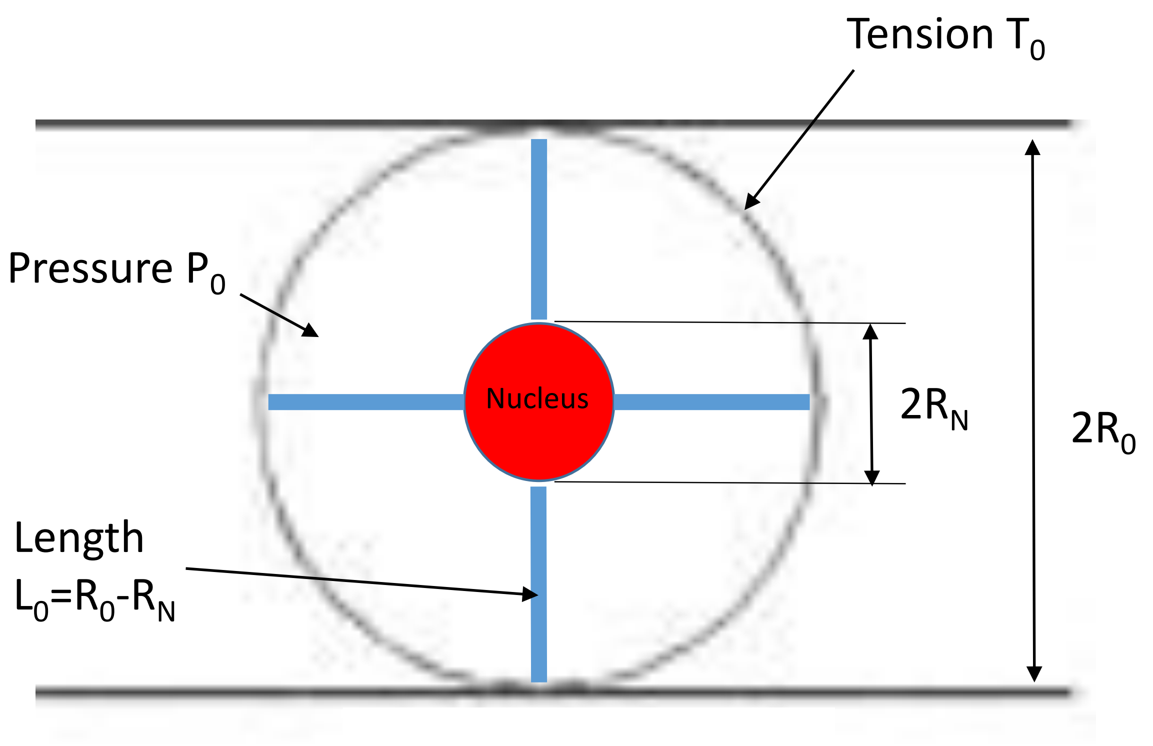
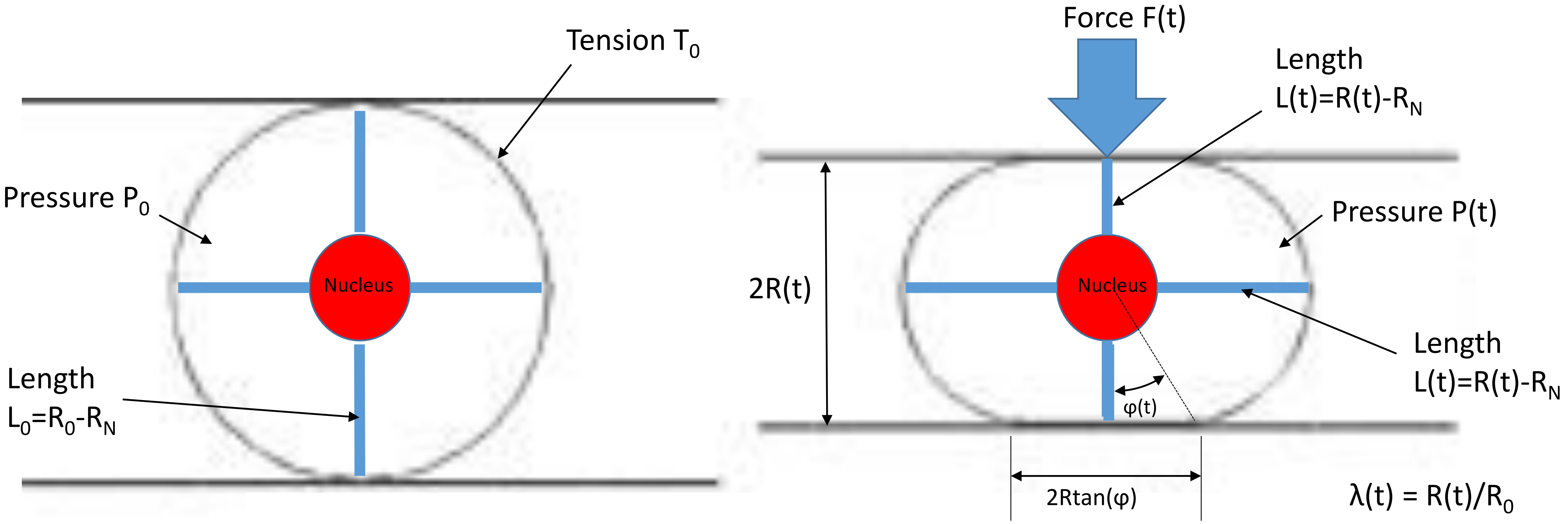

Tension T_0
Pressure P_0
Nucleus
$2R_N$
$2R_0$
Length
$L_0=R_0-R_N$



Tension T_0
Pressure P_0
Nucleus
Length
$L_0=R_0-R_N$
Force F(t)
Length
$L(t)=R(t)-R_N$
Pressure P(t)
2R(t)
Nucleus
Length
$L(t)=R(t)-R_N$
φ(t)
2Rtan(φ)
$\lambda(t) = R(t)/R_0$

Force → stresses → strains → Displacement

2 unknowns

$R(t)$

$\varphi(t)$

3 components:

Vertical Fibers
Horizontal fibers
Bulk : $P(t)$
Membrane

Equilibrium at the contact:

$P \pi R^2 \tan^2(\varphi) + \sigma_{fv} A_f = F$

Equilibrium at the apex:

$T + h_0 \sigma_{fh} = PR/2$

Inject the expressions relating the stresses to $R(t)$ and $\varphi(t)$ in these equations

Then I have 2 non linear equations of 2 unknowns

Numerical resolution

Force → stresses → strains → Displacement

4 components:

Vertical Fibers
Horizontal fibers
Bulk
Membrane

membrane

$W = \int T \, dE$

$T = \partial W/\partial E = Y (E+E')$

Force → stresses → strains → Displacement

4 components:

Vertical Fibers
Horizontal fibers
Bulk
Membrane

fibers

$$W = \int \sigma_f \, dE$$

$$\sigma_f = \partial W / \partial E$$

Force → stresses → strains → Displacement

4 components:

Vertical Fibers
Horizontal fibers
Bulk
Membrane

bulk

$W = \int P \, dJ$

$P = \partial W / \partial J = K(J-1)$

Force → stresses → strains → Displacement

2 unknowns

$R(t)$

$\varphi(t)$

4 components:

Vertical Fibers

Horizontal fibers

Bulk

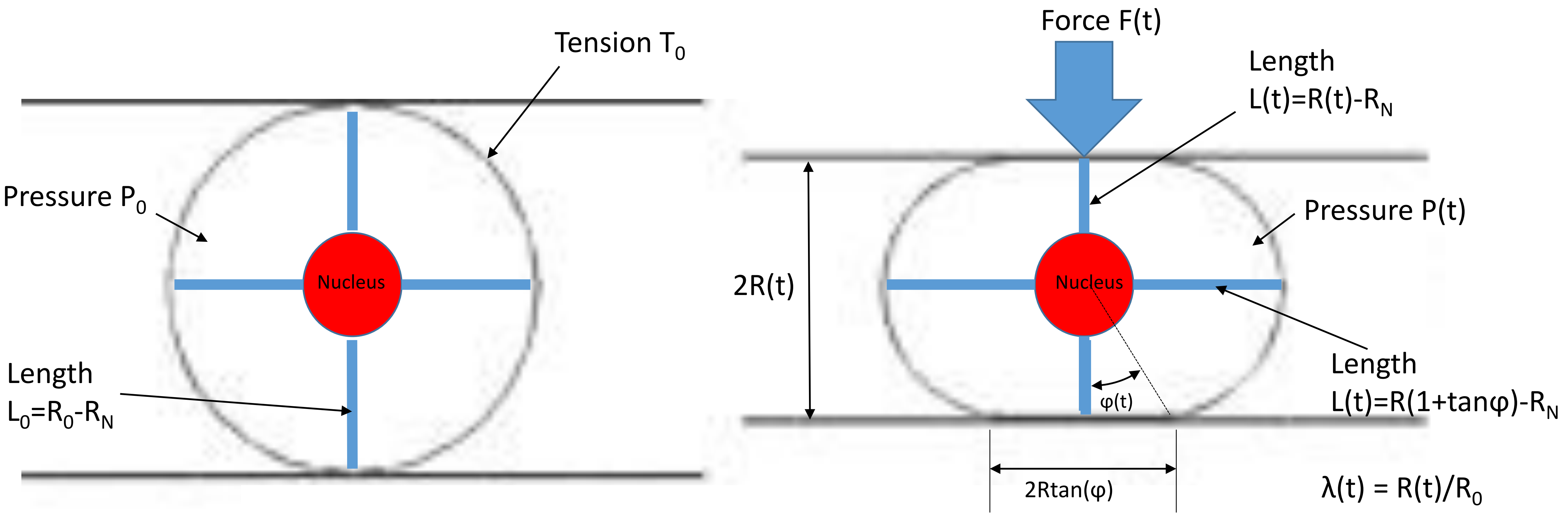
Membrane

$$J = V/V_0 = (R/R_0)^3 \, [3/2 \tan^2(\varphi) + 3\pi/4 \tan(\varphi) + 1]$$

$$E = (R/R_0)^2 \, [\tan(\varphi) + \tan^2(\varphi)/2]$$

$$E_{fv} = [\, [(R-R_N)/(R_0-R_N)]^2 - 1] \,/2$$

$$E_{fh} = [\, [(R(1+\tan\varphi)-R_N)/(R_0-R_N)]^2 - 1] \,/2$$



For the membrane

Energy per unit area

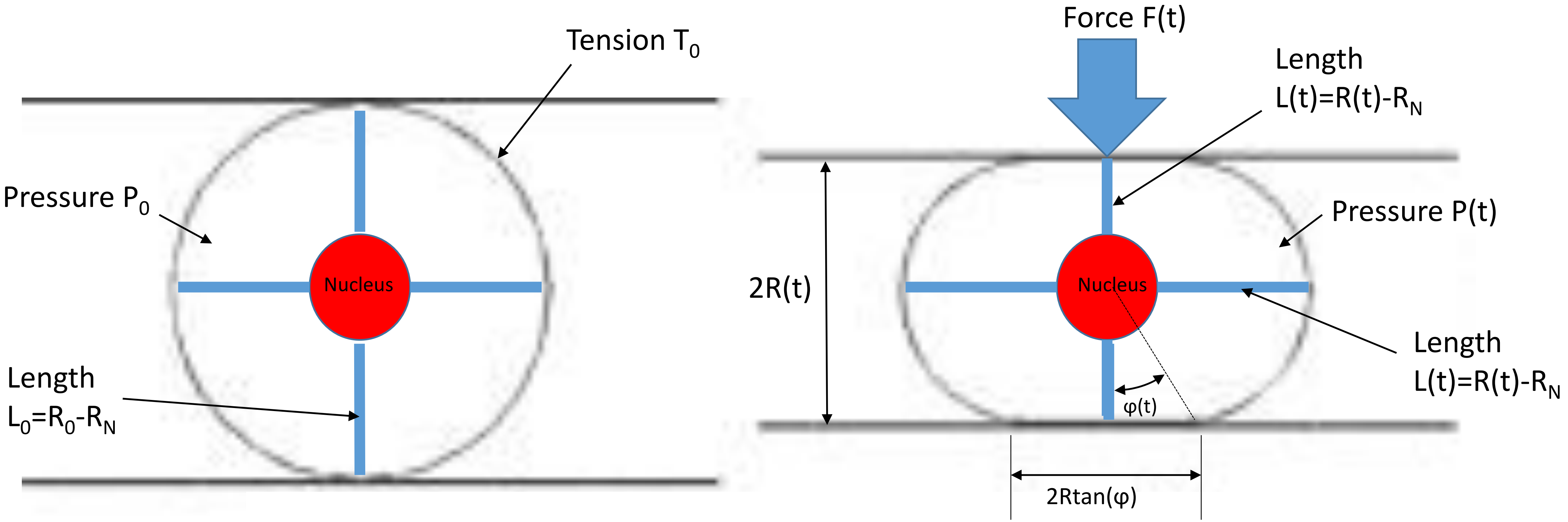
W(E)=Y/2 (E+E')^2

E' is the prestrain

$E = S/S_0 - 1$

$S = 4\pi R^2 [1+\tan(\varphi)+\tan^2(\varphi)/2]$

$S_0 = 4\pi R_0^2$



For the bulk

$$W(J)=K/2\ (J-1)^2$$

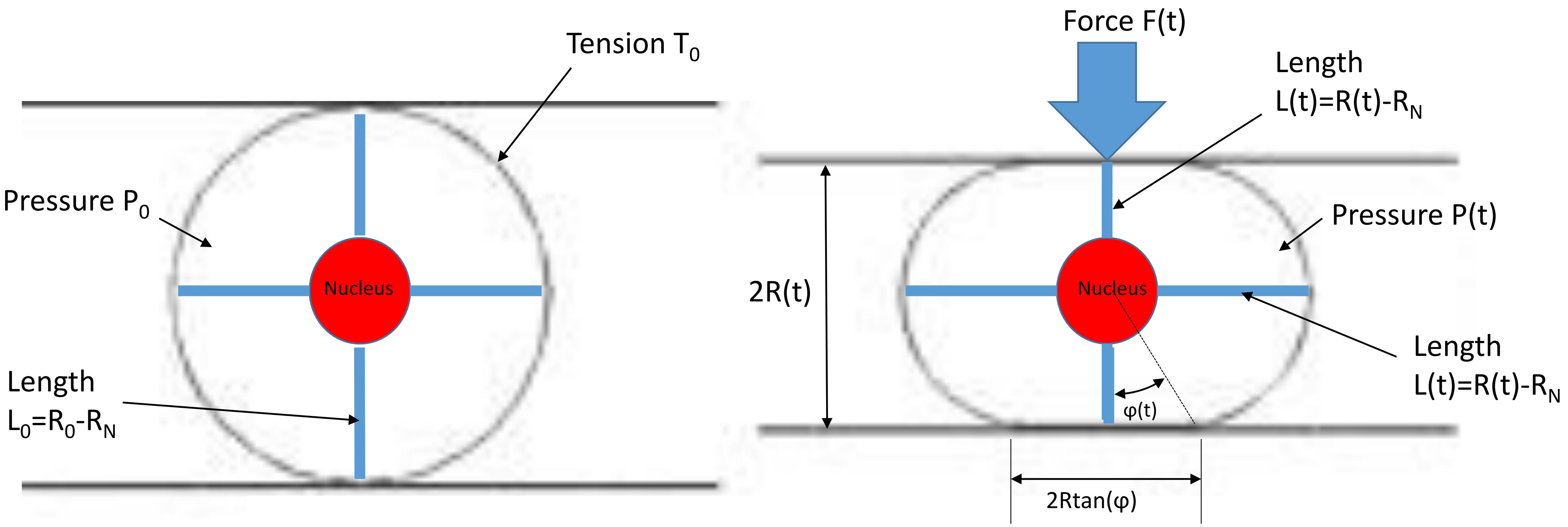
$$J=V/V_0$$

$$V = V_0$$

$$V = 2\pi R^3 \tan^2(\varphi) + \pi^2 R^3 \tan(\varphi) + 4/3\ \pi R^3$$

$$V = 4/3\ \pi R^3\ [3/2\tan^2(\varphi) + 3\pi/4\ \tan(\varphi) + 1\ ]$$

$$V_0 = 4/3\ \pi R_0^3$$



For the fibers

$W(E)=k/2\ E^2$ if $E<0$
$W(E)=k/2a\ [\exp(aE^2) - 1]$ if $E<0$

$E = [(L/L_0)\text{^}2 - 1] /2$