

# Signalling architectures can prevent cancer evolution

## ■ One Dimensional Models

### Non-Cumulative Analytical Model

$$P1[b\_ , c\_ , NT\_ , R\_ , L\_ ] := \frac{1}{1 + \sum_{j=1}^{NT-1} \prod_{NS=1}^j \begin{cases} \left( \frac{(1+b)}{(1+b-c)} \right) & L \leq R \\ \left( \frac{L+b R}{L (1+b-c)} \right) & L > R \end{cases}}$$

### Non-Cumulative Model

```
NonCumFun[b_, c_, NT_, R_, L_, s_] := (  
  (**Vector Construction***)  
  q1 = ConstantArray[0, NT];  
  Arf = Range[Length[q1]];  
  rf = Round[Mean[Arf]];  
  res1 = Range[s];  
  fw = (rf - Round[Mean[res1]]) + res1;  
  ru = # -> 1 & /@ fw;  
  Ve = ReplacePart[q1, ru];  
  
  (**Effect of R***)  
  
  Rvec = # + Table[i, {i, -R, R}] &;  
  joi = Tally[Flatten[Rvec /@ Flatten[Position[Ve, 1]]]];  
  FitVe = Ve /. {0 -> 1, 1 -> 1 - c};  
  RPosB = joi[[#]] & /@  
    (Flatten[Position[(Length[Ve] >= # >= 1) & /@ (#[[1]] & /@ joi), True]]);  
  Roro = #[[1]] & /@ RPosB;  
  hk = ConstantArray[0, Length[Ve]];  
  con = ConstantArray[b, Length[Roro]];  
  repl =  
    (#[[1]] -> #[[2]] &) /@ ({Roro[[#]], con[[#]]} & /@ Range[Length[Roro]]);  
  bene = ReplacePart[hk, repl];
```

```

FV = FitVe + bene;

(**Effect of L**)

jokk2 = Select[DeleteDuplicates[Join[First[Flatten[Position[Ve, 1]]] +
    Table[i, {i, -L, L}], Last[Flatten[Position[Ve, 1]]] +
    Table[i, {i, -L, L}]]], Length[Ve] ≥ # > 0 &];
sPos = Intersection[Flatten[Position[Ve, 1]], jokk2];
cPos = Complement[jokk2, sPos];
PPlus1 = Total[FV[ [#]] & /@ sPos] /
    (Total[FV[ [#]] & /@ sPos] + Total[FV[ [#]] & /@ cPos]);
PMinus1 = Total[FV[ [#]] & /@ cPos] /
    (Total[FV[ [#]] & /@ sPos] + Total[FV[ [#]] & /@ cPos]);

p =  $\frac{\text{Length}[sPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;
P =  $\frac{\text{Length}[cPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;

If[Length[cPos] == 0, 1.0,  $\frac{PMinus1 p}{PPlus1 P}$ ]

)

```

$$P1nc[b_, c_, NT_, R_, L_] := \frac{1}{1 + \sum_{j=1}^{NT-1} \prod_{s=1}^j \text{NonCumFun}[b, c, NT, R, L, s]}$$

## Cumulative Model

```

CumFun[b_, c_, NT_, R_, L_, s_] := (
    (**Vector Construction**)
    q1 = ConstantArray[0, NT];
    Arf = Range[Length[q1]];
    rf = Round[Mean[Arf]];
    res1 = Range[s];
    fw = (rf - Round[Mean[res1]]) + res1;
    ru = # → 1 & /@ fw;
    Ve = ReplacePart[q1, ru];

```

```

(**Effect of R**)

Rvec = # + Table[i, {i, -R, R}] &;
joi = Tally[Flatten[Rvec /@ Flatten[Position[Ve, 1]]]];
FitVe = Ve /. {0 → 1, 1 → 1 - c};
RPosB = joi[[#]] & /@
  (Flatten[Position[(Length[Ve] ≥ # ≥ 1 &) /@ (#[[1]] & /@ joi), True]]);
hk = ConstantArray[0, Length[Ve]];
benVe = b Total[(ReplacePart[hk, #[[1]] → #[[2]]] &) /@ RPosB];
FV = FitVe + benVe;

(**Effect of L**)

jokk2 = Select[DeleteDuplicates[Join[First[Flatten[Position[Ve, 1]]] +
  Table[i, {i, -L, L}], Last[Flatten[Position[Ve, 1]]] +
  Table[i, {i, -L, L}]], Length[Ve] ≥ # > 0 &];
sPos = Intersection[Flatten[Position[Ve, 1]], jokk2];
cPos = Complement[jokk2, sPos];
PPlus1 = Total[FV[[#]] & /@ sPos] /
  (Total[FV[[#]] & /@ sPos] + Total[FV[[#]] & /@ cPos]);
PMinus1 = Total[FV[[#]] & /@ cPos] /
  (Total[FV[[#]] & /@ sPos] + Total[FV[[#]] & /@ cPos]);

p =  $\frac{\text{Length}[sPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;
P =  $\frac{\text{Length}[cPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;

If[Length[cPos] == 0, 1.0,  $\frac{PMinus1 p}{PPlus1 P}$ ]

)

```

$$P1[b_, c_, NT_, R_, L_] := \frac{1}{1 + \sum_{j=1}^{NT-1} \prod_{s=1}^j \text{CumFun}[b, c, NT, R, L, s]}$$

## ■ Two Dimensional Models

### Non-Cumulative Model

$$\text{NonCumFun2D}[b_, c_, NT_, R_, L_, s_] := \left( \right.$$

```

(**Vector Construction**)
dir = {{0, -1}, {1, 0}, {0, 1}, {-1, 0}};
vece = Riffle[Range[Round[s]], Range[Round[s]]];
typ = Table[Mod[i, 4, 1], {i, s}];
seq =
  Flatten[Table[ConstantArray[dir[[typ[[i]]]], {vece[[i]]}], {i, s}], 1];
possi = Join[{{Round[NT / 2], Round[NT / 2]}},
  Table[Mod[{Round[NT / 2], Round[NT / 2]} + Accumulate[seq][[i]], NT, 1],
    {i, 1, s - 1}]];
ca0 = ConstantArray[0, {NT, NT}];
ik = ReplacePart[ca0, # → 1 & /@ possi];

(**Effect of R**)

posun = Position[ik, 1];
ereve = Flatten[Table[{i, j}, {i, -R, R}, {j, -R, R}], 1];
funiR = Table[ereve[[i]] + #, {i, Length[ereve]}] &;
antesR = DeleteDuplicates[Flatten[funiR /@ posun, 1]];
dirMa = Flatten[Table[{i, j}, {i, NT}, {j, NT}], 1];
PosR = Intersection[antesR, dirMa];
FitMa = ik /. {0 → 1, 1 → 1 - c};
con = ConstantArray[b, Length[PosR]];
repl =
  ({#[[1]] → #[[2]]} &) /@ ({PosR[[#]], con[[#]]} & /@ Range[Length[PosR]]);
bene = ReplacePart[ca0, repl];
FV = FitMa + bene;

(**Effect of L**)

eleve = Flatten[Table[{i, j}, {i, -L, L}, {j, -L, L}], 1];
funiL = Table[eleve[[i]] + #, {i, Length[eleve]}] &;
antesL = funiL /@ posun;
PosL = Intersection[antesL[[#]], dirMa] & /@ Range[Length[antesL]];
posmoreL = Position[MemberQ[Map[ik[[#[[1]]]][#[[2]]] &, PosL[[#]]], 0] & /@
  Range[Length[PosL]], False];
BorderL = Delete[posun, posmoreL];
ZoneL =
  Sort[Intersection[DeleteDuplicates[Flatten[funiL /@ BorderL, 1]], dirMa]];
sPos = Intersection[posun, ZoneL];
cPos = Complement[ZoneL, sPos];
PPlus1 =
  Total[FV[[#[[1]], #[[2]]]] & /@ sPos] / (Total[FV[[#[[1]], #[[2]]]] & /@ sPos] +
    Total[FV[[#[[1]], #[[2]]]] & /@ cPos]);
PMinus1 = Total[FV[[#[[1]], #[[2]]]] & /@ cPos] /
  (Total[FV[[#[[1]], #[[2]]]] & /@ sPos] +
    Total[FV[[#[[1]], #[[2]]]] & /@ cPos]);

```

$$p = \frac{\text{Length}[sPos]}{\text{Length}[sPos] + \text{Length}[cPos]};$$

$$P = \frac{\text{Length}[cPos]}{\text{Length}[sPos] + \text{Length}[cPos]};$$

$$\left( \text{If} \left[ \text{Length}[cPos] == 0, 1.0, \frac{P_{\text{minus1 } p}}{P_{\text{plus1 } P}} \right] \right)$$

$$P1nc2D[b_, c_, NT_, R_, L_] := \frac{1}{1 + \sum_{j=1}^{(NT^2)-1} \prod_{s=1}^j \text{NonCumFun2D}[b, c, NT, R, L, s]}$$

## Cumulative Model

```

CumFun2D[b_, c_, NT_, R_, L_, s_] := (
  (**Vector Construction**)
  dir = {{0, -1}, {1, 0}, {0, 1}, {-1, 0}};
  vece = Riffle[Range[Round[s]], Range[Round[s]]];
  typ = Table[Mod[i, 4, 1], {i, s}];
  seq =
    Flatten[Table[ConstantArray[dir[[typ[[i]]]], {vece[[i]]}], {i, s}], 1];
  possi = Join[{{Round[NT / 2], Round[NT / 2]}},
    Table[Mod[{Round[NT / 2], Round[NT / 2]} + Accumulate[seq][[i]], NT, 1],
      {i, 1, s - 1}]];
  ca0 = ConstantArray[0, {NT, NT}];
  ik = ReplacePart[ca0, # -> 1 & /@ possi];

  (**Effect of R**)

  posun = Position[ik, 1];
  ereve = Flatten[Table[{i, j}, {i, -R, R}, {j, -R, R}], 1];
  funiR = Table[ereve[[i]] + #, {i, Length[ereve]}] &;

  antesRCum = Flatten[funiR /@ posun, 1];
  dirMa = Flatten[Table[{i, j}, {i, NT}, {j, NT}], 1];
  PosR = Intersection[antesRCum, dirMa];
  indexele = Flatten[Position[antesRCum, #] & /@ PosR];
  PosRNew = antesRCum[[#]] & /@ indexele;
  fuk = # + b &;

```

```

bmatrix = Total[(MapAt[fuk, ca0, #]) & /@ PosRNew];
FitMa = ik /. {0 → 1, 1 → 1 - c};
FV = FitMa + bmatrix;

(**Effect of L**)

eleve = Flatten[Table[{i, j}, {i, -L, L}, {j, -L, L}], 1];
funiL = Table[eleve[[i]] + #, {i, Length[eleve]}] &;
antesL = funiL /@ posun;
PosL = Intersection[antesL[[#]], dirMa] & /@ Range[Length[antesL]];
posmoreL = Position[MemberQ[Map[ik[[#[[1]]]][#[[2]]]] &, PosL[[#]]], 0] & /@
  Range[Length[PosL]], False];
BorderL = Delete[posun, posmoreL];
ZoneL =
  Sort[Intersection[DeleteDuplicates[Flatten[funiL /@ BorderL, 1]], dirMa]];
sPos = Intersection[posun, ZoneL];
cPos = Complement[ZoneL, sPos];
PPlus1 =
  Total[FV[[#[[1]], #[[2]]]] & /@ sPos] / (Total[FV[[#[[1]], #[[2]]]] & /@ sPos] +
    Total[FV[[#[[1]], #[[2]]]] & /@ cPos));
PMinus1 = Total[FV[[#[[1]], #[[2]]]] & /@ cPos] /
  (Total[FV[[#[[1]], #[[2]]]] & /@ sPos] +
    Total[FV[[#[[1]], #[[2]]]] & /@ cPos));

p =  $\frac{\text{Length}[sPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;
P =  $\frac{\text{Length}[cPos]}{\text{Length}[sPos] + \text{Length}[cPos]}$ ;

If[Length[cPos] == 0, 1.0,  $\frac{PMinus1 p}{PPlus1 P}$ ]
)

```

$$P1c2D[b_, c_, NT_, R_, L_] := \frac{1}{1 + \sum_{j=1}^{(NT^2)-1} \prod_{s=1}^j \text{CumFun2D}[b, c, NT, R, L, s]}$$