

Compilation of empirical ultrasonic properties of mammalian tissues. II

S. A. Goss

Ultrasound Research Division, Indianapolis Center for Advanced Research, 410 Beauty Avenue, Indianapolis, Indiana 46202

R. L. Johnston and F. Dunn

Bioacoustics Research Laboratory, University of Illinois, Urbana, Illinois 61801
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The compilation of the literature on ultrasonic propagation properties of mammalian tissues [J. Acoust. Soc. Am. 64, 423 (1978)] is continued with the addition of 45 papers yielding over 700 lines of parametric data.

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INTRODUCTION

It emerged from the compilation of ultrasonic propagation properties in mammalian tissues [J. Acoust. Soc. Am. 64, 423 (1978); Acoust. Lett. 1, 64 (1978)] that publications containing such measured values were appearing at such a rate in recent years, that an updating could profitably be prepared within one to two years. The present work represents such an undertaking and involves 45 publications; 34 appearing since the termination of searching for the original compilation and 11 that were overlooked in that preparation. This rate activity in the field is believed to warrant serial updating.

I. METHOD

The citations of this work were obtained from searches of the current literature and from inadvertent omissions from the original compilation brought to the attention of the compilers. The earlier adopted procedure of including data from largely peer-reviewed original contributions is continued.

II. ARRANGEMENT OF THE TABLE

As before, each entry number represents a set of data reported in the cited reference, for which the tissue type, species, preparation, anatomical structure and pathology are the same. Each numbered entry line is completed for each column heading. Blank entries imply no change in the data from the above, i.e., ditto marks are employed only in the reference column.

The ordering of entries is as follows:

- (1) by tissue type—alphabetically;
- (2) by species/age—human first, then all others alphabetically (ordered with increasing age for samples of single species and preparation);
- (3) by sample preparation and handling—*in vivo*, then fresh, and finally unspecified;
- (4) by an anatomical structure reported within a particular organ or tissue type—alphabetically;
- (5) by reported pathologies, normal tissues first, then pathological states—alphabetically.
- (6) Any subsequent ordering is in terms of temper-

ature, frequency, or year of measurement.

Acoustic impedance and density information are listed in the remarks column when available. Attenuation values are listed both in Nepers per centimeter and in decibels per centimeter, for which the parenthetic numbers are converted (8.686 dB/Np) from the originally reported values in order to facilitate comparison. The list of abbreviations includes the measurement methods and other often appearing parameters.

III. DISCUSSION

Examination of Table I reveals that investigators generally continue to restrict themselves to much the same tissues and organs which have received abundant attention in the past. Thus the tissues and organs most often measured remain liver, blood, kidney, and muscle. No measurements have yet been reported for often viewed, and clinically important, tissues such as prostate, placenta, thyroid, ovary, adrenal gland, thymus, and lymph node. The general lack of measurements on *in vivo* specimens remains, especially for human tissues. Such paucity of information forces clinicians and medical device manufacturers to employ velocity and attenuation values obtained from animal tissues for estimating parameters, which ultimately will be used for examination of human tissues. The majority of pathologies measured have been restricted to brain tissue. The importance of also reporting the temperature at which measurements are made, and the dependence of the ultrasonic parameters upon temperature, have been given more attention by investigators.

LIST OF TABULATED TISSUE

<i>Tissue</i>	<i>Entry Number</i>
Blood	1-10
Blood vessel	11-15
Bone	16-26
Brain	27-33
Breast	34-48
Eye	49-56
Fat	57-66
Heart	67-75

Kidney	76-82
Limb	83
Liver	84-114
Milk	115-116
Muscle	117-124
Pancreas	125
Skin	126-131
Spleen	132-138
Tendon	139-141
Testis	142-144
Tooth	145-154
Uterus	155

LIST OF ABBREVIATIONS

AI	acoustic interferometry
CARA	critical angle reflection analysis
c	plasma protein concentration (g/100 cm ³)
f	frequency (MHz)
LD	lesion data used to calculate attenuation
NR	not reported
PE	pulse echo
PER	pulse-echo reflection
p.m.	post mortem
PO	pulse overlap
PR	pulse reflection (pulse-echo measurement re-referred to a known medium)
PS	phase speed
PT	pulse transmission
PT(IL)	pulse transmission (insertion loss)
PT-C	pulse transmission (corrected for system losses)
PT-R	pulse transmission (tomographic reconstruction)

RBC	red blood cell
Rm	room temperature
RP	radiation pressure
SA	spectrum analysis
SAR	sing around
S.D.	standard deviation
SLAM	scanning laser acoustic microscopy
T	temperature (°C)
t	time
TAP	total acoustic power
TDS	time delay spectrometry
TOF	time of flight
TOF; PE	time of flight velocity, pulse echo for attenuation
TT	transient thermoelectric
V	volume percent of red blood cells
Z	acoustic impedance × 10 ⁵ (g/cm ² s)
$\frac{\Delta v}{\Delta T}$	change in velocity with temperature (m/s °C)
ρ	density (g/cm ³)
*	data interpolated from graph

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TABLE I. ULTRASONIC PROPERTIES OF MAMMALIAN TISSUES

<u>Blood, Blood Vessel</u>												<u>Blood, Blood Vessel</u>	
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (dB/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE	
BLOOD													
1	Human	fresh heparinized	whole/none		22 ± 1	AI PT-C	3.7 7* 8* 10* 11*	1542 NR	NR (0.17) (0.19) (0.25) (0.26)	1.5* 1.7* 2.2* 2.3*	± 0.2%; ± 0.1 dB/cm hemoglobin concentration, 8.2 gm/100 cc, deoxygenated	Shung & Reid (1977)	
2	Human (male)	fresh	whole/none		37 ± 0.05	AI	7.5	1586.1 ± 5.36 1586.6 ± 5.55 1586.9 ± 5.57 1585.5 ± 5.27 1601.7 ± 7.47	NR		± S.D.; precoagulation onset of coagulation end of coagulation onset of retraction end of retraction	Grybauskas et al. (1978)	
3	Human (female)	fresh	whole/none		37 ± 0.05	AI	7.5	1579.2 ± 4.55 1579.6 ± 4.5 1580.1 ± 4.53 1579.4 ± 4.72 1596.7 ± 7.34	NR		± S.D.; precoagulation onset of coagulation end of coagulation onset of retraction end of retraction	"	
4	Human	fresh	whole/none		37 ± 0.05	AI	7.5	NR	$\alpha/f^2 \times 10^{17} \text{ sec}^2/\text{cm}$ 1460-7100		range of absorption values measured during clotting process	"	
5	Human	fresh heparinized	whole/sickle cell		22 ± 1	AI PT-C	3.7 4* 6* 7.5* 9* 14* 17*	1551 NR	NR (0.11) (0.20) (0.23) (0.30) (0.48) (0.64)	1.0* 1.7* 2.0* 2.6* 4.2* 5.6*	± 0.2%; ± 0.1 dB/cm hemoglobin concentration, 8.2 gm/100 cc deoxygenated	Shung & Reid (1977)	
6	Human	refrig. (=14 days) diluted with physiological saline	whole/none		37	PO	1.2	1559.2 1566.8 1578.0 1594.8 1604.3	NR		$\frac{1}{2}$ plasma protein 0.6 $\frac{1}{2}$ hemo-globin 1.6 1.2 3.2 3.1 8 4.6 12 6.2 16 ± 0.5%; $v = 3.39c + 1553.42$	Aubert et al. (1978)	
7	Human	NR	plasma/none		37 ± 0.01	PO	1.2	1529.6 1537.1 1543.1 1548.4	NR		1.29 gm/100 cc plasma protein 2.58 gm/100 cc plasma protein 3.87 gm/100 cc plasma protein 5.16 gm/100 cc plasma protein	"	
8	Human	NR	plasma/none		25	PT & AI	1.67 2.81 3.95 6.52 9.10 11.65 14.24 19.39 24.57 25.07 35 65 115	NR	$\alpha/f^2 \times 10^{17} \text{ sec}^2/\text{cm}$ 500 370 223 197 162 147 128 112 105 97 80 63 47		PT ± 2%; AI ± 5%	Lang et al. (1978)	
9	Human	NR	plasma/none		37	PT & AI	3.95 6.50 9.08 11.66 14.23 19.39 24.56 35 65 115	NR	$\alpha/f^2 \times 10^{17} \text{ sec}^2/\text{cm}$ 206 168 134 126 115 96 86.3 70 52 42		PT ± 2%; AI ± 5%	"	
10	Dog	fresh heparinized	whole/none		37 ± 0.01	PO	1.2	1596.6	NR		measured within 24 hrs after bleeding from 7 dogs; 4.2% plasma protein; 10.8% hemoglobin	Aubert et al. (1978)	
BLOOD VESSEL													
11	Beef	less than 3 days, stored at 4°C	aortic arch/none		22 ± 1	PR	5	1569 ± 10.8	NR		± S.D.; average of 50 measurements; $\alpha = 1.062 \pm 0.0059$, average of 12; $Z = 1.666 \pm 0.015$, data also given for tissue constituents	Shung & Reid (1978)	

TABLE I. (Continued)

<i>Blood Vessel, Bone, Brain</i>										<i>Blood Vessel, Bone, Brain</i>		
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP. (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE
12	Beef	less than 3 days, stored at 40°C	pulmonarytrunk/none		22 ± 1	PR	5	1545 ± 9.6	NR		± S.D., average of 50 measurements; $\rho = 1.044 \pm 0.0051$, average of 12; $Z = 1.613 \pm 0.013$, data also given for tissue constituents	Shung & Reid (1978)
13	Beef	less than 3 days, stored at 40°C	vena cava/none		22 ± 1	PR	5	1552 ± 10.4	NR		± S.D., average of 50 measurements; $\rho = 1.054 \pm 0.0046$, average of 12; $Z = 1.636 \pm 0.013$, data also given for tissue constituents	"
14	NR	formalin fixed	aorta and iliac arteries/none		NR	PR	5	NR	(0-1.73)	0-15	none	Hartley & Strandness (1969)
15	NR	formalin fixed	aorta and iliac arteries/calcified		NR	PR	5	NR	(11.5 - 14.9)	100-130	none	"
BONE												
16	Human 18-40 yrs.	<i>in vivo</i>	tibia/none		37	TOF; PE	0.100	3375 ± 188	(0.29 ± 0.03)	2.56 ± 0.26	average 10 measurements	Shalanskii <i>et al.</i> (1976)
17	Human	p.m.	femur/none		NR	TOF	0.100	2844.8 ± 153.6	NR		none	"
18	Human	p.m.	tibia/none		NR	TOF; PE	0.100	3238.3 ± 117.9	(0.215 ± 0.04)	1.87 ± 0.34	none	"
19	Human 40 yrs.	p.m. stored -4 to 7°C machined; flat	tibia/none		NR	TOF; PE	0.150	3472 ± 0.47% 3640	0.101 ± 7.3%	(0.88)	none mean velocity over tibial cross section	Vilks <i>et al.</i> (1974)
20	Human 40 yrs.	stored -4 to 7°C machined flat	tibia outer layer/none		NR	TOF	0.150	3397 - 3518 3247 - 3708	NR		parallel to axis perpendicular to axis	"
21	Human 40 yrs.	stored -4 to 7°C machined flat	tibia inner layer/none		NR	TOF	0.150	3407 - 3525 3367 - 3506	NR		parallel to axis perpendicular to axis	"
22	Beef (adult)	obtained fresh then ground and embedded	tibia/none		23	TOF	10	3810 - 3920 3180 - 3490 3160 - 3270	NR		$\rho = 2.00$ 2.10 parallel to bone axis $\rho = 1.98$ - 2.12 perpendicular to bone axis $\rho = 1.95$ to 2.05 neither parallel nor perpendicular to bone axis	Lees <i>et al.</i> (1979)
23	Beef (adult)	dehydrated at room temp. in vacuum for 7 days; ground and embedded	tibia/none		23	TOF	10	4180 - 4310 3460 - 3790 3160 - 3270	NR		parallel to bone axis perpendicular to bone axis neither parallel nor perpendicular to bone axis	"
24	Beef (adult)	rehydrated sample above	tibia/none		23	TOF	10	3750 - 3920 3200 - 3550 3170 - 3220	NR		parallel to bone axis perpendicular to bone axis neither parallel nor perpendicular to bone axis	"
										<u>dB/cm/MHz</u>		
25	Beef	freshly obtained then machined flat	cortical/none		NR	PT & SA	2.5-8 2.5-9	NR	7.6 4.0		shear longitudinal	Garcia <i>et al.</i> (1978)
26	Beef	decalcified	cortical/none		NR	PT & SA	1 - 6.5	NR	6 3.45 1.10		longitudinal; $\Delta\rho = 0.0\%$ (normal) $\Delta\rho = 31\%$ decalcified $\Delta\rho = 45\%$ decalcified	"
BRAIN												
27	Rat	<i>in vivo</i>	NR/none		37	LD	3.3	NR	0.32	(2.7)	none	Lee <i>et al.</i> (1979)
28	Cat	fresh	NR/none		37	TT	0.7	NR	0.014 ± 0.003 0.029 ± 0.004 0.23 ± 0.09	(0.12 ± 0.03) (0.25 ± 0.03) (1.9 ± 0.78)	absorption; stored at room temperature in physiological saline; measured <1 - 2 hours after excision	Goss <i>et al.</i> (1979)
29	Dog	fresh	NR/none		35-44*	TOF	5	1565 - 1570*	NR		measured at 0.25°C intervals; measured 5-30 after termination	Nasoni <i>et al.</i> (1979)
30	Dog	fresh	NR/none		35-43	TOF	5	1563.2	NR		$\frac{\Delta V}{\Delta T} = 0.67$ at 37°C $\frac{\Delta V}{\Delta T} = 0.62$ at 40°C $\frac{\Delta V}{\Delta T} = 0.62$ at 43°C	Bowen <i>et al.</i> (1979)

TABLE I. (Continued)

<i>Brain, Breast</i>										<i>Brain, Breast</i>									
NO.	SPECIES & AGE	PREP.	ANATOMICAL / PATH-STRUCTURE / OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION		REMARKS	REFERENCE								
								α (%)	β (dB/cm)										
31	Beef	formalin fixed (2 mo; 10%)	NR/none	10* 18* 37* 58*	SA	1	NR	(0.034) (0.080) (0.12) (0.09)	0.30* 0.70* 1.1* 0.8*	± 0.2°C; measured 44, frequency from 1 - 7 MHz	Bamber & Hill (1979)								
				10* 18* 37* 58*		2		(0.26) (0.21) (0.19) (0.16)	2.3* 1.8* 1.7* 1.4*										
				10* 18* 37* 58*		3		(0.51) (0.44) (0.37) (0.31)	4.4* 3.8* 3.2* 2.7*										
				10* 18 37 58		4		(0.78) (0.66) (0.56) (0.48)	6.8* 5.7* 4.9* 4.2*										
				10 18 37 58		5		(1.0) (0.92) (0.74) (0.68)	9.0* 8.0* 6.4* 5.9*										
32	NR	unfixed	NR/none	NR	NR	6	1534	(0.611)	5.31	$\rho = 1.037$; $Z = 1.587$	Hrazdira (1978)								
33	NR	formalin fixed (10%)	NR/none	NR	NR	6	1570	(0.968)	8.41	$\rho = 1.078$; $Z = 1.677$	"								
BREAST																			
34	Human	<i>in vivo</i>	NR/none	body	PER	1.76	NR	(0.06 - 0.13)	0.5 - 1.1	none	Chevnenko & Yukhananov (1971)								
35	Human	<i>in vivo</i>	NR/cancer	body	PER	1.76	NR	(0.17 - 0.30)	1.5 - 2.6	none	"								
36	Human	<i>in vivo</i>	NR/fibrous mastopathy	body	PER	1.76	NR	(0.29 - 0.44)	2.5 - 3.8	none	"								
37	Human	<i>in vivo</i>	NR/mastopathy	body	PER	1.76	NR	(0.13 - 0.18)	1.1 - 1.6	none	"								
38	Human 54 - 74 yrs.	fresh p.m.	NR/none	37 ± 0.2	SA	0.5-6	NR	dB/cm/MHz 0.75 ± 0.3		average 6 samples; fl.5 dependence	Foster & Hunt (1979)								
39	Human 45-52 yrs.	<i>in vitro</i>	premenopausal/cyst liquid	37	PT & AI	6.50 9.08 14.23 6.50 9.08 11.66 14.23 19.39 25.07 35 65 85 115	NR	$\alpha/f^2 \times 10^{17} \text{ sec}^2/\text{cm}$ 315 233 180 255 216 186 169 141 126 102 73.3 64 57.7 130 105 88.5 80 65 59 124 118 109 86 65 56.5 49 42.5 39.5 35.5		sample #2; PT ± 2%; AI ± 5% sample #3 sample #6 sample #7	Lang et al. (1978)								
40	Human 45-52 yrs.	<i>in vitro</i>	postmenopausal/cyst liquid	37	PT & AI	6.50 9.08 11.66 14.23 19.39 14.23	NR	124 103 88.8 81 70 81.2		sample #4; PT ± 2%; AI ± 5% sample #5; hysterectomized	"								
41	Human 77 yrs.	<i>in vitro</i>	postmenopausal/cyst liquid	37	PT & AI	3.95 6.50 9.08 11.66 14.23 19.39 24.56 25.07 35 65 85 115	NR	302 258 209 184 167 138 121 110 91 68 55 1.67 2.81 3.95 6.52 9.10 11.65 14.24 19.39		sample #7; PI ± 2%; AI ± 5%	"								

TABLE I. (Continued)

<u>Breast, Eye</u>											<u>Breast, Eye</u>	
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE
41	Continued						24.57 25.07 35 65 115		148 133 113 76 57			
									$\alpha/f^2 \times 10^{17} \text{ sec}^2/\text{cm}$			
42	Human 77 yrs.	<i>in vitro</i>	postmenopausal/ cyst liquid		25	PT & AI	2.81	NR	152 150 155 165 155 125 122 114 119 122 125 144 170 195 267 317 295 230 145 137	sample #1 PT ± 2%; AI ± 5%; pH = 0.95 1.53 2.05 2.67 3.33 4.45 5.3 6.0 6.6 7.1 8.3 9.2 9.9 10.3 10.9 11.3 11.65 11.97 12.5 13.15	Lang et al. (1978)	
43	Human 77 yrs.	<i>in vitro</i>	postmenopausal/ cyst liquid		25	PT & AI	2.81	NR	470 355 266 185 122 106 53	sample #1 PT ± 2%; AI ± 5%; concentra- tion dependence C = C ₀ 0.8C ₀ 0.6C ₀ 0.4C ₀ 0.25C ₀ 0.22C ₀ 0.10C ₀	"	
44	Human	formalin fixed (2 wks; 10%)	areola/none		23	SA	1.6* 3* 4* 5*	NR	(0.23) (0.37) (0.49) (0.63)	2.0* 3.2* 4.3* 5.5*	none	Fry et al. (1979)
45	Human	formalin fixed (2 wks; 10%)	nipple/none		23	SA	1.6* 2.7* 3.1* 3.9* 4.8*	NR	(0.24) (0.37) (0.46) (0.56) (0.79)	2.1* 3.2* 4.0* 4.9* 6.9*		
46	Human	formalin fixed (2 wks; 10%)	NR/malignant mass		23	SA	1.5	NR	(0.92)	8	none	"
47	Human	formalin fixed (2 wks; 10%)	NR/malignant tumor		23	SA	2	NR	(2.4)	21	none	"
48	Human	formalin fixed (2 wks; 10%)	NR/neoplastic		23	SA	2	NR	(1.5)	13	none	"
<u>EYE</u>												
49	Human	<i>in vivo</i>	choroid/malignant melanoma		37	SA	5-12	NR	<u>dB/cm/MHz</u> 0.9		none	Lizzi et al. (1978)
50	Human	excised stored at 40°C; 19-36 days	aqueous/none		22 ± 0.1	PT	4.2 wide band	1514.3 ± 3.9 1510.4 ± 8.6	NR		± S.D.; samples from 2 eyes; 20 measurements each	Round & Chivers (1978)
51	Human	excised stored at 40°C; 19-36 days	cornea/none		22 ± 0.1	PT	4.2 wide band	1632.1 ± 3.8 1632.5 ± 6.1	NR		± S.D.; samples from 2 eyes	"
52	Human	excised stored at 40°C; 19-36 days	lens/none		22 ± 0.1	PT	4.2 wide band	1557.6 ± 9.6 1538.1 ± 10.6	NR		± S.D.; samples from 2 eyes	"
53	Human	excised stored at 40°C; 19-36 days	sclera/none		22 ± 0.1	PT	4.2 wide band	1743 ± 27.6 1745 ± 55	NR		± S.D.; samples from 2 eyes; 10 measurements each	"
54	Human	excised stored at 40°C; 19-36 days	vitreous/none		22 ± 0.1	PT	4.2 wide band	1510.7 ± 7.3 1505 ± 2.4	NR		± S.D.; samples from 2 eyes; 20 measurements each	"
55	Beef or pig	NR	choroid/none		20	TOF	6	1533 ± 20	NR		average 10 measurements each of 10 specimens	Oksala & Varonen (1965)
56	Beef or pig	NR	sclera/none		20	TOF	6	1604 ± 6	NR		average 10 measurements each of 10 specimens	"

TABLE I. (Continued)

<i>Fat, Heart</i>												<i>Fat, Heart</i>	
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	(dB/cm)	REMARKS	REFERENCE	
FAT													
57	Human	<i>in vitro</i>	abdominal/none		35	PE	2	1476		NR	maintained near body temperature	Bullen <i>et al.</i> (1965)	
58	Human	NR	subcutaneous cellular tissue/none		NR	PT-C	0.88	NR	(0.07)	0.6	none	Chevnenko & Yukhananov (1971)	
						PER	2.64		(0.18)	1.6			
							0.88		(0.67)	0.58			
							2.64		(0.20)	1.7			
59	Beef	fresh	peritoneal/none		10	PE	10	1680*		NR	± 1%; ± 0.2°C	Bamber & Hill (1979)	
					20			1575*					
					30			1490*					
					44			1390*					
					60			1345*					
60	Beef	fresh	peritoneal/none		10*	SA	1	NR	(0.69)	6.0*	± 10%; ± 0.2°C	"	
					20*				(0.46)	4.0*			
					30*				(0.23)	2.0*			
					37*				(0.24)	2.1*			
					60*				(0.34)	3.0*			
					20*		2		(0.76)	6.6*			
					30*				(0.37)	3.2*			
					37*				(0.30)	2.6*			
					60*				(0.46)	4.0*			
					20*		3		(1.1)	9.5*			
					30*				(0.53)	4.6*			
					37*				(0.37)	3.2*			
					60*				(0.76)	6.6*			
					30*		4		(0.83)	7.2*			
					37*				(0.48)	4.2*			
					60*				(0.84)	7.3*			
					30*		5		(1.1)	10.0*			
					37*				(0.69)	6.0*			
					60*				(0.94)	8.2*			
					30*		6		(1.4)	12.5*			
					37*				(0.80)	7.0*			
					60*				(1.0)	9.0*			
					30*		7		(1.8)	16.0*			
					37*				(0.92)	8.0*			
					60*				(1.1)	9.5*			
61	Beef	refrig.	NR/none		Rm	PR	5	1480 ± 3.7		NR	± S.D.; 50 measurements	Sollish (1979)	
62	Dog	<i>in vivo</i>	omentum/none		36.3	TOF	5	1459		NR	none	Nasoni <i>et al.</i> (1979)	
63	Dog	<i>in vitro</i>	omentum/none		36.3	TOF	5	1452 - 1455 - 1432		NR	velocity measurements in intervals of 0.25°C over range indicated	"	
64	Dog	fresh	stomach/none		37	TOF	5	1411.9		NR	$\frac{\Delta v}{\Delta T}$ --2.89 at 37°C	Bowen <i>et al.</i> (1979)	
											$\frac{\Delta v}{\Delta T}$ --2.85 at 40°C		
											$\frac{\Delta v}{\Delta T}$ --2.86 at 43°C		
65	Dog	refrig. (5 hrs.)	stomach/none		37	TOF	5	1412.9		NR	$\frac{\Delta v}{\Delta T}$ --3.43 at 37°C	"	
											$\frac{\Delta v}{\Delta T}$ --2.86 at 40°C		
											$\frac{\Delta v}{\Delta T}$ --2.91 at 43°C		
66	Pig	fresh stored at 5°C	backfat/none		4 ± 1	TDS	2*	NR	(1.0)	9.0*	± 1.5 dB/cm; obtained day after slaughter	Gammell <i>et al.</i> (1979)	
					1		4*		(2.4)	20.8*			
					20 ± 1		2*		(0.80)	7.0*			
					37 ± 1		4*		(1.8)	15.3*			
					1		2*		(0.34)	3.0*			
							4*		(0.65)	5.5*			
							6*		(0.98)	8.5*			
							8*		(1.4)	12.5*			
					49		9.9*		(2.0)	17.5*			
							2*		(0.23)	2.0*			
							4*		(0.40)	3.5*			
							6*		(0.69)	6.0*			
							8*		(1.0)	9.0*			
							9.9*		(1.6)	13.5*			
HEART													
67	Beef	less than 3 days, stored at 4°C	ventricles & atria/none		22 ± 1	PR	5	1546 ± 4.7		NR	± S.D., average of 50 measurements; $\rho = 1.048 \pm 0.0036$, average of 12 $Z = 1.620 \pm 0.0074$, data also given for tissue constituents	Shung & Reid (1978)	
68	Cat	fresh <1-2 hrs. p.m.	NR/none		37	TT	0.7	NR	0.018 ± 0.009	(0.156 ± 0.078)	absorption; ± S.D.	Goss <i>et al.</i> (1979)	
							1		0.033 ± 0.006	(0.286 ± 0.052)			
							7		0.21 ± 0.03	(1.8 ± 0.3)			
69	Dog	fresh	NR/none		35-43*	TOF	5	1592-1602*		NR	measured at 0.25°C intervals over temperature range indicated	Nasoni <i>et al.</i> (1979)	

TABLE I. (Continued)

<u>Heart, Kidney</u>								<u>Heart, Kidney</u>				
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH- OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm) (dB/cm)	REMARKS	REFERENCE	
70	Dog	formalin fixed (1 yr, 10%)	NR/non-infarcted region		NR	SLAM	100	1580 ± 20 NR	41-68 (356-591) 37-61 (321-530) 48 (417) 43 (373)	± velocity variation in sample typical values; attenuation ± 10% off axis component perpendicular to grain off axis component parallel to grain	Yuhas & Kessler (1979)	
71	Dog	formalin fixed (1 yr, 10%)	NR/infarct		NR	SLAM	100	NR	38-100 (330-867) 27-70 (234-608)	off axis component perpendicular to grain off axis component parallel to grain localized variations characteristic of infarction	"	
									Np/cm/MHz			
72	Dog	NR	left ventricle/none		NR	PT-R	4-7 5	NR	0.073 ± 0.92 0.27 (2.3)	ρ = 1.06	Klepper <i>et al.</i> (1977)	
									Np/cm/MHz			
73	Rabbit (young)	NR	NR/none		NR	PT	2-10	NR	0.075 ± 0.003	9 areas of myocardium from 3 animals; (1978) 57 measurements; collagen concentration = 0.77 ± 0.02% wet weight	Mimbs <i>et al.</i>	
74	Rabbit (young)	adriamycin given (2.4 mg/kg) for at least 10 weeks	NR/none		NR	PT	2-10	NR	0.115 ± 0.005	6 areas of myocardium from 2 animals; 33 measurements; collagen concentration = 0.95 ± 0.03	"	
75	NR	NR	pericardial fluid/none		37 ± 0.01	PO	1.2	1554.2	NR	repeatability ± 0.1%; 0.24% plasma protein	Aubert <i>et al.</i> (1978)	
<u>KIDNEY</u>												
76	Dog	<i>in vivo</i>	NR/none		38.5	TOF	5	1566.6 1580.7 1569.9 1568.6 37 1571 1567 1565 1564	NR	number of specimens; ±2-2.5 m/s statistical error	Nasoni <i>et al.</i> (1979)	
77	Beef 2 yrs. Cat (adult)	fresh measured <1-2 hrs. after excision	NR/none		37	TT	0.7 1 7	NR	0.017 ± 0.007 0.033 ± 0.044 0.20 ± 0.002	(0.147 ± 0.06) (0.286 ± 0.035) (1.74 ± 0.017)	absorption; stored in room temperature in physiological saline until measured	Goss <i>et al.</i> (1979)
78	Dog	fresh measured 1 hr after sacrifice	NR/none		37	TOF	5	1570.2 1566.5 1571.1	NR	3 samples; Δv/ΔT = 1.29-1.35 m/s/°C at 37°C Δv/ΔT = 1.11-1.16 m/s/°C at 40°C Δv/ΔT = 0.93-0.98 m/s/°C at 43°C	Bowen <i>et al.</i> (1979)	
79	Dog	fresh 5-30 min after excision	NR/none		35-44* 37	TOF	5	1576*-1587* 1567 1565 1564 1578 1579 1583 1586 38.5 1588.4 1579.6 1580.2 1584.5	NR	± 2-2.5 ms statistical error; measured in 0.25°C intervals over temperature range	Nasoni <i>et al.</i> (1979)	
80	Pig	fresh <1 hr. p.m.	NR/none		4 ± 1	TDS	2* 4* 6* 8* 9.9*		(0.15) (0.37) (0.63) (0.98) (1.5)	1.3* 3.2* 5.5* 8.5* 12.6*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell <i>et al.</i> (1979)
					20 ± 1		2* 4* 6* 8* 9.9*		(0.57) (0.29) (0.46) (0.69) (0.90)	0.5* 2.5* 4.0* 6.0* 7.8*		
					37 ± 1		2 4 6 8 9.9		(0.23) (0.43) (0.57) (0.79) (1.0)	2.0 3.7 5.0 6.9 9.0		
81	NR	unfixed	NR/none		NR	NR	6	1532	(0.778)	6.76	ρ = 1.032 Z = 1.567	Hrazdira (1978)
82	NR	formalin fixed (10%)	NR/none		NR	NR	6	1547	(1.04)	9.0	ρ = 1.046 Z = 1.615	"

TABLE I. (Continued)

<i>Limb, Liver</i>												<i>Limb, Liver</i>	
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH- OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	(dB/cm)	REMARKS	REFERENCE	
LIMB													
83	Human (male)	<i>in vivo</i>	forearm/none		body	PR	5	1583.4 ± 1.0 1579.8 ± 1.7	NR		+ S.D.; 50 individual measurements on each target	Sollish (1979)	
LIVER													
84	Human	p.m.	NR/none		5*	PE	10	1550*	NR		± 0.2°C; + 1%	Bamber & Hill (1979)	
					12*			1562*					
					21*			1588*					
					30*			1600*					
					37*			1608*					
					43*			1610*					
					47*			1612*					
85	Human	p.m.	NR/none		5*	SA	1	NR	(0.14)	1.2*	+ 0.2°C; ± 10%	"	
					11*				(0.17)	1.5*			
					22*				(0.18)	1.6*			
					30*				(0.18)	1.6*			
					42*				(0.18)	1.6*			
					5*				(0.24)	2.1*			
					11*		2		(0.24)	2.1*			
					22*				(0.21)	1.8*			
					30*				(0.21)	1.8*			
					42*				(0.19)	1.7*			
					5*		3		(0.34)	3.0*			
					11*				(0.31)	2.7*			
					22*				(0.29)	2.5*			
					30*				(0.28)	2.4*			
					42*				(0.25)	2.2*			
					5*		4		(0.44)	3.8*			
					11*				(0.38)	3.3*			
					22*				(0.32)	2.8*			
					30*				(0.29)	2.5*			
					42*				(0.28)	2.4*			
					5*		5		(0.49)	4.3*			
					11*				(0.44)	3.8*			
					22*				(0.37)	3.2*			
					30*				(0.34)	3.0*			
					42*				(0.32)	2.8*			
					5*		6		(0.66)	5.7*			
					11*				(0.54)	4.7*			
					22*				(0.44)	3.8*			
					30*				(0.40)	3.5*			
					42*				(0.37)	3.2*			
					5*		7		(0.83)	7.2*			
					11*				(0.69)	6.0*			
					22*				(0.56)	4.9*			
					30*				(0.52)	4.5*			
					42*				(0.48)	4.2*			
86	Human	autopsy (refrig. 60 hrs.)	NR/micronodular cirrhosis		4 ± 1	TDS	2*	NR	(0.48)	4.2*	± 1.5 dB/cm	Gammell <i>et al.</i> (1979)	
					1		4*		(0.92)	8.0*			
							6*		(1.5)	13.0*			
							8*		(2.1)	18.6*			
					9-9*		9-9*		(2.8)	24.0*			
					20 ± 1		2*		(0.30)	2.6*			
					1		4*		(0.69)	6.0*			
							6*		(1.1)	9.5*			
							8*		(1.56)	13.6*			
							9-9*		(2.06)	17.9*			
					37 ± 1		2*		(0.23)	2.0*			
					1		4*		(0.52)	4.5*			
							6*		(0.92)	8.0*			
							8*		(1.3)	11.5*			
							9.9*		(1.8)	15.5*			
87	Human	p.m.	NR/multiple metastases		37 ± 2	SA	0.5-6	NR	dB/cm/MHz 0.7 ± 0.2		none	Foster & Hunt (1979)	
88	Human	unfixed	NR/none		NR	NR	1	NR	(0.131)	1.14	none	Hrazdira (1978)	
							2		(0.272)	2.36			
							3		(0.382)	3.32			
							6		(0.828)	7.19			
89	Human	fixed	NR/none		NR	NR	1	NR	(0.185)	1.61	none	"	
							2		(0.378)	3.29			
							3		(0.580)	5.04			
							6		(1.21)	10.50			
90	Human	fixed	NR/none		NR	PER	4.5-7.8*	NR	Np/cm/MHz 0.3*		none	Richter & Millner (1978)	
91	Human	NR	NR/none		NR	SA	2.25	NR	dB/cm/MHz 1.32 ± 0.3		autopsy specimens; 10 slices from 5 different livers	Kuc <i>et al.</i> (1978)	
92	Human	NR	NR/none		NR	PT-C	0.88	NR	(0.13)	1.2	none	Chevnenko & Yukhananov (1971)	
						PER	2.64		(0.39)	3.4			
							0.88		(0.15)	1.3			
							2.64		(0.45)	3.9			
93	Beef Cat Mouse Pig	fresh measured <1-2 hrs.	NR/none		37	TT	0.5	NR	0.01 ± 0.006	(0.09 ± 0.05)	absorption; ± S.D.	Goss <i>et al.</i> (1979)	
							0.7		0.02 ± 0.003	(0.17 ± 0.03)			
							1		0.023 ± 0.004	(0.20 ± 0.03)			
							4		0.14 ± 0.03	(1.2 ± 0.3)			
							7		0.24 ± 0.02	(2.1 ± 0.2)			

TABLE I. (Continued)

<i>Liver</i>										<i>Liver</i>											
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH- OLOGY	TEMP (°C)	METHOD	FREQ. (MHZ)	VELOCITY (m/sec)	ATTENUATION (dB/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE									
94	Beef	fresh measured <30 min	NR/none		8*	PE	10	1610*	NR		± 0.2°C; ± 1%; sample #1	Bamber & Hill (1979)									
					21*			1625*													
					37*			1640*													
					42*			1641*													
					55*			1630*													
					9*			1545*													
					20*			1570*													
					30*			1590*													
					43*			1600*													
					65*			1590*													
95	Beef	fresh measured <30 min	NR/none		8*	SA	1	NR	(0.23)	2.0*	± 10%; sample #1	"									
					21*			(0.23)	2.0*												
					37*			(0.24)	2.1*												
					45*			(0.37)	3.2*												
					58*			(0.37)	3.2*												
					8*			2	(0.33)	2.9*											
					21*				(0.28)	2.4*											
					37*				(0.29)	2.5*											
					45*			3	(0.44)	3.8*											
					58*				(0.44)	3.8*											
					8*				(0.54)	4.7*											
					21*			4	(0.40)	3.5*											
					37*				(0.38)	3.3*											
					45*				(0.52)	4.5*											
					58*			5	(0.52)	4.5*											
					8*				(0.54)	4.7*											
					21*				(0.40)	3.5*											
					37*			6	(0.37)	3.2*											
					45*				(0.56)	4.9*											
					58*				(0.57)	5.0*											
					8*			7	(0.66)	5.8*											
					21*				(0.48)	4.2*											
					37*				(0.41)	3.6*											
					45*			8	(0.61)	5.3*											
					58*				(0.68)	5.9*											
					8*				(0.79)	6.9*											
					21*			9	(0.59)	5.1*											
					37*				(0.48)	4.2*											
					45*				(0.69)	6.0*											
					58*			10	(0.77)	6.7*											
					8*				(1.0)	8.7*											
					21*				(0.72)	6.3*											
					37*			11	(0.61)	5.3*											
					45*				(0.80)	7.0*											
					57*				(0.90)	7.8*											
					9*			12	(0.19)	1.7*											
					20*				(0.19)	1.7*											
					30*				(0.19)	1.7*											
					43*			13	(0.21)	1.8*											
					65*				(0.23)	2.0*											
					9*				(0.25)	2.2*											
					20*			14	(0.23)	2.0*											
					30*				(0.22)	1.9*											
					43*				(0.21)	1.8*											
					65*			15	(0.26)	2.3*											
					9*				(0.33)	2.9*											
					20*				(0.25)	2.2*											
					30*			16	(0.23)	2.0*											
					43*				(0.23)	2.0*											
					65*				(0.34)	3.0*											
					9*			17	(0.38)	3.5*											
					20*				(0.29)	2.5*											
					30*				(0.31)	2.7*											
					43*			18	(0.31)	2.7*											
					65*				(0.43)	3.7*											
					9*				(0.44)	3.8*											
					20*			19	(0.34)	3.0*											
					30*				(0.32)	2.8*											
					43*				(0.32)	2.8*											
					65*			20	(0.49)	4.3*											
					9*				(0.54)	4.7*											
					20*				(0.40)	3.5*											
					30*			21	(0.34)	3.0*											
					43*				(0.36)	3.1*											
					65*				(0.62)	5.4*											
					9*			22	(0.63)	5.5*											
					20*				(0.49)	4.3*											
					30*				(0.46)	4.0*											
					43*			23	(0.47)	4.1*											
					65*				(0.77)	6.7*											
					96				Beef	frozen thawed			NR/none		22	TAP	1.0*	NR	0.04 ± 0.01*	(0.3 ± 0.09)	± S.D.; pressurized Frizzell <i>et al</i> 500 lb/in ² for 90 min; measured in water
																3.1*		0.21 ± 0.02*	(1.8 ± 0.2)		
																5.3*		0.36 ± 0.01*	(3.1 ± 0.09)		
																7.4*		0.54 ± 0.01*	(4.7 ± 0.09)		
																10.0*		0.75 ± 0.02*	(6.5 ± 0.2)		
					97			Beef	frozen thawed	NR/none				22	TAP	1.0*	NR	0.22 ± 0.04*	(1.9 ± 0.3)	± S.D.; measured in saline	"
																3.1*		0.31 ± 0.01*	(2.7 ± 0.09)		
																5.3*		0.46 ± 0.02*	(4.0 ± 0.2)		
																7.4*		0.72 ± 0.02*	(6.2 ± 0.2)		
																10.0*		0.85 ± 0.02*	(7.2 ± 0.2)		

TABLE I. (Continued)

<i>Liver</i>										<i>Liver</i>															
NO	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	(dB/cm)	REMARKS	REFERENCE													
98	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.15 ±	(1.3 ±	± S.D.; measured in water	Frizzell <i>et al</i> (1979)													
									0.04*	0.3)															
									0.21 ±	(1.8 ±															
									0.01*	0.09)															
									0.36 ±	(3.1 ±															
0.01*	0.09)																								
99	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.45 ±	(3.9 ±	± S.D.; separated by film from water coupling	"													
									0.1*	0.9)															
									0.63 ±	(5.5 ±															
									0.1*	0.9)															
									0.77 ±	(6.7 ±															
0.1*	0.9)																								
100	Beef	frozen thawed	NR/none		22	TT	1.05*	NR	0.05 ±	(0.43 ±	± S.D.; absorption; separated by film from water coupling	"													
									0.01*	0.09)															
101	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.5 ±	(4.3 ±	± S.D.; 3 samples; pressurized 500 lb/in ² for 90 min after storing at 4° for 15 hrs.; separated by film from water coupling	"													
									0.33*	3)															
									0.23 ±	(2.0 ±															
									0.03*	0.3)															
									0.43 ±	(3.7 ±															
0.03*	0.3)																								
102	Beef	frozen thawed	NR/none		22	TAP	0.5*	NR	0.1*	(0.87)	stored in sample holder at 4°C for 15 hrs; separated by film from water coupling	"													
									0.11*	(0.95)															
									0.26*	(2.2)															
									0.5*	(4.3)															
									0.71*	(6.2)															
1.1*	(9.5)																								
103	Beef	formalin fixed (2 mos; 4%)	NR/none		18*	SA	3	NR	(0.28)	2.4*	sample #1; ± 0.2°C; Bamber & Hill (1979)														
									(0.23)	2.0*															
									(0.23)	2.0*															
									(0.23)	2.0*															
									(0.39)	3.4*															
									(0.33)	2.9*															
									(0.31)	2.7*															
									(0.29)	2.5*															
									(0.49)	4.3*															
									(0.41)	3.6*															
									(0.38)	3.3*															
									(0.34)	3.0*															
									(0.63)	5.5*															
									(0.53)	4.6*															
									(0.48)	4.2*															
									(0.41)	3.6*															
									(0.80)	7.0*															
									(0.68)	5.9*															
									(0.59)	5.1*															
									(0.55)	4.8*															
									(0.32)	2.8*															
									(0.29)	2.5*															
									(0.26)	2.3*															
									(0.24)	2.1*															
									(0.40)	3.5*															
									(0.37)	3.2*															
									(0.32)	2.8*															
									(0.30)	2.6*															
									(0.52)	4.5*															
									(0.44)	3.8*															
									(0.38)	3.3*															
									(0.34)	3.0*															
									(0.64)	5.6*															
									(0.55)	4.8*															
									(0.46)	4.0*															
									(0.44)	3.8*															
									(0.80)	7.0*															
									(0.69)	6.0*															
									(0.57)	5.0*															
									(0.51)	4.4*															
									104	Beef			NR	NR/none		16.8	PE	NR	1559-1568	NR		4 samples	Hara <i>et al.</i> (1979)		
									105	Dog			<i>in vivo</i>	NR/none		37.75	TOF	5	1601	NR		none	Nasoni <i>et al.</i> (1979)		
									106	Dog			fresh (measured <30 min)	NR/none		38.5	TOF	5	1598.3	NR		3 samples; ± 2-2.5 m/sec statistical error; Δv/ΔT = 1.06 -1.26	"		
																								1604.3	
																								1603.3	
																								1597.5	
1602.5																									
1603																									
1599-																									
1608*																									
measured at 0.25°C intervals over temperature range																									
107	Dog	fresh	NR/none		NR	SA	3.5-5.5	NR	0.095	none	Kak & Dines (1978)														

TABLE I. (Continued)

<i>Liver, Milk, Muscle, Pancreas</i>											<i>Liver, Milk, Muscle, Pancreas</i>	
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (dB/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE
108	Dog	fresh (measured <1 hr.)	NR/none		37	TOF	5	1591.7	NR		3 samples; $\frac{\Delta v}{\Delta T} = 0.93-1.13$ m/s/°C at 37°C	Bowen <i>et al.</i> (1979)
								1594.8			$\frac{\Delta v}{\Delta T} = 0.72-0.96$ m/s/°C at 40°C	
								1604.0			$\frac{\Delta v}{\Delta T} = 0.46-0.80$ m/s/°C at 43°C	
109	Mouse	<i>in vivo</i>	NR/none		37	TT	0.5	NR	0.011 ± 0.0025	(0.096 ± 0.022)	absorption; 7 measurements; 2 animals	Frizzell <i>et al.</i> (1979)
110	Mouse	fresh	NR/none		37	TT	0.5	NR	0.0093 ± 0.0044	(0.080 ± 0.038)	absorption; 9 measurements; 2 animals	"
111	Mouse	p.m. (24 hrs)	NR/none		37	TT	0.5	NR	0.0090 ± 0.0025	(0.078 ± 0.022)	absorption; 9 measurements; 3 animals	"
112	Pig	fresh	NR/none		4 ± 1	TDS	2* 4* 6* 8* 9.9*	NR	(0.38) (0.83) (1.4) (2.0) (2.7)	3.3* 7.2* 12.0* 17.3* 23.3*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell <i>et al.</i> (1979)
					20 ± 1		2* 4* 6* 8* 9.9*		(0.37) (0.75) (1.2) (1.7) (2.4)	3.2* 6.5* 10.3* 14.7* 21.0*		
					37 ± 1		2* 4* 6* 8* 9.9*		(0.46) (0.69) (1.0) (1.4) (1.8)	4.0* 6.0* 9.0* 12.0* 16.0*		
113	NR	unfixed	NR/none		NR	NR	6	1544	(0.828)	7.19	$\rho = 1.036$; $Z = 1.6$	Hrazdira (1978)
114	NR	formalin fixed (10%)	NR/none		NR	NR	6	1567	(1.21)	10.5	$\rho = 1.054$; $Z = 1.656$	"
MILK												
115	Beef	NR	whole/none		10	SAR	NR	1488* 1509* 1528* 1543* 1553*	NR		8% solids not fat; 4% butter fat	Fitzgerald <i>et al.</i> (1961)
116	Beef	NR	skimmed/none		10	SAR	NR	1483* 1516* 1540* 1554* 1560*	NR		8% solids not fat	"
MUSCLE												
117	Human	NR	NR/none		NR	PT-C PER	0.88 2.64 0.88 2.64	NR	(0.15) (0.43) (0.15) (0.46)	1.3 3.7 1.34 4.0	transverse to fibers	Chevnenko & Yukhananov (1971)
118	Beef	fresh	skeletal/none		20 ± 1	PE & SA	1-8	NR	dB/cm/MHz 1.1 ± 0.15		5 measurements; perpendicular to fibers	Nassiri <i>et al.</i> (1979)
119	Beef	formalin fixed (2 wks; 5%)	skeletal/none		20 ± 1	PE & SA	1-8	NR	2.9 ± 0.23 1.6 ± 0.15		parallel to fibers 50 measurements perpendicular to fibers	"
120	Beef	NR	NR/none		17.0	PE	NR	1540-1552	NR		3 samples	Hara <i>et al.</i> (1979)
121	Beef	NR	fatty/none		17.2	PE	NR	1522-1550	NR		3 samples	"
122	Dog	<i>in vivo</i>	skeletal/none		31.0	TOF	5	1583	NR		none	Nasoni <i>et al.</i> (1979)
123	Dog	fresh	skeletal/none		38.5	TOF	5	1608.7 1629.3 1606- 41*	NR		± 2-2.5 m/s statistical error; 2 samples; measured at 0.25°C intervals over entire temperature range	"
124	Dog	fresh (measured <1 hr.)	skeletal/none		37	TOF	5	1589.1 1603.3 1588.8 1591.6	NR		4 samples $\frac{\Delta v}{\Delta T} = 1.08-1.23$ at 37°C $\frac{\Delta v}{\Delta T} = 0.87-1.03$ at 40°C $\frac{\Delta v}{\Delta T} = 0.65-0.82$ at 43°C	Bowen <i>et al.</i> (1979)
PANCREAS												
125	Pig	p.m. 6 hrs	NR/none		37	TDS	2* 3* 4*	NR	(0.02 - 0.3) (0.2 - 0.40) (0.3 - 0.6)	0.2 - 3* 2 - 3.5* 3 - 5*	range of 4 points; also contains data as shown in Gammell <i>et al.</i> (1979) plus data at 5 days p.m. for fixed and unfixed tissue	Le Croisette <i>et al.</i> (1979)

TABLE I. (Continued)

<i>Pancreas, Skin, Spleen, Tendon</i>										<i>Pancreas, Skin, Spleen, Tendon</i>		
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (dB/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE
125	Continued						5*		(0.6 - 0.8)	5 - 7*		
							6*		(0.75 - 0.98)	6.5 - 8.5*		
							7*		(0.92 - 1.2)	8 - 10*		
							8*		(1.1 - 1.4)	9.5 - 12*		
							9*		(1.3 - 1.7)	11 - 15*		
SKIN												
126	Human (newborn)	<i>in vivo</i>	NR/none		37	PR	2.3	NR	NR	NR	Z = 1.57 ± 0.025*	Ogura <i>et al.</i> (1978)
127	Human (male)	<i>in vivo</i>	upper abdomen/none		20 25 30 35 37 40	PR	2.3	NR	NR	NR	Z = 1.569; 8 cases Z = 1.580 Z = 1.585 Z = 1.589 Z = 1.587 Z = 1.587	"
128	Human (male)	<i>in vivo</i>	right subcostal region/none		37	PR	2.3	NR	NR	NR	Z = 1.59 ± 0.15*	"
129	Human (female)	<i>in vivo</i>	abdominal/none		37	PR	2.3	NR	NR	NR	Z = 1.60 ± 0.04*	"
130	Human (female)	<i>in vivo</i>	breast/none		37	PR	2.3	NR	NR	NR	Z = 1.57 ± 0.076*	"
131	Pig (5 mos.)	<i>in vivo</i>	NR/none		NR	PE	15 wide band	1710 ± 60	NR	NR	none	Cantrell <i>et al.</i> (1978)
						SA	7-13	NR	α/ω (dB/cm/MHz): 0.7 ± 0.7		Z = 1.87 ± 0.08	
SPLEEN												
132	Beef	formalin fixed (2 mo; 4%)	NR/none		10* 18* 37* 58* 10* 18* 37* 58* 10* 18* 37* 58* 10* 18* 37* 58* 10* 18* 37* 58*	SA	1 2 3 4 5	NR	(0.14) (0.16) (0.22) (0.16) (0.53) (0.29) (0.28) (0.23) (0.52) (0.46) (0.40) (0.33) (0.71) (0.67) (0.56) (0.46) (0.93) (0.89) (0.74) (0.59)	1.2* 1.4* 1.9* 1.4* 2.9* 2.5* 2.4* 2.0* 4.5* 4.0* 3.5* 2.9* 6.2* 5.8* 4.9* 4.0* 8.1* 7.7* 6.4* 5.1*	± 0.2°C; ± 10%	Bamber & Hill (1979)
133	Dog	<i>in vivo</i>	NR/none		38.2	TOF	5	1601	NR	NR	none	Nasoni <i>et al.</i> (1979)
134	Dog	fresh (<1hr)	NR/none		37	TOF	5	1601.3	NR	NR	$\frac{\Delta V}{\Delta T} = 1.31$ at 37°C $\frac{\Delta V}{\Delta T} = 1.07$ at 40°C $\frac{\Delta V}{\Delta T} = 0.84$ at 45°C	Bowen <i>et al.</i> (1979)
135	Dog	fresh (5-30 min)	NR/none		38.2	TOF	5	1567 1635	NR	NR	none	Nasoni <i>et al.</i> (1979)
136	Pig	fresh	NR/none		4 ± 1 20 ± 1 37 ± 1	TDS	2* 4* 6* 8* 9.9* 2* 4* 6* 8* 9.9* 2* 4* 6* 8* 9.9*	NR	(0.23) (0.91) (1.6) (2.5) (3.7) (0.22) (0.63) (1.0) (1.6) (2.2) (0.11) (0.40) (0.69) (0.92) (1.3)	2.0* 7.9* 14.0* 21.5* 31.8* 1.9* 5.5* 8.9* 13.9* 19.5* 1.0* 3.5* 6.0* 8.0* 11.6*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell <i>et al.</i> (1979)
137	NR	unfixed	NR/none		NR	NR	6	1548	(0.508)	4.42	$\rho = 1.046$; Z = 1.619	Hrazdira (1978)
138	NR	formalin fixed (10%)	NR/none		NR	NR	6	1566	(0.815)	7.08	$\rho = 1.061$; Z = 1.667	"
TENDON												
139	Beef (= 2 yrs.)	fresh (<1-2 hrs. p.m.)	NR/none		37	TT	0.5 0.7 1 3	NR	0.05 ± 0.03 0.16 ± 0.1 0.11 ± 0.04 0.53 ± 0.2	(0.43 ± 0.3) (1.4 ± 0.9) (0.96 ± 0.3) (4.6 ± 0.2)	± S.D.; absorption stored at room temperature in physiological saline until measured	Goss <i>et al.</i> (1979)

TABLE I. (Continued)

<i>Tendon, Testis, Tooth, Uterus</i>										<i>Tendon, Testis, Tooth, Uterus</i>		
NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (dB/cm)	REMARKS	REFERENCE	
139	Continued						4		0.75 ± 0.4	(6.5 ± 3)		
							7		1.4 ± 0.5	(12 ± 4)		
140	Mouse	fresh	tail/none		Rm	SLAM	100	1733 ± 56		NR	± S.D.; bathed in 0.9% saline	Goss & O'Brien (1979)
141	Mouse	rehydrated	tail/none		Rm	SLAM	100	1747 ± 66		NR	± S.D.; dried in air 30-127 min then placed on the microscope stage in 0.9% saline and measured	"
TESTIS												
142	Human	<i>in vivo</i>	NR/none		30	PE	4	1595		NR	none	Jellins & Barraclough (1978)
143	Mouse	<i>in vivo</i>	NR/none		37	TT	1.364	NR	0.023	(0.20)	absorption	Fry <i>et al.</i> (1978)
144	Mouse	fresh (<1-2 p.m.)	NR/none		37	TT	0.5	NR	0.0078 ± 0.002	(0.068 ± 0.02)	± S.D.; absorption stored at room temperature in physiological saline until measured, usually 1-2 hrs. after excision	Goss <i>et al.</i> (1979)
							0.7		0.0085 ± 0.001	(0.074 ± 0.009)		
							1		0.015 ± 0.003	(0.13 ± 0.03)		
							4		0.079 ± 0.02	(0.69 ± 0.2)		
							7		0.12 ± 0.02	(1.0 ± 0.2)		
TOOTH												
145	Human	ground & formalin fixed 5%	incisor dentine/none		NR	PR	150	3800 NSEC PULSE ± 370		NR	± S.D.; 8 samples	Barber <i>et al.</i> (1969)
146	Human	ground & formalin fixed 5%	incisor enamel/none		NR	PR	150	6250 NSEC PULSE ± 410		NR	± S.D.; 8 samples	"
147	Beef	ground & embedded in acrylic plastic	incisor dentine/none		NR	PR	150	3400 NSEC PULSE		NR	Z = 7.5 ± 2%; ρ = 2.2	Lees (1968)
148	Beef	ground & embedded in acrylic plastic	incisor dentine/none		NR	CARA	45	4140 ± 0.3% 2120 ± 0.3% 1980 ± 0.3% 3880 ± 0.3% 2000 ± 0.3% 1860 ± 0.3%		NR	longitudinal velocity; along long axis shear velocity; along long axis shear velocity; along long axis longitudinal velocity; across long axis shear velocity; across long axis shear velocity; across long axis	Lees & Rollins (1972)
149	Beef	ground & embedded in acrylic plastic	incisor enamel/none		NR	PR	150	6030 NSEC PULSE		NR	Z = 17.8 ± 3.0% ρ = 2.95	Lees (1968)
150	Beef	ground & embedded in acrylic plastic	incisor enamel/none		NR	CARA	45	6260 ± 0.3% 3460 ± 0.3% 3200 ± 0.3% 5800 ± 0.3% 3340 ± 0.3% 3070 ± 0.3% 5300 ± 0.3% 3050 ± 0.3% 2800 ± 0.3%			longitudinal velocity; along long axis shear velocity; along long axis shear velocity; along long axis longitudinal velocity; across long axis shear velocity; across long axis shear velocity; across long axis longitudinal velocity; across long axis shear velocity; across long axis shear velocity; across long axis	Lees & Rollins (1972)
151	Beef	ground & formalin fixed 5%	incisor dentine/none		NR	PR	150	3630 ± 300 NSEC PULSE		NR	± S.D.; 4 samples	Barber <i>et al.</i> (1969)
152	Beef	ground & formalin fixed 5%	incisor enamel/none		NR	PR	150	5850 ± 100 NSEC PULSE		NR	2 samples	"
153	Dog	ground & formalin fixed 5%	molar dentine/none		NR	PR	150	3200 ± 40 NSEC PULSE		NR	2 samples	"
154	Dog	ground & formalin fixed 5%	molar enamel/none		NR	PR	150	4800 NSEC PULSE		NR	1 sample	"
UTERUS												
155	Human (reproductive age)	<i>in vivo</i>	abdomen and uterine wall/none		body	PT	2.25	NR	(0.06 - 0.1)	0.5 - 1	measured attenuation from abdominal surface to inner uterine wall	Bang (1972)

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