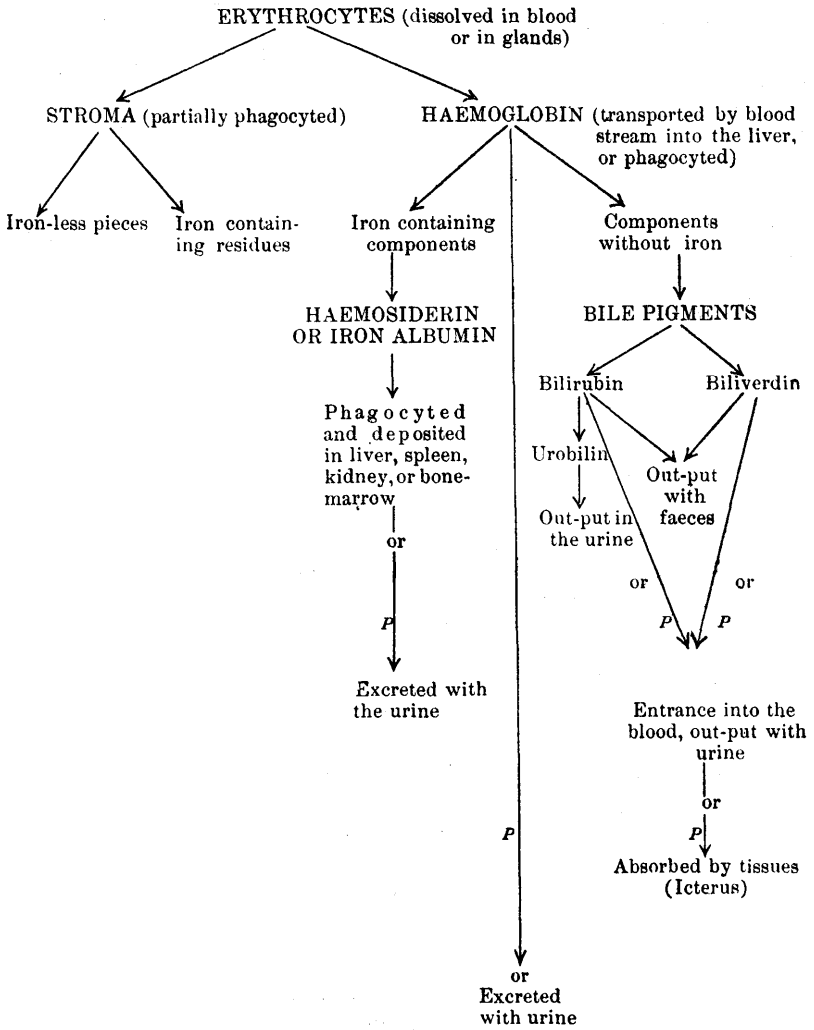
It is evident that these substances are able to alter the physical-chemical properties of serum; for instance, osmotic concentration, conductivity, viscosity, surface tension, specific gravity. As these substances are abnormal for the serum, and as the latter has the tendency to keep its physical state constant, the former are eliminated, and the consequences are alterations of

* *W. Frei*, Thesis Zurich, 1906.

† Compare *Schmidt*, Lubarsch-Osbertag's Ergebu, 3, 542, 1896; *Krans*, Cidera, 3, 416, 1896; *Kretz*, Cidera, 8 T. 495, 1902.

‡ Commemorative Publication, 1909.

the urine*. On the other hand, similar alterations can be produced by the secretions of the piroplasms, or by the metabolism caused by the fever. The decrease of osmotic pressure, conductivity, viscosity, and specific gravity of serum during the time of the disease must to a certain extent be attributed merely to dilution; for instance, a decrease of the volume of blood corpuscles within twenty-four hours from 30 per cent. to 25 per cent. means, naturally, also decrease of the absolute blood quantity and, of course, of the blood pressure, especially when sick globules are phagocyted, and thus completely disappear out of the blood. Immediately a diffusion of liquid from the tissues into the circulation systems takes place, in order to keep up the normal haemostatic pressure. The resulting want of water is covered at the next watering time, and the effect of this is dilution of the serum, for the



P—Pathological process.

* Haemolysis does also affect the respiratoric metabolism; respiration experiments would demonstrate this. Thorough research of the faeces would ascertain the quantity of bile components that pass the intestines.

issue of colloids and osmotically active serum components is slower. Another cause of decrease of osmotic concentration of serum is, according to Hamburger,* the absorption of electrolytes by stromata after dissolution of horse blood rich in CO_2. A similar phenomenon might occur in piroplasmosis.

The osmotic pressure of serum, that normally amounts to about eight atmospheres, shows in all cases (wherever the depression of the freezing point is observed)—except one—an increase up to about eighteen atmospheres (depression of freezing point = 1·312) in the first half of the disease (horse 2847). During the second part, it is always subnormal and can go down to about seven atmospheres (depression of freezing point = 0·508, horse 2975).

While the depression of the freezing point is an expression of the concentration of the electrolytes + non-electrolytes, the conductivity is only caused by the electrolytes of the serum—mainly NaCl. But it is not simply the reciprocity of the resistance, because we have to do with a heterogenous system (compare notes on conductivity). Regarding the pathological decrease of the conductivity of serum in piroplasmosis, there come three factors into consideration :—

(1) Decrease of the absolute quantity of electrolytes.
(2) Increase of non-electrolytes (sugar, urea), which reduce the electrolytic dissociation.
(3) Influence of serum colloids—
    (*a*) increase in concentration ;
    (*b*) structural alterations in such a manner that the migration of ions is protracted ;
    (*c*) absorption of ions whereby the latter become unable to transport electricity (ion-proteid-combinations).

Ad. 1.—Besides the already mentioned dilution of the serum by entrance of water and the eventual absorption of ions by stromata, there are at present no other reasons for loss of electrolytes.

Ad. 2.—A decrease of conductivity—the depression of freezing point remaining constant—already indicates increase of non-electrolytes. Comparatively exceedingly high concentration of the latter, however, signalises itself by great depression of freezing point and causes a decrease of the dissociation and, accordingly, of the conductivity. (Compare horses 2841, 2847, 2848, and 2975.)

Ad. 3.—Increase of serum colloids is shown by increase of the specific gravity, whilst the osmotic pressure remains at the same height (or becomes smaller), and the conductivity diminishes (2961 and 2975).

Though the decrease of conductivity is synchronical with the haemolysis and, certainly to the greatest extent, caused by the latter, the degree of the former is not necessarily proportional to the intensity of the latter.

The specific gravity of serum can become increased by colloidal residues of blood corpuscles, which influence the conductivity and osmotic pressure by simple mechanical absorption of ions. Decrease of osmotic pressure and conductivity without being accompanied by rise of specific gravity would signify a loss of electrolytes and, eventually, non-electrolytes. The measurement of the specific gravity therefore explains to a certain extent the results of both other methods. The viscosity of serum decreases in every instance. The internal friction of serum is a function of concentration and structure of the

*Osmot. Druck and Ionenlehre I. 531, 1902.

serum colloids and is influenced by its crystalloid components, especially by electrolytes. Therefore, the causes of the decrease of internal friction of serum can be the following :—

(1) Decrease of serum colloids (by dilution), in which case also the specific gravity becomes smaller; the surface tension, however, higher.

(2) Disappearance (absorption by residuals of blood corpuscles, which afterwards are kept back in liver or spleen) of ions that influence the viscosity of the serum colloids in a positive sense. The specific gravity decreases.

(3) Forthcoming or increase of ions with the faculty of diminishing the viscosity of the serum colloids.

The factors mentioned under (1) and (2) are probably active in every instance. The loss of ions [under (2)] is also responsible for the decrease of the conductivity. Reversion of these factors has, of course, increase of the viscosity as a consequence.

The *surface tension*, which should increase when colloids partially disappear out of the serum, shows in each of the four instances distinct decreases in the beginning of the disease, a phenomenon only explicable by variations (decrease) of the concentration of certain ions that influence viscosity and surface tension in the same (positive) sense. Unfortunately, the thorough study of the influence of every singular ion on the viscosity and surface tension of solutions of serum colloids has not yet been carried out, otherwise it would be possible, after investigation of serum with various methods, to signify by name the ions or groups of ions which decrease or increase.

The physical-chemical symptoms of the urine have to vary within wider limits than those of serum on account of the constancy of the latter. The kidneys, of course, are regulators for the serum. Parallelisms between osmotic pressure and conductivity of serum and urine show the dependence of the latter on the former (2840, 2848).

Normally osmotic pressure and conductivity of urine are higher than of serum, and the former also dominated by electrolytes (like in serum). Pathologically, however, the urine values can become less than the serum values. This does not always indicate the output of very small quantities of osmotically active substances, as the low values might be derived from dilution of the same quantity of solids by a great amount of urine. Polyuria, of course, is quite a common symptom of piroplasmosis (2961). That the decrease of osmotic concentration, conductivity, and specific gravity seems rather to be secondary and a consequence of the great urine quantity is shown by a case where no polyuria occurred, and these values did not decrease (2975; compare also 3249 and 3253).

In addition, we find alterations of the proportions of electrolytes and non-electrolytes (urea) in such a manner that the osmotic pressure remains almost constant for many days, while the conductivity varies considerably (2841).

The parallelism of alkalinity of urine with the conductivity shows that the concentration of OH ions increases and decreases with the other ions, and does not show considerable alterations during the disease. As urine is almost free from colloidal components, its specific gravity is due to crystalloids—especially electrolytes and urea—and, therefore, decreases during the disease and—by the already explained reasons—especially when the urine quantity is great.

The viscosity of urine, being only little higher than of water (only examined in two instances), seems to decrease during the attack.

RÉSUMÉ.

1. Piroplasmosis of the horse is a disease with periods also pronounced by physical-chemical alterations of blood and serum.

2. The haemolysis, produced by the intra-globular parasites, has to be considered to be the cause of a great number of physical-chemical symptoms of the serum, for the latter depend in several points on the state of the blood corpuscles.

3. Volume of blood corpuscles, viscosity, and specific gravity of the blood all decrease. Never was an increase of the viscosity noticed; contrary to what is observed in horse-sickness.

4. Viscosity, specific gravity, conductivity, and surface tension of serum also decrease, the latter especially in the beginning of the disease.

The osmotic pressure of serum decreases in every instance; in four cases out of six an increase precedes, and can amount even to more than 100 per cent. The specific gravity decreases in four instances and increases in two instances.

5. Physical-chemical alterations emphasise themselves by the methods in use before the temperature starts to rise (conductivity the first day, depression of freezing point, viscosity, surface tension, and specific gravity). Therefore, if we call incubation period the time between infection and the appearance of the first signs of the disease, it would be in some of our cases of piroplasmosis not more than twenty-four hours (2840, 2841); in other cases (3260, 3248, 3249), about four days; that is to say, much shorter than when only considering the appearance of fever.

6. The physical-chemical alterations of the urine are not typical and regular, like those of serum and blood; some of them are extraordinary, all show dependence on the state of the serum and demonstrate again the regulatory functions of the kidneys.