



@HYfU`A Yb]gW g'9I fci XYg`K]h `UbX`K]h ci hFcchHYUf.Á

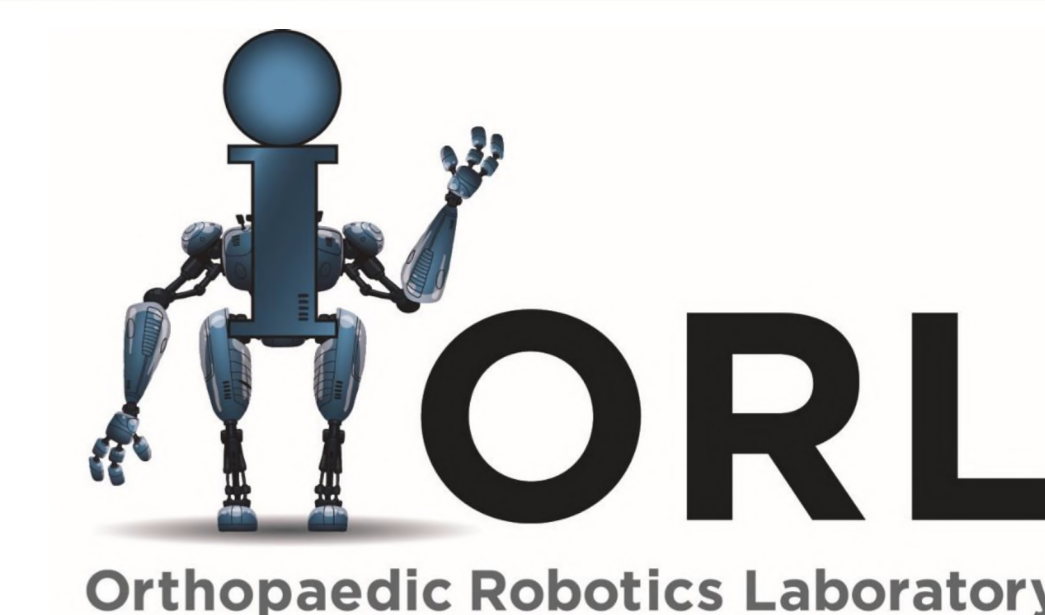
5`fcVch]Wghi Xmi g]b[`i`hfUgci bX

H YfYgU8]Yfa Y]Yf%&`FcVYfh9`"H]gl Yfa Ub%? Yj]b`K]gcb%ZGUfcg]`HU`Yi W]`ZHca cmi]`Gi ni]`ZÁ

7 Uj]b`? "7\ Ub%ZF]W UfX`9`"8 YVg]`Z? YbHufc`Cb]gl]`ZJc`_Yf`Ai gU`%

%`CfH cdUYX]WFcVch]Wg @UcfUcfmz8 YdUfha YbhcZCfH cdUYX]WGi f[YfmUbX`6]cYb[]bYf]b[`1 b]j Yfg]hmcZD]H]gVi f[\ ZD]H]gVi f[\ ZD5 ZI G5

&`8 YdUfha YbhcZCfH cdUYX]WGdcf]g`A YX]W]bY`HYW b]WU`1 b]j Yfg]hmiAi b]W ZAi b]W Z; Yfa Ubm



PITT | SWANSON
ENGINEERING
BIOENGINEERING

hfcXi W]cb

A Yb]gW g` YI fci g]cb` Vm i`hfUgci bX`]g`_bck b`lcÁ

UggYgg`a Yb]gW g`Z bW]cb`Vmia YUgi f]b[`a Yb]gW g`Á

X]gd`UMWa Yb] UbX` XYZ`fa U]cb`% DcghYf]cf` `UHfUÁ

a Yb]gW g`fcch]b`f]m]g`Zci bX`]b`Vta V]bU]cb`k]h Á

57 @]b`f]Yg`]b`+!%& `cZdU]Yb]g`*8 Ygd]H`j U]ci gÁ

HfYUfa Yb]h`hYW b]ei YgZ`H`Y`fYdcf]H`X` \ YU]b[`fUH`cZ

`UHfU`a Yb]gW g`]b`f]Yg`]g`ck` " `AYUgi f]b[`UHfUÁ

a Yb]gW g` YI fci g]cb` a Um` \ Yd` gi f[Ycbg` [i]XYÁ

HfYUfa Yb]h`UbX`UggYgg`h`Y`Z`bW]cb`UbX`g]h`i`g`cZ`H`YÁ

fYdU]fYX`a Yb]gW g`

CV`W]j Y

%` 9g]hU`]g[`i`hfUgci bX` a Yh`cX`lc` UggYgg` `UHfUÁ

a Yb]gW g`YI fci g]cb

&` 7ca dUFY` `UHfU`a Yb]gW g` YI fci g]cb` UbX`_bYYÁ

_]bYa U]W]g` VYtk`Yb`]b]hU`UbX`]b`f]YX`_bYYGÁ

f]dcghYf]cf`fcch]H`UfL

<ndch Yg]g

9I hYfbU` `cUXg` UbX`]bWYUg]b[` _bYY`ZYI]cb`k]`Á

fYgi`h]b]bWYUgYX`UHfU`a Yb]gW g`YI fci g]cb"

A Yh`cXg

GdY]fa Ybg.

"` ,`ZYg]ZcnYb` \ i a Ub`_bYYg`fa YUb`U`Y`)+`" `t` (" +

mYUfgL

"` ' `_bYY`g]hYg`!`]b]hU`Z`]b`f]YX`f]UHfU`dcghYf]cf

fcch]H`UfL`Z`UbX`UHfU`a Yb]gW g`XYZ]W]Yb

HYghDfctcVt`.

"` @`UXg`Udd`]YX`UiZ` ``YI`hYbg]cbz` \$Z() Z` \$Z`UbX` - \$Á

XY[fYyg`cZZYI]cb`k]h` *!8C: `fcVch

"` DUgg]j`Y`DUA` `fbc`cUXgk

"`)`B!`a` `cZj`U[i`g`l`cfei`Y

"`)`B!`a` `cZ]b]hYfbU`l`cfei`Y

"` &\$`\$`B`cZU]U`Vta`dfYgg]j`Y

A YUgi fYa Yb]g.

"` *!8C: `?bYY`_]bYa U]W]g

"` @HYfU`a Yb]gW g`YI fci g]cb`cZ` `X]ZYfYb]hÁ

cVgYf] Yfg`fGHZ`F`H`Z`H`8`Zi`g]b[`i`hfUgci bX

I`hfUgci bX`A YUgi fYa Yb]g.

%` :]bX`UHfU`Yd]Wt`bXmYz; YfXm]`h`i`VYfWYz`UbX`

Z]Vi`Uf` \ YUX

&` DfcVY`cb` `UHfU`g]XY` cZ`_bYY`]b`cV`]ei`Y

`cb[]h`X]bU`cf]Yb]h]cb

'`L` GHUXX`Y`Zfa`cfU`Wt`bXmY`dfcl`ja`U`lc`bYk`Vcbm`

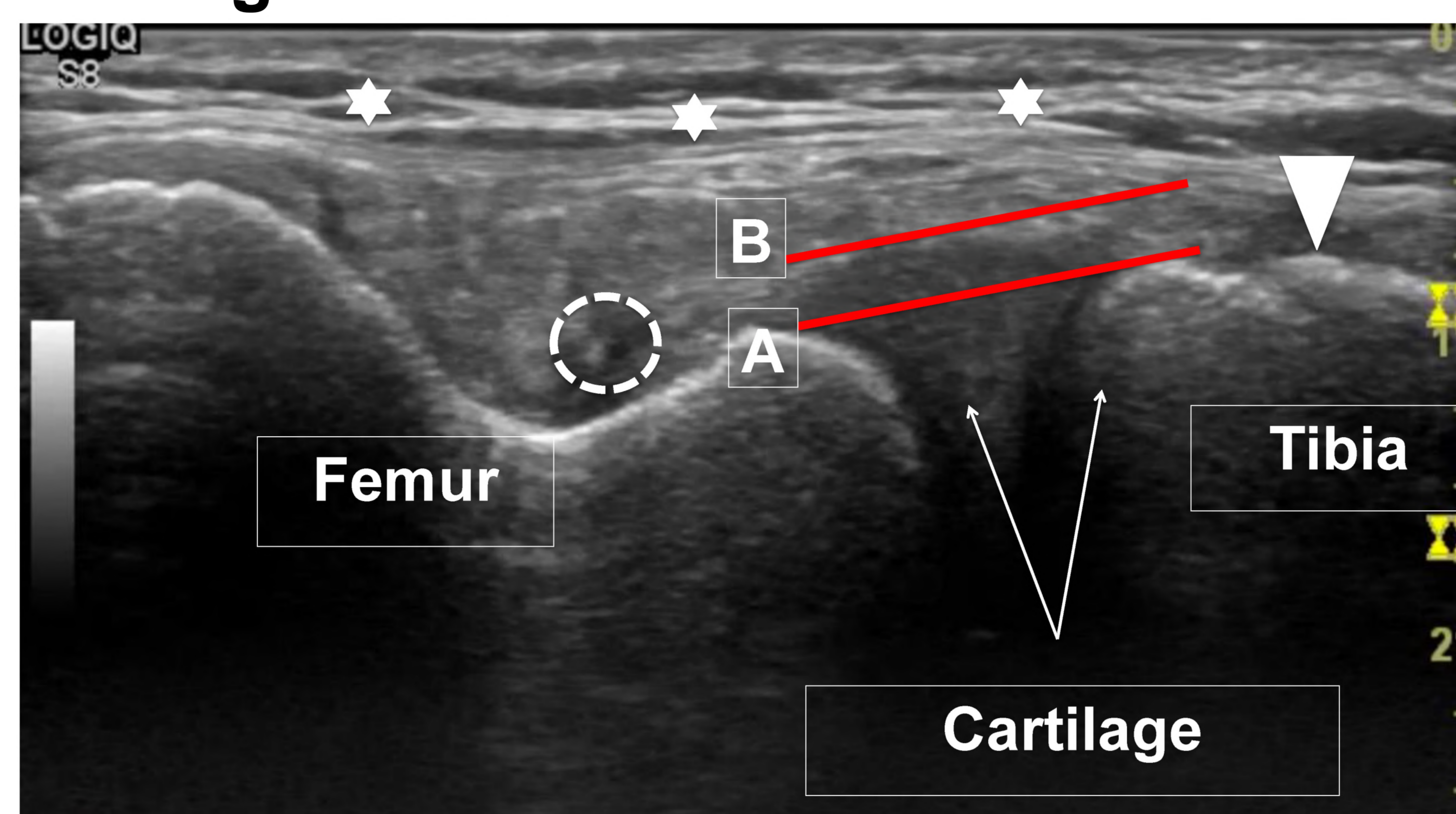
`UbXa`Uf`_

(`L` 9I`fci`g]cb`E`X]g]h]b]W`VYtk`Yb`h`k`c`d`UFU`Y`]bYg.

5`" `A`Uf[]b`cZ`H`Y`H]V]U`Vt`f]H

6`" `Ci`hYfa`cghYX[Y`cZa`Yb]gW`g

A Yh`cXg



:]i`fY`%`I` `hfUgci bX`ja`U`Y`cZ]b]hU`UHfU`a Yb]gW`gÁ

8`c`h`H`X`V]f`WY`E`]bgYf]h]cb`UFYU`cZ`d`c`d`]hYU`h`Yb`X`cbÁ

K` \]h`Y`U`f`c`k` \ YUX`E`WY`UH`X`V`cbm`UbXa`Uf`_

GHUg`E`]c]H]V]U`V`UbX

5`E`a`Uf[]b`cZ]H]V]U`Vt`f]H

6`E`ci`hYfa`cghYX[Y`cZa`Yb]gW`g

GHU]gh]WU`5`bU`ng]g.

"` `b]hYf]UHfU`UbX`]b]f]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

HU`Y`Y

"` ?]bYa`U]W]g`Z`ZYI`]cbz`UbX` `cUXg`UbU`mYX`k`]h` `K`]Vt`l`cb`g]]bYXÁ

fUb`_`hYgh

F Ygi`hg

"` I` `hfUgci bX`a`YUgi`fYa`Yb]h]g`ck`YX[`ccX`]b]hYf]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

UbX`]b]f]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

"` A`Yb]gW`g`YI`fci`g]cb

"` `bWYUgYX`]b`]b`f]YX`_bYYg`fY`U]j`Y`lc`]b]hU`_bYYg`i`bXYf`U`Á

YI`hYfbU` `cUXg`U`h`U`Ub[`Yg

"` 8`YWYUgYX`k`]h`]bWYUg]b[`ZYI`]cb`Ub[`Yg

"` Bc`X]ZYfYb]W`]b`_]bYa`U]W]g`VYtk`Yb`]b]hU`UbX`]b`f]YX`_bYYg

HU`Y`Y`@HYfU`a`Yb]gW`g`YI`fci`g]cb`Uh`\$`Z` *`Z`\$`Z`UbX` -`\$`c`ZÁ

ZYI`]cb`]b`fYgdcbgY`lc`)` \$`B`cZU]U`Vta`dfYgg]cb`fa`YUb` -`G8`L

:`YI`]cbÁ	@HYfU`a`Yb]gW`g`YI`fci`g]cb`fa`a`L	
Ub[`Y	`b]hU`h	`b`f]YX
\$s	FÈ`Á`ÈÈ	GÈ`Á`ÈÈ
'`\$s	FÈ`Á`ÈÈ	GÈ`Á`ÈÈ
*`\$s	ÈÈ`Á`ÈÈ	FÈ`Á`ÈÈ
-`\$s	ÈÈ`È`Á`Á`ÈÈ	ÈÈ`Á`ÈÈ

HU`Y`Y`&`@HYfU`a`Yb]gW`g`YI`fci`g]cb`Uh`\$`Z` *`Z`\$`Z`UbX` -`\$`c`ZÁ

ZYI`]cb`]b`fYgdcbgY`lc`)` \$`B`cZU]U`Vta`dfYgg]cb`fa`YUb` -`G8`L

:`YI`]cbÁ	@HYfU`a`Yb]gW`g`YI`fci`g]cb`fa`a`L	
Ub[`Y	`b]hU`h	`b`f]YX
\$s	ÈÈ`I`Á`ÈÈ	ÈÈ`G`Á`ÈÈ
'`\$s	ÈÈ`G`Á`ÈÈ	ÈÈ`È`Á`ÈÈ
*`\$s	ÈÈ`I`Á`ÈÈ	ÈÈ`I`Á`ÈÈ
-`\$s	ÈÈÈ`Á`ÈÈ`F	ÈÈ`I`Á`ÈÈ

F Ygi`hg

HU`Y`Y` .` `b]hYf]UHfU`UbX`]b]f]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

fUb[`Y

"`Á`ccX`]b]hYf]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

"`Á`ccX`]b]f]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á

GHU`Y	`b]hYf]UHfU`UbX`]b]f]UHfU`fY`]UV]]hmiVt`YZ]W]Yb]h]Zca`5`BCJ5`Á			
	GH`j`g`FH	H8`j`g`FH	H8`j`g`GH	`b]f]U`fUHfU`fH`L
Cj`YfU`	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`F`á	ÈÈ`F`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á	ÈÈ`F`ÈÈ ZÈÈ`ÈÈ ÈÈ`J`á
`b]hU`h	ÈÈ`G`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`È`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`G`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`J`á
`b`f]YX	ÈÈ`J`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á	ÈÈ`È`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`F`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á	ÈÈ`I`Á`ÈÈ ZÈÈ`ÈÈ ÈÈ`I`á

8]gW`gg]cb

"` `b`f]YX` `UHfU`a`Yb]gW`g`YI`fci`XYX` X]ZYfYb]h]Zca`5`BCJ5`Á

Zca` \ YU`h`mia`Yb]gW`k` \ Yb` `cUXYX

"` DfYj`]ci`g`fYdcf]h`g]]g]b[`i`b`cUXYX`A`F`=`UbX`bcÁ

`cUXg` a]i` \ h`i` VY` i`bXYfYg]h]a`U]b[`UHfUÁ

a`Yb]gW`g`YI`fci`g]cb

"` DfYj`]ci`g`g]h`X]Yg`i`]g]b[`]b]hYfbU`]H]V]U`f`c]h]h]cbÁ

a`]i` \ h`b`ch`VY` `cUX]b[`UHfU`a`Yb]gW`g`Ybci` [\

"` 5`j`c]X`XYd`ZYI`]cb`Ub[`Yg`k` \ Yb`a`YUgi`f]b[Á

`UHfU`a`Yb]gW`g`YI`fci`g]cb

"` I` `hfUgci bX` a`YUgi`fYa`Yb]g`dYfZ`fa`YX`]bÁ

g]h]b]X]b[`dU]Yb]g`W`Ub`VY` \ Y`dZ` `lc`W]b]WU`nÁ

UggYgg`a`Yb]gW`g`Z`bW]cb`UbX`g]h]i`g`dfY`UbXÁ

dcg]h`dYf]U]j`Y`m

8]gW`c]g]fYg`Bc`U`h`cf` \ Ug`U`Wt`bZ]W]cZ]b]hYfYghÁ

Wt`bW]f]b]b[`h`]g`fYgYUfW` "



F YZfYbW]g

%` 7`fYa`UA`8`Z]hU`"FUX]c`c[m]s`%`&`"

&` GW`]` \ Ua`a`Yf`7`?`Z]hU`"5`>GA`" &\$`%`&`"

'`L` :`Yi`W`hA`>Z]hU`"5`f]h`fcgWt`dmf`&\$`%`"