

ARTS1010

H\Y`@]ZY`cZ`K cfXg

7ci fgY[.]Cj Yfj]Yk

7ci fgY 8YW] g

7 fYX]h'Dc]bhg'*

Gi a a UfmcZh\Y 7ci fgY

GIVYWh5fYU.5dWSf[hWI d[f[`Y

H\]g'Wci fgY'k]``YI Ua]bY'h\Y'Zcfa 'cZh\Y'g\cfhighcfm': cW g]b['cb'a cXYfb]ghUbX'WcbhYa dcfUfm YI Ua d'Ygž'h\Y'Wci fgY'k]``YI d'cfY'h\Y'df]bW]d'Yg'h\Uh\Uj Y'g\UdYX'h\Y'XYj Y`cda YbhcZh\]g'Zcfa "'K Y'a Um Wcbg]XYfž'Zcf']bgHUbW'ž'h\Y']bZi YbW'cZ7\Y_\cj 'UbX'\]g'UXj cWUwncZh\Y'ghcfmUg'U'''g']W'cZ^]ZY'''ž'9X[Uf 5``Yb'DcYfg'UYgh\Yh\Wh\Ycf]Ygž'h\Y'XYj Y`cda YbhcZgffYUa 'cZWcbgW]ci gbYgg']b'fY`Uh]cb'hc'h\Y'g\cfhighcfmzh\Y'i gY'cZYd]d\UbmUbX'UbhJ!Yd]d\UbmUbX'h\Y'Z bWfjcb'cZWca dfYgg]cb"'\dotb'Y\XJ]f]cb'k Y'k]``YI Ua]bY hYW\b]ei Yg'UbX'gffUhY[]Yg'Wfi W]U''hc'h\Y'gi WWYgg'cZh\Y'Zcfa 'UbX'i gYZ ''hc'mci f'XYj Y`cda YbhUg'k f]hYfgž]bWi X]b['dc]bhcZj]Yk ž'bUffUh]j Y'XYg][bž'h\Y'XYj Y`cda YbhcZj c]W''UbX'h\Y'i gY'cZYWcbca mUbX gma Vc`]ga "'\dotb'\Y'\Y'\UhYf'dUfhcZh\Y'Wci fgY'k Y'k]``YI Ua]bY'h\Y']bZi YbW''cZbYk 'hYW\bc`c[mcb'h\Y'g\cfh ghcfmz]bWi X]b['h\Y'fY'Uh]cbg\]d'VYfk YYb'h\Y'g\cfhighcfmUbX'h\Y'\c['UbX'h\Y'fHUbga]gg]cb'cZh\Y'g\cfh ghcfmh\fci [\'h\Y'fY'Uh]cbg\]d'VYfk YYb'h\Y'g\cfhighcfmUbX'h\Y'\c['UbX'h\Y'fHubga]gg]cb'cZh\Y'g\cfh ghcfmh\fci [\'h\Y'fY'Uh]cbg\]d'VYfk YYb'h\Y'g\cfhighcfmUbX'Yj YfmcbY'k]```\Uj Y'h\Y'W\UbW''hc'k cf_g\cd h\Y]f'k f]h]b['YI YfW]gYg'k]``VY'dfcj]XYX'UbX'Yj YfmcbY'k]``\Uj Y'h\Y'W\UbW''hc'k cf_g\cd h\Y]f'k f]h]b['YI YfW]gyg'k]``VY'dfcj]XYX'UbX'Yj YfmcbY'k]``\Uj Y'h\Y'W\UbW''hc'k cf_g\cd h\Y]f'k f]h]b['YI YfW]gyg'k]``VY'dfcj]XYX'UbX'Yj YfmcbY'k]``\Uj Y'h\Y'W\UbW''hc'k cf_g\cd

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7 ci fgY @YUfb]b['Ci hWca Yg

%" I bXYfghUbX h\Y df]a UfmY Ya Ybhg cZg\cfhZ]Whjcb

&" I bXYfgHJbX`U`j Uf]YhmcZ[YbfYg`UbX`Zcfa g`]b`WcbHYa dcfUfm`]HYfUh fY

"8 Ya cbglfUN'ZJa]]Uf]lmk]h\j Uf]Uh]cbg'UbX'Yl dYf]a Ybhg'k]h\]b'h\Y'g\cfhghcfmZcfa

 $("7)YUfmWcadcgYkf]hhYbhYlhgi]b'9b[`]g\$

) " 7 f]h]WU``mUddfU]gY h\Y]f`ck b`k cf_`UbX'h\Y'k cf_`cZch\Yfg

HYUW]b['GhfUhY[]Yg'

@YWn fYg'k]``]bhfcXi WY'ghi XYbhg'hc'U'fUb[Y'cZk f]h]b['dfUWn]WYgža Yh\cXg'UbX'ghmYg"5'df]a UfmU]a 'cZh\Y YWn fYg']g'hc']a dUfh'U'_bck 'YX[Y'cZ\WfUZn!'k\Uhh\W\b]ei Yg'UfY']bj YbhYX'cf'Ya d`cmYX']b'Ubm[]j Yb'd]YW cZ`]hYfUhi fYžk\Uhia U_Yg'h\YgY'hYW\b]ei Yg'YZY\Wf]j Y'UbX'k\mXc'k f]hYfg'gYhhY'cb'h\Y'hYW\b]\W\`XY\N]g]cbg h\Uhih\YmXc3''K\Uhi]g']bj c'j YX']b'h\Y'\WfYUh]j Y'dfc\Wgg'UbX'\ck 'Xc'mci 'Uff]j Y'Uhih\Y'd'U\W'k\YfY'mci '\Wb g\UdY'mci f'ck b'\WfYUh]j Y'bUffUh]j Y3

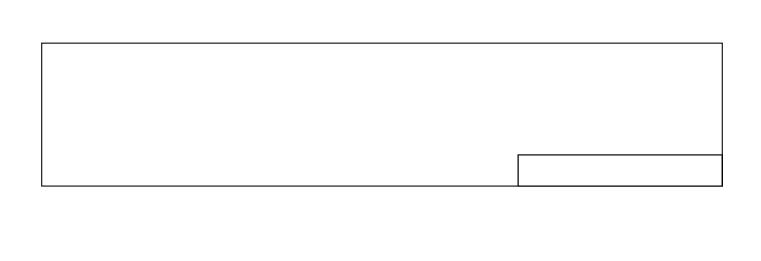
H\Y`gYa]bUfg`k]```dfcj]XY`h\Y`cddcfh b]miZcf`fl\L`Wf]h]WD``X]gW gg]cb`cZgYhHYI hg`UbX`f\L'dYYf`[fci d ZYXVUW_cb`gh XYbhg`ck b`WfYUhj Y`k cf_"`H\Y`gYa]bUf`k]````Uf[Y`mZ bWlcb`Ug`U`WfYUhj Y`k f]h]b[k cf_g\cd`UbX`k]```YbWci fU[Y`]bXYdYbXYbh`YUfb]b[`UbX`Wf]h]WD``fYZYWl]cb`cb`cb'fg`ck b`k f]h]b["'=hk]```U`gc XYj Y`cd`ghi XYbhgfii bXYfghUbX]b[`cZh\Y`dfcWfgg`cZfYj]g]b[ž'YX]h]b[`UbX`dc`]g\]b[`U'd]YWf`cZk cf_"`H\Y gi WWfgg`cZh\Y`k cf_g\cd`XYdYbXg`i dcb`]bX]j]Xi U``Yb[U[Ya Ybhk]h\`h\Y`k YY_`ma UhYf]U`/]hfY`]Yg`cb [fci d``YUfb]b[`UbX`]h]g`YggYbh]U``h\UhYj YfmcbY`UWlj Y`mdUfh]W]dUhY`]b`YUW\ k cf_g\cd"

 $\pm 0.1000 \times 10^{-10} \times 10^{-10}$

H\Y'UddfcUW\'cZ`YWh fYfg`UbX'h hcfg`]b'h\Y'Wti fgY']g'[cjYfbYX`]b'[YbYfU``Vm
•````h\Y]f'ck b']bhY``YWh U``UbX'dUgg]cbUhY'Yb[U[YaYbhk]h\'k f]h]b[

@YWhifYfg`UbX`hihcfg`]b`h\Y`WcifgY`k]```difgiY`h\Y`WcifgY`U]ag`VmXc]b[`gYjYfU``h\]b[g`Uacb[`k\]W\`UfY.

- •·····duffyWdufyb[']b 'UbX'[i]X]b['X]gW gg]cb ']b 'h\Y'h hcf]u 'UbX'k cf_g\cdg
- '''' dfcj]X]b['k f]thYb'Wca a Ybtg'cb'th\Y'k f]thYb'k cf_'mci 'gi Va]h
- """ VY]b["Uj U] UV Y hc "X]gW gg k]h mci h Y Wti fgY UbX mci f gh X]Yg
- ````i q]b['HYVXb]WU`'j cWUVi 'Ufmihc'X]gW/ qq'h\Y'Uqq][bYX'HYI hq
- ''''' Ug_]b['mci 'hc'k cf_']b'ga U``'[fci dg']b'h\Y'`YWi fY!h hcf]U`



GhUfh'XUhY.

@Yb[h\." \$\$\$

8YHJ]`g. "\$\$\$`k cfX`g\cfhighcfmž:]bU``5ggYgga Ybh'`Hi fb]h]b`gi Va]gg]cbžgi a a Uhjj Y`ZYYXVUW_ij]U'hi fb]h]b 5XX]h]cbU``XYHJ]`g.

5ggYgga Ybh7f]hYf]U

.

5 hyb XUb WY F Yei]fYa Ybhg

 \pm 0 "YWhi fYg'mci 'k]\"UWhjj Y\mYb[U[Y'k]h\ WcfY'Wci fgY'WcbhYbh'h\Uh'k]\"\Y\d'mci 'hc'UhhU]b''7@C fig % &.

I bXYfgHJbX h\Y df]a UfmY Ya Ybhg cZg\cfhZWjcb

I bXYfgHJbX U j Uf]YlmcZ[YbfYg UbX Zcfa g]b WcbHYa dcfUfm`]hYfUh fY

 \pm 0 'hi hcf]U'g'mci 'k]``'UWh]j Y`mYb[U[Y'k]h\'WcfY'Wci fgY'WcbhYbh'h\Uhk]``\Y`d'mci 'hc'UhtU]b'7@C fig '!).

8 Ya cbglfUhY ZJa]] Uf]lmik]h\ j Uf]Uh]cbg UbX YI dYf]a Ybhg k]h\]b h\ Y g\ cfhghcfmZcfa

 $7 YUfmWca dcgYkf]hhybhylhgi]bi9b[`]g\$

 $7\,f]h]WU``mUddfU]gY`mcif'ckb'kcf_'UbX'h\Y'kcf_'cZch\Yfg$

.

7ci fgY GWX YXi `Y

J]Yk 'WUqq'Ha YHJV'Y

H]a YHJV`Y

8 UHY	HmdY	7 cbhYbh
K YY_'%'% ': YVfi Ufm'!'&(: YVfi Ufm		D`YUgY`gYY`AccX`Y`Zcf`U`Z\```WcifgY`gWXYXi`Y`UbX fYUX b[q"

FYgci fWyg

DfYgWf]VYX F Ygci fWYg

- Wci fgY ci h]bY
- k YY_`mfYUX]b[g
-]bh/fb/hg]h/g f/Yi Ubh/c h\Y Wci fgY
- Ui X]c 'UbX'j]XYc 'a UhYf]U`

FYWca a YbXYX FYgci fWyg

5 "k YY_mgYhfYUX]b[g'UbX'fY`UhYX'a UhYf]U`'UfY'Uj U]'UV'Y'cb'A ccX'Y

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

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

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

_Zmci YbWci bhYf'U'dfcV`Ya 'k \Yb'UhYa dhJb['hc'gi Va]hmci f'Ugg][ba Ybhh\fci [\ 'Hi fb]hJbž'd`YUgY
hY`Yd\cbY'9| hYfbU``Gi ddcfhcb'-',) '' ' ' %cf'Ya U]`'h\Ya 'cb'Y! 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'fl *) 'XUmg'U'mYUft'' \(\frac{1}{2}\)mci
UfY'i bUV`Y'hc'gi Va]hmci f'Ugg][ba YbhXi Y'hc'U'ZUi 'hk]h\'Hi fb]hJb'mci 'a Um'Udd'mZcf'Ub'Y! hYbg]cbžVi hmci
a i ghfYhU]b'mci f'hJW_Yhbi a VYf'Zfca '9! hYfbU`'Gi ddcfhfU'cb['k]h\'Ubmch\Yf'fY'Yj UbhXcW a Ybhgt'hc
]bWi XY'Ug'Yj]XYbW'hc'gi ddcfhmci f'Y! hYbg]cb'Udd']\(\frac{1}{2}\)mci 'Ya U]`'9! hYfbU`'Gi ddcfhmci 'k]``

5 WUXYa | W < cbYghmUbX D`U[]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 qžZfca iXYi]VYfUhYiW\YUh|b[ihciUVW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hUW_bck iYX[Ya Ybh'i

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

7 cdm]b[.'i g]b['h\Y'gUa Y'cf'j Yfmg]a]`Uf'k cfXg'hc'h\Y'cf][]bU`hYl h'cf']XYU'k]h\ci h'UW_bck `YX[]b['h\Y gci fW'cf'i g]b['ei chUh]cb'a Uf_g"'H\]g'U`gc'Udd`]Yg'hc']a U[Ygž'Ufh'UbX'XYg][b'dfcYWhgž'Ug'k Y``'Ug dfYgYbhUh]cbg'k\YfY'gca YcbY'dfYgYbhg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci h'WfYX]h'

⇒ Uddfcdf]UhY 'dUfUd\fUg]b[...7\Ub[]b['U'ZYk 'k cfXg'UbX'd\fUgYg'k \]'Y 'a cghmfYhJ]b]b['h\Y'cf][]bU` ghfi Wh fY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU'žUbX']bZcfa Uh]cb'k]h\ci hUW_bck `YX[Ya Ybh'H\]g'U`gc Udd`]Yg']b'dfYgYbhUh]cbg'k \YfY'gca YcbY'dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci hWfYX]hUbX'hc d]YW]b['hc[Yh\Yf'ei chYg'UbX'dUfUd\fUgYg']bhc'U'bYk 'k \c`Yžk]h\ci hUddfcdf]UhY'fYZYfYbW]b["

7 c``i g]cb. 'k cf_]b['k]th 'cth Yfg'Vi hidUgg]b['cZZth Y 'k cf_'Ug'U'dYfgcb'g']bX]j]Xi U``k cf_"'7 c``i g]cb'U`gc]bWi XYg'dfcj]X]b['mci f'k cf_'thc'Ubcth Yf'ghi XYbh'VYZcfY'th Y'Xi Y'XUHYZcf'Zcf'th Y'di fdcgY'cZth Ya

- i bXYfgfUbX mci f'f][\hg'UbX'fYgdcbg]V]`]hJYg'Ug'U'gh XYbhUhl BGK
- VY`Uk UfY`cZd`U[]Uf]ga ž`Wcdmf][\hz'l BGK `Gh XYbh7cXY`cZ7cbXi WhUbX`5VWWdhUV`Y`l gY`cZ I BGK `=\forall H`F Ygci f\W\g`Dc`]\m\m
- VY 'Uk UfY 'cZh\Y 'ghUbXUfXg 'cZVY\Uj]ci f'Yl dYWYX 'cZYj YfmcbY ']b 'h\Y 'l BGK 'Wca a i b]hm
- `cWUHY 'gYfj]WYg'UbX `]bZcfa UH]cb'UVci hI BGK 'UbX'I BGK '@]VfUfm

Gca Y'cZh\YgY'UfYUg'k]``VY'ZJa]`]Uf'hc'mci ž'ch\Yfg'k]``VY'bYk"'; U]b]b['U'gc`]X'i bXYfgHJbX]b['cZU``h\YfY`UhYX'UgdYWng'cZ9@+69'k]``\Y`d'mci 'a U_Y'h\Y'a cghicZmci f'ghi X]Yg'UhI BGK "'\\hd.##qi VYWfi |XYg"`]VfUfm'i bqk "YXi "Ui #\`]qY#JVci hY`]qY