Darwin in the 21st Century
6th July 2009

11.00	Pat Heslop-Harrison - Introduction
11.05	Malcolm Ferguson-Smith
11.30	Pat Heslop-Harrison
11.45	Mariano Rocchi
12.05	Michael Lynch

Charles Darwin

- 12 February 1809 – 19 April 1882

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ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

- Before Charles Darwin, 'biology' was a mixture of description and philosophy
- Many antecedents: Linnaeus; Lamarck; his grandfather Erasmus Darwin – and from ancient civilization: You eat something that looks similar to something you know; you treat your disease with something similar!
- Contemporaries: Wallace, Hooker(s), Galton ...
- Charles Darwin was the first to develop testable hypotheses and was the first experimental biologist


EVOLUTION

Darwin in the 21st Century

Domestication, Diversity and Darwin: what we now know about chromosomes

Darwin knew all the consequences and wrote about them without knowing the mechanisms

ON

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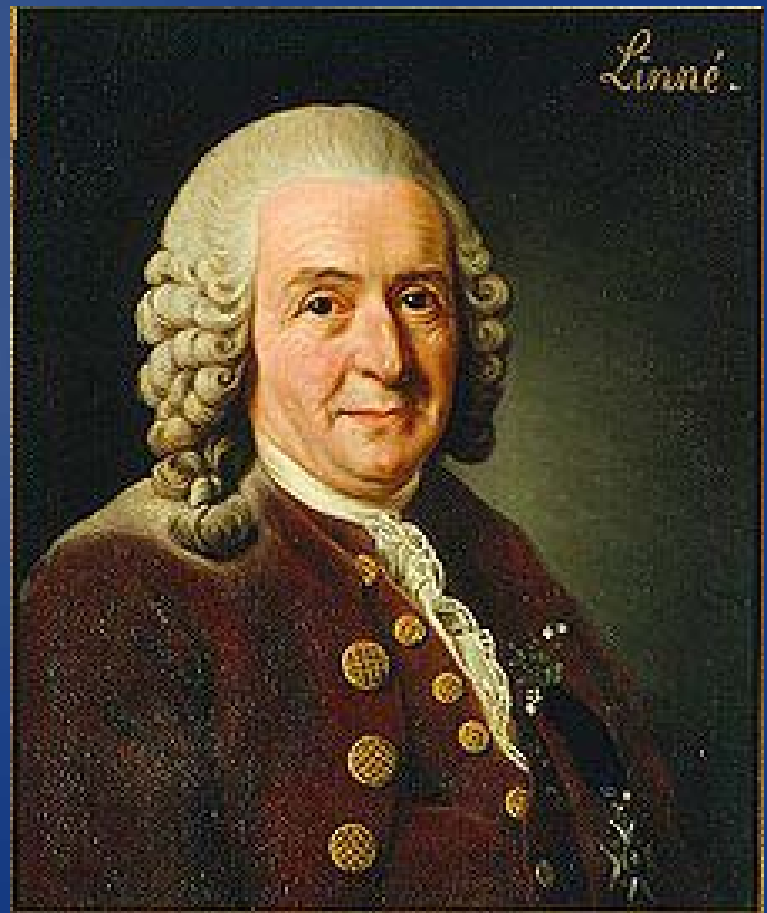
ON THE
ORIGIN
OF
SPECIES

DARWIN.

LONDON
JOHN MURRAY

Carl Linnaeus 1707-1778

- *Species Plantarum* 1753
- Father of modern taxonomy
- And what became ecology



Some ... believe that species undergo modification, and that the existing forms of life have descended by true generation from pre-existing forms. Passing over authors from the classical period to that of Buffon ... Lamarck was the first man whose conclusions on this subject excited much attention. This justly-celebrated naturalist first published his views in 1801 ...

Darwin, 1861. Origin 3rd Edition (4th Edition more on Buffon).

Jean-Baptiste Lamarck (1744-1829)

Early proponent of 'evolution' in accordance with natural laws

Flora française; Chair of Botany in 1788

Système des animaux sans vertèbres; Professor of Zoology 1801

Inheritance of acquired characters

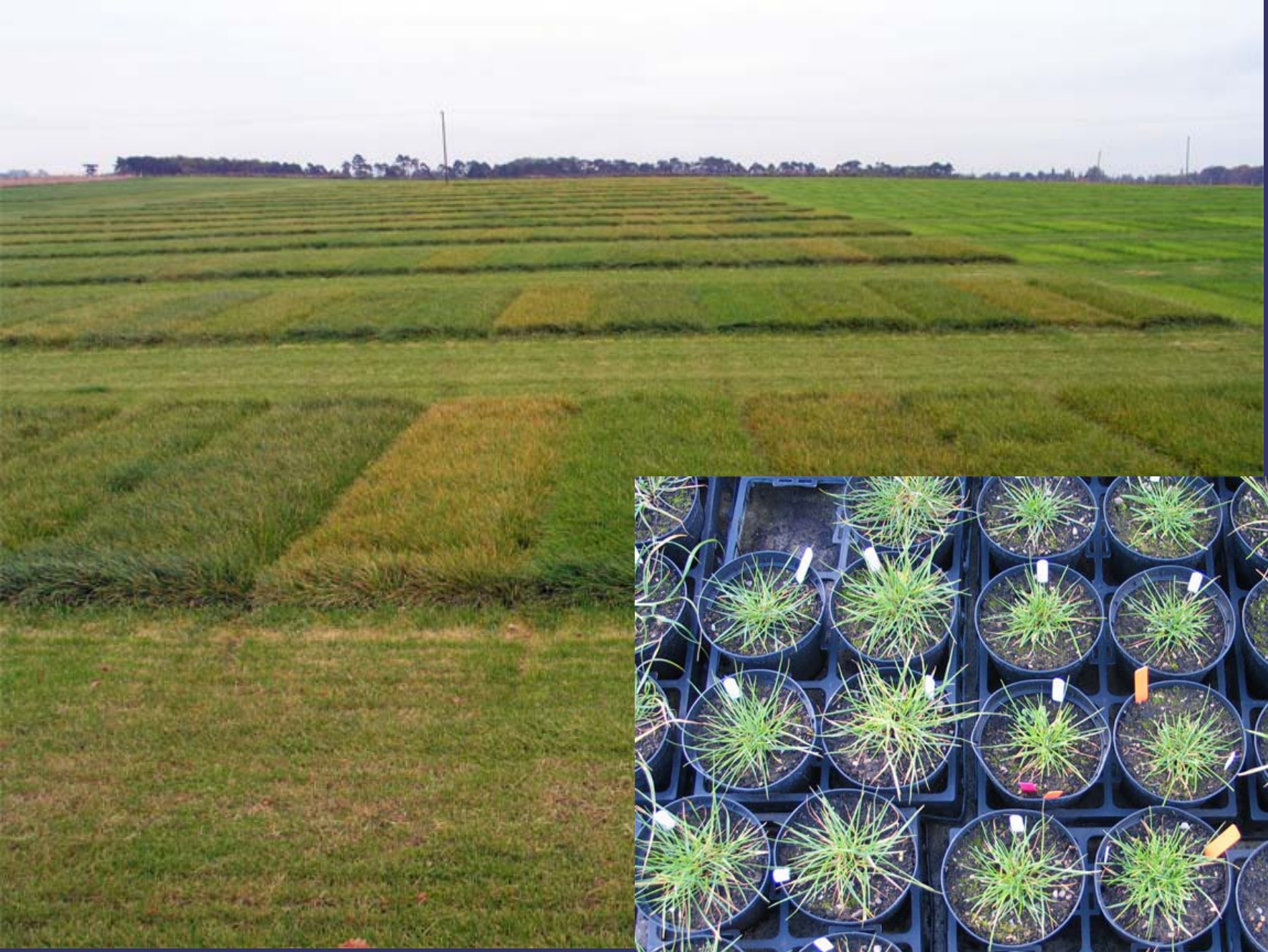
Change through use or disuse

Increasing complexity

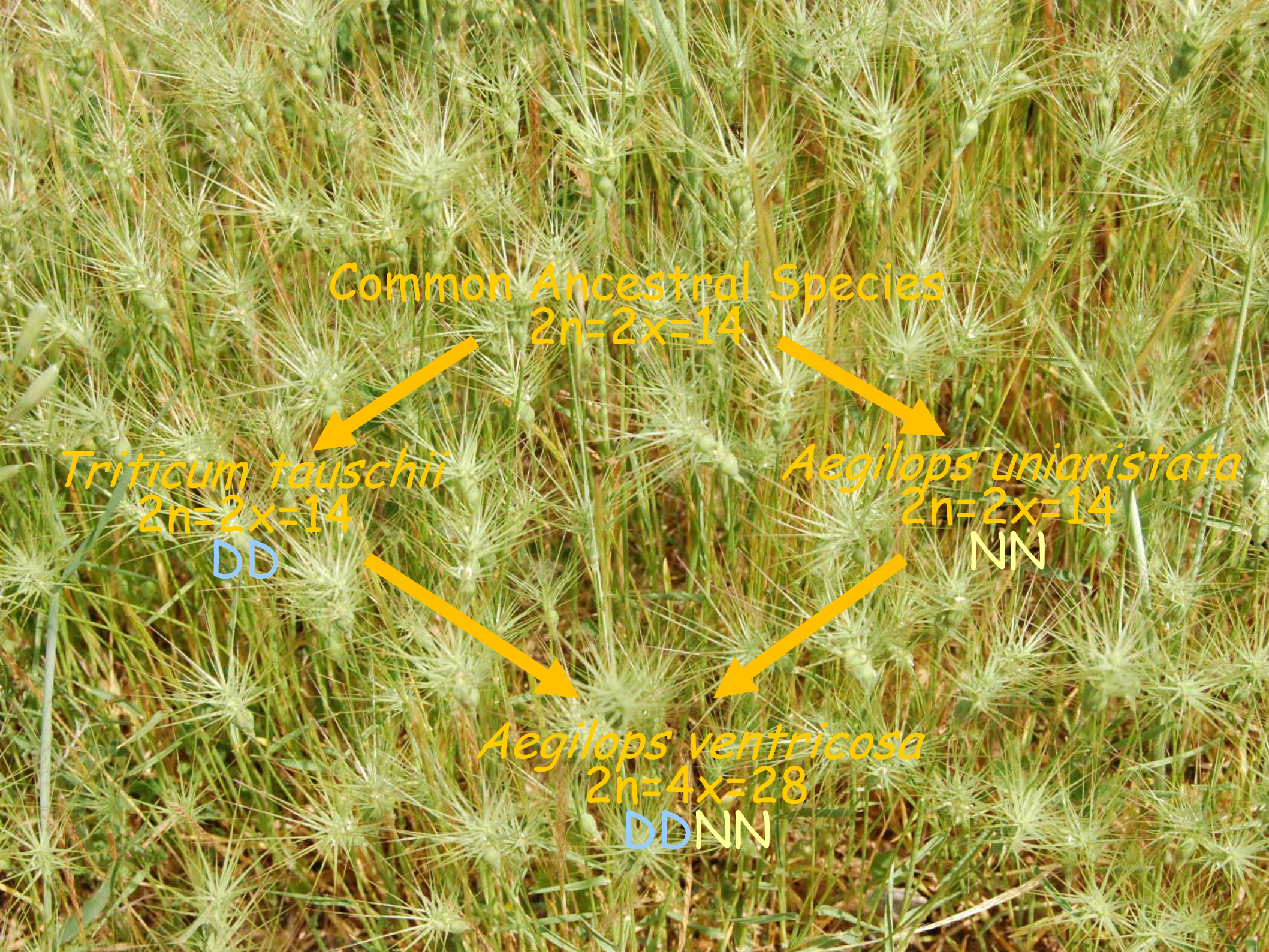
Le pouvoir de la vie – the ability/power of life to change – from simple to complex forms

L'influence des circonstances - use and disuse of characters led organisms to become more adapted to their environment

Lamarck ... upholds the doctrine that all species, including man, are descended from other species. He first did the eminent service of arousing attention to the probability of all change in the organic as well as in the inorganic world being the result of law, and not of miraculous interposition. Lamarck seems to have been chiefly led to his conclusion on the gradual change of species, by the difficulty of distinguishing species and varieties, by the almost perfect gradation of forms in certain organic groups, and by the analogy of domestic productions.



Anhalt, Barth, HH et al. Segregation distortion in Lolium: evidence for genetic effects. Theoretcial & Applied Genetics 2008


Common Ancestral Species
2n=2x=14
Triticum tauschii
2n=2x=14
DD
Aegilops uniaristata
2n=2x=14
NN
Aegilops ventricosa
2n=4x=28
DDNN

With respect to the means of modification, he attributed something to the direct action of the physical conditions of life, something to the crossing of already existing forms, and much to use and disuse, that is, to the effects of habit. ... he likewise believed in a law of progressive development; and as all the forms of life thus tended to progress, in order to account for the existence at the present day of very simple productions, he maintained that such forms were now spontaneously generated.

Alfred Russell Wallace 1823-1913

- Independent theory of evolution by natural selection;
- Widely considered to cause Charles Darwin to publish 'Origin'

Two phases of research, as defined by Francis Darwin 1899. The botanical work of Darwin. Annals of Botany os-13: x-xix.

FIRST Phase of Research

Based on observation, compilation and deduction, leading to evolutionary conclusions

Published as "On the origin of species by Natural Selection" (1859)

Charles Darwin

Second Phase of Research

'Experimental' period

Work on cross- and self-fertilization, and climbing, insectivorous and domesticated plants, where he could test the conclusions of his evolutionary work and investigate causes and consequences of speciation and extinction -

Darwin (writing to Asa Gray in 1857) "nature does not lie".

Alfred Newton
1868.

THE VARIATION

OF

ANIMALS AND PLANTS

UNDER DOMESTICATION.

By CHARLES DARWIN, M.A., F.R.S., &c.

IN TWO VOLUMES.—Vol. I.

WITH ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1868.

ANIMALS AND PLANTS UNDER DOMESTICATION

DARWIN.

VOL. I.

LONDON, JOHN MURRAY.

To any one who has attentively read my 'Origin of Species' this Introduction will be superfluous. As I stated in that work that I should soon publish the facts on which the conclusions given in it were founded, I here beg permission to remark that the great delay in publishing this first work has been caused by continued ill-health.

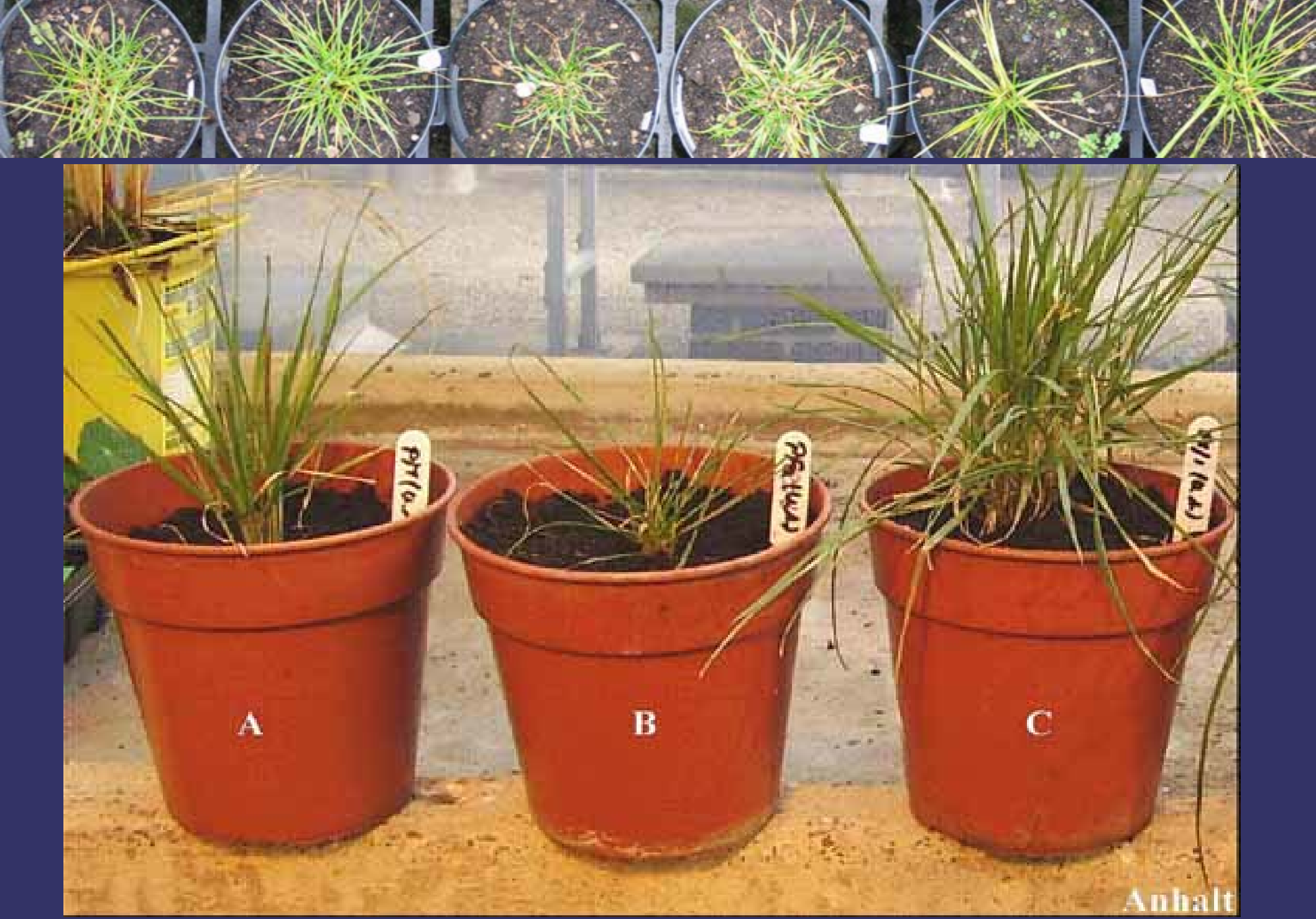
From a remote period, in all parts of the world, man has subjected many animals and plants to domestication or culture. Man has no power of altering the absolute conditions of life; he cannot change the climate of any country; he adds no new element to the soil; but he can remove an animal or plant from one climate or soil to another, and give it food on which it did not subsist in its natural state. It is an error to speak of man "tampering with nature" and causing variability. If organic beings had not possessed an inherent tendency to vary, man could have done nothing.

… I have called Natural Selection; and Mr. Herbert Spencer has well expressed the same idea by the Survival of the Fittest. … The term is so far a good one as it brings into connection the production of domestic races by man's power of selection, and the natural preservation of varieties and species in a state of nature.

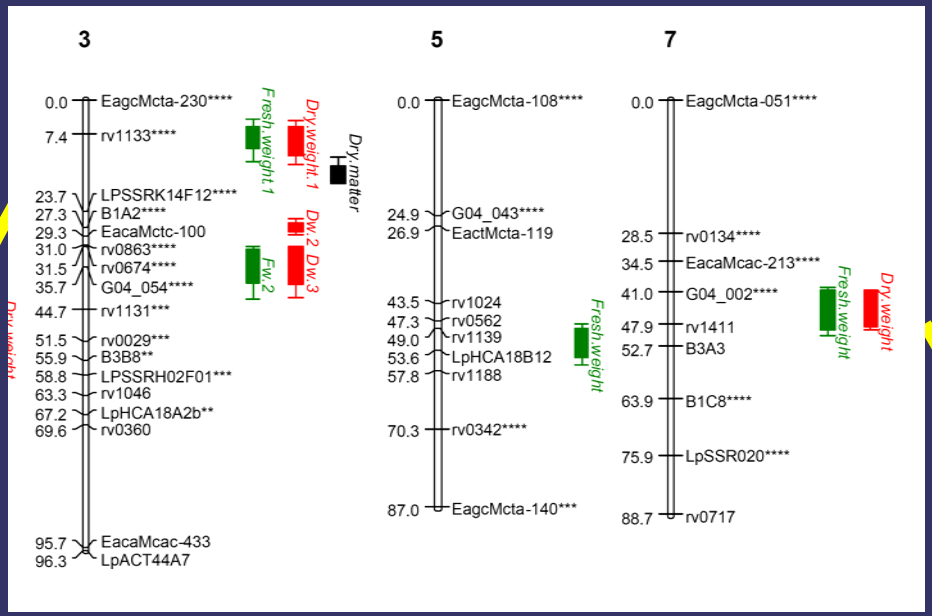
For brevity sake I sometimes speak of natural selection as an intelligent power;—in the same way as … agriculturists speak of man making domestic races by his power of selection. In the one case, as in the other, selection does nothing without variability, and this depends in some manner on the action of the surrounding circumstances on the organism. I have, also, often personified the word Nature; for I have found it difficult to avoid this ambiguity; but I mean by nature only the aggregate action and product of laws of nature.

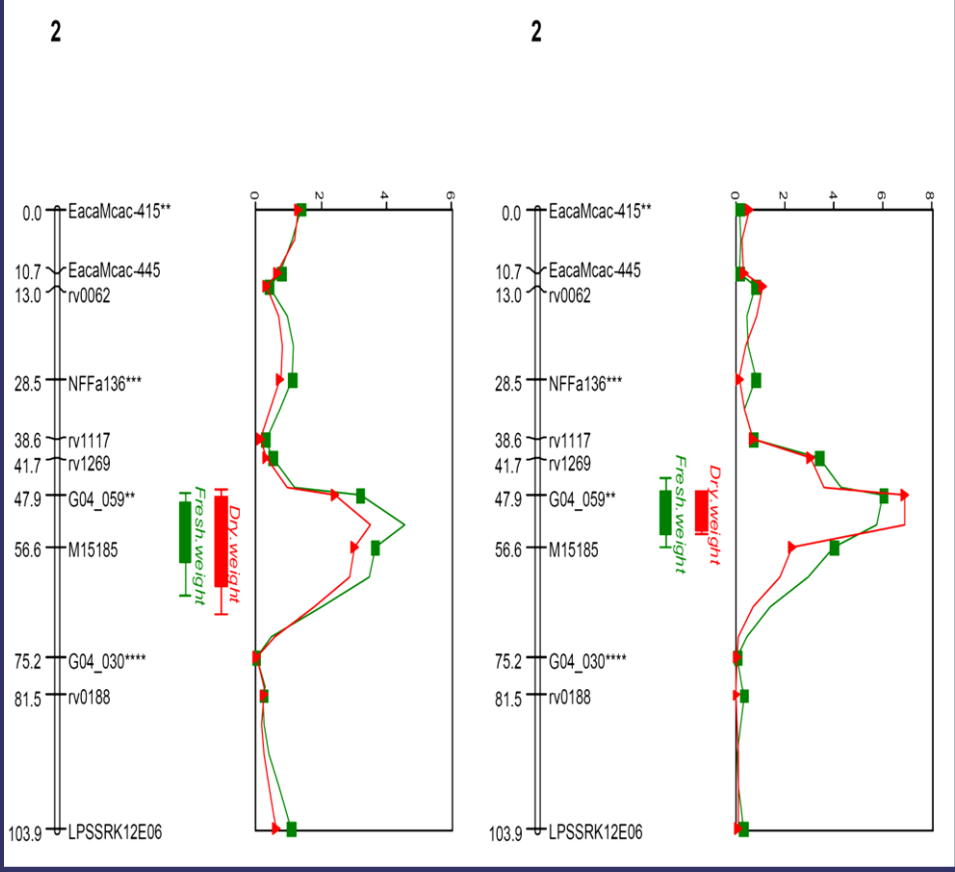
the whole subject of variation under domestication. We may thus hope to obtain some light, little though it be, on the causes of variability,—on the laws which govern it, such as the direct action of climate and food, the effects of use and disuse, and of correlation of growth,—and on the amount of change to which domesticated organisms are liable. We shall learn something on the laws of inheritance, on the effects of crossing different breeds ... During this investigation we shall see that the principle of Selection is all important. Although man does not cause variability and cannot even prevent it, he can select, preserve, and accumulate the variations given to him by the hand of nature

This problem of the conversion of varieties into species,—that is, the augmentation of the slight differences characteristic of varieties into the greater differences characteristic of species and genera, including the admirable adaptations of each being to its complex organic and inorganic conditions of life,—will form the main subject of my second work.

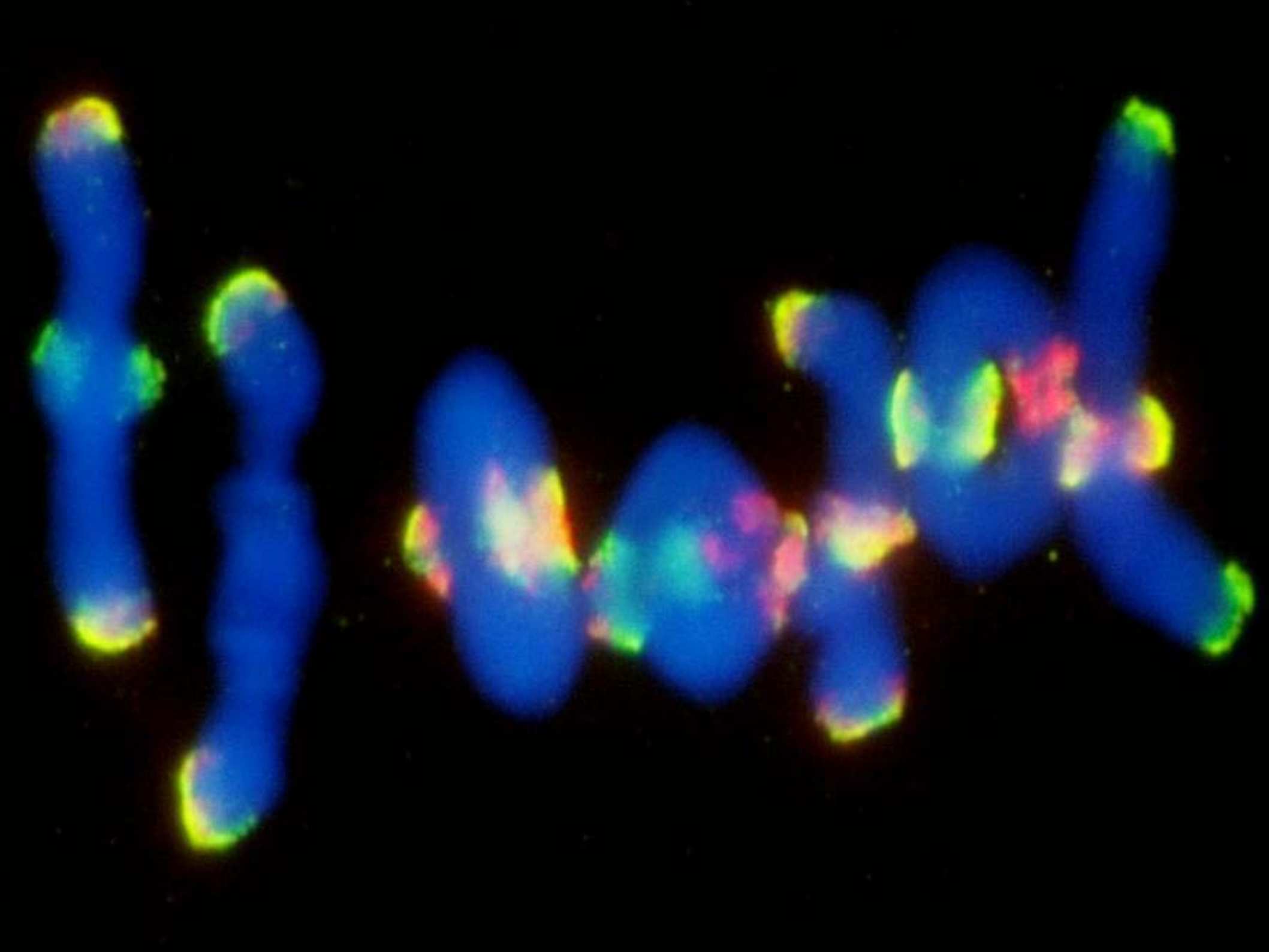


Anhalt, Barth, HH in press 2009

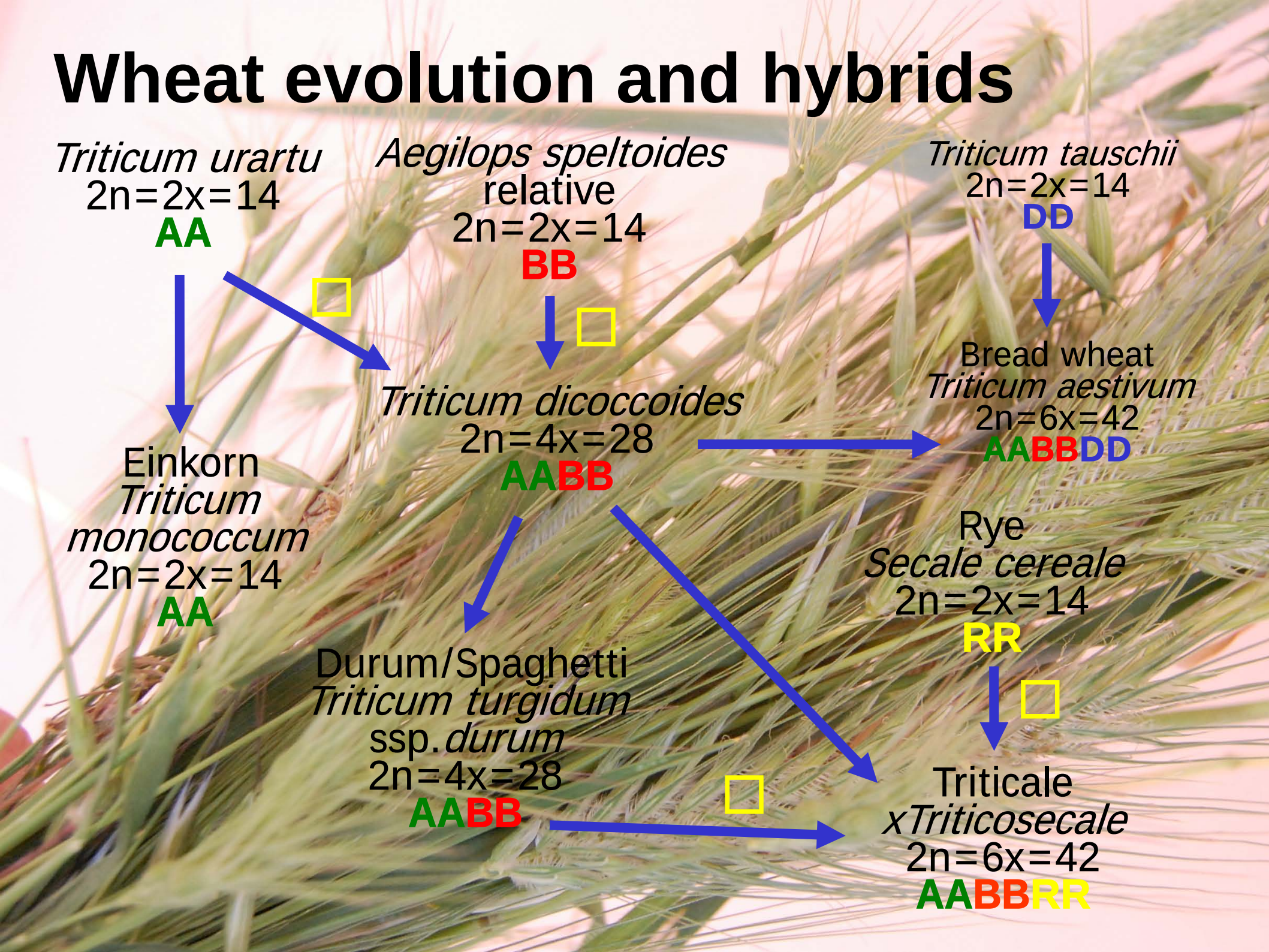




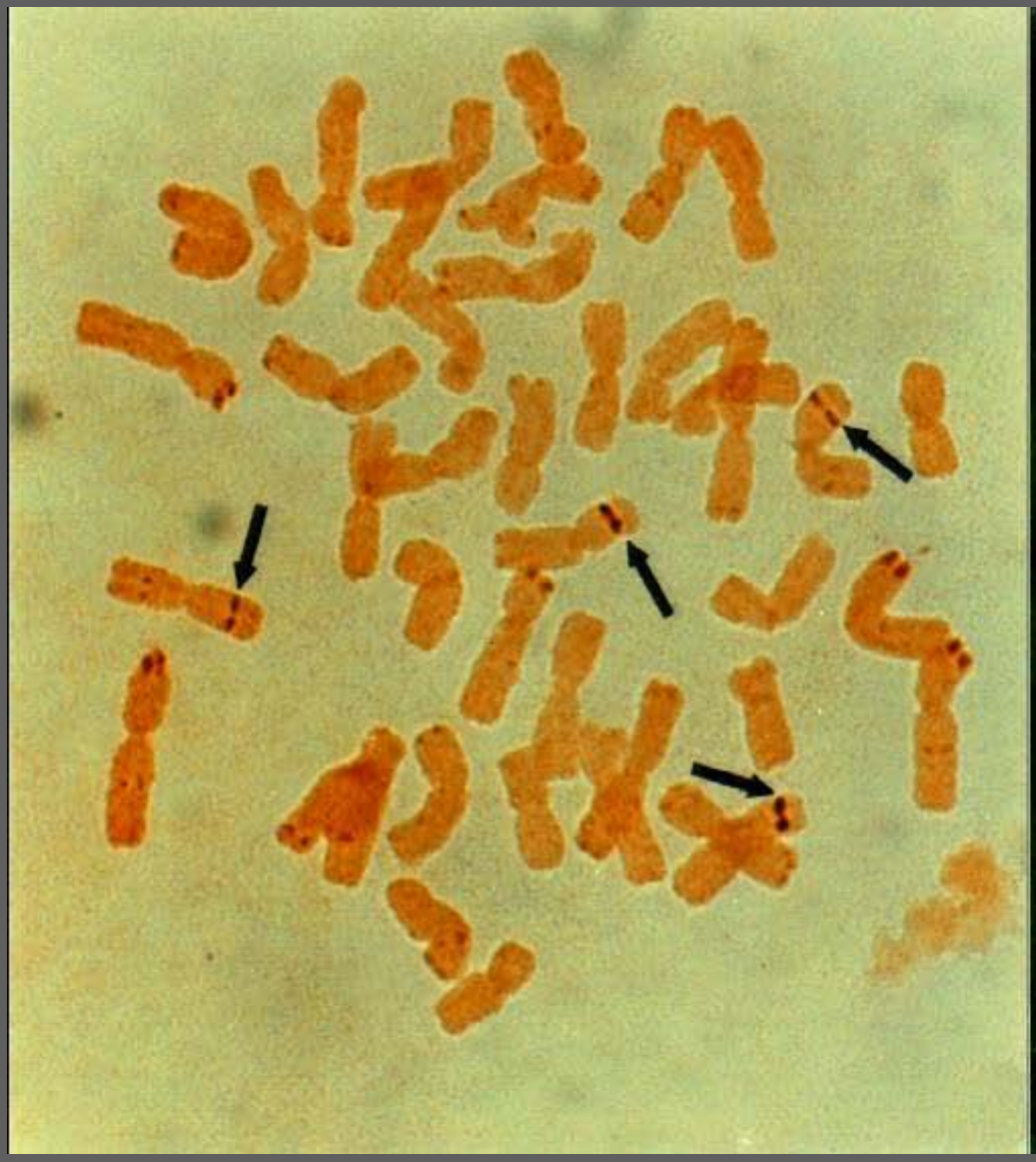
Data: Anhalt, HH, Barth. 2009 Submitted



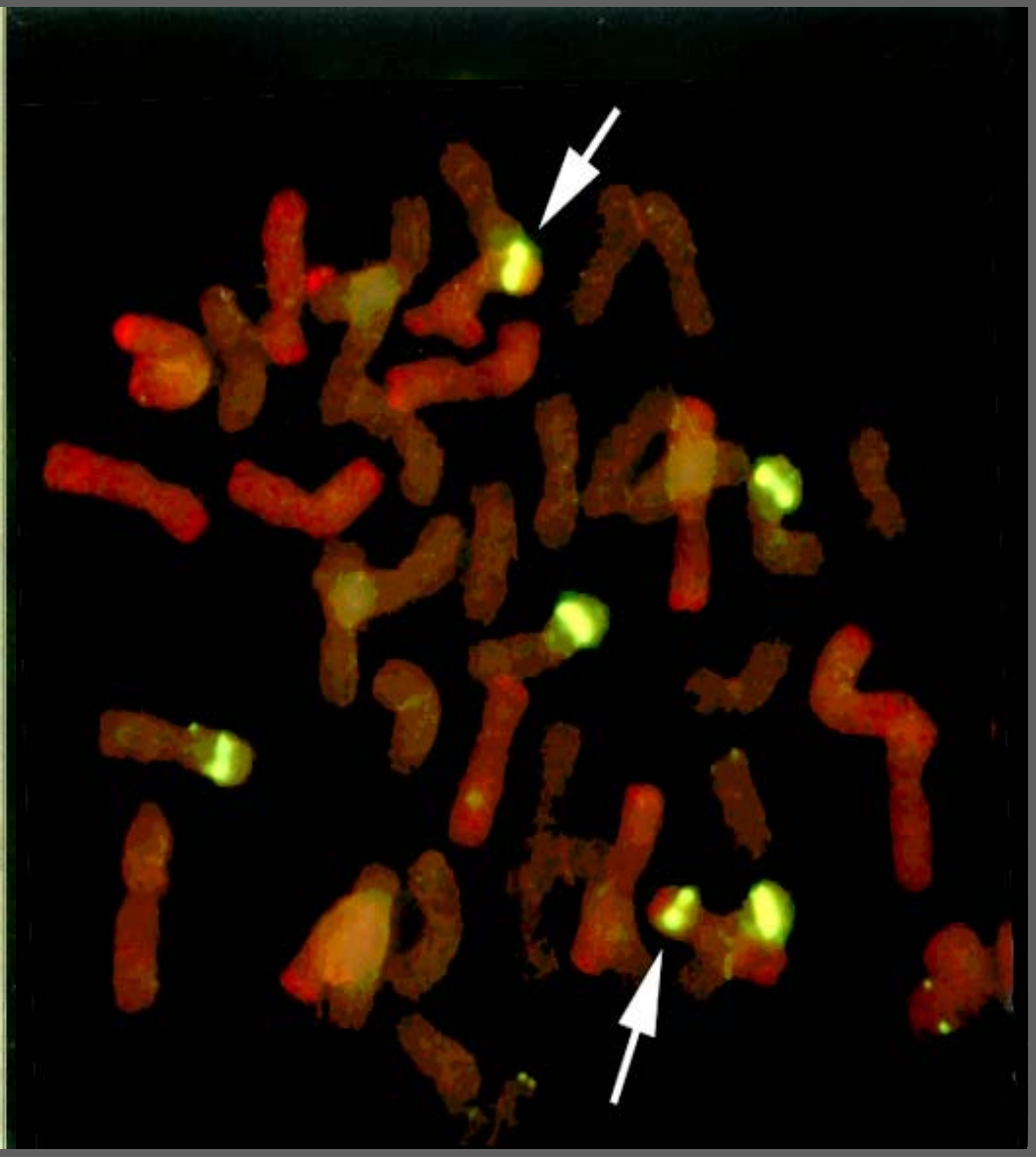
Wheat evolution and hybrids



rRNA gene expression in Triticale

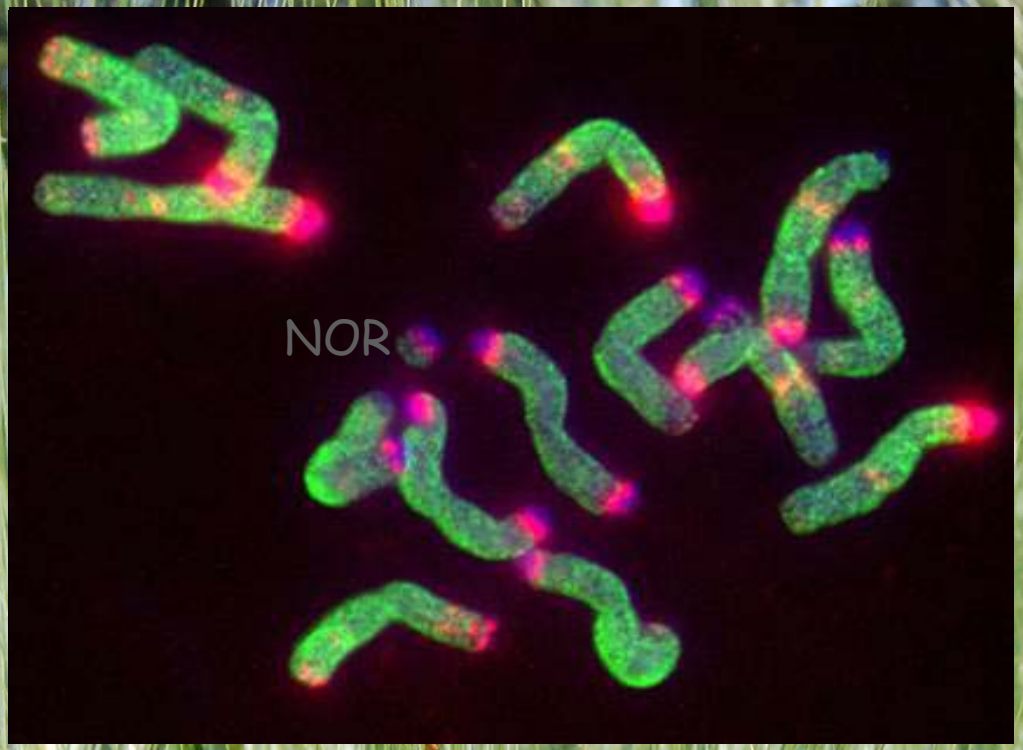


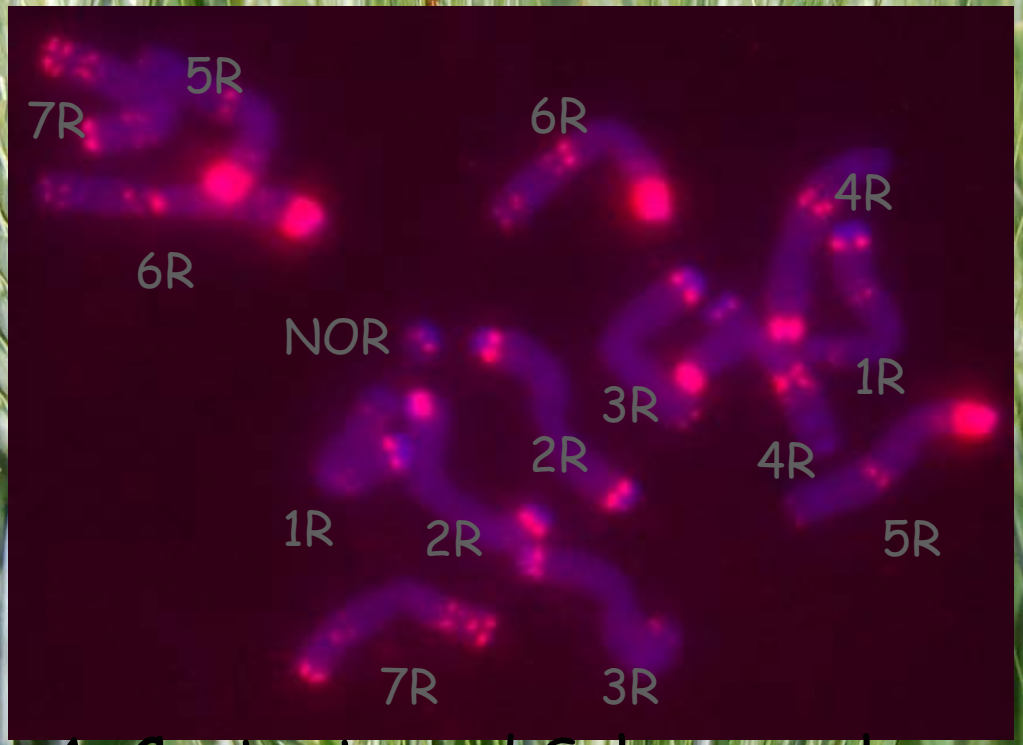
Four expression sites



Six major gene sites

Rye genome (RR)





A. Contento and Schwarzacher

- uniform signal
- large sub-telomeric blocks only low methylation
- intercalary and small telomeric bands made of 120-bp repeat unit family are fully methylated
- **NOR region is not methylated**

DAPI

Anti-methylcytosine antibody

In situ hybridization with 120-bp repeat

Rye genome (RR) heavily methylated

- CpG sites methylated
- CpNpG sites less methylation
- Low-smeared signal with *McrBC* particular in the 120-bp repeat unit family

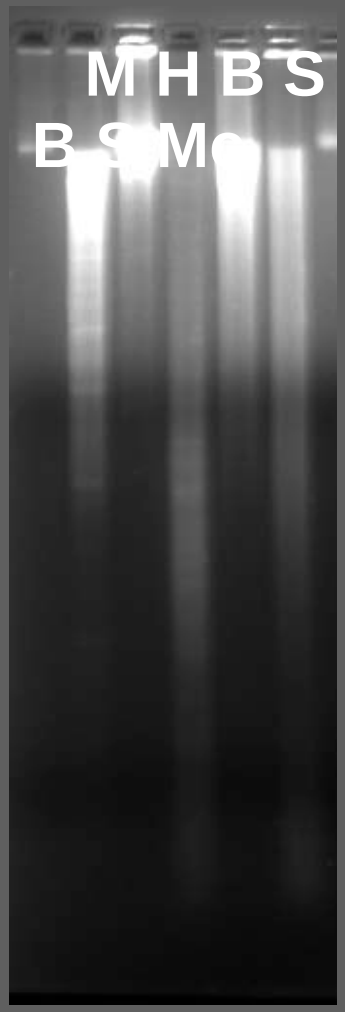
symmetrical

CCGG
M: *Msp*I
H: *Hpa*II

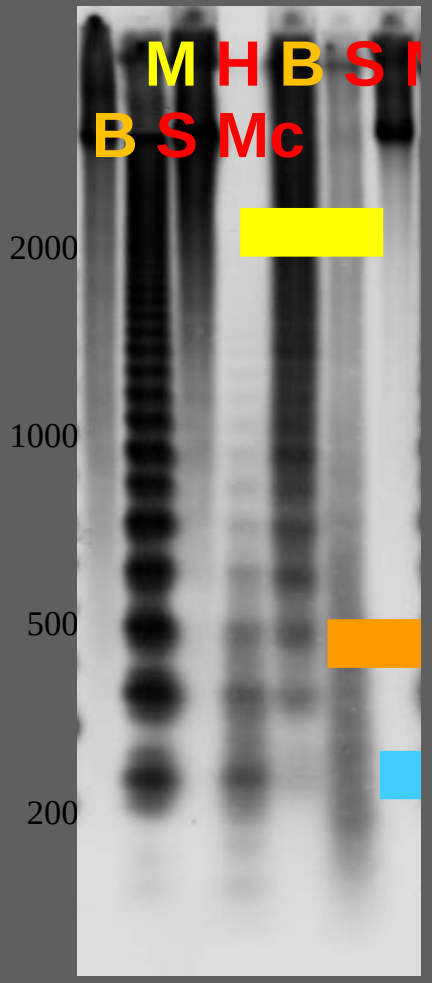
CCNGGG
B: *Bst*N1
S : *Scr*F1

uncut DNA
M: *Msp*I
H: *Hpa*II
B: *Bst*NI
S: *Scr*FI
Mc *Mcr*BC
any mC cut

Genome



120bp repeat



Probe:
Svav25/208-182

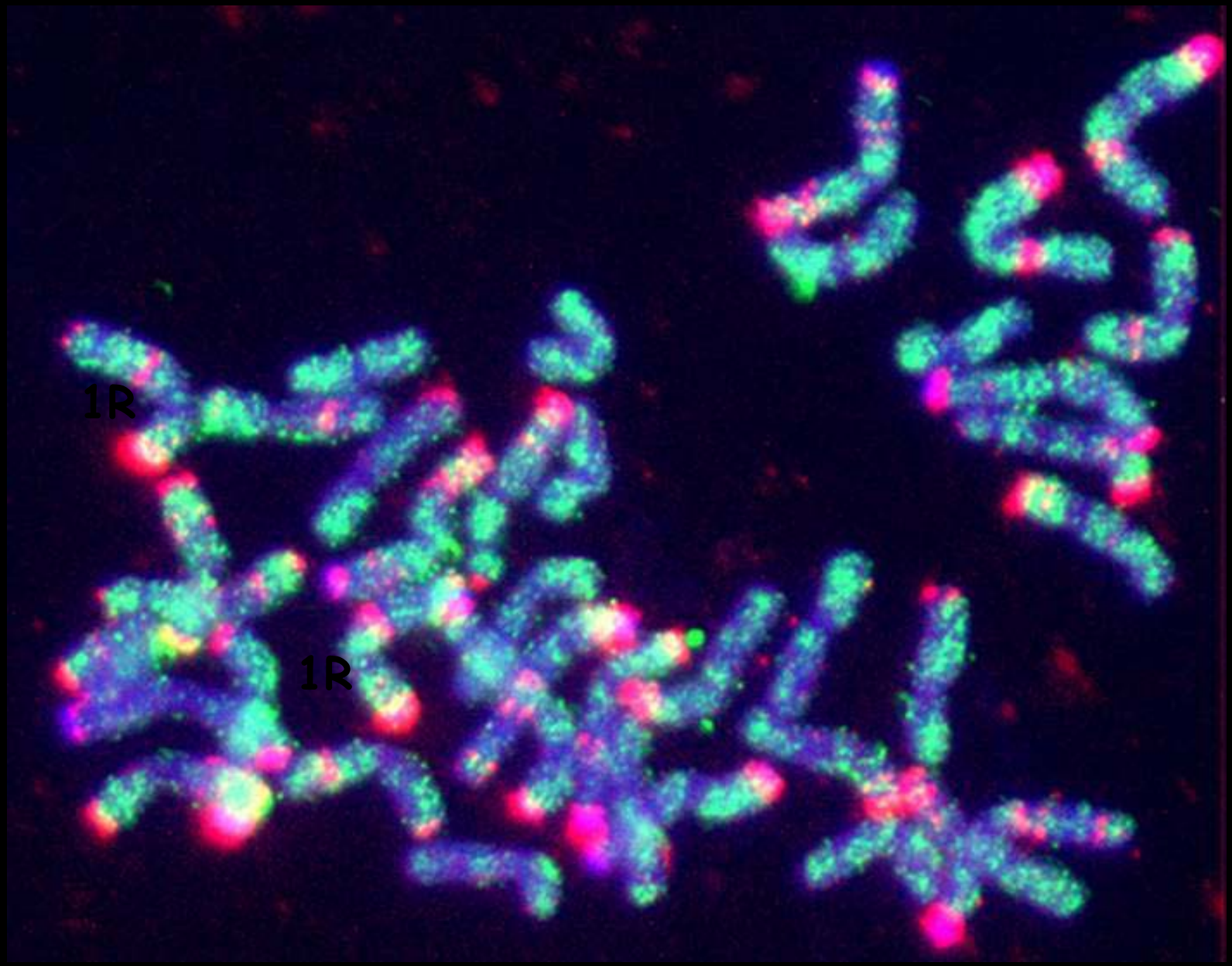
A. Contento and Schwarzacher

Triticale 'Fidelio' (AABBRR genome)

Uneven distributed signal in all genomes

Change of pattern in specific chromosomes and chromosomal regions

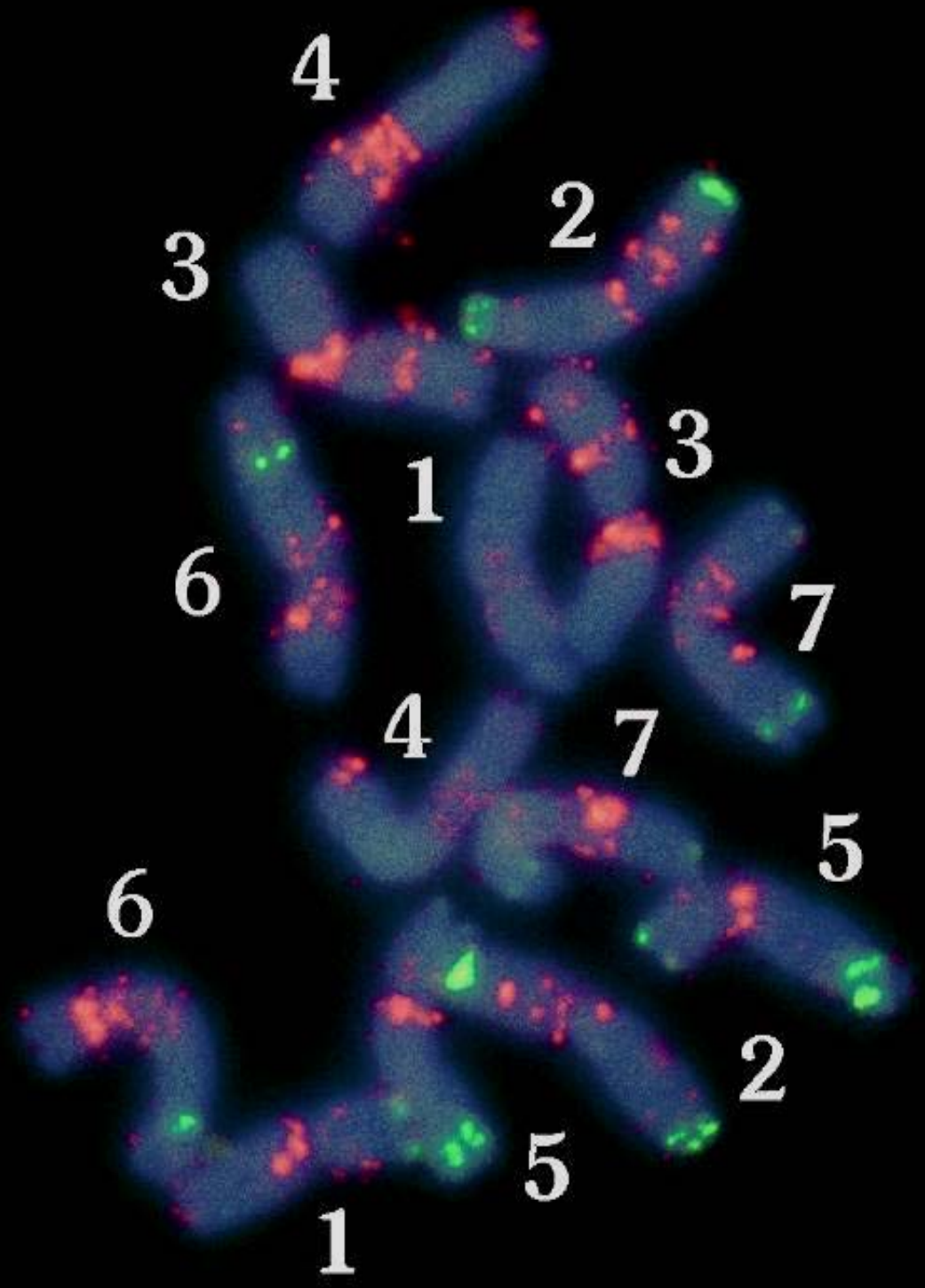
NOR of 1R is now methylated



DAPI

Anti-methylcytosine antibody *In situ* hybridization with 120-bp repeat

A. Contento and Schwarzacher



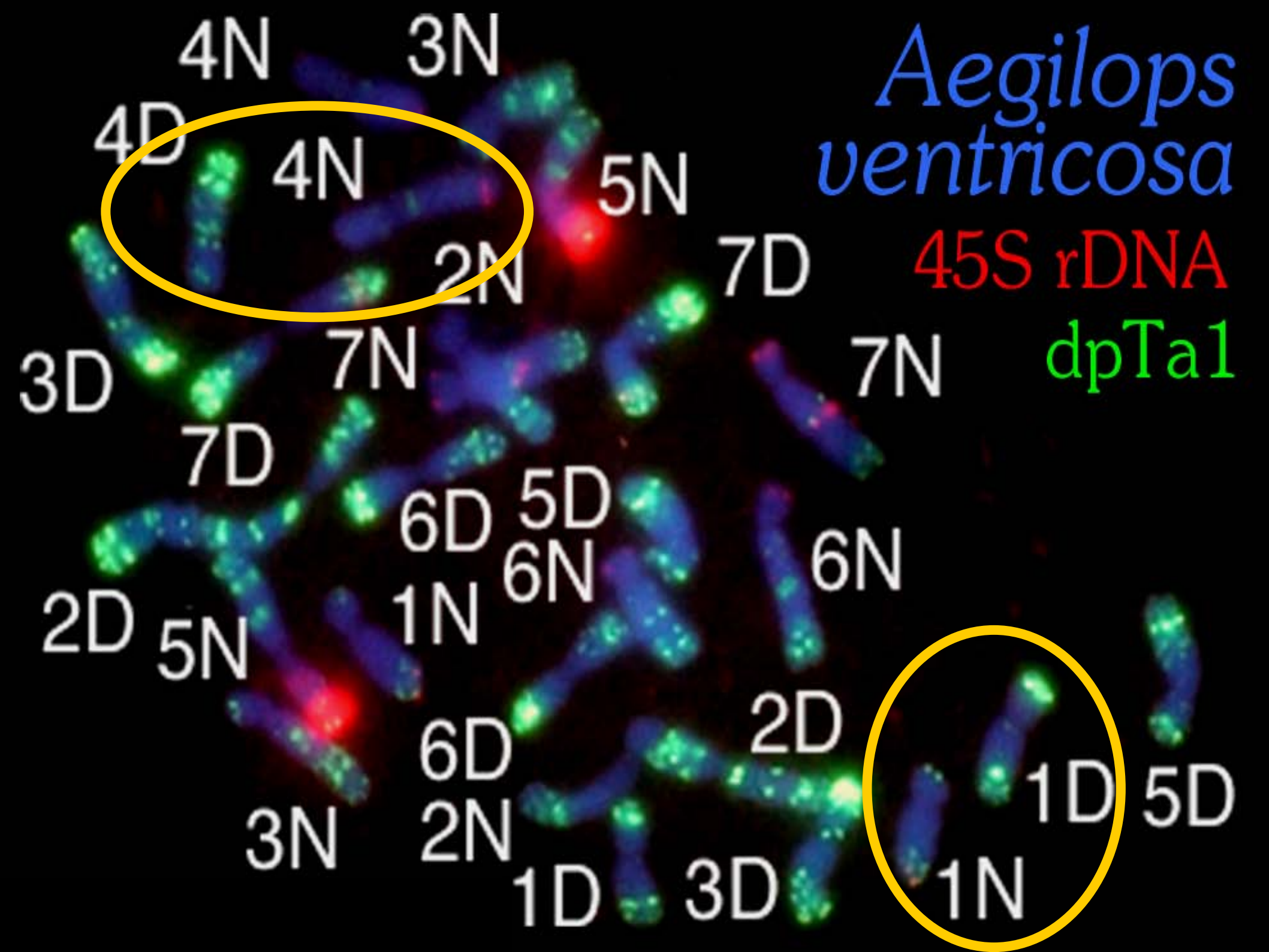
Rye
Secale cereale
2n=14

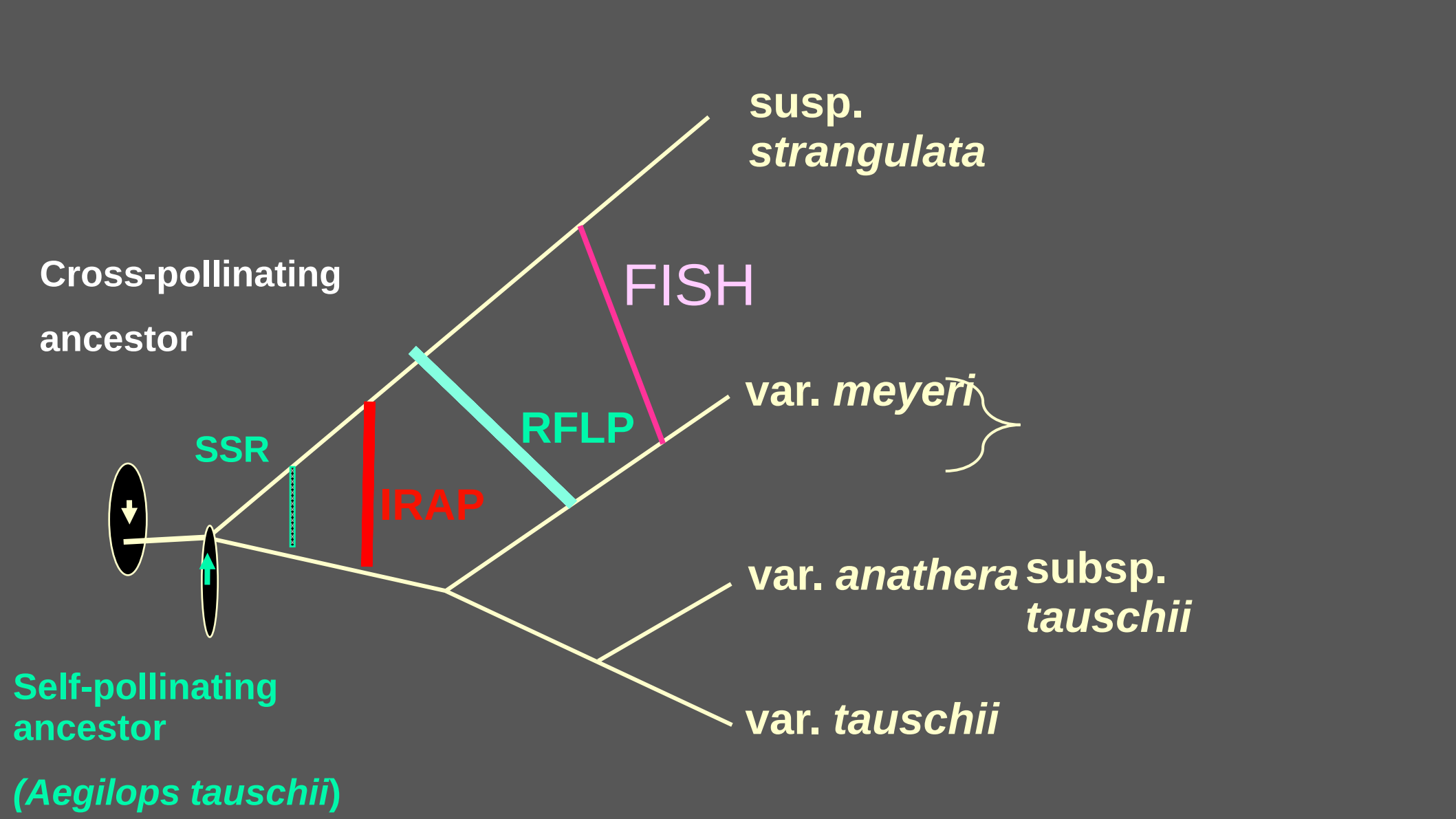
DAPI

Tandem satellite repeat probe
FITC/Alexa 488

(GACA) microsatellite probe
Cy3/Alexa 594

Wheat 'Chinese Spring'

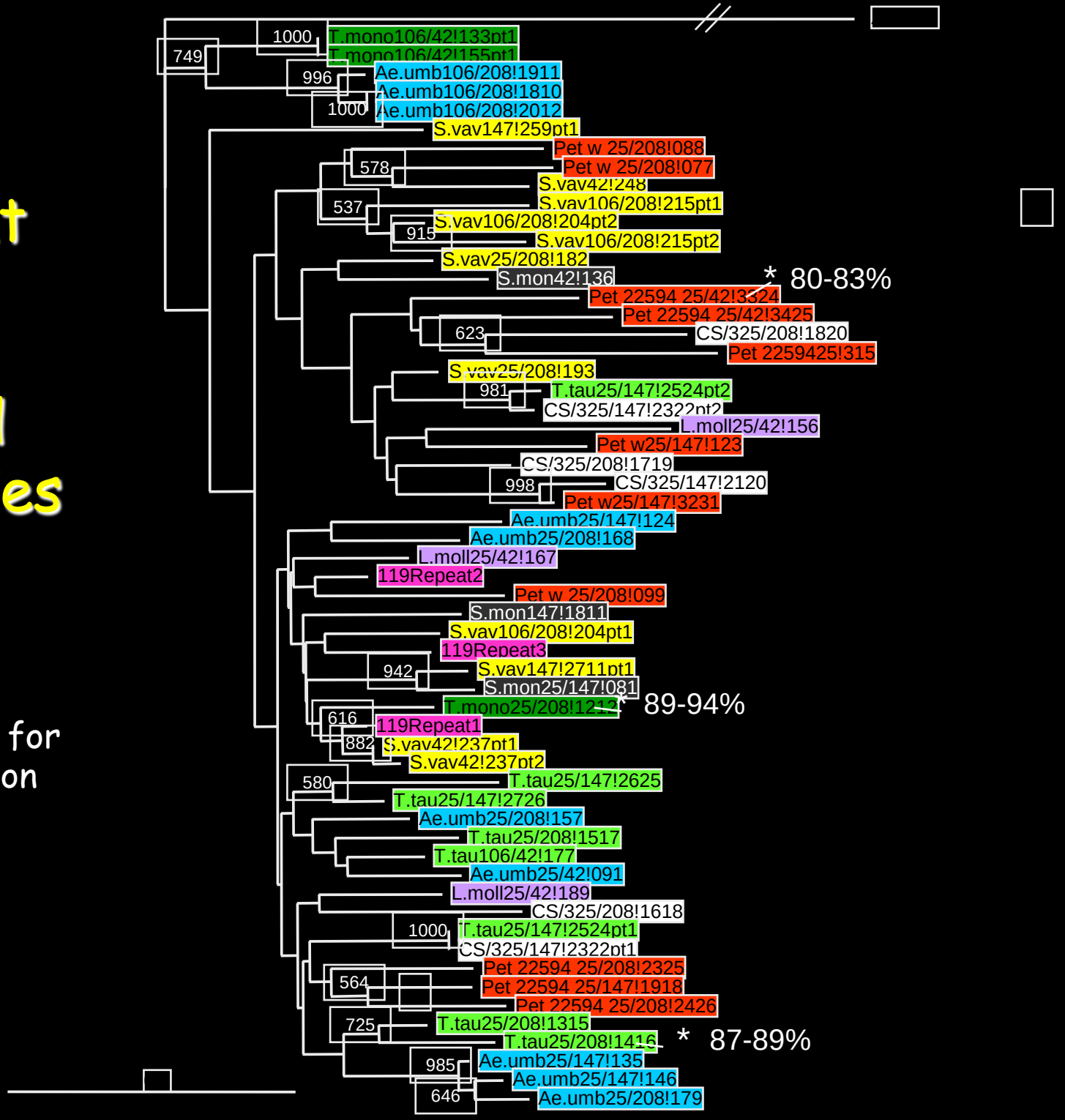

4N
3N
4D
4N
5N
2N
7D
7N
3D
7N
7D
6D
5D
6N
6N
1N
2D
5N
6D
2D
1D
5D
3N
2N
1D
3D
1N
Aegilops ventricosa
45S rDNA
dpTa1



An evolutionary model supported by molecular analyses

Saeidi, HH et al. 2010

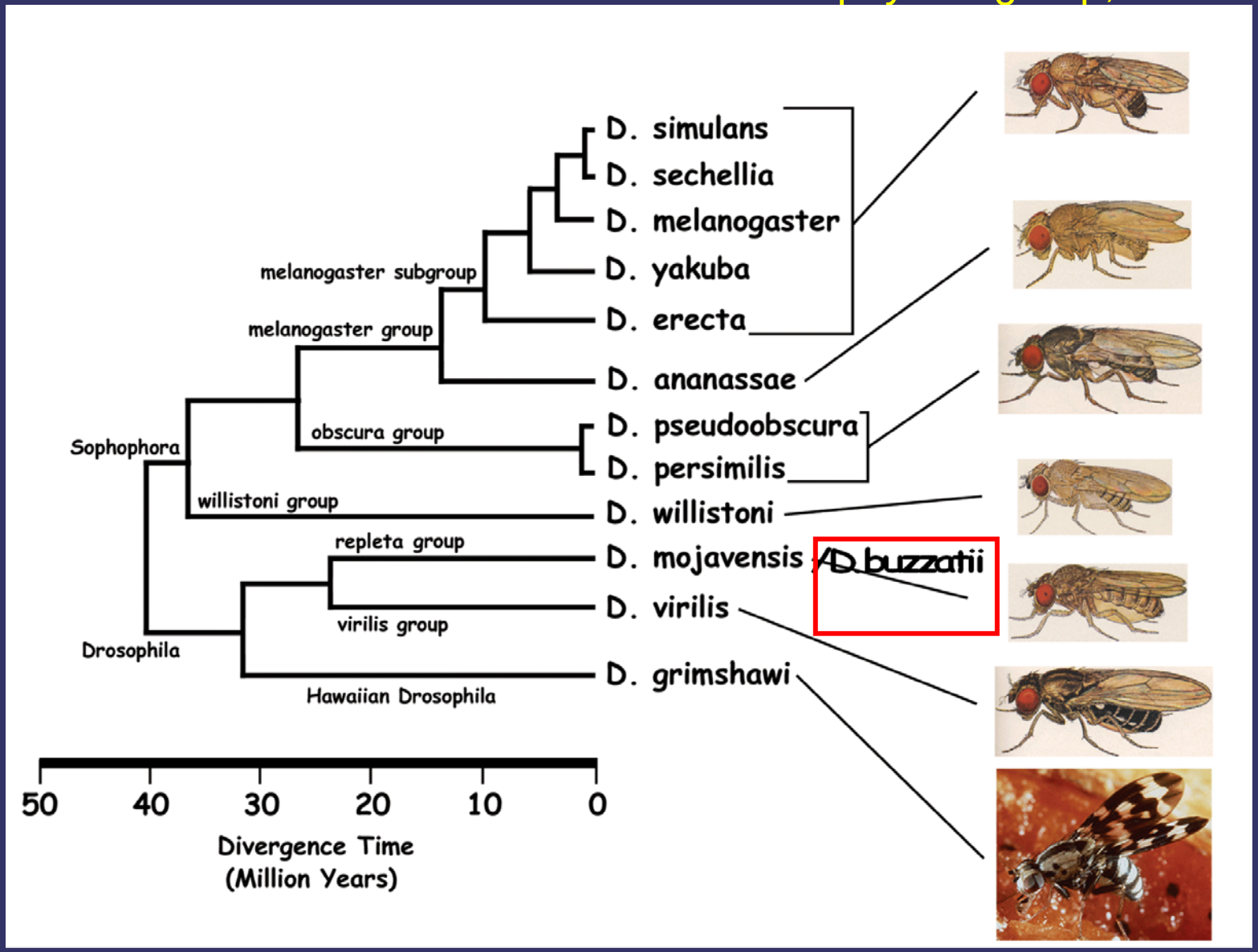
120bp repeat unit family in *Triticum*, *Aegilops* and *Secale* species

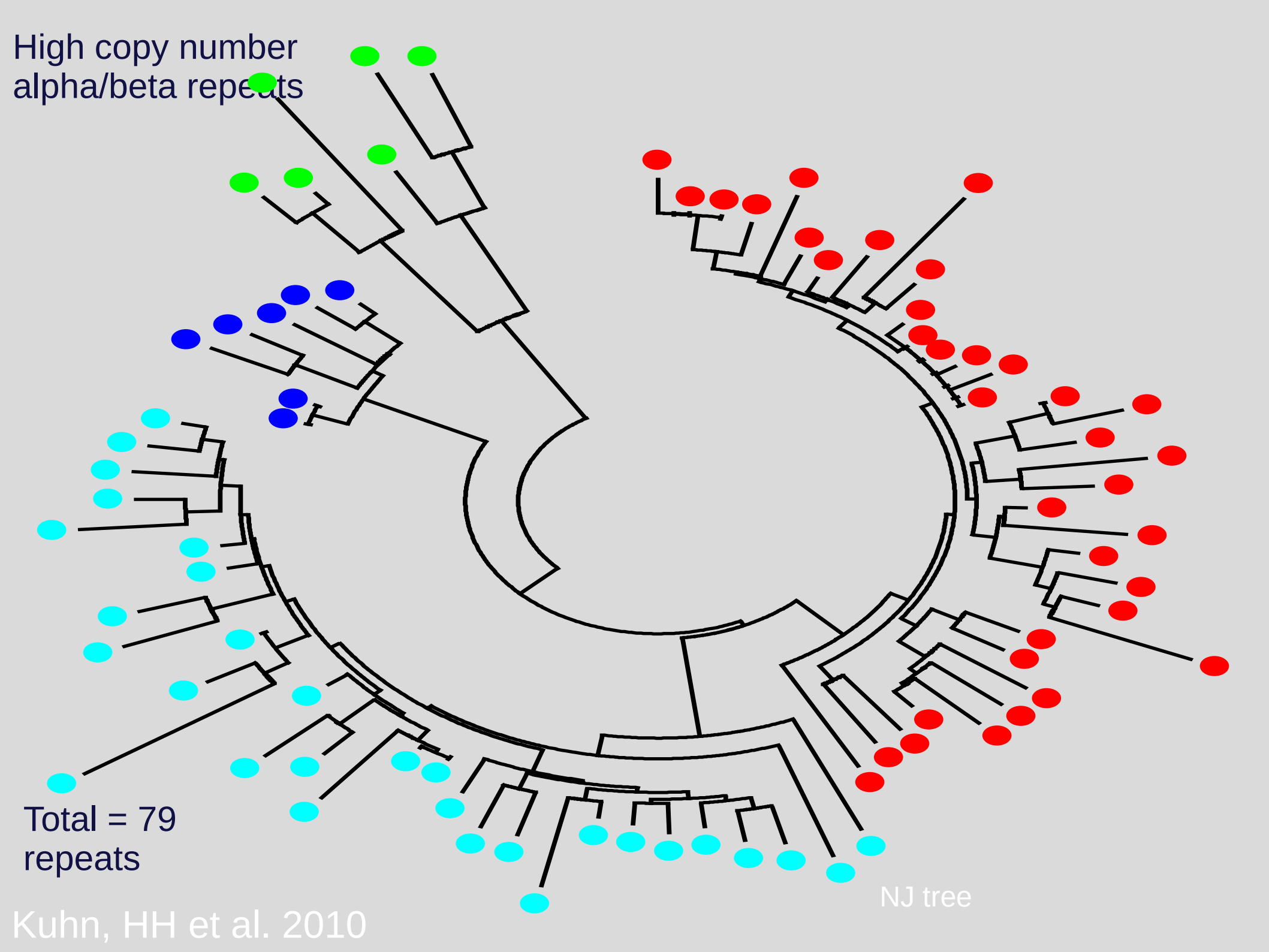


* Sequences used for *in situ* hybridization

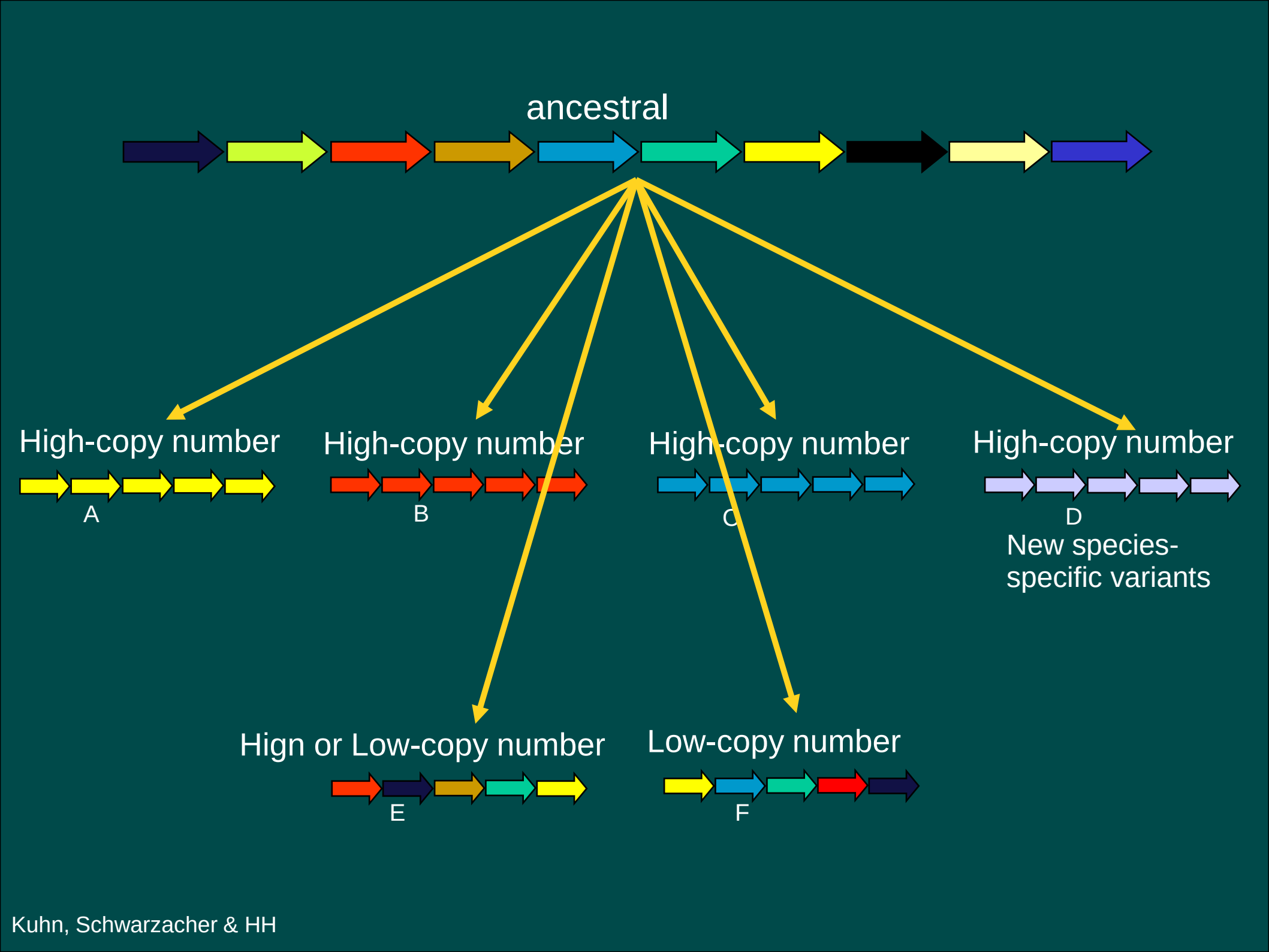
The *Drosophila buzzatii* cluster
Guto Kuhn

- ✓ well-defined South-American monophyletic group;



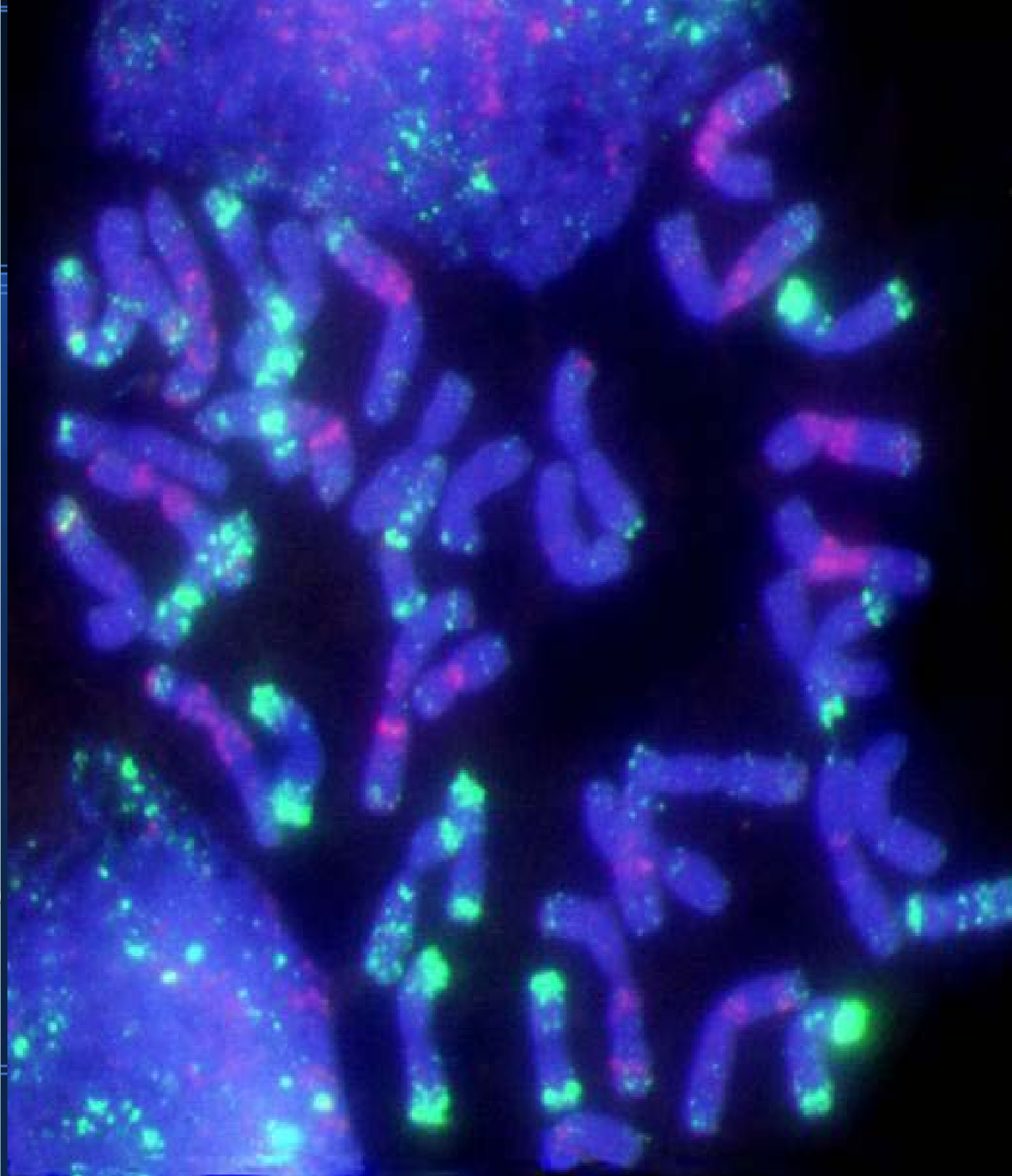


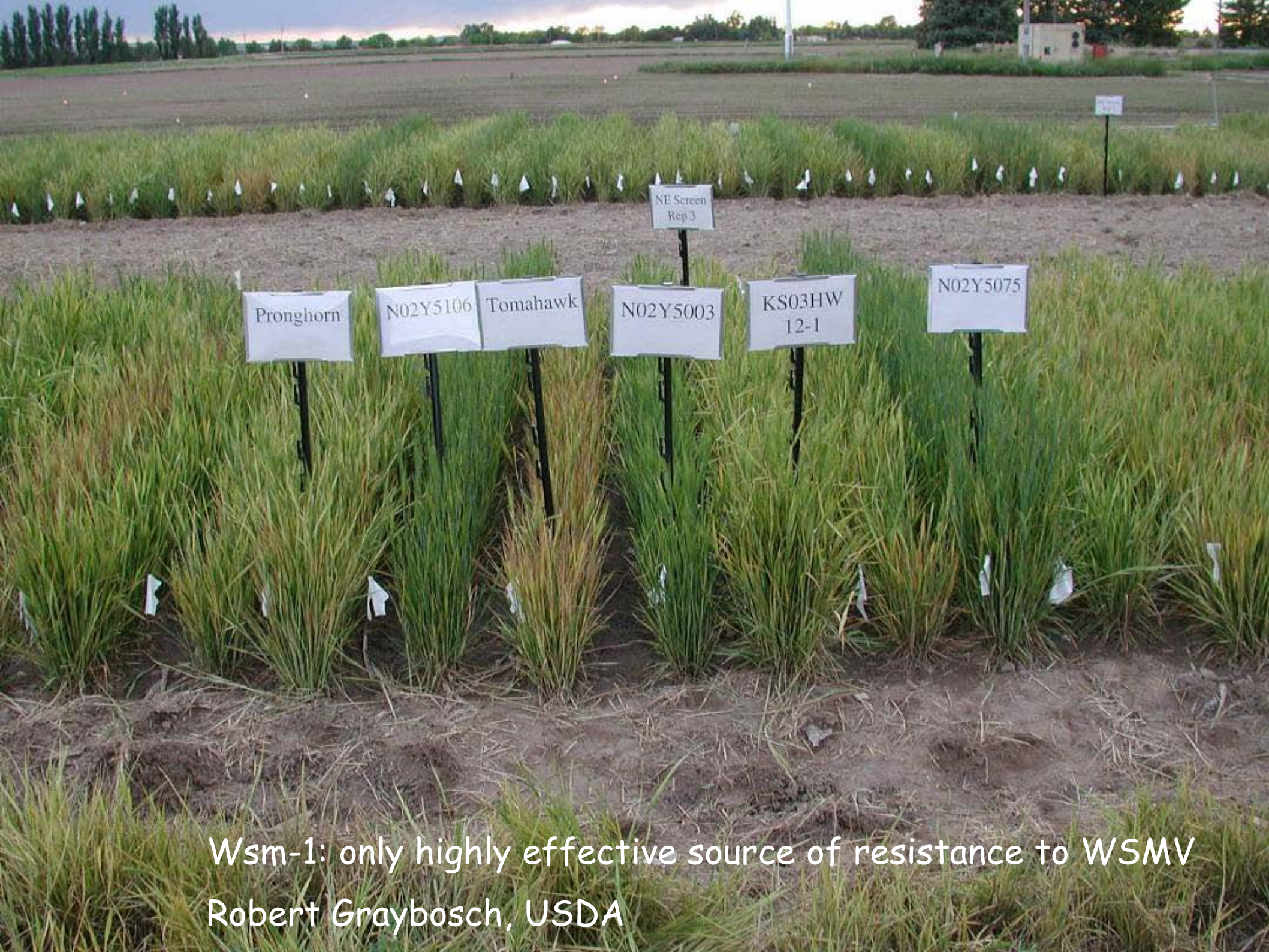
Kuhn, HH et al. 2010



Kuhn, Schwarzacher & HH

Lodging in cereals
UK July 2007





Wsm-1: only highly effective source of resistance to WSMV

Robert Graybosch, USDA


Mace wheat
Graybosch et al. 2009
In situ: Niaz Ali & Schwarzacher

Registration of 'Mace' Hard Red Winter Wheat

R. A. Graybosch,* C. J. Peterson, P. S. Baenziger, D. D. Baltensperger, L. A. Nelson, Y. Jin, J. Kolmer, B. Seabourn, R. French, G. Hein, T. J. Martin, B. Beecher, T. Schwarzacher, and P. Heslop-Harrison

ABSTRACT

'Mace' (Reg. No. CV-1027, PI 651043) hard red winter wheat (*Triticum aestivum* L.) was developed by the USDA-ARS and the Nebraska Agricultural Experiment Station and released in December 2007. Mace was selected from the cross Yuma//PI 372129/3/CO850034/4/4*Yuma/5/(KS91H184/Arlin S//KS91HW29/3/NE89526). Mace primarily was released for its resistance to *Wheat streak mosaic virus* (WSMV) and adaptation to rainfed and irrigated wheat production systems in Nebraska and adjacent areas in the northern Great Plains. Mace was derived from a head selection made from a heterogeneous, in terms of field resistance to WSMV, F_5 line. Resistance to WSMV is conditioned by the *Wsm-1* gene, located on an introgressed chromosome arm from *Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey [*Agropyron intermedium* (Horst.) Beauv.] present as a 4DL.4AgS chromosomal translocation. Mace was tested under the experimental designation N02Y5117.

Abbreviations: NRPN, Northern Regional Performance Nursery; PCR, polymerase chain reaction; WSBMV, *Wheat soilborne mosaic virus*; WSMV, *Wheat streak mosaic virus*.

Published in the Journal of Plant Registrations 3:51–56 (2009).
doi: 10.3198/jpr2008.06.0345crc

677 S. Segoe Rd., Madison, WI 53711 USA

such line, subsequently named 'Mace' (Reg. No. CV-1027, PI 651043), was deemed suitable for cultivar release. Mace is a hard red winter wheat cultivar developed cooperatively by the USDA-ARS and the Nebraska Agricultural Experiment Station and released in 2007 by the developing institutions. Mace was released primarily for its field resistance to *Wheat streak mosaic virus* (WSMV) and adaptation to rainfed and irrigated wheat production systems in Nebraska and adjacent areas in the northern Great Plains. Resistance to WSMV is conditioned by the *Wsm-1* gene (Seifers et al., 1995), situated on an introgressed chromosome arm from

Threats to sustainability: no different for 10,000 years

Habitat destruction

Climate change (abiotic stresses)

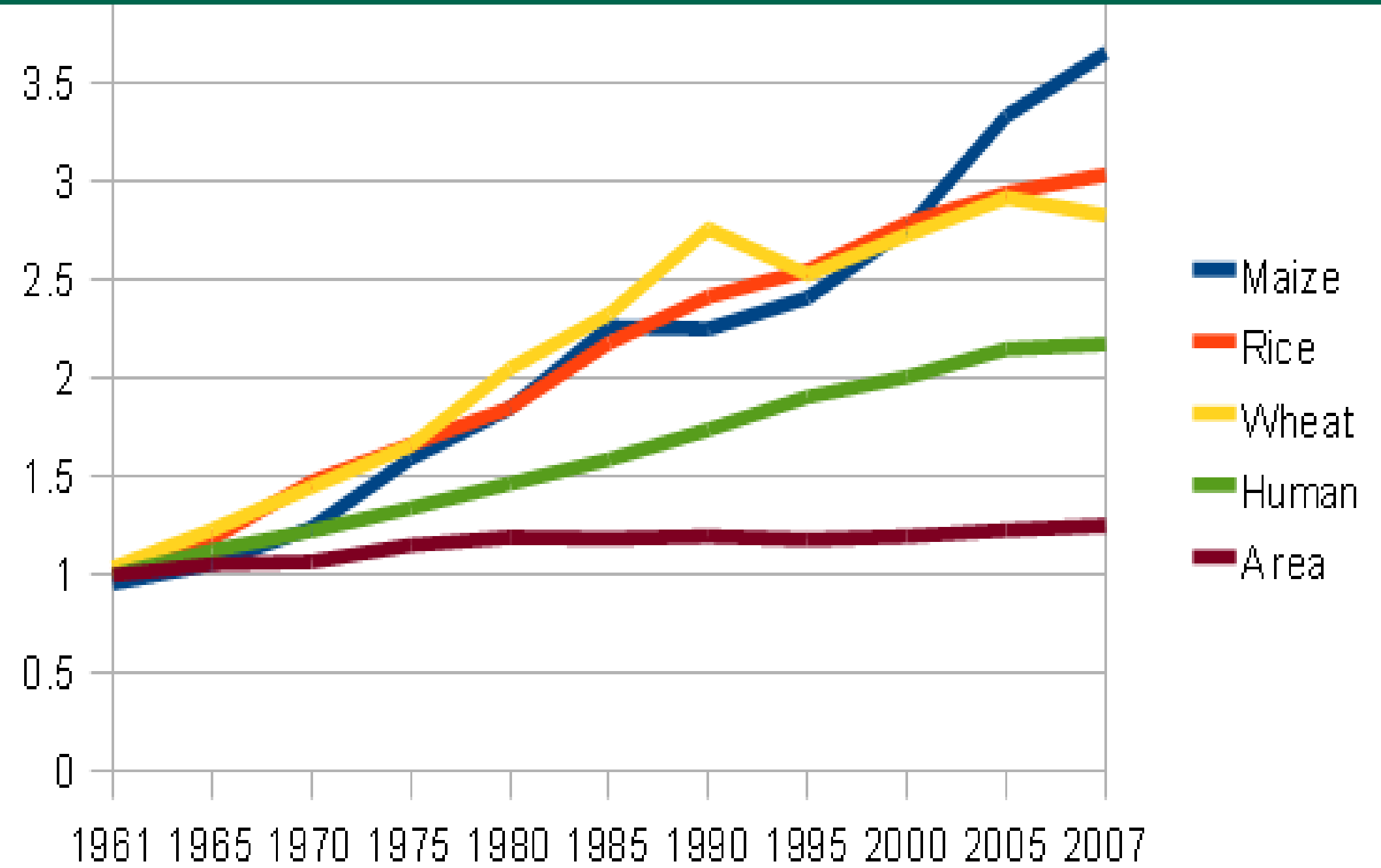
Diseases (biotic stresses)

Changes in what people want

Blindness to what is happening

Unwillingness to change

Cereal Production 1961-2007



United Nations Millennium Developme

- Goal 1 – Eradicate extreme poverty and hunger
- Goal 2 – Achieve universal primary education
- Goal 3 – Promote gender equity and empower women
- Goal 4 – Reduce child mortality
- Goal 5 – Improve maternal health
- Goal 6- Combat HIV/AIDS, malaria and other diseases
- Goal 7 - Ensure environmental sustainability
- Goal 8 - Develop a global partnership for development

United Nations Millennium Development Goals

Goal 1 – Eradicate extreme poverty and hunger

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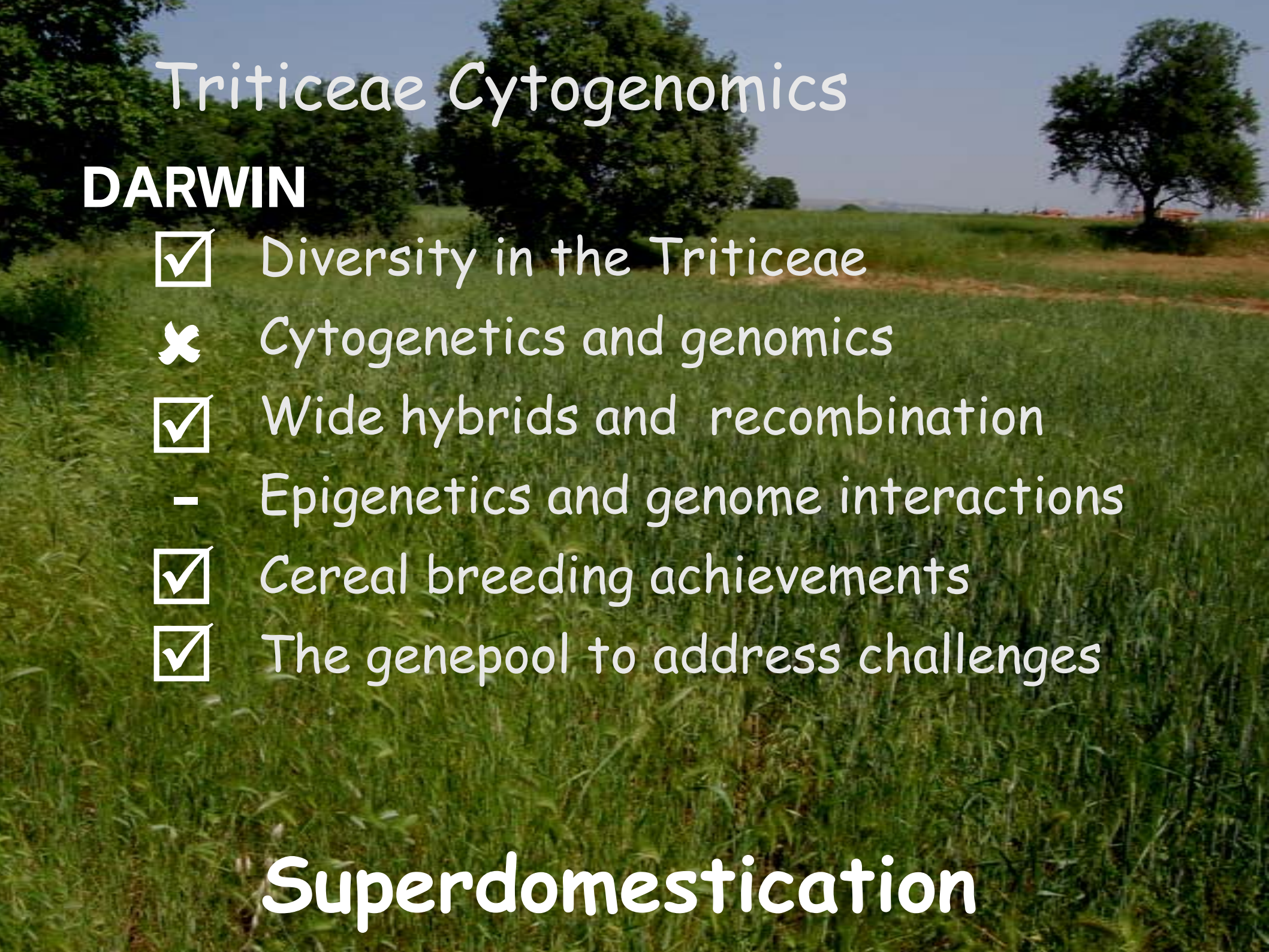
Triticeae Cytogenomics
DARWIN
☑ Diversity in the Triticeae
✂ Cytogenetics and genomics
☑ Wide hybrids and recombination
– Epigenetics and genome interactions
☑ Cereal breeding achievements
☑ The genepool to address challenges
Superdomestication

Darwin in the 21st Century

Domestication, Diversity and Darwin: what we now know about chromosomes

Pat Heslop-Harrison

www.molecularcytogenetics.com

www.molcyt.com user/pw 'visitor'

phh4@le.ac.uk

University of Leicester