

中國科學報

CHINA SCIENCE DAILY

67%&83P 67%&' QK2 7FGHI JK2LM CN11N0084 OM1N82



34567%&8 679: 8 7; <=%&?>@AB 67%&CDEB

) * 8670 + 2025, 1- 10. /+O 1. 42

RSTU <http://weibo.com/kexuebao>

%& (www.sciencenet.cn

! "# \$ % & ' () * +

V' WX YZ [

2021! "#\$%&'()*+,-./0
123456789:;<=>?@AB
CDEFG;<=>B#H J67KL: MN
;<=>B@AOPQRSTU1VW
X89Y1Z[\$]^_`ab
cdTefghYn6.*ij8klmcdT
enop1%&'qrsctu\$w\wx1
yz{|}~/.!ct{u!w
3!"\$2025!1#9\$%&^yz{|}
-/!1300'()*+,-./O+,KL
-/O12/\$3456789:W;-./
O<=>?@ABCDEF GHIJ
-K5L1300'(z)*+,-./OW
-/OM^NE-.OPNNQ/?O
PRSM\$NOF)*TUVWXYZ`
[\$NEFR] ^_`E1abW-
c\$ieDL/?f{|}) *g90\h})ij
.c\$keD\}|UVI mn/?W
{NQopqr\$NEopnsWtF%&
uvyz{|}~/.!*"wxcyh1Bz\$
:NE}b1J2{LFop|\-./Ons
1}qSMW!



!"#\$%&'()*+,-



./0123456789:;<=>? -
YZ[\n

QR1STU{gh2c}b\$V)*+|-
./O\$2/. /m}g300'(-~!
PQR! \$q6! ci t"" MRM1
m#i *ctn\$1kf-[W
1995! \$PQR%6789: `9&'(
)\$+'9\$0=1999!,-+7./}h9
NOKL1M9<W28" \$M3g;<=>B
KX\$^;B'9471f<1MW
u+7`9c\$PQR25\$+7167
89-[:6\$ c60<\}b\$@=c\$g
7>! ?]b-[:KqcW37" \$M@A
t!\ 2{BNEm|4\$ 27}WCD
EFGH^g7}^1NOI HJK-}\$
PQRLF MNvOP\$-7QNCNE|
bW2007! \$MyR1S2mnt50"" T
U'V-}:345WX} \$^YZf?N
E}b-}:W
-[%&'123" \$PQR\cn}WM^
-\$\}b`amc60%bcd12-|4W

defghgei !
X^;<=>B18@m#\$PQRm#
y\$e1_F>?Nf\$ghij;<Rkc
L1DEW
DEF>?@mnzC\$ABCpDwt
?K8EC1NEcqf\^W=}X6r \$
t!u%yG^DE" !W

] ^LDvc4J_w" \$k`E! \ \ |
yWtF-27}N*+}|1#? z!W
{ }b{FKF|A}~1\$eD %E!
1)"\$#}bLc\$%N. . \$ &A5'
(\$eD)*+D,--\$H. . %N' (\$e#
H'd/Oe\$Eq112-2: W!PQRm
#nON <=>B@AO345r W
&=[DE1t<\$PQRm#E678
jktDE4Y}^r100F\}b19: \$
O;6<=A10\>y%?1}bW
{ghc3\<=@A"" BpUM 2UN
eLUW! [=] b<=CD\$345Ei YF\$
{ }bH. . G\$HAI) J" abx%KL\$
vH. . w\$HANK) *Tm{ M} bN] 1
OhND?iab. PQ1}m}g! pQRS
T[12U!Rc\$! TLm}g60%bcd\$
HAUKHtV8mW1/O. ?W!
t=@A\$ \$PQRm#*`20F! XY
A1*P\$Mh3ufZ[67YCDW 7. \
{Bc1}b=^\$Kfghm#v1W!345
r\$^*`a7. QbKLccyJ1}b\$M
h`Jder \$fR -Dgh!W
hi j Lt! \ \$PQRm#_&=NO
kl i m\$AtRo1e: U@Apq\$6
grt10\}b1T1stWyu\$V8v=t
R\wj xyNz w500d{ | 1}b\$ \}
yhi c40%bcd\$! \ }yc20F%b
cdW jkl *22m

d6efghi j
klmnop=*qrkrs

V' zj WX-. m6789kfh9
g*h: MN " hj KN m' j kZXYX
zuyN@NUN; <OP6\$ { oyg [^y
^Zt! +pUNmq\$R Ot [^1
ssMy^1; R\$ntu11BUW #8
\$Zl nl 2L= \$? -m89dWTU
vwGxy+wKXF{ UN; <z/1{
|n_!W
QG} 30! p\$89Yu~ 625t
y^5! \$^7t@! \G} DxGh[Z
" oUN5! 1-Y\$[UNF1m8&
#W\$@ATc3m189%&Wy^5!
@Av^7t' En{ N=(nTZSs
kf12%\$ UN; <NUNP_RZl z
/2%@4t3mKTWRc\$HbV" 1U
Nkckf^)++b" oUN5! 61*
om8T (@4t3m1[WR++1@A
: #W
NG) R\$89Yu8TQ@At [^
y^1`2|X|, 1y^1HR\$ ^y^
Z62uR\Z [^71y^1\$dhMD
oH^ ARB1- NsnIRN\$H1-
NxZ [^7\$15Ay^U!RNZ [^7
1\$H^J42u. /1l Z4-y-N^

^O\$+| 1QOH2u^7U\$F\$N
1Btu1Wo=[^y^q1([]m2
S1sR\$Zoy]mT [x@N\$HeM
31yU. ?\$t=kfv812u4- +
by^UXtuU; 21+pmq! , w%
OPrOW
@! x\$yn@NUN; <Y1A5^
oy [^y^Z@4t+[WW; KX6\$
@Am#`P([, >4S51s6-\$
H1BZRq\$O+A2kcRN\$H@N
1Z7XL\$1OtX8A^ [^y^ZV
4L; m#J21T [x@N\$HeM31
UN] 1L*9kf\$Mh25 [^y^Z
RN\$H1- Ni: Hmh! Fy- Ni 1
: H; ?EkW; 5! r&RN\$H1@N
u/- Q2u- Ni: HMI ZW5! o1
c4(: yUL+\$RN\$H42u, JO
[^y^Z<i \$B [^y^Z1I JO
PrmW) *~y1O6@NJ41pL\$
HI Z\$; @A=POP1sRS=12>
dJ\$U\$t^ [^y^Z1Wh@4t3
m1Ss%?W
! " # \$ % &
<https://doi.org/10.1038/s41567-024-02732-5>

VWXYZ [\] ^ _ ` # abc

V' zj \$%&'() WX*+, m7Y
[\6q@Am#) * [-] [^ : _ 9
5: OPM' \$25a2U] [bQMcd\$
!eGf1g_ -B\$hVI Wt! i _; 4
1!m[-1] [j ck9@At+v8W1
#8\$Z! @An! 2L= [\hm9X
n9dW
] [* % : ^Ompqr! Gf1i
_ \$ @ \$ @Am#) * M' GH=hst7
u [\ @ATS GLOBOCAN 2022 i: D
pluhZ [\ 2_/^2003" 2017v1PP
im\$25t! Bw3u2h3mxmW@A
L&\$CD-1] [y12_/b5EGc
d\$! egzi U{uVI \$#_900\
T] } UW
T1@-\$u 2013" 2017! G4\$ h{
YN" uYN#%\$! ef16\$&' []
2_/9cBQMwu(N { N } *NB7N
, R+7\$0- DE" U12_/vb5Vp
cdW@AGOH^ \$ NmAX! e! p1
h. c4R/O12xm13Z! WuH4/

O126\$] /ONFR65(R6(O
7\$Dp8! R6H9KF3m1: _; W
+h\$=-/1QMvVI t! eGf1g_
-BW
; -12_M" x>\$@AL&?YNf
@F] [! 2f \$2021 YZ+2_ARBC
_AMDE-1yi 153.8R48.2%vE.
XFVGH! JBKc! Wi mL+\$ 90%
1, MV] [KNAFVGH! JBKW
uUDOPcK\$@A25Qnf &U1
2_/RBC/9! =! UwtE. X&Uf
16v! 1QR/R/S/cl W
TUXzN67n989: VWN: @A
OX%YL+[a2U] [1VI H. F!
\nz>9\$F! N-1 U [] TW@A
GO" k\$ W\$] ^ [! eGf(phV1
Dj k9\$ " ! " aG<l R_D\$G\$`
Gab/\$cgzD" \$Ode-l nZO
P1efW
! " # \$ % & <https://doi.org/10.20892/j.issn.2095-3941.2024.0159>

科学时评

Ktuvwxyz * yz { Q AI 7 } — !"#\$%&'(")*%&,-

/O1
'()*+,-.68/O1234
5678.9:;<=>?@ABCDE
F. G. \$%HI JKLMNOPQRS
T. UVWXY=ZH[9\]: ^_P
`Uabcde. fgh: ijklm.
nop3q\rN; t:uVWXi vw
`xy=z{|}~! " #AIGC\$%
&'(WXN
WX) *+, -BC. /O111
2, G. 345: 67. /k, G89
: H- ; =z{|#AI\$- : s<=
k7>F?@AST. BW: CDEF
- F- AIN
\$GRHI JrfghK9LM. 7
8NNOPQ' (WXRSTU@AIG
Y@ABCWXH(YZ. \$%[\] ^
F_`aNK AIGCbc, d. ep:fg
hi' (WX. jkl wmr nopqr
stN

UKGuHI !I. i t: R\] WX
'JRAI-} N
s` : | AI \] ' (\$ % ' (k
\K*+N+f:%&. 4Lr O1ML
<Nh:; YnO>y. AI \] A)
| PDQ. &(R " , dS) T: ? A
) \ . U>YGV=\$WRXYZy
[\] R^h! _ : a, aA) b |
\ , cd) . ' (\$ % : ef=yR
8gl _ : e | & (. O1X) X<
Nh: ;] yXYhi . A) efhi
D) . j kN
\\78c59: F; <=
fF#wl :y! "OOV(kU)
. m [I : Rno AI - } . \$%pHw.
\$%qr: e" `s, AIGC. tu: 1`
v@ABCDE: wxyz O{ | }
) Q-HVQ- ! V | } #F_R
>y. \$fN
2023112: y" 7%Altup&
() * +, - z - . / " | } " UAI
! " O, 12: tf: RAI - } ~ 3_
X456NU7y8NyH! ? A) -
} ~ : aRG>?<9f: * N
20241192: " 7\$<=>? = z
{ | - } @ ~ ! <f #A-BC
D\$E: _F@G2OA-BCN#P: I
EF: ; AI - } @ . ~ H3_I L
! N
s } | u) 9f: Y@nAI - }
. \$%QG(JHV 4LTKNU9
_ : u) @) C\LMNO. fPQR
5: / " F_STYR/U9_ : e" `
WX1`45: ~ wRGI U= _z N
OVW. ! \$% [XYZ [h: 1 J
i \] N<=Oj ^ _ p. fghV.
WX: X`kU=TK? { Pi \ OH
! ! N
k`az): D) @GP: R | ' (
u) b<+Hwu%: k! " FOO%V
R\K: si cUd\$%Sme) X
W) fg. @G] W: h<: , * cl i
\$. Hwl CRj kN, Gae" `
l , 1`m, : whk`n\$%`JR
AI-} @} N
opX) @ABCF: , yy) *
nq~?! " e) . ~ : 9mr \$r N
j >X? @AB&CDE%&CD&
8FGM

@ABCDEFGHI JKLMNOPQ

V' zj WX} -m#7\$9c5M\$-
\$! ACp\$N2h68zN" W1#7\$`8
\$ \$ - \$ \$ f D \$ D \$ k & \$ 67' |
K8! mcdTeCDEFG6' K8H\$O@
(1Y) -2HD\$*+, , GTJ: - \$)
*R{ . *p\$N" " 6f/5: -K+9
O1\$2B*3KX@4t5Oc?1UKW
mt<\$N" +f<= ! @! 6Nf\$ 6
10Tr, 7. 89 : i 4471d\$T;)) `
<Zv=8@NfV^=>\$SMNfGOBD
?@O1W
u! : N 6NN\$NAZBCD\$*3
%?E\$Y) -2HD\$*+, , GT) *D8
1E/ [RynFGH} ZhL) *89\$N
. O1gF\I J+9st\$ghKLMN9
: NGO%-<N*3) P- 1" QDpNK
*3?U1OcM" WuR4S. TR%?E\$
, GTRL. @4Bp1hHUSRi m\$O5
[+f1FVWO1\$X) +9YZ1{y" !
TriW



@A-2HRSTGUBCD-

6 9! " #

o 7 / p q r s * t u v w x y



V' z +7. | -YkfTeCSpaceXH
Nc41#8\$! " \$#\$f=EFJ%Z
&{ ' () * W+{ } * , -c" ! F5: t
! O. \ + { block2l/Nf { OK \$1 F #
! 2? f { O53N4L\$ F5' u. | S
6c789"" 10: ; <=#W
{ \$#! Fc>Dxy" h1?@J! W

SpaceX 1xCF4Zn^! Ne6A3N4L1
(: Y\$Bfh, c789C6DpEF" GH
3NI \$Oukc. J: E! { 2K} *W
SpaceXL +\$Mz { # \$! 1 / N' [
{ Ou3+ P! "" | @Q [t 30 F \ RS
^N5TQ8U@Mt 25%N 1! RVI t
3!dNB+p<t WXYZWdLf { Z [t
%NK2K [, B] 1R^/N1S? \$m
2O53N4L \$FsHea1W
+ { \$SpaceX_ { # \$! 1 QKz. a56
. | \$? ") - 3bh} | \$O%cdHueR
fW@g+Jh1! z) ^YAb32KY\$2
K [Ti j uk | 6fZ \ , WEI n. \$f F

SpaceX z1 { O5 mNn? @! W
t { 2KLopt SpaceX 1! ? +1r
Lq"" { # \$! 2? f f { %3N4LW #
\$! y3,) ^Y1 33! rs2761! I
tL=zu{ ' () * WvFwx; ! ! { }
(^Y) - b31y' \$ + \$ { F; Tef {
cTx [2? 5: 3N4LW
+W1' () * \$ # \$! Kqcz (c
789\$@z & { ' () * 6dff { S6
10: ; <=#Wt =; <=#1hkR3U
X SpaceX Bf ^A1E! p# { =#Z | \$
{ uy' { # \$! f c789) - C6DpE
F1. ?W j { | m