The physical-chemical peculiarities of blood and serum of animals which possess immunity against horse-sickness differ but very little from normal. Volume of blood corpuscles and specific gravity of blood are only slightly subnormal, while the average viscosity even is somewhat above the normal value.

Hyperimmunisation consists in infusing great quantities of blood from a highly sick into an immune horse. The following are the physical-chemical alterations of immune blood and serum which have been mixed with pathological blood in vivo (examination made shortly before and after hyperimmunisation) :—

In all instances the volume of blood corpuscles is increased after infusion. The differences of the values before and after hyperimmunisation are, however, not greater than normal variations—but still I believe that the increase has to be ascribed to the infusion, as it is met in each case, and it is quite natural that it is so. After an absolute increase of the blood quantity, a certain amount of blood liquid is diffusing out of the vessels in order to prevent a fatal increase of the blood pressure. Therefore the blood becomes more concentrated with regard to blood corpuscles.* A few days after the operation the volume of globules has gone down again.

The same is to be said about the specific gravity of blood and serum. It increases after the first or second hyperimmunisation (except 3119), but also these increases could range within normal limits.

In all cases, except one, the conductivity of serum is lower after the second infusion than it was before the first one. The simultaneous increase of specific gravity explains the phenomenon. The abovementioned diffusion will chiefly refer to water and christalloids. Colloids, however, which diffuse not so easily, will be kept back and increase the specific gravity and at the same time the resistance for the migration of ions. For the same reason the viscosity should increase what apparently proves to be right.

The descending order of variations is the following :—

Vol. blood corp., viscosity blood, viscosity serum, surface tension serum, conductivity, specific gravity blood, specific gravity serum,

that is to say, the same as in normal horses.

(4) Serum Horses.

From these horses which had been hyperimmunised, great quantities of blood were taken in almost regular intervals, and therefore they are from a physical-chemical standpoint horses with artificial anaemia, and the results are of general pathological interest.

* Compare *Tigerstedt*, Ergebnisse der Physiologie, 1907.

Serum Horses—Influence of Bleeding.

Date.	Number.	Sex.	Age.	Condition.	Remarks.	Blood.			Serum.					
						Volume of Blood Corpuscles.	Viscosity at 25° C.	Specific Gravity at 37° C.	Specific Gravity at 37° C.	Conductivity at 37° × 10^{-4}	Viscosity at 25° C.	Surface Tension at 37° C.	Index of Refraction at 37° C.	Amount of Serum (Blood = 1).
9/6/08	1162	Geld.	11 yrs.	—	Hyperimmunised 26 days ago ..	32	—	1·0508	1·0271	145·7	1·90	—	—	½
17/6/08	,,	,,	,,	Poor	Bled on June 9, 6 litres	25½	2·9	1·0440	1·0260	147·1	1·76	5·94	—	½
29/6/08	,,	,,	,,	Rather poor	,, ,, 18, 4 ,, ...	24	2·45	1·0424	1·0247	148·7	1·59	—	1·34481	½
1/7/08	,,	,,	,,	Poor	,, ,, 30, 6 ,, ...	20	2·23	1·0377	1·0244	149·7	—	—	—	½
13/7/08	,,	,,	,,	Rather poor	—	24	2·51	1·0405	1·0227	146·1	1·59	—	1·34395	⅔
14/7/08	,,	,,	,,	,,	Bled on July 13, 4 litres	21	2·43	1·0391	1·0223	156·8	1·55	—	1·34390	⅔
9/6/08	1288	Geld.	17 yrs.	—	Hyperimmunised 28 days ago ..	31	—	1·0495	1·0287	149·7	1·98	—	—	½
17/6/08	,,	,,	,,	Fairly good	Bled on June 9, 6 litres	23½	2·9	1·0430	1·0257	150·0	1·82	5·93	—	½
29/6/08	,,	,,	,,	,,	,, ,, 18, 4½ ,, ...	23	2·72	1·0421	1·0257	148·0	1·79	5·83	—	½
1/7/08	,,	,,	,,	,,	,, ,, 30, 6 ,, ...	19½	2·25	1·0378	1·0227	150·8	1·58	5·92	1·34324	⅖
13/7/08	,,	,,	,,	,,	—	22	—	1·0437	1·0251	151·0	1·68	—	1·34541	⅔
14/7/08	,,	,,	,,	,,	Bled on July 13, 6 litres	20	2·42	1·0402	1·0236	158·3	1·58	—	1·34453	⅔
9/6/08	1085	Mare	Aged	—	Hyperimmunised 26 days ago ..	39	—	1·0537	1·0264	144·2	1·88	—	—	½
17/6/08	,,	,,	,,	Good	Bled on June 9, 6 litres	28½	3·21	1·0445	1·0238	142·1	1·79	5·99	—	½
29/6/08	,,	,,	,,	Fairly good	,, ,, 18, 4 ,, ...	24	2·66	1·0428	1·0243	150·5	1·70	—	—	½
1/7/08	,,	,,	,,	,,	,, ,, 30, 5 ,, ...	20½	—	1·0372	1·0217	150·0	—	—	—	½
13/7/08	,,	,,	,,	,,	—	26	—	1·0430	1·0234	150·0	1·60	—	1·34463	⅔
14/7/08	,,	,,	,,	,,	Bled on July 13, 4 litres	22½	2·58	1·0392	1·0221	156·8	1·57	—	1·34388	⅔
9/6/08	1660	Geld.	Aged	—	Hyperimmunised 28 days ago ..	23	—	1·0444	1·0263	147·2	1·89	—	—	½
17/6/08	,,	,,	,,	Fairly good	Bled on June 9, 6 litres	18½	2·37	1·0367	1·0219	145·4	1·59	6·28	—	½
29/6/08	,,	,,	,,	Poor	,, ,, 18, 6 ,, ...	18½	2·61	1·0378	1·0230	145·8	1·80	6·08	—	⅓
1/7/08	,,	,,	,,	,,	,, ,, 30, 4 ,, ...	17	1·97	1·0353	1·0219	147·0	1·48	6·03	1·34283	⅖
13/7/08	,,	,,	,,	Rather poor	—	17½	2·30	1·0347	1·0208	145·9	1·58	—	1·34277	½
14/7/08	,,	,,	,,	Poor	Bled on July 13, 2 litres	17½	2·24	1·0356	1·0215	154·6	1·60	—	1·34279	⅖

9/6/08	1672	Geld.	Aged	—	Hyperimmunised 29 days ago ..	42	—	1·0574	1·0273	150·0	1·89	—	—	½
17/6/08	,,	,,	,,	Fairly good	Bled on June 9, 6 litres	32	—	1·0471	1·0236	154·0	—	—	—	½
29/6/08	,,	,,	,,	,,	,, ,, 18, 2 ,, ...	27½	3·05	1·0436	1·0229	149·6	1·64	6·02	1·34365	⅖
1/7/08	,,	,,	,,	,,	,, ,, 30, 6 ,, ...	24	2·34	1·0389	1·0208	150·3	1·40	6·04	1·34267	½
13/7/08	,,	,,	,,	,,	—	28	—	1·0437	1·0217	153·0	—	—	—	½
14/7/08	,,	,,	,,	—	Bled on July 13, 4 litres	24	2·42	1·0394	1·0201	158·6	1·44	—	1·34234	½
18/6/08	1293	Geld.	Aged	Fairly good	Hyperimmunised 27 days ago ..	27½	3·39	1·0464	1·0268	145·6	1·96	5·79	—	½
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	20½	2·78	1·0407	1·0236	148·8	1·71	5·89	—	½
30/6/08	,,	,,	,,	,,	Examined before bleeding	20	2·54	1·0403	1·0250	145·2	—	6·14	1·34723	½
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	16	2·05	1·0348	1·0218	146·0	—	—	—	½
13/7/08	,,	,,	,,	,,	Examined before bleeding	19	2·34	1·0373	1·0229	144·4	1·66	—	1·34382	⅔
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	16	2·10	1·0337	1·0212	146·4	1·54	—	1·34267	⅔
18/6/08	1972	Geld.	Aged	Fairly good	Hyperimmunised 24 days ago ..	31½	4·22	1·0519	1·0267	146·0	2·04	5·79	—	⅖
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	27	3·26	1·0464	1·0236	149·7	1·75	5·75	—	½
30/6/08	,,	,,	,,	,,	Examined before bleeding	26½	3·05	1·0463	1·0250	143·0	—	6·13	—	⅓
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	25	2·61	1·0438	1·0227	145·0	—	—	—	½
13/7/08	,,	,,	,,	,,	Examined before bleeding	27	3·17	1·0455	1·0245	146·7	1·72	—	1·34529	⅔
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	26	2·81	—	1·0226	150·0	1·60	—	1·34384	½

Serum Horses—Influence of Bleeding.—(*continued.*)

Date.	Number.	Sex.	Age.	Condition.	Remarks.	Blood.			Serum.					
						Volume of Blood Corpuscles.	Viscosity at 25° C.	Specific Gravity at 37° C.	Specific Gravity at 37° C.	Conductivity at 37° × 10.⁴	Viscosity at 25° C.	Surface Tension at 37° C.	Index of Refraction at 37° C.	Amount of Serum (Blood = 1).
18/6/08	3451	Geld.	6 yrs.	Fairly good	Hyperimmunised 26 days ago ..	33	3·67	1·0489	1·0239	147·4	1·73	5·65	—	½
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	28	3·19	1·0452	1·0214	150·3	1·56	—	—	½
30/6/08	,,	,,	,,	,,	Examined before bleeding	29	3·06	1·0459	1·0227	147·8	—	—	—	½
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	26	2·52	1·0412	1·0203	149·2	—	—	—	½
13/7/08	,,	,,	,,	,,	Examined before bleeding	28½	2·97	1·0444	1·0213	150·0	1·55	—	1·34323	⅔
,,	,,	,,	,,	,,	6,000 c.c. taken. Examined 2 hours after bleeding	30	3·00	1·0437	1·0200	152·5	1·46	—	1·34224	⅔
20/6/08	2270	Geld.	Aged	Good	Bled in past 80 days, 48,000 c.c. Bled 6,000 c.c. 2 days ago	16½	2·26	1·0352	1·0214	158·6	1·49	5·79	—	⅔
20/6/08	2903	,,	9 yrs.	Fairly good	Bled in past 80 days, 48,000 c.c. Bled 6,000 c.c. 2 days ago	23½	2·64	1·0416	1·0224	152·6	1·62	5·75	—	⅔
20/6/08	3091	,,	11 ,,	Good	Bled in past 80 days, 46,000 c.c. Bled 4,000 c.c. 2 days ago	17½	1·97	1·0355	1·0204	155·8	1·47	5·77	—	⅔
20/6/08	3172	,,	13 ,,	Exceedingly poor	Bled in past 80 days, 44,000 c.c. Bled 2,000 c.c. 2 days ago	22	2·75	1·0396	1·0217	150·0	1·59	6·03	—	⅔
22/6/08	3033	,,	15 ,,	Rather poor	Bled in past 82 days, 44,000 c.c. Bled 6,000 c.c. 4 days ago	17	2·55	1·0352	1·0214	148·7	1·59	5·67	—	⅔
22/6/08	3064	,,	13 ,,	Fairly good	Bled in past 82 days, 48,000 c.c. Bled 6,000 c.c. 4 days ago	20	2·24	1·0370	1·0208	151·2	1·43	5·46	—	½
22/6/08	3084	,,	11 ,,	Good	Bled in past 82 days, 48,000 c.c. Bled 6,000 c.c. 4 days ago	25	2·66	1·0375	1·0197	147·5	1·38	5·23	—	½

The alterations in the peculiarities of blood and serum caused by loss of blood are considerable.

After the operation also a diffusion of water with salts takes place through the walls of the vessels, like after infusion, but in the reverse direction, namely, from the tissues into the blood.

The consequence is a dilution of the latter, specially with regard to corpuscles and colloids.

The visible results are: Decrease of volume of erythrocytes, of viscosity, and specific gravity of blood and serum, and also of the index of refraction of the latter.

The conductivity increases because the quantity of colloids in the serum is less; they are much slower restituted than electrolytes with their comparative easy diffusibility. The behaviour of the surface tension is not yet sure; sometimes it decreases, sometimes it increases, the latter being probably the rule.

The alterations of blood and of serum caused by the loss of blood, amounting from 12 *to* 16 *litres within twelve or twenty days respectively, are in no instance restituted* ad integrum *in two weeks' time.*

The results obtained from normal, sick, and immune animals by the various methods are collected in the following tables:—

Table showing volume of blood corpuscles, see page 128.

„ „ viscosity of blood and serum, see page 129.

SPECIFIC GRAVITY OF BLOOD AND SERUM (AT 37° C).—AVERAGES FROM ALL VALUES.

	Normal.		Horse-Sickness.		Immune and Hyperimmune.	
	Blood.	Serum.	Blood.	Serum.	Blood.	Serum.
Number of examinations	48	50	90	100	18	20
„ animals	48	50	57	62	18	20
Average	*1·0521*	*1·0261*	*1·0494*	*1·0233*	*1·0500*	*1·0262*
„ for normal horses	1·0521	1·0261	1·0521	1·0261	1·0521	1·0261
Difference from average for normal horses	0	0	−0·26 %	−0·27 %	−0·20 %	+0·01 %
Maximum	1·0605	1·0306	1·0655	1·0300	1·0574	1·0296
Minimum	1·0447	1·0226	1·0412	1·0189	1·0444	1·0231
	%	%	%	%	%	%
Variation above average	0·80	0·44	1·53	0·65	0·70	0·33
„ below „	0·70	0·34	0·78	0·43	0·53	0·30
„ total	1·50	0·78	2·31	1·08	1·23	0·63
„ above normal average	0·80	0·44	1·27	0·38	0·50	0·34
„ below „ „	0·70	0·34	1·04	0·70	0·73	0·29
Values above average	46	48	42	56	50	55
„ below „	54	52	58	44	50	45
„ above normal average	46	48	23	10	28	55
„ below „ „	54	52	77	90	72	45

CONDUCTIVITY OF SERUM (AT 37° C.) × 10-4.—AVERAGES FROM ALL VALUES.

	Normal.	Horse-Sickness.	Immune and Hyper-immune.
Number of examinations	50	100	20
„ animals	50	62	20
Average	*146·8*	*142·3*	*146·1*
„ for normal horses	146·8	146·8	146·8
Difference from average for normal horses ..	0	−3·1 %	−0·5 %
Maximum	160·4	150·3	153·2
Minimum	140·5	130·9	141·9
	%	%	%
Variation above average..	9·2	5·6	4·8
„ below „	4·3	8·0	2·9
„ total	13·5	13·6	7·7
„ above normal average	9·2	2·4	4·4
„ below „ „	4·3	10·8	3·3
Values above average	40	47	45
„ below „	60	53	55
„ above normal average	40	13	35
„ below „ „	60	87	65

SURFACE TENSION OF SERUM (AT 37° C.).—AVERAGES FROM ALL VALUES.

	Normal.	Horse-Sickness.	Immune and Hyper-immune.
Number of examinations	42	23	10
„ animals	36	23	10
Average	*5·95*	*5·85*	*5·89*
„ for normal horses	5·95	5·95	5·95
Difference from average for normal horses ..	0	−1·7 %	−1·0 %
Maximum	6·45	6·17	6·27
Minimum	5·37	4·98	5·44
	%	%	%
Variation above average..	8·4	5·5	6·5
„ below „	9·8	14·9	7·6
„ total	18·2	20·4	14·1
„ above normal average	8·4	3·7	5·4
„ below „ „	9·8	16·3	8·6
Values above average	57	65	50
„ below „	43	35	50
„ above normal average	57	48	20
„ below „ „	43	52	80

COMPARISON OF THE COEFFICIENT OF OPTICAL REFRACTION WITH OTHER VALUES.

Horse.	Date.			Index of Refraction at 37° C.	Viscosity at 25° C.	Specific Gravity at 37° C.	Conductivity at 37° × 10^{-4}
3704	10/7/08	Horse-sickness	End	1·34213	1·49	1·0193	144·7
3631	29/6/08	,,	,,	1·34226	1·56	1·0199	141·7
3662	10/7/08	,,	Climax	1·34264	—	1·0191	135·1
3663	10/7/08	,,	End	1·34301	—	1·0191	139·5
3706	10/7/08	,,	,,	1·34308	1·62	1·0203	145·7
3663	13/7/08	,,	Past	1·34311	1·60	1·0218	148·0
3667	10/7/08	,,	End	1·34324	—	1·0193	138·1
3702	10/7/08	,,	,,	1·34358	1·58	1·0212	147·4
3705	10/7/08	,,	,,	1·34366	1·63	1·0198	140·8
3706	14/7/08	,,	,,	1·34372	1·68	1·0217	147·7
3704	13/7/08	,,	,,	1·34374	1·67	1·0218	144·3
3668	10/7/08	,,	,,	1·34395	—	1·0209	138·5
3338	29/6/08	,,	,,	1·34419	1·70	1·0228	142·1
3457	2/7/08	,,	,,	1·34423	—	1·0201	135·7
3475	2/7 08	,,	Past	1·34456	—	1·0242	147·8
3668	13/7/08	,,	,,	1·34473	1·69	1·0232	140·7
3627	2/7/08	,,	,,	1·34473	—	1·0243	149·0
3450	29/6/08	,,	,,	1·34481	1·96	1·0245	146·2
3685	Average for 6 values	Normal	—	1·34502	1·62	1·0238	149·2
3707	10/7/08	Horse-sickness	End	1·34529	1·79	1·0239	141·3
3682	Average for 6 values	Normal	—	1·34549	1·69	1·0247	148·9
3634	8/7/08	Horse-sickness	Past	1·34576	—	1·0243	150·9
3465	8/7/08	,,	,,	1·34642	—	1·0259	146·0
3340	8/7/08	,,	End	1·34653	—	1·0257	141·8
3701	10/7/08	,,	Past	1·34689	1·85	1·0259	147·0
3701	13/7/08	,,	,,	1·34743	1·99	1·0274	138·4
3400	10/7/08	,,	,,	1·34784	2·06	1·0274	140·3

The differences in the physical-chemical properties of blood and serum between normal horses, horses in different stages of horse-sickness, and immune horses are shown by the tables on pages 177, 178, and 179.

RESULTS.

Horses suffering from horse-sickness are distinguished by the following peculiarities from normal horses (average values) :—

Volume of blood corpuscles and viscosity of blood are supernormal during the climax, but considerably below normality during the end of the disease and a certain time after it. Specific gravity, viscosity, and conductivity of serum are lower than normal at the climax and at the end of the attack.

The differences between normal and immune horses are as follows :—

The average volume of blood corpuscles is lower than normal. The specific gravity is evidently subnormal, because the average is lower, and 72 per cent. of the values of immune and hyperimmune horses lay below the normal average. The same is the case with the surface tension of serum ; eight of ten values are lower than the normal average.