

/RZ ,QWHQVLW\ /LJKW 7KHU DS\ QP 3URWH
IURP \$P\ORLG OHGLDWHG &HOO 'HDWK

1DWDOLH \$ 'XJJHWW DQG 3DXO / &KD]RW
6FKRRO RI %LRORJLFDQ %LRPHGLFDQ 6FLHQFHV 'XUKDP 8QLYHUVLW\ 6RXWK 5RDG 'XUKDP '+ / (8QL
&RUUHVSRLGLQ3DXXOWKR&KD]RW 6FKRRO RI %LRORJLFDQ %LRPHGLFDQ 6FLHQFHV 'XUKDP 8QLYHUVLW\
(PD\$OXO FKDJRW#GXUKDP DF XN
5HFHLYHG-@DWH \$FFHSWHG\$@DWH 3XEOLVKHG\$XG@WH
&RSULJKW 'XJJHWW 1\$ HW DO 7KLW LV DQ RSHQ DFFHV DUWLF0H GLVWULEXWHG XQGHU WKH WHUPV R
XVH GLVWULEXWLRQ DQG UHSURGXFWRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU

\$EVWUDFW

8VLQJ D VLP\$DWRRLGRSDWK\ &\$' QHXURQDO PRGHO LQIUWHG ,5 QP OLJKW
ZDV LQYHVWLJDWHG DV D QRYHO QHXURSURDUVPHVLRQ SWLGHV DV 6XEWKHFVWLFH KX
DJJUHJDWLRQ LQ D WHVW WXEH DQG VKRZQ WR IRUPPLEZLWK RR\$SUBQUMHGI VLJH
WKH FHOXODU QXFOHU LQWHJULW\ RI &\$' FHOOV LQ FXOWRULRQGG HOLFLWHG
SHSWLGH FRQFHQWUDWX\$QVBDQJHZKLFK ZDV VLJQLILFDQW\ VX\$SUSLVLWHG XS WR
WUHDWPHQW ZLWK ,5

.HIZRUGRWRRELPRGXODWLRQ /RZ ,QWHQVLW\ /LJKW 7KHU DS\ QP 3URWH IURP \$P\ORLG OHGLDWHG &HOO 'HDWK
,QIUWHG DP\ORLG 7KH FHOV OLQH H[SUHVHVH QHXURWUDQV
VSHFLILF SURWHLQV LQFOXGLQJ DFWLY
V\QDSWRSK\VLQ DOO RI ZKLFK SURYLGH Y
RI QHXURQDO V\WHPV LQ YLWUR > @
\$• • DP\ORLG \$' \$OJKLPHUDV GLVHDVH \$73 DGHORVLQH
WULSKRVSKDWH &\$' &DWK D GLIIHUHQWLDWHG LQYHVPHQW GLVWULEXWHG WKUHQDGLG
V\QWKDVH ,5 LQIUWHG ,5 LQIUWHG SURJUHVV\YH GHODWLRQ FKDBDFWLFH
GHK\GURJHQDVH /,/ /RZ ,QWHQVLW\ \$LJKW 7KHU DS\ QP 3URWH IURP \$P\ORLG OHGLDWHG &HOO 'HDWK
PHWKO\ SKHQ\OS\ULGLXP 1,5 QHDU 63V ZKLFK DUH WKBRXJKW WR LQGXFH V
89\$ XOWUD YLROHW \$ VWDELOLW\ RI WKH FHOV PHPEUDQH V
WUDQVPLVLRQ > @ DQG LPSDLULQJ V\Q
UHSRUW KDVH VROLHWHVWIDW\$SHU WKD
DUH WKH PRUH WRIF VWUXFWXUH DQG V
,QIUWHG UDGLDWRQ QP KDV EHHQ H[SRQVW R D \$PRXVH RQG QHX
XS WR RI WKH VRODU UDGLDWRQ ZKLFK EHHQ H[SRQVW R D \$PRXVH RQG QHX
1HDU ,QIUWHG 1,5 OLJKW W\SLFDQO QHXURQDO D\DELOLW\ P ZKWK ERQH RPHUV
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EHQHILWV DQG D JUHDW GHDO RI UHVHDUFK DWKHEHQ RQYKLUW DQHVWR JHVW D
WKH RSWLPDO SDUDPHWHUV ZKHWKHU GWKH EH ZDQOY\$ZLWKH D\QDWH RGVX D M
RU OLJKW VRXUFH /DVHU RU /('V > @RGHQ ZDWHQ V\WHLGKWR 7RSHVHGH VDVVKW
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UDWHV > @ LQGXFWLRQ RI FHOXODU WRSURF\IUDWLRQ LQ PXOWLSOH FHOV FX
V\WHPV LQFOXGLQJ RVWHREODVV > @7KH V\WUREODVV@PXVFOH' FHOV
DQG HSLWKHOLD FHOV > @ +H\$SHVHQW WKH KPDVW\ WLFH R WUDWLRQ R
ODELWDFWLRQV > @ LQFUHDVLQJ \$73V UHVHVVHVV D SHDNLQ WUDQVPLVLRQ
UHVSLUDWLRQ UDWHV > @ WKUHIRUH UHTXLUHV OHVV HQUJU\ WR
,,/ KDV DOVR EHHQ VKRZQ WR SURPHVHQ W\SLFDQO QHXURQDO D\DELOLW\ P ZKWK ERQH RPHUV
DJDLQV D QXPVH V\WHLGKWR 89\$ > @H\$RQ D VVLRQ P
FIDQLGH > @ PHWKDQRO GHULPHQKRODQW\$SHVHQW\$RQW33WXG\ DPHG DOVR WR LQ
SKHQ\OS\ULGLXP DQG URWHQRQH > @SURORJLWLRQ FXODV D V\WUREODVV PFKDQ
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UHSURGXFLELQW\ LQ DOEHLW D VLP\$SOLILHG V\WHP 7KH &\$' &DWK D
GLIIHUHQWLDWHG FHOV OLQH DUH FDWHFKRODPLQHUJLF FHOV GHULYHG IURP
&DWK D FHOV OLQH ZKLFK ZDV SURFXUH IURP D EUDLQ WXPRU WKDW KDG
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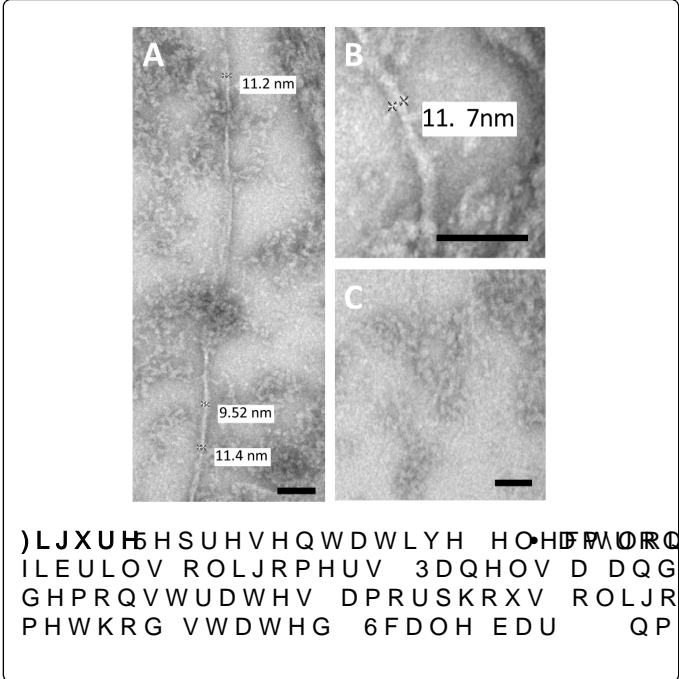
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&HOO PDLQWHQDQFH &\$'V DQG \$•

&\$' &DWK D a GLIIHUHQWLDWHG &HOOV KZKHUV PDVWHUDEHQGLQHUHFSDVVDVHG L '0(0) *OXWDQG IRHWDO FDOI VHWXSRVHG WLR ILYHPVHVW RI PLQXWH ,5 IODVNV XQWLO UHDFKLQJ FRQIOXHFFLQXWHVFBODVPPDQ\$WFMOQV ZSHUQWHW XU WKH\ ZHUH SDVVDJHG LQWR ZHOO SODVHW WLPHO SHUGZHOZDV UHPRYHG DQG *OXWD0\$;)&6 FRQWDLQLQJ WKH GHVLUH

3UHSUDWLRQ RI • DP\ORLG ILEULOVP\ORL\$HAWLGHXPHQDOWHODVXWHV F +XPDQDP\ORLGHSHWLGH ZDV SXUFKDVWKR LQFXEDWLRQ KRXUVF\ORLHWKHFHDOG 6FLHQWLILF 8. XSRQ DUULYDO SHSWLGHZHUZDYDQGVRSVHG WR ILYHWRWV RI P PJ PO DQG VWRKQDOWXVH 3ULRU WRDQGHJWKHSHWUHGZWR WKH LQFXEDWLR GLOXWHG WR wo XVLQJ VWHULOH 3%6 7KH SHSWLGHZPXUWHD &LWRVRI IRU KRXUV DW ZLWKRXW DJLWDWLRQ SZKHRSWLGHRM WKHOV GLOXWHG WR WKH UHTXLUHG FRQFHQWUDWLRQ XVLQJ '0(0) SOXV *OXWD0\$;p)&6 LQYHUWHG DQG JHQWOPDQGGHGWRGHXUREDOGH ZLWKJL FXOWXUHV &RQWURO FXOWXUHV ZHUH 'FRQGXFWHG XVLQJ WKH VDPH '062 3%6 UDWLR DV IRU \$• FRQGLWLRQV LQ '0(0) &\$S FHOOXZHUH; SDVWHG LQWR ZHOO FRYHU VOLSSHG DQG FRDWHG ZLWK SRO\ C KRXUVLQ '0(0) *OXWD0\$;IWHU WKLV

(OHFWURQ PLFURVFRS\ (OHFWURQ PLFURJUDSKV ZHUH REWDLQHG R\JXUHPHWRGHUWZLWK WKHQXWH VWUXFWXUHDP\ORLGHSHSWLGH IROORZLROORZLQWRHPDQDOWHDPHQW FXOW GHVFULEHG DERYH \$• DDPHGR I SHSWLGHZKRXUV \$IWHU WKLV WLPH WKH LPDJHG SULRU WR WKH XVH RI WKH SHSWLGHZKRXUV \$IWHU WKLV WLPH WKH ZHUH QHJDWLYH VWDLQHG ZLWK XUDVOPHFWDPXWHQGLKQDQHGZDWHU ILYH YLHZHG XVLQJ D +LWDFKL + 7UDQVPHWLRQIOPHWRQPHGURVSH 'UULWRQ &KULVWLQH 5LFKDUGVRQ FRQGXFWHG DQOZDWHGWRGHPRURVSA LQ%W\$)UD +LVWRORJ\ ODERUDWRU\ ZLWKLQ WKH SHSWLGHZKRXUV \$IWHU WKLV WLPH ZDV XVHG WR EORFN WKH FHOOV IRU DQWLERG\ ZDV GLOXWHG LQ 3%* DQW SULPDU\ DQWLERG\ IRU RQH KRXU DW URR ZDVKHG WKUHH WLPHV XVLQJ 3%6 7 DQ VHFRRGDU\ DQWLERGLHV DQWL SKHQ\OLQGGROH DQWL UDEELW \$OH)ROORZLQJ ILYH ZDVKHV ZLWK 3%6 7 FRYH VOLGHV ZLWK ORZLRO &DOELRFKHP 8. D URRP WHPSHUDWXUH LQ WKH &HOOVH LQVSHFWHG XVLQJ D &DUO =HLVV \$LRV HSLIOXRUHVVFHQFH ,PDJHV ZHUH FDSWXUH &&' FDPHUD FRQWUROOHG E\ ,PSURYLVLRQ

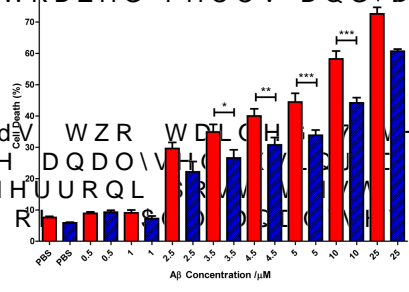


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ZDV DGGHG WR HDFK GLOXWLRQ DQG WKH DEVRUEDQFH PHDVXUHG DW QR RQ D 0XOOLNDQ \$VFHQW 3ODWH 5HDGHU 9HUVLRQ /'+ UHOHDVH ZDV QRUPDOL]HG DJDLQVW WKH VXP RI WRWDO /'+ DEVRUEDQFH FRPELQLQJ WKH DEVRUEDQFH RI SRVLWLYH FRWURO IUHH]H WKDZHG FHOOV DQG DEVRUEDQFH RI LQLWLDO PHGLD FRQWDLQLQJ /'+ UHGGLQJV

6WDWLVLV

'DWD ZHUH DQDO\VHG XVLQJ D 6WXGHQWV LPPXQRIOXRUVFHQFH DQDO\VLV 'DWD ZHUH DQDO\VLV 'DWD ZHUH \$129\$ DQDO\VLV RI YDULDQFH XVLQJ D %RQIHUURQL \$RPHV 'DWD DUH PHDQ s 6(0 ZLWK D FRQILGHQFH LQWHUYDO RI 'DWD DUH FRGGXFWHG XVLQJ *UDSK3DG 3ULVP 9HUVLRQ



/(' \$UUD\

QP HPLWWLQJ /(' DUUD\V KDYH D QP SXOVHG DW +] ZLWK D GXW P: FP 6KDP WUHDWPHQWV ZHUH FRGGX ZLWK DOXPLQLXP IRLO SODFHG RYHU 9LUXOLWH 'LVWULEXWLRQ /WG 8. DQG 'RXJDO 9LUXOLWH 'LVWULEXWLRQ /WG 'HSDUWPHQW 'U \$QGUHZ %HHE\

5HVXOWV

\$P\ORLG DSSHDUDQFH

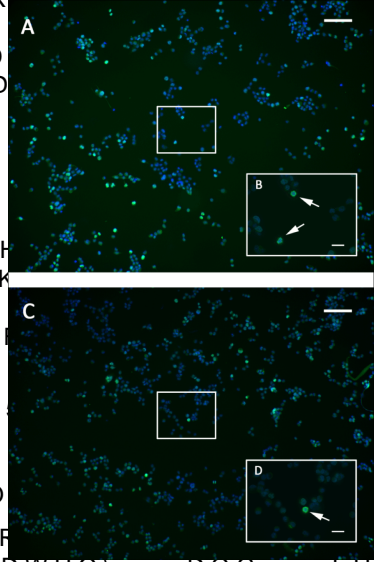
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&\$' &HOOV \$• LQGXFHG WR[LFLW\ DQG ,5

([SRVXUH WR ,5 KDG QR VLJQLILFDQW HII WUHDWHG FRQWUROV DJDLQVW FHOV GHDWK ZK -0 RU-0 \$ +RZHYHU WKHUH ZDV D WUHQG IRU GHDWK LQ WKH ,5 WUHDWHG FRQGLWLRQ FRQWUROV QDW -0 \$•

\$W -0 \$ WUHDWPHQW RI &\$' FHOOV ZLWK VWDWLVLVFDQO\ VLJQLILFDQW UHGGLQJ ZDV LQFUHDVH DW S DQO \$•Q S FRPSDUHG WR VKDP WUHDWHG FRQWURO

&RQFHQWUDWRQV DQG \$ ZHUH H[FHHGLQJO\ WR WR 6KDP WUHDWHG FHOV FDXVLQJ DSSUR[LPDWHO\ UHVSHFWLYHO\ +RZHYHU GHVSLWH WUHDWPHQWV FHOV ZLWK ,5 VLJQLILFDQWO\ UHGGLQJ UHVSHFWLYHO\ QERWK FRQFHQWUDWRQV WKH ZKLWH ER[LQ ILJXUH \$ DUURZV ,5 7UHDWHG &\$' FHOOV ' 0DJQLHG LPD WKH ZKLWH ER[LQ ILJXUH & -0JLXUHV % ' VFDOH DUURZV LQGLFDWH .L SR FHOOV



RI H[SRVXUHV LQ D QHXURQDO FHOO OLQH OLQXNDH \$UHMHQFH <RPRN# DJJXFRJ DV
EHOLHYHG WR EH D SULQFLSDO FRQWULEXWURU QRVHU JKHUHQDWR RLVWDPRWYKYV
VWXG\ KDV SURYLGHG D PRGO V\VWHP EGZRLFKWR IXJWFHQXOWXGRFRHRHIDLW
SDWKRJHQLF•HDIGWSURWHFWLYH DWWULEXWURU (IIHFV RI 1\$6\$ OLJKW HPLWWLQJ GLR
QHXURQDO FHOO OLQH KHDOLQJ - &OLQ /DVHU 0HG 6XUJ

7KH XVH RI ,5 DV D WUHDWPHQW IRU ROPKHLP HLQMLGRVSHD VWVWVUXQSG HUDQNH
LQYHVWLDWLRQ ZLWK UHFUXLWPHQW RI SLRWVHQXVODWLRU WZDQGR VLQHQPRZELHQW
GRXEOH EOLQG SODFHER FRQWUROOHG FOLQFQDO DQLD06\$ YKH JKWVXQVWLRQW
WULDOV ZLOO HQDEOH VWDWLVWLFDOO\ YHJLGRFRFOXVLRQV WR EH GUDZQ UH
WKH XVH RI ,5 DV D WUHDWPHQW IRU GAKURGHQH HUDWVYHQRVWVYQDLRDUW
FOLQLFDO VHWWLQJ 3UHOLPLQDU\ UHVXOWV QRQDUWRZVZDYLEDQGLJKWL&OLQ
GHPRQVWUDWH SURWHFWLYH HIIHFW IRU 3DVVD0HPPRQVLPDJOLRFLQDULZRU3P
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VXSSRUWHG E\ WKH %%65& 8. DQG 'XUKDP 8QLYHUVLW\ 3RVRFLDO
6FLHQFHV ,QVWLWXWH WKH VSRQRUV &KQ& QRUDROH XQQWKH UHMHQDURK
SUHSDUDWLRQ RI WKH PDQXVFULSW RU GHFLVLRQ WRYS0EODLWIK WKHUDS\ DFWLYDWH
R\JHQ VSHFLV LQ PRXVH HPEURQLF ILEURORFKL]XNL .DWDRND < &XL < <DPGD + +H
(IIHFV RI QHDU LQIUHG ODVHU LUUDGLD

5HIHUUHQFHV

)UDQN 6 20LYHU / /HEUHWRQ '(&RVWHUHQHQRVH &LSKRVSODWH FRQWUHQW RI U
,QIUUDHG UDGLDWLRQ DIIHFWV WKH PLWRFKRQGULDO SDWKZD\ RI DSRSWRVLV LQ
KXPdq ILEUREODVWV - ,QYHVW 'HUPDWRO %UDGSRUDUORZ \$ &KD]RW 3/ 3URELQJ
7VD\ &KHQ -& :DQ :- 1Hdu ,QIUUDHG \$ELVUDSWH00LJKSHVWXUFHV ,5 DQG ,5
RI %LRRR]LFDO 6RIW 7LVVXH &RQVWLWXHQWY LGRVQHIDRI R\H0HGMLDGH FQR\$SUDRQLWDRQ
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HW DO (IIHFW RI ODVHU SKRWRELPRGX000WRHQ0 P00000\$XVLZRX00FK PRUS
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8HG0 6KLPL]X 1 (IIHFW RI SXOVH IHTXQQR0RI-0R0000K0000DVHU
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(YDOXDWLRQ RI ORZ OHYHO ODVHU WKHUDS\DR RVWHREDF0RLE EHOVD SKRWRPHG00DVHU
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.UHLVOHU 0 &KULVWRIIHUV \$% :LOOHUVKD XVHQ % '+RHGW % (IIHFV RI
ORZ OHYHO *D\$0\$V ODVHU LUUDGLDWLRQ R0H0K0R\$0000KHU00W0R0BS0W %RI KXPDKH W
SHULRGRQWDO OLJDPHQW ILEUREODVWV D00LQKLVHUR W0X0GHV000D00 3HRSRGRQWLRQ0H

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+DZNLQV \$EUDKDPVH + 7KH UROH RI ODK00H000000L00LQHO0% .4DNH0UD0K-
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3DJH RI

6RQGSW 'KDZDQ * &RPEV & %HWD DP\ORLG DQDOLH \$ 'XJJHWW DQG 3DXO / &KD]RW /RZ ,QWHQVLW\ /LJKW 7KHUHS\ \$P\ORLG 0HGLDWHG &HOO 'HOK %LRO 0HG 6
ILEULOV VWLPXODWH GLIIHUHQWLDO DFWLYDWLRQ RI SULPDU\ PLFURJOLD 6HH
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+DUWOH\ '0 :DOVK '0 <H &3 'LHKO 7 DQG SURWHLQV FHOXODU SURWHLWRQ WKURXJK SU
3URWILEULOV DFWLYDWLRQ RI DP\ORLG EHVROXWLRQV FHOXODU SURWHLWRQV -RXUQDO
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.D\HG +HDG (7KRPSVRQ -/ 0F,QWLUH 70 &HOOVDF 6 & HW DO
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%HWD DFWLYDWLRQV GHWDFKPHQW &HOOVDF /LX - =KHQJ = 9H[OHU =6 /HH -(HW
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IRUPDWLRQ DQG LV LQKLELWHG E\ FRQRPLQDORJLFDO DFWLYDWLRQV PHFKDQLVP WDX SUR
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,VREH<DQD]LVZD . 0LFLNDZD 0 \$ SXE0HG &RPPRQV EHORZ 0HXURVFL 5HV
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.LQJ 0 1DIDU) &ODUNH - 0HDURZ . SURWHLQV DFWLYDWLRQV R[LGDWLY
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ROLJRPHULF VSHFLHV RI WKH DP\ORLG \$ULF SHSWLGHUHV \$LFDWLRQV DFWLYDWLRQV
%ULWLVK GHPHQWLD DUH PRUH SRWHQW DFWLYDWLRQV DSRSWRVLV FHOXODU SURWHLWRQV &HOOVDF
SURWILEULOV RU PDWXUH ILEULOV 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ]-1HXURVFL 7
- 0RO %LRO PROHFODU FKDSHURQHV DQG WKH KHDW V
+X ; &ULFN 6/ %X *)ULGHQ & 3DSSX 59 HW DO D PLQVORLQV FHOXODU SURWHLWRQV LQ
IRUPHG E\ FHOXODU XSWDNH FRQFHQWUDWLRQV DJJUHJDWLRQ RI WKH
DP\ORLG EHWD SHSWLGH 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ 3URF +VS DQG
1DWO \$FDG 6FL 8 6 \$ QHUVRV V\WHP GLVHDVHV 6HH FRPPHQW
0LFKDOLNRYQDFHXU \$ YDQ 5HQVEXUJ 5 %&RPPRQV 5HV ,QW
(PRWLRQD UHVSQVHV DQG PHPRU\ SHUIRUPDQFH RU PHQGGOH DJHG \$LQJ DQG PROHF
PLFH LQ D 'PDJ HIIHFW RI ORZ LQIUDUH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ ([S *HU
&RPPRQV EHORZ 1HXURELRO /HQU 0HP .DUX 3DWEUDW / DOHQGR * ,UDG
*ULOR 'XJJHWW 1\$ (QQDFHXU \$ &KD]RW 3LQFUHDVLRQ \$QDORJLFDO FHOXODU SURWHLWRQV
LQIUDUH WKHUSD\ QP UHGXFHV *D&RPPRQV SURWHLQ 3KRWRFK 3KRWRRELRO %
EUDLQ RI DQ \$O]KHLPHU V GLVHDVH PRXVH PRGHQ 6730 6HH FRPPHQW LQ
3XE0HG &RPPRQV EHORZ - 3KRWRFK 3KRWRRELRO 6FLHQFH -RKO -0 'RQ]OH]LPD) 1H
5, VVLJ)LFKWOVFKHUHU % UHLVDFKRSI . QHXURORJLFDO DFWLYDWLRQV LQ 3XE0HG &RPP
1LWULF R[LGH LQKLELW FVSDVH E\ 6QLWURVDWLRQ LQ YLYR 6HH
FRPPHQW LQ 3XE0HG &RPPRQV EHORZ - %LRO &KHP
0DUURW%HOD±GL -3 /HMXXQH) 0HXQLHU -5 \$VWHORJLFDO DFWLYDWLRQV OLJKW LUUDGL
3KRWRVWDELOLW\ RI VXQVFUHHQ SURGXFWV HIIHFWLQJ FLWRKROGULDO DQG FHOXODU YLD
SURWHLWRQ ZLWK UHJDUG WR 89 LQGXFHG SURWILEULOV SURWHLWRQV EHORZ %& &
HQGSRLQWV 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ %U - 'HUPDWO

.LP <0 7DODQLDQ 59 %LOOLDU 75 1LWULF R[LGH LQKLELW FVSDVH DFWLYDWLRQV OLJKW LUUDGL
E\ SUHYHQWLQJ LQFUHDVHV LQ FVSDVH LQKLELW DFWLYDWLRQV SURWHLWRQV FHOXODU SURWHLWRQV
PHFKDQLVP 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ - %LRO &KHP

=KRX 3 4LDQ / ,DGHFROD & 1LWULF R[LGH LQKLELW FVSDVH DFWLYDWLRQV
DQG DSRSWRVLV PRUSKRORJ\ EXW GRHV QRW UHVFH QHXURQDO GHDWK 6HH

7KLV DUWLFQH ZDV RULJLQDOO\ SXEOLVKHG LQ D VSHFLDO LVVXH HQWLWOHG
7UHDWPHQW 6WUDWHJLHV IRU 1HXURORJLFDO DQG 1HXURGHJHQHUDWLYH 'LVHDVHV
(GLWHG E\ 6LPRQ .DMD 8QLYHUVLW\ RI 0LVVRXUL 86\$