

⇒ a a][fU]Y
6Ub_



6Ub_! '5`[Ya Yb

< cb[Uf g

: Y`hi Xc_`j Ybb]`dÅbni_ØÇb`XÉU_`Z]nYhÅgY`bÅ`_Ø3

=fU]Ubg

Dcggc`dfY`Yj UfY`]b`ØUgY`QgYbnU`dU[UfY`~Y`gdYgY`X]
Wta a]gg]cbY3

J fU[Yb`cZYf`dfcj]g]Ygjn]`b`k UbbYf`i` [Y`X`UΔUW]b`Yb`VYdUW`X`UbX

A Ybbm]`U_`ØhgÅ[Y`UbbU_ž`U`bYa`U`gU`%`VUb_ca
U`hca`U`h`%`i`U`gnb`%`ca`3

E i U]`gbc`~Y`gdYgY`X]`Wta a]gg]cbY`gY`dfY`Yj`c`XU`i`bU
VUbW`X]j`YfgU`XU`U`a`]U3

J fU[Yb`cYj`Y`Y`XY`dfcj]g]Ygjn]`b`U`gi` [Y`X`UΔUW`hV]^Yb`[Y`XU`hca`U`hj`Ub`Yb`Ub`XYfY`VUb_`XUb`XY`^ci`k`Y

6Ub_! 'C dYbYb j Ub`Yb`VUb_fY_Yb]b[

< cb[Uf g

GnYfYbÅ`_VUb_gn`%` `i`b]m]`h]`"

J Yf`_UfYb`XUhi`Yb`VUb_fY_Yb]b[`inci`k`]`Yb`cdYbYb

=fU]Ubg

J cfY]`Udf]fY`i`b`Wbhc`WffYbH`"

GnYfYbÅa`_a`Y[gn`Ø`b]Yb]`U`VUb_gn`%` `i`%`"

J Yf`_UfYb`XUhi`i`k`VUb_fY_Yb]b[`k`]`gi`]hYb

J cfY]`W]i`XYfY]`_a`]c`Wbhc`WffYbH`"

@`Y`hgÅ[Yg`cb`]bY`VUb_gn`%` `i`b]m]`h]`]3

J fU[Yb`cZ`Y`Yb`VUb_fY_Yb]b[`Ub`cdYbYb`j`]U`Yb`cb`]bY`dfcW`Xi`fY

Dcggc`Udf]fY`i`b`Wbhc`WffYbH`cb`]bY3

6Ub_`%`m`i`j`U[m`i`]hY`_`%`m`i`Udc`_a`U`X3

J fU[Yb`k`Y`_Y`gccfhi`Ufhi`nU`_f]^[Yb`a`Yhi`k`fY_Yb]b[

F]Wj`Yf`i`i`bU`Wf`H`U`X]`XW]`hc`c`i`bU`Wf`H`U`X]`Wf`X]`hc3

@`Y`hgÅ[Yg`hY`YZcbcb`VUb_]`Ø[nY`_Yh]`b`h`Å`nb]`3

J fU[Yb`cZi`_VUb`dfcW`Xi`fYg`_i`bhi`]h]`cYfYb`j`]Ui`k`hY`YZccb

Dcggc`YZY`hi`UfY`cdYf`U]`cb]`VUb`Wf`Y`XU`_a`]c`W`i`_UfY3

A]`mYb`h`di`g`Ø`VUb_gn`%` `i`%`j`UbbU_`3

J fU[Yb`k`Y`_Y`hmdYg`VUb_fY_Yb]b[Yb`Yf`VYgW]`_VUf`n]`b

E i U]`h]d]`X]`Wb]`WffYbH`gbc`X]gdcb]V`]3

Zc`m`i`gn`%` `U

HmdY`VUb_fY_Yb]b[

Wbhc`WffYbH`

HU`Uf`Å`gn`%` `U

HmdY`VUb_fY_Yb]b[

Wbhc`X]f]gdUf`a`]c

⇒ a a][fUh]Y
6Ub_



gnYa Å'nj'gn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`dYf'gcbUY

_ÖnÖg'gn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`Vt]bhYgUrc

[mYfY_gn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`dYf`VLa V]b]

XYj]nLgn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`]b j Ui hUYgYfU

Ön`Yfj'gn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`Uh]YbXUY

X]1/2gn1/a `U
HndY`VUb_fY_Yb]b[

VtbrC`dYf`gi XYbh]

J UbbU_`Uj]`_ÖhgÄ[Y_3
J fU[Yb`cZYf`a UbbXY`^`gY`_cgYb`a cYHb`VYfU`X`k cfXYb]j`ccf`XY`VUb_fY_Yb]b[

7]`gbc`XY]`Vtcb]`a Ybg]`dYf`]`VtbrC`3

A Ybbrnj`VY`_YfØbY`_U`bYa nYh`Ön]`i hU`1/2c_3
J fU[Yb`cZYf`dfcj]g]Yg'n]`b]j`ccf`]bhYfbUh]cbUY`cj Yfg]Wf]`j]b[Yb

E i U]`gbc``Y`Vt`a a]gg]cb]`dYf`]`Vcb]Z]W]bhYfbUh]cbU]3

< UY`cd`1/2`U`_1/2m1/2z] Ub`fU`fU`V]nrcg]f1/2g3
J fU[Yb`cZYf`Yb]j`YfnY`Yf]b[`]g]b[]Y`U`i`k`VUb`__Ufh[Ygt`Yb`k`cfXh

7 fÄi`bfUgg]WfUh]cbY]b`Vtgc`U`a]U`WfUj`Yb[U`ga`Uff]hU`c`fi`VUH3

? Udc`_VgY`_ZÖnYh]h]g3
J fU[Yb`cZi`Yb`WYei`WcY`Y`_f]`hV]`i`k`VUb_fY_Yb]b[

F]Wj`YfI`i`b`]VfYfrc`XY[`]`Ugg]`b]3

A Y`_cfU`U`a`Y[hU`Uf]h]g]`_Ua`U`h]1/23
J fU[Yb`bUf]`bZcfa`Uj]Y`cj`Yf`XY`gdUffYbhY

E i U`Ä]`hUgg`X]`]bhYfYgg]`g`]f]gdUfa`]3

< c[mUb`h`XbU`_a`Y[j`ÅXYb]`U`WgU`i`_h`_3
J fU[Yb`k`Y`_Y`a`UfhY[Y`Yb`XY`VUb`_bY`a`h]bX]Yb`i`g`UW]rcZYf`VYbhj`Ub`ZfU`XY

⇒`WY`a`cXc`dchY`dfch[[Yfa]`XU`Y`ZcX]3

⇒a a][fU]Y
6Ub_



9j YgnYHhYa 'U_1/2m1/2 "
J Yf_UFYb'XUhi 'i k 'VUb__Ufhj Yf'cfYb'VYbh

< c'ga Uff]hc`U'a]UWfFU'X] VffYX]hc

9`cdh1/2 'U_1/2m1/2 "
J Yf_UFYb'XUhi k 'VUb__Ufhk YfX'[Ygtr`Yb

@U'a]UWfFU'X] VffYX]hc ÄgUHU'fi VUHU

@Y'hi X'1/2]h]hUb]'Ugn1/2 `1/2 3
J fU[Yb'cZXY'VUb_i k 'VUb_fY_Yb]b['_Ub'V'c__YfYb

DchY'V'cWfFY]'a]c'Vobhc'VffYbH'3

Gn0_gÄ[Ya 'j Ub'Y[mÖ^_1/2m1/2U'
J Yf_UFYb'XUhi 'Yb] Yfj Ub[_UfhbcX][`YYZha XUhi '[Yb'_Ufha Yf`YYZh

< c'V]gc[bc'X]i bUWfFU'gog]h]h] U

6Ub_!':]bUbV]ÇY`i `d

< cb[Ufg
GnYfYbÄ_ 'hÖV]bZcfa W]i ha Y[hi Xb]'U`h]Y'f` "
J fU[Yb'bWf]'bZcfa Uh]Y'cj Yf`Yb]b[Yb

=h]U]Ubg
J cffY]'Uj YfY'XY`Y]bZcfa Uh]cb]'f][i UfXc]'dfYg]h]"

GnYfYbÄ_ 'hÖVYha Y[hi Xb]'U_Ua Uh]Wf' "
J fU[Yb'bWf]'bZcfa Uh]Y'cj Yf'XY'fYbH] cYh

E i U `Ä]'hUgg'Xf]bHfYgg]3

GnYfYbÄ_ 'hÖVYha Y[hi Xb]'U`Y'n1/2c[f'f' "
J fU[Yb'bWf]'bZcfa Uh]Y'cj Yf`\nøch\Y_Yb

J cffY]'Uj YfY'XY`Y]bZcfa Uh]cb]'g]'a i h]]dchWf]"

GnYfYbÄ_ 'WgnÄ'b]Y[mi'Y'n1/2c[!hUb]W]X]j U"
J fU[Yb'ca 'h]gdfY_Yb'a YhYYb`\nøch\YY_UX]]gYi f

J cffY]'dUf`UFYVob i b'Vobg `YbH'f][i UfXc]'a i h]
]dchWf]"

9n'Uh'Y'g `U_1/2A 1/2žUa]hj YgnY_"
J Yf_UFYb'XUhi 'i k `YYfgY`i]g_ccdh

Ghc'Vta dfUbXc`U'a]Udf]a U'WgU'

9n'U'a 1/2cX]_]b[UhUbžUa]hj 1/2f'c'c_"
J Yf_UFYb'XUhi 'Yb'hk YYXY'Y][YbXca '_ccdh

Ghc'Vta dfUbXc i bU'gVobXU'df'cdf]YH'4

GnYfYbÄ_ 'Ö^Y'n1/2c[ch'
J Yf_UFYb'XUhi 'i k `nøch\YY_k]'j Yfb]Yi k Yb

J cffY]'UWbXYfYi bU'gVobXU']dchWf'

GnYfYbÄa 'ZY'Øj]ng[1/2hUb]'U'a Y[Äj `Y'n1/2c[ch'
J Yf_UFYb'XUhi 'i k `nøch\YY_k]`\Yfn]Yb

J cffY]'f]bY[cn]UFY]'a]c'a i h c']dchWf]'c"

=a a][fUh]Y
6Ub_



?]UX%Ugn%bh]b[UhUbhj %]f`c`c`"
J Yf`_UFYb`XUhi`Yb`Y][YbXca`_`ccd`hca`h`Y`cbXYfj`Yf\i`fYb`

Ghc`UMei`]gHubXc`i`bU`dfcdf]Yh%4XU`UZZ]HUFY`

5`Vfi`Hii`Aj`Yg`Q`YXY`a`Ya`'SSSSSS`"
5`Ub[`Y`Yb`\cYj`YY`i`k`Vfi`hc`'Uf]b`_ca`Yb`]g`

=`a`]c`fYXX]hc`cfXc`Ubbi`c`A`SSSSSSSS`"

6Ub_`!`J`YfnY`_Yf]b[

<`cb[`Uf]g`

GnYfYbA`_V]nrcgf%h`_Ob]"

J`Yf`_UFYb`XUhi`_]bhYfYggY`\YYZi]b`Yb`j`YnY`_Yf]b[

=`hU]Uubg`

J`cfY]`g]di`_UFYi`bU`dc`]mU`Ugg]WfUh]j`U`

`U`_%]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`g`_`U`WgJ`

i`hU%V]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`j`]U`[]`

A`YhV]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`g`_`U`j`]hU`

Y[`AgngA`V]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`g`ub]hUf]U`

[`Ad`%fa`!V]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`U`i`hc`

_]g%U]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`dYf`[]`Ub]a`U`]Xca`Yg]W`

`cd%V]nrcgf%h`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`W`b]f`c`]`Z`f`hc`

Y`n%`c[j`AX`Y`Ya`

HndY`j`YfnY`_Yf]b[

df`ch]n]cbY`a`i`h`c`

H`bi`i`j`j`U[`m`cb`

HndY`j`YfnY`_Yf]b[

Ugg]WfUh]cbY`g`_]`Vb`]XY[]`gi`XYb]h`

=a a][fUh]Y
6Ub_



VgdcdfV]nrcgfr1g
HndYj YfnY_Yf]b[

dc`]mU'Vc`Yrhj U

j U[mcbV]nrcgfr1g
HndYj YfnY_Yf]b[

Ugg]WfUh]cbY'g]'h]c`]X]'dfcdf]Yh1/4

1/2j é] V]nrcgfr1g
HndYj YfnY_Yf]b[

Ugg]WfUh]cbY'Vcbf'c`Y]'bcbXUh]cb]

h nV]nrcgfr1g
HndYj YfnY_Yf]b[

Ugg]WfUh]cbY'Vcbf'c`]']]bWbX]

< 1bm\i bLd]['ZYXn'UV]nrcgfr1g3
J fU[Yb`cY] Y'`a UcbXYb`XY`XY_]b[j Ub'i k 'j YfnY_Yf]b['Xi i fh

DYf`ei Ub]`a Yg]`gUfI` VcdYf'c#U3

A Ybbm]VY`_Yf0`UV]nrcgfr1g3
J fU[Yb`cY] Y'`XYj YfnY_Yf]b[`_cgh

E i U`Ä]` Vg'c`XY`fUgg]WfUh]cbY3