

H0X`]W\ Yf`I bZU``]b`@Ub[ k ]YX. ) +!>\ f][ Yf  
gh]fVh`bUW\ `Dc fgW\ Y!7 fUg\

H0X`]W\ Yf`J Yf\_Y\ fgi bZU``]b`@Ub[ k ]YX!@cW\ \Ui gYb.`9]b  
) +!>\ f][ Yf`ghUfV`bUW\ `Y]bYa `Dc fgW\ Y!! bZU``z`Y]b  
%- !>\ f][ Yf`k i fXY`j Yf`Yhnh"

A 0bW\ Yb`fc hgt

9]b`hfU[ ]gW\ Yf`J Yf\_Y\ fgi bZU``YfY][ bYhY`g]W\ `Ua `GUa ghU[ z`XYb  
&("5i [ i gh&\$&( z]b`@Ub[ k ]YX!@cW\ \Ui gYb z`XYf`XUg`@YVYb`Y]bYg  
) +!>\ f][ Yb` : U\ fYfg`Zc fXYfhY""8 Yf`J c fZU`` [ YgW\ U\ [ Y[ Yb`%&.\$&  
I \ f]b`XYf`9gW\ Yb f]YXYf`GhfU» Yz`U`g`Y]b`Dc fgW\ Y`j cb`XYf  
: U\ fVU\ b`UV\_Ua `i bX`g]W\ `0VYfgW\ `i [ z`k Ug`ni `Y]bYa `gcZc fh][ Yb  
9]bgUhm`j cb` : Yi Yfk Y\ f`i bX`F Yhhi b[ gX]Ybgh`Z0\ fhY"

5`g`X]Y`B chZU``X]YbghY`Y]bhfUZy b z`ZUbXYb`g]Y`Y]bYb`Dc fgW\ Y`7 UVf]c  
Ui ZXYa `8 UW\ ``Y[ YbXz`ei Yf`ni f` : U\ fVU\ b""8 Yf`%- !>\ f][ Y  
6Y]ZU\ fYf`\_cbbhY`VYfY]hg`Ui g`XYa ` : U\ fnYi [ `VYZfY]h`k YfXYb z  
k A\ fYbX`X]Y` : Yi Yfk Y\ f`Yi hY`a ]h`XYf`gW\ k ]Yf][ Yb`5i Z[ UVY  
VYgW\ A Zh][ h`k UfYb z`XYb` : U\ fYf`ni `fYhYb""@Y]XYf`\_cbbhYb`g]Y`bi f  
bcW\ `XYb`HcX`XYg`) +!>\ f][ Yb`ZYghghY``Yb"

F Yhhi b[ ga U» bU\ a Yb`i bX  
GhfU» YbUi ZVYfY]hi b[

8]Y`i a [ Y\ YbXYb`A U» bU\ a Yb`XYf`F Yhhi b[ g\_fAZhY`ghUbXYb`ja  
NY]W\ Yb`XYf` ; Yk A\ f`Y]ghi b[ `j cb`G]W\ Yf\ Y]hi bX`XYf`gW\ bY``Yb  
<`j`Z`""8 Yf`j Yf`YhnhY`6Y]ZU\ fYf`k i fXY`gcZc fh]b`Y]bY`A 0bW\ bYf  
?`b]\_ [ YVfUW\ hz`k c`Yf`a YX]n]b]gW\ `VYhfYi h`k i fXY""8 ]Y` : Yi Yfk Y\ f  
\ UhY`ni XYa `X]Y`5i Z[ UVYz`Ui g`Ui ZYbXY`6Yhf]YVgghcZY`ni  
VYgY]h][ Yb`zi a `k Y]hYfY` ; YZU\ fYb`ni `j Yf\]bXYfb"

8]Y'9gW\Ybf]YXYf'GhfU»Y'k i fXY'k Å\fybX'XYf'[ YgUa hYb  
A U»bU\ a Yb'ca d'Yhh'[ YgdYffhž'i a 'X]Y'G]W\Yf\Y]h'XYf'DUggUbhYb  
ni '[ Yk Å\ f'Y]ghYb'i bX'Y]bYb'fY]Vi b[ g'cgYb'5V'Ui Z'XYf  
FYhhi b[ gU\_h]cb'ni 'Yfa Ò[ 'j]W\Yb"K Y]hYfY'9]b\Y]hYb'k i fXYb'ni f  
l bhYfghØhni b[ 'Ub[ YZcfXYfhž'i a 'bUW\5VgW\i gg'XYf  
l bZU`UbU'mh]\_Xi fW\Y]bYb'; i hUW\hYf'X]Y'GhfU»Y'[ fØbX']W\ 'ni  
fY]b][ Yb'i bX'k ]YXYf'ZØf'XYb'J Yf\_Y\ f'ZfY]ni [ YVYb"

## I bZU`i fgUW\Y'i b`Uf

Ni f'[ YbUi Yb' l bZU`i fgUW\Y'k i fXYb'gY]hYbg'XYf': Yi Yfk Y\ f'\_Y]bY  
5i ggU[ Yb' [ YhfcZZYb"8]Yg'XYi hYh'XUfUi Z'\]bž'XUgg'k Y]hYf\]b  
9fa ]hhi b[ Yb'Ub[ YghY`'hik YfXYb'a ØggYbž'i a 'X]Y'[ YbUi Yb  
l a ghÅbXY'ni '\_ÅfYbž'X]Y'ni 'X]YgYa 'hfU[ ]gW\Yb'J cfZU``[ YZØ\fh  
\UVYb'\_ØbbhYb"l bZÅ`Y'k ]Y'X]YgYf'k YfZYb'ja a Yf': fU[ Yb'Ui Zi bX  
a UW\Yb'XYi h]W\ž'k ]Y'k ]W\h][ 'g]W\YfY': U\fdFU\_h]\_Yb'i bX  
dfÅj Ybhj] Y'A U»bU\ a Yb'ja 'GhfU»Ybj Yf\_Y\ f'g]bX"

8]Y'J cfZÅ`Y'Ui Zi bgYfYb'GhfU»Yb'g]bX'cZhi bj cf\YfgY\VUfž'XcW\  
gc`W\Y'hfU[ ]gW\Yb' l bZÅ`Y'\_ca a Yb'ja a Yf'k ]YXYf'j cf"  
J Yf\_Y\fgUi Z\_`Åfi b[ 'gck ]Y'j YfghÅf\_hY'?cbhfc`Yb'\_ØbbhYb  
a Ò[ 'j]W\Yfk Y]gY'XUni 'VY]hfU[ Ybž'Å\ b']W\Y'HfU[ ÒX]Yb' ]b'XYf  
Ni \_i bZhi'ni 'j Yf\]bXYfbž'XcW\ZØf'X]Y'6YhfcZZYbYb'i bX'X]Y  
<]bhYfV`]YVYbYb'V`Y]Vh'X]YgY'HfU[ ÒX]Y'i bj Yf[ YggYb"

9g'V`Y]Vh'ni 'VYcVUW\hYbž'k ]Y'X]Y`c\_U`Yb'6Y\ØfXYb'i bX  
=bgh]hi h]cbYb'Ui Z'X]YgYb'J cfZU``fYU[ ]YfYb'i bX'k Ug'U'g'bÅW\ghYb  
GW\f]hhY'i bhYfbca a Yb'k ]fXž'i a 'X]Y'J Yf\_Y\fgg]W\Yf\Y]h'Yf\Ø\Yb"  
8]YgY'; YgW\Y\ b]ggY'nY][ Yb'X]Y'J Yf'Yhn`]W\\_Y]h'i a 'GhfU»Ybj Yf\_Y\ f  
i bX'i bhYfghfY]W\Yb'X]Y'J YfUbhk cfhi b[ 'XYf'J Yf\_Y\ fghY]'bY\ a Yf"  
l a gc'k ]W\h][ Yf']gh'Ygž'X]Y'5i [ Yb'cZZYb'ni '\U'hYb'i bX'g]W\ 'ghYhg  
Ub'X]Y'J Yf\_Y\fgfY[ Y'b'ni '\U'hYb"

< ]bhYf[ fi bX]bZcfa Uh]cbYb'ni a  
J Yf\_Y\ fgi bZU`

J Yf\_Y\ fgi bZÅ`Y'ghY`Yb'Y]b'YfbghYg[ YgY`gW\UZh]W\Yg'DfcV`Ya

XUfž'i bX`]\fY`l fgUW\Yb`g]bX`]\Ài Z[ `j ]Y`gW\W\h][ " `b`8Yi hgW\`UbX  
[ ]Vh`Yg`À\`f`]W\`NY\bhUi gYbXY`j cb`J Yf`\_Y\fgi bZÀ``Ybž`k cVY`]X]Y  
NU\`Yb`]b`XYb`YhnhYb`š\`fYb`\_cbghUbh`[ YV`]YVYb`g]bX``@Ui h`XYa  
GhUh]gh]gW\Yb`đi bXYgUa`h]g]bX`ja`š\`f`&\$&&]bg[ YgUa`h`&"+) \*  
A YbgW\Yb`VY]`J Yf`\_Y\fgi bZÀ``Yb`]b`8Yi hgW\`UbX`i a`g`@YVYb  
[ Y`\_ca`a`Yb``8Ug`a`UW`h`XYi`h`]W\ž`k ]Y`k ]W\h][ `df`Àj`Ybh]j`Y  
A U»bU\`a`Yb`g]bXž`i`a`X]Y`5bnU\`XYf`gW\k`Yfk`jY[ YbXYb`i`bZÀ``Y  
ni`fYXi`n]YfYb`"

9]b`k`YgYbh`]W\Yf`: U`\_hcf`ZØf`J`Yf`\_Y\fgi`bZÀ``Y`]gh`X]Y  
; YgW\k`]bX][`\_Y]h``Ghi`X]Yb`nY][`Ybž`XUgg`\`Ò\`YfY  
; YgW\k`]bX][`\_Y]hYb`b]W\h`bi`f`X]Y`K`U\`fgW\Y]b`]W\`\_Y]h`Y]bYg`l`bZU``g  
Yf\`Ò\`Ybž`gcbXYfb`Ui`W\`X]Y`GW\k`YfY`XYf`J`Yf`Yhni`b[`Ybž`X]Y`VY]  
gc`W\Yb`i`bZÀ``Yb`YbhghY\`Yb`\_`ÒbbYb``A`Y]gh]g]bX`: U\`fUbZÀb[`Yf`i`bX  
↑`b[`Y`:`U\`fYfž`k`jY`]a`j`cf`]Y[`YbXYb`i`bZU``ž`ØVYfdfcdfh]cbU`  
VYhfc`ZYb`` `b`8Yi hgW\`UbX`g]bX`: U\`fUbZÀb[`Yf`nk`]gW\Yb`%,`i`bX`&(  
š\`fYb`]b`Y]bYa`VYgcbXYfYb`F]g]\_cVYfY]W\ž`k`Ug`Ui`Zj`YfgW\]YXYbY  
: U`\_hcfYbž`k`jY`a`Ub[`Y`bXY`9fZU\`fi`b[`i`bX`a`Ò[`]W\Yfk`Y]gY`Ui`W\  
f]g`\_UbhYg`: U\`fj`Yf\`U`hYbž`ni`fØW`ni`ZØ\`fYb`]gh`"

## 5`\_hi`Y``Y`GhUh]gh]\_Yb`ni`J`Yf`\_Y\fgi`bZÀ``Yb

8]Y`U`\_hi`Y``Yb`NU\`Yb`XYf`J`Yf`\_Y\fgi`bZU``ghUh]gh]\_`XYg`8Yi`hgW\Yb  
J`Yf`\_Y\fgg]W\Yf\`Y]hgfUhYg`fB`J`GF`Łj`YfXYi`h`]W\Yb`X]Y`\_ca`d`YI`Y  
@U[`Y`Ui`ZXYb`GhfU»`Yb```a`š\`f`&\$&'`k`i`fXYb`ØVYf`&(`"\$\$\$  
J`Yf`\_Y\fgi`bZÀ``Y`fY[`]ghf]Yfž`k`cVY`]UbghY][`YbXY`HYbXYbnYb`VY]  
l`bZÀ``Yb`a`h`DYfgcbYbgW\UXYb`ZYghni`ghY``Yb`g]bX``6YgcbXYfg  
Ui`ZÀ``][`]gh`X]Y`Ni`bU\`a`Y`j`cb`l`bZÀ``Ybž`X]Y`Xi`fW\`5`\_c\`c`cXYf  
8fc[`Yb`VYY]bZi`ggh`k`i`fXYbž`k`Ug`Ui`Z`X]Y`B`chk`YbX][`\_Y]h]j`cb  
j`Yfgh`Àf`\_hYb`?`cbhfc``Yb`i`bX`5i`Z`\_`Àfi`b[`\]bk`Y]gh`"

⇒`U`\_hi`Y``Yb`š\`f`k`i`fXY`ZYgh[`YghY``hž`XUgg`WU``&\$`i`U``Yf  
J`Yf`\_Y\fgghc`hYb`Ui`Z`l`bZÀ``Y`a`h`DYfgcbYb`\_fUZh`k`U[`Yb  
ni`fØW`ni`ZØ\`fYb`g]bX``8]Yg`nY][`hž`k`jY`k`]W\h][`Yg]ghž`X]Y  
²`ZYb`h`]W\`\_Y]h`ØVYf`g]W\YfYg`: U\`fj`Yf\`U`hYb`i`bX`X]Y`;`YZU\`fYb`j`cb  
,`VYfa`ØXi`b[`i`bX`5V`Yb`\_i`b[`Ua`GhYi`Yf`Ui`Zni`\_`ÀfYb`"  
5i`Z`\_`Àfi`b[`g`\_Ua`dU[`bYb`i`bX`[`YgYh`]W\Y`A`U»bU\`a`Ybž`k`jY`X]Y  
9f\`Ò\`i`b[`XYf`đi`»[`Y`XYf`ZØf`;`YgW\k`]bX][`\_Y]hgØVYfhfYhi`b[`Ybž`

gc`Yb`XUni`VY]hfU[ Ybž`X]YgY`NU\`Yb`ni`gYb\_Yb"

F Y h h i b [ g U \_ h ] c b Y b ` i b X ` 9 f g h Y ` < ] ` Z Y

8]Y`gWk`bY`Y`F`YU`\_h]c`b`j`c`b`F`Y`h`i`b`[`g`X]Y`b`g`h`Y`b`[`g`h`i`b`  
I`b`ZU`g]h`i`U`h]c`b`Y`b`Y`b`h`g`W`k`Y`X`Y`b`X`" `ϕ`8`Y`i`h`g`W`k`U`b`X`g]b`X`X]Y`  
F`Y`h`i`b`[`g`X]Y`b`g`h`Y`[`i`h`i`c`f`[`U`b]g]Y`f`h`ž`i`b`X`[`a`[`[`U`Y`Y`b`Y`g`g`W`k`Y`f`Y`b`  
I`b`ZU`g`ž`k`]Y`[`b`X]Y`g`Y`a`[`[`U`ž`k`Y`f`X`Y`b`g`c`Z`c`f`h`a`Y`f`Y`f`Y`9]b`Y`h]Y`b`  
U`U`f`a`]Y`f`h`8]Y`9]b`g`U`h`\_`f`Å`Z`h`Y`g]b`X`g`d`Y`n]Y`[`[`Y`g`W`k`i`h`ž`i`a`[`i`b`h`Y`f`  
8`f`i`W`\_`n`i`U`f`V`Y]h`Y`b`i`b`X`[`b`\_`f]h]g`W`k`Y`b`G]h`i`U`h]c`b`Y`b`g`W`k`b`Y`[`i`b`X`  
Y`Z]n]Y`b`h`@`V`Y`b`ni`f`Y`h`h`Y`b`"B`Y`V`Y`b`X`Y`f`h`Y`W`k`b]g`W`k`Y`b`F`Y`h`i`b`[`[`g`h`  
U`i`W`k`Y`b`Y`a`Y`X]n]b]g`W`k`Y`9`f`g`h`j`Y`f`g`c`f`[`i`b`[`j`c`b`[`f`Ö»`h`Y`f`6`Y`X`Y`i`h`i`b`[`ž`  
X`U`g]Y`X]Y`7`U`b`W`k`b`X`Y`f`J`Y`f`Y`m`h`Y`b`U`i`Z`Y]b`Y`Y`f`Z`c`[`f`Y]W`k`Y`  
;`Y`b`Y`g`i`b`[`Y`f`Y`V`]W`k`Y`f`Y`f`Ö`Y`b`\_`U`b`b"

9g`[`]V`h`n`U`\`f`Y]W`k`Y`ϕ]h]U`h]j`Y`b`i`b`X`D`f`c`[`f`U`a`a`Y`ž`X]Y`X`U`f`U`i`Z`  
U`V`n]Y`Y`b`ž`X]Y`6`Y`j`Ö`\_`Y`f`i`b`[`[`b`9`f`g`h`Y`f`<]`Z`Y`U`i`g`n`i`V`]X`Y`b`"9]b`Y`[`i`h`  
]b`Z`c`f`a`]Y`f`h`Y`i`b`X`\`U`b`X`i`b`[`g`Z`Å`\][`Y`²`Z`Z`Y`b`h]W`k`\_`Y]h`\_`U`b`b`  
Y`b`h`g`W`k`Y`X`Y`b`X`X`U`n`i`V`Y]h`f`U[`Y`b`ž`]b`X`Y`f`Y`f`g`h`Y`b`D`\`U`g`Y`b`U`W`k`Y`b`Y`a`  
I`b`ZU`[`Y`Y][`b`Y`h`Y`A`U»`b`U`\`a`Y`b`ni`Y`f`[`f`Y]Z`Y`b`ž`V]g`d`f`c`Z`Y`g`g]c`b`Y`Y`  
<]`Z`Y`Y`b`h`f]Z`h`8`U`\`Y`f`g]b`X`f`Y`[`Y`a`Å»][`Y`G`W`k`i`i`b`[`Y`b`i`b`X`  
ϕ`Z`c`f`a`U`h]c`b`g`\_`U`a`d`U[`b`Y`b`i`b`U`V`X]b`[`V`U`f`ž`i`a`[`Y]b`6`Y`k`i`g`g`h`g`Y]b`Z`Ø`f`  
X]Y`J`Y`f`U`b`h`k`c`f`h`i`b`[`[`j`a`G`h`f`U»`Y`b`j`Y`f`\_`Y`\`f`ni`Z`Ø`f`X`Y`f`b"

8 Y h U ] g

6 Y g i W k Y b ` G ] Y ` i b g ` U i Z . ` b ! U [ " X Y