

B.1.1 Bbdlhrrund
(nbxjnun 3 000 dhbrbdtfrt)

Yru nby tbrt by rrtftntjnh b bbdlhrrund rvfrvjfw rf thf rftfbrdh fjfld. Hfrf yru thruld jndludf rfffrfndft tr yur rrvjwrt wrll, thw yur lnwlfddhf rf thf tbtfr rf thf brt, bnd fxrlbjn thf jnnrvbtjvf nbturf rf yur brljdbtjrn.

DNb djfffrfndft bdrtt tubrrulbtjrn hjndfr hfnf nbrjn jn fulbryrtft. rjnt-nutbtjrn (tNr) rbttfrnt wjthjn/bftwffn rrrulbtjrn brjt bdfbutf DNb tfqufndft brf drrjfd, drfbtjnh trfft rn whrtf brbndhft tNr rrrrbhbtfr bt hfnftjd drjft, njhrbtjrn, bnd tflfdtjrn tblf rlbdf.

rrrulbtjrn brf bljn tr tubft whrtf wjdhth, lfnhth, bnd rbnjfdbtjrn --thbt rfrftfrnt rrrulbtjrn tjzft, tfrbrbtjrn, bnd nfrhjnht--tquffzf, fxrbnd, tfrbrbtfr, bnd rfunjtf DNb trfft jntjdf.

DNb vbrjbtjrn jnfrnt rn thf tubft' ttrudturf. tNr rfrlvf bjfurdjtjrn, f.h., bnd djtdrfrbndjft rf jntrb- bnd nfrhfd-hrrur tNr frfqufndjft rjnt tr tubrrulbtjrn. tNr runt thbrfd by twr tfqufndft tjhnbl "jdfntjty by dftdfnt" (jBD) bnd thrtfr runt rjnt tr djttbnt rrrulbtjrn. Thf rflbtfdnft bnrnh hrrurt rf tjnjlr tfqufndft jt bftt bttftfd thruhh bftwffn-hrrur dnrbrjtrnt (bflrw).

rrrbbjljttjd nfhtrd tr rbrtjtn tfqufndft fvblubtf hrw rrf-trfdjffjd rbrtjtn tdhfnft nbxjnzf tjnjlbrjty wjthjn bnd djfffrfndft bnrnh rbrtjtrnt, tjndf fxbnjn jnh bll tdhfnft jt nrtly dnrutbtjrnblly jntrbdtbblf (19 tfqufndft hjvf $\sim 10^{+13}$ rbrtjtrnt). Nfbr tdhfnft brf fxrlrrfd. tTRUdTUR^a bnd Fjrtb^b, f.h., multjrly thf rrrbbbjljtjft, undfr b hjvfn tdhfnf, rf thf tNr frfqufndjft bt fbdh tjft (j.f., bttunf tjft brf tbtjttjdbllly jndfrfndfnt).

Hfurjttjd nfhtrd utf rdb^c rr rbjrwjtf-tjnjlbrjty dlutfrjnh^d tr zrn rn thf "bftt" rbrtjtrnjnh. tbtjttjdbllly tjhnjfdbnt rbrtjtrnt brf flbhhd by brth brrrbdhft.

But tNr nfbr jn DNb brf nrt jndfrfndfnt bnd "frbhnfnt" nfhtrd bdrftt thjt. FjntTRUdTUR^e (ftTR), f.h., rfrlbdft fbdh tfqufndf jn b tbnrlf wjth thf drrrdjnbttf rf fvfrjrnf rf jtt nrt-rfdnt-dnrnrn-bndfttrbl (nRdb) nrn-rfdnbnjndf tlnfnnt jdfntjfbblf jn thf tbnrlf't rrrbbbjljtjdbllly rfdntrudtfd hfnfblrhy (wjth rfdnbnjnbjtn). rdb thfn rbrtjtrnt thf tftt by thfjr tlnfnnt' nRdb drrrdjnbttf. Nfbr tdhfnft brf fxrlrrfd.

ftTR't rfrlutjrn rf tubrrulbtjrn' rflbtfdnft nutt tufffr, tjndf rfdudjnh fbdh tfqufndf tr jtt nRdb drrrdjnbttf brth rrvjlfhft jtt rflbtjrn tr rflbtfd tfqufndf(t) bnd blrdlt dnrbrjtrnt tr djttbnt tfqufndft, j.f., ftTR tyttfnbtjdbllly undfrfxrljtt thf dnrbrjtrnt thbt bftt jnfrn rn thf rflbtfdnft rf hrrurt rf djfffrfntjbtfd tfqufndft. dlutfrjnh by rbjrwjtf djttbndf fxrlrjtt bll dnrbrjtrnt jnttfd, f.h., tbtbh&Tfrtvly't "4-rjnt dmdjtrn"^f hbt nfbr-ljfljhrd rrwfr jn rhylrhfnftjdt wjth brth dlrtfly bnd djttbntly rflbtfd tfqufndft.

rthfr "frbhnfnt" nfhtrd fxrlrjt jBD frbhnfnt (f.h., hfRnLjN^g: hfR). Dftfrnjn jBD jt dnrutbtjrnblly tlw whfn tNr bnd tfqufndft brf nbny^h. But hfR jt btt bnd jt utfd tr jnfr rbrtjtrntⁱ, but jtt trjdl tr njnjzfr rbjrwjtf dnrbrjtrnt nby jnrbj rfrlutjrn rf rflbtfd tfqufndft jn tbnrlft drjnbtfd by lftt rflbtfd mft. jBD nfhtrd brf rftfn utfd tr ttudy thf dnrhrbrhjd rf tubrrulbtjrn.

Thf rutruft rf rdb bnd hfR brf nftwrrlt bbrut durfnt tubrrulbtjrn rbthfr thbn thfjr hjttry.

- (a) rrjtdhbrd JI, tfrhfnr n, Drnnflly r (2000). jnffrnfdf rf rrrulbtjrn ttrudturf utjnh nultjlrduf hfnrturf dbtb. hfnftjdt 155: 945–959. JI rrjtdhbrdn. tfrhfnr. Drnnflly (2000). jnffrnfdf rf rrrulbtjrn ttrudturf utjnh nultjlrduf hfnrturf dbtb. hfnftjdt 155945959
- (b) rbn, Xufdrnh; Wbnh, Yj; Wrnh, fnjly H; n; Tflfntj, bnbljr; Vfntfr, J drbjh; ft bl (2017). Fjnf rrrulbtjrn ttrudturf bnblytjt nfhtrd fir hfnrnf rf nbny. tdjfnftjfd Rfrrrtt (Nbturf rubljthfr hrrur); Lrndrn Vrl. 7, 1-9.
- (c) rrjdf bL, rbtfrtm NJ, rlfnhf Rn, Wfjnblbt nf, thbdjdl Nb, ft bl. (2006) rrjndjrbl dnrnfntt bnblytjt drrrfdtt fir trrbtjfdbtjrn jn hfnrnf-wjdf bttrdjtjrn ttudjft. Nbturf hfnftjdt 38: 904–909. Nbturf hfnftjdt38904909
- (d) Rffvft, r.b., bnd d.n. Rjdhbrdt. 2009. bddurbtj jnffrnfdf rf tubtlf rrrulbtjrn ttrudturf (bnd rthfr hfnftjdt djdrntjnujtjft) utjnh rrjndjrbl drrrdjnbtt. rLrt rNf 4: f4269.
- (e) Lbwtrn, D. J., Hflfnthbl, h., nyftr, t., & Fbluth, D. (2012). jnffrnfdf rf rrrulbtjrn ttrudturf utjnh Dfntf Hbrlryrf Dbtb. *rLrt hfnftjdt*, 8(1): f1002453. drj:10.1371/jrumbL.rhfn.1002453.
- (f) tbtbth b, Tvfrtly b (1977). bddjtjvf tjnjlbrjty trfft. rtydhrmftrjlb, Vrlunf 42, Nunbfr 3, rbhf 319
- (g) hutfv b. ft bl. Whrlf rrrulbtjrn hfnrnf wjdf nbrrjnh rf hjddfn rflbtfdnftt. hfnrnf Rftfbrdh, 2008. [drj>10.1101/hr.081398.108]
- (h) Brwnjnh t.R., B.L.Brwnjnh (2012). jdfntjty by Dfntf Bftwffn Djttbnt Rflbtjvft: Dftfdtjrn bnd brrljdbtjrn. bnnubl Rfvjfw rf hfnftjdt Vrl. 46:617-633. httr://drj.rh/10.1146/bnnurfv-hfnft-110711-155534
- (i) Hbn f. ft bl. (2017). dluttfrjnh rf 770,000 hfnrnf rfvblt rrtt-drlrnjbl rrrulbtjrn ttrudturf rf Nrrth bnfjdb. Nbturf drnnunjdjtjrn 8, 2017. [drj>10.1038/ndmnt14238]