

## THE TRANSMISSION OF YELLOW FEVER

EXPERIMENTS WITH THE "WOOLLY MONKEY" (*LAGOTHRIX LAGOTRICHA* HUMBOLDT), THE "SPIDER MONKEY" (*ATELEUS ATER* F. CUVIER), AND THE "SQUIRREL MONKEY" (*SAIMIRI SCIREUS* LINNAEUS)\*

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PLATE 12

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In two previous publications (1, 2) from this laboratory it has been shown that certain *Cebus* monkeys can be infected with yellow fever virus but that the manifestations of disease are usually mild compared with those in *Macacus rhesus*. From time to time it has been possible to obtain specimens of other South American monkeys for experimentation.

### *Experiments with Lagothrix lagotricha Humboldt*

The Humboldt monkey, "woolly monkey," or "barrigudo," is a gentle creature but, unfortunately, it is not hardy. Many live only a short time in captivity. It is difficult to arrange a diet upon which they can thrive.

Attempts have been made to infect twelve young animals of this species with yellow fever virus. In three instances a fever has followed inoculation. *Lagothrix* 2 had a temperature of approximately 102° when on April 2, 1929, it was inoculated with Asibi strain virus. On April 17 the temperature reached 104.8°

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and blood was transferred to *Lagothrix* 3. On April 18 the temperature of No. 2 was still 104°, but it fell thereafter to normal and later to subnormal (96°). The animal was sacrificed on April 30; the autopsy showed nothing suggestive of yellow fever. *Lagothrix* 3, inoculated on April 17, had a temperature of 105.8° on April 20; there was fever also on the following 2 days. On April 20 blood was transferred to *Lagothrix* 5 and mosquito Batch 177 was allowed to feed. No. 5 did not react. On May 8 Batch 177 fed on *Rhesus* J1. The latter showed no fever during 16 days of observation; it was then given an immunity test but continued afebrile. The control for the immunity test, *Rhesus* J2, died with yellow fever. On May 2 *Lagothrix* 3 was moribund; he was bled and sacrificed. There were no lesions suggestive of yellow fever. Tests with sera in 3 cc. amounts from No. 2, taken 12 days after the last febrile access, and from No. 3, taken 9 days after the last fever, showed protection against virus. Serum from No. 2 also protected in a dose of 2 cc., but a like quantity from No. 3 failed; the control which received normal *Lagothrix* serum died on the third day.

On July 27, 1929, *Lagothrix* 11 was inoculated with citrated blood containing virus of the Asibi strain. On August 8 the temperature reached 106°, and blood was transferred to *Rhesus* J10. The latter showed a slight fever on August 12 and for 6 days thereafter. The maximum temperature was 104.8°. On September 13 he was given a test dose of virus, which he survived without showing fever.

*Ateles ater* 2 was injected subcutaneously with infectious liver emulsion, containing Asibi strain virus, on May 29, 1929. The temperature of the animal at that time was 102.9°. On June 3 the temperature had risen to 103.8° and mosquito Batch 207 was allowed to feed; the same batch was applied on June 4, but probably very few mosquitoes fed at that time. On June 7 the temperature of No. 2 had dropped to 100.9°; the animal had no appetite, was weak and obviously ill. He was sacrificed, but no gross lesions suggestive of yellow fever were found. Microscopically the liver appeared uninjured and the parenchyma was stocked with glycogen. The kidneys showed a slight cloudy swelling, and two focal abscesses were noted in the section examined. Liver emulsion from *A. ater* 2 was inoculated into *Rhesus* J3 and caused the death of the animal on June 15, the eighth day after inoculation. The gross and microscopic pictures were typical of yellow fever. Mosquito Batch 207 was allowed to feed on *Rhesus* J7 on July 4. The animal died on July 9 with typical yellow fever.

None of the other "woolly monkeys" have exhibited any reaction to yellow fever virus. However, it is only fair to state that three died from undetermined causes within a week after inoculation. Protection tests have been made with sera from *Lagothrix* Nos. 6, 7, 11, and 12. *Rhesus* monkeys were protected by serum from the last three. Serum from No. 6 failed to protect; this animal had been fed upon by mosquitoes, but never showed the slightest reaction. *Lagothrix* 11 has

already been discussed. *Lagothrix* Nos. 7 and 12 had been inoculated with virulent blood from animals experimentally infected with the Asibi strain, but they had not shown a febrile reaction. However, serum from No. 7 gave perfect protection to *Rhesus* J8, while that from No. 12 enabled *Rhesus* J13 to survive.

#### *Experiments with Ateles ater F. Cuvier*

The spider, or "aranha," monkey, is a long-legged, ungainly creature, but gentle and not difficult to handle. It lives well in captivity. Four specimens have been used in the course of our experiments. Nos. 1 and 4 were inoculated with infectious blood, Asibi strain, but did not show a temperature reaction. However, the serum of No. 4, taken 14 days after inoculation, protected a *rhesus* monkey against virus (see Table III).

*Ateles ater* 3 was fed upon, September 16, 1929, by two batches of mosquitoes infected with the S.R. strain. On September 20 and 21 the animal showed fever; the highest temperature noted was 104.5°. *M. rhesus* J14 was injected with 6 cc. of blood on September 20. He died on September 25 with typical gross and microscopic lesions of yellow fever. Mosquito Batch 249 was also allowed to feed on September 20. On September 23 *A. ater* 3 could not stand up, because of tetany in the limbs. It was found dead on the morning of September 24. The lobule peripheries of the liver were paler than normal, but the organ did not approach in color the typical boxwood of yellow fever. There was a faint icterus discernible in the intima of the aorta. There were a few brownish streaks, probably of changed blood, on the gastric mucosa. Bladder urine contained 0.3 gm. of albumin per liter. Other findings at autopsy appeared to have no relation to a possible yellow fever. The microscopic examination revealed no necrosis in the liver; there was a little fat around the portal spaces and a moderate engorgement of the vessels; a few leucocytes were present and the Kupffer cells were loaded with clumps of dark pigment (the blood had not been examined for malarial parasites). The kidneys showed a moderate cloudy swelling and some congestion of the vessels.

On October 10, mosquito Batch 249 (engorged on *A. ater* 3, September 20) fed on *Rhesus* J18. Subsequently the monkey had fever for 2 days, but survived. On October 26 the same batch fed on *Rhesus* J20. The animal died with typical yellow fever on November 2.

#### *Experiments with Saimiri sciureus Linnaeus*

The squirrel monkey or "macaco cheiro," is but little larger than the marmoset and almost as active. Of the Brazilian species thus far used

for experimentation it seems to be the most easily infected and is the only one which shows hepatic necrosis with any regularity.

Up to the present time thirty *Saimiri* monkeys have been either fed upon by infected mosquitoes or inoculated with blood or liver from animals thought to be infected. Not all have reacted, and of those that died or showed fever, not every one has been proved to have had yellow fever. Table I lists those animals which showed suggestive lesions at autopsy, those from which positive transfers were made to *Macacus rhesus*, and those whose sera after recovery gave protection against yellow fever virus.

Only a limited number of protocols will be given in full. Supplementary data will be found in the accompanying charts, tables, and schematic representations of transfers.

*Saimiri* 3 was inoculated intraperitoneally on March 8, 1929, with 4 cc. of citrated blood, containing Asibi strain virus, from *M. rhesus* B2. On March 8 and 9 the temperature ranged from 102° to 102.7°; on March 12 it reached 103.9° and in the morning of March 13 it was 104°. On both of the latter days blood was transferred to *Saimiri* 4. *Saimiri* 3 was found dead on March 14. At autopsy jaundice was doubtful. The heart and lungs were negative. The liver in general was pale; the lobule centers appeared darker, with yellow (fatty) peripheries. The spleen seemed normal. The kidneys were much injected, with a trace of subcapsular hemorrhage. The stomach contained changed blood mixed with food. Microscopic examination showed the liver architecture completely disorganized. There was a severe necrosis, irregularly affecting the midzones. Leucocytes, both polymorphonuclear and mononuclear, were present in great numbers. There was congestion of all blood spaces, and a little diffuse fatty infiltration (Figs. 1 and 2). The kidneys showed injection of vessels and a suggestion of cloudy swelling.

*Saimiri* 13 was fed upon May 16, 1929, by mosquito Batch 154, infected with the Asibi strain. The initial temperature was 102.6°. On May 18 the temperature reached 103.9°, on May 19 it was 104.2°, and on the following day 105°. There was fever until May 22, again on May 24, and from May 27 to 30. On 3 successive days, May 18, 19, and 20, blood was transferred to *Rhesus* R6 and *Saimiri* 14; mosquito Batch 195 was allowed to engorge on these same days. *M. rhesus* R6 died on May 24 with typical yellow fever. Mosquito Batch 195 was applied to *Rhesus* J5 on June 12; the animal showed no febrile reaction, but later survived its immunity test. On June 19 the mosquitoes were injected subcutaneously into *Rhesus* J6; the latter had fever for 3 days and was killed when moribund with yellow fever, on June 27. *Saimiri* 13 was bled for a protection test on June 7 and on the following day was given a test dose of virus. On June 10 and 12 the temperature reached 104° and blood was transferred to *Rhesus* J4 upon two occasions. The *rhesus* showed no reaction. On June 22, No. 13 was bled again. The results of protection tests are indicated in Table III.

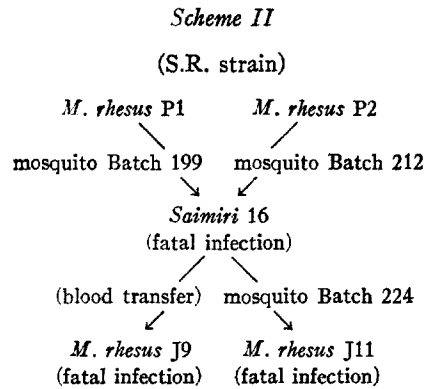
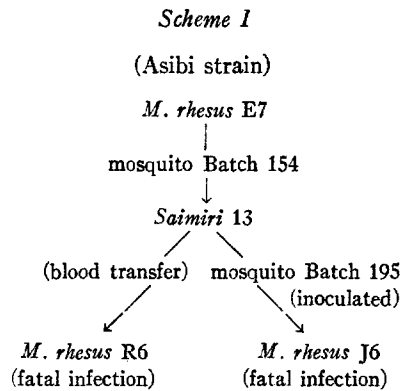
*Saimiri* 16 was fed upon on July 12, 1929, by mosquito Batches 199 and 212, infected with the S.R. strain. On July 16 its temperature reached 104° and blood was transferred to *Rhesus* J9 and *Saimiri* 17; mosquito Batch 224 was allowed to

TABLE I  
*Yellow Fever Infections in Saimiri sciureus*

<i>Saimiri</i> No.	Mode of infection	Virus strain	Out-come	Criteria of infection
1	Inoculation of blood	Asibi	D	Necrosis and fat in liver. Cloudy swelling in kidneys.
2	"	"	D	Liver necrosis and disorganization. Cloudy swelling in kidneys.
3	"	"	D	Febrile reaction. Gastric hemorrhage. Severe liver necrosis.
5	"	"	D	Febrile reaction. Virus transferred back to <i>rhesus</i> .
6	Mosquito feeding	"	R	Febrile reaction. Serum gave positive protection test. Mosquitoes fed on No. 6 produced immunity in <i>rhesus</i> monkey.
9	Inoculation of blood	"	R	Transfer from No. 6. Serum gave positive protection test.
13	Mosquito feeding	"	R	Febrile reaction. Virus transferred back to <i>rhesus</i> by blood inoculation and by mosquitoes. Serum gave positive protection test.
16	"	S.R.	D	Febrile reaction. Gastric hemorrhage. Liver necrosis. Virus transferred back to <i>rhesus</i> by blood inoculation and by mosquito feeding.
18	Inoculation of blood	Asibi	D	Liver necrosis. Cloudy swelling and many casts in kidneys.
20	"	"	R	Febrile reaction. Serum protective.
22	Mosquito feeding	"	D	Febrile reaction. Virus transferred back to <i>rhesus</i> by blood inoculation and by mosquitoes. Liver necrosis.
23	"	S.R.	R	Febrile reaction. Virus transferred back to <i>rhesus</i> .
25	Inoculation of blood	"	S	(Transfer from No. 23.) Febrile reaction. Liver necrosis.
27	Inoculation of liver emulsion	"	D	(Transfer from No. 25.) Febrile reaction. Liver necrosis.
28	Inoculation of blood	"	D	(Transfer from No. 27.) Liver necrosis.

D = died. R = recovered. S = sacrificed.

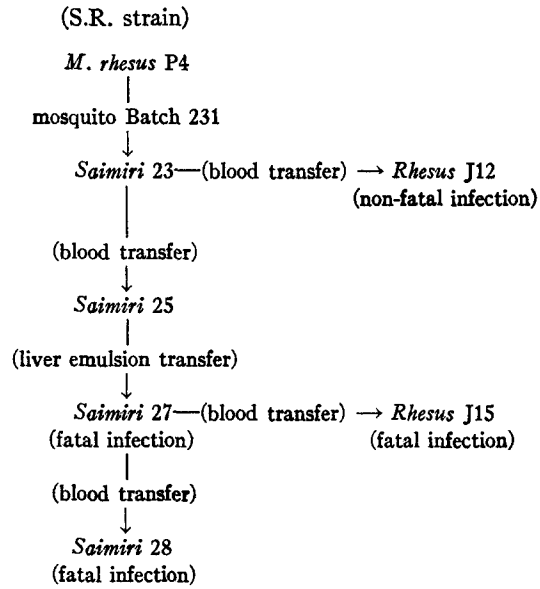
feed. On July 17 the temperature of No. 16 dropped to 94°, and it was sacrificed when moribund. There was a suggestion of icterus in the tarsal plates and in the intima of the aorta. The liver was friable, very pale, and fatty. The stomach contained a small amount of definite black vomit. The other organs did not



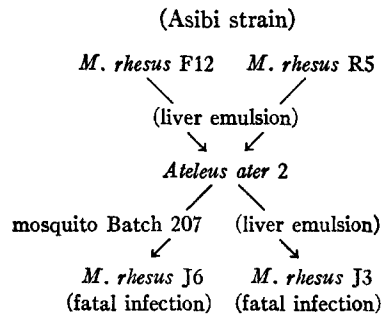
appear grossly abnormal. Microscopic sections showed the liver columns to be jumbled. There was severe necrosis, more especially in the mid-zones, but even here there were occasional fairly normal nuclei to be found. There appeared to have been considerable removal of necrotic material. There was a great invasion of leucocytes, principally polymorphonuclears. Congestion was general and

small hemorrhages quite numerous. The kidneys showed congestion and a mild cloudy swelling. *M. rhesus* J9, which had received blood from this *Saimiri*, died with typical yellow fever on July 20. Mosquito Batch 224 fed on *Rhesus* J11 on

*Scheme III*

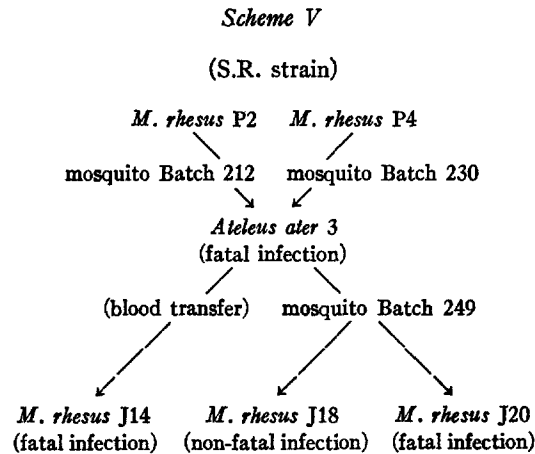


*Scheme IV*



September 10; the animal was found dead on September 15. The lesions were typical of yellow fever.

*Saimiri* 23 was fed upon September 9, 1929, by mosquito Batch 231, infected with the S.R. strain. On September 13 the temperature reached 104.4° and on September 14 it was 104°. Blood was transferred to *Saimiri* 25 and to *Rhesus* J12. The latter had fever on the sixth and seventh days after inoculation, but recovered. No. 25 had fever on September 22, 23, and 24, the maximum being 104.7°. On September 24 the animal was killed and a transfer of liver emulsion made to *Saimiri* 27. No. 25 had a definite icterus in the tarsal plates. The liver was extremely friable; the general color of this organ was orange, with certain areas apparently hemorrhagic; the normal markings were obliterated. The stomach contained a food bolus smeared with changed blood. Microscopically, the liver



showed severe necrosis, midzonal, but usually extending more toward the portal spaces; there were a trace of fat present and a great many leucocytes. The kidneys showed a little cloudy swelling, with a few early casts.

*Saimiri* 27, inoculated with liver from No. 25 on September 24, had a temperature of 104.1° in the afternoon of the 26th. On September 27 the morning temperature was 104.5° and the afternoon temperature 94.5°. Blood was transferred to *Saimiri* 28 and to *Rhesus* J15. No. 27 died during the night of September 27-28. None of the organs were remarkable except the liver, which was very friable and of a uniform yellowish-gray color. Microscopically, the liver showed some necrotic cells, especially in the mid-zones, and a heavy, widespread infiltration of fat in large globules; congestion was moderate. Kidney changes were thought to be largely postmortem. *M. rhesus* J15, inoculated on September 27, had a fever of 105.4° on October 3. On October 4 the morning temperature was 104.8° and the



afternoon temperature 101.9°. The animal was very ill and was sacrificed; the autopsy revealed gross and microscopic lesions of yellow fever.

*Saimiri* 28 had a temperature of 102° when inoculated; the maximum thereafter was 103.6°, but the animal was found dead on October 3. There was a definite icterus of tarsal plates and intima of aorta. The liver was very friable; it was the

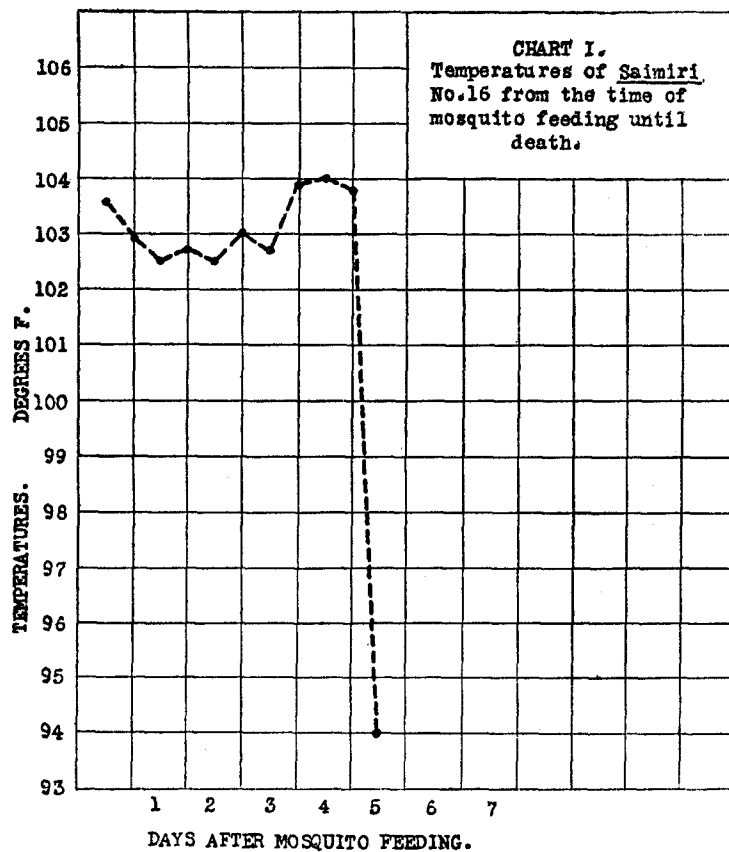


CHART I

color of putty except for a little superficial mottling. The kidneys were swollen, the cortices opaque, the vessels injected. The stomach contained a little changed blood. Microscopically the liver showed only a few cells approaching normal in the portal spaces. Necrosis was very extensive; the involved parenchyma showed disintegration of cytoplasm, karyorrhexis of nuclei, etc. There were congestion,

infiltration of fat, and invasion of leucocytes. The kidneys showed postmortem changes.

*Saimiri* 23 was given an immunity test with Asibi strain virus on September 28, a fortnight after the last fever. On October 3 the temperature rose to 104.2° and blood was transferred to *Rhesus* J16. The latter never reacted. Serum from

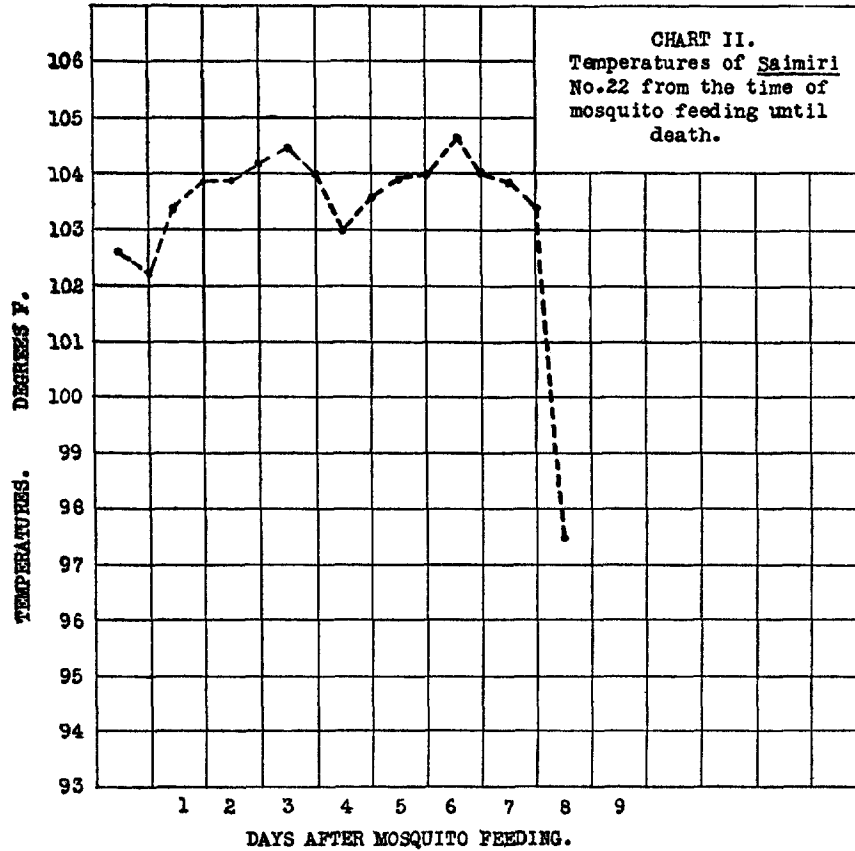


CHART II

No. 23 proved to be highly protective against yellow fever virus (*Rhesus* J19, Table III).

#### Pathology

Although two of the spider monkeys (*Ateles ater*) became exceedingly ill following the introduction of yellow fever virus, the lesions at

autopsy were not comparable to those found in human beings and in *rhesus* monkeys which have died with the disease.

A considerable number of *Saimiri* monkeys have succumbed to

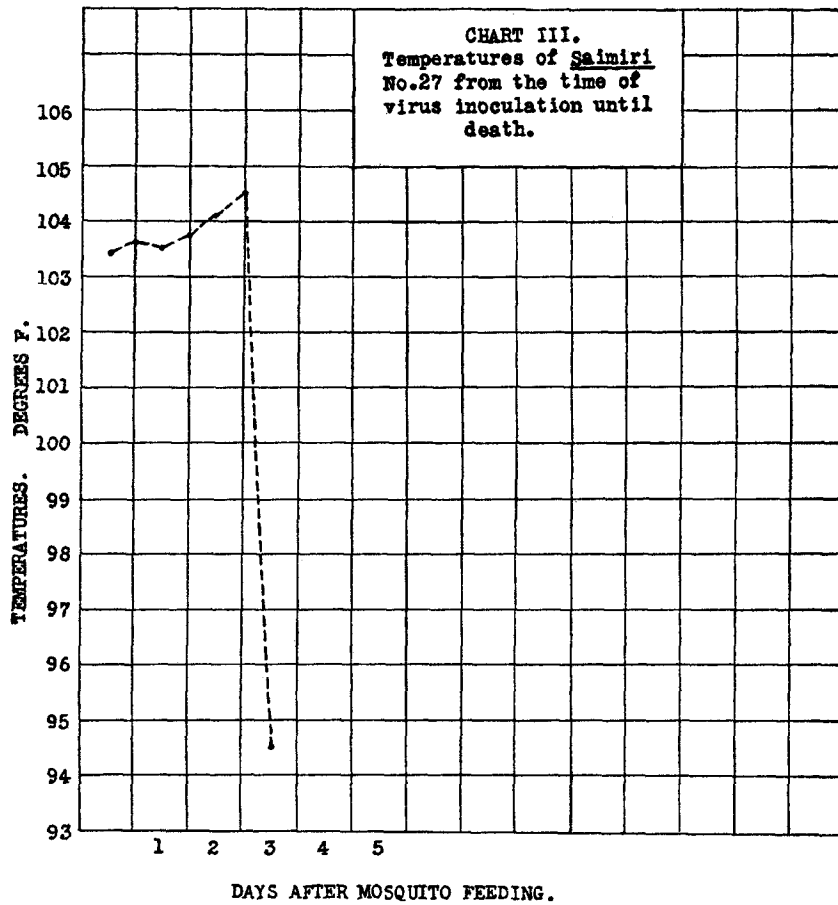


CHART III

yellow fever infections. In some of these fatal cases the gross appearances at autopsy were quite typical of yellow fever.

The liver was orange, yellow, or grayish in color, obviously fatty, and very friable. At several autopsies changed blood was found in the stomach. Icterus

TABLE II  
*Temperature Reactions of Infected Saimiri sciurens*

Saimiri No.	Source of infection		Strain	Temperatures A.M. and P.M.												
	Blood or tissues from	Mosquito Batch No.		Initial day	1	2	3	4	5	6	7	8	9	10	11	12
1	<i>Rhesus</i> P13 and P6	—	Asibi	—	102.0 102.6	102.6 102.8	102.4 102.1	103.8 103.7	103.5 103.6	103.2 103.0	102.8 103.7	103.4 103.2	97.2 S			
2	<i>Rhesus</i> B2	—	"	103.0 102.7	101.9 102.0	102.1 103.7	103.5 103.0	102.6 102.4	D —							
3	<i>Rhesus</i> B2	—	"	102.7 102.0	102.1 102.5	103.0 103.8	103.7 103.6	103.4 103.9	104.0 103.0	D —						
5	<i>Rhesus</i> E7	—	"	103.8 103.7	103.8 103.9	104.2 102.0	103.7 102.0	101.8 102.1	102.6 102.7	102.4 102.0	97.2 100.0	98.6 100.0	D —			
6	—	135	"	102.9 102.2	101.9 102.2	102.5 102.8	102.4 102.4	101.8 102.0	102.1 102.3	102.4 102.5	100.2 101.2	100.8 101.9	102.9 103.2	103.4 104.6	104.0 103.7	103.2 101.8*
13	—	154	"	102.6 102.2	102.0 102.2	103.9 102.6	103.4 104.2	104.4 105.0	104.8 104.5	104.2 104.0	103.9 103.8	104.6 104.0	103.9 103.6	103.5 —	104.2 104.0	104.4 104.2*
14	<i>Saimiri</i> 13	—	"	—	103.2 102.6	102.4 103.0	103.7 104.2	D —								
16	—	199 & 212	S.R.	—	102.9 102.6	102.7 102.6	103.0 102.8	103.9 104.0	103.8 94.0S							



TABLE III  
Immunity Tests with Sera from South American Monkeys

Experi- ment No.	Test animal <i>M. rhesus</i> No.	Test strain of virus	Brazilian animal tested	Original infection strain	Amount of serum used	Interval between in- roduction of virus and withdrawal of serum	Interval between last fever and withdrawal of serum	Reaction of <i>rhesus</i> to test			
								Length of fever	Maxi- mum tempera- ture	Out- come	Days of fever (from infection of expt.)
I	L1	Asibi	Normal <i>Saimiri</i> (Control)	—	cc.	days	days	days	*F.	Outcome	Days of fever (from infection of expt.)
	L2	"	<i>Saimiri</i> 10	Asibi	2	—	—	2	104.4	D	4
	L5	"	<i>Saimiri</i> 6	"	2	17	16	1	104.8	D	4
	L3	"	<i>Lagothrix</i> 3	"	2	27	16	5	104.9	R	—
II***	L4	"	<i>Lagothrix</i> 2	"	2	15	9	1	104.2	D	4
	L10	"	Normal <i>Lagothrix</i> (Control)	—	2.7	28	12	2	104.1	R	—
	L11	"	<i>Lagothrix</i> 3	Asibi	3	15	9	5	105.2	R	—
	L12	"	<i>Lagothrix</i> 2	"	3	28	12	4	105.0	R	—
III	J8	"	<i>Lagothrix</i> 7	"	3	14	No fever	—	103.5	R	—
	L9	"	<i>Lagothrix</i> 6	"	3	15	No fever	1	104.7	D	4
	L8	"	<i>Saimiri</i> 9	"	1.8	20	No fever	7	105.0	R	—
	L7	"	<i>Saimiri</i> 13	"	2	22*	No fever	10	105.0	R	—
	L6	"	<i>Saimiri</i> 13	"	3	{ 39 14**	8	5	104.3	R	—
	L13	"	Normal <i>Saimiri</i> (Control)	—	3	—	—	1	105.6	D	4
	L14	"	<i>Aotus</i> 1	Asibi	3	17	No fever	5	105.2	R	—
	L15	"	<i>Lagothrix</i> 12	"	3	17	No fever	7	105.0	R	—
L16	"	<i>Lagothrix</i> 11	"	3	27	14	—	103.7	R	—	
L17	"	<i>Saimiri</i> 17	S.R.	3	15-23	No fever	3	104.9	D	8	
L18	"	<i>Saimiri</i> 20	Asibi	3	31	14	7	104.7	R	—	
M5	"	—	—	No serum injected	—	—	2	104.9	D	6	

IV	M4	Asibi	Normal <i>Aotus</i> (Control)	—	2.4	—	—	6	105.5	R	—
	M3	"	Normal <i>Alouatta</i> (Control)	—	3	—	—	7	105.9	R	—
	M1	"	Normal <i>Cebus albifrons</i>	—	3	—	—	2	105.9	D	5
	M2	"	(Control)	Asibi	3	14	No fever	—	103.8	R	—
	L19	"	<i>Ateles ater</i> 4 <i>Cebus albifrons</i> 3	"	3	31	Chronic fever	2	104.7	R	—
V	M6	"	<i>Aotus</i> 2****	"	2.4	16	No fever	15	105.2	S	17
	M7	"	<i>Cebus albifrons</i> 4****	"	2.2	14	No fever	—	103.7	R	—
	M8	"	<i>Alouatta</i> 2****	S.R.	3	18	13	—	103.5	R	—
	M9	"	<i>Saimiri</i> 23	"	1.9	38	32	—	103.6	R	—
	M10	"	Normal <i>Ateles ater</i> (Control)	—	2.8	—	—	2	105.4	D	6

\* Blood taken before second inoculation of virus (immunity test).

\*\* Blood taken 39 days after original inoculation and 14 days after immunity test.

\*\*\* Experiment includes repetition of tests on *Lagothrix* Nos. 2 and 3, using larger amounts of serum than in Experiment I.

\*\*\*\* Serum was taken from these animals, before they were given virus, for use in Experiment IV.

D = death. R = recovered. S = sacrificed; animal had tuberculosis.

was sometimes noted in the tarsal plates and in the intima of the aorta. Microscopically, necrosis and a great disorganization of architecture were often found in the liver. The hepatic lesions had not the typical and clear-cut distribution noted in *Macacus rhesus*, but apparently affected primarily the mid-zone. There was a great invasion of leucocytes, of both mononuclear and polymorphonuclear types. Nuclei of degenerated cells were swollen and the space between nucleolus and cell membrane was usually almost lacking in chromatin. Although the routine fixation was in formaldehyde solution, hematoxylin and eosin staining sometimes showed intranuclear eosinophilic bodies which probably represented the inclusions described by Torres (3). There were noted at times a severe congestion of the vessels and occasional small hemorrhages. The kidneys showed varying degrees of parenchymatous degeneration, with cast formation; congestion was frequently present.

#### DISCUSSION

It has been possible to pass yellow fever virus from *M. rhesus* to the three species of Brazilian monkeys considered in this report and back to *M. rhesus*. The "woolly monkey," *Lagothrix lagotricha*, has proved relatively refractory to virus inoculations. Two "spider monkeys," *Ateles ater*, have been infected, but the lesions produced have not been typical of yellow fever. About 50 per cent of the "squirrel monkeys," *Saimiri sciureus*, used in experimentation undoubtedly have become infected and many have died; lesions at autopsy have been very suggestive of yellow fever.

At the present time there is very little in the literature relative to infection experiments with the species used by us. Aragão has mentioned in one of his papers (4) that Dr. José Teixeira had secured infections of *Saimiri* monkeys in the Instituto Oswaldo Cruz in Rio de Janeiro. In the discussion of Hindle's paper before the Royal Society of Tropical Medicine and Hygiene, Sir James Kingston Fowler (5) said that as early as 1914 the West African Yellow Fever Commission had considered the use of New World monkeys in the study of yellow fever.

In Table III are noted the protection tests of sera from certain species not considered in the text. Some of these will be taken up in future publications. The "caiarára" monkey, *Cebus albifrons*, was discussed in a previous paper (2). At that time we had no data on the protective properties of the normal serum from this species. The serum of *C. albifrons* 4 was tested before the inoculation of virus (Table III, Experiment IV) and again 14 days after inoculation. The animal became immunized even though no fever developed. Six days after



inoculation, when the monkey had a temperature of 103.5°, blood was taken for transfer to *M. rhesus* J17. The latter did not react.

As noted in the protocols, two *Saimiri* monkeys which were known to have been infected (Nos. 13 and 23), were given a second inoculation of virus. In each instance the temperature subsequently rose to 104°, or higher, but apparently no virus reached the blood stream, because transfers of blood to *M. rhesus* produced no infections.

#### SUMMARY

1. *Saimiri sciureus* has been infected with yellow fever virus, both by the inoculation of infectious blood and by the bites of infective mosquitoes. Some of the monkeys have died, showing lesions, including hepatic necrosis, suggesting yellow fever as seen in human beings and in *rhesus* monkeys. Virus has been transferred back to *M. rhesus* from infected *Saimiri* both by blood inoculation and by mosquito bites. The virus undoubtedly has been maintained through four direct passages in *Saimiri*. Reinoculations of infectious material into recovered monkeys have not given rise to invasion of the blood stream by virus. Sera from recovered animals have protected *M. rhesus* against the inoculation of virus.

2. It has been possible to pass the virus to and from *Ateles ater* by the injection of blood or liver and by the bites of mosquitoes. The livers from two infected animals have shown no necrosis. The serum from one recovered monkey proved to be protective for *M. rhesus*.

3. Only three out of twelve *Lagothrix lagotricha* have reacted to yellow fever virus by a rise in temperature. Probably none have died as a result of the infection. In only one instance has the virus been transferred back to *M. rhesus*. The sera of recovered animals have had a protective action against yellow fever virus.

The writer gratefully acknowledges the help of his fellow workers, Dr. J. A. Kerr and Mr. Raymond C. Shannon, in some of the experiments here reported.

The identification of the "squirrel monkey," *Saimiri sciureus*, was given by Mr. Tate, of the American Museum of Natural History, in a personal communication to Dr. Sawyer.

## REFERENCES

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## EXPLANATION OF PLATE 12

FIGS. 1 and 2. Liver tissue of *Saimiri* monkey No. 3, which died following inoculation with yellow fever virus of the Asibi strain. Hematoxylin and eosin. Fig. 1  $\times 145$ . Fig. 2  $\times 462$ .

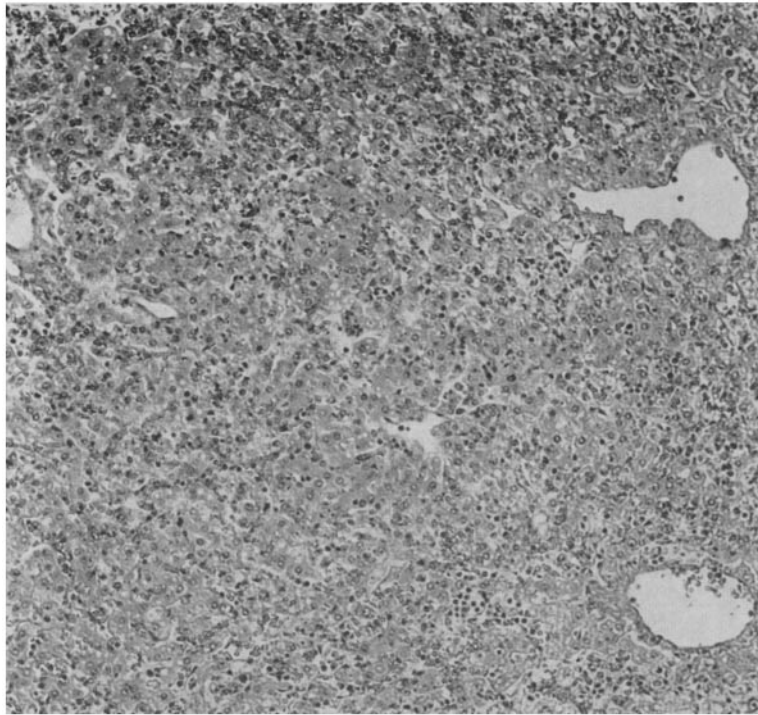


FIG. 1

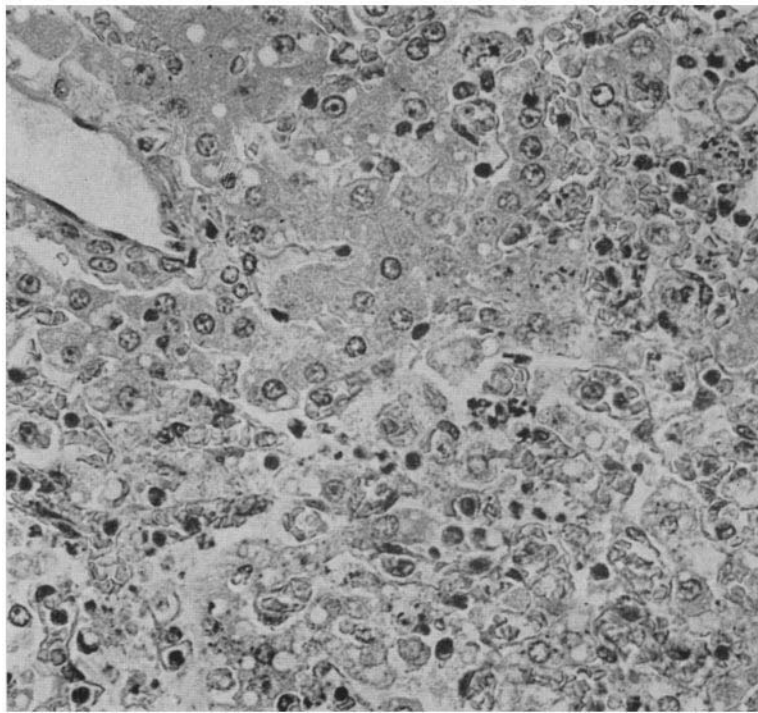


FIG. 2

(Davis: The transmission of yellow fever)