

**CRIM2038** 

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

## 'GhUZZ'7cbhUWh'8YhU]`g'

## '7cbj Ybcfg'

BUa Y	9a U]`	5j U]`UV]`]m	@cWJhjcb	D\cbY
< ck UfX GYfWca VY	\"gYfWca VY4 i bgk "YXi "Ui	Hi YgXUmg"!(""\$"	, I	\$(\$&\$-'%\$*
	g g	CfVmUddc]bha Ybh		

### GWXcc``7cbHJWhʻ±bZcfa Uh]cb

GWXcc``cZGcWJU``GWJYbWYg

Fcca '%) -

A cfj Yb 6fck b 7 &\$

Ya U]`. 'gcgg4 i bgk "YXi "Ui

d\cbY. '\$&'-',) '% \$+

# 7ci fgY<sup>-</sup>8YHJ]`g

7 fYX]h'Dc]bhg'\*

Gi a a UfmcZh\Y'7ci fgY

GiVYWh5fYU. 5d\_[`a^aYk

 $+ b^*h^* ]g^*W^* i fgY^*m^* i k^* ]^* [U]b^*U^*W^* ]h^!WU^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i c^* j YX^*]b^*Ubh^!gcW]U^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b^* i bXYfgHUbX]b[^*cZ\ck^*m^* i b[^*dYcd^*Y^*VYW^* a Y^*]b] i bXYfgHUbX]b[^*cZ\ck^*m^* i$ 

## 5ggYgga Ybh

± ih ]g Wti fgY mci 'UfY YI dYWY X 'hc 'UfHY bX 'Uh 'Y Ugh', \$i 'cZhi hcf]U'g 'f]bWi X]b['cb`]bY 'hi hcf]U'gŁ" 'H\]g a Y Ubg h\Uhmci a i gh'UfHY bX '%\$#&cZhi hcf]U`g" '= mci 'UfHY bX 'Ygg 'h\Ub', \$i 'cZhi hcf]U`gžmci 'a UmVY 'fY Z gYX 'Z]bU` UggYgga Ybh' 'H\]g 'a Y Ubg 'h\Uh]Zmci 'Xc 'bch'UfHY bX 'Uh 'Y Ugh', \$i 'cZdcgg]V 'Y 'hi hcf]U`gžmci f'Z]bU` Ugg][ ba Y bha UmfYWV]j Y 'U'a Uf\_'cZnYfc": cf'h\Y'di fdcgY 'cZUfHY bXUbW' a cb]hcf]b['z'h\Y'Z]bU` UggYgga Y bh Zcf'h\]g 'Wti fgY ']g 'h\Y'fYgYUfW. 'YggUmk cfh\') \$i 'cZmci f'cj Y fU``[ fUXY 'Zcf'h\]g 'Wti fgY" 'H\]g ']g 'h\Y UfgYgga Y bh']h\a 'h\Uhk]``VY'[ fUXY X 'UhnYfc']Zmci 'Xc' bcha YYhih\Y'Ufh\bXUbW' 'fYei ]fYa Y bh'Zcf'h\]g \Wti fgY"

### 5ggYgga Ybh'HUg\_g'

5ggYgga Ybh'tUg_	K Y][ \h	8iY'8UHY	Gh XYbh@YUfb]b[ Ci hWca Ygʻ5ggYggYX
5bbctUtYX'6]V`]c[fUd\mi	&) ı	%) #%\$#&\$% `%%)) `DA	% <u>*</u> (
; fci d'DfYgYblUljcb'	&) ı	%#%#&\$%	&ž ž) ž*
F YgYUfVX '9ggUm'	) \$1	&) #%#&\$% `%%) - `DA	%ž&ž ž*

5ggYgga Ybh'8YHJ]`g

UbX'dfcj ]XY'Yj ]XYbW!VUgYX'fYWca a YbXUljcbg'Zcf'h\Y'dfYj Ybljcb'cZUbX']blYfj Ybljcb'k ]t\ 'mci t\ 'Uhf]g\_'cZUbljgcWjU``VY\Uj ]ci f'UbX'cZYbX]b[ "'K f]thYb'ZYYXVUW\_'U[ U]bghXYlU]`YX'a Uf\_]b[ 'fi Vf]Wdfcj ]XYX'l\fci [ \ A ccXY'f&) \$\$'k cfXgŁ"'H\]g'lUg\_'k ]``VY'h\Y'Z]bU``UggYgga YbhZcf'h\Y'Wci fgY"

### 5 http://bxubww.F.Yei ]fYa Ybhg

 $\label{eq:continuity} D`YUgY`bchY`h\Uh`YWh fY`fYWcfX]b[g`UfY`bchUj U]`UV`Y`Zcf`h\]g`Wci fgY"`Ghi XYbhg`UfY`ghfcb[`miYbWci fU[YX`hc UhhYbX`U```WUggYg`UbX`WcbhUWhh\Y`7ci fgY`5i h\cf]mnhc`a U_Y`U`hYfbUh]j Y`UffUb[Ya Ybhg`Zcf`WUggYg a ]ggYX"$ 

## 7 ci fgY GWX YXi `Y

#### J ]Yk 'WUgg'ha YHJV'Y

#### H]a YHJV`Y

8UhY	Hmd Y	7 cbhYbh		
K YY_'%''%*'GYdhYa VYf'! &\$'GYdhYa VYf	@YWi fY	H\Y`WYbIfU``dfcV`YaUIjW`I\Y`U[Y#W]aY`WfjY Ai`Ijd`Y`Yd]ghYac`c[]Yg`UbX`kcf_]b[`UWfcgg X]gW]d`]bYg"``H\Y`dfcV`Ya`cZU[YbWh'		
	Hi hcf]U`	±blfcXi Wjcbg. dUffjWjdUblgžh\Y'i b]lhžUggYgga Yblnž Yl dYWfUljcbgžcVYWjj Yg"		
K YY_"&."&" "GYdhYa VYf"!	@YWhi fY	DfcV`Ya UhjgUhjcbg. mci h\žfjg_žWfja Y"		
&+ GYdhYa VYf	Hi hcf]U`	F ]g_`VUgYX`UggYgga Ybh ; fci d`Zcfa Uh]cb		
K YY_" ." \$"GYdHYa VYf"! ("C WhcVYf	@YWi fY	H\Y`bYi fcgWJYbWY`cZUXc`YgWYbWY`UbX`f]g [YbYhJWgžYd][YbYhJWg`UbX`XYj Y`cda YbHU` bYi fcgWJYbWY		
	Hi hcf]U`	f#? 'Yd][ YbYh]WghfUhY[ ]Yg		
	C b`]bY'5WMjj]hm	BdWY`S`UkS`V[`XS`Uk		
K YY_'(.'+'C WcVYf'!''	@YWnifY	A YbW``\YU`h\`UbX`gi VgWbW'i gY		
CWhcVYf	Hi hcf]U`	K cf_]b[ 'k ]h\ 'dYfgcbU']hmX]gcfXYfg		
K_YY_^).^%( ^C WhcVYf^!^%	@YWhi fY	H\Y`dfcV`Ya UhjWZJa j`m		
CWcVYf	Hi hcf]U`	H\Y`WcghcZ]bhYfjYbh]cbz`UbX`h\Y`WcghcZbch ]bhYfjYb]b[		
	5ggYgga Ybh	5gg][ ba Ybh %Xi Y k YY_ ) . A cbXUm%( C WcVYf %) - da		
K YY_'*.'&%'CWhcVYf'!'&)	@YWhifY	7\]XaUhfYUhaYbh		
C Whc VY f	Hi hcf]U`	: 5G8		
K YY_"+."&, "C WhcVYf"!"%	@YWhi fY	H\Y`Wcaaib]mm`UfYUg`cZai`hjd`Y`XYdf]jUhjcb		
Bcj Ya VYf	Hi hcf]U`	Dc`]Mjb[ ']b'UfYUg'cZa i `hjd`Y'XYdf]j Uhjcb		
K YY_', . '( 'Bcj Ya VYf'!',	@YWn fY	DYYfg'UbX'gWkcc`		
Bcj Ya VYf	Hi hcf]U`	; Ub[g		
K YY_''%'Bcj Ya VYf'! % Bcj Ya VYf	@YWhifY	7 f]a ]bU`]gUh]cbg. `Xfi [gž'Ubh]!gcW]U``VY\Uj ]ci fž gYl i U`]h]Yg		
	Hi hcf]U`	K \Uhk ci `X'\UddYb']Zk Y'XYWf]a ]bU`]gYX'Xfi [ g3		
	5ggYgga Ybh	; fci d'Ugg][ ba YbhXi Y'A cbXUmBcj Ya VYf'%. %) - da		
K YY_"%\$."%	@YVVi fY	Mci h\žh\Y`a YX]U`UbX`Wf]a Y		
K YY_'‱'&) 'Bcj Ya VYf'!	5ggYgga Ybh	F YgYUfVX '5gg][ ba Ybh' 'Xi Y'A cbXUmBcj Ya VYf		

- ; c`Xgcb`6`UbX`A i bW]Y`>`f&\$\$\*Ł'Mci l\\ž'7f]a Y`UbX`>i gh]WY.`7f]h]WU``=ggi Yg`@cbXcb.`GU[Y
- ; ccXk ]bžJ "'UbX'6"'8Uj ]g'f&\$%\L''`~7f]a Y'ZJa ]`]Yg.'; YbXYf'UbX'h\Y']bhYf[ YbYfUh]cbU``hfUbgZYf'cZWf]a ]bU` hYbXYbW]Yg"<u>"'HfYbXg'UbX']ggi Yg']b'Wf]a Y'UbX'Wf]a ]bU``^ ghJWY' (%("</u>
- <ca Y`z`F "'@]bWc`b`UbX`6"'<YfX`fl% - \text{L""F ]g\_\_UbX`fYg]`]YbWf. '7 f]a Y`UbX`j ]c`YbWf`dfYj Ybh]cb`]b
  5Vcf][ ]bU``Wca a i b]h]Yg""\(\frac{5i ghfU`]Ub\' BYk \(\frac{NYU`UbX\'>ci fbU\`c\z'7 f]a \(\frac{1}{27}\)f]a \(\frac{1}{20}\)cc[ m' \(\text{&f}\)\(\te
- =fj]bYž'H"`A Ui bXYfgž'8"`UbX'G\Yff]b[hcbž'; "'fl%-) Ł'KagfZ [` 3gefc\$'[S, ba'[Ukł SV\_ [` [efc\$f[a` S` V ba'[f[Ueł A Y`Vci fbYž'A UWA ]``Ub'9Xi WUh]cb"
- @UbWfDfzB"f&\$%) L"7\UdhYfx)..8Yj Y`cda YbhcZ5bfjgcWjU`6Y\Uj ]cf"]b'5Xc`YgWbh; ]fg"'H\Y XYj Y`cda YbhcZWfja ]bU`'UbX'UbfjgcWjU`'VY\Uj ]cf"'>"A cf]nchUbX'@"'? UnYa ]Ub"'@cbXcbz Gdf]b[Yf." --!(%&"
- A UghYbž'5"'G"'UbX'>"'8"'7cUhgkcfh\`f%-, Ł"'~H\Y`XYjY`cdaYbhcZVcadYhYbWY']b`ZUjcfUV`Y`UbX i bZUjcfUV`Y`Ybj]fcbaYbhg.'@Yggcbg`Zfca`fYgYUfW\`cb`gi WWYggZ\``V\\]`XfYb""'<u>5aYf]WUb`dgmW\c`c[]gh`)'</u>f&Ł&\$)"
- A i bWJY'>'f&\$\$( Ł'K agfZ S` V 5 d\_ W'3 5 df[US^;` fca VgUf[a` &bX'9X'@cbXcb.'GU[ Y'
- B]`Ubž`D""`FcVYffUž`>"/; Yfacj`ž`>"`f&\$\$+Ł`3gefc\$´[\$`KagfZ, eaU[\$^\$`V Ug´fgc\$^[eegWež`AY`VcifbYž DYUfgcb"
- Ca U\_1^D\_f&\$\$' \L'D W\eba` V[` Y fa KagfZ 5 d[\_ W < Uk \_]\bg^DfYgg^@Y]\W\\UfXh
- DUfX]b]ž8"žF"K U``Yf'UbX'G"K "'<Uk Yg'f&\$%) Ł"'7\UdhYf'% .: Ua ]`]U`` ♣DZi YbWYg'cb'h\Y'8Yj Y`cda YbhcZ GYf]ci g'7cbXi WhDfcV`Ya g'UbX'8Y`]bei YbWrl'H\Y'XYj Y`cda YbhcZWf]a ]bU``UbX'UbhJgcWJU``VY\Uj ]cf"'>" A cf]nchUbX'@''? UnYa ]Ub"'@cbXcbž'Gdf]b[ Yf. '%\* +!% \$"
- D]ei Yfcž'5"'F "ž'K "'; "'>Ybb]b[gž'6"'8]Ua cbXž'8"'D"': Uff]b[hcbž'F "'9"'HfYa V`Umž'6"'7" K Y`g\`UbX'>"'A "'F"; cbnU`Yn`f&\$%\*\!''~5`a YhU!UbU`mg]g`i dXUhY`cb`h\Y`YZZYWfg`cZYUf`m`ZJa]`m#dUfYbh'hfU]b]b[`dfc[fUa g`cbUbh]gc\\]U``VY\Uj]cf`UbX`XY`]bei Yb\\m''~<u>>ci fbU``cZ9I dYf]a YbhU``7 f]a]bc`c[m</u>'\&f&\.\&\-!&(, "
- Dcmbhb[ 'G'UbX'A cf[ Ub'; 'f&\$\$+Ł'A gfcSYWage'? ac\$^BS` [Ue [ '3gefcS4S 57 MF
- GUa dgcbžF"'>"'UbX'G"'K "'F Ui XYbVi g\'f&\$\$\\\"<u>8]gcfXYf']b'i fVUb'bY][\Vcf\ccXg.'8cYg']h'YUX'hc'\\\f\</u>a Y3\\\\ G'8YdUfha YbhcZ>i gh\\\\"CZ>i gh\\\\"Dfc[fUa gzBUh\cbU''=\bgh\hi hY'cZ>i gh\\\\"
- $GUbXYfg\ddot{z}>"`UbX`; \ fU]b[\ Yf\ddot{z}F\ "`f&\$\$'\ L`KagfZ\ <gef[UW, kagdYg[VWfa\ Uabe\ S`V\ Uagdfe\ [`@W'\ EagfZ\ I\ S'Me\check{z}\ GmXbYm`H\Y`:\ YXYfUf]cb`DfYgg"$
- GWX]bX`Yfž<"`G"`UbX`7": "'8"'6`UW\_`f&\$%) {"'7 \ UdHYf`&+.`9Uf`mDfYj YbHjcb`cZ7f]a ]bU``UbX`5bHjgcW]U` 6Y\Uj ]cf.`5`F Yj ]Yk `cZ=bHYfj YbHjcbg`]b`=bZUbWmUbX`7\]`X\ccX"'<u>H\Y`XYj Y`cda YbhcZWf]a ]bU``UbX UbHjqcW]U``VY\Uj ]cf</u>"`>"`A cf]nchUbX`@'`? UnYa ]Ub"`@cbXcbž`Gdf]b[ Yf.`(' ' !((\*"
- Ga]h\žF"'f&\$\$' Ł'KagfZ <gef[UW; VWSeł Ba'{Ukł BoSUf[UW£7 i "ca dhcbžK] "Ub\_

 $\label{eq:hydro} HJVVYhtgžG":UbX`F":>`f&$%) &"`7 \UdhYf`%``DfYbUhU``UbX`DYf]bUhU``: UWcfg`]b'h\Y`8Yj Y`cda YbhcZ DYfg]ghYbh7f]a ]bU`]hm': H\Y`XYj Y`cda YbhcZWf]a ]bU``UbX`UbhJgcWJU``VY\Uj ]cf"'>"`A cf]nchUbX`@"`? UnYa ]Ub" @cbXcbž`Gdf]b[Yf.'%* +!% $"$ 

HfYa V`Umž`F "`9"`f&\$%) Ł"`7\UdhYf'' .`5bh]gcW]U``6Y\Uj ]cf'6YZcfY'h\Y`5[Y-7f]a Y`7i fj Y.`7Ub 8Yj Y`cda YbhU``7f]a ]bc`c[m7cbh]bi Y`hc`-{ bcfY`8Yj Y`cda YbhU``Cf][]bg3'<u>H\Y`XYj Y`cda YbhcZWf]a ]bU`UbX`Ubh]gcW]U``VY\Uj ]cf</u>"`>"`A cf]nchUbX`@'`? UnYa ]Ub"`@cbXcbž`Gdf]b[Yf.'' -!(-"

K ]Xca ž7"'G"'UbX'<"'K ]'gcb'f&\$%)  $E'' = bhYf[YbYfUh]cbU''hfUbga ]gg]cb'cZj ]c'YbWY''<u>J ]c'YbWY''UbX'a YbhU' \YU'h\</u>"'>"'@|bXYfh'UbX'="@Yj Uj ž'Gdf]b[Yf. '&+!()"$ 

.

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

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

### Gi Va |qq|cb cZ5qqYqqa YbhHUq\_q

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

#mci 'YbWci bhYf'U'dfcV'Ya 'k \Yb'UhYa dhJb[ 'rc'gi Va ]hmci f'Ugg][ ba YbhNhfci [ \'Hi fb]hJbž'd'YUgY
hY'Yd\cbY'9I hYfbU'Gi ddcfhcb'-', ) '' ' ' %cfYa U] 'h\Ya 'cb'YI hYfbU'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'f1 \*) 'XUmg'U'mYUft'' #c'ici
UfY'i bUV'Y 'rc'gi Va ]hmci f'Ugg][ ba YbhXi Y 'rc'U'ZJi 'hk ]h\ 'Hi fb]hJb 'mci 'a Um'Udd'mZcf'Ub'YI hYbg]cbž'Vi hmci
a i ghfYhJ]b 'mci f'hJW\_Yhbi a VYf'Zfca '9I hYfbU''Gi ddcfhfU'cb[ 'k ]h\ 'Ubmch\Yf'fY'Yj UbhXcW a Ybhgt'hc
]bWi XY'Ug'Yj ]XYbWY 'rc'gi ddcfhmci f'YI hYbg]cb'Udd']WUhJcb"'#mci 'Ya U]''9I hYfbU''Gi ddcfhmci 'k ]'`
Ui hca UhJWJ'`mfYWY]j Y'U'hJW\_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k ]'``bYYX'hc'gdYWJZJWJ'`mUg\_'Zcf'cbY''
Hi fb]hJb'U'gc'dfcj ]XYg'i dXUhYg'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hYf"

; YbYfU``mž'UggYgga YbhiHug\_g'a i ghVY'gi Va ]hhYX'Y`YVWfcb]\W)``mj ]U'Y]h\Yf'Hi fb]hjb'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`hYfbUhj Y'gi Va ]gg]cb'XYHJ]`g''

cfi]bZcfa Uh]cbicbi\ckihcigi Va ]hUgg][ ba Ybhgicbi]bYij ]UiA ccXiY.i\hdg.#gh XYbh'i bgk "YXi "Ui #\ck! qi Va ]hUgq][ ba Ybha ccXiY

## $5\,WUXYa\,W< cbYghmUbXDU[\,Uf]ga$

D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i=iWUbiHU\_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiWXYUh]b[ihciUWW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hiUW\_bck iYX[Ya Ybh'i

- i bXYfgHUbX'mci f'f][\hg'UbX'fYgdcbg]V]`]h]Yg'Ug'U'gh XYbhUhI BGK
   VY'Uk UfY'cZd`U[]Uf]ga ž'Wcdmf][\hz'I BGK 'Gh XYbh7cXY'cZ7cbXi WhUbX'5VWWdhUV`Y'I gY'cZ IBGK =7 HF Ygci fWrg Dc`]Wh

## 5 WUXYa ]W±bZcfa Uhjcb

: cf`YggYbhJU``gh XYbh]bZcfa UhJcb`fY`UhJb[ 'hc.

- fYei YghgʻZcfʻYl hYbg]cb/`UhYʻgi Va ]gg]cbgʻ[i ]XY`]bYg/
- fYj ]Yk 'cZa Uf\_g/
- I BGK < YU`h\ UbX GUZYmdc`]W]Yg/
- YI Ua ]bUh]cb dfcWXi fYg/