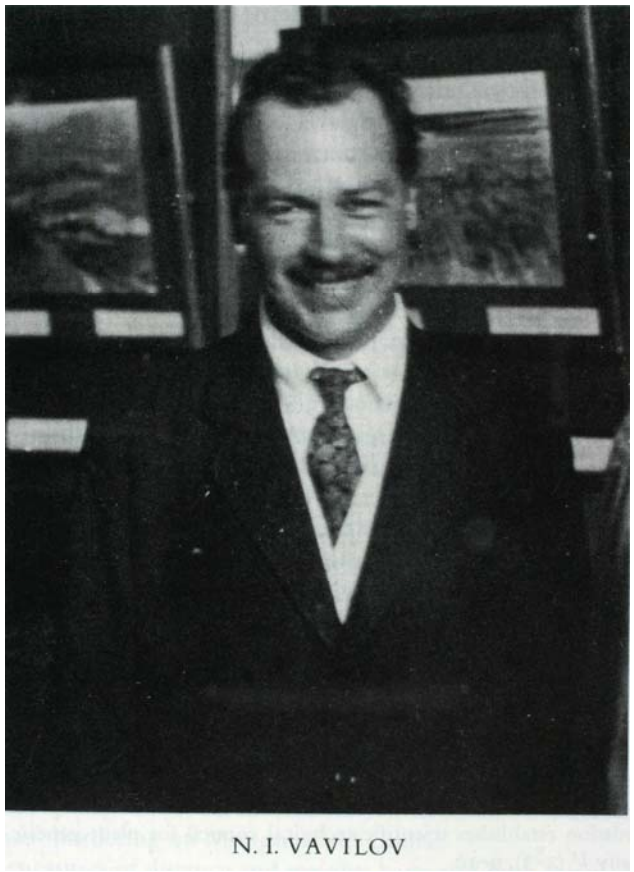
INTRODUCTION



N. I. VAVILOV

MEXICO AND CENTRAL AMERICA

Fig. 15. N. I. Vavilov in a Mexican market place, buying bean seeds.

Nikolai I.Vavilov (1887-1943)

Born in Moscow 1887, studied with William Bateson (first director of John Innes Institue) 1913/1914, Professor at Moscow University 1914, in Saratov 1917, President of the Lenin Academy of Agricultural Sciences and Director of Institute of Applied Botany in Leningrad (St. Petersburg) 1921; establishment of more than 400 research institutes with staff of 20,000; 1921-1934: expeditions to about 180 areas around the world, he himself 52 different countries; elected foreign member of the Royal Society of Great Britain 1942.






Further Photographs and a Drawing

Above, left with William Bateson. - Below, right: imprisoned in August 1940, first in Moscow, later in Saratov, died of starvation on 26 January 1943

[For most of the sources of the photographs see google, Bilder Vavilov].

Vavilov‘s Major Expeditions

According to http://www.vir.nw.ru/history/vavilov.htm

- **1916 Expedition to Iran (Hamadan and Khorasan) and Pamir (Shungan, Rushan and Khorog).**
- **1921 Acquaintance trip to Canada (Ontario) and USA (New York, Pennsylvania, Maryland, Virginia, North and South Carolina, Kentucky, Indiana, Illinois, Iowa, Wisconsin, Minnesota, North and South Dakota, Wyoming, Colorado, Arizona, California, Oregon, Maine).**
- **1924 Expedition to Afghanistan (Herat, Afghan Turkestan, Gaimag, Bamian, Hindu Kush, Badakhshan, Kafiristan, Jalalabad, Kabul, Herat, Kandahar, Baquia, Helmand, Farakh, Sehistan), accompanied by D.D. Bukinich and V.N. Lebedev.**
- **1925 Expedition to Khoresm [Usbekistan] (Khiva, Novyi Urgench, Gurlen, Tashauz).**
- **1926-1927 Expedition to Mediterranean countries (France, Syria, Palestine, Transjordan, Algeria, Morocco, Tunisia, Greece, Sicily, Sardinia, Cyprus and Crete, Italy, Spain, Portugal, and Egypt, where Gudzoni was explored by Vavilov's request) and to Abyssinia (Djibouti, Addis Ababa, banks of Nile, Tsana Lake), Eritrea (Massaua) and Yemen (Hodeida, Jidda, Hedjas).**
- **1927 Exploration of mountainous regions in Wuertemberg and[?Bavaria], Germany).**
- **1929 Expedition to China (Xinjiang - Kashgar, Uch-Turfan, Aksu, Kucha, Urumchi, Kulja, Yarkand, Hotan) together with M.G. Popov, then alone to Chine (Taiwan), Japan (Honshu, Kyushu and Hokkaido) and Korea.**
- **1930 Expedition to USA (Florida, Louisiana, Arizona, Texas, California), Mexico, Guatemala and Honduras.**
- **1932-1933 Trip to Canada (Ontario, Manitoba, Saskatchewan, Alberta, British Columbia), USA (Washington, Colorado, Montana, Kansas, Idaho, Louisiana, Arkansas, Arizona, California, Nebraska, Nevada, New Mexico, North and South Dakotas, Oklahoma, Oregon, Texas, Utah);**
- **Expedition to Cuba, Mexico (Yucatan), Ecuador (Cordilleras), Peru (Lake Titicaca, Puno Mt., Cordilleras), Bolivia (Cordilleras), Chile (Panama River). Brazil (Rio de Janeiro, Amazon), Argentina, Uruguay, Trinidad and Porto Rico.**
- **1921-1940 Systematic explorations of the European part of Russia and the whole regions of the Caucasus and the Middle Asia.**

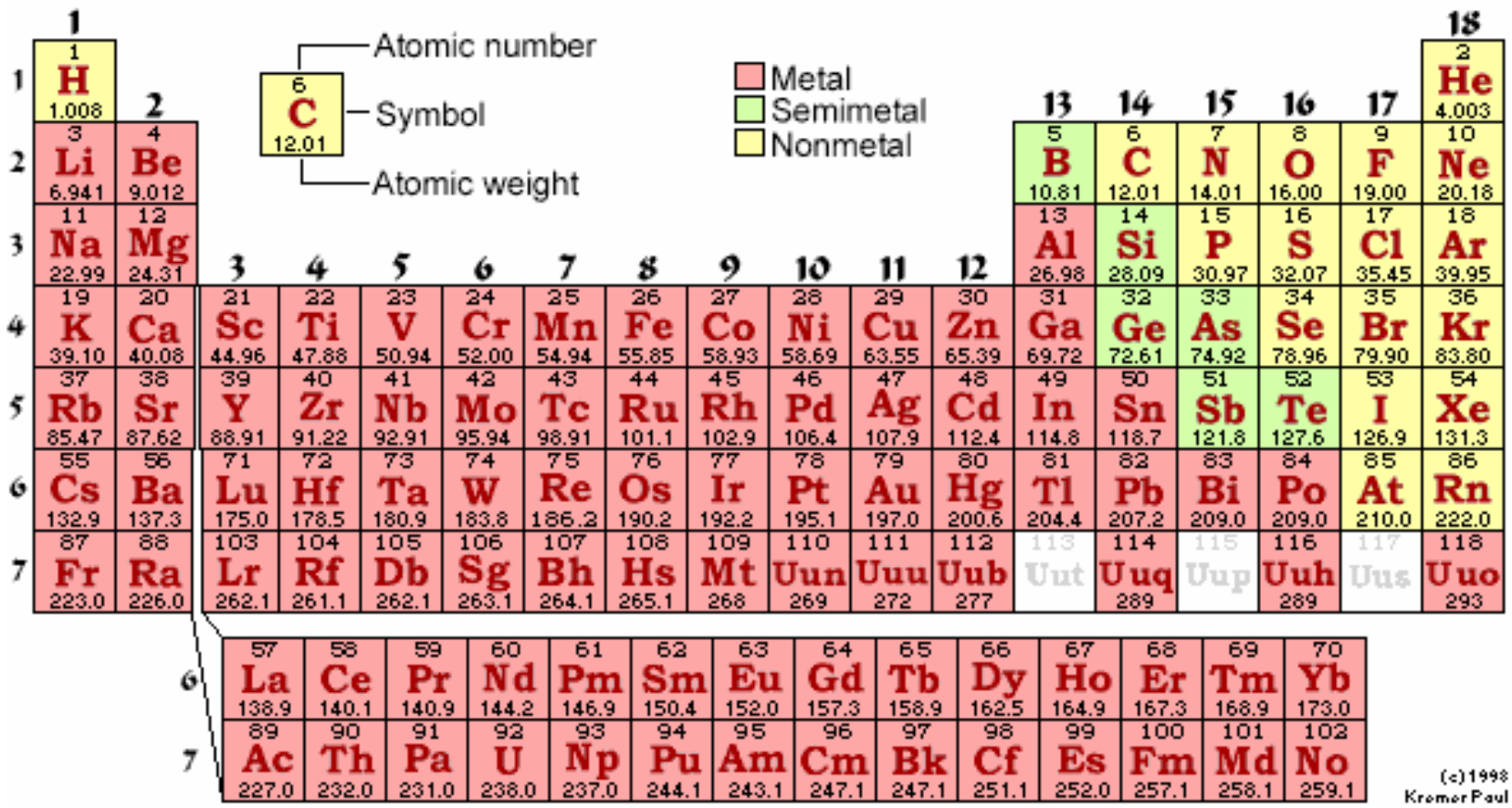
N. I. Vavilov (1922):
THE LAW OF HOMOLOGOUS SERIES IN VARIATION

(1935): THE LAW OF HOMOLOGOUS SERIES IN THE INHERITANCE OF VARIABILITY

The Objects of Vavilov's Papers

- **"The multitudinous chaos of innumerable forms obliges investigators to look for some way of simplification. The process of differentiation will go on inevitably, adding to the records of existing forms, and giving a true conception of Linneons [species]. But parallel to differentiation it is natural to search for ways of *integration* of our knowledge of Jordanons [races] and Linneons [species] themselves. If some 130,000 [240,000] Linneons [species] are difficult to manage for investigation, the work with tens and hundreds of millions of Jordanons [races/varieties] will be still more complicated."**
- **"As formerly, in the study of dead organic and inorganic worlds, so at the present, the problem before the investigator of the animal and plant world is to explore the regularities in polymorphism, and to establish its classes."**

Vavilov 1922, p. 88: "The existing systems of Linneons [species] and varieties ought to be fundamentally changed, and constructed according to a general plan. Instead of occasional characters, which usually determine species and varieties, it would be more rational to follow a general system. The greatest problem of systematists is to build up a general well sustained monotypical system, where *similarity and homological series of variation* would be considered as the fundamental basis, instead of an indefinite tangle of names impossible to remember." [Ansatz erinnert an das Periodensystem der Elemente, im Folgenden nach Kremer Paul:]



General Scheme of Variability in Species of the Papilionaceae:—

	Heritable variable character	*Pisum sativum* L.—Pea	*Vicia sativa* L.—Vetch	*Vicia faba* L.—Broad-bean	*Lens esculenta* Moench.—Lentil	*Lathyrus sativus* L.—Grass pea	*Cicer arietinum* L.—Chick pea	*Glycine hispida* Max.—Soybean	*Phaseolus vulgaris* L.—Bean	*Canavalia gladiata* DC—Canavalia	*Stizolobium hassjoo* Piper—Velvet bean	*Cajanus indicus* Spreng.—Pigeon pea	*Medicago sativa* L.—Blue alfalfa	*Trifolium pratense* L.—Red clover	*Lotus corniculatus* L.—Bird's foot trefoil
Blossom characters	Color of blossom: White	+	+	+	+	+	+	+	+	+	+	..	+	+	+
	Rose	+	+	+	+	+	+	+	+	+	..	..	+	+	..
	Red	+	..	+	..	+	+	+	+	+	..	..	+	+	..
	Violet-blue	+	+	+	+	+	+	+	+	+	+	..	+	+	..
	Yellow	+	..	+	..	..	+	..	..	..	..	+	+	..	+
	Variegated: Color of standards quite different from color of wings	+	+	+	..	+	..	+	+	..	..	..	..	..	..
	Wings and standard spotted or striped	..	+	..	..	+	..	+	..	..	..	+	+	..	+
	Size of blossom: Large	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Small	+	+	+	+	+	+	+	+	..	..	+	+	+	+
Fruit characters	Structure of pod wall: With parchment layer	+	..	+	..	..	..	..	+	+	+	..	..	..	..
	Without parchment layer	+	+	+	+	+	+	..	+	..	..	+	..	..	..
	Form of pod: Linear	+	+	+	..	+	..	..	+	+	+	+	..	..	+
	Rhombic	..	+	+	+	+	+	..	..	..	..	..	+	..	..
	Crescent shaped	+	+	+	..	..	..	..	+	..	+	..	..	..	..
	Sword shaped	+	..	+	..	..	..	..	+	+	+	..	..	..	..
	Bead-like	+	+	+	..	..	..	..	+	..	..	+	..	..	..
	Hairy	..	+	+	..	+	+	+	+	..	+	+	..	..	..
	Smooth	+	+	+	+	+	..	..	+	+	..	+	..	..	+

	Heritable variable character		*Pisum sativum* L.—Pea	*Vicia sativa* L.—Vetch	*Vicia faba* L.—Broad-bean	*Lens esculenta* Moench.—Lentil	*Lathyrus sativus* L.—Grass pea	*Cicer arietinum* L.—Chick pea	*Glycine hispida* Max.—Soybean	*Phaseolus vulgaris* L.—Bean	*Canavalia gladiata* DC—Canavalia	*Stizolobium hassjoo* Piper—Velvet bean	*Cajanus indicus* Spreng.—Pigeon pea	*Medicago sativa* L.—Blue alfalfa	*Trifolium pratense* L.—Red clover	*Lotus corniculatus* L.—Bird's foot trefoil
Fruit and seed characters	Color of ripe pod	Yellow	+	+	..	..	..	..	..	+	..	..	..	..	..	..
		Green	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Violet (with anthocyanin)	+	+	..	+	+	+	+	+	..	..	+	+	+	..
		Yellow-green	+	+	..	..	+	+	+	+	+	..	+	..	+	..
		Black (dark brown)	+	+	+	+	..	+	+	+	..	+	+	..	..	+
		Spotted (striped)	..	..	..	+	+	..	..	+	..	..	+	..	..	..
	Size of pod	Large	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Small	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Surface of pod	Smooth	+	+	+	+	+	+	+	+	+	..	+	..	..	+
		Tuberculate	+	+	+	..	..	..	..	+	+	..	..	..	..	..
		Convex	+	+	+	+	+	+	+	+	+	+	+	..	..	..
		Flat	+	+	+	+	+	..	+	+	+	+	+	..	..	..
	Seed form	Spherical	+	+	+	+	+	+	+	+	..	+	+	+	+	+
		Oval (egg-shaped)	+	+	+	..	..	+	..	+	+	+	+	+	+	..
		Cylindrical	..	+	+	..	..	..	..	+	+	..	+	..	..	..
		Flat (disk-shaped)	+	+	+	+	+	..	+	+	+	..	+	+	+	..
		Angular	+	+	+	..	+	+	..	+	..	..	..	..	..	..
		Kidney-shaped	+	..	+	..	..	..	..	+	+	+	..	+	+	..
	Seed surface	Smooth	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Wrinkled	+	+	+	..	+	+	+	+	+	..	..	..	..	..
	Seed color	White	+	+	+	..	+	+	..	+	+	+	+	..	..	..
		Yellow	+	+	+	+	+	+	+	+	+	..	+	+	+	..
		Green	+	+	+	+	+	..	+	+	..	..	+	+	+	..
		Gray	+	+	..	+	+	..	+	+	..	..	+	..	..	..
		Rose	+	+	+	+	+	+	..	+	+	..	+	+	..	..
		Red (terra-cotta)	+	+	+	+	+	..	..	+	+	..	+	..	..	..
		Brown	+	+	+	+	+	+	+	+	..	+	+	+	+	+
		Black	+	+	+	+	..	+	+	+	..	+	+	..	..	..
	Variegation of seed coat	Marbled	+	+	+	+	+	+	+	+	..	+	+	+	+	+
		Punctate	+	+	..	+	+	+	+	+	..	..	+	..	..	+
		Spotted	+	+	+	+	+	+	+	+	..	..	+	..	..	..

	Heritable variable character		*Pisum sativum* L.—Pea	*Vicia sativa* L.—Vetch	*Vicia faba* L.—Broad-bean	*Lens esculenta* Moench.—Lentil	*Lathyrus sativus* L.—Grass pea	*Cicer arietinum* L.—Chick pea	*Glycine hispida* Max.—Soybean	*Phaseolus vulgaris* L.—Bean	*Canavalia gladiata* DC—Canavalia	*Stizolobium hassjoo* Piper—Velvet bean	*Cajanus indicus* Spreng.—Pigeon pea	*Medicago sativa* L.—Blue alfalfa	*Trifolium pratense* L.—Red clover	*Lotus corniculatus* L.—Bird's foot trefoil
Seed characters	Color of Cotyledons	Green (gray)	+	+	..	+	..	..	+	+	+	+	+	..	..	+
		Yellow	+	+	+	+	+	+	+	+	..	..	+	..	..	..
		Red (orange)	+	+	..	+	..	..	..	+	..	..	..	..	..	..
	Seed size	Large	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Small	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Color of scar	White	+	+	+	+	+	+	+	+	+	+	+	..	..	+
		Brown	+	+	+	+	+	..	+	+	..	..	..	..	..	..
		Black	+	..	+	+	..	..	+	+	+	..	..	..	..	..
Leaf characters	Leaf structure	With tendrils	+	+	..	+	+	..	..	..	..	..	..	..	..	..
		Without tendrils	+	..	+	+	..	+	+	+	+	+	+	+	+	+
	Leaf form	Linear	..	+	..	+	+	..	..	..	..	..	..	..	..	+
		Wedge-shaped	+	+	+	..	..	..	+	+	..	..	..	..	..	..
		Oval	+	+	+	+	+	+	+	+	+	+	+	+	..	+
	Size of leaf	Long	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Short	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Wide	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Narrow	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Leaf margin	Entire	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Toothed	+	+	+	..	..	+	..	..	..	..	..	+	..	..
	Hairiness of leaves	Hairy	..	+	..	+	..	+	+	+	+	+	+	+	+	+
		Smooth	+	+	+	..	+	..	..	..	+	..	..	+	+	+
	Color of stipules	Green	+	+	+	+	+	+	+	+	+	+	..	..	..	..
		With anthocyanin	+	+	+	..	+	+	+	+	+	..	..	..	..	..
	Color of leaves	Yellow	+	+	..	+	..	+	+	+	..	..	..	+	+	..
		Green	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Waxy layer on plant	With waxy layer	+	+	..	..	+	..	..	..	..	..	..	..	..	..
		Without waxy layer	+	+	..	+	+	+	+	+	+	..	+	..	..	+

Heritable variable character			*Pisum sativum* L.—Pea	*Vicia sativa* L.—Vetch	*Vicia faba* L.—Broad-bean	*Lens esculenta* Moench.—Lentil	*Lathyrus sativus* L.—Grass pea	*Cicer arietinum* L.—Chick pea	*Glycine hipida* Max.—Soybean	*Phaseolus vulgaris* L.—Bean	*Canavalia gladiata* DC—Canavalia	*Stizolobium hassjoo* Piper—Velvet bean	*Cajanus indicus* Spreng.—Pigeon pea	*Medicago sativa* L.—Blue alfalfa	*Trifolium pratense* L.—Red clover	*Lotus corniculatus* L.—Bird's foot trefoil
Stem characters	Stem structure	Straight	+	+	+	+	+	+	+	+	+	+	+	..	..	+
		Twining	+	+	..	..	..	..	+	+	+	..	..	..	..	..
	Plant height	High	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Intermediate	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Dwarf	+	+	+	+	..	+	+	+	+	+	+	..	..	+
	Hairiness of stem	Hairy	..	+	..	+	..	+	+	+	+	+	+	+	+	+
		Smooth	+	+	+	..	+	..	..	..	+	..	..	+	+	+
	Form of stem	Cylindrical	..	+	..	..	..	+	+	+	+	+	..	..	+	..
		Four-sided	+	+	+	+	+	+	..	+	..	..	+	..	+	+
		Fascia-like	+	..	..	+	..	..	+	..	..	..	+	..	+	+
	Color of shoots	Green	+	+	..	+	+	+	+	+	+	+	+	+	+	+
		With anthocyanin	+	+	..	+	+	+	+	+	+	+	+	+	+	+
	Color of stem	Green	+	+	..	+	+	+	+	+	+	+	+	+	+	+
		Violet (with anthocyanin)	+	+	..	+	+	+	+	+	+	+	+	+	+	+
	Habit	Erect	+	+	+	+	+	+	+	+	+	+	+	+	..	+
		Decumbent	+	+	..	+	+	+	+	+	..	+	+	+	..	+
Biological characters	Vegetative period	Early	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Late	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Formation of albinos	Present	+	+	+	+	+	+	..	+	..	..	..	+	+	..

General Scheme of Variability in Species of the Gramineae[1]:—

	Heritable variable character	*Secale cereale* L.—Rye	*Triticum sativum* Asch. & Gr.—Wheat	*Hordeum sativum* Jessen—Barley	*Avena fatua* L.—sens. ampl.—Oats	*Panicum miliaceum* L.—Millet	*Andropogon sorghum* Bnot.—Sorghum	*Zea mays* L.—Corn[2]	*Oryza sativa* L.—Rice	*Agropyrum repens* L.—Couch grass
Inflorescence	Articulation of spikelets and florets (tendency to self-sowing) — Spikelets and florets breaking apart on ripening (rachis brittle)	+	+	+	+	+	+	+[3]	+	+
	Articulation of spikelets and florets (tendency to self-sowing) — Spikelets and florets not breaking apart (rachis not brittle)[4]	+	+	+	+	+	+	+	+	+
	Hulledness — Grain hulled (tightly enclosed in glumes); not shattering on maturity	+	+	+	+	+	+	+	+	+
	Hulledness — Grain naked (easily separated from hull in threshing); easily shattering in ripening	+	+	+	+	+	+	+	+	+
	Compactness — Compact	+	+	+	+	+	+	+	+	+
	Compactness — Loose	+	+	+	+	+	+	+	+	+
	Compactness — Intermediate	+	+	+	+	+	+	+	+	+
	Sexuality — Dioecious	+[5]	..	..	..	..	..	+	..	..
	Sexuality — Monoecious	+	+	+	+	+	+	+	+	+

[1] +: Occurrence of the character in some forms of the species.

[2] Including variations in both ear and tassel.

[3] In teosinte, *Euchlaena mexicana*, which gives fertile hybrids with corn, and in such hybrids.

[4] Also in rye, barley, wheat, and a number of species of *Aegilops*, there is a type with separation of only the upper part of the glume (type of *Aegilops cylindrica*).

[5] Found by V. F. Antropova in breeding cultivated rye (1930).

	Heritable variable character		*Secale cereale* L.—Rye	*Triticum sativum* Asch. & Gr.—Wheat	*Hordeum sativum* Jessen—Barley	*Avena fatua* L.—sens. ampl.—Oats	*Panicum miliaceum* L.—Millet	*Andropogon sorghum* Brot.—Sorghum	*Zea mays* L.—Corn	*Oryza sativa* L.—Rice	*Agropyrum repens* L.—Couch grass
Inflorescence	Awnedness	Spikelets awned	+	+	+	+	..	+	..	+	+
		Spikelets awnless	+	+	+	+	+	+	+	+	+
		Spikelets short-awned and semi-awned	+	+	+	+	+	+	..	+	+
		Spikelets with deformed awns (*furcatum* type)	+	+	+	..	..	..	..	..	..
		Spikelets with awnlike appendages	+	+	+	..	..	..	..	..	..
	Character of awns	Coarse	+	+	+	+	..	+	..	+	+
		Fine	+	+	+	+	..	+	..	+	+
		Barbed	+	+	+	+	..	+	..	+	+
		Smooth	..	+	+	+	..	..	..	+	..
	Number of florets in a spikelet	One floret	+	+	+	+	+	+	+	+	..
		Two florets	+	+	(+)	+	+	+	+	+	+
		Several florets	+	+	..	+	..	..	..	..	+
	Color of glumes	White (straw-yellow)	+	+	+	+	+	+	+	+	+
		Red	+	+	+	+	+	+	+	+	+
		Brown	+	+	+	+	+	+	+	+	+
		Gray (black)	+	+	+	+	+	+	+	+	+
		Violet (anthocyanin)	+	+	+	+	+	+	+	+	+
	Hairiness of glumes	Hairy	+	+	+	+	..	+	+	+	+
		Smooth	+	+	+	+	+	+	..	+	+
	Rachis	Simple	+	+	+	..	..	..	..	+	+
		Branched	+	+	+	+	+	+	+	+	+
	Hairness of rachis	Very hairy	+	+	+	+	+	+	+	+	+
		Smooth	..	+	+	+	+	+	..	..	+
		Slightly hairy	+	+	+	+	+	+	+	+	+
	Waxy layer on glumes	Present	+	+	+	+	+	+	+	+	+
		Absent	+	+	+	+	+	+	+	+	+

	Heritable variable character		*Secale cereale* L.—Rye	*Triticum sativum* Asch. & Gr.—Wheat	*Hordeum sativum* Jessen—Barley	*Avena fatua* L.—sens. ampl.—Oats	*Panicum miliaceum* L.—Millet	*Andropogon sorghum* Brot.—Sorghum	*Zea mays* L.—Corn	*Oryza sativa* L.—Rice	*Agropyrum repens* L.—Couch grass
Grain	Color	White	+	+	+	+	+	+	+	+	..
		Green (gray-green)	+	+	+	1	..	+	+	+	+
		Black (dark gray)	+	+	+	+	+	..	+	+	+
		Violet (anthocyanin)	+	+	+	..	..	+	+	+	..
	Form	Round	+	+	+	+	+	+	+	+	..
		Elongate	+	+	+	+	+	+	+	+	+
	Size	Large	+	+	+	+	+	+	+	+	+
		Small	+	+	+	+	+	+	+	+	+
	Consistency of grain	Vitreous	+	+	+	+	+	+	+	+	+
		Mealy	+	+	+	+	+	+	+	+	+
		Waxy (reacting with iodine in contrast to preceding types)	..	(+)	+	..	2	+	+	+	..
Vegetative characters	Leaf structure	Leaves with ligula	+	+	+	+	+	+	+	+	+
		Leaves without ligula	+	+	+	+	+	..	+	+	..
	Stem structure	Hollow	+	+	+	+	+	+	..	+	+
		Solid	+	+	..	3	..	+	+	..	+
	Color of seedlings	Violet (with anthocyanin)	+	+	+	+	+	+	+	+	+
		Green	+	+	+	+	+	+	+	+	+
		Variegated (with white bands)	+	+	+	+	..	+	+	+	+
	Form of growth	Upright	+	+	+	+	+	+	+	+	+
		Sprawling	+	+	+	+	+	+	+	+	+
	Hairiness of stem below the inflorescence	Smooth	+	+	+	..	+	+	..	..	..
		Hairy	+	+	+	..	..	..	+	..	..

[1] In *Avena strigosa* Schreb.
[2] Waxy forms found in Japanese investigations in *Panicum frumentaceum* and *Panicum italicum*.
[3] In *Avena byzantina* Koch have been found forms with very thick-walled straw.

	Heritable variable character		*Secale cereale* L.—Rye	*Triticum sativum* Asch. & Gr.—Wheat	*Hordeum sativum* Jessen—Barley	*Avena fatua* L.—sens. ampl.—Oats	*Panicum miliaceum* L.—Millet	*Andropogon sorghum* Brot.—Sorghum	*Zea mays* L.—Corn	*Oryza sativa* L.—Rice	*Agropyrum repens* L.—Couch grass
Vegetative characters	Hairiness of leaf sheath	Smooth	+	+	+	+	+	+	+	+	+
		Hairy	+	+	+	+	+	..	..	+	+
	Hairiness of leaves	Smooth	+	+	+	+	+	+	+	+	+
		Hairy	+	+	+	+	+	..	+	+	+
	Waxy layer on stems and leaves	With waxy layer	+	+	+	+	+	+	+	+	+
		Without waxy layer	+	+	+	+	+	+	+	+	+
	Thickness of straw	Thick	+	+	+	+	+	+	+	+	+
		Thin	+	+	+	+	+	+	+	+	+
	Nodes	Hairy	..	+	..	+	..	..	+	..	..
		Smooth	..	+	..	+	..	..	+	..	..
	Height of plant	High	+	+	+	+	+	+	+	+	+
		Dwarf	+	+	+	+	+	+	+	+	+
		Medium	+	+	+	+	+	+	+	+	+
	Color of straw	Yellow	+	+	+	+	+	+	+	+	+
		Violet (anthocyanin)	+	+	+	+	+	+	+	+	+
	Color of leaves	Dark green	+	+	+	+	+	+	+	+	+
		Light green	+	+	+	+	+	+	+	+	+
	Width of leaf	Narrow	+	+	+	+	+	+	+	+	+
		Medium	+	+	+	+	+	+	+	+	+
		Wide	+	+	+	+	+	+	+	+	+
	Size of leaf	Large	+	+	+	+	+	+	+	+	+
		Small	+	+	+	+	+	+	+	+	+

	Heritable variable character		*Secale cereale* L.—Rye	*Triticum sativum* Asch. & Gr.—Wheat	*Hordeum sativum* Jessen—Barley	*Avena fatua* L.—sens. ampl.—Oats	*Panicum miliaceum* L.—Millet	*Andropogon sorghum* Brot.—Sorghum	*Zea mays* L.—Corn	*Oryza sativa* L.—Rice	*Agropyrum repens* L.—Couch grass
Biological characters	Growth habit	Winter type	+	+	+	+	..	..	..	+	..
		Spring type	+	+	+	+	+	+	+	+	..
		Semi-winter type	+	+	+	+	+	+	+	+	..
	Earliness	Late forms	+	+	+	+	+	+	+	+	+
		Early forms	+	+	+	+	+	+	+	+	+
	Ecological type	Hydrophytic	+	+	+	+	+	+	+	+	+
		Xerophytic	+	+	+	+	+	+	+	..	+
	Cold resistance	Low	+	+	+	+	+	+	+	+	..
		High	+	+	+	+	+	+	+	+	+
	Response to fertilization	High	+	+	+	+	..	..	+	..	..
		Low	+	+	+	+	..	..	+	..	..
	Character of blossoming	Open	+	+	+	+	+	+	..	+	+
		Closed	+	+	+	+	..	+	..	+	..
	Formation of albinos		+	+	+	+	..	+	+	+	..

5. **Formulation of the Law of Homologous Series:**— The regularities discussed above may be presented by symbols as follows. As we have seen, different Linneons and different genera show great numbers of varying forms. At the same time the range of this variability is similar in related Linneons and genera. For brevity we will designate the different variable characters by letters, *a, b, c, d, e, f, g, h, i, k,* etc. Different expressions of these characters may be designated by subscripts as $a_1\ a_2\ a_3\ a_4\ \ldots\ b_1\ b_2\ b_3\ b_4$, etc. For example the color of the glumes may be designated by the letter a; white glumes will then be a_1, yellow a_2, red a_3, grey a_4, etc.

Linneons and genera are distinguished not only by these characters, but also by specific complexes of morphological, physiological, and genetic nature. These specific differences we may call *radicals*. There can be radicals of species, genera, and whole families. Thus for three closely related Linneons of the same genus we may have the following expression of their morphological and physiological properties:

$$L_1\ (a + b + c + d + e + f + g + h + i + k\ \ldots)$$
$$L_2\ (a + b + c + d + e + f + g + h + i + k\ \ldots)$$
$$L_3\ (a + b + c + d + e + f + g + h + i + k\ \ldots)$$

L_1, L_2, and L_3 are radicals distinguishing these Linneons from one another; *a, b, c* . . . are the varying characters, such as color and form of the glumes, leaves, stems, etc. Each of these characters can be complex in itself, and may be correspondingly divided into a greater or smaller number of morphological and physiological units: a_1, a_2, a_3, etc. Each of these morphological units may be represented in terms of its genotypic composition, in turn, if this is necessary and possible.

SUMMARIZING THE REGULARITIES

- **Vavilov 1935: "Species and genera that are genetically closely related are characterised by similar series of heritable variations with such regularity that knowing the series of forms within the limits of one species, *we can predict the occurrence of parallel forms in other species and genera.* The more closely related the species...in the general system, the more resemblance will there be in the series of variations."**
- **"Whole families of plants in general are characterized by definite cycles of variability occurring through all genera and species making up the family."**

Further Essential Results on “RADICALS”

RADICAL (from Latin, radix: root, basis) “1. Of, pertaining to, or arising from the root. 2. Arising from the base of a stem or an underground stem” (McGraw-Hill Dictionary of Bioscience).

“Radix (from Latin, *basis*) is the number base of a numeral system. For example, binary is "base 2” and thus has a radix of 2” (Wikipedia).

- **Vavilov 1922, pp. 76/77: “Although every one will say there is no difficulty in distinguishing rye and wheat, there are, as a matter of fact, *very few characters really specific to each of these genera* which cannot be met with, although perhaps in some rare varieties, in the other, and which could be considered radicals.”**
- **“*Radicals* of Linneons [species] and genera could be understood as *morphological and physiological complexes specific for single genera and Linneons [species]*; they could be of special genetic nature, but in this direction our knowledge is at present too limited.”**
- **“If we consider from this point of view the modern classifications of plants by systematists into Linneon species and genera, we notice that in many cases they are perfectly correct, through intuition, as the *specific characters of radicals were taken as a basis for the division into Linneons [species] and genera*. Several systematists like Linne, Jussieu, de Candolle, and Boissier, were very sagacious in this respect. But in many other cases it was quite different. *Varietal alternative characters were often mixed with those of radicals*;..”**
- **“From this representation of systematical units it is clear that for systematics and classification of genera and Linneons, as well as for phylogenetical purposes, *only characters of radicals ought to be taken as a basis of separation*.”**
- **“A great number of examples of such an unsuccessful division can be seen in the family of *Cruciferae*. Such genera as *Sinapis* and *Brassica* are not divisible by radicals; their division is based on varietal alternative characters, and as a result it is difficult, and even impossibTe, to say to which genus some varieties are related. Many Linneons of *Cruciferae* appear to be simply different varieties of the same Linneon.”**

Vavilov and Lamarckism

Who is the author of the following comments?

- **"*Changed habits produce an inherited effect*** as in the period of the flowering of plants when transported from one climate to another. ***With animals the increased use or disuse of parts has had a more marked influence***....The great and inherited development of the **udders** in cows and goats in countries where they are habitually milked, in comparison with these organs in other countries, is probably another instance of the **effect of use**. Not one of our domestic animals can be named which has not in some country **drooping ears**; and the view which has been suggested that the **drooping is due to the disuse of the muscles of the ear**, from animals being seldom alarmed, **seems probable**."
- "...natural selection will preserve and thus separate all the superior individuals, allowing them to intercross, and will destroy all the inferior individuals. By this process long continued…combined no doubt ***in a most important manner with the inherited effects of the increased use of parts***, it seems to me almost certain that an ordinary hoofed quadruped might be converted into a **giraffe**."

[**The author is Charles Darwin**!]

Vavilov and Darwin

Vavilov: "In *Pangenesis* and *Mututionstheorie,* we find many facts signifying the existence of parallel variation. " Suchen wir in irgendeiner Flora," writes de Vries in *Mutationstheorie,* p. 454, "diese abgeleiteten Varietäten zusammen, so fällt sofort auf, dass dieselbe Abweichung in der verschiedensten Familien, Gattungen, und Arten wiederkehrt. Überall bilden die Varietaten Reihen von parallelen Formen." *Mutationstheorie,* I. p. 454."

Vavilov: "So far as we know, this kind of variation is not "occasional," as Darwin supposed it to be, *but quite general*…the detailed study of hundreds of Linnean species belonging to different families shows that there are no plants which are an exception to this rule. *Therefore, we may conclude that, in general, closely allied Linnean species are characterized by similar and parallel series of varieties*…" (Italics by Vavilov 1922, pp. 57/58).

"Variation does not take place in[to] all directions, by chance and without order, but in distinct systems and classes analogous to those of crystallography and chemistry. The same great divisions into orders and classes manifest regularities and repetitions of systems" (Vavilov 1922, p. 85).

"The same varieties certainly existed long before selection itself, and the appearance of their series, irrespective of any selection, was in accordance with the laws of variation" (also p. 85).

Vavilov and Darwin (continued)

Vavilov 1935, p. 65: "An exhaustive botanical study of a great number of cultivated plants and their wild relatives, based upon the extensive collection of world materials…has revealed a complete series of heritable forms *within the limits of many species*, surpassing our expectations."

(1935, p. 89): **"Existing systems of Linneons and varieties must be re-evaluated *according to their harmony with a general plan*."**

(1935, p. 90): „The great amount of factual material which the present-day biologist has at his disposal forces him to approach the species in a dialectical fashion, and not to consider it as a fixed entity, the reflection of an act of creation, as the species was formerly regarded. "Since that time, as biology is studied in the light of the theory of evolution"—writes Engels in "Dialectics of Nature"—"in the domain of organic nature, one after another there disappear the hard and fast limits of classification, daily there is an increase in the intermediate links which will not yield to classification. More exact investigations throw organisms out of one class and into another, and *distinguishing characters become hardly more than symbols, losing all absolute significance*."

However, this is what Vavilov really thought (1935, p. 91): *"Thus the Linnean species, in our conception, appears to be a distinct, complex, mobile, morpho-physiological system related in its origin to a definite environment and area, and in its intraspecific hereditary variability, subject to the Law of Homologous Series."*

Yet, species distinction "not absolute" (p. 91).

Law of Homologous Series: Why Relevant for the Future?

1. **Allows *predictions* in actual plant breeding**
2. **Allows *predictions* in systematics**
3. **Distinguishes between *apparent* and *real* plant or animal species and genera (variation of homologous series *vs.* more constant/or really constant 'radicals')**
4. **Thus, the law is focussing the attention on the *essential questions* of the origin of species (e.g. the origin of irreducibly complex systems/synorganized structures/living fossils and others instead of peripheral phenomena, like melanism in about 100 species of butterflies, resistances due to losses of gene functions and other so-called proofs of the synthetic theory)**
5. **In science: pluralism of ideas is *fertile* and, in fact, *necessary* for open problems and progress (in contrast: totalitarianism is *sterile, detrimental,* and *murderous*)**