

4QFDJFT *EFOUJGJD_BUJPO PG 'P\$@QTFSB NQPS
\$BMMJQIPSIJBEBPDDVS JO +FEEBI ,JOHEPN PG *

/D\OD \$ + \$O 6KDUHHI

.LQJ \$EGXOD]L] 8QLYHUVLW\ .LQJGRP RI 6DXGL \$UDELD

&RUUHVSQRQGLQJD\WWDW\$RU \$O 6KDUHHI)DFXOW\ RI 6FLHQFH \$O)DLVDOLDK .LQJ \$EGXOD]L] 8QLYHUVLW
(PD\W\ODGU#KRWPDL FRP

5HFHLYHG0GDWH \$FFHSWHG GDWH -XO\ -XOEOLVKHG GDWH

&RS\ULJKW \$O 6KDUHHI /\$+ 7KLV LV DQ RSHQ DFFHVV DUWLFOH GLVWULEXWHG XQGHU WKH WHUPV RI W
XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU

\$EVWUDFW

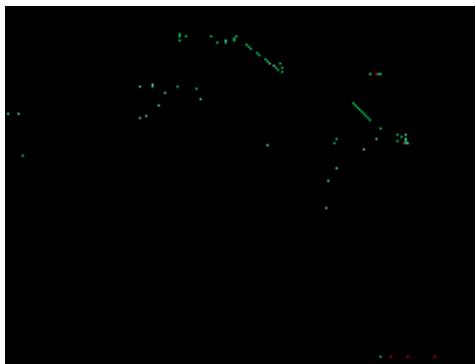
\$Q LPSRUWDQW JRDO LQ IRUHQVLF HQWRPRORJ\ LV WKH LGHQWLILFDWLRQ RI QH
FDUFDVVHV ,Q NLQJGRP RI 6DXGL \$UDELD WKHUH DUH UDUHO\ VVXGLHV RQ FDUL
DV D PRGHO IRU VVXG\ D NH\ IRU WKH LGHQWLILFDWLRQ & EASXORHUVLGHQH FWRI RI E
GHIUHQW KDELWDW GHVHW XUEDQ DJULFXOWXUH DQG FRDVWDO LQ -HGGDK F
ZDV SUHSDUHG 7KH EORZIO\ VSHFKHWZRPLDFKPHRDXQGSKZDQFBID PDUJQGDOLV
&KU\VRP\D DOZKIEWHSWWXG\ ZDV FRQGXFWHG WR FUHDWH GDWDEDVH LQIRUPDWLR
.LQJGRP RI 6DXGL \$UDELD JHRJUDSKLFDO UHJLRQ DQG LW LV HVVHQWLDO WR W
FRXQWU\

& L W D W \$ R Q 6 K D U H H I / \$ + 6 S H F L H V , G H Q W L I L F D W L R Q S R V I H S U D D @ Q S / K R M K P S N R H R W / D X Q W L Q O - R Z G Q D H
6 D X G L \$ U D E R B - 1 X U V) R U H Q V L F 6 W X G

3 DJH RI

D Q G E O D F N) L J X U H) L J X U H V

J H Q D O G L O D W L R Q F K H H N Z K L W L V K R U V H O O R Z L V K



) L J X U H D W H U D Q & L B D A R H A D G S M K R Z L Q J R Q W K H P H U R Q D Q G J U H D W H U D P S X O O D

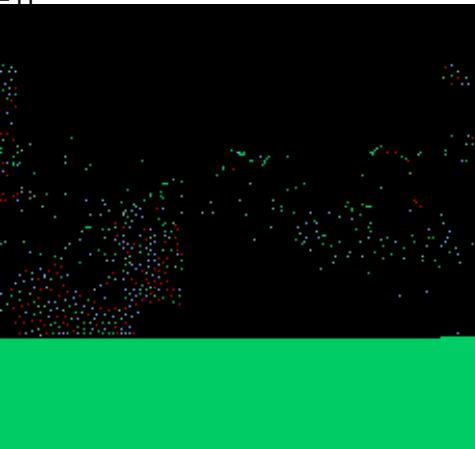
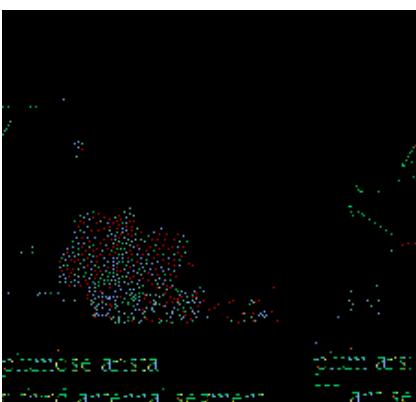
U R Z R I E U L V W O H V

D Q G D E G R



) L J X U H D W H U D O G R U K P D O D Y F L H S K R Q D Q J R I S U R P L Q H Q W V X E V F X W H O O X P

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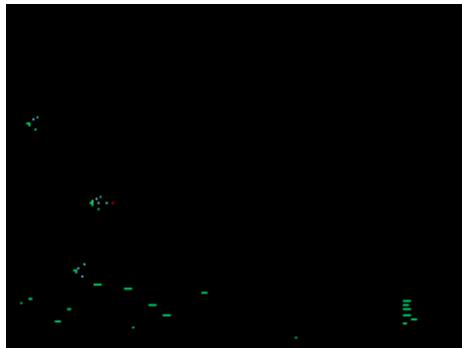


) L J X U H D W H U D Q & L B D A R H A D G S M K R Z L Q J S O X P R V H D U L V W D

) L J X U H D W H U D O Y L H Z K P D W J K L Q D D Z L U Q J D Q G O R Z H U F D O \ S W H U V XSS H

* O R E - 1 X U V) R U H Q V L F 6 W X G
, 6 6 1 * 1) 6 D Q D F F H V V M R X U Q D O

9 R O X P H k , V V X H k



)LJXUHRUVDO &KDIQERBESGRPHQ URZV
FRORWVME GRPLQDO WHUJLWH DQG S

SRLQW WR EODFN
RVWHUTRO PDUJLQV RI WKH VSHFLHV RI & DO
IRUH(I L9 0 TD[()-50(/DevicGHQWL6U1ric HL9 0 TD



)LJXUHK PDUJPHANOLAOOLF GDUN EOXB WK



)LJXUDWHUDO DQ W&KHULOREL FVHLHZL ORJ
JHQDO GLODWLRQ

ZKLWLVK

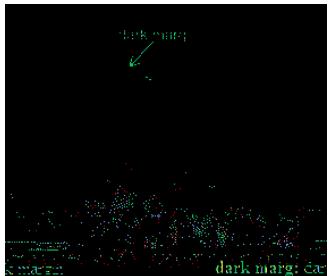


gen dil: genal dilat
ps gen: post-gene

)LJXUDWHUDO DQ W&KRHJRDIFMSKBRDQJ JHQDO
GLODWLRQ DQG SRVWJHQD

& L W D W \$RQ6 Hm2QW D W L L -222(4)-9(+222(4)-9

)4(8(O)-36 S L Q)4(G L H8)U9X.X U.6 705.2K60.9 c 304.9 726.9 I 705\$(W)-6-227(\$)3(I



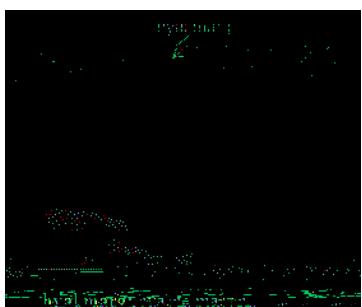
)LJXUH 9HQWUDO &YKLPHDZU JRLQD\KORIZVQ J
DQWHULRU ZLQJ PDUJLQ

GDUNHQHG



)LJXUH /DWHUDO &YKLPVZJ\DRAH S\K\OROUD [\\HOORZLVK ORZHU FDO\SWHU

VKRZ



)LJXUH 9HQWUDO &YDQBLRK&ZLQJ K\DOLOQH
ZLQJ PDUJLQ



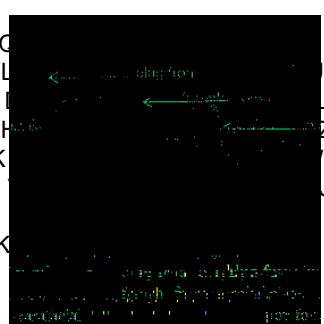
)LJXUH\$QWHULRU Y&KHZBD\PHD\ODG DVKRZL
H\HV WRXFKLQJ ZLWK VKDUSO\ GHPDUF
RPPDWLG LD

1RWHV RQ VSHFLHV

&KUIVRAFHDDFHS\DEODFLXV 'LDJQ\RVHV ZLWK
PHGLXP VLJH F\PHQW\QJWKQDO GLODWLRQ DC
RUDQJH ZLWK RUDQJH WR \HOORZ KDLU DQWHUL
:LQJV HQWLUHO\ KDOLQH)LJXUH
JUD\)LJXUH ODOH IURQV YHU\ QDUURZ H
RPPDWLG\QDS SHU WZR WKUGV HQODUJHG DQG VK
VPDOO RQHV LQ ORZHU WKUG)LJXUH)URQ
PLGGOSD\QDRW\QHGG ZLWK GDUN EUIRZQ\WIR EODFN
RUELWDO SODWH DQG SDUDIDFLDO GDUN JUD\LVK

RZQLVK)LJXUH
VK WR GLUW\ ZLWK
HG IURP JLQJ LQ WKH

ZLWK
/RZHU F
H
DQG VK
)URQ
PLGGOSD\QDRW\QHGG ZLWK GDUN EUIRZQ\WIR EODFN
RUELWDO SODWH DQG SDUDIDFLDO GDUN JUD\LVK



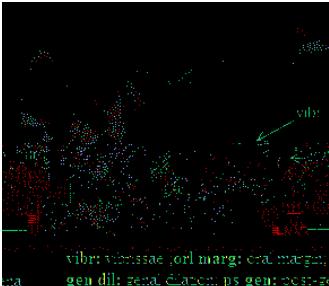
)LJXUH\$QWHULRU Y&KHZBD\PHD\ODG DVKRZL
GDUN EURZQ EXOJLQJ IURQV GDUN JUD\
SDUDIDFLDO

)LJXUH RUVDO &KHZBD\PHD\ODG

'LVWULE\XWLRO\PHDDFHS\ODG\QW\HFRUGHG LQ
dV > @ WKHQ VSUHDG TXLFNO\ DQG
> @LVVSHFLHV KDV EHHQ UHFRUGHG LQ
0HGLWHUUDQHDQ UHJLRQ > @ 3DODHDU
,V > @ SUHVHQWO\ FRYHULQJ WKH 6
\$IJKDQLVWDQ &KLQD -DSDQ > @ 8QLW
DQG %UDJLO > @ ,W LV DOVR UHFRUGHG
.XZDLW 2PDQ 3DNLVWDQ 8QLWHG \$UDE
\$UDELD > @

& LWDW \$RQ6KDUHHI / \$+ 6SHFLHV , GHQWLILFDWLRQS RVIHSDQD QDSK RNUKPSMR HRVFDXQUW LQ O-RHZG QD
6DXGL \$UDERB - 1XUV)RUHQVLF 6WXG

3DJH RI

& KU\VRPDDJLQD@GHPDQQ 'LDJQRVIDWUH
VSHFLHV XXDOO\ H EPRPG'LQ VO A Q WMDOLF GDUN EOXYH
)LJXUH 6XUIDFH RI JHQDO GLODWLRQ DQG S
WR \HOORZ KDLUV YLEULVVVDH ZHOO DERYH WKH
DUDFWHULVWLF E\ GHHSO\ GDUNHQHG RI DQWHU
ZLWK RUDQJH
XUH ,W LV
)LJXUH

vibr: vibrissae (oral margin, oral margin,
gen dilt: genal dilator, ps gen: postgen
)LJXUHDWHUDQ&PLBDYRKRHSUDVKRZLQJNDW
VHWDH
)LJXUH/DWHUDO DQWHULRU YLHZ RI
GHYHORSHG YLEULVVVDH
& K PDUJL
HOO
KEOLF (J\SW
RXWK
\$OVR
UDE
)LJXUH
'LVWULEXWULSRQFLHV JHQHUDOO\ FRPPRQ LQ VXE
> @ ,W ZDV UHFRUGHG LQ %XUNLQD)DVR &HQ
&RQJR .HQ\D 0DGDJDVF DU 0DOL 1DPLELD 1L
\$IULFD 6HQHJD 6RPDOLD 6XGDQ 7DQ]DQLD
RFFXUV LQ NLQJGRP RI 6DXGL \$UDELD <HPHQ
(PLUDWHV ,UDQ 3DNLVWDQ > @
KEOLF (J\SW
RXWK
\$OVR
UDE
)LJXUH
& KU\VRP\D DLOEIPRMSLWV ZLWK PHGLXP
OHQJWIKDDQG DEGRPHQ PHWDOOLF EOXYH
HQWLHUH\ K\DOLQH)LJXUH \$QWHUVRHWVISLUDFOH ZKLWLVK SURHSLVWHUQD
VHWD EOHZ DQWHULRU VISIDWHSQWHWEDQDOW)LJXUH
)LJXUH 0DOMHDJOMLWKA PZDHOHO GHYHORSHG RXWHU YHUWIFDO
VHWDH)LJXUH JHQG6000UDWIRORIDQGL & RWKWLW
ZKLWH KDLUV)LJXUH 0DOH IURQV YHU\ QDUL
RWKHU ZLWK RPPDWLG LD XQLIRUP LQ VLJH)LJX
GDUN EURZQ WR EODFN FRORU WKH IURQWR F
ZKLWLVK)LJXUH QWHQQDO VHJPHQW ZKROO\ G
)LJXUH \$W OHDVW VRPH KDLUV RQ ODWHUD
SRVWHULRU HGJH RI WHUJLWH 9 RI IHPDOH ZLWK
RVH WR HDFK
PDOH ZLWK
QG SDUDIDFLD
)LJXUH
'LVWULEXWULRDPDLEMSYHU\ FRPPRQ VSH
0HGLWHUUDQHDQ UHJLRQV DQG KDV EHH
.XZDLW /HEDQRQ /LE\D 2PDQ 3DNLVWDQ
6\ULD 8QLWHG \$UDE (PLUDWHV DQG 7XUM
H[SDQVLRQ WRZDUGV FHQWUSDFKURBW
H[SDQVLRQ WRZDUGV FHQWUSDFKURBW
QWVDEHQFHG LQ 3RUWXJDO > @ DQG F
UHFHQWO\ KDYLQJ UHDFKHG 3RODQG > @
> @ :HVW ,QGLHV
)LJXUH\$QWHULR&KDYLQJFREON KHDG VKRZL
ZLWK RPPDWLG LD XQLIRUP LQ VLJH
'LVWULEXWULRDPDLEMSYHU\ FRPPRQ VSH
0HGLWHUUDQHDQ UHJLRQV DQG KDV EHH
.XZDLW /HEDQRQ /LE\D 2PDQ 3DNLVWDQ
6\ULD 8QLWHG \$UDE (PLUDWHV DQG 7XUM
H[SDQVLRQ WRZDUGV FHQWUSDFKURBW
H[SDQVLRQ WRZDUGV FHQWUSDFKURBW
QWVDEHQFHG LQ 3RUWXJDO > @ DQG F
UHFHQWO\ KDYLQJ UHDFKHG 3RODQG > @
> @ :HVW ,QGLHV
)LJXUH/DWHUDO&KDYLQJFREON VKRZL
SURHSLVWHUQD VHWD

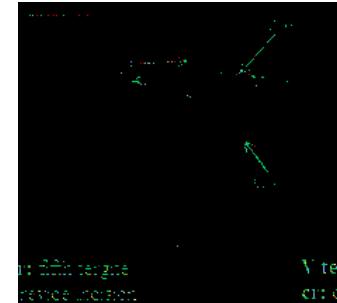


)LJXUHQWHLURU YLQHWDQFH RI LKHPDQH WR KRZLQJ GDUN
EURZQ IURQV ZLWLVK IURQWR RUELWDO SODWH DQG SDUDIDFLDO



em iii ant seg; third antenna segment

)LJXUHDUN JUD\LVK WKLUG DQWHQQDO VHJPHQW



ii: disk targets
device selection

Vte
cr: c

)LJXUHRUVDO YLHZ SRVWHULRU SDUW RI IHPDOH DEGRPHQ

'LVFXVVLRQ

%ORZRLHFXU LQ DOO ELRJHRJUDSK\ UHJLRQV DQG FRQWDLQ DURXQG
VSHFLHV IDX@D RI

1 X R U W8H Y D

6]SLOD . 3DS 7 5X VIOQJSIK R O RJMORV WWDKUH ODUYD RI
&DOOLSKRULGDH UPLHDJL Q QGXFL QDOD X VWSMLNUUD
&DOOLSKRULGDH OHG 9HW (QWRPRO a
3UDGR H &DVWUR & 'LSWHUD RFSDWUHULLRQ
FRPPXQLWLHV IURP /LVERQ 3RUWXJDO DQG WKH XWLOLW\ RI)RUHQVLF
(QWRPRORJ\ LQ /HJDOWH QFLYQHUVLW\ RI /LVERQ
3RUWXJDO
5RJQHV)DXQD(XQBSDOOLSKRULGDHHG)DXQD
(XURSDHD 'LSWHUD)DXQD (XURSDHDQ YHUVRQ
RPSVR) 1RPHQFCMDRUXV 6WDWLWLFV 5HWULHYHG -DQXDU\
IURPLSWHWWH%LR6\VVWHDPMDDNEDFVH RI :RUOG
'LSWHUD
&DUYDQ%R GH3DMQSR .H\ WR WKH DGXOWV RI WKH PRVW
FRPPRQ IRUHQV'LLISWISBKDKV RSPHYULQMDVLOHLUD
GH (QWRPRORJLD
ODULQ&LV &RQWULBDFQ RQ LPLQHNDQOOLSKRULGDH
OD \$UJHQWLQD 2SHUD /LOORDQD
3UDGR H &DVWUR & 6HUUDQR \$ 0DUWLQV 'D 6LOYD 3 *DUF-D 0'
&DUULRORI IRUHQVLF LQWHUHVW D VVWXG\ RI VHDVRQDO FRPPXQLW\
FRPSRVLWLRQ DQG VXFFHVVLRQ LQ /LVERQ 3RUWXJDO OHG 9HW (QWRPRO
<DQJ 67 .XUDKDVKL + 6KLDR 6>LHRM 7D.LHADQWR WKH EORZ
ZLWK D FKHFNOLVW RI UHFRUGHG VSHFLHV DQG WKH GHVFULSWLRQ RI D QHZ VSHFLHV
RI 3DUDGLFKRVLD 6HQLRU :KLWH 'LSWHUD &DOOLSKRULGDH =RRNH\W
<RXPH)WVL'RQLQ%NORQ&JXEUH)FIMW<WR &RUGRQ
HW DO)LWYHWSUHFRBDQDLSRQULGDH 'LSWHUD UHDUHG
IURP PDJJRW FROOHFWHG RQ UDW FDULRQV FRUSVH GXULQJ D IRUHQVLF
HQWRPRORJ\ H[SHULPHQW LQ WKHD RFDQGSXV RI WKH 8QLYHUVLW\ RI
&DPHURRQ ,QW - %LRVFLHQFHV
6]SLOD . H\LGHUQWLRFIDWRS HDQ DQG OHGLWHUUDQHDQ
EORZ~'LLISWHDQDOOLSKRULGDH