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12 September 2011 Last updated at 11:35 GMT



Glasgow University in bid to create 'inorganic life'

Scientists in Scotland are undertaking pioneering research to create life from inorganic chemicals.

All life on earth is based on organic biology - in the form of carbon compounds - but the inorganic world is considered to be inanimate.

A team from Glasgow University has demonstrated a new way of making inorganic chemical cells.

The aim is to create self-replicating, evolving inorganic cells which could be used in medicine and chemistry.

The project is being led by Professor Lee Cronin from the university's College of Science and Engineering.



Prof Cronin wants to create an 'inorganic biology'

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Lucky socks

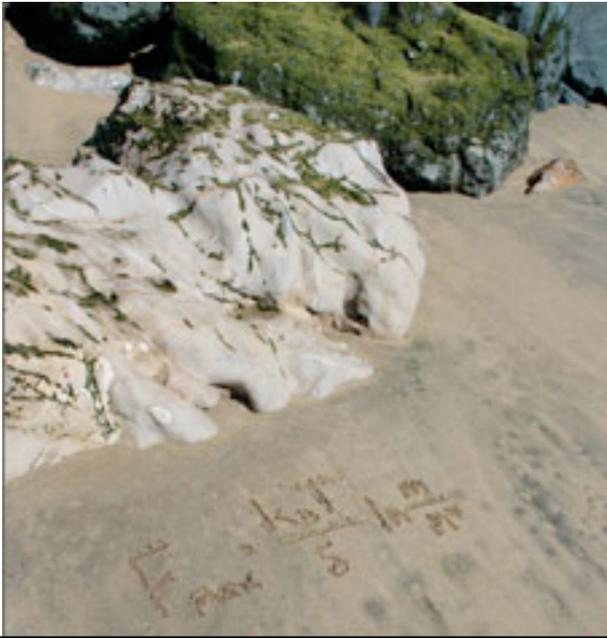
Today's Lecture:

Chapter 3

When: Stopwatches at Many Scales

Chapter 4

Who: "Bless the Little Beasties"



Rob Phillips
Jean Koster
Julie Theriot
with an introduction by Miguel Ángel
**PHYSICAL BIOLOGY
OF THE CELL**

I 1, 2, 3, 4.

Facts of life

II 5, 6, 7, 8, 9, 10, 11

Life at rest

III 12, 13, 14, 15, 16, 17

Life in motion

IV 18, 19, 20

Meaning of life

Chapter 3

When: Stopwatches at Many Scales

3.1 Hierarchy of temporal scales

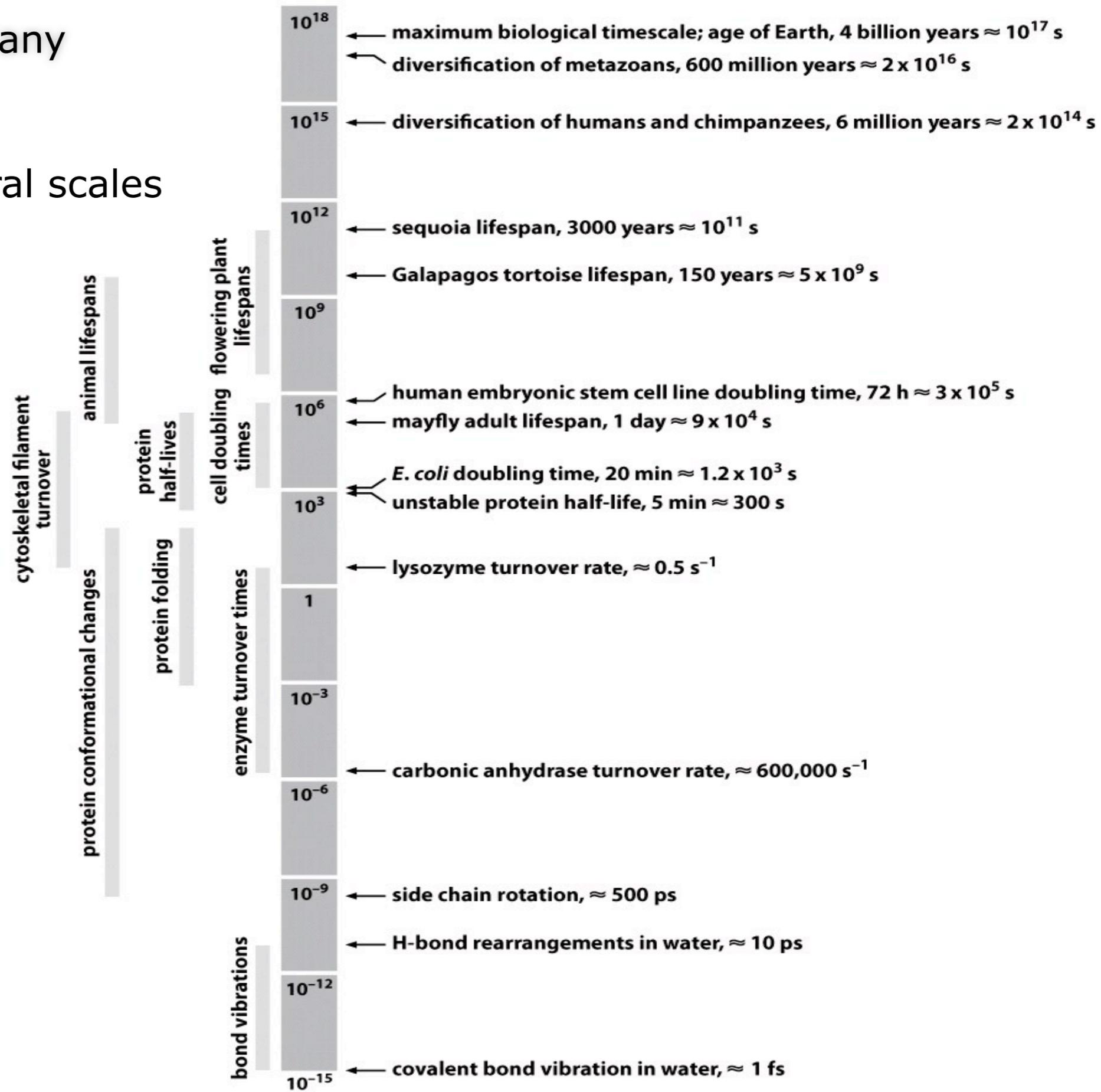


Figure 3.1 Physical Biology of the Cell (© Garland Science 2009)

3.1.1 a sample of a huge diversity of temporal scales



development of *Drosophila*

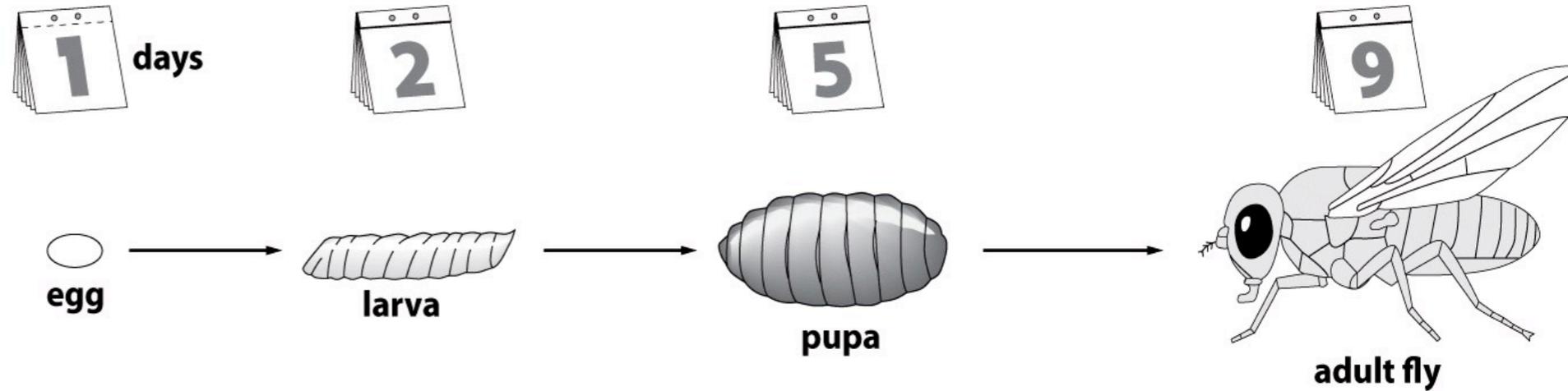
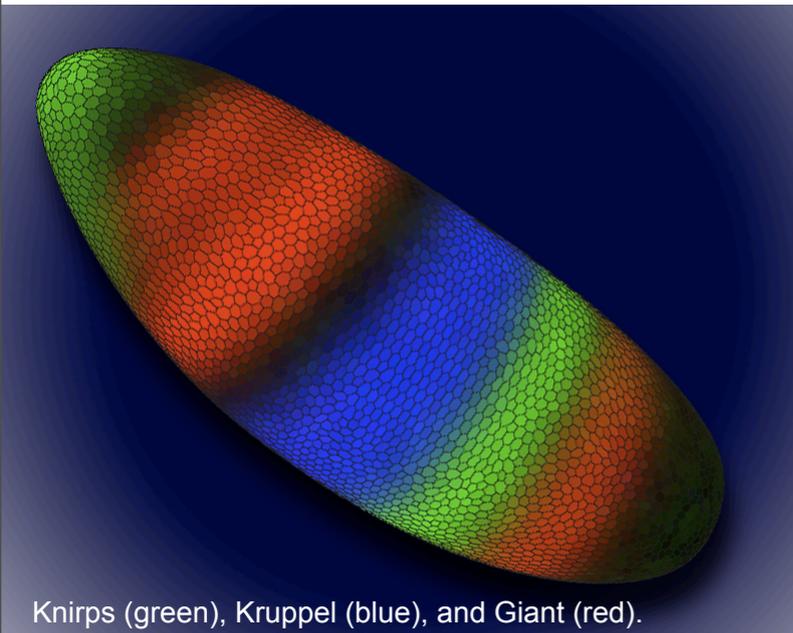


Figure 3.2a Physical Biology of the Cell (© Garland Science 2009)



early development of *Drosophila* embryo

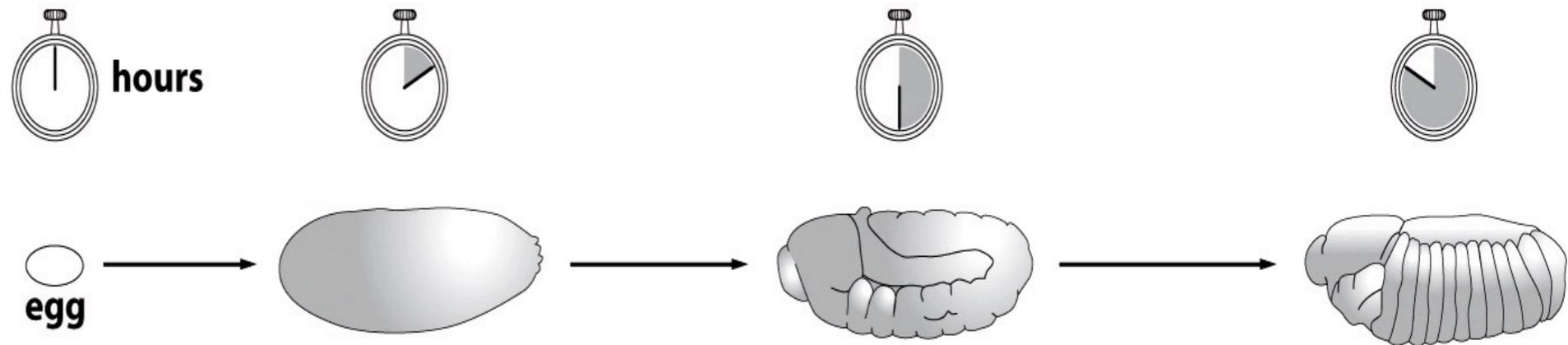


Figure 3.2b Physical Biology of the Cell (© Garland Science 2009)

Knirps (green), Kruppel (blue), and Giant (red).

bacterial cell division

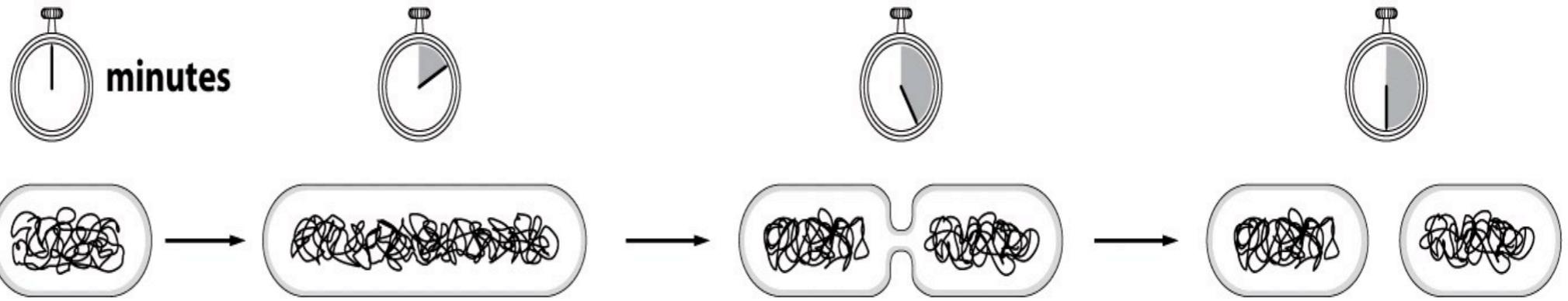
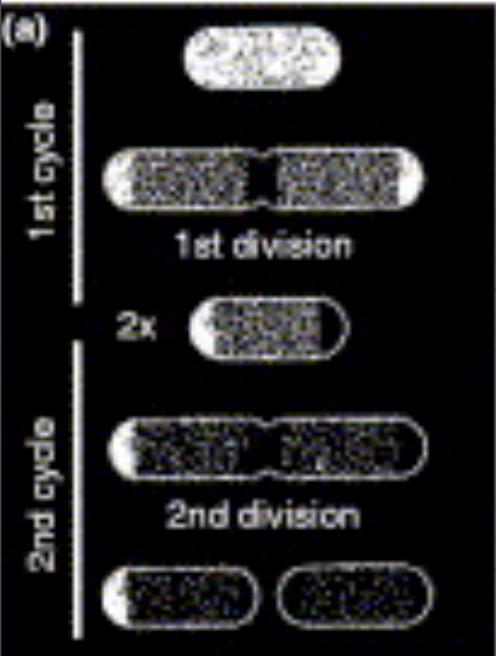


Figure 3.2c Physical Biology of the Cell (© Garland Science 2009)

cell movements

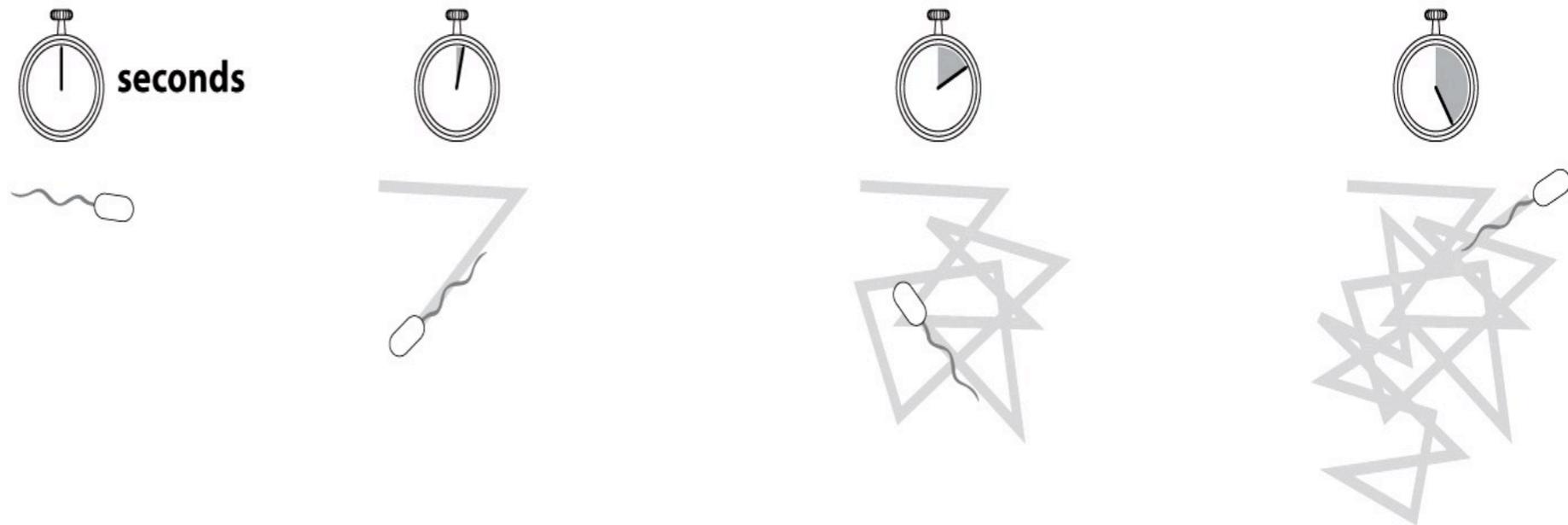
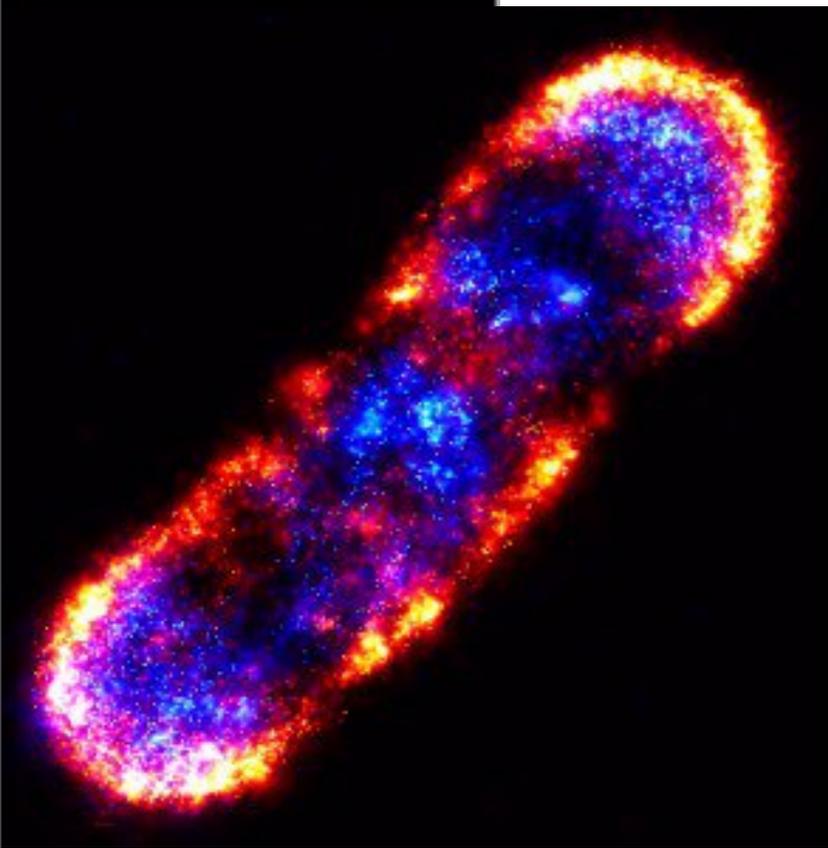
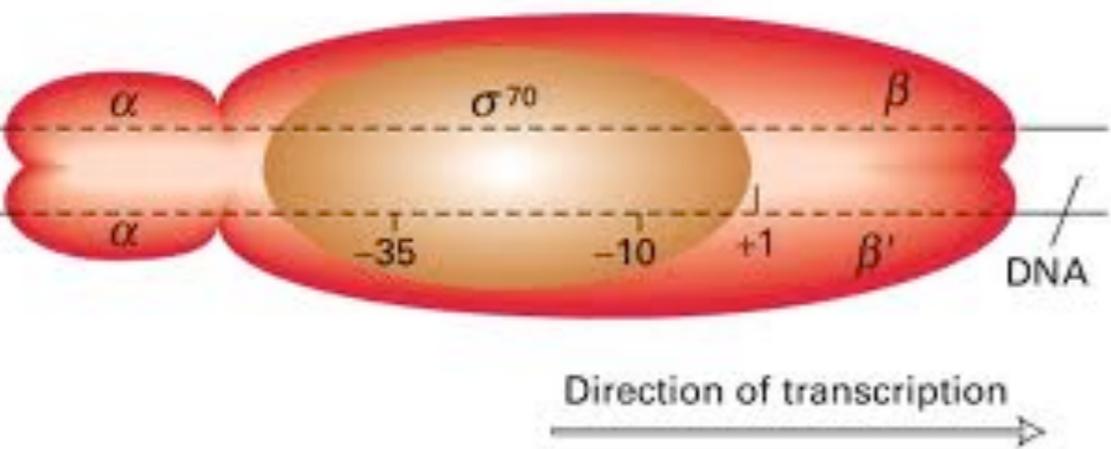
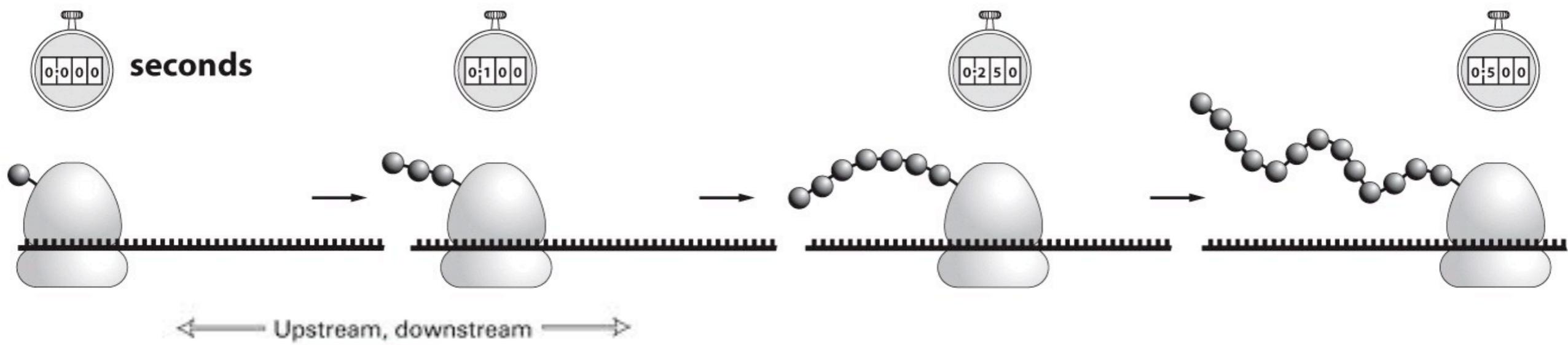


Figure 3.2d Physical Biology of the Cell (© Garland Science 2009)



protein synthesis



transcription

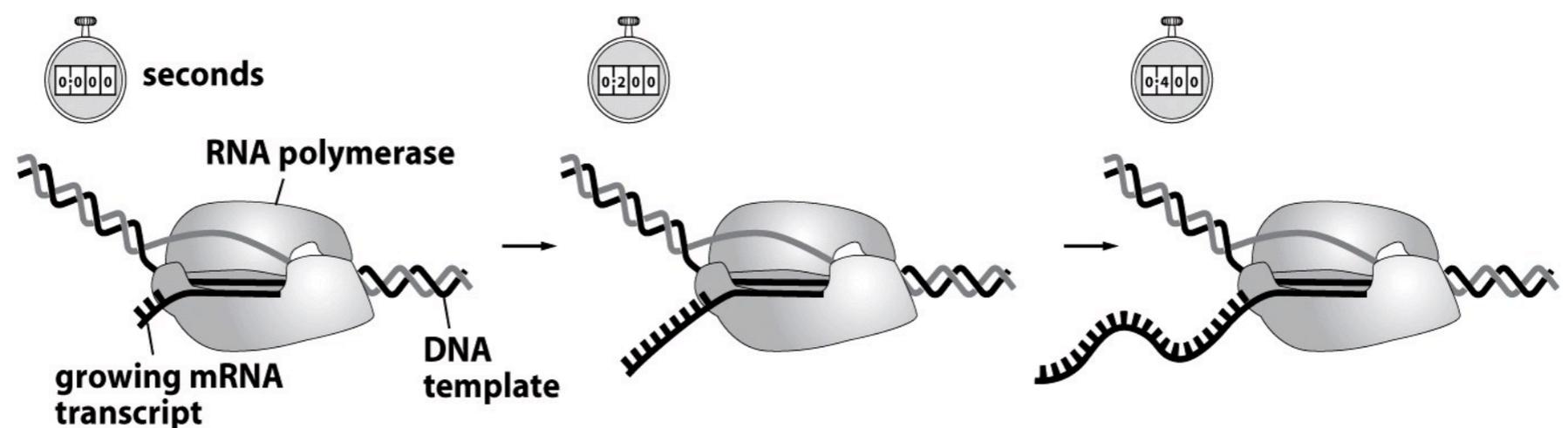
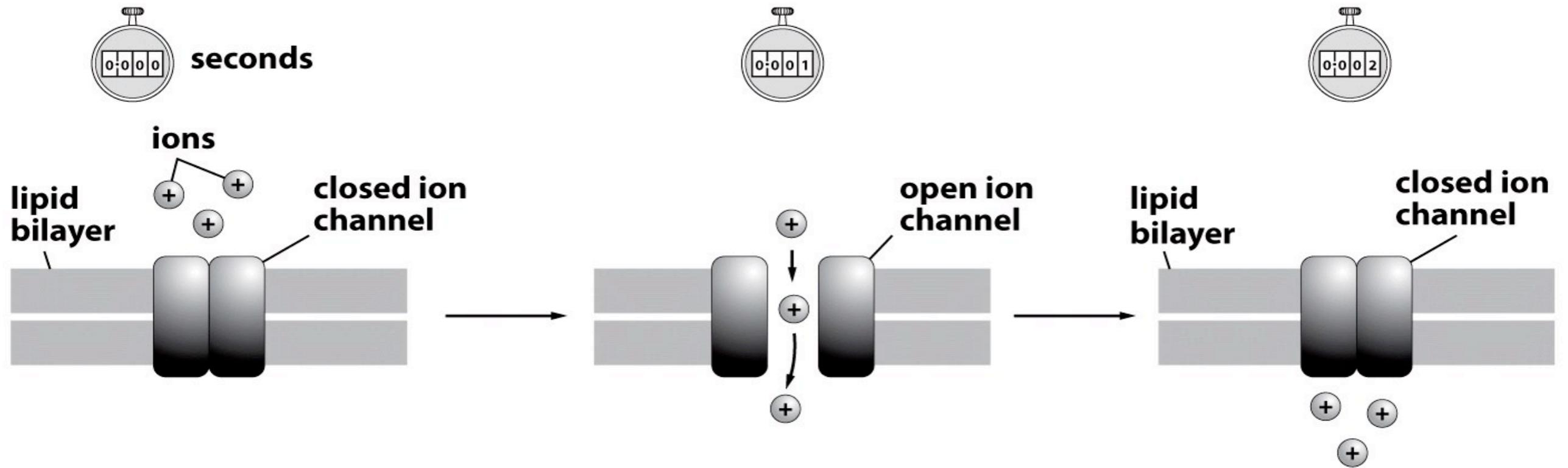


Figure 3.2f Physical Biology of the Cell (© Garland Science 2009)

gating of ion channels



enzyme catalysis

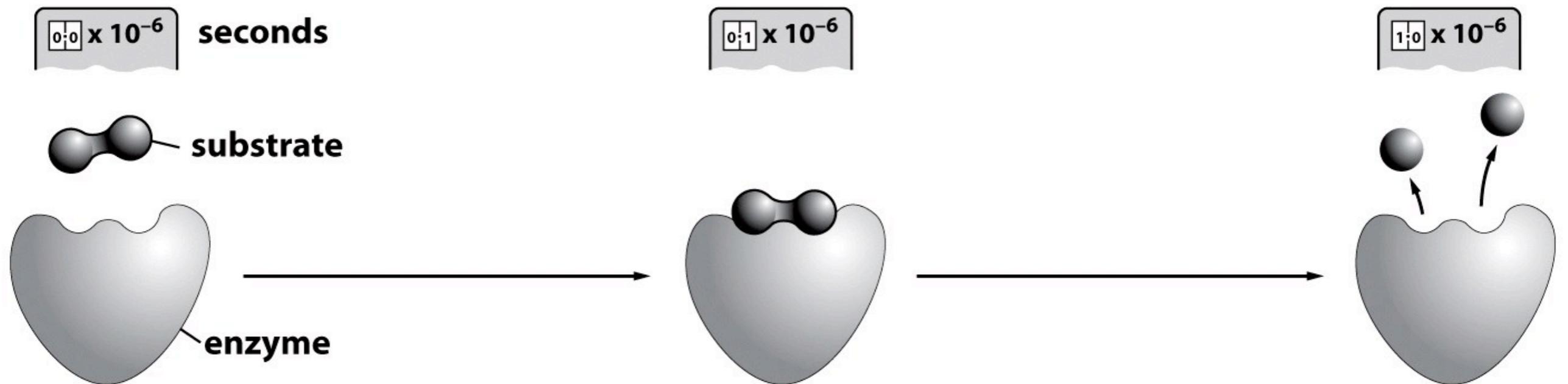


Figure 3.2h Physical Biology of the Cell (© Garland Science 2009)

How do we measure?

METHOD	direct observation	fixed time points	pulse-chase	product accumulation
TYPICAL TIME SCALES	milliseconds to hours	microseconds to years	minutes to days	minutes to days
TYPES OF PROCESSES	individual transformations	population changes	continuous (e.g., metabolism, transport)	biosynthetic or enzymatic
EXAMPLE	cell crawling	bacterial growth curve	axonal transport	GFP expression

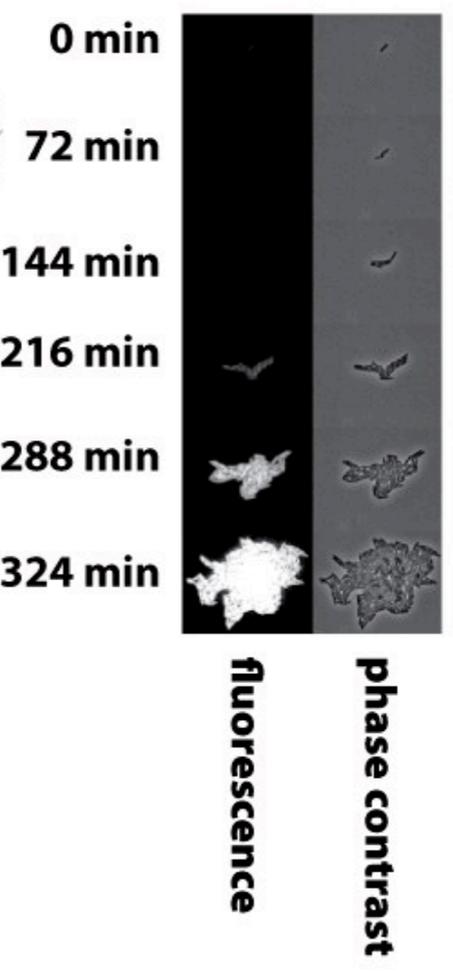
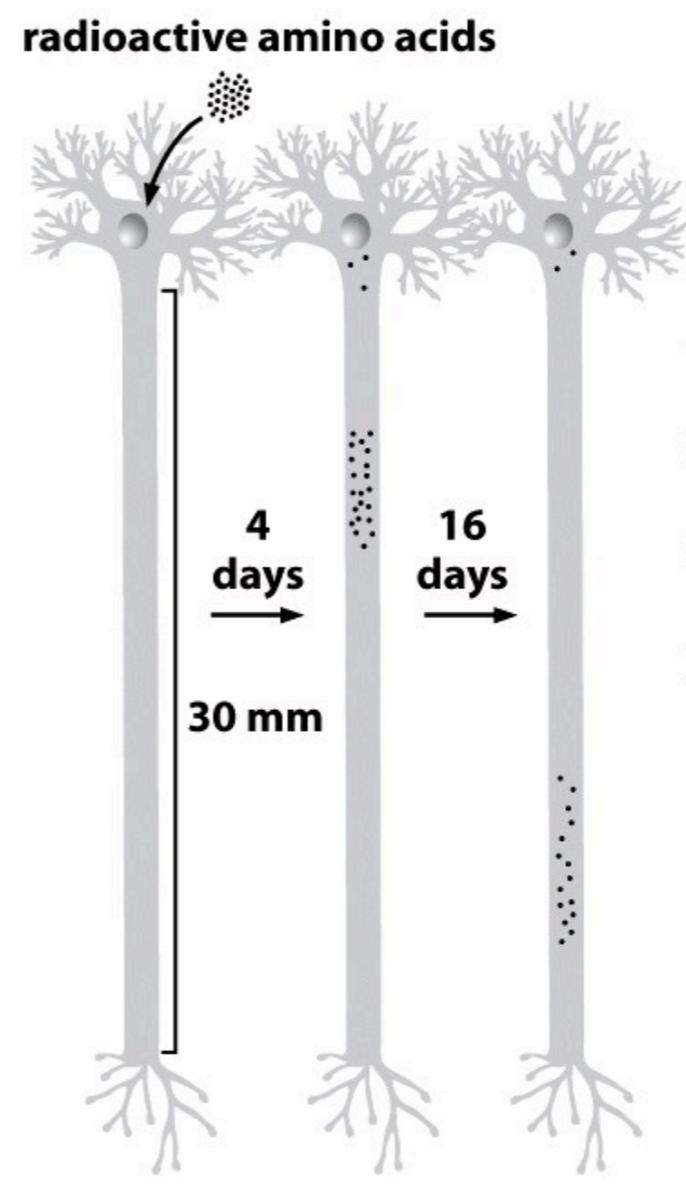
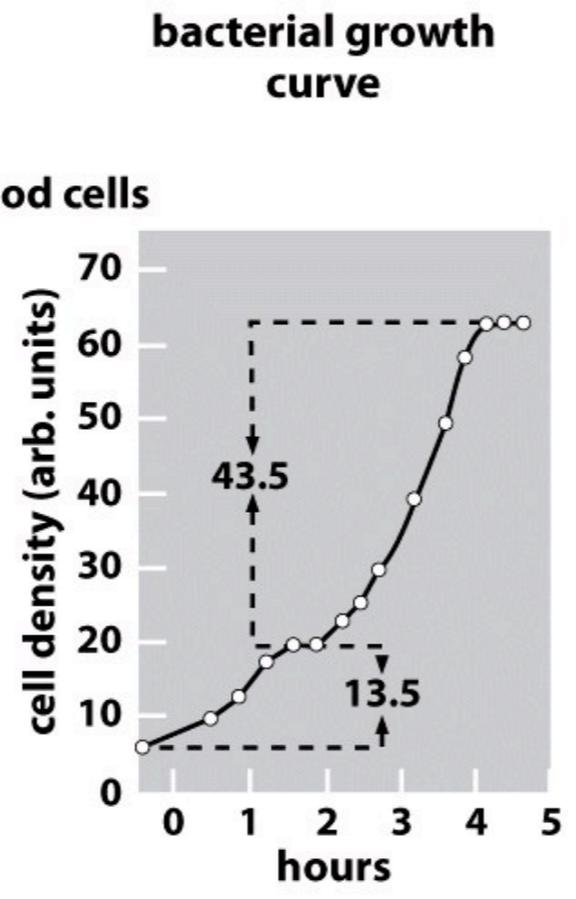
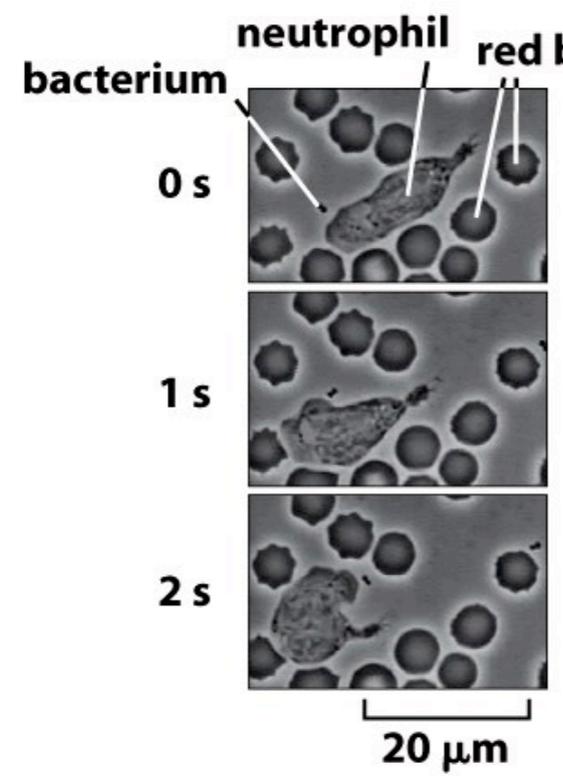
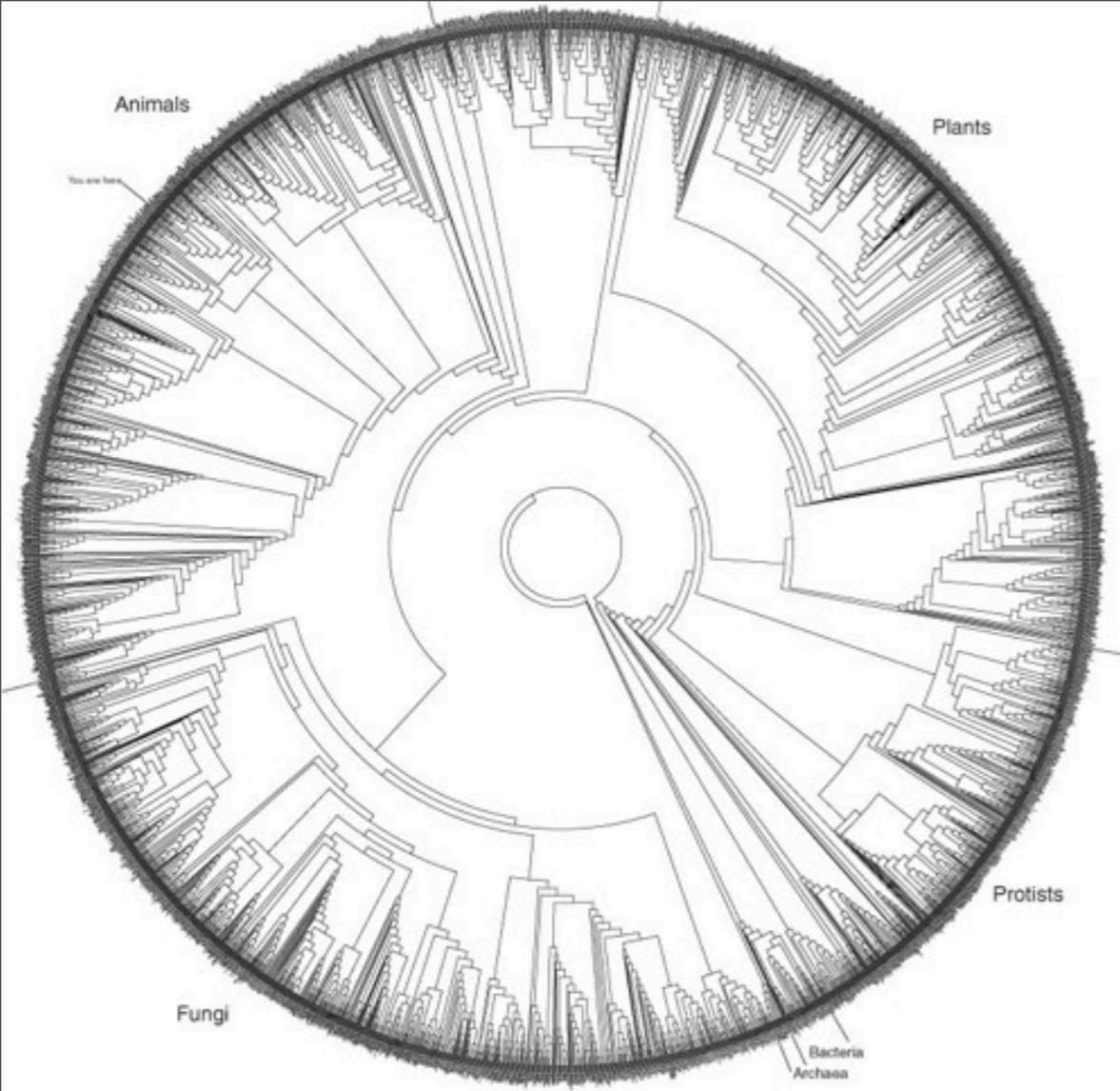
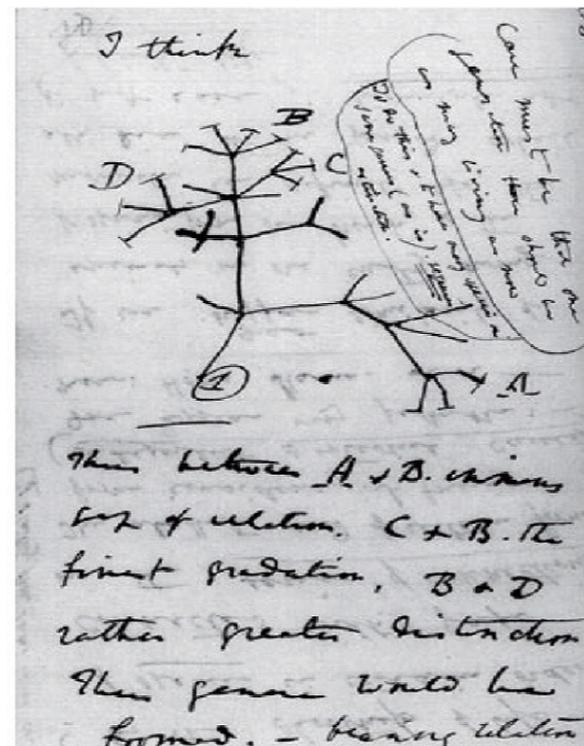


Figure 3.3 Physical Biology of the Cell (© Garland Science 2009)



3.1.2 the evolutionary stopwatch

(A)



(B)

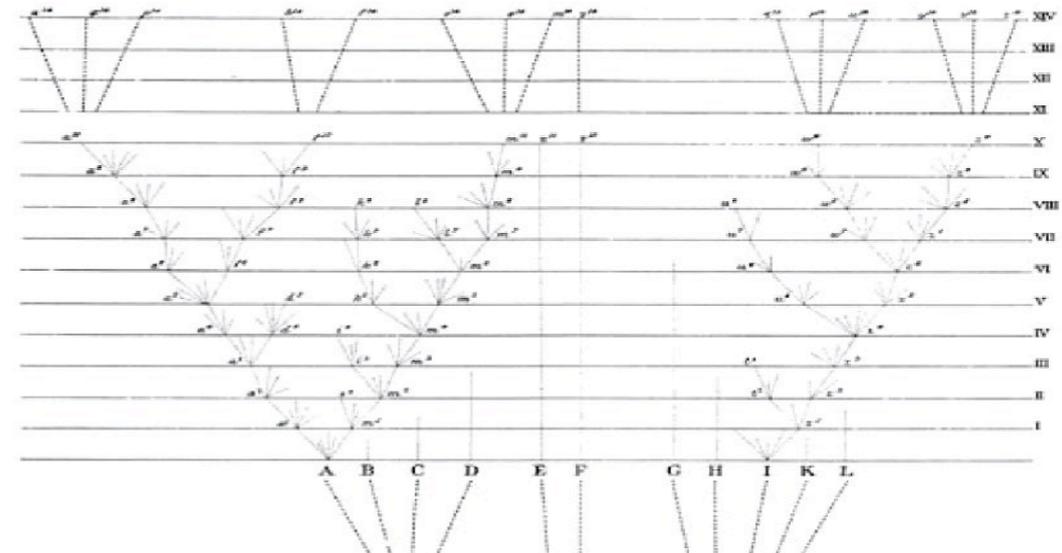


Figure 3.4 Physical Biology of the Cell (© Garland Science 2009)

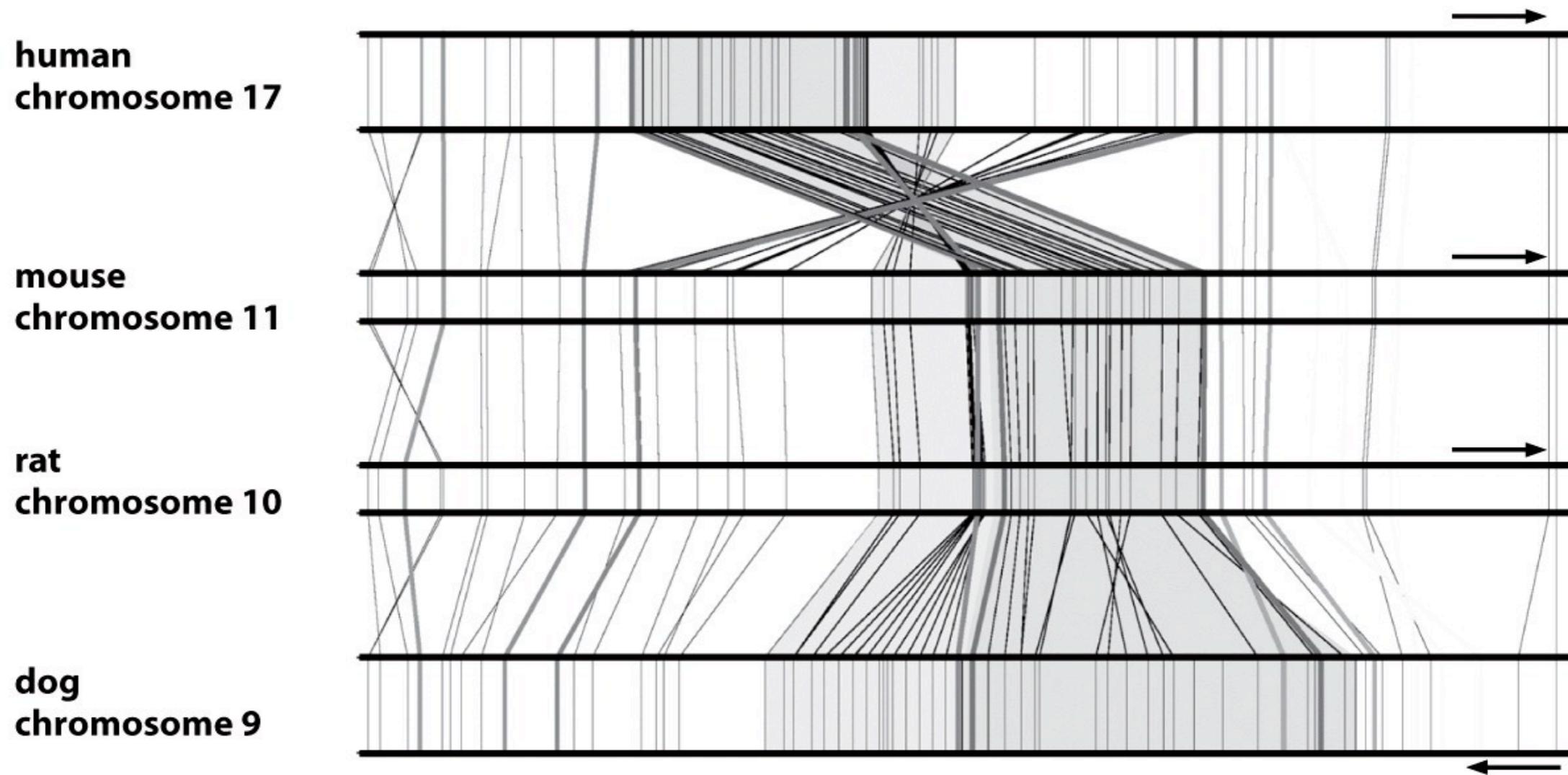
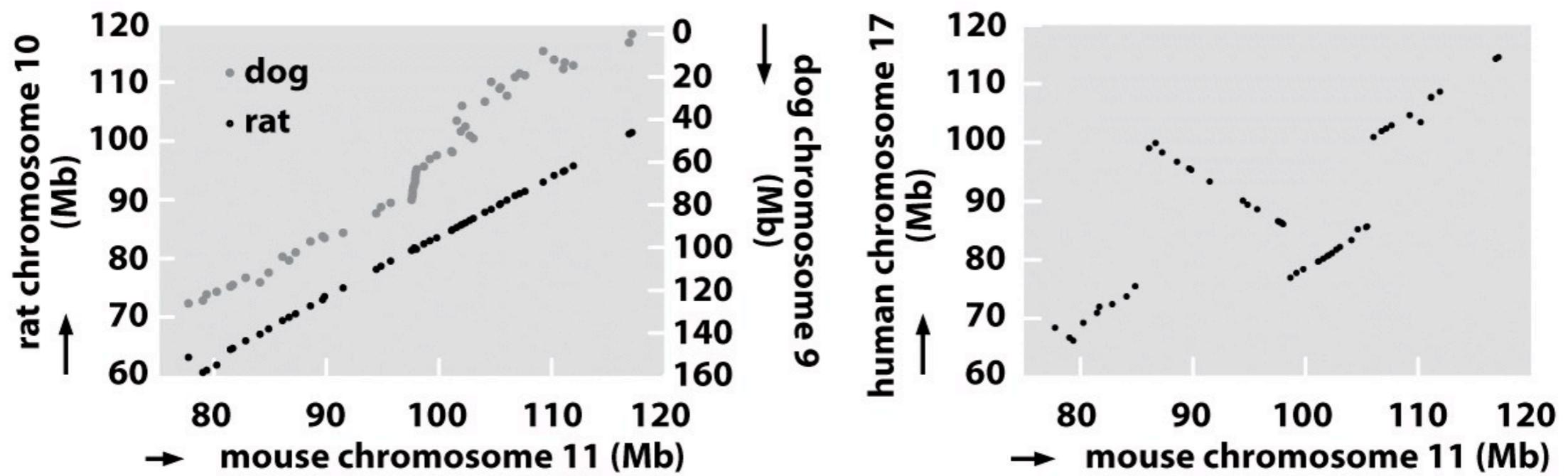
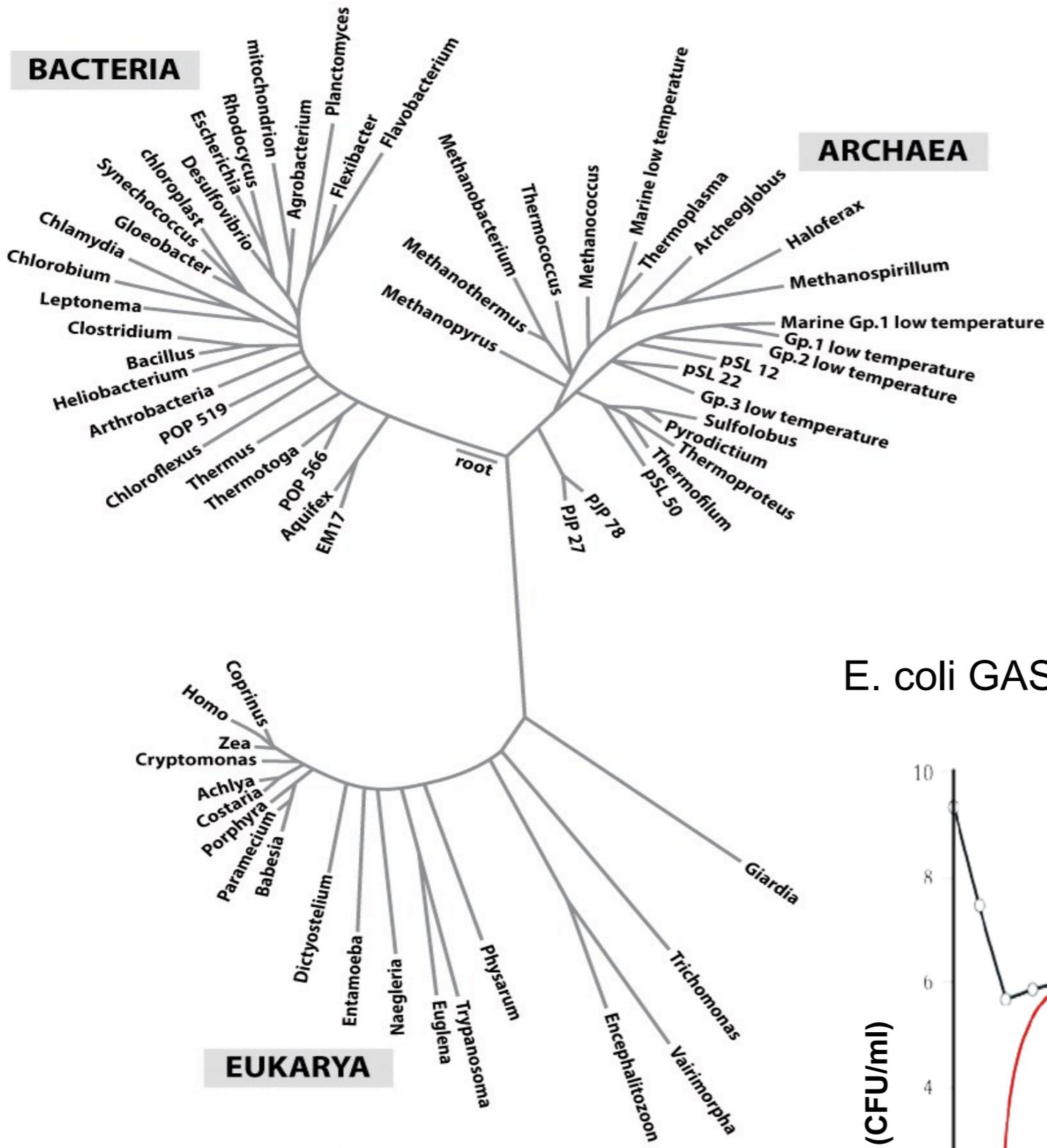


Figure 3.5 Physical Biology of the Cell (© Garland Science 2009)



E. coli GASP mutants emerge in the stationary phase

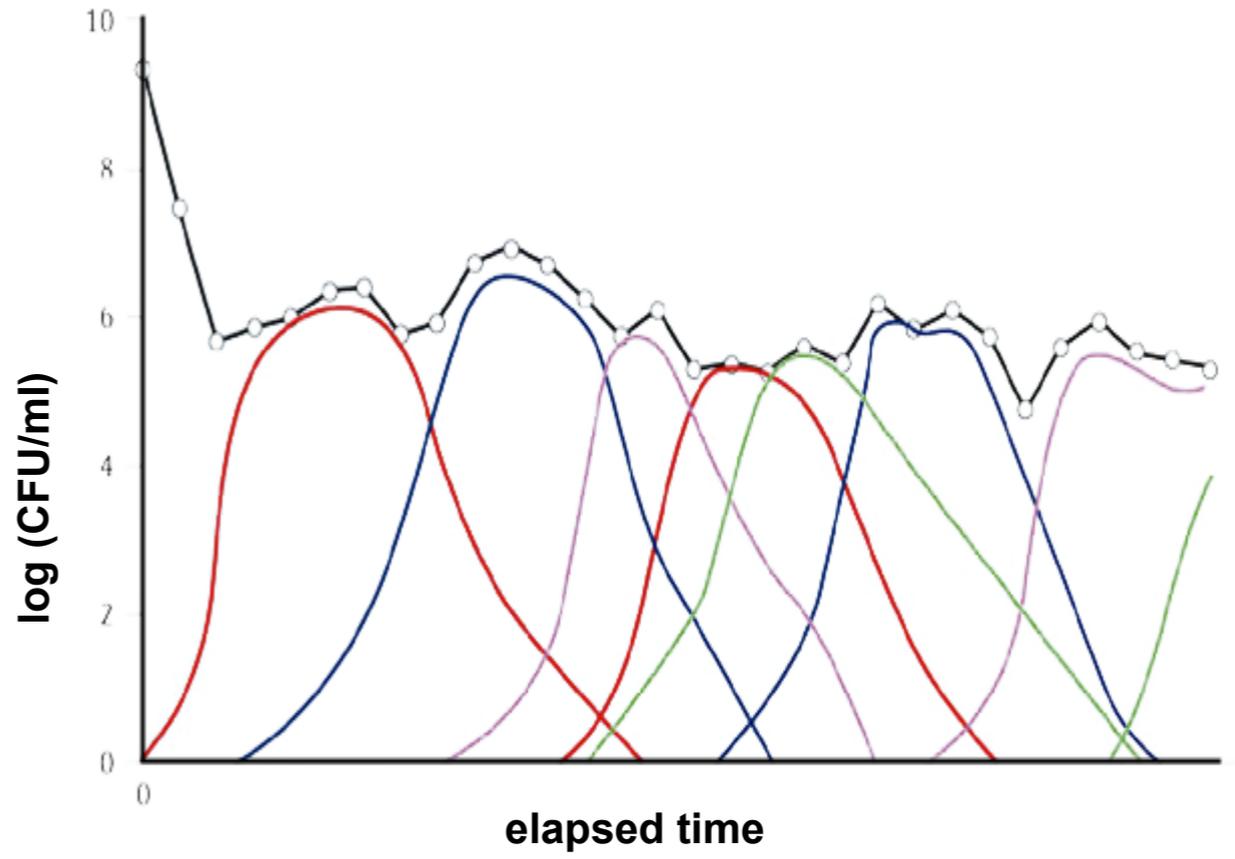
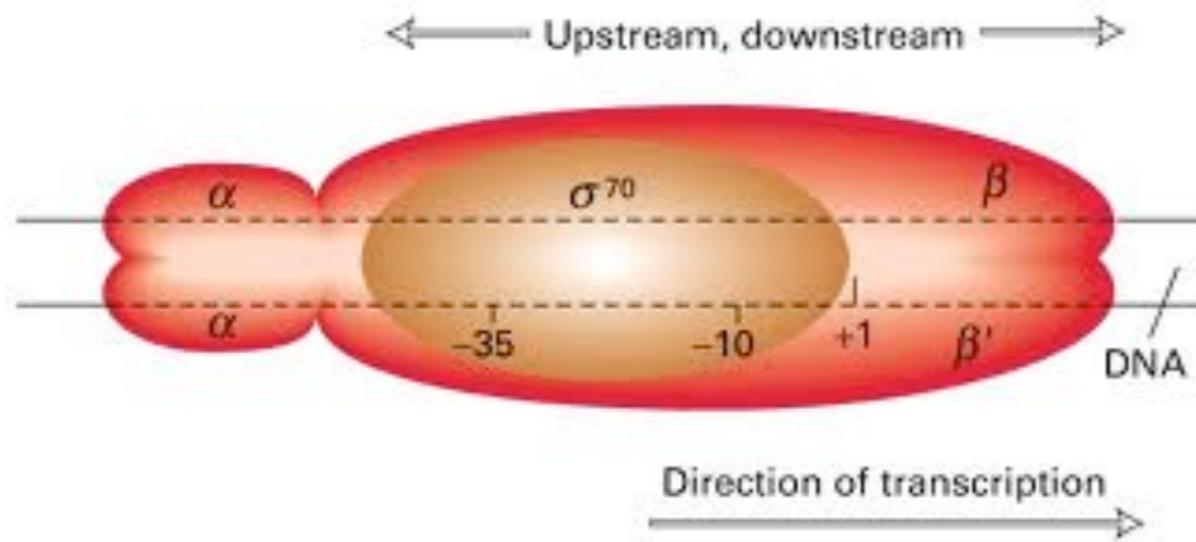


Figure 3.6 Physical Biology of the Cell (© Garland Science 2009)

3.1.3 the e.coli cell cycle as our standard clock (@ least its log phase...).

0 \longleftrightarrow +

- σ^{70} (RpoD) - the "housekeeping" sigma factor
- σ^{38} (RpoS) - the starvation/stationary phase sigma factor



RpoS wt (cooperate) and RpoS 819 (defects).

minutes

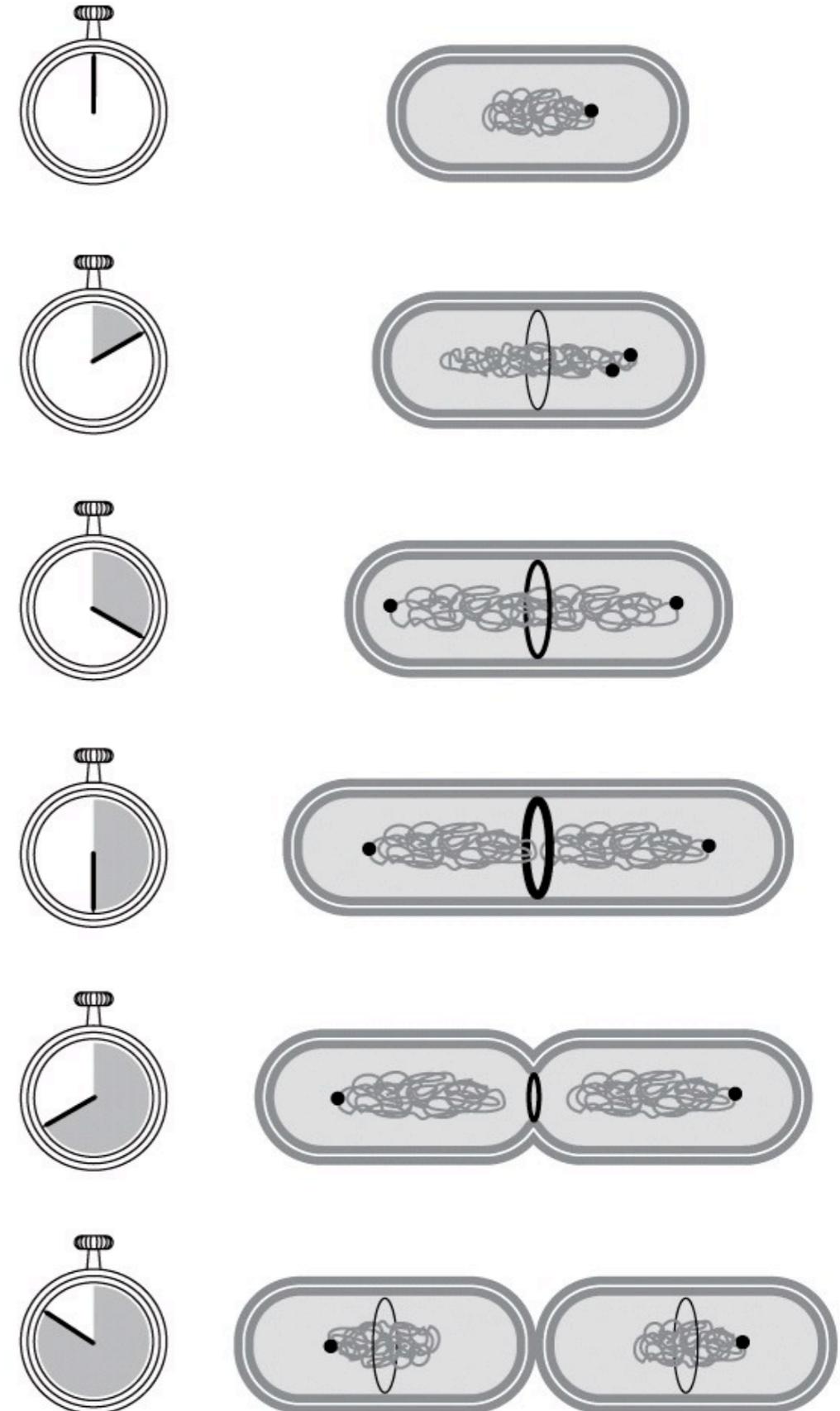
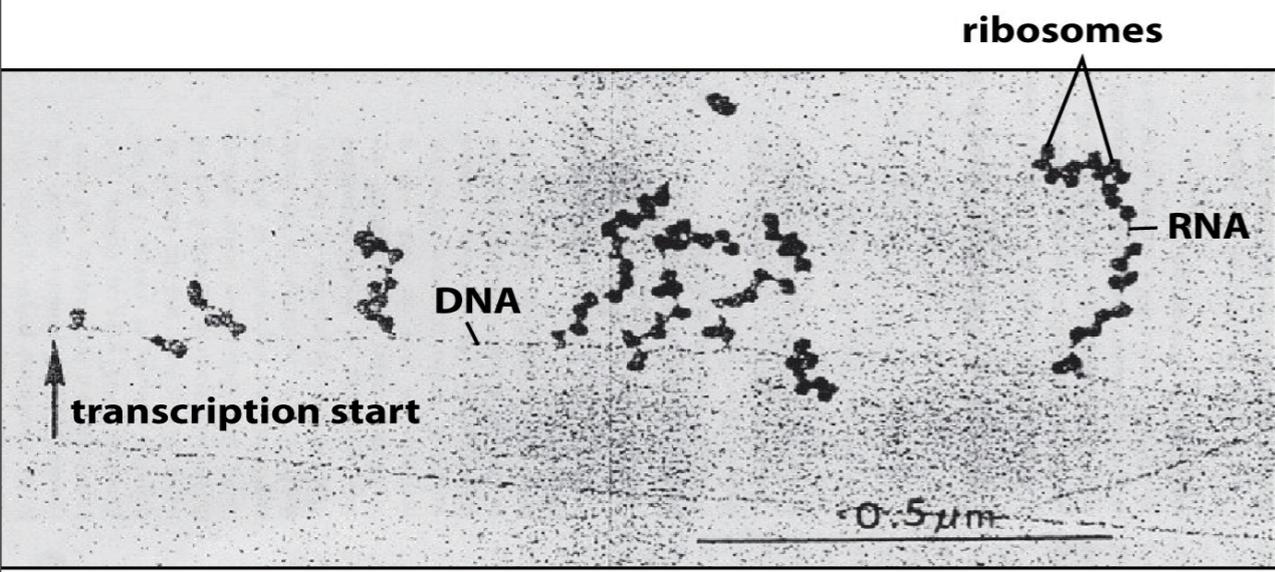
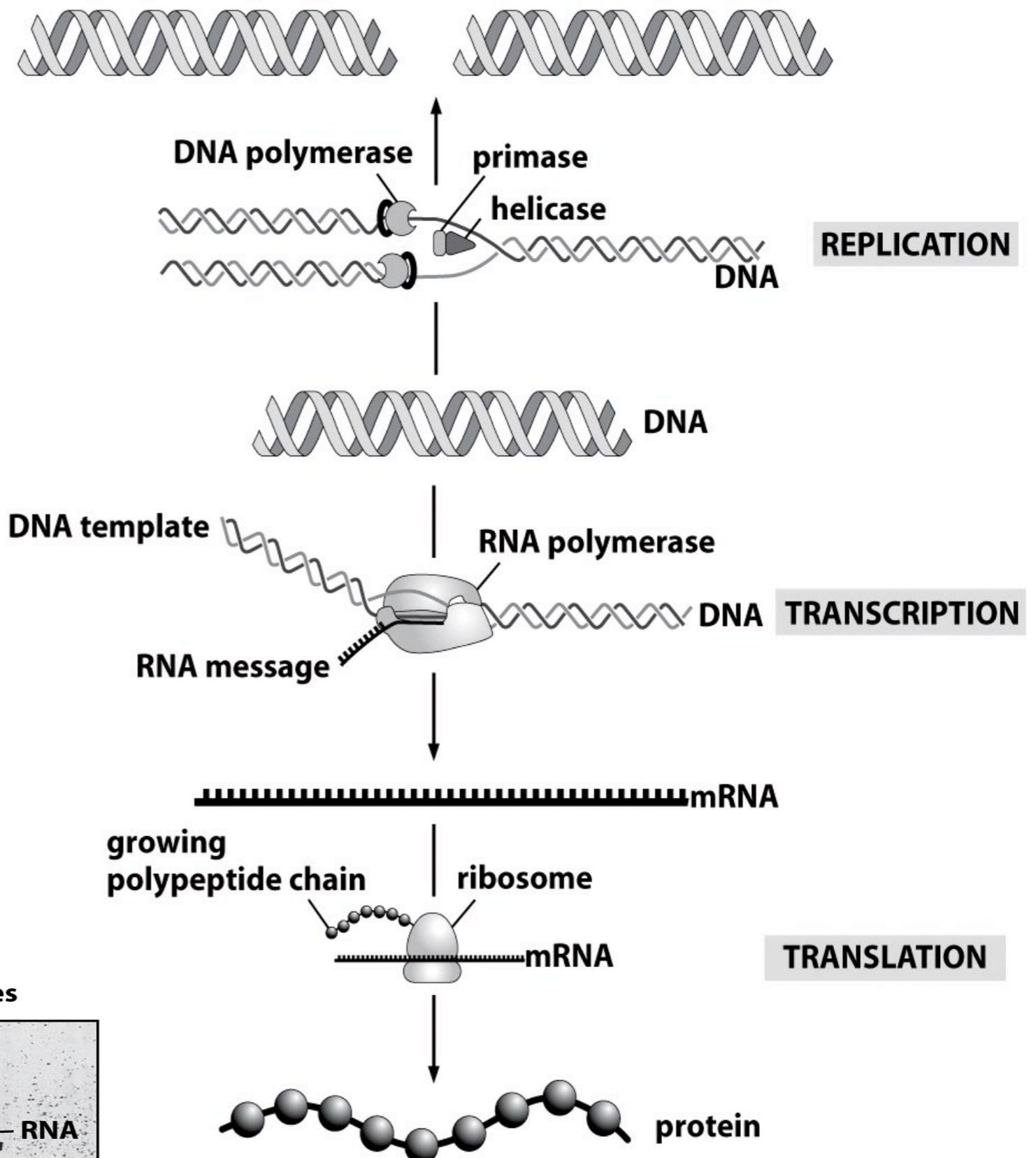


Figure 3.7 Physical Biology of the Cell (© Garland Science 2009)

- procedural
- relative
- manipulated.

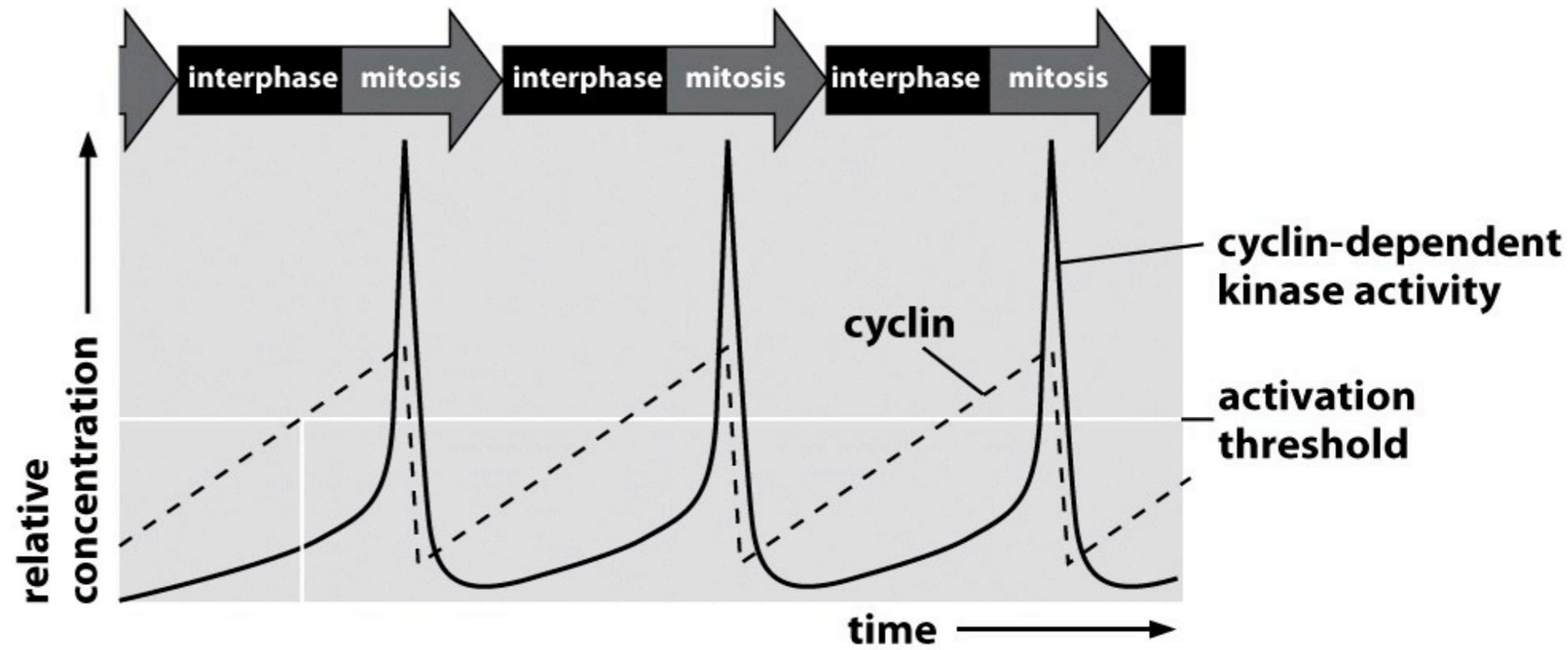


Physical Biology of the Cell (© Garland Science 2009)

Figure 3.9 Physical Biology of the Cell (© Garland Science 2009)

Xenopus laevis

(A)



(B)

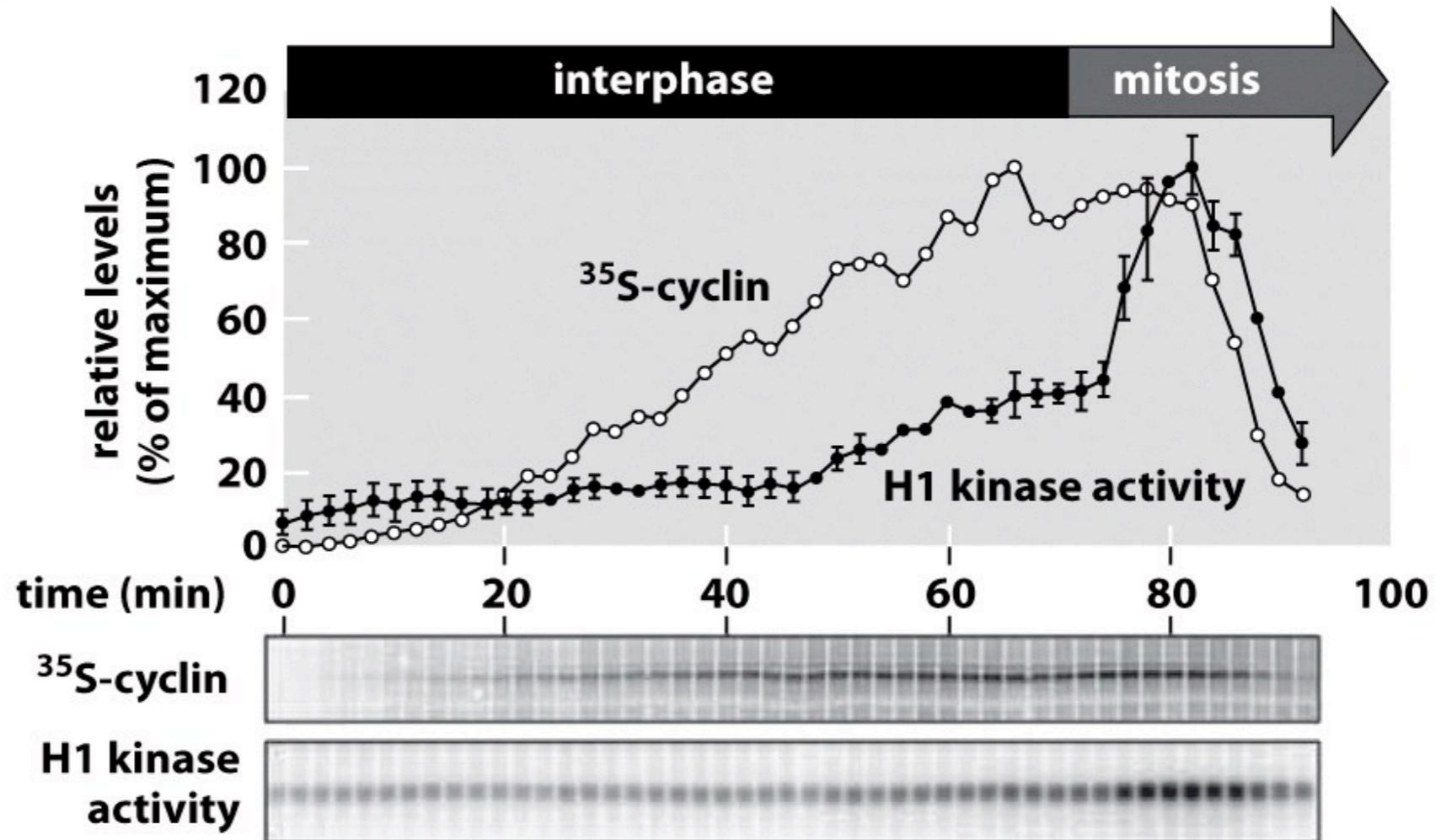


Figure 3.10 Physical Biology of the Cell (© Garland Science 2009)

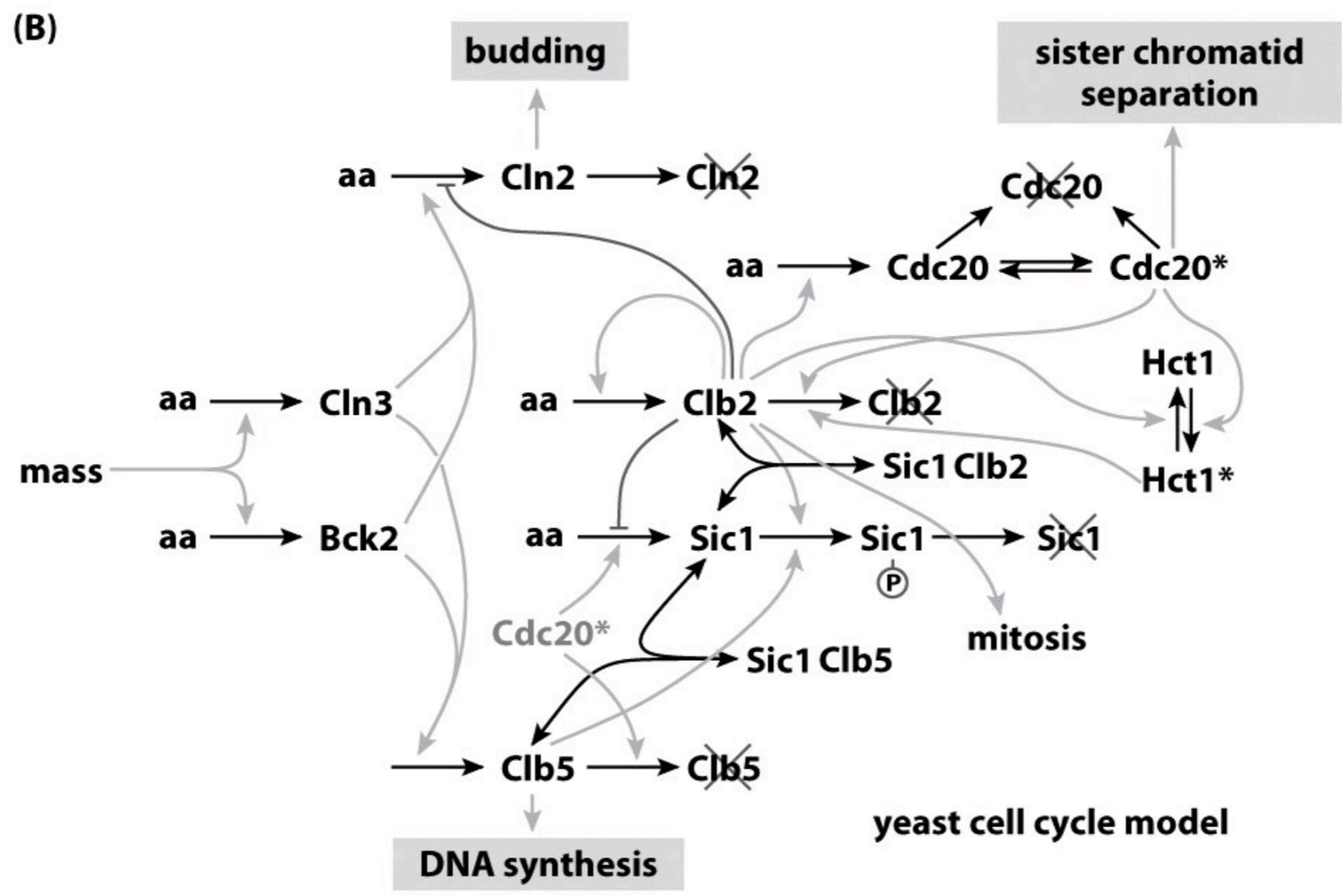
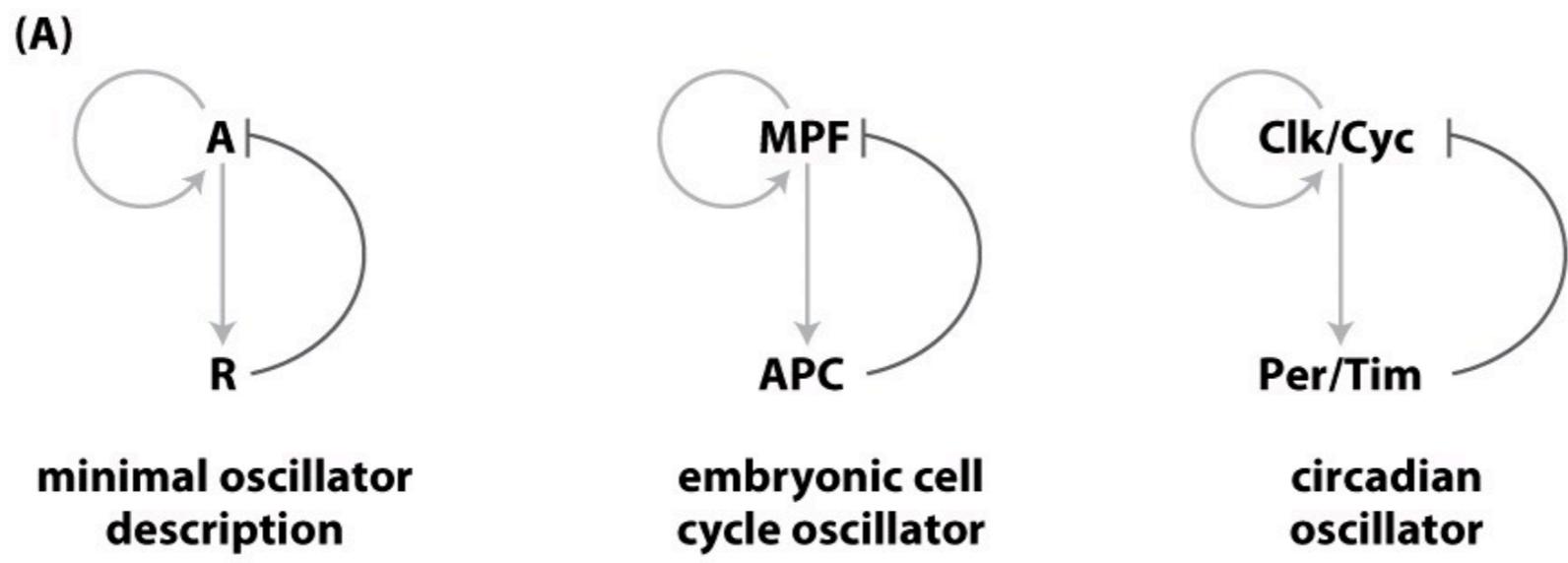


Figure 3.11 Physical Biology of the Cell (© Garland Science 2009)

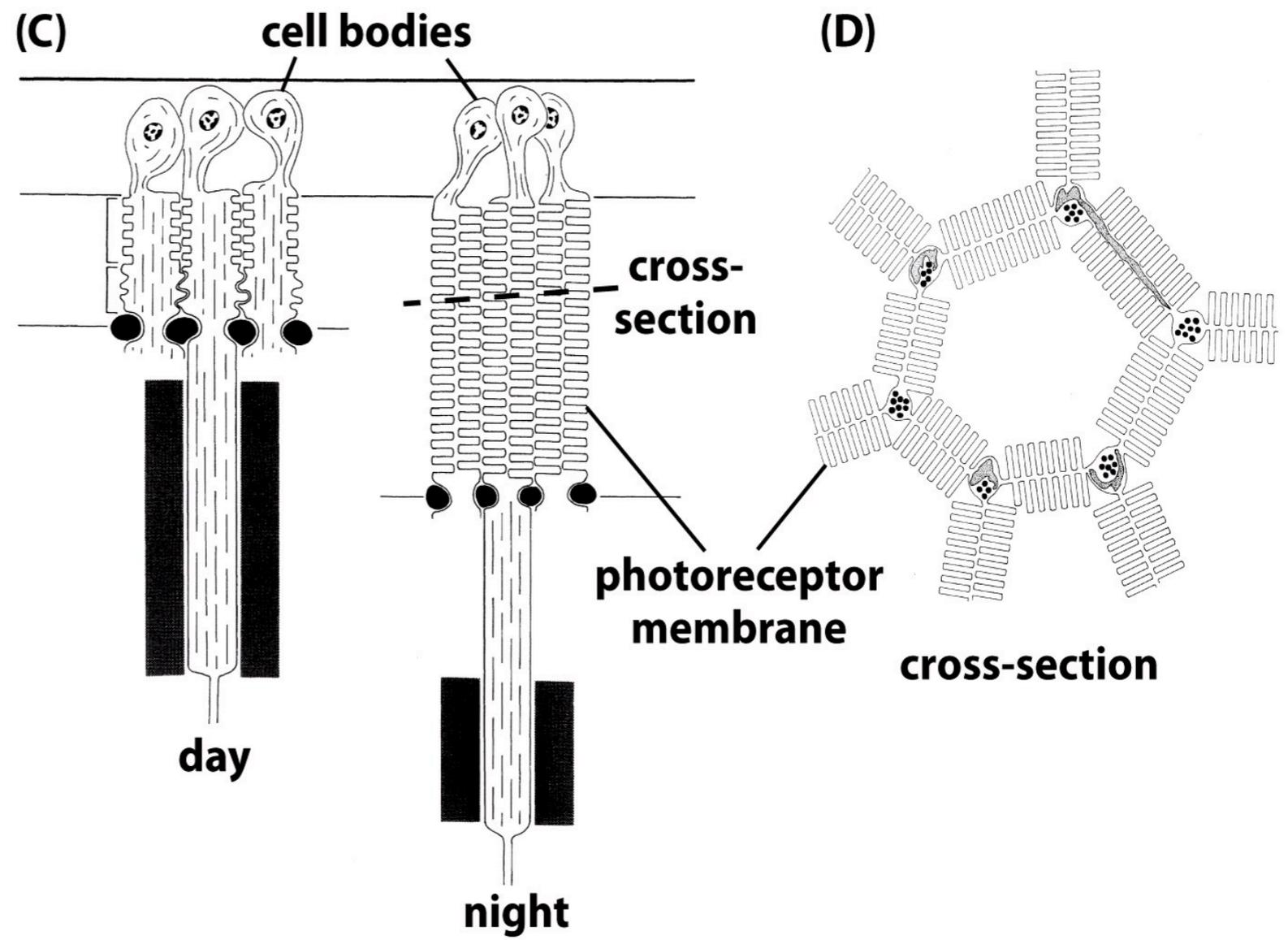


Figure 3.12cd Physical Biology of the Cell (© Garland Science 2009)

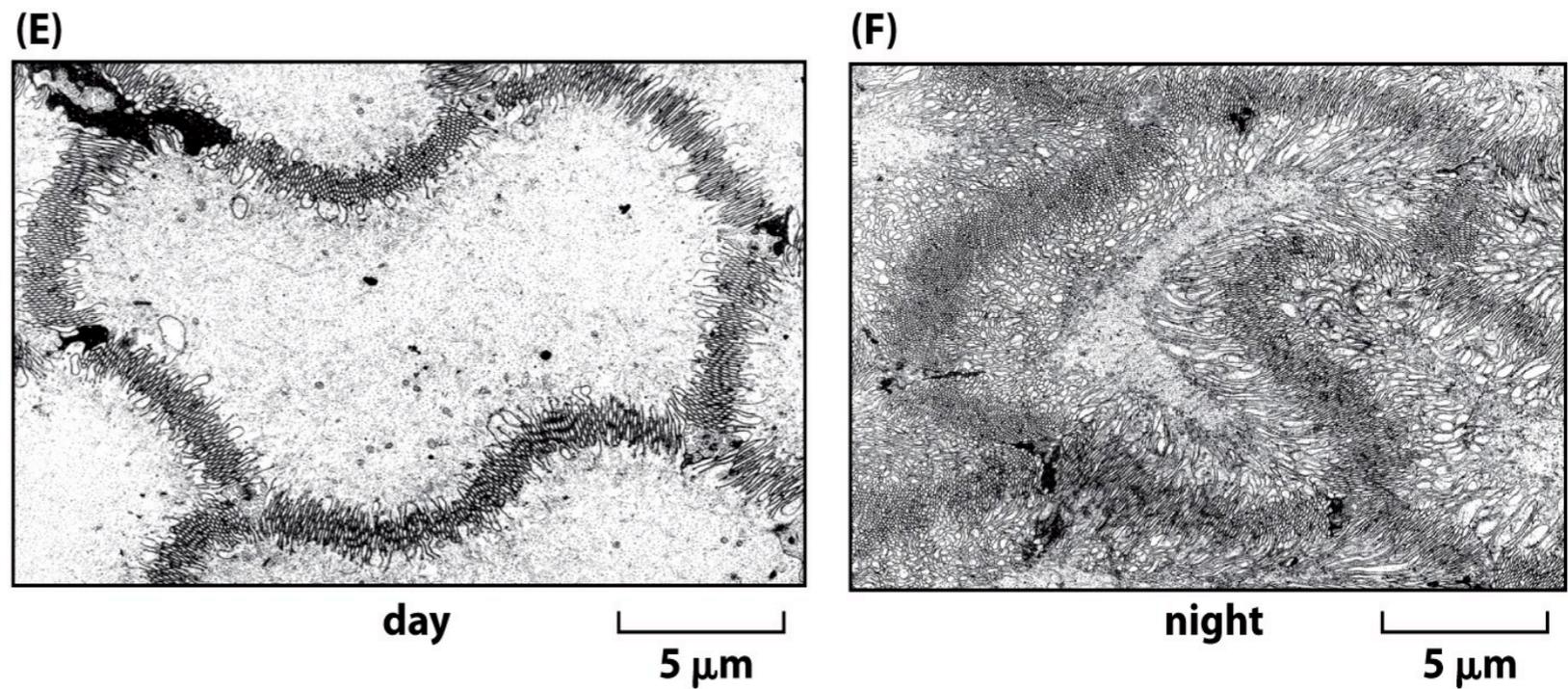


Figure 3.12ef Physical Biology of the Cell (© Garland Science 2009)

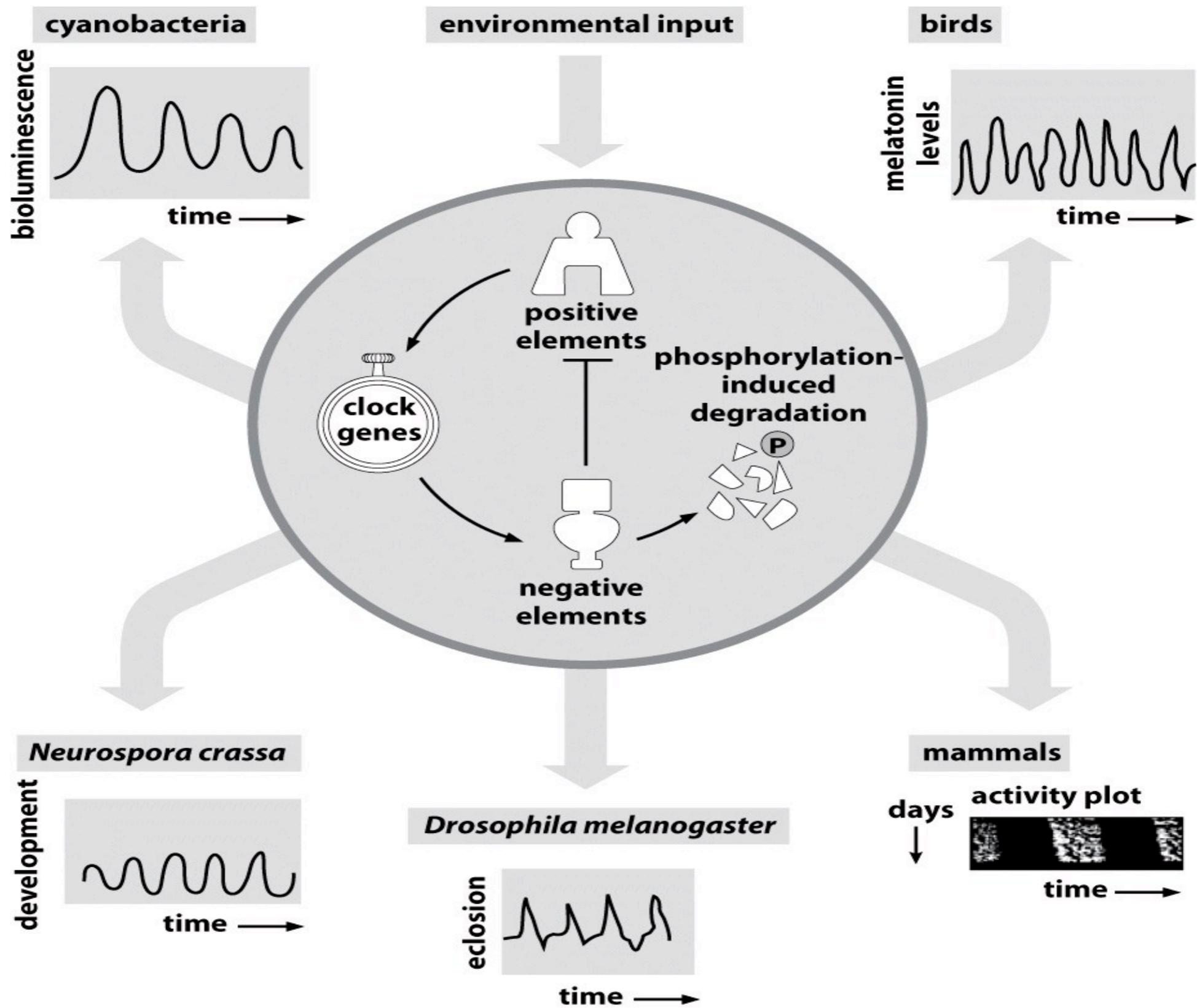


Figure 3.13 Physical Biology of the Cell (© Garland Science 2009)

Synechococcus elongatus:

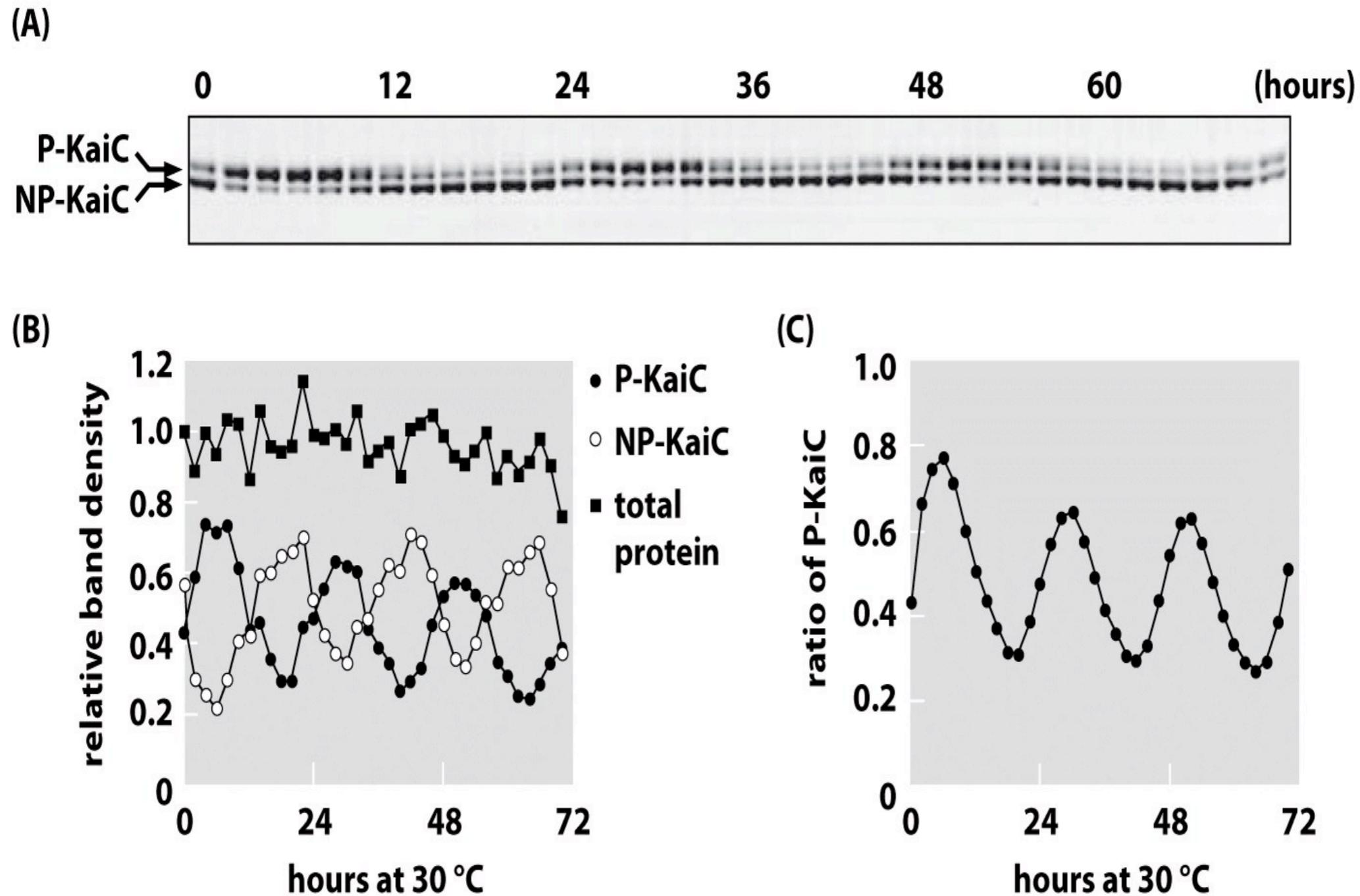
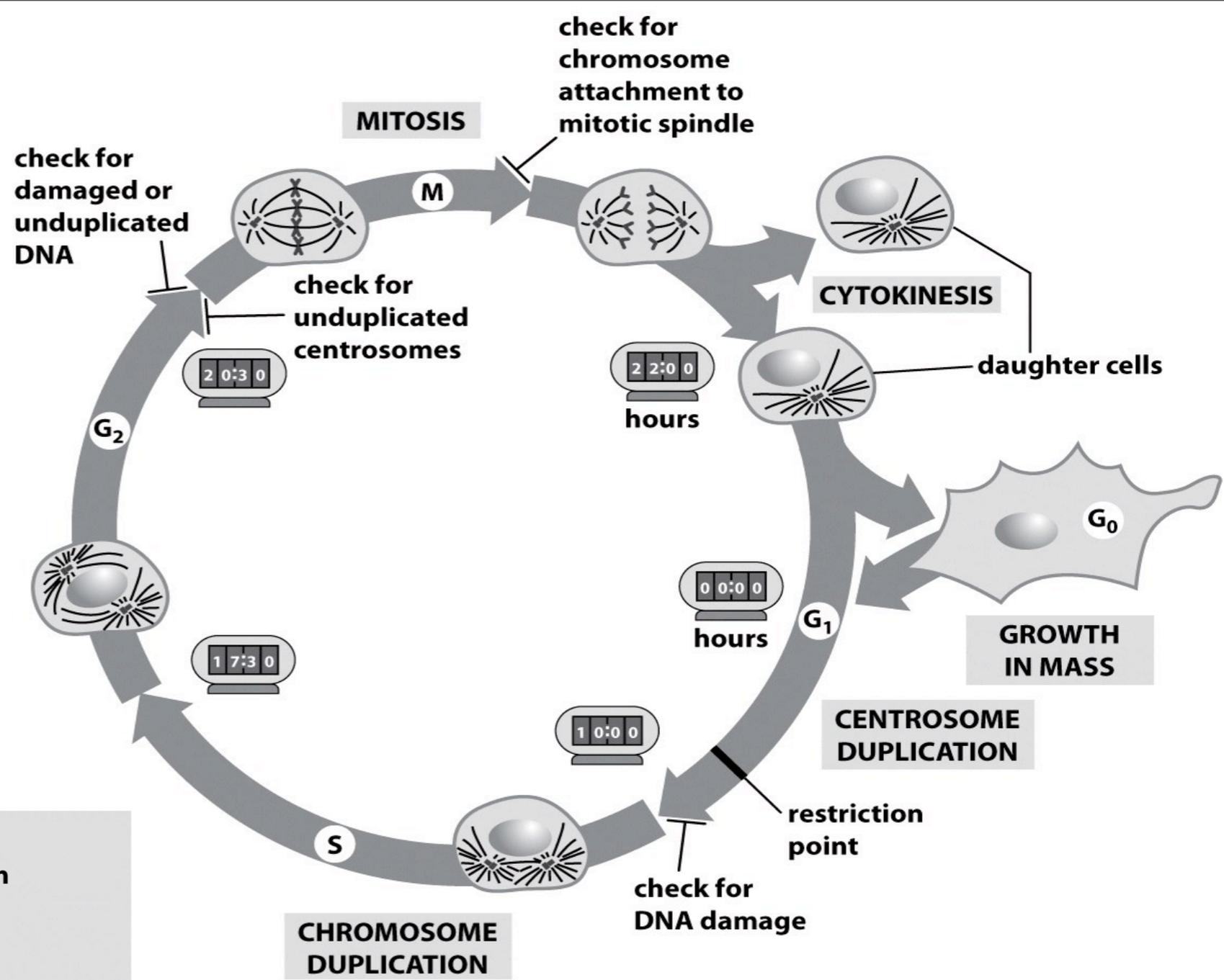


Figure 3.14 Physical Biology of the Cell (© Garland Science 2009)

KaiC: auto phosphorylates and de-phosphorylates.
KaiA: enhances KaiC autophosphorylation.
KaiB: inhibits the effects of KaiA

- procedural
- relative
- manipulated.

•fibroblast cycle (checkpoints)



| Biology of the Cell (© Garland Science 2009)

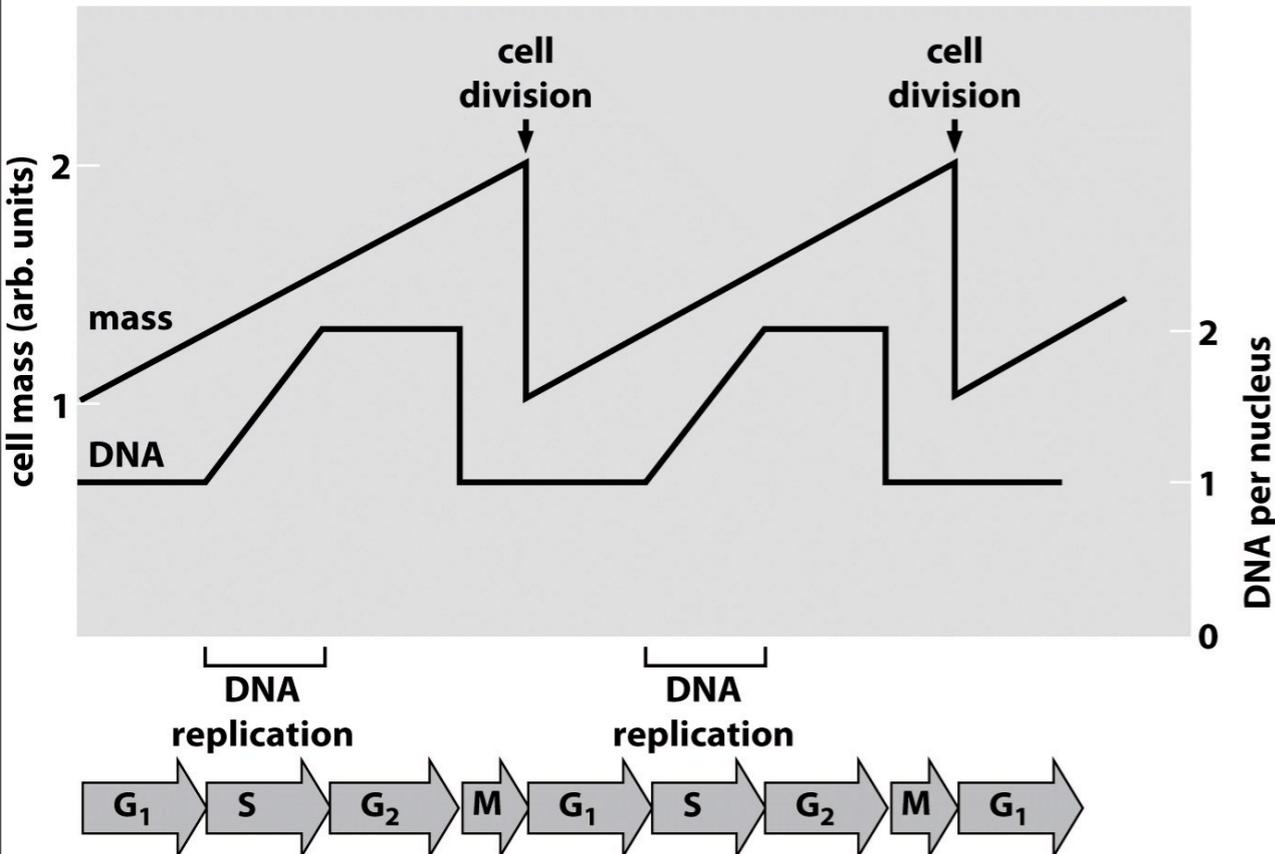


Figure 3.15b Physical Biology of the Cell (© Garland Science 2009)

•genetic (transcriptional nets)

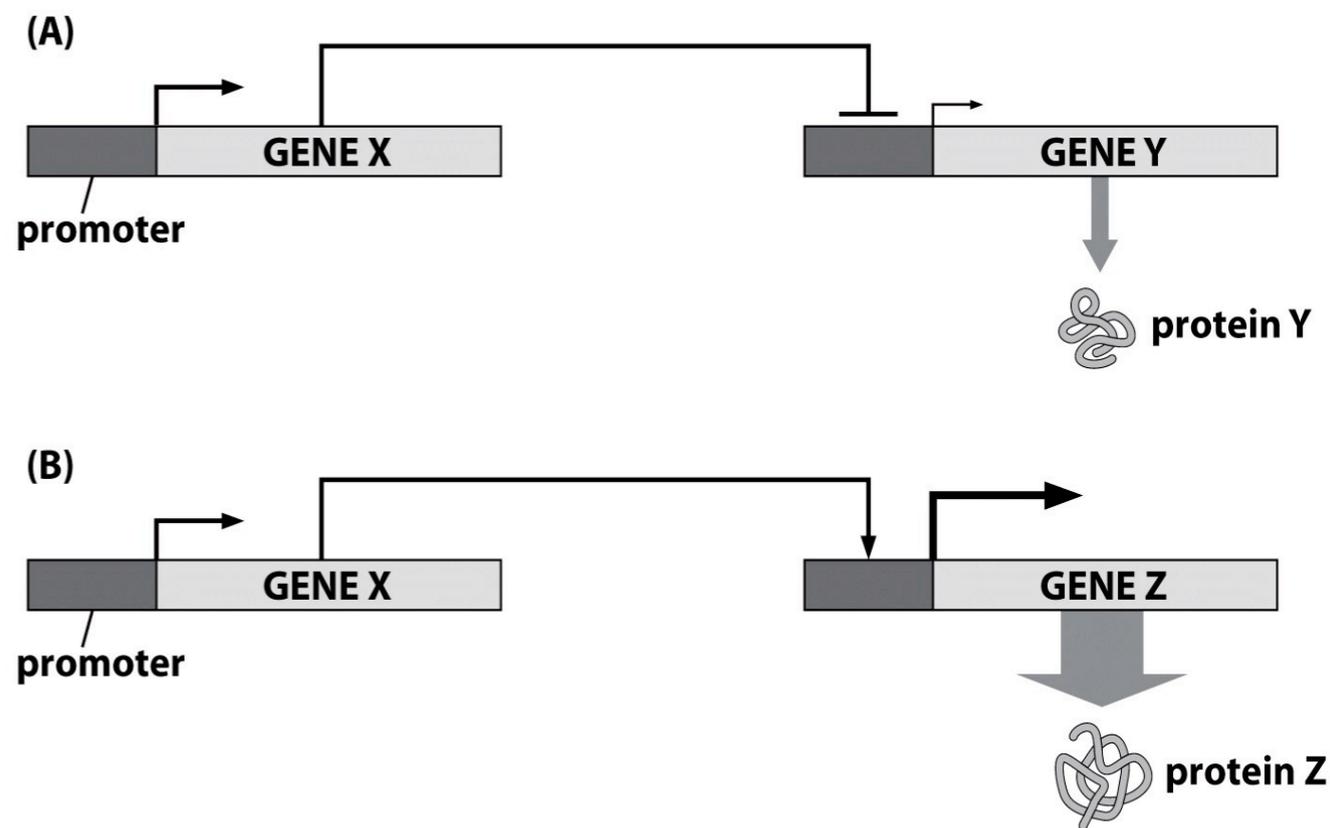
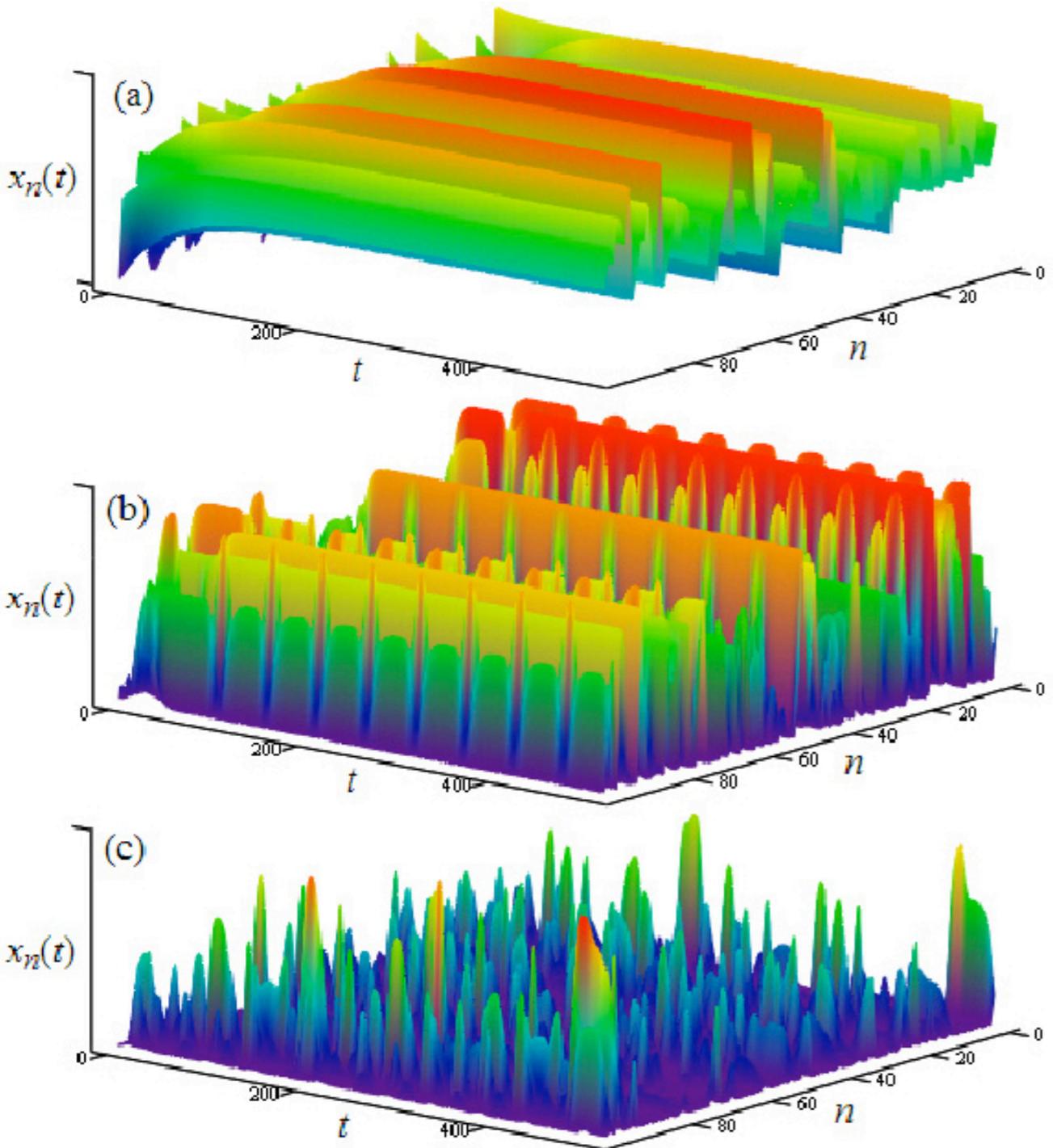


Figure 3.16 Physical Biology of the Cell (© Garland Science 2009)

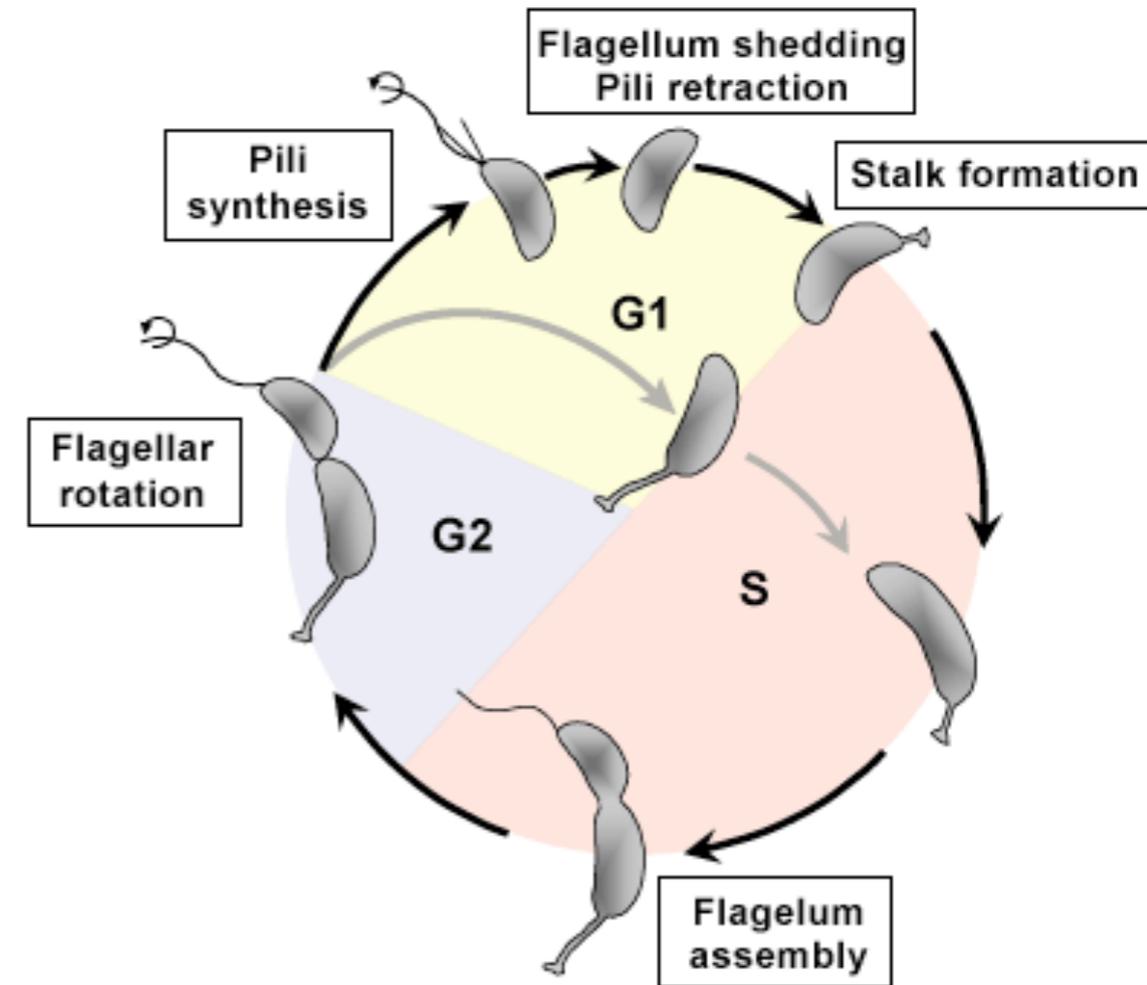
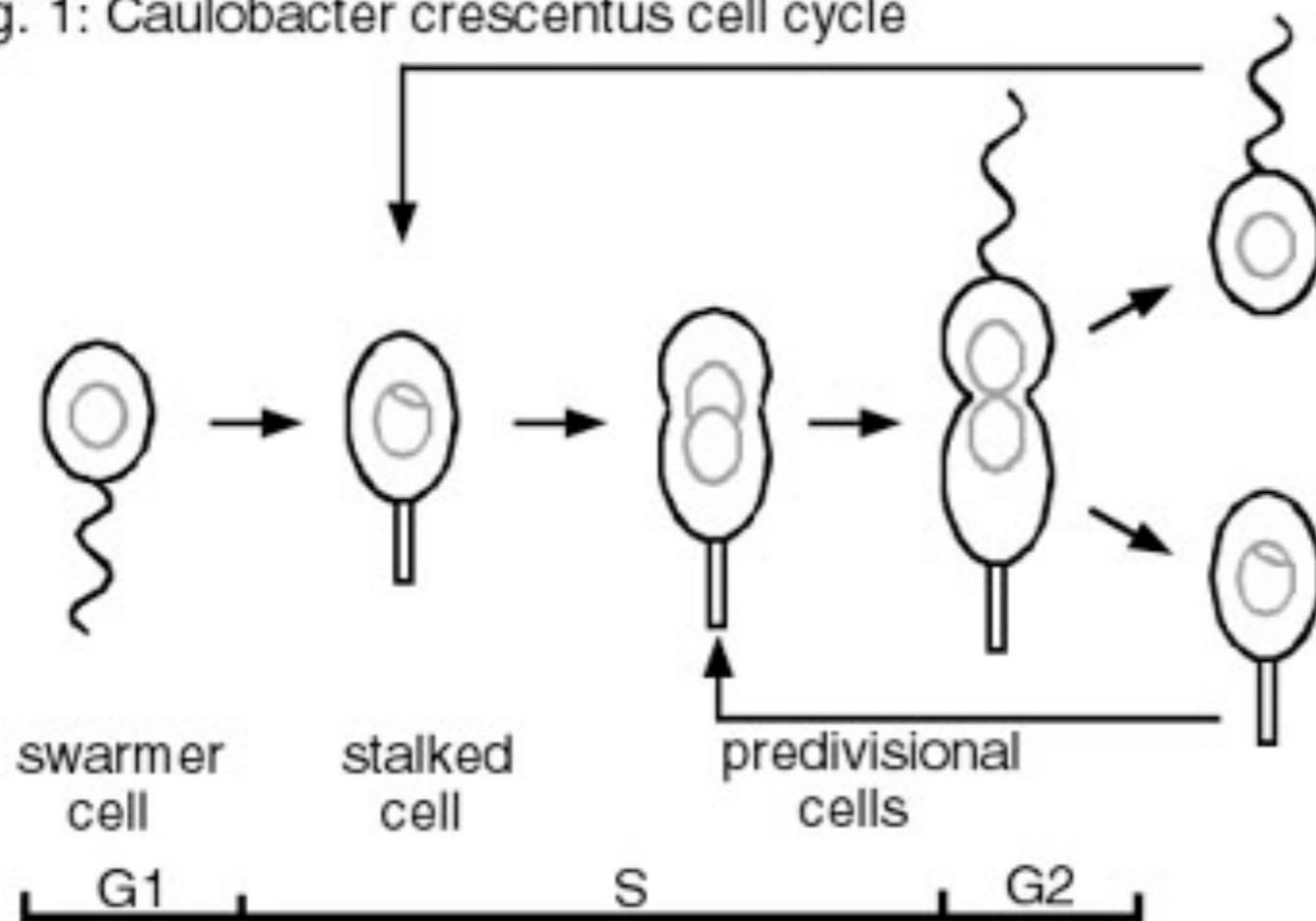


•differentiation as NK-net attractors (Kauffman)

Caulobacter crescentus



Fig. 1: *Caulobacter crescentus* cell cycle



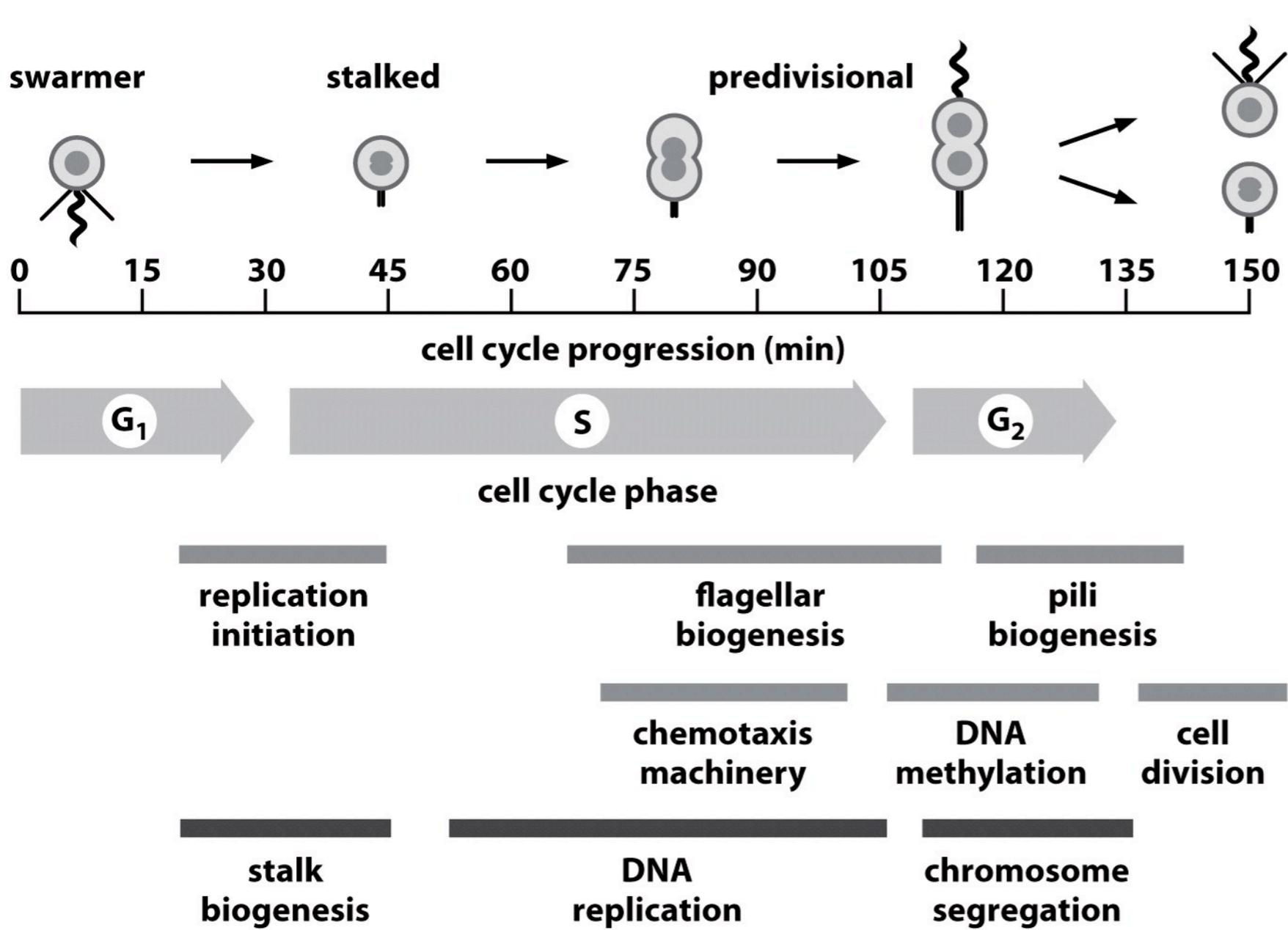


Figure 3.17a Physical Biology of the Cell (© Garland Science 2009)

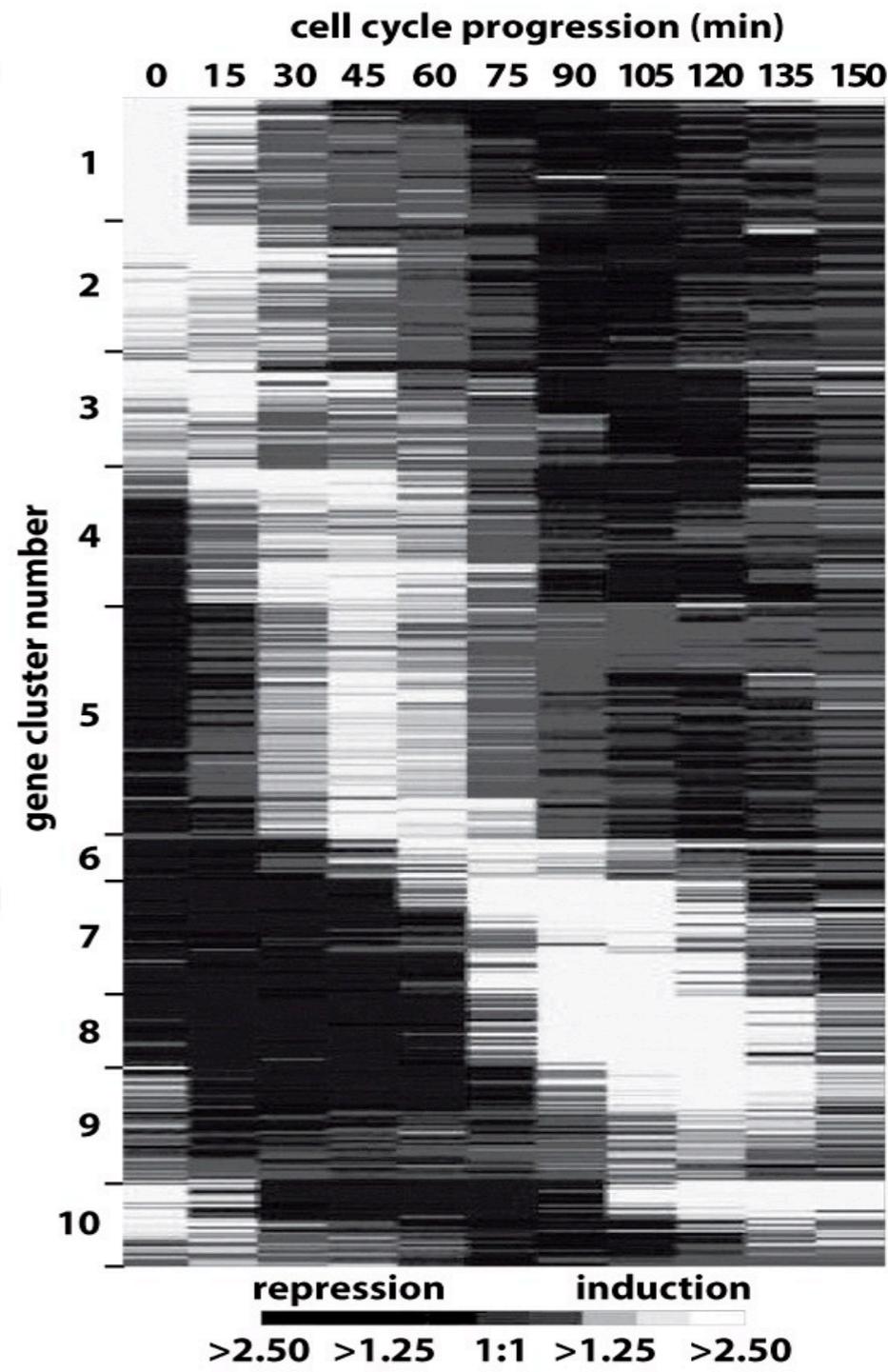


Figure 3.17b Physical Biology of the Cell (© Garland Science 2009)

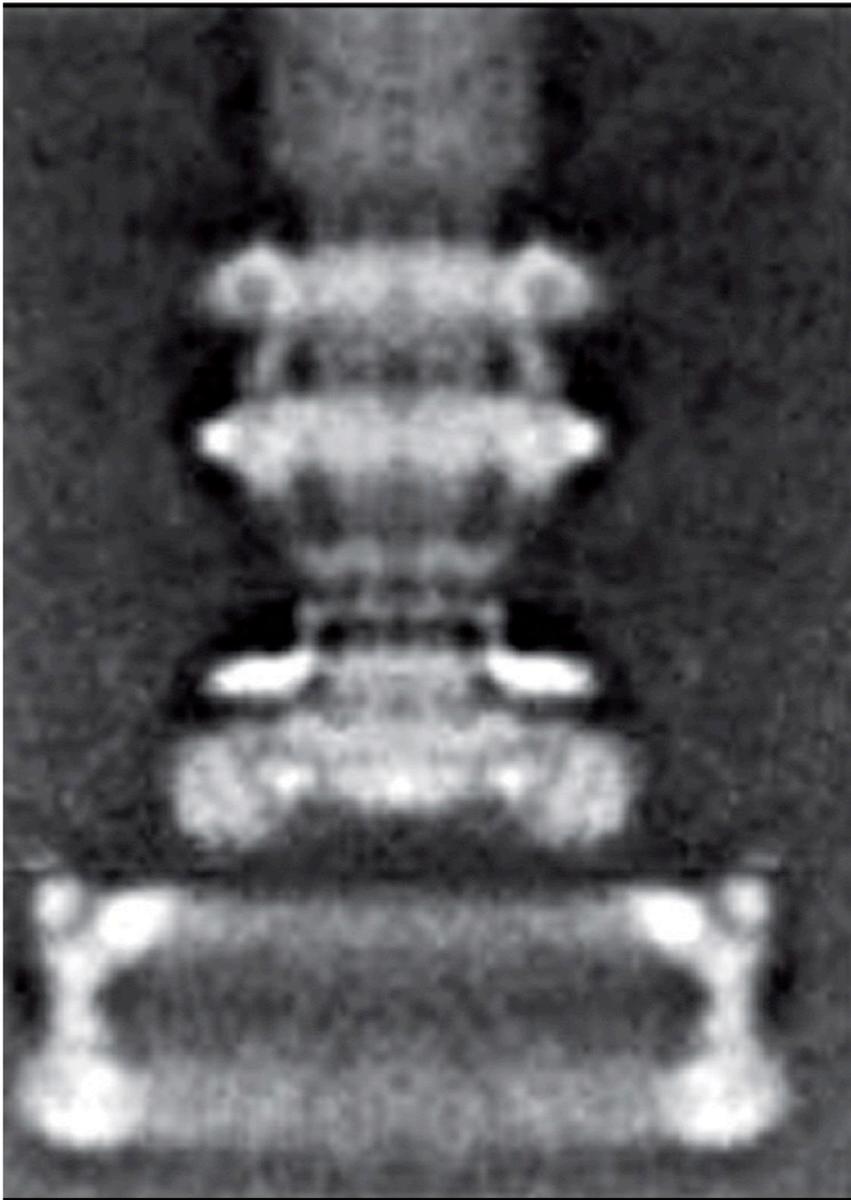
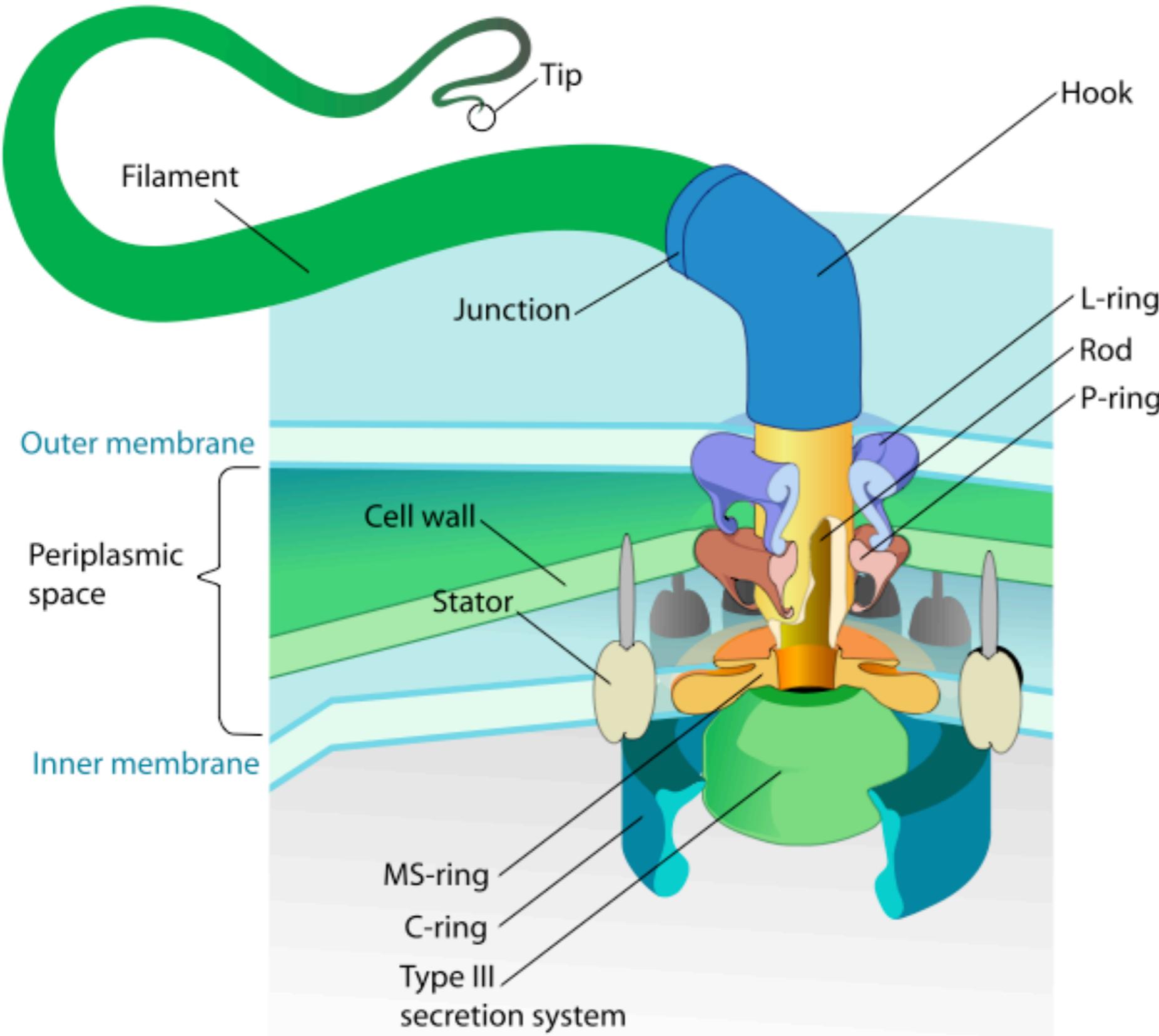


Figure 3.18b Physical Biology of the Cell (© Garland Science 2009)

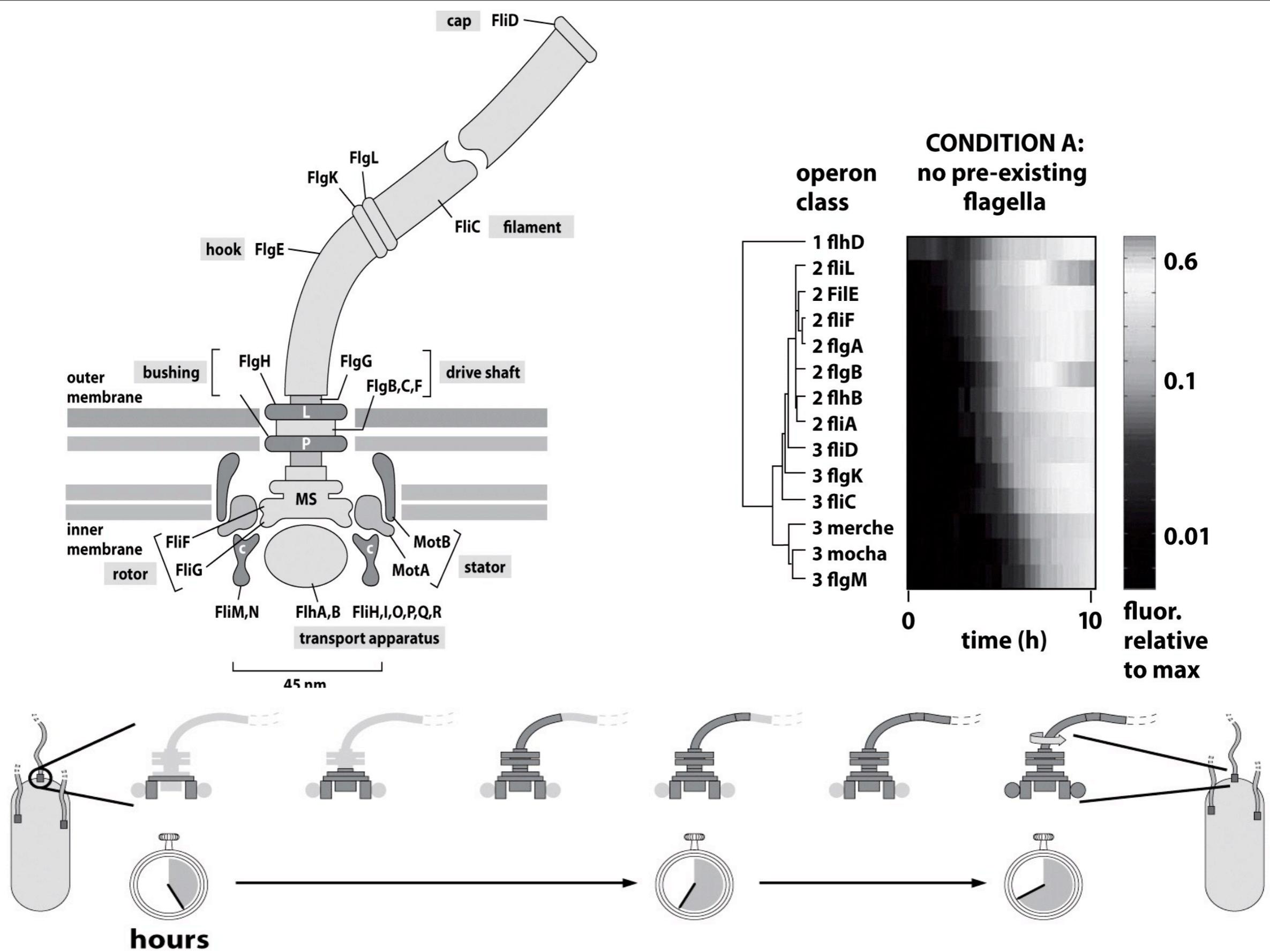


Figure 3.19b Physical Biology of the Cell (© Garland Science 2009)

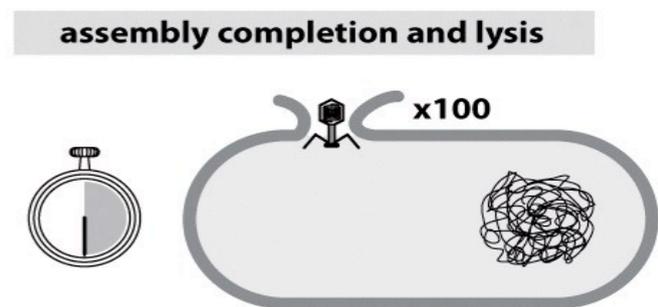
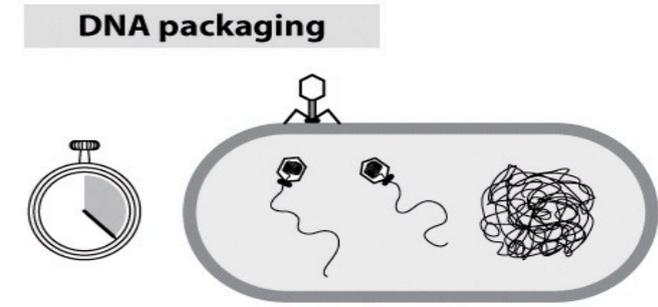
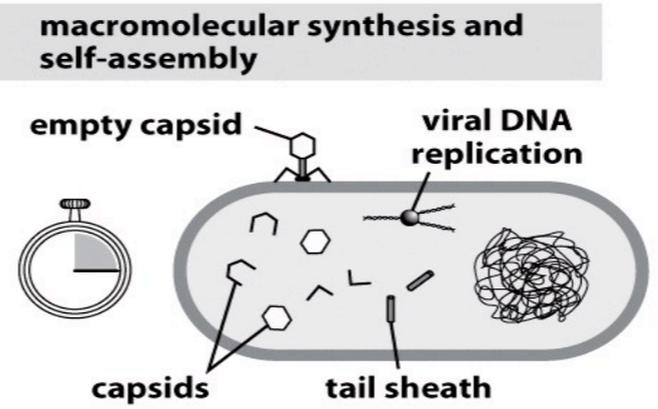
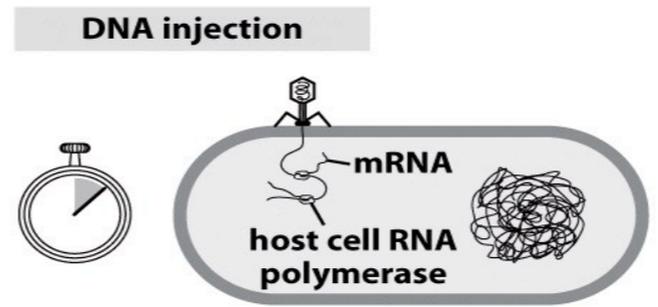
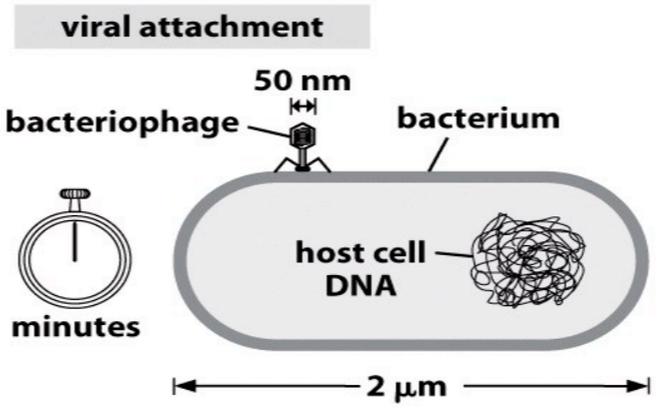
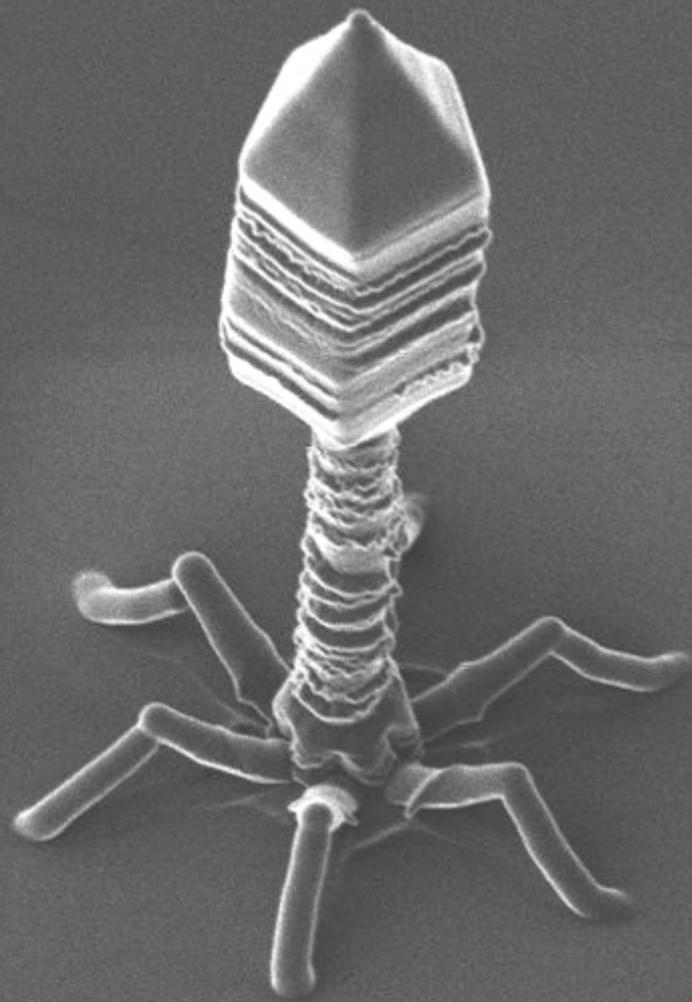
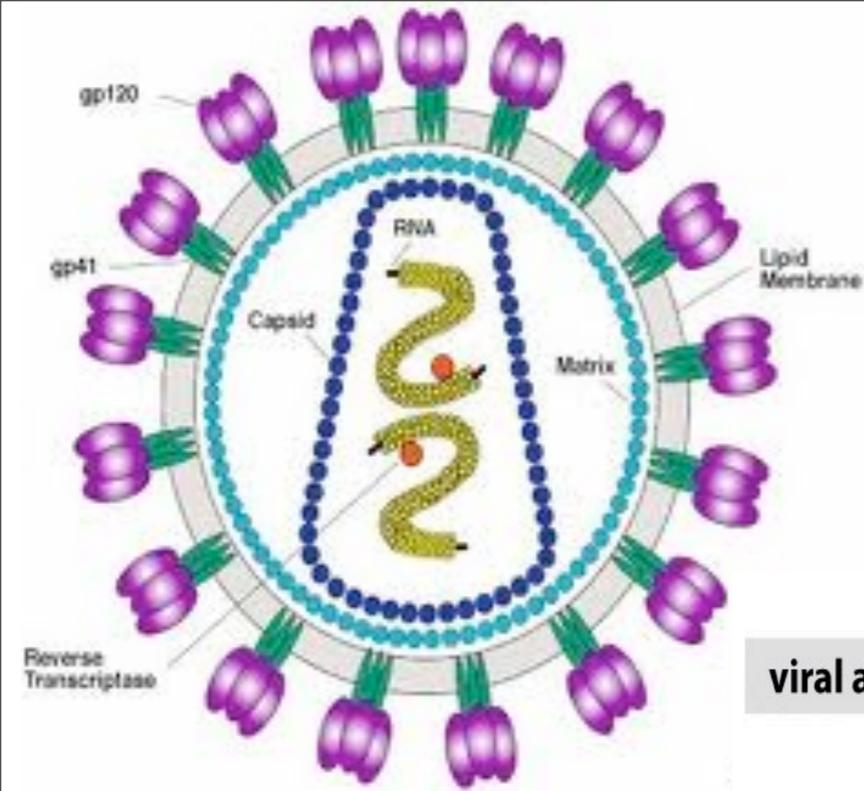


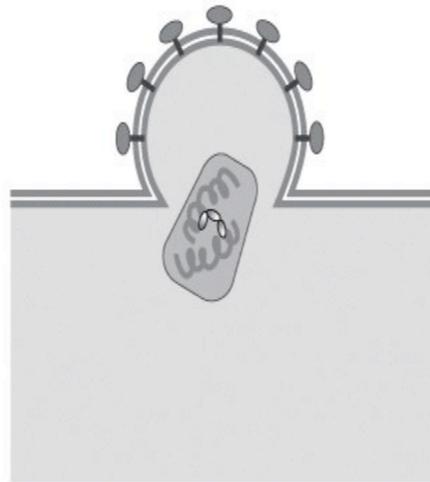
Figure 3.20 Physical Biology of the Cell (© Garland Science 2009)



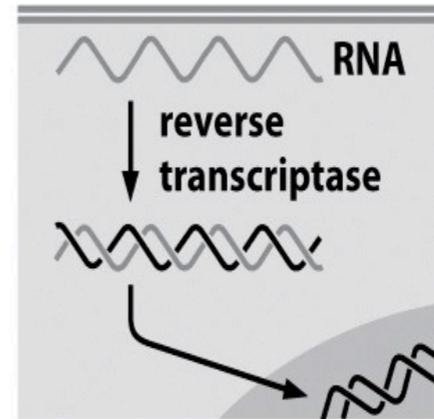
viral attachment



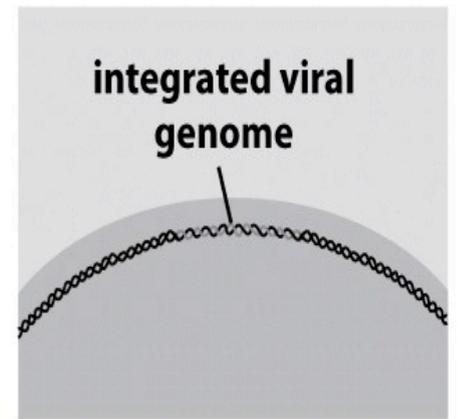
viral uptake



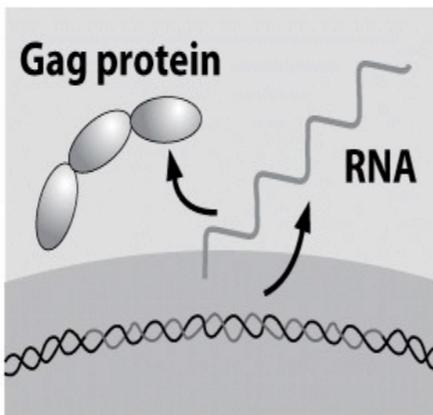
genome release and reverse transcription



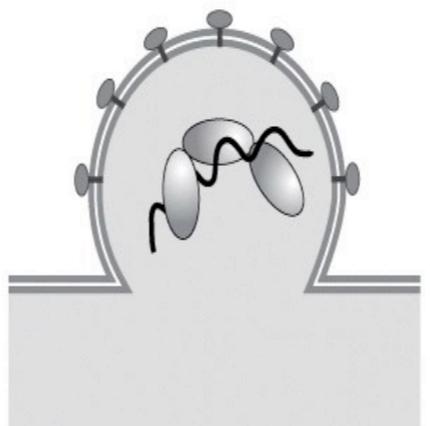
DNA integration



RNA and protein synthesis



assembly and budding



maturation

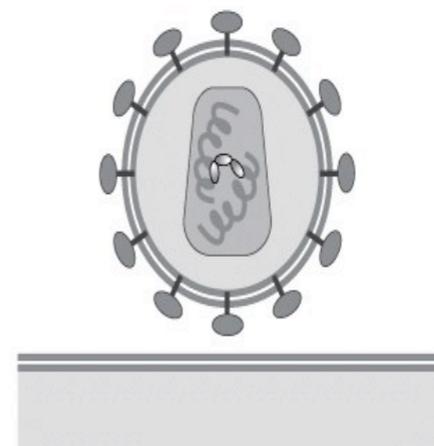
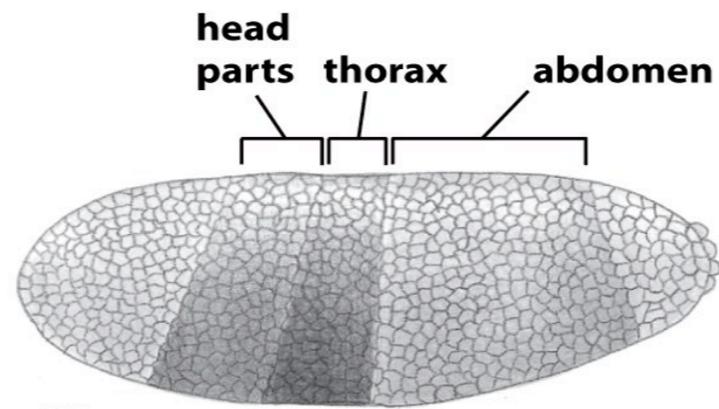
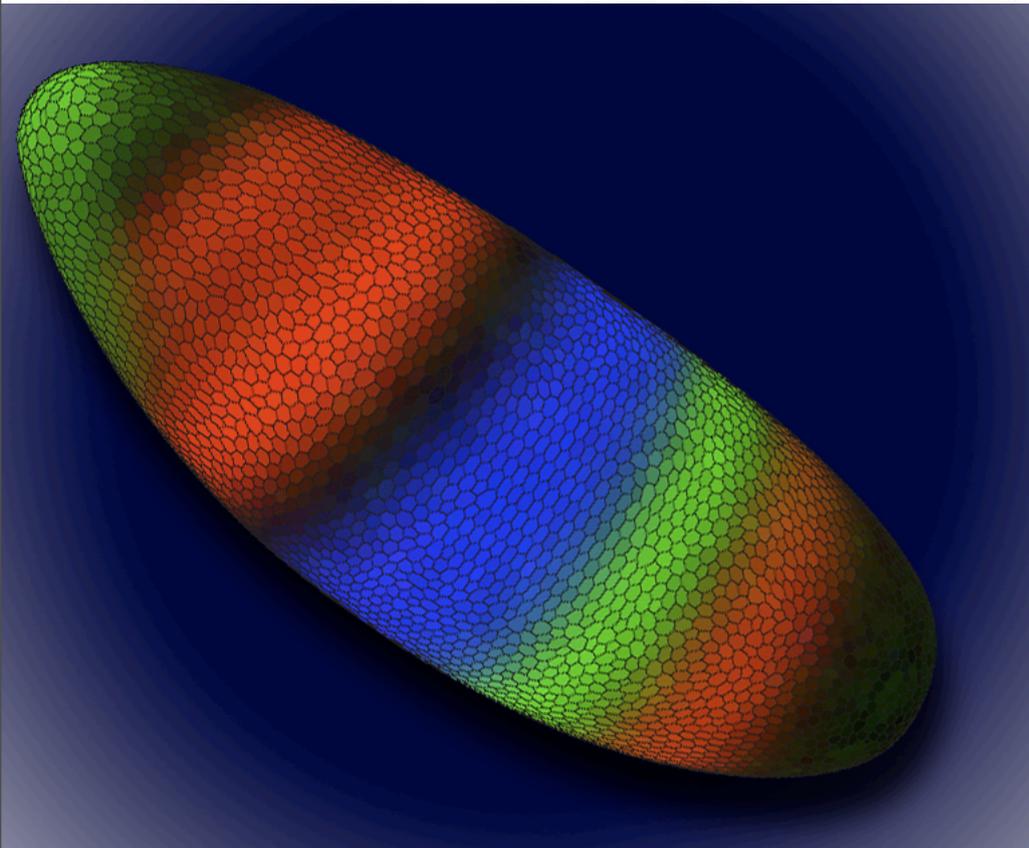
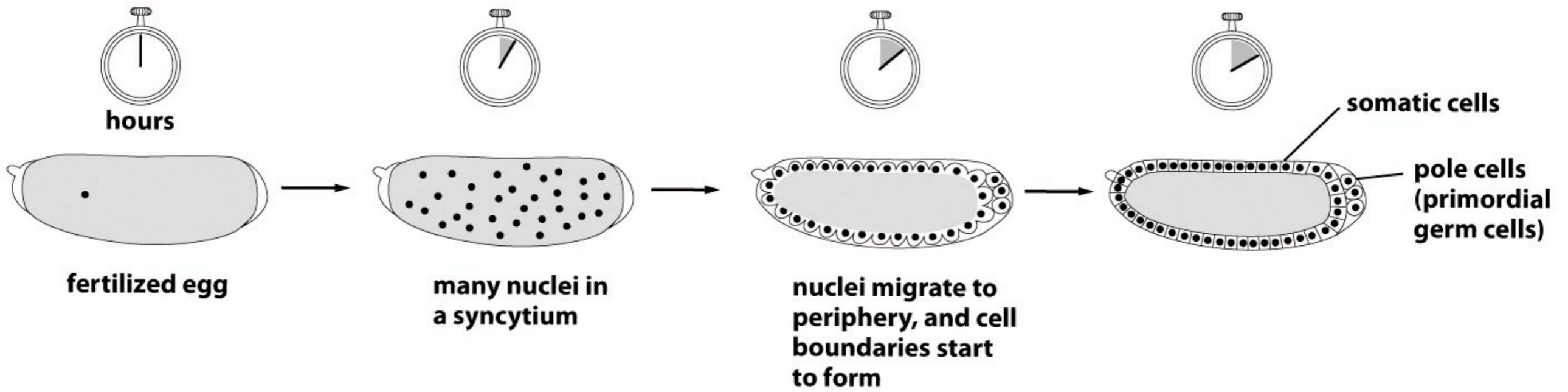
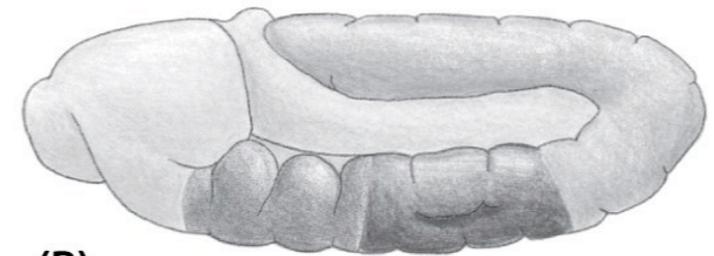


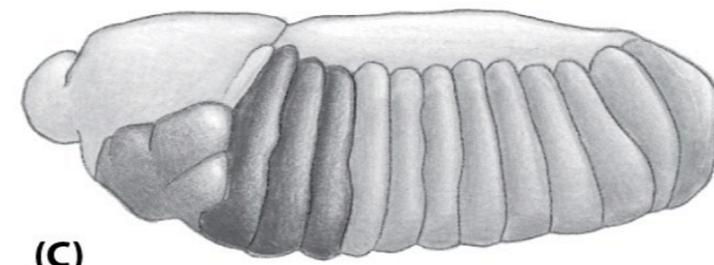
Figure 3.21 Physical Biology of the Cell (© Garland Science 2009)



(A)



(B)

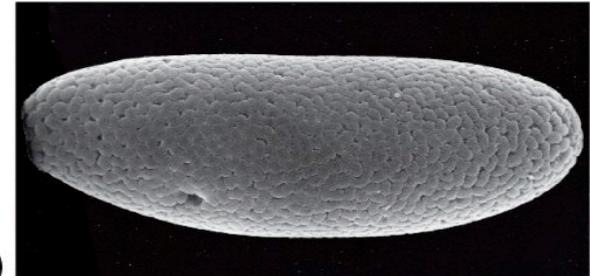


(C)

0.5 mm



(D)



(E)



(F)

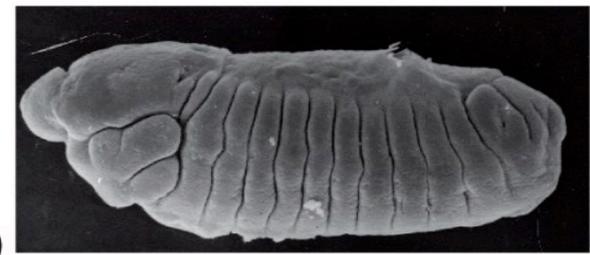


Figure 3.23 Physical Biology of the Cell (© Garland Science 2009)

- procedural
- relative
- manipulated.

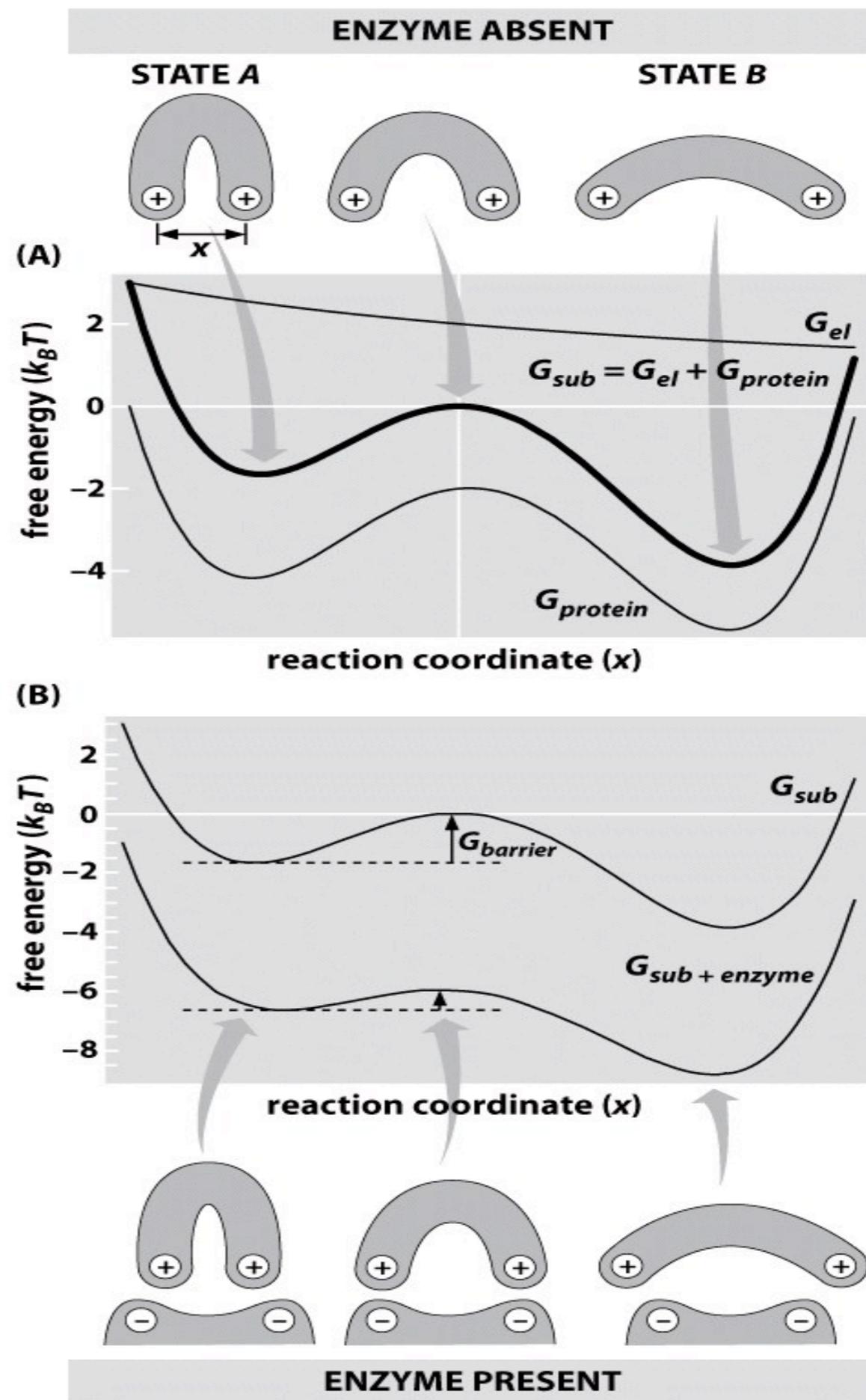


Figure 3.24 Physical Biology of the Cell (© Garland Science 2009)

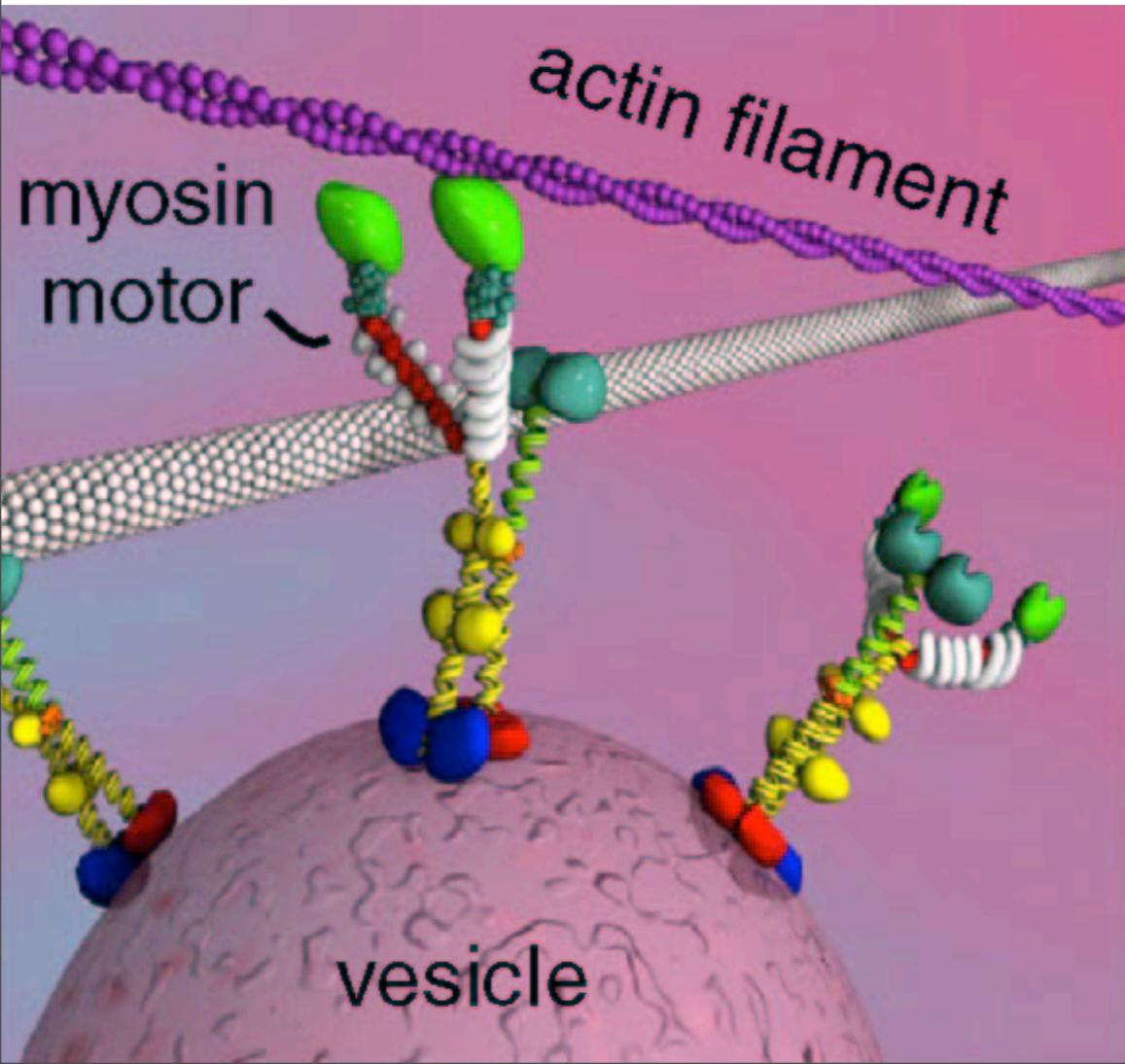
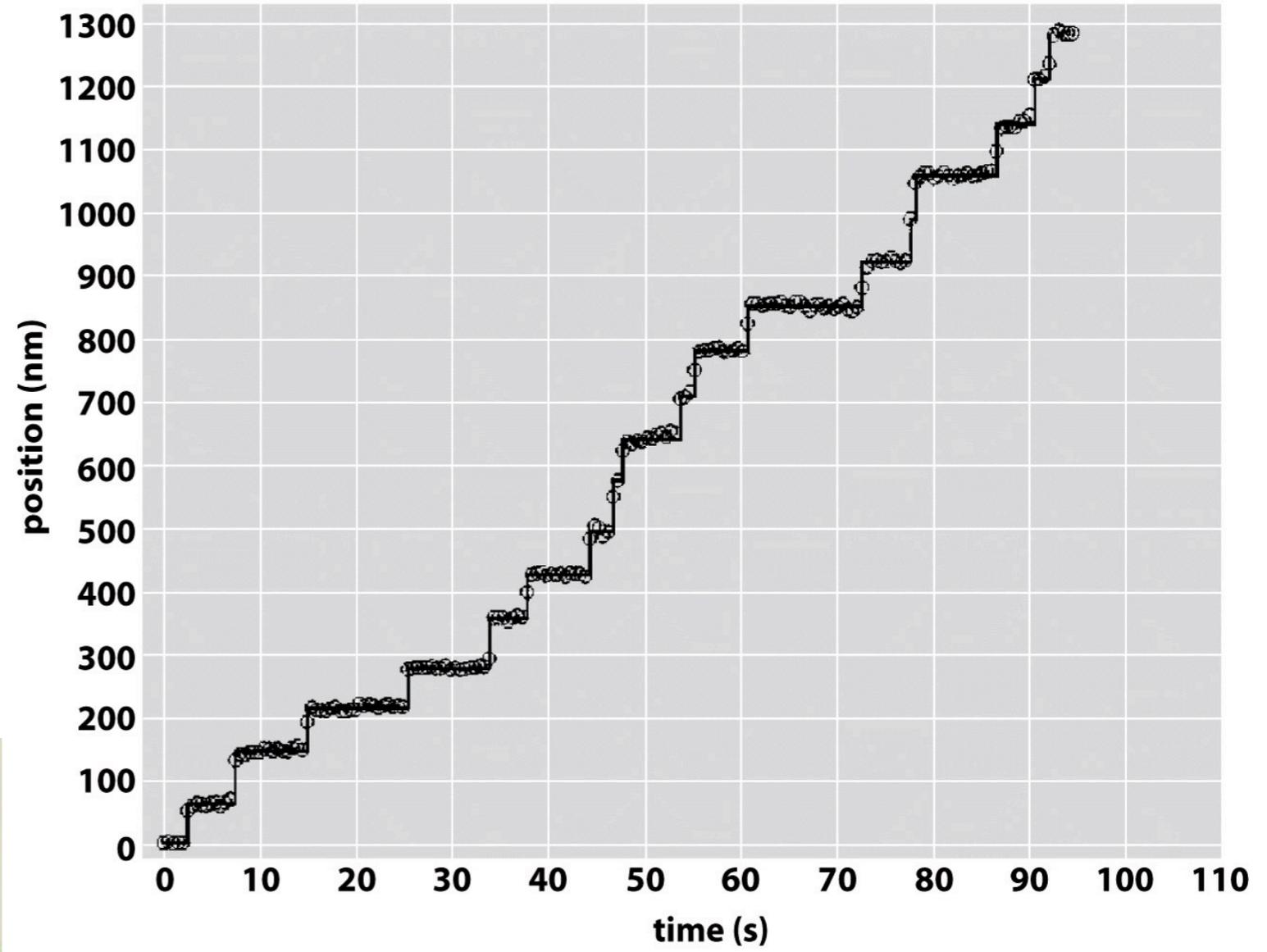
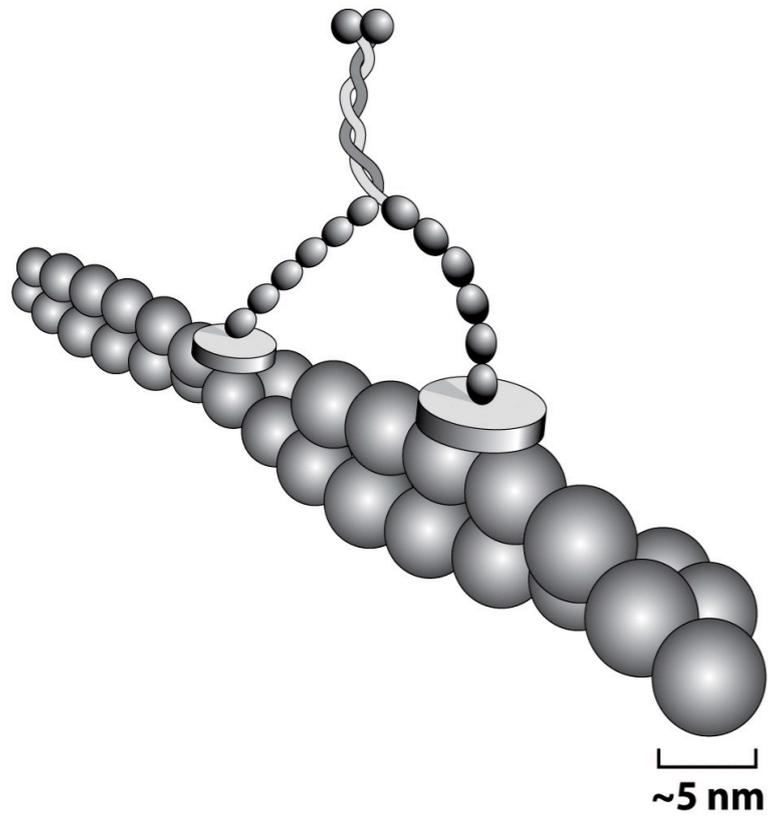


Figure 3.26b Physical Biology of the Cell (© Garland Science 2009)

+ pumps

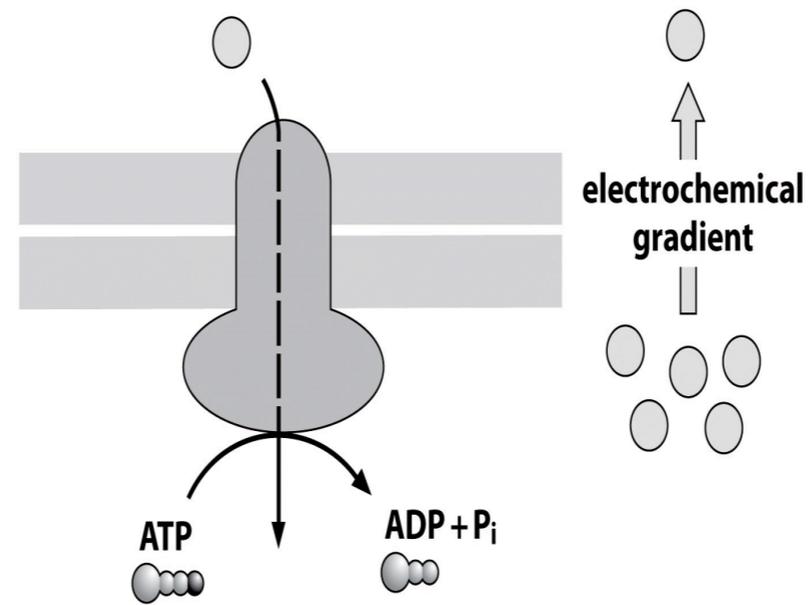


Figure 3.27 Physical Biology of the Cell (© Garland Science 2009)

+ “replication limit”

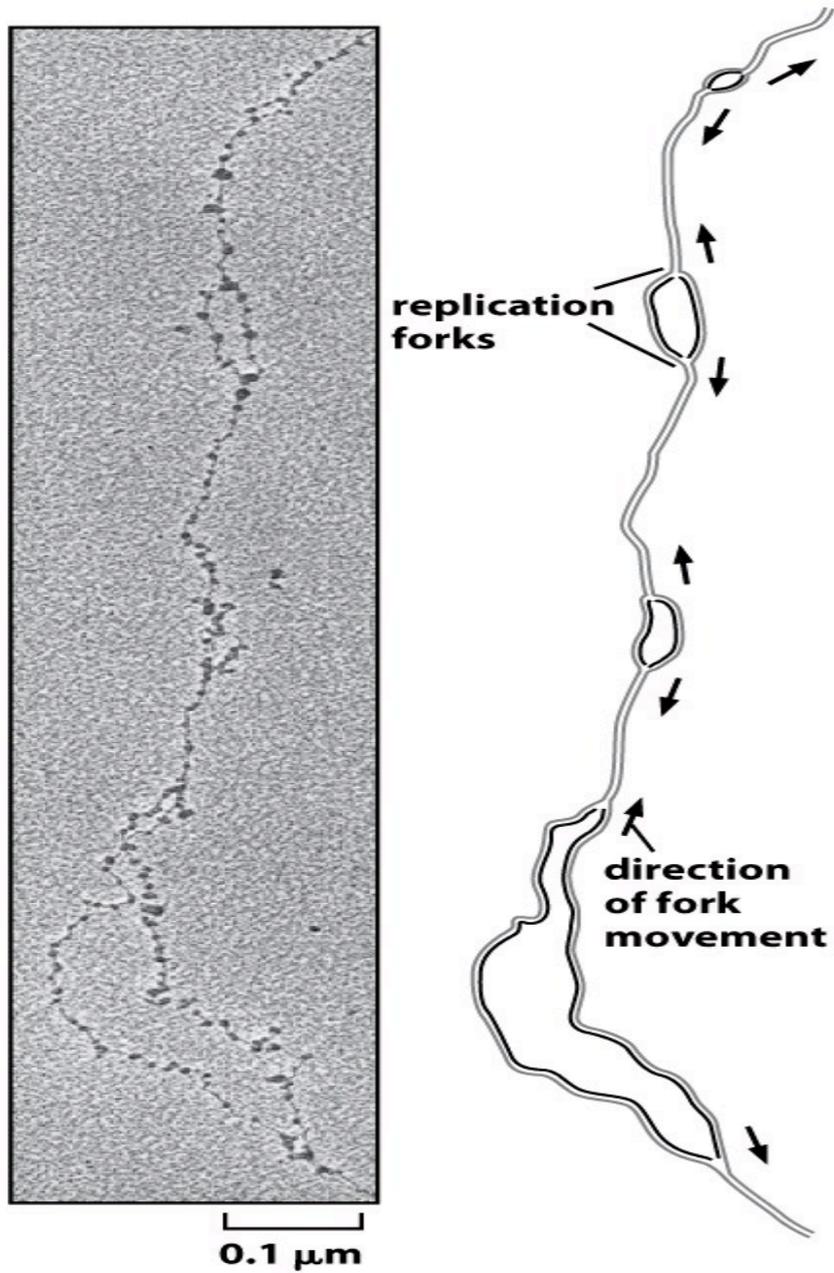
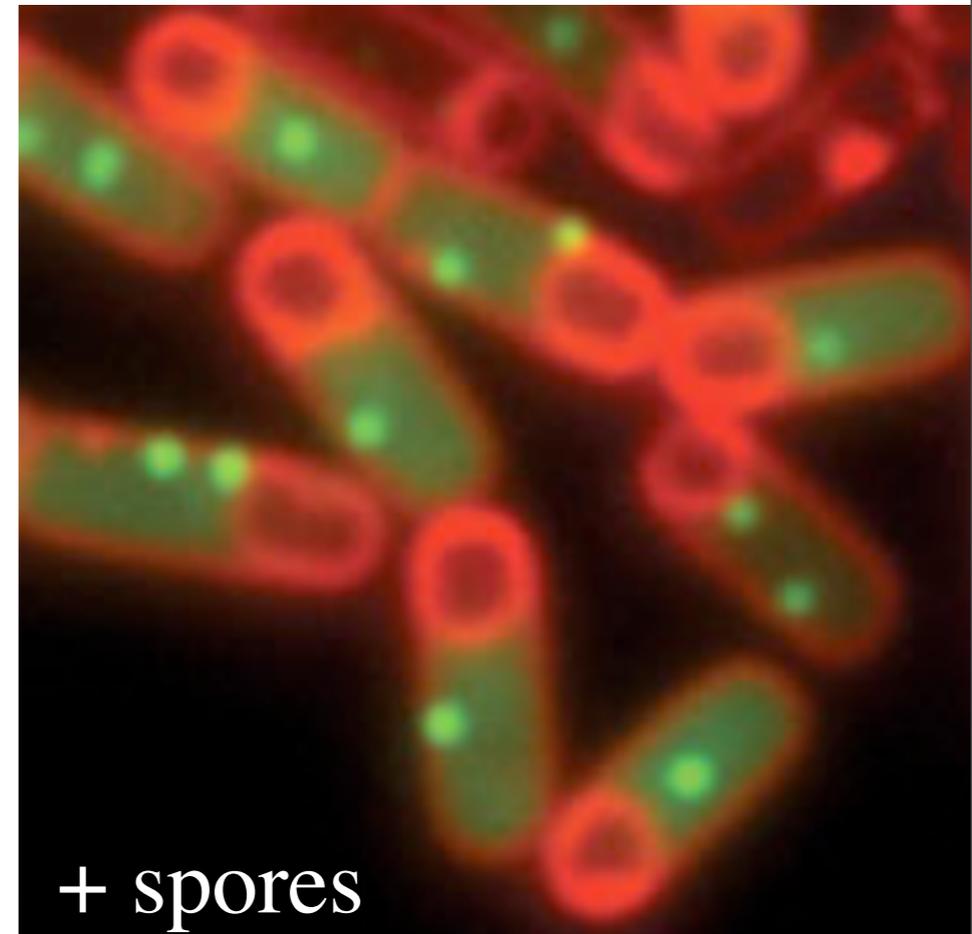


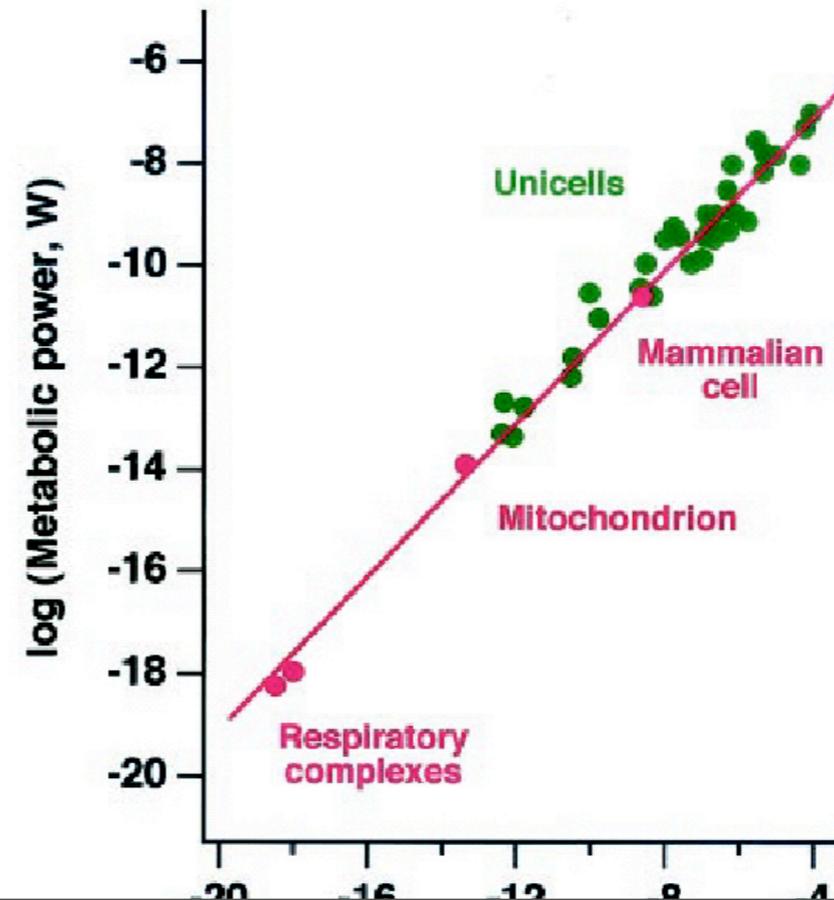
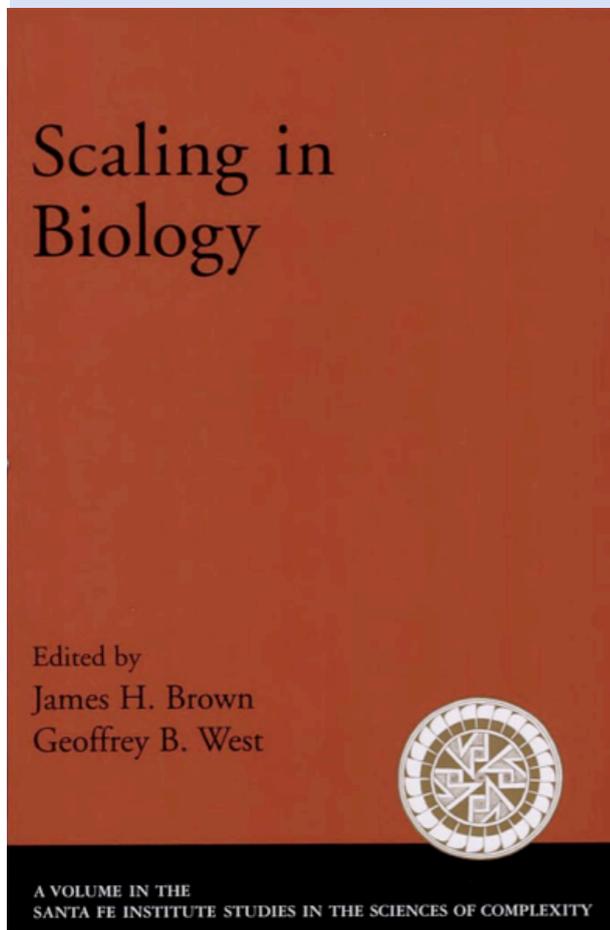
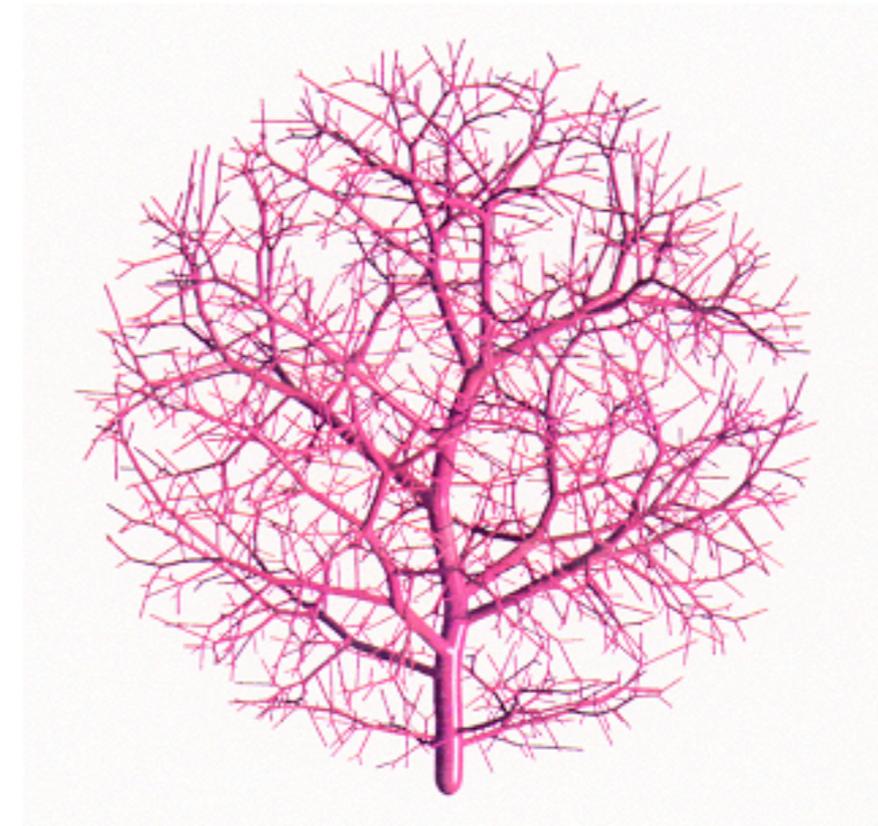
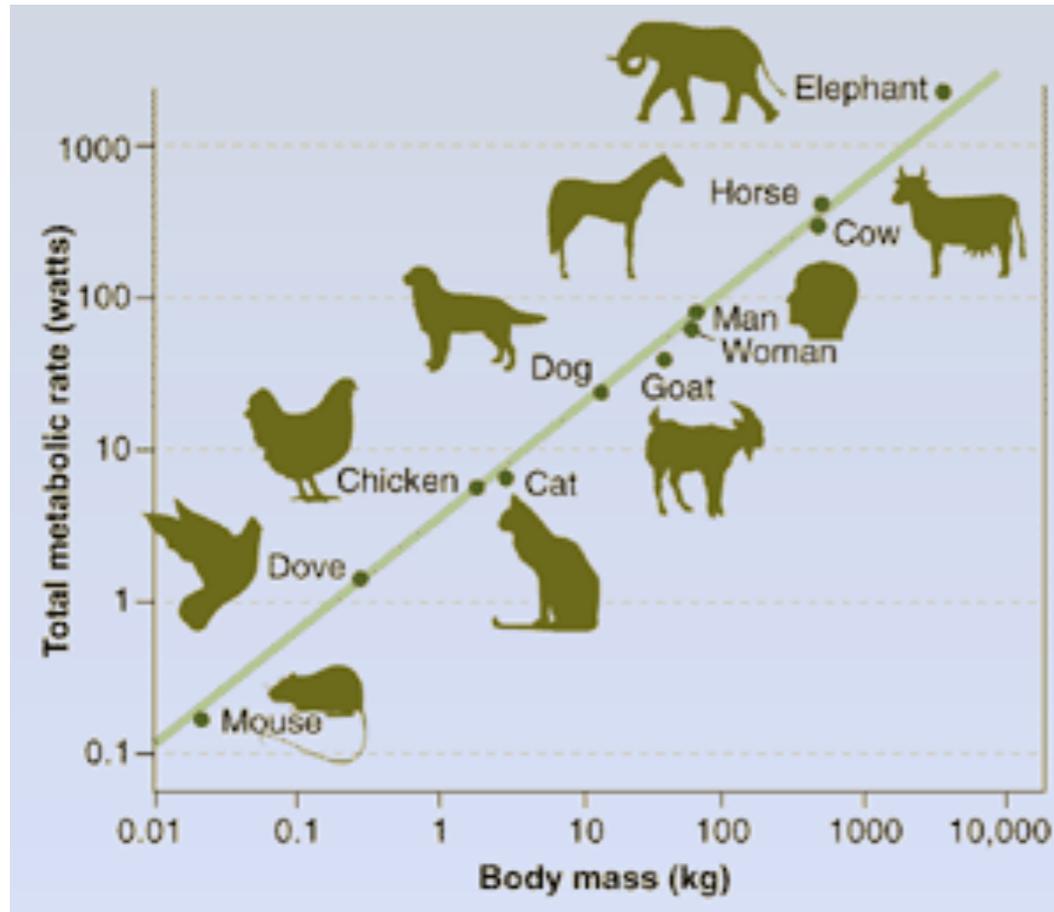
Figure 3.28 Physical Biology of the Cell (© Garland Science 2009)



+ spores

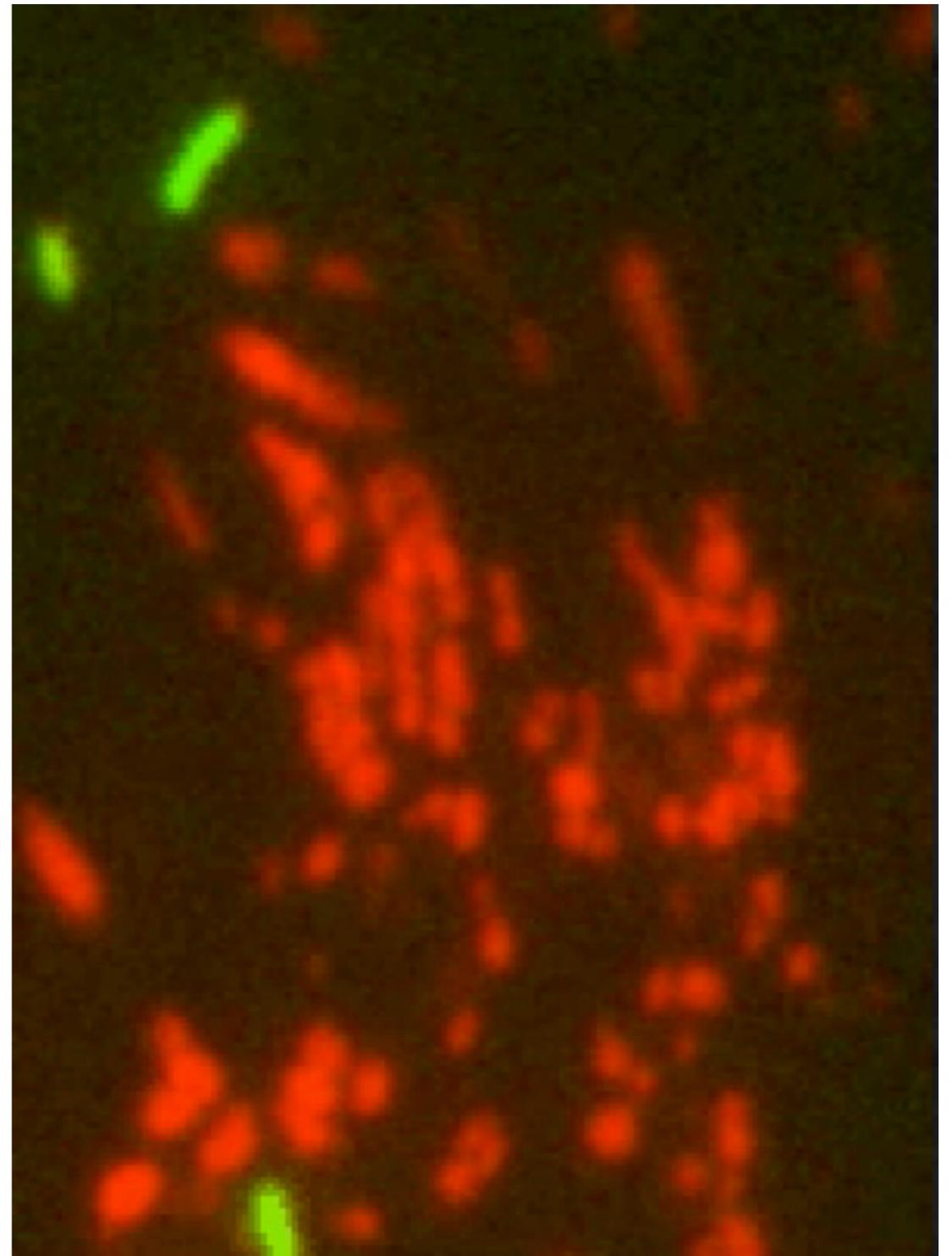
● Allometric scaling is not geometric(2/3) but (3/4)!

$$Y \propto m^{3/4}$$



Questions?

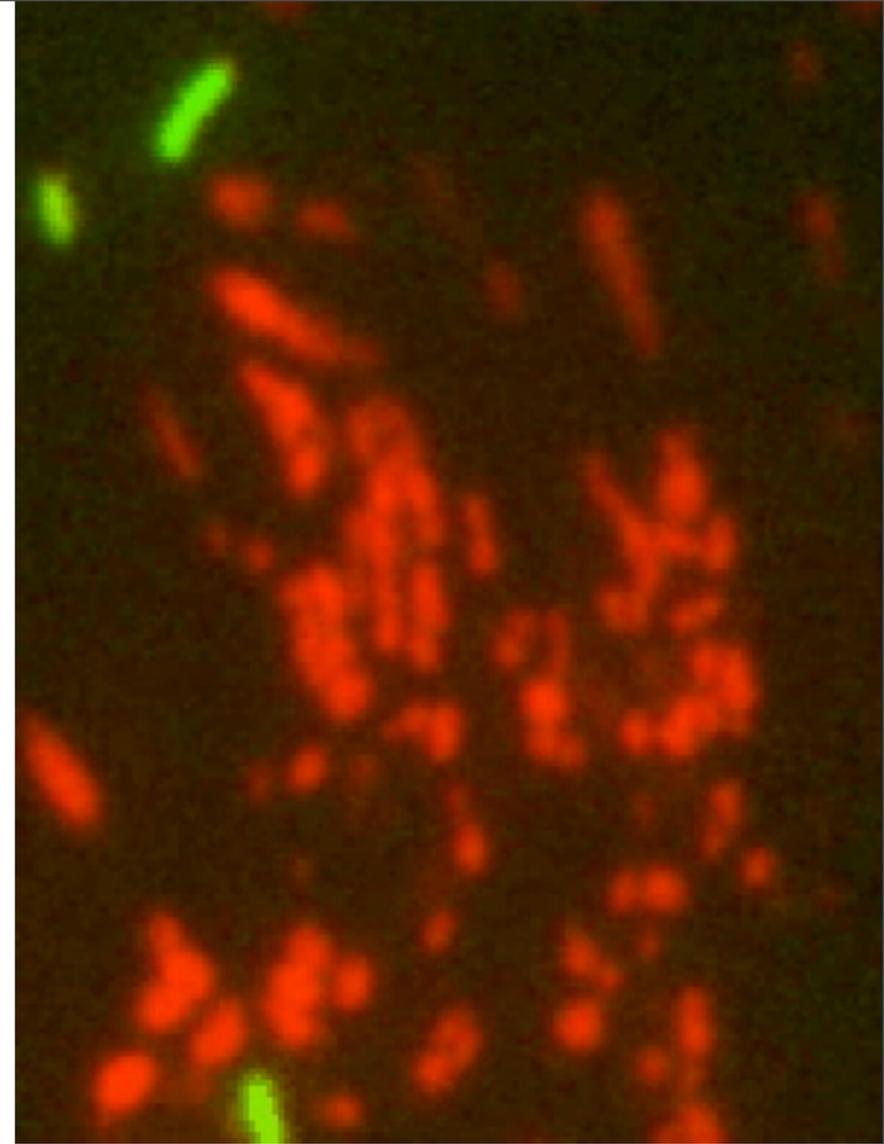
coffee break.



Chapter 4

Who: "Bless the Little Beasties"

on key model systems.



Replica plating and bacterial mutants

modern genetics started with peas.

selection and screens (conditional **mutants**).

e.g. temperature dependent mutants

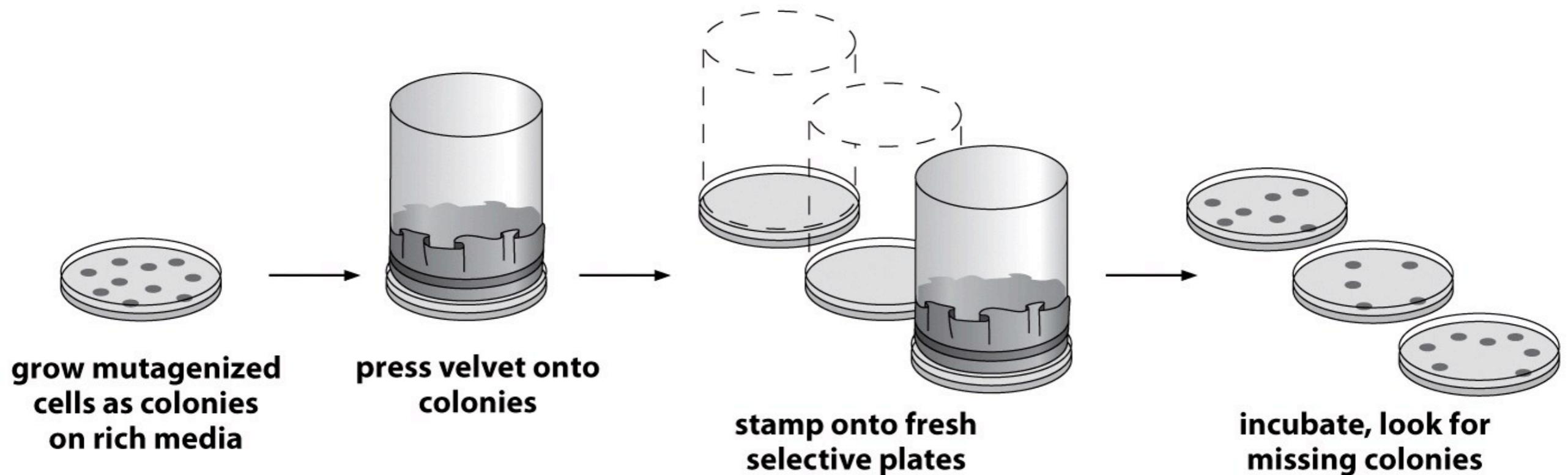


Figure 4.1 Physical Biology of the Cell (© Garland Science 2009)

Column biochemistry

4.2 Hemoglobin: a model protein.

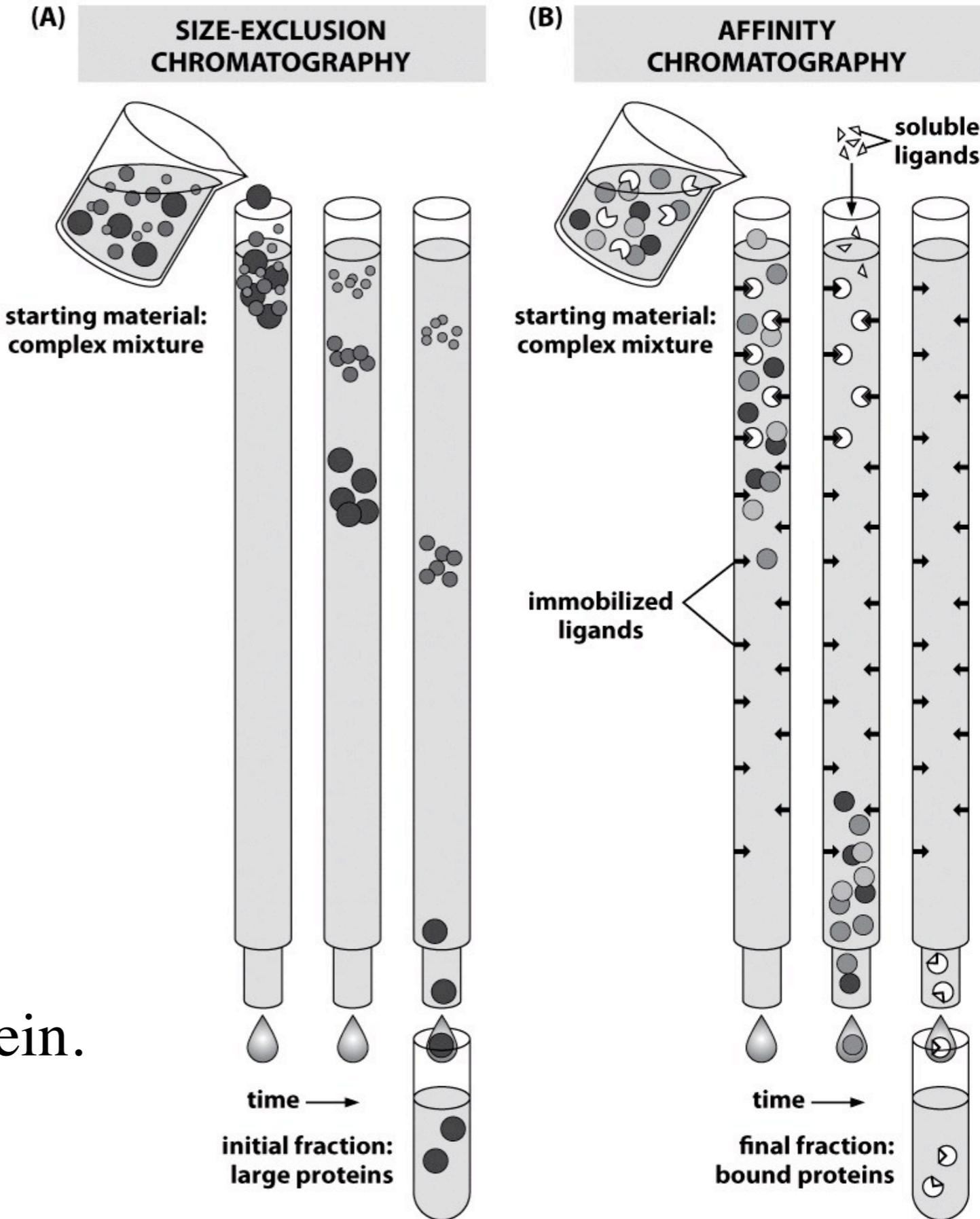


Figure 4.2 Physical Biology of the Cell (© Garland Science 2009)

receptor-ligand binding structural biology origins

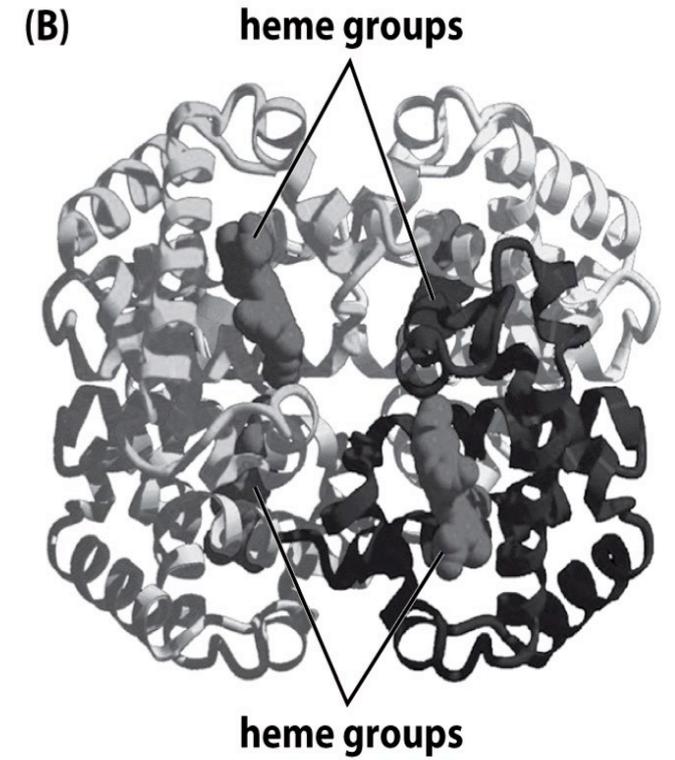
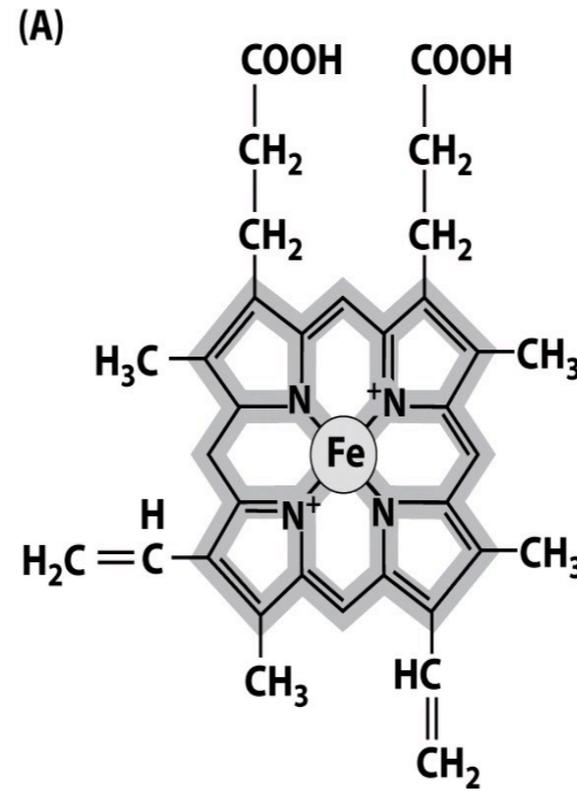
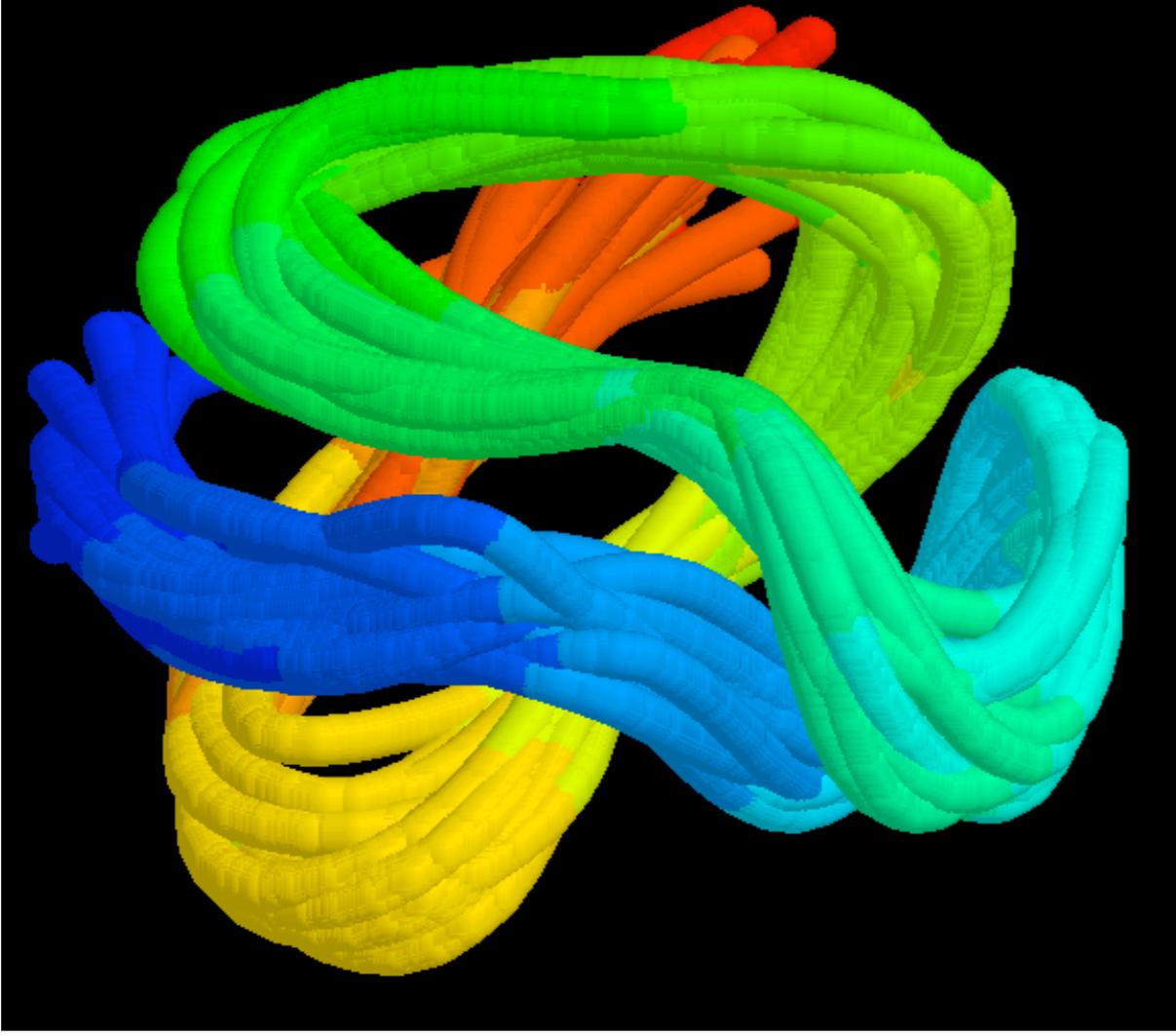
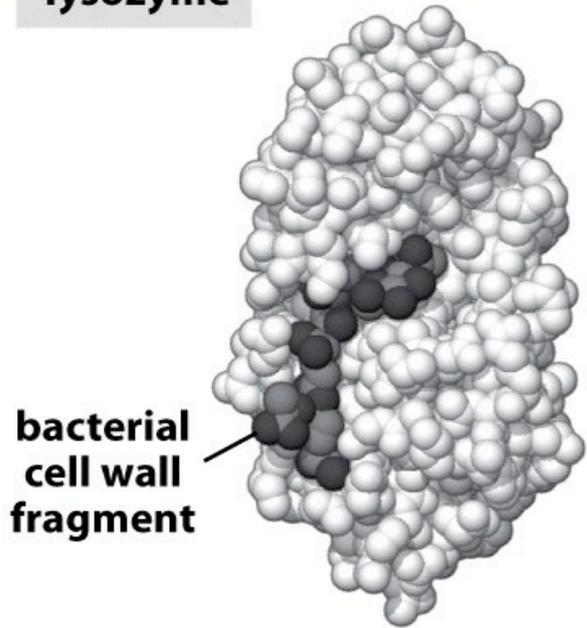
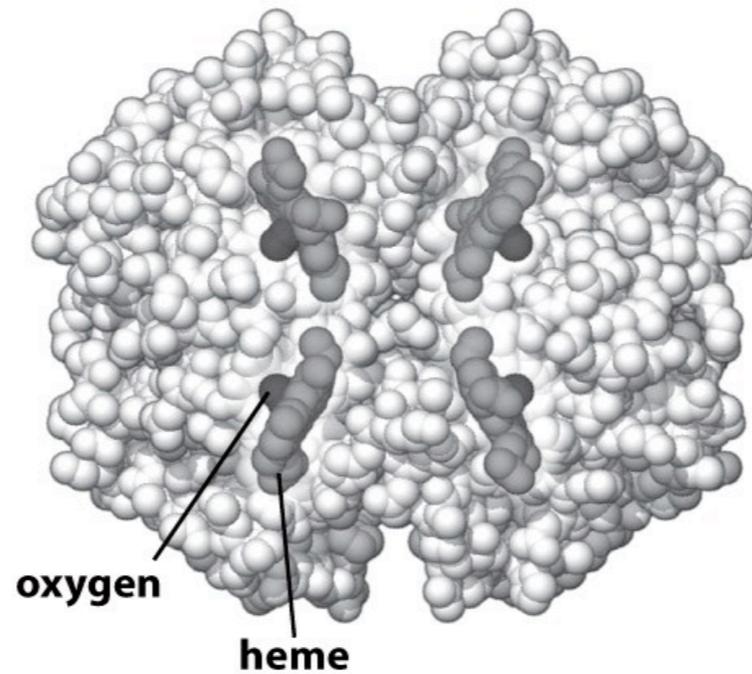


Figure 4.6 Physical Biology of the Cell (© Garland Science 2009)

lysozyme



hemoglobin



MHC

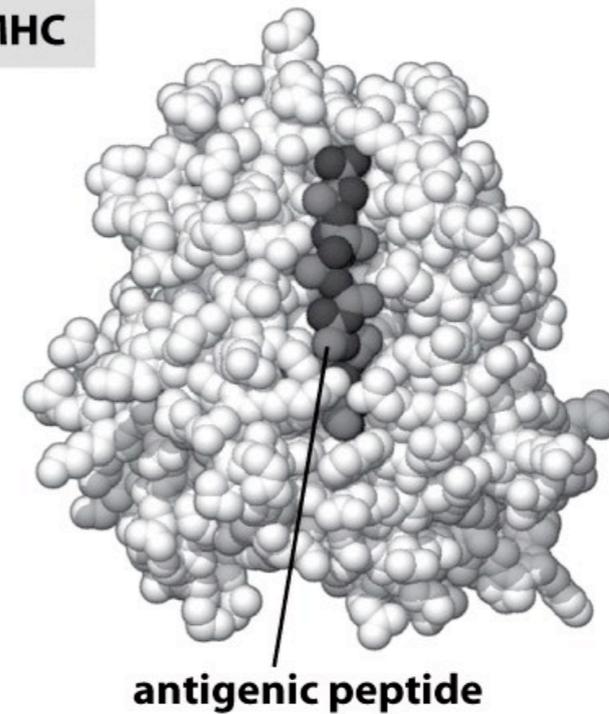


Figure 4.3 Physical Biology of the Cell (© Garland Science 2009)

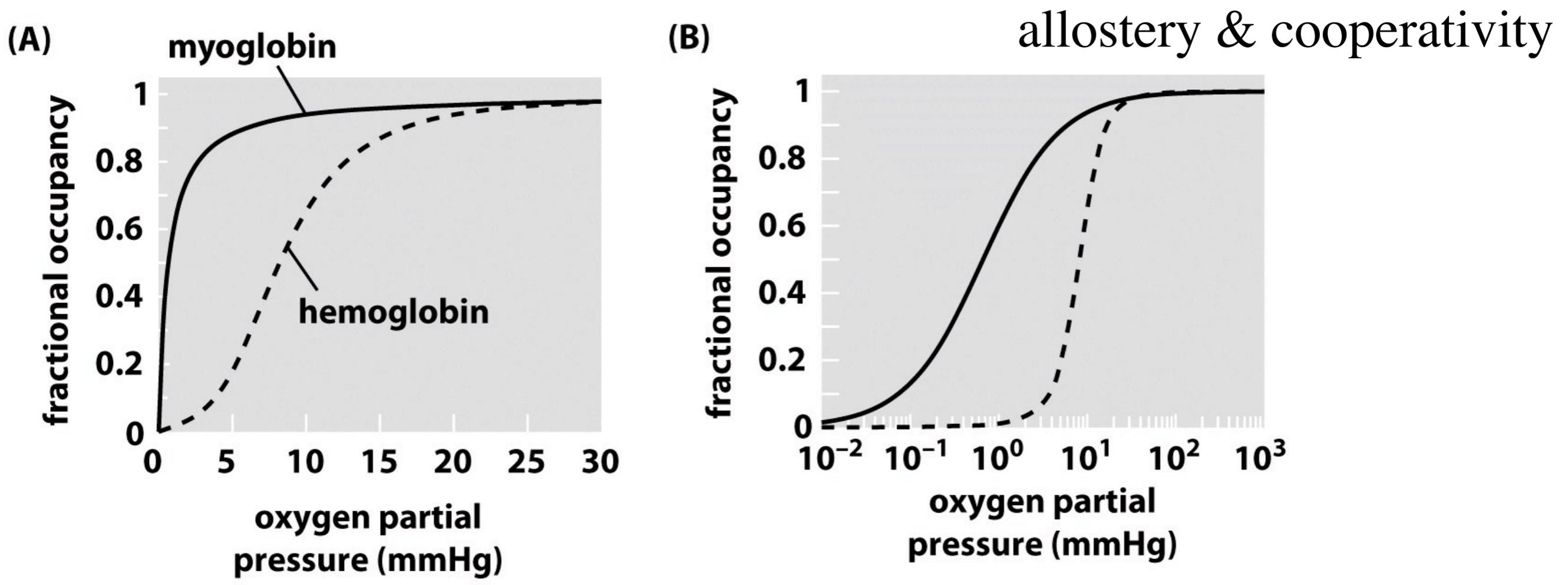


Figure 4.4 Physical Biology of the Cell (© Garland Science 2009)

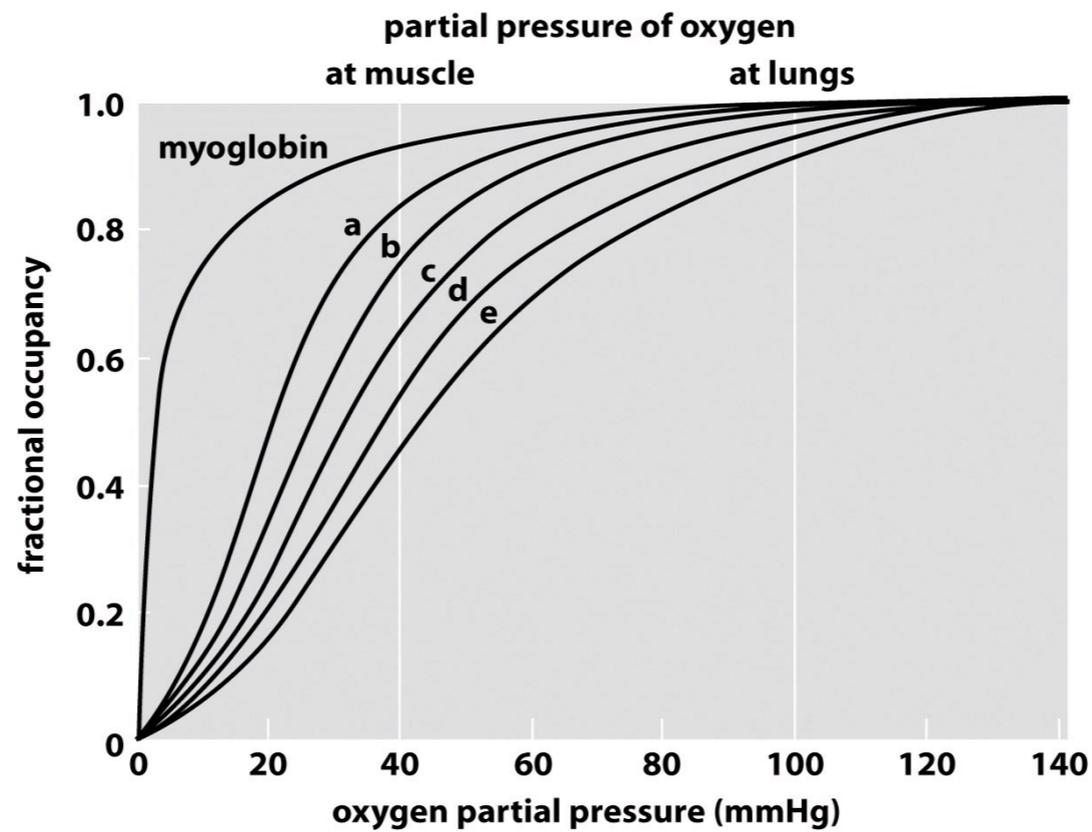
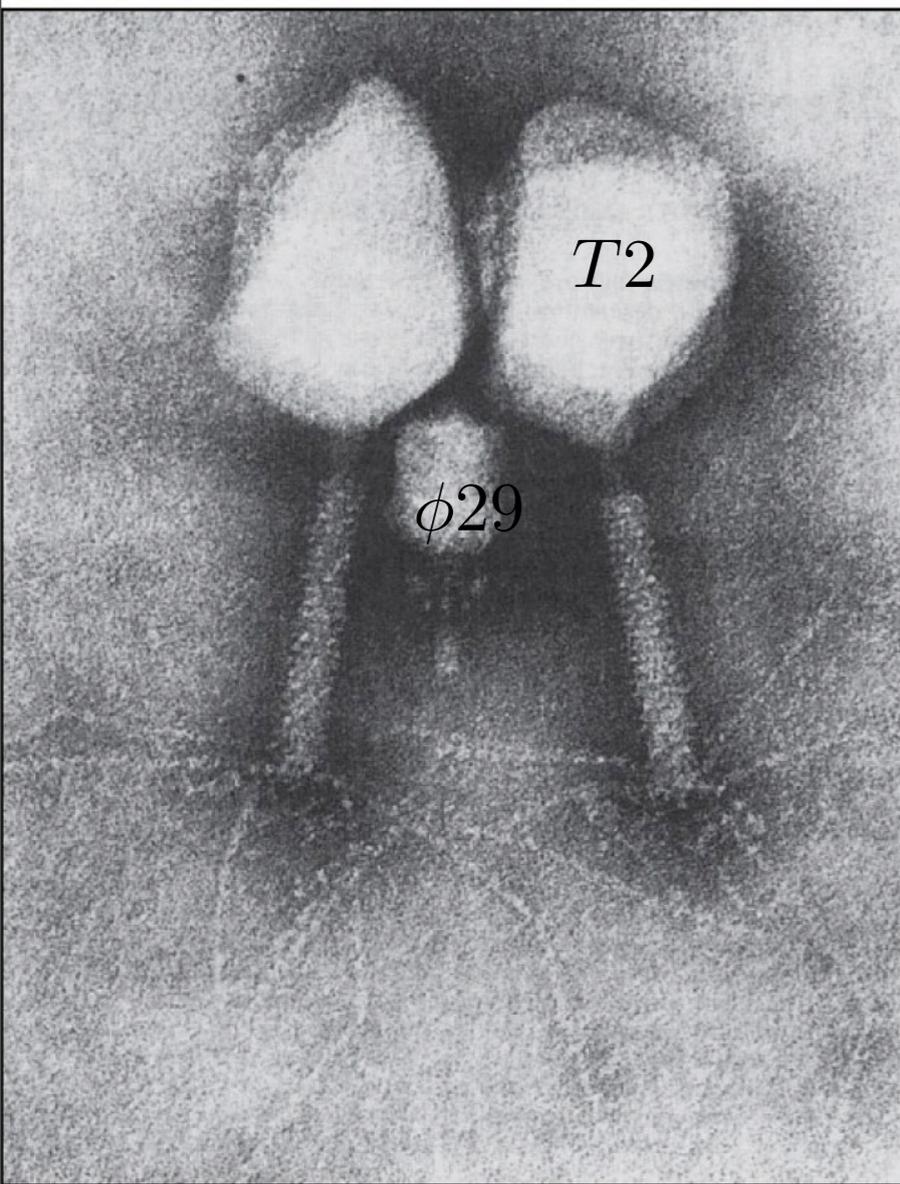


Figure 4.5 Physical Biology of the Cell (© Garland Science 2009)

4.3 Phages (Hydrogens of MolBio)



T2

$\phi 29$

100 nm

Figure 4.7 Physical Biology of the Cell (© Garland Science 2009)

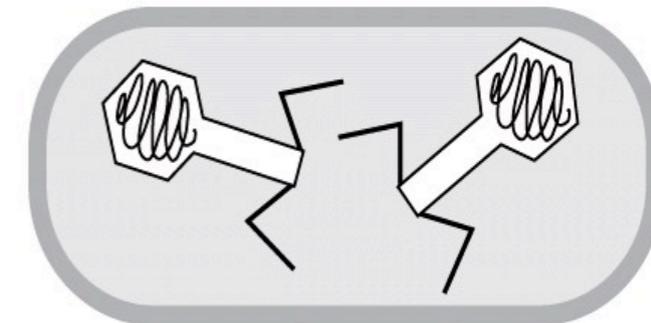
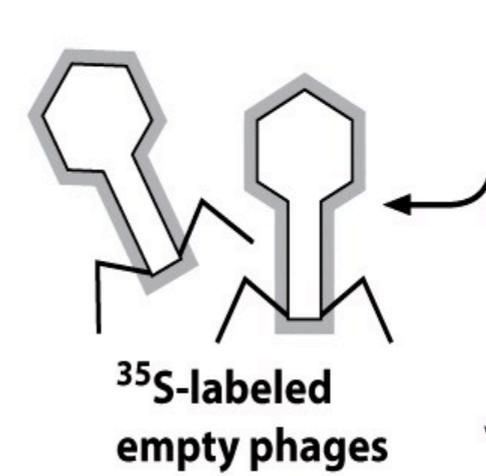
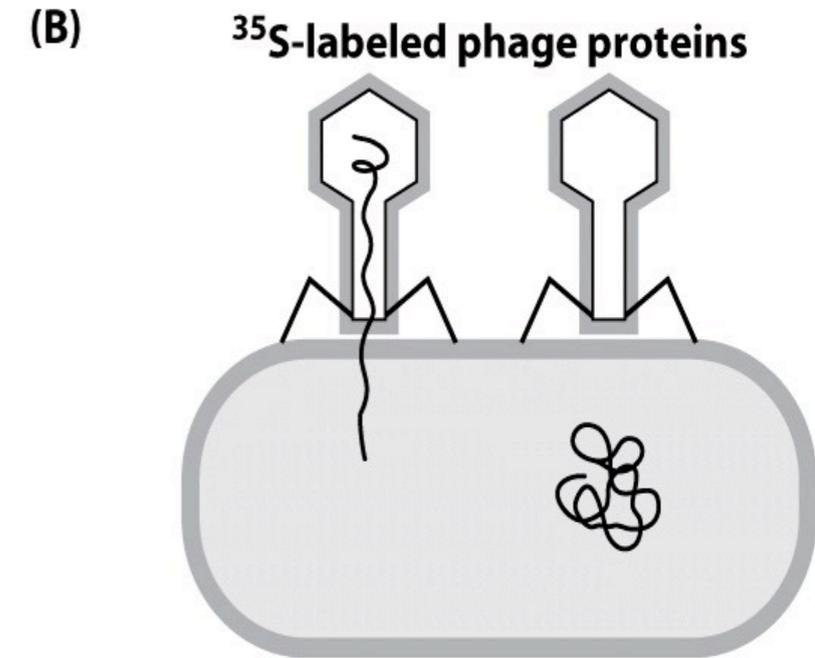
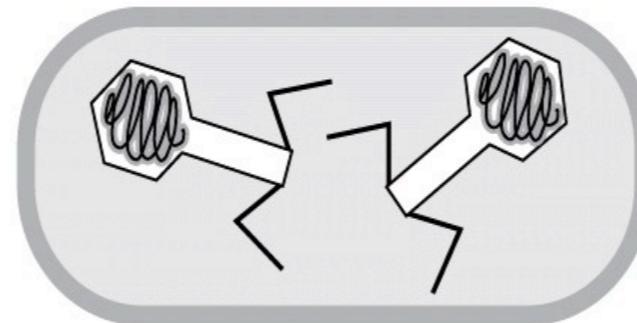
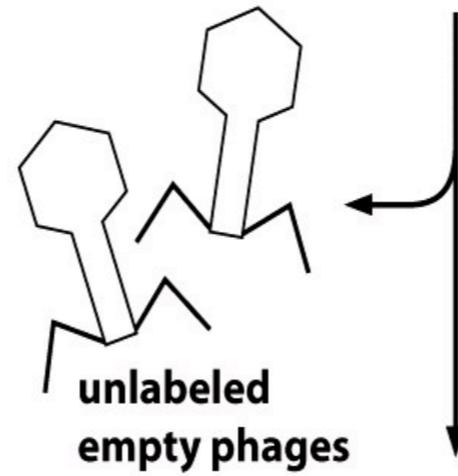
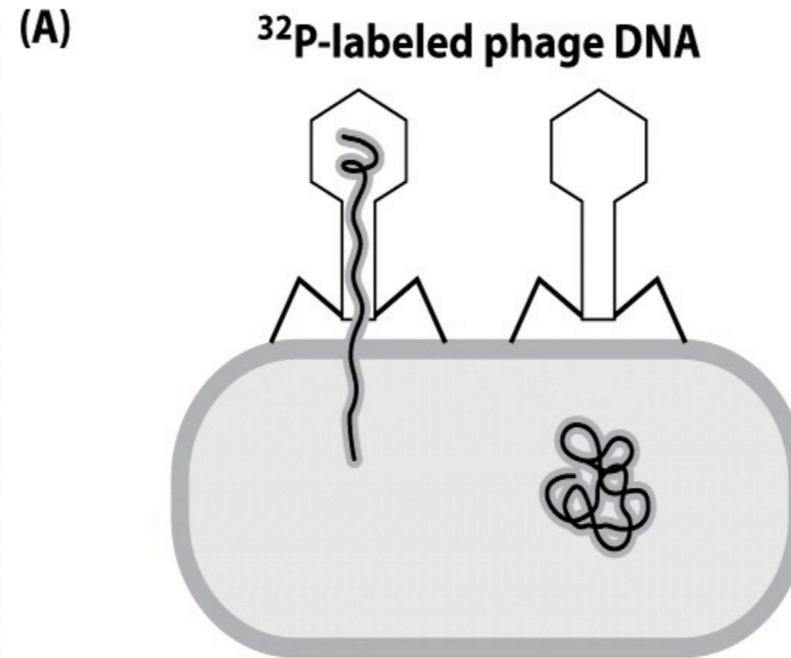
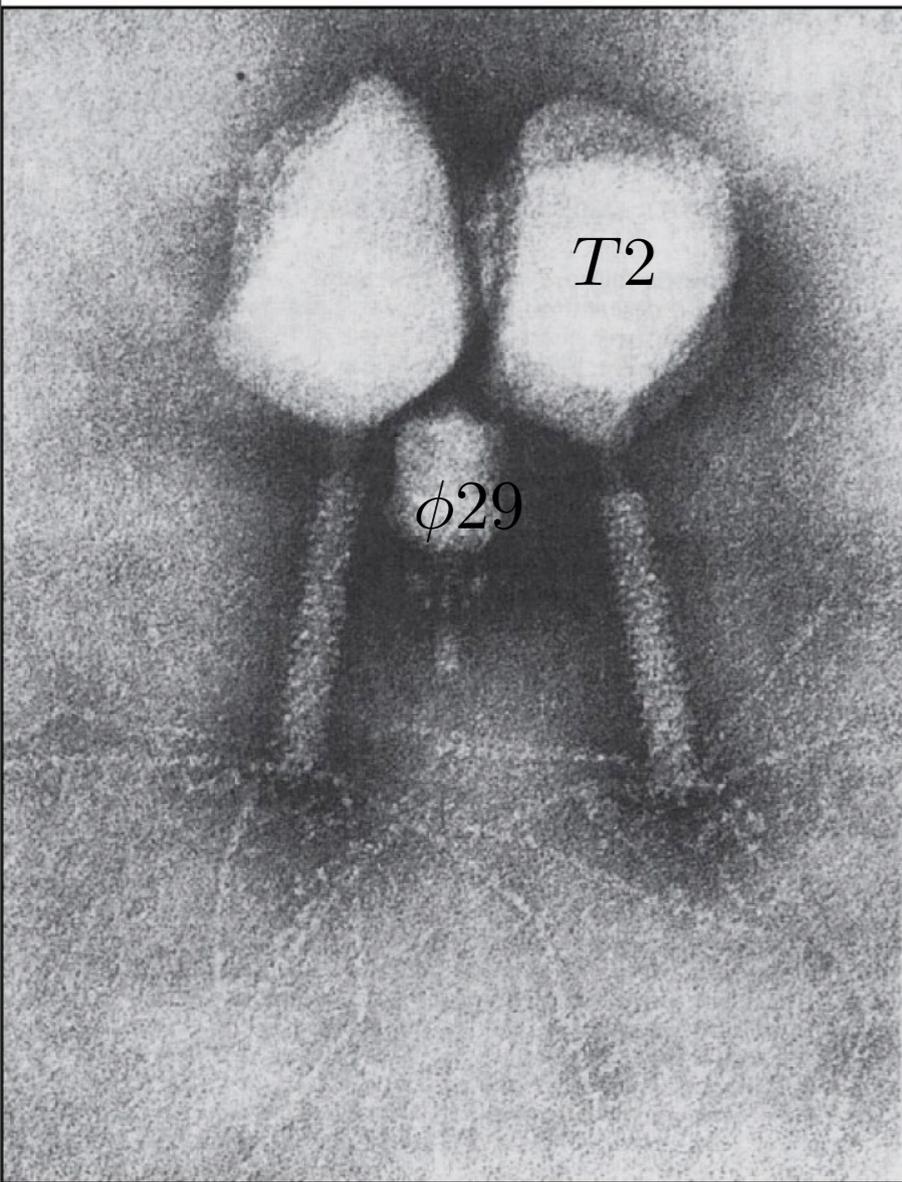


Figure 4.8 Physical Biology of the Cell (© Garland Science 2009)

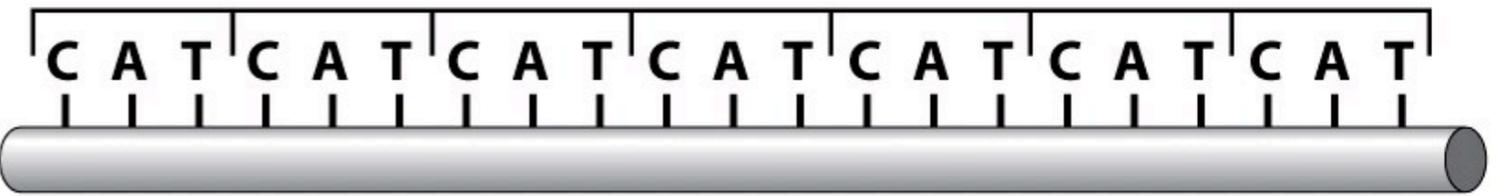
Hershey-Chase experiment.



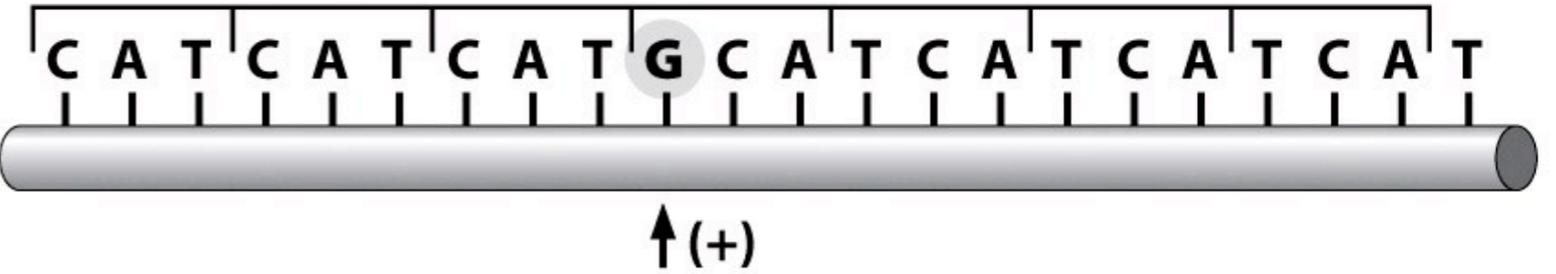
100 nm

Figure 4.7 Physical Biology of the Cell (© Garland Science 2009)

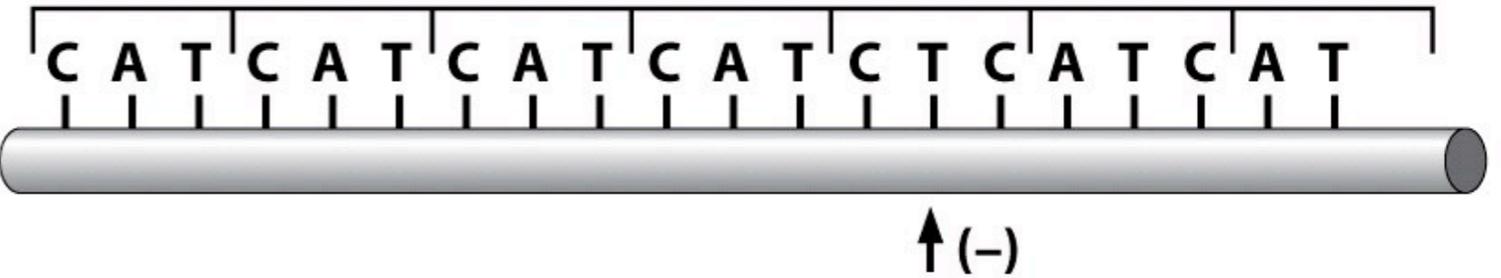
wild-type gene



base added



base deleted



base added, base deleted

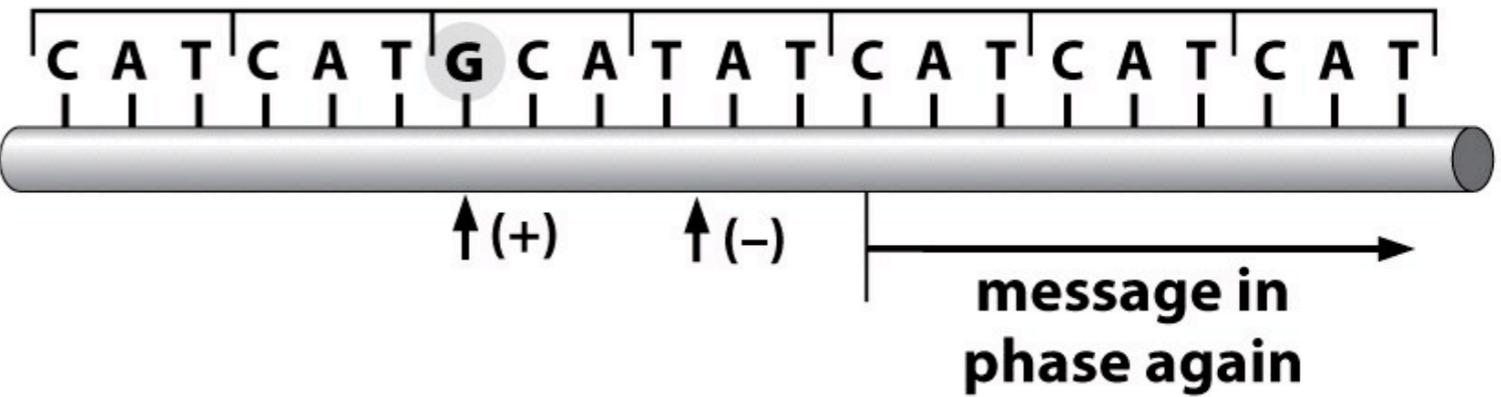


Figure 4.9 Physical Biology of the Cell (© Garland Science 2009)

Codon confirmation experiments.

Phages and modern biophysics.

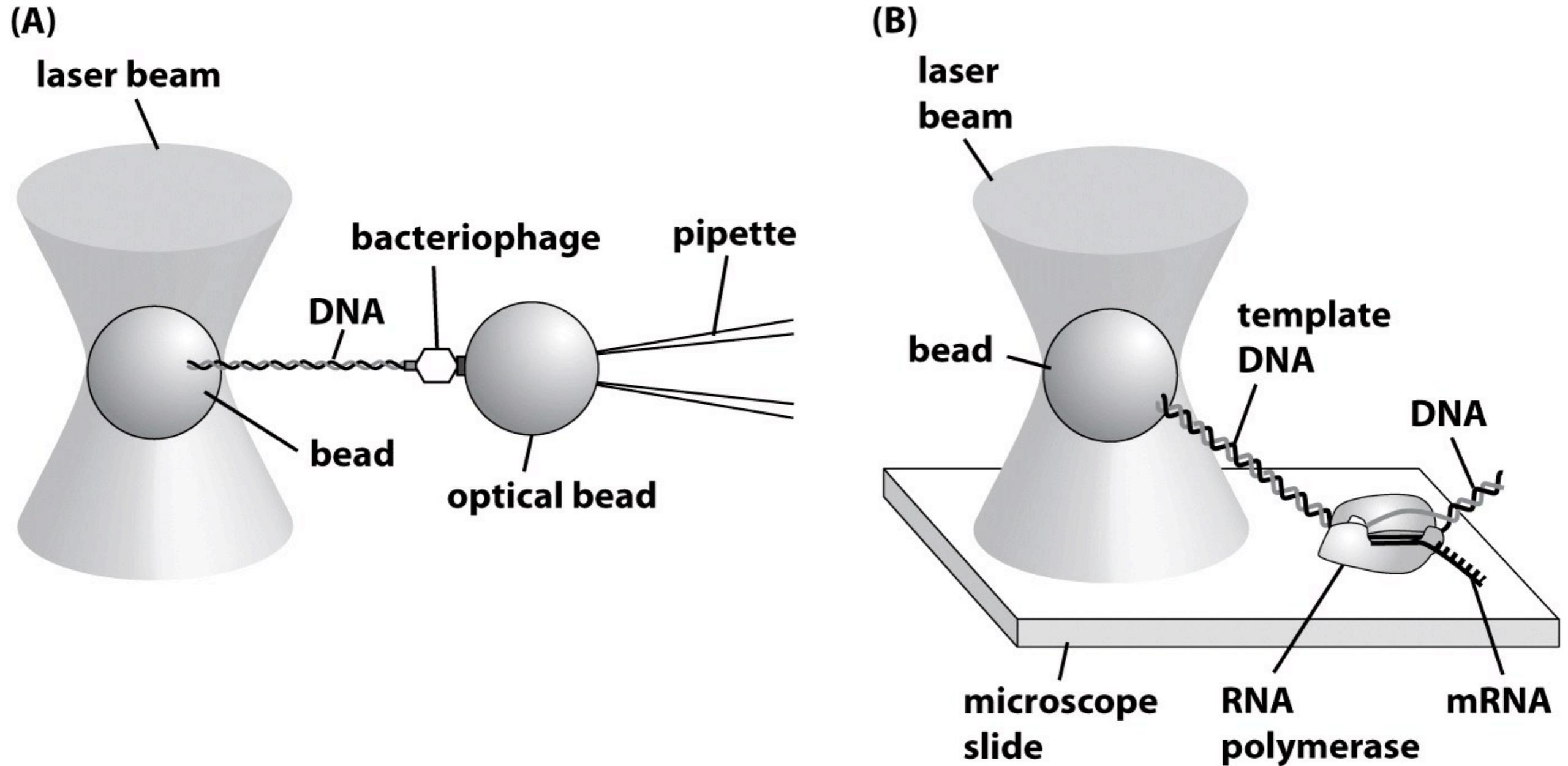


Figure 4.12 Physical Biology of the Cell (© Garland Science 2009)

4.3 Of course E. coli

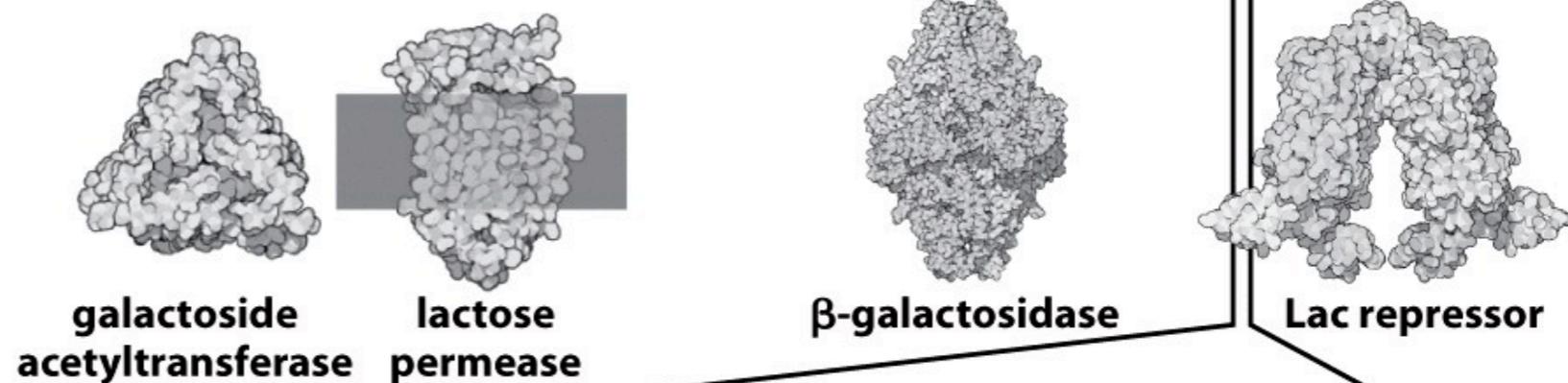
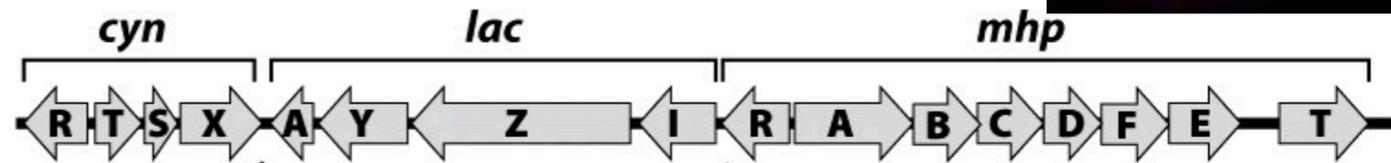
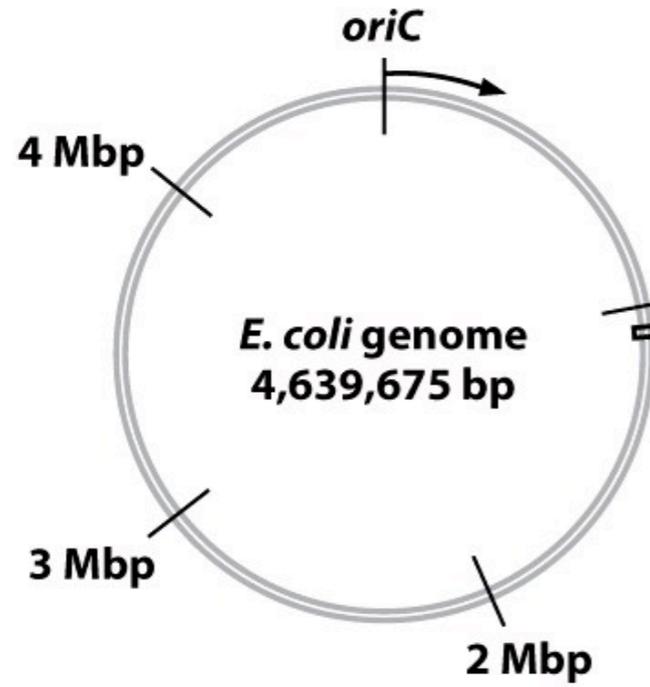
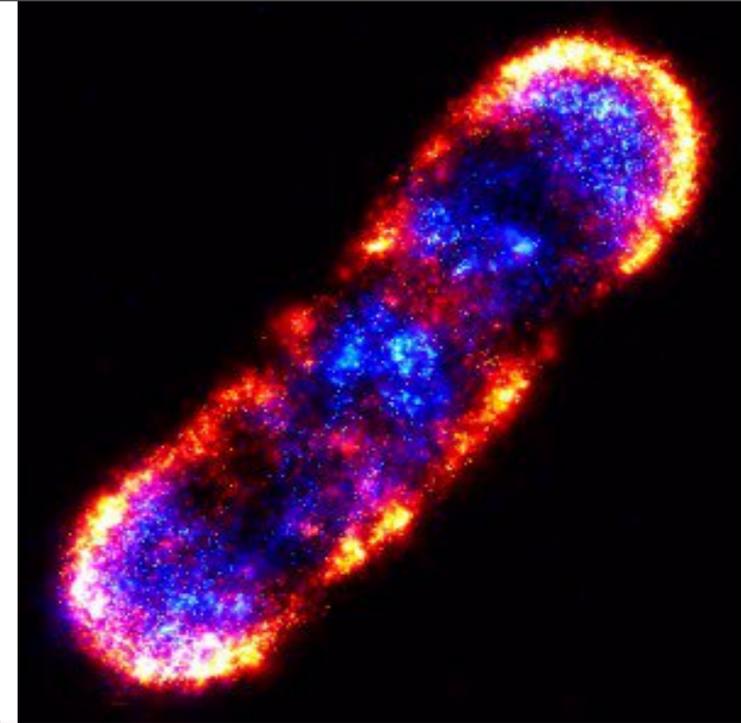


Figure 4.13 Physical Biology of the Cell (© Garland Science 2009)

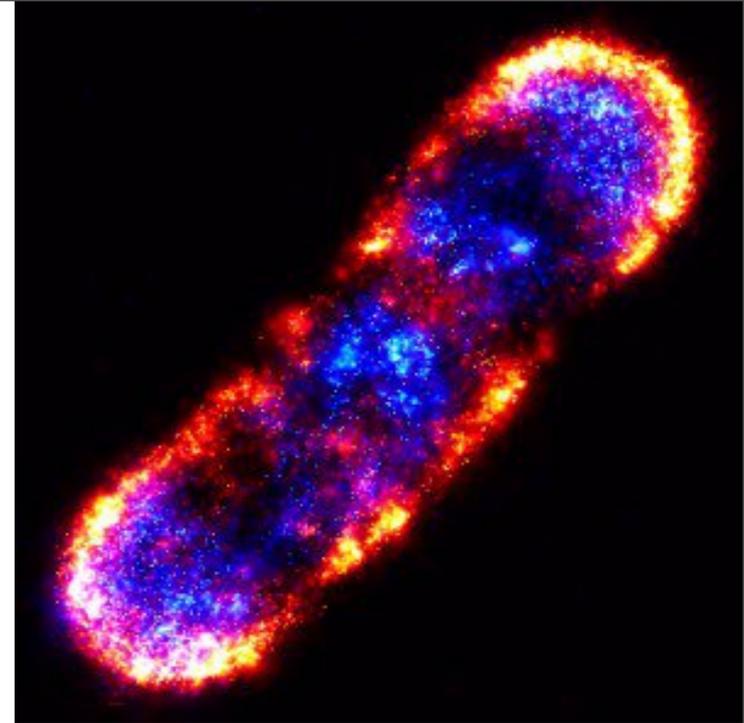
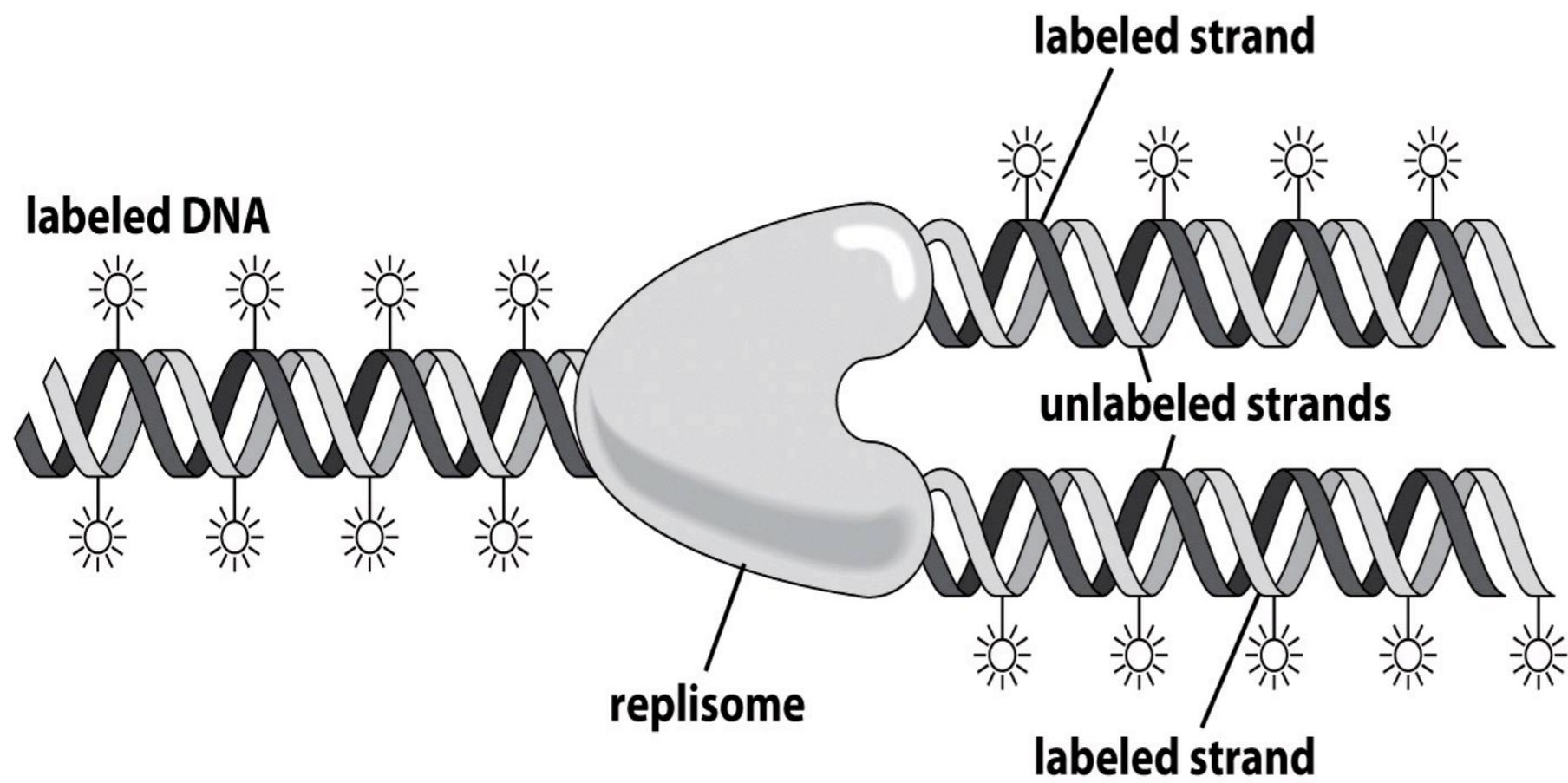
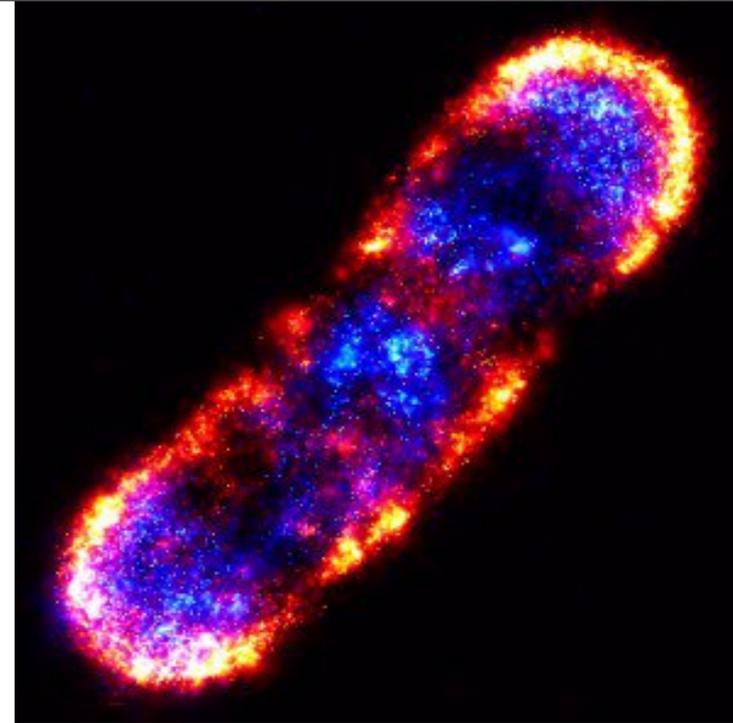
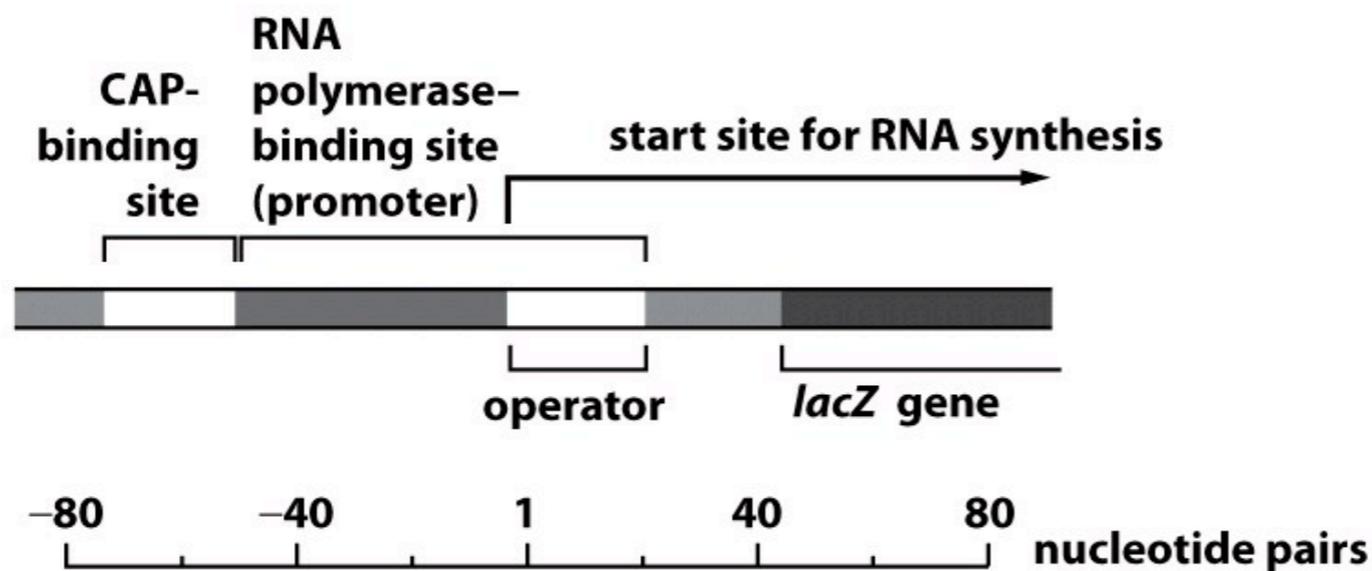


Figure 4.14 Physical Biology of the Cell (© Garland Science 2009)

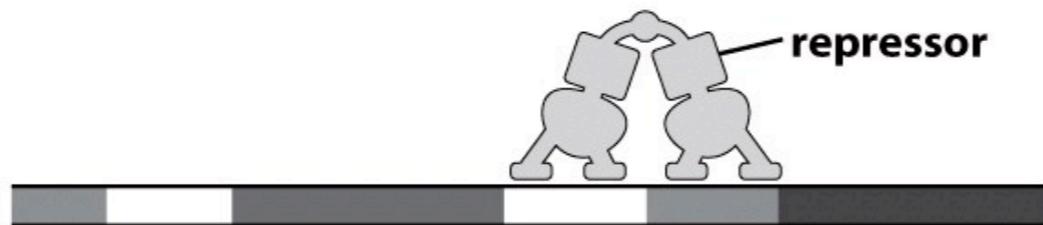


+ GLUCOSE
+ LACTOSE



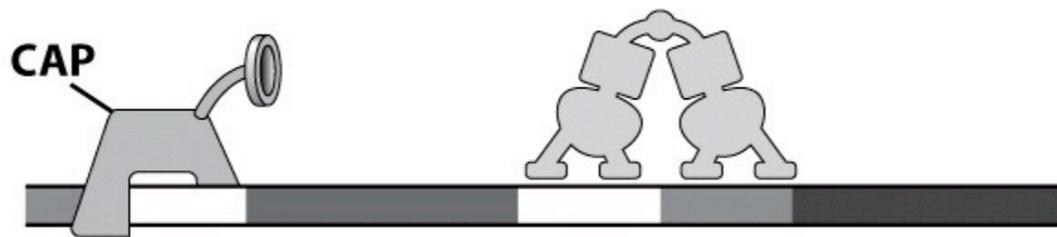
OPERON OFF
because CAP
not bound

+ GLUCOSE
- LACTOSE



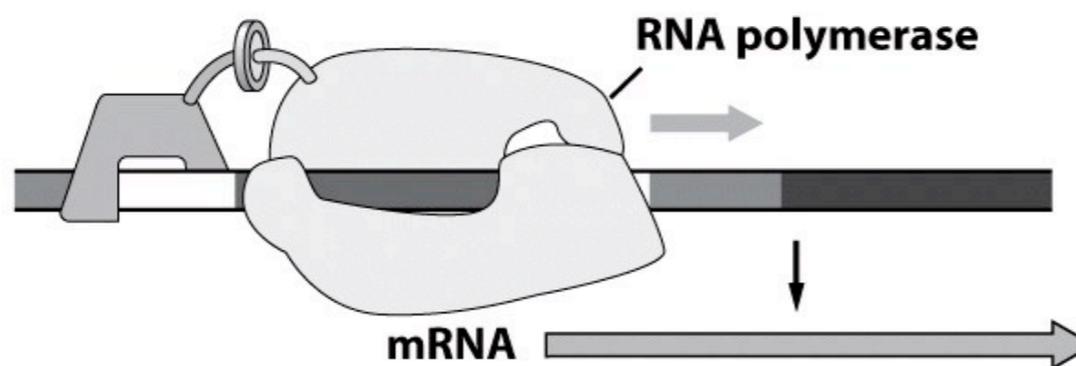
OPERON OFF both
because Lac repressor
bound and because
CAP not bound

- GLUCOSE
- LACTOSE



OPERON OFF because
Lac repressor bound

- GLUCOSE
+ LACTOSE



OPERON ON

Figure 4.15 Physical Biology of the Cell (© Garland Science 2009)

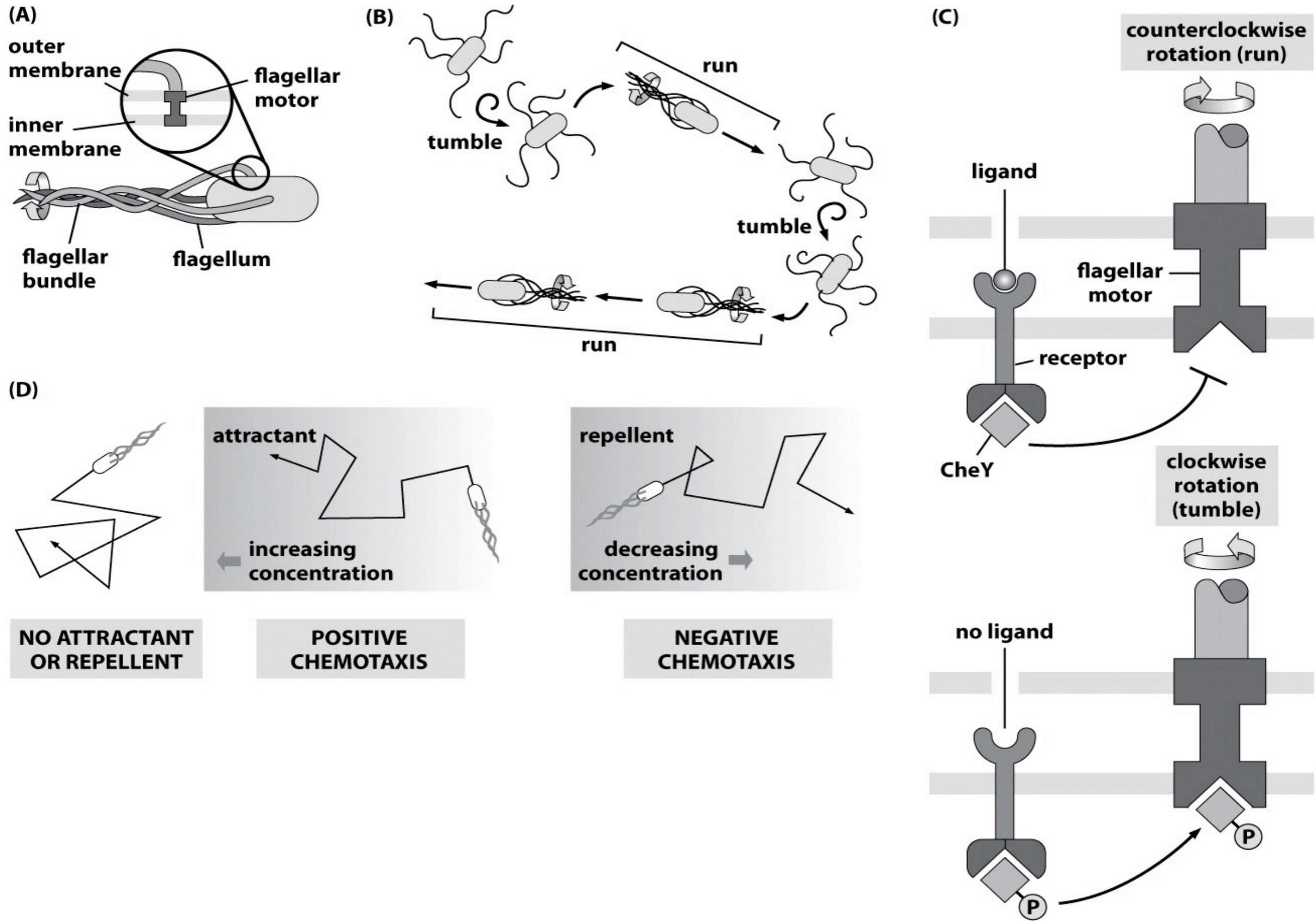
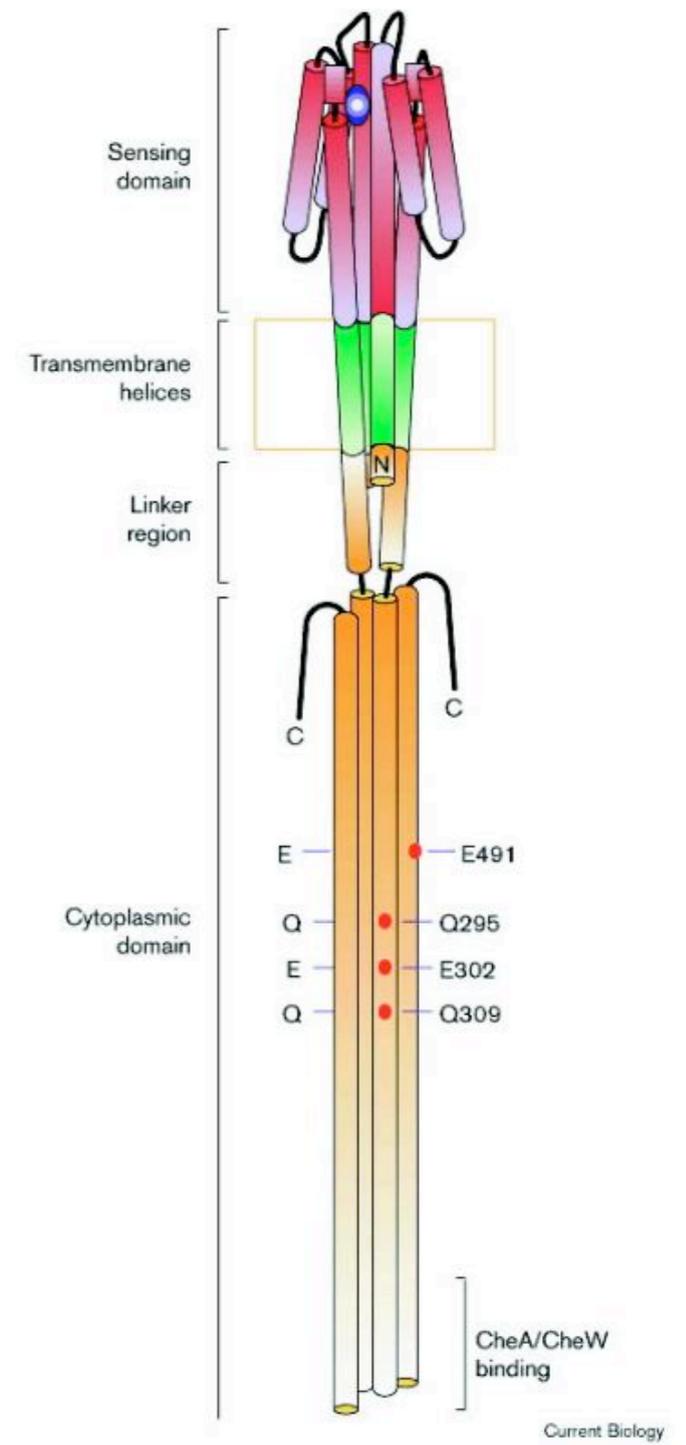
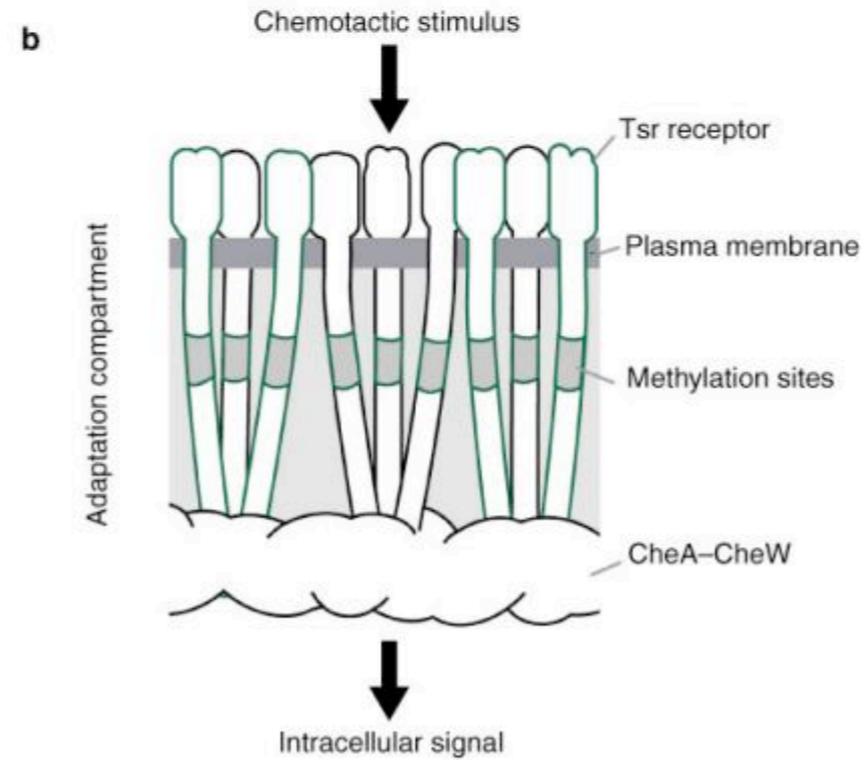
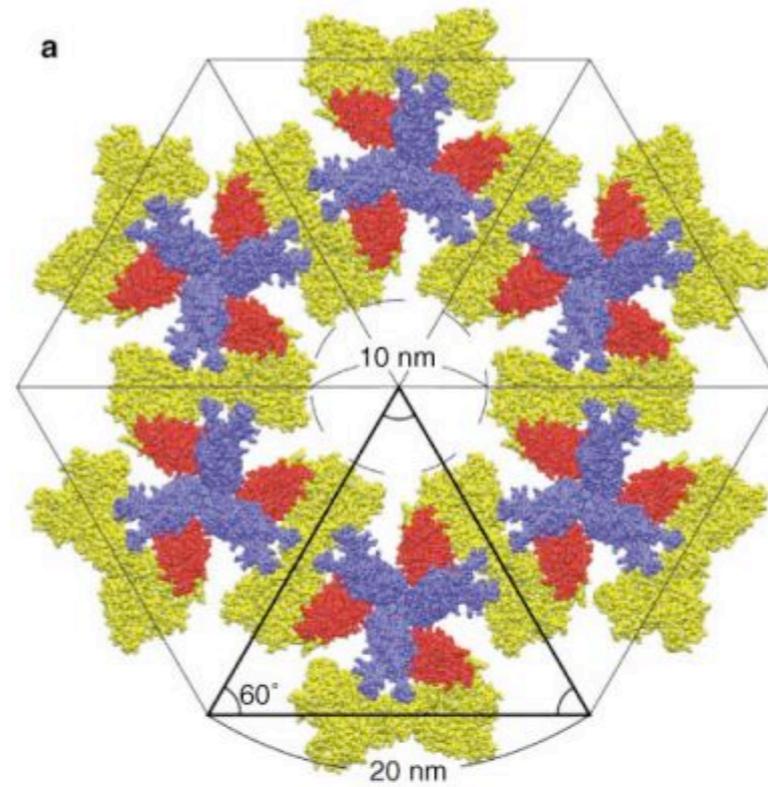
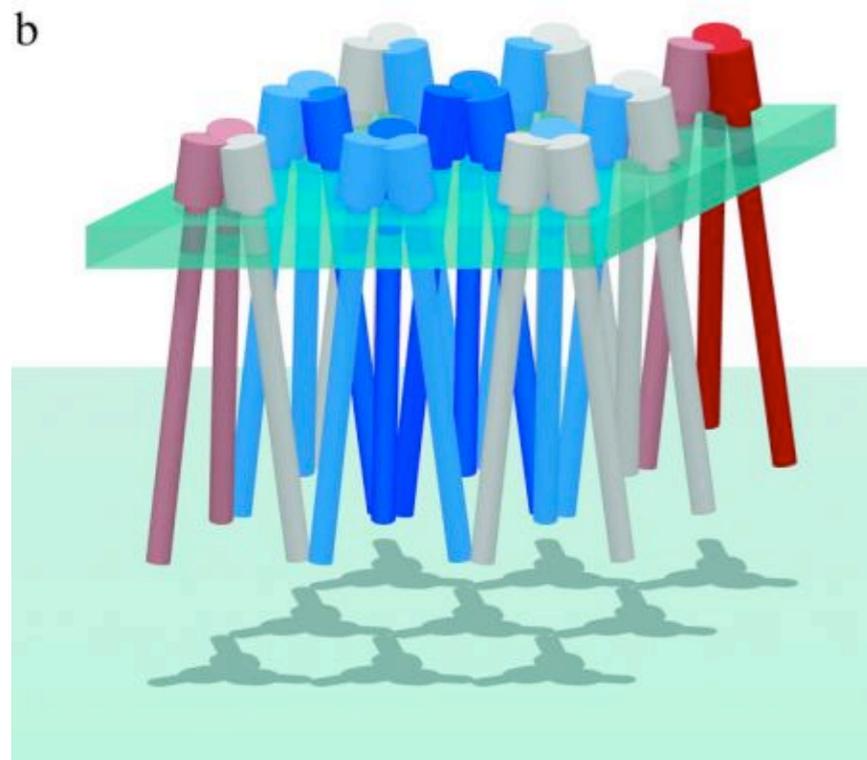
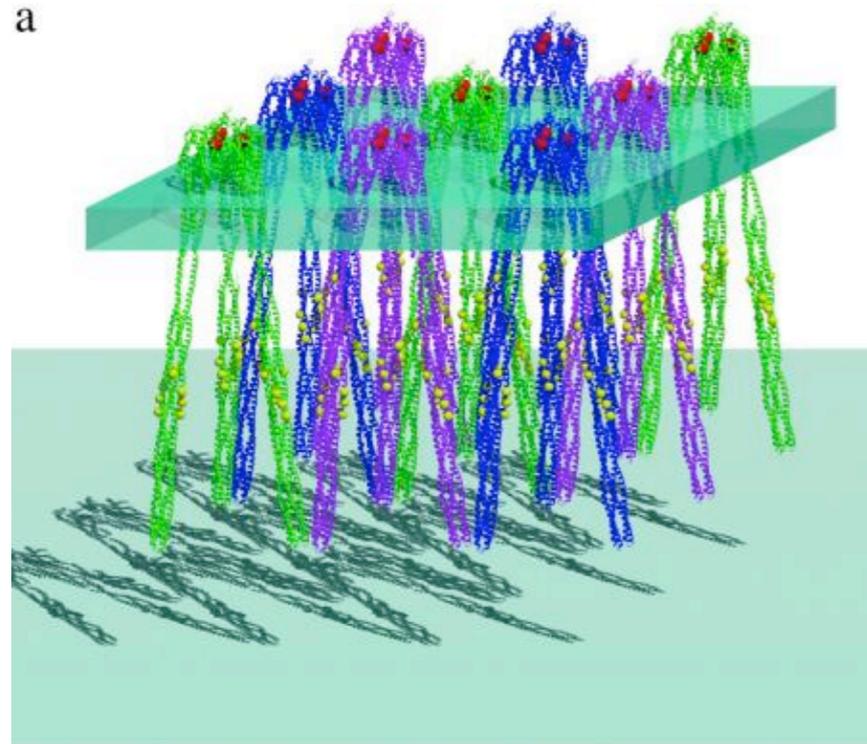
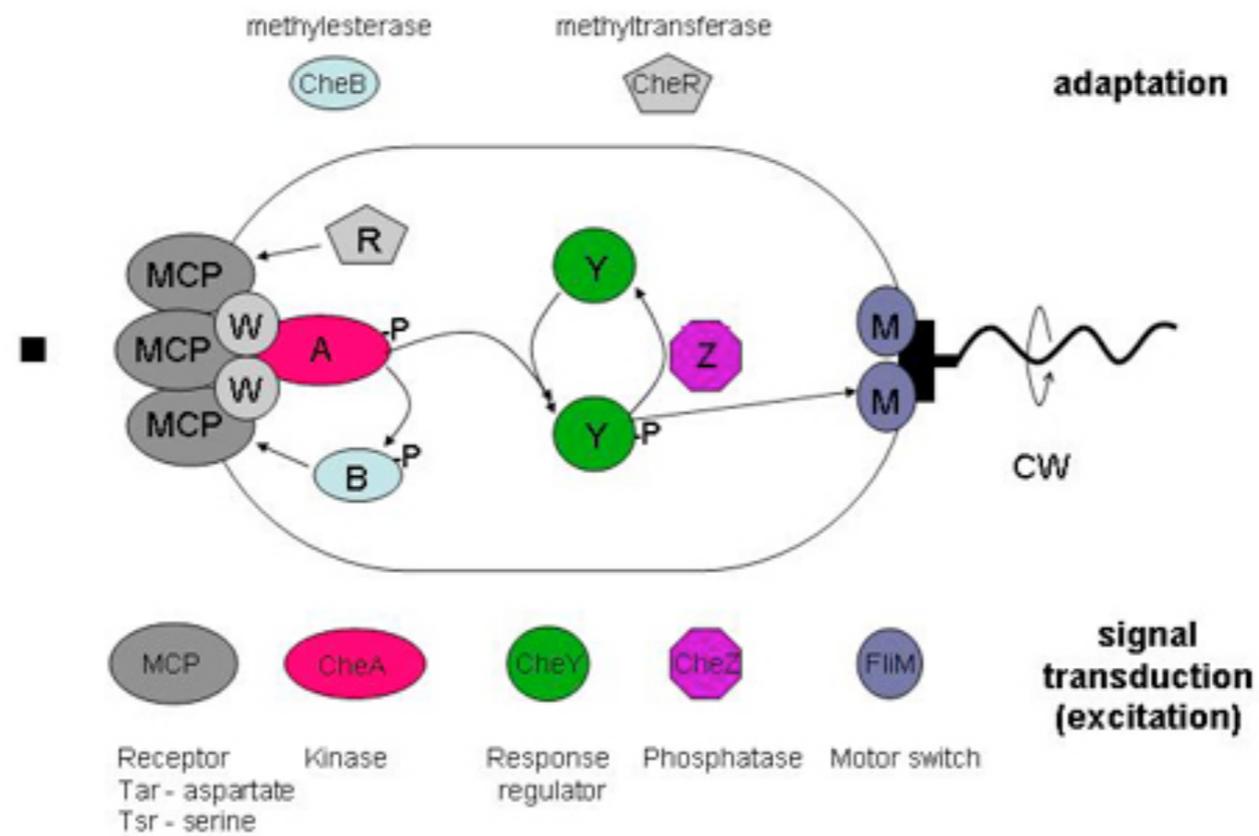


Figure 4.16 Physical Biology of the Cell (© Garland Science 2009)



Cells and structures within them (zoom in): protein-machines



E. coli “cognition” and its intracellular networks

4.5 Yeast

cell-cycle mutants

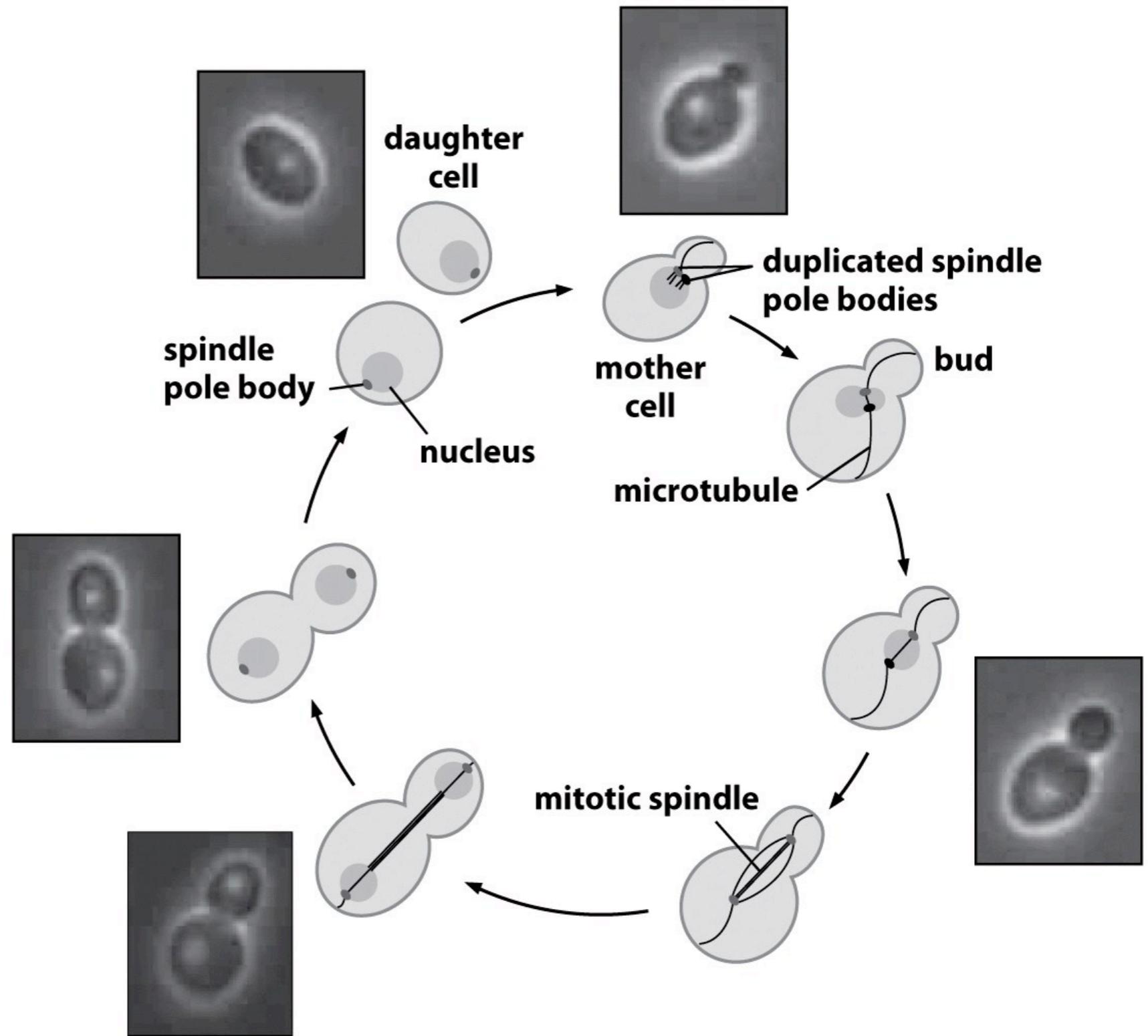


Figure 4.17 Physical Biology of the Cell (© Garland Science 2009)

membrane traffic
& polarity

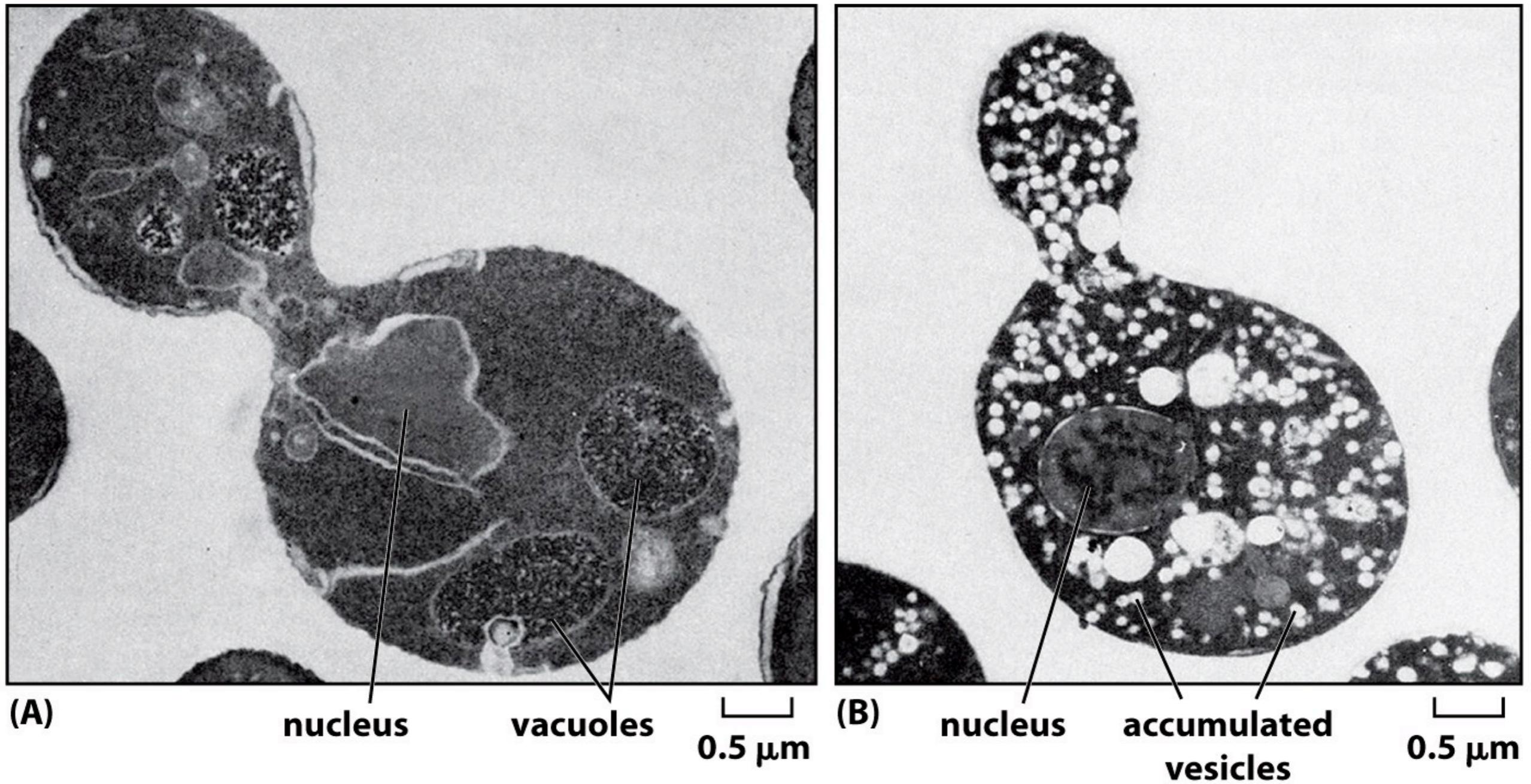


Figure 4.19 Physical Biology of the Cell (© Garland Science 2009)

proteomics

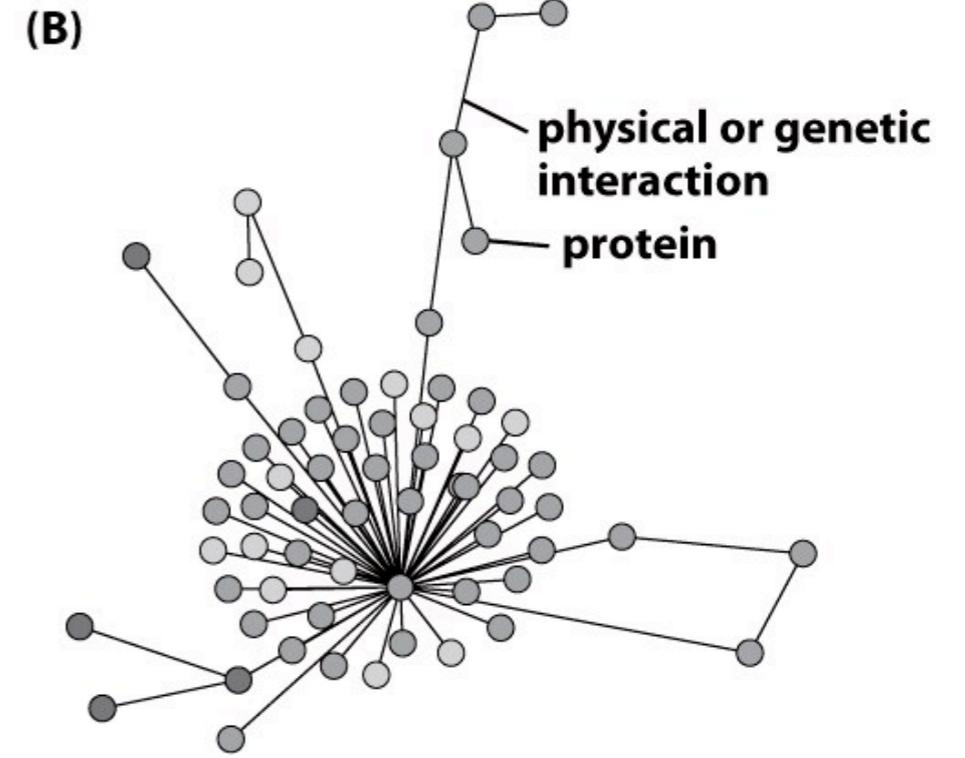
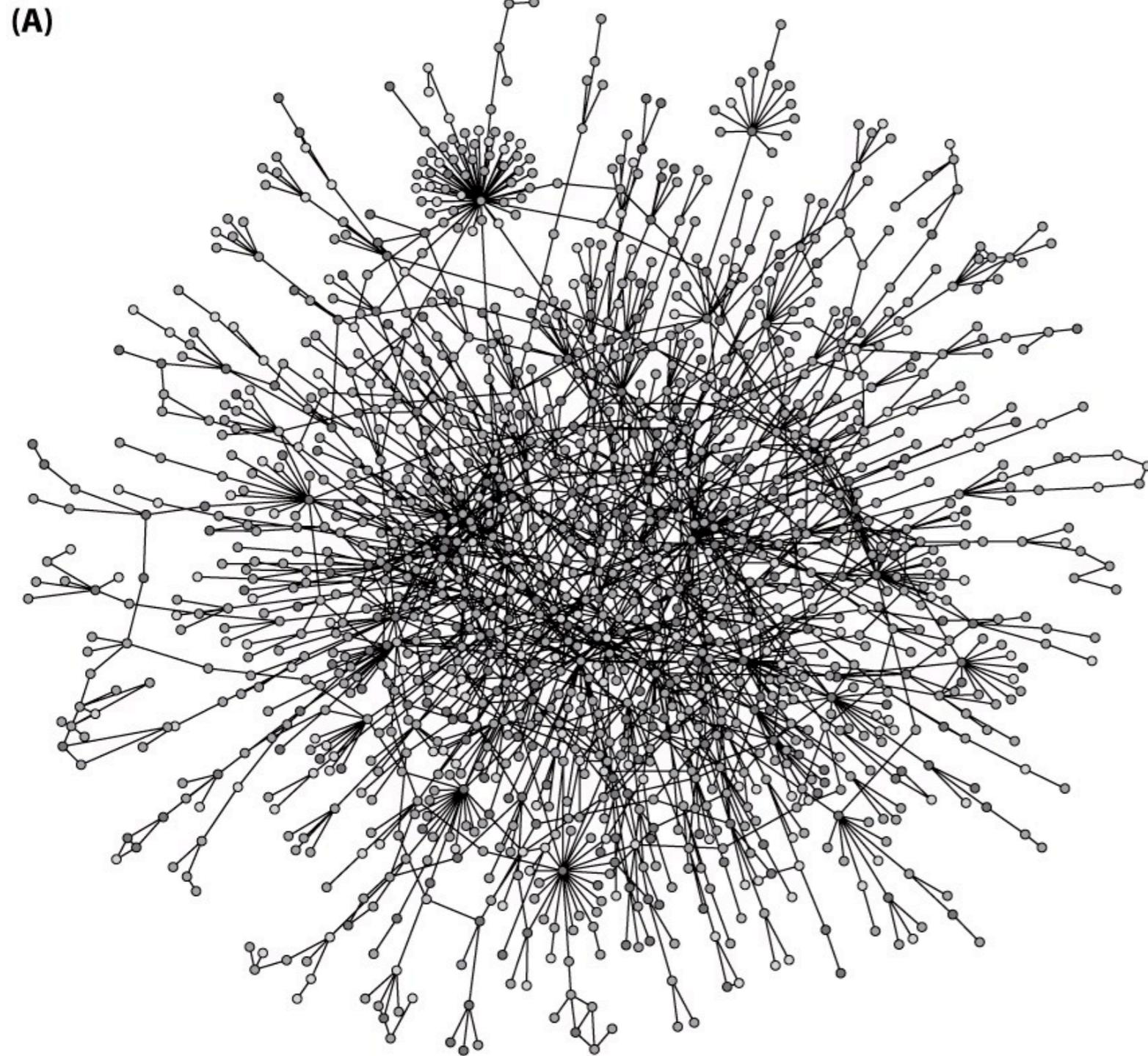


Figure 4.20 Physical Biology of the Cell (© Garland Science 2009)

4.6 Flies

modern genetics (Morgan)

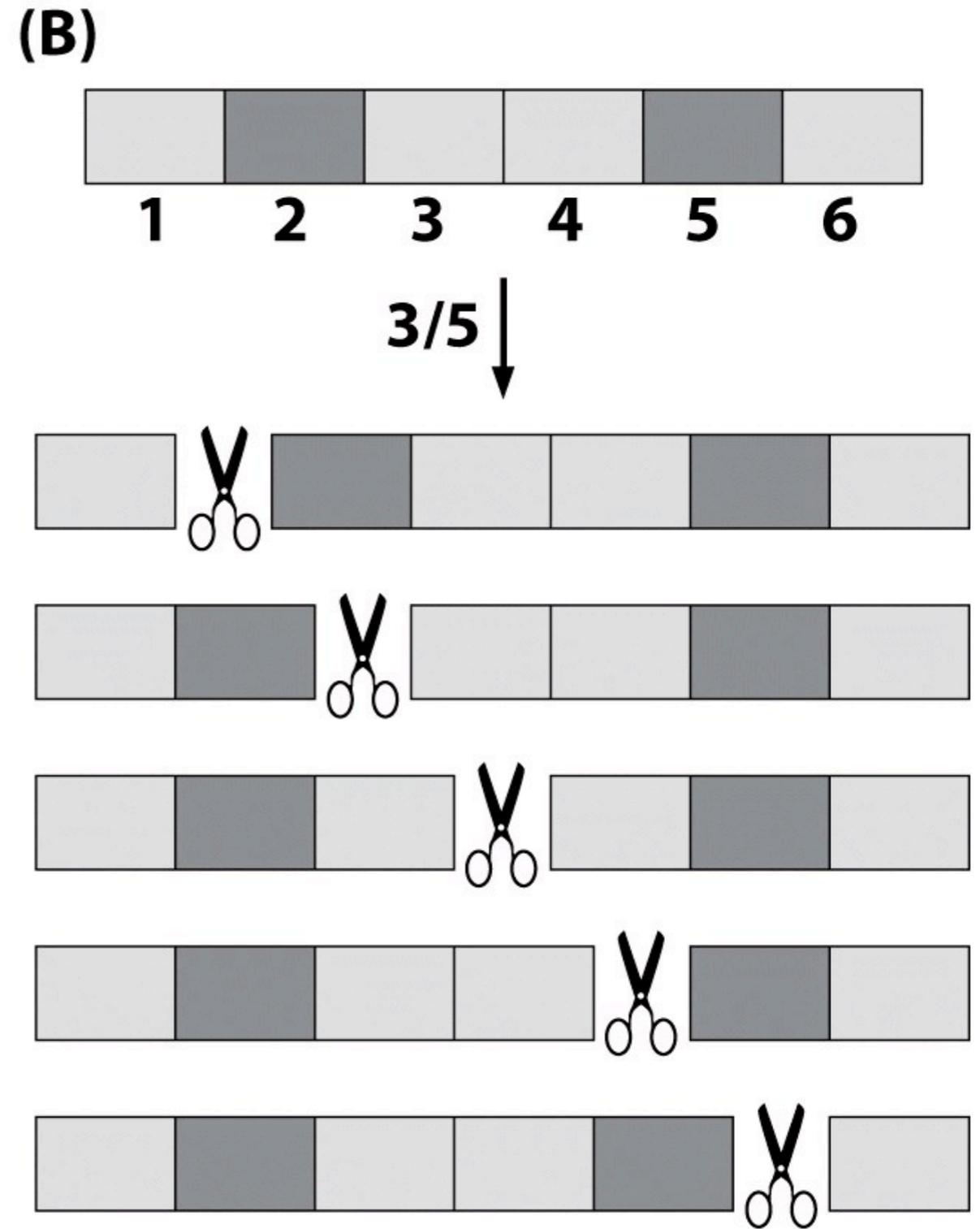
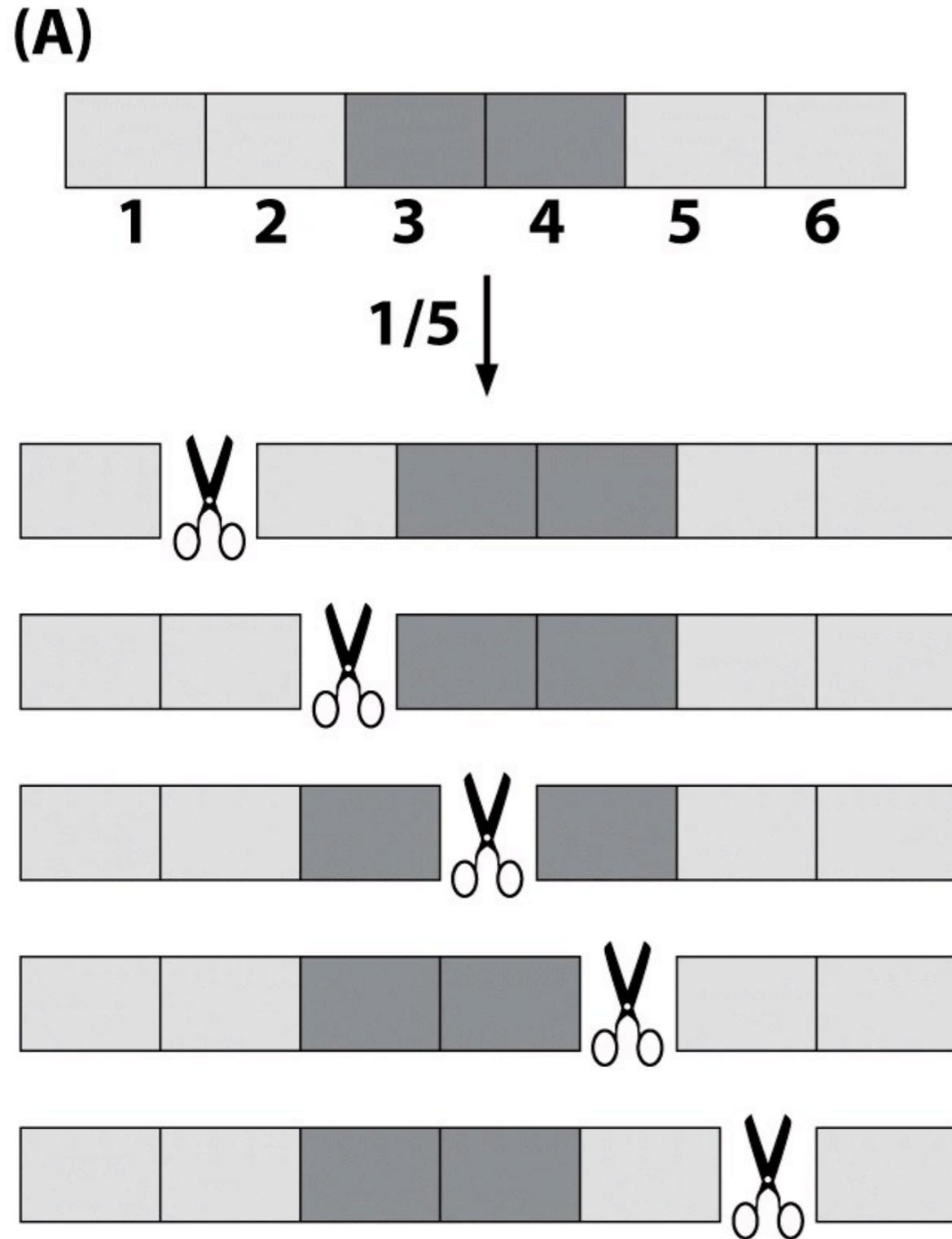


Figure 4.21 Physical Biology of the Cell (© Garland Science 2009)

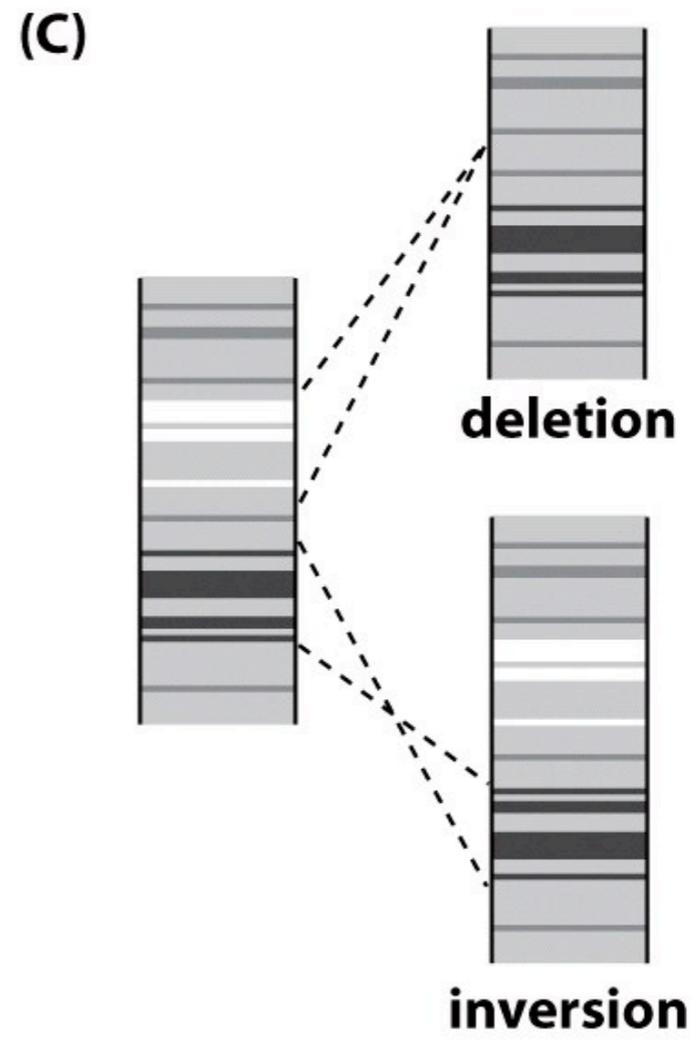
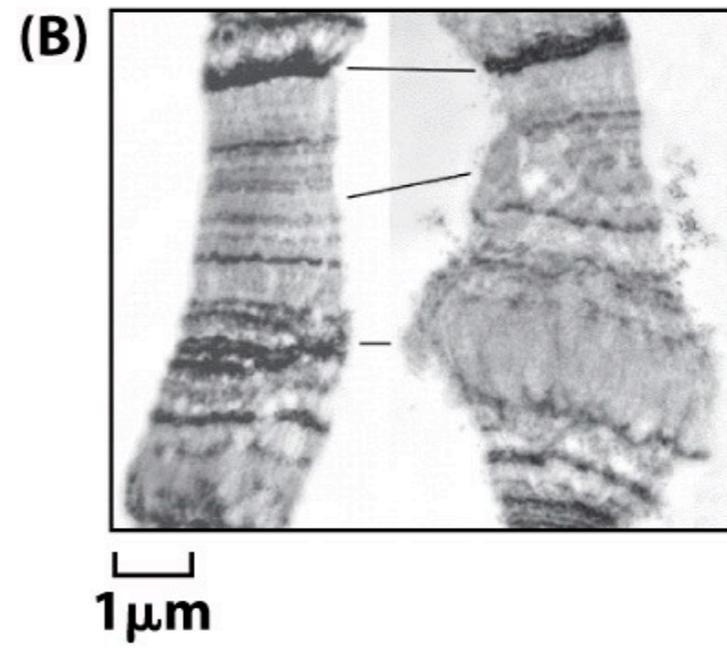
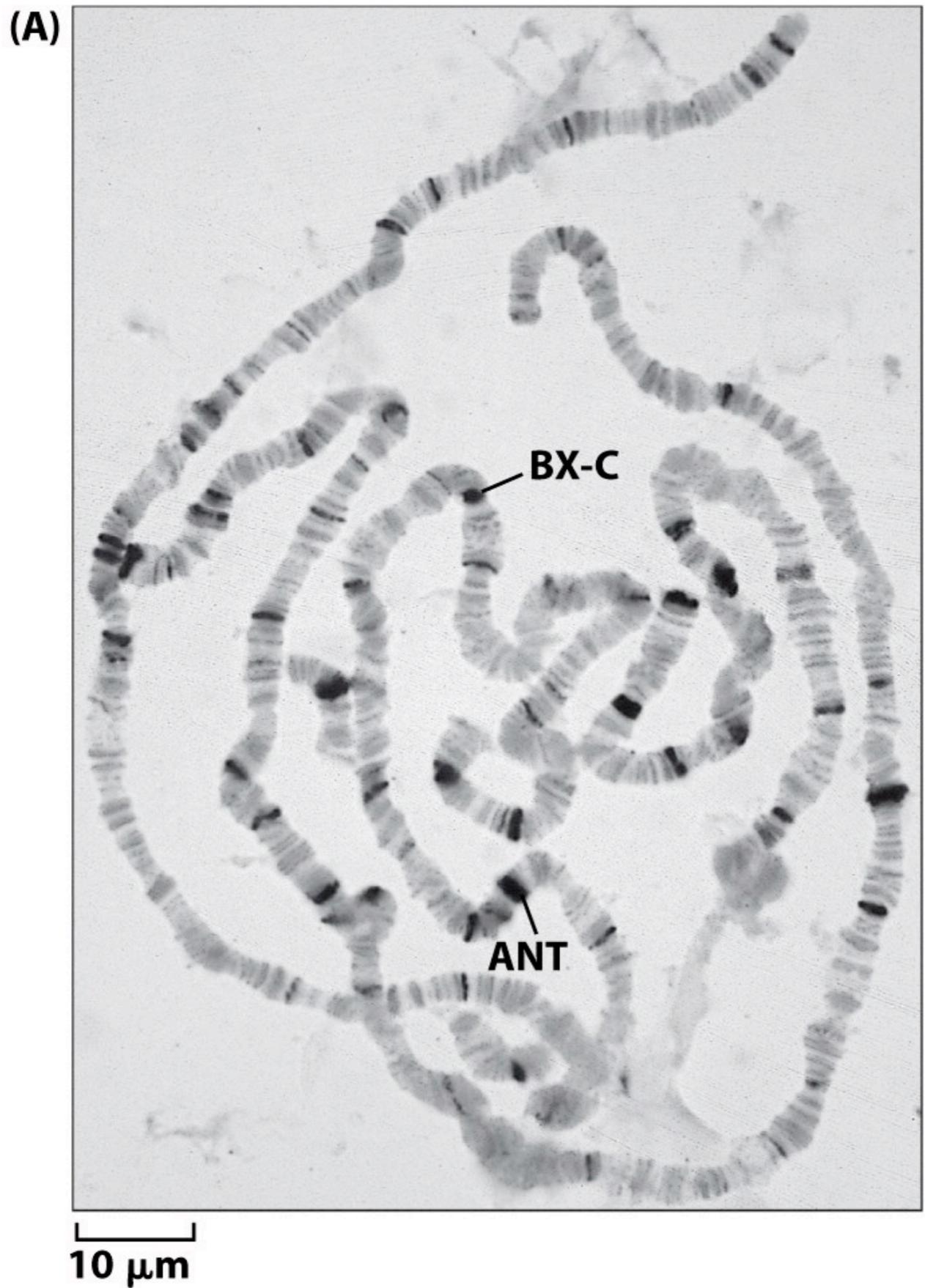
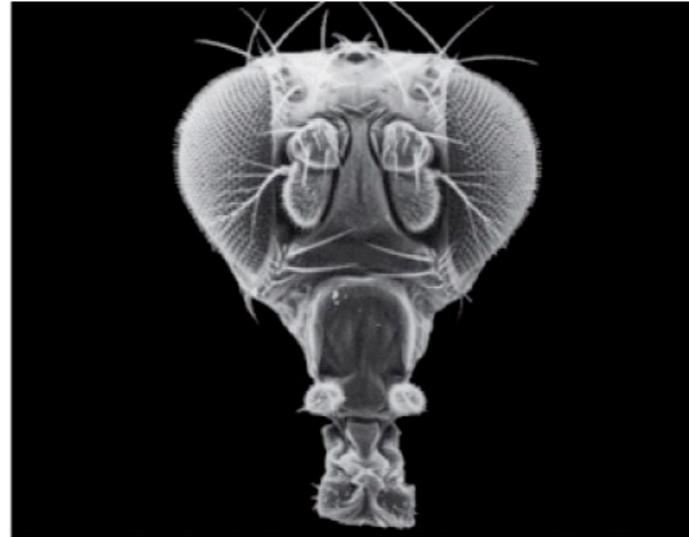


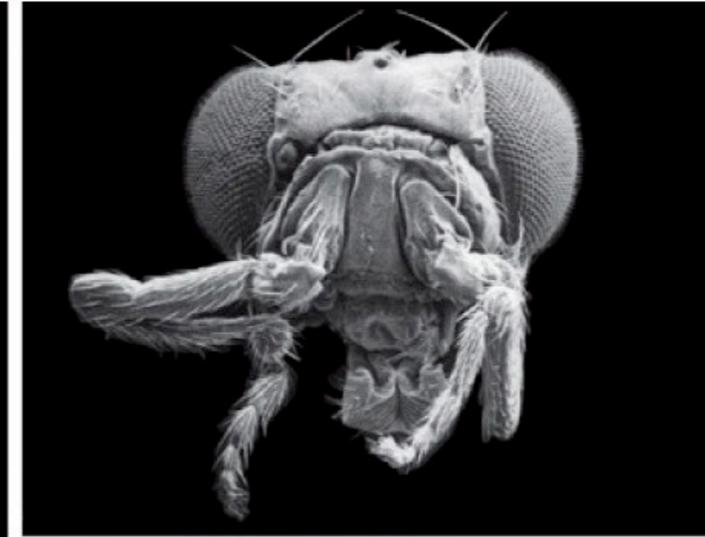
Figure 4.22 Physical Biology of the Cell (© Garland Science 2009)

single genetic changes can result on complete re-specification of complex body parts.

(A)



wild-type



Antennapedia

(B)



wild-type



bithorax

4.7 Mice to Man.

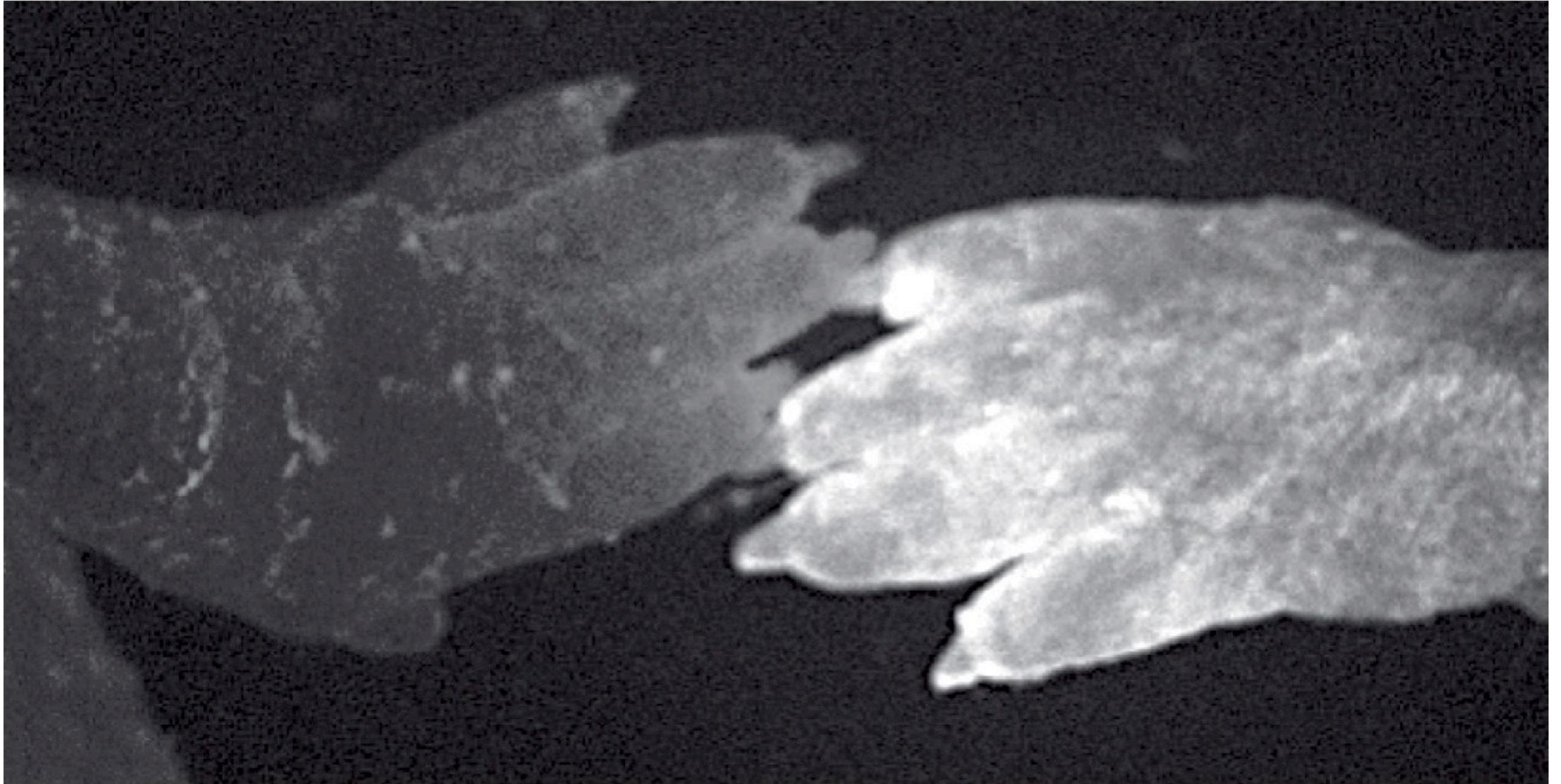


Figure 4.24 Physical Biology of the Cell (© Garland Science 2009)

in mammalian development:

- embryonic totipotency (isolated from human embryos in 1998)

4.8 exotica

tetrahymena

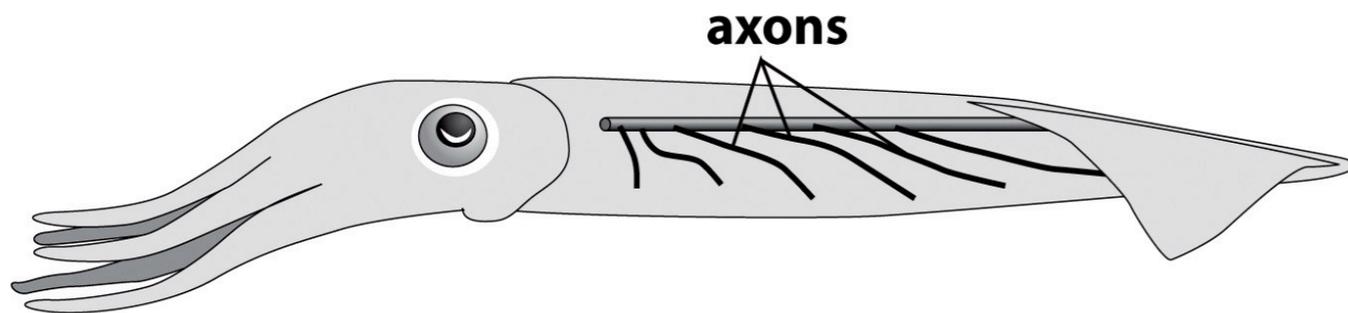
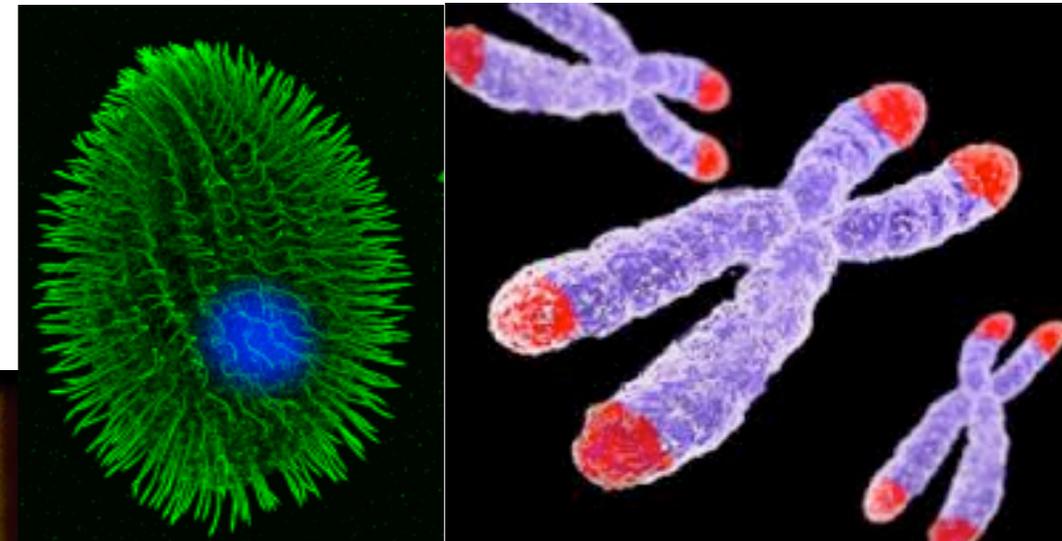


Figure 4.25 (part 1) Physical Biology of the Cell (© Garland Science 2009)

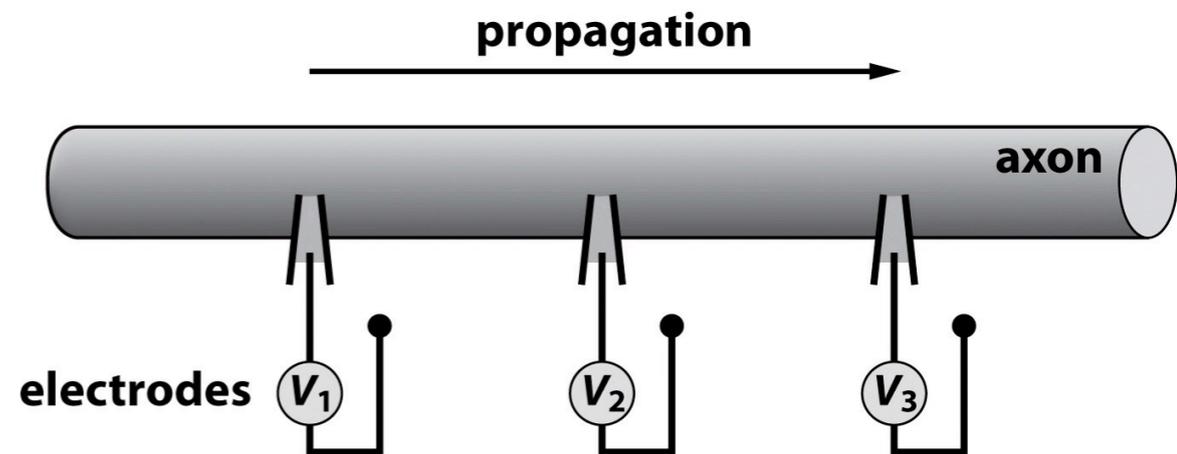
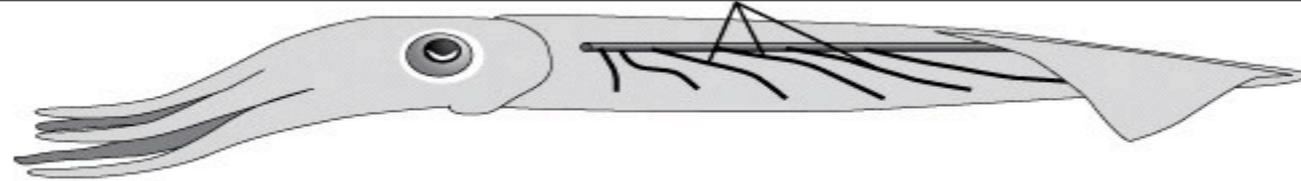
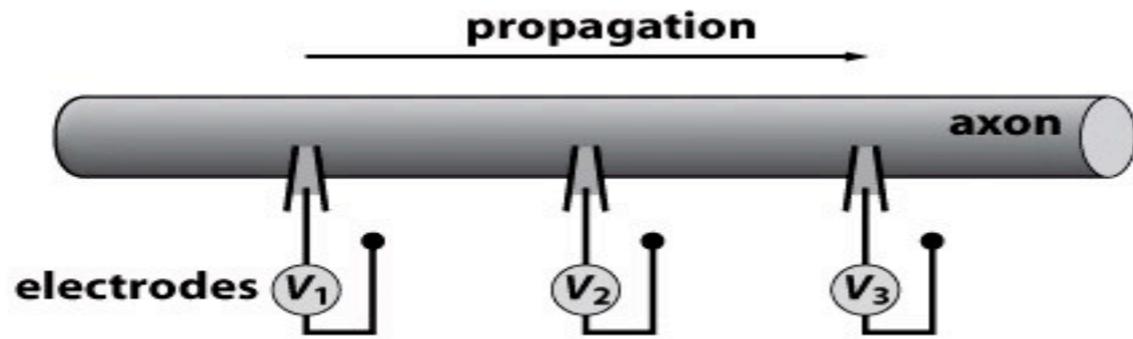


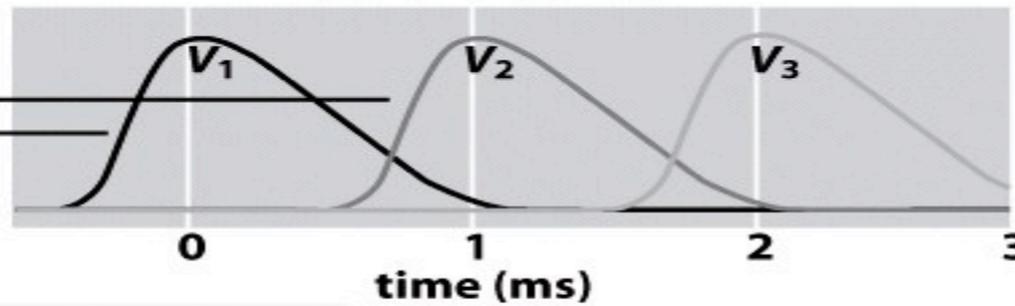
Figure 4.25 (part 2) Physical Biology of the Cell (© Garland Science 2009)



$$V = \frac{k_B T}{q} \log \frac{C_{out}}{C_{in}}$$



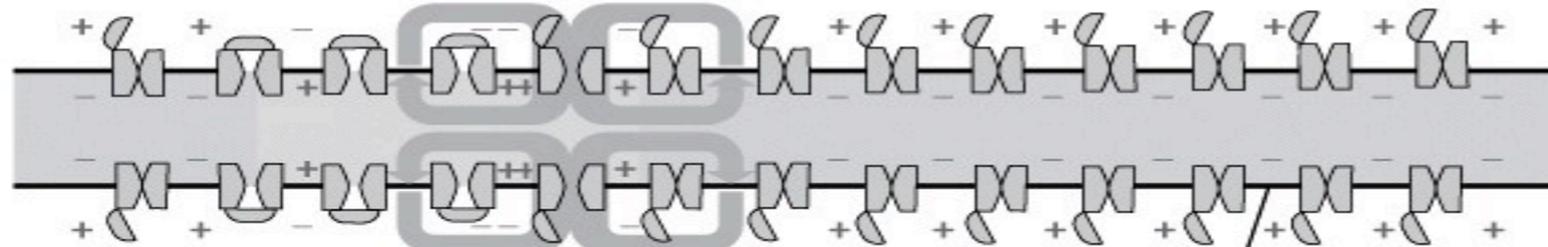
action potential



instantaneous view at $t = 0$

propagation →

Na^+ channels closed inactivated open closed



membrane repolarized depolarized resting

instantaneous view at $t = 1$ ms

propagation →

Na^+ channels closed inactivated open closed



membrane

repolarized

depolarized

resting

axon cytosol

Figure 4.25 Physical Biology of the Cell (© Garland Science 2009)