Control of DNA Replication by Anomalous Reaction-Diffusion Kinetics

Department of Physics, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada

Xenopus

–

Xenopus
laevis

S

$I(t)$

S

$I(t)$

$I(t)$

$I(t)$

S

t

$\triangle$

$f(t)$

$$f(t) = 1 - S(t) = 1 - e^{-2vh(t)},$$

v

$I(t)$

$I(t)$

Diffusion-based search.—

S

$G1$

Xenopus

S

S

one one

t_r

$(t_s + t_r)$

t_r

N_s

$$I(t) = \frac{N_s(t)}{L[1 - f(t)][t_s(t) + t_r]} = \frac{N_s(t)e^{2\upsilon h(t)}}{L[t_s(t) + t_r]},$$

$f(t)$

$N_s = N_s(t)$

S

κ_s $N_s(t) = \kappa_s t$

$$\frac{I(t)}{\upsilon/L^2} = \frac{\frac{L}{\upsilon}\kappa_s t e^{2\upsilon h(t)}}{(\frac{\ell_o}{\lambda})^{1/\alpha}[2e^{2\upsilon h(t)} - 1]^{1/\alpha}\tau + t_r}$$

$$= \frac{\mathcal{I}_0 t e^{2\upsilon h(t)}}{\mathcal{T}_0[2e^{2\upsilon h(t)} - 1]^{1/\alpha} + 1} = \frac{\mathcal{I}(t)}{\mathcal{T}(t) + 1},$$

L

υ $I(t)$

α $\mathcal{I}_0 = \kappa_s L/\upsilon t_r$ $\mathcal{T}_0 = (\ell_0/\lambda)^{1/\alpha} \times$

(τ/t_r) $\mathcal{T}(t)$

$t_s(t)/t_r$ $\mathcal{I}(t)$

$\mathcal{T}(t) \ll 1$ $I(t) = d^2h(t)/dt^2$

$h(t)$ $h(0) = \dot{h}(0) = 0$

$t \to \infty$

$I(t) \sim \exp[2\upsilon h(t)(1 - 1/\alpha)]$ $I \geq 0$

$h > 0$ $I \to 0$ $\alpha < 1$

$I \to$

0

$I(t)$ S

both

$\alpha \approx 1/2$

$\alpha \approx 2/3$

$I(t)$

v

S in vitro

$N_s(t)$

$I(t)$

$\dot{N}_s(t) =$

$\kappa_s - \gamma N_s(t)$ γ $N_s \to$

κ_s/γ S

κ_s

et al.

6

38

7

et al. 277

et al. 320

12

275

et al. 300

et al. 3

1

71

71

73

98

117

112

94

36

et al. 96

32

95

96

93

et al. 87

37

12

195

1

$L/(v t_{rep}) \gg$ 1 $L = 3.07 \times 10^6$ kb $v = 0.6$ kb/min t_{rep} $L/(v t_{rep}) =$ $\mathcal{O}(10^5)$

21

78

316

Principles of Nuclear Structure and Function

92

279

59