

5HJ 1R

&RGH 1R

1DPH

6HFRQG <HDU ± 0DUFK

7LPH +RXU
&RRO RII WLPH 0
3UHSDUDWRU\ 7LPH

3DUW ± ,,,
%, 2/2* <
0D[LPXP 6FRUHV

*HQHUDO ,QVWUXFWLRQV WR &DQGLGDWHV
 x 7KHUH LV D μ&RRO RII WLPH¶ RI PLQXWV LQ HDFK
 WKH ZULWILQJ RYUHPHDFK)XUWKHU WKHUH LV
 HQG RI WKH %RWDQ\ ([DPLQDWLRQ DQG EH
 ([DPLQDWLRQ
 x 8VH WKH μ&RRO RII WLPH¶ WR JHW IDPLOLDU ZLWK TX
 x 5HDG WKH LQVWUXFWLRQV FDUHIXOO\
 x 5HDG TXHVWLRQV FDUHIXOO\ EHIRUH DQVZHULQJ
 x &DOFXODWLRQV ILJXUHV DQG JUDSKV VKRXOG EH VK
 x 0DOD\DODP YHUVLRQ RI WKH TXHVWLRQV LV DOVR SU
 x *LYH HTXDWLRQV ZKHUHYHU QHFHVVDU\
 x (OHFWURQLF GHYLFHV H[FHSW QRQ SURJUDPPDEOH F
 ([DPLQDWLRQ +DOO

39%e8¿•9 Áh;• >(8#;'9¿?f4jÁ

x '9¿f9Š 6,-q9'D (;/>, ?*8n"9-; 6;?39'199D; 3:# <
 8)D >> o8-9.9h; í < 8># ?*8n"9 (:d-;?45 6;
 (:d #; j;s#9';;uD ,9'9,D #w8>/ ;t; Á 'q;s#9'8-
 '°;s#8"Dí E ?31 19Á ? 8%ejÁhD 2;#8?'8
 ,;•3.;,8-9 4- 39'9,- ' q8?'8 (8 9yí
 x <Á 8)D >> ? 8%ejÁ (.9 ->t 8'; q.jÁ 6<f#"
 > w8'; (?-8 9h; í
 x '9¿?f4jÁ ,;2;3'; —"8(<¿x 38-9h" í
 x q.jÁ 2;#;s#9'D;uD 8%ejÁ —"8(<¿x 38-9h" í
 x "hD <n0; Áì 9f#jÁì f 8); Áì s93 q.?(t/9Á #>
 o8-9.9h" í
 x ? 8%ejÁ ,0-81q90; '°9-9n;oD
 x 34e,;••0qD 6,38 ejÁ > 8 ;h" í
 x ?f(8f 8,; Á > w8'8 8q 8Àh;?0,/; Á 29> -;• .
 0 D?f 8"9 D (."3; (:d87819Á (?-8 9h;38¾ (8 9yí

3\$57 ± \$
 %27\$1<

0D[LPXP

6FRUHV

7LPH

&RRO RII WLPH

0L

, 4XHVWLRQV WR \$QVZHU \$OO TXHVWLRQV (DFK TX

6FRUHV

6HOHFW WKH GLVHVVH UHVLVWDQW YDULHW\ RI %K

D +LPJLUL

E 3DUEKDQL .UDQWL

F 3XVD *DXUDY

G 3XVD .RPDO

8QGHU XQIDYRXUDEOH FRQGLWLRQV PDQ\ JRRSODQ
 NQRZQ WR HQWHU D VWDJH RI VXVSHQG HG GHYHORS

,, 4XHVWLRQV WR \$QVZHU DQ\ HOHYHQ TXHVWLRQ

TXHVWLRQ FDUULHV

6FRUHV

u

6

2]RQH DFWV DV D VKLHOG IRU DEVRUELQJ XOWUDY

D 1DPH WKH UHJLRQ RI DWPRVSKHUH ZKHUH R]RQ

E :ULWH WKH XQLW XVHG WR PHDVXUH R]RQH OD

0DWFK WKH IRORZLQJ RUJDQLVPV WR WKHLU OLIH

\$	%
%XWWHU\IO\	D
&URZ	E
3DUURW	F
7RUWRLVH	G
	H

\HDUV

\HDUV

ZHHNV

\HDUV

\HDUV

7KH '1\$ IUDJPHQWV FDQ EH VHSDUDWHG XVLQJ JHO

D 1DPH WKH JHO XVHG LQ WKLV WHFKQLTXH

E :ULWH WKH QDPH RI WHFKQLTXH XVHG WR UHP

3\$57 ± \$
%27\$1<

0D[LPXP

6FRUHV

7LPH

&RRO RII WLPH

0L

, s; .o; ? 8%ejÁhD>,2;#; í 8?.8 ? 8%eÿ8;3:# í

?ÿ8¿6Du

;3> > 8 ;q9.9h;s 'j19À '9sD ,e<?n5¾ f*: 9 90<>
f(#9?.8&?459 ¿‡9k >3o-;> " '?,#D

D79 9.9

E(8¿*8'9 f 8r9

F(<6 E.3D

G(<6 ? 8,Á

f(#9 <0 687 .ej19À # 8 j190; ;1j190; o;3.;s
6<|8jD'; Á '95fD9-83•-9?0hD f(?349h;s;í E
3•-;> ?(>.rD"

,, ;3> > 8 ;q9.9h;s >#i90; (#9>'8sD ? 8%ejÁh
q.>,2;#; í 8?.8 ? 8%eÿ8;¿3:# ?ÿ8¿6Du

6<.e'9À'9sD.;s Áf 83-0,D9."j>1 309>k ;h;s

3 ,8-9 8?68½ (819 3¿q9h8/;oD

D 8?68½ 8">t ;s r..d (819" #D

E 8?68½ 1h8¾ (?-8 9h;s -<#D,D

? .; (9 ? ¿h;:39 1 3-;> :39# 803; #s9.9hs;

		*9
9f#40+	D	3¿5
8h	E	3¿5
#q	F	2D
,	G	3¿5
	H	3¿5

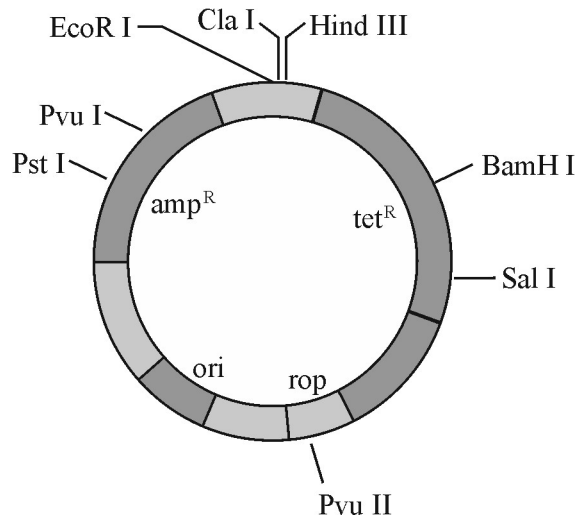
> À 0 D?f 8?)8/69699<5"j>1 ?3¿#9.9h83;s#8"D

D #9';?3o9 (?-8 9h;s > y9>¤ ?(>.2;#; í

Ef(±;# > y9À '9sD\$?3¿#9.9>k ;h8¾ (?-8 9h;s

68?i#9 39%e-;> ?(>.2;#; í

2EVHUYH WKH IROORZLQJ ILJXUH



D ,GHQWLI\ WKH ILJXUH

E :KDW GRHV URSHWL RUL GHQRWH "

6\QHUJLGV KDYH VSHFLDO FHOOXODU WKLFNHQLQJ
:ULWH WKH QDPH DQG IXQFWLRQ RI WKLV VWUXFWX

&RQWUROOHG EUHHGLQJ H[SHULPHQWV FDQ EH FD
:KDW DUH WKH DGYDQWDJHV RI WKLV SURFHVV "

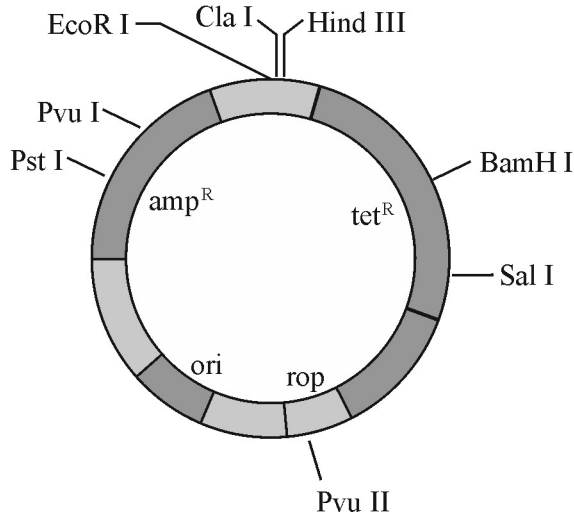
%LR IRUWLILFDWLRQ LV D SUDFWLFDO DSSURDFK V
IRXU VXFK FURSV UHOHDVHG E\ ,5,

7KH SURGXFWV RI HFRV\ VWHP SURFHVVHV DUH QD
DQ\ IRXU VXFK VHUYLEFHV

,Q ¶V 'HOKL UDQNHG IRXUWK DPRQJ WKH PRVW
DUH WKH SDUDOOHO VWHSV WDNHQ WR UHGXFH YHK

,QFUHDVH LQ WKH OHYHO RI JUHHQ KR XVH JDVHV O
FRQWUROOHG "

;3> > 8 ;q9.9h;s 9f# '9.:d9h;



D 9f# r8"s D#9.9k/9-; í

E f(±;# 9f#q9>Q⁵WHLW URS lsL9L3 R9b'
6< 9t9h;š;

69'¿ 9 ; 1;> >>,?f 8>>(08¿ f j19À 8">t ;s f(?#e #.
>6y;08¿ #9h'9 (/9;D ?(>.r"D#9>¤ &¿v>,"rD

=f#9, *: 6i0'q90<> '9-fr9# f*:(9:dDjÁ
' q;38¾ 68&9h; í #9>¤ ?,™ Á394% D8h;

,';5e.849-;> ?.8 e >,k>t ;q;38¾ # ;s .; f(8?-8
6,:(',8"D *?-8?)8¿n9)9?h5¾í\$5, (;/q9/h9-
q.q90;• '80D 391 1;> ?(>.2;#; í

386 3e3•-;> f(f 9--90<> o8 ;ssj>10, 386
3e3•8 ?63'jÁ sD 393d9h81;oD#i90; '80D 386
3e3•8 ?63'jÁ 2;#; í

19À ?08 q9>0 ,3; ,09': .9h>tn ' .j1;> (n9 -9À
'808 •8',8"DÀ79h;o8-9.;sí#D87'jÁ ,;?' ' o8 ;s
,09': ." # -;s#9';?3o9 6g: .9k ' (9 Á ">ry8

7.9# =7 38# j1;> &9 e ? 81#8('q9'D -8h;s;í
>#j>' '9-fr9h8"

*HQBWLFDQOO\ PRGLILHG SODQWV KDYH EHHQ XVH
 DGYDQWDJHV RI VXFK SODQWV

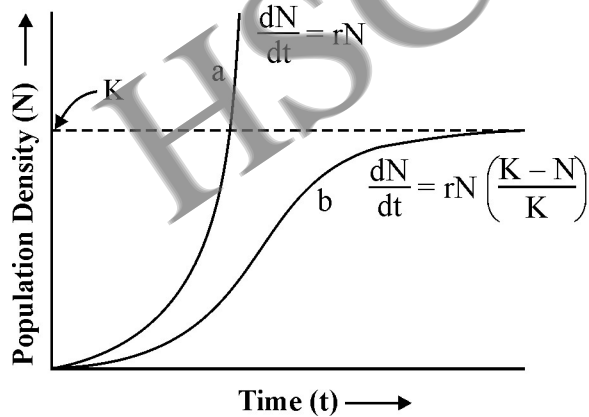
,Q \$PHULFDQ &RPSDQ\ (OLOLOO\ SURGXFHG KY
 GRZQ WKH PHWKRQ IROORZHG LQ WKLV WHFKQLTXH

3\UDPLG RI HQHUJ\ LV QHYHU EHHQ LQYHUWHG ZKV

,,, 4XHVWLRQV WR :ULWH DQ\ WZR IURP WKH IROO
 FDUULHV 6FRUHV u 6FRUH

OHORLGHJ\QH LQFRJQLWLD LV D QHPDWRGH SDUDV
 ,W¶V LQIHFWLRQ FDQ EH SUHYHQWHG E\ ELRWHFKQR
 D 1DPH WKH VWUDWHJ\ 6FRUH
 E ([SODLQ WKH SULQFLSOH EHKLQG WR RWUHWUDW

7KH IROORZLQJ JUDSK VKRZV WZR W\SHV RI SRSXO



D 1DPH WKH JURZWK FXUYHV 6FRUHV
 E :KDW GRHV μ ¶ VWDQG IRU " 6FRUH

,Q \$QJLRVSHUPV IHPDOH JDPHWRSK\WH LV NQRZQ
 GHYHORSFHQW

'9# ,8, 3.;q9- 66ejÁ (0 34ejÁh8-9 (?-8 9h;s;í
 j>' ,8, 3.;q9- 66ej1;> >#i90; ?'8T0DÁ 2;#; í

À ?,.9h¾ u'9-8- >>009y9 =f#9,,8-9 ¾6;09
 '9¿v9k;í u'9 30 *9k '9¿v8" .:#9 394%,8h; í

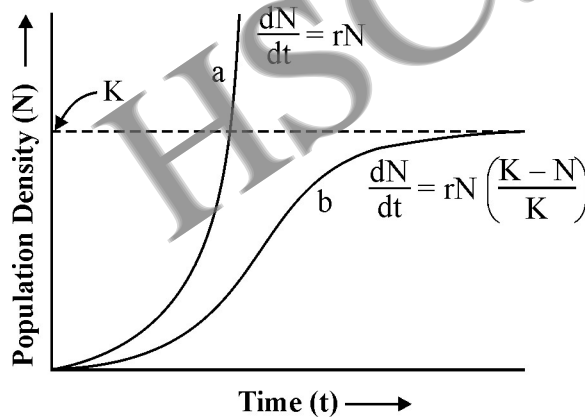
#0 :28- E¿‡ (9.,99D0; 68&e,yí r;>"8oD

,, ,;#À 3>. ? 8%ej19À >#i90; .>opq9>D2;#; í
 8?.8s9';?ÿ8¿ 3:# ?ÿ8¿6Du

(; -90>k 9-;> ?3.; >1 f ,9h;s .; '9,?//8 8"D
 >,?08 9>> >' ¾>98 eD E '9,>,8 9>α f ,">q
 > /;h;38¾ >> 3 68?i#9 39%e-90<‡ 68&9k9n;oD

D E 6fD8, 9-;> ?(>.2;#; í ?ÿ8¿
 E E 6fD8, 9-;> ##g 394%,8h; í ?ÿ8¿6D

;3> > 8 ;q9.9h;s f 8)9Á .oD #.q90;• ?(8t;?05¾ ?f
 ¿3; Á áD 3 '9.:d9h;



D?f 8qD ¿3; 1;> ?(>.2;#; í ?ÿ8¿6D
 E μr.9|>' 6< 9t9h;š; ?ÿ8¿

6(;5D(9 19À):>,-9Á 8,9>,8>>),9>' f*9D-868hD
 3919h;s;í E f*9?-868h9>α 3939& 31¿k8 n
 394%,8h; í

3\$57 ± %

=22/2* <

0D[LPXP

6FRUHV

7LPH

&RRO RII WLPH

0L

, \$QVZHU DOO TXHVWLRQV IURP (DFK TXHVWLRQ FDU

1DPH WKH FHOOV LQ WHVWHV ZKLFK V\QWKHVL]H D

'LIIHUHQW FRQWUDFHSWLYH PHWKRGV DUH JLYHQ E

D &X 7

E 6DKHOL

F 0XOWLORDG

G /LSSHV ORRS

([SUHVVHG VHTXHQFHV LQ WKH JHQH DUH FDOOHG

D ,QWURQV

E 0XWRQV

F ([RQV

G &LVWURQV

,, \$QVZHU DQ\ QLQH TXHVWLRQV IURP (DFK TXHVWLRQ

6FRUHV

,Q D FODVVURRP GLVFXVLRQ D VWXGHQW VDLG W

IDWKHU \$QDO\WH WKH VWDWHPHQW DQG JLYH UHDF

'LIIHUHQW FRQWUDFHSWLYH PHWKRGV DUH XVHG

6XPPDULVH WKH QDWXUDO PHWKRG DQG EDUULHU PH

'1\$ LV WLJKWO\ SDFNHG VWUXFWXUH DQG LV IRXQG

D ([SODLQ WKH FRQFHSW RI QXFOHRVRPHV

E 'LIIHUHQWLDWH EHWZHHQ HXFKURPDWLQ DQG K

3\$57 ± %

=22/2* <

0D[LPXP

6FRUHV

7LPH

&RRO RII WLPH

0L

, s; ,;#À ,<s; 3>. y8 ? 8%ejÁh; q.>,2;#; í 8?.8s9'
 8?.8 ?ÿ8¿ 3:# ?ÿ8¿6Du
 3=5"q9>0 ¾?f 8 '; Á (8%9t9h; -; —39t9h; -;
 > w;s ? 84j1;> ?(>.2;#; í

;3> > 8 ;q9.9h;s ¿+ '9?.8&' ,8¿...j19Á ,>tn#D
 >m ;h; í

D &X 7

E 6DKHOL

F 0XOWLORDG

G /LSSHV ORRS

:'; 19Á D(6DD > w;s 6g:h¾6; 1;>rD?(.D

D ,QWURQV

E 0XWRQV

F ([RQV

G &LVWURQV

,, ,;#À 3>. >#i90; ø ? 8%ej1ÁhD q.>,2;#ÿ8¿.o;
 3:# ?ÿ8¿6Du

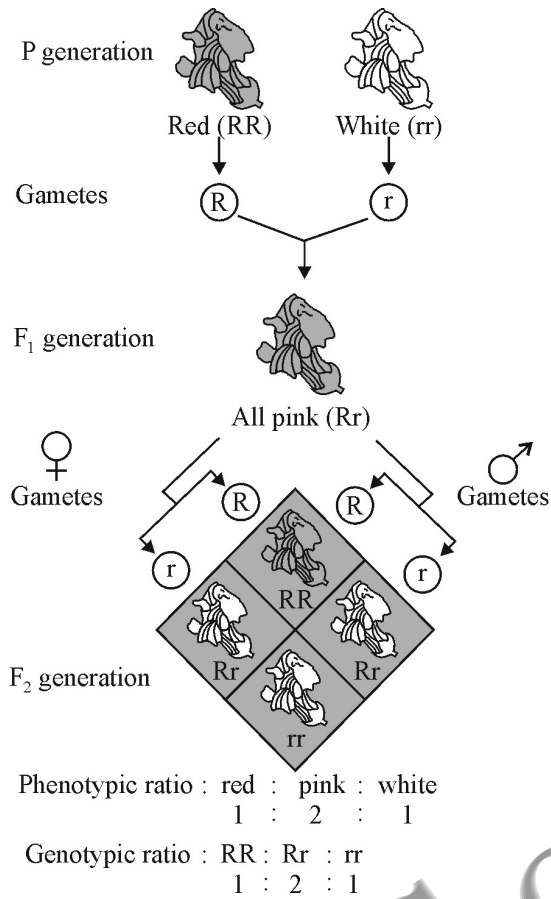
.; 39%e8¿•9/z86Dk-9Á .; ;m9>α 09 '9¿p-9h;s#
 (9#83D>"sD +9f(8->t ;s;í E f(±83' 394 0' > -μ;
 8."jÁ 2;#; í

'6 e8 396D?)8 ' '9-fr9h;s#9'D 3939& #. ¿+ '9'
 ,8¿...jÁ (?-8 9h;s;í ¿+ '9?.8&'q9';• '8k;/Á >,?q ;
 *8.9-¿ >,?q ; 394%: .9h; í

'1\$=! ,8-9 (8 D'e<z9?-8?68,; 18-9 8">t ;s;í

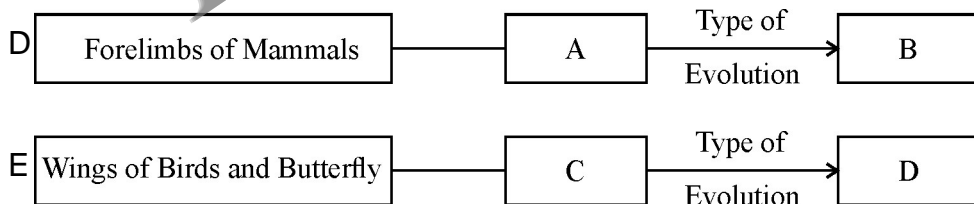
D'e<z9?-8?68 s 4- 394%: .9h;

E -<?f 8,8,9'; >7,?/8?f 8,8,9'; #v90;• 3e#e86 2;f



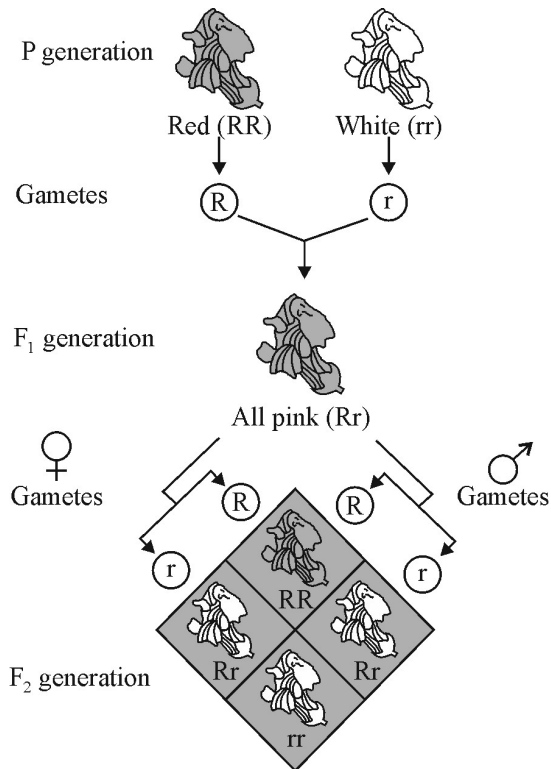
D 2EVHUYH WKH DERYH FURVV DQG QDPH WKH SK
E :ULWH GRZQ WKH WKHRUHWLFDQO\ JLYHQ H[SO

&RPSOHWH WKH ER[HV ZLWK WKH VXLWDEOH ZRUGV
>\$QDORJXV +RPRORJXV &RQYHUJHQW HYROXWLRQ



([SODLQ WKH IDFWRUV DIIHFWLQJ WKH +DUG\ :HLQ

,QQDWH LPPXQLW\ LV D QRQ VSHFLILF W\SH RI GH
EDUULHUV &DWHJRUL]H WKH EDUULHUV DQG JLYH R



Phenotypic ratio : red : pink : white
1 : 2 : 1

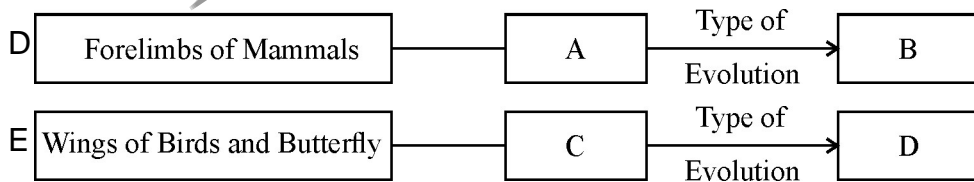
Genotypic ratio : RR : Rr : rr
1 : 2 : 1

D, ; 19À > 8 ; q9n; • 6i." '9.:d9k; #D f(#9+86 s 2;#; í

E E f(#9+86q9'; • >>6r8r9 394%: ."jÁ 2;#; í

#8>2 > 8 ; q9.9h;s3-9À '9#D8- 38h; Á (?-8 9k; ? 81jÁ (<.9t9h;

>\$QDORJXV +RPRORJXV &RQYHUJHQW HYROXWLRQ



78 ¿ -> 3-9¾ * ¿ ... D e;09f*9->q *8&9h;s jÁ 394%: .9h; í

67 ,8- f(#9?.8&?459 s ?'819)9D - f(#9?.8& ,8¿ ... ì '80;#. *8.9-/-; Á ,;? f'(-3¿"09h;s#D E *8.9-/-; >1 %87." 679# 3¿ ...: .9h; í

&RPSOHWH WKH WDEOH JLYHQ EHORZ

&ROXPQ ± ,	&ROXPQ ± , ,	&ROXPQ ± , , ,
7\SKRLG	_____	6WRPDFK SDLQ \$,QWHVWLQDO SHUIRUDWLRQ
_____%	5KLQRYLUXV	6RUH WKURDW KRDUVHQ
0DOLJQDQW_0DODUL	DKLOO KL&K IHYHU	
_____'	:XFKHU&KULP	QLF LQIODPPDWLRQ RI O\

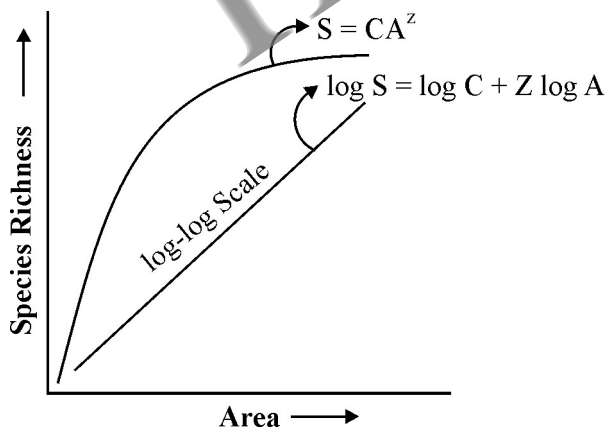
&RQVXPSWLRQ RI GUXJ DQG DOFKRKRO DIIHFWV WKH
YHU\ EDGO\ /LVW WKH ZDUQLQJ VLJQV RI DOFKRKRO

,GHQWLI\ WKH GLVDGYDQWDJHV RI 51\$ RYHU '1\$ DV

&RPSOHWH WKH WDEOH ZLWK DSSURSULDWH WHUPV

2UJDQLVP	6FLHQWLILF QDPH	%LRDF
)XQJXV	_____ \$	&LWULF DFLG
_____%	\$FWREDFWHU DFHWL	\$FWL
)XQJXV	7ULFKRGHUPD SRO\VSRUXP	
<HDVW	_____ '	6WDWLQ

, , , \$QVZHU DQ\ WKUHH IURP TXHVWLRQV (DFK TXHVWLRQ
6FRUHV



2EVHUYH WKH JUDSK DQG DQVZHU WKH IROORZLQJ
D 1DPH 6 \$ = DQG & LQ WKH JUDSK 6FRUHV
E 1DPH WKH VFLHQWLIVWV ZKR H[SOD6QRGH6SHFL

#8 > 2 #s9.9h;s (n9 (<¿q: .9h;

&ROXPQ ± ,	&ROXPQ ± , ,	&ROXPQ ± , , ,
7\SKRLG	_____	6WRPDFK SDLQ \$, ,QWHVWLQDO SHUIRUDWLRQ
_____%	5KLQRY	6BXM WKURDW KRDUVHQQHV
0DOLJQDQW_0DODUL	0DKLOO KL&K IHYHU	
_____'	:XFKHUR	6KULRQLF LQIODPPDWLRQ RI O\P

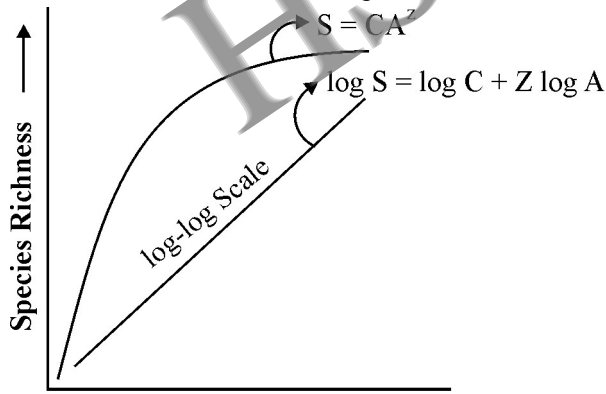
, %eq9>α-; , -h; ,.;s9>α-; (?-8 .; 3e^9-; > 48...9
 ,8'69 3; ,8- ? .8 e>q ? ,84,8-9 *8&9h;s;í , %eq9>α-
 , -h; ,.;s9>α-; %;.; (?-8 q9>α (8- 6< ' Á 09#D
 '9# 3±; s '90-9Á 69í ¾í í>- ?(d9k; ¿í ¾í í
 -; • ?(8.8-Á 394%: .9h; í

9# ,8- 38h; Á (?-8(00D (<¿q: .9h;

2UJDQLVP	6FLHQWLILF QDPH	%LRDF
)XQJXV	_____ \$	&LWULF DFLG
_____%	\$FHWREDFWHU	DFHWL \$FHW
)XQJXV	7ULFKRGHUPD	SRO\VSRUXP
<HDVW	_____'	6WDWLQ

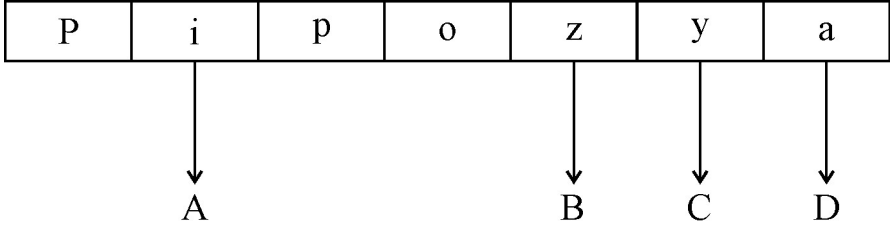
...

,;#Á 3>.-;11 ? 8%ej19Á >#i90; ,;>spq9'
 q.> ,2;#; í ,;s;ÿ8¿ 3:# ?ÿ8¿6Du



f 8)D9.:d9k;B> > 8 ;q9.9h;s ? 8%ej.ÁhD;#;
 Df 8)9>0 \$ = s&3 r9>' f(#9'9&: .9h;s; >s2;#; í
 ?ÿ8¿6D
 E6D:5e6D9- /9?05¾590D%: .9k 48f±œ>α ?(>.2;#; í
 ?ÿ8¿

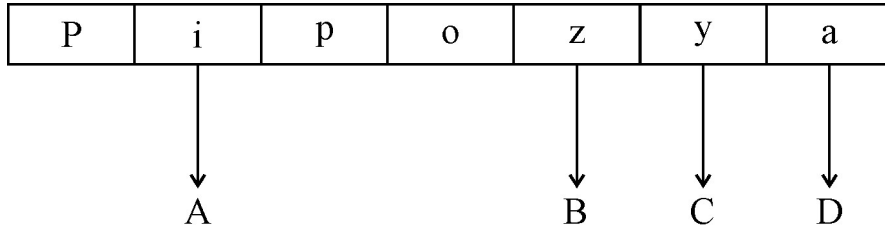
D ,Q ODF 2SHURQ ODFWRVH DFW DV LQGXFHU P
 H[SODLQ LW 6FRUH
 E 2EVHUYH WKH GLDJUDP RI ODF 2SHURQ DQG LGR
 6FRUHV



6H[XDOO\ WUDQVPLWWHG GLVHDVH 67' DUH PDLQQ
 D 1DPH DQ\ WZR H[DPSON RI VH[XDOO\ WUBQVPLV
 E ([SODLQ DQ\ WZR PHWKRGV DGRSW\GRWRV SUHY
 +HDPRSKLOLD 6LFNOH FHOO DQHPLD DQG 3KHQ\O
 D :KDW GR \RX PHDQ E\ OHQGHOLDQ 6LFRRUJHU "
 E :KLFK RQH RI WKH DERYH LV DQ H[DPSON RI
 OHQWLRQ WKH FDXVH RI WKH GLVRUG\FRUV

BBBBBBBBBBBBBB

D08 D8(?/8"9À 088D ?f(. #™8f# -9 f(3¿q9h;s;í
 E f(±83' 390-9.;q9 394%: .9h; í ?ÿ8¿
 E08 D(?/8"9>¤ ? . 8 9f# '\$.:%9kD3' rD sD
 2;#; í ?ÿ8¿6D



>>0 9 'e?.8 jÁ f(&8',8-; >>0 9 *Žq90<> "D
 (.;s#Dí

D>>0 9 'e?.8 jÁh; .oD %87." 2;#; ?ÿ8¿
 E>>0 9 'e?.8 jÁ # -;s#9'; >> > 8?•o .oD
 ,8¿...jÁ 2;#; í ?ÿ8¿6D

7:?,8):09-ì 69h9Á>6À ' : ,9-ì)9'-9À 9?,8'</9- s9
 >,¾? 09-¾ 9?68¿ /; Á "Dí
 D>,¾? 09-¾ 9?68¿ ¿ s8Á" rD ?ÿ8¿
 E,; 19À #s9.9h;s 89;6D; 19À #8"¤? *8½ /¿
 ¾ >, ,? *8196" E 9?68¿ ¿ o8 8';• 8."
 394%: .9h; í ?ÿ8¿6D

BBBBBBBBBBBBBB

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