

# EFFECTS OF ORAL ADMINISTRATION OF A FUEL CELL PRODUCT WATER TO MACACA MULATTA

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#### Foreword

This work was performed under Project No. 6302, "Toxic Hazards of Propellants and Materials," Task No. 630201, "Toxicology," at the request of the Manned Spacecraft Center, National Aeronautics and Space Administration, Houston, Texas, under NASA-MSC Contract T-31248-G. Dr. Walter W. Kemmerer, Jr., served as contract monitor for NASA-MSC and Dr. Kenneth C. Back as technical consultant for the Aerospace Medical Research Laboratories. The work was accomplished during January and February 1965 in the Toxic Hazards Branch, Physiology Division, Biomedical Laboratory. The assistance rendered by members of the Veterinary Medicine Division, Aerospace Medical Research Laboratories, and the medical technologists of the Toxic Hazards Research Unit, Aerojet-General Corporation, is gratefully acknowledged.

This technical report has been reviewed and is approved.

WAYNE H. McCANDLESS Technical Director Biomedical Laboratory Aerospace Medical Research Laboratories

## Abstract

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A fuel cell product water, proposed as a supply of drinking water in space vehicles, was administered to *Macaca mulatta* at a rate of 35 ml per kg twice daily as the sole source of fluid intake for a 14-day period. Two of eight animals exhibited body weight and hematologic changes that were directly related to enteric disturbances. These, however, were apparently of a spontaneous nature since one of two control animals was also affected, although somewhat less severely. No apparent subacute oral toxicity of the fuel cell product water was demonstrated in monkeys. This indicates that product water having similar chemical and physical properties should present no serious hazard to humans when consumed as drinking water for short periods of time.

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#### SECTION I

## Introduction

The water that is a by-product of the electrochemical reaction within fuel cells has been proposed as a supply of drinking water in space vehicles. Contaminants contributed by the cell materials, however, may show considerable variation in both quantity and quality depending on the accumulated time of operation and the load placed on the cell.

The Gemini fuel cell developed by the General Electric Co., West Lynn, Massachusetts, contains membranes of a polystyrene sulfonic acid polymer treated with an antioxident, tertiary butyl hydroquinone. These membranes separate the gaseous hydrogen and oxygen that react within the matrices of the polymer. In the early stages of operation, there is leaching of tertiary butyl hydroquinone and unpolymerized polystyrene sulfonic acid. This is followed by a period of minimum concentration of contaminants. With continued operation, there is an increase in amount due to breakdown of the membrane at the molecular level. Data received from the Manned Spacecraft Center revealed a total solids content of 65 mg per liter, of which 49 mg were volatile and considered primarily organic, in water produced after approximately 100 hours of operation of the same cell that was the source of the water used in this study. These amounts had risen to 412 mg per liter and 400 mg per liter, respectively, after about 680 hours.

Unpublished studies conducted for the General Electric Co. by the Dow Chemical Co., Midland, Michigan, revealed no evidence of subacute toxicity for mice when product water from a similar fuel cell was used as the sole source of drinking water for 30 days, even when concentrated to one-tenth the original volume. Soluble polystyrene sulfonic acid was identified as the major component of the soluble residue and cellulose as the major insoluble material in the water used.

The present study was undertaken using monkeys to determine any subacute toxic effects of the fuel cell product water.

#### SECTION II

## Method

The product water was supplied by the Manned Spacecraft Center on 18 Jan 1965. Fifteen 2.5-liter samples of aliquots collected between 11 Oct and 4 Nov 1964 were furnished. The collection period covered a span of approximately 200 to 750 hours of operation of the cell.

The samples were pooled by mixing in two 5-gallon-capacity plastic carboys. The pooled specimen had a weakly acid taste and a faint greenish-yellow color. A small amount of suspended solids was present, either as white stringy material or light and dark colored particulate matter. Microbiological, chemical, and organoleptic analyses of the pooled product water were conducted by the Biospecialties Branch, Physiology Division, Biomedical Laboratory, and the results reported as follows:

Microbiological Analysis –

Total Plate Count (at dilutions from 10<sup>-1</sup> to 10<sup>-5</sup>): negative.

nemical	and	Organoleptic	Analysis –
nH		2.83	

pH	2.83	
Conductivity	690.00	µmhos/cm
Nitrate N	2.1	ppm
Ammonia N	2.0	ppm
Chlorides	9.3	ppm
Sulfates	8.0	ppm
Phenols	< 0.04	ppm
Barium	5.5	ppm
Iron	0.2	ppm
Manganese	0.2	ppm
Odor	accep	table
Color:		
Apparent	33	units (approximate)
True	10	units (approximate)
Turbidity	5	Jackson units (approximate)

Ten male *Macaca mulatta* monkeys weighing between 1.9 and 3.2 kg were used in this study. Two of these, A40 and A70, were randomly selected to serve as controls and were given tap water rather than fuel cell product water. The remaining eight animals, A44, A46, A48, A54, A60, A62, A68, and A74, were given the product water. The ten monkeys were selected by sex and weight from a group of approximately 35 animals recently released from a 90-day quarantine period following procurement. Their general condition was good, although there had been a high incidence of respiratory infections and enteritis during the quarantine period and sporadic cases of enteritis were still evident in other animals.

The animals were housed in individual hanging wire-mesh cages in the same room as the remainder of the group from which they were selected. Water was available ad libitum during the pre- and post-administration observation periods. During the period of administration of fuel

cell product water or tap water, however, no other water source was available. A uniform diet was fed during the entire period of the study. The animals were given Purina Monkey Chow in the morning and an apple in the afternoon. The amount of chow given was based on the animal's appetite as determined by the caretaker. During the period of product water administration, the animals were fed shortly after the water was given.

The pooled product water, or tap water in the case of control animals, was administered for a 14-day period at a rate of 35 ml per kg twice daily. Animals were weighed on the first and eighth days of administration to determine the volume to be given. Administration was accomplished over a period of approximately 15 seconds by use of a size 8 French disposable plastic infant feeding tube passed via the nasal route and a 100-ml syringe.

Hematologic and body weight data were acquired on all animals 13 (6 Jan 1965) and 7 (12 Jan 1965) days prior to, and 1 (2 Feb 1965) and 10 (11 Feb 1965) days following administration of product water. Body weights were obtained by having a caretaker hold the animal while standing on a physician's office-type scale and subtracting the caretaker's weight from the gross weight obtained. Blood specimens were obtained by femoral vessel puncture. A portion of the specimen was placed in a tube containing a small amount of heparin and the remainder in a tube without anticoagulant. The following determinations were made: white cell count, white cell differential, red cell count, packed cell volume, hemoglobin concentration, sodium, potassium, calcium, inorganic phosphorus, alkaline phosphatase, lactic dehydrogenase (LDH), serum glutamic oxalacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), serum protein, serum albumin, and serum globulin. Routine clinical methods were used in making these determinations. These are shown in the introduction to the individual animal data (Appendix).

Additional data were collected on several animals following the completion of the original protocol. Clinical observations were confined to those days when the additional blood specimens were collected. Following the collection of the 10-day postadministration data, however, the animals were moved to new quarters, placed in smaller cages, fed a variety of fruit and vegetables, and were exposed to subnormal room temperature for several days due to heating system failure.

# SECTION III Results

No difficulty was encountered in administering the water to the animals. One monkey regurgitated several ml during administration on one occasion and on another occasion an animal regurgitated while eating. In one instance, a control animal (A70) exhibited symptoms of gastric discomfort for several hours after eating.

Body weight and hematologic data acquired on the individual animals are given in the Appendix. Clinical observations are included.

Animal A48 in the product water group had a marked decrease in body weight during the administration period. A continued loss of weight was observed during the following 17 days. Two other animals, A62 in the product water group and A70 in the control group, also showed a decrease in body weight during the 14-day period. The loss was not as marked, however, and did not continue. A comparison of the trend of the body weights of the other animals failed to reveal any apparent differences.

Evaluation of the hematologic data revealed that animal A48 in the product water group was affected to the greatest degree. A shift to the left in the white cell differential, reduction in red cell count, packed cell volume, and hemoglobin concentration, and some electrolyte and enzyme changes are most apparent in the postadministration period. A reduction in serum sodium and potassium was evident in the first postadministration specimen and in inorganic phosphorous in the additional samples. The alkaline phosphatase level was significantly reduced for several weeks and a reduction in SGPT and possibly SGOT are noted in the second postadministration sample. A reduced SGPT level in A62 and possibly SGOT levels in A60 and A62 were observed in the first postadministration samples. Both these animals were in the product water group. A62 also showed an apparent reduction in red cell count, packed cell volume, and hemoglobin concentration in the postadministration period.

Three animals, A48 and A62 in the product water group and A70 in the control group, developed enteric disturbances during the administration period. The first symptom noted was a depressed appetite. This was first observed in A62 on the second day of the administration period, in A70 on the fifth day, and in A48 on the sixth day. Loose stools and/or diarrhea were then observed for several days after which the retarded appetite persisted. Animals A62 and A70 recovered clinically prior to the end of the 14-day period. A48, which was housed in a cage adjoining that of A62, was more severely affected. The enteritis lasted until several days after the end of the administration period and the retarded appetite persisted for at least 3 weeks. Dehydration was of little significance in the affected animals apparently due to the forced fluid intake. A moderate depression of activity was observed in animal A48, but A62 and A70 were only slightly affected.

Cultures of rectal swabs taken from the above animals during the acute stage revealed only bacteria of the coliform group. No Salmonella or Shigella species or other organisms of significance were isolated.

Loose stools were observed from Animal A74 on two occasions, and A60 exhibited a slightly depressed appetite on one occasion during the administration period. Although both these animals were in the product water group, the transient nature of these symptoms indicate they were of little significance.

No effects were observed on the activity, appetite, or digestive system of the other animals. Signs of generalized dehydration were not noted. Some dry lip lesions were observed in the majority of animals in both the product water and control groups near the end of the administration period. These were apparently due to lack of fluid intake by mouth since they healed rapidly when the animals were again given water ad libitum.

# SECTION IV

A comparison of the body weight and hematologic data with clinical observations reveals that the changes observed were associated primarily with animals that developed enteric disturbances. The magnitude of these changes was directly related to the severity of the condition.

The relationship of the fuel cell product water and the incidence of enteric disturbances is not established, however. The fact that one of the control animals was affected and sporadic incidents of enteritis were observed in other animals in the colony appears to indicate that this was a spontaneous condition not related to the product water. Since both animals in the product water group were more severely affected, one slightly and the other considerably, the response to the condition may have been modified. Due to the small number of animals involved, the current data do not substantiate or refute this possibility.

#### SECTION V

## **Summary and Conclusions**

A fuel cell product water was administered to *Macaca mulatta* as the sole source of fluid intake for a 14-day period. Body weight and hematologic changes in 2 of 8 animals were directly related to enteric disturbances. These were apparently of a spontaneous nature since one of two control animals receiving tap water was also affected, although somewhat less severely.

The present study failed to reveal any apparent subacute oral toxicity of the fuel cell product water in monkeys and it should, therefore, present no serious hazard to humans when consumed as drinking water for short periods of time. Since the physical and chemical properties of product water vary with the accumulated time of operation of the fuel cell, however, this conclusion may not be applicable in all situations.

10 11 12 13 14 15 16 17 18 19

		Appendix INDIVIDUAL ANIMAL DATA	
HEM/	HEMATOLOGY		
Column	un Test	Units	Method
1 2-9	White cell count White cell differential: Neutrophiles, Blasts, Myelocytes, Bands, Lymphocytes, Monocytes, Eosinophiles, Basophiles	per cubic mm %	Coulter Counter, Model B Wright's Stain
10	Red cell count	X 10 <sup>6</sup> per cubic mm	Coulter Counter, Model B
11	Packed cell volume	%	Micro technique – International Micro-Capillary Centrifuge, Model MB and Reader
12	Hemoglobin concentration	gm per 100 ml	Cyanmethemoglobin – Hycel, Inc.
14-16	Sodium, Potassium, Calcium	mEq per liter serum	Flame photometry – Coleman Junior Spectrophotometer, Model 62 and Flame Photometer, Model 21
17	Inorganic phosphorous	mg per 100 ml serum	Air Force Manual 160-49, Laboratory Procedures in Clinical Chemistry and Urinalysis, pp 10-17 - 10-18, Department of the Air Force, Washington, D. C., 1962
18	Alkaline phosphatase	Klein-Babson-Read units	Phosphatabs-Alkaline Quantitative, Warner-Chilcott
19	Lactic dehydrogenase (LDH)	Units per ml serum	Cabaud-Wroblewski, Dade Reagents, Inc.
20	Serum glutamic oxalacetic transaminase (SGOT)	Units per ml serum	Reitman-Frankel, Modified, Dade Reagents, Inc.
21	Serum glutamic pyruvic transaminase (SGPT)	Units per ml serum	Reitman-Frankel, Modified, Dade Reagents, Inc.
22-23	Total protein, Albumin	gm per 100 ml serum	Gornall, A. G., C. J. Bardawill and M. M. David, <i>J Biol Chem</i> , 177:751- 766, 1949, modified
24	Globulin	gm per 100 ml serum	Calculated from 22 and 23

ANIMAL:	ANIMAL: Monkey		MUN	NUMBER:		1114		SEX:	: Male		STUDY:	Fuel	Cell Product Water	Produ	lot l	iater							
		2 3	-7	2	9	5	8	6	10	H	12	13	77		16	~	18	19	8		52	53	57
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12 Jan	10,219	24		<b>ר</b>	67		8		3.33	36	11.3	8,0	149	4-4	5.7	5.2	19.0	500	শ্ব	સ	6.8	4.6	2.2
2 Feb	9,865	17			8	T		F	3.98	36	0-11		150	5.1	5.6	5.8	26.5 520	520	સ	28	6.6	4.9	1.7
11 Feb	171.8	17			73	N	2	F	3.84	36	11.0		277	5.0	5.5	6.2	17.0 480	480	<b>%</b>	81	7.3	4-4	2.9
* REMARKS: g. Nuc	le l	a. Hypochromia, ated RBC - Numbe		Num	b, b,	,	Hyperc	chr.	hromia,	c, Mic	Microcytosis,		d. Macrocytosis,	srocy	tosi	່ຍ່		Anisocytosis,		f. Targ	Target Cells	l Ils,	
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OBSERVATIONS:	TIONS:																						
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38       11.0       a       146       4.5       5.2       5.7       26.5       390       40       31       6.4       3.4         38       11.0       a       142       4.4       5.4       6.1       21.0       390       45       31       6.4       3.8         39       11.0       a       142       4.4       5.2       5.8       20.5       390       45       22       6.2       4.2         37       10.6       146       4.5       5.3       6.4       18.5       280       26       22       6.7       4.2         37       10.6       146       4.5       5.3       6.4       18.5       280       26       22       6.7       4.2         37       10.6       146       4.5       5.3       6.4       18.5       280       26       26       7       4.2         37       10.6       146       4.5       5.3       6.4       18.5       280       26       26       7       4.2         2       1       18.5       2       6.4       18.5       280       26       2       6.7       4.2         2       1	1 2 3 4 5 6 7 8 9 WBC Ne B1 MY Ba Ly Mo Eo Bs	3 4 5 6 7 8 B1 My Ba Ly Mo Eo	4 5 6 7 8 My Ba Ly Mo Eo	5 6 7 8 Ba Ly Mo Eo	හ සි	හ සි		6 8	<u>.</u>		цÞ	12 Hb	13 Renk*	JL BN		16 Ca	~	18 Alpts	19 LDH	20 SGOT	21 SGPT		23 Alb	2 2
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BODY WEIGHT:	IGHT:																							
Date	6 Jan		12 Jan	g		19 Jan	an	26	26 Jan	2 Feb		11 744				-		-						
kg	2.1		2•3	-		2•0	0		2.5	2.0	+	0.0											T	
EXPERIM	EXPERIMENTAL PROTOCOL:	DTOC	: TO	ļ							•	-				_			_					
Control Fuel cel	Controlled diet and environment 6 Jan Fuel cell product water 19 Jan thru 1	and st w	l en ater	11rd	Jai	nt n ti	6 Ja aru		o 11 F eb 196 <u>'</u>	to 11 Feb 1965. Feb 1965 - 35 ml per kg twice daily.	al per	kg twi	loe da	41y.										
OBSERVATIONS:	: SNOI																							
										ANIMAI	ANIMAL DATA REPORT	REPORT												

			- dactor	1074		0.	SEX: Mele	ele	STUDY:	Fuel	Cell F	Product	st Wa	Water					- F	-	
ANIMAL:	: Monkey		NUMBER: 200		┝	` -			ſ		1, 1	1 2 1	191	17	18	19	8	21	22	53	54
		2	4	9	<b>D</b>		10			L) Remk*	Na I				- o	LDH	SGOT	SGPT 1	Prot	<b>dlb</b>	Glo
Date	WBC	Ne Bl	My Ba	ΓΛ	OW	FO		_	+	_	2 1 21 1	+	6-0 4	4.7	17.5	880	04	28	1.9 4	4.2	3.7
6 Jan	18,097 5	53		35	80	N	2 4.87	7 43	£•21		2			+		4	C Y	35	7.7 1	6•7	2.8
		ç		3 1.7	η	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1 4.66	6 42	12.0	) <b>g-</b> 2	148	4.5	5.8	7.9	20.02	440	R	2			0
12 Jan		1	+	-	-		L 57	2 10	11.3	B	152	4.3	5.9	5.1	34.0 440	011	22	જ	0.2	2.5	0
2 Feb	11.540	54		2 47	t		•} •		+		2		2 20 20	5.7	22.5	340	35	18	7.7	4.9	2.8
11 Feb	10.150	27		67	m	N	1 4.22	38	11.7		ק			-		·	5	ę			
													-+		21.0		7	22			
18 Feb		+	+																		
* REMA	REMARKS: a.	Hypo		a, b,		per(	Hyperchromia,	ပ်	Microcytosis,	1	d. Mae	Macrocytosis,	tosì:	3, e,	Anis	Anisocytosis,		f. Target		Cells,	
τΩ	g. Nucleated RBC	ed RE		- Number			an an an ann an an an an an an an an an			an an an an an an an an an	and the second second										
BODY W	BODY WEIGHT:															-		-			
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	6 Jan	d	12 Jan		19 Jan	ä	26 Jan	2 R	Feb	11 Feb			a gangan sa na sa sa								
ke lo	2.3		2.3		2•0	0	2 •3		2•2	2•3			a and the state of the state						a a second a final second a s		
EX PER. Cont: Fuel	EXPERIMENTAL PROTOCOL: EXPERIMENTAL PROTOCOL: Controlled diet and environment 6 Jan Fuel cell product water 19 Jan thru 1	ROTO( et al duct	JOL: nd envi water	Lrom 19	lent Jan	6 J thru	an to 1 Fel	11 Fet 1965	to 11 Feb 1965. Feb 1965 - 35 ml	l per	kg twic	twice daily.	.ty.	•							
OESERVAT 24 Jan		te	CONS: Appetite slightly depressed.	ly d	erqe	ased	-														
									ANIMAL	ANIMAL DATA REPORT	EPORT										

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				- 1				11	rr		1		l	
	510	3.7	3.8	3.0	2.8									
	Alb Alb	4.2	4-4	4.0	4.3			ils,						
	22 Prot	7.9	8.2	7.0 4.0	7.1 4.3			Target Cells,						
	21 SGPT I		31	2	58	જ								
	20 SGOT	ર	약	22	જ	ઝ		is, f.						
	19 LDH	340	230	230	180			Anisocytosis,					. 9	
-	18 Alota	2.5	31.0	21.5	21.5 180	27-0							078 De	
a ter	17	6.9	5.9	5.1	6.4			в, <b>в</b> .					ting	
ict Vi	16 Ca	5.4	5.7	5.4	5.0			ytosi				۲ <u>۲</u>	Lood	
Product Water	15 X	4.5 5.4	4-5 5-7	5.3 5.4	4.0 5.0			croc				dai	t p	
	77 g	7	ગ્ર	े र	977			d. Ma				tuloe	te vi	QRT
STUDY: Tuel Cell	13 Remict		44		•			c. Microcytosis, d. Macrocytosis,		11 <b>Je</b> b	2.0	1965. - 35 ml per kg twice daily.	some anorexia, loose stools with blood tinged mucus.	ANIMAL DATA REPORT
STUDY:	12 H	11.7	11.0	9.8	10.0			rocyt				55. E 1 10	1008	AL DA
		38	36	32	35			c. Mic		2 Teb	1.8	ם ו	æ exte	IIN
SEX: Male	10 BBC	4.39	3.82	3-42	3.69			Hyperchromia,		Jen	2•0	to 11 <b>Fe</b> Feb 1965		
SEX	6 <sup>4</sup>	3 -	8	e,				chr		26				
	to fr	<b>9</b>	7	θ	Ŋ			Abei		a	6	pru		
OI	5 7 7 5 1.37	4	ŀ	<b>h</b>	4					19 Jan	1.9	рр Фр	n ad	
NUMBER: <b>462</b>	6	3 3	47	57	58			ber.		<b>P</b>		Ja	Enterio disturbance diarrhes.	
BER:	ν d		e					Hypochromia, ed RBC - Numbe		Jen	2.4		d1.	
MUN	-7 ∳		<b>_</b>					- L		12	N	DL: Bter	Enterio ( diarrhem	
-	~ E		-					Dod A					iar.	
>	2		37	36				a. Hy aated		B	ღ	PRO duc		
Monke		13,926	13.653	13,123	15,209			H H	IIGHT:	6 Jan	2•3	TENTAL	NTIONS: -28 Jan Slight	
ANIMAL: Monkey		6 <b>Jen</b>	12 Jan	2 Peb	11 Feb	18 Feb		* REMARKS: g. Nuc	BODY WEIGHT:	Date	kg	EXPERIMENTAL PROTOCOL: Controlled diet and environment 6 Jan Fuel cell product water 19 Jan thru 1	OBSERVATIONS: 21 Jan-28 Jan 18 Feb Slight	
	÷						L	1	<b>#</b>	<u> </u>		ľ	- A	

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AN IMAL:	.: Monkey		INUM	NUMBER:	<b>A</b> 68	8		SEX:	Male		STUDY:	Fuel	Cell	Product Water	act W	ater					i		
		2 3	3 4	5	9	2	8	6	10	1	12	F1	77	15	16	17	18	19	8	57	22	ಸ	54
Date						Mo	E B	Bs RI	RBC 1	PCV	ЧЪ	Remk* Na	Na	м	Ca	р.	Alpts	HUI	SGOT	SGPT	Prot	AIb	Glo
6 Jan	13,018	8		F	52	н	-		4.66	42	12.3		150	4-4	5.7	6.6	24.5	880	64	50	7.7	4•0	3.7
12 Jan	12,628	ন্থ			8	ε	θ	<b>†</b>	4•32	42	12.3		152	5.2	6.1	6.4	30.0	520	শ্ব	39	2.2	4.7	3•0
2 Feb	7.925	37		N	55	-#	-1	1 t.	4 <i>•5</i> 3	4	11.3	Ð	345	4•4	5.8	5.6	27.0 440	440	35	31	7.1	4.2	2.9
11 Feb	8,128	5		<b>–</b>	れ	Ś		л т	4-50	to 1	12.0		150	4.7	5.6	6•4	25.0	280	31	35	7.1	4•9	2.2
		<b> </b>																					
* REMARKS: g. Nuc	a. leate	Hypochromia, ed RBC - Numbe	schrc 3C -	Mum	ber, b		perc	Hyperchromia,		c. Micı	Microcytosis,	1	d. Macrocytosis,	crocy	tosi	ູ ບໍ່		Anisocytosis,		f. Targ	Target Cells	ells,	
BODY WEIGHT:	EIGHT:																			-			
Date	6 Jan		12 Jan	an	19	Jan		26 Jan	g	2 Feb	77	Feb											
kg	2•3		2•5	2		2•0		2•5		2.4		2.7											
EXPERI Contro. Fuel co	EXPERIMENTAL PROTOCOL: Controlled diet and environment 6 Jan Fuel cell product water 19 Jan thru 1	ROTOC and ct w	OL: env ater	<b>ir</b> o 19	Jan	t 6 thi	Jen Tu l	r to ll Feb -		Feb 1965. 35 ml per		kg twice daily.	daily	.•									
OBSERV	OBSERVATIONS:																						
										MTWA		ШОСТО КШАС ТАМТИА ШОСТОС КШАС ТАМТИА	La contra c										· · · · · · · · · · · · · · · · · · ·

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AN IMAL:	: Monkey		N	UMB	ER:	NUMBER: A74			SEX:	: Male		STUDY:	Puel	Cell		uo t	Product Water	54						
	г	2	6	4	5	9	-7	ω	6	10	ц	12	13	77	15	16	17	18	19	20	51	22	R	77
Date	WBC	Ne	В		Ba	Ly	Мо	Ео	Bg	RBC	PCV	ЧH	Remk <sup>*</sup> Na	Na	×	C B	д.	Alpts	LDH	SGOT	SGPT	Prot	<b>A</b> 1b	GIO
6 Jan	8,993	28				66	Э	8	н	4.91	11	13.3		877	4.1	5.5	7.2	25.0	230	Ŝ	42	7.9	4.4	3.5
12 Jan	10,297	<u></u> З				42	4	θ	Ъ	4.06	36	10.6	đ	1112	3.8	5.4 4.1	4.1	31.0	360	<del>ا</del> لح	સ્ટ	7.0	4.6	2.4
2 Feb	12,937	म			н	<b>4</b> 4	<b>t</b>	Ø		3.79	38	11.0		117	3•4	5.3	5.6	34•0	180	<b>4</b> 0	ୟ	6.8	4•3	2.5
11 Feb	10,619	36				52	N	6	-	3.98	38	11.3	•	777	4•3	5.1	6•9	34.0	280	31	22	7.0	4.2	2.8
									-															
* REMARKS: g. Nuc	Ľ ۲	Hy ed	a. Hypochromia, ated RBC - Numbe	hron -	nia Vuml	, b.		yper	chre	Hyperchromia, c	c. Mic	Microcytosis,		d. Mac	Macrocytosis,	tosi	в, е,		Anisocytosis,		f. Target	cet C	Cells,	
BODY W	BODY WEIGHT:				ſ			f					ľ						F		ŀ			
Date	6 Jan	a	ิส	12 Jan	đ	ř	19 Jan	g	26	26 Jan	2 Feb	ר ק	Feb.			İ								
kg	1.9			2•3	~		1.8	~	LV.	2•0	1.9		2•2											
EXPERI Contro Fuel o	EXPERIMENTAL PROTOCOL: Controlled diet and environment 6 Jan Fuel cell product water 19 Jan thru 1	t a uct a	nd .	L: ber	10 1 1 0 1	Jar	lt ( ltb	) Ja Lru		to ll Fel Feb 1965	to ll Feb 1965. Feb 1965 - 35 ml	- H	per kg twice daily.	wice	daily	.•								
OBSERV	OBSERVATIONS:	144		1 3																				
24 Jan	Loose stool	8 t 0	01.		•																			
																								<u> </u>
											MIN	NT DA	ANIMAL DATA REPORT	jRT										

ANIMAI	AN IMAL: Monkey		NUMBER: A40	ER:	P40	_	دں ا	SEX: Male	ala	<u>کا</u>	STUDY: Fuel	Fuel C	Cell P	Product Water	ct Wa	ter -	Control	rol					
	-1			5 m	\$, ev		8						17		16	17	18	19 1 חנו	20 20	21 21		22 23 Drot ATA	24
Date	WBC	Ne B1	Μ	<u>8</u>	ΓA	ਸ OM	SH OH	S RBC		2	QH QH	кешкж	Na	4	e Ca		ATPUS		TODC .	7 350			5
6 Jan											-		148	47	5.8	8.8	3.0	390	53	28	8.2	8.2 4.2	4.0
12 Jan	10,880	7			86	9		т Т	4.26	36	11.0	æ	148	3.9	5.6	4.7	27.0	27.0 280	2	39	7.2	7.2 4.4	2.8
2 Feb	10,249	6T		8	75	4		- - -	4.13	38	7.11		611	4-4 5-4		5.6	42.0 600	600	55	28	6.6	6.6 4.4	2.2
11 Feb	13,316	29		Ъ	64	F	e	ъ 3	3.99	37	10.6		348	4.5 2	5.4	6.7	27.0 600	600	55	স্থ	2.0	7.0 4.3	2.7
* REMARKS: g. Nuc	le l	a. Hypochromia, ated RBC - Numbe	hror hror	nia, Numb	b, b		)erc	Hyperchromia,		Micr	c. Microcytosis,		d. Macrocytosis,	rocy	tosit	e,		Anisocytosis,		f, Tar	Target C	Cells,	
BODY W	BODY WEIGHT:																						
Date	6 Jan		12 Jan	g	19	19 Jan		26 <b>Ja</b> n		2 Feb	7	Feb					an an an an an an an						
kg	2•4		2.7	~	••	2•4		2•5		2•6		2.7				;	and the second se						
EX PERIMENTA Controlled Tap water ]	EXPERIMENTAL PROTOCOL: Controlled diet and environment ( Tap water 19 Jan thru 1 Feb 1965	AL PROTOCOL: diet and environment 6 Jan 19 Jan thru 1 Feb 1965 - 35	L: envi u l	Feb	<b>19</b>	<b>t</b> 55 -	Jan 35	1 1 1 2 0	ll Feb per kg	1965. tvice	e daily.	Ly.											
OBSERV	OBSERVATIONS:																						
										ANTMA	L DAT	ANIMAL DATA REPORT	RT										× ×

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Inte         I         2         3         4         5         6         7         8         10         11         12         13         14         15         16         17         18         19         20         21         22         23         24           6         1         3         4+40         11         12-3         144         4+2         5.0         5.9         5.9         5.9         5.9         5.7         4+2         5.0         5.9         5.9         5.7         4+2         5.0         23         5.1         13         7.3         4+2         5.0         5.9         5.9         5.9         5.9         5.9         5.7         4+2         5.0         5.9         5.9         4+2         5.0         5.9         5.9         5.7         4+2         5.0         5.9         5.9         5.9         5.7         4+2         5.0         5.9         5.9         5.9         5.0         4+2         5.0         5.9         5.9         5.0         4+2         5.0         5.9         5.9         5.7         4+2         5.0         5.9         5.7         4+0         5.7         4+0         5.7         4+0         5.7<	9       10       11       12       13       14       15       16       17       18       19       20       21       22       23         80       RBC       RCW       HD       Remk* Na       K       Ca       P       Alpts LDH       SGOT       SGPT       Froit Alb         44.40       41       12.3       144       4.25       6.9       30.0       280       35       31       7.1       3.72         44.40       41       12.3       144       4.2       5.0       6.9       30.0       280       35       44.0       40       5       5       5       5       4.0       5       5       4.0       5       5       4.0       5       5       4.0       5       5       4.0       5       5       4.0       5       5       5       5       5       5       5       5       5       4.0       5       5       4.0       5 </th
HBC         Acv         HD         Remic* Ma         K         Ca         P         Allpel LDH         SGOT         SGFT         Prod         Allph           44.40         41         12.3         144         4.2         5.0         6.9         30.0         280         35         31         7.1         3.7         1           44.40         41         12.3         144         5.3         4.0         35         31         7.1         3.7         1         4.2         1         4.2         39         4.0         35         31         7.1         3.7         1         4.2         1         4.2         4.2         4.2         4.4         5.3         4.4         5.5         39         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         4.0         5         5         4.0         5         5         4.0         5         5         4.0         5         5         5         5         5         5         <	BIG       Act HD       Remich Ma       K       Ca       P       Alltis LDH       SGOT       SGOT       SGOT       Alltis       Alltis<
44-40       41       12-3       144       4-50       6-9       30-0       260       35       31       7.1       3-7         4-10       39       12-0       148       3-8       5-6       5-9       23-5       440       55       39       7.2       4.2         4-19       39       11.7       6-8-1       148       5-6       5-9       23-5       440       25       6.2       4.0         2       4-19       39       10.6       a       146       4.4       5.2       7.4       35-0       600       55       28       7.3       4.0         2       4-00       36       10.6       a       146       4.4       5.2       7.4       35-0       600       55       28       7.3       4.0         2       4+0       36       26.5       50       28       7.3       4.0       26       28       7.3       4.0       27       4.0       26       28       7.3       4.0       26       28       7.3       4.0       27       24       2.3       2.5       28       7.3       4.0       26       28       7.3       4.0       27       2.4       2.	40.40       41       12.3       144       4.2       5.0       5.9       30.0       35       31       7.1       3.7         40.40       41       12.0       148       3.8       5.6       5.9       23.5       44.0       25       39       7.2       4.2         40.19       39       11.7       0.6       148       3.4.6       5.9       23.5       44.0       25       50       40       25       40
4.20       39       12.0       148       3.8       5.6       5.9       23.5       440       55       39       7.2       4.2         2       4.19       39       11.7 <b>e.g-1</b> 148       4.4       5.3       4.8       34.0       390       40       25       6.2       4.0         2       4.00       36       10.6 <b>a</b> 146       4.4       5.2       7.4       35.0       600       55       28       7.3       4.0         2       4.00       36       10.6 <b>a</b> 146       4.4       5.2       7.4       35.0       600       55       28       7.3       4.0         2       4.00       36       10.6 <b>a</b> 146       4.4       5.2       7.4       35.0       600       50       28       7.3       4.0         chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       2.4       2.3       2.5       2.5       2.6       28       7.3       2.5       2.4       2.5       2.5       2.6       28       7.3       2.5       2.4       2.5       2.5       2.6       2.6       2.6       2.6       2.6       2.6	4.20       39       12.0       148       5.6       5.9       23.5       440       55       39       7.2       4.2         2       4.19       39       11.7 <b>6.6</b> -1       148       4.4       5.2       34.0       390       40       25       6.2       4.0         2       4.10       36       10.6 <b>a</b> 146       4.4       5.2       7.4       35.0       600       55       26       4.0         2       40.00       36       10.6 <b>a</b> 146       4.4       5.2       7.4       35.0       600       55       26       4.0         2       40       5       5       50       50       26       20       26       20       20       26       26       20       26       26       20       26       28       7.3       4.0       27       2.3       4.0       27       26       28       7.3       4.0       27       2.5       2.5       2.5       2.6       28       7.3       4.0       27       2.4       2.5       2.6       28       7.3       4.0       27       2.4       3.5       2.6       28       7.3
4.19       39       11.7       0.6       148       4.4       5.3       4.8       34.0       390       40       25       6.2       4.0         2       4.000       36       10.6       146       4.4       5.2       7.4       35.0       600       55       28       7.3       4.0         2       4.000       36       10.6       2       26.5       50       28       7.3       4.0         chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26.5       50       28       7.3       4.0         26       11       7.5       2.6       50       28       7.5       4.0         26       11       7.5       1       7.5       7.5       7.5       7.5         2.4       2.3       2.5       1       1       7.5       1       1       7.5       1       1         2.4       2.3       2.5       2.5       5.5	4.19       39       11.7       0.6-1       148       4.44       5.3       4.8       34.0       390       40       25       6.2       4.0         2       4.00       36       10.6       2       146       4.44       5.2       7.4       35.0       600       55       28       7.3       4.0         2       4.00       36       10.6       2       146       4.44       5.2       7.4       35.0       600       55       28       7.3       4.0         Phromia       .       Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26       3.0       2.5       28       7.3       4.0         26       Jan       2       2.5       1       Nacrocytosis, e. Anisocytosis, f. Target Cells,       1         2       2.4       2.3       2.5       3.5       50       28       50 <t< td=""></t<>
2       4.00       36       10.6       a       146       4.4       5.2       7.4       35.0       600       55       28       7.3       4.0         chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26.5       50       28       7.3       4.0         chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26.5       50       28       7.3       4.0         chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26.5       3.2       28       7.3       4.0         zó Jan       2       2       1       7       2       2       2       2       1         zó Jan       2       2       2       2       2       5 <td< td=""><td>2       4.00       36       10.6       a       146       4.44       5.2       7.4       35.0       50       58       7.3       4.0         1       1       1       1       1       26.5       50       28       7.3       4.0         1       1       1       26.5       50       28       7.3       4.0         1       1       26       1       26       50       28       7.3       4.0         1       1       1       1       26       1       26       28       1       1       1         26       1       1       2.5       1       1       2.5       2.5       1</td></td<>	2       4.00       36       10.6       a       146       4.44       5.2       7.4       35.0       50       58       7.3       4.0         1       1       1       1       1       26.5       50       28       7.3       4.0         1       1       1       26.5       50       28       7.3       4.0         1       1       26       1       26       50       28       7.3       4.0         1       1       1       1       26       1       26       28       1       1       1         26       1       1       2.5       1       1       2.5       2.5       1
Chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       26 Jan     2 Feb       2.4     2.5       2.4     2.5       2.4     2.5       1 Feb 1965.       ml per kg twice daily.	Stan     2 Feb     11 Feb     26.5     50     28       Chromia, c. Microcytosis, d. Macrocytosis, e. Anisocytosis, f. Target Cells,       Stan     2 Feb     11 Feb       26 Jan     2 Feb     12 Feb       21 Jan     2 Jan     2 Jan       20 Jan     2 Feb     11 Feb       21 Jan     2 Jan     2 Jan       20 Jan     2 Jan     2 Jan
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