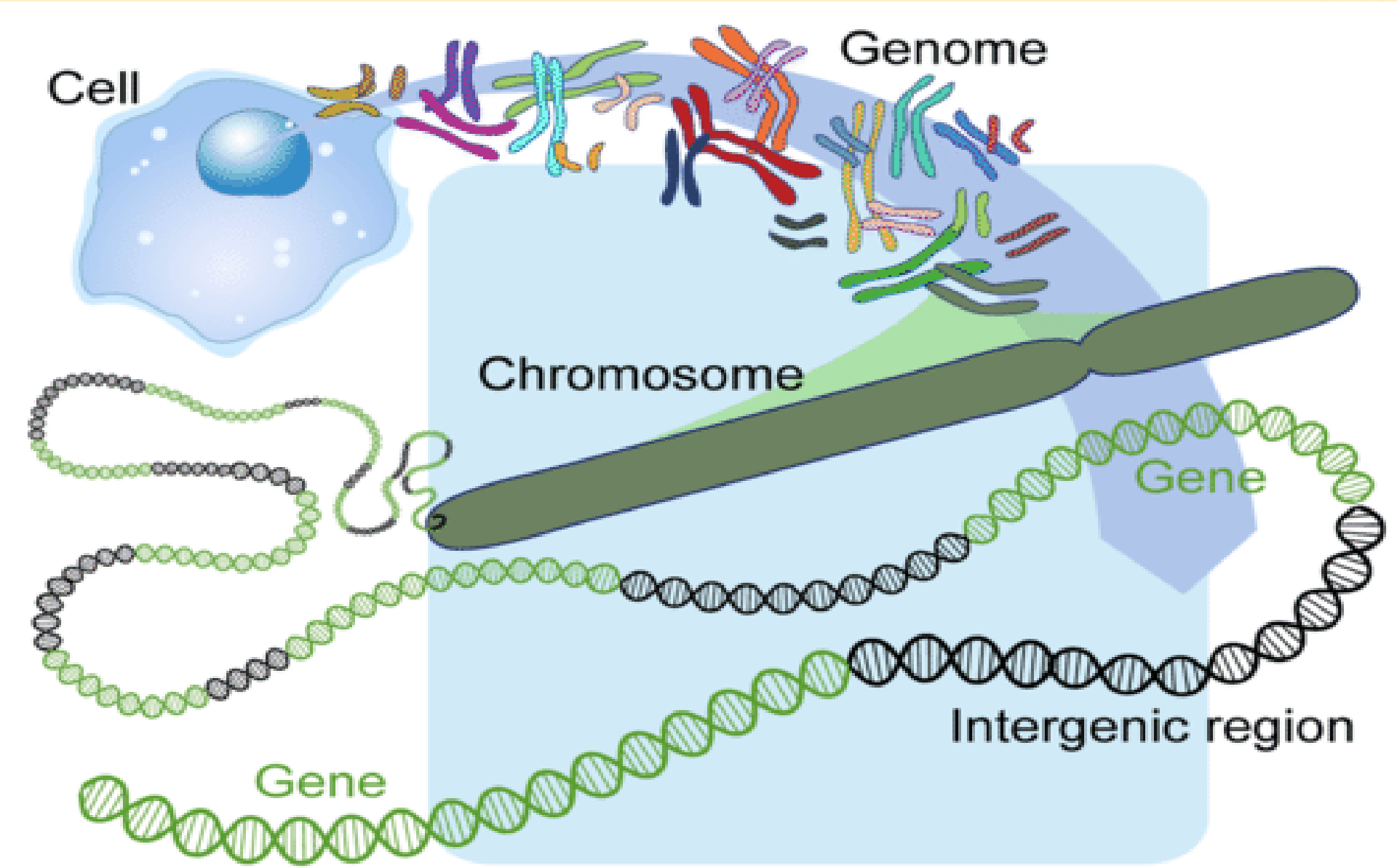
# ГЕНОМИ РОСЛИН: НАВІЩО ЇХ ДОСЛІДЖУВАТИ

М. АНТОНЮК

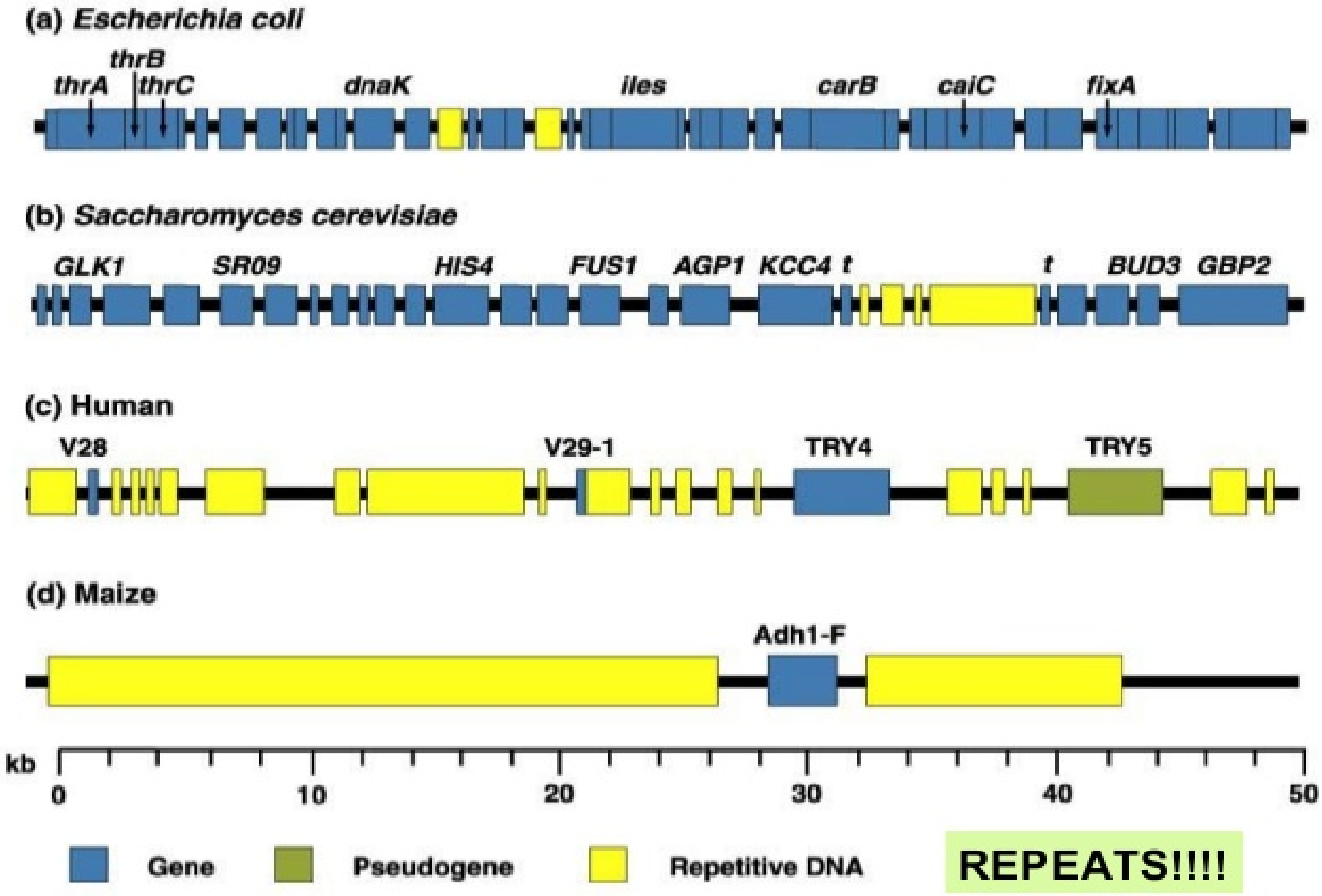
## genome

A genome is the complete set of genetic information in an organism. It provides all of the information the organism requires to function. In living organisms, the genome is stored in long molecules of DNA called chromosomes. Small sections of DNA, called genes, code for the RNA and protein molecules required by the organism. In eukaryotes, each cell's genome is contained within a membrane-bound structure called the nucleus. Prokaryotes, which contain no inner membranes, store their genome in a region of the cytoplasm called the nucleoid. The full range of RNA molecules expressed by a genome is known as its transcriptome, and the full assortment of proteins produced by the genome is called its proteome.


Cell
Genome
Chromosome
Gene
Intergenic region
Gene

# The C-value paradox

- The C-value is the total number of DNA nucleotide residues in the genome (per haploid set of chromosomes).
- When you compare this to the complexity of the organism you find a massive disparity.
- Clearly the amount of DNA is not proportional to that required to produce all the proteins made by the organism.


(a) Escherichia coli
thrA
thrB
thrC
dnaK
iles
carB
calC
fixA
(b) Saccharomyces cerevisiae
GLK1
SR09
HIS4
FUS1
AGP1
KCC4
t
t
BUD3
GBP2
(c) Human
V28
V29-1
TRY4
TRY5
(d) Maize
Adh1-F
kb
0
10
20
30
40
50
Gene
Pseudogene
Repetitive DNA
REPEATS!!!!

| | | | |
|---|---|---|---|
| *ruddii* (smallest genome of an endosymbiont bacteria) | 160 kbp | 182 | |
| *. genitalium* (smallest genome of a free living bacteria) | 580 kbp | 470 | |
| *pylori* | 1.7 Mbp | 1,600 | |
| *vanobacteria S. elongatus* | 2.7 Mbp | 3,000 | |
| ethicillin-resistant *S. aureus* (MRSA) | 2.9 Mbp | 2,700 | |
| *subtilis* | 4.3 Mbp | 4,100 | |
| *cellulosum* (largest known bacterial genome) | 13 Mbp | 9,400 | |
| **rchaea** | | | |
| *anoarchaeum equitans* (smallest parasitic archaeal genome) | 490 kbp | 550 | |
| *hermoplasma acidophilum* (flourishes in pH<1) | 1.6 Mbp | 1,500 | |
| *ethanocaldococcus (Methanococcus) jannaschii* rom ocean bottom hydrothermal vents; pressure >200 atm) | 1.7 Mbp | 1,700 | |
| *yrococcus furiosus* (optimal temp 100$^0$C) | 1.9 Mbp | 2,000 | |
| **ukaryotes - multicellular** | | | |
| ufferfish *Fugu rubripes* (smallest known vertebrate genome) | 400 Mbp | 19,000 | |
| oplar *P. trichocarpa* (first tree genome sequenced) | 500 Mbp | 46,000 | |
| orn *Z. mays* | 2.3 Gbp | 33,000 | 20 |
| og *C. familiaris* | 2.4 Gbp | 19,000 | |
| himpanzee *P. troglodytes* | 3.3 Gbp | 19,000 | 48 |
| heat *T. aestivum* (hexaploid) | 16.8 Gbp | 95,000 | 42 ( |
| arbled lungfish *P. aethiopicus* (largest known animal genome) | 130 Gbp | unknown | 34 |

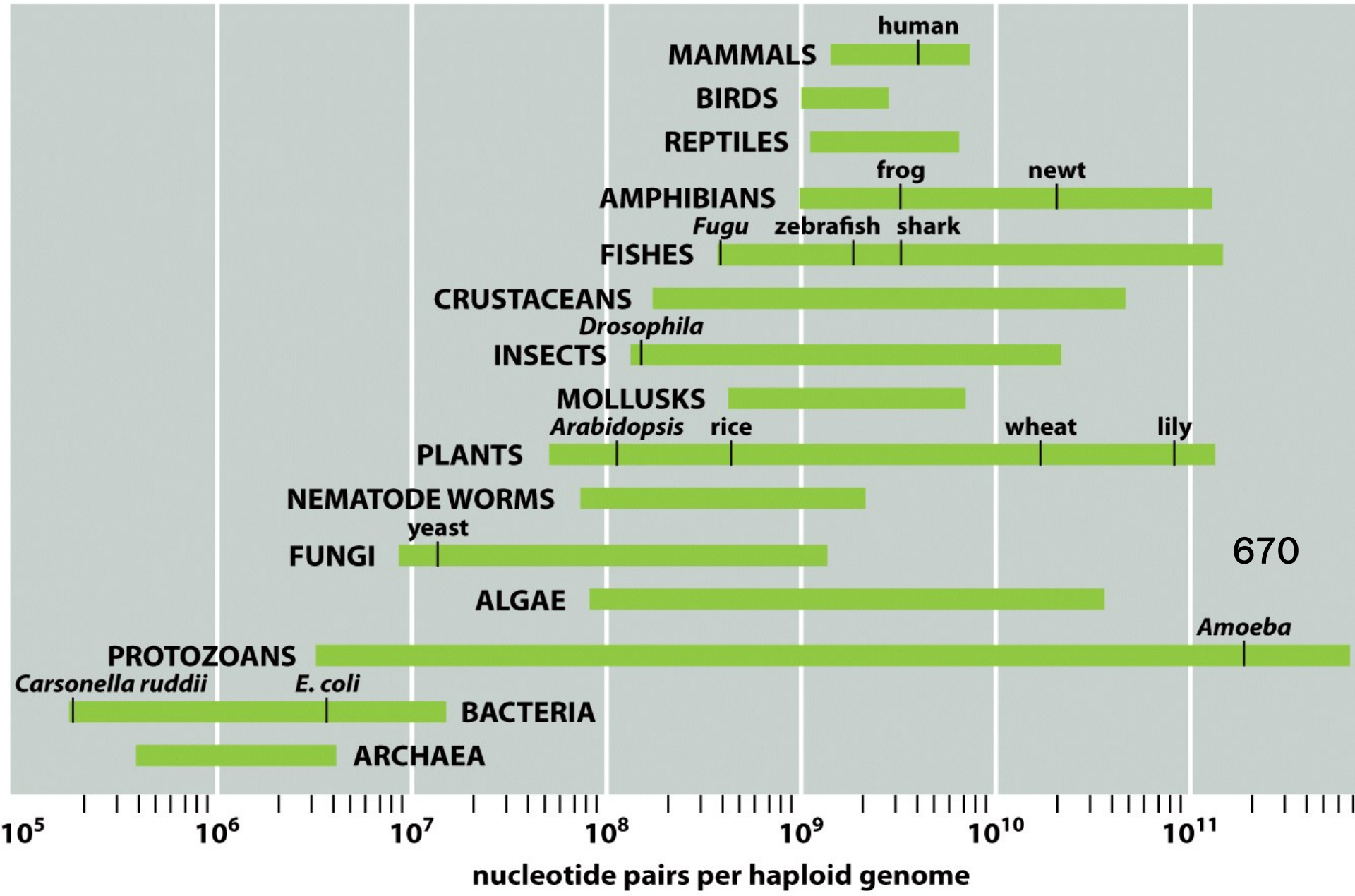
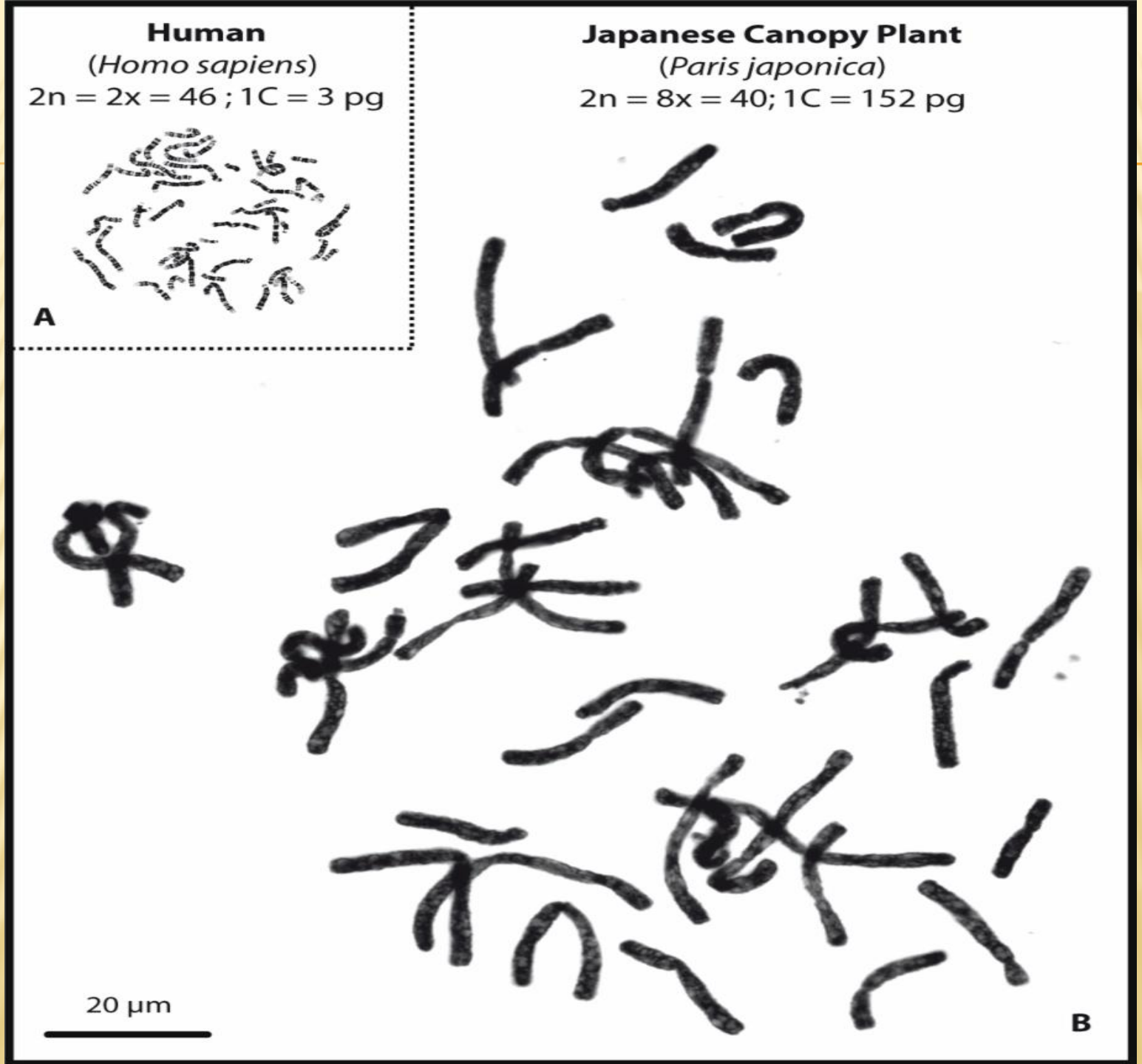



Figure 1-41 Essential Cell Biology 3/e (© Garland Science 2010)

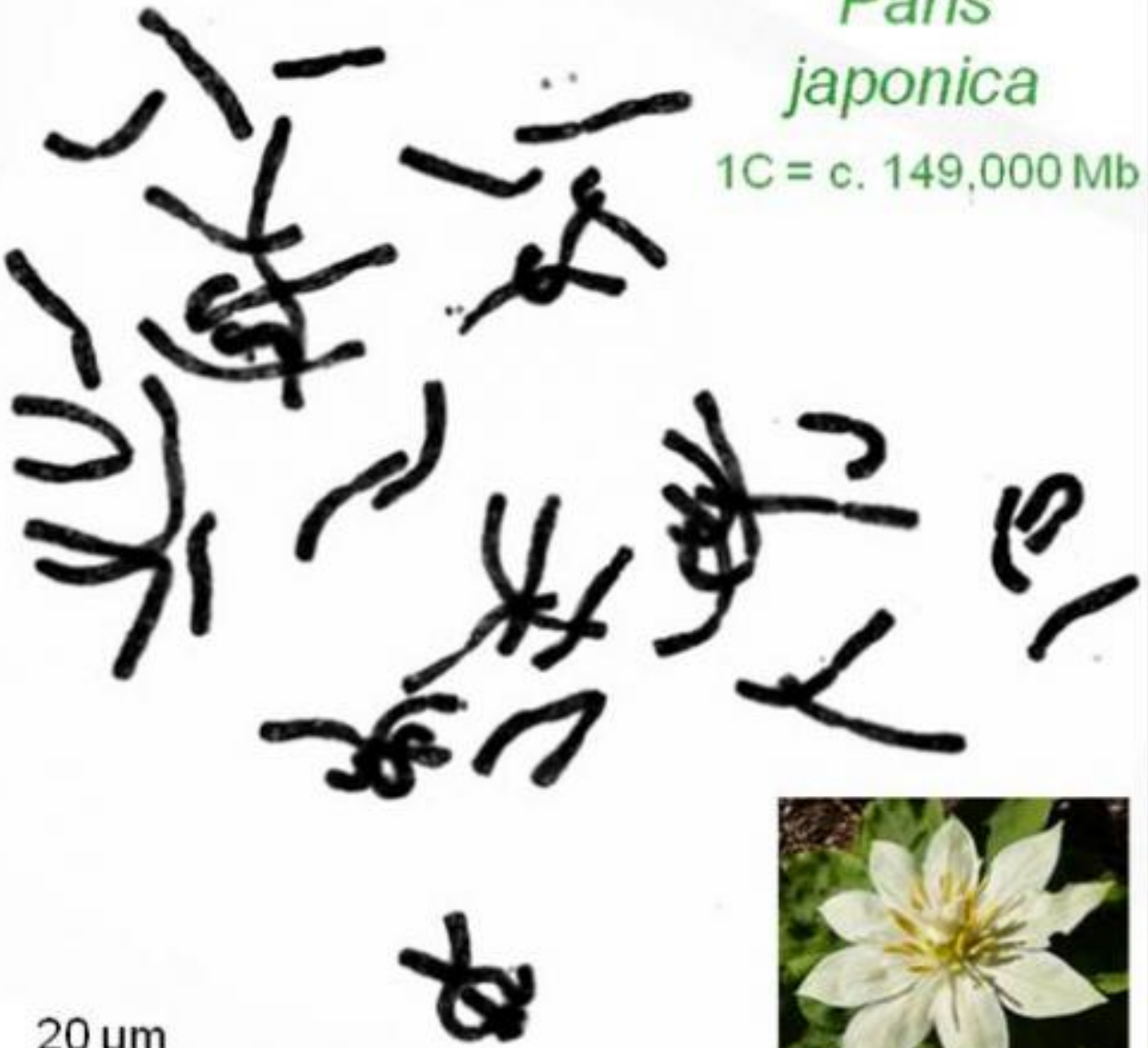

Human
(Homo sapiens)
2n = 2x = 46 ; 1C = 3 pg
A
Japanese Canopy Plant
(Paris japonica)
2n = 8x = 40; 1C = 152 pg
20 µm
B

*Genlisea aurea*

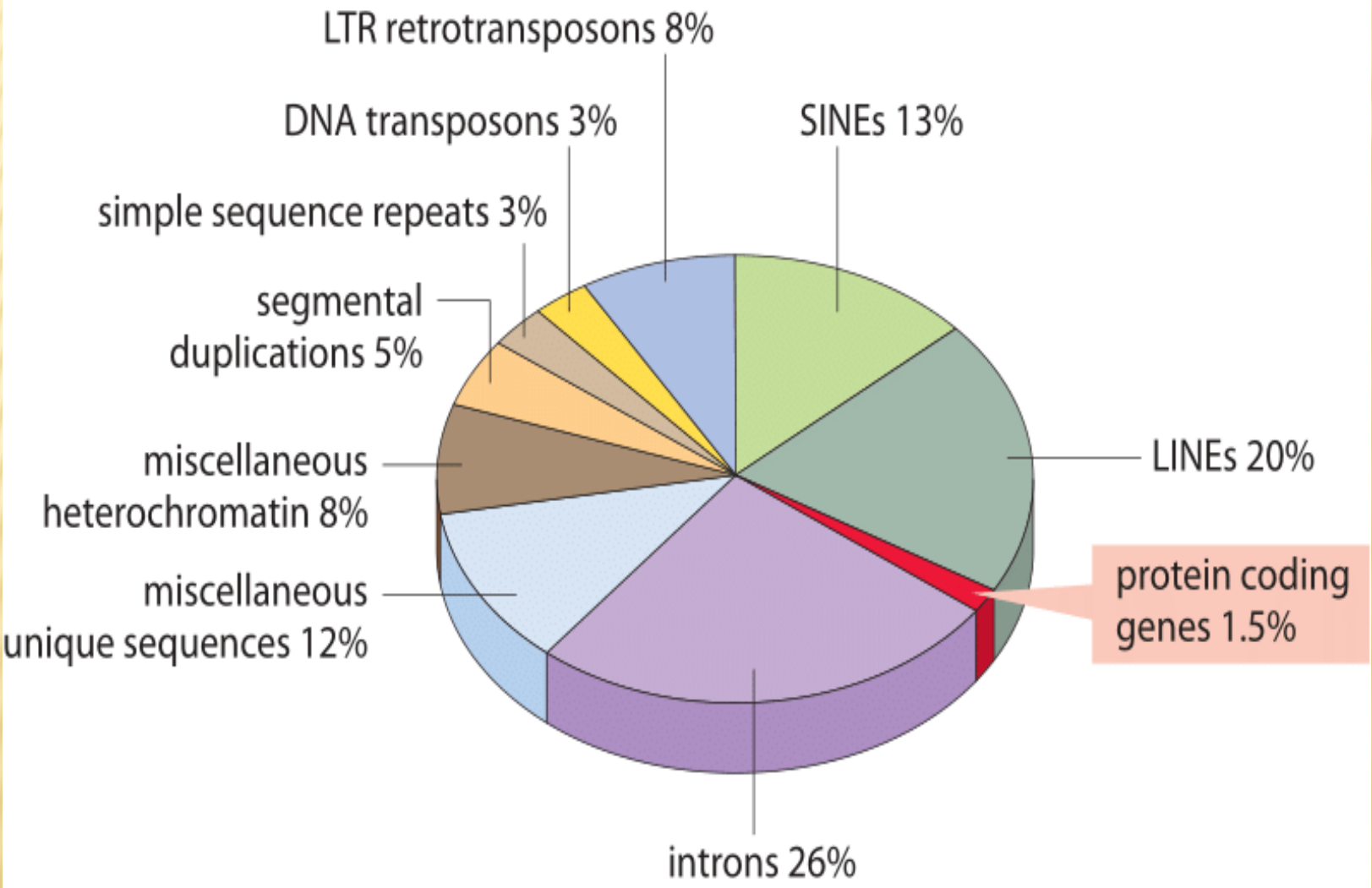
1C = 63.7 Mb

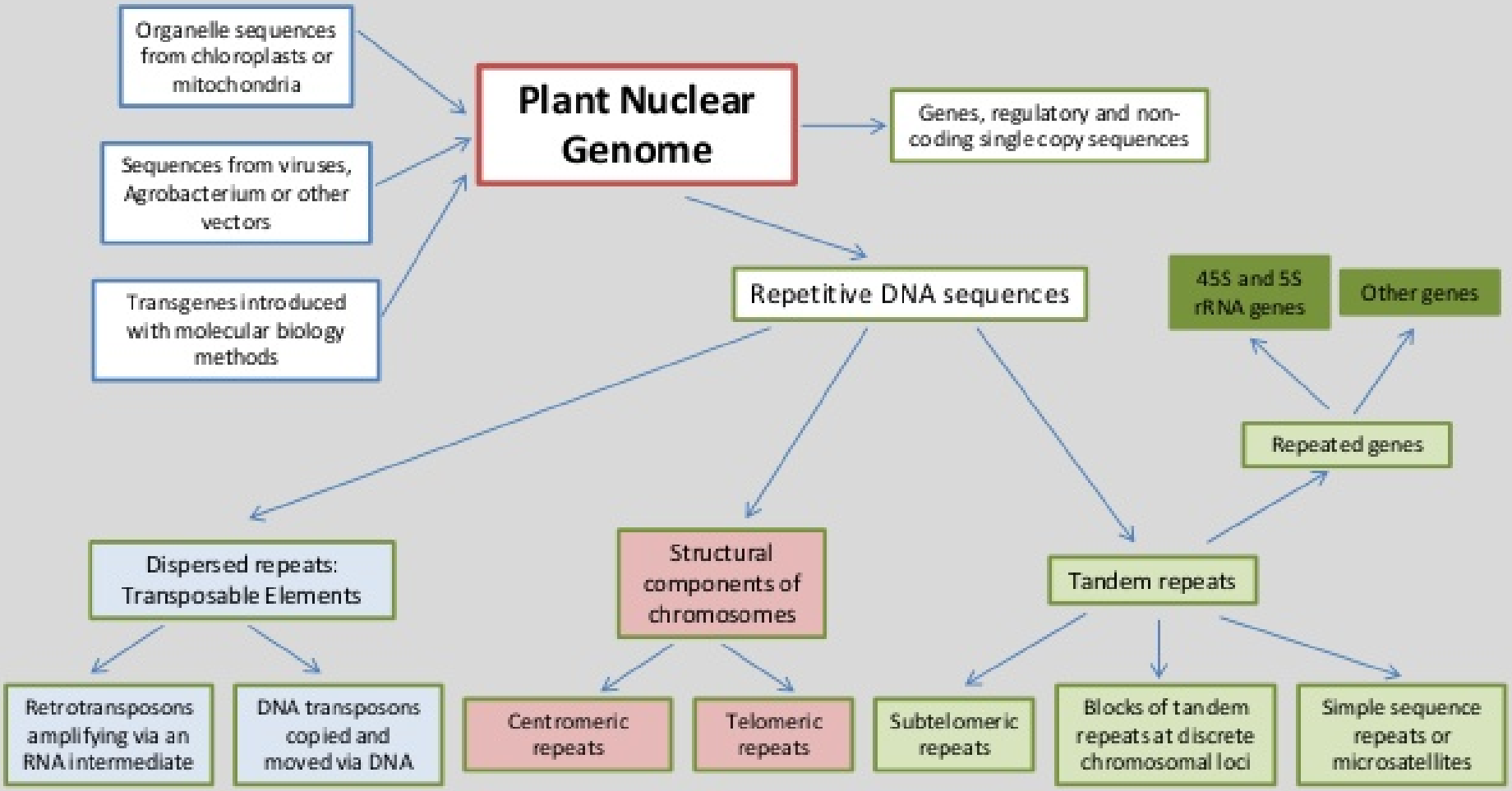
*Paris japonica*

1C = c. 149,000 Mb



main components of the human genome






DNA sequence components of the plant nuclear genome
Heslop-Harrison & Schmidt 2012. Encyclopedia of Life Sciences

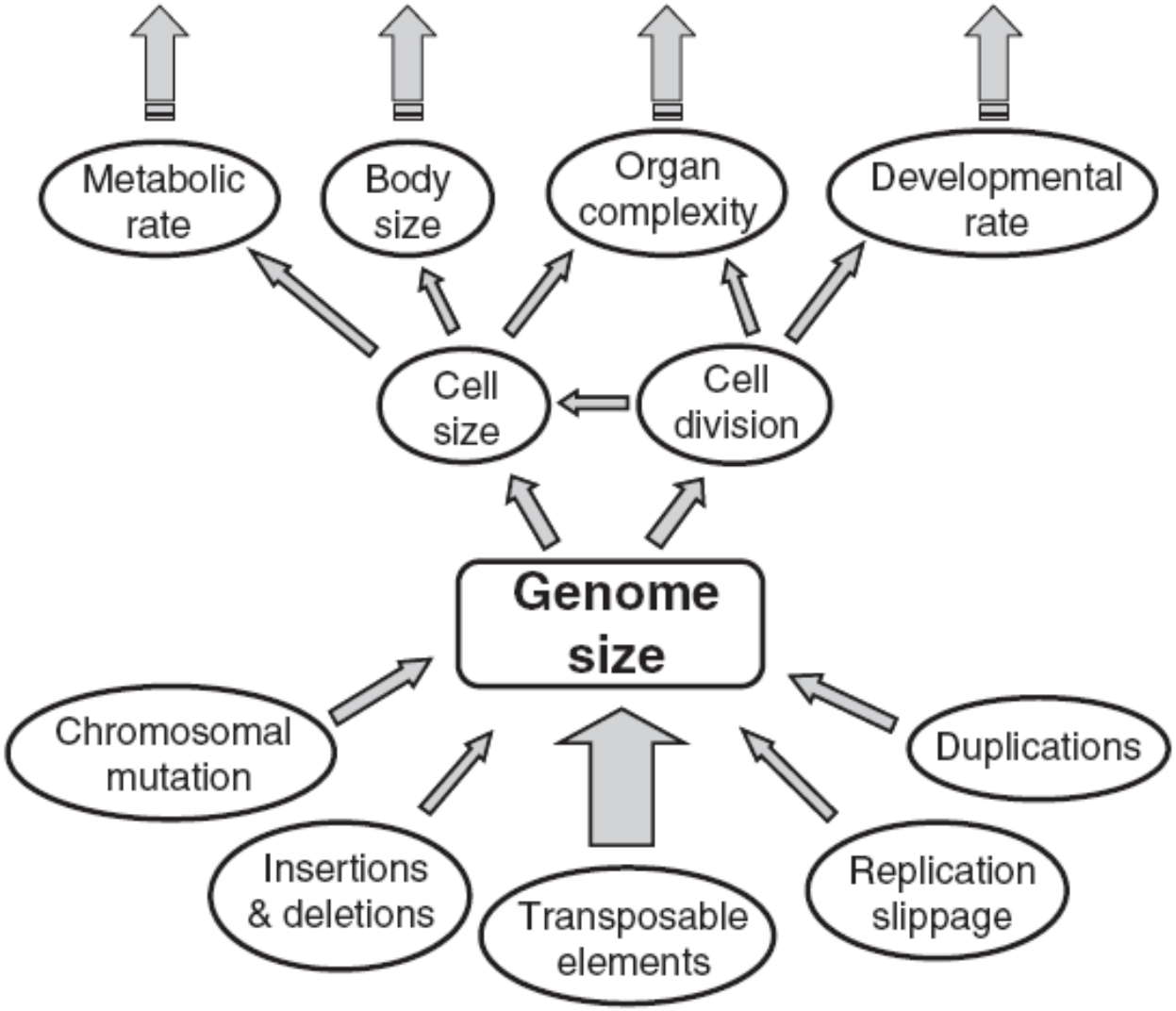
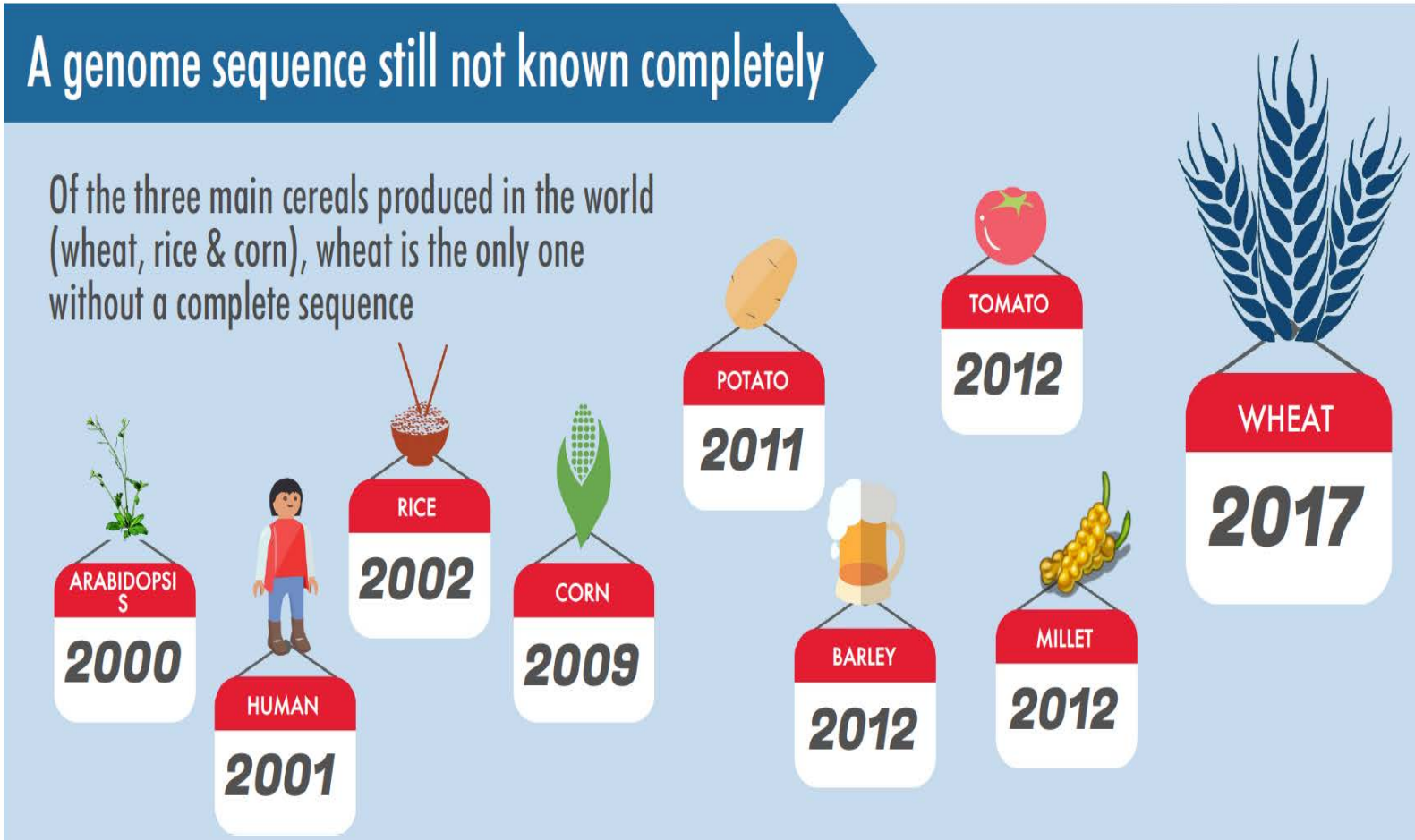
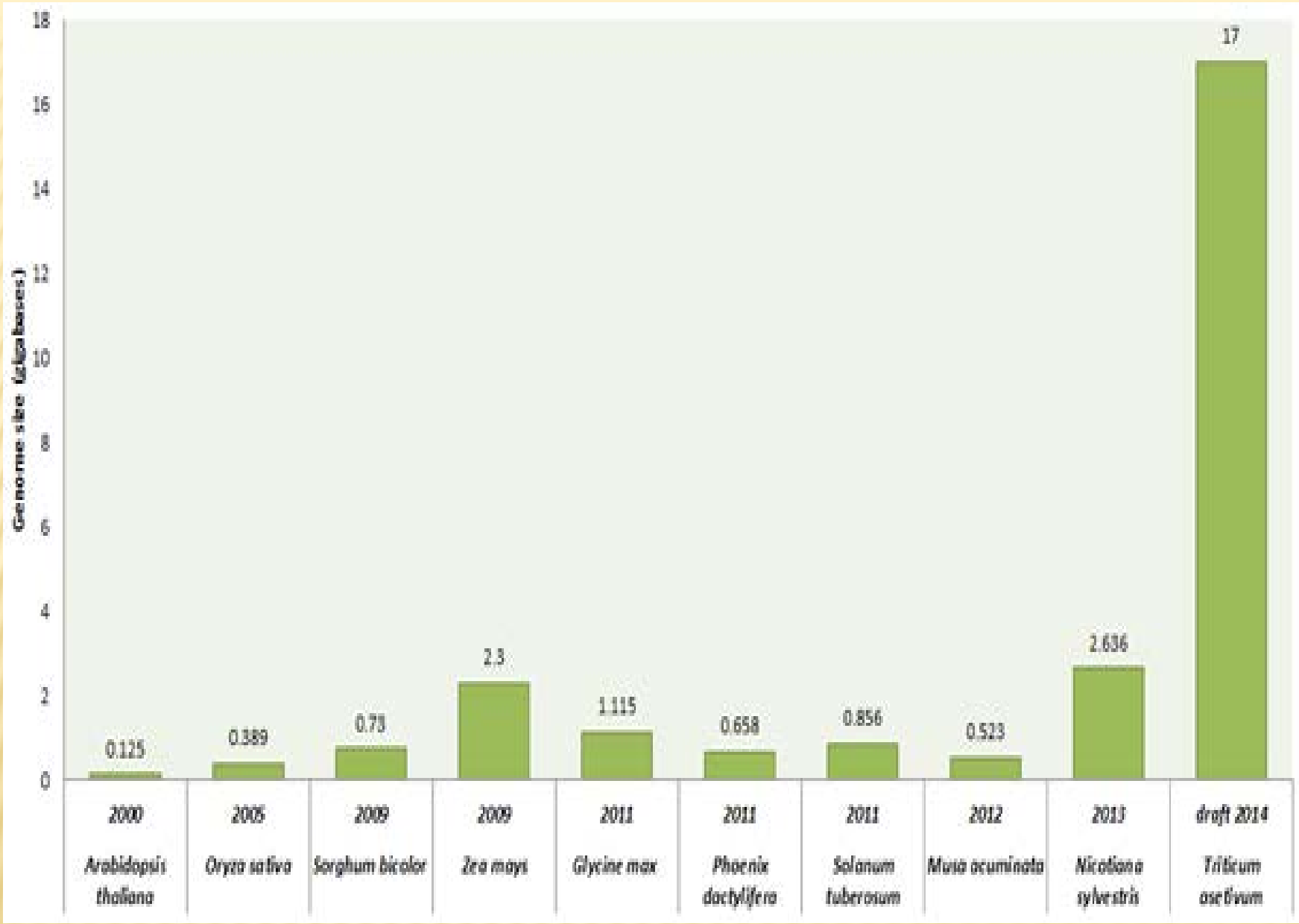



FIGURE 1.16 The cascading consequences of changes in genome size. Many different mechanisms contribute to variation in genome size, but regardless of the source, bulk DNA exerts a strong causative influence on cell size and division rate. As a result, genome size may be linked to one or more features at the organismal level, depending on the biology of the group in question. These, in turn, can have important ecological impacts. The implications of this set of interactions (and the reverse) for evolutionary theory are discussed in detail in Gregory (2004a) and Chapter 11.


A genome sequence still not known completely
Of the three main cereals produced in the world (wheat, rice & corn), wheat is the only one without a complete sequence
ARABIDOPSIS
2000
HUMAN
2001
RICE
2002
CORN
2009
POTATO
2011
BARLEY
2012
TOMATO
2012
MILLET
2012
WHEAT
2017


Genome size (Gigabases)
18
16
14
12
10
8
6
4
2
0
0.125
0.389
0.73
2.3
1.115
0.658
0.856
0.523
2.636
17
2000
Arabidopsis thaliana
2005
Oryza sativa
2009
Sorghum bicolor
2009
Zea mays
2011
Glycine max
2011
Phoenix dactylifera
2011
Solanum tuberosum
2012
Musa acuminata
2013
Nicotiana sylvestris
draft 2014
Triticum aestivum

## Preferred attributes of a model crop species

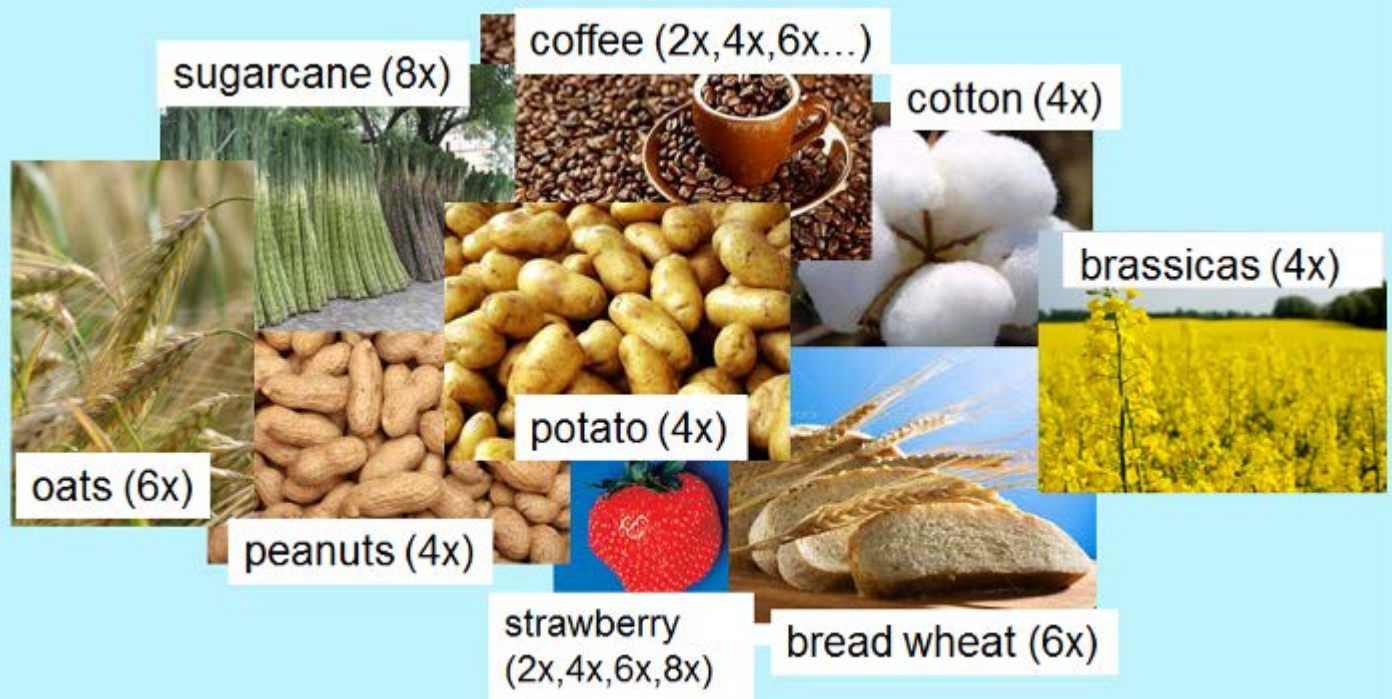
| Attributes |
| --- |
| Small genome |
| Rapid life cycle |
| Easily transformed |
| Diploid genetics with few chromosome/gene duplications |
| Well positioned in plant phylogeny |
| Small stature for growth in small space |
| Large number of seeds produced |
| Convenient for discovery of gene–trait linkages at low cost, high speed |

# *Arabidopsis thaliana*

- Small flowering plant- mouse eared cress (Brassicaceae)
- The primary model organism in plant biology (small stature, 45 day generation time, high seed yield, simple genome, easy to transform)
- Genome sequenced (125 Mb)
- Many established genetic resources: mutant lines, microarrays, EST databases
- Widespread distribution in nature

TABLE 1.3. A HYPOTHETICAL CASE OF THE EFFECTS OF GENOME EXPANSION AND CONTRACTION

| Event | Diploid chromosome number | 2C DNA content |
|---|---|---|
| Ancestral genome | 4 | 1 pg |
| Autopolyploidy | 8 | 2 pg |
| Divergence, loss of DNA sequences | 8 | 1.9 pg |
| Retrotransposon explosion | 8 | 2.3 pg |
| Alloploidy with species containing 6 chromosomes as diploid number and 2 pg of DNA/2C nucleus | 20 | 4.3 pg |
| Retrotransposon explosion | 20 | 5.3 pg |
| Loss of chromosome pair (one of pairs containing ribosomal RNA genes) | 18 | 5.1 pg |


sugarcane (8x)
coffee (2x,4x,6x…)
cotton (4x)
brassicas (4x)
potato (4x)
oats (6x)
peanuts (4x)
strawberry
(2x,4x,6x,8x)
bread wheat (6x)


rassica rapa Genome (2015).pdf


The chickpea genome 2017.pdf


The common bean genome 2017.pdf


The foxtail millet genome2017.pdf


The jatropa genome 2017.pdf


The Kiwifruit Genome (2016).pdf


tus japonicus Genome (2014).pdf

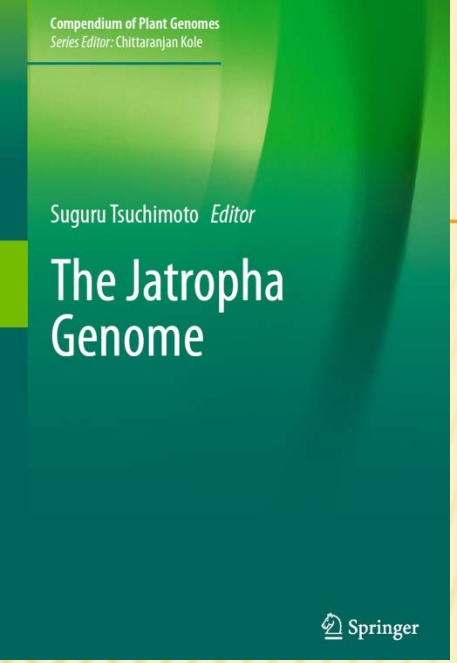

The Olive Tree Genome (2016).pdf

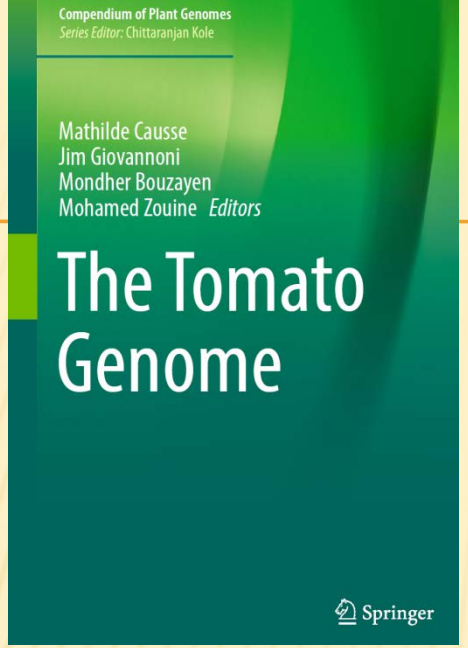

The peanut genome 2017.pdf


The pigeonpea genome2017.pdf


The potato genome 2018.pdf


The Radish Genome (2017)


Compendium of Plant Genomes
Series Editor: Chittaranjan Kole
Suguru Tsuchimoto Editor
The Jatropha Genome
Springer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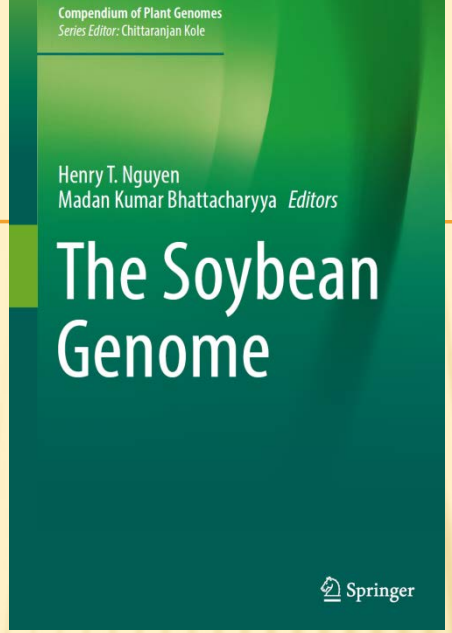
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The Soybean Genome
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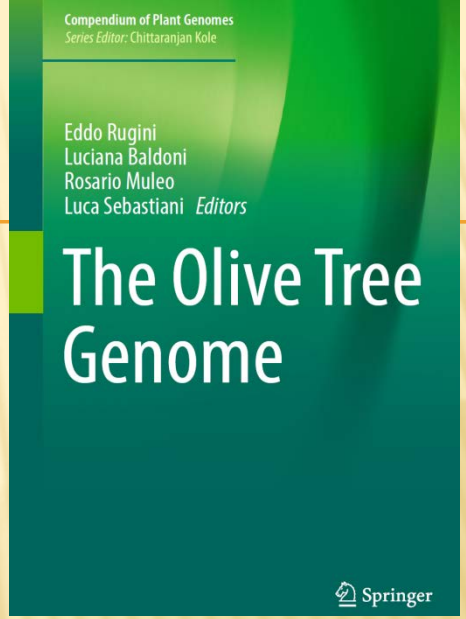
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The Olive Tree Genome
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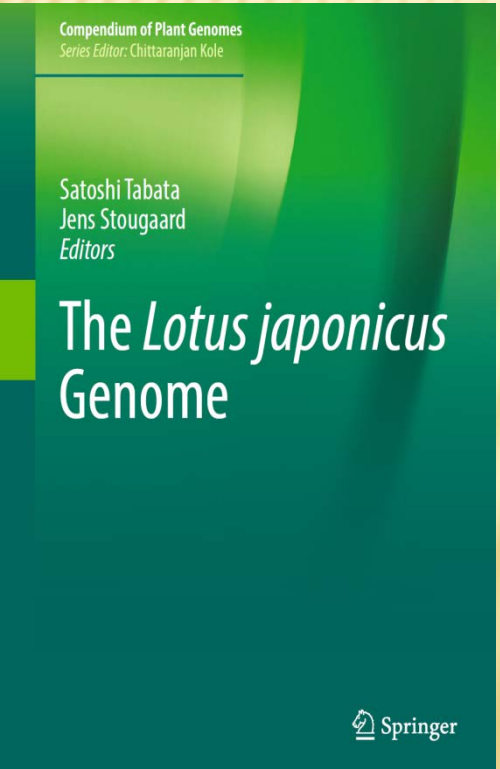
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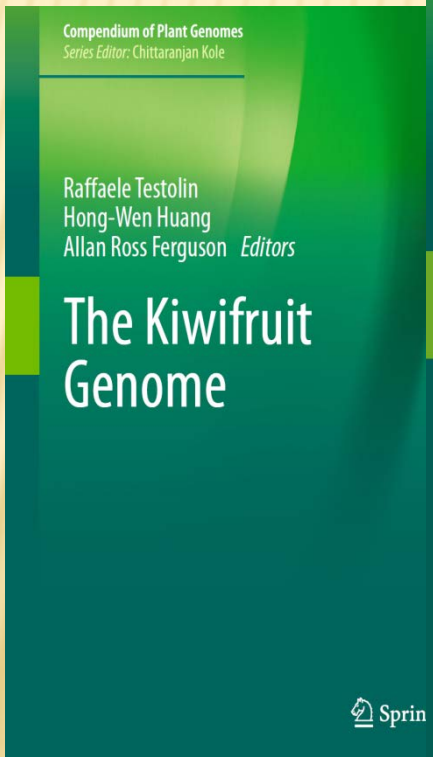
Editors
The Lotus japonicus Genome
Springer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Series Editor: Chittaranjan Kole
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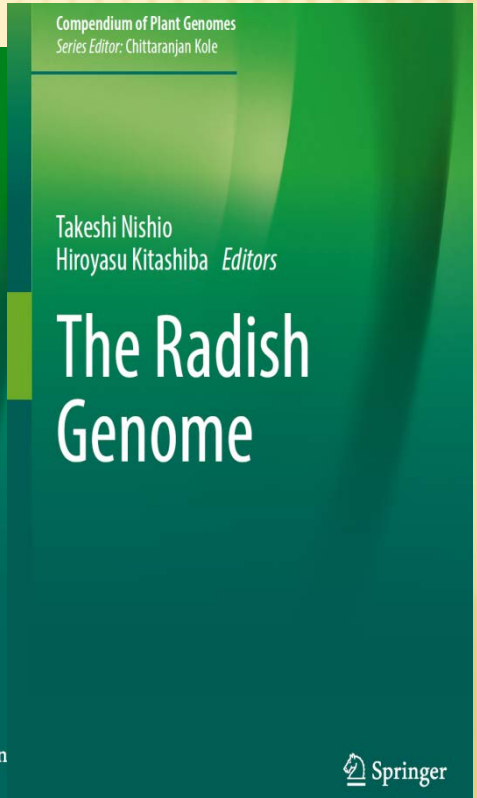
Hong-Wen Huang
Allan Ross Ferguson Editors
The Kiwifruit Genome
Sprin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The Radish Genome
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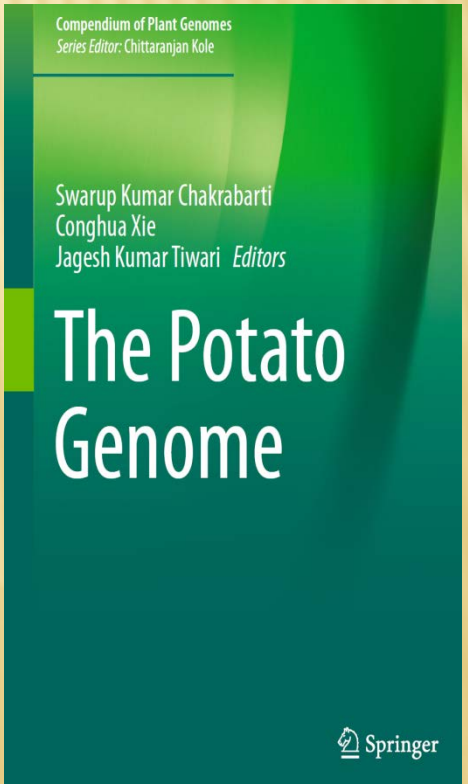
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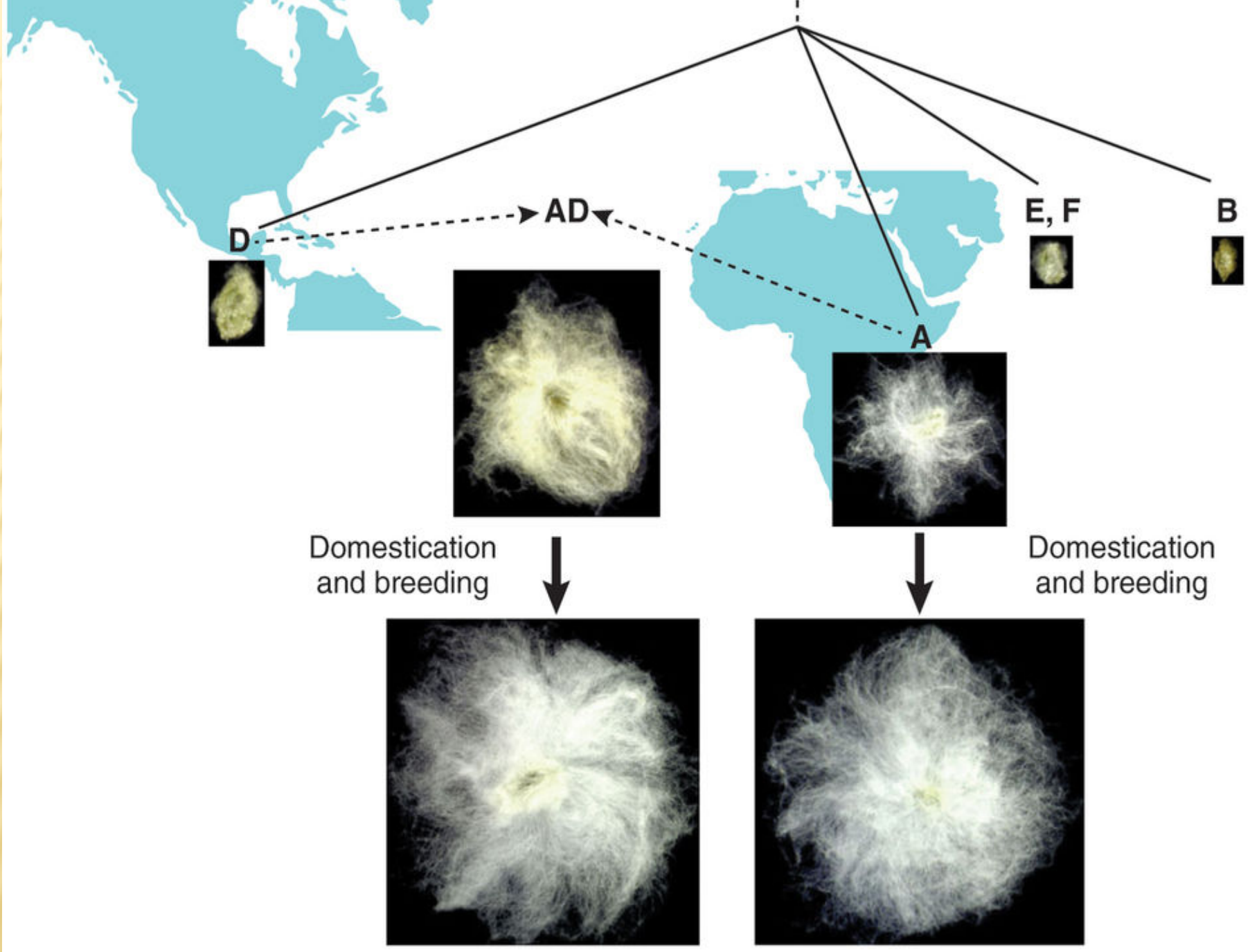
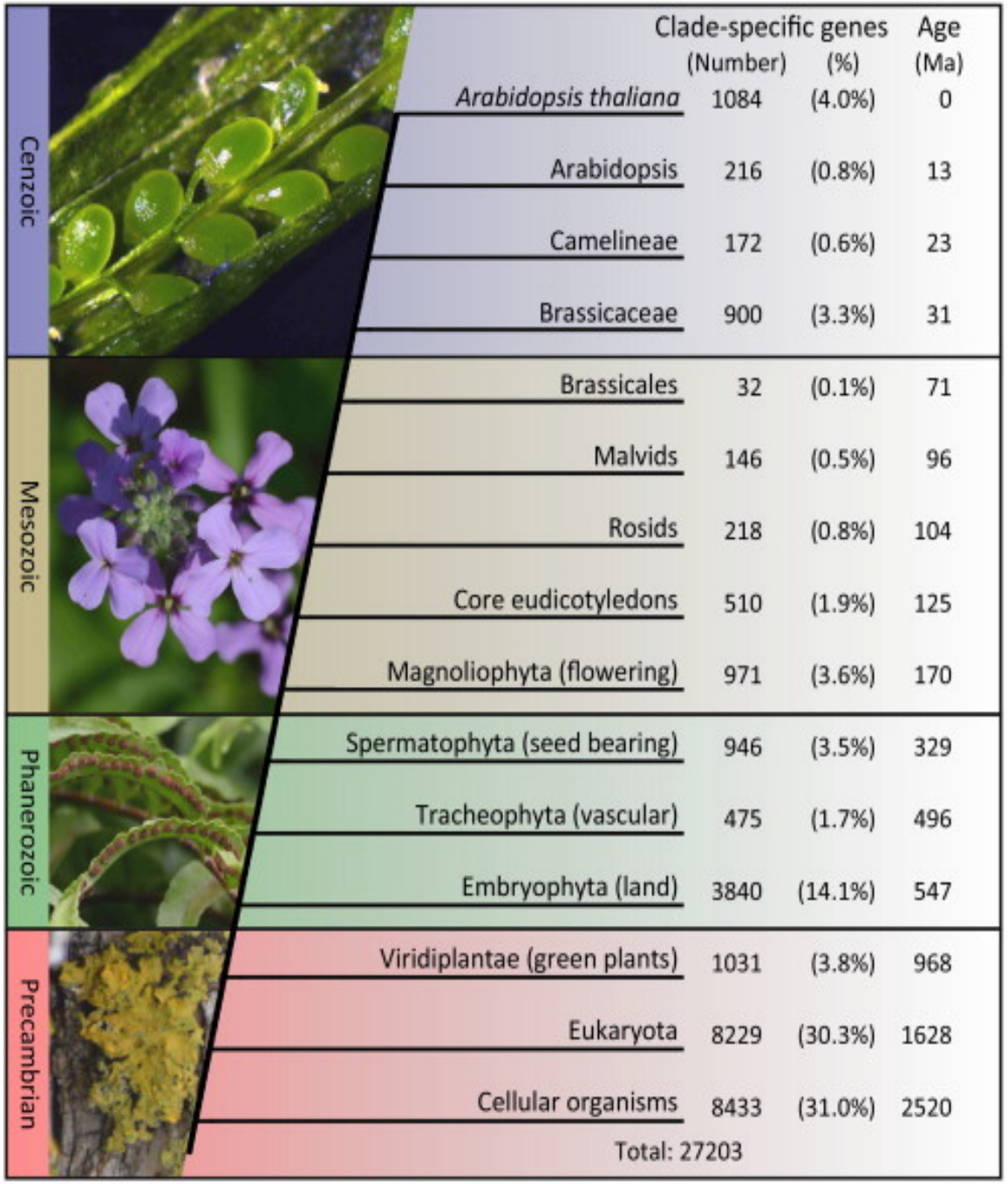
Conghua Xie
Jagesh Kumar Tiwari Editors
The Potato Genome
Springer

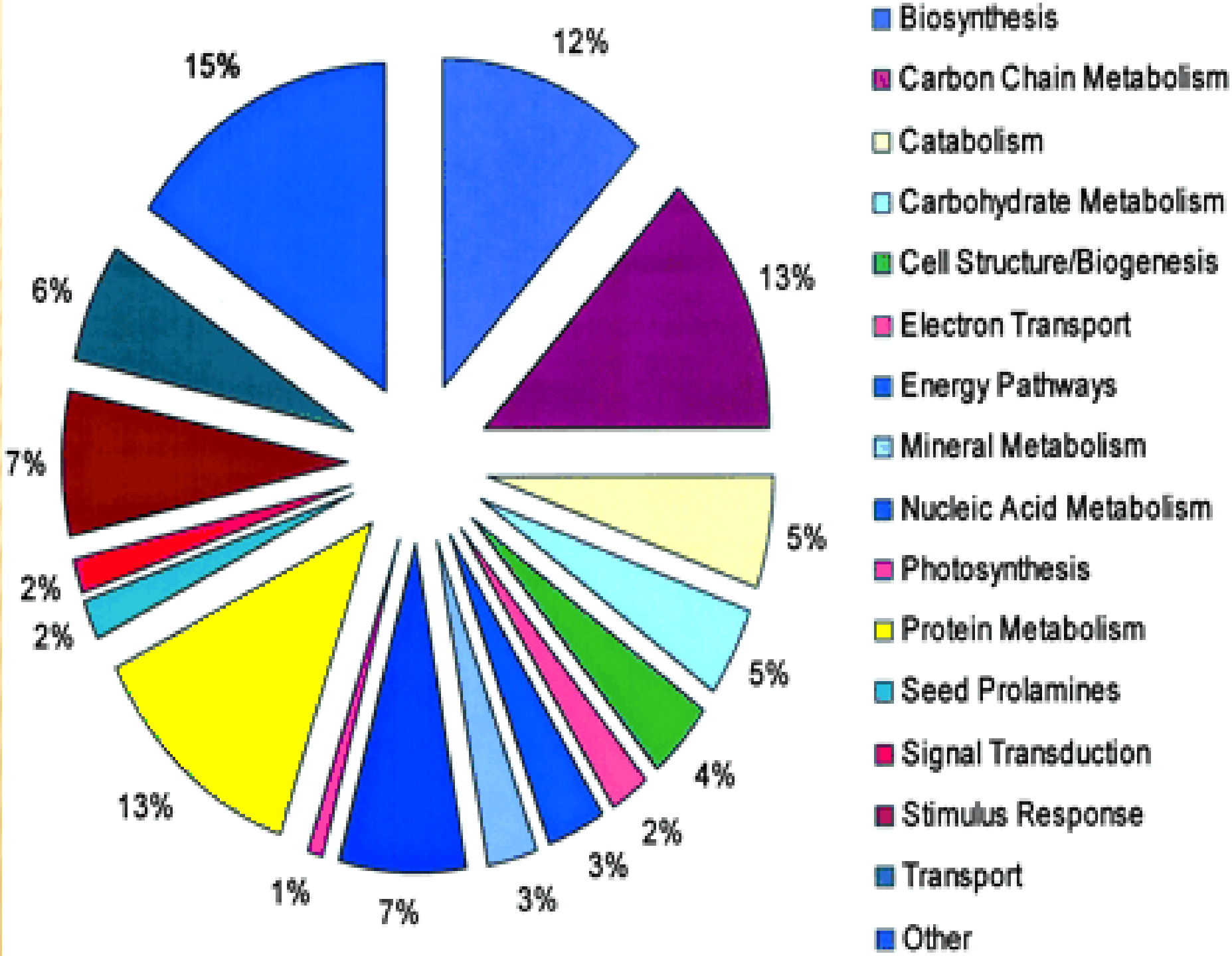
# ЕВОЛЮЦІЯ ГРУП ОРГАНІЗМІВ І ГЕНОМІВ

- 70 % ідентичність генів рослин до генів тварин
- Походження груп рослин
- Еволюція метаболічних шляхів  у рослин


D
AD
A
E, F
B
Domestication
and breeding
Domestication
and breeding




TRENDS in Plant Science

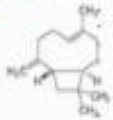

12%
13%
5%
5%
4%
2%
3%
3%
7%
1%
13%
2%
2%
7%
6%
15%
Biosynthesis
Carbon Chain Metabolism
Catabolism
Carbohydrate Metabolism
Cell Structure/Biogenesis
Electron Transport
Energy Pathways
Mineral Metabolism
Nucleic Acid Metabolism
Photosynthesis
Protein Metabolism
Seed Prolamines
Signal Transduction
Stimulus Response
Transport
Other

# ВИВЧЕННЯ РІЗНОМАНІТНОСТІ

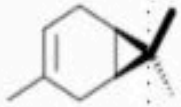
- 1. Збагачення генофондів на гени стійкості до біотичних та абіотичних чинників
- 2. Вивчення та управління метаболічними процесами у рослин
- 3. Зміна властивостей рослини


2010.06.19

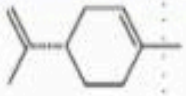
Pinene
(Pines)



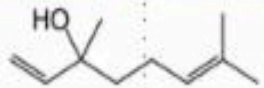
Caryophyllene
(Peppercorns)



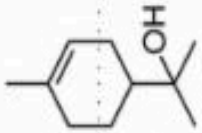
Carene
(Cedar, Rosemary)



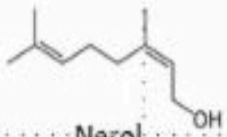
Limonene
(Citrus Lemon)




Linalool
(Mints, Lavender)

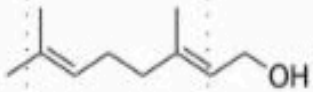



Terpineols
(Junipers, Orange Peel)

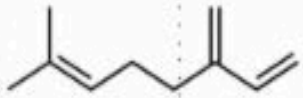



Nerol
(Lemon Grass)

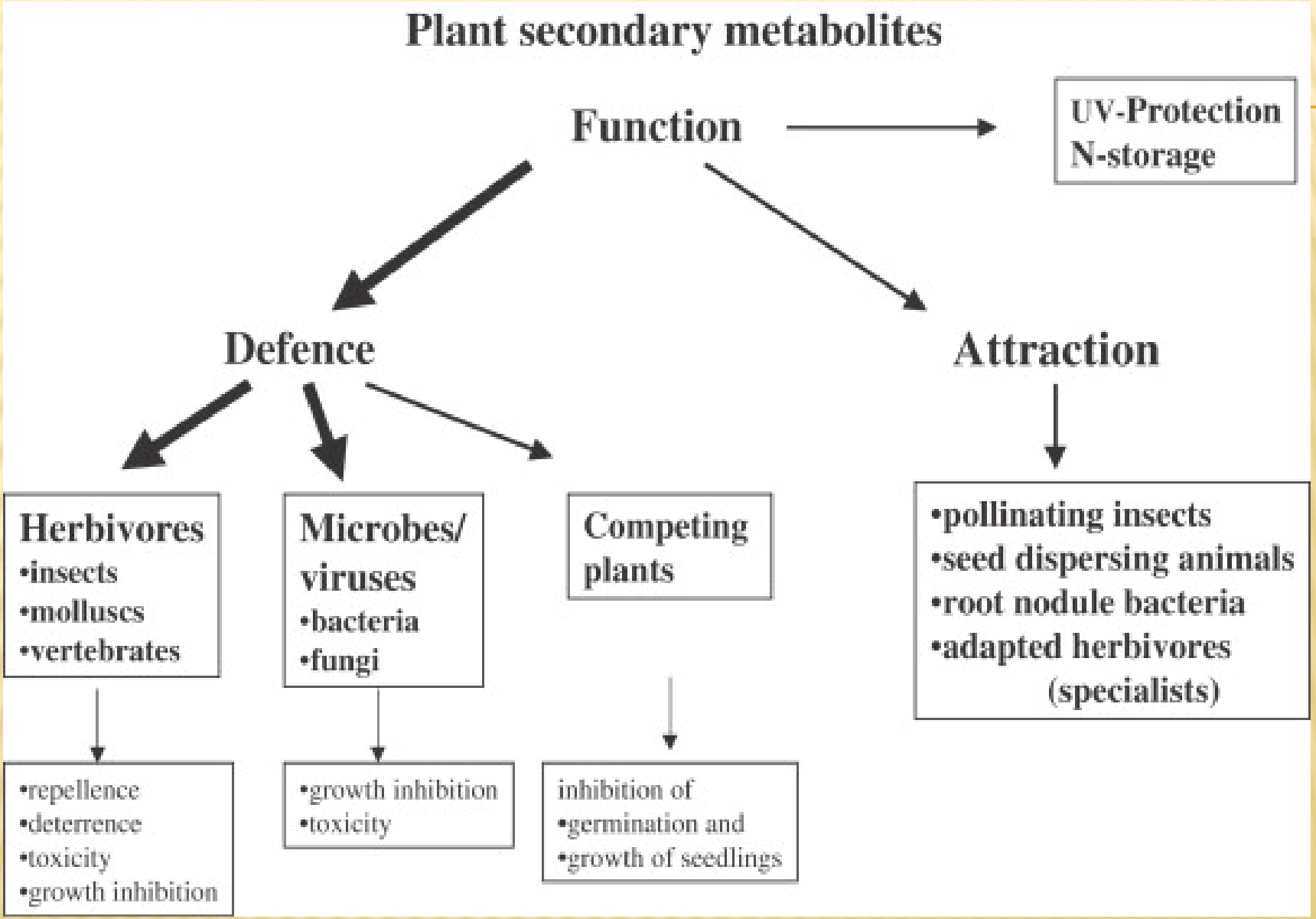
Humulene
(Hops)



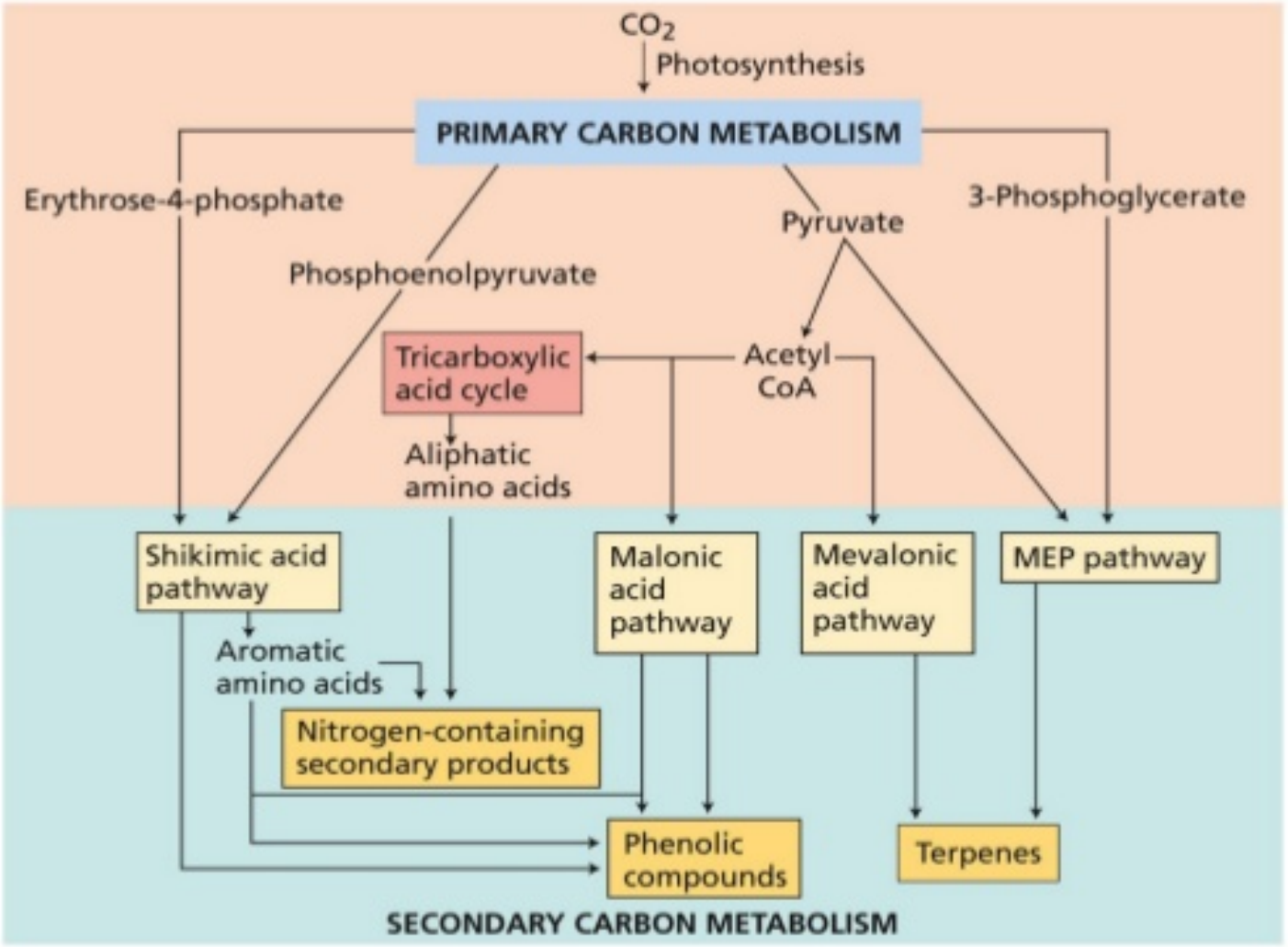

Geraniol
(Roses & Wine Grapes)



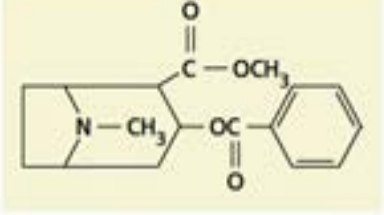
Myrcene
(Myrtles & Cannabis)


Plant secondary metabolites
Function
UV-Protection
N-storage
Defence
Attraction
Herbivores
•insects
•molluscs
•vertebrates
Microbes/
viruses
•bacteria
•fungi
Competing
plants
•pollinating insects
•seed dispersing animals
•root nodule bacteria
•adapted herbivores
(specialists)
•repellence
•deterrence
•toxicity
•growth inhibition
•growth inhibition
•toxicity
inhibition of
•germination and
•growth of seedlings

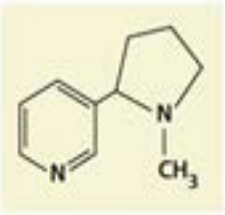
# Major pathways of secondary-metabolite biosynthesis



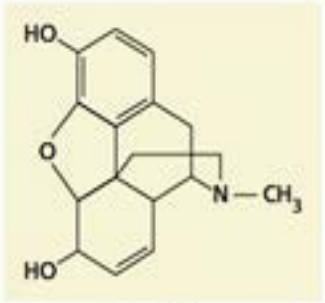

PLANT PHYSIOLOGY, Fourth Edition, Figure 13.4 © 2006 Sinauer Associates, Inc.

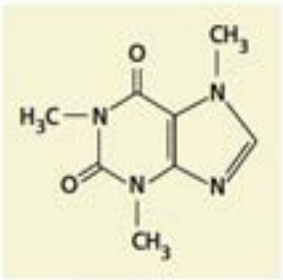


Cocaine

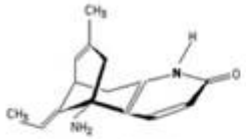


Nicotine

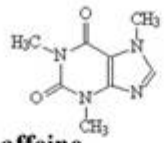




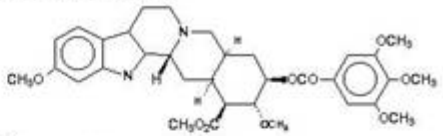
## An Assortment of Alkaloids



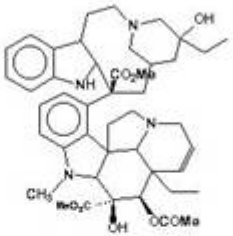
**huperzine A**
*Chinese herbal medicine*
*nootropic*



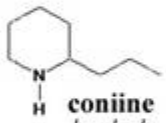
**caffeine**
*Coffea arabica*
*study*



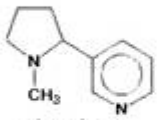
**reserpine**
*Indian herbal medicine*
*antipsychotic*



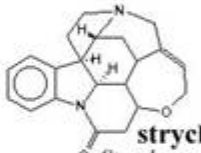
**vinblastine**
*Madagascar periwinkle*
*antileukemic*



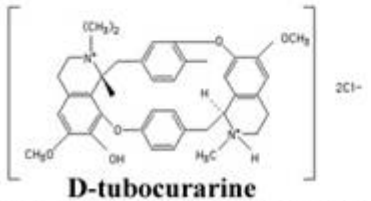
**coniine**
*hemlock*
*ants, Socrates*



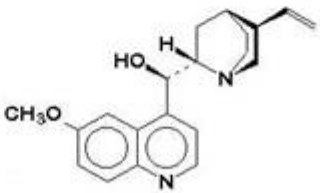
**nicotine**
*tobacco*
*Black Leaf 40*
*insecticide*



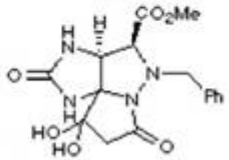
**strychnine**
*Strychnos nux-vomica*
*rodenticide*



**D-tubocurarine**
*arrow poison, muscle relaxant for surgery*

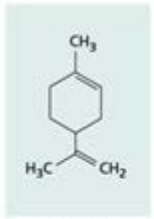


**quinine**
*Cinchona tree, antimalarial*



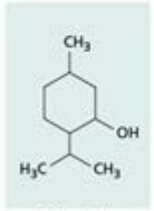
**saxitoxin**
*deadly algal toxin*
*chemical warfare agent*
*CIA suicide pill*

(A)



Limonene

(B)



Menthol

# РОСЛИНИ ДЛЯ ПАЛИВА