

NOVEMBER 15, 2018

4TH ANNUAL



Brandeis

Innovation Showcase

SHAPIRO SCIENCE CENTER

Brandeis | EXPLORE
WITHOUT
BOUNDARIES

IN PARTNERSHIP WITH:



K Y`Wc a Y`hc`6fUbXY]gI b]j Y fg]mÑg(h\Æ
5bbi U` ðbcj Uh]c b`G\ck WUgY°Æ

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H\fc i [\ci h\Y`Yj Ybhk Y`YbWci fU[Y`mci`hc`j]Yk`h\Y`dcgYfÆ
dFYgYbUh]c bğ`YUfb`a cFY`UVci h\Y`ghUfri dgUbX`dfcXi WrgÆ
`Ui bW\YX`Vm6fUbXY]g]gri XYbhğZUW`mž`UbX`ghUZZj]g]hici fÆ
YI \]V]hc fgž`YbhY`f\Y`fUZZY`UbX`j chY`Zcf`mci f`ZUj c]hYÆ
]bcbj Uh]c b"Æ

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H\Y`6fUbXY]g`ðbcj Uh]c b`G\ck WUgY`k Ug'a UXY`dcgg]V`YÆ
h\fc i [\`h\Y`[YbYfci g]g] ddcfhcZ`h\Y`<UggYbZY`X`Ua]mÆ
ð]h]Uh]j Yg`UbX`ci f`Yj Ybh]gd c bğc fgÆ

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Hassenfeld Family Innovation Center

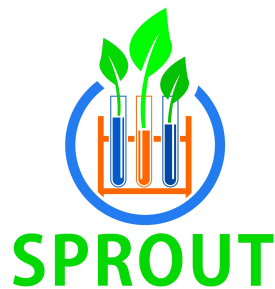
BRANDEIS INTERNATIONAL
BUSINESS SCHOOL

BRANDEIS OFFICE OF
TECHNOLOGY LICENSING

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6fUbXY]g' ðbcj Uh]cb`K Y`Wca Yg'Mci °Æ



Brandeis Innovation ShowcaseÆ

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H\Y`C ZZ]W`cZH YW\bc`c[m@]W]bg]b[`UbX`h\Ys

< UggYbZY`X` : Ua]m`ðbcj Uh]cb`7 YbhYfs

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7 ca Yj]g]hici f`hUV`Y`Zc`f`ci f`fUZZY`UbX` []j YUk Umgža YYh\Y`ghUZZUbX``YUfb`a cfY`UVci hs
ghUfhi dg`UbX`h\YW\bc`c[]Yg`Wca]b[`ci hcZ6fUbXY]g`s

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H\Y`C H@gYfj Yg`fYgYUfW\Yfgž]bj Ybhc fgž YbhYdfYbYi fg`UbX`]bXi g`fmi`K Y`dfcj]XY`gi ddcfhs
UbX`]bZUghfi W\i fY`hc`6fUbXY]g`]bj Ygh[Uhc fg`Zc`f`h\YW\bc`c[mXYj Y`cda Ybž`Wca a YfWU`]hUh]cbs
UbX`h\Y`XYj Y`cda YbhcZdfcXi Wg`" K Y`dfcj]XY`]bXi g`fmiK]h`W`h]b[`YX[Y`h\YW\bc`c[]Yg`Zc`fs
]W]bg]b[ž Ug`k Y`Ug`fYgYUfW\`Wc`UVcfUh]cbg"ss

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H\Y`< UggYbZY`X` : Ua]m`ðbcj Uh]cb`7 YbhYf`dfcj]XYg`U`i V`Zc`f`]bcj Uh]cb`UWfcgg`h\Ys
6fUbXY]g`WJa di g`" H\Y`W`bhYf`Yb[U[Yg`gh XYbhgžZUW`hž`fYgYUfW\YfgžU`i a b]`UbX`ghUZZs
dfca ch]b[`Wc`UVcfUh]cb`UbX`X]gWc] Yfmi\fc i [\`fYgYUfW\ž[fUbhg`UbX`dUfthYfg\]dgžs
]bWi X]b[`ci f`g][bUhi fY`dfc[fUa gž`7 cfdg žGD5F?`UbX`GDFCI H"ss

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Poster Session Guide

Dc ghYf` , Æ	DfYgybhY fÆ	Dfc YWbÆ	Dfc [fUa Æ	D ["s
%Æ	A Ufg\U""7 \Ub[Æ	5 =7 Ud]hU`Æ	GD5 F? `UbX`#7 c fd gÆ	s
&Æ	FYUni fFU\ a UbÆ	<md YfF -69Æ	GDFC I HUbx`#7 c fd gÆ	s
' Æ	: YfbUbXc`5 [i]YfUÆ	@JhUa 6]nÆ	GD5 F?Æ	s
(Æ	>cY`K]gc bÆ	GUZYF]XYÆ	GD5 F?Æ	s
)Æ	; U`Yb`?UfUb!A Ugc bÆ	; fYYb7 \c]WYÆ	GD5 F? `UbX`#7 c fd gÆ	s
*Æ	A Uf]U!9]f]b]DUbXY`]UÆ	8fi [`8Yg] [b`<Yd`6Æ	GDFC I HÆ	s
+Æ	9bYhA i _j fUn]hUÆ	5 K 9GÆ	GD5 F?Æ	s
, Æ	8Ub]Y`"; UfW]U`A i f]`cÆ	Bccgd\YfYÆ	GD5 F?Æ	s
-Æ	6fYbXU`@/a cgÆ	; fYYb@JVGÆ	GDFC I HUbx`#7 c fd gÆ	s
\$\$Æ	gJUW?fui ggÆ	<=J`J UWW]bYgÆ	GDFC I HÆ	s
%%Æ	5bbU`<Yb_]bÆ	a HC F`#b\]V]h]c bÆ	GDFC I HÆ	s
%&Æ	@hVYh`<YXgffc a Æ	7 \fc b]W`#ZYWh]c bgÆ	GDFC I HUbx`#7 c fd gÆ	s
% Æ	5a Y`Y`XY`7]fzc b]hU]bYÆ	5?5Æ	GD5 F?Æ	s
% (Æ	FcVU`6i` [U`>]cÆ	Bca UX`8U]fmÆ	GD5 F?Æ	s
%) Æ	>Ygg]WU`GUbc bÆ	gmGH9A]W: `ck Æ	GD5 F?Æ	s
%*Æ	J]j`Y`_J`]a U`Æ	@/Ufb`H`fc i [\`HYW`bc`c [mÆ	#7 c fd gÆ	s

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Poster Abstracts

#1 5"≡7 Ud]fU`A UbU[Ya Ybh! `Gc`j Y`hY`[Ua Y`cZÆ
 ei Ubh]fU]j Y`hfUX]b[`k`]h`5"≡Æ
 HYuA` :A Ufg\U`7\Ub[Æ

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K Y`Vi`jX`8YYd`fY]bZc`fWYa`Ybh`@`Ufb]b[`f5"≡`e`i`Ubh]fU]j`Y`hfUX]b[`gc`i`h]c`bg`hc`Æ
 [YbY`fU`hY`fY`h`fbg]b`hY`Z]b`UbW]U`a`Uf`_`Y`hg`h`fc`i`[`\"`Ui`bW`]b[`ci`f`5`d`\"`U: L`5"≡: i`bX`Æ
 k`]h`5"≡`7`Ud]fU`A`UbU[`Ya`Ybh`5`gk`Y`U`\"`_`bck`ž`5"≡`]g`hf`Ub`gZ`c`fa`]b[`a`Ubm]b`Xi`gf]Y`gZ`Æ
 UbX`h`Y`e`i`Ubh`\`Y`X[`Y`Z`bX`g`U`fY`bc`X`]ZY`fY`bW`"K`Y`gd`Y`W]U`nY`cb`h`]g`gY`hc`ZU`[`c`f]h`a`g`Æ
 h`Uh`V`Y`U`h`i`g]b`;`c`ž`Dc`_`Y`f`Ub`X`8`c`hU`!`ž`U`ja`]b[`hc`V`Y`h`Y`Z`f`gh`Z`Y`k`hc`U`X`U`d`h`]h`g`V`W`Y`gg`ž`m`Æ
]b`hfUX]b[`G]b`W`k`]b`b]b[`GD5`F?`]b`Y`U`f`m`i`&`\$`%`ž`k`Y`i`g`Y`X`h`Y`Z`b`X]b[`hc`Vi`jX`ci`f`5"≡`Æ
 hfU]b]b[`]b`Z`f`U`gf`i`W`h`fY`U`b`X`k`Y`b`h`c`b`hc`W`c`a`d`Y`h`Y`A`U`gg`7`\"`U`Y`b[`Y`6`c`g`c`b`g`a`a`Y`f`Æ
 W`c`\`c`f`h`K`Y`\`U`j`Y`a`U`X`Y`W`c`b`h]b`i`ci`g`d`fc`[`f`Y`gg]b`X`Y`j`Y`c`d`a`Y`b`h`ž`h`Y`g]b[`ž`c`d`Y`f`U`h]c`bg`U`b`X`Æ
 Z`b`X`f`U]g]b[`ž`U`b`X`b`ck`k`Y`U`f`Y`[`Y`h]b[`W`c`gY`hc`\"`Ui`b`W`ci`f`Z`f`gh`\`Y`X[`Y`Z`b`X`ž`c`b`Y`g`h`Y`d`Æ
 W`c`g`Y`f`hc`ci`f`[`c`U`c`Z`f`Y`j`c`i`h]c`b]n]b[`h`Y`\`Y`X[`Y`Z`b`X`]b`Xi`gf`m`ik`]h`5"≡`Æ
[\`h`d`g`##`k`k`"U`M`a`"k`c`f`X`#Æ](#)

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HF-69.5 'HfUbgZc fa Uhj Y '5 ddfcUW\ 'Hc 'Gh X mÆ
FB5!6]bX]b['DfchY]bgÆ

HUa . FYUni fFU\ a Ubž>cg\i U '@dgc bžK Y]b 'Li žÆ
A]MUY`FcgVUg\Æ

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Hf b'dYfW bhc Zci f[YbYg'WfYUH' U'gdYW]U`WUgg'cZdfchY]bgWU`YX'FB5!V]bX]b[Æ
dfchY]bgfF6Dgk" F6Dgd'UmWYbfU`fc'Yg]b'YggYbh]U`V]c'c[]MU`dfcWYgg'g'UbX'\UjYÆ
VYYb'ja d']WUH'X']b'a UbmX]gYUgY'g'g' W\Ug'5a mc hfc d\]W@UH'fU`GWYfcglgž: fU[]Y' LÆ
GrbXfca YžUbX'WUbwYf" F6Dg[c j Yfb' hY'gY' d'fcWYgg'g'V mV]bX]b['hc' hUf[Yh'FB5g]b'UÆ
WY`!gdYW]Z]Wa UbbYf" hY'fY'Zc'fY'žUWW' fUH' 'UbX' WY`!gdYW]Z]WFB5' hUf[Yh]X'Ybh]Z]WU]hc'bÆ
Zc'f'Ub'F6D']g'Wf' W]U`hc' i' b'fUj'Y']b[']hg'fc'Y']b' d'\mg]c'c[]MU`UbX'X']gYUgY' g'fUH'g'K'YÆ
XYj'Y'c'dYX'U' hY'W'bc'c[m'WUdUV'Y'c'Z]X'Ybh]Zm]b['F6D' hUf[Yhg]b'U'g']hY'Ug'%) \$Æ
8fc'gd d\]U' bYi' fc'bg'_bck' b'U'g' hUf[Yhg'c'ZFB5!V]bX]b['dfchY]bg'X'Ybh]Z]Y'X' '6m'9X]h]b[Æ
fHf-69Łžk \]M' fY'g' 'hY'X']b' h'fY'Y' 'di' V']WU]hc'bg' '6Y'WU' i' gY' 'Wc'a' d'Y'h]b['hY'W'bc'c[]Y'gžÆ
Wfc'gg]b_]b['UbX']a' a' i' b'c'd'fY'W]d']hU]hc'b'f7 @ĐŁ'UbX'FB5']a' a' i' b'c'd'fY'W]d']hU]hc'b'f'ĐŁÆ
UbU'mglgž'U'fY' i' b'UV'Y'hc']b]Y'gh] [UH' 'F6D!FB5' hUf[Yhg]b'U'WY`!gdYW]Z]Wa UbbYf'ž'F-69']gÆ
hY'c'b'm' hY'W'bc'c[m'h'U'h'WU'b']X'Ybh]ZmV]c'c[]MU`m'fY'Y'j' Ubh'F6D' hUf[Yhg]a' d']WUH'X']bÆ
\Y'h'fc[YbY'ci'g'X']gYUgY' WY`g' '6mi' g]b['gd'fc'i' h[f'Ub'ž'k'Y'gY'Y'hc']a' d'fc'j'Y' i' d'c'b'F-69'V mÆ
Ya' d'c'm]b['U'Wc'a' di' hU]hc'bU`Udd'fcUW\ 'hc' WfYUH'U' f'Ub_YX']g'ic'Z' hUf[Yhg'h'U'hÆ
a']b]a']nY'g'd'chY'bh]U`ZU'gY' d'c'g]h]Y']g[b'U'g'G]b'WY' F-69']bXi' WY'g'U'a' c'Y'W'U'f'a' U'f'c'bÆ
FB5' hUf[Yhgž'k'Y'U]a' 'hc' \U'fb'Y'gg'h'Y'X']gh]b'Wh'd'U'h'Y'fb'g'c'Z'h'Y'gY'a' U'f_g'hc' WfYUH'U'Æ
X']gW]f]a']b'U'h]Y']gWc'fY'Zc'f'Y'UW\ 'FB5' hUf[Yh'K'Y' \m'd'c'h'Y'g]hY' h'U'h'f'Ub_]b['V'U'gY'X'c'b'U'Æ
X']gW]f]a']b'U'h]Y']gWc'fY'k']fY'ZY'Wh'h'Y'V]bX]b['gh'fY'b[h'c'Z'h'Y'F6D!FB5']bhY'f'U'W]c'bg' h']gÆ
Wc'a' di' hU]hc'bU`UX'j' UbW'a' Ybh'k']Y'b'UV'Y' fY'gY'U'f'W'Y'fg'hc'Zc'W'g'c'b'gY'Y'W'h'X'F6DÆ
hUf[Yhg]a' d']WUH'X']b'X']gYUgY' g'fUH'gž'WU'f'm]b['_Y'm'UX'j' UbW'a' Ybh'g]bÆ
d\U'fa' U'W'i' h]WU'g'UbX'U'WUX'Ya']W'fY'gY'U'f'W'Æ

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#3

@hUa 6]nÆ

HUa .: YfbUbXc '5 [i]YfUžHU\U'5''U]hž>i Ub 'G''N' 'i U[UÆ
fUXj]gc fÆ

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@hUa 6]n]g'Ub'c'b`bY'd`Uhžc fa `XYg[bYX'hc `WcbbYWhgUfri dgZca `@h]b'5a Yf]WU'k]hÆ
]bj YgčfgZca `Ufci bX'hY'k c fX" GHUfri dgUfY'dfcj]XYX'k]h'hY'hc c`g'bYYXYX'hc fU]gyÆ
WUd]hU`Zca `hY'í f[\h'`]bj YgčfgžUbX`]bj YgčfgUfY'dfYgYbhYX'k]h'W fUHYX'ghUfri dgÆ
hUh\Uj Y`VYYb'j YhYX'h fci [\`U'W gča `Xi Y'X]] YbWY'dfc WYggžU`cb[g]XY'fY'Yj UbhÆ
a Yhf]Wg'hc `hY'ghUfri d`UbX`]bXi gfmžYbUV`]b[`a c fY`Wc bZXYbhXYWg]c b'a U_]b["Æ
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HAY`YbhfydfybYi fg\]d`YWc gmhYa `]b`@h]b'5a Yf]WU`]g'fUd]X'm[fck]b[`Yj YfmYUfzVchÆ
]b`hyfa gczbi a VYfcZghUfri dgUbX`Ua ci bhg]bj YghYX"<ck Yj Yfz'hYgy' [fck h'gUfy'bc hÆ
cWw ff]b[`]b`hUbXYa /UghY'a Uf_YhWc b]bi Yg'hc `VY'j UghmX]gWcbbYWHYXžghUfri dgk]hÆ
\[\`dchYbh]U`gh`ghf [[`Y'hc fU]gy`WUd]hU`Zca `hY'f[\h]bj Ygčfgž]ZfU]gy`UbmWUd]hUÆ
UhU`"hY`UW_cZXUHž a Uf_YhžU[a YbhU]c b`UbX`U`ghU bXUfX]nYX'dfc WYggžU`gcÆ
Vi fXYbg]bj YgčfgUbX`XYhYf'hYa `Zca `a U_]b[`Ub`UWhi U`]bj Ygča Ybh'5g'gi WžÆ
@hUa 6]nWUhyfg'hc`hk c`_]bXg'cZi gyfg`GHUfri dgZca `U`VUW_] fci bXg'UbX'd\Ugyg'hUhÆ
cZYf'gc`i h]c b'g'hc`d fcV`Ya gžUbX`]bj Ygčfg'k]h'X]ZZYfYbh]bj Ygča Ybhfyei]fYa YbhgžÆ
k \YhYfj Ybh fy`WUd]hU`Zfa gžUb[`Y`]bj YgčfgžUWWY`fUhc fg`cc_]b[`hc`a UbU[`Y`U'dcc`A
cZghUfri dgžcfU'di V`Wcfd f] Uhy`]bgh]h]c b'k]h'U`ghU`Y`]b`hY`YWc gmhYa "Æ

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: cf'hY`Zfgh% `a cbh'g'cZ[c]b[`]j Yžk Y'd`Ub'hc`WUdhi fy'`G` '\$\$`a`]`c bžfydfygybh]b[Æ
+ `cZ'hY'hc`hU`WUd]hU`Uj U]UV`Y`]b`hY`YWc gmhYa `Ugd'fc`YWHYX`"hY`GD5F?`WUd]hU`\Ug4
U`ck YX`i`g'hc`Wc bXi`Whd'fy`ja`]bUfmfYgyUfW`UbX`WfYUhy`hY`6YHU`XYj`Y`cda`YbhÆ
gWYXi`YX'hc`"Ui`bW`]b`: YVfi Ufm&\$%- "Æ

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GUZYF]XYÆ

HYUa . :>cY`K]gcbž@/bU`A i hYa VUž6U_Yf?UgUk i `]Æ

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GUZYF]XY`]gU`bYtk cf_cZ`]WbgYX`a c hc fWmWY`hU]f]XYfgfhU]bYX`]b`XYZYbgj Y`Xfj]b[Æ
 UbX`Yei]ddYX`k]h`gUZYhm[YUf`@VYf]Užk YU`fyei]fYa Ybhg]hc`VYWc`a Y`U`f]XYf`UgÆ
 ZccXYX`hY`]bXi gfmk]h`a Ubmi bhfU]bYX`f]XYfgfYg`h]b[]b`][`b`i`a VYfgcZUWm]XYbhgÆ
 UbX`XYU`h`g`C`i`f`ghU`f`i`d`k`]`f`Y`X`i`W`U`W`M`X`Y`b`h`g`k` \`]`Y`d`f`c`j`]`X`]`b`[`Y`Z`]`W`Y`b`h`f`U`b`g`d`c`f`h`U`h`c`b`Æ
 DUggYb[Yfgk]`f`yei YghU`f]XY`h`f`c`i`[` \`h`Y`GUZYF]XY`k`YVg]h`c`f` \`c`h`]bY`UbX`d`UmUÆ
 ghUbXUfX]nYX`fU`h`i`g]b[`U`a`cV]Y`a`cbYmUWw`i`bh`h`Y`d`f`c`Y`Wh`k`]`V`Y`[`]b`]b`A`cbfcj]UÆ
 k]h`U`d`]chZcW`gYX`cb`i`b] Yfg]mgh`XYbhg`k` \`c`U`f`Y`cbY`c`Z`h`Y`U`f`[`Y`gh`i`g`Y`fg`c`ZÆ
 a`c`h`c`f`W`h`W`Y`h`U`]g`K`Y`k`]`Y`b`[`U`[`Y`W`g`h`c`a`Y`f`g`h`f`c`i`[` \`c`i`h`Y`U`W`Y`j`Y`b`h`g`ž`g`W`U`a`Y`X`]UžÆ
 UbX`bYtk cf_]b[`k`]h`U`c`b[!hYfa`d`Ub`h`c`Y`I`d`UbX`k`]h`]b`@VYf]U`UbX`]b`h`c`h`Y`f`K`Y`ghÆ
 5Z]WUb`W`c`i`bh]Y`g`Æ

#5

; fYYb7 \c]WY| Æ

HYUa . : U`Yb`?UfUb!A Ugc bžFUZJY`A Ufh]bg; i]a UfUYgžÆ
 DY]rcb[`Li YžA UYj Y`8cbc`i`Y`žGcZ]U`FY[U`UXcÆ

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; fYYb7 \c]WY| `Y`d`g`W`c`b`g`a`Y`f`g`e`i`]W`_`m`]X`Y`b`h`]Z`m`U`b`X`d`i`f`W`U`g`Y`d`f`c`X`i`W`g`h`U`h`U`][`b`Æ
 k]h`h`Y`f`j`U`i`Y`g`; fYYbGWc`fY`g; `U`f`Y`d`Y`f`g`c`b`U`]n`Y`X`h`c`i`g`Y`f`d`f`Y`Z`f`Y`b`W`g`U`b`X`Y`j`U`i`U`h`Y`Æ
 Zc`c`X`d`f`c`X`i`W`g`Z`c`f`Z`Y`g`b`Y`g`ž`b`i`f`h`]c`b`U`j`U`i`Y`ž`Y`U`h`g`U`Z`Y`m`ž`U`b`]a`U`k`Y`Z`U`f`Y`d`f`U`W`h`]W`g`žÆ
 W`c`f`d`c`f`U`h`g`]g`]h`U`]b`U`V`]]m`i`U`b`X`h`f`U`b`g`d`U`f`Y`b`W`m`; fYYb7 \c]WY| `d`U`b`g`h`c`]W`b`g`Y`h`Y`]fÆ
 ; fYYbGWc`fY; `X`U`H`U`V`U`g`Y`U`b`X`h`Y`W`b`c`c`[`m`h`c`Y`W`c`a`a`Y`f`W`g`h`Y`g`U`b`X`[`f`c`W`f`g`]`g`m`Æ
 d`f`c`j`]`X`]`b`[`W`c`b`g`a`Y`f`g`k`]h`U`a`Y`U`b`]b`[`Z`d`Y`f`g`c`b`U`g`l`c`d`d`]b`[`h`c`ž`h`Y`m`Y`d`[`f`c`W`f`m`Æ
 g`h`c`f`Y`g`N`d`Y`f`g`c`b`U`]n`Y`h`Y`]f`c`b`]b`Y`W`g`h`c`a`Y`f`Y`I`d`Y`f`Y`b`W`U`b`X`f`Y`h`U`]b`#`U`]b`W`c`b`g`]c`i`g`Æ
 W`c`b`g`a`Y`f`g`Æ

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6ccgħb['fUħcbU`Xfi ['XYg][b'Zcf<YdUħhġ'6'Vm`Uf[Y!gWU`YÆ
dfcXi Wħcb'cZħY`L`Ubħ[YbÆ

HYUa .`5a mA]bYž7\]Y'I YXUžA]WY`Y`@Jb[ħcbžA Uf]U!9]f]b]Æ
DUbXY`]UÆ

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<6l`]ġħY`ga U`Ygħd fchY]b`YbWcXYX`]b`ħY`<6J`[Ybca Y`UbX`UgVYYb`g\ck b`ħc`VY`UÆ
a U`cfU[Ybh]b`ħY`d fc [fYgg]cb'cZ]Wf\c]g]Ubx`YdUħcWY`i`UfWUfW]bca U`fk77ĒħUħÆ
fYġ`ħġZca`Wħcb]W<6J`]bZYWħcb"<6l`UZYWħg'a i`hjd`Y`WY`i`Uf'd fc WYggYgžY]ħYfcb`]ħgÆ
ck b'cfħc [YħYfk`]ħ`ħY`d fchY]bgħUħ]h'Uf[Yħg`Hci [\`]ħġ'hi a c f][Yb]WdchYbh]U`UgÆ
VYYb`XYa cbgħUħYXžbY]ħYf]ħġ'gh] Whi fY`bcfħY`a c`YW`Ufa YWUbb]ġa gVmk \]W`]ħÆ
a YX]UħYg`]j`Yf!UggcW]UħYX`X]gYUgYgUfY`_bck b"Æ

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Ci fġi X]Ygd fci]XY`ħY`d cgg]V`]]mħc`icj Yfd fci WY`ħ]ġ]Ubħ[Yb`]b`][\`m]Y`Xg]UbX`UħÆ
Wc bW bhUħc bgħUħYI WYX`ħY`gc`i`V`]]m`]a`]ħcZ]ħġWc a a YfW]U`miUj U]UV`Y`mcd\]]nYXÆ
Zcfa g]b`U`WcghYZ]W]Ybha UbbYf`HAY`ci Hwca Y`cZci fġi X]Yg]gYIdYWYX`ħc`d fci]XYÆ
ħY`ghYdd]b[`ġħcbY`ħc`icj YfWca Y`ħY`gWUbhUj U]UV]]]mħcZħY`<6l`d fchY]bžUbX`k`]`Æ
\Uj Y`ħY`Zc`ck]b[`]a dUWh`UĒU`ck`Zc fYI hYbg]] Y`W]b]WU`hf]U`gžVĒZUW]hYħYÆ
\[\!ħfci [\di hXfi [`UbX`ga U`a c`YW`Y`]b\]V]ħc fġWYb]b[žWĒU`ck`Zc fġfi Whi fU`Æ
ġi X]Yga U_]b[`Xck bgħYUa`XYj Y`cda YbħcZd\Ufa UWc`c []WU`]b\]V]ħc fgħUf[Yħ]b[`<6l`A
Vm fUħcbU`XYg][b`d cgg]V`Y`HAYgY`Ēa`]YgħcbYgħUfY`cZdUħ]W`Ufj U`i`YžYgdYW]U`mÆ
VYWU`i`gY`Wħcb]W]bZYWħcb`Vm<6J`]ġU`YUX]b[`WU`i`gY`cZ\i a Ub`WUbbWfkc fXk`]XY`Æ
HAYfY Zc fYžħY`ck !WcghUj U]UV]]]mħcZ\][\`m]di fY`UbX`ž bWħcbU`m\ca c [YbYci g`<6l`Æ
k`]`gYfj Y`]b`UWWY`YfUħ]b[`XYj Y`cda YbħcZbcj Y`Ubħj]fU`ħYfUd]Yg]UbX`d fci]XYÆ
a i W!bYXYX`bYk`ħYfUdYi h]WUddfcUWYg'Æ

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#7

5 Z]WU b'K ca Yb'9bYf[mGc'ì h]c b g'f5 K 9GŁÆ

H Y Ua . '9bYhA i _i fUn]H Uż; VYb[U' C b]ž Df]gM]`U' Fk UbXUfi [U']Æ

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H Y 'UJa 'c Z5 Z]WU b'K ca Yb'9bYf[mGc'ì h]c b g'f5 K 9GŁ]g'hc 'Y Wc bca]WU`mYa dck YfÆ
Wca a i b]h]Y g]b'5 Z]WU ž Ygd YW]U`mk ca Ybž h fci [\]b WfY Ug]b['h Y]f UWWY gg'hcÆ
d fc Xi Whj Y 'fy gci fWY g'UbX 'UggY hž]b Wi X]b['fy bYk UV'Y 'gci fWY g'cZY bYf[mž'hc 'Yb\ UbWYÆ
h Y]f Y Wc bca]Wk Y`VY]b['UbX 'Y ZY Whj Y 'd Ufh]M d U h]c b]b 'h Y 'a U]b g'fY Ua 'Y Wc bca]WÆ
U Whj]h]Y g'k]h]b 'h Y]f Wc a a i b]mž Wc i b h f m]UbX 'Wc b h]b Y b h'U h'U f[Y "'5 K 9G'd U f h b Y f g'k]hÆ
U'k ca Yb]g'c f[Ub]h Y X '[fci d'hc 'gY hi d 'U'Vi g]b Y gg'h U h d fc Xi WY g'UbX 'gY`gV]c [Ug'UbXÆ
c f[Ub]WZY fh]n Y f Zfca 'U'Wc a a i b]mV]c X][Y g'hc f"'5 K 9G'k]`]b j Y g'hi]b 'h Y 'V]c X][Y g'hc f'UbXÆ
Wc 'ì cd Y f U h Y 'h Y 'Vi g]b Y gg'Zc f'U'd Y f]c X'c Zc b Y 'UbX 'U'U'Zm Y U f g'Xi f]b['k \]W h Y m k]`Æ
Y b h Y f]b hc 'U'd fc Z]h g'U f]b['U[f Y Ya Y b h k]h 'h Y 'k ca Yb]g' [fci d"'5 Z h Y f h Y 'd Y f]c X'\ U gÆ
Y 'U d g'X '5 K 9G'k]`Y I]h h Y 'd U f h b Y f g' d 'UbX '[c 'UbX]b j Y g'hi]b 'U' b Y k 'Wc a a i b]m' h YÆ
d fc V'Ya 'h U h k Y 'U f Y 'h f m]b['hc 'U X X f Y gg]g'Y b Y f[m d c j Y f m]b 'Gi V'GU\ U f U b'5 Z]WU"'C j Y fÆ
* \$ \$ 'a]`]c b' d Y c d 'Y]b 'h]g' d U f h c Z5 Z]WU 'Xc 'b c h \ U j Y 'U W W Y gg'hc 'U' f y b Y k U V 'Y 'gci f WY 'c ZÆ
Y b Y f[m]UbX '* + 'c Z h Y a 'j Y]b 'h Y 'fi f U'U f Y U" H Y 'a c g h U Z Y W h Y X 'U f Y 'k ca Y b 'V Y W U i g'Y A
h Y 'V][[Y g'hi Vi f X Y b'c Z Y b Y f[m]g'c b \ c i g'Y \ c 'X' Wc c_]b['Xc b Y 'V m h Y a "' H Y 'Z b X g'k YÆ
f Y W Y j Y X 'Zfca 'GD5 F? \ U j Y 'U gg]g' h Y X 'i g]b' f Y []g' h Y f]b['5 K 9G]b 'Nja V U V k Y 'V Y W U i g'Y 'Y j Y bÆ
hc 'fi b'U'd]c h]b'U'fi f U'U f Y U'mc i 'b Y Y X'hc 'V Y 'f Y []g' h Y f Y X" H Y 'Z b X g'k Y f Y 'U'g'c' i g'Y X'hcÆ
Y b h Y f'UbX 'U h Y b X 'c h Y f'Vi g]b Y gg'd]h W W 'Wc a d Y h]h]c b g'hc 'Ui [a Y b h h Y 'd]c h i Z b X g' H YÆ
f Y a U]b]b['Z b X g'U f Y 'Zc f h Y 'Wc b g'f i Wh]c b'c Z h Y 'V]c X][Y g'hc f'k \]W 'k Y 'Y I d Y W h'hc 'V Y []bÆ
g c c b"Æ

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ÆY`Bccgd\YfYÆ HYUa .:8UbY` ; UfWJU`A i f]`cÆ

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ÆY`Bccgd\YfY`hfUbgZcfa`g`h`Y`fY`gY`UfW`U`bX`Y`U`fb]b[`Y`I`d`Y`f]Y`b`W`c`b`Y`b`Y`b`hc`U`b`Æ
]b`h`f`U`W`h]`Y`]b`h`f`Z`U`W`Y`h`U`h`X`]gd`U`mg`k`Y`V`g`c`Z`W`c`b`W`d`hg`h]Y`X`hc`]b`h`f`X`]g`W`d`]b`U`fm`Æ
W`c`b`b`Y`W`h]c`bg`U`b`X`U`d`d`]W`U`h]c`bg`"6`mid`f`Y`g`Y`b`h]b[`W`c`b`W`d`hg`U`h]`U`f]c`i`g`Y`j`Y`g`c`Z`W`c`a`d`Y`I`]m`Æ
U`b`X`[`]j`]b[`]i`g`Y`fg`h`Y`W`U`b`W`Y`hc`W`c`"U`V`c`f`U`h`Y`ž`h`Y`B`c`c`g`d`\`Y`f`Y`V`f]b[`]g`h`Y`c`m`c`Z`Æ
_`b`c`k`Y`X`[`]Y`U`b`X`f`Y`g`Y`U`f`W`Y`hc`U`b`m`V`c`X`m`i`k`]b[`]hc`Y`U`fb`ž`bc`a`U`h`Y`f`h`Y`]f`c`W`U`h]c`b`c`f`Æ
Y`X`i`W`U`h]c`b`U`V`U`W`_`f`c`i`b`X`"ÆY`B`c`c`g`d`\`Y`f`Y`c`d`Y`f`U`h`Y`g`c`b`hc`d`c`Z`U`b`c`b`hc`c`[`]m`c`f`Æ
Z`f`U`a`Y`k`c`f`_`h`U`h`\`Y`d`g`c`f`[`]U`b]n`Y`W`c`b`W`d`hg`]b`U`b`]b`h`f`W`c`b`b`Y`W`h`X`k`U`m`"ÆY`B`c`c`g`d`\`Y`f`Y`Æ
Z]b`X`g`i`b`j`e`i`Y`W`c`b`b`Y`W`h]c`bg`V`Y`h`k`Y`Y`b`Z`b`X`U`a`Y`b`h`U`U`b`X`g`Y`Y`a`]b[`]m`X`]gd`U`f`U`h`Y`]X`Y`U`g`z`Æ
d`f`c`j`]X`]b[`]W`f]h]W`U`]b`g][`h`g`Z`c`f`U`b`m`f`Y`g`Y`U`f`W`Y`f`z`g`i`X`Y`b`h`ž`c`f`V`i`g]b`Y`gg`"ÆY`B`c`c`g`d`\`Y`f`Y`Æ
U`h`Y`a`d`hg`hc`d`f`c`j`]X`Y`U`Z`c`i`b`X`U`h]c`b`Z`c`f`h`Y`X`Y`a`c`W`U`h]n`U`h]c`b`c`Z`_`b`c`k`Y`X`[`]Y`ž`Y`b`U`V`]b[`]Æ
U`b`m`c`b`Y`U`b`n`k`\`Y`f`Y`hc`\`U`j`Y`U`W`W`gg`c`f`W`c`b`h`f]V`i`h`Y`hc`b`Y`k`X`Y`j`Y`c`d`a`Y`b`h`g]b`g`W]Y`b`W`U`b`X`Æ
h`Y`W`b`c`c`[`]m`Æ

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#9

; fYYb@JVgÆ
HYUa .:6fYbXU@/a cgž8Uj]X'K UHYfa UbÆ

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; fYYb@JVg]g'U'd`Ugh]Wk UghY`fYWmW]b[`Wca dUbmik cf_]b[`hc`hUW_Y`hY`d'fcV`Ya`cZÆ
d`Ugh]W`UV`k UghY`VmWc`YWh]b[`]h`UbX`fY]b'fcXi`W]b[`]h`VUW_]b'hc`Ub`", \$`V]`cb`a`Uf_Y`hÆ
Ug'fUk`a`UHf]U`"A`cfY`d`Ugh]W\UgVYYb`a`Ubi`ZUWhi`fYX`]b`hY`"Ugh`%\$`mYUfg'h`Ub`U`cZÆ
hY`"Ugh`WY`bhi`fmi`H`]g'c`Yfd`Ugh]Z]WU]h]c`b`\Ug`\UX`XY`hf]a`Y`bHU`"YZ`W]g]b`ci`f`d`UbY`hÆ
@JVcfUhc`fmk`cf_]g'd`Uf`hmi`hc`V`Ua`Y`]b`h`U`h`f`ci`h]bY`"UV`k`cf`_`fY`c`j`Yg`U`f`ci`bX`g]b[`Y!i`gY`žÆ
X]gd`c`gU`V`Y`d`Ugh]W]hY`a`gž`g]`W`U`g`d]d`Y`hY`h]d`V`cI`Y`g`"K`\]Y`Y`Z`c`f`g`\Uj`Y`V`Y`Y`b`a`UXY`hc`Æ
d`fca`chY`fYWmW]b[`]b`hY`"UV`ž`-, i`cZU`"UV`d`Ugh]Wk UghY`i`h]a`UHf`mY`bX`gi`d`]b`"UbX`Z]`g`Æ
K`Y`k`]`hUW_Y`h`]g'd`fcV`Ya`VmWc`YWh]b[`d]d`Y`hY`h]d`V`cI`Y`g`UbX`hf`Ub`gž`c`fa`]b[`hY`a`]b'hc`Æ
[`ccX`g'a`UXY`Z`fca`%\$`\$i`fYWmWYX`ž`c`WU`"m`g`c`i`fWY`X`a`UHf]U`g`"D]d`Y`hY`h]d`V`cI`Y`g`U`fY`Æ
Wca`a`cb`mi`gY`X`]b`U`"fY`gY`U`fW`ZUW]h]Y`g`UbX`U`fY`a`UXY`Z`fca`\][`le`i`U`]m`Æ
d`c`m`d`f`c`d`mY`bY`f]`DD`d`Ugh]W`G]b[`Y!i`gY`d]d`Y`hY`h]d`V`cI`gU`Y`g]b`hY`B`c`f`h`9UghYI`WY`X`Æ
(`"a`j]c`b`i`b]h`g`#`m`f`Y`e`i`U`h]b[`hc`%`a`j]c`b`d`c`i`bX`g`c`Z`WY`Ub`ž`\][`le`i`U`]m`ž`g]b[`Y!i`gY`Æ
d`Ugh]W`X`i`a`dY`X`]b'hc`a`Uf_Y`h`U`bbi`U`"m`f`g`hY`U`X`c`Z`X]g`d`c`g]b[`c`Z`d]d`Y`hY`h]d`V`cI`Y`gž`k`Y`Æ
c`Z`Y`f`U`W`U`X`Y`a`]W]b`g]h]i`h]c`b`g`UbX`6]c`hY`W`Wca`d`Ub]Y`g`U`Wc`"Y`Wh]c`b`gY`f]`jW`"5`Z`hY`fÆ
Wc`"Y`Wh]c`b`ž`k`Y`fYWmWY`hY`d]d`Y`hY`h]d`V`cI`Y`g]b'hc`bY`k`d`fc`Xi`W]g'a`UXY`Z`fca`%\$`\$i`Æ
fYWmWY`X`a`UHf]U`"UbX`Z`c`W`g`d`fc`Xi`W]h]g`U`Y`g`h`c`k`U`f`X`g`fY`gY`U`fW`UbX`@998`; fYYbÆ
ZUW]h]Y`g`hY`; fYUHf`6`c`g`c`b`5`fYU`]g`Ub`jX`Y`U`d`U`W`h`c`"U`i`b`W`; fYYb@JVgUg]h]g]UÆ
6]c`hY`W`\i`V`ž`%`U`W`U`X`Y`a`]W`fY`gY`U`fW`ZUW]h]Y`g`UbX`c`j`Y`f`%\$`\$`@998`; fYYb`WY`f]Z]Y`X`Æ
Vi`]X]b[`g'Æ

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#10

J UWM]bYg'fUf[Yh]b[' < ð 'Gi [Ufg'Zc f'6fc UXÆ
 BYi fU`nUh]cbÆ
 HYUa . '8i b['B[i mYbž-gUUW?fUi ggÆ

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HLY [cU`cZh]gd fc YWh]g'hc 'XYHYfa]bY'k \YhYf'gck !fY'YUgY 'ja a i b]nUh]cb'a YhlcXgE
 WUb'Y`W]he i Ubh]fUhj Y`mUbX`ei U`fUhj Y`mVYHYfUbh]VcX]YgU[U]bgh' < ð "" ð'dfYj]ci gÆ
 fYgYUfWžk Y`Uj Y`XYj Y`cdYX`WUfVc`mXfUHY!VUgYX`j UWM]bYg'Wc`bU]b]b['U'g[UfÆ
 fA Ub- 'c][cgUWUf]XYE'hUh]g'Wca a cb'cb'hY'g' fZUWY`cZ < ð "" '5bh]VcX]Yg'hUhV]bXÆ
 hc'h]g'g[UfUfY`Ua cb['hY'a cghVfcUX`m'bYi fU`n]b['Ubh]VcX]Yg'hUhXj Y`cd`]bÆ
 dUh]Yb]hg]bZYWhYX`k]h'hY'j]fi g`H i gž]g]a i 'U]cb'cZg]a]Uf'g[UfV]bX]b['Ubh]VcX]YgVmÆ
 j UWM]bU]cb]g'Wc`bg]XYfYX`U'dfca]g]b['UddfcUW`hc' < ð 'j UWM]bYg`i g]b['ci f'bcj Y`Æ
 X]fYWhYX`Yj c`i h]cb'hY`Wbc`c[mžk Y`XYg][bYX`g[UfWi gYfj UWM]bYg'hUhk YfY`hYbÆ
 hYghYX`]b`fUVV]hg`K Y`Zc i bX`hUh'hY`Ubh]VcX]Yg'fU]gYX`]b'hY`c f][]bU`UddfcUW`V]bXÆ
 dYfZYfYb]U`mhc'hY`Wc`fY`fU`hYf'hU`b'hY`h]d'g'cZhY`g[Ufg`': cf'hY`W`ffYbhd'fc`Y`Wžk YÆ
 hYghYX`gck !fY'YUgY 'ja a i b]nUh]cbžUbX`k Y`Z]bX`hUh'a i W`\[\Yf'Ubh]VcXm]h]fYfgWUbÆ
 VY`cVhU]bYX`Vmi'h]g'a YhlcX`"Gi X]Yg'hc`Yj U`i UhY`Ubh]VcXmgY`YWhj]mUfY`i bXYfk Un'Æ

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#11

5`Bcj Y`b\]V]rcfcZa HC F`]b`hY`8]gYUgYgcZ5 []b[Æ
HYUa .`5bbU`<Yb_]bž@hVYh`<YXgfc a Æ

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7 UbWfUbx`bYi fcXY[YbYfUhj] Y`X]gYUgYgUfY`Z][\hYb]b[`gdYWHYfg`cca]b[`cb`hYÆ
\cf]rcb`cZci f`c`X`U[Y`"HAY`VUVmVcca Yf[YbYfUh]cb`]g`bck`ZUWY`tc`ZUWY`k`]h`h`Y`gYÆ
XYj UghUhb[`WcbX]hcbgž`Ubx`]h`]g`gk`]zhmVYWca]b[`U`a`Uggj] Y`di`V`]W\YU`h`Vi`fXYb"Æ
8mgfY [i`U]h]cb`cZ`h`Y`a`Ua`a`U`]Ub`HUf[YhcZFUdUa`m]b`f`a`HC`F`E`g][bU`]b[`d`U`h`k`U`mg`]g`UA
Wca`a`cb`ZY`U`h`fY`c`Z`h`Y`gY`X]gYUgYgž`Ubx`HUf[YhYX`]b\]V]h]cb`cZa`HC`F`\c`X`g[fYU`hÆ
dfca]gY`U`g`U`f`ci`hY`c`Z`h`Y`U`ha`Y`b`h`C`i`f`U`V`c`f`U`h`c`f`i`U`g`X]gWc`j`Y`f`Y`X`U`b`c`j`Y`]b\]V]rcfcZÆ
a`HC`F`g][bU`]b[`f7`6`5`E`7`6`5`U`W`h`g`h`c`i`[\`U`X]g]b`Wha`Y`W`U`b]ga`Z`c`a`d`f`j`]c`i`gmÆ
XYgW]VYX`a`HC`F`]b\]V]rcfcž`k`\]W`g`[[Y`g`g]h`a`U`m`\`U`j`Y`U`h`Y`f`U`d`Y`i`h]W`V`Y`b`Y`Z`h`Z`c`f`g`c`a`YÆ
X]gYUgYg`"K`Y`U`f`Y`W`f`f`Y`b`h`m`W`c`b`h]bi`]b[`k`c`f`_`h`c`Y`i`W`X`U`h`Y`h`Y`a`Y`W`U`b]ga`c`Z`U`W`h]cb`]bÆ
cfXYf`h`c`]X`Y`b`h]Z`m`h`Y`X]gYUgYg`a`c`gh`_`Y`m`h`c`f`Y`gd`c`b`X`h`c`7`6`5`!`V`U`g`Y`X`h`f`Y`U`ha`Y`b`h"Æ

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#12

5 'GhfUHy [mhc 'hfYUh7 \ fc b]W ðZYWhjc bgÆ
HfUa .8Yj]dfUgUX'; c''UdU''Ubx '@hVYhÆ
<YXgfca Æ

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A cghfYw ffYbhUbx 'X]Z]W 'hlc 'hfYUh]bZYWhjc bgUfy 'WU i gYX 'VmVUWHY f]U 'h UhUfYÆ
gi gWdh]V 'Y 'hc 'Wca a cb`mi gYX 'Ubh]V]ch]Wg''Gi Wk 'Wk fc b]WVUWHY f]U'']bZYWhjc bgUWwci bhÆ
ZcfUddfcI]a UhY`m) \$\$\$X\$YUhg'Ubbi U`m]b`hY'I "G'z'UbX 'Ufy 'U'a U'cfWca d']WUhc bÆ
]b '\jd 'Ubx '_bYY 'fyd 'UWYa Ybhgi f[Yf]Yg'k \Yfy 'hY ']bW]XybWw 'cZ]bZYWhjc b']g%&i "Æ
7 \ fc b]W]bZYWhjc bg'dYfg]ghVYWU i gY 'Ubh]V]ch]Wg'Ufy 'cb`mY ZYWhj] Y 'U[U]bghUWhj Y`mÆ
[fck]b['VUWHY f]U'' <ck Yj Yfz'U'ga U''bi a VYf'cZVUWHY f]U'']b 'Ub]bZYWhjc b'UfYÆ
ei]YgWbh'z'Ubx 'hYfyZcfY'gi fj]j Y 'hfYUha Ybh''hYgY'ei]YgWbhWw `g'Ufy '_bck b'UgÆ
I dYfg]ghY fgj ''hY 'cb['Wci fgYgcZhfYUha Ybhfyei]fYX 'Zcfhi VYfW 'cg]g'Ubx '@ra Y 'X]gY UgyÆ
WU b'U'gc 'VY 'Uhf]Vi hYX 'hc 'hY 'X]Z]W 'mi]b'Y]a]bUh]b['dYfg]ghY f'Ww `g''@Ughm'z'dYfg]ghY fÆ
Ww `g'Ufy 'VY]Yj YX 'hc 'd'Um]Ub]a dcfUbhfc 'Y]b`hY 'Ya Yf[YbWw 'cZUbh]V]ch]WfY g]ghUbwW "Æ
hYgY 'cVgYfj Uh]c bgXYa cbghfUhy 'hUhU'Xfi ['hc 'hfYUh'dYfg]ghY f'Ww `g'k ci 'X'UXXfy gg'UÆ
Wf]h]WU''i ba YhbYXX"Æ

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5 '\UbxZ 'cZUbh]dYfg]ghY f'Wca dci bXg\Uj Y'VYYb'fydcffYX]b`hY ''j]hYfUhi fy'z'Vi h'bc bYÆ
\Uj Y 'fyUwYX 'hY 'W]b]W''K Y '\Uj Y 'X]gWc j YfyX 'U'Wca dci bX'z'D&&*z'hUh'WU i gY gÆ
VUWHY f]U 'hc]b]h]UhY [fck h' d'fYa Uhi fy`m''K Y '\mdch\Yg]hY 'hUh'h\]g'Wca dci bX'k]'Æ
WU i gY 'ei]YgWbhWw `g'hc 'VYWca Y'gYbg]h] Y 'hc 'Wca a cb`mi gYX 'Ubh]V]ch]Wg'z'h'i gÆ
dfcj]X]b['U'a cfy 'Y ZYWhj] Y 'hfYUha Ybh'ZcfWk fc b]W]bZYWhjc bg'Æ

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#13

5"?"5"Æ
HYUa . 5a Y`Y`8Y`7]fZc bHU]bYÆ

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5"?"5" fB`gc`?bck b`5gW`hi fyE]gU` : Ug\]cb`VfUbx`hUh]bZcfa`gWc`bgj`a`Yfg`hY`W`hi`fu`Æ
]bZi`YbWY`gVY\]bX`hY]fWc`hY`g`9UW\`gY`Ugc`b`5"?"5"XY`g[]`bg`U`"]bY`c`ZWc`hY`g`h`U`h]gÆ
]bZi`YbWY`X`V`mU`W`hi`fy`ZY`UW\`U`fh]WY`c`ZWc`h\]b[`\c`X`g`U`g`c`f`m`h`c`]h`h`U`h]g`d`f]b`h`Y`X`c`b`]h`gÆ
HU[`\`b`U`X`X]h]c`b`5"?"5"U]a`g`h`c`g`h`U`f`h`W`c`U`V`c`f`U`h]c`b`g`k`]h`U`f`h]g`U`b`g`Z`f`c`a`h`Y`W`hi`fy`h`Y`mÆ
\[`\]\[`\h]b`h`Y`[]`j`Y`b`"]b`Y`g`h`Y`f`V`i`g]b`Y`g`j`a`c`X`Y`Z`c`c`k`g`Y`h]WU`a`U`b`i`Z`U`h`i`f]b[`\`U`b`X`Æ
d`f`c`X`i`W`h]c`b"Æ

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#14

Bca UX`8U]fmÆ
HYUa . FcVU`6i` [U`>]c`ž9]hUVYh`?YYZY`ž`?mY`D`i`a`a`Y`fzÆ
k`c`b`U`A`U`h`Wi`_Æ

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Bca UX`8U]fm]gU`Zc`f`d`f`c`Z]h`g`U`f`h`i`d`Z`c`W`g`Y`X`c`b`d`f`Y`g`Y`f]`j`b[`\`h`Y`f] [\`h`g`c`Z]b`X][`Y`b`c`i`g`E
d`c`d`i`U`h]c`b`g`h`f`c`i` [\`\c`WU`Z`c`X`g`"K`Y`d`U`f`b`Y`f`k`]h`U`b`Y`g`h`U`V`]g`Y`X`W`c`d`Y`f`U`h]`Y`]b`Æ
9`h`]c`d]U`a`U`X`Y`i`d`c`Z`(%a`Ya`V`Y`f`g`k`\c`W`c`Y`W`h`W`U`a`Y`a`]`_`Z`f`c`a`W`U`a`Y`Y`f`X`Y`f`g`U`b`X`Æ
h`Y`b`h`f`U`b`g`d`c`f`h`h`Y`f`U`k`d`f`c`X`i`W`h`c`U`a`U`f`_`Y`h]b`h`Y`W`U`d]h`U`ž`5`X`X]g`5`V`U`V`U"Æ

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H`Y`W`c`d`Y`f`U`h]`Y`]g`c`g]b[`\`(\$i`c`Z`h`Y]f`d`f`c`X`i`W`h`X`U]m`X`i`f]b[`\`h`f`U`b`g`d`c`f`h`X`i`Y`h`c`g]`b`Æ
Y`l`d`c`g]`f`Y`"K`Y`k`]"`d`f`c`j`]X`Y`h`Y`W`c`d`Y`f`U`h]`Y`k`]h`h`Y`h`Y`W`b]W`U`U`b`X`V`i`g]b`Y`g`g`E
`b`c`k`Y`X[`Y`h`c`a`c`X]z`m`h`Y]f`h`i`W`]b`h`c`U`f`Y`Z]f]`Y`f`U`h`Y`X`j`Y`\]W`Y`k`]h`Y`l`]g]b[`\`h`Y`W`b`c`c`[`m]Æ
H`Y`b`h`Y`W`c`d`Y`f`U`h]`Y`k`]"`V`Y`U`V`Y`h`c`]b`W`f`Y`U`g`Y`W`c`Y`W`h]c`b`e`i`U`b`h]h]Y`g`h`c`a`Y`Y`h`h`Y`\][`\Æ
X`Y`a`U`b`X`Z`c`f`W`U`a`Y`a`]`_`U`b`X`W`U`d`h`i`f`Y`h`Y`ž`"a`U`f`_`Y`h]`U`i`Y`c`Z`h`Y]f`[\][`\`e`i`U`]"mÆ
d`f`c`X`i`W`h]Æ

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#15

grGÐA]W: `ck Æ
HYUa .>Ygg]WU'GUbcbz'5Xk cU'5gUfYÆ

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grGÐA]W: `ck 'U]a g'hc ']bWfYUgY'GÐA '(science, technology, engineering, mathematics) 'X]j Yfg]miUbX '\Uj Y'V'UW_k ca Yb'VY'hY'Zc fy Zc bhi'YUXYfg']b'hYgyÆ
]bXi g'f]Yg'UbX'ja d'fcj Y'YWc bca]Wc ddc f'ri b]h]Yg'Zc f'a]bc f]m'k ca Yb'"H'Y'd fc [fUa Æ
gYfj Yg'hc'g' d'd'Ya Ybh[]f'g']b'hY'; fYUHY'f'6c g'c b'UfYU'k]h'U'WWYgg'hc'd'fYfYei]g]hYÆ
Wci fgYg']b'hY]f'GÐA 'hfUW'_UbX'Wc bbYWh'hYa 'k]h'c'h'Yf'YUXYfg']b'hY'Z]Y'X"Æ

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H'Yfy]g'U'X]fY'b'Y'YX'hc']bWfYUgY'GÐA 'X]j Yfg]m'k]h']b'a U'c'f'Wc'fd'c'fU'h]c'bg'UbX']bXi g'f]Yg'Æ
k]h']b'bcj U'h]c'b'd'U'h'Zc'fa'g'<c'k Yj Yf'Z'X'Y'gd]h'Y'X'i WU'h]c'bU''d'fc [fYgg'c]j Yf'h'Y'd'U'ghÆ
gYj YfU'm'Y'U'fgz'\][\g'W'c'c'a]bc f]m'g'ri XYb'hg]h]''UW'_U'WWYgg'hc'h'Y'Y'X'i WU'h]c'bU'Æ
fYgc'i fW'g'h'U'hk]''d'fY'd'U'fY'h'Ya'Zc'f'Wc''Y[Y'g' W'W'gg''8'U'h] [U'h'Y'f'Y'X'Z'ca'h'Y'c'Z]WYÆ
Zc'f'7]j]f][\h'g'g'c'k YX'h'U'h'V'U'W'_g'ri XYb'hg]U'fY'a i W'Y'gg']_Y'm'hc '\Uj Y'U'WWYgg'hc'Æ
5Xj UbW'X'D'U'W'Ya Ybh'Wci fgYg']b'GÐA 'Z]Y'X'g'H'g'U'W'_c'Z'U'WWYgg'hc'Zci b'X'U'h]c'bU''GÐA Æ
g_]g'd'i hg'V'U'W'_g'ri XYb'hg]U'h]U'g][b]Z]WU'bh'X]g]U'Xj Ub'U[Y]b'd'fY'd'U'f]b['Zc'f'U'Xj UbW'X'Æ
GÐA 'Wci fgYg]UbX'WU'fY'Y'fg''5'g'U'Wc'bg'Y'ei Yb'W'Z'g'ri XYb'hg']b'GÐA 'Z]Y'X'g'U'fY'U'V'ci h'*Æ
d'Y'f'W'Y'bh'a c'fY'_Y'm'hc'W'U'Ub[Y'a U'c'fg'h'U'b'bc'b!GÐA 'g'ri XYb'hg']: i f'h'Y'fa c'fY'Z'h'Y'Æ
bi a V'Y'f'c'Z'V'U'W'_k ca Yb']b'GÐA '\U'g'b'ch]a d'fcj YX']b'h'Y''U'gh%' m'Y'U'fg'UbX']b'Z]W'Z'Æ
X'Y'W]b'Y'X'V'm%' "'5'g'U'f'Y'g' 'h'z'& 'c'Z'V'U'W'_k ca Yb'U'fY'f'Y'd'fY'g'Y'bh'Y'X']b'h'Y'GÐA Æ
k c'f'_Zc'f'W"ÆÆ

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GÐA 'WU'fY'Y'fg'd'fcj]X'Y'Y'i W]h]b['c'd'd'c'f'ri b]h]Y'g'Zc'f'V'fY'U_]b['h'Y'bc'fa'U'bx'c'Z]Y'f]b[Æ
i dk U'f'X'a c'V]]miUbX'Y'Wc'beca]W'g'Y'W'f]m'hc'k'ca Yb'U'bx'a]bc'f]h]Y'g'H'g'd'fc [fUa 'k]'Æ
[]j Y'ci f'g'ri XYb'hg'h'Y'Y'X'i WU'h]c'bU''hc'c'g'h'U'hk]''c'd'Y'b'X'c'c'f'g'hc'Wc''Y[]U'h'U'bx'Æ
Ya d'c'm'a Ybh'c'd'd'c'f'ri b]h]Y'g']b'h'Y'GÐA 'Z]Y'X"Æ

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#16

@Ufb`H fci [\`HYWbc`c [mÆ

HfUa .`8Uj]X`<Ua dhc bžDcc`U`7` \UbXfU_UfžNj]]Uc`7` \YbžJ]j Y`_UbUbXA
DUbXYmJ]a U`Æ

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þ`c fXYf`hc` ž` bXUa YbHj`mWUub[Y`hY`Zci bXUhc]bc`cZci f`][\`gWcc`YXi WUhc bU`Æ
gmghYa žk Y`bYX`hc`g`ck` Yj Yfmigri XYbh`h`U`h`h`Y`miUfY`bchi`gh`h`Y`fYHU]bYfg`cZÆ
_bck`YX[Y`Vi`hU`gc`WU`b`VY`h`Y`WfYUhc`fg`cZbYk`_bck`YX[Y`UbX`fYgYUfW`"Hc`Xc`h`]gÆ
k`Y`k`j`" \Uj Y`hc` ž` bXUa YbHj`mWUub[Y`h`Y`fY`U`hc]bg`][d`VY`h`Y`Y`b`g`WY`bh]ghg`UbX`h`Y`Æ
Wc`a`a`i`b]m`"K`Y`k`j`i`gY`Ub`Y`ghUV`]g`Y`X`UbX`g`W`W`ggž`"a`c`XY`h`U`h`U`g`k`c`f`Y`X`Zc`f`+Æ
mYUfg`fh`Y`K`<G`6`f`U`b`X`Y`]g`Gi`a`a`Y`f`F`Y`g`Y`U`f`W`D`fc`[`f`U`a`Ł`ž`k` \Y`f`Y`i`b`X`Y`f`d`f`j`]Y`[`Y`X` \][\Æ
gWcc`gri`XY`bhg`U`f`Y`d`U`]f`Y`X`k`]h`[`f`U`X`i`U`h`Y`gri`XY`b`h`a`Y`b`h`c`f`g`X`i`f`]b`[`h`Y`g`i`a`a`Y`f`U`b`X`Æ
Wc`b`X`i`W`h`]b`e`i`]f`m`V`U`g`Y`X`G`H`A`f`Y`g`Y`U`f`W`d`f`c`Y`W`h`g`"C`i`f`c`V`Y`W`h`j`Y`]g`hc`fi`b`h`]g`d`c`[`f`U`a`Æ
X`i`f`]b`[`h`Y`g`W`cc`"X`U`m`U`h`K`U`h`U`a`<`][\`G`W`cc`ž`gc`h`U`h`]h` \U`g`U`h`f`U`b`g`ž`c`fa`U`h`j`Y`Y`Z`Y`W`h`Æ
c`b`h`Y`[`Y`b`Y`f`U`" \][\`g`W`cc`d`c`d`i`U`h`]c`b`"ÆÆ

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Hc`ja`d`Ya`Y`b`h`h`]gž`k`Y`k`j`d`f`c`j`]X`Y`" `Wc`a`d`c`b`Y`b`h`g`%"`5`b`]b`Y`I`d`Y`b`g`j`Y`"]h`c`Za`U`h`Y`f`]U`g`Æ
U`c`k`]b`[`X`Y`Y`d`f`Y`g`Y`U`f`W`]b`U`b`Ya`Y`f`]b`[`Z`Y`X`h`U`h`W`U`b`V`Y`]b`j`Y`g`h`[`U`h`X`g`la`d`m`"H`Y`g`Y`Æ
_]h`g`k`j`"gd`U`b`U`f`U`b`[`Y`c`Z`h`c`d`]W`g`Z`f`c`a`U`i`[`a`Y`b`h`]b`[`h`Y` \i`a`U`b`i`g`l`b`[`h`Y`W`bc`c`[`m`h`c`i`g`l`b`[`Æ
mYUgh`hc`gri`X`m`a`i`h`U`h`c`b`g`" &"`A`U`h`W`]b`[`f`Y`g`Y`U`f`W`Y`f`hc`<G`gri`XY`bhg`k` \Y`f`Y`[`f`U`X`gri`XY`bhg`Æ
U`f`Y`f`Y`W`i`]h`Y`X`hc`"Y`U`X`U`a`c`X`i`Y`c`Z`h`Y`f`Y`g`Y`U`f`W`W`c`i`f`g`Y`U`h`h`Y` \][\`g`W`cc`" "Æ
Z`i`f`f`W`i`a`8`Y`g`j`]b`k` \Y`f`Y`k`Y`k`j`d`f`c`j`]X`Y`U`"h`Y`f`Y`j`U`b`h`"h`Y`f`U`h`i`f`Y`U`b`X`k` \Y`f`Y`k`Y`k`j`Æ
h`Y`U`W`k`h`Y`[`f`U`X`i`U`h`Y`gri`XY`bhg`hc`"X`Y`g`j`[`b`U`b`X`"Y`U`X`f`j`[`c`f`c`i`g`f`Y`g`Y`U`f`W`V`U`g`Y`X`d`f`c`Y`W`h`g`Æ
k`]h`h`Y`<G`gri`XY`bhg`"Æ

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K`Y` \Uj`Y`U`f`Y`U`X`m`h`Y`g`h`Y`X`c`i`f`Z`f`g`h`d`f`c`h`c`h`m`d`Y`ž`k` \Y`f`Y`K`<G`gri`XY`bhg`W`f`Y`U`h`X`U`X`Y`j`]W`Y`Æ
h`U`h`W`c`b`g`j`h`Y`X`c`Z`i`g`l`b`[`g`Y`b`g`c`f`g`h`U`h`X`Y`h`Y`W`h`Y`X`U`W`W`Y`f`U`h`c`b`U`b`X`h`h`i`ž`f`c`a`[`f`U`j`]h`U`h`c`b`U`Æ
j`Y`f`h`W`"U`b`X`W`c`b`j`Y`f`h`Y`X`]h`]b`h`c`j`]V`f`U`h`c`b`g`Z`Y`h`c`b`h`Y`g`]b`c`Z`U`d`Y`f`g`c`b`" "H`]g`m`Y`U`f`ž`h`Y`g`Y`Æ
gri`XY`bhg`k`j`"Y`U`X`U`b`X`W`c`b`X`i`W`h`Y`I`d`Y`f`]a`Y`b`h`g`U`Z`h`Y`f`g`W`c`c`k`]h`h`Y`K`<G`V`]c`h`Y`W`W`i`V`"Æ
B`Y`I`h`m`Y`U`f`ž`k`Y`U`]a`hc`fi`b`U`f`Y`g`Y`U`f`W`V`U`g`Y`X`W`c`i`f`g`Y`U`h`K`<G`"9`j`Y`f`m`c`b`Y`]g`k`Y`W`c`a`Y`hc`Æ
W`c`"U`V`c`f`U`h`Y`f`g`c`a`X`Y`4`V`f`U`b`X`Y`]g`Y`X`i`L`"Æ

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Brandeis Innovation Partners

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A Ugg7 \U`Yb[YÆ

A Ugg7 \U`Yb[Y]g'hY'a c gh'gUfhi d!Z]YbX`mUWWY YfUhc f'c bÆ

hY'd`UbYH"Gc Z]YbX`mz'hUhihYmHU_Y`bc`Yei]mZfca `UbmicZhY]f'ghUfhi dg`HAYm[]j`Y`ci hÆ
cj`Yf`&A`[`cVU`mYUW`mYUf]b`Yei]mZfY`WUg`d`f]nYg'hc`ghUfhi dg`k`c`UfY`gc`j`b[`[]`UbhÆ
dfcV`Ya`g'fUbb[]b[`Zfca`YbX]b[]bZUbhia`c`ftU`]mUbbX`W`f]b[`V`]bXbYgg`]b`W`]XfYb`z`hcÆ
\UfbYgg]b[`hY`c`WU`b`f]YbYf[m'c'f'Y'f'U'X]WU]b[`hY`U'f'g'Y'b]Wk`U'f'W'f]g]b[`6U`b[`U'X'Y'g`zÆ
UbbX`Y`j`Y`b`hc`g`j`Y`f]b[`W`h`fU`bc`fa`g`U'f'c`i`b`X`a`Y`b`g'f'i`U`h`c`b"Æ



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HAY`6fUbbXY]g`i`b]j`Yfg]m; fUXi UHY`DfcZYgg]c`bU`Ghi`X]YgÆ

; fUXi UHY`DfcZYgg]c`bU`Ghi`X]Yg`f] DGZ`U`X]j`]g]c`b`c`Z`h`Y`F`U`V`V`G`W`c`c`Æ

cZ7`c`b`h]b]b[`Ghi`X]Y`g`Z`Y`i`h`Y`b`X`g`h`Y`V`Y`b`Y`Z]h`c`Z`U`6fUbbXY]g`i`b]j`Yfg]mÆ

[fUXi UHY`YXi`WU]h`c`b`hc`U`X]j`YfgY`k`c`f_]b[`d`f`c`Z`Y`g`g]c`b`U`d`c`d`i`U`h`c`b"Æ

K`Y`c`Z`Y`f`%&`z` `mic`b]bY`z`d`U`f`h]a`Y`a`U`g`h`f`h]g`X`Y`[`f`Y`Y`g`U`b`X`c`b`YÆ

d`c`g`h[fUXi UHY`W`f]Z]WU]hY`]b`hc`X`U`m]g]b!X`Y`a`U`b`X`Z]Y`X`g`K`]h`Z`c`i`f`%\$!`k`Y`Y`_`g`Y`g`g]c`b`g`Y`U`W`Æ

mY`U`f`z`g`i`X`Y`b`h]g`V`Y`b`Y`Z]h`Z`f`c`a`U`Z`Y`i`j`V`Y`X`Y`[`f`Y`Y`W`c`a`d`Y`h]c`b`h]a`Y`]b`Y`h`U`h`a`Y`Y`h]g`h`Y`]f`b`Y`Y`X`g`Æ

U`g`Z`"i`h]a`Y`d`f`c`Z`Y`g`g]c`b`U`g`"C`i`f`W`c`i`f`g`Y`g`U`f`Y`U`g`n`b`W`f`c`b`c`i`g`z`Y`b`U`V`]b[`g`h]`X`Y`b`h]g`hc`Y`b[`U[`Y`Æ

Z`f`c`a`U`b`m`k`Y`f`Y`]b`h`Y`k`c`f`X`z`k`Y`]Y`c`i`f`k`Y`V`W`c`b`Z`Y`f`b`W]b[`hc`c`g`Y`b`U`V`Y`Z]W`m`ic`Z]W`Æ

\`c`i`f`g`z`[`f`c`i`d`k`c`f`_`z`U`b`X`d`f`Y`g`Y`b`h]h]c`b`g`"Ghi`X`Y`b`h]g`Y`U`f`b`]b`W`U`g`g]Y`g`h`U`h`U`f`Y`g`a`U`V`m`X`Y`g][`b`z`Æ

W`U`d`d`Y`X`U`h`%`c`f`&\$`X`Y`d`Y`b`X]b[`c`b`h`Y`Y`j`Y`"7`c`i`f`g`Y`g`U`f`Y`Y`X`V`m]b`X`i`g`f`m`Y`i`d`Y`f`g`k`c`Æ

X`Y`]j`Y`f`]b`X]j`]X`i`U`n`Y`X`g`d`d`c`f`h`U`b`X`d`f`c`Z`Y`g`g]c`b`U`]b`g][`h]g"Æ

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6fUbbXY]g`b`hY`f`b`U]c`b`U`6i`g]b`Y`gg]G`W`c`c`Æ

- HAY`"8U`m`G`h`U`f`h`i`d`f`l`8G`z`d`f`c`[`f`U`a`U]a`g`h`c`W`f`Y`U`h`U`A`

]j`]b[`Y`b`h`Y`d`f`Y`b`Y`i`f`g]d`"U`V`c`f`U`h`f`m`c`b`i`b]j`Yfg]mÆ

W`U`a`d`i`g`Y`g`V`m`V`f]b[]b[`hc`[`Y`h`Y`f`g`h]`X`Y`b`h]g`k`]h`Æ

X]j`YfgY`V`U`W`_`[`f`c`i`b`X`g`f`U`b[]b[`Z`f`c`a`Z`f`Y`g`l`a`Y`b`hc`Z`f`Y`g`l`n`t`a`]b`h`Y`X`D`l`8`g`"DU`f]h]M]d`U`b`h]g`Æ

[`U]b`Y`i`d`Y`f]Y`b`W`]b`W`f`c`g`g`X]g]W]d`]b`U`f`m`W`c`"U`V`c`f`U`h]c`b`z`V`f`U]b`g`h`c`f`a`]b[`U`b`X`]X`Y`U`h]c`b`z`Æ

U`b`X`[`f`c`i`d`d`f`c`X`i`W`h]j`]m`z`]b`W`i`X]b[`U`X`!`c`W`Y`U`X`Y`f`g]d`i`b`X`Y`f`g`Y`j`Y`f`h]a`Y`Æ

W`c`b`g`f`U]b`h]g`"H`Y`m`U`g`c`V`Y`W`c`a`Y`U`d`f`c`i`X`d`U`f`h`Y`f`c`Z`U`g`h`U`f`h`i`d`z`f`Y`U`X`m`h`c`V`Y`Æ

`U`i`b`W`Y`X`U`h`h`Y`Y`b`X`c`Z`h`Y`Y`j`Y`b`h`"H`c`U`X`X`hc`h`h]g`z`d`U`f]h]M]d`U`b`h]g[`U]b`h`Y`a`Y`b`X`c`i`g`Æ



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cddcfh b]hYgfc 'bYfk cf_k]h' a Ybfcfgk \c 'UfY 'h'ci [\h'YUXYfgUbx 'YI dYftg]bÆ
h'Y 'Z]Y 'X 'cZYbfYd fYbYi fg\]d"Æ

- H'Y '5gdYf'7YbhYf'Zcf; 'cVU''9bfYd fYbYi fg\]d'k UgZci bXYX 'Vm@ycbUfX '5gdYfzÆ
T, *z'h'Y '7YbhYfgYfj Yg'Ug'U 'WUa di g'k]XY '\i V'hc 'YI Ua]bY 'Ubx'i bXYfgUbxÆ
YbfYd fYbYi fg\]d 'UWfcgg'W 'hi fYg'Ubx 'Vc fXYfg/dfcj]XY 'U 'X]] YfgY 'fUb['Y'cZÆ
'YUfb]b['YI dYfjYbW'g'h'fci [\ 'Wci fgy g'z'g'a]bUfgz']b'h'f'bg\]d g'z'Vi g]bYgg'd 'UbgÆ
Wca d'Yh]h'c b'g'z'Z]Y 'X 'j]g]h'z'Ubx 'a 'YYh]b['g'k]h' ['cVU''YbfYd fYbYi fg/d fYgYbh'h'YÆ
Ubbi U''5gdYf'5k UfX 'Zcf; 'cVU''9bfYd fYbYi fg\]d 'Ubx '6fUbxY]g'5'i a b]Æ
9bfYd fYbYi fg\]d '5k UfX'g'Æ
- H'Y '9bfYd fYbYi fg\]d 'Ubx 'b'bcj U'h'c b '@UV]g'Zc W g'Y'X 'c b 'XYj Y'c d]b['h'Y 'g'U'f'hi dÆ
W 'hi fY 'Ua cb['Vi XX]b['YbfYd fYbYi fg'Ubx 'Ybf]M\]b['h'Y 'gd]f]h'c Z]b'bcj U'h'c b 'UbxÆ
h'fUbg'z'c'fa U'h'c b 'h'fci [\ 'UW'h'c b 'Ubx 'YI Ua d'Y''5a cb['j 'Uf]ci g'k c'f'g'c'd'g'UbxÆ
UW'h]]h'Y'g'h']g'm'Y'U'f'z'h'Y 'Z]f'g'h'Ubbi U''9bfYd fYbYi fg\]d '7 c b Z]Y b'W'Y '\c'g'Y'X 'U' d'U'b'Y'Æ
X]g'W' gg]c' b'c' b'f'h'Y 'Z' hi fY 'c'Z'8'U'f'U' 'U' b'U' 'm]W'g]b' G'h'U'f'hi d'g'f'k]h' h'Y 'd'U'b'Y']g'h'g'U'f]b[Æ
h'Y]f' d'Y'f'g'c' b'U'']b'g] [\ h'g'hc'k U'f'X'g'h']g'd]c' b'Y'Y'f]b['Z]Y 'X''K' Y''c'c_'Z'c'f'k U'f'X' 'h'c'g'Y'Y]b[Æ
m'ci]b'ci f'Z' hi fY 'Y'j Y'bh'g'Æ

S

S

6fUbxY]g'A U_Yf@JVÆ

Gi ddcfh]b['YXi WU]h'c b'U'z'gc W]U''Ubx 'h'Y'W'bc'c []WU'']b'bcj U'h'c b'zÆ
h'Y '6fUbxY]g'A U_Yf@UV]g'c'f]Y'bh'Y'X 'U'f'ci b'X 'U'j]g]c' b'c'Z'gc W]U'Æ
↑ g]W' 'XYg] [b'YX 'hc'g']d' d'c'f'ha U_Yfgk \c 'a 'YbX''H'Y'mÆ
Wc''U'V'c'f'U'h' 'c' b'Wca di h]b['d'f'c'Y'W'h'g'hc' 'XYj Y'c d' b'Y'k 'Z'c'fa g'c'Z'W 'hi fY 'U'bx 'W'f'U'z]b'U'Æ
Wca a i b]m]W'bh'Y'f'Y'X'g'Y'h]b["Æ



S

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H'Y '<]U'h'7 U'f'Y'f'7 Y'bh'f'Æ

H'Y '<]U'h'7 U'f'Y'f'7 Y'bh'f'U'gg]g'h'g'hi XYbh'g'Ubx 'U'i a b]]b'XYj Y'c d]b['h'Y'Æ
g_]g'hc' h'f'U'bg'z'c'fa 'h'Y]f'i b]e'i Y 'V'U'W_['f'ci b'X'g'z']V'Y'f'U''U'f'g'Y'X'i WU]h'c b'UbxÆ
YI d'Y'f]Y'bh]U''Y'U'fb]b[]b'hc' 'a 'Y'U'b]b['Z' 'd'f'c'Z]Y'gg]c' b'U''Z' hi fY'g'UbxÆ
fY 'U'h'c'bg\]d'g''<]U'h'Y' b[U['Y'g'Y'a d'c'm'Y'f'g'z'Wc''Y'U[i Y'g'z'd'U'f'Y'bh'g'Ubx 'Z]a]]Y'g'Æ
Ubx 'h'Y ['f'Y'U'h'f'6fUbxY]g'Wca a i b]m]h'c'U'W\]j Y'h']g'a]gg]c' b"Æ



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A Ugg6]c'Æ

A Ugg6]c']g'U'bc'h'Z'c'f'd'f'c'Z]h'c'f['U'b]n'U'h'c' b'Z'c' i b'XYX']b' % ,) 'h'U'h'Æ
f'Y'd'f'Y'g'Y'bh'g'Ubx 'd'f'c'j]X'Y'g'g'Y'f'j]W'g'Ubx'g']d' d'c'f'hi'Z'c'f'h'Y'k' c'f'X'f'g'Æ
'Y'U'X]b[]Z]Y'g'M]Y'b'W'g'g']d'Y'f'W'i'g'h'Y'f''A Ugg6]c']g'Wca a]h'Y'X'hc'Æ
U'X'j'U' b'W]b['A Ugg'U'W'i'g'Y'h'g'f'i'Y'U'X'Y'fg\]d']b' h'Y ''Z]Y'g'M]Y'b'W'g'hc' ['f'c'k 'h'Y']b'X'i'g'f'm'z'U'X'X'Æ
j'U'i'Y'hc' h'Y '\Y'U'h'W'U'f'Y'g'm'h'Y'a 'U'bx']a d'f'c'j'Y' d'U'h]Y'bh']j'Y'g'f'Y'd'f'Y'g'Y'bh]b['%z\$\$\$Z'Æ
V]c'h'Y'W'bc'c ['m'Wca d'U'b]Y'g'z'U'W'U'X'Y'a]W]b'g]h'i' h'c' b'g'z'X]g'Y'U'g'Y'Z'c' i b'X'U'h'c'bg'Ubx 'c'h'Y'f'Æ
c'f['U'b]n'U'h'c'bg]b]c'j'Y'X']b''Z]Y'g'M]Y'b'W'g'Ubx '\Y'U'h'W'U'f'Y'z'A Ugg6]c' 'Y'j'Y'f'U['Y'g]h'g'Æ



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