

BIOM4951

F YgYufWx 'H\Yg]g'5

HYfa %Z &\$&



7ci fgY`Cj Yfj JYk

GHJZ7cbHJW8YHJ`g

7cbj Ybcfg

BUa Y	9a U]`	5j U]`UV]`]m	@cW]h]cb	D\cbY
A UH\Yk `6fcX]Y	h\Yglg"V]ca YXYb[4 i bgk "YXi "Ui	VmUddc]bha Ybh	GUa i Y`g') %)	
H]Ubf] c ; i c	h[i c4 i bgk "YXi "Ui	VmUddc]bha Ybh	GUa i Y`g') %)	

GWXcc`7cbHJW8Zcfa Uh]cb

Gh XYbhGYfj J]Wg`W]b`VY`WcbHJW8X`j]U`i [bgk "hc# YVZcfa g"](#)

7 ci fgY'8YHJ`g

I b]hg'cZ7 fYX]h(

Gi a a UfmicZ\Y'7 ci fgY

H\Y'hYg]g'dfcj]XYg'Ub'cddcfi b]mZcf'mci 'hc'Vf]b['hc[Y'hYf'Yb[]bYYf]b['df]bW]d'Yg'YUfbYX'cj Yf mci f'dfYj]ci g'mYUfg'cZgh XmUbX'Udd'mhYgY'df]bW]d'Yg'hc']b]bcj Uhj Y'mgc'j Y'dfcV'Ya g'gi V\Ug'hY XYj Y'cda YbhcZU'gdYW]ZWXyg[bZ'dfcW'gg'UbX#cf'hY]bj Ygh[Uh'cb'cZU'\md'chYg]g" H\Yg]g'dfc'YW'g'UfY W'ca d'Yi Z'cdYb!YbXYX'dfcV'Ya g'hUhU'ck 'fcca' Z'cf'mci f'WYU'hj]mZ'UbX'hY'UW'ei]g]h'cbZ'UbU'mg]g'UbX]b]h'fdYU'h]cb'cZfYgi 'hg" H\YfY'UfY'a i 'h'd'Y'dcgg]V'Y'gc'i h'cbg'cf'W'cbW] g]cbg'Uh'hY'ci hgYh'UbX'gi Z]W]Ybh W'ca d'Yi]mhc'fYei]fY'U'XY[fY'cZ'dfc'YW'id'Ubb]b["H\Y'hYg]g'fYei]fYg'mci 'hc'Z'fa i 'Uh'Y'dfcV'Ya g']b gW]Ybh]Z'Wcf'Yb[]bYYf]b['h'fa g'za UbU[Y'Ub'h'W'cb]W]d'fc'YW'h'UbX'Z]bX'gc'i h'cbg'Vm'Udd'm]b['gW]Ybh]Z]W'UbX Yb[]bYYf]b['a Y'h'cXg" M'ci 'k]'U'gc'XYj Y'cd'mci f'UV']mhc'k cf_]b'U'fYgYUfW'UbX'XYj Y'cda Ybh Ybj]f'cba Ybh'Mci 'a i gh]XYbh]Zm'U'gi dYfj]gc'f'UbX'dfc'YW'id]cf'hc'Ybfc']b[]b'h]g'W'ei fgY"

7 ci fgY'5]a g

H\Y'hYg]g'dfcj]XYg'Ub'cddcfi b]mZcf'hY'gh XYbh'hc'Vf]b['hc[Y'hYf'Yb[]bYYf]b['df]bW]d'Yg'YUfbYX'cj Yf hY]f'dfYj]ci g'mYUfg'cZgh XmUbX'Udd'mhYgY'df]bW]d'Yg'hc']b]bcj Uhj Y'mgc'j Y'dfcV'Ya g'gi V\Ug'hY XYj Y'cda YbhcZU'gdYW]ZWXyg[bZ'dfcW'gg'UbX#cf'hY]bj Ygh[Uh'cb'cZU'\md'chYg]g" H\Yg]g'dfc'YW'g'a i gh VY W'ca d'Yi Z'cdYb!YbXYX'dfcV'Ya g'hUhU'ck 'fcca' Z'cf'gh XYbh'WYU'hj]mZ'UbX'hY'UW'ei]g]h'cbZ'UbU'mg]g'UbX]b]h'fdYU'h]cb'cZfYgi 'hg" H\YfY'a i ghVY'a i 'h'd'Y'dcgg]V'Y'gc'i h'cbg'cf'W'cbW] g]cbg'Uh'hY'ci hgYh'UbX'gi Z]W]YbhW'ca d'Yi]mhc'fYei]fY'U'XY[fY'cZ'dfc'YW'id'Ubb]b['Z'ca 'hY'gh XYbh'H\Y'hYg]g'fYei]fYg'hY gh XYbh'hc'Z'fa i 'Uh'Y'dfcV'Ya g']b'Yb[]bYYf]b['h'fa g'za UbU[Y'Ub'Yb[]bYYf]b['dfc'YW'h'UbX'Z]bX'gc'i h'cbg'Vm'Udd'm]b['Yb[]bYYf]b['a Y'h'cXg" Gh XYbh]U'gc'XYj Y'cd'hY]f'UV']mhc'k cf_]b'U'fYgYUfW'UbX'XYj Y'cda Ybh Ybj]f'cba Ybh'

7 ci fgY'@YUfb]b['Ci hW'ca Yg

% 8Yj Y'cd'U'XYg][b'cf'U'dfcW'gg'cf']bj Ygh[Uh'U'\md'chYg]g'Z'ck]b[]bXi ghfm'UbX'dfcZ'gg]cbU' Yb[]bYYf]b['gh'UbXUfXg"
& 7 f]h]W'mfYZYW'h'cb'U'gdYW]U'ghVcXmcZ_bck 'YX[Y'fY'Uh'X'hc'hY]f'hYg]g'hc'd]W'
' " 5dd'mgW]Ybh]Z]W'UbX'Yb[]bYYf]b['a Y'h'cXg'hc'gc'j Y'Ub'Yb[]bYYf]b['dfcV'Ya "
(" 5bU'mgY'XU'U'cV'YW]j Y'mi g]b['ei Ub]h]U'h]j Y'UbX'a Uh'Ya Uh]W]'a Y'h'cXg"
) " 8Ya cbgh'U'h'cf'U'UbX'k f]h'Y'b'W'ca a i b]W]h]cb']b'dfcZ'gg]cbU'UbX'Um'Xca U]bg"
*" Gc'j Y'V]ca YX]W'dfcV'Ya g'Vm'Udd'm]b['7 @Cg%')"

HYUW]b['Gh'U'h] []Yg'

H\Y'W'ei fgY']g' h]i [\h'Ug'Ub']bX]j]Xi U'fYgYUfW'dfc'YW'z'hc'XYj Y'cd'U'Yj Y'cZ'fYgYUfW'g_]`g'UbX Ui h'cbca m'

5XX]h]cbU'7 ci fgY' hZ'ca Uh]cb

H\YfY']g'bc'cZ]W]U'W'Ugg'h'a Y'Z'cf'h]g'W'ei fgY'Z'k \]W'd'UW'g'U'Z'cW'g'cb'gY'Z'a ch]j Uh'X'Y'Ufb]b[" M'ci 'a i gh gh'Ybgi fY'mci f'Ybfc'a Ybh'UbX'fY[]gh'U'h]cb']g'i d'hc'XUh']b'mci f'Ybfc'a Ybh'Mci 'a i gh\Uj Y'gY'YW'h'X'U'dfc'YW'h'VY'Z'fY'k YY_'\$'cZ'h'fa "'-Z'mci '\Uj Yb]h'X'cbY'gc'U'fY'UX'mZ'd'YUgY'W'cb'U'W'h'hY'W'ei fgY'W'c'fX]b'U'hc'f" M'ci f'Z]W]h'hc'!Z]W]h'a Y'b'Y'Xg'hc'VY'cf[Ub]gYX'k]h' mci f'gi dYfj]gc'f'Z'Ug'mci 'UfY'Yi dYW'h'X'hc'a Y'h'h'Y'a 'Uh'Y'Ugh'cb'W'dY'f'k YY_"

9I dYWUhcbg'cZGhi XYbhg

- E WX_ af[hSfW ^Sd [Y
- ? Wwf kagdegbWh[eaddWg'Sdk
- 5 a_ b WWS ^fZWSeeW_e_ W fe a` f[W
- 3 ffW V fZWI Ww] \$ fgfad[S^a` Ua` VgUf[Y fWdSfgdWdWh[W e

5ggYgga Ybh

5ggYgga YbhUg_	K Y][\h	8i Y'8UHŸ	7ci fgY'@YUfb]b[Ci hWca Yg'5ggYggYX
%": ðhŸf]a 'F Ydcfh	;%\$	A cbXUmK YY_ '%%%%) - 'da	%ž&ž' ž'(ž) ž*

5ggYgga Ybh% ðhŸf]a 'F Ydcfh

Gi Va]gg]cb'bcŸg. 'Mci 'a i ghgi Va]hU'XfUZhcZmci f'@]hŸfUŸi fY'F Yj]Yk 'hc'Ga Ufh]b_]b[ž'hYb'gi Va]hmcif
Ga Ufh]b_]b['ZYXVUW_ 'hc' A ccX'Yždf]cf'hc'gi Va]gg]cb'cZmci f'ðhŸf]a 'F Ydcfh' C bW' mci 'fYW]j Y'hY
ga Ufh]b_]b['ZYXVUW_ž'd'YUgY'i d'cUX'h]g'hc' A ccX'Yž'UbX'hY'gi Va]gg]cb'hc'k]'cdYb'žcf'mci "
8i Y'XUHŸ. 'A cbXUmK YY_ '%%%%) - 'da

ð'hYg]gž'hYfY'UfY'hfY'X]ZYfYbhUggYgga YbhghU[Yg"

H\Yg]g'5. 'ðhŸf]a 'F Ydcfhf%\$| ŁžGi dYfj]gcf'7\YW_]ghfG5# BŁ

H\Yg]g'6. 'Dfc[fYgg'GYa]bUf'UbX'F YZYW]cb'f%\$| Ł

H\Yg]g'7. ':]bU'fYdcfhf*) ŁžDUfh]W]dU]cb'f) Łž'7cbZYfYbW'DfYgYbU]cb'f%\$| Ł

Mci f'cV'YW]j Yg]b'H\Yg]g'5'UfY

%' Hc'Vi]X'mci f'_bck 'YX[Y'VUgY'cb'mci f'gdYW]WfYgYUfW'hcd]W
&" I gY'hU]_bck 'YX[Y'VUgY'hc']bžcfa 'mci f'gdYW]Wdfc'YW]U]a g'UbX'a Y'hcXc'c[m'
' " 7ca d'YH' d'fY]a]bUfmk cf'_hc'k UfXg'a YH]b['hY'gdYW]Wdfc'YW]U]a g"

Hc'UggYgg'h]gž'hYfY'UfY'hk c'UggYgga YbhUg_g'žcf'H\Yg]g'5"P

ðhŸf]a 'fYdcfhf%\$| Ł

%' @]hŸfUŸi fY'fYj]Yk 'cf'Yei]j U'Ybhf) \$| Ł
%' K \Uh]g'hY'dfcV'Ya 'hc'VY'gc'j YXž'UbX']hg'g][b]WU]bW'3
&" A i gh]bW] XY
%"

% >i ghZVWhcb'cZha Y'U'cWWhcb'ZcFYUWX'hUg_
' " 5j U]UVY'fYgci fW'g']XYbhZ]YX
(" F Yei]fYX'hfU]b]b['UbX'i dg_]`b[']XYbhZ]YX

% Dfc YVh8YdYbXYbhDfYdUfU]cbg'f&\$i Ł
% 7 Ub'hY'ghi XYbhUWX]Yj Y'hY'U]a g']b'hY'h]a Y`]bY3'K \UhdFc[fYgg'\Ug'VYYb'a UXY
U'fYUXmB
&" Dfc YVhgdYWZ]V'Vi ha Um]bWi XY
% 9j]XYbW'cZhfU]b]b['cb'gdYWZ]WYei]da Ybh
&" 9j]XYbW'cZgca Y'i dg_]`b[']b'bYk 'gcZk UfY#a YhcXg
' " DfY'ja]bUfmfYgi `hg
(" DfY'ja]bUfmig_YhWYg
)" 7 ca dcbYbhg#dUfYg'cfXYfYX
*" 8YhU]YX'Vi X[YH † %o %o

F Ygci fWg

DfYgWf]VYX F Ygci fWg

F Ygci fWg'k]`VY'a UXY'Uj U]UV'Y'rc` \Y'd'ghi XYbng] i]XY'hYa`]b'hY]f'ci fbYmZcf'H\Yg]g'5"

9I hYbg]cbg

Mci`Wb'Udd'mZcf`gdYWU`Wcbg]XYfU]cb`k` \Yb`]'bYgg'cf'c'hYf'WfW`a`gHUbWg`]bHfZYf'k`]h'mci`f`UggYgga`YbhdYfZ'fa`UbW"

C`hYf'Udd`]W]h]cbg`Zcf'YI`hYbg]cb`cZgi`Va`]gg]cb`cZ'hYg]g`fYdcfng`fY"[`"Yei`]da`YbhVfYU`Xck`bZ'YhWŁ

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%`8]gW`gg'hY'dcgg]V`]hmicZUb`YI`hYbg]cb`k`]h'mci`f'gi`dYfj`]gcf`Zfgh"
&"`F`Yei`Ygh`WUb`h`Yb`VY`cX[`YX`Vm'hY`'ghi`XYbh`YfY` \hdl.##]bmi`f`Wca`#m&hdnj."`H\Y`'gi`dYfj`]gcf`k`]'
  h`Yb`fYW`]j`Y`Ub`Ya`U`]Ug_]b[`h`Ya`'rc`Uddfc]`Yz`VY`Zcf`]'h]g`YgWU`UH`X`'rc`h`Y`XYW]g]cb`d`Ub`Y""
'`" `F`Yei`Ygh`a`i`ghVY`cX[`YX`Vm`K`YY`_*`cZ'h`fa`"
(" `DUbY`'XYW]g]cb`k`]'`VY`'a` UXY`Vm`Yb`X`c`Zk`YY`_`+"
)"`H\Y`XYW]g]cb`k`]'`VY`'a` UXY`Vm`U`d`Ub`Y`-'`Wcbg]gh]b[`'cZ'h`Y`<`cG`f`b`f`h`Y]f`bca`]b`YYŁ`Z`H\Yg]g`
  7`ccfX]b`Urc`fz`Ub`X`%`c`h`Y`f`d`Y`fg`cb`"
*"`G`h`XYbng`g`l`ci`'X`VY`U`Y`f`f`X`'rc`h`Y`Z`U`W`h`h`U`h`h`]g`]g`b`ch[`i`U`f`U`b`h`Y`X`Z`Ub`X`'h`i`g`g`l`ci`'X`b`ch`f`Y`m`cb`
  [`Y`h]b[`'Ub`'YI`h`Ybg]cb`"
+`" `Hmł]WU`nZ`YI`h`Ybg]cbg`U`fY`[`f`Ub`h`X`I`D`'HC`" `k`YY`_g`" `H\Y`'Yb[`h`'cZ`h`Y`YI`h`Ybg]cb`b`YYXg`'rc`VY`
  f`Yei`Y`gh`X`Ub`X`'g`h]Z`YX`Vm`h`Y`'gi`d`Y`fj`]gcf`"DUbY`'k`]'`XYW]XY`h`Y`'Yb[`h`'cZ`h`a`Y`[`f`Ub`h`X`"
" `

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DfcWXi fY]Zmci`ZU]`H\Yg]g'5ž6`cf'7

: U]`]b`H\Yg]g'5`f]bHf]a`fYdcfha`Uf_`O)`\$i`Ł`-`a`i`ghfY!Ybfc`]'b`H\Yg]g'5`U[`U]b`"

: U]`]b`H\Yg]g'6`fgYa`]bUf`a`Uf_`O)`\$i`Ł`-`a`i`ghfY!Ybfc`]'b`H\Yg]g'6`U[`U]b`"

: U]`]b`H\Yg]g'7`-`Gh`XYbng` \Uj`Y`h`f`Y`c`d`h]cbg`"

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%`fY!Ybfc`'Zcf`H\Yg]g'5ž6`UbX`7`U[`U]bžbYk`dfc`YWh`UbX`'gi`dYfj`]gcf`
&"`fY!Ybfc`'Zcf`H\Yg]g'7`U[`U]bžgUa`Y`dfc`YWh`'b`YYXg`Wcbg`Ybhc`Z`Ub`Uddfcdf]U]h`'gi`dYfj`]gcf`/`'gh`XYbh`
'`" `G`h`XYbh`Xc`Yg`Z`f`h`Y`f`k`c`f`ž`fY!`gi`Va`]hg`h`Yg]g`U`Z`f`U`'a`U`l`c`Z`*`k`YY`_g`"5`agŁ`Wa`Uf_`WUdd`YX`U`h`
)`$i`" `z`gh`'b`ch`g`U`h]g`Z`U`W`c`f`mž`h`Yb`b`YYXg`'rc`fY!Ybfc`"

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H\]g`Ughicd]cb`]g`cb`mUj`U]UV`Y`]Z`h`Y`c`f][`]bU`'a`Uf_`k`Ug`(`\$ZCF`]Z`h`Y`'gh`XYbh]g`]b`h`Y]f`UghigYa`YghYf`VY`ZcfY`[`fUXi`U]h]cb`fY[`UfX`Ygg`cZ`h`Y`c`f][`]bU`'a`Uf_`Ł`"

: U]`]b`H\Yg]g'6`/`7`fk` \Yb`hU`Yb`g]a`i`hU`b`Yci`g`nŁ`-`Gh`XYbng`a`i`ghfY!Ybfc`]'b`H\Yg]g'6`U[`U]bž`UbX`WUbbch`WcbW`fYbhm`Ybfc`]'b`7`" `H\Ym`WUb`h`Yb`hU`_`Y`H\Yg]g'7`k` \Yb`H\Yg]g'6` \Ug`VY`Yb`g`U]h]g`Z`U`W`c`f]m`Wca`d`Y`h`X`"

ŁXi ghfmH\YgYg

K`Y`Yb`Wci`fU[`Y`'gh`XYbng`'rc`g`YY`_d`U`f`b`Y`f`g` \]dg`k`]h`]'b`Xi`ghf`mž`gc`'gh`XYbng`WUb` \Uj`Y`U`Wc`!`gi`dYfj`]gcf`Z`ca`"

]bXi gfm' <ck Yj Yfz]ZWbZXYbhU]hm]g'fYei]fYXž'U'WbZXYbhU'X]gWcgi fY'U[fYYa Ybhf7 8 5Ł']g'cV'][Uhc fm'

Gi Va]gg]cb'cZ5ggYgga YbhiHUg_g

@UVcfUhcfmfYdcfhg'UbX'a U'cf'Ugg][ba Ybht'k]''fYei]fY'U' [Bcb'D'U\[\]Uflga '8YWUfUhc'7cj Yf'G\YYH'](#)

5gg][ba Ybht'g\ci 'X'VY'gi Va]hY'X'cb'hja Y''5'XU]mdYbU'hmcZ) i 'cZhY'a Uf_g'Uj U]UV'Y'Zcf'hUh
Ugg][ba Ybhk]''Udd'mZcf'k cf_'fYW'j YX'UZf'hY'Xi Y'XUH''5bmiUgg][ba Ybhia cfY'hUb') 'XUmg''UH'k]''bch
VY'UWV'dh'X''H\Y'cb'mYI Ya dh]cb'k]''VY'k \Yb'df]cf'dYfa]gg]cb'Zcf''UH'gi Va]gg]cb'\Ug'VYYb'[fUbh'X'Vm
hY'7ci fgY'W'cfX]bUhc'f''9I hYbg]cbg'k]''VY'[fUbh'X'cb'mcb'a YX]WJ''cf'W'ca dUgg]cbUH'[fci bXg'i bXYf
YI hfYa Y'W'fW'a ghUb'W'g''

5 WUXYa]W< cbYgmiUbX`D`U[]Uf]ga

D@5; =F ≠GA

6Yk UFY`5b`Ugg][ba YbhUUh]bWi XYg`d`U[]Uf]gYX`a UHYf]U`k]`fYW]j Y`U`\$i : U]žUbX`gh XYbhtg`k \c
d`U[]Uf]gY`a UmZ]`hY`Wti fgY`Gh XYbhtg`k \c`d`U[]Uf]gY`k]`\Uj Y`hY]f`bUa Yg`YbHYfYX`cb`U`d`U[]Uf]ga
fY[]ghYf`UbX`k]`VY`]UV`Y`hc`X]gW]d`]bUfmiUW]cbž]bWi`X]b[`YI`Wi`g]cb`Zca`Ybfc`a`Ybh`
#]g`YI`dYWYX`hUUhU`gh XYbhtg`a`i`ghUUhU`h]a`Yg`gi`Va`]hY]f`ck`b`k`cf`_`Zcf`UggYgga`Ybh`Gi`Va`]h]b[`hY
k`cf`_`cf`]XYUg`cZgca`YcbY`Y`gY`k`]h]ci`hWYUfmiUW_bck`YX[]b[`hY`gci`fW`cZVcffck`YX`a`UHYf]U`cf`]XYUg`]g
d`U[]Uf]ga "

5WUXYa]WbZcfa Uh]cb

7CI FG9'9J5@! 5H€B'5B8'89J9@CDA 9BH

Gh XYbhZYXVUW_\Ug\YdYX'hc'g\UdY'UbX'XYj Y'cd'h\]g'Wci fgYz]bWi X]b['ZYXVUW_cVHU]bYX'Zca'cb!
]bY'Yj U'i Uh]cbg'Ug'dUfhcZI BGK 'g'Ug'dUfhcZI BGK 'g'a m9I dYf]YbW'dfcWgg"Mc i 'UfY'\][\`m
YbWci fU[YX'hc'Wca d'YH'gi W\ Ub'cb!]bY'Yj U'i Uh]cb'hck UfX'hY'YbX'cZHYfa "': YYXVUW_UbX'gi [[Ygh]cbg
dfcj]YX'k]"VY'ja dcfhUbh]b]ja dfcj]b['hY'Wci fgY'Zf'Z hi fY'gh XYbtg"

85H9G'HC' BCH9

FYZf'hc'A m BGK 'Zcf'a dcfhUbh8UH'gžUj U]UV'Y'Uh