

# 7ci fgY<sup>\*</sup>Cj Yfj ]Yk

## GHJZZ:7cbHJWhi8YHJ]`g

## 7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`]lm	@cWJhjcb	D\cbY
GcbmU`@]ZgVX\]m	0 2 0 3	VmYa U]` Uddc]bha Ybh	K %\$(	

## GWXcc`7cbHJWhi±bZcfa Uhjcb

GWLcc``cZhLY`5fhg`UbX`AYX]U

Fcca " ‰ž@Yj Y`" žFcVYfhK YVghYf'6i ]`X]b[ fj %(Ł

D\cbY.`f\$&Ł'-',) '(,)\*

9a U]`. 'gUa 4 i bgk "YXi "Ui

**9**/aal **¼**. i 9a '±bcc``7 cbHJWf±b7cfa

# 7ci fgY 8YW] g

7 fYX]hDc]bhg'('

Gi a a UfmcZh\Y 7 ci fgY

BchY.

### 5ggYgga Ybh

### 5ggYgga YbhHUg\_g

5ggYgga Ybh'hJg_	K Y][ \h	8i Y'8UHY	Gh XYbh@YUfb]b[ CihWca Yg 5ggYggYX
DfUWjWU``YI Ua ]bUhjcb'	' \$1		%ž <sup>*</sup> &
DYfZcfa UbW\#dfYgYbHJhjcb	')	K YY_g <sup>-</sup> , !%\$	%ž <sup>*</sup> &
A UghYfWUgg'Wf]h]ei Yg'	%) ।	% #\$( #&\$&%`%% \$\$`DA	ı
9bgYa V`Y`Wcblf]Vi lijcbž dYfZcfa UbWYgždUfhW.YW_]b[ liYgh	&\$I	Bch5dd`]WUV`Y	(

### 5ggYgga Ybh'8YhJ]`g

5ggYgga Ybh'% DfUWh]WU`Yl Ua ]bUh]cb

GhUfhXUhY. Bch5dd`]WUV`Y

@Yb[h\.'%]!&\$ a ]bi hYq

#### 8 YW] g.

 $H\Y'YI\ Ua\ ]bUh]cb'cZdYfZcfa\ UbWY\Ug'lk\ c'fY`UhYX'dUffg''':\ cf']bghfi\ a\ YbhU``UbX'j\ cWU``ghi\ XYbhg'%) \ --- \&\$ a\ ]bi\ hYg'cZWcbWYfhfYdYffc]fY'k\ ]```VY'dYfZcfa\ YX']b'`U'gYa\ ]!Zcfa\ U``WcbWYfhYbj\ ]fcba\ YbhUhh\Y'YbX'cZH& f&& \L''`5hh\Y'YbX'cZH'\ \z''ghi\ XYbhg'k\ ]```VY'YI\ Ua\ ]bYX'cb'\HYW\b]\WD``fYdYffc]fY'\UbX'g][\\h'fYUX]b[\ 'Uddfcdf]UhYhc'\h\Y]f']bghfi\ a\ YbhU``cf'j\ cWU``gdYW]U`]gUh]cb'fJ\ \L'''7\ ca\ dcg]h]cb'ghi\ XYbhg'k\ ]``'dfYgYbh'k\ c'dcfhZc`]cg'cZ\ k\ cf_\'''XYZfqhUhh\Y'YbX'cZH&/h\Y'gYWcbX'Uhh\Y'YbX'cZH'\ ''$ 

: YYXVUW\_, K f]hh/b fYdcfhcb dfUW]wU`YI Ua 'UbX'Wca dcg]hjcb dcfh7c`]c"

#### 5XX]h]cbU`XYhU]`g.

Gi Va ]gg]cb bch/g. @j Y DYf7cfa UbW/k ]h\ F YWcfXYX 7 ca dcbYbhg

B WcXad\_S`UWbcWeW fSf[a`ek]``VY`WcbXi WYX`Xi f]b[ 'kcf\_g\cd'gYgg]cbg']b'H%'UbX'H&"'' ≠bglfi a YbHu`]glfg UbX'j cWU`]glfg'k]``'dYfZcfa 'cbY'Wcad'YHY']HYa']b'YUWX'HYfazik\]WX'a UmVY'U'acj Ya YbhcZU``Uf[Yf'kcf\_/WcadcgYfgz'g]a]`Uf`mz'k]``'dfYgYbhih\Y'dYfZcfa UbW'cZcbY']HYa'cf'acj Ya Ybh'''

: YYXVUW. "k f]hhyb fydcfhq

#### 5XX]hcbU`XYHJ]`q.

H\]g`k]```VY`U`%\$!a]bi hY``YWi fY!fYWjhU``dfYgYbhUhjcbžWcadf]g]b[`DckYfDc]bhcf`df]bhYX`bchYgž'j YfVU` dfYgYbhUhjcb`g]h Uhjb[`h\Y`kcf\_fgŁ'dYfZcfaYX`k]h\]b`]hg`\]ghcf]WU`ž'W``h fU`ž'aig]WU``cf`UYgh\YhjWWcbhYlhž UbX`h\Y`dYfZcfaUbW\`cZh\Y`kcf\_]hg\Z'

Gi Va ]gg]cb bch/g. @j Y Df/g/bh/h]cb UbX DYf/cfa UbW

Hi fb]hb gYhb[. H\]g ]g bchU Hi fb]hb Ugg][ ba Ybh

5ggYgga Ybh' . A UghYfWUgg Wf]h]ei Yg

@Yb[h\.')\$\$ k cfXg Zcf YUW Wf]hjei Y

8YHJ]`g.

5 d[f[cgWek]```VY`giVa]hhYX`UWfcgg`H%z`H&`UbX`H' "``H\YgY`k]```VY`fY`UhYX`hc`a UghYfWUggYg`dfYgYbhYX`Vm j ]g]h]b[ 'YI dYfhg`]b`U`fUb[ Y`cZaig]WU`ghm`Yg`UbX`UWf]j ]h]Yg"``7 f]h]eiY`eiYgh]cbg`k]```VY`gWUZc`XYX`hc YbWcifU[ Y`ghiXYbhg`hc`]XYbh]Zm`]ggiYg`Zcf`X]gWigg]cbz`UbX`hc`XfUk``]b\_g`Uacb[ 'dYfZcfaUbW'Y`YaYbhg UbX`g\W.c`Uf`m`]hYfUhifY"```

#### 5XX]h]cbU`XYhU]`g.

 $: cfWfg']b'Aig]WAUghffWUgg'GYf]Yg'k]``VY'dfYgYbhYX``]jY'cf'cb`]bY'fH67Łcb': f]XUmg']b'KYY\_g'\%z')'UbX-'''$ 

Gi Va ]gg]cb bchYg. K f]hhYb 5gg][ ba Ybh

Hi fb]hjb gYhjb[. H\]g ]g bchU Hi fb]hjb Ugg][ ba Ybh

5ggYgga Ybh (. '9bgYa V`Y'Wcblf]Vi h]cbždYfZcfa UbWgždUfhWXYW\_]b[ 'hYgh

GhUfhXUhY. Bch5dd`]WUV`Y

8YW]`q.

8]fYWhZYXVUW\_Xi f]b[ 'fY\YUfgU'g'UbX'k cf\_g\cdg'UbX'U'Zcfa U`'fYdcfh'Uhh\Y'WcbWi g]cb'cZh\Y'gYgg]cb" Gh XYbhgfWcbhf]Vi h]cb'hc'YbgYa V'Y'dYfZcfa UbW'g'UbX'k cf\_g\cdg'k ]``'VY'UggYggYX'h\fci [\'U'dUfh W\YW\_]b[ 'YI Ua ]bUh]cb"

7`eW\_T^WbSdfZUZWU][`Yk]``VY`i bXYffU\_Yb`]b`H%z`H&`UbX`H' "`±bX]j ]Xi U``mcf`]b`ga U```[fci dgz'ghi XYbhg`k]`` dYfZcfa `k cf\_g'cf`Yl Wfdhg`cZk cf\_gz'ghi X]YX`UbX`dYfZcfa YX`Xi f]b['h\Y'hf]a YghYf"``K\YfY`Uddfcdf]UhYz Yl Wfdhg`k]```VY`gY`YWhYX`Vmh\Y`dUfh!W\YW\_]b['Yl Ua]bYf"

 $\hbox{Gi Va ]} gg] cb "bch \hspace{-0.07cm} \text{Gi Va ]} gg] cb "bch \hspace{-0.07cm} \text{Gi Va ]} b[ "cf"] j \ Y "cf" \hspace{-0.07cm} \text{fYW} \hspace{-0.07cm} \text{fXYX} "dYf \hspace{-0.07cm} \text{fa UbW}$ 

 $\label{eq:higher_high_substitution} \mbox{Hi fb]h]b "gYhh]b[."H\]g"]g"bchU"Hi fb]h]b"Ugg][\ ba\ Ybh$ 


# FYgci fWfg

### DfYgWf]VYX F Ygci fWYg

% 9j Yfmh]b[ ']g'7cbbYWhYX.'H\Y'Dck Yf'cZA i g]WVm8Ub]Y` 6UfYbVc]a

&"`A chjcbž'9a chjcbž'UbX'@cj Y. `H\Y'B Uhi fY'cZ5fhjghjWDYfZcfa UbWY'Vm'H\ca Ug'7 Ufgcb'A Uf\_

' "'@YhnYfg'hc'U'Mcib['DcYhVmFU]bYf'F]`\_Y

### FYWca a YbXYX FYgci fWYg

7ci fgY 9j U`i Uh]cb UbX 8Yj Y`cda Ybh

DYfZcfa UbWY`ghi XYbhg`\Uj Y`Yl dfYggYX`h\Y`bYYX`Zcf`a cfY`di V`]WdYfZcfa UbWY`cddcfhi b]h]Ygž'UbX Wca dcg]h]cb`ghi XYbhg`\Uj Y`Ug\_

### Gi Va ]gg]cb cZ5ggYgga YbhHUg\_g

### Hi fb]h]b Gi Va ]gg]cb

Image: Ybwei bhyfu'dfcv'ya k \yb'uhhya dhjb[ 'hc'gi va ]hmci f'Ugg][ ba Ybhh\fci [ \ 'Hi fb]h]bž'd'YUgY

Hy'Yd\cby'9| hy'fbu''Gi ddcfhcb'-', ) '' ' ' %cf'Ya U]''h\Ya 'cb'Y! hy'fbu'hy'hgi ddcfh4 i bgk "YXi "Ui "''Gi ddcfh
\ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY\_XUmg'UbX'-.\$\$Ua '-').\$\$da 'cb'k YY\_YbXg'fl \*) 'XUmg'U'mYUft'''=Z'mci
UfY'i bUV'Y'hc'gi va ]hmci f'Ugg][ ba YbhXi Y'hc'U'ZJi 'hk ]h\ 'Hi fb]h]b'mci 'a Um'Udd'mZcf'Ub'Y! hy'bg]cbž'Vi hmci
a i ghfYhJ]b'mci f'h]W\_Yhbi a VYf'Zfca '9! hy'fbU''Gi ddcfhfU'cb[ 'k ]h\ 'Ubmch\Yf'fy'Yj UbhXcW a Ybhgt'hc
]bWi XY'Ug'Yj ]XYbW' hc'gi ddcfhmci f'Y! hy'bg]cb'Udd']WUh]cb"'=Zmci 'Ya U]''9! hy'fbU''Gi ddcfhmci 'k ]'`
Ui hca Uh]WJ'`mfYW']j Y'U'h]W\_Yhbi a VYfZ'Vi h]Zmci 'hY'Yd\cbY'mci 'k ]``bYYX'hc'gdYW]Z]WJ'`mUg\_'Zcf'cbY''
Hi fb]h]b'U'gc'dfcj ]XYg'i dXUhy'g'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hyf''

; YbYfU`mž'UggYgga YbhiHug\_g'a i ghVY'gi Va ]hhYX'Y`YVWfcb]\WJ``mij ]U'Y]h\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ ba Ybh''=b']bgHJb\W'g'k \YfY'h\]g']g'bchdcgg]V`Yž']hk ]```VY'gHJhYX'cb'mci f'\\circ i fgY'g'A ccX`Y'g]hY'k ]h\U`hYfbUh]j Y'gi Va ]gg]cb'XYHJ]`g"

cfi]bZcfa Uhjcbicbi\ckihcigi Va ]hUgg][ ba Ybhgicbi]bYij ]UiA ccXiY.i\hdg.#gh XYbhi bgk "YXi "Ui #\ck! gi Va ]hUgg][ ba Ybha ccXiY

# 5 WUXYa ]W<cbYghmUbX D`U[]Uf]ga

D`U[]Uf]ga `]g`i g]b[ 'h\Y`k cfXg`cf`]XYUg`cZch\Yfg`UbX`dfYgYbh]b[ 'h\Ya `Ug`mci f`ck b"`±hWJb`hU\_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b[ 'hc`UWW]XYbhJ``mWcdm]b[ 'Zfca `U`gci fWY`k ]h\ci hUW\_bck `YX[ Ya Ybh'

IBGK [fcidg'd'U[]Uf]ga ]bhc'h\Y'Zc``ck]b[ 'WUhY[cf]Yg.

 $7 \text{ cdm}b[...i g]b[...h\Y.gUa Y.cf.j Yfmig]a] \Uf'k cfXg'hc'h\Y.cf][]bU''hYl h'cf']XYU'k]h\ci h'U\V_bck `YX[]b[...h\Y.cf][]bU''hYl h'cf']XYU'k]h'cf']$ 

# 5 WUXYa ]W + Zcfa Uh]cb

: cf `YggYbh]U``gh XYbh]bZcfa Uh]cb `fY`Uh]b[ `hc.



fYei YghgʻZcfʻYl hYbg]cb/
`UhYʻgi Va ]gg]cbgʻ[ i ]XY`]bYg/
fYi WhicZo Uf g/