Nuclear envelope, nuclear pores, nucleocytoplasmic transport

- **Know the organization of the nuclear envelope and associated proteins.**
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Nuclear envelope, nuclear pores, nucleocytoplasmic transport

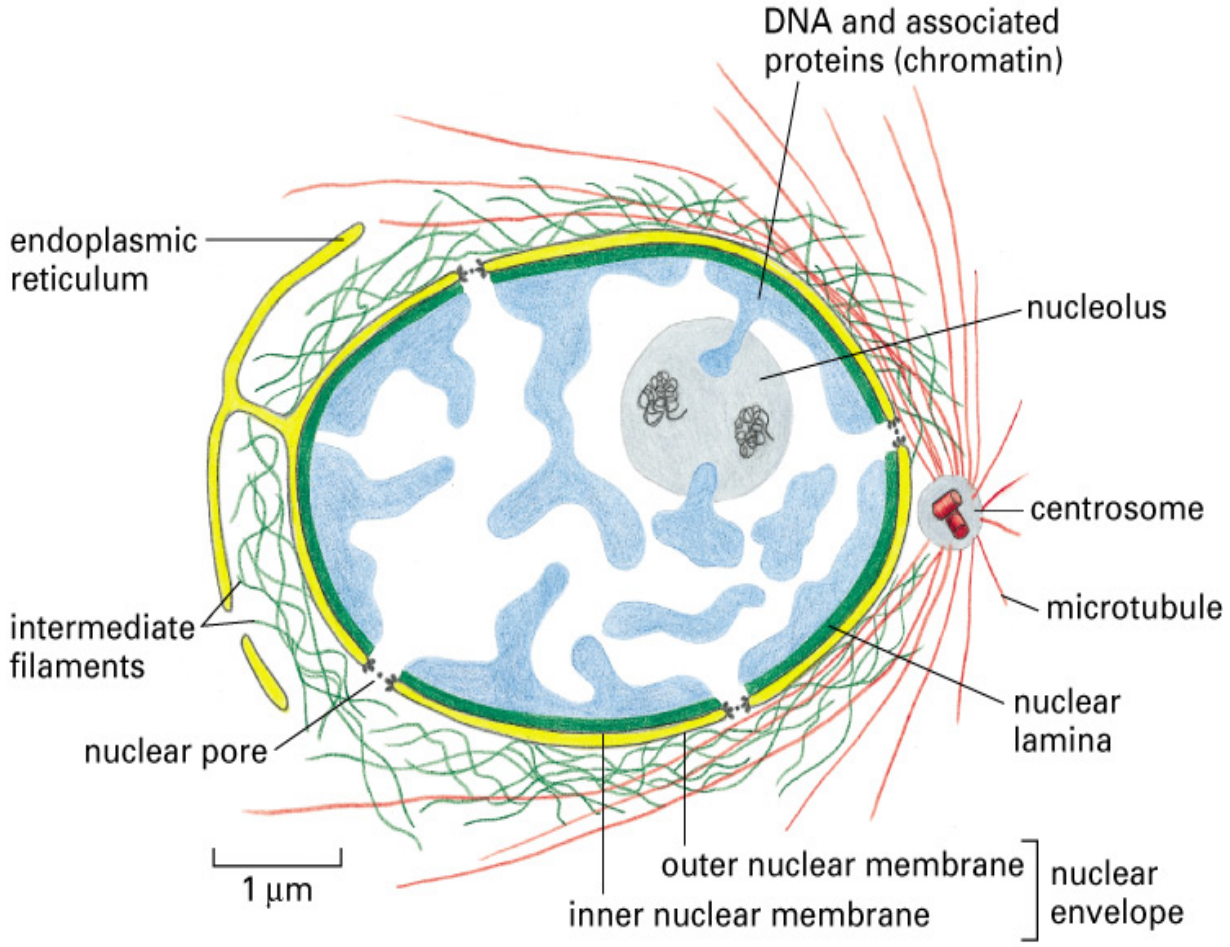
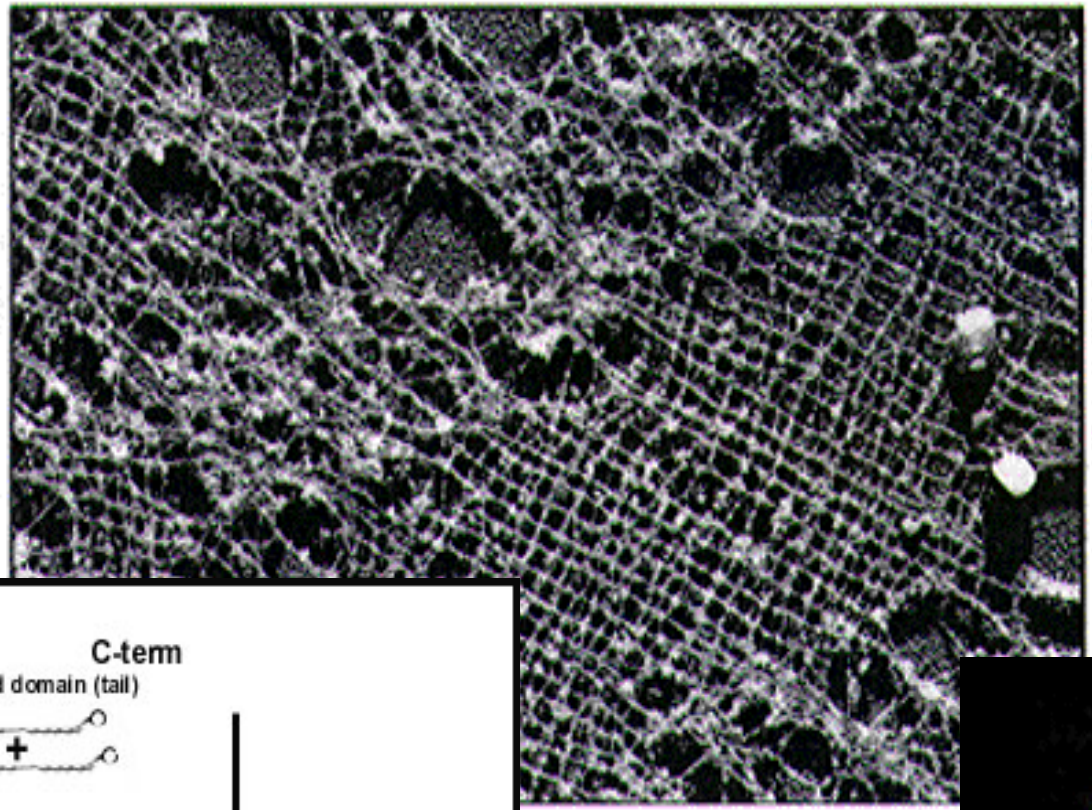
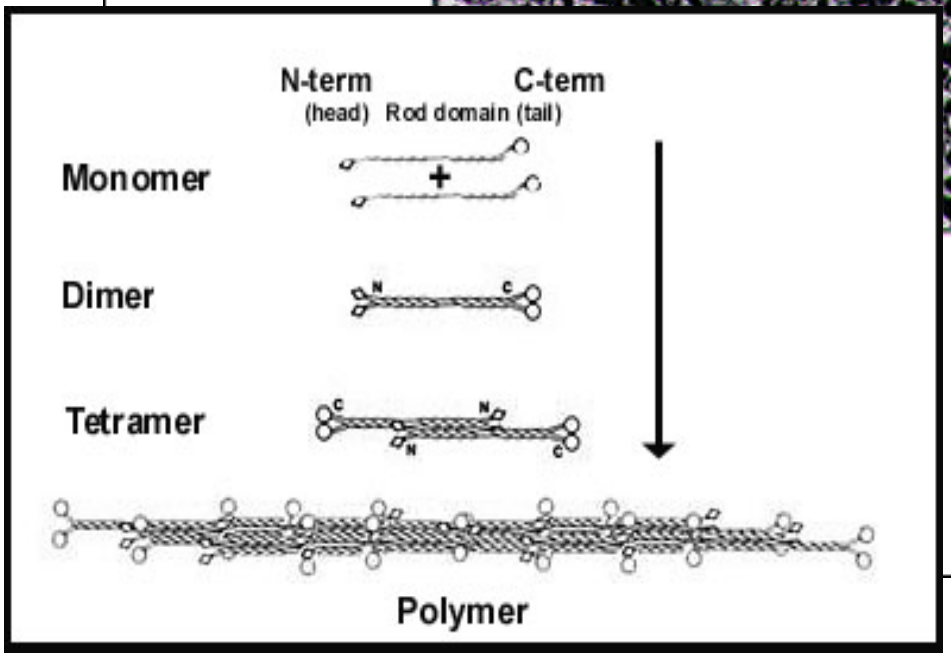


Figure 4–9. Molecular Biology of the Cell, 4th Edition.

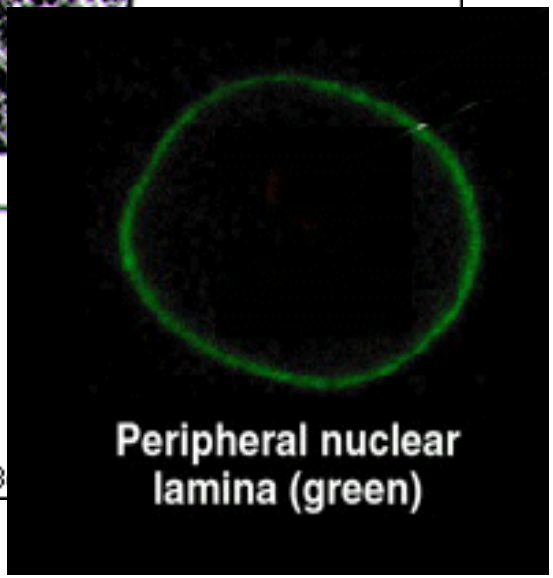
Nuclear lamina (animal cell)

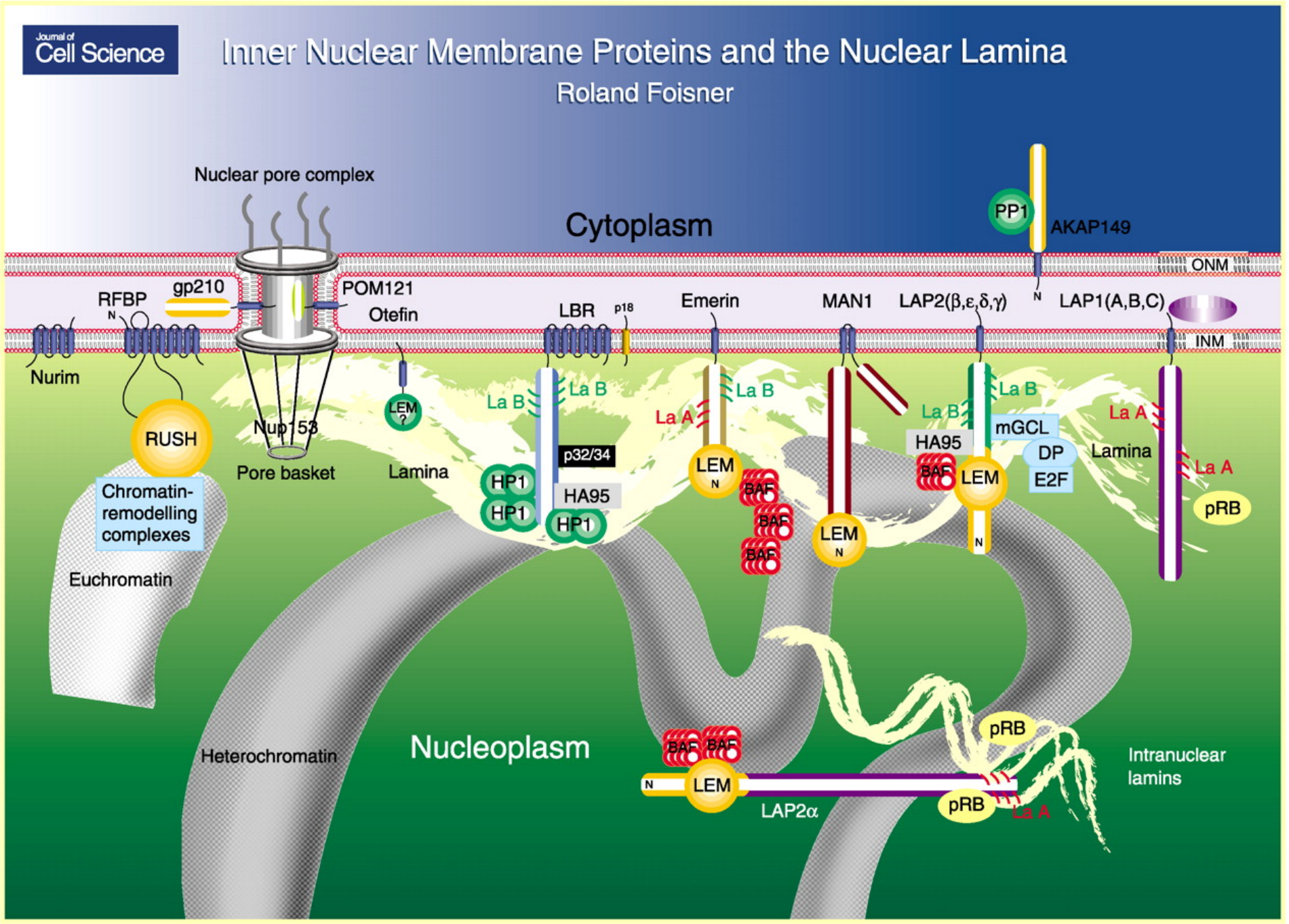




1 µm

From The Art of MB

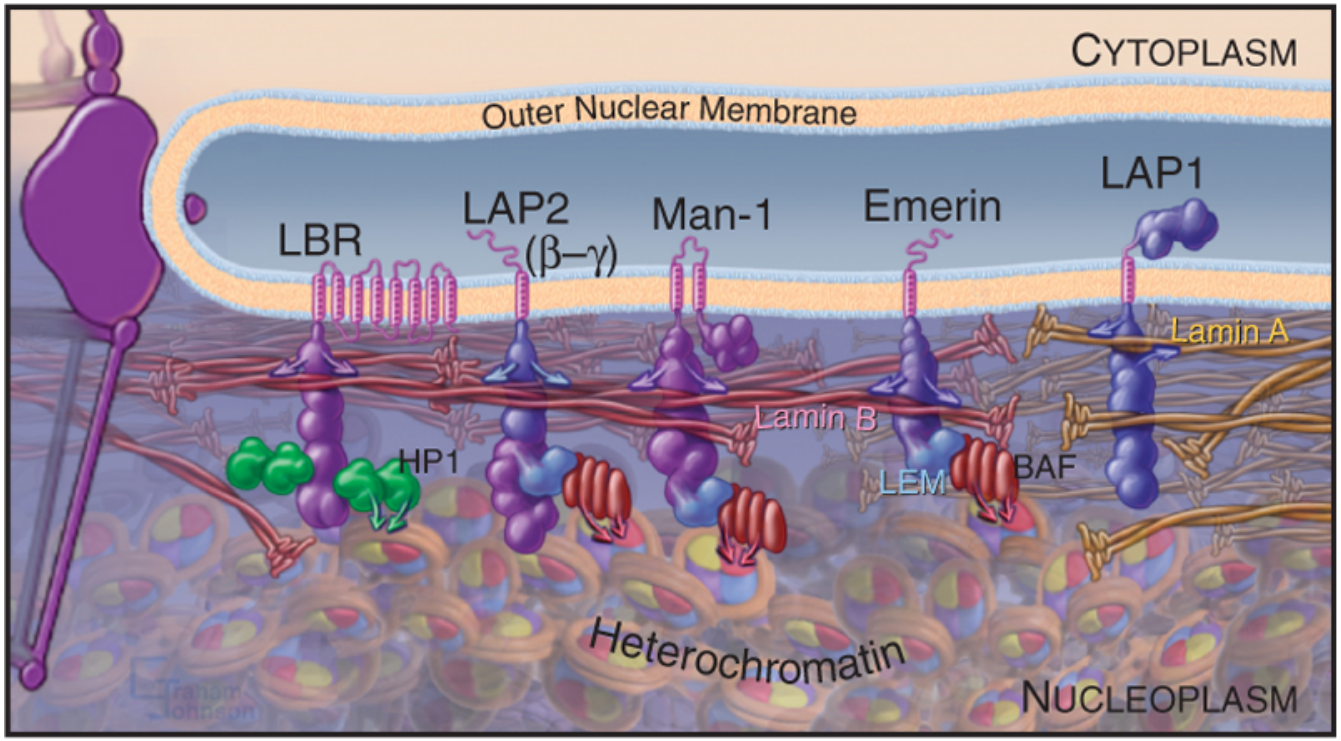




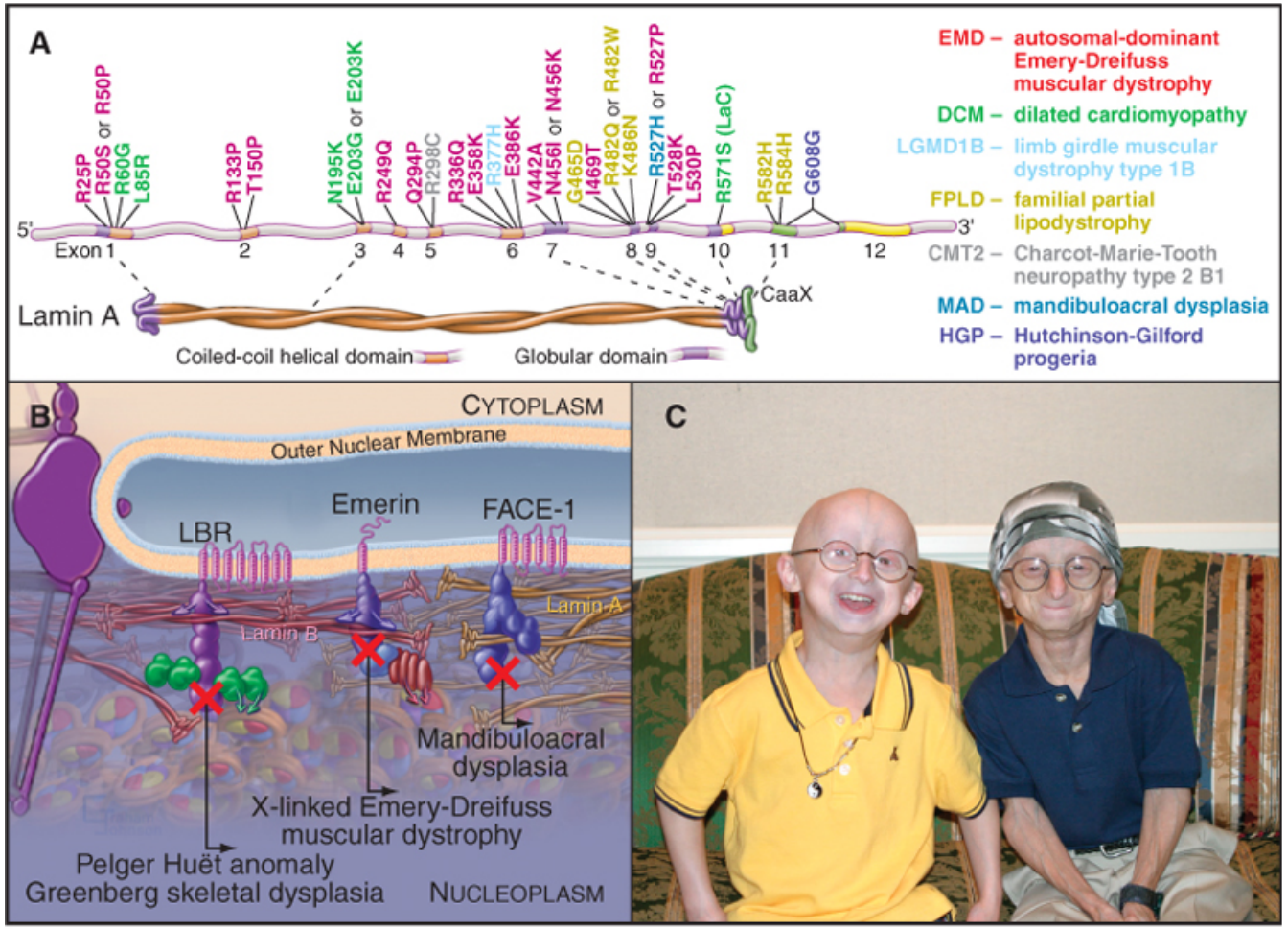
Foisner R J Cell Sci 2001;114:3791-3792

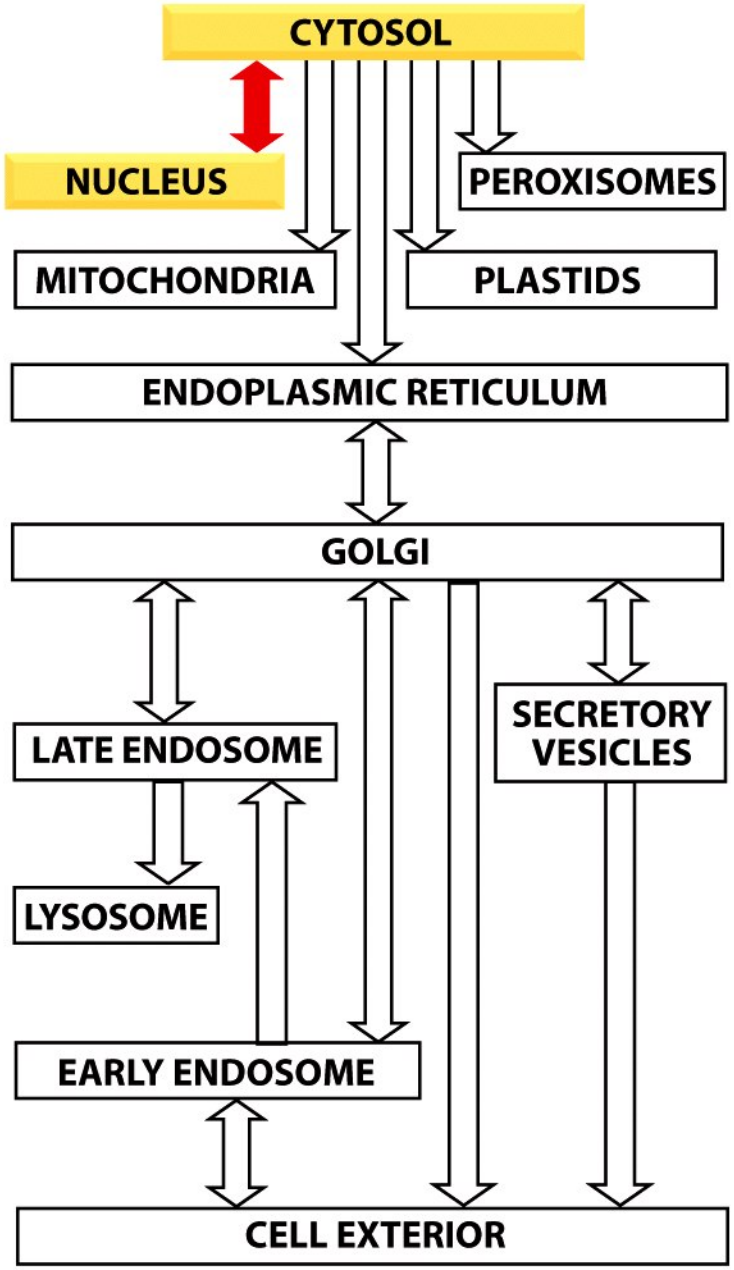
SEVERAL MAJOR INTEGRAL MEMBRANE PROTEINS OF THE INNER NUCLEAR MEMBRANE INTERACT WITH BOTH THE NUCLEAR LAMINA AND CHROMATIN.

- The lamin B receptor (LBR), lamina-associated protein 2 (LAP2), Man-1, and emerin all bind lamin B.
- LBR associates with chromatin via HP1.
- The other three associate with chromatin via BAF.
- Emerin and LAP1 also bind to lamin A.



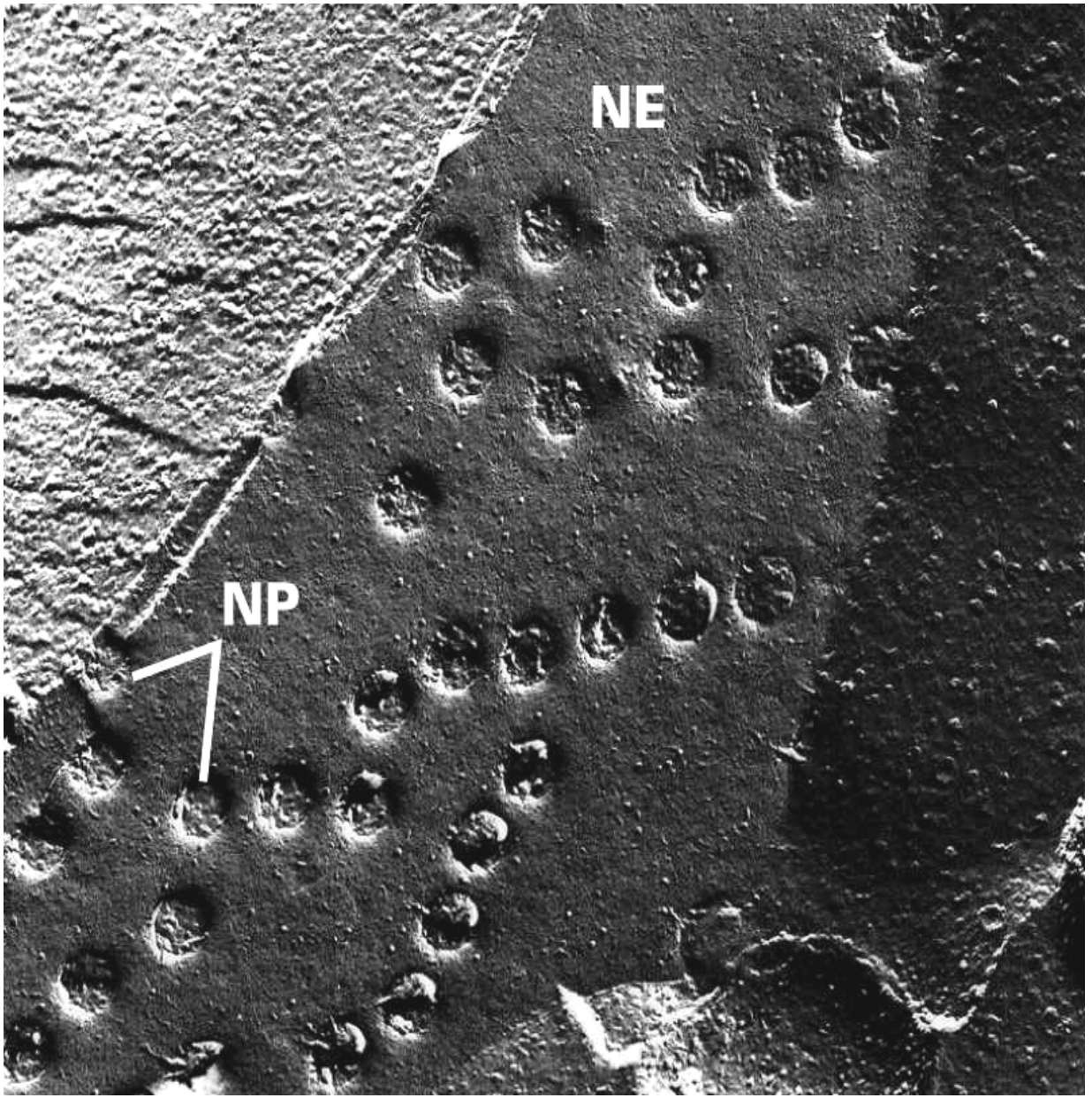
HUMAN DISEASES ASSOCIATED WITH NUCLEAR ENVELOPE ABNORMALITIES.




CYTOSOL
NUCLEUS
PEROXISOMES
MITOCHONDRIA
PLASTIDS
ENDOPLASMIC RETICULUM
GOLGI
LATE ENDOSOME
SECRETORY VESICLES
LYSOSOME
EARLY ENDOSOME
CELL EXTERIOR

Nuclear pores (NP) in nuclear envelope (NE)

Freeze fracture viewed with electron microscope



Electron micrograph of a thin section showing face-on views of negatively stained nuclear pores.

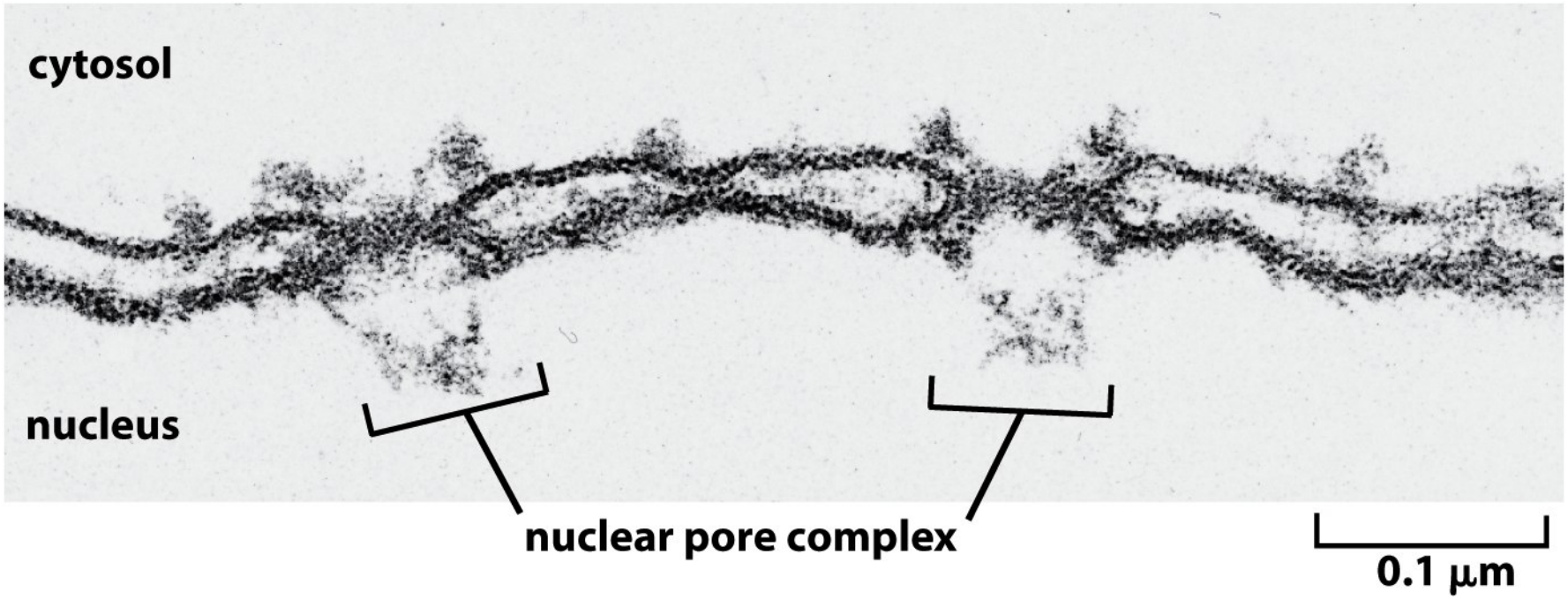
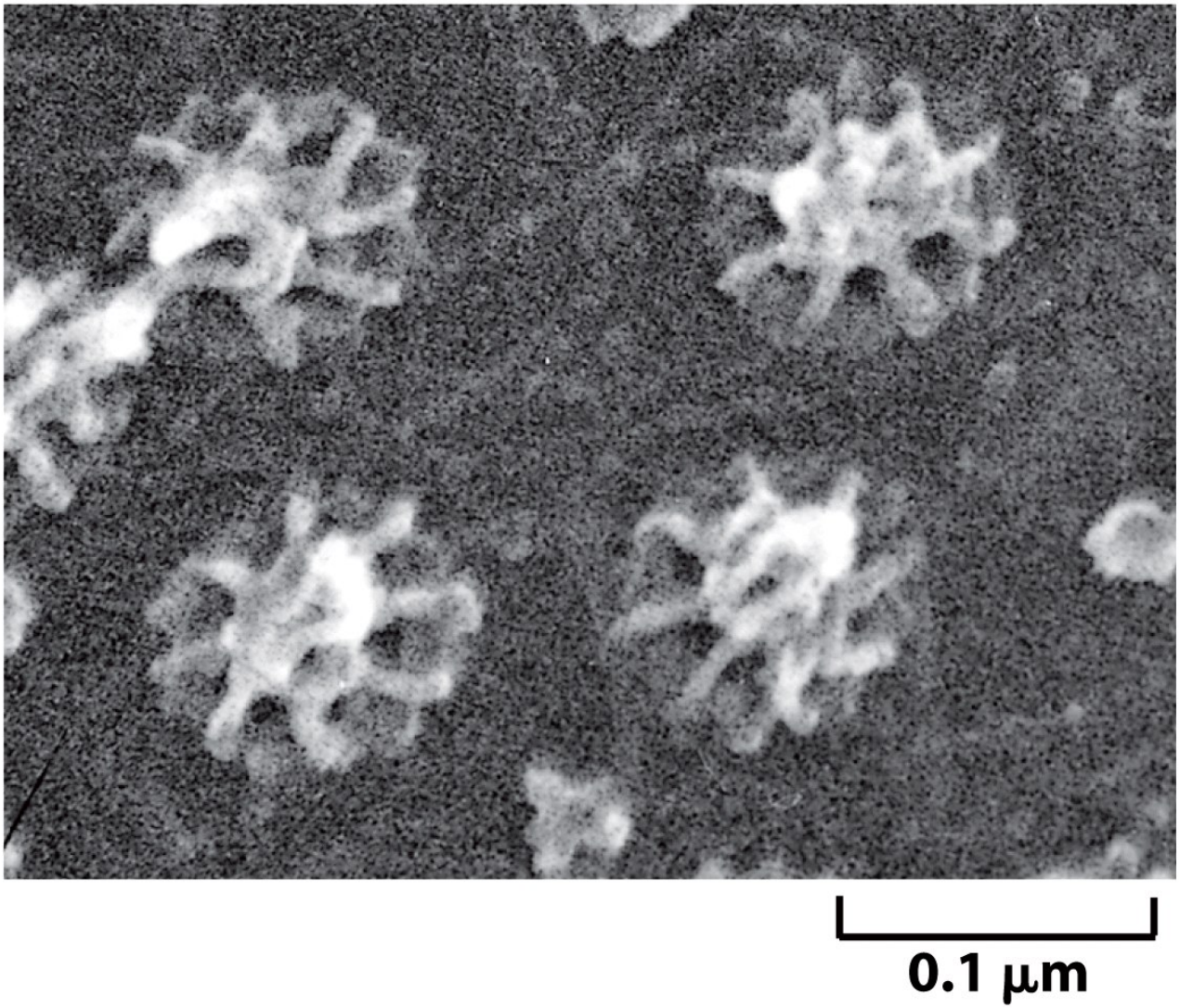


Figure 12-9(C)



Nuclear pores as viewed by SEM, from the nuclear side of the nuclear envelope. This type of image clearly shows the nuclear basket. Xenopus oocytes nuclei have a very night density of nuclear pores, and are often used for these studies.

Figure 12-9(B)

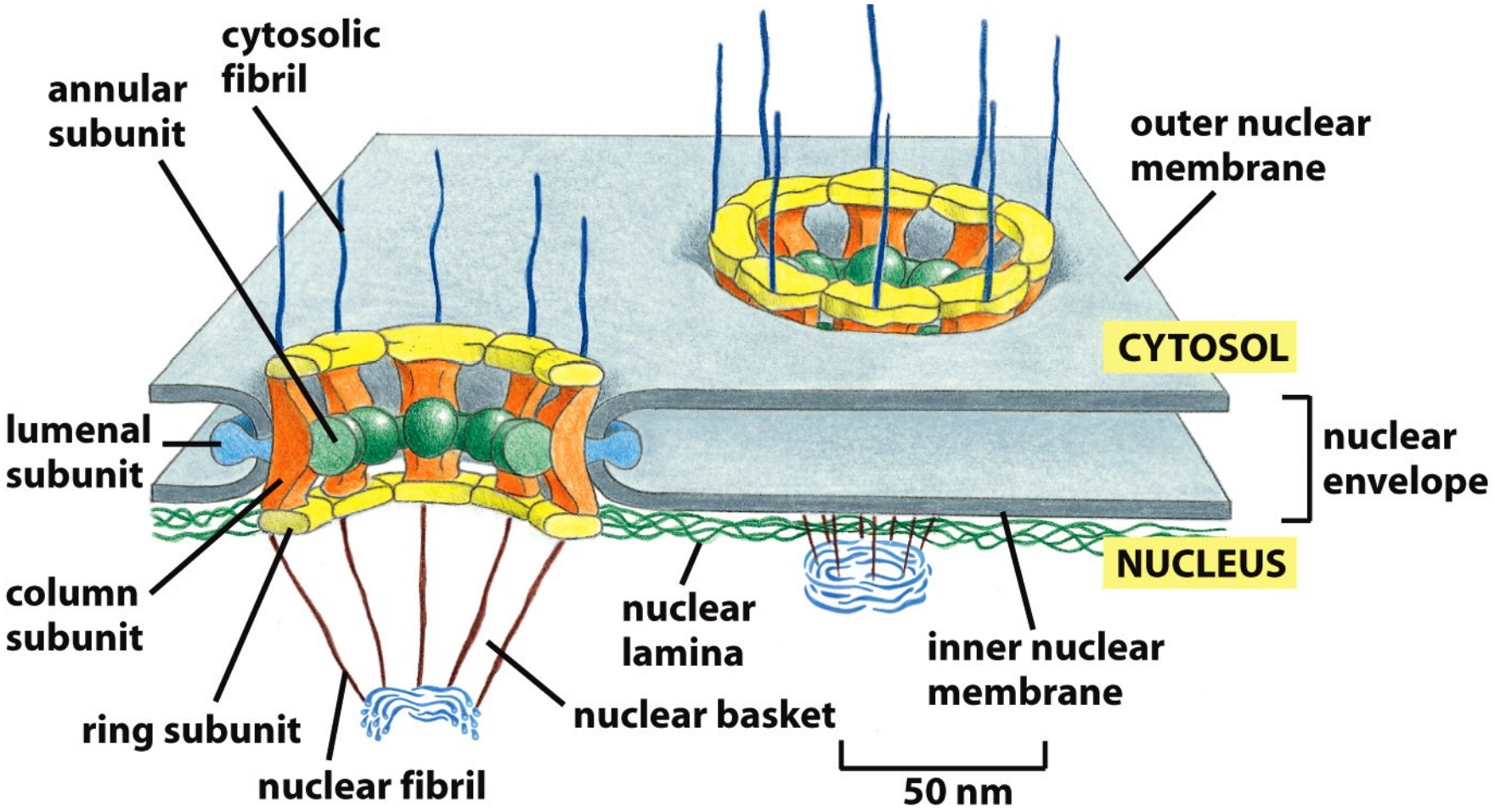

cytosolic fibril
annular subunit
outer nuclear membrane
CYTOSOL
lumenal subunit
nuclear envelope
column subunit
NUCLEUS
nuclear lamina
inner nuclear membrane
ring subunit
nuclear basket
nuclear fibril
50 nm

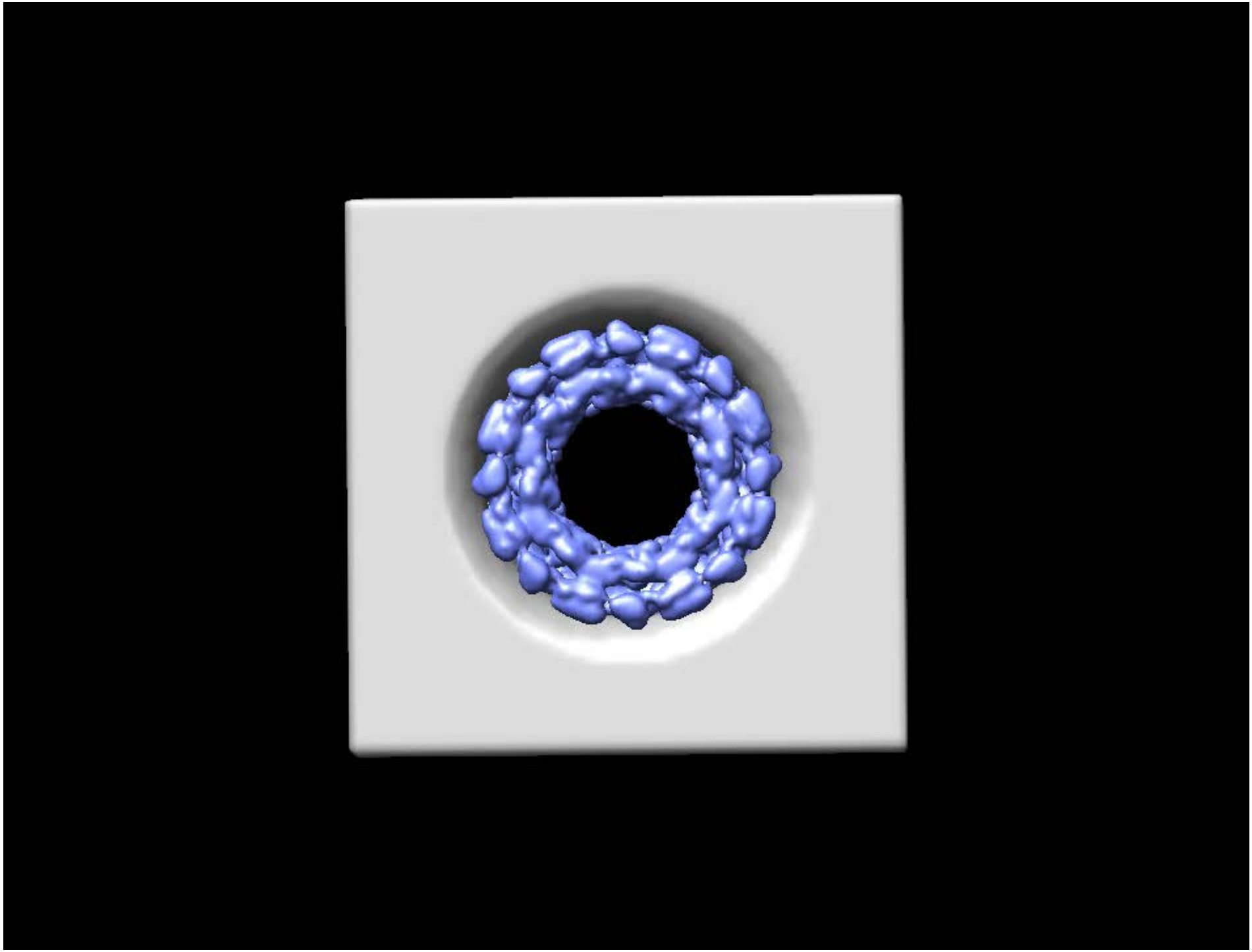
Figure 12-9(A)

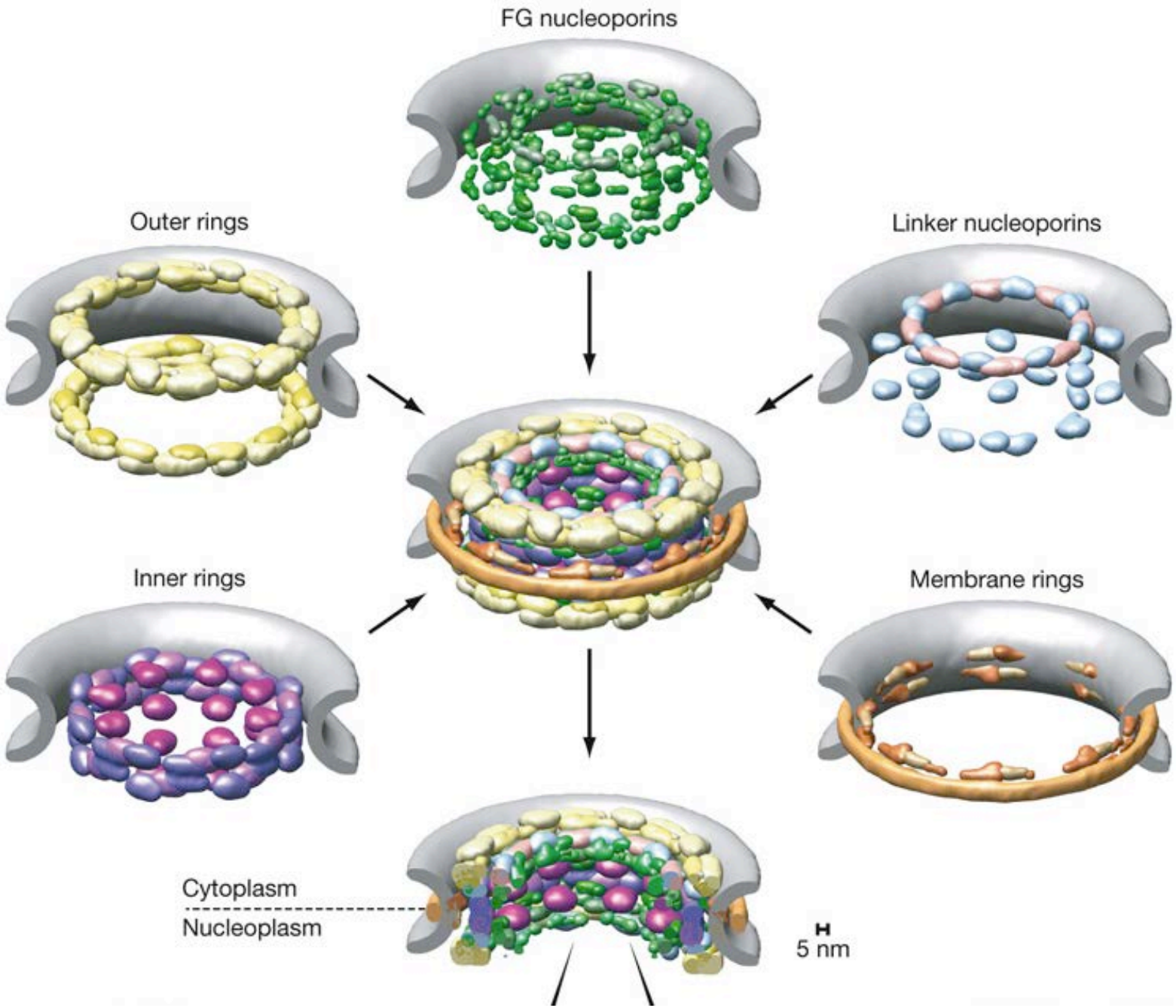
The molecular architecture of the nuclear pore complex.

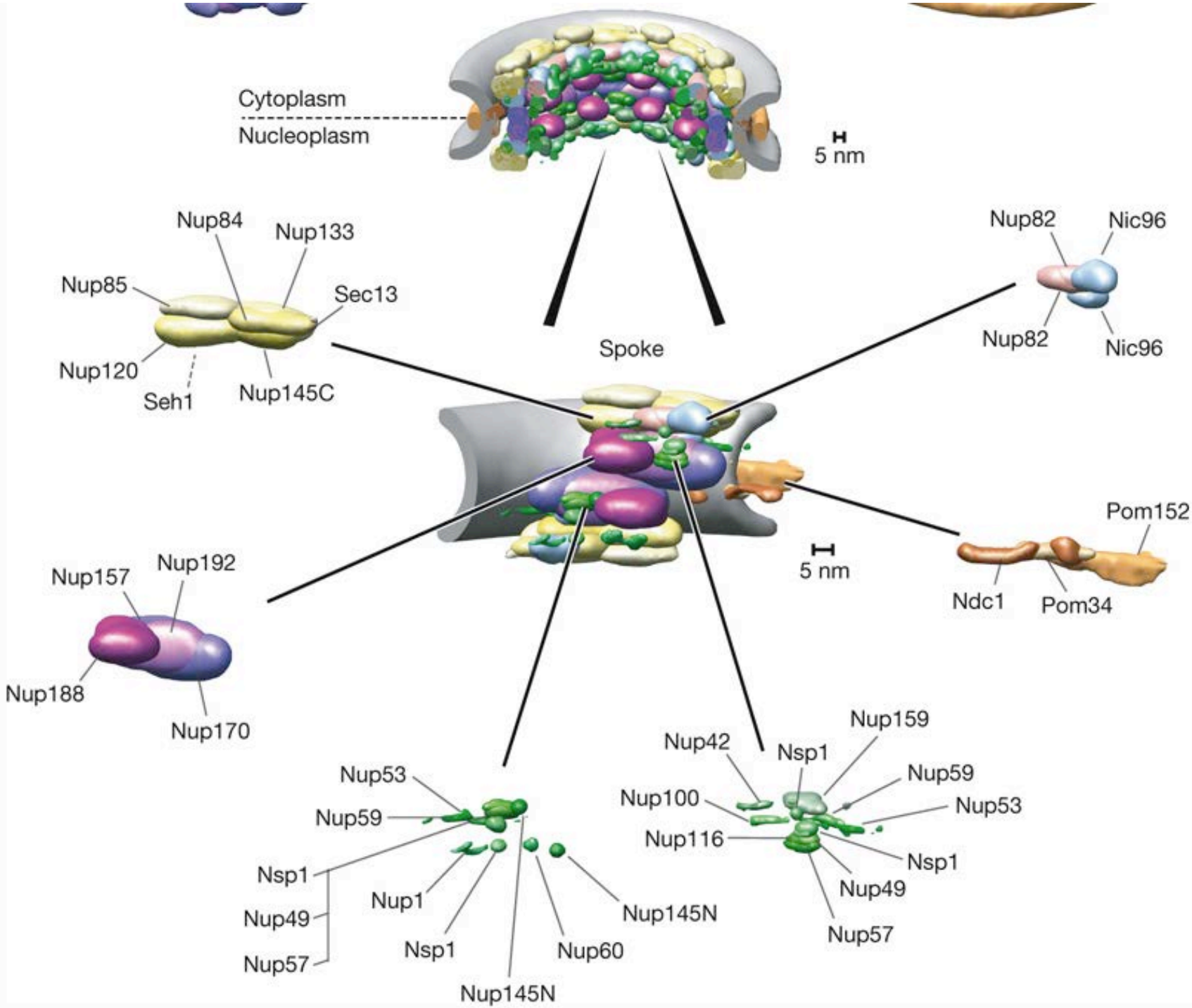
Alber F, Dokudovskaya S, Veenhoff LM, Zhang W, Kipper J, Devos D, Suprapto A, Karni-Schmidt O,

Williams R, Chait BT, Sali A, Rout MP.

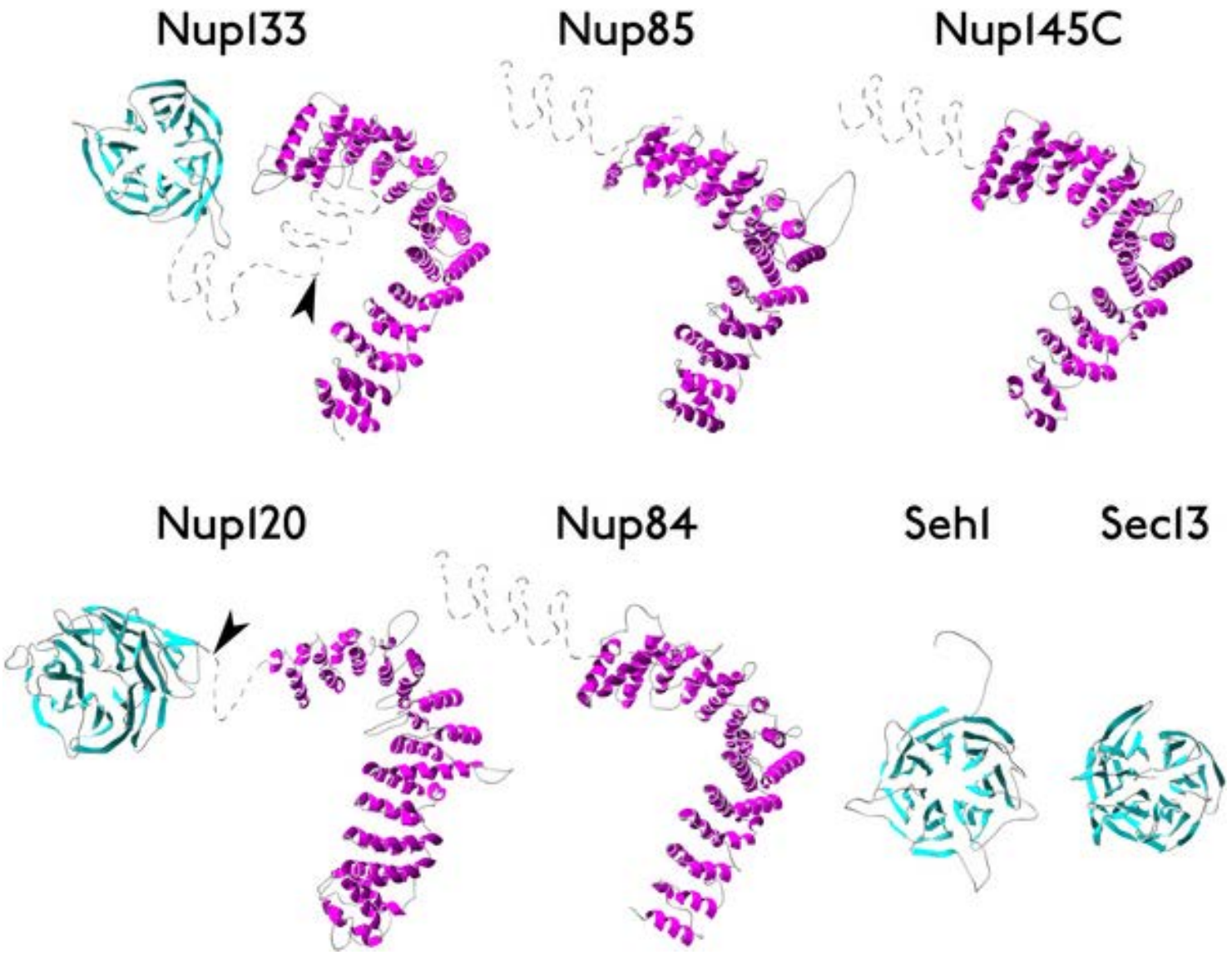
Nature. 2007 Nov 29;450(7170): 695-701.




FG nucleoporins
Outer rings
Linker nucleoporins
Inner rings
Membrane rings
Cytoplasm
Nucleoplasm
5 nm

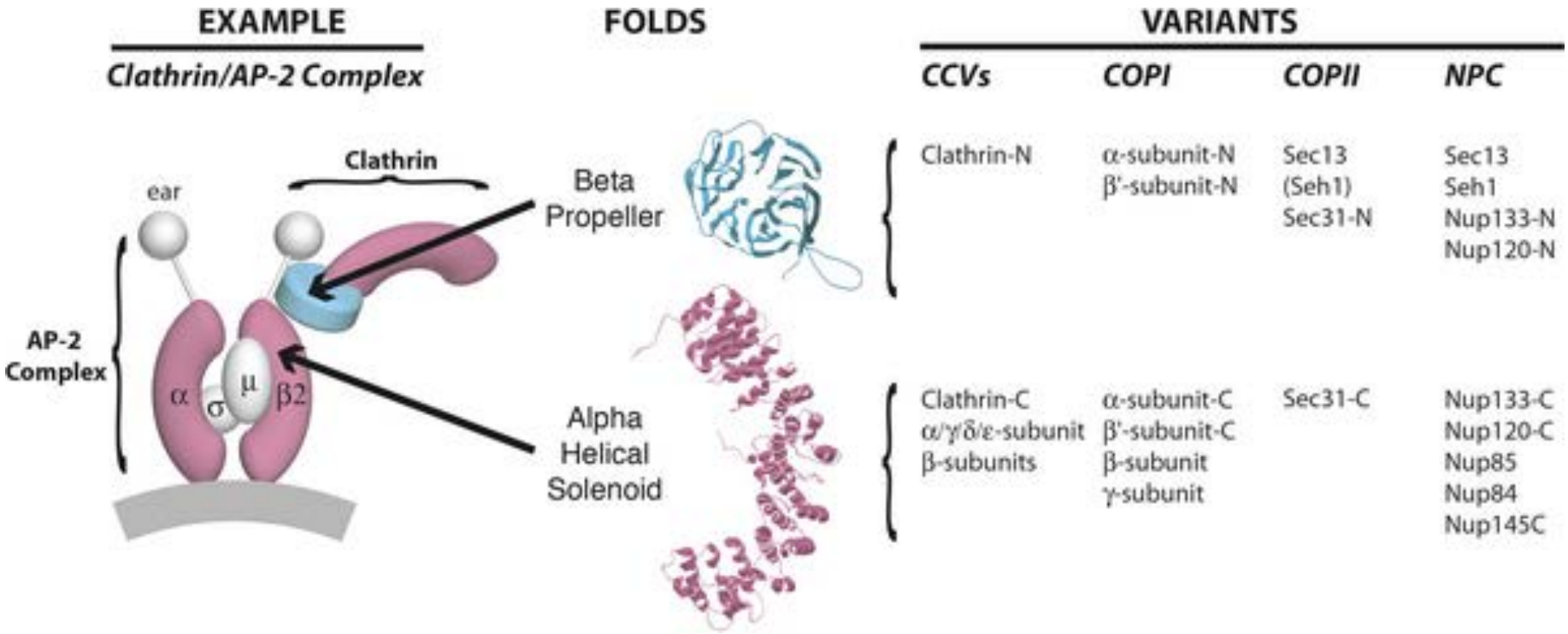

Cytoplasm
Nucleoplasm
5 nm
Nup84
Nup133
Nup85
Sec13
Nup120
Seh1
Nup145C
Spoke
Nup82
Nic96
Nup82
Nic96
5 nm
Pom152
Ndc1
Pom34
Nup157
Nup192
Nup188
Nup170
Nup53
Nup59
Nsp1
Nup49
Nup57
Nup1
Nsp1
Nup145N
Nup60
Nup145N
Nup42
Nsp1
Nup159
Nup59
Nup100
Nup53
Nup116
Nsp1
Nup49
Nup57

The Outer Ring Complex Nups Form "Solenoid-Beta Propeller" Structures



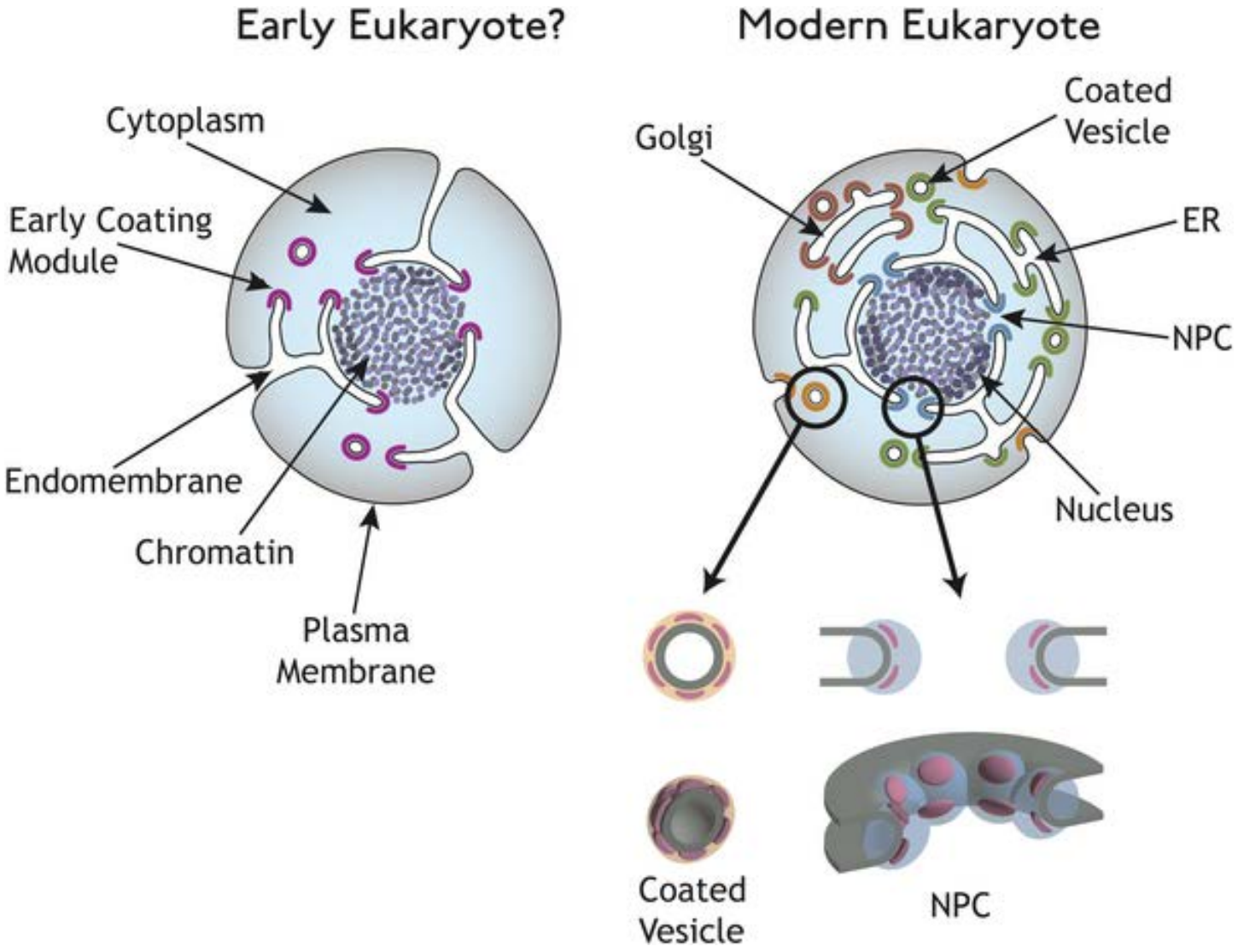
Devos et al. (2004) PLoS Biol 2(12): e380.

Outer Ring Nups are Similar to Vesicle Coat Proteins



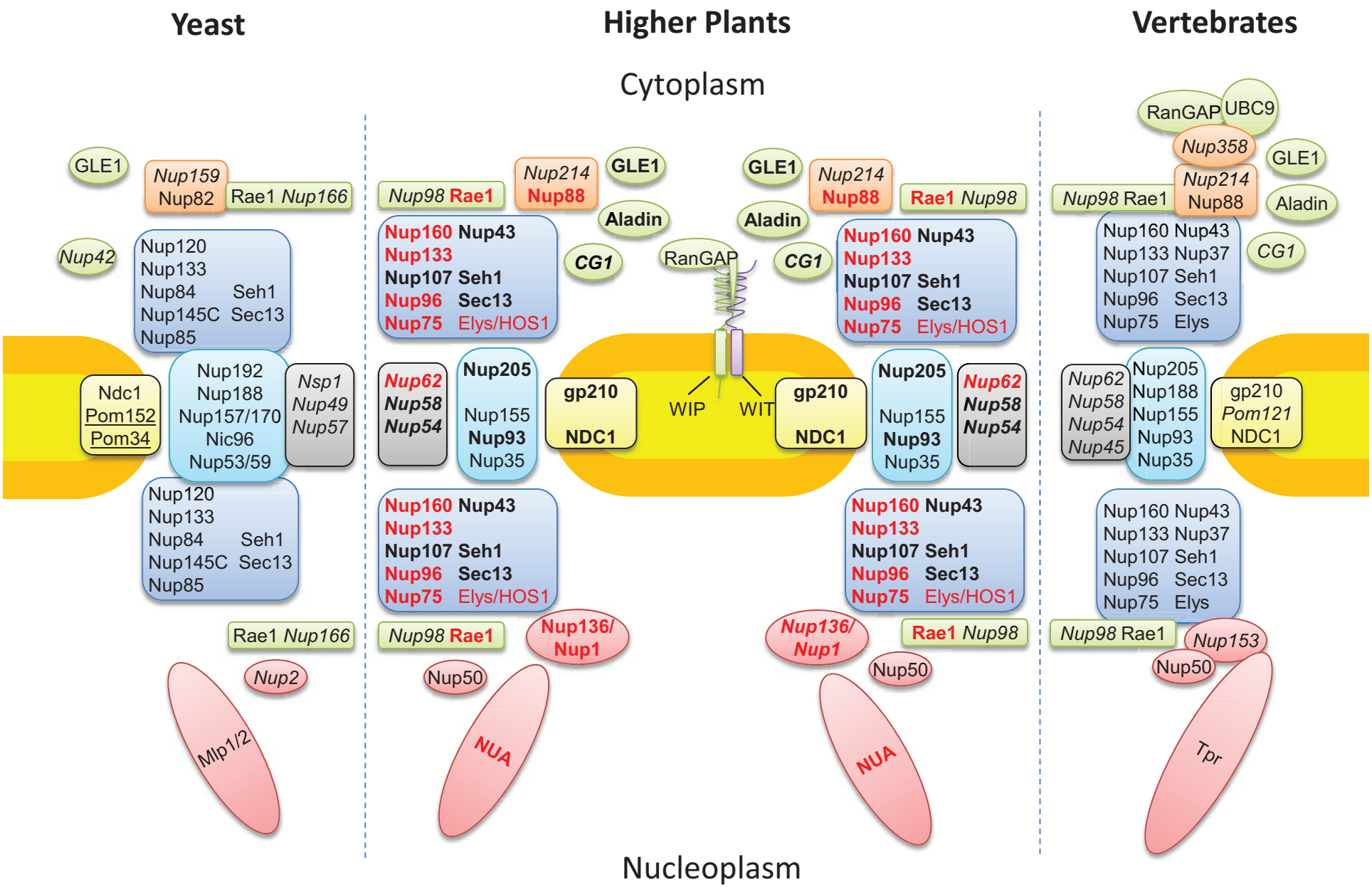
Devos et al. (2004) PLoS Biol 2(12): e380.

Model of nuclear pore evolution

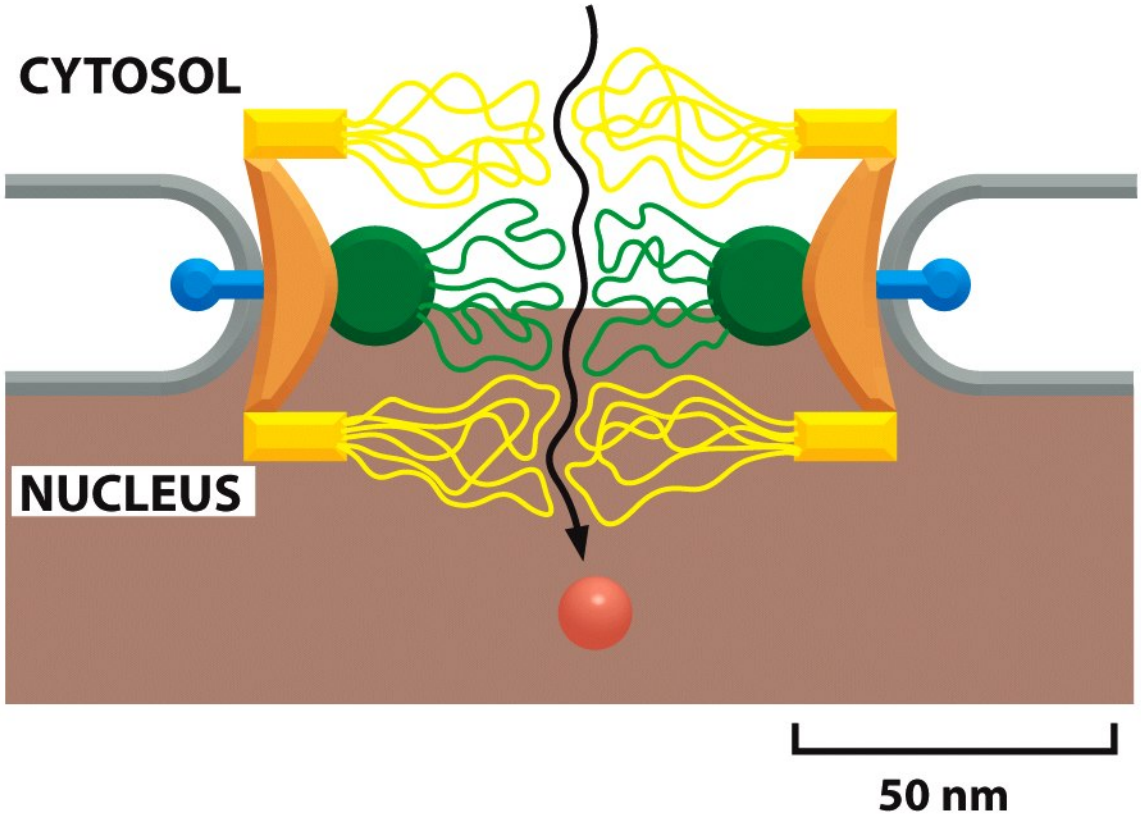


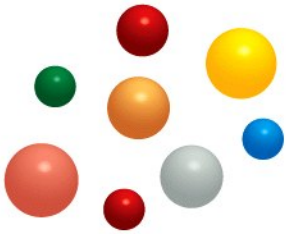
Devos et al. (2004) PLoS Biol 2(12): e380.

Nuclear pores are similar across kingdoms

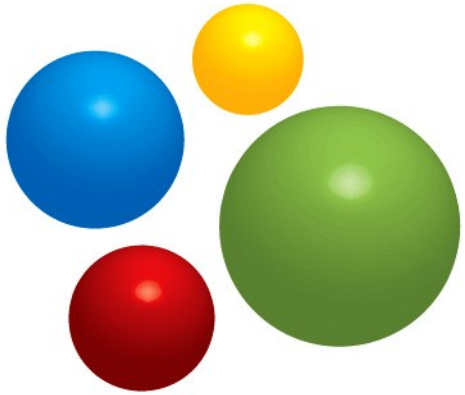


Nuclear pores act as a diffusion barrier





size of molecules that enter nucleus by free diffusion



size of macromolecules that enter nucleus by active transport

Molecules larger than ~50kDa cannot freely enter the nucleus

Figure 12-10

A nuclear localization signal is necessary and sufficient for transport into the nucleus

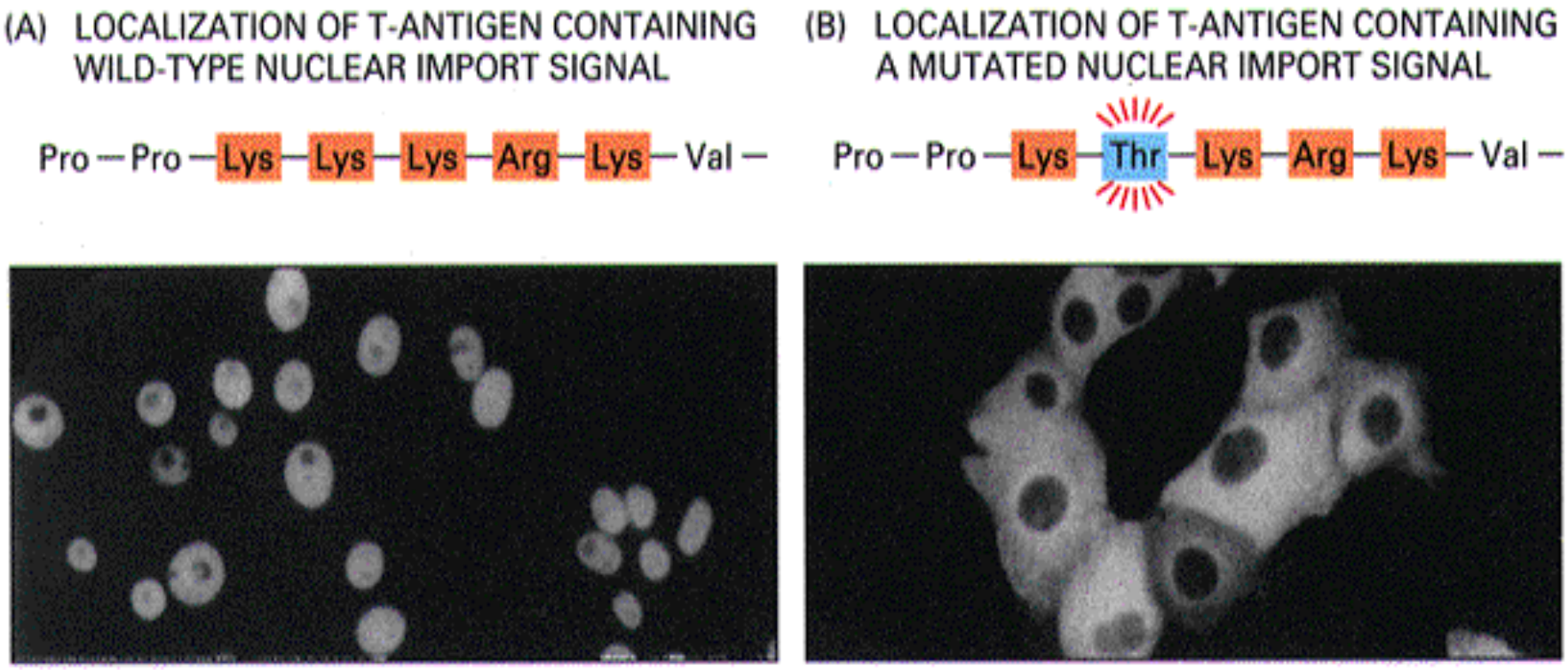


Figure 12-11

Nuclear Localization Signals Bind to an Import Receptor (or "Importin")

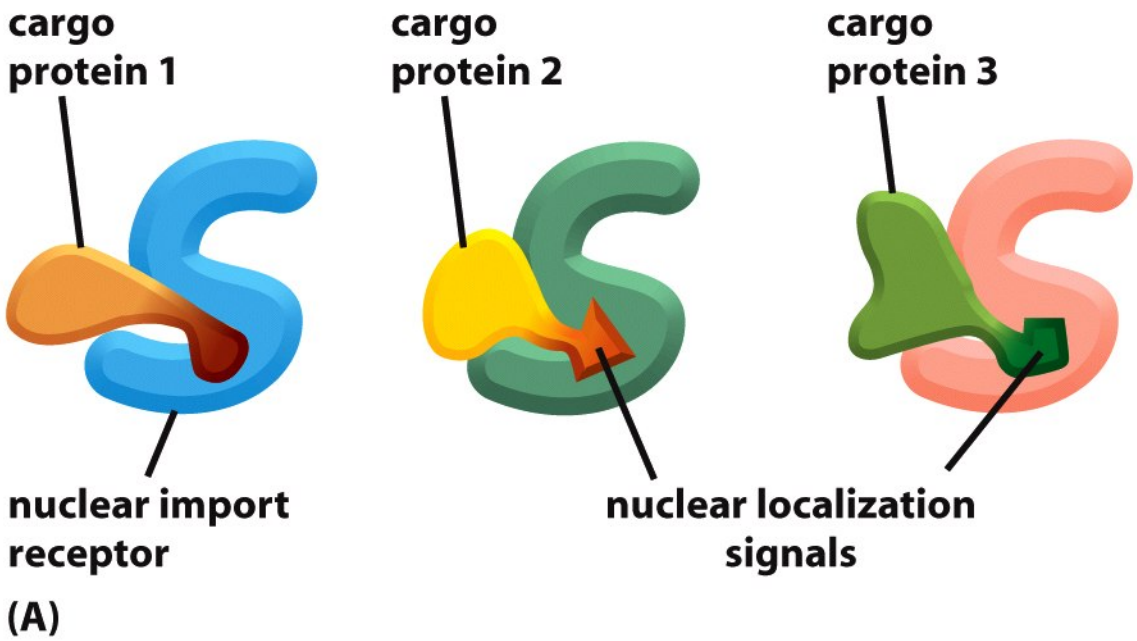


Figure 12-13

Binding to Importins is Regulated by Ran

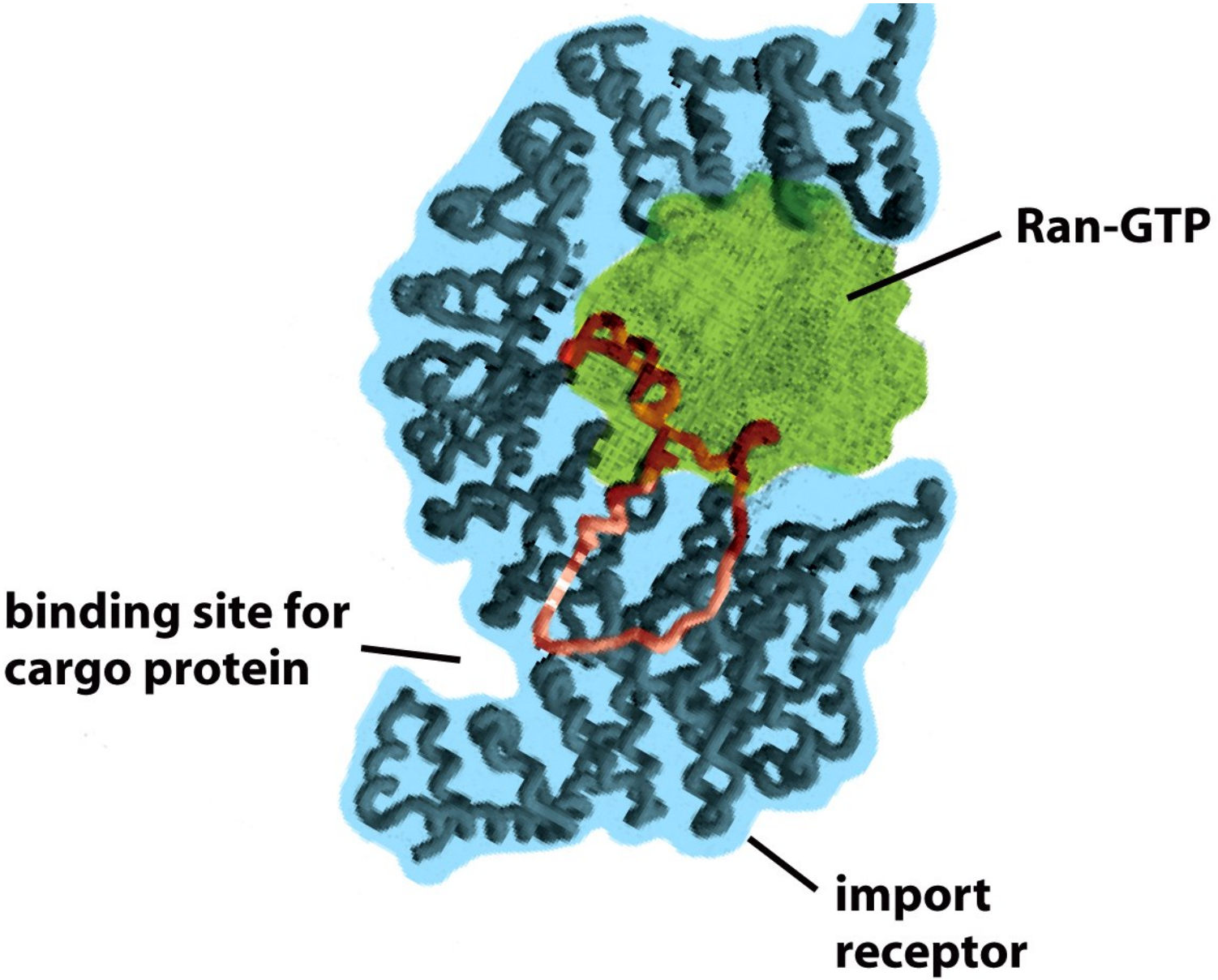


Figure 12-16

Binding to Importins is Regulated by Ran

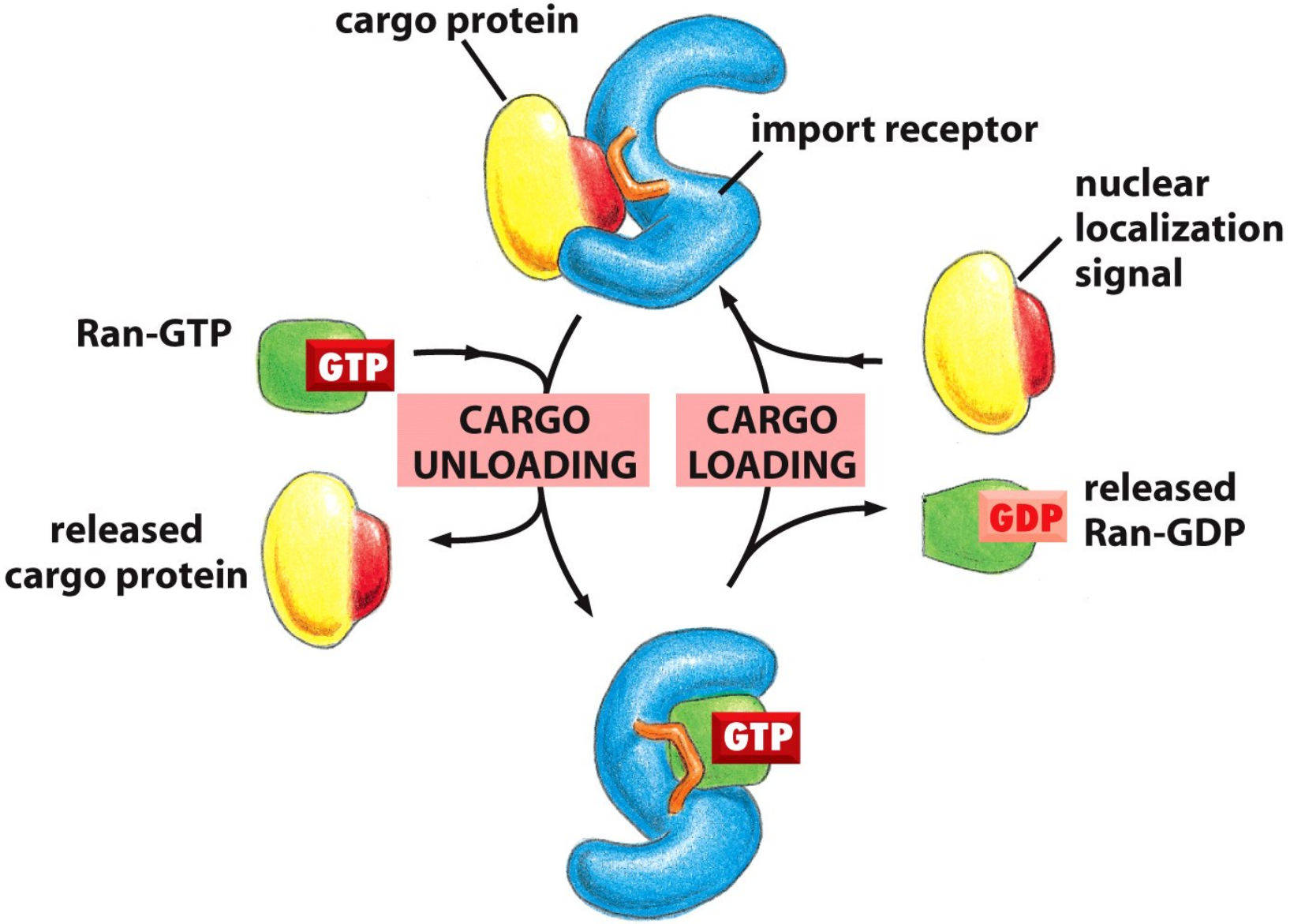


Figure 12-15

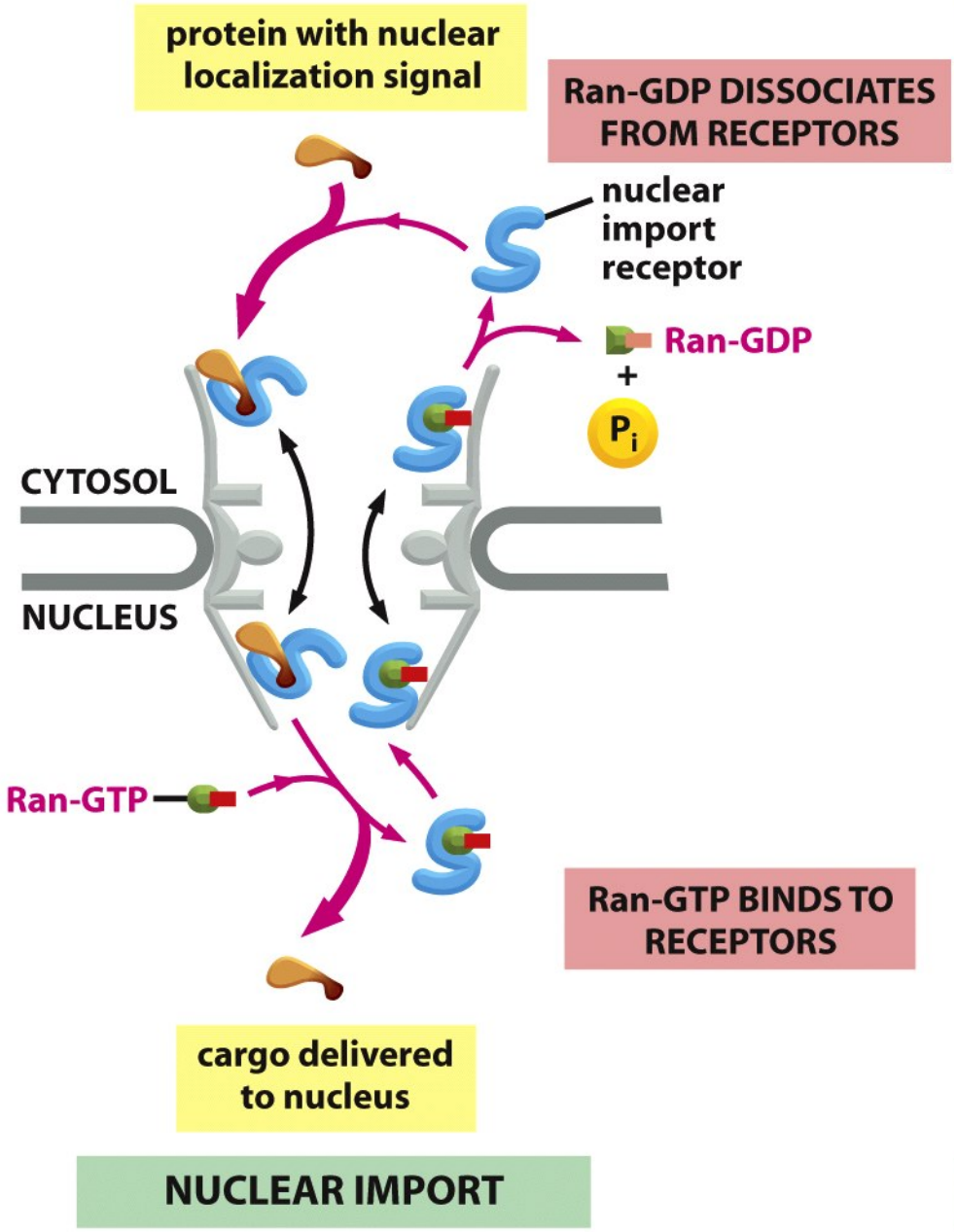


Figure 12-15 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Figure 12-15

The Ran Cycle

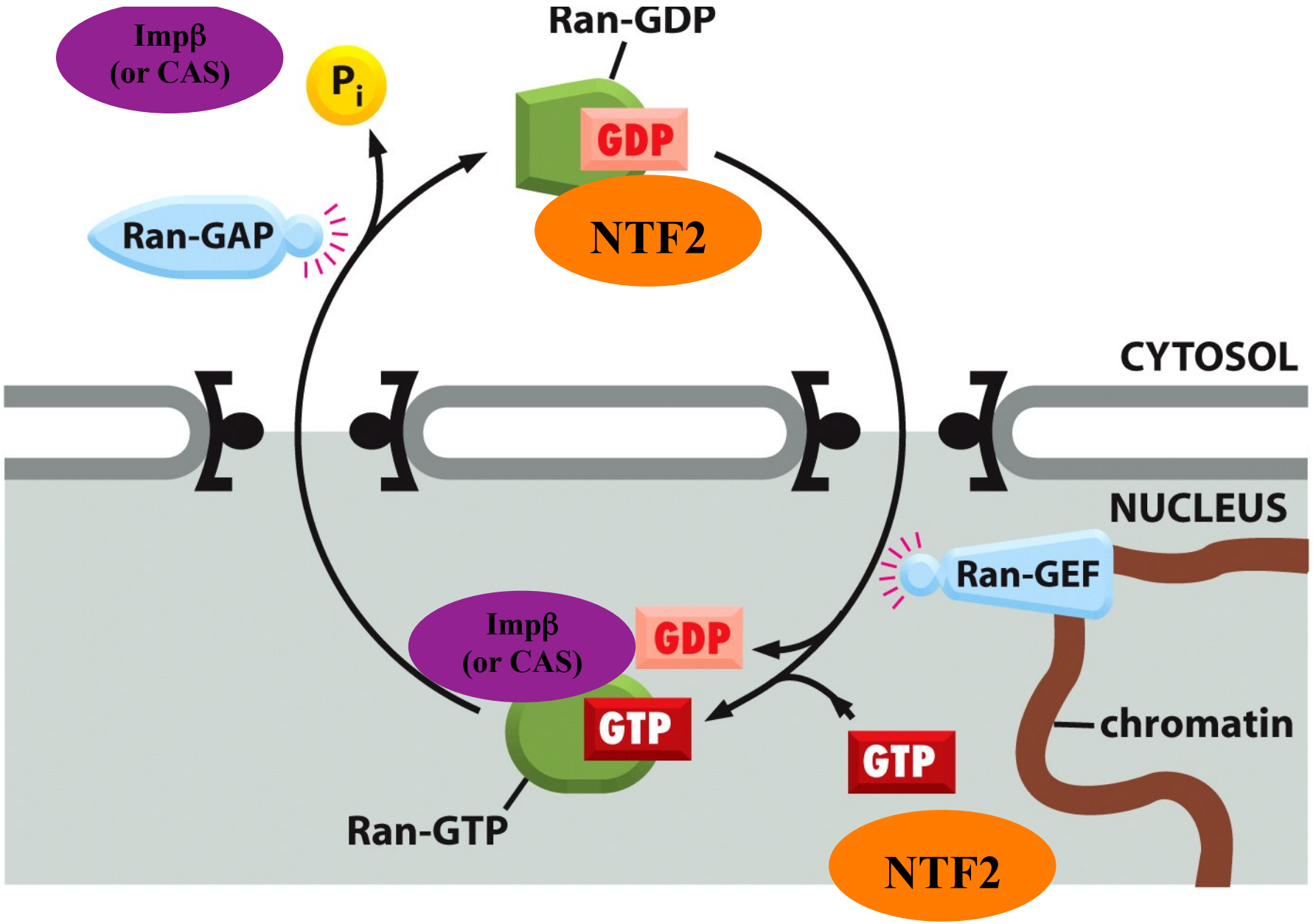
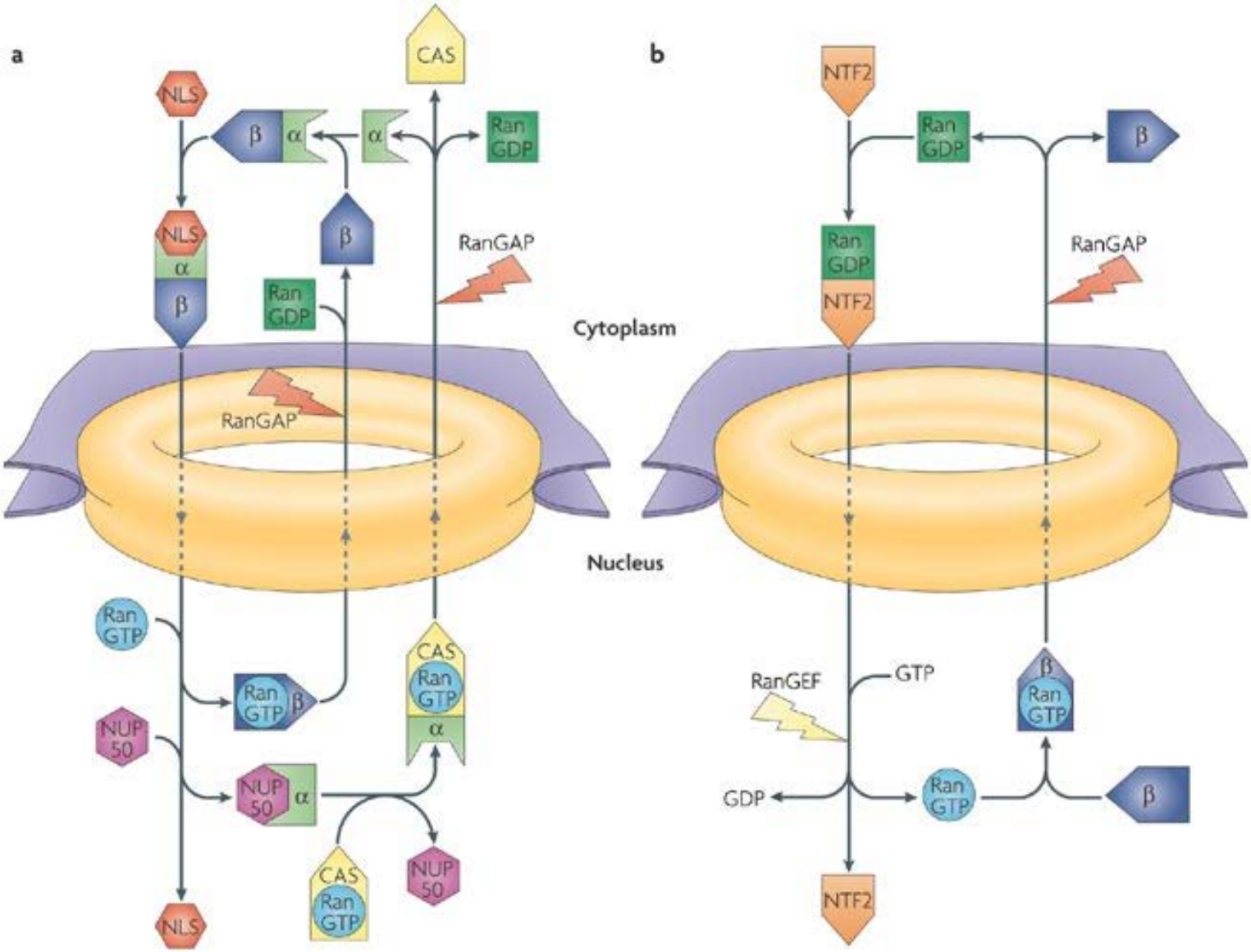


Figure 12-14

It is, of course, more complicated…



Stewart (2007) ***Nature Reviews Molecular Cell Biology*** **8**, 195-208

Nature Reviews | Molecular Cell Biology

Nuclear Export Uses the Same Principles as Import

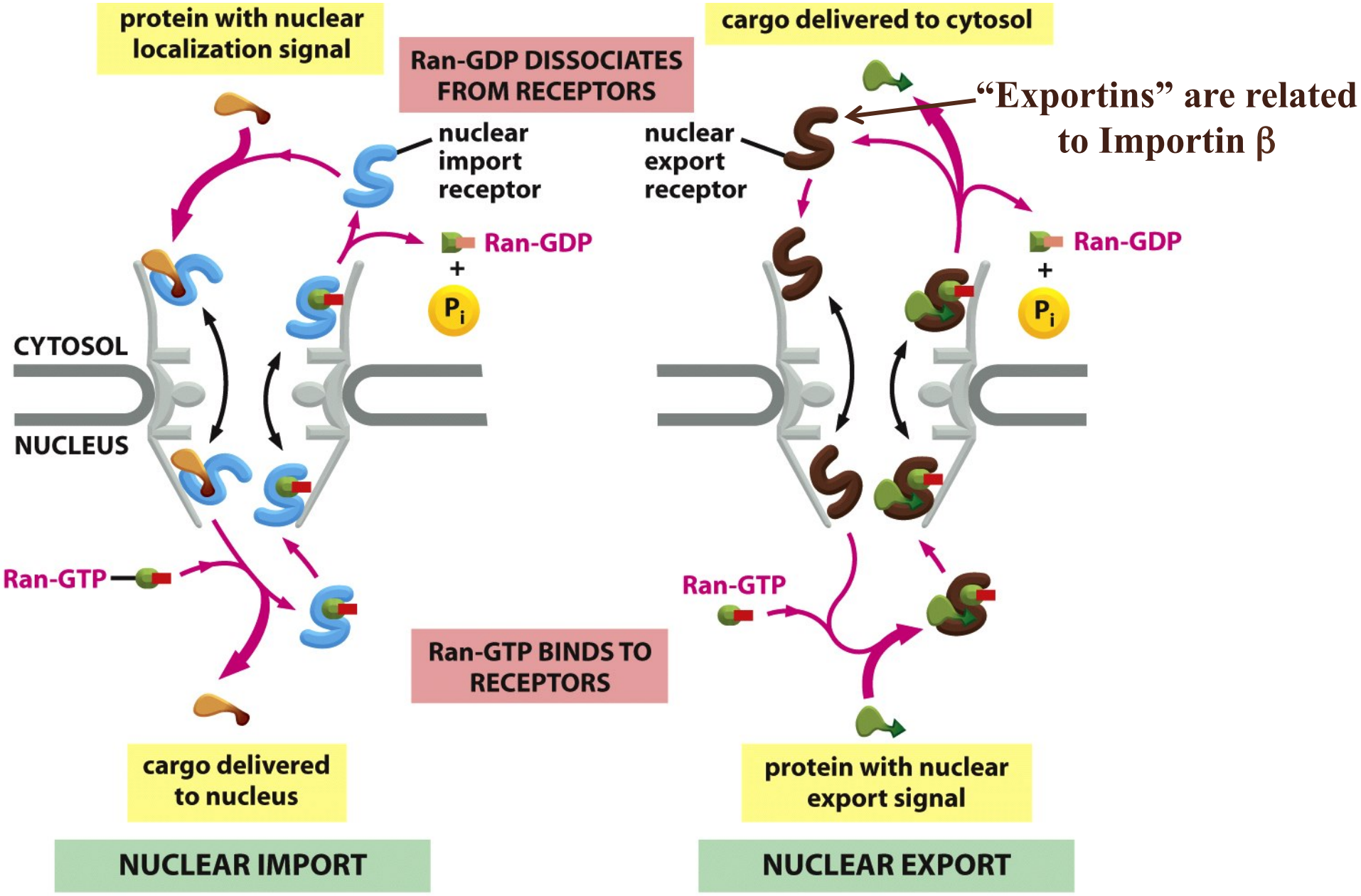
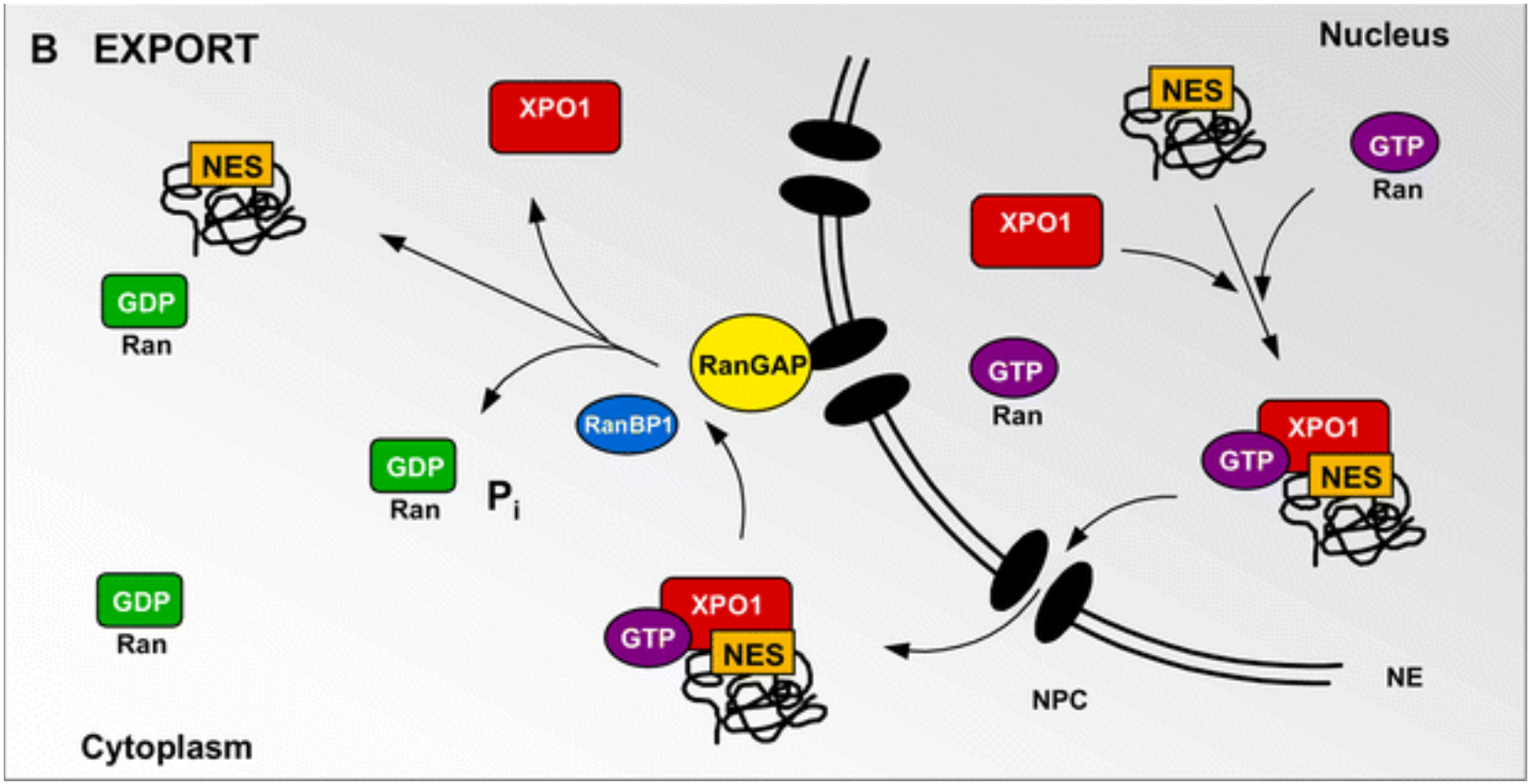
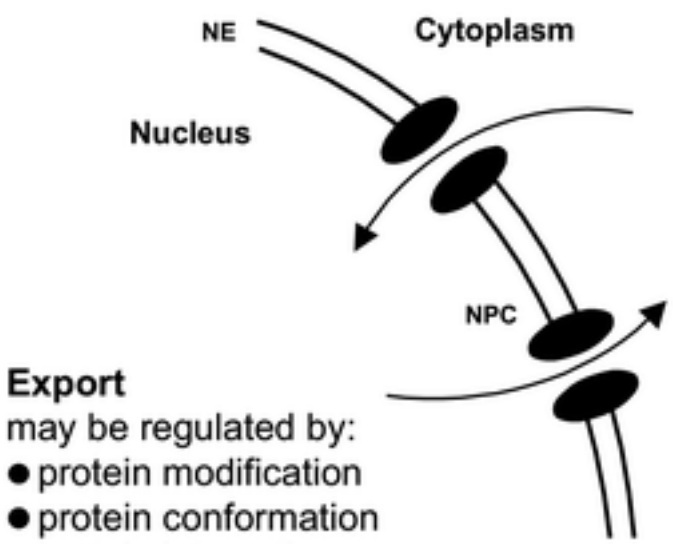


Figure 12-15 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Nuclear export of proteins



Regulation of nuclear transport

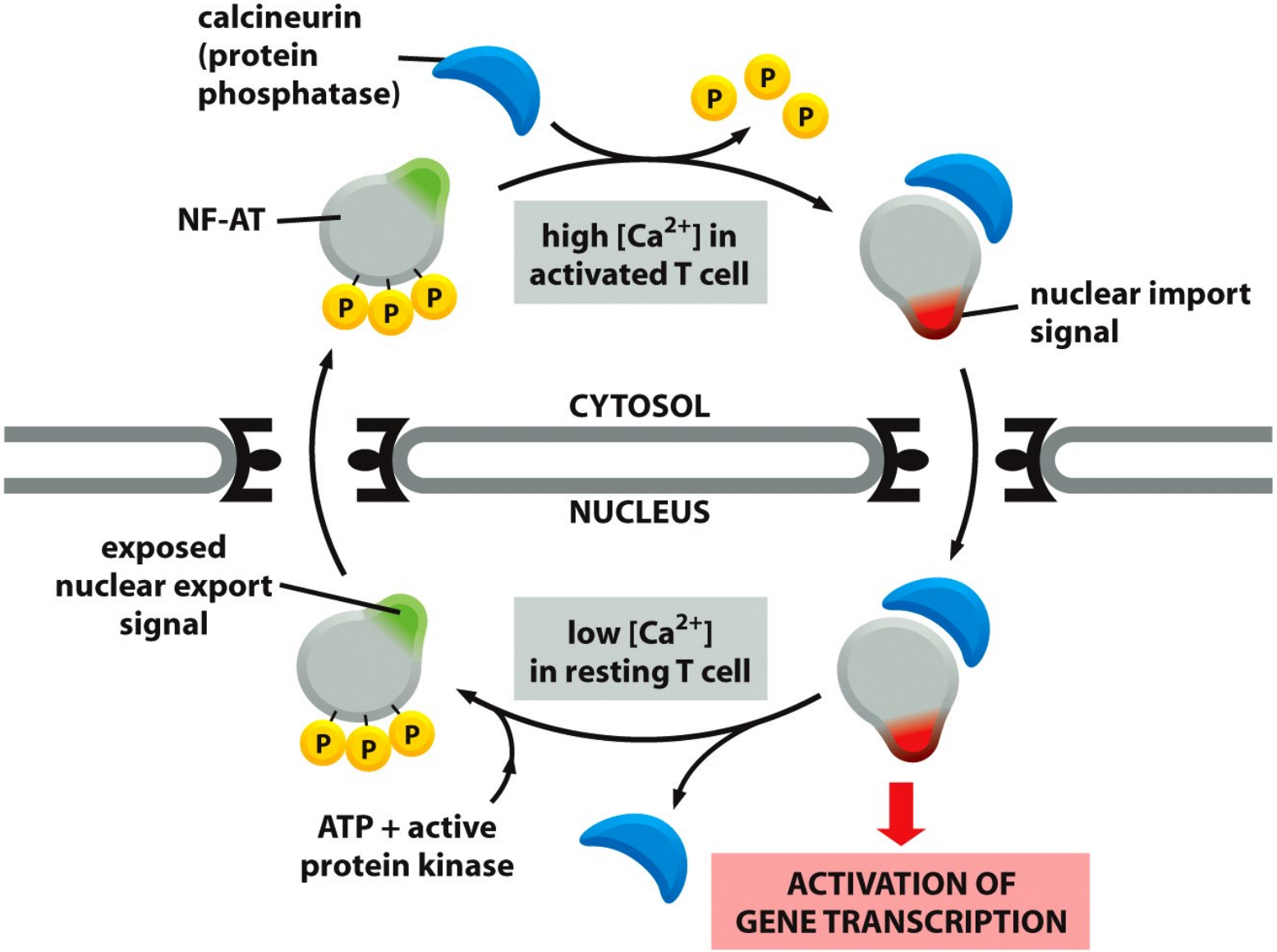


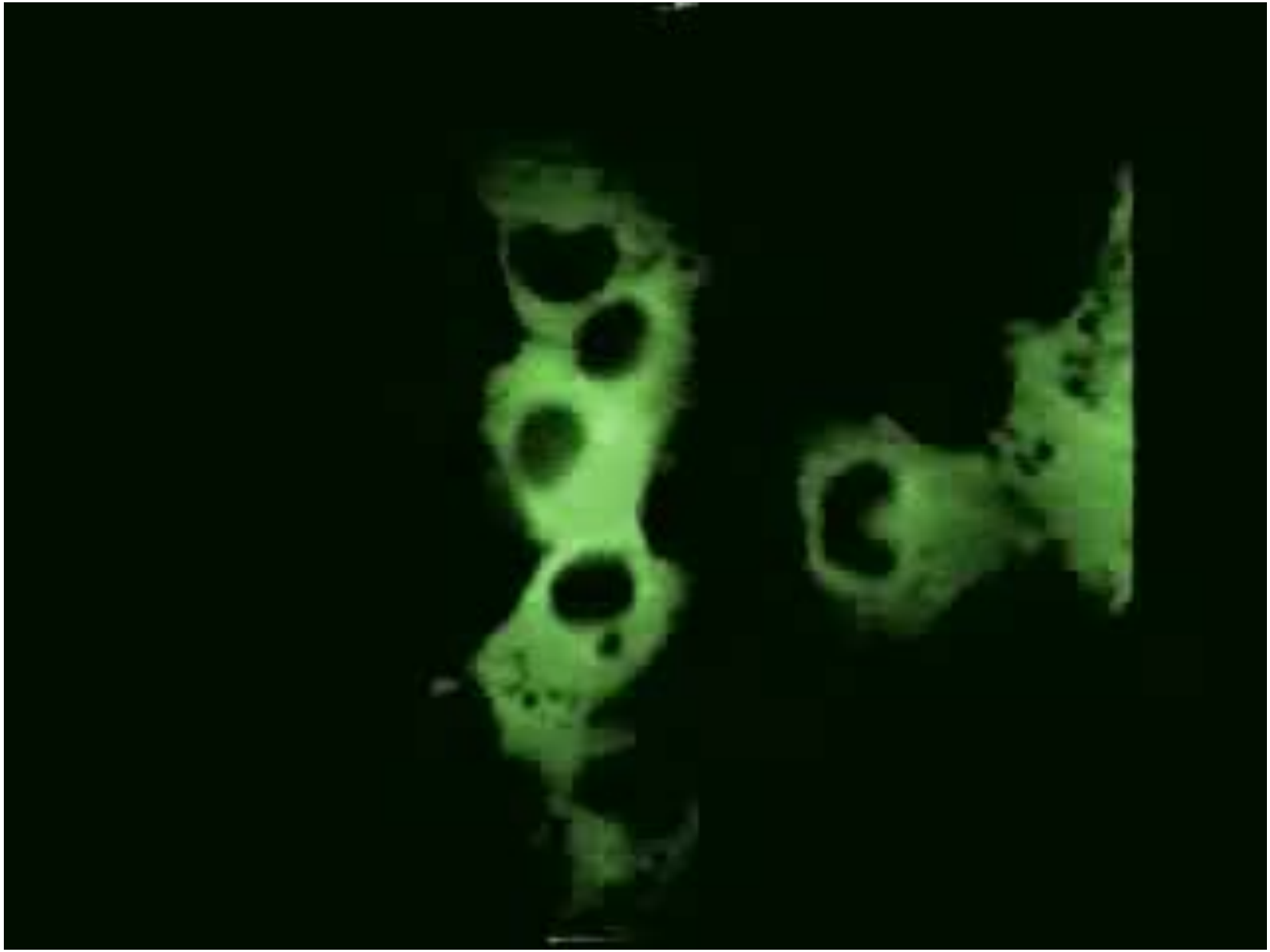
Import
may be regulated by:
- protein modification
- protein conformation
- protein interaction
- cytosolic retention

Export
may be regulated by:
- protein modification
- protein conformation
- protein interaction
- nuclear retention

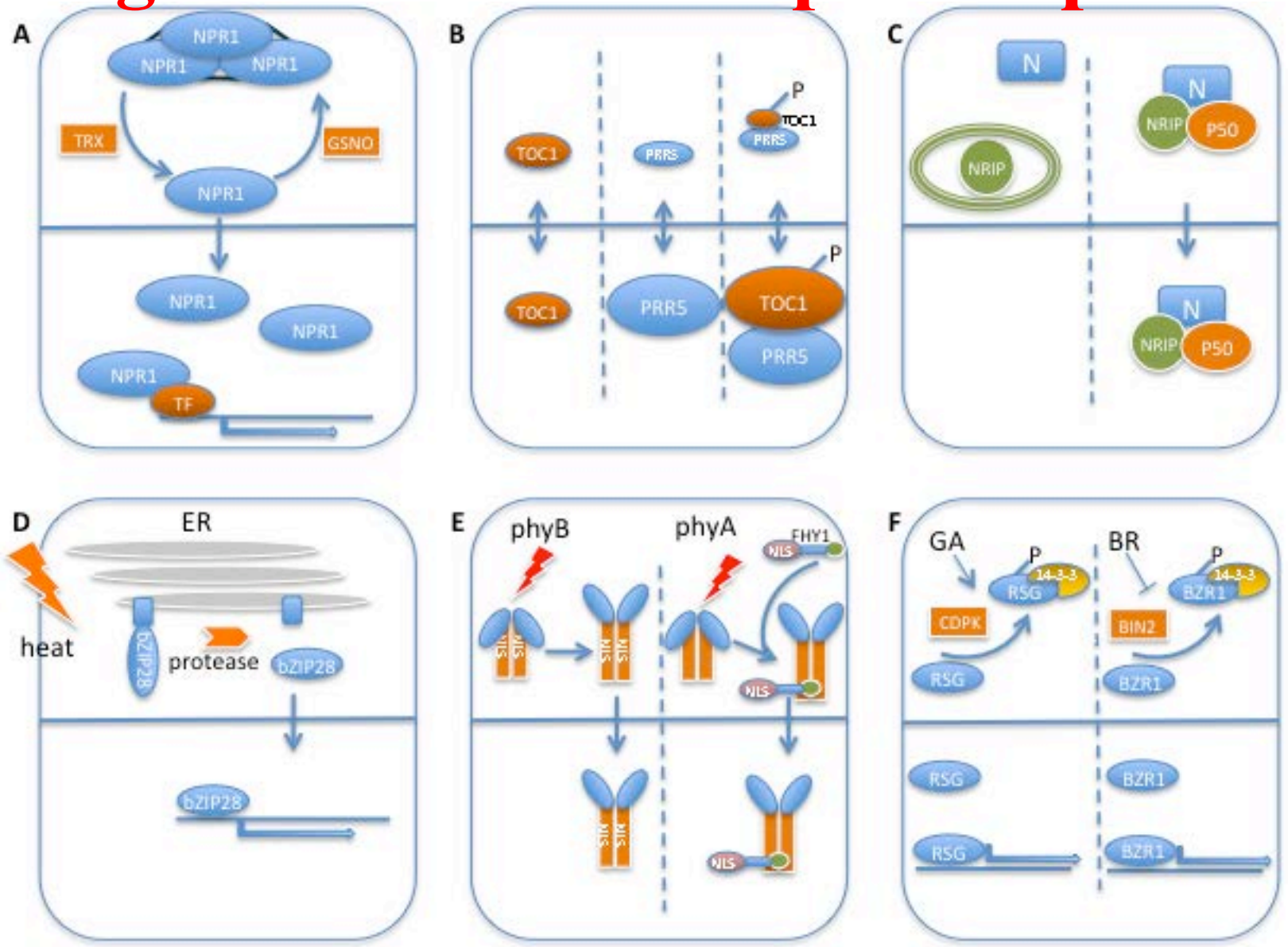
Degradation

Regulated nuclear import is a step in signal transduction!



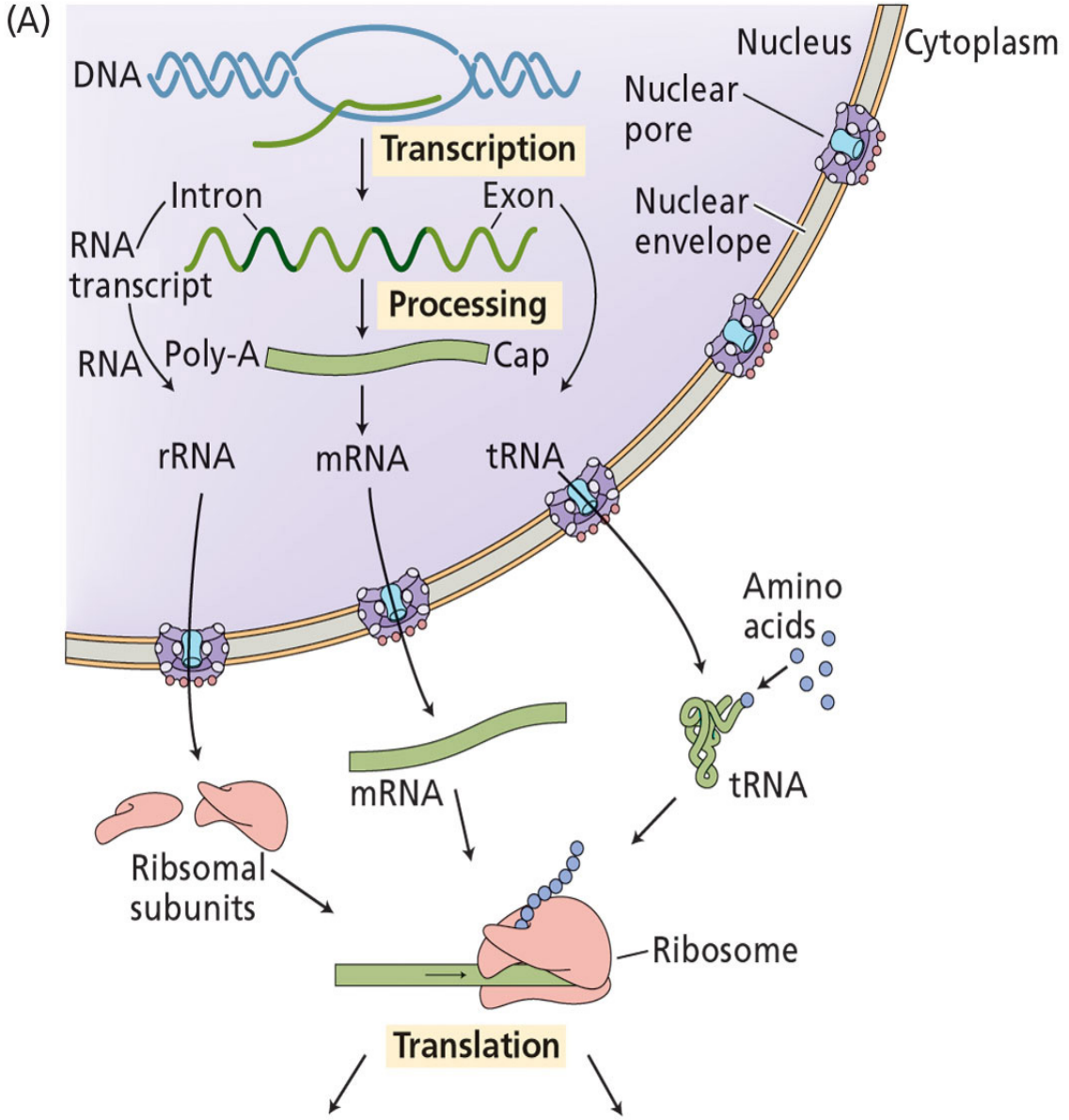


Regulated nuclear import in plants



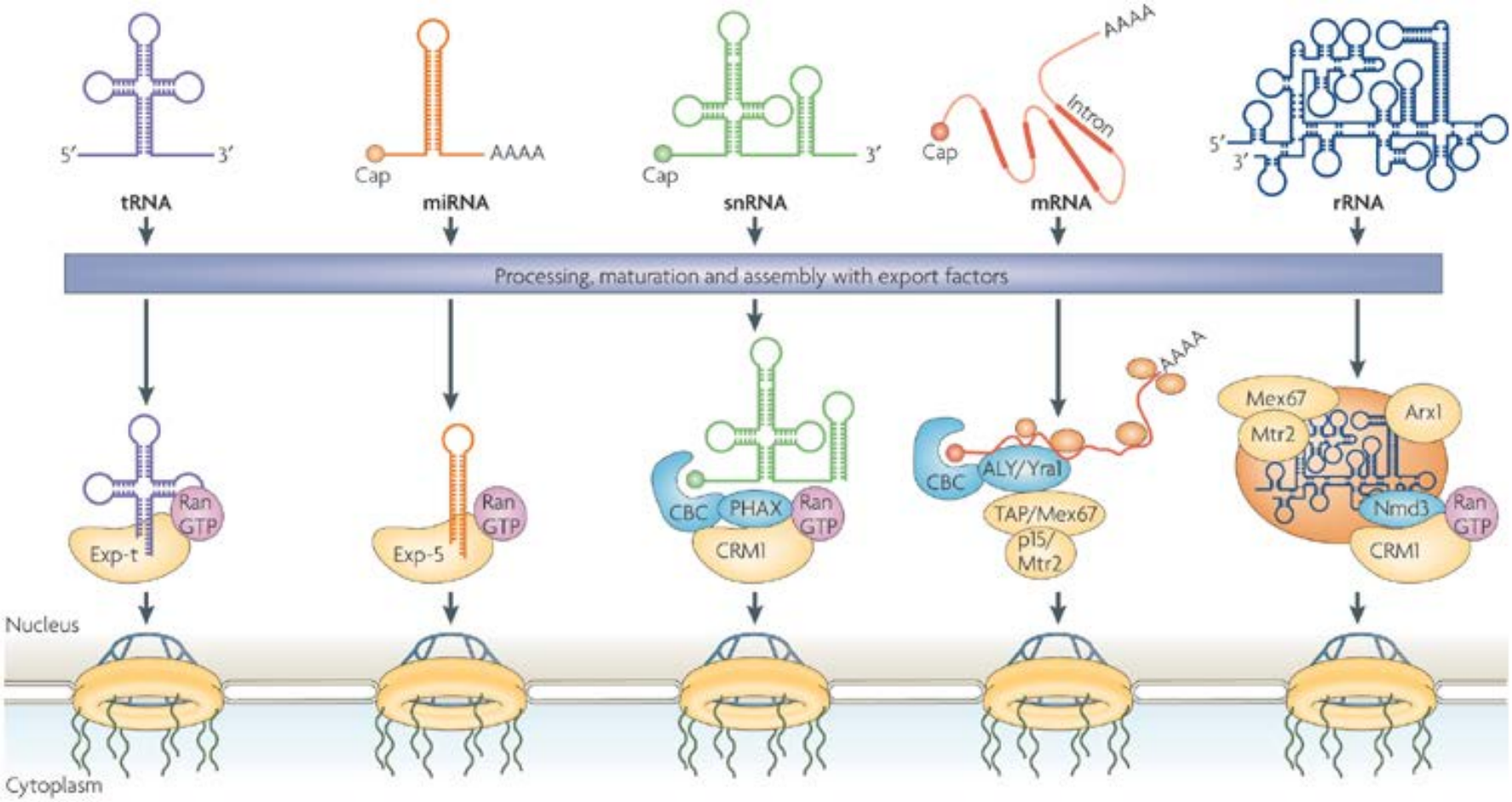
Regulation of nucleocytoplasmic trafficking in plants.Meier I, Somers DE.Curr Opin Plant Biol. 2011 Oct;14(5):538-46.

Different RNAs exported from nucleus



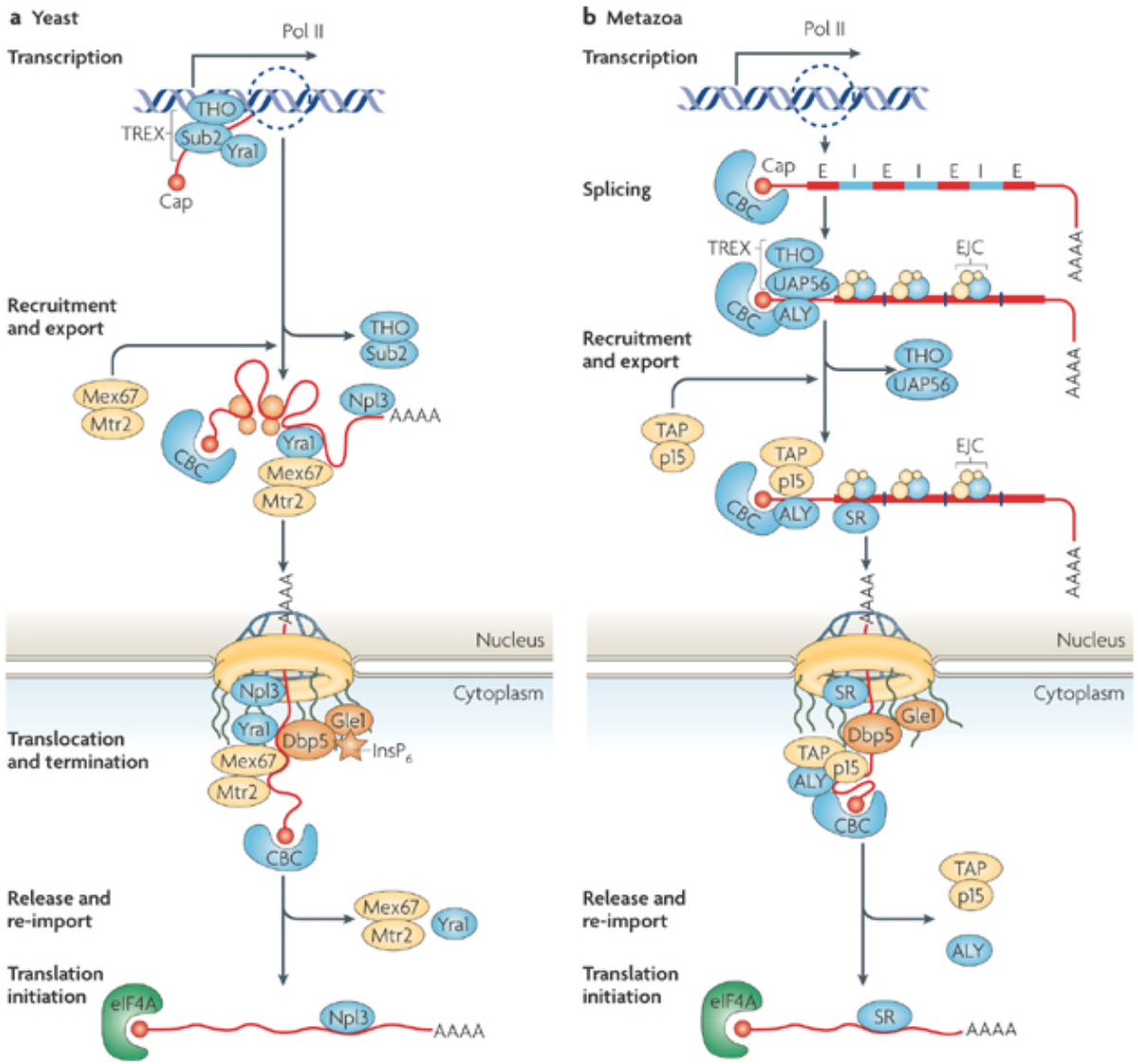
PLANT PHYSIOLOGY, Third Edition, Figure 1.10 (Part 1) © 2002 Sinauer Associates, Inc.

Overview of the different RNA export pathways and the export factors



Nature Reviews | Molecular Cell Biology

Transcription-coupled or splicing-coupled mRNA export



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