STALIN PRIZE

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LAND IN BLOOM

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The books of the classics of science seem to us to bear an air of majestic calm. Their serenity is deceptive, however. They were intended for battle, and it was in fierce conflict that they won their right to live. All of them rose in rebellion against what in their time was regarded as incontrovertible knowledge. And to this knowledge, that was armed with the power of long tradition, they opposed their rebellious controversial and unprecedented arguments.

Ptolemy's epicycles in astronomy, phlogiston in physics and the theory of the invariability of species in biology have long been abandoned, however. We scarcely remember the names of those against whom Galileo, Lomonosov and Pasteur conducted their controversies, of those whom Timiryazev ruthlessly fought all his life. Assertions, daring for their novelty, have become obvious truths. And when we read one of the victor-books we now scarcely hear the storm that once raged in it.

Today these books loom before us like a mountain landscape, lit up with a steady, unfading light.

We are accustomed to look upon them with respectful wonder.

In some ways these books are like the paintings by old masters. It is well known that the colours on canvases that have survived generations of men darken and acquire a special, elusive tint. Artists call this imprint of centuries the patina of time.

The works of the great scientists of the past are also, as it were, covered by the patina of time. Even the epoch in science in which they lived and worked appears to us to be tinted by an unusual colour. In our childhood, did not the year in which indomitable Copernicus compelled the Earth to vacate the "shrine" of the world in favour of the Sun seem to us to be an exceptional year; and that day on which that book with the long and clumsy title: *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, came off the press and was completely sold out by the evening, seem a different day from all others? And the decade 1859-69 that followed it! Thousands of people of the most diverse professions, beardless youths, mature adults who had been trained by Belinsky's passionate essays, and old folks who still remember the living Derzhavin, thousands of Russians, were the first in the world to take up a slender, simply written, book, evidently intended for popular consumption, entitled *Reflexes of the Brain*, and a few years later opened another book, that was so unlike an ordinary textbook, entitled *The Principles of Chemistry*, and on both occasions had felt a little giddy, as it were. It seemed as though the skull had become transparent and that it was possible to see the "grey matter" of the cerebral hemispheres through it, and nature's greatest mystery—the psychical work of the brain—had become revealed. The harmonious, majestic Law enunciated in *The Principles of Chemistry*, more universal than the laws governing the motion of stars and planets, embraced the entire universe, the bricks of which it is built—chemical elements, matter itself. . . . The name on the title page of *Reflexes* was Sechenov; the name of the author of *The Principles* was Mendeleyev.

How much water has flowed away since then! In the West the man who wrote *The Origin of Species,* Charles Darwin, was still alive, but a period of dull stagnation was already approaching.

It was then that the pigmies, "a horde of specialists, all sorts of 'ists' and 'ologists,'" as Kliment Arkadievich Timiryazev angrily called them, crept out of all the cracks and crevices of western science. It was then that, overrunning science, they proclaimed that "our age is not an age of great tasks," and they denounced "every one who tried to rise above the common level and scan a wider horizon" as a dreamer and fantast.*

This happened at the time when capitalist society itself was entering its decline and beginning to emit the smell of decay like that of a rotten field in which the crop has been kept standing too long.

It was in that gloomy period that the idea arose that it is necessary to turn to the distant past to see the fabulous giants of science, for no such giants exist now, nor could any arise, it was claimed.

I knew a certain university lecturer. He had not lived in those countries, the epigonal science of which Timiryazev had condemned. Amazing events were taking place under that lecturer's eyes; in his country the science of living nature was, with unexampled daring, raising and solving problems which had been regarded as insoluble and even impossible, like attempting to square the circle.

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* K. A. Timiryazev, "Darwin as a Type of Scientist." An address delivered in 1878.

But this man kept repeating:

"Present-day biology is a Mont Blanc, no, an Everest of irrefutable facts and conclusions that have been tested and retested a thousand times. The times have passed when somebody could come along and lightly stir up with his walking stick, like an anthill, all that had been obtained before him. Our task is to peer diligently into the microscope, number bristles and draw variational curves. A new Darwin is inconceivable. We will be satisfied if we add our pinch of sand to Everest."

He was a contemporary of Pavlov, Michurin and Williams—giants who were second to none in the entire history of natural science. But it seemed as though he was blindfolded. Only in the distant past did he see the creators of "Everest."

But at the time he said this, the "irrefutable" in science was already being refuted. In the incorruptible, powerful light of the new knowledge the smug theories that were being taught in the universities, the dogmas which claimed to be as incontrovertible as the multiplication tables, were proved to be crude fallacies, biased interpretations of preconceivedly chosen facts. Everybody saw that the "conclusions that have been tested a thousand times" were often only jugglery borrowed from bourgeois idealistic biology.

It was not particulars of second-rate importance that were swept away. The battle raged around the very fundamentals of biology. We know that the struggle that the new waged against the old, the living against the dead, materialism against idealism, had raged before, throughout the entire history of biology; but never had it been waged so uncompromisingly and with such triumph for the new; and never had practice of such wide range intervened in controversies about theory.

It was as if the fetters that had bound the ancient science of life had been broken. The profound and exact understanding of living phenomena took the place of lifeless dogmas, reservations and biased interpretations. And so irrefutable was the proof of the effective power of this understanding that all the best representatives of biology, irrespective of the opinions they had formerly held, became convinced that the old views could be adhered to no longer.

This is what happened under our eyes. We are proudly conscious of the fact that it could have happened in no other country but ours.

A revolution in the world-wide development of biology has been brought about. We are witnesses of it.

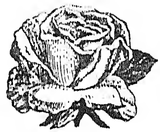
. . .The storm will subside and the new knowledge will then stand out, cast in beautiful and perfect mould. It will appear majestically calm; and the patina of time will also cover the struggle and victory of those fearless innovators, the scientists of our day.

We, the Soviet people of the Stalin epoch, have seen how, in one of the biggest ideological battles fought in the history of natural science, a science of unprecedented might was born, and how this might endows man with fabulous power over nature. And all the obstacles that only yesterday had been proclaimed fatally insurmountable, fall before it.

It is the science of life which teaches man how to transform the surrounding world and to re-create living nature. It is Soviet, Michurin agrobiology. Its features are unexampled. It is the science of the people.

It is about this science that we shall speak here.

THE BATTLEFIELD. GREEN LAND



THE INHABITANTS OF GREEN LAND

We live in Green Land.

This is an immensely vast land. Its inhabitants are constantly around us.

We trample upon them on badly-swept paths. We disdainfully throw them out together with stale crusts covered with greenish, lacelike mould. We admire them at the florists.

Without them we could not exist. They provide our food. They give us pleasure. What city dweller does not hasten to spend a summer's day on the soft, silky grass amidst the rustle of leaves that sounds like the soft lapping of the waves on the seashore? Who has not enjoyed the charm of "mushroom excursions" in the autumn woods? And there are few who have not brought home a bunch of blue cornflowers, or of violet bluebells: they make the most crowded home brighter, cleaner and more cheerful.

And yet, most of us treat the inhabitants of Green Land, the plant world, with supreme contempt.

"They don't live, they vegetate," we say contemptuously of people who eat, drink, sleep, work lazily, read only for pastime, imperceptibly grow old and never see anything beyond their noses.

To us plants seem to be feelingless, powerless and motionless—almost lifeless.

Absent-mindedly, we pluck a leaf and crush it between our fingers. That is all it amounts to: a sticky mess. Can it contain anything of particular importance, or interest?

Those who think like that do not realize that although they meet with millions of plants, they do not really know them. Such people merely roam on the borders of Green Land. They do not know how vast this world is. They have no idea that it is wilful and strong and not uncomplaining and weak; that it is inhabited by tribes more wonderful than those fabulous peoples described by the geographers of the Middle Ages; that there are whole "continents" in this world that have been less explored than the wilds of Africa; and that it contains the most profound and mysterious riddles concerning everything that lives on Earth.

LIVING DUST

Nobody has as yet counted the exact number of inhabitants of Green Land.

In various reference books and textbooks on botany hundreds of thousands of plant species are described.

In the depths of Green Land are hidden extensive invisible regions. We live in clouds of extremely minute living creatures. Bacteria, microscopic fungi and their spores fill the air we breathe. Every drop of river water near big cities carries with it several thousand microorganisms. Even the smell of the earth, the dank smell that everybody is familiar with, comes from the fact that every pinch of it is inhabited by millions of soil bacteria.

Without suspecting it, we ourselves carry in our bodies an incalculable number of alien lodgers.

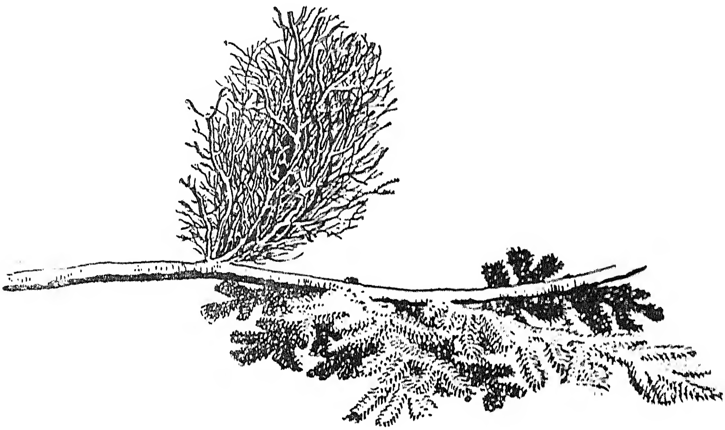
Two centuries ago Carl Linnaeus, the Swedish naturalist, compiled his "system of nature." He classified minerals, animals and plants. He had a separate shelf for everything he saw around him. He counted stamens and pistils, saw how they were arranged in flowers, and the army of the vegetable kingdom lined up obediently in classes, orders, genera and species.

But Linnaeus positively did not know what to do with the invisible myriads of microbes. Giving them up in disgust, he threw them all into one box and labelled that box "Chaos."

Generations of scientists brought a little order in this "chaos." They found in it the most frightful foes of man side by side with his friends—omnipresent scavengers who cleaned up all the refuse, all the dead matter of the earth, soil-creating microbes and "promoters" of important chemical processes on land and in the sea.

But the "chaos" has not been completely cleaned up to this day. This living dust does not yet represent the lowest border of life. At about the turn of the twentieth century it was ascertained that even smaller creatures exist, perhaps of a new order. The ordinary optical microscopes are unable to help us to see them. These creatures are of extremely different kinds, but, speaking generally, it may be said that in dimensions they stand in relation to microbes as flies stand to man. These strangers, whose mysterious life goes on in and around us, have been named viruses, and the smallest of them are called ultraviruses. We constantly see traces of their enormous and sometimes formidably destructive work. Before the invention of the electronic microscope, bacteriologists were unable to find the microbes of many hundreds (about a thousand) of very infectious diseases. All they knew was that they were caused by viruses.

For example, an elusive foe crosses a potato field and leaves the plants charred and withered; an invisible foe attacks a tobacco plantation and the leaves turn yellow and flabby from mosaic disease. You hear the low swish of "witches' brooms" in the wind: these are the twisted, half-dead branches of trees that have been attacked by an invisible assassin.



"Witches' brooms" on a branch of a conifer

Viruses infect people with rabies, measles, trachoma, mumps, encephalitis, infantile paralysis and even with common colds and the "fever" that breaks out on the lips; viruses are the cause of plague among poultry and dogs, and of the frightful foot and mouth disease among cattle.

And what about the invisible devourers of bacteria—bacteriophagi!

In a tiny bowl in a laboratory there is some "bouillon" clouded with a dark, muddy substance—this is a culture of deadly bacilli. But it is enough to add a few drops of the "phagi" to the bouillon for the latter gradually to become clear—the muddy cloud becomes lighter and thinner, melts away and disappears. The bacilli have gone; they have been devoured by the bacteriophagi.

Scientists are still debating among themselves about what viruses (or to be more exact, many of the viruses) are, about what bacteriophagi are—the tiniest living creatures in the world, or only a specific kind of matter? But man has already succeeded in taming these unexpected friends from the ultramicroscopic world. Bacteriophagi are sold in drug stores; they are a protection against and a remedy for dysentery.

Of course, even if they are living creatures, they cannot be called either plants or animals. They can be compared with the tribes that wander on the borders of Green Land.

For a long time, however, scientists seemed to discern among genuine bacteria distinct features of a plant nature. In their opinion, these tiny assassins and scavengers are the brothers of the algae, or subaquatic plants. It would be more correct, however, to class even bacteria neither in the vegetable nor the animal, but in the "third kingdom" of living nature about which we have just spoken. Bacteria are, as it were, a living bridge between the most primitive living creatures and the plant world.

But the moment we say "algae" we certainly find ourselves within the borders of Green Land.

A stagnant pool at the bottom of a pit is covered with cloudy, green slime. Let us take any drop of this slime and examine it under a microscope. We will witness a wonderful scene—a multitude of tiny swimmers darting hither and thither, waving pairs of antennae.

The virginal whiteness of the snowy wastes in the Far North is spotted with huge red patches. Bloody fields stretch across these uninhabited, desolate wastes. Ancient explorers were horrified at the sight of them, for they never dreamed that the snow was stained by myriads of algae, the close kinsmen of the agile green swimmers mentioned above.

The South. Torrid summer heat. During the hottest weeks the inlets of the sea, where the water is a little fresher, "bloom" and give off an unpleasant smell of decay. The water is turbid, as if impregnated with lees the colour of verdigris. These are living lees; they consist of myriads of algae. . . .

The reddish-brown slime on rocks; the green stain on your fingers after you have touched the moist bark of a tree . . . these are algae too!

The beds of seas and oceans are covered with meadows and forests of algae. They sway with the motion not of the wind, but of the waves; at great depths they are eternally motionless. The mariners of olden days were very much afraid of floating islands; they too are formed by algae. And among the invisible, incalculable mass of living minutae with which the briny expanses are always full, there are also multitudes of algae, which in seawater take the place of land bacteria. Toothed cogwheels, tiny boats, stars, quaint, porous balls, prickly "hedgehogs" of siliceous algae, or diatoms. . . .

Their number is so great that their remains, settling at the bottom of ancient seas, form whole strata of the earth's crust. There is even a mineral called "diatomite."

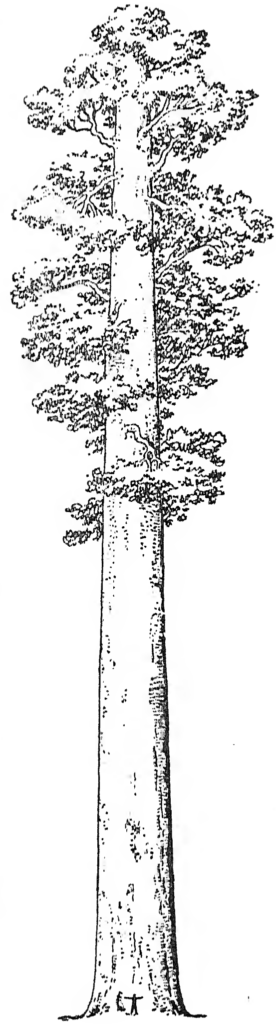
In admiring the sea, our eyes do not discern these transparent fields of diatoms stretching for thousands of kilometres—we see only the bright blue expanse. And yet the life of the seas is dependent upon them. Millions of crustacea, themselves microscopic or barely perceptible, graze in these vast fields. Swarms of fish and gigantic whales feed on these tiny living creatures. Birds catch fish; humans catch fish. For the inhabitants of many parts of the globe fish is the staple food. And so it turns out that all are fed by the living dust we call algae.

A PLANET IN AN OLIVE-COLOURED MIST

Together with the Lilliputians, the plant world gave birth to the biggest giants that the Earth ever bore. In the mountains of California there are a few survivors of the colossal ancient trees sequoias, or mammoth trees. Their living bulk grew in the course of three, four, and some people even think five or six thousand years. Perhaps they still found the last of the mastodons. They reach as much as twelve metres in diameter and almost forty metres in circumference. You cannot embrace these trees, you can only walk, or ride, round them. One such tree would be enough to provide the timber for building a whole settlement.

There are only twenty-six groves of these giant sequoias, and every tree has a name, like a ship.

Several decades ago some sequoias were planted in the Crimea. These "infants" are still small, no bigger than an old pine tree.



Sequoia, or mammoth tree

Only recently has the highest building built by man exceeded the height of "nature's skyscrapers," the hundred-and-fifty-metre eucalyptus trees of Australia.

We have said that millions of square kilometres of sea are occupied by "films" consisting of microscopic algae, but on the sea beds beneath them, on vast "continents" which no Columbus has ever trod, there are submarine forests of giant algae. The macrocystis reaches a length of three hundred metres; it is the longest living creature on Earth. . . .

Our land forests are living cities with multiple-storied buildings. Their basements are their roots and myceliums which penetrate the moist soil. The mossy carpet that is spread over the soil is the ground floor. Out of the grass rise the feathery ferns, and also bushes and shrubs. And then tower the trunks of trees. . . .

Over this forest-city soar air travellers: pollen, floating seeds, microorganisms and their spores. Wingless and of the lightest weight, they probably reach the upper borders of the stratosphere. . . .

If there are astronomers somewhere in the azure depths of the sky who direct their telescopes towards the Earth they see our planet in an olive-coloured mist. That mist is the fields and forests, the Earth's plant world.

We are not merely guessing, we know that the cosmic astronomers, if there are such, must see the Earth exactly in this way.

On Mars, that stern planet to which the sun sends more meagre rays than it does to us, the planet of waterless wastes and rarified air like that on our highest mountains, the polar cap melts and shrinks in the spring and the reddish expanses slowly turn green.

But on those parts of the planet which are bound by winter unequaled for its severity by anything we know on

Earth, astronomers have also noticed a strange bluish tint. What is it? The astronomers began to study the rays that are reflected by the dull surface of Mars. And recently the veteran Soviet scientist, G. A. Tikhov, member of the Academy of Sciences of the U.S.S.R., tried to ascertain from this reflected light, from these signals that flashed through the infinite cold spaces of the universe, what could be found on distant Mars. Mars does not come nearer to us than 55,000,000 kilometres, and then only in periods of great opposition; but Tikhov confidently asserts that there is plant life on Mars. That is a general statement; it can be put more concretely—there are evergreen plants there of the type of our northern conifers, but procumbent!

A science that is truly like a fairy tale—astrobotany, star botany—is already coming into being under our eyes in our country!

And if we can explore the meagre life of Mars in such detail, how many hundreds of millions of kilometres away must Green Land on our Earth make itself felt in the universe?

THREADS OF LIFE

Every green leaf is the most mysterious laboratory that exists on Earth. Every second that a ray of the sun strikes it, the most daring dream of the chemist comes true in it—the creation of living from nonliving things. Only a green plant can make living matter out of inorganic matter. This "creation of life" begins in a wonderful and beautiful way. It begins with the work of the sunray that has been entrapped by the plant. This process is actually called "photosynthesis," that is, creation with the aid of light.

What is this photosynthetic process? We already know a great deal about it. The materials for it are extremely simple: the carbon dioxide in the air, water, and the solutions of salts absorbed from the soil by the roots.

And all the colourless plant creatures—plant parasites, moulds, fungi, and furthermore—all animals and all mankind—are boarders in this wonderful green kitchen: it feeds them all. Carnivorous animals devour herbivorous animals, and the latter feed on plants—and all subsist on the food prepared by the green plants.*

And so, green plants are our common food providers. But it turns out that we must also be grateful to them for the air we breathe.

It is they who, splitting the carbon dioxide and water in the course of the photosynthetic process, in the end, after a series of chemical changes, excrete pure oxygen (apparently produced from the water and not from the carbon dioxide as scientists had thought for a very long time).

We may assume that all the oxygen in the air has been produced—in the course of millions of years—by green plants.

For millions of years the plant cells have been weaving the floating fabric that clothes the globe—the atmosphere, without which we could not exist.

We can hardly picture to ourselves what our Earth would have looked like had there been no plants, and hence; the living creatures depending upon them.

Most of the chemical processes would have ceased.

The soil on which steppes and fields now spread and forests and orchards grow would not have existed.

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* We leave out of account the small number of microorganisms which rather diligently prepare organic matter for themselves, not with the aid of the powerful energy of sunlight, but with the aid of the chemical energy of the oxidation of the various minerals in the environment which these microorganisms inhabit (chemosynthesis).

There would have been no white chalk and limestone cliffs.

Nothing of that to which our eyes are now accustomed and are familiar with would have remained.

In all probability, the continents of the Earth would have resembled the surface of the moon: sharp, rugged rocks and plains carpeted with pebbles and broken rock. And all this enveloped in suffocating carbonic dioxide and acrid ammonia.

That is what would have been had there been no plants, and hence, no life, on Earth.

What power life possesses to have altered all this! Whence comes this power?

It is the power of the Sun. The green leaves, like billions of wonderful solar machines, catch the energy of the sun's rays. And then it starts its tremendous work on Earth.

Thus we may say: the power of the sun has been caught and brought to Earth by green plants.

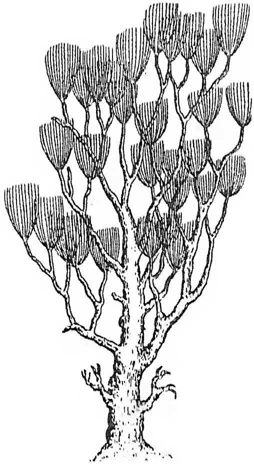
And out of its rays they spin the endless threads of life which has clothed, beautified and changed everything on our planet.

A GREAT ARMY

Phytogeographers, the scientists who study the geographical distribution of plants, divide Green Land into twenty or thirty regions, into hundreds of provinces and areas, which are inhabited by a motley population with amazingly diverse habits and customs.

A veil of sulphur-producing bacteria as wide as the Black Sea hangs over the sulphur-hydrogen poisoned depths of that sea.

Grey-blue saxaul trees grow in the "lifeless" deserts —trees that give no shade, with twisted, crooked trunks, unlike any other trees on Earth. A scientist engaged in re-



White saxaul

search work at the Repetek Desert Station told me that when he found himself in such an ancient saxaul wood in the southeastern part of the Kara Kum Desert he could not get rid of the strange feeling that he had been carried to another planet, to a "lunar forest" that he had read about in some fantastic story in his boyhood.

Here is a tree that will take three people to embrace. It has only two leaves, and the height of a century-old tree is only thirty centimetres. The Wonderful Welwitschia of the Kalahari Desert resembles most of all a low, round table.

Some inhabitants of Green Land are, perhaps, stranger than the strangest captives in the Zoo, and even than the creatures of our wildest imagination.

The creeping cedars in the mountains of the Far East. The Carnegiea cactuses which look like huge, dark, many-armed candelabra placed by gigantic Cyclops along the dreary tablelands of Mexico. The lace tree of Jamaica, which weaves the finest lace in the water. The sheep's fescue of the mountains of New Zealand which cling to the barren rocks by a thousand roots that are covered with flowery fur. Schistostega moss which glows with an emerald light in gloomy caves.

Gymnast plants, which easily climb steep cliffs to which only birds can fly.

The celebrated Rafflesia arnoldi of Sumatra, which seems to consist of the flower alone, which is over a metre in diameter and looks like raw flesh, so that even flies settle on it as if it were carrion. It has no stem and no leaves. Its monstrous flower, the largest in the world, rests on the roots of other trees and subsists on their sap.

There are rapacious plants which devour animals: the flytrap, which catches incautious insects in its leaf, which it suddenly doubles up like a fist; the sundew, which excretes a treacherously bright, sticky sap that looks like dew; the bladderwort which sets traps under water for daphnia, for the larvae of mosquitoes, and even for small fish; the stomach plants—nepenthes and sarracenia—which digest their victims in sacs, the walls of which excrete a liquid similar to gastric juice. If there were a Tom Thumb, the plant world would have seemed to him to be filled with frightful foes, with unexpected and terrible dangers.

The interior of the flower of the cuckoopint is hot; its temperature is equal to that of the blood of a man stricken with fever.

The Indian shrub Desmodium, or tick trefoil, waves its hundreds of fan-leaves every one or two minutes—it is a "gesticulating" plant. The leaves of the shy Mimosa begin to tremble as if stricken with cold if the glass case is suddenly removed from it in a cold room. The stamens of the Barberry "jump" at the slightest touch. They are more sensitive than our eyelashes. It is said that the white acacia also closes its leaves sometimes if it is struck a hard blow. And once, on a hot day, a red lady fern was seen to wave its fronds in a rotatory way just like the tick trefoil. . . .

There are cook and confectionery plants. Their fruit are the most delicious food on Earth. Many of the medicines sold in our drug stores are made from pharmacy plants. We admire the artist plants; their petals are coloured with all the shades of the solar spectrum. And the living fortresses that are protected by spikes, armour and poisons, a few drops of which are enough to knock out an elephant!

In their life cycle ferns change from a sex into an asexual generation, presenting themselves to us first in the form of tiny leaf shoots, and then in the form of the familiar gorgeous plants that adorn our woods.

Many grasses and trees start life with a long air voyage. And who would guess that this motionless forest giant that stands like a stone pillar came from this winged seed?

The stern "soldiers" of the taiga—the conifers—with their needles, scales and cones, strangely resemble the club mosses, the tiniest inhabitants of the lower depths of the damp and gloomy forest.

Grasses have marched victoriously all over the globe, becoming transformed either into trees (bamboo) or into the turf that carpets our meadows. For man there are no more valuable plants than the grasses; they provide food for hundreds of millions of people.

And what about the twenty-five thousand varieties of the Composites: daisies, dandelions, cornflowers, wormwood, thistles, asters, sunflowers, the remarkable rubber plants kok-saghyz and tau-saghyz—are all grasses; some are trees (in the tropics). The "baskets" of the Composites hold hundreds of tiny flowers in the same way as the faceted eyes of insects are made up of hundreds of eyelets.

This is the youngest and numerically the largest army of the plant world; its ranks contain a tenth part of all the seminiferous plants known to botanists, and there is, perhaps, not a place on the dry land that some detachment of the Composite army would not conquer.

Grasses, Composites, the somewhat smaller army of Legumes, the large family of orchids with the most gorgeous flowers in the world; the purges, sometimes in the form of quaint trees and sometimes as plain, modest grass blades; the motley crowd of madders, which include the cinchona and coffee trees, and the yellowish, coarse, roadside grasses—such are the mightiest of the armies of Green Land.

The coal seams under the ground remind us of the primordial gloomy forests of ferns, mare's-tail and club mosses which formed these underground store of solar energy. And today the Far Eastern Express races in a few days through the taiga, which (with the South American Hylaea) is the largest forest in the world.

And for all that, the steppes are pressing hard on the forests. Perhaps it will not be the hollow oak, the veteran of the virgin forest, but the fast-growing, multicoloured grasses of our meadows, their serried ranks swaying with the wind, that will be the principal heroes of the plant world today! Indeed, it is not simply a struggle between trees and grass. Man, too, is not watching it dispassionately. With this struggle, with forests advancing and retreating, and with man's intervention in this, we shall deal again later on. . . .

EXPLORER AND MASTER

Once upon a time the land, vast and virginal, stretched around primitive man. The great plant world provided him with roots, fruits, grains and bulbs; it sheltered him in inclement weather; man hunted in the forests.

Man explored the roads of Green Land for many thousands of years. When did he pass from collecting her gifts to vanquishing her? When did he become not only her explorer, but also her master?

Perhaps it was the women who, when gathering edible tubers and the ears of wild grasses for the children and for the common hearth while the men were away hunting, were the first to notice that strong shoots sprang up from seeds that were accidentally dropped. But a long time had to pass before this simple and astonishing observation became firm and necessary knowledge.

How can we obtain an insight into the gloom of those millenniums that have passed away never to return? Let us try to picture to ourselves that remote life that is so unlike that which surrounds us today.

For primitive man, "lean" times alternated with "fat" times, and there were far more "lean" ones than "fat" ones.

Now let us picture the scene.

A bad year comes—an invasion of mice or ants; or a predatory raid by the hunter-warriors of a neighbouring tribe—and the community is left without its sacredly-guarded store. We said community; but from time to time hundreds of communities found themselves in this situation. All the members of the community suffered in times like this, but the greatest sufferers were the women, the mothers, the guardians of the sacred hearth. They were the first to meet with grief and disaster.

And so they hastened to collect a new store. At some time or other it at last occurred to a woman of one of the communities to mend matters by multiplying the remnants of the old store, or the new store that had been collected, to make this store grow of its own accord. In warm climates this does not take long—the life cycle of an annual plant lasts no more than two to four months.

We must suppose that agriculture, man's great accomplishment, began many times and in many places and then expired again. When, however, it became established at last, it was not due to casual causes, not to some particular misfortune, or to the individual observations of keen-minded and observant people. No, it was due to important and general causes. Human society had to grow up, to mature, for this. The very conditions of human life had to change for this.

It took place on the border line between the old and the new Stone Age. The people, who did not yet know the use of metals, armed with stone axes and with spears and arrows with stone heads, lived in tribal communities. There was no state, but the communities were already living closer together; life had become more settled. They already had domesticated animals—dogs and pigs.

The stone mattock was the first agricultural implement. The work was done by women, the "ear gatherers."

What grew on the first fields?

To judge from the seminomad, forest tribes of Africa, the Malay Archipelago and South America, man's first crops were roots and tubers. Among the present-day tribes these crops are represented by taro, arrowroot, yam, batata and manioc. All these are weeds. It is still forest agriculture. That, perhaps, is what man started with. But that did not carry him very far. It was only a supplementary source of food for the tribe; hunting was still the chief occupation.

But as soon as agriculture became real agriculture, the edible roots of the jungle had to yield first place to grains. The cultivation of grain began in very ancient times. In the broken pots found on the sites of some of the oldest human habitations in Europe, grains of wheat and barley have been found; at some time or other they had got attached to the sea clay of the primitive potters; they stuck to the clay, became immured, the scientists found them after it had occurred to them to break the shards.

These are the very first traces of agriculture we know of. They date back eight to ten thousand years, perhaps.

In the pile-dwelling encampments that existed five or six thousand years before the present era (remains of them are found in Switzerland, for example) there was already "regular" agriculture. And in the Orient, in the land of Elam, about seven thousand years ago, they sowed millet, wheat and sugar cane. Among the Sumero-Akkadians, agriculture appeared somewhat later. In Babylonia they already sowed legumes; they also had orchards: the ancient books refer to "beautiful gardens." The date palm provided bread and sweet "mead," a beverage made from dates; and of barley, according to the ancient geographer Strabo, the Babylonians had as much as "nowhere else."

Three or, perhaps, more thousand years ago, agriculture was also known to our ancestors, the forefathers of our nation, who inhabited our southern steppes.

Over six thousand years ago the Egyptian agriculturists threw grains into the warm, alluvial soil still moist from the flooding of the Nile. The Egyptians borrowed their cereals from the Sumero-Akkadians.

In the Far East, in the valley of the broad, full-flowing Yangtze, the great centre of Chinese agriculture was laid. The ancient annals mention five plants which the mythical Emperor Shen Nung is said to have taught his subjects to grow: rice, two kinds of millet, wheat (or barley) and soya beans. This is supposed to have been in the twenty-eighth century before the present era.

Nobody knows exactly when the two chief transoceanic centres of agriculture arose—the tablelands of Mexico and Peru; but everything there was different from what it was in the Old World. Of cereals they had only maize. After maize came huautli or amaranth—clusters hung with panicles. They also grew potatoes, tobacco, pumpkins and beans. And it is strange to imagine that among them also grew our sunflowers, only they were not cultivated, they grew as weeds in the maize fields.

The time when the centres of agriculture were divided and separated from each other has long passed away—the fields have joined over whole continents. And the number of varieties of crops has vastly increased.

What do you not see in the noisy, motley, merry market place in the summer, or in the fruit shops in the autumn, with their piles and pyramids of fruit, smelling sweet, spicy and slightly of wine! Fruit—rosy, purple, golden, dark with a touch of green, translucent, smooth and rough, some of the most capricious and others of ideally symmetrical shape. . .

And if in addition we look at the coloured illustrations in handbooks on pomology and peruse the *Pharmacopoeia* with its host of medicinal herbs, and recall our Agricultural Exhibition before the war when a plot of land in a suburb of Moscow was converted into a wonderland containing wonders, the existence of which many had not even suspected, then the number of plants which man has subjugated will seem to us to be incalculable. After all, about ten thousand years have passed since man compelled the first plant to live not in its own way, but as he wanted it to live.

And this inexhaustible abundance of forms and varieties is all the more astonishing for the reason that they all came from a comparatively small number of wild species.

Approximately thirty thousand species of plants, in one way or another useful to man, have been discovered. But the overwhelming majority of these thirty thousand only pay tribute—man has not become their complete master. We utilize the riches of the forest, but, with rare exceptions, forests grow of their own accord without man's intervention. In the bright woods in the spring we drain the sweet, transparent sap that oozes "when with keen hatchet the birch is injured." In the summer and autumn we go into the woods to pick berries and mushrooms; we did not plant them. On the seashore, seaweed is collected; it is used for fertilizer, and iodine and agar are made from it, both needed equally in the bacteriological laboratory and in the confectionery factory. Expeditions set out in search of medicinal herbs. And the Egyptians made their famous papyrus from the wild papyrus plant.

All this is hunter's prey in Green Land. It is what the hunter and explorer collects.

But the plants that grow in fields, vegetable gardens, orchards and hothouses number no more than five thousand. And very many of these man has only brought to his habitation, where they have remained as they were before. There are hundreds and even thousands of plants that we simply admire and cultivate for our pleasure. There are the ornamental plants. Hundreds still fastidiously cling to some particular corner of the Earth and will not grow in other parts; these are rarities of no great importance to man.

If we brush these aside and take only those plants which man has re-created, those that serve as his food and provide him with clothing and industrial raw materials, we will have barely a few hundred species.

A celebrated botanist of the last century (De Candolle) was of the opinion that the "list" of the chief agricultural plants—forty-four species in all—became established seven or eight thousand years ago and underwent little change during the ensuing five or six thousand years. It was only during the past two thousand years that man set about enlarging the list.

It is calculated that the chief plant species cultivated (and re-created) by man number 327; of these 269 are natives of the Old World and 58 of the New World.

It is from this "nucleus" that man has obtained his vast and infinitely varied world—his world of green servants. There were a few thin, small-eared varieties of wild wheat. Today, 1,500 varieties of wheat ripen in the fields of our globe.

As for the plants that man has "tamed," in our country alone no less than two hundred species are cultivated. No country cultivates more.

SERVANTS

We ought to become more closely acquainted with man's devoted green servants. They deserve it.

There can be no doubt that the first among them is the Grass family; and the most important member of this family is wheat. Once upon a time man sowed wheat near his habitation—before almost all other plants; and today, too, man gathers more of wheat grain than of any other grain in the world—amounting to as much as 150 to 160 million tons per annum.

Only a little way behind comes rice. Our ancestors called rice "Saracen's millet," and that is what it is called in Leo Tolstoy's *Childhood*. The chief rice crops are obtained in Asia. In many Asiatic countries rice is for many hundreds of millions of people what bread grains are for us.

Almost on a par with rice comes maize—the most ancient crop on the Continent of America. In Mexico and the United States more maize is grown today than of any other grain crop.

After these three grasses, but a long way behind them, come oats. The annual world crop of this cereal amounts to only a half or a third of those mentioned above; and oats began to serve man much later than they did. The Romans and the Greeks regarded oats as a weed. Theophrastus, a disciple of Aristotle's, called the "father of botany," found nothing good in oats. Pliny, the Roman who in the first century of the present era, nearly four hundred years after Theophrastus, wrote thirty-seven books on "Natural History," believed that oats were not a cereal at all, but a disease that afflicted barley: diseased barley degenerated into oats, he claimed. The strangest and most contemptuous names were invented for oats, suggesting goats, sheep and even the smell of goats. The Russian word for oats—"ovyos" —is also similar to the Latin word "ovis," which means "sheep." These names suggested that oats were fit for food only for goats and sheep.

We, however, put oats fourth among all the cultivated cereal crops! Pliny and Theophrastus failed to divine the future.

The ancestor of our rye was also for a long time a weed, an uninvited guest in wheat and barley fields. Rye did not figure in the agriculture of antiquity. It appeared as a cultivated crop in the mountainous regions of the Orient, in the Caucasus and in Central Asia.

It is believed that rye is now sown on a par with barley, a crop that is so ancient that grains of it are found in the oldest of the Egyptian pyramids.

Millet too has been serving man since those far-off, prehistoric times which archeologists are studying; and it has been serving him faithfully and well. What Russian has not eaten millet porridge? The Latin name for millet is still current in botany—"panicum"—from the word "panis," which means "bread." Hence, in the days of antiquity the term "bread" was often associated with millet grains.

Five hundred million tons—such is the average annual world crop of cereals.

People sow other grasses too: sorghum, which does not fear drought, it is even called "the camel of the vegetable kingdom"; sugar cane—the "honey without bees" of the ancients; and meadow grasses: bluegrass, brome grass, and rye grass. Man grows copses of the giant grass—bamboo.

Many scientists are convinced that the vast cohort of the Legume or Pea family (otherwise known as the Papilionaceae) come second only to grasses in their importance to man. It is sufficient to mention peas and beans; soya, which is well known in our country and in China, is food for tens of millions of people; and lentils, of which a Biblical hero was so fond that he sold his birthright for a mess of this pottage—all these are legumes. Everybody is also familiar with ground nuts—arachis. From legumes medicines are obtained: from liquorice and from the Peruvian tree (the famous balsam). The best meadow grasses are also legumes: alfalfa, clover, melilot, vetch, vigna and esparto grass.

These are wonderful grasses: they renew and enrich the soil.

No organism, animal or plant, will grow or develop if there is no nitrogen in its food, for no living body can be built without nitrogen. Without nitrogen there can be no protein substances, the foundation of life.

Everybody knows what high value is attached to nitrogenous fertilizer, which has to be put into soil that is poor in nitrogen.

But how can that be? How can a plant suffer from a lack of nitrogen? There may be little in the soil, but over the soil there is a vast ocean of air, nearly four fifths of which consists of nitrogen. The leaves and stems simply bathe in it!

But the whole point is that the plant cannot take the nitrogen from the air. The elusive nitrogen passes through the pores of the leaves, slips past the hungry tissue, even penetrates it and slips out again and leaves no trace. The plant can take it only when it ceases to be a gas, when it forms nitrates, when water dissolves it and the roots absorb it. . . . But it is not so easy to catch and "fix" (as the chemists expressively call it) the volatile nitrogen!

Long ago a few but very important exceptions to what we have just said were found in the plant world. And the most important of these exceptions are the legumes. After they have grown, ripened and been harvested, the soil is found to contain not less but more nitrate compounds than before, the very nitrate compounds that plants need so much!

The secret of the legumes was discovered in the eighties of the last century. The discovery was amazing. It was a story about the friendship between a bean plant and an invisible being.

On the rootlets of legumes tiny nodules are formed; sometimes there are so many of them, and they are arranged on the rootlets in such a way, that they look like strings of beads.

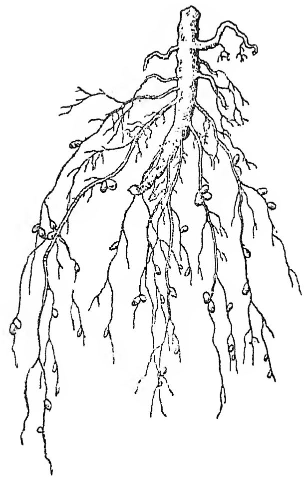
These nodules contain bacteria. The plant feeds them and they multiply in masses. And then it was found that they do not remain in debt to the plant. These invisible little friends are able to catch and fix the nitrogen in the air, and they catch so much that there is enough for the plant-host, and some is left over in the soil.

So that is what legumes mean for the soil!

This family does not consist solely of grasses; certain wonderful trees belong to it, the very names of which seem to reflect the flaming sun of the South: cassia and tamarind, the campeachy tree from which blue and black dyes are obtained. The copal tree, from which is obtained the famous resin to make lac; the carob, Brazilwood and cinnamon trees, all the mimosas and acacias with fragrant yellow, pink and white flowers.

Genuine acacias and mimosas are children of the tropics. In our northern latitudes we sometimes call acacias "mimosa." Who has not bought and placed in their rooms these yellow mimosas, which in the early spring are brought from the South to the North in aircraft and express trains!

As soon as they appear in the streets—even if the March daylight is still meagre, the feet are treading in slush, and sleet is whirling around us—the Northerner knows that spring has come!


The tubers on rootlets of legume

And the fragrant weeks of May in the cities in the Ukraine, when the entire city—beginning with the platform at the railway station—is impregnated with the honeyed breath of acacias, and the pavements are carpeted with the soft, springy, fading clusters of their blossoms! Let the botanist interrupt us angrily and say that these are not acacias at all, but *Robinia Pseudoacacia,* we shall love them none the less for that.

We will note right here that the yellow acacia is not an acacia, and is not even related to the white; its botanical name is Caragana.

Incidentally, among the Legume family we find the most wonderful plant in the world (although it is not a servant nor a friend of man)—the "living telegraph," the Indian shrub Desmodium, or tick trefoil, which we have already mentioned. It received its name even before the electric telegraph existed. At that time important news was conveyed by semaphores placed on high ground at visible distances from each other. The ancient naturalists compared the tick trefoil with such a semaphore telegraph because of the way it waved its leaves.

The Mulberry family cannot, of course, be compared with the Legume family; but at one time even this family played an important part in the lives of the people in many countries of the Orient. For thousands of years a dozen or so fig trees and a grove of mulberry or silkworm trees, with milkwhite fruit or those exuding a ruby juice, provided food for the poor in Babylonia, Greece and Judah. And a handful of olives (for the sake of which we will here mention the Oleaceae, or Olive family).

Still further to the south, in the dense and luxuriant jungles of the tropics, half-naked people picked the fruit of another member of the Mulberry family—the bread tree. This fruit is as large as a man's head and has a compact, sickly-sweet, satisfying pulp. It was baked as we bake bread.

The Mulberry family continues to serve man today.

The figs of antiquity are a treat for us too. As was the case many centuries ago, the ruby-coloured juice stains the baskets, the hands of the vendors, the wide bowls and even the yellow, clayey, hard-trodden ground of the market places in Central Asia.

The leaves of the mulberry tree provide food for silkworms.

All the members of this plant family are rich in sap, and this sap is used for food (like that of the queer cow tree of South America), or is used in industry (like the rubber-bearing sap of the ficus, own brother to the hospitable fig tree; the resins of the shellac trees), or else are death-dealing saps: the upas or antiaris, the "tree of death" mentioned in Pushkin's famous poem, also belongs to the Mulberry family (although it must be said that the appearance of this tree is much more modest than that described by the great poet).

An uninformed person will probably be surprised to learn that hemp, hops and nettles are relatives of these fiery-coloured southerners; and so close is the relationship that many botanists unite them with the mulberries in one family. This, of course, enhances the importance of the Mulberry family. In China, hemp is one of the most ancient of the cultivated plants; and in the steppes of our country it was cultivated five hundred years before the present era.

For all that, neither legumes nor mulberries can in our times be put second to cereals as food for man. This place belongs to a plant that was unknown throughout the thousands of years of development of civilization in the Old World and, speaking historically, is a recent visitor from across the ocean —the potato. Two hundred million tons are harvested every year, and almost half of this amount is harvested in our country. It is here that the best varieties in the world are raised; and here a discovery was made that marked a revolution in the cultivation of potatoes. Here the potato found a new homeland!

From the Solanum family man took for his vegetable gardens the eggplant and tomato, tobacco for his plantations and petunias for his flower beds.

The small and humble Buckwheat family gave man buckwheat (a relative of the sorrels). The humble buckwheat is a true grain plant, although it does not belong to the grasses; it is more of a grain plant than even the "grain-legumes."

And the plant which provides clothing for man, the most important plant for spinning in the world—cotton—was taken by man from the Mallow family.

There is a beautiful old story told by the celebrated Russian educationalist K. D. Ushinsky about "how a shirt grew in the field." In the field this shirt was called flax.

The Flax family is a small one, but it has given man one of the most ancient cultivated plants in the world. Excellent linen fabrics were woven in Babylonia and Egypt five thousand years before the present era. So long ago had man appreciated the value of flax! Russian linen was already spoken of at the time when our Russian state was only just formed, and it was always referred to as the "celebrated" Russian linen.

Today, too, the foremost country in the world in the production of flax is our motherland—the Soviet Union.

The vast army of Composites, the Sunflower family, has given us numerous garden plants: dahlias, gorgeous chrysanthemums, asters, daisies and immortelles. The most "poetical" of the weeds is the cornflower (man has even transplanted it to his flower beds). It is impossible to picture a Ukrainian village without those yellow-headed beauties—the sunflowers. The medicinal Composites provide man with santonica seeds (from a variety of wormwood) and pyrethrum (from the flower of the Caucasian daisy). Lettuce, chicory, artichokes and Jerusalem artichokes are used for food.

The milky sap of some of the dandelions proved to be a valuable raw material for the manufacture of natural rubber. This great discovery was made only recently, but from the moment it was made a new era opened in the relations between man and the Composite flower plants. We can proudly say that this discovery was made in our country.

For the first time the fame of hevea, which before our times was regarded as the sole producer of natural rubber, was shaken, and yet this fame was widespread. Whole books were written about the tropical hevea plantations and about the adventures of rubber seekers. True, less was written about the downtrodden slaves—the Indians and Indonesians—

who were driven to work on these plantations, and who died in vast numbers from yellow fever—and about the fierce and bloody struggle for rubber the imperialist pirates waged against each other. . . .

Their secret and avowed agents, followed by entire armies, took part in this struggle. For the possession of hevea, as for the possession of oil deposits, war was waged. During the recent world war the Japanese occupied Southeast Asia and the Pacific Islands and thus gained possession of nearly the whole of the world rubber supply. They triumphed. But their triumph was shortlived.

The struggle for hevea is still proceeding, however. Today, the Americans are striving with all their might to gain possession of all the sources of tropical natural rubber in South America and in Southeast Asia; and they are trying to oust the British and Dutch imperialists from Asia.

Hevea is actually called the rubber tree; and this brings us to the quaint Spurge family. Only a few members of this family have been tamed by man. The castor-oil plant provides castor oil. The seeds of the tung and spurge are full of quick-drying and most valuable technical oils. And strangely enough, in this family, which is characteristic for its corrosive, poisonous saps, we find the Brazilian "underground bread," cassava, mandioc, the roots of which are ground into flour.

In the same way as we obtained many of the flowers in our gardens from the Composites, so we got most of our fruit and berries from the Rose family. Fruit and berries constitute its main strength and glory, although they bear the name of the "queen of flowers," the rose.

And the beautiful rose has a multitude of varieties and forms. Gardeners are particularly proud of their catalogues in which are listed and described the ancient, world-famous and also very recent varieties of roses.

But the subfamily of the rose plant proper should be started not with this tender and gorgeous product of refined gardening, nor even with the wild forefather of the rose—the hedgerose, but with inconspicuous grasses: five-fingers, lady's-mantle and geum; and also with the small, common berries that hide at the roots of trees in the forests or on clumps of bog: the cloudberry, stone bramble and wild strawberry. And so we get the kinsman of the wild strawberry lying in the strawberry beds like elongated scarlet drops—the large, soft and succulent strawberry. The prickly blackberries of harvest time in the woods and hedgerows—and the sweet, crumbly raspberries in the garden.

The Apple subfamily is to be found everywhere: apple, pear, mountain ash, quince, hawthorn and medlar.

Bird cherry, apricot, plums, sweet and sour cherries, almond and peach belong to a subfamily of the cherries.

Botanists are of the opinion that from this family, the choicest among the perfumery and culinary plants, there is a direct transition to the humble legumes.

The list of man's green servants is inexhaustible and we cannot help skipping many of them; but we must put in a good word for some of them. Surely, even a brief enumeration of our friends who have served man faithfully and well for centuries deserves no less attention than the celebrated list of Greek ships in the *Iliad*!

We must say something about the Umbelliferae, or Parsley family. It is doubtful whether your attention has been often attracted by the tiny flowers clustering in hundreds in "umbrellas," but their leaves are certainly familiar to you. These are our indispensable kitchen "greens": fennel, parsley and celery. Cummin and carrot also belong to this family of fragrant summer grasses—some low and some tall and spreading.

And beets and spinach—cousins (in the Goosefoot family) of the roadside goosefoot with its fishy smell, and of that fantastic tree of the desert, saxaul.

The extensive Madder family brings our woodruff and madder into kinship with the coffee and cinchona trees. The history of the latter is replete with dangerous expeditions, mysterious abductions, fierce pursuit, heroic deeds and the inhuman traffic in the health, life and death of thousands of people—a history, somewhat different from, but just as extraordinary, instructive and as characteristic of the fierce struggle for profit that is raging in the capitalist world as is the history of hevea.

What else must we mention?

The humble Crucifer family has supplied us with cabbage, turnips, radish, radishes, horseradish and capers. The Lily family has supplied us with lilies and tulips, aloes, and what are more important, onions, garlic and asparagus. The name of the Walnut family speaks for itself. The Mentha family provides essential oils. Of the thousand members of the Pepper family man has domesticated only one—pepper; and of the five hundred acrobat plants of the Grape family, only the wine grape has served man for many thousands of years.

We must mention the Gourd family, for the sake of pumpkins, marrows, cucumbers, watermelons and cantaloupes; and the Rutaceae or Rue family (all citrous bearing!) and the Tea family, to which both tea and camellias belong. And the deliciously sounding name of the Chocolate family—cocoa and kola, the fruit of which drives weariness away.

We must mention the Palms, because the date palm provides food for the people in the vast areas of North Africa, Arabia and the Middle East; and the Cocoanut—on the coasts and islands of the tropics—provides food, drink and clothing, and, in addition "vegetable ivory."

Then there are the Bananas. . . . A curious historical riddle is connected with their soft, sweet, horn-shaped fruit. The inhabitants of America knew them before Columbus discovered that continent, but nothing resembling the cultivated banana has been discovered among the wild flora of America. That shows that somebody must have introduced them there. Who were the people who crossed the ocean, evidently many centuries before the famous Genoese did so, and brought with them from their native land not a cruel and avaricious lust for gold, not rapine and plunder, but shoots of plants?

There is still one plant that we must mention before bringing our list to a close. It too is a faithful servant of man, but up till now we have found no place for it. It is a unique plant of its kind: it is not a "means of consumption," not a "natural product," but a "means of production!" And the entire technology of the twentieth century, in spite of all its wonders, has not invented a substitute for it. Straight from the field it goes into a modern, complicated machine and works as part of its steel body. A machine part that grows in the fields!

We have in mind the teasel, of the Teasel family, sister to the beautiful scabiosa. The spiky heads of the teasel are attached to carding machines for combing wool, and thus help to produce the finest and softest woolen fabrics.

ALPHONSE DE CANDOLLE

Alphonse De Candolle, the Geneva botanist, was the son, father and grandfather of botanists. It was a botanist dynasty that existed for nearly a century and a half. Alphonse De Candolle added thirteen volumes to the seven volumes on botany that his father had written. They contained an extremely detailed survey of the plant world, a guide to Green Land of a kind that even the Swede Carl Linnaeus, the "father of classification" and pedantic classifier of all living things, dared not dream. No individual could have performed such a Herculean task by himself. De Candolle divided it among many scientists in different countries, but he remained the initiator, the managing director and most zealous labourer in this task. And if there were a throne in the vegetable kingdom, as there is in every real kingdom, De Candolle would have considered it only natural and fair that it should become the heritage of his family.

At that time, botanists were already repeating a new name: Charles Darwin.

But Alphonse De Candolle had no intention of sharing his throne with anyone. Had he not years before the appearance of Darwin's *Origin of Species* written *An Explanatory Geography of Plants*—a book in which, as a result of most extensive and scrupulous research, were established the principles and laws of distribution of plant species throughout the world?

He was seventy-seven when, in 1883, he published his *Origin of Cultivated Plants*. Darwin had already passed away. De Candolle survived him, but, of course, he replied to the Hermit of Down. Triumphant, he, with an aged hand, aimed a heavy and long prepared missile at the departed one; he aimed it straight at Darwin's *Variation of Animals and Plants under Domestication*. It was the last shot in a duel that had lasted a quarter of a century.

True, De Candolle did not always mention the name of his opponent during those years. But he had him, constantly had him, in mind. The duel then became a stubborn and silent one. This theory, which explained how as a result of the operation of natural, dispassionate and fundamentally simple laws, the whole of living nature that surrounds us in all its infinite variety could arise; which asserted that by taking advantage of these laws man himself created new forms of life—this theory of evolution sounded almost like a personal insult to the Swiss professor. It was an incursion, a rude invasion of his plant world, the world that he had described.

His plant world! Here it was in the catalogues of his huge herbarium. The father, Augustin Pyrame, had founded this herbarium. The son, Alphonse, had enlarged this treasure house. Today it is being still further enlarged by the grandson, Casimir. The De Candolle dynasty! And the great-grandson, a schoolboy of fourteen, prepares his botany lessons among shelves and glass cases that rouse the wonder and envy of all Academicians.

But when the high-spirited and restless schoolboy runs out with his book under his arm silence reigns in the rooms of the herbarium. At rare intervals the rustle of the Curator's papers may be heard. But he too goes, and only a very quiet old man is left. After a time he gets up and goes out to give battle to Darwin on the very field on which the English naturalist had won his chief engagement.

What suggested his theory to Darwin?

Human practice; human activity in the living world; the activity and methods by which breeders raised new breeds of animals and moulded new plants at their own will.

That is where Darwin discovered his law of evolution!

But Alphonse De Candolle was determined not merely to shake the leaves and break the stem, but to uproot Darwin's theory.

And so he too studied the history of agriculture. His capacious memory did not weaken with the years, it merely became sterner and stricter. It unfailingly delivered the necessary series of facts from the invisible collections gathered by marvelous erudition. And his aged hand did not tremble as he entered these facts in his papers. No, those who for so many decades had seen on his brow the golden diadem of the chief of the science of botany had no reason to be ashamed of their king!

Did we say the science of botany? Yes, that is what it was at one time. It contained his whole world. Botany was his trade. But now it is too tight for him. When you sum up the whole of life you cannot fit it into botany alone, like a picture in a frame. Life is bigger than a "métier," as the French call it, it is bigger than a trade. . . .

It was not a difficult task for him, when starting on his book, to fill it with facts taken from the domain of palaeontology, archaeology, linguistics, the history of states and nations, monarchies and republics, wars and laws, myths and customs. He had them all at his finger tips.

His book is replete with the most minute researches, treasure-troves known to none, or long forgotten, ingenious comparisons and minor and major discoveries, more so than in his previous books, than in his *System*, and his *Explanatory Geography*. And just as in those books, in which he was the first to compare the distribution of plant species over the face of the Earth with the past history of our planet and had made a bold sketch of geography in connection with the structure and work of the bodies of plants and, in doing so, had invented a new term: "physiological geography," so in this new book his treasure-troves, comparisons and discoveries give rise to a magnificent picture of the green world in constant transformation, a world as vast as the ocean.

What? Can this be seen in the book *he* wrote? Constant transformation—in other words, evolution? Yes. That is the logic of his book, of his science!

But was he aware of this himself? Did he realize that the facts of his science were already stretching forth a hand to his adversary? And that subsequent generations will remember De Candolle not by what he wanted to convince them of, but by the way he promoted the theory of evolution that he had so passionately set out to destroy?

No. The aged scientist failed to see this. As was the case when he wrote his *System of Plants*, he tried to manipulate his thousand-faced facts, tried to command refractory science.

The shelves next to his writing desk were packed with reference books on varieties and with nursery gardeners' catalogues; through the windows, through the mist on the mountain slopes, he could see vineyards and fields bearing ripening crops which could not have existed on Earth were it not for man. He leaned back in his comfortable armchair and gazed absent-mindedly at this amazing second, man-made nature that spread all around. He opened and clenched his hand several times and rubbed his numbed fingers to set the blood coursing again and resumed his writing.

He wrote that there is nothing and there has been nothing: there is no second nature; man has not created new plants, and there are no new plants. The forty-four species in wild nature that man took a fancy to seven or eight thousand years ago remained without subtraction or addition during the ensuing five or six thousand years. Not omnipotence but impotence. Not the triumph, but the helplessness of reason. Not the mastery of nature, but dependence upon nature's charity.

Stubbornly De Candolle searched the jungles and prairies for the wild brothers of present-day cultivated plants, for the most exact copies of all that man cultivates, in order to prove that man did not create them, but found them ready-made. He triumphed when he found what he sought. But he was too good a botanist not to realize that in many, far too many cases the kinship that he preassumed was dubious. And then he was driven to despair, for there are dozens of man's green servants who do not show even a trace of wild ancestry!

But he refused to yield so soon. He blamed the geographers, historians and archaeologists. He angrily accused the annals of geology of being incomplete. He considered that the names of plants had been compiled by people with dull and indolent imaginations.

And so he placed his hopes in future investigators. They would fill the gaps. Tirelessly searching the ashes of thousands of years ago, they will find in the blackened hearths of the palaeolithic age, or in the terraced pyramids of the Kingdom of Antiquity, a handful of precious, charred seeds. And this handful of seeds will link the kinless boarder of field or garden with some free inhabitant of the banks of the Zambezi.

Hopes are not facts—that he knew. But he could not wait any longer. His life was drawing to a close. He fired the missile that he had been preparing for several decades, in which he had placed all his hopes, into which he had put all he possessed—and it proved to be of insignificant explosive power.

He lived another ten years only to see that his missile, far from destroying, had actually reinforced its target, and to read in several encyclopedias: "De Candolle—Darwin's colleague."

De Candolle's hopes were never realized. Nobody ever found the wild twin-brothers that he tried to find. Nor could they be found, for they did not exist.

The cultivated plants which man has most of all employed in agriculture for thousands of years are indeed kinless. Man himself created them.

THE CIRCLE EXPANDS

De Candolle shut his eyes to the fact that out of each "tamed" species man has created scores, hundreds and in some cases thousands of varieties; and the total number of these new forms, breeds and varieties produced by man, the creator, is incalculable.

The "six thousand years," during which the chief group of cultivated plants underwent little change according to De Candolle, were by no means a lifeless period of stagnation and inaction. Already at that time man was performing wonders of creation.

De Candolle was gravely mistaken.

But there is one thing in which he was not mistaken. Man did indeed gain infinitely from the plants that he took from nature. But what an infinitely small number he took from her! From what a tiny skein did he, in the course of eight or ten thousand years, spin those wonderfully long, sunny threads of agriculture!

And there is another thing in which De Candolle was right.

We know that man has created a great deal of what had not existed in Green Land before he came; but this took an immense amount of time. The periods must be counted in ages. We are surprised when we hear of a man or woman who has lived to a hundred. The bulk of the principal technical inventions without which our lives seem inconceivable, were made during the past hundred and fifty years.

It is easy to say a thousand years, but it is difficult to imagine it. The formation of our Russian state began a little over a thousand years ago. The Turks were not then in Constantinople, and the Slavs, our ancestors, called it Tsargrad.

Nobody in the Old World suspected the existence of America and dared not sail far beyond the Pillars of Hercules, the ancient name for Gibraltar. Of all the cities that we know today, cities with millions of inhabitants, capitals proud of their antiquity and glory, of all the cities whose names are now mentioned in the newspapers every day, only five or six existed at that time. Everything in our daily lives, in our work, in our homes, in our knowledge and customs has undergone such a radical change that it is difficult for us to picture the people of those times and make them stand out before us as if they were alive. The languages people spoke were different from those that are spoken now.

That is what a thousand years means.

The history taught in schools, including the history of antiquity, covers, in the main, about three thousand years.

But man has engaged in agriculture for at least nine or ten thousand years!

There was a sad feature about the agriculture of the olden days, however, the agriculture that De Candolle saw around him.

In the mines and factories, at the loom and lathe, people were employed who were skilled at their trade. Peasant labour, however, was not regarded as skilled. It was called "unskilled labour." Everybody with a pair of hands and a strong back could perform it. For thousands of years it was thought that nothing else was needed to deal with living things, with plants, which are more complex than the most complicated machine.

Huge cities sprang up. Factories were built. Technology performed miracle after miracle and entirely changed man's life and changed the face of the Earth.

But the peasants—De Candolle's countrymen, the Swiss tillers and shepherds, the French winegrowers and the German ploughmen—tilled the soil, tended their flocks and cultivated their vines in the same way as was done by the Roman colons.

An almost paradoxical situation arose.

Man's friendship with the living world commenced in times immemorial, from the time man became human. But he learned about this living world and mastered it to a far less extent than he learned about and mastered the non-living, mechanical world. And vast Green Land continued to spread around him almost untouched.

Its entire surface was visible to him. There was no need to make test borings and to sink pits. It was only necessary to stoop to pluck a leaf, to break a stem. But geological explorers were far more familiar with the treasures hidden in the depths of the earth's crust than the botanists were with the treasures in the interior of Green Land.

During the past decades numerous remarkable discoveries have been made in the plant world, and more are being made as time goes on. Man is making such discoveries all around him, sometimes even on garden paths. Suddenly we recognize old acquaintances. The evergreen rattleboxes quietly throw out their earlike blossoms in the hothouse and nobody dreams that field rattleboxes provide fibre for the textile industry. The yuccas with their tall flowering shafts are becoming a valuable industrial crop, also for the textile industry. We have learned that the gorgeous dahlia and the tender colocasia are rich in sugar.

The handbooks on gardening recommend the yellow-headed goldenrod "for planting round tree and bush groups and for decorating backgrounds." But it turns out that its sap, sticky, white and somewhat acrid like that of the dandelion, congeals into rubber.

Under our eyes something is happening which the historians say happened in the dim and distant past at the dawn of civilization: wild species are being domesticated. The dandelion rubber-bearing plants—krym-saghyz, tau-saghyz and particularly kok-saghyz, whose names were only recently unknown to botanists—have been transferred to the fields. This has happened in our country.

Who does not know what nettles are? They seem to follow in man's footsteps, nestle up against his house, grow right up to the windows, rise thickly in shady places behind fences, and even run into the road. Man has been living side by side with them for thousands of years and gives vent to bursts of anger when he incautiously grasps them with his hand or steps upon them with bare feet. Of what use are they? You can cook nettle soup once in a year, say. It seemed as though man knew by heart everything there was to be known about them; but only a quarter of a century ago it was ascertained that nettles can be used for clothing, that it is a textile plant. And the fibre of Chinese nettle—ramie—is like silk.

Ramie also grows in our country now. In the twenties, the extensive introduction in the agriculture of the U.S.S.R. began of trees, shrubs and field crops that had never been cultivated in Russia before. A crowd of strangers seemed to rush into the wide-open gates of our country. The Australian eucalyptus found a new home on the banks of the Rion, in ancient Colchis. Strange names appeared in the columns of the newspapers: feijoa, avocado, pompelmous, grapefruit and limequat. Strange fruits appeared at the fruiterers.

Chemists and technologists investigated about three thousand plants, and they know exactly how each one can be utilized, what can be obtained from them. But what about the others? Even many of those which man cultivates are still enigmas.

Unexplored tracks wind through Green Land. Those who follow them may, perhaps, be led to parts that nobody has even heard of. There is no need to cross the sea for this. It is like in a fairy tale: the cave containing the treasures is right close by; but the entrance to it will be revealed only to the one who knows its secret, who will say: "Open, Sesame!"

Man has dealt mainly with flowering plants, a little with conifers; but of the lower plants only the mushroom has been useful to him.

But the word "antibiotics" flew round the world. For centuries physicians have been vainly seeking quick and effective remedies for certain very noxious infectious diseases. They have now found these remedies. Antibiotics destroy many microbes that are mankind's worst enemies. The discovery of antibiotics ushered in a new epoch in the field of medicine.

The most well-known of the antibiotics is penicillin, which is obtained from mould. Who would have thought that this unpleasant concomitant of dampness can be of such great service to man? Other antibiotics have been discovered in bacteria, in actinomycete fungi, from which streptomicin, for example, is extracted. In a matter of ten years we learned about a multitude of unexpected friends of man. Bacteria which destroy pyogenic microbes are called bacillus prigrotus, "magic wands." During the war they were used in army hospitals, and wounds quickly healed, inflammation of the frontal air-sinus was healed more quickly and the condition of diphtheria patients greatly improved.

Antibiotics have been found in the higher flowering plants.

Where is the prophet who will foretell on what continents our brave navigators will land, what parts the explorers of Green Land will see—the navigators and explorers of your generation, young reader?

And will not in time substitutes be found for our most faithful servants—the cereals of the fields and the dear old cherry, apple and pear trees of our orchards?

After all, the long history of the cultivation of plants did not proceed according to plan; much in it depended on chance. The "power of the soil" hovered over the agriculturist, who for centuries was dependent upon nature's charity—upon rain and dry weather in season. Man groped his way through Green Land.

Still, there are no grounds for assuming that substitutes will have to be found for the principal plants in the cultivated group.

This group was collected in the course of thousands of years. The earliest agriculturists experimented and erred, experimented again, rejected one thing and tried a different one. And what has been sifted in the sieve of millenniums, what has stood the test of centuries has become firmly established. It cannot be said that these are due to chance.

That's the first point.

But that is not all.

Of course, man overlooked many things in the plant world around him. Many friends remained unrecognized. But man recognized first of all precisely those which could most faithfully serve him; those which did not hide, but came forth to serve. It was these that man saw first. That's the second point.

Thus, we already have two explanations as to why man, while groping and erring an incalculable number of times, in the end did not err in his choice of the principal cultivated plants.

There is a third, the most important explanation. Man did not simply experiment, err and experiment again. He worked on the plants that he took for cultivation, and we know that he re-created them. These plants are not at all now what they were before. They have been given new and priceless properties. Nothing like them exists in nature.

How, then, can man dismiss his old and faithful servants?

The area in Green Land subjugated by man will be vastly expanded; new opportunities will arise for the re-creation of living forms; man will make extensive use of the treasures of the entire plant world.

It is possible, and probable, that all the cereals of the fields will be transformed beyond recognition.

Still, man will not cast away the fundamentals of his ancient choice; he will not obliterate the results of his former long and arduous labour.

"IMPOSSIBLE!"

A century and a half ago, the German scientist Alexander Humboldt set out on a voyage to South America. He took with him Linnaeus' *Systema Naturae* and a table of the "natural plant orders" drawn up in the Botanical Garden in Paris by Jussieu, the Chief Horticulturist of the French Republic.

In South America Humboldt came across a crowd of plants that were not listed either in the *System* or in the table. He found himself in a virgin, primordial forest. Life, generated by the earth, rose above the earth and became the habitation of myriads of other lives. Flowers never seen before blossomed on the branches and in the fissures of the bark of trees. Fluttering leaves betrayed the presence of small and also enormous creatures surrounding the explorer. Moss, which covered the trunks, examined through a magnifying glass, looked like the scaly weeds of the ancient coal epoch, "the forests of great silence." In the mossy thickets darted clawed creatures which looked like minute scorpions or lobsters.

Carl Linnaeus, who died in 1778, stout, phlegmatic and assiduous, classified everything in the world—plants, animals, minerals, and even the naturalists themselves. But the tropical jungle at once overwhelmed and destroyed the whole of the Linnaean system in its maelstrom of forms. It proved to be a drop in the ocean!

On returning from America Humboldt tried in his own way to investigate the wonders of Green Land, to find some clue to the fantastic intricacies of the primordial forest, to count not the breeds of plants, but the chief forms the plant organism is capable of assuming.

At the time when Napoleon was beating the Prussians at Jena and Auerstedt, Humboldt, in Berlin, was writing his *Ideas on the Physiognomics of Plants.*

He described palmlike, baobablike, cactuslike and other "forms," some very strange and fanciful.

But Humboldt's list proved to be very incomplete. Surprisingly enough, he was unable to "fit" into it plants of the most common forms, such as oak and birch. Evidently carried away by the brilliant colours of Cumaná and Caracas, he simply forgot about the humble forests of Europe.

Nor would Humboldt have been able to say why such forms exist and not others, whether it is possible to change some forms into others, or even create entirely new ones.

New generations of botanists took the place of the old. Much that was not known in Humboldt's time became known. Voluminous books on botany found room for every plant that came under the eyes of scientists either in living or dried form.

Nevertheless, some of the habits and caprices of the inhabitants of Green Land remained riddles.

Why do palms grow in Batumi and reindeer moss and dwarf willow in Taimyr? Why does cowwheat bloom in the autumn? Why must winter cereals be sown in the autumn? Remaining in the ground in the winter, the crop can be harvested only in the following year. And why is winter fatal for spring crops? They must be sown in the spring and ripen in the same year.

"Why? Why?" But science could not say very much about this.

Do what you like, it said; peaches dislike the climate of Saratov or Kursk. Wheat refuses to ripen beyond the Arctic Circle. Specific features of the species—it can't be helped!

Water assumes its smallest volume at 4° Centigrade. It is impossible to alter this. If you want it different you should have created a different world. Is it not the same with the specific features of species?

True, the scientists did try to ascertain what prevents some plants from growing in the South and others in the North. Some handbooks on botany even gave mathematical calculations on this score.

For example, if we add up the mean daily temperatures of the places where oats grow during the whole period needed for the crops to ripen, the total will amount to 1,940° Centigrade. If the oats fail to get that amount of heat they will perish.

"And so," concluded the authors of calculations of this kind, "the reason why it is impossible to grow oats beyond the Arctic Circle is clear."

Actually, however, this "impossible" is not clear at all. Why does one plant need this particular sum of temperatures while another plant is content with less? And is this particular amount always necessary, or can it be different?

Arithmetic gave no answer to these questions. It merely said the same thing in different words: every plant has its own inherited features, its own law of life.

The hundred thousand plants described in botany books had a hundred thousand laws of life.

Inherited features! As inevitable as fate!

Here the power over nature with which science had armed man came to a halt.

In travelling through Green Land, the botanists were obliged to note, compare and describe the queer habits of its inhabitants with the assiduity of conscientious secretaries, to study them with the utmost care, only in order to bow down before them. . . .

THE MYSTERY OF MYSTERIES

A FEW OBSERVATIONS ON SWEET PEAS, LUCK AND TUMBLER PIGEONS

Whenever I recall the time, long ago, when I first heard about that fatal heredity that stood in the way of man's mastery of living nature, the vision of the Bible studies teacher at the high school I attended rises before me.

I went to school in a town in the South. It was a small and quiet town in those days. But a broad white staircase led from it to a hill that bore the name of an ancient tsar. In the grey, stone-fenced gardens of the cottages on the outskirts the mallows were abloom with simple yellow and pink flowers with a core in the middle. Outside the town, at the turn of the road, there were some lime kilns and the locality all around seemed to be covered with ashes, but in April a carpet of tulips interspersed with blue irises was spread along this road on the low, sloping hillsides; in May red patterns of poppy took the place of the tulips. The hills were low, but peaked and looked like small extinct volcanoes—the glare of sunset burst over them, and for a long time flaming clouds hovered over them, casting a red light on the ground.

From rough tables placed on the pavement outside of cafés came the rattle of dominoes, and a few paces from the street, near the damp wall of the yard, grew a large clump of wild fennel which gave off a sweet, pungent smell; the rainbow-coloured trails of snails could be seen on the mossy stones. A prickly Lycium tree hung over a precipice overlooking some ancient white foundations and ruins that were two thousand years old.

. . . Later, the northwest winds blew whirling waterspouts over the cracked, yellow clay soil. There was a smell of tar in the harbour where, in the shallow, malachitelike water, needlefish stood motionless among the seaweed that reminded one of lettuce. In the autumn the smell of fish pervaded the town. Oxen hauled along the road tall carts laden with the last sheaves. The steppes were deserted, the heavy grain had been packed in the barns, flocks of migrating birds settled on the salt lakes. In the distance the tiled roofs of farmhouses and villages could be seen and the strains of Ukrainian melodies were wafted through the resonant air.

And to us schoolboys, all this was beautiful, as beautiful as youth.

We left our town, all of us going to different parts of the country, but no matter where we were, we were always keen to get news from it—in the newspapers, magazines or radio broadcasts. We watched the town grow, as it were. One day we learned that it was already numbered among the eighty-four Soviet cities that had populations of over a hundred thousand. It was still famed for its fish, but it was now a very lively city, famed for its steel mill and for the inexhaustible deposits of iron ore in its environs. When I went to school there, the oats and thin wheat belonging to the landowner Olive grew over those deposits.

We were proud of our city.

But this fine city of our boyhood no longer exists. It was razed to the ground by the Hitlerite invaders. Two thousand years had passed over it; it had been a city of antiquity, a medieval city, a modern Russian city, a Soviet city, but all that which men had built, all that we had recalled and had been proud of, was barbarously destroyed.

We know that the city is rising again out of the ruins, rising on the bones of those who perished in antitank trenches, of those who were tortured to death in the fascist dungeons, and of those who were buried under the ruins, on the bones of its Soviet Army defenders and partisans. There, in those nameless graves, lie our schoolfellows, our kinsmen and our comrades. . . .

The city will rise out of the ruins and be more beautiful than before; but it will be a different city. Therefore, we must not forget what was destroyed. We must not forget or forgive the destroyers even when our heroic and industrious people have wiped out all traces of the frightful destruction they perpetrated. . . .

The school I attended was as firm as a bastion, a grey, two-storey building. It is difficult for me to picture it in ruins.

At that time it towered like an indestructible rock over Stroganov Street and bore the name of Alexander the Blessed. The preceptor of my class was a clergyman.

The rotten throne of the Romanovs was already cracking and swaying in St. Petersburg. After the February Revolution, the bewildered school administration ordered that Kerensky's Provisional Government be substituted for Tsar Nicholas in the morning prayers.

The October Revolution swept away the Kerensky government.

The Whiteguard newspapers published false reports about the situation on the fronts of the Civil War, but little credence was given to these reports. The town was sustained by rumours. Several of our senior schoolfellows were missing.

They had gone to the stone quarries, in the labyrinths of which were hiding those who had taken part in the cruelly suppressed revolt against the Whiteguard masters of the town.

Under the protection of Denikin's bayonets, the lessons at school had to go on as if nothing had happened, according to a curriculum that had been sanctioned many years ago by a tsarist Minister for Education who had gone long ago. We did not obediently submit to this. It was not easy to go through these lessons, which we thoroughly detested. Paper arrows kept flying from the back desks. Or somebody would get up during the Bible lesson and with an innocent air ask:

"Your reverence, is it true that man came from monkeys?"

It was at that time that we first saw Darwin's books, in tattered, cardboard covers. They were smuggled into school by one of our schoolmates whose father was a doctor. They were classed as prohibited literature. The natural history teacher never even mentioned the existence of such books. A handsome fellow in pince-nez, the idol of all the lady teachers in the town, his chief interest was his silky moustaches, silk ties and his easy victories among the fair sex, but he was not well up in natural science and sincerely believed that the octopus was closely related to the medusae and corals.

Nevertheless, the Bible studies teacher hated him, hated him as one who was trying to take the bread out of his mouth. This enmity was the talk of the town.

A short man, his clothes always besprinkled with snuff, our Bible studies teacher was burdened with a large family. In his myopic eyes, the universe always seemed to be painted in black colours. Care had lent him almost biblical pathos. We schoolboys, quick to find apt nicknames, called him Saucepan, for his dented and greasy bowler hat did indeed look like a saucepan.

Three times a week, during the Bible lesson, our preceptor, waving the sleeves of his cassock, would try to discredit the natural history teacher.

"Circulation of the blood, nature, chemistry!" he jeered. "But take a hen's egg: a chicken comes out of it, a chicken!" And than he would cock his head and ask in a whisper: "But perhaps it's a duckling, eh?" Then, raising his voice, he asked: "Who put the chicken there? Break the shell and look: nothing but soft egg. A daily miracle under the eyes of the blind, the miracle of Enoch and Elijah!"

What Enoch and Elijah had to do with it we did not quite understand, and Preceptor Saucepan's miracles seemed amusing to us.

How could we guess that this jaundiced Bible instructor had actually formulated the riddle of heredity over which the most celebrated scientists in the world were racking their brains?

We would certainly have laughed in the face of anyone who would have told us that there were scientists in universities who, on the score of this same riddle of heredity, were fiercely rushing into battle against the theory of variability and, evidently, also regarded the prophet Moses as the greatest explorer in the world!

No, we knew nothing about these scientists.

But we possessed the greatest treasure man can have—youth. Not a shadow of doubt concerning the omnipotence of the human mind entered our heads. Was not the old, sordid, evil, stupid and cruel world breaking up under our eyes? And with a sort of unerring instinct it was not about the times of Dickens' England, but about the early advent of a new and happy time that we read in Darwin's old books.

"Look! There is not a single corner of nature around us untouched by man. Man has re-created the Earth in order to live on it!" we read in these books; that is how we interpreted them.

Under Darwin's guidance we traced the wonderful genealogies of different breeds of pigeons: the pouter pigeons puffed up with pride, the tumbler pigeons somersaulting in the air, and those winged postmen the carrier pigeons. We gazed with respect at man's friend, the dog: the bandy-legged dachshund, that brave watchman the sheepdog, the enormous Newfoundland, and the common house dog.

And the flower beds with all the colours and shades of the rainbow and all the scents that Oriental poets had dreamed of—are also the work of man! Man is the actual creator of the world in which he lives.

From generation to generation man selected animals and plants. He chose for breeding the hens that laid most eggs, the pigeons of the most curious shapes, and the wheat with the heaviest ears. And gradually, under man's hand, the few, common breeds grew into all the thousands of cultivated breeds that had not existed before—the breeds with which man, of his own will, desired to populate the earth. . . .

This sounded like a hymn in praise of man. And we said: if man succeeded in doing all this yesterday, what will he not be able to do in the bright, free world of tomorrow!

The students at the Alexander High School grew up to be engineers, doctors, navigators, economists, and some became biologists. But the science of biology with which they had to deal in earnest several years later poured a great deal of cold water on their youthful ardour.

That science seemed to be under a spell. Fatal heredity! True, the scientists did not speak about it in the naive and crude way our Bible instructor had spoken about it; they wrote their books in a high-flown and grandiloquent style, and no dictionary could help you to understand it; and to the uninitiated the allegedly Russian sentences in those books would be as unintelligible as differential equations.

But all they wrote reduced itself to the old, simple question: why does a chicken hatch from the hen's egg?

And what a fierce battle with Darwin and his theory flared up as soon as this question was put!

At first the sceptics politely and slyly pretended to agree that man did re-create living nature by selecting from generation to generation the parental pairs that he needed. But, they went on to assert, he was able to breed the thirty-six-pound, fat-tailed sheep only because there were fat-tailed sheep among the sheep species. Selections can be made only when there is something to select from. What did Darwin explain? With what kind of magic wand did he endow man? He explained nothing, he endowed man with no wand. "Wait and see," that is the only moral to be drawn from his much overrated books.

We are like the maiden with the broken pitcher at the well, they said. Oedipus failed to solve the riddle of the Sphinx. What is heredity? Why does a chicken hatch from the egg? What is variability? Why does fortune smile on some breeder whose long and painstaking search is suddenly crowned by the birth of some strange specimen as if in accordance with the proverb: "There is a black sheep in every family," and why does this specimen serve as the beginning of an entirely new breed?

And so a rather amusing situation arose in the field of science of that day. At school we had learned—from Darwin's books—of the proud statements of the brave pioneers, men who in their practical work renewed living nature. They had said, in effect:

"What variety of sweet pea would you like me to grow? The number of these varieties already exceeds a hundred.

And what beautiful names they have! But fashion is inexorable: in sweet peas it changes quicker than it does in hats. What can we flower creators do? We, too, are dependent on fashion! But we can give the flowers any colour we desire. What colour would you like?"

"And I will make any fruit larger and sweeter than those we have now."

"I will change the feathers of birds to suit your wishes. It will take me three years to do it."

"And in six years I will be able to change the shape of the head or beak of this bird."

That's the kind of people Darwin wrote about!

And with our own eyes we saw around us the multitude of animals and plants, the innumerable inhabitants of our planet, called into being by man; animals and plants that had not existed before, that had been created by unknown breeders.

But the learned biologists who were teaching young students at the universities of both hemispheres obstinately shook their heads. No, they saw nothing. They knew of no reçipe for changing breeds. Chance. Lottery luck! No Academy in the world was capable of producing the slightest change in the shape of the bodies of any organism that could be transmitted to future generations.

Then, brushing aside the memory of old Darwin, scientists who had made the "riddle of heredity" their own property came to the middle of the stage in the field of biology. The new science was called genetics. In narrow beds the geneticists planted peas, beans and snapdragon. Then they examined and compared the shades of seeds and petals through a magnifying glass, laid out their crop in complicated compartments like cards in a game of patience, turned the handles of their adding machines, and thousands of sheets of paper were covered with brain-racking formulas in which were calculated with infallible precision "the most frequent cases," the "average deviation" and even the "average error."

At one time the pages of books on biology were redolent of woods and meadows: the breath was felt of the millions of living creatures that inhabit the land, the air and water; a multicoloured, beckoning, and somewhat mysterious world lived in all its scintillating beauty in the books of the great zoologists and botanists. What a naive, utopian time that was! Later, books on biology became more like textbooks on algebra.

The philosopher Kant had said long before this that science was science to the extent that it included mathematics; and so the geneticists proudly asserted that only thanks to their efforts was the frivolous biology of the olden days beginning to become a real, exact science.

At that time genetics was still young. Many biologists recalled with amazement its recent, unexpected and sensational appearance "like the appearance of a meteor in the starry sky." Pompous and masterful, it hewed a path for itself through the thickets of the old science of biology. Its very history looked unusual. We heard of a long-deceased Catholic monk whom the geneticists regarded as the founder of their doctrine. His name was surrounded with legendary fame. When we were at school, in our battles with Saucepan, we had not even heard of the existence of that monk. And not only schoolboys. A few years ago, any scientist in the world would have been very much surprised had he been asked if he had heard of Mendel.

But how did this controversy about the power of man arise? When did it arise? Clearly, it must have arisen long before our time. Perhaps it was in the time of De Candolle? Or of Mendel? Or perhaps earlier?

Outwardly, they looked like respectable professors. They did not start their experiments with incantations, they did not wear medieval mantles with wide, winglike sleeves, nor did they adorn their heads with caps like those worn by the Syrian magicians. No, they ascended their rostrums wearing prosaic suits of modern cut and delivered their lectures in sober and intelligible terms.

Express trains were already speeding along the railways, telegraphs were sending messages from one end of the land to another with the rapidity of lightning, spectral analysis revealed to astronomers the structure of the stars.

The professors of biology advanced the most up-to-date, profound and ingenious arguments to prove that species were not variable.

To believe that the descendants of any animal or plant could be transformed into some other animal or plant seemed as absurd and as unscientific to these professors as, say, believing in fiery serpents.

"Show us a hen that has grown a peacock's tail," they demanded sarcastically.

True, there were people upon whom sarcasm had no effect. For example, in the eighteenth century, young Afanasi Kaverznev, whose fate, in the opinion of the writer on the history of science, "in some way resembled that of Lomonosov,"* published a treatise on *The Metamorphosis of Animals*. Abou twenty years after Kaverznev, that champion of freedom Alexander Nikolayevich Radishchev, wrote about *Man His Mortality and Immortality*. An exile in Ilim, a town c

* Professor B. E. Raikov, *Essays on the History of the Ide of Evolution Before Darwin*, Vol. I, Academy of Sciences of th U.S.S.R., 1947, p. 95.

which the European Doctors of Natural History had never heard, he, with unprecedented daring, wrote about the oneness of nature, about the oneness of man and the animal world, about the oneness of soul and body, which "are the product of the same substance." Yakov Kaidanov, a physician, brother of the celebrated historian Ivan Kaidanov, Pushkin's tutor at the Lyceum, wrote a book in which he developed the idea of stages in the evolution of life on Earth.

There were others, and their number grew as time went on; and not in one country, but in many.

Only a few wise ancients still believed in the immutability of species. There were evolutionists among the French enlightener philosophers of the eighteenth century, the forerunners of the French Revolution. Erasmus Darwin, the grandfather of Charles Darwin, wrote in clumsy verse a poem in which he sang of the metamorphosis of the living world. . . .

Often, the sarcastic professors were obliged to hear ironic questions:

"So you say that every one of the tens and hundreds of thousands of species was created spontaneously? But how did that take place? Did a complete goose appear all at once, or was the task facilitated by a goose egg placed under a bush? Did the new living creature become condensed out of the air, or did it spring out of the earth?"

But for all that, solemn silence reigned in the ancient, vaulted corridors of Academies and solemn, half-vacant lecture halls of ancient universities with their Gothic windows cut in seven-foot walls. The voices of restless doubt scarcely penetrated them.

In 1809, Jean-Batiste Lamarck, the celebrated French naturalist, then sixty-five years old, published his theory of evolution, of the gradual development of living beings. He boldly asserted: Yes, the living world changes; and he proved this with facts. With a keen eye he traced the main trends of evolution. There was much that he could not yet explain: how wings first appeared in wingless creatures; how the eye—that wonderful organ which enables us to know objects that are separated from us as surely as if we touched them—how eyes appeared in those creatures which formerly had been blind; and how it happened that the tiny, invisible bubble of some primitive organism on earth generated worms, then fish, then naked amphibious reptiles, then scaly reptiles, birds, animals, and finally, man. This was not merely change, but a sort of ascent—higher and higher up a wonderful ladder—how did it occur?

All this still remained a mystery to Lamarck. Perhaps there was some concealed striving towards perfection within the organisms?

But when Lamarck forgot about this fantastic "striving" that he had invented in order, somehow, to fill the gaps in the vast, millions of years' history of life on Earth which he was unable otherwise to explain, when he spoke about how *these living creatures* could actually change, he said things that were much simpler and more intelligible. Organisms do not float in airless space. They germinate, grow and develop in a material environment. This environment, of course, affects their growth and development; and changes that take place in it cause changes in them too. Conditions of life endow animals with certain needs; these needs, these new habits, lead to an increased exercise of certain organs. And ("as everybody can convince himself from his own experience," Lamarck added), the exercise of organs develops them.

"And I think that they develop more and more from generation to generation. For example, it is easy to imagine that, formerly, giraffes had ordinary short necks. But their ancestors were confronted with the need constantly to reach the leaves of trees, and so, gradually, their necks lengthened."

But people would not listen to Lamarck. He was ridiculed with condescending irony.

"Our colleague wants to warn the curious against the danger of their descendants becoming like giraffes. And journalists will develop elephants' trunks, for they are always keeping their noses to the wind and are constantly poking them everywhere," they said.

And the worthy professors tried to forget Lamarck.

Shortly afterwards another French scientist came to take Lamarck's place—Geoffroy Saint-Hilaire.

"Animals," he asserted, "change as a direct result of the influence of environment. Thus, when more oxygen appeared in the air, the respiration of some of the reptiles increased, their blood became warmer and flowed more strongly to the skin. That is why some of the tree lizards were transformed into birds."

"Is that so?" came the answer. "But cats have not changed in the least since the Egyptians filled their 'cities of the dead' with their mummies."

This argument seemed to be so convincing to those who advanced it that they smugly nodded to each other and said:

"This second one, Geoffroy, is as comical as that first one, Lamarck."

After thus laying out their opponent, the very learned professors of famous universities resumed their calculations of the number of times floods must have drowned this sinful world in order to wash away all these ammonites, ichthyosauri, and mammoths, all these enormous mare's-tails and sigillarias that resembled lampglass cleaners, in order to make it possible to populate the earth with birds, wolves, sheep, daisies and most learned professors of famous universities.

This highly academic occupation, which, as the reader will observe, had nothing of the worshipping of fiery serpents about it, was interrupted by Charles Darwin.

What did Charles Darwin actually do?

He showed that the people who had to deal with living nature were never guided, and never could have been guided, by the comfortable theory of the invariability of species and breeds. Darwin reminded the scientific world of the unknown pioneers in plant and animal breeding who, although they could not boast of scientific degrees, had long ago proved in practice that life is change. It was they who created the multitude of living creatures such as had not existed before: trees with branches weighted down with fragrant fruit, cereals with fat ears, thoroughbred cows which provide "rivers of milk" and to which the common term "mammal" is scarcely suitable, the fantastic goldfish and the "phoenix" cocks with tails fifteen feet long.

Science had ignored the work of these men, although it should have been studied, and scientific conclusions should have been drawn from it. They were not magicians. No, without being aware of it themselves, they applied the laws of development, of the evolution of living beings—the laws that have always operated in nature, only much slower, and without the guiding hand of man. G25115/48324

The entire living world on Earth, all the innumerable beings around us, gradually developed from a few primitive ancestors as a result of the operation of these natural laws. They could not have come into existence in any other way.

To a publisher who pre sed him to give an account of his life, Darwin replied to the following effect:

"My name is Charles Darwin. I was born in 1809. I studied, made a voyage round the world, and studied again."

The town of Shrewsbury was a small one; the house of his father, a physician, stood on a steep river bank; near the house there was a garden with a hothouse. The town was surrounded by pastures. Nature was right next door. Darwin's family knew and loved her. His ancestors had been farmers. His great grandfather had wandered with knapsack on his back and mallet in hand collecting minerals. His grandfather Erasmus, a physician and philosopher, had written poems entitled: "Zoonomy, or the Laws of Organic Life," and "The Temple of Nature."

When he was nine years of age Darwin entered Dr. Butler's school, a typical English school such as Dickens described in *David Copperfield*. In his reminiscences Darwin said: "Nothing could have been worse for the development of my mind. . . ." Dr. Butler compelled his pupils to learn languages that nobody spoke and the history and geography of countries that had long ceased to exist, and with that considered that his duties as an educator were at an end. This was "classical education" in its purest form.

But young Darwin passionately read books that were not mentioned in Dr. Butler's curriculum, books about nature, about living life. In his spare time he wandered by the river and in the fields. His room was filled with boxes containing insect collections and with chemical retorts. His schoolmates nicknamed him "Gas."

His father sent him to Edinburgh University to study medicine; Charles was also to become a doctor. Charles was a dutiful son, but his father should have studied his inclinations more.

The medical colleges in those days were also very much like Dr. Butler's school. They bore the heavy burden of medieval scholastics. Those who were attracted by the hard, noble and humane profession of a doctor were willing for the sake of it to push their way through this jungle. But Darwin's interests were far away from medicine, from ailments and the methods of healing them. He yawned as he listened to the lifeless enumeration of ligaments and joints during "lectures on human anatomy as dull as the lecturer himself." "The subject disgusted me," he wrote. The anatomic theatre with its half-decaying corpses depressed him. Twice he was present at operations. There were no anesthetics then. The horrible shrieks of the patients haunted him for many years afterwards.

He did not attend a third operation.

He preferred to go on excursions with his new friend, Grant, a zoologist.

Old Dr. Robert Darwin, who had a rather fantastic but very self-confident conception of his son's inner world, interpreted his coolness towards medicine as a sign of his utter incapacity for experimental science, and so he took a new decision regarding him: Charles must enter the Church. And the dutiful son went to Cambridge to study theology. Many years later he wrote concerning this: "Considering how fiercely I have been attacked by the orthodox, it seems ludicrous that I once intended to be a clergyman."

And he summed up his "academical studies" in the following striking words: "I think that all the valuable knowledge I obtained, I acquired by self-education."

Perhaps this is what enabled him to take a freer attitude towards many of the dogmas of university science of those days.

He found his real "university" outside of school; and it was at this "university" that he studied all the time, from the moment he entered Dr. Butler's school.

This was the university of nature—living nature, not dissected into decaying parts as in the anatomic theatre; it was the pastures where grazed herds of animals created by famous breeders as if in rivalry with each other: Bakewell's New Leicestershire sheep, magnificently shaped Shorthorn cattle, bred by the brothers Collins by persevering and methodical selection; it was the farms where they bred Yorkshire, Lancashire and Berkshire pigs which looked like living pork and bacon factories; it was the fields in which Monkswell wheat and Hopetown oats were ripening. . . .

Animal and plant breeding had never been so profitable in England. The woollen, linen, cotton, leather and meat industries were developing rapidly and were insistently calling for raw materials. Fifty years before Darwin, Bakewell made six thousand guineas out of one thoroughbred ram by "hiring" it for the summer to farmers who wished to improve their flocks. Concerning the achievements of the sheep breeders Darwin wrote that it looked as though they drew on the wall a shape that was perfect in every respect and then gave it life. . .

This is what Charles Darwin, with infinite patience, studied in his real "university."

And in the same way as he, in Edinburgh, had made long excursions with the zoologist Grant, so, at Cambridge, he explored the meadows and marshes with the botanist Henslow, the Welsh mountains with the geologist Sedgwick, and spent hours in conversation with Whewell, later the world-famous writer on the history of science.

Diligent, very modest, preferring to listen rather than speak, noting everything and storing in his mind everything that he noted, read and heard and returning to his store dozens of times in silent and patient reflection, Charles Darwin, by the end of his term at Cambridge, had developed nto a full-fledged naturalist. In scientific circles he was treated as an equal. He had already made several small zoological discoveries, had written several essays and, at the age of eighteen, had read a paper before the Plinian Society in Edinburgh.

In 1831, the little 235-ton brig, H.M.S. *Beagle,* set out on a voyage round the world. The commander, Captain Fitz-Roy, consented to take a naturalist with him. Henslow insisted that that naturalist should be Darwin, but it was first of all necessary to perform the difficult task of convincing the old doctor in Shrewsbury that his son, who had obediently studied theology, had already grown up—but had not become a clergyman. Robert Darwin seemed dumbfounded and emphatically refused to give his consent. He knew his son better than everybody else did, he asserted, but in the end he was obliged to yield to obvious facts.

On December 27, the *Beagle* set sail.

Darwin took with him the first volume of Charles Lyell's *Principles of Geology,* which had just come off the press; a book which showed that the time had come when the old and obsolete views in the natural sciences must give way to new views.

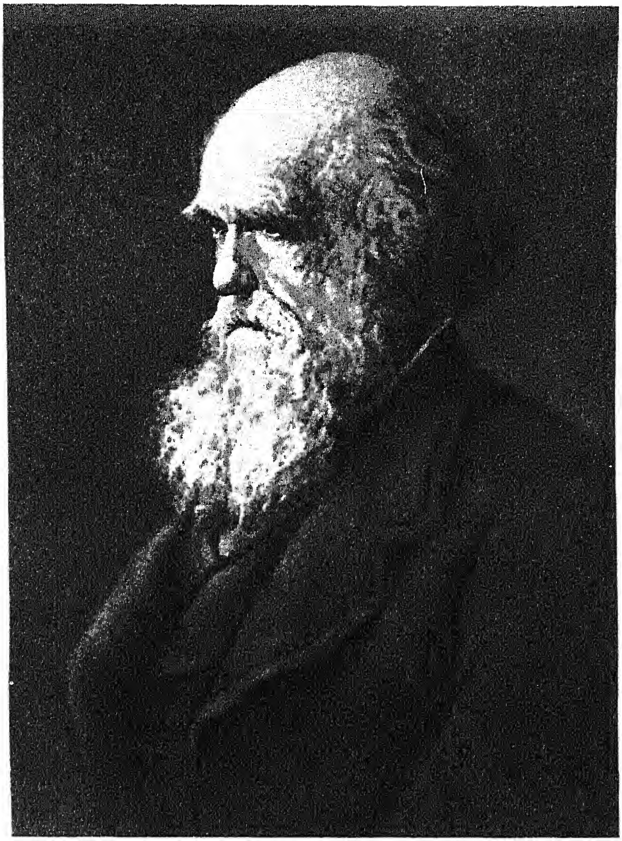
Lyell came out as a reformer of the entire science of the history of the Earth. The professors of biology were still counting the cataclysms which, in their opinion, had from time to time swept every living thing from the face of the Earth. But Lyell asserted that there had been no cataclysms in the history of our planet. He buried the cataclysmic theory in the common grave of the ancient myths—at all events, as far as the geological aspect of the problem was concerned—and showed that everything on Earth—the deep hollows in the beds of the oceans, the mountains towering above the clouds and the gorges through which swift rivers run—

could have been formed in the course of vast stretches of time by the ordinary, common causes that operate under our eyes at the present time.

The five years' voyage in the *Beagle* was Charles Darwin's most important university. Before theorizing about the living world he made himself familiar with it. With his own eyes he saw the immense variety of this world. He traced the slow changes in the forms of living beings, often imperceptibly passing from one to the other as the *Beagle* sailed, mile after mile, along the endless ribbon of the coast of the American continent. He studied the fauna of the islands off Cape de Verd and of the Galapagos Archipelago, so strangely resembling and yet not resembling—the former that of Africa and the latter that of America, that is to say, the fauna of those continents to which the islands were most closely situated. It looked as though the island fauna were the cousins of the continental fauna. . . .

He found the bones of extinct armadilloes of the size of rhinoceroses, and sloths the size of buffaloes and elephants. And they had inhabited the places that are now inhabited by armadilloes and sloths, but different, smaller ones! In his diary Darwin wrote: "This wonderful relationship in the same continent between the dead and the living, will, I do not doubt, hereafter throw more light on the appearance of organic beings on our earth, and their disappearance from it, than any other class of facts."

On examining the remains of these long-extinct beings, however, Darwin sometimes found extraordinary characters, which reminded him of some group of animals that exist today. And not only of one group. He also detected characters that belonged to entirely different groups. It seemed as though several families, and even orders, had collected together in one being. And this being appeared to be the



CHARLES DARWIN

junction from which several roads of life later branched out. . . .

In the environs of Montevideo, Darwin was fortunate enough to see not extinct but living inhabitants of the estuary of La Plata for which it was not easy to find a fitting place on ready-made shelves. This was the Molothrus bird that looked like a starling but had the habits of the cuckoo, and a tucotuco—a blind rodent "with the habits of the mole."

Bones lay bleaching near the river Paraná. Darwin stood among innumerable skulls and ribs, hot from the sun. This was a vast cemetery of animals that had perished in a bad year. How ruthlessly life deals with those who cannot stand the severe test it puts them to! . . .

Gradually, in the course of this five years' voyage, an irresistible feeling came over Darwin. At first it was indeed a feeling rather than a clear thought, namely: that all that the naturalist had witnessed in the vast Land of Life was closely and inherently connected; all seemed to be the separate pages of a single book.

Which book?

There was a fact, a minor one by appearances, which, the more Darwin thought about it, the more significant it became to him. In the Galapagos Archipelago, where the huge tortoises and heavy iguana marine lizards caused one to recall the reptiles of some Jurassic period, Darwin was particularly surprised by the finches, ordinary, tiny birds with nothing antediluvian about them. Darwin counted thirteen varieties. They all closely resembled each other and constituted a fairly friendly flock. The interesting thing about this, however, was that every island had its own variety of finch, and each of these, in some way, however small, was different from those on the other islands. Could it be supposed that the "creative power" that had created the queer population of Galapagos had taken care, firstly, to put on them the American impress (as it had put the African impress upon the inhabitants of the islands off Cape de Verd), and secondly, had created a separate variety of finch for every rock that jutted into the ocean, and furthermore had tried to make the difference between the varieties just barely perceptible?

Darwin returned home in 1836. His notebooks (which were not made public until long after his death) leave no doubt that already at that time he was firmly convinced that the question about a "creative power" must be answered in the negative. In 1837, it was no longer a "feeling," but a distinctly defined thought.

Darwin, however, published only his geological observations, his theory of the origin of coral islands (atolls), which has been retained in science to the present day, and a treatise on the Cirripedia, an order of Crustacea like acorn shells and barnacles and allied parasitic forms. This was a fundamental work on the Cirripedia, which hitherto had been a brain-racking problem to systematizers because of the confusion of species, varieties and families.

Five zoologists worked for six years on the material Darwin collected, and his book, *Journal of Researches During the Voyage of H.M.S. "Beagle" Round the World* was read like a thrilling novel.

He went away a self-taught amateur and came back a universally recognized scientist of outstanding talent. But few of those who flung open before him the doors of scientific societie and expressed regret that this grave, sober-minded researcher, who always backed his arguments with hundreds of facts, so rarely appeared at university centres, knew that he was sitting at home filling closely-written pages of notebooks with researches of quite a different kind.

He married; he lived like a hermit at Down, in Kent. But, tormented by a severe ailment which clung to him to the end of his days, suffering such great pain that he wrote his will in anticipation of death, Charles Darwin, the man whose chief object in life was his work, his notebooks, but who about himself wrote: "I am happy," this man did not publish his researches for twenty-three years. This fact-fanatic still thought that he had not yet collected enough! And he went on collecting and collecting. Pioneers in animal and plant breeding now knew his address. He himself bred pigeons to test the effect of selection.

When, in 1859, yielding to the entreaties of his friends—Lyell, the geologist reformer, and Hooker, the botanist—he at last published his *Origin of Species,* he himself thought that he was acting hastily. . . . *

Darwin's theory is taught in our schools; it is universally known. Perhaps it is necessary to deal with it only very briefly.

In the first place he proved once and for all, in the most irrefutable manner, the evolution of the living world. After Darwin no person possessed of reason and logic could think of challenging the fact of evolution.

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* A significant fact compelled Darwin's friends to be particularly persistent in urging Darwin to publish his researches. The naturalist Alfred Russel Wallace had sent from the distant tropical islands in Southeast Asia an essay entitled "On the Tendency of Varieties to Depart Indefinitely From the Original Type." It was becoming quite clear that "new ideas" were already in the air. And although the most numerous scientific circles that predominated in Academies and universities had no inkling of these new ideas, Darwin's friends feared that he would come "second" in the field owing to his tardiness.

What compels species, genera, families, orders, classes and types of animals and plants to change?

It is doubtful whether any other naturalist of that time realized as well as Darwin how complex nature is. He specially mentioned that he recognized the possibility of change under the direct influence of environment as suggested by Geoffroy, and the influence of changes of habits of life, of the new "habits" and new conditions, as suggested by Lamarck.

But that is not the chief point. Darwin's great discovery was the law of natural selection. Selection! The very term itself shows how Darwin was led to this idea. Human practice, the experiments of men-creators, suggested this idea to him. And, by analogy with the "artificial selection" employed by animal and plant breeders, Darwin coined the now-famous term: "natural selection."

Darwin's line of reasoning was very simple.

No two organisms are exactly alike. Not even those that are closely related. Some are bigger than others, some are stronger, others are weaker. And even if we do rarely find some which outwardly are "as like as two peas," "as if cast from the same mould," there are undoubtedly intrinsic differences between them: some stand cold better, others heat; one of the two can bear hunger better; one is more susceptible to disease.

Among plants the same (or similar) differences may be noted.

In one way or another, the lives of animals and plants with differences between them will not be exactly the same (leaving fortuitous cases aside and speaking of a large number of lives).

Where it is necessary to fight tooth and nail the advantage will obviously be on the side of those who possess strong teeth and claws.

Where it is necessary to flee from foes, it will be easier for those to save their lives who are more agile, fleeter-footed or are better able to hide, and also those who possess the best "protective" colouring, who, as it were, merge with their surroundings and escape the eye of the pursuer.

Drought ruthlessly destroys all plants except the drought-hardy; and only the more cold-hardy grasses, trees, animals, birds and the larvae of insects can survive severe winter.

The struggle for existence weeds out the weak, the less fit; this weeding out proceeds in hundreds and thousands of directions; it has been going on continuously ever since there has been life on Earth.

Since every generation goes through the test and on every occasion the less perfect organisms are "weeded out" and only the most perfect, those which have "passed the test," survive, the tree of life in every generation seems, as it were, to have been pushed a step further towards perfection. The struggle for existence flares up again, but this time among the victors, among the strongest; they must now go through the test, which each time becomes more stern and severe, and hence, the process of perfection, adaptation, development, of evolution of life, does not cease, but goes on and on.

What seemed inexplicable, what Lamarck and Geoffroy had vainly racked their brains over, and about which the divines shed tender tears as they glorified the inscrutable wisdom of the Creator, was explained in the most natural manner: the appearance of birds' wings, the thinking brain, the seeing eye, the chlorophyll-bearing apparatus of leaves and millions and millions of other examples of *fitness* in living nature. The chisel of natural selection had carved all this out in the course of thousands of generations. "Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life," observes Darwin, "and, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

A simple beginning. But what a vast number of consequences this confession has had in all spheres of natural science! Vast and often difficult is the literature on Darwinism.

The creator of it himself needed only a few lines to sum up his theory. He regarded the whole of the bulky volume of *The Origin of Species* merely as "lengthy proof" of the correctness of these few lines!

". . . that the more complex organs and instincts have been perfected, not by means superior to, though analogous with, human reason, but by the accumulation of innumerable slight variations, each good for the individual possessor," seemed to Darwin impossible to deny—"if we admit the following propositions, namely, that all parts of the organization and instincts offer, at least, individual differences—that there is a struggle for existence leading to the preservation of profitable deviations of structure or instinct—and, lastly, that gradations in the state of perfection of each organ may have existed, each good of its kind."

This is Darwinism in its concisest form.

Darwin adds: "The truth of these propositions cannot, I think, be disputed."

Did Darwin explain everything?

No, not everything, by far!

He merely noted that in the organic world "individual differences" are constantly arising; being a true scientist, he had no doubt that these differences do not drop from the skies, but are caused by natural, material influence, by environment. But how are they caused? Darwin did not know. Still less could he say what had to be done to bring about any particular change in an animal or plant.

"We cannot at present explain either the causes or nature of the variability of organic beings," he admitted.

Is this surprising? The men whose practical work helped Darwin to create his theory—the breeders of the beginning and middle of the nineteenth century—the horticulturists, animal breeders and field-plant breeders of bourgeois society—were almost totally unable to change living beings at their own will; mainly, they waited for the appearance of the changes they needed, lay in wait until an animal in their herd or a plant in their garden or plot with the characters they desired "jumped out," and then they matched them with each other.

It follows, then, that selection was still divorced from variability. And so it largely remained in Darwin's theory. And indeed, many of the individual differences that appeared he called "indefinite variability." He could not yet discern, discover, the operation of precise laws here; this was a realm of chance to him.

Darwin saw hosts of living beings engaged in fierce and universal competition, in which the possessors of chance advantages were the winners; the others were ousted from the field. And it seemed to Darwin that this competition was similar to the competition, to that "war of all against all" that he saw raging around him in bourgeois England: the powerful and rapacious profit-seekers of the City of London scoured round for new markets and ruthlessly crushed their weaker competitors; the bankrupts were pushed to the wall, while the lucky ones who had "saddled" fortune, grew rich and were elevated to the peerage; and all—lords, factory owners and merchants—crushed the farmers and the workers. . . .

On every step of the living world—among the animals, among the various plants, and even among the invisible microbes—there reigns (as Darwin imagined) this "eternal order" (it would be more true to say: chaos). Everywhere it is the same, or almost the same. The spherical coccus is infinitely different from the mighty oak, or from the chamois with its lightning-like movements. The development of life is the rise at every stage of something new, something unprecedented. But Darwin seemed not to see the sharp changes in the steps of life. He believed that, in general, development always and everywhere proceeded in a similar way: variability—usually "indefinite," competition, "weeding out" by selection—no matter what may arise as a result of it: new bacteria, or the highest of the mammals, even man!

It was almost like Lyell, who also attributed the flooding of its valley by the Thames, the formation of the great hollows in the beds of the Pacific Ocean, the volcanic activity at the end of the Cretaceous period which we can scarcely imagine, and the Glacial period, when ice covered a good half of Europe, to "ordinary" causes like those that are operating around us today. Nothing had changed. Nothing new, nothing unprecedented had happened, or is happening. Eternal, immutable, "ordinary" order, like that in "cosy" England in his day.

Looked at through the spectacles of this theory, the grand evolution of living nature became embodied, was transformed into, a stream flowing in a monotonous, perhaps far too monotonous valley. It grew wider. It grew deeper. It became a river. It carefully gathered to itself additional thousands, well, say millions, of gallons of water—but the same kind of water. But new steps in the wonderful ladder? Abrupt and mighty turns? Leaps and flights, each revealing a vast, new, unknown world with its own amazing laws, with whole continents of hitherto unseen flourishing life? No, that you did not find in Darwin's book!

Still, one had to have a very keen eye to discern at that time the preconceived ideas, the gaps and the strained interpretations in Darwin's book. Two men possessed such keen eyes then. They were the great contemporaries of Darwin—Marx and Engels. They regarded these arguments of Darwin's as "the first, provisional, imperfect expression of a recently discovered fact" (Engels' well-known appraisal in the *Dialectics of Nature*).

Darwin's theory did not yet place in man's hand a ready weapon for mastering the living world.

But a Herculean task was performed. The doctrine of the invariability of organisms was put an end to once and for all. It was proved with the utmost clarity that the laws that govern evolution are natural, understandable laws, and that man can reproduce their operation.

The simplicity of these great ideas, their indisputable character, and how this was proved, had the effect, as Darwin recalled later on, of a bombshell among his scientific contemporaries who, ignoring Lyell, were still engaged in calculating how many cataclysms had befallen our much-suffering planet. And Darwin himself, with almost forced impartiality, observed that it seemed to him that the veil had now been torn from the "mystery of mysteries."

It was no longer possible to wave all this aside. What could sarcasm do against hundreds, nay, thousands, of irrefutable facts described in this polite, unbiased and somewhat heavy style. Not a trace of fantasy. Not a shadow of frivolity.

Bulky volumes of the most sober-minded, practical prose, concerning which Marx said: "One has to put up with the crude English method of development, of course." Their author, who had upset the dogma of the creation of species by divine will, said about himself that he was totally lacking in imagination. But he handled the whole of natural science like a master. It looked as if he had zoology, botany, physiology, anatomy, geography, geology, paleonthology and agronomics conveniently stowed away in his jacket pockets.

Like Byron's *Childe Harold*, which had appeared half a century earlier, Darwin's *Origin of Species* was sold out in one day.

THE MONASTERY IN BRNO

> One enthusiasm he had—the cultivation of pansies.
>
> G. K. Chesterton, *The Club of Queer Trades*

At this very time, a certain monk in the Czech town of Brno, which under the Austro-Hungarian Empire was known as Brünn, was experimenting with plants.

From photographs we know what he was like: a square skull with an extraordinarily high forehead, small, myopic eyes staring coldly through spectacles, thin, tightly-compressed lips, a clean-shaven, prominent chin.

This monk kept bees, took meteorological observations, planted flowers and collected rarities in the environs of Brno. But he was taken up most of all with crossing different plants and their hybrids—the unusual, mixed varieties that resulted from this crossing. This hybridizing was a passion with him, and he devoted to it all the time he was free from his monasterial duties.

Many people engaged in hybridizing plants at that time.

It probably commenced in 1716, when Cotton Mather, a Boston clergyman, a fierce witch hunter, who, in between his persecutions of old women suspected of practising witchcraft, reflected on the grandeur of the creator of the universe, noticed the mutual pollination of red, blue and yellow "Indian corn" (as maize was then called). In the following year a certain Thomas Fairchild obtained in his garden the first artificial hybrid by crossing a red carnation with a "Sweet William." Linnaeus himself crossed a Marvel-of-Peru with a goatsbeard. In Russia, Germany, England and France, thousands of brushes in the hands of botanists and amateur gardeners dusted the stigma of some flowers with the pollen of others.

But Gregor Mendel, monk of the Order of St. Augustine, introduced into these experiments an unusual perseverance and an unimpassioned, mathematical love of order.

The secret of Napoleon's success lay in that he strove to be stronger than his enemy at the decisive moment at the decisive spot. For this short but infinitely important moment, there existed, as if in an extreme abstraction, only this particular spot, into which all forces must be hurled to win the battle.

Brother Gregor, who had fled from the hurry and bustle of everyday life, possessed this art of abstraction to an extraordinary degree. His numerous predecessors had sought the guiding thread in the intricate labyrinth of innumerable crossings, but in vain. Those who want to catch everything, catch nothing.

The chief and most important thing is to concentrate all attention on one particular plant species. On one plant, and on one only! All the first experiments will be made on this one, he resolved.

Let it be a pea. It is easy to cultivate. It is not an exotic rarity. Schoolchildren study the distinct structure of its flowers: it is almost like a chart. The differences between its varieties have been precisely defined and described. And every flower is self-pollinating. This gives you an ideally pure scheme without any absurd and vexatious interferences. And so, let it be a pea.

The nursery gardeners sent their old and venerable customer thirty-four varieties of seeds. He examined the packets very strictly and distrustfully. He was in no hurry—he had left all worldly bustle outside the monastery gates.

He started by subjecting these envoys of the merchants to a severe interrogation: Are they pure? A two years' probation . . . that is what is needed for a beginning! Plant, gather the crop, compare; plant, gather and compare again. All this he did. One variety failed to stand the test; it was found to be impure. Mendel rejected it. From the rest he selected twenty-two plants.

Now everything was ready. What for? For indiscriminate crossing—just higgledy-piggledy?

No! A battle is won at the decisive point. "How beautiful and complex is every blade!" declaimed the naive and sentimental, raising their arms to heaven and turning up their unseeing eyes. Complexity? These garden peas have hundreds and thousands of characters? Even tens of thousands if you set yourself the aim of describing everything?

Let it be so. What does Mendel care about that? He selected one and only one character, chose a mate for it from a different variety and waited to see what happened to this character in the offspring of the crossing of these two varieties.

In this way he selected seven pairs of characters. Seven pairs of clear and distinct differences. And he set to work on seven experiments.

He artificially pollinated dozens of flowers of the plants designated for each of these experiments. When the seeds had ripened in the pods he planted them all. And again he gathered the crop—to the very last seed. In some cases, even this was not the end. . . . He displayed such painstaking, meticulous and thorough zeal as had never been heard of before in experiments of this kind. Mendel himself confessed that in these first experiments with peas he thoroughly investigated ten thousand plants. One of the "Mendelists" who studied the life and work of the Augustinian wrote later: "For the time factor, i.e., number of generations, Mendel substituted, so to speak, the space factor, i.e., number of simultaneous descendants, which was of profound intrinsic importance."

In particular (this was the second experiment), Mendel crossed peas which produced yellow grains with green-grained peas. In this case he singled out this one pair of characters—all the other differences between the two varieties, amounting to hundreds, perhaps, did not interest him for the time being.

The two years' probation to which he had subjected his plants had convinced Mendel of the purity of these varieties: the "yellow" peas did not produce a single green grain, and the "green" ones did not produce a single yellow one.

He crossed these two varieties.

We know where this event that was so pregnant with consequences took place. The little garden in the Monastery yard has been perpetuated in hundreds of photographs—a narrow plot of ground 35 x 7 metres, surrounded by a wire fence and brick posts.

Here Mendel gathered his crop. What was it like in this second experiment? Neither yellow nor green? That is what it should have been: were not yellow peas crossed with green? But all the grains were found to be yellow! Mendel examined every one of them. It seemed as though there had been no crossing at all!

When he became convinced of the unimpeachable yellowness of his "mulatos" he obstinately planted all these grains. He laid out his cards in a second game of patience. This time he did not interfere at all. He did not pluck out stamens to prevent self-pollination, he did not cross the plants, he just waited, leaving his "mules" to their fate.

The pattern of the cards was worked out again: this time the *majority* of the grains were yellow—but not *all*. There were green ones among them. It looked as though the latter had been hiding under the apparent yellowness of the first-generation hybrids and had now come into the open.

But what was this game of hide and seek? Mendel was not inclined to stand in sentimental and rapturous awe before the wonders and caprices of nature. He was not going to allow himself to be fooled by some kind of a "disorderly heredity" which had been almost proclaimed a law by the French botanist hybridizer Charles Naudin, whom the Paris Académie had praised to the skies!

There *must be* some order here, and Mendel will find it: he had not for nothing planted *all* the yellow grains he had gathered from the crossed peas; not a single one had slipped out, he held all the cards.

He spread out before him the harvest from 258 peas; slowly, grain by grain, he examined the whole heap. Eight thousand and twenty-three grains: six thousand and twenty-two yellow ones, two thousand and one green ones.

This was the order that was concealed in this heap! This was the law that all the fatuous hybridizers had overlooked!

In the second generation the hybrids of yellow and green peas split up in such a way that the number of green ones is *one third* of the number of yellow ones.

He planted his hybrids again and again. He crossed them, in particular, with the pure original plant.

As a result, Mendel's mathematical mind worked out the history of the heap of eight thousand grains as follows.

When the "yellow" and "green" peas were crossed the first time, the yellow variety "factors" everywhere met those of the green; but the yellows proved to be stronger than the greens and suppressed them. In every pair the yellows were the prevailing, or *dominant,* ones and the greens were yielding, or *recessive* (such were the names that Mendel gave them).

Yes, they were paired by the masterly will of the experimenter, but they did not mix. Mendel had no further doubt about that. When the pollen ripened in the egg cells in the ovules of the peas grown from the supposedly yellow seeds of the first hybrid generation, the pairs divided, the green and yellow germs separated. The cards were again laid out according to colour. With the new pollination, however, it was chance that shuffled them; at the time the second generation of pea grains was generated the experimenter had deliberately not interfered. Chance! But have not mathematicians created a whole doctrine about chance? It is called the "theory of probability." The problem of what happened in the flowers of the pea hybrids could be easily solved by it.

Indeed, what *could* have happened?

There were *four* possibilities.

A yellow could meet with a yellow.
A yellow could meet with a green.
A green could meet with a yellow.
A green could meet with a green.

Everything is now clear. Any pair that contained a dominant yellow had to bring forth yellow grains. And only in one out of the four cases, when a green met a green, were green grains produced.

One green to three yellows!

As the medieval Schoolmen used to say: "Quod erat demonstrandum"—"Which was to be proved."

Thus, in the second generation we could expect the pea hybrids to split up into yellow grains and green grains in the proportion of three to one.

This is the law of heredity that was established by Mendel.

The plant "mulatos" were now in the power of brother Gregor. He could command them like a general commanding his troops. He tested his law not only on peas, but on several other plants. The patterns in his game of patience became more and more intricate. In whatever direction he turned his cold, myopic eyes, the living organism split up into a heap of characters—they did indeed become like a pack of cards that one can take in one's hands and shuffle. And Mendel marked his character-cards with Latin letters: capital letters for the dominant characters and small letters for the recessive.

Several years later he wrote a paper about his discovery, in a fine, round, firm hand, and read this paper in the course of two sessions of the Brünn Naturalists' Society—on February 8 and March 8, 1865. The forty pedagogues, physicians, apothecaries and government officials assembled in the schoolroom where the sessions were held, and who regarded themselves as experts in the natural sciences, listened to him with unconcealed boredom. They could make neither head nor tail of these self-confident and complicated mathematics and, after passing the usual vote of thanks to the speaker, they dispersed with a feeling of relief.

The *Transactions* of the society, which included Mendel's paper, were read by numerous important scientists of that time, but the great theory of evolution was then marching triumphantly through the world and the scientists had no time for the caprices of the descendants of the pea fraternity, or for a pedantic algebra that smacked of monasterial scholasticism. The famous botanist, Karl Nägeli, wrote to Mendel: "I am convinced that with other forms you will get entirely different results."

"Take up hawkweed," he added, casually, as it were. "It would be particularly well if you succeeded in getting hybrid pollination in hawkweed."

Nägeli knew what insidious advice he was giving. It was not for nothing that hawkweed was called "crux et scandalum botanicorum"—"the cross and scandal of botany." One very learned botanist named de Vries wrote three Latin treatises on the medley of species, subspecies, varieties and races among hawkweed. He devoted his whole life to hawkweed, but obtained no results.

Stern brother Gregor was not accustomed to have the cards falling out of his hands; but here the pattern in his game of patience would not work out. His experiments produced strange and unexpected results. In some cases, despite all his efforts, the crossed hawkweeds were quite sterile; they did not produce a single seed. In other cases, plants that grew out of hybrid seeds split up in the most amazing fashion in the very first generation; but in subsequent generations, on the contrary, they would not split up at all. Mendel worked patiently on the tiny yellow and red flowers, but in vain. The daylight was too weak to enable him to examine the minute stigma and confusion of staminal filaments that looked like living dust. Mendel sat over them for hours with a mirror and magnifying glass and got up staggering, with burning eyes. In his quiet, cloister study he arranged and rearranged his capital and small Latin letters in different combinations, but all in vain! The entire alphabet of Virgil and Cicero was unable to help him. . . . And to think that this was just a wretched field grass! And this at a time when the whole of the plant world should have obeyed the law that he, Mendel, had discovered!

Fate assuaged the bitterness of failure for Mendel. Even when most deeply engrossed with his peas and hawkweed he never forgot his monasterial and congregational affairs, and his persevering labours in this field were rewarded. In 1868 he was appointed prior of the monastery. He now became an important and influential person in the town. He was appointed a director of the Moravian Mortgage Bank. But Prior Mendel started a lawsuit over the monastery's taxes. The case was endless; it dragged on for years. Mendel had no more time for his gardening experiments. He now employed a gardener, and from time to time the obstinate prelate, now jaundiced, flabby and aged, would stroll among the budding fruit trees and curse his enemies under his breath. His enemies triumphed. He was forced to witness the sequestration of the property of his monastery. In 1883 the Horticultural Society sent him a medal—but this was small consolation. In the following year he died from Bright's disease, regretting most of all that he had not finished writing his last, decisive appeal that would have shattered all the webs woven by the lawyers in the imperial High Court.

GIANTS AND PYGMIES—TWENTY-TWO MICE GENERATIONS

> The creativeness of the poet, the dialectics of the philosopher and the skill of the researcher—these are the materials which go to make up the great scientist.
>
> K. A. Timiryazev

A period of twilight set in in Western science.

On a raw April day in 1882, almost two years before the death of the stubborn prior, Charles Darwin, the aged, invalid and man of solitude who had roused the whirlwind that had been raging all over the world for a quarter of a century, passed away. And those who disliked this whirlwind believed that it would now subside.

The people of minor deeds and cautious ideas now became masters of the field of the natural sciences in the West. The "fossils" who, twenty years ago, had fiercely championed the dogma of eternal creation, again made themselves obnoxiously heard. What? Were they still alive? Yes, they were still alive. . . .

And all those who in that gloomy time tried to turn back the wheel of science united in order by their joint efforts to bury Darwinism with its creator, and to make science once again the handmaiden of the Church as it had been in the olden days.

True, this time the wolves put on sheep's clothing.

"Evolution!" they declaimed from their professorial chairs. "Evolution is the greatest idea of our progressive age! Yes, it goes on. . . ."

"Unfortunately" . . . added some of them under their breath.

"But . . ." here they assumed a mysterious air . . . "old Darwin did not understand it at all!"

"The organism of its own accord miraculously adapts itself to all changes in its environment"—mumbled some of them.

"It develops the organs it needs and causes those it does not need to disappear"—asserted others, interrupting the first.

What was this? Were they clutching at the timid, uncertain ideas, at the fantastic dreams of the first evolutionists whom they themselves (or their worthy fathers) had ridiculed not so long ago?

Yes. That is exactly what they were doing.

Only they remembered, not the strong, but the weak aspect of Lamarck's ideas. For example, the "striving towards perfection" that he had invented. As for Lamarck's idea that the new needs of the organism, created by its new conditions of life, cause changes in the form of the body, in the characters of the organism, they interpreted them in this way: the organism creates the new organs it needs at will.

The false interpreters of Lamarck stuck out their chests and said:

"We proclaim a new trend in science. Its name is—psycho-Lamarckism."

"Psycho-Lamarckism." What is it?

Well, listen.

"The organism changes itself, for it possesses a mysterious vital essence. Evolution harbours the divine will."

It was a cunning trick to compel the theory of evolution, the destroyer of the dogma of eternal creation, to sing "Hosanna!" This senile dogma had collapsed, but for all that, a place was found for God in mundane affairs. As they used to say in the olden days: "The King is dead. Long live the King!"

To the chagrin of the tricksters, the trick did not come off as easily as they had wished. It was not so easy to blunt the materialist spearhead of the theory of evolution. A galaxy of researchers took the place of the one who lay under the marble slab in Westminster Abbey.

And louder and louder was heard the voice of a young scientist, more and more confidently drowning the chorus of "Hosannas!"

This was the incorruptibly stern and clear voice of reason; it was, in addition, the voice of the conscience of science.

It belonged to a Russian. His name was Kliment Arkadievich Timiryazev.

His life was a remarkable one.

He was born in St. Petersburg in 1843. When little Kliment was five years old, a friend asked his father what careers he intended for his four sons. His father answered: "I will make five blue blouses like those worn by French workingmen, I will buy five guns, and we will go with others—to the Winter Palace!"

It was not for nothing that Kliment's father mentioned the French workingmen. That was the year 1848, the year of the revolution in France which overthrew Louis Philippe, the year of the June insurrection of the workers of Paris, the proletariat's first great class battle, which re-echoed throughout the world. It is doubtful whether Timiryazev's father, a poor nobleman who held republican views, appreciated the full significance of that battle. But his honest soul was filled with hatred and disgust for General Cavaignac, the bloody butcher of the heroic workingmen, and for other oppressors of the people.

When Kliment grew a little older, his father told him about the Russian Decembrists, about the first French Revolution, and about Robespierre—"a pure and holy man." He brought up his children in the firm principles of straightforwardness in life, service to the people and contempt for all forms of servility.

The chief thing that was ingrained in the children of the Timiryazev family from their earliest years was—respect for human labour, for the labour of the people.

Many years passed, and Kliment Arkadievich Timiryazev, already a very old man, wrote with a trembling hand his dedication for his book *Science and Democracy*, a copy of which he sent to Vladimir Ilyich Lenin.

He dedicated his book "to the beloved memory" of his father and mother, Arkadi Semyonovich and Adelaida Klimentievna Timiryazev. He wrote:

"From my first gleam of consciousness, in that dark period when, in the words of the poet, 'under the paternal roof not a single pure, human, fruitful seed of life was dropped,' you, by precept and example, implanted in me boundless love for truth and burning hatred for all, and particularly public, falsehood. To you I dedicate these pages, which are bound by a common striving towards *scientific truth*, and towards ethical, public-ethical, *socialist* truth. . . ."

At the age of fifteen Kliment began to earn his own living.

At the age of eighteen he entered the St. Petersburg University. At that time the police kept a "dossier" for every student as if he were a criminal, and all students were ordered to sign in their "matriculae" a pledge of good behaviour, in other words, to pledge themselves to be humble and obedient.

In protest against this humiliation, the students organized meetings and strikes. Kliment Timiryazev was one of the strikers. He was expelled from the University, but in spite of that he graduated, as an extern student, and was awarded a gold medal for his graduation exercises. "I captured science in battle," he stated in his reminiscences.

He brilliantly passed his Master of Science and, later, his Doctor of Science degree examinations. He was elected a professor of the Petrovsky Academy (now the Timiryazev Academy of Agricultural Sciences); in the Moscow University he established the first Chair of Plant Anatomy and Physiology.

To the hall in which Timiryazev lectured flocked students of all semesters and all faculties. His name became famous. People came from all over Russia to attend his lectures and to inspect his laboratory.

Then his fame spread over the world. One after another, foreign academies and universities elected him as their honorary member. He was written about as the most celebrated botanist in the world.

But he came out with the assertion that the whole of society should become the collaborator and judge of science, which must serve the people; that "science must climb down from its pedestal and begin to speak in the language of the people, that is, in popular language." He defined the task of science as it had never been defined before, namely: "to combat every manifestation of reaction—such is the most general and the most urgent task of the natural sciences." And he expressed the opinion that all that had been done in science so far was only its prehistory, that the real history and really powerful development of science would commence when it became the science of the people, and when tens of thousands from the ranks of the people began to work in it.

In 1878 he delivered a speech in which he openly pointed to the approaching twilight of science in the West. It was then that he referred to the "ists" and "ologists" who were beginning to multiply in such profusion in the European universities, to the hordes of pygmies who denounced as "dreamers and fantasts every one who tried to rise above the common level and scan a wider horizon." And while denouncing the pygmies he, in wonderful words, defined the work of the giants who blazed new paths in science: "The creativeness of the poet, the dialectics of the philosopher and the skill of the researcher—these are the materials which go to make up the great scientist."

Poet, philosopher and skilled researcher—all merged in one organic whole! Much, indeed, did the author of this definition demand for the man that he would agree to call a "great scientist."

But it became increasingly evident that he applied this unexampled criterion not only to the work of others, but also, and primarily, to his own work. This is what he *demanded from himself*.

What did Timiryazev discover? It is difficult to relate briefly the results of a long and fruitful life. Here we will mention only a few things.

There is not a man on Earth gifted with sight who has not noted the greenness of the plant world. It is one of the first impressions a child obtains almost from the moment it looks around. How many thousands of years does man know that plants are green? As many as man himself exists on Earth!

Nevertheless, nobody ever knew why it is so, why the green world is green!

Timiryazev explained this. Not only did he explain it, he showed that a green leaf could not be of any other colour; if it were, the plant could not perform its wonderful work: "create with the aid of light," photosynthesis. Leaves bear precisely the colour that enables them to absorb those rays of the solar spectrum that are most active in the photosynthetic process.

That is why the green leaf had to assume the green colour. Natural selection pushed and led it in this direction in the course of millions of years. This was one of Timiryazev's discoveries.

While still a youth, Timiryazev set out to solve a problem which everybody considered, and did indeed appear to be, insoluble. He set out to discover the most hidden secret of the green leaf, the secret of how living matter is formed out of the simplest of mineral substances in the leaf of a plant—the profoundest riddle of living nature.

And so, one after another, the researches of the Russian scientist began to be made public, scores of researches. And they inexorably led to the conclusion that Timiryazev had succeeded in doing what in the opinion of those who preached the existence of a mysterious "vital force" could not possibly be done: he had solved the riddle. Photosynthesis, that "creation with the aid of light" that goes on in the living leaf while it is lit by the sun's rays, was no longer a mystery!

Timiryazev ascertained which particular rays of the solar spectrum the leaf absorbs and, to put it in his own words, traced "their fate in the plant." He studied the green cells with their grains of chlorophyll and showed how they fix the energy of light and convert it into a chemical energy and into internal work. He showed definitely that it is with the aid of this energy that the photosynthetic process takes place; he even drew up an "energetics balance sheet" for it. The study of the physics and chemistry of "creation with the aid of light" was placed on a firm basis. No room was left for the "vital force" in the phenomenon that only recently had been inexplicable.

It was found that natural laws operate in an immense sphere of living nature in which for ages before Timiryazev botanists, physiologists, even physicists and chemists had believed that a miracle reigned.

Year after year, decade after decade, he stood, as it were, like an unrelieved sentry, repelling all attacks against it, upholding it in all its scientific strictness and purity. He did not simply propagate "Darwinism," nor merely develop it further; he added something new to it.

Up to the middle of the nineteenth century there had appeared to be two roads for human activity in the world of living nature: one for theory and another for practice. "Knowledge is power," is an old saying, but being in the power of the agelong conception that species are immutable, the science of biology left man helpless in face of the living organism.

On the other hand, the practical plant and animal breeders were creating new forms of life, but they were doing this very slowly. Practice was not enlightened by theory. In this slow renovation of nature there was something resembling blind, elemental processes.

It seemed as though a wide chasm separated theory from practice.

Darwinism served as a bridge across this chasm; and in this, to a considerable degree, lay its strength.

But this bridge, boldly thrown across the chasm, was not yet sufficiently strong and wide. Darwin noted and proclaimed facts. He revealed the immense value of the work of the practical breeders for solving the "mystery of mysteries." But the bridge was not wide enough for two-way traffic—not wide enough to enable theory to repay with interest what it had borrowed from practice.

Darwin said in effect:

"Look: this is how it was in the history of domesticated animals and cultivated plants. And this is how it was in nature."

But Timiryazev added:

"This is how man must and will act to change the nature of animals and plants in the direction he deems necessary."

Timiryazev turned the theory of evolution in the direction of man's might, he turned it to the service of man. By word and deed he propagated what was then a new science. And he himself gave this unprecedented science a name—*experimental morphology*—the science of the transformation of living forms by man.

Once upon a time, long ago, when human knowledge was still limited, there were scientists who covered all fields. They were called "walking universities."

Under the eyes of our older generation Timiryazev displayed such almost legendary universality in a period when the natural sciences had already made gigantic strides in their development.

Indeed, it is difficult to find a sphere of the science of life on which Timiryazev has not left his mark.

He felt as much at home in the field of zoology as in the green world of plants.

And physicists wrote to him: "We regard you as one of ourselves, and we are learning from you . . . watching your experiments, we cannot help recalling the work of the great creators of physics. . . ."

He was one of the creators of Russian agronomics; he proclaimed that the noblest aim of the efforts of science is to grow two ears of corn where one had grown before.

"Nature is the common people," he reiterated. "She loves work, she loves horny hands; and if she must reveal her secrets, she prefers to reveal them to those in whose interest it is to do so."

And what eloquence he possessed! It was indeed fiery. Nobody before him had written about science and scientists as he did.

All that Timiryazev said and wrote, all his scientific researches and discoveries—his proud, mighty, fearless, really human science—came down like a hail of stones upon the turbid, green quagmire where the frog choirs of "ists" and "ologists" croaked their "Hosannas."

And what a splashing there was in that quagmire! That fiery eloquence struck every clump and reached the very bottom of it!

"Unheard of!" croaked the "ists" and "ologists." "He is saying what Darwin dared not prove—that the whole of living nature originated from lifeless nature."

"He is a rebel! He is driving the creator out of the universe he created!"

"I don't understand this business with the green leaf," grumbled Pfeiffer, the German botanist. "But what a daring conclusion! This man simply ignores Dr. Julius Sachs, although it is common knowledge that Dr. Sachs knows all there is to know about the physiology of plants."

And lowering his voice to a confidential whisper, Pfeiffer added:

"I think the figures in those Moscow experiments have been faked. Yes, yes, of course they have been faked."

But Dennert, the idealist philosopher, would not be consoled.

"Your hair stands on end when you see the poison of materialism percolating among the masses of the lower classes," he wailed.

And from London were wafted the sighs of Sir Oliver Lodge, the celebrated physicist:

"Alas, the sea no longer protects England's shores. Yesterday, in the bus beside me, a common artisan was reading a book about how the most beautiful flowers have adorned the earth in accordance with the crude laws of nature."

After uttering this, Sir Oliver entered a darkened room and prayed to the spirits to tell him by knocking on a small round table how to lay the immortal theory of evolution into its coffin, so that it could go with its mortal creator: Sir Oliver devoted the spare time his laboratory allowed him to spiritualism.

But the spirits were either deaf or incapable of fulfilling the request of this worthy member of the Royal Society; they never told him how to eradicate the theory of the development of the living world.

At about this time, Professor August Weismann was delivering a course of lectures on the theory of evolution in the town of Freiburg, in Germany. He was regarded as a Darwinist, true, with the prefix "neo"; which meant that the Professor was not an ordinary, but an improved brand of Darwinist.

Professor Weismann cut off the tails of mice, waited until these mice had offspring, and cut off their tails too. And he went on doing this to twenty-two generations of mice. He carefully measured the tail of every newborn mouse to see whether it was shorter than that of its predecessors. But the tails of the mice of the twenty-third generation were just as long as they were supposed to be among the mouse tribe.

"From this I see," argued Professor Weismann, "that it is quite a mistake to regard living organisms—even these mice which fear not my knife—as integral beings. Actually, they consist of two parts, one fitted into the other. Life is like a casket which contains another casket. Inside the external mouse that I see there is another mouse, internal and invisible. I can cut off the tail of the external mouse, but I cannot reduce the tail of the internal one even by a single millimetre."

In short, Weismann proclaimed that all living organisms consist of a body and of a germ substance. It would be a mistake, however, to suppose that by germ substance Weismann meant simply the germ cells that exist in mice as well as in the countless multitudes of other organisms. No, Weismann did not have in mind the ordinary cells which, in due time, form organisms, and which can be taken and placed under the microscope, sketched, photographed and studied; he spoke of a substance which, of all the substances in the world, and the only one in the organism (unlike the "body substance"), is alone endowed with the mysterious power to reproduce life, a substance unknown to the chemist and invisible under the microscope!

This germ substance carries within itself the hereditary factor (Weismann called them determinants); and no matter what happens to the body of an animal or plant, nothing can change the hereditary factor. When living beings multiply, it means that the germ substance produces from itself a new germ substance. What is to grow—a chicken, a frog, or wheat—is determined by the mysterious and invisible hereditary factor. The body is their product—but they are not influenced by the body in any way. Mortal bodies are only containers for the germ substance. It is immortal; it eternally produces itself.

The germ cells are frames for the germ substance; they are germ cells precisely because they contain the germ substance. Vain are the hopes of histologists, cytologists, embryologists and anatomists of being able to penetrate the secret of the germ cells with the aid of needles, sharp knives, chemicals and microscopes. These ignoramuses even imagine that they can see the living body generating these cells together with its other cells, and that it cannot be otherwise, since there are such things as logic and common sense! How naive they are! Not a single germ cell is generated by the body; it learns its secret directly from another germ cell; and this secret is an immortal substance which engenders the perishable body that is obedient to it and, concealed within it, governs the body and later casts it off and enters another body.

Weismann's arguments caused no chagrin whatever to the opponents of Darwin.

"Indeed," they concluded, "this destroyer of mice tails is by no means so terrible. Evidently, if the little prefix 'neo' is added to Darwinism, its teeth fall out."

But we must take note of these amazing arguments in which everything is turned topsy-turvy: they marked the appearance on the scientific stage of a "hereditary substance" which was alleged to be endowed with a mystical secret, was omnipotent and impervious to all influences. Strange to say, this inexplicable "substance" was destined to live long in the innumerable books of the followers of the Freiburg "mice operator."

Thus, biology was menacingly faced with "fate in the shape of heredity."

An unexpected event occurred. Gregor Mendel's treatise had remained unpublished for nearly forty years and seemed to have been definitely forgotten by everybody. But in the first half of 1900, three botanists: Hugo de Vries in Leiden (Holland), Karl Correns in Berlin, and Erich Tschermak in Vienna, one after the other, announced to the scientific world the discovery of this treatise. And suddenly, the unknown prior of the Augustinian monastery came to life again. His name flashed through Germany, Austria, England and Scandinavia; it penetrated the laboratories in Paris, and then crossed the ocean and marched triumphantly through the United States. With unprecedented rapidity a new science sprang up, first called Mendelism and later renamed genetics.

"This is the profoundest thing that can be said about the hidden secrets of life!" exclaimed the champions of the new science. "Gregor Mendel, the greatest biologist of the nineteenth century, long ago knew in all its details what Weismann has told us only recently. What clarity and profundity! What magnificent mathematical symbolism! The ancient Pythagorians who believed in the harmony of numbers were mistaken in worshipping the number 36. They ought to have engraved on the gates of their temples: '3:1.' "

The first geneticists felt like navigators who had landed on a hitherto unknown continent.

Tens of thousands of microscopes were turned on ovule and pollen cells in search of the hereditary substance—the repository of the mysterious germs. Tens of thousands of pens and pencils wrote out brain-racking formulas for the most complex segregation of characters.

. . . A slow stream of protoplasm washed the dark contours of the nucleus within the cell. In the cell there was spread a net with numerous nodes. These nodes resembled brilliant grains, and the net sometimes looked like a patch of the starry sky. The cell was alive: the researchers saw changes taking place within it. The cell grew: it was preparing to split into two. At this moment the contours of the nucleus began gradually to melt away. The net that resembled the starry sky vanished. Its loops grew thicker, and soon it was transformed into rods or threads. They could be counted.

This is what happened in all cells, both germ and body cells.

The geneticists zealously set to work to count these rods or threads. It was found that their number is usually invariable in every species of animal and plant. The radish has 18, the thorn-apple 24, the queen bee 32, man and the monkey 48, some of the butterflies 80, and sedge as many as 112.

The rods greedily absorbed the dyes with which the microscope operators stained their preparations. This had long ago suggested to them a name for these rods, and this name was adopted by science: chromosomes, i.e., "dye-absorbing bodies."

When they were stained they became more distinctly visible in the cells. These tiny rods or threads in the nucleus were not all the same. One was hooked, another had something like a head, a third resembled a comma, a fourth looked like an exclamation mark without the dot, and a fifth looked like a period in bold type. . . . And it was found that the germ cells contained only half the number of chromosomes found in the body cells.

Evidently, there was some important biological significance in this difference, in this smaller amount of chromatin substance in the germ cells. Their function is to fertilize, to unite with another germ cell, and if the number of chromosomes were not reduced before that, it would double with every fertilization. It would grow to infinity. Very soon the entire work of the cell would be disturbed, would become impossible; life would cease at its very birth.

And so processes of amazing harmony and complexity took place under the eyes of the scientists; deep and important processes that took place in the tiny, living body of the cell. It was not only the nucleus, of course, and still less only the chromosome threads stained in laboratories, that took part in these processes.

What a field of observation for not one but many sciences: physiology, cytology, biochemistry, embryology—the sciences of the individual development of the organism!

But the geneticists were inclined to regard everything that concerned germ cells as their indivisible property. What did they care that these are living bodies, tiny, frail and infinitely complex? The Mendelists were interested only in "germs," only in the "hereditary substance." All they saw they, as it were, compared with their crossings, a model of which was provided by the experiments that had been made in the monastery garden in Brünn. Only a corner of the veil had been slightly lifted over what took place in the cell, much remained unclear. Through his microscope the biologist actually saw only a small part of what took place. Although nobody had ever seen a continuously existing chromosome in the cell, but only the chromatin substance which gathers together in rods and threads during division and scatters in the spongy net again in between divisions—the Mendelists, giving rein to their fancy, bravely made up in their imagination for what they could not see. "Maternal" and "paternal" chromosomes "come together" and form "pairs" when crossing, and "separate" again when new germ cells ripen.

That's what it is: Mendel's "germs" are in those chromosomes! That is their exact address!

That is how the chromosome theory of heredity came into being in genetics.

THE MORGANISTS

Chromosomes became the chief heroes of the day in geneticist laboratories. The printed pages of Mendelist books, and special supplements printed in costly, snow-white, glazed paper, teemed with tens of thousands of illustrations of chromosomes, looking like clusters of worms. Neither the biggest stars of Hollywood, nor even the President of the United States himself, could boast of having their portraits in the newspapers, books and magazines as often as the chromosomes of flies, snapdragon, peas and thorn-apple were portrayed in the innumerable publications of the American Mendelists.

This was because the leadership of the entire vast army of geneticists was soon captured by the school headed by the American Thomas Hunt Morgan.

Morgan supplemented Mendelism with Morganism.

Morgan announced that, Mendel notwithstanding, some groups of characters do not "split," because, as he explained, their germs are contained in one chromosome; *whole* chromosomes and not parts of chromosomes disperse among different cells!

Later he announced that indivisible characters also separate sometimes, and this is because the chromosomes, in pairing up for their last "dance" before parting, become too closely interwoven and interchange parts of themselves!

Morgan also announced that it was far more convenient to conduct genetic research not with peas, and certainly not with hawkweed, but exclusively with a certain tiny fly, compared with which the ordinary house fly seems a giant. In America, these flies are found in orchards and plantations. Of a yellowish-grey dust colour, these flies, on bright, sunny days, drink the sweet juice of overripe fruit, and for this reason farmers called them "fruit flies."

And so, glass test tubes were distributed to the Mendelist laboratories all over the world containing American "fruit flies," otherwise known as Drosophila. They were fed on a pap cooked with raisins.

Thousands of books were published dealing with the breeds, races and genealogies of these flies. The different shades of their eyes were described with a minuteness with which no poet has ever described the eyes of his beloved. Even the hairs of their tiny bodies were measured and numbered.

And Morgan, who made all these "great discoveries," announced to the universe that he had calculated exactly where and how in the bowels of the minute fly nucleus threads (which even under the microscope are barely perceptible rods and commas) lie the extremely diverse Mendel's germs—the genes, upon which the appearance and hereditary transmission of all characters depend.

If a fly is born with red eyes, it is because it has a red eye gene in its chromosome. If a fly is born with curved wings, it is due to the action of the curved wing gene.

Morgan and his followers—the Morganists—drew up most detailed charts of all four pairs of Drosophila chromosomes. Those charts indicated the places of several hundred genes; and according to Morgan's calculations, the total number of genes in a Drosophila is 7,500, no more and no less.

> Life is like a game of cards. Each of us holds in his hand two aces, two deuces, two treys, two fours, and so forth. One of the aces, one of the deuces and one of the treys we have inherited from our mother, the other ace, deuce, trey, etc., we have inherited from our father. All our characters, length of nose, for example, are determined (excepting the results of an accidental blow, excessive indulgence in alcohol and various other external influences) by the cards we hold in our hand, or genes, which determine all our specific characters.
>
> H. J. Muller. Paper read at the Moscow Institute of Experimental Biology, 1934

Thus, within a few years, out of the simplest experiments in crossing and the counting of grains and fly hairs, there sprang up, as if by the wave of a magic wand, the huge and spreading tree of genetics.

This was a very surprising product of "pure reason."

It reminded one of the fabulous tree the fakir grew from a date stone before the eyes of the crowd.

The Morganists spoke about genes with such confidence that one would have thought they had seen them with their own eyes.

Sceptics were at liberty to smile when they were told that the "spring" gene compels spring wheat to ripen in the year it is planted, and that the "egg-laying" gene induces white Leghorns to lay three hundred eggs a year. And when bees build their hexagonal honeycomb cells, it is obviously the "mathematical gene" that whispers to them how to lay out their particles of wax.

Yes, sceptics were at liberty to smile and even to recall Molière's doctor who, as is known, when asked why a sleeping draught sent one to sleep, wittily answered in the Latin lines:

Quia est in eo
Virtus dormitiva,
Cujus est natura
*Sensus assupire**.

But you did not feel like laughing when you were told that the cause of "wide wings" lies precisely in the first chromosome, in the company of the causes of "sloe eyes" and "giant bodies," and that the "hairy" gene is exactly 23 1/2 Morganides from the "dwarf" gene according to the third Drosophila chromosome. A "Morganide" is a unit of space within the chromosome introduced by the Morganists. This name again reminded one of the man who, by no means a Tom Thumb, felt quite at home inside minute threads.

He knew quite definitely that the genes within them lie in a row, like apothecary's tablets in a Lilliputian test tube.

In the Middle Ages, the pious monks who spent their lives in prayer and vigils were visited by visions. Their cells constantly teemed with tiny demons who tickled their heels while they kneeled in prayer, sprinkled dried birds' droppings on their shaven crowns, squeaked in the corners like mice, and peeped over their shoulders when they were writing with such eager curiosity that the pens made blots on the paper. It is known that one day, Luther, being exceptionally pestered by the Devil, threw an inkwell at him.

The Morganists were intimately acquainted with the invisible and inscrutable genes. They even treated them with a certain amount of familiarity. Consequently, what happened in 1933 might have been anticipated. In that year the English geneticist Painter, who had been examining and making drawings of Drosophila chromosomes for many years, noted

* Because it contains a sleepy virtue, the nature of which is to lull the senses.

some thickenings, belts and stripes on the nucleus threads of the cells of the saliva glands of this fly. They arranged themselves like a chain. Painter was astounded. He got up from the microscope, feeling something akin to what forefather Abraham felt when, if we are to believe the Bible story, the Lord God himself appeared before him in the plains of Mamre.

"I think," he whispered, "I see genes. . . ."

But alas, even the chromosomes could not be found in the nucleus in the spaces between two divisions of cells. As the reader already knows, the chromosomes become clearly visible only when the cell is ready to divide. In the "resting" nucleus of a cell that is not dividing only the net with nodes is perceptile, but no rods or threads.

This did not disturb the Morganists in the least.

They even invented and got inserted in the dictionaries of nearly all languages the verb "to Mendelize," signifying the behaviour of characters during crossing in obedience to the rules of the departed prior. And according to these rules, and the Morganists' formulas, it followed that gene-germs exist. The body contains but does not create them; on the contrary, they create the body. The body is mortal—they are immortal. In due time they change their "receptacles"; they pass from the parents to the children, and then to the grandchildren. And in all of them they continue their existence, merely changing their short-lived corporal integument now and again, like a snake changing its skin.

As the reader will observe, however, there was absolutely nothing original about these "deductions." The world had already heard these topsy-turvy arguments from Weismann, the Freiburg cutter of mice tails. The organism consists of two distinctly different substances—the germ substance and the body substance. One of these parts of the organism (the only one we know)—the short-lived body—is the temporary by-product of the other, which is concealed from all the parts—the germ substance. The seemingly independent life of the body—the only life we know!—is, as it were, the reflection of another, totally unknown, immortal life of mysterious hereditary germs.

The Mendelist-Morganists took over in its entirety this fantastic, gloomy nonsense, this invention of an archobscurantist who proclaimed that real life was the plaything of hidden, mysterious, unvanquishable forces. More than that, they made this the foundation, the point of departure, of Mendelism-Morganism.

"What is a hen?" the Morganists asked in their books with an air of importance. And they answered in all seriousness: "A hen is the means by which the egg creates another egg!"

Is this a joke? Is it the "tricky" problem with which junior class schoolboys amuse themselves? Is it a medieval exercise in scholastic subtlety?

Oh, no! It is the "science" of the twentieth century, the "science" of the Morganists.

The Morganists (like Weismann) asserted that the germ cells of organisms (the visible receptacles of the invisible germs) always come directly from these very germ cells.

They actually called it: the continuity of the germ substance. The egg creates the egg!

But this scheme ran counter to the simplest facts. Take plants, for instance. From the seed a stem grows. And only a long time after, somewhere at the top of the stem, there opens (in flowering plants) a flower bud with pollen and ovules. Except by some stretch of the imagination, it is difficult to see "continuity of the germ substance" here. Let us take a modest flower like the Begonia. You can take a leaf from this plant, slit it, plant it firmly in moist ground, and from this leaf a complete, new plant will grow—roots, stem, leaves and flowers. Here, the hereditary substance is most obviously not "immortal": the leaf creates it anew.

The Morganists shut their eyes tight and did not see these facts and hundreds like them.

Tens of thousands of the most intricate crossings and forecasted "splittings" among the hybrid offspring were supposed to confirm the flawless correctness, harmony and mathematical precision of the Mendel-Morgan theory. There was a sort of hypnotizing power in this unprecedented flood of calculations, in this biology which had been converted into a collection of theorems couched in an especially invented obscure language which the uninitiated cannot understand.

And those who yielded to this hypnotism failed to see that the entire algebra of the geneticists, which appeared not to admit of a shadow of doubt, was just suspended in a vacuum. It was a thread that started from nothing, from an imaginary point, and led to nothing.

The Morganists' maps of the microscopic "country," where 7,500 gene-pills were nicely packed in four Drosophila chromosomes, were no more authentic than the map of Lilliput that was known only to Captain Lemuel Gulliver.

Knowledge is power. But the knowledge which the Morganists strove for with such zeal deprived man of the power he already possessed.

The majority of the Morganists frankly opposed their science to Darwinism. They were quite right in doing so. What is there in common between the great theory that revealed the "mystery of mysteries" and the gloomy announcement: "Strictly private. No entrance!"; between confidence in the might of human reason and worshipping at the shrine of fate in the shape of heredity; between the proud narrative of how man is transforming living nature and the preaching of man's impotence, the muttering of aphorisms like: "To obtain a new variety it is first of all necessary to possess it."?*

Some of the Mendelists, however, proclaimed themselves Darwinists. They, of course, were Darwinists of the same type as Weismann. But what bridge did they find between their arguments and the theory of evolution propounded by the "Hermit of Down"? Not what was immortal in that theory, but what was tentative and imperfect. Not yet being able definitely to explain the cause of hereditary changes in the organism, Darwin, by his theory of indefinite variability, opened the door to chance. The Mendelist-Morganists enthroned chance; it became the substance and foundation of what they thought about living nature. Laws vanished, firm connections fell apart, life disappeared—the chaos of chance reigned everywhere. The theory of probability became the supreme ruler amidst this chaos. Biology was transformed into bare statistics.

Actually, there was no need whatever for a strict examination of germ cells (about which the geneticists talked so much), or even of the gene itself. What is a gene? How does it operate? Thomas Hunt Morgan did not worry very much about questions like these. In fact, they scarcely interested him. He wrote out and combined division formulas—that was enough for him. He was even proud of the fact that his science remained a purely *formal*, purely mathematical science unburdened by vexatious physiological particulars, like mathematics itself.

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* The aphorism uttered by Jordan (a French botanist classifier of the nineteenth century who denied evolution and believed that species were created by God), is constantly repeated by the Mendelists and was approvingly quoted by Professor S. I. Zhegalov in his book *An Introduction to the Breeding of Agricultural Plants*, 1930, pp. 79-80.

Scientists directly engaged in the study of life on Earth, of its history, of the extremely fine structure of every drop of protoplasm, looked with amazement at this fussy "formalism" which was interested in nothing and boastfully claimed that it knew everything. Biochemists and physiologists who watched the complex network of events that takes place at every point of the living body declared that Morganism is a suitcase packed with hypotheses. Cytologists saw in the cell a membrane, plasm and chlorophyll-bearing grains (if it was a green plant), they saw the nucleus and the constant and undoubtedly very important participation of the nucleus in the general life of the cell, in its respiration and metabolism—but they did not see any genes. Embryologists vainly waited for an answer to the question: since all cells receive a complete set of genes, why do some cells form wings, others feelers, and still others the facets of the eyes of these same Drosophilae? Paleontologists simply could not understand all this talk about the universal "chaos of chance" when obvious and strict law is observed in the development of the branches of the living world!*

The formal geneticists had no time for all this. Turning the handles of their adding machines, they felt more infallible than the Pope. It was not Charles Darwin, the great naturalist, who was dear to their hearts, but his cousin, Francis Galton, the anthropologist statistician. This member of the Royal Society measured hundreds of human skulls by the methods of a science of his own invention—biometry; he compiled tables and charts and tried to prove mathemat-

* The perplexity of these paleontologists is eloquently expressed by the American writer Simpson, who in 1944 published an entire book for the purpose of "reconciling" Morganism with the science that studies the history of life on Earth—*Tempo and Mode in Evolution.*

ically the existence of superior and inferior races, of people of superior and inferior hereditary natures. And on departing from this mortal world at the advanced age of ninety, he bequeathed to it the behest to develop another science that he had invented—eugenics, the science of breeding human beings "in order to raise the standard of their breed" (evidently Galton pictured this "breed" as something like the breed of white poodles). Galton's eugenics was most fully developed in the racist, cannibal ravings of the Hitlerites. And Y. A. Philiptschenko, a Russian Mendelist, well known in the twenties, wrote a book in which he admiringly compared Galton with Mendel.

It is not surprising, therefore, that until very recently, it was among certain statisticians (whose entire knowledge of living nature was, perhaps, restricted to the domestic cat) that the most zealous advocates of and experts in the chromosome theory of heredity were found.

When I read Morganist textbooks, consisting of short paragraphs written in clipped American phrases—the prose of people pressed for time, written like instructions with formulas to be obeyed implicitly like military commands—I cannot escape the feeling that these formulas have been hatched in the most perfect, gleaming white incubators housed in hermetically sealed premises.

They are formulas of test tubes and preparations lying quietly on cover slips. All that one can suppose is that the world outside is like them in all things. Indeed, it does look like them when you look at it through those tightly-closed windows. And as long as the windows are kept shut, the formulas remain omnipotent. The universe is subjugated with the aid of an adding machine. The whole of nature keeps in line with a tiny Drosophila fly. But that lasts only as long as a mere incubator, a test tube filled with Drosophilae and a writing desk with an adding machine suffice for the work!

But supposing that for other, vast problems, it is necessary to open the windows? How the possessors of the sheets of paper filled with omnipotent formulas screw up their eyes against the bright light and the rebellious wind! Shut the windows! Put a stop to this disorder! Don't let that wild whirlwind hinder us from listening to the even tenor of obedient life in the thermostats! . . .

Nevertheless, the Morganists were obliged to give some answer to the question: how, after all, did the evolution of the living world take place, and is now taking place? No person of sound mind and judgment can any longer have any doubt that it *did* take place!

Why has the inscrutable heredity substance changed if nothing can change it? After considerable wavering the Morganists answered: if it has changed, then it was evidently due to unusual causes—also enigmatic and mysterious. . . . What causes? The reply was—silence. . . .

"Knowledge" of this kind did not promise very much power!

But just as visions appeared to the pious monks when worn out by their vigils, so some of the Morganists, from time to time, had dreams; and the less promising their theory, the wilder were those dreams.

The question was: "What is a living being?" We can guess how this was answered: "A particular case of general rules." "In the same way as all books of infinite variety are composed of a little over thirty letters, so is the whole of the animal and plant world in its infinite variety composed of hereditary genes" (We are quoting literally the reasoning about living beings by Professor A. S. Serebrovsky!).

And the Morganists talked not about the world of living things, but about a *gene fund,* about the sum total of genes scattered among living beings, like diamonds in a mine.

But if that is the case, cannot these genes be matched with each other in a different way? Cannot the cards be served differently? Why does a duck need a beak? And why do domestic animals need ears?—this same Professor A. S. Serebrovsky asked with an air of profundity. He was irritated in particular by the numerous and useless vertebrates. We may assume that his esthetic sense was akin to that which proclaimed that Apollo Belvedere had been superseded by the "Rolls-Royce," and which erected brick boxes for human habitations. The body of an animal should be streamlined like the body of an airplane. A. S. Serebrovsky had already invented names for the new sciences of rearranging pebbles and re-serving cards: "logics," "agogics," "technics."

Unfortunately, all he produced was a wingless butterfly. He would have been more convincing had he succeeded in providing wings for at least one living creature that had never risen in the air before.

PROFESSOR MULLER'S FLIES

> He showed me a vast number of flies most beautifully coloured. . . .
>
> Swift, *Gulliver's Travels*

Muller was a pupil of Morgan.

He laboured in the laboratory with tireless zeal. From the test tubes teeming with Drosophilae he expected an answer to the riddle of heredity, to the riddle of variability, the riddle of what controls forms, and many other riddles.

To achieve this it was necessary to get at the hereditary substance; the means of getting at it, however, in Muller's opinion, had to be not simple, but extraordinary.

So Muller invented the queerest means of changing the hereditary nature of the winged captives in his test tubes. One day he put them under X-rays, and the flies which had been in the green spotlight of these rays brought forth unusual offspring. Among the teeming creatures, so small that they looked like tiny dots, it was possible through a strong magnifying glass to see some with white and vermilion eyes, some with black bodies, some with curved wings, and some almost wingless.

This happened in 1927. In that year, all the Drosophilae in the world, all the vast millions of the fly population that the geneticists had bred in their test tubes: the "fat-bellied" flies, the flies with "elephant's" eyes, flies with "deer horn" wings, the "dachshund" flies, the "comma" flies and the "telescope" flies—could all feel themselves heroes of the day. Not only the geneticist scientific magazines, but the daily newspapers of all countries, morning and evening editions, grave and gay, wrote about them.

This was one of the greatest sensations that had ever occurred since the science of genetics had come into existence. Muller had succeeded in breaking into the impregnable fortress of heredity!

This ushered in a period of the most surprising experiments on the lines conducted by Muller. The geneticists regarded themselves as commanders of siege towers. They now operated with real battering rams to breach the fortress walls of heredity. One of them caused variations in the offspring of a thorn-apple with the aid of radium. Another compelled the larvae of Drosophilae to perspire in a steam bath. A third tried ultraviolet rays on mice. A fourth murdered the animals he was experimenting on with the strongest poisons. A fifth proposed that wheat be treated with X-rays.

"We will start an entire fountain of variations, and then we shall obtain everything we need. We will breed any variety you please, even the most amazing; for example, such as will grow in the sandy desert or in the zone of permafrost," were the claims heard on every side.

Readers of popular articles were advised to read carefully the forthcoming issues of magazines in order not to miss the reports of a new species of living being produced by means of X-rays, or the emanations of radium.

But these reports failed to appear. Years passed, but the biologists were obliged to go on talking in their lectures about Professor Muller's flies and to put off the promised radical change in the structure of all domesticated animals and field plants to a more and more indefinite future.

The monotony of these constantly repeated prophecies that never came true at last wearied the prophets themselves. Their raptures began to seem affected. Obviously, the matter was not so simple as had at first appeared. Some of them even dared to express doubt.

"After all is said and done, what new breed, the pride of the fly world, have the X-rays produced? Most of these 'white eyes,' 'vermilion eyes' and 'curved wings' are just freaks. And a large number of the altered flies have been changed so thoroughly that they have actually lost their power of existence: is it not a fact that large numbers of the larvae of Muller's flies failed to hatch? . . ."

Indeed, when turning his green spotlight upon his test tubes, Muller himself had no idea what would come of it. And when he obtained variations in his flies, he could not say why they changed in this particular way and not in another. It was like in the old fairy tale: "Go—I don't know where; bring—I don't know what."

And the idea began to creep into many minds that it may have been a mistake to repose these joyous hopes in the American flies that had been treated to X-ray shower baths.

"The same method could be tried to mend watches," they said in effect. "Throw the watch on the floor. In all probability, most likely, in fact, it will break. But don't lose hope that at some time, with some watch treated in this way, the blow will cause the screws and wheels to arrange themselves in a way that the most highly-skilled watchmaker could not devise, and the watch will go splendidly!"

THE BIRTH OF A GREAT SCIENCE

THE PERFECT SLIPPER. MORE ABOUT THE PYGMY SCIENCE AND THE GIANT SCIENCE

> They possessed the art of explaining the concrete with the aid of the abstract, the real with the aid of its shadows, the art of systematizing a few hastily and biasedly collected observations and of extracting from them in their retorts the laws that govern the universe.
>
> Romain Rolland, *Clérambault*

At the time when the first geneticists were still feeling like Columbuses who had discovered America, there were among the "Mendelists" two who boasted particularly of their disapproval of Darwin's theory of evolution. These were the German geneticist Lotsy and the English geneticist Bateson.

The mirage has dissolved, they said. This can be proved like a theorem in geometry. It is obvious that no power on earth can create new hereditary germs. Animals and plants changed because the germs that were created at the dawn of time intermixed and combined in different ways. Life is like a game of cards, and the mathematical discipline of combinations must be regarded as the chief branch of the science of biology. Thus, we are reverting to the great Linnaeus who said: "There are as many species as were created in the beginning by the Infinite Being." Only it is necessary to substitute in this excellent and pious utterance the words "hereditary germs" for the word "species."

Incidentally, Bateson, in agreement with some of his colleagues, was of the opinion that the hereditary germs that were created at the "dawn of time" were not made of very good material. Many of those that were then created have been destroyed, so that the world today is poorer in germs than it was in the past.

This, then, is the whole explanation of evolution that so much engages the minds of these Darwinists! Evolution took place because the germs got mixed up and shuffled like playing cards, and also because the creator had somewhat botched his work.

Organisms lost first one and then another germ and, of course, changed.

But, as every schoolboy knows, at the "dawn of time" only microscopic living beings resembling amoeba existed. All plants, animals, and man, appeared later.

Well, supposing? That did not worry Bateson, Lotsy and those who shared their views. With unassailable logic they drew the conclusion that—the most complex living beings are amoeba and infusoria, while the simplest is—man. And although it seems as though evolution has taken place, actually, it has not. It is just an amusing story of how the absent-minded "slippers" and amoeba lost out of the basket nearly all the germs the kind god had given them when he let them go out for a walk.

The simplest amoeba and "slippers" are more complex than man! The world turned upside down!

Well, "if you don't like it, don't listen. . . ." But Bateson and Lotsy were not joking. They fought tooth and nail against the materialist explanation of evolution. This is what they asserted:

Perhaps the Paramecia (infusoria called "slipper animalcules" from their shape) had already had transmitted to them from generation to generation a genetic substance that was capable of curling the tails or blunting the teeth of animals, but owing to the absence of tails and teeth, these things had to bide their time.

Copies of the German and English magazines in which the arguments of Bateson and Lotsy were published reached Moscow, and here they were read by a tall, thin man with a high, straight forehead and pointed beard.

"Curliness of nonexistent tails and bluntness of nonexistent teeth among the Paramecia!" he muttered, and his fine blue eyes flashed angrily. "Some kind of retarding germs, button germs, which, until time pressed them, prevented the appearance of all these toothed and tailed germs! And this in the twentieth century! They call it advanced science! It would be good to press the button that retards the mental mechanism of these resurrected Schoolmen who, if we are not careful, will be arranging witch trials again!"

He took a sheet of paper and wrote on it the following words: "Darwinism," "Lamarckism," "Mendelism," "simple heredity," "complex heredity." The man with the face of a medieval knight compared the theory of evolution and the structures that had been added to it: numerous theories that dealt with individual aspects of the process of development, variability and heredity.

Suddenly he laughed and threw his pen down. Kliment Arkadievich Timiryazev, the celebrated professor of the

Moscow University, the most notable botanist in the world, rose up from his chair.

"One thousand one hundred and fifty second part!" he said, still laughing and holding a corner of the sheet of paper on which, half in jest and half in earnest, he had made certain calculations. "This is the insignificant fraction $\frac{1}{1,152}$. This is all the Mendelists can claim in the vast field of facts that Darwinism is cultivating. It is the true measure of their growth!"

He had seen Darwin with his own eyes, and on his memory had been impressed forever the living image of the grand old man, whose face revealed a matchless combination of almost peasant simplicity, keen vigilance and leonine strength. There was only one other man in whose face Timiryazev had seen such a combination—Leo Tolstoy.

At that time Darwin was already very feeble and his family protected him from annoying callers; but he came out to see Timiryazev, sank heavily into his armchair, and gazed from under his overhanging eyebrows at the young Russian botanist who had found his way to Down, that quiet rural retreat where Darwin had taken shelter from his noisy fame.

"Come, I will show you," said the host, rising as heavily from his chair as he had sat down in it. At the door a tame squirrel leaped upon him and ran up his arm towards his white beard.

He led his visitor to the hothouse. In it there were some pots with strange plants. The leaves, covered with slimy hairs, closed up like fists when the aged, slightly bent fingers with swollen joints and flat fingernails carefully placed in them pieces of meat or small insects. These were insectivorous plants, the objects of one of Darwin's latest researches, "plants of prey," which devoured living things and digested them as the stomach of an animal digests food. These plants were so amazing that, until Darwin's researches, many botanists had denied their very existence. In the hothouse at Down, Timiryazev saw them with his own eyes—a living witness to the unity of life, to the common, fundamental phenomena of life in the animal and plant worlds.

Darwin asked his visitor what he was engaged in. The latter told him what he had been continuously thinking about since his student days—the creation of life in green plants by the aid of light. Outside the glass frames of the hothouse heavy branches were waving slowly. Darwin looked towards them.

"Yes, chlorophyll," he said thoughtfully. "That, perhaps, is the most interesting of organic substances. . . ."

He too was *thinking* about that! At that moment it seemed as though in departing from life he gave his blessing to the labours and fearless thoughts of the young Russian scientist.

Timiryazev bid farewell to Darwin. On parting the aged naturalist talked about the country from which his young visitor had come. The words he uttered became deeply impressed in Timiryazev's memory.

"You will meet here," said Darwin, "many blind people who do nothing else but strive to drag England into war with Russia. But you may be sure that in this house sympathy will be on your side; every morning we pick up the newspaper wishing to read news about you having gained new victories."

At that time Russia was at war with Turkey.

Thus ended the meeting between the naturalists of two generations, of two countries, between two great naturalists.

Darwin, that extremely modest man who was so exacting towards himself, died long ago.

Nor is Timiryazev with us any longer. But to us Timiryazev does not represent the past, not yesterday; he is our contemporary. He lived to see the opening of our present great epoch. He was able to work among and with those who were building our society, our state.

In the October days of 1917, this seventy-four-year-old scientist, member of the most celebrated Academies in the world, at once took the side of the insurgent people. To him, this was the logical deduction of all his life's work, of his science. He welcomed the socialist revolution like a joyous festival, like the realization of his most cherished hopes. He did not waver a single day, or a single hour. He bore the whole of the great culture of mankind in all its purity; but his shoulders were not weighted by "the burden of the old world."

The workers at the car-repair shops on the Moscow-Kursk Railway elected him a member of the Moscow Soviet. It was then he wrote to the Moscow Soviet that magnificent letter that later was reproduced in many languages. "And so, comrades, let us all set to our common task and work with a will, and may flourish our Soviet Republic created by the self-sacrificing deeds of the workers and peasants, and only just saved, under our very eyes, by our glorious Red Army!" Such were the concluding words of this letter.

He was elected a member of the Socialist Academy, was President of the Association of Self-Taught Worker Naturalists, and was a member of the State Scientific Council.

And he continued to work in his mighty field of the science of living nature; he wrote new books in which he ardently responded to social events and passionately propagated this science.

Life and labour—these were synonyms for Timiryazev. He worked to the end. Mortal sickness tore from his hand the pen with which he was finishing the preface to his book *The Sun, Life and Chlorophyll*.

In his last hours he received a letter from Vladimir Ilyich Lenin. Lenin had read Timiryazev's book *Science and Democracy*, a copy of which the scientist had sent him, and he wrote as follows:

"April 27, 1920. Moscow.

"Dear Kliment Arkadievich,

"Thank you very much for your book and the kind words that accompanied it. I was simply enraptured on reading your remarks against the bourgeoisie and in favour of Soviet government. I firmly grip your hand and with all my heart wish you health, health and health!

"Yours, V. Ulyanov (Lenin)."

At the dying scientist's bedside sat the Communist physician B. S. Weisbrod. Timiryazev said to him:

"I have always striven to serve mankind and I am glad that during these, for me, grave moments, I see you, a representative of the Party that is really serving mankind. The Bolsheviks, who are carrying out Leninism—I believe, I am convinced—are working for the happiness of the people and will lead them to happiness. I have always been yours and with you. Convey to Vladimir Ilyich my admiration of the genius he has displayed in solving world problems in theory and in practice. I deem it happiness to be his contemporary and a witness to his activities. I bow my head to him and I want everybody to know it. Convey to all

KLIMENT ARKADIEVICH TIMIRYAZEV

comrades my sincere greetings and wishes for the successful continuation of their work for the happiness of mankind."

These words are now engraved on the monument at the Agricultural Academy that bears the glorious name of Timiryazev.

His heart ceased to beat at midnight on April 27, 1920.

Before the Great Patriotic War the collected works of Timiryazev were published by order of the Soviet Government. The last volume of the series came out when the conflagration of the war lit by predatory Hitlerite imperialism was raging in the West.

Then we read in a new light the pages Timiryazev had written during the war of 1914-18. In them he denounced the monstrous propaganda of race hatred. With what burning words of ire he lashed "those whose speciality it is to unchain the demon of war"! Falsehood, "falsehood in all its forms," such is the poisoned weapon of the warmongers. Dooming millions to torture and death, they push their own peoples "blindfolded" into the abyss.

In June 1917, in that very June in which the Bolsheviks led the demonstration of four hundred thousand people in Petrograd and red flags struck fear into the hearts of the ministers of the Kerensky government, the seventy-four-year-old scientist published an article entitled "The Red Flag."

In this article he appealed to the tormented peoples of half of Europe who were groaning under the jackboot of the Hohenzollerns, and to the other, also tormented, constantly sold and constantly betrayed, shamefully exploited and deceived peoples in the countries of false, so-called "western democracy," saying: "Rise up and count your oppressors, and after counting them, tear out of their hands the sacred rights they have insolently robbed you of: the right to live, the right to work, to light and primarily to liberty, and then, truth and reason, productive labour and the honest exchange of its fruits will reign on earth."

That is what Timiryazev was. And that is why we say that for us he does not represent the past, not yesterday, but is our contemporary.

Timiryazev's voice reaches us resonantly and clearly.

In very many of his scientific views Timiryazev was ahead of his times. His books contain pages, the meaning of which was fully revealed only by the science of today; and they also contain pages that will undoubtedly indicate the path for science of tomorrow.

Today, too, Timiryazev is one of the builders of our natural sciences. During the controversies and debates that arise in our country in the fields of the biological and agricultural sciences, the disputants often find that Timiryazev had already pondered over many problems that seem to have risen for the first time today.

"I advise all researchers who come to me," says Academician T. D. Lysenko, "to read more, and with the greatest attention, primarily the works of Darwin, Michurin and Timiryazev. I myself extremely often read passages from them whenever I am in a fix, whenever I am in a difficulty."

Darwin, Timiryazev, Michurin! It is no accident that these names rise in our minds side by side.

Timiryazev's assistants and pupils are alive. And who can count the pupils of his pupils—academicians, professors, breeders, agronomists and kolkhoznik experimenters? The great scientist lives in the works of Soviet biologists, botanists and plant physiologists, in Soviet agricultural science, the most advanced in the world, which is creating new animals and new plants, a science in which, in our Soviet state, the place of the ancient power of the land has been taken by power over the land. He laid its foundation. Was he not called "the patriarch of Russian agronomics"?

That is why there is an inseverable connection between our today, our science, and Kliment Arkadievich Timiryazev.

As regards the other "camp," which Timiryazev denounced and fought, he spoke of the possibility of a revival of witch trials . . . and we became the witness of "monkey trials," the criminal prosecution in America of teachers of the theory of evolution. The expert witnesses and inquisitors at the frightful trials in Hitler Germany were scientific specialists in "race purity." The monstrous ravings of racialism fanned the flames in the infernal furnaces at Treblinka and Majdanek.

Later, after German Nazism was smashed, we saw this monstrous raving cross the ocean and find supporters among the pro-fascist fomenters of a new war, among those who are striving to impose a "new American order" upon the world.

And we have also seen the "ists" and "ologists" degrade biology in the "leading" countries of "Anglo-Saxon democracy" who are actually putting into practice the idea that "our age is not the age of great tasks," and we have seen how arguments about the inviolability of "germs" logically lead to hatred of human creativeness and to the disgusting man-breeding theory.

> When you become a little acquainted with scientists, you find that they are the least inquisitive of men. A few years ago, being in one of the big cities of Europe, the name of which I will not mention, I visited the Natural History Museum in the company of one of the curators who very kindly described all the fossils to me. He told me a great deal about everything, including the Plyocene strata. But when we found ourselves in front of the first traces of man, he turned away and, in answer to my question, he said that this was not his showcase. I realized the immodesty of my question. Never ask a scientist about world secrets that are not in his showcase. They do not interest him in the least.
>
> Anatole France, *Garden of the Epicureans*

At the time when Lotsy and Bateson were singing the praises of the perfect "slippers" and were trying to prove that living creatures cannot be re-created, the whole world rang with the fame of a man in whose hands nature appeared to be as soft wax.

Who was this man? He had no scientific degrees, was not well up in geneticist formulas, and did not at all believe in an immortal, inviolable heredity substance. That is why Lotsy and Bateson not only refused to regard this man as a worthy opponent, but even failed to note his existence. Kliment Arkadievich Timiryazev, however, regarded his work as one of the greatest events in the field of biology, and was far more interested in him than in all the intricate ratiocinations about infusoria possessing curly-tail germs.

That man was Luther Burbank. He had growing in his garden in California black roses, blue poppies, daisies the size of saucers, cactuses without thorns, looking like giant cabbages, and at table he served "sun berries" such as no horticulturist had seen before, and sweet, fragrant fruit th had ripened on nightshade and elder.

Burbank was called the "Californian Wizard." He himself had no objection to the light air of mystery that surrounded him. The son of a Massachusetts farmer, he had wandered a great deal from state to state in America, and had acquired exactly that tenacity that is needed to prevent yourself from being knocked down and trampled upon in the jungle "war of all against all." On getting rich he established a "firm." A firm is supposed to have secrets, and the goods it sells must have no competitors. Every new plant of his was raised in the strictest secrecy, as if behind a thick curtain; and only a few visitors were allowed to enter the magic garden in Santa Rosa.

Those who were allowed to enter were met by the owner, an elderly, faultlessly dressed gentleman in a soft hat and high, starched collar. He had the good-looking, youthful face of a hundred-per-cent American who was lucky in business and was convinced that everything in the world was "O.K."

This gentleman led the visitor round the nurseries and with humorous quips and jests showed him his wonders.

After commenting on the weather and praising the Californian climate he proudly showed his seedless plums. First he showed one in which the stone has as yet only partly gone. It was soft and narrow, shaped like a half-moon. Then he showed the same kind of plum, but of four or five later generations. There was practically no stone in this—just a tiny seed, like a grain of wheat. Even the most experienced visitor was unable to repress his astonishment when his teeth bit through the fruit as if it were a strawberry.

Some visitors enquired whether Burbank was guided in his work by the laws of Mendel and wanted to know how these laws should be studied to be able to achieve similar results.

Burbank advised them to start studying Mendel by reading Darwin, and after reading Mendel, to read Darwin again still more thoroughly.

Burbank's urbanity, however, was only a screen to hide the difficulties the wizard had had to contend against in his efforts to learn from the great scientist Darwin in the country, one of the "democratic liberties" of which was the liberty to take criminal proceedings against the theory of evolution.

A veritable storm raged around him. He was called a blasphemer and even worse. Sermons were preached against him, and he received abusive letters and telegrams. And all this because he was working with nature, took advantage of her laws, directed her forces in the way he desired, thought about how to create new varieties. . . . And then he announced that he had achieved useful and splendid results. "But I had a perfect gale blowing round my ears while the storm lasted," he said.

When the storm blew over everything became "O.K." Everything? Yes, as far as the firm was concerned. But his science, the wizard's new, unprecedented science, did not become "O.K." Not a single professor gave it recognition. The whole of America talked about Burbank, but the "serious scientists" of America were not in the least interested either in him or in his plants. These scientists were the least inquisitive of all men.

I don't know whether the elderly gentleman with the well-groomed almost ageless face often pondered over what his life's work might become. Perhaps he became resigned to the fact that three fourths of it had been wasted. What did it matter? He exchanged it for good, sound dollars.

A firm must advertise. The name of the farmer's son appears in many books with elegant and somewhat high-flown titles, for example *The Harvest of the Years*. His achievements are described in twelve thick volumes, containing sparkling wit, good humour, mist. And what will certainly strike the reader's imagination most of all are the colossal flowers, the fruit of monstrous dimensions, the story about the twenty thousand plum trees grown in nine months, and about the sixty-five thousand blackberry-raspberry hybrids destroyed at the wizard's command.

Burbank died in 1926, and his "firm of wonders" went out of existence at once. No successors to Burbank were found in America. Nobody cared about what became of his orchard. It was sold by auction, and the newspapers did not even report the sale.

STRUGGLE AND TRIUMPH

> For merriment
> our planet
> is little equipped
> Joy
> must be
> torn
> from future days.
>
> V. Mayakovsky

In the end, all the work of Luther Burbank, the "Californian Wizard," the whole of his very long life, remained but an episode, which had no particular consequences for the history of science. More than anything, it was the individual luck of a man who was born "with a silver spoon in his mouth." And he certainly tried hard to make the most of his luck; he compelled the trumpets of sensation to talk, to shout about it, and he displayed everything he laid his hands to before his contemporaries under the magnifying glass, as it were, of hundred-mouthed publicity.

That is how this man exchanged the pure gold of knowledge about man's power over nature that he had acquired—and also the further knowledge he might have obtained—for tinsel and gilt.

At that time there was not another man in the world who looked forward to the appearance of that true, mighty science that would enable man to alter, to remould living forms, who hurried this science and called for it so insistently and so passionately as Kliment Arkadievich Timiryazev. This science was to mark an entirely new stage in the old science of biology, a turning point in it equal to Darwinism. Darwin proved the existence of evolution—it was now time for man to take it in hand. Timiryazev felt intensely, he positively *knew* that the time was rapidly approaching when that page in the history of biology *must* be turned. And he also knew that the features of this new science would be entirely different from those of its academic predecessors, that it would be a *people's* science.

In his ardent expectation he carefully guarded the first shoots of this science. Looking back at the dreary Weismann-Mendelist desert, the colour of which tinted the landscape of bourgeois biology, the great Russian scientist was, perhaps, inclined to overrate somewhat what could be taken as the shoots, or even the germs, of the new science. How many inspired pages he wrote about Luther Burbank! And yet he knew perfectly well that this was not yet the new science, that it was still far from the stage that would be equal to the Darwinist stage.

Meanwhile, quietly, without the noise and clamour of publicity, without any sensational fanfare of trumpets, this mighty science was already born, not across the ocean, but in the native land of Timiryazev who had foretold its coming. And it possessed *all* the features he had foretold, and one more—amazing modesty.

The obstacles in the path of this new science were exceptionally great at that time. No deft pens were found to glorify it. Its creator was almost a beggar. His life was one of hard toil. A thick wall of hard-hearted indifference surrounded his work and strangled it.

But he stubbornly persevered in his task. He was already at work at the time when the monk Mendel was vainly trying, in the garden of the monastery in Brünn, to subject hawkweed to the "pea laws." The page in the history of biology was already turned and a chapter containing unprecedented knowledge had already been written when Bateson and Lotsy were talking highfalutingly about the fluffy tails of infusoria.

We now have before us the results of the great life's work of the creator of this mighty science. We see how enormous these results are. All that was done by Burbank (and so skilfully trumpeted throughout the world with the aid of excellently-organized American publicity) looks minute by the side of these results; and that applies only to the purely practical achievements, to what had been directly done by the hands of the two renovators of the soil. The importance, however, of the revolution brought about in the scientific conception of the general and most profound laws that govern the development of living nature, cannot even be measured with the yardstick of the Californian wizard's "harvest of the years." There is no comparison.

Thus, in Russia, near the town of Kozlov, there lived and worked a transformer of nature, the greatest in the history of mankind.

He did not strive for sensation. He was of the opinion that blue poppies could wait. He did not guard any "firm's secrets." The gates of his orchard were wide open for everybody.

Nature did not bestrew the path of Ivan Vladimirovich Michurin with roses. Later on he produced his own rose (among hundreds of other new plants), the Michurin Tsaritsa Sveta (Queen of the Earth), which was superior even to the Bulgarian Kasanlyk, from which the precious rose oil is produced.

The external outline of his life is simple in the extreme.

He was born in 1855 in the Pronsk Uyezd, Ryazan Gubernia. The Michurins were regarded as belonging to the nobility, but when the head of the family died they found that they were paupers. Ivan was unable to finish his high-school education. His childhood early came to an end. He had to earn his living. He took a job as a clerk at the railway station; later he inspected and repaired railway clocks. He was skilful at all things. He constructed intricate mechanisms; once he built a dynamo machine.

But mechanics had no special attraction for him; he was drawn to the land, to the flower pots that crowded his cottage and to the tiny garden around it, where, in the spring, the young leaves budded and the apple trees broke out into white flame, to have their branches weighted down with rosy-cheeked fruit in the autumn.

In that part of the country, nearly all the quiet provincial cottages were surrounded by orchards, and from a distance many of the villages looked to the wayfarer like green clouds. Love for the land, for the art of horticulture, was handed down from generation to generation in every family.

The Michurins were also a horticultural family. In the olden days, almost in the reign of Catherine, Ivan's great-grandfather produced "Michurin" pears.

The hot, Californian sun that lit up Burbank's wonders did not shine in Kozlov. The sky was often overcast, stern winter buried the cottages in the poverty-stricken villages under snowdrifts.

Both on loamy soil and on the more than two-foot thick layers of black soil reigned the same "frightful poverty of Russian nature" as the magazines of the metropolis described it; the frightful poverty of the Russian countryside reigned everywhere at that time.

What grew in the orchards which had been cultivated by loving hands for generations?

Antonovka, Anis, Borovinka and Terentevka apples; Bessemyanka and Tonkovetka pears, and Vladimirskaya cherries

And that is all. These varieties could be found in the "garden catalogues" of the time of Vasili Shuisky.*

Years passed. At night the mechanic, watchmaker and amateur gardener Michurin pored over his bench. Ten years later he bought from the local priest a small plot of waste land on the bank of the river Lesnoy Voronezh, and when he had paid for it the new landowner had seven rubles left in his pocket. He could not afford to hire vehicles to remove to the new plot; his family had to walk many versts carrying on their backs the little property they possessed and all the plants Michurin had grown. And there they began life like the Swiss Family Robinson, in a shack, their dinner consisting of rye bread and tyurya—a cold soup, consisting of the same rye bread and onions cut up in water.

"The one thing I saw," he wrote, "was the unusual poverty of Central Russian horticulture in general and, in particular, the poor assortment of plants, as compared with other countries and our own South."

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* Beginning of seventeenth century.—*Tr.*

Let not the poverty of nature be added to the poverty of life.

And the poverty-stricken orchard owner stubbornly and perseveringly set to work on his new plot.

What did he count on? From where did he expect assistance?

Summing up his thirty-three years' work on the land, he wrote* that he met with "almost no attention on the part of the public and still less from the government. . . . As for financial support, it is needless to speak about it."

A commercial nursery? But what strange advice was heard by those who intended to be his customers! "You ought to start growing only your own varieties of fruit trees and bushes from seeds. Believe me, I am saying this for your good. And if you obtain the seeds of the necessary quality and cultivate them as I will teach you, you will get not wildings, but new, good varieties, quite suitable for your climate, and at relatively small expense. . . ."

"For the information of customers," the nursery owner announced that he was paying little attention to the outward finish, to the beauty of his nursery or of the plants he sold. He made it perfectly plain (in order that customers may not make the mistake of coming to buy from him) that there were other commercial nursery gardens where they made a specialty of external appearance and beauty.

He made no secret of his methods, he talked about them, shouted about them, and would have been glad to teach them to everybody!

And so from the very outset he destroyed all possibility of publicity.

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* In *Progressive Fruit and Vegetable Growing*, August 1911.

No business acumen, no connections, no scientific diplomas. And yet he set out to solve a problem which the most celebrated scientists in the world would have regarded as fantastic.

In the course of time the rumour spread and gained strength among all those connected with horticulture about Michurin's orchard being the most remarkable orchard in the world. The most incredible things were said about it: that apples a pound and a half in weight ripened in it; that from the summer to late autumn the owner picked hundreds of different fruits such as do not grow even in the Crimea and are not described even in a single book; that the torrid South had shifted to Kozlov.

Only the authorities in Kozlov, Tambov, and still more in St. Petersburg continued to remain indifferent to all this. And the bureaucratic professors too. A horticulturist digging in garden beds, crossing something or other, producing Bellefleur and Kandil apples, and Beurré pears—what had all this to do with lofty science?

One day the Archipresbyter of Kozlov burst in upon Michurin.

"Oh, you!" he said in sorrow and in anger. "Won't you subdue your evil passion? You are crossing pears with mountain ash! It is an adulterous desecration of the Lord's garden! You are tempting my flock!"

And an inquisitive governmental clerk sent an official letter containing the idiotic question: "Have you noticed anything in common between birds' eyes injured by a red hot iron and a similar injury to the kidneys?"

But what Michurin was doing was too great, too obviously out of the ordinary to be ignored, and fame—a strange one, also "secret," officially unrecognized and unnoticed—gradually gained strength and carried his name far and wide.

It carried his name across the ocean, Americans became interested in Kozlov.

The winter of 1898, which had been extraordinarily severe, had devastated the orchards in America. The Canadian Farmers' Congress met. It was a funereal gathering. It placed on record that tens of thousands of cherry trees, all the varieties of cherries in the country, had perished . . . all the varieties but one—the Michurin Plodorodnaya, which several farmers had in their orchards and which had passed through that winter as if nothing extraordinary had happened.

The Michurin Plodorodnaya? Michurin? Not Burbank (who was also breeding cherries). Not somebody else. . . .

Where does this Mr. Michurin live?

Professor Mayer, of the U.S. Department of Agriculture, travelled to Kozlov.

A letter in an envelope bearing stamps engraved with the Statue of Liberty and the portrait of an American President was sent posthaste to Kozlov.

The letter enquired whether Mr. Michurin would like to sell his nursery, not the whole, perhaps, but part of it, although it would be preferable if he sold the whole—trees, bushes and everything, lock, stock and barrel. . . .

Strange! This Mr. Michurin goes on eating his meagre dinner on his waste plot, but refuses to sell anything!

Several years passed and another enquiry came:

. . . Would not the wizard, Mr. Michurin, care to come to America? An entire steamship would be placed at his disposal. In America he would have land and dollars, everything the wizard Mr. Burbank had.

But again Michurin is adamant. He refuses even to enter into negotiations. Several months later, in 1914, looking back from the threshold of his three-score years on the

Michurin Plodorodnaya Cherry

life he had passed through, he wrote: ". . . the years have gone by and my strength is exhausted. . . . It is very painful, of course, to have laboured so many years for the common good with no recompense and then to be deprived of security in old age. . . ." But he had the strength to refuse that tempting American offer!

There are moments when a man's whole soul, his whole being, appears before us in a dazzling light.

We, of course, would have known Michurin, with his indomitable will and warm, passionate, Russian heart, even if this American invitation episode had not occurred; but still, how brilliantly it lights up the character of the living Michurin!

The transatlantic sirens were utterly mistaken. For Michurin, life and work meant—not after mental reflection, but purely as a matter of course—life for his native land, and work for his native land. Concerning the land which he had seen from the moment he had opened his eyes in his cradle; where Michurin pears had grown for a hundred years and in poor churchyards, under the pine trees, elderberries loomed red around the graves of his ancestors; where, no matter how far into the past you may look, had always lived people like himself who had the same Russian names for trees and grasses, cottages and clouds, brides and children, the same cares and the same wonderful skill, the same villages and towns; concerning the land on which, almost in his childhood ("since I can remember") he had chosen, and loved, the lot and labour of the master and friend of its green attire—concerning that land, he said that he wanted to convert it into a flourishing garden. He learned from Nature and fought her in order to compel her *here* to give all her gifts, to pour out *here* "all the abundance of the South." That was the aim of his life.

It was he who wrote: "It is disgraceful to think that everything of the best can be obtained only from abroad."

It was he who poured ridicule on those who were willing "to drag at the tail of other nations" and on those who argued that "God in the shape of foreigners will send us varieties."

The aim of one's life is not exchangeable for dollars—even for thirty-two thousand dollars a year (as was promised Michurin).

He continued his lone struggle.

He turned sixty. The First World War was already raging.

"I worked with my whole family, consisting of my wife, my sister-in-law and two children, but by the will of fate, one after another, my assistants dropped out of the work. . . ."

He would not, however, regard himself as old, not for anything, but for the first time the word "fear" dropped from his pen: ". . . fear that, although I am not yet old, my turn too will come to leave the stage. . . ." This man of iron will had no fear about himself; his fear was roused by the vision of his uprooted nursery, of the doom of all his wonderful varieties, every tree of which he had raised himself; of the destruction of his life's work, of his dream of making his native land a beautiful, flourishing garden.

Actually, what had he to hope for? His clear mind carefully weighed the chances: they were insignificant.

But still he kept on.

He worked as hard—even harder—as when he was young and knew not what tiredness is.

And he saved his orchard during those hard years of the imperialist war, and later, of the Civil War, famine and ruin.

The year 1922. The Executive Committee of the Tambov Gubernia Soviet received the following telegram from the government.

"Experiments in raising new varieties of cultivated plants are of enormous state importance. Send forthwith a report on the experiments and work of Michurin, of the Kozlov Uyezd, for submission to the Chairman of the Council of People's Commissars, Comrade Lenin. Confirm execution of this instruction."

The date of this telegram, February 18, 1922, can be regarded as the date of the actual discovery of Michurin for our country, and for the whole of mankind.

It also marked the beginning of a new life for the Michurin nurseries.

Their chief was sixty-seven years old. Subsequently, he wrote:

"Hardly had the Civil War come to an end when no other than Vladimir Ilyich Lenin, whose memory we all revere, gave his attention to my work. In 1922, on the instructions of Vladimir Ilyich, the work I was doing was expanded to unparalleled dimensions."

Michurin lived another thirteen years; and the greatest part of his achievements was accomplished in this period when his work "expanded to unparalleled dimensions." If this period were subtracted, Michurin, while remaining a great man, would not have been the Michurin the whole world knows today.

This change in the fortunes of the great transformer of nature, this amazing turn in his affairs, is a striking demonstration of what our Soviet system of government means for the development of true, progressive science.

The following is what Ivan Vladimirovich himself wrote about it.

"I had . . . a tiny garden with hybrids which were not being used for the disgraceful reason of the neglect and forgetfulness that was characteristic of the tsarist-landlord system. Today, I am the director of a huge scientific research institution, the only one of its kind in the world, covering an area of several hundred hectares, with hundreds of thousands of hybrids. . . . The Bolshevik Party and the Soviet Government did everything to make the work that I initiated prosper. This gave me great opportunities to pass at once to the widest experiments with plants, literally on a mass scale."

Thus, thanks to the care of the Party, the Soviet Government and the great leader of the Soviet people, Comrade Stalin, the work of Michurin rapidly developed, Michurin science grew.

Lenin and Stalin discovered Michurin and brought his science within reach of the entire people.

Twice Michurin was visited by M. I. Kalinin. The work of the man who had cut new paths for human knowledge and power was acknowledged by high government awards.

He broke into tears when he was handed the Order of Lenin.

In 1932, the name Kozlov disappeared from the map. The town was renamed Michurinsk.

The eightieth birthday and the sixtieth anniversary of the creative activities of the most worthy citizen of this town arrived. The entire country celebrated that day. And the man in whose honour these celebrations were held had the following telegram before him:

"Comrade Michurin, Ivan Vladimirovich.

"Most sincerely congratulate you, Ivan Vladimirovich, on the occasion of your sixtieth anniversary of productive labour for the good of our great motherland.

"Wish you health and new achievements in work of transforming fruit growing.

"I press your hand warmly.

"J. Stalin."

I. V. Michurin answered:

"Dear Joseph Vissarionovich. Your telegram is the highest honour conferred on me in all my eighty years. It is dearer to me than all other awards. Your great attention makes me most happy.

"Yours,
"I. V. Michurin."

Twenty-one years before he had grieved over his bygone life.

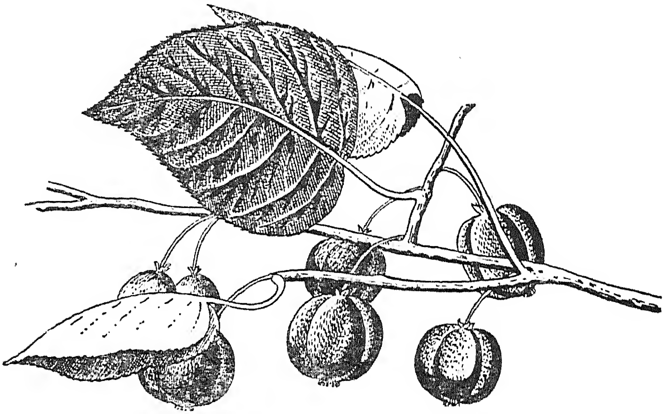
Now:

"Life has changed—it is full of the meaning of existence, it is interesting and joyful."

And yet he was more than twenty years older.

Evidently, youth and age cannot be reduced merely to "physiology," to grey hair and wrinkles!

During all these years there had been a regular pilgrimage from all parts of the country to Michurin's wonderful orchard: thousands of scientists, agronomists and horticulturists, students' excursions, research workers from kolkhoz laboratories, and rank-and-file kolkhozniks.



Michurin Actinidia Ananasnaya

At the gates the visitors were obliged to leave their baggage of accustomed conceptions and traditional knowledge as one leaves one's umbrella and galoshes in the hall.

It seemed as though the very power of the frowning sky and of stern winter ceased at these gates.

A motley crowd of hitherto unseen plants welcomed the visitors. The branches of apple and pear trees were barely able to carry the weight of enormous fruits. The winding stems of Far Eastern Actinidia clung to poles in the ground, but here they bore large, heavy, sweet, amber-coloured berries that smelt and tasted like pineapple. Peaches fraternized with apricots. In one year almonds threw out shoots seven feet long. What looked like bunches of grapes hung from the branches of a strange tree—a blend of the sweet and sour cherry. And next to it a capricious southerner—a grape vine—waved its tendrils with their scalloped leaves in the light breeze.

The creator of this wonderful orchard received the visitors in his study workshop where, between bookshelves and maps, stood cupboards containing test tubes, retorts, wax models of fruits and mechanic's tools. On the table stood a microscope and an electrostatic machine. Next to his armchair stood a carpenter's bench, and near the window a turner's lathe. On the walls hung barometers, thermometers and hydrometers, and the corners were occupied by sprays, budding tools and pruning knives nearly all of Michurin's own invention.

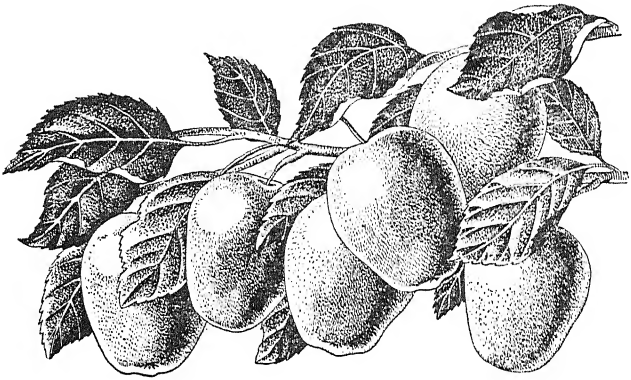
In fairy tales we read of sorcerers who understood the language of birds; but this old man with the rough hands of a workingman, always well-braced and rather dandified, proudly wearing the decorations awarded him by the Soviet Government, understood the mute language of plants.

Seedlings grew from the stones of fruit that had ripened on the young branches of a tree, and next to them grew seedlings from the stones of fruits taken from the old branches of the same tree. Michurin's eyes could distinguish between them at a glance.

He knew that it made a difference whether a cutting for grafting was taken from a young tree or an adult, from a lower or an upper branch.

Here is a seedling on which the experimenter had crossed a cultivated with a wilding. At present it looks like a wilding. But Michurin is waiting. He knows that the nature of the hybrid is not established at one stroke. A struggle goes on within it, and gradually, from under the wild integument, appear the properties of the cultivated parent that the experimenter needs, but now reinforced by the hardiness and stamina of the free denizen of the woods.

How can anyone say that the natures of young and of mature plants are the same? In a young plant nothing is fixed; it is susceptible to all influences. It is like a child, and if care is not taken it will, just as easily, stray from the path, and

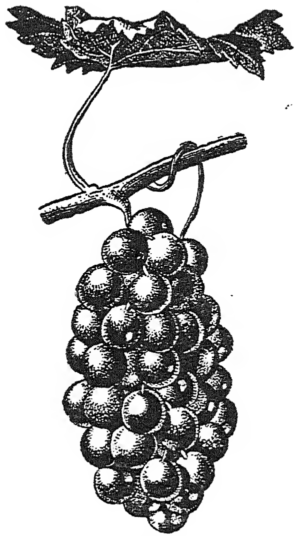


Kandil-Kitaika apples

in the hands of an inexperienced gardener will grow up to be something entirely different from what he expected. A great deal of work has to be put in before a hybrid, even one obtained according to all the rules, is brought up to the age when one's mind can be at rest concerning it.

In raising his celebrated Kandil-Kitaika, Michurin crossed with a Kitaika a tender, Crimean Kandil-Sinap. The hybrid seedlings, however, more and more resembled the pampered Crimean. Michurin grafted the living buds of one of the seedlings to the crown of a Kitaika, and the mother brought up her children in her own way. She checked the influence of the father. On reaching "manhood" the grafted buds proved to be a new variety, which did not in the least fear the northern frost, however severe.

This was the first case of the employment of Michurin's mentor method.



Michurin white northern grape

How was the northern grape created? By what Michurin called "Spartan training." He did the opposite of what all other horticulturists would have done—he transplanted the precious vines from rich soil to poor, where they grew in great congestion. He did not fertilize the soil and barely turned it. He was training not tenderfoots, but fighters, and they had to be inured to all hardships and difficulties.

But when it was necessary to nurse a feeble seedling, to fan the precious spark of life in an infinitely precious hybrid obtained from an audacious crossing, when it was necessary to convert a tender shoot into the progenitor of a new breed, to compel its thin, barren branches to break out in blossom and bear fruit—how Michurin tended the plant then! He mixed and sifted the soil with his own hands. He protected it from cold, from the scorching sun and from biting winds.

He at once guessed what the future of some tiny shoot would be from its appearance alone, from certain elusive characters. One day he wrote: "The close setting of leaf blades, short and thick leafstalks, indicate that the new variety will *bear abundant, large and late-ripening fruit* with a compact, sweet flesh of dark red colour. . . ." and he drew a sketch showing the size of the fruit. This referred to a sweet and sour cherry hybrid which not a single person had seen before.

On another occasion he observed: "Soil of a heavy, clayey composition produces more lasting fruit; soft, rich soil, however, in most cases, produces quickly perishable fruit; seedlings from such fruits produce new summer-ripening varieties."

This was "botanical clairvoyance" unparalleled, perhaps, in the entire history of man's collaboration with the green world.

The plants obediently revealed to Michurin what was dearest and most precious in them; they submissively proceeded along the hard but glorious road on which he led them.

When he deemed it necessary, he could cross beings whose kinship was infinitely remote. The very idea that a "marriage" between them was possible would never have entered anyone's mind. Pumpkin and melon. Cucumber and melon. Cherry and birdcherry. Pear and mountain ash. Raspberry and wild strawberry. Almond and peach. The "betrothed" ones were recalcitrant, but Michurin knew many ways of coaxing them.

He grafted a twig of mountain ash on to a pear tree. On the stigma of the mountain ash that was being brought up on pear-tree sap he placed a mixture of pollen which contained a little of the mountain ash's own pollen that it was accustomed to. The obstinate creature then yielded. It united with the pear—and an unheard-of hybrid was born.

When Michurin wanted only some of the properties of the wild plant to pass to the cultivated variety, to strengthen but not to smother it, he took the pollen from the first blossoms of a young wild tree and pollinated with it the blossoms on the best branch of an old, strong, cultivated tree.

When reading Michurin's books—the records of extraordinary victories—you catch yourself thinking: "Of course, I learned from the textbooks that plants are living things, but I actually realize it only now."

For example: he feeds an apple-tree cutting with the sap of a pear tree. When it has grown and a twig is formed he "weans" the young apple tree and roots it; but what strange fruit will now bud on this apple tree? Is it an apple or a pear? And half a century later, when the sapling will have long been crossed with a regular Pippin Shafranny apple tree and a new seedling will have been grown from one of its seeds, the wonderful pear-apples will bud on it too.

He even grafts lemon on a pear tree! And the geneticist visitors gaze in wonder, not believing their eyes, and finger the strange, shiny citrus leaves of the pear tree.

When he wanted to copy Burbank he, without any exceptional difficulty, produced a Burbank "Plumcot," a plum and apricot hybrid; and in place of the giant walnut trees he grew several dwarf ones from which it is possible to pick the nuts easily and conveniently without having to put up "scaffolds" or even to rise on tiptoe.

But he determined to get what Burbank did not have even under the burning sun of California: a tree that grew fruit resembling preserves and sweeter than honey. He crossed the ancient Tsarskaya Pear, the variety that Ivan Grozny, perhaps, took with his dessert (at all events, it can be found in the authentic gardeners' catalogues of 1613), with the American Idaho. He planted the seedlings in the richest soil—river alluvial. But he thought that this was not enough. He did not stint fertilizer, abundant and especially chosen for this black soil, which was as rich as the silt of the Nile. On top of that, he covered it with manure. With the aid of a large hypodermic syringe he even injected sugar solution under the tender bark of the seedlings. This he did for five years. The juice of the very first fruits of the young trees was like thick syrup. And this property was retained forever by this extraordinary confectioner's pear. It was unfailingly transmitted to all its descendants, even those raised from seeds.

He called this new variety "Surrogat Sakhara"—sugar substitute.

All these are only individual features of Michurin's great creative work, only sketches from the "harmonious system of theoretical views," that he created, "which enable everyone to become a participant in the conscious direction of the stream of evolution, to become Nature's partner, as it were."*

Michurin's approach to the living organism was the very opposite of the Mendelists'.

In their view, an organism is, practically, not a living thing. They regard it as a dump for characters, just a heap of toy bricks each labelled: "annual," "perennial," "winter hardy," "warmth loving," "early ripening," "late ripening". . . . Take a brick from one heap and another from another heap and put them together, bearing in mind the invariable, rough rules of the game that, in peas, for example, yellow dominates over green, and that you can't do anything about it. After that, leave everything to chance. This is all that the breeder's work amounts to.

In that thick volume *Russian Pomology* by Edouard Regel, the St. Petersburg botanist, which taught how to cultivate orchards in Russia, Michurin, in his youth, read

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* Quoted from the book by that ardent champion of Michurin's theory and investigator of his life and work I. I. Prezent, Member of the Lenin Academy of Agricultural Sciences of the U.S.S.R., *In Collaboration With Nature*, Lenizdat, 1946, p. 101.

the following: "It is not in our power to change the properties given to plants by the Creator." Later, when Regel's spiritual successors boastfully trumpeted that they had discovered all the laws that governed hybridization, Michurin firmly and calmly observed: "No, the science of hybridization does not yet exist, and at present the word 'hybridization' is translated into popular language as follows: heap together, mix, shake, and something different will arise."

What Michurin discovered about the actual laws that governed hybridization, what he *knew* about "domination," or, to put it more correctly, about the influence of the properties of the father or mother predominating in the offspring, was infinitely more subtle and complex than the crude combinations of the Mendelists.

The properties of the adult predominate over the young plant, of the local over the imported, of the adapted over the unadapted, of own-rooted plants over grafted plants, old properties over newly acquired ones.

To put it more finely and individually: the properties of the parent that are most adapted to the conditions in which the hybrid finds itself will predominate; of the parent whose particular properties are exceptionally pronounced in the given year and whose flowers are taken (for hybridization) nearest to the stem.

The chief thing, said Michurin, is not to take any pair of plants that one takes a fancy to for some reason and to cross them on the bricklaying principle ("any child can do that"). No, emphasized Michurin, the chief thing is, "firstly, intelligent selection of pairs for crossing; and secondly, the very special mode of training seedlings until they begin to bear fruit and during the first five years they bear fruit."

All this was unheard of to the priests of caste, extremely haughty, Weismann science. That science was isolated from life and from the people by the highest of walls; but it was the prevailing science in that day, and Michurin had a hard time.

He fought. He was a fearless and indomitable fighter. How fiercely he denounced these "margarine wiseacres," these "caste priests of jabberology," "our worshippers of everything silly that comes from abroad," the people who with thick "Pomologies" and Morganist tracts under their arms, groped around blindly, not seeing the greenness of the trees, the tender and vigorous shoots springing out of the ground, the buds breaking out in the spring, the boundless expanse of fields and ripening fruit besprinkled with beadlike dew on an autumn morning! Only clusters of wormlike chromosomes hovered everywhere before their unseeing eyes in the gloom of a colourless world. . . .

Yes, Michurin knew that life is life.

He saw that tender foreign varieties, crossed with native ones, produced offspring which at once turned in the direction of the local parent, and in the second generation resembled it still more, entirely, without any splitting whatever. For this is not a game of hide and seek between gene-germs; it is a collision, two lives come into conflict, and the strong one vanquishes the weak one.

That is why Michurin, deeply and sensitively grasping the actual laws of life, was able to bend that life in the direction he needed. Carefully, patiently and unerringly, he directed the development of his trainees, the unusual plants that he had created. He attached eight "mentors" to the hybrid seedling, he changed it eight times before he succeeded in getting that excellent variety of apple Bellefleur-Kitaika. This transformer of nature knew how to create new properties that neither of the parents possessed, and how to destroy an undesirable property. His method was not temporarily to hide a toy brick in the Mendelist game of dominants and recessives, but to vanquish that property with the power of the newly developing life and remove it from the latter's path forever.

Here is a plant before us, the shape of which had been moulded in the course of thousands of years. Man, the creator, must remould it.

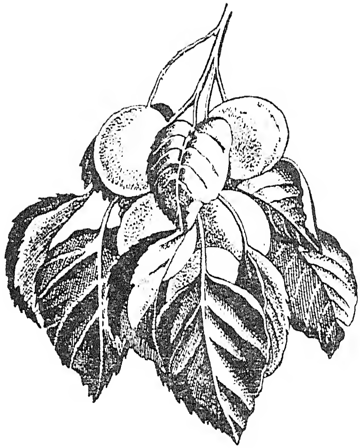
The Morganists obligingly palmed off a list of capital and small Latin letters and said in effect: here is this plant, from its crown to the tips of its roots!

What an obvious falsehood! Can an organism, which is so complex, and has such a long path of life "behind it," be all over alike? The first cells of the seedling shoot that breaks through the ground are at the base of the stalk or stem, at the root neck. And the last cells, generated by the adult and now aging body, are the buds in the crown. And the perseverance, the stamina and strength of the hereditary properties of these cells, of these parts of the body, are entirely different.

Neither in time nor in space (in different parts of its body) is the organism all over alike; and it is most important of all to know when and where to handle it so that it will "obey" you and help you to remould it.

It is also necessary to know how to strengthen its pliability, to knock it out of the groove of agelong heredity routine.

Hence the numerous, amazing distant crossings Michurin performed; distant in the relationship between the species and even genera that he crossed. And geographically distant, too. To produce his wonderful dessert pear Michurin Beurré Zimnaya, he crossed the foreign Beurré Royal with a wild Ussurian pear. Antipodes, strangers to each other, they were both alien to the soil of Tambov. Everything about the hybrid seedling was timid and uncertain; it seemed to be



Michurin Severny (northern) apricot

groping in a strange place. But man grasped it with a firm hand and led it along.

The very planting of the seeds of fruit trees that from time immemorial had been grown from cuttings shatters their heredity. When he set about "northernizing" the apricot, transferring it seven hundred versts from Rostov-on-Don to Kozlov, Michurin heard of a tree that was the only survivor in an orchard belonging to a stubborn fruit grower in Stanitsa Archadinskaya, three hundred versts north of Rostov. He obtained stones from this unique tree (the fruit grower brought them from Rostov) and then compelled the apricot to make a further leap northwards—a matter of four hundred versts—by planting it in Kozlov. The clue to the riddle is that he took "the stones from a new, young variety and, moreover, one knocked out of its groove. . . ." It was a matter of *training*—all the control plants, straight graftings of southern apricots on to Kozlov stock, perished from cold.

Nevertheless, grafting performed with an understanding of the laws of life of the "partners," is also a powerful means of remoulding plants. Nobody proved this more incontrovertibly and clearly than Michurin. What he achieved bordered on the miraculous. Two organisms unite, they obtain their nutrition from a common source, they interchange sap, and their hereditary natures draw closer. For example, plants that have been first grafted to each other cross much more easily.

The "mentor" directs the development of its "ward." The southern almond could not be "northernized" by transplanting. But a seedling, grafted on to a Siberian variety of almond and "boarding" with it for only two years, after which it was "put on its own feet," no longer feared the Tambov winter; nor did any of the layers taken from it. A Mongolian almond, grafted, when still a young shoot, under the bark of a cultivated plum tree, changed beyond recognition. A pear-apple, a pear-lemon, and dozens of similar amazing and indubitable facts—and Michurin was able to affirm: "That vegetative hybridization is undoubtedly possible, is a question which I consider definitely settled."

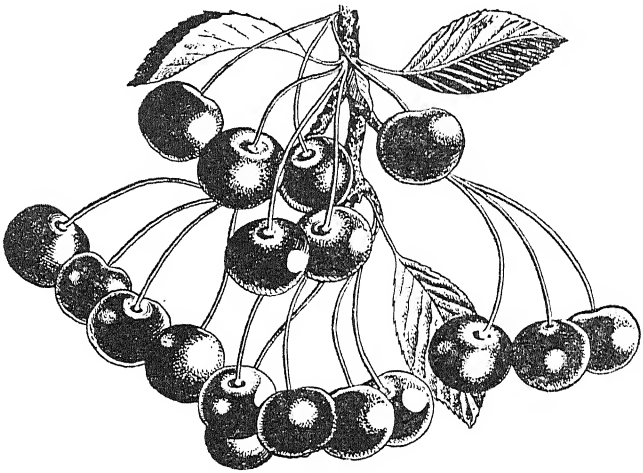
The hybridization—sexual and vegetative—of plants definitely chosen according to plan, hundreds of precise and infallible methods of intervening in their life and development, and all this combined with the constant, daily training and strict and ceaseless selection and matching—these were not simple recipes like the Mendelist rearrangement of toy bricks; they were the key to the actual transformation of nature.

LAND IN BLOOM

After the October Revolution, in the period when Michurin's work flourished most, that work not only increased in volume; the nature of it underwent a qualitative change. Michurin placed it at the service of socialist construction. He wanted to be the most active participant in this construction. He sought and carried out tasks in the service of his country. "The time has come," he said, "when the country has a right to demand from agricultural science results that meet her needs and hopes."

And he strove to make his work part and parcel of the state plan.

He acted in the same way as the poet Vladimir Mayakovsky acted in those same years in another sphere. Surprising though it may appear, there is a certain affinity between them, and it is inherently correct to draw a comparison between these two fearless pioneers.



Ultraplodorodnaya cherry

New orchards were laid out covering many thousands of hectares. Michurin called them "orchard fields," and he raised the Ultraplodorodnaya cherry for them. It was to be superior to the old Plodorodnaya that had so astonished the Canadian farmers in the winter of 1898. And indeed, in the summer fruit-bearing months, this tree looked like one huge cluster of cherries.

Work of construction on a gigantic scale was going on all over the country. New cities sprang up. Factory chimneys began to smoke in what only recently were deserted steppes.

Industrial centres sprang up like magic. That was the period of the first Stalin five-year plans.

At that time the idea rose of planting green belts around the industrial giants, and this idea became one of urgent importance. One of its initiators and ardent champions was Michurin. For him to say "it is needed" meant "go and do it." Green belts—but not simply green, but fruit belts. Fruit-tree groves, orchards and avenues around the cities. That meant that varieties of fruit trees had to be raised that would stand the severe climate of the Urals and Siberia, where many giant industrial plants and new cities were being built.

Later, A. D. Kizyurin, a citizen of Omsk, came forward with his sensational solution of the Siberian fruit-growing problem: he induced his apple trees to spread out on the ground. In this way they pass through the winter covered with snow. Michurin was thinking on the same lines: trees must be low so that the snow could serve them as protection. And so he raised several varieties of dwarf cherries. He dreamed of cherry gardens—of Ukrainian cherry gardens!—near Leningrad.

But this did not close his account with the Cherry family. He raised another variety—a cherry for all. It was to be able to grow everywhere—on the richest and poorest soil, it was to fear nothing, and demand almost nothing for itself. All the fruit on it was to ripen at the same time, so that the picking could be done in one round, without delays, with an immense saving of time and with fewer workers. Cherry growing was to be put almost on factory production lines. It would be possible "within a short space of time to pick the crop on enormous areas and to supply the workers' districts of the big industrial cities with first-class standard fruit. . . ."

The entire country, millions of hands, are now planting shelter belts in the steppes and fields. We, the contemporaries of the biggest plan in the history of the world, of the Stalin Plan to ensure stable big crops, now perfectly well understand what such belts signify in the struggle against that frightful scourge drought, in the struggle to change the very climate of our country. But Michurin was one of those who had long appreciated their significance, had propagated the idea, and had urged that planting be started at once, "because," he said, "we have the kolkhoz system!"

He had his own, Michurin, point of view on this matter, however. Why only walnut and maple, when it is possible. . . . And he showed by deeds what is possible: he offered his special varieties of plums, currants, sweet birdcherry, and also his Polyovka cherry. It was the most unexacting of trees, he claimed; it needed no tending. All you have to do is plant it, and it will produce a crop every year. The point of view of the great transformer of nature—that fruit trees should be used for shelter belts—was adopted and incorporated in the state shelter-belt planting plan.

Towards the end of his life Michurin conceived the idea of completely "reconstructing" the cherry tree. Just before he died he said to one of his pupils: "The cherry tree doesn't grow right. The cherry stone too ought to be edible. . . ."

This pupil—now a Leningrad botanist—succeeded in carrying out this idea: the fruit of cherry trees he raised contain stones like almonds.

Michurin was convinced that fruit must, and soon would, "become an essential part of the diet of all working people and not merely a delicacy."

He boldly and swiftly enlarged the "fruit" circle. Who, except village boys, eats ashberries, the scarlet beads worn by the sad lady of the autumn woods? Michurin changed the nature of the mountain ash and its fruit became suitable for "dessert." It will now provide delicious berries for the table of the inhabitants of towns and villages situated near the Arctic Circle.

He created a variety of Actinidia that is richer in vitamin than lemon.

His apricots, which bear the name that is precious in our country—Tovarishch (Comrade), withstood the extremely severe winters of 1928-29 and 1941-42, when even apple trees that are accustomed to frost perished.

He regarded gooseberries as one of our popular fruit crops, but they were infected by an American parasitic fungus, brought in by the lovers of "foreign varieties." The cry went up: "Save our gooseberries!" Michurin solved the problem which the European plant breeders, under whose eyes all gooseberry plants inexorably perished, had vainly tried to solve. He raised a variety that was immune to this fungus.

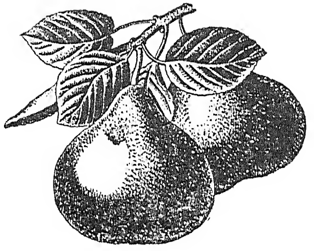
Michurin was appealed to from all sides on important as well as on minor matters. Confectioners and pastry cooks needed a harmless but tasty "dye" for confectionery and pastry. Workers in industry enquired whether cork oak could be made to grow elsewhere, besides the Caucasus and the Crimea.

Michurin kept no secrets. As regards cork oak, he sent comprehensive instructions how to transplant that tree in the North.

During the celebration of his jubilee the American Professor Hansen said:

"No plant breeder in the world has ever been able to boast of as many varieties as Ivan Vladimirovich can show."

Michurin raised about three hundred and fifty varieties—nearly a whole extensive forest of plants—that had not existed on earth until this extraordinary man came along.



Michurin Beurré Zimnaya

Somebody has calculated that the number of varieties of apples that Michurin alone produced is equal to the total number that existed in France at the time of Louis the Fourteenth.

He himself summed up his life's work as follows: "I have succeeded in shifting more than a thousand kilometres to the north of their previous borders, southern fruits and berries that are most tender, most sensitive to cold, and at the same time most valuable, and I have secured for them an early ripening unheard of before." At the back of the book by Academician I. I. Prezent, *In Collaboration With Nature*, there are two maps.

At the bottom of these maps there are some black lines. Two of them run almost along the edge of the Azov Sea, at the angle where Rostov stands; a third runs somewhat higher—at Stalingrad and Voroshilovgrad. These are the former northern borders of apricots and of all the known southern varieties of pears and grapes. But a red line winds sharply along the Volga, gives a twist towards Moscow and then runs further north towards Leningrad. This line indicates the present northern border of the Michurin Beurré Zimnaya. Another red line takes in Tambov and Kursk. This is the northern borderline of Michurin apricots. These are "victory lines," showing man's victories over nature. They are indeed astonishing! The maps show red rings at Kirov, Yaroslavl and beyond Chelyabinsk. They indicate the areas where Michurin varieties of grapes are now grown.

Over three hundred varieties created in one lifetime! Remember that plant breeders toiled for years to produce just one variety. And is this word "variety" adequate when speaking of what Michurin did? The plant properties of many of them have been changed so radically that if a botanist were to find them in a wild state he would class them as new species and even genera.

In the address he delivered at the historic session of the Lenin Academy of Agricultural Sciences on July 31, 1948, Academician T. D. Lysenko said the following about the varieties Michurin produced: "Many of them were produced without sexual hybridization, and all of them were the result of strictly directed selection, including systematic training."

A CREATOR

You ask yourself: what is the key to the riddle of this great phenomenon that bears the name Michurin? What is the secret of this unexampled life?

A real biography of Michurin has not yet been written.

That great diviner, art, is already trying to reproduce his image.

We will endeavour to describe at least some of his traits of character.

He was a man of iron will and indomitable determination. Stern in home life and at work, he never flew into a rage, never posed, never gave way to strain, or to hysterical outbreaks. Outwardly plain, a lover of methodicalness, consistency and straight, sharp lines, which ran through his whole life, his inner world was extremely complex and deep.

Burbank kept quiet, smiled a barely perceptible, ironic smile, perhaps, when the storm of abuse and charges of blasphemy raged about his ears. But it is doubtful whether the Archipresbyter of Kozlov walked out of Michurin's house as proudly and formidably as he had walked in, when he came to upbraid him and to save his soul. In all probability he flew out with tingling ears, as if they had been soundly boxed.

There is another feature that you will invariably find in every man of importance, in every man who has added a brick to the vast edifice of human culture, viz., extraordinary capacity for work. But even though you are aware of this, you are nevertheless amazed at the feats of labour Michurin performed in the course of his life. In Michurin, however, this feature bore a peculiarly Michurin stamp; it was different from that of Timiryazev, Darwin, and other great lovers of work.

There was scarcely anything in his orchard that was not the work of his hands, and there was certainly not a thing he could not do.

No work was too rough for him. This man, lean and by no means of giant stature, carried tons on his shoulders in the course of his life; and to the end of his life he was passionately fond of every kind of "handicraft" and was able to introduce into it the finest workmanship and true art.

Already at the time when he was a railway clerk he drew up a catalogue of all the trees of any value, or in any way remarkable, in the orchards of all the amateur horticulturists for many scores of miles along the railway. Later he enlarged the area of his explorations, extended them to other gubernias. Michurin's eyes could see people from unexpected angles. In the flour market in Vladimir there was a merchant, D. P. Goncharov, and his son. Michurin makes the following entry in his notebook: "Through him try and get a Vasilevsky cherry." This was a southern cherry that grew in Afon. "Sorokin, the meat merchant, an ardent amateur," also has some of them. To everybody, Nikolai Mikhailovich Dereventsev was "a carter at the third hiring station," but to Michurin he was, in addition, a man who owned two early-ripening cherry trees.

In those years Michurin rose before dawn and worked in his orchard until it was time for him to go to his office. At sundown his two little assistants—his son and daughter, Kolya and Masha—hoped that their father would at last allow them to romp and play, but the father, keeping a stern hand on himself, kept an equally stern hand on his family.

The autumn days were too short for Michurin and there were long evenings before him, so he continued his work in the orchard by the light of "Bat" storm lamps that flickered in the wind, and later, in his workshop, he would practice grafting on willow twigs. . . .

Stubborn perseverance and determination: if a thing doesn't work out try and try again; do it a third, fourth, fifth and sixth time.

He had 2,800 peach seedlings. In the summer he could not admire them enough. The winter destroyed them all. He wrote in his diary: "This is enough to kill all hope that peaches can be grown in our locality. But, in the first place, a man wants what he hasn't got; and in the second place, what has man's stubborn, persevering labour and patience not achieved?" ". . . hence, I will continue the struggle. . . ."

This feature, this quality, is amazing. Obstacles yield to such determination. But evidently, in order to achieve something really important, truly great, one must possess something more—the strength for another supreme effort. *This* you will not find even among all big men.

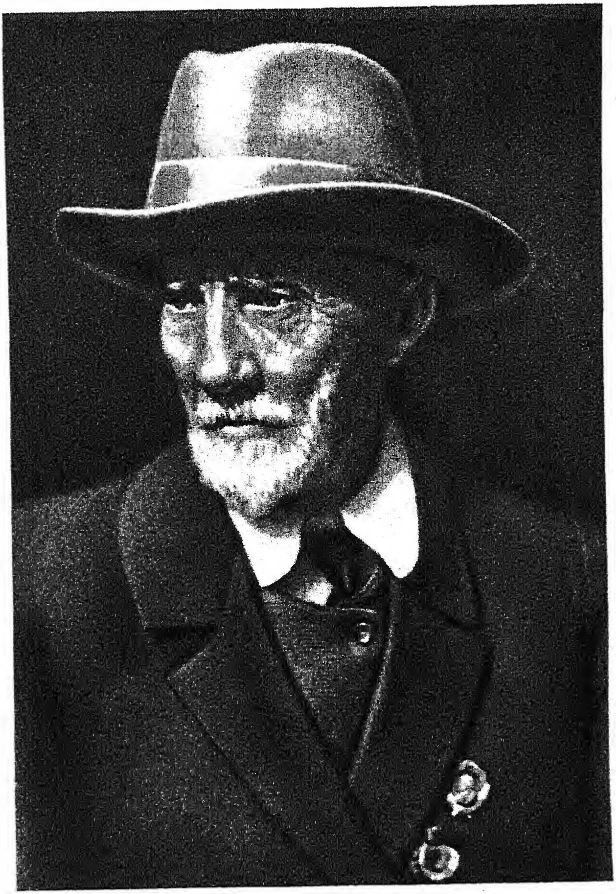
When all possibility of further progress along the chosen road has been exhausted and the goal has not been reached, or even if the goal has been reached, but from it a new goal, as yet unseen by others, comes into view, a grander and more difficult one, more urgently necessary to reach—then one must possess the clearness of vision, an incorruptibly sober and eternally enquiring mind and, above all, the will and the courage to make the supreme effort, to "rebel against oneself."

Giants, and only giants, could do this. Several times Pushkin set about writing in an entirely different style, although what he had written hitherto seemed to his contemporaries to be an unsurpassed pinnacle (he "changed his pen," as one of the students of his works has aptly expressed it). Leo Tolstoy did the same. Students of Shakespeare have long ago noticed with amazement the same thing in the works of that playwright. We know how Ivan Petrovich Pavlov altered the course of his work at the turn of the present century (when he dropped his researches into the digestive glands for which he was awarded the Nobel Prize and took up conditioned reflexes), and again prepared to start all over again just before he died, when he was over eighty.

It is this great power to make such steep flights that most of all astonishes one in the character of Michurin. The Phoenix power of self-regeneration was inherent in Michurin to an amazing degree.

Michurin, when young, was an ardent follower of A. K. Grell, who taught that it was possible simply by acclimatization to harden "southerners" and convert them into "northerners" (which he tried to prove in his "acclimatizing orchard" on the Sparrow Hills outside of Moscow). With a passion that even his teacher did not feel, Michurin started "acclimatizing," and to this he devoted all his labours, all his time and all his meagre funds; he preached his faith in public, pleading and urging others to follow his example. No setbacks discouraged him. This went on for many years.

At last he got to the bottom of it; he exhausted all the possibilities of acclimatization that thousands of others had



IVAN VLADIMIROVICH MICHURIN

regarded as inexhaustible. And no sooner did he distinctly realize this than he took an abrupt turn. He abandoned Grell. Everything, from the very start, had to be done in a different way. Henceforth, Grell had no more formidable enemy than Michurin. "I . . . too was infatuated with Grell's method of acclimatization," he wrote. ". . . I too acclimatized by magic means. . . . " "An immense amount of labour, money and time has been wasted. . . ." "I urge you not to deceive yourselves with false hopes. . . ."

He arrived at the paradoxical conclusion that what he needed for a nursery was poor, bad soil. He threw up everything. Although nobody had ever tried to plant a single tree (let alone lay out a nursery) on such soil, he abandoned his little well-arranged, black-soil orchard in the suburb of Turmasskaya which everybody envied, into which he had put his whole life and had brought to such a state that neighbours passing by said: "A picture! Can't keep your eyes off it!"—and bought from the local priest a piece of waste land that nobody wanted on the bank of the river Lesnoy Voronezh. The poor man was reduced to beggary. He, his wife, his sister-in-law and his children hauled all the trees and bushes on their backs for a distance of eight versts.

This piece of waste land is today the most famous orchard in the world. This migration in 1900 was the beginning of the *real* Michurin.

Thus, in the very same year of the resurrection of Gregor Mendel, when the latter's forgotten treatise was discovered by Tschermak, Correns and de Vries, and formal, Mendelist genetics was born, in that very year another event occurred, the significance of which was the very opposite of that of the discovery of the "pea treatise," an event that passed unnoticed at the time but which, in the end, produced tremendous results!

It is interesting, and important, that Michurin understood the significance of such "breaks" and crucial turns in his work not only intuitively, but consciously and clearly. He knew that people must acquire knowledge by tireless search for the new, and that science develops dialectically.

We find in his notes a clear-cut formula which shows the difference between creative growth and dogmatic ossification, a formula so striking that I want it printed in italics:

"My followers must run ahead of me, contradict me, even destroy the fruits of my labour, while at the same time continuing it, for only such consistently destroyed work can promote progress."

Here he rises above everything he himself created!

Unusual and unexampled is also the fact that from the very beginning, he, a poverty-stricken horticulturist, fully appreciated the meaning and object of his labours and consciously set himself his unprecedented gigantic aims. In the very earliest years he even apologized in the press for being obliged to tear himself away from these aims, for being obliged to sell trees, seeds and seedlings out of his orchard in order to obtain the means wherewith to live.

How was this possible, even allowing for his genius and boundless strength? What backing did he have?

Sometimes you read: he worked alone in old Russia. But those who are isolated from the people never achieve anything important. Never.

The fact is that there were people in Russia who, even in the darkest times, cooperated with Michurin, respected him, learnt from him, paid heed to every word he uttered. There was a Russia that knew Michurin—the Russia of the common people, peasant, worker and railwaymen horticulturists, his neighbours in Tambov, and those who corresponded with him, exchanged cuttings and seeds with him, and came to visit him from the remotest parts of the country.

He himself was bound by the strongest ties with the traditions of Russian horticulture, and moreover, nobody watched the development of science more closely and pondered over all that was new and valuable in biology, botany, the splendid Russian natural sciences, more deeply than he.

The circle that Michurin regarded as his *own* was the circle of horticulturists, including the real scientific horticulturists, particularly those united around the magazine *Progressive Fruit and Vegetable Growing*. On the pages of this magazine Michurin was sometimes referred to simply as Ivan Vladimirovich. But this circle was unable to render him the effective, material assistance he so badly needed.

"We know your needs, but what can we do? . . ." It seemed as though this fame was doomed to remain impotent and "secret," doomed to this by the chilly, contemptuous silence of that *other* Russia, official Russia, the powers that be.

Nevertheless, Michurin felt all the time that he was not alone, that he was not working in an icy vacuum. . . . This was the backing he had, this is where his indomitable spirit gained new strength to press forward on the path he had chosen.

It is now time in still another respect to supplement the impression of Michurin the reader may have gained from what we have written in the preceding pages. We must give an idea of the scope and character of Michurin's work.

This man with the horny hands of a labourer and the brain of an explorer of nature and a philosopher, the man who was unable to complete his high-school education and whom nobody trained to write, spent all his life not only in his orchard but also at his writing desk. The literary heritage he left is enormous and has not been completely investigated to this day. It probably runs into several thousand pages.

He had a style of his own; one can at once recognize his phraseology. But for all that, he never strove for a "beautiful" style, he was not a man of letters. His style is almost the very opposite of the slick "literary" style.

His pen was his agent, nay more, his comrade. He thought and searched with it. That is why he did not need any slashing phrases. His words had to be as precise as possible, as obedient as possible, and had unprejudicedly to follow the thought. By themselves they are nothing; the thought is everything.

Hence the unwieldy sentences, often with five genetives strung in a row.

He wrote down tasks for himself, the result of the day's work, what he had been thinking; "problems to be solved." "Notes on what I have read, and appraisal of same"; "rules that have been worked out," descriptions of fruit, painstaking notes of experiments; new laws he had discovered; he made sketches and drawings with explanations; he argued, engaged in controversy, he drew caricatures—nothing personal, merely blows in the ideological struggle, generalized images of the hateful vehicles of lifeless dogmas "from the caste of the priests of science" (to quote one of the captions); he moralized, put down on paper the standards of conduct of a naturalist, and what he demanded of him.

Taken on the whole, his writings are the confessions of a long and active life, with its external events, struggles, labours, book reading, reflections, knowledge obtained by experience—and its infinitely complex and deep inner world.

The least that Michurin strove for in his writings was "polish." But when putting a clear thought that had been thoroughly weighed and felt by an ardent heart, his pen gave birth to sentences of lofty elegance, of genuinely appealing strength and passion. He wrote of the "flourishing garden" that his native land must become. He coined the famous aphorism: "We cannot wait for favours from Nature; we must wrest them from her." Or: "Outwardly too, our country must become the most beautiful country in the world." He readily found exceptionally human expressions and spoke as nobody had spoken before him.

"Socialist construction carried on under the guidance of the Bolshevik Party with Comrade Stalin, the dear leader of all working people, at the head, has already made all of us live to see the wonderful deeds achieved both in cities and in villages, in the laboratories of industrial plants and academies, deep in the bowels of the earth and high up in the air. *I have a feeling as if now, in the eightieth year of my life, I have suddenly met an agreeable person I had never known before.* (My italics—V. S.) Everything has changed so wonderfully."

Another coined sentence: "V. I. Lenin's great idea of renovating the land is becoming the practical task of the vast masses in the Soviet Union."

He writes of his "dream" as a naturalist, a renovator of the land, and these are the words that he sets down on paper: ". . . that people should stop in front of a plant with the same interest and the same bated breath as they stop in front of a new locomotive, a more perfect tractor, a hitherto unseen harvester combine, a strange airplane, or in front of some new, unprecedented machine of unknown construction."

Of course, he deliberately penned that final "machine of unknown construction." He was fond of rolling sentences. Like Pavlov, he had a partiality for old-fashioned words and figures of speech; that is how his term "mentor" was coined.

He flaunted them somewhat, just as he did the solemn old fastidiousness of his starched collars.

But what a genuine, integral, profound sense of beauty he possessed! Of the beauty and charms of the world around him, of the living, blooming, fruitful world that his hands were changing. He saw it with the eyes of an artist: "Colour—bright, greenish-yellow, with tender reddish-pink flush on the sunny side. . . ," "The fruit is magnificently coloured with a scarlet design on a beautiful yellow-saffron background. . . . Flesh—compact, of yellowish colour, a remarkably piquant, wine-sweet and slightly sour, spicy flavour and fine aroma. . . ."

He wrote about the "boundless book of nature," of which all our knowledge "constitutes only one short line"; he urged his followers not only to reprint his "green book," but to continue and develop it.

And we see that the potent force that moved him served as a powerful impetus to work and transformed that work into a joy—that it, of course, consisted of the conviction that the work was important and useful, and of the passionate desire to achieve by it the utmost man can achieve; but we also see that it consisted of something more, something without which the work of a great naturalist, like that of the artist, is impossible. That something was poetry—the sense of the poetry in nature and of the lofty poetry of one's own creative work.

Ivan Vladimirovich died on June 7, 1935.

What he created was not merely a wonderful orchard with a multitude of unprecedented trees; it was a mighty science of the living world and of man's power over that world, mightier than any science that had existed before.

Darwin explained evolution; Michurin *created* it.

This marked a new and most important stage in the development of the entire science of biology.

Mendel preached submission to fate in the shape of hereditary properties. "Dominants" and "recessives," you can't do anything about it, submit to things as they are.

The profound laws that govern the development of living beings that Michurin discovered made it possible to alter them in a given direction, to control "domination," to mould heredity. This marked an epoch in man's knowledge of nature.

Michurin raised Darwinism to a higher stage and, moreover, endowed it with a new quality—it became *creative* Darwinism. It is difficult to find a chapter, or department, of theoretical biology that has not been radically affected by Michurin's discoveries.

The most important generalization made by Academician T. D. Lysenko—the law of phasic development—is also based on Michurin's ideas concerning the different qualities of an organism's tissues at different periods of its life and, as a consequence, the different qualities of the parts of the body of, for example, an adult plant.

Nor is there a single department of agrobiological science to which Michurin's ideas have not indicated a new path—whether we take sexual and vegetative hybridization, the powerful means of altering hereditary nature by training, by the influence of the conditions of life, or the theory of deliberate selection of pairs for crossing, which marks a revolution in plant breeding. The achievements of Soviet agricultural science are unexampled. There is nothing anywhere abroad to compare with them. But diverse as the creative work of Soviet agrobiologists and plant breeders may be, it can be boldly asserted that all the best achievements have been attained on Michurin lines.

This applies to animal as well as to plant breeding. Soviet animal breeders are raising new breeds of cattle, are saving old breeds from degeneration, are compelling cows to give thousands of extra litres of milk per annum, and hens hundreds of eggs, and they are enlarging the fleeces of sheep. Proudly they say:

"This has been achieved only by employing Michurin's methods. Animal breeding must become Michurinist—in that lies its future."

And what about agricultural machine building? You may ask what Michurin's biological theory has to do with this; but put this question to the engineers, the designers of those amazingly "clever" agricultural machines that operate on our fields.

"The object on which all these machines operate is life, living beings," they will tell you. "Only by profoundly understanding the nature of these living beings in the Michurin way was it possible to build these new machines which no machine designer in the world has been able to invent before."

Biology is the basis not only of the agricultural sciences, but also of the science of medicine. There is no longer any doubt now that Michurin's theory endows this most ancient of the sciences too with fresh power. Much that is very important will be (is already being) changed in physiology and biochemistry. . . .

Michurin science is a new, materialist science of nature which casts away the husk of formalism, of reactionary idealistic pseudo science.

Michurin science teaches how to change the world that surrounds man in the interests of the people. It is a people's science in the truest sense of the term. That is why it could not arise in the realm of the dollar (apart from the fact that there was no genius like Michurin there), nor get on to its feet in tsarist Russia.

It blossomed forth in our country, the U.S.S.R.

The great and modest renovator of the soil who was almost unknown before the revolution was elected an honorary member of the Academy of Sciences of the U.S.S.R.

The wonderful orchard in Michurinsk is now our central institution for the study of pomology.

Michurin science has been brought within the reach of the whole people.

Thousands of Michurin's pupils and followers in all parts of the U.S.S.R. are continuing his great work. Michurinist academicians, professors and plant breeders, geneticists—genuine investigators of heredity and not the Mendelist brand—agronomists and advanced kolkhozniks are further promoting and developing Soviet, Michurin, agrobiological science. It is with its might that nature is being vanquished and the fight is being waged to make our country a flourishing garden.

—

COMMANDER OF THE FIELDS

THE DISCOVERY OF VERNALIZATION

On a shelf near Michurin's desk, among the few, carefully chosen books the great transformer of nature kept at hand, stood a thin little book printed on cheap, greyish paper.

This booklet bore the title: *Bulletin of Vernalization*. Next to the title was the inscription: "To my beloved teacher Ivan Vladimirovich, from a pupil unknown to you. T. Lysenko. 1921/IV/1933."

To the bulletin there was carefully attached a newspaper portrait of the author of the inscription. The author was Lysenko, who was working in the Ukraine, far away from Michurinsk, and had never engaged in horticulture; he confined his studies to field crops.

The inscription on the greyish booklet, the title of which could not have been explained by any of the old dictionaries, was an error; it is beyond doubt that the pupil was not unknown to the teacher.

* * *

About two years after tens of thousands of articles in the entire press all over the globe had solemnly reported the mutations of the flies X-rayed by Morgan's pupil Muller, there happened. . . . Actually, nothing really happened. It was simply that a brief news item appeared in the Soviet press to the effect that in the village of Karlovka, in the Poltava Region, a peasant had sown Ukrainka wheat in the spring, the wheatears had filled and had yielded a crop. That was all.

. . . Ukrainka? But isn't that a winter wheat? Must it not be planted in the autumn?

Yes. But in this case it behaved like a spring wheat!

Who was that peasant? D. N. Lysenko. It was said that he had done something to the wheat; had performed some trick on it. He had soaked the wheat—in the winter too—and when the grains began to sprout he put them into sacks and buried the sacks in the snow. In the spring he planted these grains.

There is another detail that must be mentioned here: not only did this peasant's Ukrainka wheat ripen in the year it was planted, but its yield was very high—24 centners to the hectare.

And the story goes that old Lysenko did all this—soaking the grains, burying them in the snow, and so forth—on the advice of his son, an agronomist.

Actually, even before the grain was harvested in Karlovka, scientists might already have heard about the conversion of winter varieties into spring varieties. In January 1929 an All-Union Congress of Geneticists was held in Leningrad. The even tenor of the proceedings at this congress was disturbed by a young specialist from the provinces, whose mode of dress laid no claim to professorial "good form." He spoke with a marked Ukrainian accent, and did not use any such terms as "mutation," "lethal," "crossing over," "transmutator," "inhibitor," or "allelomorph." Not once did he mention Morgan, Muller, Goldschmidt, Bridges, or the other luminaries in genetics of that time.

From the rostrum he related wonderful things. He said that in the course of its development a plant passes through special phases, which had slipped the attention of all the geneticists in the world; and that this phasic development that nobody knew about is the most important thing in the plant's course of life. He said that the same variety of wheat can be both a spring and a winter variety. If, for example, the seeds of winter varieties are kept under a definite, relatively low temperature before the buds had broken through the husks, these seeds can safely be planted in the spring.

Many of those in the hall listened to the speaker with a polite smile—provincial experiments with wheat, rye, barley, vetch, rape and peas. But with what perseverance these experiments are being made! Whole collections of varieties planted every ten days for a period of nearly two years; and the daily notes taken of this vast multiplicity of crops filling thick diaries!

One of the participants in the congress leaned towards his neighbour and enquired:

"Who is he?"

"An agronomist from Ganja. That's in Azerbaijan Lysenko."

"Lysenko? Never heard of him. . . ."

When the speaker finished, a famous geneticist mounted the rostrum.

"In what Comrade . . . er, er . . . Lysenko has told us I see . . . if I may say so . . . nothing new. What I want to say is—nothing fundamentally new."

And he went on to say that his young colleague had read a very interesting paper, supplied with interesting illustrations, showing that thought is pulsating even in the most remote, so to speak, corners of the periphery.

"Many investigators, however, have dealt with the problem our colleague touched upon. We have heard that winter plants need a rest period. Others, strictly speaking, have attached great importance to chilling. The data obtained by Gassner led to the cold-sprouting method, which closely approximates to the methods employed by our colleague. All these hypotheses rest on very, very shaky grounds. As this assembly knows, Professor Maximov's experiments have revealed the inadequacy of the cold-sprouting method. And nobody would be surprised if Comrade Lysenko failed to obtain in other districts confirmation of the data he has obtained in Azerbaijan."

Is that all? And so, this provincial question of converting winter into spring crops may be regarded as finished with. . . .

In the six volumes of the report of the congress proceedings, the paper read by Trofim Denisovich Lysenko, the agronomist from Ganja, took up just five pages.

A few years later, however, extraordinary news began to appear with increasing frequency in all the newspapers. We learned that a powerful instrument had been placed in man's hands with which to compel winter crops to behave like spring crops and to lend new strength to spring crops. Several years after that the following calculation was made: to transport the extra crop the country obtained in one year from the employment of this method, a thousand fully loaded trains would be needed. That meant that in the summer of the year to which this calculation applied (1937), the extra crop amounted to ten million centners.

We also read that the cause of the mysterious degeneration of potatoes in hot and dry localities had been discovered. From now on the potato crop in our southern steppes would be equal to that hitherto usually harvested only in our central and northern regions.

The newspapers reported the rejuvenation of the old and feeble varieties of bread grains, which plant breeders all over the world had given up in despair ("as if new blood has been infused into these varieties!"), that the yield of cotton had been increased and that, according to all the data, cotton will be grown in the Ukraine that will be in no way inferior to that grown in Central Asia.

In connection with every item of news a name was mentioned:

Lysenko.

At that time, a friend of mine, a newspaper editor, a little, grey-haired man who had retained all the passionate ardour of youth and was unable to imagine life and work without it, asked me, waving the newspaper containing an item dealing with the institute of which Lysenko was the director:

"Have you read *The Island of Dr. Moreau?*"

Of course I had. In that story H. G. Wells told about a certain surgeon, a genius in his art, who, shutting himself off from the world, altered living beings as tailors alter trousers and coats. He created humanlike beings out of bulls, pigs, hyenas, rabbits and pumas. Nature yielded to his knife as clay yields to the potter's tool.

But, as the readers of this story know, Moreau's fantastic island was never found. It was lost somewhere in the South Pacific with its palms, the pearly ring of coral reefs and strange inhabitants. The novelist spared neither the brilliant surgeon nor his work. He tells us that the humans that Moreau had created began more and more distinctly to reveal animal features. The bipeds dropped on all fours, and they forgot the words of the language the surgeon had taught them. The cries of the jungle again awoke the echoes of the lost island, one of the gloomy visions of the author of *The Time Machine*.

Perhaps this English author of imaginative tales regarded the fate of this island and of its semihuman inhabitants as a forecast of the fate of the civilization he saw around him?

But the facts given in the newspaper the grey-haired but young-hearted editor was waving in front of me while his bright eyes flashed youthfully behind his thick spectacles, were more amazing than Moreau's fictitious island. A still greater power over living nature had been discovered and was not being wasted on amusement, on the making of freaks; no, it was being used entirely for what was most needed, most urgent and most important. It was creating a whole special world of plants, man's collaborators and assistants.

The home of these extraordinary plants, the Odessa Institute of Selection and Genetics directed by Academician T. D. Lysenko, became a centre of regular pilgrimages.

One heard that this was the most amazing factory in the world for altering nature; but this analogy was very incorrect. It in no way resembled a factory.

The tramway winds through the quiet streets of the old suburb that adjoins the port of Odessa, the Odessa of gay and luxurious districts that we have read about in so many books.

From this suburb the sea has retreated very far. You cannot see it; one would think it was not there. Low houses with rough-hewn stone walls and window shutters; the tiring gleam of lime over the yellow, cracked soil. Dusty acacias and sophoras. Prickly lycium growing on the edges of the vegetable plots. The metal segments of tall factory chimneys, and the factory buildings themselves.

We reach the railway and the city ends. The sign "Kiev-Moscow" is all the eye can catch on the cars as the express dashes by. Beyond lies the steppe. The golden green sea of ripening corn, barely visible tracks bordering the fields, and the barely perceptible smell of growing, succulent grass.

You are no longer in the suburb. This is the golden granary of Soviet land—the Ukrainian steppe. It commences here, on the Black Sea coast.

Telegraph poles run down the road to the town that bears the legendary name Ovidiopol, in honour of the Roman poet Ovid, the bard of "Metamorphoses"—the wonderful transformations of living nature.

Near the Ovidiopol road, in a small wood, the red-tiled roofs of white houses gleam between the tree branches—glass hothouses and a strange row of reflector lamps over a plant bed. And all around are fields and fields, divided up into strips and squares.

The exceptional stillness of the steppe at once enfolds you. And whichever way you look, you see only the rolling waves of the ripening corn as the wind blows over it—stretching right to the very horizon, which is also shimmering and quivering from the hot streams of midday air that rise from the ground.

And this field, imperceptibly merging with the rich fields of the neighbouring kolkhozes, was the principal laboratory of the Odessa Institute of Selection and Genetics.

The laboratory where the most hidden laws governing the life of plants were revealed.

In the museum of this Institute they showed you two sheaves; one looked like a bundle of bast, the other was a splendid bunch of stalks, all bearing heavy ears.

Both sheaves were of the same variety of wheat; but the first was grown from nonvernalized seed, the second from vernalized seed.

That was a trophy of victory.

But the first link in the rather long chain that led to the victory of ideas, discoveries and deductions could no longer be found in the now famous institute in Odessa.

In quest of the first link one had to travel to Azerbaijan, to a humble plant-breeding station, the one from which the young scientist Lysenko, dressed with no claims to professorial "good form," had arrived at the genetics congress in Leningrad in 1929.

1925.

In that year Trofim Denisovich Lysenko was appointed to the plant-breeding station in Ganja (now Kirovabad).

He was twenty-seven. His is quite an ordinary biography. He was born on September 17 (old style), 1898, in the village of Karlovka, in the Ukraine. His father, Denis Nikanorovich Lysenko, was what is called a middle peasant, neither poor nor well-to-do. Trofim graduated from the Poltava Horticultural School, took a two-year course of plant breeding in Kiev, and after that entered the Kiev Agricultural Institute. While still a student, he raised at the Byelaya Tserkov station of the State Sugar Trust an early-ripening tomato, the Erliana 17. In that year, 1923, he had his first article published in the *Bulletin of the High-Grade Seed Growing Administration of the State Sugar Trust.*

Many Soviet specialists were also sons of peasants and they had grown up in pretty much the same way as Trofim Lysenko. Perhaps it was only his perseverance, his extraordinary thirst for knowledge and his undeviating pursuit of the road he had chosen that distinguished him from the rest. And one other very characteristic feature: for him, knowledge was something that was immediately put into practice. It is doubtful whether he then suspected that this was the Michurin feature about him.

And so he found himself in a region of yellowish soil cracked in the summer heat, under a high, blue, cloudless sky.

It was autumn. The Ganja Plant-Breeding Experimental Station, quite recently opened, lay in a lowland part of Azerbaijan. Cotton fields, already harvested, spread all around, intersected by a network of small irrigation ditches, most of which were dry.

The young plant breeder was commissioned to work not on cotton, the principal crop in the region, but on legumes. They provided feed for cattle; on some fields they were grown in order to be ploughed into the soil like green manure; and they always enriched the soil with nitrogen, for, as we know, the roots of legumes are inhabited by nitrogen-fixing bacteria, so that fields on which these plants are cultivated are enriched with most precious nitrates.

Here, in Ganja, it would have been possible to grow the southern legumes with the exotic names—mung bean and vigna, but there was a shortage of water. A fierce struggle had to be fought for it. In the summer the irrigation ditches carried their rippling loads to the cotton fields; the "white gold," cotton, could not be allowed to suffer from thirst.

There was no time for legumes.

In the autumn, of course, and in the winter, there was plenty of water. Nay more, the harvested cotton fields no longer needed it. But what can be done in the fields in the autumn and winter?

In Ganja, however, these seasons are not like our northern, frowning autumn, nor like our winter. This was Azerbaijan, where the sun does not stint light and heat.

Would it not be possible, therefore, to plant legumes in the autumn and winter, in the months when there is plenty of water, and let cotton have the summer?

This was the first audacious idea that occurred to the young plant breeder in his new and unaccustomed place of work.

The fact that, having arrived in Ganja in the autumn, he did not wait until the spring to commence work on his legumes, already revealed the "Lysenko style."

Towards the winter he planted peas, vetch, horse beans and lentils. He proved to be right in upsetting the agricultural calendar; most of the plants that were planted in the winter survived.

It was natural to expect, of course, that the most successful would have been the early-ripening varieties, those which, in the North, go through their development quickest. Evidently, they need the smallest amount of "total temperature"; hence, these should have been the most suitable for the winter crop that Lysenko had planned.

But the first crop in the spring of 1926 revealed some little irregularity. The first to ripen were Victoria peas, those very same Victorias that were so common in Byelaya Tserkov and were never in a hurry to run through their short pea lives.

This need not have attracted much attention. A slight irregularity! As Goethe said long ago: the "Tree of Life" never grows strictly in accordance with theory (a fact which, incidentally, rarely disturbed the authors of theories); and the copybook maxim says: "Exceptions prove the rule."

And the fact itself should, no doubt, have been regarded solely from the point of view of the selection of the best varieties for winter crops; after all, that daring, nay, audacious, object was achieved!

But Lysenko looked at this unimportant fact from quite a different angle.

We are now entering the thinking laboratory of a scientist of unusual talent just when a discovery is coming to light, and we clearly see where Lysenko's behaviour under such circumstances differs from that of researchers of "ordinary" talent.

Experienced plant breeders, trained in the study of the most complex phenomena, would, of course, have noticed what Lysenko had seen.

And in all probability, in footnotes to a magazine article, among a heap of polyglot references to "the literature on the subject," they would have described the caprices of the Victoria and of several other varieties, so that the history of science might be informed that it was these researchers who witnessed this caprice and were the first to attribute it to the "specific hereditary properties" of the given varieties.

Lysenko, however, discerned in this particular fact the operation of an as yet unknown law—a law so important that its discovery promised great changes in the whole science of agriculture and even in our conception of the nature of the life of plants. (It is interesting to recall that it was with peas that Mendel established his "laws." And it was peas that convinced our researcher of the fallacy of these "laws.")

It was then that Lysenko began to plant a collection of agricultural crops, including the grain crops rye, wheat and barley. He put seeds in the ground every ten days for the course of nearly two years in the autumn, in the winter, in the spring and in the summer.

Quite unexpected things were discovered.

The wheat, rye and barley obstinately grew in tillers and refused to throw up stalks in some cases, or, in others, if planted in the spring, managed to fill heavy ears by the summer.

In some cases they became winter crops, in others they became spring crops, although all belonged to the same variety!

It followed, therefore, that "fate" in the shape of heredity was not the sole and autocratic ruler of their destiny.

What else, then?

The spring of 1928 was late and cold. This shortened the warm summer, and again one would have thought that only the quickly-developing plants, the early-ripening spring varieties, would manage to "slip through" that short summer and do all that a plant is supposed to do during its span of life.

But the opposite happened.

In the summer the crop was garnered from dozens of varieties that had been planted fifteen to twenty days later than in the preceding year, 1927, when the spring had been much warmer. The cold spring had not "stunned" them, but, on the contrary, had quickened their lives. It transformed them into early-ripening, spring varieties.

Why had nobody observed these astonishing facts before? Was it not because the Morganists had approached plants with their preconceived theories? In fact, the Morganists even prided themselves on having freed themselves of the duty of watching the waywardness of an organism's individual existence.

They resembled that celebrated physician, the spoilt child of fortune, who, as soon as a patient began to tell him about his ailments, would interrupt him and say:

"I know, I know. I know everything, old man! Don't you tell me; I'll tell you what's the matter with you."

Could a poor little plant from this bed, say, tell a celebrated professor, who had studied the structure of "hereditary substances," anything he did not know already?

So the Morganists turned away from these wretched little living blades with an air of boredom and disdain. Had they not in their formulas of heredity established once and for all what fate had prescribed for the whole of this green mob? Identity papers had been issued them for the whole of their lives. Was this not the triumph of science?

In order to see the real life of plants, however, these very self-confident formulas had to be cast aside!

The deduction that followed from Lysenko's first experiments was, at least, that it was no longer possible emphatically to assert that these plants are winter crops, those spring crops, that these are early and those later ripening. Winter crops? That depends upon the conditions. Early? It depends where.

But Lysenko drew another and much more profound deduction from these experiments, viz., that all these "caprices," exceptions and chance deviations were due to the operation of a law not yet known to academic science, and that this law was surprising, and at first sight even seemed paradoxical.

According to this law, growth and development are not the same thing.

Does not winter wheat grow in a hothouse? It grows splendidly—a rich, tillered grass. Excellent green fodder for cattle! But it refuses to throw out ears. Throughout all its hothouse life, winter wheat appears to remain in its juvenile stage. Picture to yourself a child that had grown to the size of a giant, but had remained a child with chubby hands and feet and lisping speech.

Next to this child-giant there is a dwarf—a tiny stalk that had sprung from a seed accidentally dropped by the roadside. This is an old-man dwarf—it has an ear, as tiny as itself, and it contains only two tiny grains. It was unlucky, life had dealt hardly with it, but for all that, it was more fortunate than the hothouse "juveniles." It did everything wheat is supposed to do: it sprouted, threw up stalk and ear and withered, bringing forth offspring—its two grains.

And so—what is development?

Here it is worth mentioning again the cold spring in Ganja when, in spite of the cold, many of the winter wheats, even those that were planted late, managed to ripen, that is to say, became spring wheat.

The cold spring did what no hothouse could do.

Evidently, at the beginning of its development, wheat must go through a certain stage, or phase, and it cannot do this without cold.

But what the Ganja spring did, man can do. Knowing that a winter variety needs cold during its first stage of development, man can give it the necessary dose when the germ in the grain is just beginning to grow. A winter variety, thus "vernalized," will slip through this important stage and in its subsequent development will behave like a spring variety.

The history of science records the following.

Abbot Cremonini, a professor at Padua, was invited to look through Galileo's telescope.

"You will see Jupiter's satellites and the spots on the Sun," he was told.

But the learned abbot turned away with indifference, saying:

"Jupiter has no satellites, and there are no spots on the Sun, why, then, should I look through the telescope?"

Much as the Morganists would have liked to repeat Cremonini's answer, nothing of the kind could happen in our country in relation to Lysenko's discovery.

When, in January 1929, Lysenko spoke at the Leningrad Congress about controlling the plant organism, his remarks did not make any particular impression upon the formal geneticists who were assembled there. They listened to him, but did not hear him, as if their ears were stuffed with cotton wool. The "cotton wool," was the preconceived, dogmatic theory that was "accepted by the best authorities in Western Europe and America."

But Soviet science was not confined to the Morganists, to those who regarded the paper Lysenko read at the congress as a "provincial problem." This happened in the U.S.S.R., in the country where the Bolshevik Party and the Soviet Government do not allow a single grain of genuinely progressive scientific thought that serves the people to fall on barren ground.

The Year of Great Change was already beginning. The gigantic building operations of the First Stalin Five-Year Plan were changing the face of the country. The small private-property countryside was being superseded by the collective-farm, socialist countryside.

The collective farmers—kolkhozniks—were striving to obtain harvests such as had never been obtained before, and they appealed to the agricultural scientists to teach them how to till the soil, plant seeds and tend the plants better than before.

How, then, could the new knowledge that Lysenko had acquired, knowledge that promised an unprecedented power over plants, over the bread grains with which the country's fields were sown, remain unnoticed?

The word "vernalization" suddenly flashed across the country. It is difficult to say now who first pronounced the word. This word signified that people were already putting the new knowledge into practice, were "vernalizing" bread-grain seed, in a businesslike way controlling what until recently had been the secret of their development.

The research initiated in Ganja assumed unprecedented dimensions, and Trofim Lysenko continued to direct them. But he was now assisted by thousands of kolkhoznik experimenters in the Ukraine, in Kazakhstan, around Moscow and around Kursk. The experimental beds in Ganja expanded into thousands of hectares of kolkhoz land!

"Had this not been the case," Lysenko wrote later, "not only would our laboratory researches have remained within the laboratory walls and would never have reached the fields, but the very elaboration of the theory of the problem would not have had the achievements to record that it has at the present time."

The truth of every theory is tested by practice. Whoever wants to fell a tree takes up an axe. If man had never felled trees, but had only discussed how trees should be felled, people would no doubt have been found to send a woodman into the woods armed with a penknife. And it would have been impossible to argue with people like that.

It is the same in science. Theories containing a little truth and many preconceived ideas can sometimes exist only in laboratories, or books, for quite a long time if millions of people do not have to work with the aid of these theories, to test them on a large scale in practical work.

In tsarist times, the peasants ploughed with wooden ploughs and scattered seeds from a basket. On the landlords' "home farms" the English Ransome threshing machine was regarded as the highest achievement, and a German separator roused the surprise and envy of neighbours.

It was the kolkhoz, socialist countryside that put agricultural science to a test such as it had never been subjected to before.

That is why the new science of the control of plant life could appear, vindicate its right to live and grow so rapidly as no science has grown at any time in human history, only in our Soviet land.

THE STAGES OF LIFE

Lysenko transferred his major researches from Azerbaijan to the Ukraine in 1930. By order of the government the Ukrainian Institute of Selection and Genetics set up in Odessa a special department for these researches.

Lysenko now had the opportunity to make extensive use in his experiments of the precious collection of the All-Union Institute of Plant Industry in Leningrad. This collection had been gathered in all parts of the world; it was a replica in miniature of what man has created in the fields of the globe throughout the whole course of his history. In the spring of 1932, 1,427 samples of Azerbaijan wheats were planted in Kazakhstan; here eighty per cent of these wheats behaved like spring varieties and produced a crop in the summer.

In the same spring the same collection of wheats was planted in the Gigant State Farm in North Caucasus, and nearly the whole lot behaved like winter varieties. Only five per cent of the wheats planted formed ears.

In Ganja, Indian wheats ripened nearly thirty days before the Finnish varieties; but in Hibini, the Finnish varieties caught up with and even outstripped the Indian wheats. Here, at Lysenko's request, a collection of cereals was planted by the pioneer in Arctic agriculture, I. G. Eichfeld.

No scientific experiment had ever before been conducted on such an extensive area, and by so many experimenters.

It was soon definitely established for numerous varieties what "dose of temperature" each needed at this first stage of development which is now known as the vernalization stage.

To be able to control the properties winterness and springness! Only a few years before, such a problem would have baffled all the scientists in the world. At the present time, however, it is an ordinary, everyday affair.

The seeds are spread out on the barn floor and plentifully dowsed with water. Then their temperature seasoning commences. Winter wheat is kept at a temperature ranging from zero to $+3°$ Centigrade for 35 to 50 days (according to variety); spring wheat is given 5° to 12° above zero Centigrade for a period of one to two weeks.

Yes, spring wheat too! For the object was not to perform a mere conjuring trick—to convert spring into winter wheat —but to find out how to control the development of plants.

"Vernalizing spring wheat!"—a strange word combination! It's like saying "making spring wheat springy"; but it means accelerating the ripening of grain crops and increasing the harvest gathered from the kolkhoz fields.

The vernalization of seeds on a mass scale has been practiced for many years in the Soviet Union. When statistics came into its rights it was calculated that the increase in the harvest resulting from the sowing of vernalized seeds is equal to an average of one centner per hectare; and this, in 1937, amounted in the Soviet Union to ten million centners—the amount of grain which, as we have already mentioned, would take a thousand freight trains to carry!

Agronomic experiments on a small plot transformed in less than ten years into ten million centners of grain—is not this an amazing result of a scientific discovery?

Now that we are speaking of the general law of development of plants, there is no need to repeat the word "cold" any more. Winter crops need cold in the first phase, and even then, some varieties can be vernalized at 10° Centigrade (sometimes even higher); but when this is done, their "childhood" is drawn out for several months. The temperature of 15° above zero at which some spring varieties are vernalized is not cold even for warmth-loving southern plants.

Cotton demands almost tropical heat—20° to 30° Centigrade; but after it goes through the vernalizing phase it will become much more compliant and will be content with the ordinary temperature of our summer.

Thus, in passing, the reason why cotton did not thrive well in the Ukraine was explained: it was not because it is cold there, but because, for a certain short period in the spring, the cotton did not get its dose of heat for the vernalizing phase.

And so, in order to complete its development, the plant organism must go through two certain, distinctly different phases.

Phases? But you have just read about one—the vernalizing phase. Is it not enough to put plants through this phase to make them flower and produce fruit?

Here the researchers at the Institute of Selection and Genetics recalled the enormous Mexican maize that grew in Odessa in the hot summer of 1931. The term "cereal" did not suit it in the least. Strange shoots, as tall as a house, tropical plants with segmented stems and narrow, sinuous leaves; but not a cob anywhere, not on one of these giants!

They had long safely passed the vernalizing phase. What, then, had caused this unrestrained and sterile growth? The culprit was found. It was the Odessa day. It is too long. There was too much sun for tropical maize! In its native land, day and night are almost of equal length.

Among the numerous experiments that were performed at the Institute in 1931-32, some were extremely simple. In the spring, when the northern wheat in the field had already thrown up stalks, a score or so of the plants were covered with flower pots. Only for a few hours a day. Everything remained as before, except that for these plants the day was a little shorter.

And then what? Even then they produced no seeds.

At the end of the summer and in the winter vernalized winter wheat was planted in the hothouse. They never eared. Barley, for which a short, ten-hour day with intervening long, dark nights were artificially created, grew for two whole years, threw out leaf after leaf, and perished without earing.

Next to this barley, another barley was planted, which had no night at all. Daylight was followed by electric light. And this barley positively galloped through its whole span of life, from seed to ear, in less than a month.

Mexican maize which has not traversed the photo or light phase

In this way the second phase of a plant's development, the *light* phase, was discovered. The plant can enter this second phase only after passing the first. In this second phase, too, every plant presents its demands. One seeks more light. It would not mind if the sun shone for twenty-four hours. Another needs a short day. Each demands its proper ration of light.

Later, the plant will again become less capricious in the matter of light; it will still need it, for without the sun's rays the "green factories," where organic matter is made out of inorganic, cannot work. But these factories can work in every kind of day, long or short, that exists on the surface of the globe; and the plants will no longer enter into altercation with surrounding nature over their light ration. . . .

We do not yet know all the phases. It is obvious that after the light phase, plants pass through other phases we do not yet know of. It is doubtful whether there are many. Lysenko thinks that there are no more than four or five.

The study of the first phase—vernalization, and the as yet unfinished investigation of the second—the light phase, have already given man immense power over the plant organism.

We have said: temperature ration, light ration. But does this mean that only temperature is important for a plant in the beginning, and that later only light is important? Of course not. Both in the beginning, and later, a plant needs moisture, nutritive substances, and goodness knows what else. But in the spring there is plenty of moisture in the soil, there is any amount of air, and food is stored in the seed. From the long chain of which all the links are needed for a plant's life and development the investigator picks the one that is decisive at the given moment: temperature in "infancy," light in the "juvenile" stage.

There can be no doubt that the exceptional importance of the law he had discovered was already clear to Lysenko after his first experiments in Ganja. But a scientist must be cautious in drawing deductions. At first, Lysenko spoke only of the law of development of annual seed plants. He soon ascertained that rye, wheat, barley, cotton, millet, soya bean, rape and clover were subject to this law.

Esparto grass grown from vernalized seed flowered when there was not a single flower in the neighbouring control beds. Winter vetch, after vernalization, sprang up green in a few weeks, sprinkled all over with flowers.

Potatoes, too, submitted to this law, and then the perennial grasses.

But what about shrubs and trees? The researcher did not investigate them for the time being, but it was already evident that the old truism that a plant is a living organism, and that life is development, had presented itself to us in a glaringly new light.

Big achievements in science stimulate the growth not only of one but of many of its branches. Numerous facts, which seem so different, draw closer together. Harmonious order arises in the apparent confusion of an extensive group of phenomena. This order now seems natural and self-evident, and many people think to themselves: how strange that we had not noticed it before!

Soon, what had been won by science in fierce battle appears to us to be elementary truth, as binding as twice two are four.

Before me lies the second edition of *The Principles of the Ecology of Animals* by Professor D. N. Kashkarov of Leningrad. This is the swan song of a great ecologist. He died and was buried in 1941 at Khvoinaya Station; through this station a train had passed, carrying evacuees from Leningrad, at the gates of which Hitler's hordes were standing.

I open the book at page 40. Here, the author, a zoologist, speaks of the theory of phasic development, and I read about the importance of Lysenko's law for understanding the life and development of animals (about which, in all probability, the discoverer of this law did not think at all when he was planting his collection of legumes in Ganja).

Then follow examples. Quite a number. In the case of calves, young pigs, and the young of many other mammals, dependence on external temperature decreases as the animals grow older. In other words, at different stages of development they make different temperature demands upon environment—they are more exacting at the beginning than they are later; again, in other words, they do not at once acquire that true warm-bloodedness which, after all, makes the higher vertebrates (mammals and birds) independent of the fluctuations in the temperature of external environment!

In the hot summer, caterpillars, on reaching the "third age," as the entomologists call it, lose their mobility, they "hibernate" in their cocoons and pass the winter in this way. But the first warm breath of spring wakes them, and animated, active and voracious they hastily finish their transformation. Something has changed within them. The effect of the rays of the spring sun upon them was the very opposite of that of the sunrays of the preceding summer: the latter had sent them to sleep; the former roused them.

Sheep are not fastidious animals. They feel as fine when the temperature is 2° below as well as when it is 20° above zero Centigrade. But how capricious they become in the mating season! They feel well now only when the temperature ranges between 2 1/2° and 9 1/2° C. When the lambing season approaches, the temperature "optimum" changes again for the ewes: it must now be no lower than 6° and no higher than 17 1/2° C!

Such are the curious changes in the animals' requirements as regards the "temperature factor" alone.

What are these changes due to?

They bear the impress of the history of the species, and this reveals the grand general biological and evolutionary meaning of the law of phasic development.

That is why northern plants, winter cereals, the seeds of which wait in the frozen ground for the spring, acquire the need for cold. That is why the seeds of the camel's thorn which grows in our southern steppes, first need strong heat (for it is hot in the South when these seeds are ripening) and then moisture (only afterwards do the autumn rains begin there); otherwise the seeds will not sprout, no matter where you plant them.

The wild ancestors of domesticated sheep lived in foot-hills. During the mating season, in the early autumn, they climbed high up into the mountains; it was cooler there. They lambed in the spring. And so the present "optimum" for ewes is the spring temperature of the land of their ancestors.

When we say that definite temperatures of external environment are more important for young than for adult mammals, and when we see how warm-bloodedness is developed, we peer into the very depths of time: for at the end of the Cretaceous, or in the early Tertiary, period the remote ancestors of the present-day higher mammals were only acquiring the ability to regulate the temperature of their bodies.

The caterpillars which fall asleep already in the summer in mere anticipation of the cold—the hibernating chrysalides—are they not the descendants of the beings of the great Ice Age, when the short, raw, cold summer was followed by the long, cruel, deadly frost of winter?

This throws light on the general biological significance of the law of "phasic" development. One cannot help recalling the simplest and most elementary facts. Known to everybody, they acquire a new and profound meaning; they line up with the amazing facts that Lysenko spoke about. It transpires that we have before us a single family of phenomena.

Do not the caterpillar and the tadpole pass through a series of very distinct and sharply delimited phases, familiar to every child, before the one is transformed into a butterfly and the other into a frog? And in every phase the organism presents different demands to environment, so that by delaying the satisfaction of these demands it is possible, for example, to raise a gigantic tadpole that will never grow into a frog. We know that sometimes a species adapts itself to such delays (evidently it had experienced them often in the course of numerous generations); and there are amphibious animals which have acquired the ability to remain forever gigantic tadpoles. Who does not know the axolotls, the favourite inhabitants of all physiological laboratories and "nature study rooms" in all schools? Special and very cunning devices must be resorted to to compel the axolotls to grow into the "adult form," the amblystoma. . . .

These transformations, of course (as, also, their delay among the amblystoma), bear the impress of the long preceding evolution of these animals.

We see, then, that the law of phasic development provides the simplest explanation of all the facts enumerated, and a multitude of others like them.

That is why in 1942 (that is, soon after Daniel Nikolayevich Kashkarov, Professor of Zoology [Vertebrates] at the Leningrad University, for the last time in the besieged hero-city, had gone over the page proofs of his *Principles of the Ecology of Animals*), Fyfe, the well-known English cytologist (specialist in the science of the living cell), said that even if the theory of phasic development had been the only theory Lysenko had worked out, his name would have become famous among plant breeders and physiologists in all countries.

But the discovery of the law of phasic development was only the first "phase" of Lysenko's research work.

THE MYSTERY OF BIRTH

In January 1933, Lysenko made an extraordinary promise—to produce in two and a half years a new variety of wheat suitable for the Odessa Region.

The most important and extraordinary part of this promise was the definite period he fixed: two and a half years.

This meant producing a new variety according to a plan, although the Morganist textbooks asserted that new, useful varieties can be raised only at the end of a long chain of trial and error, error and trial. . . .

Lysenko called them "textbooks for treasure hunters."

The new variety had to be a very early ripener. And so, at the Institute of Selection and Genetics, they took two late varieties (not even grown in the Odessa Region), Erythrospermum 534/1, which is, in fact, a winter wheat, and Girka 0274—and crossed them!

A strange couple!

Not only are they both very late varieties, but both suffer from smut in the torrid summer heat, their grains are of an inferior quality, and they suffer from a host of other defects. In the catalogues, the enumeration of these defects takes up several lines of close print. In short, the fact that these two varieties were taken as the initial material for a new one was, to say the least, surprising.

Who would have thought of enquiring whether there was anything good about these two hopeless varieties? Lysenko, however, did display special interest in some of their favourable properties. He found that Girka 0274 is susceptible neither to rust nor to loose and stinking smut; and when Erythrospermum 534/1 is vernalized, its ears fill with heavy grains which do not scatter. In short, he found that neither of them would have been so bad . . . if their vices had not outweighed their virtues by two to one! Indeed, a fine sieve was needed to sift their good from their bad properties.

But it looked as though Lysenko hoped to find a sieve that would enable him to free his wonderful couple of all their vices, and not only leave them their own virtues, but add some that they had not possessed, for example—early ripening.

Never since men began to work on plants had anybody been inspired with such hopes; but here, the power of the new knowledge about the life of plants came into play.

Utilizing this new knowledge, Lysenko first of all discovered that the numerous and diverse vices the two varieties suffered from were, in fact, due to one cause in each of them. It was a skein that easily unraveled if you found the end of the thread and pulled it.

Lysenko had already been familiar with Azerbaijanian Erythrospermum in Ganja. This wheat dallied for a long time in the vernalizing phase and in the end turned out to be "neither peacock nor raven"—it had too much winterness for a spring crop, and too much springness for a winter crop.

But what about the Odessite Girka 0274? It shot through the vernalizing phase like a bullet. The trouble started later; the stems positively refused to throw out ears. Who would have thought that, after entering life so precipitously, this wheat would suddenly become such a dawdler? When, at last, it set about completing its work it was already too late; the heat had dried the soil and the crop could not escape smut.

Both were late varieties, but it was found that the cause of lateness was different in each case: one was delayed in the vernalizing phase, the other (Lysenko was already able to make an exact diagnosis!) in the light phase.

The idea that had prompted Lysenko to make this sudden choice will now be clear.

In a book by Academician D. A. Dolgushin, D. Sc. Agr., in which the life of the new variety of wheat raised by Lysenko is described, I see an illustration. Variety "A" is depicted as a combination of a long thin and a short thick line. Variety "B" is depicted by a short thin and a long thick line. What will happen if the two varieties are crossed? This question is answered by a third diagram. The whole of it is short: it is a combination of a short thin and a short thick line. This is an early-ripening variety that combines the best features of both parents, and is therefore free from the defects of both. It easily passes through the vernalizing phase—for one of the parents had contributed to the "common cause" its ability to vernalize quickly; the other had given the hybrid as a "dowry" its ability to pass without difficulty through the light phase.

Hence, it is the combination of these two very late varieties that must produce a variety that is above all early ripening. And since the hybrid will be free from the parents' chief vices, it will be free from the other defects the chief vice had brought in its train.

The idea of raising a plant variety according to plan occurred to Lysenko in the winter of 1932. Had he waited for the spring to try it, then, "in all probability," says Dr. Dolgushin, "Academician Lysenko would never have forgiven himself, so utterly would it have run counter to one of the distinguishing features of his work."

Girka 0274, Erythrospermum 534/1 and Lutescens 062 were planted in clay pots in the hothouse on December 8, 1932. The stubborn Azerbaijanian was vernalized: an electric sun beamed on the shoots at night. At the end of January all the plants in the hothouse threw out ears.

It was then that the marriage was consummated between Erythrospermum and Girka; and also between Erythrospermum and Lutescens for the purpose of comparison. Neither of the alliances was very fruitful: only 114 grains were gathered. These too were planted in pots on April 17.

Soon shoots appeared.

Nearly all the hybrids threw out ears before their parents; only a few waited until the ear-forming period of the more early-ripening parent; not one of the hybrids threw out ears later than this.

On July 19, 1933, the "harvest" was gathered from the pots. Next day the second hybrid generation was planted in seventy-five pots. Everything proceeded according to plan, but nothing definite could yet be said. Hybrid forms were produced, but not a new variety. The scientist had not yet created a new life—one that could stand firmly on its own feet and go out into the world independently, without human tutelage. But he had to make haste—all he had for the whole operation was two and a half years!

How could he manage within this time? If he planted in the field, he would get no more than three generations in the two and a half years.

It was necessary to alter the passage of time itself. The age-old division of the year into winter, spring, summer and autumn, into the periods when Nature is awake and when she sleeps, must be abolished. No sleep! Not two and a half years, but thirty months of creative work! And every day in these months must be used.

The third generation of hybrids was born in October. Their growth was spurred on by electric lamps, artificial, summer daytime temperature, and watering with a fertilizer mixture.

November. The first ears. . . . But what was the matter with the pollen? The glumes of many of the flowers became widely separated, the loosened stigma lay limply on the side. A day and a night passed. Then another day and night. Forty-eight hours of painful suspense. . . . Would life commence, or be cut off forever?

Another forty-eight hours. . . . The whole experiment hung by a hair. Lysenko was raising an early-ripening variety—and the earliest ears were the most valuable! It would not matter if all the rest perished, if only these survived!

What had killed the pollen? The dull, autumn daylight that feebly penetrated the perspiring glass frames—the feeble sunlight which the unslumbering Klieg lamps had, after all, been unable to assist? The feebleness of the thin leaves on the pale, tall stalks? They had not been grown, but driven up. The dry steam heat of the hothouse? The temperature, dropping on frosty days?

Whatever it was, it made no difference now. Next time it would be better, perhaps, to avoid the dullest and severest winter months. Better not drive the plant so fast, and plant at such a time as will cause the ears to appear no earlier than February, even March.

"Next time. . . ." But what about now? What must be done now?

At last, in some of the flowers (how many hundreds of times, day and night, had sleepless eyes peered at them with eager expectation!)—yes, in some of the flowers, the ovaries slightly lengthened.

The researcher could breathe more freely now—the most early ripeners were saved.

The seeds from these were taken on December 27. All the rest were rejected and thrown away. The crop amounted to: 193 grains from the hybrids 534/1 × 062, and 20 grains from the most important hybrids 534/1 × 0274.

Twenty grains!

What confidence in the correctness of his hypothesis the man must have had not to fall into despair when all he had in his hands after a hectic year's work was this slender thread in the third generation!

The descendants of these twenty—the fifth hybrid generation—were at last removed from the flower pots and the hothouse. This was the first ordinary planting in open ground. Next to them the hybrids of Erythrospermum and Lutescens also grew.

The fierce winds of the spring of 1934 parched the earth. It was streaked all over with black fissures. It looked dull from the dust suspended in the air. Mirages loomed on the horizon.

Wireworms, threadlike and voracious, seemingly germinated by the thirsting soil, now reduced to dust, attacked the tender shoots in the breeding beds. The assistants took them out of the traps in handfuls. From morning until late at night, these beds, protected by standing barley, were constantly visited by research workers from the Institute. Perhaps it would be more correct to say that they lived here, leaving for short intervals to get some food and sleep, but annoyed with themselves for leaving.

They knew every one of these feeble and precious charges of theirs. With what impatience they watched every tiny event, the constant and barely perceptible changes that took place in those beds! The scrolls of the young leaves unfold. Sometimes growth is faster, sometimes slower. Individual, frail stalks begin to bush and bunch. . . . There had been nothing like this the day before. Today the leaves are covered with a grey film. What change will take place tomorrow?

During those long days, their throats parched with thirst and eyes blinded by the merciless glare of the ground and sky, the biologists, agronomists and plant breeders from the Institute, some with magnifying glasses and others without, searched among the hundreds of transient characters for the features of the new variety.

When harvest time came, the experimental plot was denuded by stern selection. The families that were to be the progenitors of the new variety had to be singled out from the rest. The culling process was continued in the laboratory according to the size, shape and fullness of the seeds. Only four families passed all the tests: three from the crossing with Girka, and one from the crossing with Lutescens. These four families were given the following numbers respectively: 1155, 1160, 1163 and 1165.

But only a handful of seeds were obtained from these families; and only a year remained to the date which Lysenko had solemnly appointed.

On July 19, 1934, the grains from the four families were planted in 40 boxes, 48 grains to the box. Flies, Swedish and Hessian, were swarming around the place. Nobody knew how high they flew, or how to guard against these winged crop destroyers. The entomologists were asked whether it was possible to keep the flies off by means of a fence, but they shook their heads and said:

"You see, nobody has ever planted anything at this time of the year and no precise data has been collected for July."

The little hut in which the seeds were vegetating was closely covered with gauze.

A few, sparse shoots appeared sporadically. On August 1 there were still large, black, bald patches in the boxes. Lysenko was away from Odessa at the time. He returned on the 2nd.

"Reduce the temperature at all costs!" he commanded. "Even if you put them into the refrigerator at the port!"

But there was no need to do the latter. On three evenings running, the assistants put ice into the gauze-covered hut. The ice kept all night, but towards morning it melted.

On August 6, the earth in the boxes was covered with a green bristle of shoots.

The harvest was gathered in the autumn, in the hot-houses.

In October, the seeds were planted in 223 boxes, 84 seeds to the box.

The people at the Institute are not likely to forget that winter soon!

Fierce frost, unusual for the South, set in in December. The iron stoves in the hothouses were kept burning all night, but the mercury kept dropping: 6°, 5° . . . on January 5 it dropped to 1° C.

The wintry sun that appeared next day did not help much. In the evening the wind rose. Ragged clouds raced across the bleak, dreary sky.

The thin walls of planks and glass were all that protected the precious plantlets from the icy gloom of the stormy winter night.

They put in another stove which devoured fuel all night. The dim eyes of electric heaters were turned on the plants. They even lit primus stoves, the roar of which was drowned by the wind that howled down the chimneys, driving clouds of acrid smoke back again into the hothouse.

All the Klieg lamps were turned on, 20 of them, each of 300 candle power—not for the light phase, nobody was thinking about that now, but also for heat.

The smoke and stench in the hothouse was suffocating. They poured oil on the fire. The hissing of homemade oil burners added to the din.

Inexorably the mercury dropped: 0°, 1° below. . . . The earth in the boxes was now as hard as stone.

Then somebody burst in with an armload of blankets.

The thermometer showed 3° below zero. The grey dawn appeared.

But the danger had not passed. The shoots looked pale and the leaves wilted. Many of them had perished, poisoned by the sulphuric gas from the stoves.

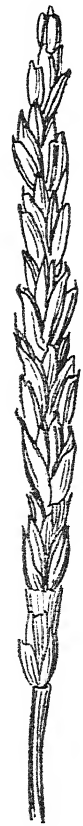
Among those that survived, the first to throw out ears was hybrid 1163. This was in the latter half of February. Later it produced half a kilogram of seeds. Hybrid 1155 produced a little more. The other two produced about one and a half kilograms each.

They were to go up for the tests in the summer. The competitors were: the celebrated Saratov Lutescens 062, out of Erythrospermum and Girka, and two Odessa varieties—Albidum and Alborubrum.

All turned up at the starting post on April 3. On July 5, 1163 ripened. Next day 1165 and 1155 followed suit, and a day later the fourth hybrid did the same. The Saratov variety reached the finishing post on the 8th. The two Odessites—Albidum and Alborubrum—came in neck to neck on the 9th. Girka 0274 came trailing in the rear on July 10. The ears of Erythrospermum 534/1, which had not been vernalized, did not fill until August.

The crop produced by the "competitors" was fairly good, but things were not so good as regards resistance to smut and rust. In fact, one of the four hybrids—1165—had to be rejected.

At the time the hybrids were being put through their tests on the experimental plots, another, also unprecedented, experiment was made. A thousand seeds from the "swiftest" of the four—1163—were not planted in the open ground, but in pots, one grain in each pot. During the long spring days the light for the shoots was reduced for a few hours each day in order to delay their light phase. As a result, they began to bush. A whole forest of stems grew out of a single root. Each wheat bush looked like a tiny copse.



Lutescens 1163 (natural size)

When the thousand "copses" were planted out in beds at a distance of half a metre from each other, the tall stems (there were as many as fifty in some bushes) threw out ears. The grains were harvested in July. The thousand seeds—25 grams—had grown into 25 kilograms. This was a thousandfold yield!

Another sowing, another wheat generation—and by the autumn of 1935, Lysenko had 130 kilograms of grains of the new variety. A little over a year had elapsed since July 1934, when, from the eight selected plants of the newly obtained 1163, the first 15 grams—600 grains—of seed were collected.

It was now worth while looking back.

In two years and ten months a new variety had been raised, tested and propagated to such a degree that its grains could already be poured into the corn bin. During this period ten generations of spring wheat had followed one after the other—ten years had been squeezed into two and a half.

After the Lutescens 1163, another new variety was raised—the Odessa 13. As might have been expected, it proved to be superior to the first: the road through the Unknown Land was laid!

Lysenko was particularly proud of the fact that not one of the intervening hybrid generations had required more than two square metres of hothouse space: he had gone straight on and had not erred.

When the time came to propagate the varieties, it seemed to him that a thousandfold yield was not enough. He succeeded in getting a fifteen-hundred-fold yield!

Later, the spring barley Odessa 14 and some winter wheats were raised. Of the latter, Odessa 3 was both frost and drought hardy, and its yield was above that of the standard varieties.

Man became complete master of the secret of birth.

None of the proudest descendants of the feudal barons or reigning princes of the Middle Ages, whose pompous names fill the records of Courts of Heraldry, can boast of a pedigree like that of the potato tuber.

True, the fame of the potato family is not so very ancient. It goes back only about four hundred years. In this, the potato family cannot compete with those whose ancestors were knighted by Frederick Barbarossa, or by Pepin the Short. But the shortness of its fame is more than compensated by the wonderful feats it has performed in all fields of the globe.

The potato family appeared in the world arena in the sixteenth century, when the Spanish Conquistadors were drenching the land of the Indians with blood. It was there, on the plateaus of the Cordilleras, that the European invaders, greedily hunting for gold, heard about the unknown plant, papa.

Several decades later a strange drawing in colours, brought from across the Atlantic, amazed the savants in Europe who were compiling catalogues of herbs.

Many more years were spent in hunting for potato tubers. Admirals and pirates took part in this quest, but for a long time the elusive quarry escaped the hunters. Ship masters filled their holds with batatas, thinking they were potatoes. Sir Walter Raleigh, adventurer, buccaneer and an admiral of "Merry England," brought to that country, in the time of Shakespeare and Queen Elizabeth, some Virginian openauks. He planted them in Ireland, thinking he was planting potatoes.

Finally, two potato tubers found in Chile toured the cities of Europe, meeting with numerous adventures on the way. But even when these fosterlings of the Chileans had brought forth offspring in the Old World, the people there did not dare bake or boil them forthwith. The clergy anathemized these "devil's apples." This bumpy fruit of the earth was both tempting and repellent.

In the eighteenth century, Parmentier, a French savant and potato enthusiast, planted potatoes near Paris. Later, he brought Louis XVI a bunch of pale-yellow flowers, and that corpulent monarch pinned them to his camisole. Parmentier kept his field closely guarded in the daytime, but he withdrew the watchman at night. This was a ruse he played on the local peasants. Under cover of night he crept up to his field and discerned their dark figures carrying sacks and, furtively looking around them, denuding the unguarded beds. From his hiding place he gleefully watched his precious tubers passing into the peasants' sacks. He would have clapped his hands with delight had he not been afraid of scaring the depredators. He was proud of the success of his ruse, which served to illustrate the truth of the proverb: "forbidden fruit is sweetest."

Soon spreading potato fields were seen in Alsace and in Ireland. Potatoes began to spread over Europe. Papa now served as the food of many thousands of people. But from time to time potato disease broke out. Phytophtor—the "plant devourer" known as "blight"—an invisible and ruthless fungus, devastated field after field. That frightful visitor, famine, appeared in the countryside. And then the owners of all flour stocks, the masters of the land and of the country—merchants, nobles and landlords—filled their coffers. From time to time, the people, driven to despair, rose in revolt. Mercenary soldiers quelled these revolts, and blood, of which so much had been shed in the history of the potato family, flowed again.

In Eastern Europe, in Imperial Russia, the serfs were forcibly driven to the potato fields. With lash and rod the peasants were compelled to grow these outlandish plants and to eat unheard-of food grown in the ground. "Potato riots" broke out. They were cruelly suppressed. In Russia too the Chilean papa left a bloody trail. . . .

Potato plant in bloom

Decades passed. Whatever the rulers of those countries in which it grew may have been, the potato honestly performed its task in the fields.

Its virtues were obvious. Soon there was no need to employ either cunning or force to induce people to grow it: everywhere potatoes were grown willingly.

Today, potatoes are food for hundreds of millions of people. We may say that it has conquered the whole world, and has become almost as essential as bread. About fifty dishes are made with potatoes; we eat them with the midday and also with the evening meal; we Russians enjoy potato cakes with cranberry sauce, and potatoes in their jackets with herring. In fact, it is hard for us to imagine that about two centuries ago our ancestors did not know what potatoes were, that potatoes did not figure in the menu at the feasts of Lucullus or, sixteen hundred years later, did not appear at Gargantua's table. Thousands of scientists and scores of special research institutes have studied the potato, and it seemed as though everything that could be learned about it had been learned.

And yet, the inexplicable caprices of the potato baffle botanists, potato growers and agronomists today, no less than in the earliest period of the potato family's appearance in the world arena.

What strange things happen to this native of South America . . . and precisely in the South! It absolutely refuses to settle anywhere in the broad plains either of Arizona or Provence, on the banks of the Tiber, or in the Ukraine, Crimea, the Lower Volga and Azerbaijan, not to speak of Central Asia.

To gather scores of tons of potatoes per hectare around Moscow is an ordinary matter. Even in the Arctic Circle, in Hibini, a crop of thirty tons per hectare is not rare. But here, in the rich, steppe soil, under a beneficent sky, it is possible to "scrape together" barely four to five tons. And how little the tiny "nuts" the Southerners dig up on the plots resemble potatoes!

Most inexplicable and worst of all was that here the potato quickly degenerated. The very first generation of potatoes that grew in the South showed a reduction in size; and the third and fourth generation already lost all its vital strength. Under every bush were found only a half and sometimes even a quarter of a pound of wretched tubers, about the size of nuts.

Whole trains had to be taken away from hauling coal, machines and manufactured goods in order to ship seed potatoes to the South. In the market places in the Crimea, the price of potatoes was on a par with that of fruit. Every year, tens of thousands of tons of fine, starch-packed tubers were transported from the North to the South, but they were doomed; after they were planted they sickened and degenerated into wretched, sterile dwarfs. It looked as though some lethal element lay hidden in the steppe soil and sapped the vital strength out of the vast potato armies that the North kept sending.

"The soil is unsuitable for potatoes," said the scientists.

"All the trouble is caused by the soil!"

"But there are dozens of different kinds of soils in the South, and potatoes degenerate on them all," retorted others. "What has the soil to do with it? An invisible foe is not a new thing for science. Its name is microbe. Degeneration is a disease."

"No," said still others, shaking their heads. "In our times, not a single microbe can escape the bacteriologist researcher; and since we do not know the degeneration microbe, it shows that no such microbe exists. Degeneration is a disease, but it is caused by a virus."

Here a fourth group smiled doubtfully:

"Why a virus?" they asked. "Only because it is invisible and you cannot find it? The trouble lies in the climate. The native of the mountains cannot stand the climate of the plains."

The last group came close to the truth, as close as people can be who have learnt to observe facts and not to imagine things about them; but they failed to understand the meaning of the facts they themselves described, and they did not know the whole truth.

"What is climate?" those scientists might have been asked. "Does the Ukrainian summer resemble that of the Chilean plateaus less than it does the dull days, the white nights and the cold of Hibini?"

They would not have been able to answer these questions.

* * *

In 1933, the "potato problem" arose in the Odessa Institute of Selection and Genetics. The following experiment was tried: a large field was planted with potatoes, and as soon as the tubers formed they were dug up—a plot of 0.1 to 0.2 hectares every day. The tubers were carefully weighed. It could be seen that the tubers increased in size day after day and at the same time the number on each root increased too. Some days the daily increase was equal to a ton per hectare. These were dull days. On hot days the increase was insignificant; it dropped almost nine-tenths. The underground "starch factory" stopped work on such days.

This confirmed Lysenko's assumption. The trouble was not the soil, or microbes and viruses, or climate in general, but high temperatures. The action of almost every extra degree of heat could be calculated in terms of centners and tons of lost crop. But the drop in the yield was not the only result; the potato's vital strength was sapped, it could not produce healthy offspring, it degenerated.

It was no use arguing about the cause of degeneration; measures had to be devised to escape the summer heat.

Outstrip it? Lysenko already possessed a powerful instrument for accelerating the development of plants—vernalization.

Seed tubers were made to sprout at a temperature of 12° to 15° C. After that they were kept in the air and light for three weeks. The scientist speeded up the development of the potato organism in the same way as an engine driver puts on speed when he wants to bring his train to its destination quicker.

Then the tubers were planted in open ground. They grew rapidly. The crop was harvested at an exceptionally early date. But still they did not completely escape the summer heat. Degeneration was delayed, but not eliminated. What could vernalization do when the vernalizer was obliged to start with dwarf potatoes, with "nuts" born of debilitated plants?

What was to be done? They could not cool the southern summer!

Here we must forget about potatoes for a little while. Let us look at this strange cotton bush. It is an Abyssinian. Like the Mexican maize we spoke about, that grew as tall as a house, it, too, cannot stand the long, Ukrainian summer day. Abyssinian cotton has never produced bolls in our South. And here, on top of this, it was kept in constant light for two whole years (this cotton is a perennial). Naturally, it grew in height, and threw out leaves, but did not flower . . . except for one branch. On this branch flowers budded. The research workers at the institute will tell you that they have several times even picked bolls containing white fluff from this branch. It was a queer branch; it looked like a stranger on the bush; as if it had come from another plant!

The mystery is easily explained. This branch was shaded from the light for fourteen hours every day—not for very long, however; only for thirty days, and in the first year of the bush's life. After that, the sun was allowed to shine on the branch as it did on the rest of the bush. But this made no difference to it now, it had passed the light phase.

This wonderful transformation of the branch no longer surprises us; we know the reason for it. What deserves our special attention, however, is the following.

The transformation took place in the growing buds of the shaded branch, and everything that grew out of them was also transformed. From them grew the branch that later produced bolls. This shows that there was no need for the millions of new cells that were born of the transformed cells to go through the light phase; that had been done for them by their ancestors—the cells in the shaded buds.

But this transformation could not pass back from the branch to the stem. The branch was born of the stem, and if, after transformation, it had transformed the whole bush, it would have meant that ancestors come from descendants!

If that is the case, then another surprising (for scientists of the Weismann persuasion) deduction arises, a paradoxical one, in fact.

It is wrong to say that a *whole* plant is in such and such a phase. Phasic transformations take place in the growing buds. What had grown before remains in the preceding phases; only what grows later is in the new phase. This shows that the body of a plant consists of parts of different phasic ages. The oldest part of a plant is the bud, full of sticky sap, which has just unfolded in the crown. The youngest—and the oldest! It is older than the lower branches. Older than the stem. It is even older than the plant's "foundation," its neck, the cells of which are the first to emerge from the seed, from the ground, and are the first to see the light.

This deduction was enough to surprise everybody; everybody but Lysenko. He did not think he had made any exceptional discovery; the great Michurin had long been aware of this, and had applied this knowledge in his practical work.

If there are, indeed, infants on the growing crown of a plant that are born older than all the old folks, then there must be some means of proving this by experiment.

Lysenko took two cuttings from a tomato plant—both from the upper part of the stem, but one from above the first flower bud and the other from below it. He planted both cuttings—and the first flowered much earlier than the second.

Thus, the developing body of a plant does, indeed, consist of phasically different parts and seems to be woven out of a mass of contradictions.

What has all this to do with the degeneration of potatoes?

It has this to do with it. A cutting from the crown of a potato plant is planted. By the will of the experimenter, this cutting is thus transformed into an independent organism. The crop of tubers that grows at its roots is gathered. These tubers very much resemble those that are dug up at the proper time from under the very plant that had been operated on. Is there anything surprising in this? The plants are not even brothers—they are one and the same plant, only dissected by the plant surgeon into two parts.

Lysenko, however, did not allow himself to be deceived by this outward resemblance. The experiment was not finished—it had only just begun.

The tubers were planted in the open ground: those that were taken from the original plant were planted separately from those produced from the cutting taken from the crown.

This revealed the deceptive nature of the resemblance! The crop from the tubers taken from the original plant was more than twice as large as that from the tubers produced from the cutting. The latter gave a wretched handful of tiny balls. There was no difficulty in recognizing these "nuts." They were degenerate tubers, like those gathered every year from the potato fields in the South!

The crown was "old"; the plant was younger than the crown. The "old one" produced degenerate tubers. Degeneracy is old age.

The secret of old age was discovered.

Potato tubers that are planted in the South develop in the hot summer. Their "eyes," the germs of the future plants, age quickly as soon as they awaken to life. They bring forth a generation that is senile from the first day, in the cradle, so to speak.

How can old age be combated? Is there any treatment for it?

To vanquish old age has been man's dream since the days of antiquity. Perhaps science of the future will be able to postpone the beginning of old age for a long time and to abolish all the ills and suffering that it brings in its train. . . .

"Science of the future!" In the particular case of potatoes, old age is already vanquished!

Lysenko's prescription is now universally known: plant the potatoes not in the spring, but . . . in the height of the summer.

This seems very simple to us now. Of course, summer-planted potatoes will form tubers when the heat has subsided. They will escape the fierce heat of the July and August sun, they will avoid old age.

In the beginning, however, this sounded like madness to many people. Fancy planting in the heat of the summer, potatoes that degenerate because of heat!

The first experiment in summer planting was commenced on July 6, 1933. In 1934, eighteen kolkhozes became Lysenko's collaborators in this new undertaking to combat the degeneration of potatoes. A year later the number of such kolkhozes grew to five hundred, and the experimental field had expanded to 1,600 hectares of kolkhoz land.

A year after that it expanded into tens of thousands of hectares.

By order of the Government, command over the vast army of kolkhozniks and sovkhoz employees who had declared war on "potato old age" was taken by three General Staffs, by three institutes: the Odessa Institute of Selection and Genetics, covering the Ukraine, the Azov and Black Sea coasts, the Crimea and North Caucasus; the Potato Institute, covering the Saratov, Stalingrad and Chkalov regions; and the Karaganda Experimental Station, covering Kazakhstan.

Early in 1939, a conference of potato experts from all over the Soviet Union was held in Odessa, the soil around which had for so long been fatal for potatoes.

Here the five years' struggle against the degeneration of potatoes was summed up. Delegates spoke about the record potato crops obtained in the Ukrainian villages and Don stanitsas, and about the potato fields in Turkmenia.

The victory was astounding.

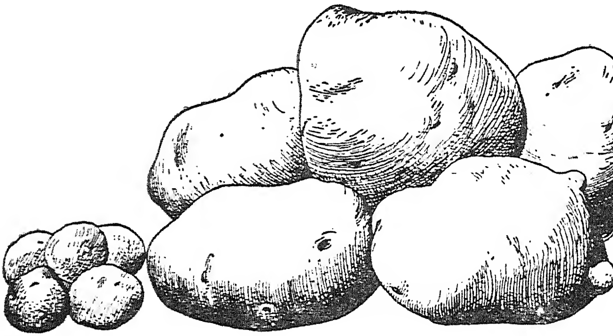
The Ideya Ilyicha Kolkhoz, near Melitopol, gathered tubers weighing over a kilo each. "Our kolkhozniks had never seen such potatoes before." In October, the Dvigatel Kolkhoz and Dimitrov Kolkhoz, in the Frunze District, dug up thirty tons of potatoes per hectare. The Lenin Kolkhoz in the Slobodzeisk District dug up as much as fifty tons per hectare. And a woman kolkhoznik named Khudolii had for the third year running obtained over seventy tons per hectare.

Nor was there any need to stop planting potatoes in the spring. Not "for breeding," of course. "Spring" potatoes grown from sound "summer" tubers were used only for the kitchen. Thus, in the South, they got two potato crops in the year.

They were already thinking of sending the first, the very earliest, crop to the North, to Moscow and Leningrad, to get there only a little later than the flocks of migrating birds which hastened from the South.

Meanwhile, the summer-planting area kept on expanding, and before the war the number of hectares so planted ran into six figures. Potatoes were planted in the summer not only in the Ukraine, but also in the southeastern regions of the country, in Transcaucasia, and in Central Asia.

Record crops were obtained: 300, 400 and 500 centners per hectare. We saw the potato grown in the kolkhozes in the South at the All-Union Agricultural Exhibition that was held before the war: heavy, bumpy, monster tubers, one and a half to two kilos to the bush, and we wondered whether these were the old acquaintances we were accustomed to meet on our plates at dinner, or whether they were newcomers.



Ella potatoes
Left: tubers from spring planting. Right: tubers from summer planting

Indeed, there was something to wonder at, for in those prewar years, other formerly unsuspected things were revealed too. It was found that the whole appearance of the potatoes that were rejuvenated by summer planting underwent a change. The Ella variety, for example, after a few generations, broke all the rules of botany: its anthers were no longer of an orange colour as they were supposed to be, its leaves became paler, and the arrangement of the lobules on the leafstalks changed.

The most important thing is that each succeeding crop of summer-planted potatoes showed increased productivity. It looked as though these summer tubers were accumulating productivity! In 1940, an important experiment was made. An

Early Rose variety, obtained from a summer planting in the South four years previously, was brought to Moscow from Odessa to be tested in the fields of the Institute of Genetics of the Academy of Sciences of the U.S.S.R., side by side with a Moscow Early Rose variety, which had never travelled to the South, and had never degenerated. The Southerner produced 480 centners to the hectare, the Moscow variety produced 220 centners.

The idea then arose in many people's minds that the last word about summer planting had not yet been said, and that, perhaps, it was not only a "local" problem concerning the South.

. . . On June 10, 1945, Trofim Denisovich Lysenko, a member of the Academy of Sciences since 1939 and already winner of two Stalin Prizes, was awarded the title of Hero of Socialist Labour. The decree conferring the title upon him stated that it was for "distinguished service in developing agricultural science and for increasing the yields of agricultural crops, particularly of potatoes and millet. . . ."

* * *

At the Odessa Institute there is a photograph that was taken in the initial period of summer planting. On the left side of the photograph there is a tiny heap of five tubers, the total weight of which was 100 grams. This was the yield of a potato that had degenerated as a result of several years of spring planting. On the other side there is a huge heap, also of five tubers of the same Ella variety, and each of them weighed five and even ten times as much as the entire five of the left.

When I looked at this photograph, which so vividly demonstrated the wonderful result of employing a method so amazingly simple, I recalled the old story about how

Columbus stood an egg on end. He gently tapped the end on the table; the end was sligthly flattened and the egg remained standing. It was a very simple trick; but nobody had even thought of it before.

I did not, however, tell anybody then about the analogy that had arisen in my mind. Had I done so, I would have received the very reasonable answer that summer planting, which opened a new epoch in the cultivation of potatoes all over the world, was not the result of happy intuition. It was a logical deduction from the theory of phasic development and from the profound theory that the nature of plant organisms changes in accordance with changed conditions of life.

MARRIAGE FOR LOVE

The Morganist geneticists were convinced that the mysterious "hereditary substance" must guard the purity of varieties and breeds; that it would keep the best varieties of grains unchanged and unspoilt for ages, like canned food. They reposed all their hopes in this substance and regarded it as being as firm as a rock; it would never let them down.

"Avoid mixing, even in the slightest degree," they urged. "Cross only animals of the closest kinship. Pollinate plants with their own pollen. And then this precious hereditary substance will remain in our hands. It will be unable to escape."

This was the famous "inbreeding" method, as the geneticists call it.

Of all plants, the Morganist geneticists were most sure of wheat. Wheat is a self-pollinator. Every wheat ear pollinates itself. They raised thoroughbred livestock by crossing only the nearest kin. As for rye, which is pollinated by the wind, they demanded that a special law be passed that there should be a space of at least a kilometre between ryefields of different sorts. What a bother this kilometre zone was to the kolkhozes! How could this rule be kept in densely populated areas? Neighbours who had lived in peace and friendship for years and years, quarrelled because of it. Agronomists who attempted to reduce this zone only a tiny bit were threatened with prosecution.

The Morganists were stern and implacable. Were they not guarding the cell that contained the Phoenix "pure variety"?

To those who complained they said consolingly:

"The Pharaohs and the Incas of Peru knew the value of inbreeding. As everybody knows from history, these wise rulers married only their sisters."

They did not hesitate to slaughter a most valuable bull, or a stallion, if they had any suspicion that the breed had been "mixed." They almost put a stop to the breeding of karakul sheep in the chief centre of this industry—in Uzbekistan—by rejecting the finest rams even without seeing them, solely on the basis of pedigree records. They cleared out *all* the best rams, so that in 1936, scarcely a ram could be found in the whole republic for a new thoroughbred sheep farm that was being organized. The pedigree records were dispassionately checked in Moscow by the Morganist Vasin—to him, everything was clearly visible three thousand kilometres away. . . . And they almost destroyed the excellent Lisitsyn rye—they began to line it up according to the Morganist rule, to obliterate the slightest stain of impurity, and its yield catastrophically dropped until the Morganists were stopped.

And so, in spite of the most vigilant guard that was kept over it, the willful "hereditary substance" did change, and the more vigilantly it was guarded, the more irrevocable was the change. The prisoner slipped through the guards' fingers like water.

Even the most tried and tested varieties degenerated. The strangest and saddest changes took place among the plants that seemed to be the most safeguarded against change—the self-pollinators, like wheat. They appeared to sink into senility. They became unrecognizable! Only the old folks now remember the names of many varieties of wheat that were famous throughout the South a few decades ago.

The life of a wheat variety runs twenty-five to thirty years. Half a century is like the age of Methuselah.

Lysenko first made his surprising proposal in 1935. To the ears of the Morganists it was sheer heresy. He said that in order to save varieties from perishing, and to restore vitality to the senile ones, it is necessary not to strengthen, but from time to time to *remove* the guard over them, and to help the self-pollinators to cross.

The means for this were the simplest. Just a pair of scissors to cut the stamens in the ears. Without stamens, without pollen, these ears will not be able to pollinate themselves; but nature will take care of them. Together with the larks, butterflies and golden humblebees, clouds of pollen fly over the green wheatfields, and the latter will pollinate the clipped ears. The new, alien blood will rejuvenate the senile plants. Later, the grains can be collected, planted and grown again, and after this is done once or twice more, the grains can safely be planted in the fields.

At first this was regarded as a joke, but Lysenko was not to be daunted. With his customary determination he forthwith set to work on experiments to rejuvenate degenerate varieties. And then the storm broke!

"Lysenko wants to destroy all our varieties! Does he realize what he will gather from those clipped ears?"

"Selection entrusted to the wind! As sure as eggs are eggs, the fields will be reduced to a chaos of 'sport' segregations!"

But nothing of the kind happened. There was no chaos.

What did happen was the very opposite of what the Morganists had prophesied.

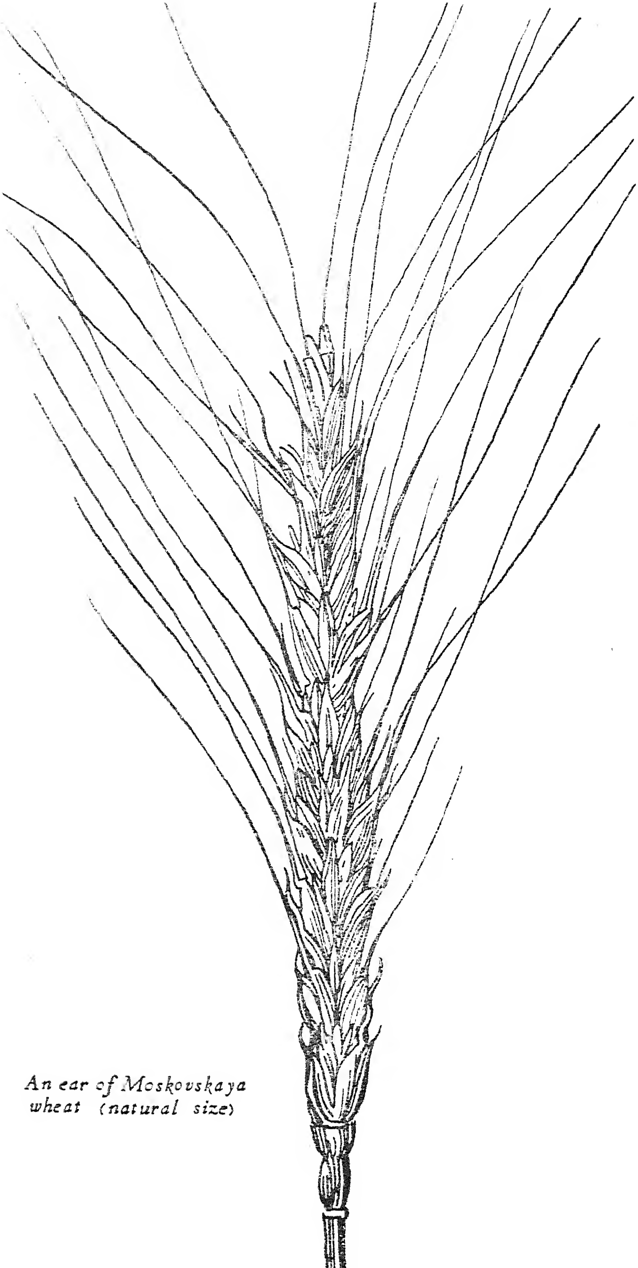
At the All-Union Institute of Selection and Genetics in Odessa I was invited to go down a narrow track between long strips of ground on which the descendants of the clipped ears were growing. They could easily be distinguished with the naked eye. One strip contained the descendants of the tall plant—how even and vigorous were all three rows of plants which had sprung from its seeds! Another strip contained tillered plants with grey-tinted leaves—there was no need to enquire about them, all the plants spoke loudly for themselves.

The most remarkable thing was that all the crossed, rejuvenated plants growing on these strips were taller and more luxuriant than those growing on any strip planted with ordinary seeds obtained by self-pollination.

Later I saw a still more striking demonstration of the potency of the new "blood" infused into the old variety. I held in my hands huge, bristly, barleylike ears of the spring wheat Melanopus and the gigantic ears of the Moskovskaya wheat, rejuvenated by intravarietal crossing!

What did this mean? Not only was there no chaos, there was no sign even of any segregation! Why?

The wind carries a cloud of pollen. And from this cloud the plant elects the pollen suitable for it. It does not pollinate itself with just any kind of pollen. It *chooses* its pollen. Only organisms that suit and strengthen each other combine if nature is given a free hand.



An ear of Moskovskaya wheat (natural size)

In this field, among the clipped ears marked with red thread, we, as it were, stood on the threshold across which we could clearly and distinctly see the operation of the most profound, important and beautiful laws that govern all living things on Earth—both animals and plants.

We were not surprised at the bold and beautiful words with which Lysenko described what was going on among his wheats:

"Marriage for love!"

* * *

The controversy still raged around the fundamental question: does the nature of plants and animals change if the conditions of their existence change? In other words, can the characters and properties that plant and animal organisms acquire during their lives be transmitted to the offspring?

This is a very old question. In the past, savants quite rightly regarded it as a philosophical question, for it is directly connected with our conception of what life is, of what its essence is.

This brings us to the "watershed" that divides materialism from idealism in biology.

Darwin was convinced that the variability of living beings depends on certain changes in their environment (what kind of changes Darwin did not know exactly). To say that organisms change of their own accord is tantamount to saying that they live and develop not on Earth, but in a mystical vacuum, in other words, that they are not subject to natural laws, that miracles reign in living nature.

Darwin's opinion was expressed in approximately the following terms: Whoever wants to cross animals that are closely related to each other must keep them in the most different conditions possible. A few breeders, guided by their power of observation, acted in accordance with this principle and kept their animals in two or more farms remote from each other and situated in different conditions. Then they mated individuals from these farms and obtained excellent results.

These are ideas that the Morganist genetics would never have supported! The geneticists would have said: "It reminds one of the musicians in the celebrated fable who imagined that if they arranged themselves in a different order their music would be more harmonious."

From the lofty pinnacle of their science, the geneticists looked down with supreme contempt upon the agronomists who had invented the idea of working the soil in a special way for high-grade crops and of carefully selecting the seeds almost one by one; upon the horticulturists who nursed every seedling in their nurseries; upon the animal breeders who fed their thoroughbred stock on the choicest food. . . .

"It is something like the rattles with which the natives of Central Africa try to influence the moon and the sun," they argued. "Not stables, but pedigree records are important!"

But here the disadvantages of the Morganists' observation tower came to light. It was situated in a "vacuum" and was cut off from Earth.

Michurin plainly and bluntly described as absurd the idea of those who imagined that an organism can form of its own accord, without the influence and participation of the environment from which it obtains the entire composition of its body, down to the last atom, and which surrounds it from its birth to its death!

One day Lysenko happened to observe the following: Some spikelets of the well-known couch grass had been pollinated with pollen taken from other stems in the same bunch.

Couch grass never fructifies if pollinated with its own pollen. But in these spikelets grains developed.

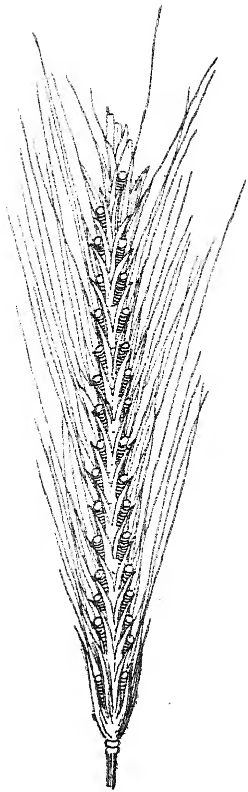
That showed that the pollen from another stem was already an alien pollen.

But it comes from the same plant!

So they performed the following experiment at the Odessa Institute.

Rye is also sterile if self-pollinated. Cuttings were taken from a stalk of Tarashchanskaya rye and planted separately under entirely different conditions. When the flowering period drew near they were put together again. Later, all the ears filled with grains, although they could not have obtained their fructifying pollen from anywhere except the stems of what only recently had been one plant.

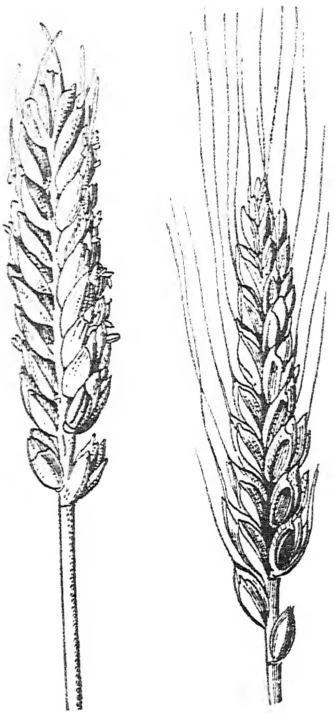
The organism's heredity changed in some way when the conditions of its life were changed. Nothing like this could have been learned from Mendel's formulas. Why, then, wait for segregation according to these formulas?



An ear of Tarashchanskaya rye (two-thirds natural size)

So Lysenko re-examined the complex and confused pedigrees of the dual-nature plants—hybrids.

Here is a hybrid obtained from the crossing of awned with awnless wheat. The first generation. All the hy-



Wheat ears: awned and awnless

brids of this generation should have been the same. This is the celebrated law of the uniformity of the first generation. But are they so uniform? Here is one with smooth ears, as it should be according to the textbooks, because the awnless is the dominant. Next to it there is one that is also smooth-eared—but not quite. It pricks the hand; bristles are sprouting from it like the hair on a youth's upper lip. What a hasty and indifferent eye must have run over this family if it failed to see the differences in the brothers! But here are some that one simply cannot fail to see unless one deliberately turns away from it. Look at these bristles! These plants take exactly after their mother, the awned Azerbaijanka 2115! They are real "mama's darlings". . . .

Many hybrids of garden plants resemble only the mother for generation after generation. Others, on the contrary, obstinately take after the father, as if there had never been a mother. Segregations occur in he proportion of 1 to 141!

The Mendelists either shut their eyes to all this, or, suddenly waking up, set to work to explain the exceptions by means of especially invented, extremely complex, gene analysis formulas; they put it all down to the improper behaviour of the chromosomes.

But there is a simpler explanation: like in Andersen's fairy tale—the king is naked!

Mendel forcibly crossed his peas and then added up the results of all his experiments, he jumbled up the life history of hundreds of pea families. In this way he obtained the average of big numbers, and in this lifeless average the living plants behaved as if they were a pack of cards in which germs were shuffled like kings and deuces.

Mendel cared nothing about the fate of each individual family; but he ought to have displayed less haughtiness towards the inconspicuous rank and filers of his pea army. He ought to have asked them under what conditions they were living. It is very doubtful whether the yellow would then, always and in all circumstances, have dominated over the green

And it would do no harm to enquire with what rule that monk measured the degrees of yellowness. By rule of thumb? Were all the peas of the first generation as absolutely equal in yellowness as he claimed?

The Mendelists imagine that the germ cell is only the receptacle of the chromosome—only the receptacle of the "hereditary substance."

Actually, however, the germ cell, even the tiniest, is not a receptacle, not a bag to hold something or other, and not only a means of obtaining a new organism in the future. It is itself an organism. Of course, its living body contains organs that are more important and some that are less important. Like every body, it is infinitely complex; we can grasp, perhaps, only a hundredth part of its complexity! Fancy declaring that this body, with its wonderfully perfect and subtle structure, is nothing more than a bag to hold the chromosome!

Its nucleus, and the chromosomes within it, are also tiny organs of the microscopic living body of the cell, capable of developing and changing (like all other organs). It is not a casket for the hereditary substance, like the casket in the Russian fairy tale which contained the soul of wicked Kashchey the Immortal, and the key of which had been thrown into the sea.

Every organism lives, grows, casts off one thing and needs another. If this were not so, it would not be a living organism. If it were not so it would perish the moment it was born.

But what can be more important for the germ cell than to unite with another tiny being like itself, with another germ cell? Upon this depends the entire future existence of both, the entire fate of the being that will grow out of them! How can one imagine that at this crucial moment they lose the compass of selection, without which life would cease to be life and become a pack of cards which can be shuffled? How can one imagine that the germ cell unites promiscuously, with the first cell that happens to come along?

No, that cannot be. That would contradict everything we know about the history of life on Earth, about the millions of years of evolution of animals and plants, about the motive force of this evolution—natural selection, which has endowed them with the ability to fight, to adapt themselves, to hold their place in the sun.

The "forced marriages" of Mendel's peas were short-lived; they led to a multitude of segregations in the offspring—the couples brought together by the jaundiced abbot constantly strove to part. But must the offspring of free pollination in "marriages for love" behave in this way?

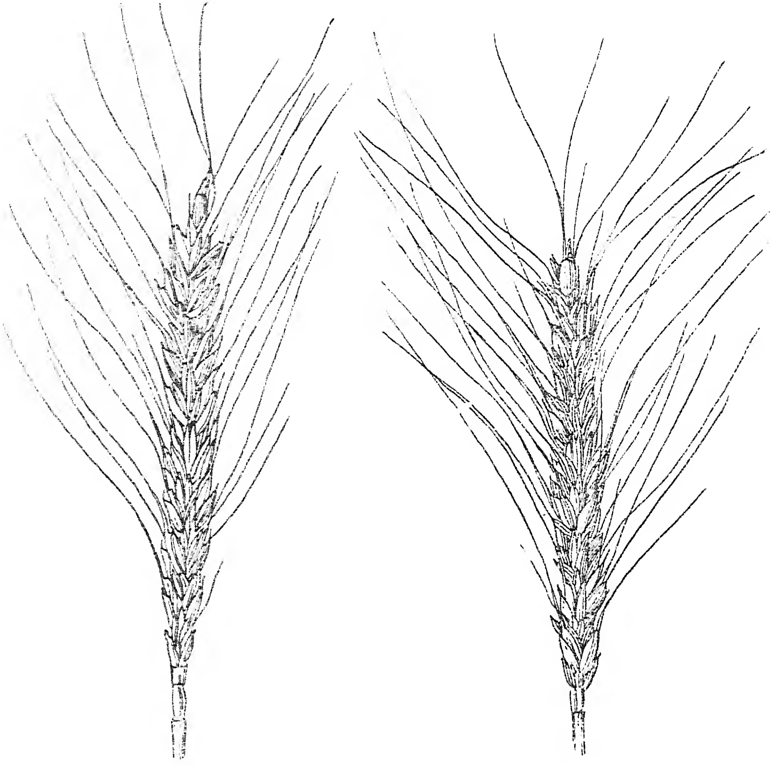
If all this is true, varieties will not be killed but rejuvenated by intravarietal crossing. And above all, there is

Wheat ears. Left to right: Lutescens 062 (natural size), Odessa 3 and Odessa 12 (two-thirds natural size)

no need to have kilometre zones between the different varieties of rye!

Years passed. The kilometre cordons between the rye fields disappeared. And the varieties of wheat rejuvenated by Lysenko now grow in all parts of the Soviet Union.

Hundreds of articles have been written about intra-varietal crossing. Dispassionate columns of figures have summed up the struggle, the effervescence of thought, the



Wheat ears. Left: Ukrainka. Right: Hostianum 237 (two-thirds natural size)

bold challenge hurled at rigid tradition and the thorny but joyous path traversed by the scientist towards the discovery of the profound secrets of the phenomenon, the name of which is Life.

More years will pass, and plant breeders will select from each variety many plant families having special characters, and they will raise from them new and better varieties. So it has always been, ever since man began to compel the green world to serve him. Our famous wheat Lutescens 062, which is regarded as the "standard southern variety," was grown from a few ears taken once upon a time from a field of Poltavka.

The reason for it is that a variety also lives, like any one of the billions of plants that constitute it.

Free pollination—"marriage for love"—is already serving to re-create plants. In 1945, the All-Union Institute of Selection and Genetics obtained 59,000 grains that had developed from wind-blown pollen on plots of four varieties of winter wheat—two new varieties: Odessa 3 and Odessa 12, and two old ones: Ukrainka and Hostianum 237. Since then, three generations of free hybrids have come, one after another. They were found to be still more virile, more adapted, and more fruitful. And yet, these four varieties are the best for many regions of the Ukraine.

"Therefore we can say," the researchers at the Institute told me, "that the Institute is now in possession of no less than a hundred centners of the most fruitful seeds of winter wheat for the southern regions of the Ukraine."

And what about Lysenko's cotton Odessa 1, the staple cotton for the new cotton-growing districts, obtained by means of selection and culling in the first hybrid generation, in that seemingly uniform generation, which the plant breeders who trusted the Augustinian monk refused to take into account!

> In nature, by means of variability and natural selection, the most beautiful forms of animals and plants could be and are being created. *By mastering these means, man can, firstly, create similar beautiful forms in an immeasurably shorter time; and secondly, can create forms that did not and could not appear in nature even in millions of years.*
>
> T. D. Lysenko. Paper read at the session of the Lenin Academy of Agricultural Sciences, December 23, 1936

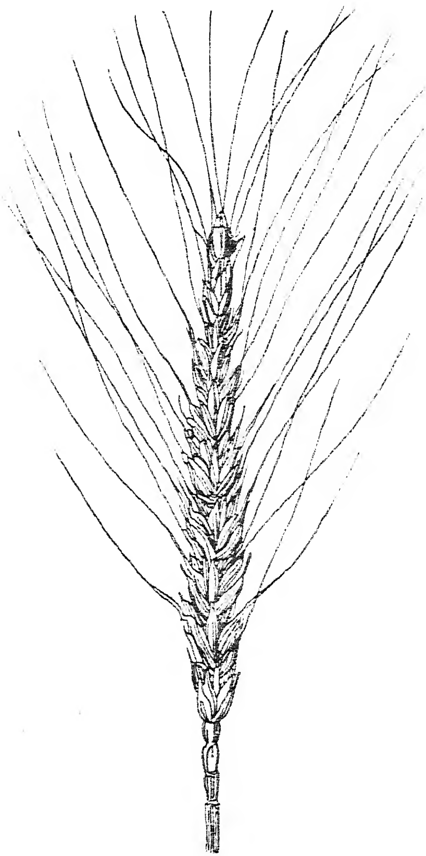
Kooperatorka was standing in the hothouse bending with the weight of heavy ears. It had a strange appearance. Dense growths hung over the clay pots. The stout stems were branched. In many cases there were two ears on one stem.

What had happened to Kooperatorka?

Like the Krymka, from which the plant breeders had only recently raised Kooperatorka's forebears, it had been a common winter wheat. At the Odessa Institute it was ascertained that it passes through its vernalizing phase at a temperature ranging from 0° to 15-20°C. At 0° or 2° it requires forty days for this; at 15-20° it needs 100 to 150 days. That meant that if planted in the spring it would never ripen.

When the re-training of Kooperatorka commenced they allowed it to vernalize in "medium" temperatures. It dallied, tillered more than was necessary, but for all that, it pushed on along its road. When it had almost completed the journey, almost at the end of the road, they suddenly raised the temperature. How obstinately it tillered! Had it been not a voiceless living creature, but one with a throat and lungs, it would have grumbled and growled. But its trainers had the patience to wait; it was already approaching the very end of its road, and when it "crept up" to the end it threw out stalks.

Its late grains were planted, and a curious thing happened. This time Kooperatorka was not so stubborn, and ripened more quickly. The third time it ripened still more quickly. One could see this acceleration without consulting the calendar. On each occasion all the Kooperatorka generations were planted together, and the third hothouse generation was always "faster" than the second, and the second faster than the first.



An ear of Kooperatorka wheat (two-thirds natural size)

Incidentally . . . the temperature in the hothouse was raised from the very outset, and the first generation simply dropped out of the race; it refused to compete under these conditions. The plants failed to ear, and by the autumn they had almost entirely perished.

The re-training of the wheat was regarded as finished and its appearance was like that described above. Even outwardly it no longer looked like its former self. It was planted in the spring with the ordinary spring sowing, without vernalization, like any other kind of spring wheat. Next to it they planted the same Kooperatorka, even from the same great-grandfather ear, only this one had had no hothouse experience.

I saw both strips at the end of May. The winter wheat spread over the land in stunted, seedless grass clumps three or four inches high. The hothouse plants, about thirty inches high, were already earing. It was almost useless trying to make oneself believe that they were the same kind of plant, the offspring of the same ear. It contradicted absolutely everything we had learned from the old textbooks on genetics.

But there was nothing to argue about. I saw it with my own eyes.

Lysenko read a paper on the first results of his experiments with Kooperatorka in December 1936, at the Fourth Session of the Lenin Academy of Agricultural Sciences.

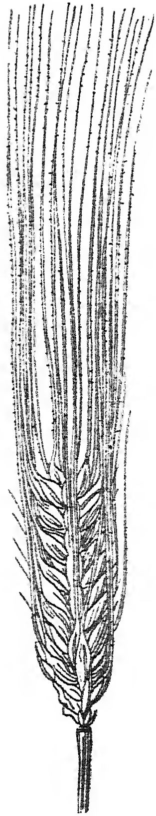
"Are you altering heredity?" a voice in the audience enquired.

"Yes, heredity," answered Lysenko.

"Searching for perpetuum mobile!" sarcastically interjected the celebrated Muller (this close disciple of Morgan had just arrived in the U.S.S.R. and, pretending to be a friend of our country, endeavoured to enlighten Soviet scientists with the wisdom of Morganism).

Four years later Lysenko made the final summing up. He said: "In 1935 I did not know of a single case of a spring wheat being made out of a winter variety. . . . Today, any man who sets about it can fairly easily transform hereditary winter varieties into hereditary spring varieties. Simultaneously, we learned how to transform spring varieties into winter varieties. . . ."

And he related how the spring barley Pallidum 032 was transformed into a winter crop, which turned out to be more winter hardy than all other barleys; and the spring wheat Erythrospermum 1160, after re-training, rivalled the Saratov variety Lutescens 0329, the most cold-hardy wheat in the world. If anybody now attempted to plant these "trainees" in the spring they would perish and never throw out an ear.



An ear of Pallidum barley 032 (two-thirds natural size)

Here, too, the method of re-training is simple and intelligible. Whereas winter Kooperatorka was kept at the upper limit of temperature permissible for its vernalization, and this limit was gradually raised higher and higher, the spring variety undergoing re-training was, at the necessary moment, brought down to and kept at the lower limit, and this limit was shifted lower and lower.

Another characteristic thing is the following: Lysenko's opponents asserted that by his "re-training" method he was introducing a daring innovation in science. He himself, however, believed that he was merely recalling ordinary, and even trivial, things that had been forgotten.

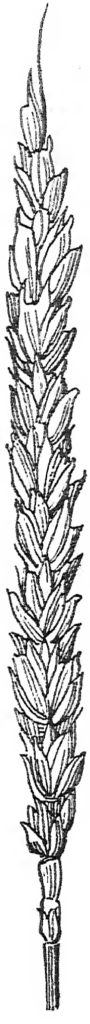
Does not everybody know that the further north a plant-breeding station is situated the more winter hardy are the varieties it grows? Of course, the art of the plant breeder must be given its due; but apart from that, there is something in the material that he handles. Nature itself re-trains plants and makes northern varieties more wintery and southern varieties more springy. How can it be otherwise? Cereals which, from generation to generation, passed through their vernalizing stage in a severe climate, were bound to be shifted in the direction of greater winterness. On the other hand, a warm climate, which keeps cereals at the upper limit of temperature during the first phase of their development, alters their hereditary basis in the direction of greater springness.

Michurin, of course, was perfectly aware of this, as is proved by the answer he gave to an enquiry from some comrades in the Urals: ". . . I most emphatically assert that it is fully possible to establish and carry on commercial fruit growing in the Urals, but on the one sole condition that local fruit-plant varieties are bred from seeds on the spot. . . ."

What else was the re-training method (already employed by Michurin in raising the northern apricot), what else was it (like the method of selecting pairs in crossing), if not the direct application of Michurin science?

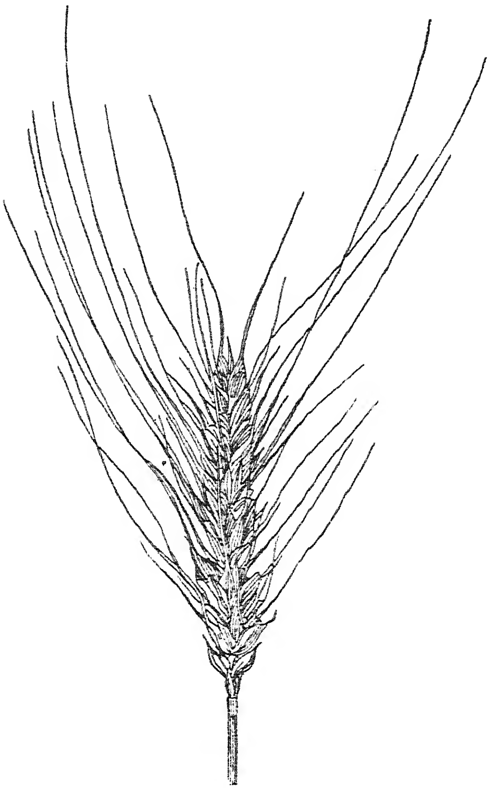
Thus, the plant breeder cooperates with nature. The new thing in the experiments with Kooperatorka, compared with nature's gigantic experiment, is that, by mastering the means employed by nature, man can "create similar beautiful forms in an immeasurably shorter time," and, undoubtedly, "can create forms that did not, and could not, appear in nature even in millions of years."

That is what Lysenko thinks about it.



An ear of Lutescens 0329 wheat (natural size)

Over a decade has passed since the first experiment with Kooperatorka was made. Michurinist plant breeders have re-trained numerous varieties, and these varieties grow in our fields. Their habits have been studied. The methods of re-training them have been precised and accelerated. From the transformed Kooperatorka, strains have been produced with high, early-ripening properties, and also strains with a vitreousness of grains that remind one of the hard-grained wheats. The re-trained Ukrainka and Hostianum 237 no longer fear stinking smut. The yield of Novokrymka 204 exceeds that of spring wheats.



An ear of Novokrymka wheat (two-thirds natural size)

At the Siberian plant-breeding stations man has converted spring wheats into the most frost-hardy winter wheats ever known.

In the address he delivered at the session of the Lenin Academy of Agricultural Sciences of the U.S.S.R. on July 31, 1948, Lysenko reported a fact that is more astonishing than all, namely, the transformation, by training, of one species into another—of hard, 28-chromosome wheat into soft, 42-chromosome wheat.

THE STORY ABOUT THE POPLAR TREE

> . . . Nor scarce a breath that cares to fret
> The sleep of silver poplar leaves. . . .
>
> A. Pushkin

It is now time to tell the happy and edifying story about the poplar.

Who would have thought that the pyramidal poplar trees—the ornaments of our southern towns—are senile and on the verge of degeneration? In the middle of a hot summer the dry tops turn dark above the silvery leaves, as if autumn had touched them. Year after year the soft timber rots. Not a single tree can avoid premature death. The corrupting influence lies in their sap, and affects all the poplar trees in the world.

But how quickly and gracefully these beautiful trees grow in the early part of their lives! Poplar "islands" could spring up in the southern steppes in a short space of time, and the hot winds, caught in their green, leafy nets, would be powerless to parch the earth.

This could be. But in order that it should be it is necessary to infuse new life into the trees. Lysenko had a right to undertake this task because it is similar to that of reviving degenerated wheat.

For ages, poplar trees had been grown from cuttings; the task was to rejuvenate them by planting from seeds.

Very simple it would seem . . . but here the trouble began!

All . . . absolutely all . . . the pyramidal poplar trees produced only male flowers. It looked like a conspiracy of women-haters. Verily, an arborial Zaporozhskaya Sech![1]

The search for "lady poplars" began in the Odessa libraries.

From the bookshelves and cupboards was taken everything that had ever been written about pyramidal poplars.

But the books, thick and thin, the heavy tomes in grave, old-fashioned binding, the pamphlets in gay, canary-coloured covers, the dissertations written in dry, terse language and the voluble magazine articles—all contradicted each other.

"In Europe only male specimens of the pyramidal poplar are met with," wrote V. M. Penkovsky ponderously. "Females were a rarity, and, moreover, were not of pyramidal shape; their upper branches stood out from the trunks."

"No, in Russia there are a few female specimens," interrupted the St. Petersburg *Great Encyclopedia*. "The tree is a native of Persia."

The opinion of the *Great Encyclopedia* was shared by the *Granat Encyclopedia*, but Professor Sukachev's *Dendrologia* objected in a deep, bass voice:

"The only type in cultivation are male poplars. They are natives of the Himalayas."

At this point the famous tree expert Morozov joined in the discussion.

"This poplar," he said, "appeared suddenly in the black poplar family, and there are no female poplars."

"Nobody knows whether that is true or not," retorted the magazine *Na Lesokulturnom Fronte*. "It is quite possible that the pyramidal poplar was brought from the Himalayas. It is no less probable that it first appeared in Lombardy. All that is definitely known is that for two thousand years men have cultivated male poplars."

"Two thousand?" remarked Professor Kern ironically. "People are always exaggerating! In the time of Pliny the Elder, there were no pyramidal poplars at all in Italy. And they found their way into France only yesterday, one might say, only in 1749. Later, Napoleon the conqueror had them planted along the roads of Europe. And that is how they spread."

Professor Curdiani, however, had heard nothing about Bonaparte's weakness for poplar trees.

"In Georgia," he remarked imperturbably, "only female specimens of the pyramidal poplar are met with."

This remark was parried by Professor S. V. Myasoyedov, who retorted: "Only male specimens of the pyramidal poplar are known."

It was enough to drive one to despair.

An ancient myth tells us that three goddesses, unable to agree as to which of them was the most beautiful, appealed to the handsome youth Paris to judge between them.

Lysenko's assistants, whose heads were in a whirl as a result of the disagreement among the scientists, appealed to the Botanical Institute of the Academy of Sciences and enquired whether there were such things as "lady poplars" in nature, or not.

"Humph!" the Botanical Institute answered after some delay. "That's a poser. We would advise you to make enquiries at the Voronezh Agricultural Institute, and at the Wooded Steppe Station of the Central Black-Earth Region."

So they sent an enquiry to Voronezh.

At last the long-expected answer was received. Professor Kapper regretted to say that he had never seen any female poplars. But there was no need to despair; the only female poplar that he knew of happened to be growing in the region of Odessa, in the very region where, if he was not mistaken, his inquisitive colleagues were living.

Soon after this a reply was received from the Wooded Steppe Station. To find female poplars was the simplest thing in the world, they said. They had been seen in Saratov ("we have not been able to verify this," the letter added cautiously). But if the matter was urgent, it was advisable to go at once to Tashkent, where female poplars are growing all over the place. It was something like the ancient land of the Amazons. And they would give anything there for a twig from a male poplar!

The people who were most surprised on receiving this information were those in Tashkent:

"What? Female poplars? Are you not mistaken? Is that what they said: female poplars? We mean specimens of Italian pyramidal poplar that bear flowers with stigma, and without stamens. Is that what you mean too? No. Alas, we have never heard of anything of the kind. . . ."

In the region of Odessa, the "inquisitive colleagues" already despaired of finding the "fair sex" of the poplar race. They scoured every public garden in Odessa, even the tiniest square, and every village in the environs of the city in search of a female poplar.

But the old saying is true: "Seek and you will find."

Female poplars were discovered in four places at once, and in the most unexpected places: Kiev, Uman, Mliyev and Sagaraj.

At last the precious cuttings arrived at the hothouse in Odessa and thirstily absorbed te nutritive Knop's solution from the glass jars!

At flowering time a sticky pollen covered the pistils.

And lo, after many scores, perhaps hundreds of years, man gathered the seeds of the pyramidal poplar and planted them.

The seedlings grew swiftly. Gazing at the thick, fluffy leaves and the silvery glint that ran up to the very tops as the light wind blew through them, the researchers at the Institute smiled: No, the curse of the poplar race was not hovering over them!

The sequel to the story about the poplar was published in the magazine *Agrobiologia.**

"Ten years have passed since seeds from crossed pyramidal poplar trees were obtained and planted. The seedlings of the rejuvenated pyramidal poplars that we planted at one time in the grounds of the All-Union Institute of Selection and Genetics now form an avenue of strong, long-lived and rapidly growing poplars. Among them are five female specimens. Agriculture is receiving a new and necessary variety of tree."

POTATOMATO

Behind, a dragon's fiery tail was spread;
A goat's rough body bore a lion's head.

The Iliad, VI

Volume II of the *Transactions of the British Royal Society*, published in 1667, contained the following story:

In Florence there were orange trees, the fruit of which were half lemon and half orange. These trees had not been brought from other countries, and at the time the story was written they were being extensively reproduced by grafting.

A similar report was later received from another Eng-

* No. 2, 1947. Article by I. D. Kolesnik.

lishman, who asserted that he had not only seen such trees, but had bought their fruit in 1664, in Paris, whither they had been sent by Genoese merchants. On some of the trees he found oranges on one branch and lemons on another, and sometimes he found fruits that were half orange and half lemon, or three-quarter of one and one quarter of the other, which is in consonance with the report from Florence.

That is how the world learned about the "bizzare" tree with the twin fruit. Scientists disputed about this tree for two and a half centuries. In 1927, this "bizzare" tree was again investigated by the Japanese geneticist Tanaka. Tanaka saw fruit covered with tumors and warts. Here and there the golden-coloured rind bore lemon-coloured stripes. The knife, in cutting through the outer orange tissue, plunged into the pale, extremely sour pulp of lemon.

In 1825, a gardener named Adam, in his garden in Vitry, near Paris, grafted a bud from the beautiful bush "golden shower" onto ordinary broom. The day he chose to do this must have been an unlucky one, or perhaps his skill betrayed him on this occasion; be that as it may, the graft seemed a failure. . . . Adam gave the plant up in disgust, but a little later a shoot broke out at the spot at which he had made the graft. In leaves and in the flowers that gathered in a violet cluster, it strangely resembled both the scion of the "golden shower" and the broom stock. After that, cuttings of the new dual plant found their way into all gardens. They did not produce fertile seeds. Nobody succeeded in repeating Adam's accidental experiment. And the low tree with the violet clusters of flowers was named "Adam's broom."

Darwin saw the plant, and came to the conclusion that Adam's broom was a hybrid, a real hybrid, although there had been no crossing.

"This fact is extremely important and sooner or later will cause physiologists to alter their views about sexual reproduction," was the note Darwin made.

It looked as though the corner of a curtain had been raised. Fertilization, a special, exceptional phenomenon, always hidden by a veil of mystery, took its place among other phenomena, and the veil fell away. Here there had been not pollination, but only grafting. More light was thrown upon the nature of the most important and most enigmatic event: the union of two lives to produce a third, new life.

But it was just around this point that the hottest battle flared up.

What! The hybridization of a flowering plant—and without flowers, without pollination, without any fertilization whatever! What! The union of "hereditary substance" without the dancing of chromosome couples, and without the sacred rites so conscientiously and meticulously described by the biographers of germ cells! Horrible to relate—this obliterates the border line between the germ and the body cells; it destroys the most inviolable refuge of the "hereditary substance?"

Meanwhile, biologists learned to obtain hybrids by grafting. In bowls, flowerpots and experimental plots, the most wonderful creatures grew. Their stems looked like two different halves stuck together lengthwise. In some cases one plant served as the bark, while the inside consisted of the other plant. Some of the plants consisted of three organisms. Some resembled a cake with different layers: one layer consisted of the body of one organism, the next one of another organism, after that came a layer like the first, and then another layer like the second, and so forth.

On seeing the shoots of a semitomato-seminightshade, the botanist Winkler at once thought of the heroine of the hoary myth—Chimera. Since then all these incredible creatures have been called "chimeras." Only, if we are to believe Homer, the frightful monster that Bellerophon killed consisted of three parts—a lion's head, a goat's body and a dragon's tail; but here one living body lies like a cloak over another, over a second, and a third, as if they have been glued together!

And the strangest thing of all is that these medleys live and grow as if there were nothing extraordinary about them. They have the same number of organs as every respectable organism is supposed to have, only each organ is also a medley, or like a cake with layers. The bark and leaves, for example, constitute one living creature, but the veins of these leaves and the pith under the bark constitute something entirely different. But for all that, combined, they constitute one body!

The fact that such creatures can exist is so extraordinary that it seems impossible to invent anything more wonderful.

But the neo-Darwinists and geneticists of the Morganist persuasion shrugged their shoulders and said:

"Clearly, each plant retains its own identity. They cannot influence each other. We would rather believe in the existence of the fiery dragon. It is simply a chimera."

They were not in the least surprised at the existence of chimeras they saw with their own eyes, they were not surprised that sometimes even the microscope is unable to reveal what, in particular, belongs to each of these "separate" plants. No, this did not seem surprising to them. "It is simply a chimera."

But under no circumstances would they agree that the "hereditary substance" (which they have never seen) in the living creatures which had united in a chimera can undergo any change.

Much pain was caused the sceptics by Professor Lucien Daniel of Rennes, in Brittany. He grafted turnips on cabbage, wild carrot on ordinary carrot, mustard on cabbage, and joined medlar with hawthorn. He performed experiments that looked like conjuring tricks—he inosculated grasses. By means of grafting he rejuvenated potatoes and grape-vines. He found an assistant in his son Jean. Very soon the young botanist won a name for himself in science; in doing so he followed in the footsteps of his father. And his father had great expectations of him. In 1914 Jean went to the war against Germany and did not return. His dissertation, *The Influence of Mode of Life on the Structure of Dicotyledons,* appeared in 1916 with the author's name in a black border.

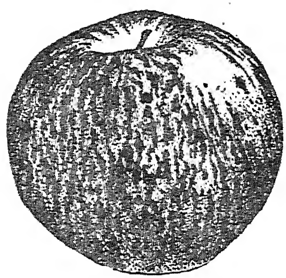
Born a peasant, tireless and persevering in his work, Lucien Daniel continued his task alone. When his eightieth birthday was celebrated (in 1936) an amazing collection was opened for public view in the Biological Gardens: 173 tubs and flowerpots containing hybrids born of "creative grafting."

"Chimeras, all chimeras!" reiterated the sceptics. They applied this term equally to what grew in Daniel's tubs and to his theories.

Daniel had transferred nightshade to belladonna, potatoes to tomatoes, wormwood to chrysanthemum; at the bottom of a two-storeyed structure of sunflower and Jerusalem artichoke grew tubers (of a kind that nobody had ever seen either in sunflowers or in artichokes), and at the top of the artichoke seeds germinated. For four hundred years, Jerusalem artichokes in France had been sterile! . . .

Lucien Daniel died in 1940. Sad were the last months of the veteran scientist's life: under the window of his house, past the Biological Gardens and the Palace of Scientific Research, marched the jackbooted soldiery of Hitler. . . .

Daniel's whole life was a long controversy. He multiplied the number of his hybrids, thereby refuting the Morganists; these were his new arguments against them. But he was too ardent a controversialist calmly to study the phenomenon of vegetative hybridization (on fewer specimens, perhaps, but thoroughly, to the very end), to ascertain the place it occupied among the other phenomena of life, to see what light it threw upon the very essence of life, to trace the operation of the general laws of this phenomenon, and to convert vegetative hybridization into an instrument of man's power over plants. . . .



Bellefleur-Kitaika apple

But Michurin did make this study. He did not argue. For him, the question of the possibility of vegetative hybridization was settled once and for all. He merely observed that it is possible to obtain hybrids "not only from different varieties of the same species of plants, but also from different species and even genera." And he allowed nothing to interfere with his work.

After discovering the laws of vegetative hybridization, the great transformer of the plant world used it to create new varieties, new breeds. He always obtained a grafted hybrid whenever he needed one. The "mentors" compelled the young seedlings to bear fruit sooner, they moulded their shape, size, flavour and storage qualities. The pear apples Reinette Bergamotte, the Kandil-Kitaika and Bellefleur-Kitaika, which have been accepted as standards in forty-four regions in our country; the plums Reine Claude Ternovy and Tyorn Sladky, and the cherry Krasa Severa—are some of the splendid Michurin sorts produced by vegetative hybridization.

Lysenko performed his first experiments with grafted hybrids in 1937. In starting on them he was definitely conscious of the inseverable connection between these experiments and the knowledge acquired by Michurin. Having this in mind, he wrote a year later: "We will be able to hybridize potatoes with dahlias, potatoes with Jerusalem artichoke, etc. It will be possible to obtain vegetative hybrids between tender peaches and apricots and hardy plums and sloes; hybridize lemons, tangerines, oranges and other citrus fruits with *Citrus trifoliata* (with wild trefoil citrus), which is considerably more frost hardy."

He started with the plant that is second in importance only to the cereals—the potato, his old "enemy."

Those who visited the All-Union Agricultural Exhibition in Moscow before the war saw with their own eyes hybrid tubers which combined the properties of both . . . both what? "Parents"? That is what we are obliged to say, because there is no term yet for this unprecedented method of bringing forth new offspring. "We now believe," writes Lysenko, "that in all cases it is possible to achieve radical changes of a hybrid character as a result of the interaction of the scion and stock." The cutting for the graft must be *young* (the significance of this important condition was revealed by Michurin). The leaves must not be left on the grafted shoot (or, leaving them on the scion, they must be plucked from the stock). The leafless one of the couple will have its food ready-made; it will be prepared by its partner. Then, the "sponger" will be forced to change; we will confidently wait for the vegetative hybrid. "There is not a graft of a phasically young plant that will not show changes in heredity," was the way Lysenko summed it up in 1948.

The situation with the potato was as follows:

The Epicure variety produces white tubers, the ordinary potato with which everybody is familiar. The tubers of the Odenwälder Blaue look strange to the uninitiated: they are of a bluish colour, as if they had been doused with iodine in the well-known school experiment; bluish, even with a tinge of violet. Neither of these two varieties of potatoes could be possibly mistaken for the other.

The Epicure was grafted on to the Odenwälder Blaue and the stolons of the latter plant produced white tubers! Only a few of them had a slight bluish tinge, as if to prove their mixed origin. But in the other experiment, where the experimenter set out to obtain tubers from the second partner, the Epicure, the underground shoots—the stolons—bore light-blue tubers.

Various combinations of varieties were tried; and again, the red-tuber Wohltmann, grafted with a white Epicure, and an Alma, produced white tubers. The purple Maika and the pink Early Rose also became white after joining their lives with the white-tuber Alma and Cobbler.

But what will happen with the offspring of these plants which had changed their age-old natures?

The now paler tubers of the Maika, grafted with a white Courier, were again planted. There was to be no more grafting, no interference. The Maika was free to return to its original path.

But it did not return to that path. It produced white flowers. The red veins in the leaves vanished. Young, white tubers clung to the stolons.

The experiment was performed the other way round: the Courier at the bottom and the Maika at the top. The tubers were dug up and planted again. When blooming time arrived, the petals were found to be of a violet colour. It looked as though the Courier and the Maika had exchanged colours.

Potatomato

And in the ground, elongated tubers were formed, like those of the Maika.

"Parents" sharply differing from each other were deliberately chosen to make the experiment more striking. The Morganists—who did not believe that vegetative hybrids were possible—were confronted with them before they could "deny" their existence.

A "15-line" tomato was grafted on to a red Wohltmann and a strange plant resulted—a "potatomato." That was the name given it, being borrowed from a similar vegetative hybrid raised by Burbank. The potatomato grew, flowered, and down below, under the tomato leaves, potato tubers appeared. The potato remained a potato; the only change was that the tubers of the Wohltmann were quite white.

The potato's nature, however, did not always stand the test of such "supernatural" unions. There were cases when the stolons of potatoes, grafted with tomatoes or eggplant, showed woody thickenings instead of tubers.

Well known all over the southern part of our country are the black, seemingly ruffled up leaves and tiny, tart and sickly-sweet berries of the nightshade—the food of the birds. Like all weeds, it is not fastidious. It does not need much to live its short-allotted span of life near some blank wall, or on a dungheap.

Well, a tomato was grafted on to a nightshade. The leaves were plucked from the tomato to compel it to feed on the sap of the nightshade. The tomato on the nightshade flowered a month earlier than usual—the nightshade had trained it to grow fast under severe conditions.

An eggplant was grafted on to a nightshade; this eggplant also flowered a month earlier than those that grow freely in the open ground.

Purple fruit appeared on the amber-yellow Albino variety after it had been grafted on to a Mexican tomato bearing small, red fruit. Feeble sunflowers that had uncomplainingly allowed themselves to be strangled by that plant octopus broom rape, suddenly acquired a lion's strength after they had been grafted on to Jerusalem artichokes, which are not afraid of any broom rapes.

The seeds of tomatoes that had been grown on a pepper plant were planted in the open ground; the new generation brought forth a tough, freakish fruit—half pepper, half tomato.

One after another, remodelled and sewn together fruits appeared in Odessa, and also at Gorki Leninskiye, the experimental base of the Academy of Agricultural Sciences, near Moscow.

This new work was taken up by experimenters in all parts of the country. As Lysenko stated in a lecture he delivered in 1946, thousands of people, "from Young Pioneers to old-age pensioners," began to practise grafted hybridization.

This is what we read:

At the subtropical crops station in Sochi, the "trefoil citrus," the hardiest of the citrus family, is used as a mentor for orange and tangerine trees.

Young Communist Leaguer Fedor Solodovnikov, a post-graduate student at the Moscow Potato Institute, obtained hybrids by grafting the cultivated Alma variety on to the wild Demissum potato.

A young scientist Filippov decided to cross a wild potato with a cultivated one in order to give the latter the hardiness of the former. First he compelled the wild one to grow on the cultivated one (in conformity with Michurin's vegetative approach method). When the blossoms appeared on the scion, Filippov pollinated them with the pollen of the stock—and hybrid seeds resulted.

We have read a report from Krasnodar about grafted tobacco hybrids; and from Kirovsk, in the Far North, about melons which are amazingly early ripeners and give a fabulous yield—these melons had been grown on a pumpkin.

The method of grafting melons on pumpkins was devised by Serafima Petrovna Lebedeva, and for this she was awarded the Order of the Red Banner of Labour. Verily, the melon travelled to the North riding on a pumpkin.

At Bolshevo, near Moscow, N. V. Brusentsov, an old Michurinist experimenter, grew an enormous plant seven feet high that had three storeys: tomato at the bottom, potato in the middle, and a different variety of tomato on top.

And more and more clearly emerged the outlines of the general laws that govern the most vital phenomena—the reproduction, variation and growth of living organisms.

Here is a letter from Sukhumi relating how cuttings from a hybrid tobacco plant "sprouted" up in a clump of tobacco plants totally unlike each other (recall the experiment on budding Tarashchanskaya rye performed in Odessa).

Here is a report about a vegetative pear on the Caucasian coast. This fact is so remarkable that it is worth relating at length.

This pear tree was seen growing about eight kilometres from Tuapse by a fruitgrower named Melnikov. Nobody tended it. It bloomed twice a year—with ordinary blossoms the first time, but with double blossoms the second. Some of these double blossoms produced an unusual kind of berry. Melnikov thought that the tree was diseased; he found out what it was later.

The fruit of this tree had the ordinary flavour of the pear, but it had no seeds; no germ cells had taken part in

Vegetative hybrid pear
Left: one-year shoot with group of leaves from the petioles of which fruit is formed. Right: fruit of vegetative hybrid pear

its creation. "At the present time," wrote the researcher, "science knows of innumerable cases of amazing metamorphosis, but for all that, the case of the vegetative pear is one of the most interesting." Spreading leaves and petioles, and the calyxes of the flowers—such are the materials from which the vegetative pear grew. Leaves, calyxes and fruit—different organs and phenomena having no resemblance to each other, draw together! And the flowers with their germ cells—are they not also the "metamorphosed" leaves? Yes, the researcher who wrote about the vegetative pear thinks that they are, thus reviving the old idea of the naturalist philosophers of the past.

Michurin too knew of the existence of these vegetative pears. He purposely sent his close assistant to the North Caucasus to get some of their fruit and cuttings. This was in 1931. Michurin was of the opinion that the new phenomenon was of "outstanding world-wide interest."

The Sochi Subtropical and Southern Crops Experimental Station took this Tuapse pear tree in hand. Today, it is the forefather of a whole tribe of pear trees that bear "leafy" fruit.

For many decades the most authoritative investigators, leaders in biological thought, had been firmly convinced that the phenomena of reproduction and the phenomena of nutrition and growth were in no way connected; it was now proved that they were closely connected.

More than one generation of offspring has been grown from the seeds obtained from vegetative hybrids. After studying them, comparing them with the organisms which owe their existence to the more ordinary course of things, Lysenko was able more clearly to formulate his most general conception of the essence of the living thing.

. . . Thus, a new life is germinated, is born, a tiny material dot in the material world. It will build and shape its body out of the materials of this world.

But this dot represents two billion years of development of life on Earth, millions of years of evolution of the given branch of life, thousands of years of formation of the species. And this has made our dot what it is: has endowed it with the ability to present definite demands to its environment, to take from its environment different elements in different combinations, and to work them up in a particular way and no other so as to obtain a "plastic substance," from which the living body will be built.

Every plant builds itself, its body, out of the plastic substances which it itself chooses, takes from its environment and works up.

But . . . but supposing we give it some other kind of plastic substances?

How can that be done?

We now have the answer to this question: vegetative hybridization.

Graft a bud on a different body. It will now be compelled to "build itself" out of "bricks" already made to a different "measure" by another organism different from its own.

Lysenko is of the opinion that this fact is of capital significance for the vegetative cutting taken in this example. Its innermost, hidden life will *unite* with the life of the other plant with which it has been joined and will resemble it in some degree or other.

That this is so we *see*. Now, the most precise methods of objective research supplement the evidence of our eyes. These most interesting researches have been conducted for several years already at the Bach Institute of Biochemistry in Moscow. They have shown, for example, that the phasic "turns" in a plant's development are reflected in a radical change in the intensity and direction of the processes of synthesis and disintegration of the substances in its cells. And it is possible chemically to distinguish a vernalized shoot from an unvernalized one.

Several of the first unfolded leaves of the tiny shoot are sent to the laboratory, and the chemist there can foretell whether the plant will be a late or an early ripener, whether it will fear the cold blasts of winter and the dry winds of summer.

It was this "prophetic" chemistry (made possible by Michurin's theory) that subjected the seed offspring of vegetative hybrids to a close and strict examination. In this case it was a tomato. The chemist simply stated that he had before him a body of changed chemical composition with a new type of metabolism. He examined two, three, ten, twenty, a hundred fruits; and the conclusion he drew was beyond doubt: the change that had taken place in them was fully in conformity with natural law. It was a chemically, and naturally, changed body.

The characters of the offspring of the vegetative hybrids also segregated: the characters of the "father" separated from those of the "mother." But *what* was segregated? Chromosome pairs? There were no chromosome pairs here. Not a single chromosome passed from the stock to the scion, or vice versa. There was not even a hint of the Mendel mechanism of segregation. But segregation did take place.

It was not chromosomes that joined and separated, it was two lives, that now fought and now united, only to be thrown back to the previous paths by the force of external circumstances.

And Lysenko drew the extremely important conclusion: "*Consequently, the plastic substances produced by the scion and the stock*" (on another occasion he said more definitely, "the sap"), "*like the chromosomes, and like any particle of the living body, possesses the characters of the breed. . . .*"

Foaming at the mouth, the Morganists challenged what could be seen, felt . . . and even tasted. They challenged it because this, at one blow, wrecked beyond repair the very essence of their whole "system."

And while, with eyes shut tight, they were shouting: "It cannot be!", the hybrid fruit of the tomato that had been grafted on to the nightshade grew in such numbers that they were even put on sale. They had a somewhat tart and spicy flavour. Many people liked them. A little girl would come to a shop and say:

"A kilo, please. Oh no, not tomatoes; vegetable hybrids. Mama said I was to get nothing else."

She had no suspicion that many esteemed and learned professors had uttered incantations, bidding the fruit that the salesman was weighing out for her, and which had already passed the state varietal tests, to rot, to moulder and turn to nothing.

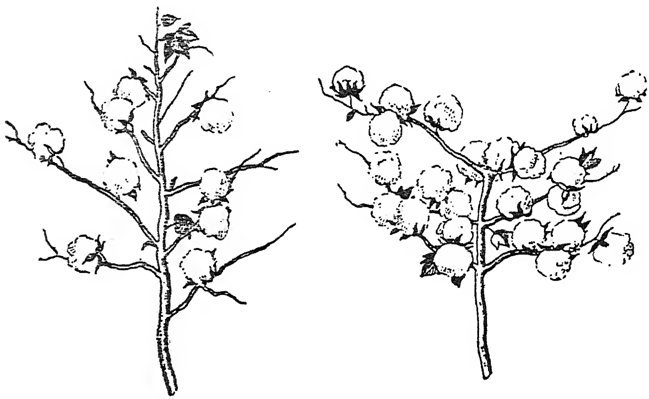
THE THING MOST NEEDED

I remember that when I first visited the Odessa Institute it seemed to me that I was looking through a pair of magic spectacles, which enabled me to see the hitherto unseen life of plants; to see how grasses grow; to see the mysterious process of formation of living tissue; and things that had been a riddle to me before became simple and easily understood.

I was shown a cotton plant. It looked like a Christmas tree decorated with tufts of cotton wool to represent snow. "Topping according to Lysenko's method," I was told. When the first four or five buds appear, the top of the plant is clipped and the superfluous side buds, together with the old leaves, are removed. As a result, all the sap goes into the precious cotton bolls. Quite simple. But this "Christmas tree" grew in the *Ukraine*! Is it so long ago that we pictured to ourselves the snow-white cotton growing in the scorching plains under a deep-blue sky, so dense that the sun seems to hang motionless in it, and the caravans of camels with the double bales of cotton monotonously swinging on their flanks?

It was only in the Soviet period that we grew accustomed to the idea that cotton also grows outside the villages in the Ukraine.

And concerning Lysenko's topping method, we heard that it results in an additional one and a half hundredweights of cotton per hectare. One and a half hundredweights of cotton wool—a veritable mountain! You remember the old tricky question: how much does a ton of feathers weigh?



Cotton plant
Left: before topping. Right: after topping

And for a long time already, from 85 to 90 per cent the total cotton crop in our country has been topped.

This method of topping cotton is a particularly striking illustration of the feature that distinguishes Lysenko's experiments.

They invariably have in view: the broad masses. Their invariable watchword is: make it intelligible to every kolkhoznik; make it workable for every kolkhoz.

So in all things, big and small.

Sowing in wide-spaced rows is being more and more extensively practised. The spaces between the rows have to be cultivated. To supply the whole country, hundreds of thousands of cultivators are needed, and the factories cannot turn them out fast enough. But the kolkhozes cannot wait. So Lysenko shows them how to make cultivators out of "zig-zag" harrows, and this can be done in any village smithy.

Who does not remember how, in hundreds of villages, Lysenko turned the kolkhoz poultry on the weevil pest that had attacked the sugar-beet crop? How he discovered a foe for the pernicious tortoise beetle—the ichneumon fly, the telenomus—how he bred them and sent them to the infected fields to exterminate the beetles?

Vernalization, the summer planting of potatoes, intra-varietal crossing and the topping of cotton were being employed on immense areas; Lysenko was directing the "battle for millet," and also scores of experiments in Gorki Leninskiye, Odessa and at many other centres, to improve what had been done and to find new methods—when the war broke out. During the war he wrote:

"...We have concentrated all our scientific work exclusively on the solution of extremely important scientific problems in order to help the kolkhozes and sovkhozes, during the arduous period of the war, to increase the country's food and raw materials resources. . . . Scientific problems, on the solution of which years could be spent with relatively little harm in peacetime, demand immediate solution under the conditions of life created by the war."

A long, icy spring and a short summer prevented the wheat from ripening in the fields of Siberia and North Kazakhstan—the country's important granaries in that stern year 1941. The approaching autumn morning frost threatened to kill the as yet unripe grain. . . . The latter half of August.

A series of swift experiments ("literally in the course of one week"). And the conclusion: Reap! Reap the ripest at the end of August and all, all the rest, between September 5 and 10! The grain will ripen in the sheaves; if left standing, it will perish!

Winter is at the gates. Often, in the East, the grain has no time to dry, and a process of spontaneous heating begins in the grain heaps. To prevent this the grain is put out in the open to freeze, in the same way as the laundress freezes her washing when hanging it out in the winter. In the spring this grain was planted, and then came complaints that much of it failed to sprout. But now, in wartime, every grain is precious! Lysenko and his assistants intervene in this ancient practice. Freeze? Yes, but there is a limit; not more than 5-10° C. below zero in the heap. The peasants had allowed the temperature to go down to 30-40° C. below zero to "make it more effective."

In passing, Lysenko made another discovery, which nobody but he, perhaps, could have made. After harvesting, the grain goes through a rest period, and after that becomes more sensitive to frost than grain which has not gone through such a period.

All this was only the beginning of the struggle to heighten the germination of seed. This problem, which soon arose in all its magnitude, proved to be a very acute practical problem and a new and important theoretical one.

It was the problem of the life of the grain.

We had almost grown accustomed to very frequent complaints about the poor germination of seed in the northern and eastern regions. There were cases when in sowings of spring wheat, barley and oats, barely one grain in three sprouted. And this was not due to the spoiling of the grain by bad storage.

And so, in one visible phenomenon—the fact that the seed did not sprout—Lysenko began to discern two very different, diametrically opposite phenomena. Seed may not sprout because it had lost its power of germination; and also because it had not yet acquired it.

For seed also lives and has its stages of life.

Here we must recall the rest period.

The existence of this period was known; it was called "after-harvest ripening." It was known that this period could last a month. Nobody suspected that it could last for the whole of six months.

Lysenko was not a bit surprised by this feature of the seed's biology. It must have been acquired by the field "spring" plants in the cold zone of the globe. How else could they have protected themselves from premature and fatal germination on fine autumn days during the "Indian summer," with its crystal-clear air and floating gossamer threads of spider webs? But these seeds, which must pass on the germs of life to the ensuing summer, to the ensuing year, do not allow themselves to be deceived by this last, brief return of warmth. Nor are they roused by thaws in the winter, or by too early spring in which Jack Frost still holds sway. The grains, bulbs and tubers, the harvest of the previous summer, wait, held back from rushing into danger by their rest period.

There is nothing mysterious in this. It is simply that the nutritive substances in them are not yet in a soluble, assimilable state. Their thick, compact husks prevent the entry of air, sometimes of air and moisture. If at least a tiny part of the husk is removed, then, in warmth and moisture, the germ's food inside will be "properly cooked."

But since there are two kinds of absence of germination, how important it is quickly to distinguish one from the other! What we have just said above enables this to be done. Take a hundred or so of the grains of the given consignment, steep them in water to make them swell, remove a fragment of the husk from the germ with a needle—if the seed is alive it will sprout at once. . . .

They are alive! The spring sowing, the sowing of a great country at war is approaching. The people cannot wait until dawdling nature slowly and hesitatingly removes the "spell" from the seeds; after all, they are of man's creation, only in his powerful hands can they become living and fruitful plants. He himself must revive them!

And so, in the first grim years of the war, under the direction of Academician T. D. Lysenko, the revival of the seemingly dead seeds was begun on a mass scale. The barns were cleared out. The seeds were spread out in thin layers on the open ground and the spring breezes swept over them.

The warmth roused them from their slumber. And when planted, the germinating ability of the seeds rose from thirty to ninety, and in many cases to a hundred per cent. This is what happened in the kolkhozes and sovkhozes in the Chelyabinsk Region, in Kazakhstan, and in Siberia.

And Lysenko, who had here entered a new sphere which nobody had explored in any detail—the biology of the seed, the life of the seed—was already musing: "Agricultural science must devise a method of compelling the seeds of weeds to sprout quickly under field conditions, after which it will be possible to destroy them easily by one or other method of soil cultivation." The biological clue to this is a deep study of the seed's rest period. "This is greatly needed for practical purposes. . . ."

It was greatly needed also because the revival of seed was not only a problem for the North. It was also a problem for the South, where summer planting had vanquished senility in potatoes. There, the problem was called: the planting of freshly-harvested tubers. But freshly-harvested tubers refuse to sprout in the same year. They have *their own* cycle of rest and development that had been worked out by the entire history of the plant's life. They "sleep" until the next year, when a new potato generation will grow from them. Methods of rousing the dormant tubers had already been devised before the war. In 1941, experimental plots planted with freshly-harvested tubers occupied a total area of five thousand hectares (in Transcaucasia and Central Asia).

The task now was to employ these methods on a much more extensive scale.

Much depended during those war years on winning the battle for potatoes. No other crop, except sugar beet, perhaps, could supply an equal amount of food and raw materials per unit of area.

. . . At that time millions of workers and office employees, armed with spades and hoes, went to allotments outside their towns; and in the towns pale-violet blossoms amidst dark-green foliage covered backyards and waste lots. The kolkhozes, sovkhozes and factory food-supply farms greatly enlarged their potato areas.

But before the land could give the country potatoes for food in the autumn, whole mountains of them had first to be put into the ground! Where were these seed potatoes to come from? The problem seemed insoluble.

But a solution was found, and an astonishing one. There was no need to use "mountains" of extra potatoes for seed. In spite of the old adage about the cake, it turned out that you can eat your potato and plant it.

Before the potatoes were peeled and put into the pot, the "tops"—small parts with an "eye," were cut off, and these "tops" proved to be excellent seed. There is scarcely anybody in our country now who is not familiar with the "tops" method of planting potatoes and has not employed it; and it can be said without exaggeration that this method provided food for millions of people during the grim years of the war.

This method was proposed by Lysenko. No, he did not merely propose it; he launched a regular campaign in its favour. He delivered speeches, wrote articles for the newspapers and wrote pamphlets and leaflets containing simple instructions on how to go about the business, so that every kolkhoznik and every housewife could distinguish the "top" (the bud end of the tuber) from the "bottom," cut the tops without wasting any of the potatoes for the pot for cooking, and store the "tops" in dry sand or earth to prevent them from rotting before planting time.

He found an army of fellow campaigners—the Young Communist Leaguers, the Young Naturalists, and thousands and thousands of school children.

Everybody could plant "tops." But Lysenko saw in this method not only "almost unlimited possibilities of increasing supplies of potato seed," but also confirmation of his own conception of the life of plants.

Nobody, as a rule, plants large-size potatoes for seed. It seems a waste to do so; and besides, what a tremendous weight of potatoes per hectare would have to be used. Even average-size potatoes are rarely used for this purpose. As everybody knows, seed potatoes are small. It makes no difference, the variety, the "gene" is the same in small and in large potatoes—so the Morganists taught.

But Lysenko did not agree with this; this business of "balancing the gene account" may apply to office bookkeeping, but not to life, he argued. Large-size potatoes are better for planting; they possess stronger reproduction power than small ones.

With the "tops" method it is possible to use this stronger "reproduction power" of large-size potatoes for seed without depriving the housewife of any of her food stocks. The "top" of a 150-gram potato "will, as a rule, produce a larger yield than a whole potato weighing 40-50 grams. . . ."

We will never forget the winter of 1941-42! The enemy had reached the heart of our country. The ring around the City of Lenin had almost closed and its heroic defence by all those who had remained in it, the story of which will never fade in history, had begun.

Enemy troops trampled the black earth of the Oryol and Kursk regions; swastika-marked tanks were tearing along the roads of the Azov coast. The black smoke from explosions enveloped Sapun Hill near heroic Sevastopol.

In that grim but glorious winter the myth about the invincibility of the Hitlerite hordes was shattered. The German divisions were shattered by the powerful blow struck by our army; the men in dirty-green greatcoats whom the "Führer" had ordered to capture Moscow were hurriedly retreating westward, or freezing amidst the firs and birches in the regions outside of Moscow. Amidst the intense frost, that was equally cruel to the enemy and to our men, our great army routed and pursued the Germans and their vassals at Tikhvin, at ancient Holm and Toropets, beyond Mozhaisk, near Yelets, and in the steppes of the Rostov Region.

In that winter the apple orchards in Ulyanovsk were frozen.

In that winter, which was even severer in the East, the experimental crops of winter wheat at the plant-beeding stations in Siberia and at the one in Chelyabinsk, and the wheat, and even rye, in the fields of the Siberian Scientific Research Institute of Grain Husbandry, in Omsk, perished.

They were experimental crops, because no variety of winter wheat yet existed that was really suitable for cold Siberia. This was not the first year that the plant breeders had been grappling with the problem of producing such varieties. They were most urgently needed, but they had not yet been created.

But why did the wheat perish?

It could not stand the cold. That seemed obvious. But the loss of the crop in the country's eastern granary was too vital a matter to allow this answer to satisfy Lysenko. It seemed to him to be too vague and indefinite.

So he began to experiment. Scores of experiments, one after another. The results were unexpected. Some of the Siberian varieties can stand a soil temperature of 26° C. below zero; nature had indeed trained them to be cold hardy. In Omsk, however, the temperature of the soil at a depth of 5 centimetres was scarcely 20° below zero. And yet the wheat perished.

It did not perish from the frost, but from the consequences of the frost—a difference like the one laughed at in the humorous Ukrainian saying: "Danila did not die; illness killed him," but a very important one for all that!

The dry, snowless windstorms raised clouds of prickly dust which bombarded and broke the frail, frozen shoots. The soil, frozen as hard as stone, cracked unevenly, and the ice crystals in the cracks tore the tender tissues of the rootlets.

The plants could survive if protection from mechanical damage could be found for them.

Lysenko advised the experimenters what to do, and again his advice was surprising, paradoxical—plant the seed in the stubble of the previous crop. The fields were not to be ploughed after the spring crop was harvested, but gone over twice, crosswise, with disc seed drills. The soil was interlaced with and held together by innumerable rootlets from the previous crop. It would not subside or crack, no ice crystals would get at the rootlets of the new crop and the tissues would remain undamaged. The life of the past would take under its protection the life that was coming to take its place.

The plant breeders are raising bread grains suitable for Siberia. They have already produced a hardy winter rye. We are expecting a good variety of genuine Siberian wheat. It is not an easy matter to produce such a variety; no wheat, neither cultivated wheat nor its forebears, wild wheat, has ever grown under such conditions. The plant breeders are re-training the most valuable of man's cereals. But while the plant breeders are completing their noble and most difficult task, there is already practically no variety of winter wheat that could not stand the Siberian winter if the proper agrotechnical measures were taken. This is what Lysenko's proposal signifies. This is why wheat is now being planted in stubble in thousands of kolkhozes in Siberia. And this is why, at the historic session of the Lenin Academy of Agricultural Sciences of the U.S.S.R. held in 1948, the sowing in stubble method was spoken of as a great discovery.

During those grim war years, when the enemy had seized the ancient granaries of our country and intended to strangle her, our people, led by great Stalin, performed what no other people had ever performed, and what to future generations will, perhaps, seem like a miracle.

At that time, in addition to other gigantic problems, our Soviet people solved the enormous problems connected with our agriculture. And in those years, each problem was like a battle front. It was a battle for bread, for the food of millions, for the life of our country.

And the soldier on these fronts, Lysenko, went where the country most loudly called him. He developed his theory further and pondered over agronomic methods and harrows. He was both a researcher and an agronomist, a field engineer; but that field stretched over millions of hectares, and so he acted as a superagronomist, or, as I would like to say—the People's Agronomist of our country.

THE HISTORY OF THE DANDELION

One day, while working on the introduction to his book, *The Theoretical Principles of Vernalization*, Lysenko summed up what had been achieved. He enumerated the major items—what we have related in these pages and what we have not managed to relate: acceleration of the field life of cereals, vernalization and summer planting of potatoes, the saving of winter crops in the winter, the deliberate selection of parent couples in crossing, a variety created in two and a half years, and "an entirely new method of seed growing. . . ." This last short phrase, in its turn, was of rich and complex content: it contained Lysenko's fundamentally important thesis that the best seeds are obtained from plots with the highest yield; and it also contained the idea that he strongly insisted on, namely, that preserving the purity of a variety does not mean preserving only its "shirt," the rough collection of its outward characters, but preserving its entire *living* substance. It also included the rejuvenation of varieties by intravarietal crossing and new, quick methods of multiplying the first handful of precious seeds—in short, that which, serving as the basis of seed-growing work since the latter half of the thirties, had indeed created "an entirely new method of seed growing."

Lysenko mentioned many other things. And he wrote that all of them were but branches growing on one stem, all were "offshoots" of the theory of phasic development.

As we know, this theory is of profound general biological significance. The knowledge of the important law of development of living beings with which it has armed science has opened for man a new field of creative work, a new field for the alteration of nature. These new potentialities ought to be described with striking words: evolution taken into human hands.

Therefore, another "offshoot" of the theory of phasic development could have been expected, this time dealing directly with the foundation of foundations of biology, with the very essence of the theory of evolution.

Darwin was alive when science in our country was already competing for first place as regards scope and depth of research in the sphere of Darwinism. A whole galaxy of splendid scientists soon raised the theory of evolution in Russian science to an immense height. K. A. Timiryazev, the brothers Kovalevsky, I. I. Mechnikov, A. N. Severtsov, M. A. Menzbir—and a host of others.

What they did was of fundamental importance for science. Their work infinitely enriched the theory of evolution itself as well as our knowledge of how the evolution of life proceeded on Earth, of how each individual organism develops, and how this individual development refracts, reflects, the long history of incalculable generations behind this tiny germ.

Actually, it was Russian scientists who introduced the evolutionary principle into all branches of the science of life.

And Soviet science—the heir to the best traditions of Russian science—wrote a most important new chapter of the world "biography" of Darwinism. Research, the deepening of the great theory of the development of living nature, has advanced with giant strides in our country.

It was in Soviet times that the late Academician Severtsov published his major, classical works.

In Soviet Land, Darwinism found a second motherland. Here it rose to a new stage and acquired unprecedented qualities. It became creative Darwinism.

Michurin science has become a fundamentally new stage in the entire development of Darwinism.

So what is there surprising in the fact that Academician T. D. Lysenko, the foremost representative of Soviet creative Darwinism, came out with his ideas about the very essence of the theory of evolution?

The ideas that Lysenko expounded on November 5, 1945, in his lecture at the improvement courses for state plant-breeding station workers, that he expounded later in his articles in *Sotsialisticheskoye Zemledelye*, and in a number of other articles and books, must, undoubtedly, have arisen in his mind much earlier. Already in 1943, the cluster sowing of kok-saghyz that he had recommended, and which he regarded as being inseverably connected with his new conception of the very ABC of Darwinism, was being widely practised; and earlier still, in 1940, his lecture on "Engels and Certain Problems of Darwinism" that he delivered at the Academy of Sciences gave all grounds for anticipating his subsequent ruthless criticism of "intraspecific competition."

Yes, the controversy raged around the question of intraspecific competition, of the mutual struggle between individuals in the same species, which authors of textbooks on Darwinism were inclined to proclaim as one of the three pillars that supported the theoretical edifice erected by the "hermit of Down."

Lysenko was simply of the opinion that there was no such thing as intraspecific competition.

A dandelion

But when we were at school, did we not, together with theorems in Euclid, study calculations which showed that one pair of elephants could fill the world with elephants in the course of seven hundred and something years, and that one dandelion plant could fill the world with dandelions in less than ten years, if all the young elephants survived and all the winged dandelion seeds sprouted? There appeared to be nothing to argue about. "Struggle for existence," was the conclusion drawn in the textbooks. Only a tiny fraction of the newborn creatures survive. The rest are destroyed in the ruthless battle of life. And the textbooks capped this with the observation: "This battle is exceptionally fierce, of course, among the individuals of the same species, for they all demand the same thing from external environment. Hence, they, first of all, come into conflict with each other."

Lysenko was perfectly well aware that in the opinion of "many (if not all) Darwinists," these arguments led with inexorable logic to intraspecific competition. Recognition of this competition was even "taken out of the brackets," as it were, assigned to the category of copybook truisms not worth rehashing. Their comforting presence behind the scenes was taken for granted as an additional guarantee of the stability of the edifice that is being erected, in the same way as an architect takes it for granted that the earth is solid, and a mathematician, that an axiom is correct.

Is not propagation in geometrical progression a fact? And, consequently, the necessity of weeding out, of selecting, among all these hordes that are striving to fill the earth? And consequently, competition within these hordes?

But in this seemingly stout chain of "consequentlies," Lysenko found the weak link.

Geometrical progression—consequently, competition within the "hordes".... Nonsense! In seven hundred years the elephants would be pressing closely side to side from the Tropics to the Hyperboreas; but meanwhile, hunters are finding it more and more difficult to find elephants even on the shores of Lake Chad.

The tacit assumption of overpopulation, of congestion (which they did not always take the trouble to find and point to in nature, but in the most cases accepted on faith, on the basis of mathematical calculations)—was not this the first weak link in the "chain"?

Lysenko enquired ironically: So, actually, the poor rabbits suffer more from each other than they do from wolves and foxes?

And how, he enquired further, does this intraspecific struggle harmonize with the theory of natural selection, with Darwin's theory itself? Does not natural selection result in the species acquiring and accumulating useful characters? In what way is the direct or indirect mutual extermination of the individuals useful for the species? Perhaps suicide is the best method of sustaining life and health?

In opposition to the arguments and observation of those who recognize the existence of an intraspecific struggle, Lysenko adduced his own arguments and facts; and they were extremely characteristic. Knowing Lysenko, one could have foreseen what they would be. They were the arguments of agrobiology, and the facts were taken from the practice of the agriculturist.

It is interesting to recall that Darwin established his theory by contrasting the armchair speculations of those who argued about the "invariability of forms" to the results of the work of men who were actually altering the living world. Today, Lysenko, in controversy with Darwin on a certain question, also bases himself on the needs, the experience of the men who cultivate the fields, and on the vast experience gained in socialist fields at that!

What is a crop, what is a good crop? After all, it is the achievement of living harmony in the fields within the particular variety of plant that is being cultivated and its harmony with the other varieties, its field neighbours, with its predecessors, and with the plants that will be planted after it. The science of crop raising is precisely the science of this living harmony.

"One can believe," says Lysenko, "that weeds, which are varieties other than wheat, for example, hinder the latter, suffocate it. But nobody will believe that sparsely-sown, and therefore weed-mixed, wheat is better off in the field than densely-sown pure wheat. . . ."

Darwin warned that "it must never be forgotten that all living organic beings strive to propagate in geometrical progression."

And yet, real, practical agriculture often has to grapple with the problem of obtaining a crop of seeds that will at least suffice for sowing. Lysenko mentions alfalfa and clover. Sometimes the land on which these have been grown has to be planted with other crops because the amount of seed collected from alfalfa and clover crops is not even equal to the amount originally sown.

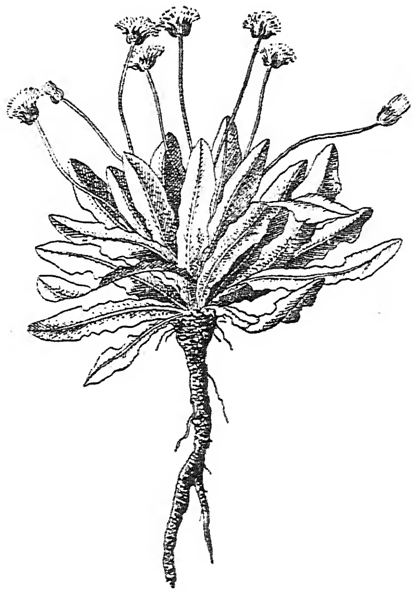
Why is this? Where is geometrical progression?

Alfalfa seeds are not aviators capable of riding the wind, and not cunning enough to take a ride in the wool or stomachs of animals, as the seeds of so many other plants are. No, they simply and modestly fall to the ground. But they fall on a thick, smooth, dark-green, sweet-smelling carpet; they do not reach the soil and cannot sprout. They are useless. Hence, as a result of many thousands of years of natural selection, the species alfalfa acquired the ability to adapt itself to the conditions of its environment. When thickly sown, it hardly ever sets seeds; every plant, in the following year, simply throws out new shoots from the roots.

But, Lysenko points out, if alfalfa, planted in the field, is thinned out, leaving small clumps, or "bouquets," each "bouquet" will set seeds.

Why do seed growers exert such effort and care forthwith to eliminate admixtures of low-yield varieties from purebred varieties of seeds? One would think there was nothing to worry about—after one or two generations the higher-yield variety, that is, the hardier one in the "struggle" between varieties, would completely oust the feeble one that had entered the fight in microscopic proportions. Isn't that so? But it is not so. The feeble admixture will multiply, grow, and eventually overpower the strong one. Every experienced seed grower knows that this is true. But why is it so?

If it were alone, the "feeble" variety would be unable to withstand the attacks of pests and disease; it would be unable to combat the weeds. But here it is completely surrounded by its strong "comrades" of the plant species, and the "admixture" begins unhindered to propagate under reliable protection. Lysenko quotes the example of the wheat Odessa 13, which is not affected by the Hessian fly, and Lutescens 062, which is; in this respect the Lutescens, which, in general, is an excellent variety, is weak. Now let us imagine that some admixture of Lutescens had got into a field planted with Odessa. There will be scarcely any Hessian flies in this "inhospitable" field, and the chances of survival for each Lutescens plant will be much greater than in its own field.



Kok-saghyz

Lysenko took his stand on the experience of seed growers, of the kolkhoz fields, of the work of millions of human hands and, with his characteristic ardour, he fiercely attacked those who challenged his claims on alleged "academic" grounds that were inimical to the interests of the people.

But what about the dandelion, that classical example of propagation in geometric progression? Very well, let us take the dandelion, but a variety that is very useful to man—kok-saghyz.

As long as kok-saghyz was sown in lines, so that the growing plants should not crowd each other, it grew badly, barely sprouted, and only a few, fluffy seeds appeared on each plant. The amount of seed collected was scarcely equal to the amount planted.

In 1943, Lysenko proposed a radical change in the method of cultivating kok-saghyz. It must be sown in clusters, he said, 100 to 200 seeds in each cluster (even 200 to 300 if the supply is plentiful).

Two hundred seeds to the cluster—what congestion there must be there! But this did not daunt Lysenko. He argued as follows.

Kok-saghyz is an inhabitant of the thicket, it is a "cellar dweller." To plant it alone in the sun and wind, carefully to smooth its leaves and walk on tiptoe around it to break up the soil and not allow even a blade of grass to remain near it, would be a disservice to it.

When planted in clusters, however, a bunch of buds will spring up, a cap of kok-saghyz leaves clinging closely to each other, rather long, and smoother-edged than our ordinary dandelion. The small thicket will rise out of the cluster, and its mortal enemy, the weeds, will be unable to get at it. The soil underneath is more moist, and the dew remains in its depths until midday—it has its own microclimate. . . .

The cluster sowing of kok-saghyz has been practised for a number of years already, and Lysenko considers that he has a right to draw the conclusion: "in this case, the question of intraspecific competition does not exist for agricultural practice."

The cluster-sowing method rapidly spread throughout the country and, as the textbooks on plant breeding say, has become the chief method of growing kok-saghyz.

The cluster-sowing method has resulted in an increase in yield (taking the returns of the plantations on which this method is employed on a large scale) not of "so much per cent," but of several hundred per cent.

Formerly, the average yield of kok-saghyz root (for the sake of the milky sap of which this plant is cultivated) did not exceed 4-5 centners per hectare. Before the war, the kolkhozniks in the Sumy Region harvested an average of 13.9 centners per hectare, and in one district in the Kiev Region 16.5 centners. This was regarded as a record, and bigger yields were obtained only in very small plots.

But today, in the postwar period, the kolkhozes that have adopted the cluster-sowing method are harvesting 20 and 30 centners of roots per hectare. Crops of 40-50 centners per hectare are not rare, and scores of kolkhozes have achieved the record of 100 centners and over.

That is how the turning point in the history of the dandelion was reached.

We have no plantations of the notorious hevea in our country, but we can already say that the time is coming when the "natural rubber problem" will no longer confront us. Our own plantations of the humble dandelion will provide us with all the rubber we need. And rubber of excellent quality, second to none in the world.

Rubber growers have worked out a harmonious combination of measures for the cultivation of kok-saghyz. The tending of the plants begins even before they are born—with the preparation of the soil on which they are to grow; and this preparation is conducted with exceptional attention and care. Deep ploughing: where the stratum of ploughing soil is thin, it is gradually thickened. The soil must be rich in food for the roots, and so plenty of manure, or peat, is "ploughed in."

Most often the seeds are planted in the spring, but autumn planting is not rare. When the planting is done in the spring, it is first of all necessary to waken the seeds; for, as is the case with the majority of wild plants, they have long been immersed in deep slumber; only in a hot summer would they sprout well of their own accord. The seeds are therefore moistened and kept moist from three to three and a half weeks at the temperature of thawing ice; this is called "stratification." The shoots then spring up within ten to fourteen days after the seeds are planted.

But before planting the seeds the planters go out into the fields again. The soil has to be harrowed or rolled with a disc harrow, for when sown, the tiny, capricious seeds will be covered only by a very thin layer of soil, a centimetre, or one and a half, which can easily harden into a dry crust, and this danger must be averted before the seeds are put into the ground.

Usually, the fertilizer (humus) is put in simultaneously with the seeds, and after planting, the clusters are again sprinkled with humus.

Soon, the black, soft earth is dotted with small, green spots—tiny pairs of egg-shaped seed leaf lobules. Now, special care must be taken to prevent these feeble, helpless and slow-growing shoots from being strangled by weeds.

When three or four leaves have appeared in the plantlets they must be given extra nutriment in the shape of nitrogen, phosphorus and potassium. This has to be done again and again; and the soil between the clusters, or rows, must be closely watched: it must in proper time be weeded, hoed and gone over with a horse-drawn cultivator. In the southern regions, in Kazakhstan, say, the fields must be plentifully watered ten to twelve times in the course of the summer.

In short, the soil must be of the best, and the plants must receive continuous attention.

Thus, to get all the wealth kok-saghyz can give, a very high level of agricultural technique must be employed; and this can be done only on collective farms, in the kolkhozes; previous attempts of individual peasants to grow kok-saghyz ended in failure. It is no accident that the cultivation of kok-saghyz on a mass scale developed after the Soviet countryside had been collectivized. And it is only in our country that the discovery of kok-saghyz could become a world-important discovery of a new and immense source of natural rubber.

What persistent efforts have been made abroad too to find such sources to supplement or supplant hevea! The celebrated Edison pointed to the golden-rod (a relative of the dandelion); later, the Mexican shrub guayule, which, incidentally, is cultivated in our country too, became known. But what is obtained from the few plantations of these rubber-bearing plants abroad cannot stand comparison with the achievements of our kolkhozniks. So immense are these achievements that even abroad, particularly in the United States — even the possessors of hevea—eyes gleam longingly, as much as to say: if only we could get some of that Soviet dandelion!

It is now obvious to everybody that we are revolutionizing the cultivation of natural rubber. There seems to be nothing secret about our "secret," but for all that, in spite of all efforts, nobody in the United States, or in any other country, can get anywhere near to our present rubber-plant yields.

The chief "secret" here is the socialist, collectivized countryside.

Often our kolkhozniks harvest the kok-saghyz crop in the very first year, but sometimes it is left over to the second year. This is done mainly for the purpose of obtaining seed; in the second year the kok-saghyz flowers more profusely. Incidentally, facts go to show that with cluster sowing the kok-saghyz "seed problem" can well be solved on one-year plantations.

The plant breeders have "taken in hand" the recently wild dandelion; they are altering it, creating new varieties, still richer in rubber. Researchers and practical plant breeders are almost continuously improving the methods of cultivating it.

Not long ago Lysenko proposed that kok-saghyz be grown not only from seeds, but also from cuttings taken from the roots. The cuttings are planted in clusters. The plants that grow from these cuttings acquire branching roots containing about one and a half times as much rubber as the ordinary roots. This is an extremely important innovation, which, as Academician I. V. Yakushkin, one of our most celebrated plant breeders, said, "in two or three years should revolutionize the cultivation of rubber-bearing plants."

Every year our advanced practical agriculturists make real discoveries in the cultivation of kok-saghyz. For example, in 1939, A. A. Parmuzina, Hero of Socialist Labour, a woman kolkhoznik in Sumy, harvested 71.3 centners of roots per hectare, but in 1945 she harvested 132 centners per hectare. Y. S. Hobta, Hero of Socialist Labour, a kolkhoznik in the Kiev Region and one of the most remarkable women in the Ukraine, regularly harvests 100 centners of roots per hectare. And there are hundreds of other highly skilled kok-saghyz growers in the Ukraine, in Byelorussia, in the Oryol and Vladimir regions, in Kazakhstan and near Leningrad.

How short and yet amazing is the history of man's friendship with the wonderful dandelion!

It was only in 1931 that science first learned of its existence, that it was first described and given its botanical name.

At that time the research party headed by the botanist L. E. Rodin found kok-saghyz in Eastern Tian Shan, on the frontiers of mountainous China. It grew only in three valleys: the Kegen, Sara-Jass and the Tekess; all three valleys are situated at very high altitudes—from 1,800 to 2,100 metres above sea level, and all three were isolated from the world and from each other. There, hidden in the grass and thickets, grew the tiny yellow flower heads of kok-saghyz, an ancient "relic," as the botanists say, of the Ice Age, which found its last refuge behind the impregnable walls of Tien Shan.

Our Soviet explorers found this plant, saved it from extinction, perhaps, and again opened for it a wide road into the world, on the condition, however, that it serve man.

* * *

But what about the dispute over the intraspecific struggle?

It must be said that there is much that is faulty in Darwin's term "struggle for existence." It is a figurative expression and, moreover, has a good half a score of meanings; to take it literally would be a mistake.

K. A. Timiryazev used to say that although he had expounded, propagated and lectured to students on Darwinism for tens of years, he had not once uttered the "unfortunate expression" "struggle for existence."

This applies still more to the term "intraspecific struggle."

Ninety years ago there lived not only the great scientist Charles Darwin, but also the simple English gentleman Charles Darwin, aged and ailing, living, in the reign of Queen Victoria, in the secluded village of Down, in the County of Kent.

This gentleman was not free from the prejudices of the English bourgeois society in which he lived. He read the book by the parson Malthus *An Essay on the Principle of Population*, in which it was argued that the human population increases in geometrical progression, whereas the means of subsistence increase in arithmetical progression and, therefore, distress and poverty among the masses are an inevitable consequence of the operation of the laws of nature. It is different with animals, sighed Malthus; their numbers do not increase in geometrical progression. Lacking confidence in his ability to console the hungry with his plea of "the laws of nature," parson Malthus cravenly and crossly advised that these turbulent and ungrateful masses be compelled to take their cue from the animals and stop breeding so fast.

Charles Darwin, the gentleman, read this cunning but nonsensical book and imagined that, in speaking of geometrical progression in the procreation and overpopulation of animals and plants, he was applying the concept invented by Malthus, who actually had set up as an example to man, animals which knew not overpopulation. And Darwin, the by no means fearless researcher, but reader of Malthus' book, endowed living nature with some of the features of "proud Albion," with her bickering of merchants and manufacturers, avaricious quest for markets, and frightful slums where the poor lived.

It is well known that this did not escape the keen eyes of the English naturalist's great contemporaries, Marx and Engels. Marx thought it amusing that Darwin should have reproduced among the animals and plants English class society with its competition and "war of all against all," which the philosopher Hobbes rightly perceived in this society. And Engels thought it "absolutely childish to desire to sum up the whole manifold wealth of historical evolution and complexity in the meagre and one-sided phrase 'struggle for existence.' That says less than nothing."*

We know also that, with his friend Charles Lyell, Charles

* Frederick Engels, *Dialectics of Nature*, International Publishers, New York 1940, p. 208.

Darwin shared the current belief of the society he lived in that everything in the world was arranged without rough jolts and shocks, and that everything proceeded, and would continue to proceed, "as it is doing now." Both friends repeated the statement of the idealist philosopher Leibnitz: "nature does not leap"; and the impress of this fallacy was left on *The Principles of Geology* and also on that great book *The Origin of Species.*

No, not everything written by Darwin is as infallible as the multiplication table, not by a long way.

That the interconnections in the living world are far more complex than straight-line "struggle" is obvious truth to present-day science.

Lysenko, therefore, has all grounds for insisting that all the antagonisms between organisms should not be thrown into one heap. Of course, there are antagonisms between individuals in the same species; if this were not so the species would stagnate, they would not develop. These antagonisms must be studied; but they must not be confused with the antagonisms between species. Surely, the antagonism between hares and wolves ought to be distinguished from the disagreements among the hares themselves!

It is beyond doubt that the facts adduced by Lysenko, we would even say whole spheres of facts, are compelling Darwinist theoreticians to re-examine many questions concerning the place and role of "struggle" in the living world.

It is beyond dispute that overpopulation is far more rare in the living world than examples showing "geometrical progression" would lead one to suppose. The millions of fish spawn and seeds from trees barely suffice to maintain the previous numbers of their species. The old naturalists Wallace and Bates, who travelled in the tropics in Darwin's time, noted that it was much easier for them to find ten new species of insects than at least two specimens of the same species. And present-day ecologists are well aware of this rarity of real overpopulation.

It is beyond dispute that besides struggle in living nature there is mutual aid, mutually beneficial coexistence, and that activity of living organisms in their environment without which the appearance and existence of innumerable other organisms would be impossible. "The interaction of . . . living bodies includes conscious and unconscious cooperation equally with conscious and unconscious struggle," writes Engels in *Dialectics of Nature*.

And lastly, it is beyond dispute that if a "species" is not an imaginary, conventional concept of ours, but a reality created by natural selection (after all, natural selection operates for the benefit of a species), then the relations between the individuals of the species should be qualitatively different from the relations between the individuals of different species. Every attentive observer of nature sees this constantly around him.

But our object in this chapter was not to go deeply into the subtleties of these complex questions, but to tell the wonderful, man-made history of the wonderful dandelion.

LYSENKO

This was in the summer of 1938. The Supreme Soviet of the U.S.S.R. was in session. Late one night I went to pay a visit to the Vice-Chairman of the Soviet of the Union. Lysenko had not yet permanently settled in Moscow and had arrived from Odessa.

We went down into the garden. At this hour the noises of the street were no longer heard. In the light of an electric bulb the golden-glows growing near the brick garden wall looked as if they had been cut out of paper. Under them Lysenko had planted potatoes.

"The Morganists say that I deny genetics," said Lysenko. "That is not true. Genetics is the science of heredity and variability. I do not deny it. I fight for genetics. My institute in Odessa is called the Institute of Selection and Genetics. What we deny is their absolutely invariable 'three to one.' And we deny their 'bits of heredity.' "

He smoked a great deal, and spoke with a marked Ukrainian accent, with the southern pronunciation of "g" like "h." And again, as was always the case whenever I met Lysenko, I was overcome by the strange, irresistible feeling that the man sitting on the bench next to me in this garden was bubbling internally in an extraordinary way, as if he were constantly living under higher pressure than other men. I have had occasion to meet other scientists who are enthusiastic over their work and discoveries. About such men it is said: "They are completely taken up with their work." But in the case of Lysenko, this lightly used expression applied in the literal sense, so much so, that the term "enthusiastic" sounded feeble. It was as if some concentrated power had caught and possessed him.

Lysenko said: "One must work. One must argue with work—not with empty words. About Kooperatorka and 'defenders' of Darwin. Darwin, they say—I mean the Morganists—taught that under all conditions variability proceeds indiscriminately in all directions. It proceeds in the same way in every environment. Therefore, according to them, the directed alteration of organisms is impossible. What they don't understand is: What variability is there in the desert? Desert variability. What variability is there in a bog? Bog variability."

This simply-expressed thought about variability astonished me at the time. What Lysenko denied was a widely current academic interpretation of Darwinism, namely, that the variability of an organism has no direct connection with external conditions; that there was nothing in common between variability as such and the future evolution of the descendants of a given animal or plant; that any cereal may accidentally give rise to a slightly more wintery variety or to a slightly more springy variety, irrespective of where it grew; that natural selection, the struggle for life, will give the advantage to the winter variety in cold places and to the spring variety in warm places.

The textbooks of that time failed to note the fallacy of this idea of variability being dependent on mere chance, and the living organism was, as it were, torn to pieces: variability in one box, evolution in another, with only the frail bridge of selection between them.

But here, in ordinary conversation, in passing, as if it were something self-evident, Lysenko showed that life is not distributed in boxes, and that the organism cannot be torn out of nature which had given it birth. There is one life and not particles of life; and there is a deeper, more complex and vital connection between variability and evolution. We are not discussing lifeless bodies, not anatomical preparations, but things of flesh and blood that live in the world and not in a vacuum!

That is what Lysenko's simple retort meant. In it I discerned a wonderful feeling for the theory of evolution—I cannot express it otherwise. It was as if the man who had uttered it had a compass inside him which unerringly indicated to him the true meaning of this great theory. To be able to judge it in this way one must not receive it from outside, not learn it from books, but feel it inwardly.

It was long past midnight. One after another, the lights in the windows went out. The clicking of the garden gate as the belated inhabitants of the house arrived ceased. We were alone in the garden. Lysenko could talk without end about the subject that absorbed his whole life, but I knew that next morning he had to be in the Kremlin, where the foremost people in the Soviet Union were deciding the affairs of our country, so I took my leave.

October 1939. A large hall in the centre of Moscow was filled to overflowing. Crowds pressed round the entrance doors, waiting for hours in the hope of being able to procure a ticket, or of slipping past the doorkeepers and getting into the hall. Of people coming out of the hall they enquired eagerly: "Did you see? Did you hear? Has he spoken already? Has he demonstrated his specimens?"

What had drawn all these people to this place?

The printed invitations had prosaically announced a conference on "problems of genetics and plant breeding." And if anything was demonstrated, it was just ordinary fowls, which, taking advantage of this first opportunity in the history of the feathered race to address such a distinguished audience from a platform, filled the hall with their cackling. Yes, and potato and tomato plants in pots were carefully placed on the red cloth-covered presiding board's table as if they were precious orchids, until finally the table looked like a stand at an agricultural exhibition.

But why had not only plant breeders and geneticists, but people engaged in the most diverse departments of biology, and not only biologists, but philosophers, medical men and writers, gathered in this hall? And for a whole week watched the proceedings with concentrated attention? Why was a conference on narrow and seemingly very special problems of agricultural science taking place in the hall of one of the biggest philosophical institutes in Moscow, to which many had come from other cities?

The answer is very simple. This was a contest between two trends in biology, and the issue concerned the fundamental principles of our conception of living phenomena.

It so happened that on the first day of the conference the Michurinists occupied the seats on the left side of the hall, the Morganists with all their supporters occupied those on the right, while the centre seats were taken by the "cautious" waverers, whom some wit in the hall at once rightly dubbed the "marsh."

An eminent geneticist, a member of the Academy of Sciences, took part in the debate. To back his arguments he quoted from hefty tomes printed in different languages; the gloss of the paper as he turned the pages could be seen even in the back rows. According to these authorities there was no other science of genetics in the world except that expounded by prior Mendel, the American Thomas Hunt Morgan, and the Dane Johannsen who, thirty-six years ago, had "proved" that selection was powerless in "pure lines," that no alterations occurred in "pure varieties," and that it is impossible to create anything new.

"And yet," said the speaker with a note of chagrin in his voice, "neither Academician Lysenko, nor, as we have heard, Academician Keller, agree with this."

Many other speakers had expressed disagreement with this, but evidently the eminent geneticist regarded only academicians like himself as worthy opponents. In this he, in a way, copied Napoleon, who in moments of anger sometimes addressed dumbfounded prefects and shy foreign diplomats as "General," for he could not conceive of anybody of lower rank than a general daring to come before him.

TROFIM DENISOVICH LYSENKO

The academician's place in the rostrum was taken by a professor—a tall, thin man with a fine head of silvery hair.

He spoke slowly and distinctly, in a condescending tone, pronouncing each word separately, and bowing with each word he uttered as if afraid it would break in falling from the extraordinary height of his lips. Ironically imitating the manner of a schoolteacher, he gave an elementary exposition of the trite maxims of formal genetics. What was all the fuss about? Plants are of the spring variety because they possess the spring gene, and they are of the winter variety because they possess the winter gene.

He was followed by a sheep breeder from the South, who said:

"There are no two conflicting groups. All the advanced Soviet scientists side with Lysenko."

"Let us return to our muttons!" somebody on the "right" shouted sarcastically.

But the sheep breeder continued unperturbed:

"There are no two groups. There is a small, obsolescent group of Morganist geneticists."

When the pots with the potato and tomato plants had filled the whole platform, the young enthusiast Avakian, one of Lysenko's assistants, explained:

"These are vegetative hybrids."

"Incubuses and succubuses!" interjected the tall, silvery-haired professor from his seat, wishing to show thereby that he believed no more in the possibility of vegetative hybrids than he believed in the existence of these hellish personages taken from the demonology of the Middle Ages.

Then Lysenko mounted the rostrum.

His speech was entirely different from the rest. It was like a flood let loose. He did not give his auditors a moment's respite. His was not a modulated speech, with pauses during which the tension is relieved by a smile, or by laughter in the hall.

He spoke of the enormous responsibility to the country borne by plant breeders and agrobiologists. They were entrusted with the science of the procreation of the plant that provided man's daily bread. Much was demanded of them. They were constantly being asked: how much have you done? Can you grow two ears where one grew before? The country is waiting! This must be understood and always remembered. *The people are waiting!*

"I would not have entered into controversy with the late lamented Johannsen and Mendel, I have no relation with them; but life compels me to do so."

He denied that there were any "Lysenkoites." There were Michurinists; there was the great Michurin science.

He then went on to deal, point by point, with the questions around which the fight in that hall had been raging for seven days.

An order had been sent out not to plant one variety of rye nearer than a kilometre from another. That order was backed by the whole of Morganist "classical" ("of the bourgeois class, that is," punned Lysenko without a smile), genetics. Do what you like, but find that kilometre, otherwise, you'll be prosecuted.

"I did not sleep whole nights, wondering whether this was right.

"White and red poppies grow side by side. Nobody troubles to put 'zones' between them. Nevertheless, the white poppies produce white offspring and the red ones red. Does not this show that no zones are needed? Does it not show that with free pollination the plant *chooses* its pollen and does not cross indiscriminately?"

That is how Lysenko expounded his idea of "marriage for love" in the plant world.

The country is demanding that the Far East should grow all the bread grains it needs. Winter-hardy varieties of rye and wheat must be produced at the earliest date. Who will do this? The Morganists? Those who teach that we must wait years for some kind of accidental segregation?

He spoke very bluntly:

"They do not even know how to approach the problem of cold hardiness! They have no inkling of what it is!"

Lysenko pointed to the exhibits of potato and tomato plants that filled the platform and explained his experiments in asexual hybridization—the very thing that his opponents most furiously denied.

"We started on vegetative hybridization two years ago, and we now have in our country more vegetative hybrids than there have ever been in the whole world. I don't know whether this hall could hold all the people who would come here with vegetative hybrids if they were invited."

Two-storey stems stood in the pots with their abundant foliage: white potato on blue, red on white, eggplant on potato, tomatoes ripening on nightshade, a stout pepper plant lending its shoulders to support a giant tomato. . . .

Lysenko turned and pointed to the exhibits on the platform with a gesture of silent triumph.

Already at that time, before the war, it was quite evident on whose side truth was in this controversy. In an article in a youth magazine this was formulated as follows:

"Two trends are in conflict: the old and the new.

"One trend looks back and worships the past; the other trend is seeking the road that leads forward.

"One argues that man is impotent in face of 'hereditary characters,' the other is convinced of the unlimited power of human knowledge.

"One tears the living organism into two parts: the 'germ' and the 'body'; the other says that the living being is not a pack of cards to be shuffled, and not a stuffed pie.

"One asserts that there is an insurmountable wall between hereditary and nonhereditary alterations; the other believes that many of the nonhereditary alterations can become hereditary, and it is within the power of man to make them so.

"One is convinced that nature is meagre and monotonous, and that it is possible from a single laboratory-bred fly to form a judgment about all the animals and plants in the world; the other knows that the creative diversity of nature is infinite, and that to acquire real power over nature it is necessary to study real life and not schemes drawn up in the study."*

But for years the Weismann-Morganists, repeating the platitudes of the most reactionary theory propounded by bourgeois biology, furiously defended their positions, which were hopeless in Soviet science and had been condemned by the people.

The gaunt hand of the dead clutched at the living. But the ranks of the Morganists grew thinner and thinner. Convinced by the obvious, many scientists announced their abandonment of formal genetics. In the colleges, the students deserted their Mendelist "teachers."

The Mendelists, however, kept on repeating despondently what everybody was already tired of hearing:

"Lysenko is annihilating genetics."

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* *Smena*, No. 1, 1941.

They would have liked to say "Michurinists," but they also wanted to drive a wedge between Michurin and Lysenko on the lines of the ancient motto: "divide and . . ."

One day (this was in 1936) Lysenko, rebutting this charge, said in his characteristically picturesque language in which the humour of the Ukrainian people is peculiarly reflected:

"If a man denies bits of temperature, does that mean that he denies the existence of temperature?"

Lysenko says:

"I am not a lover of debating for debating's sake on theoretical questions. I enter into debate" ("and into heated debate," he takes care to add), "only when I see that in order to carry out certain practical tasks it is necessary for me to remove obstacles in the path of my scientific activities."

He never forgets that these "practical tasks" are: bread for the country, food for the millions. How can one crack jokes and stand on ceremony when *this* is being grappled with? "Ivan Petrovich is studying a certain problem and is arriving at a very interesting conclusion; but I hold a different opinion. . . ." says Lysenko, mockingly impersonating an "opponent" in an academically polite debate.

He likes common sense, by which the wisdom of the common people is guided. With a sly smile he says: "We know that in science we cannot always be guided by common sense, but it is not wise to go against common sense; if you do, you will lose your own common sense."

He speaks with withering scorn of the Morganists who assert that "heredity" lies in the organism's body, but it is not itself a body; and that "the entire organism, down to its last molecule, that is to say, its entire phenotype, can be altered, but the genotype (the very same organism) remains entirely unaltered!"

In geneticist terminology, phenotype is the body as such; genotype is hereditary nature.

The idea of the "renovation of varieties," of free intravarietal crossing, "marriage for love," was suggested to Lysenko not only by the white and red poppies growing in the same field without losing purity of breed, without becoming pink, but also by the simple fact that children in the same family resemble each other more than their parents resemble each other. Hence, their offspring will, of course, be strong and evened out, and will not perish in the chaos of segregations!

He believes in the power of life, that a healthy organism stands firm and cannot be thrown over by a slight push. Strange to relate, those who assert that the hereditary substance is impregnable and that man is impotent in face of nature, are just the ones who have no faith in life and are constantly afraid that it will be extinguished by the slightest breath of wind.

In the eyes of the people, human labour is sacred and worthy of the highest respect. The people are never contemptuous towards one who works, and towards what has been made by human hands.

Well, Lysenko, the son, grandson and great-grandson of people who had grown grain with their own hands, a citizen of the country where labour has been proclaimed a matter of honour, glory, valour and heroism, reads the supercilious observations of Muller, who describes all the horticulturists, stockbreeders and agronomists, all the men and women who have created our plants, our livestock, our poultry and our domestic animals—the friends of and second nature around man—as ignoramuses!

In these observations Lysenko discerns the contempt of the scientist-aristocrat towards what he regards as the rough, unskilled labour of mankind.

Barely able to restrain his anger, Lysenko exclaims: "What, the labour of man the creator is senseless and useless?!"

He repeats over and over again: "Good, high-standard agrotechnique and zootechnique cultivate plant varieties and animal breeds, whereas bad agrotechnique or zootechnique worsen and spoil already existing good plant varieties and animal breeds."

In his own scientific activities he feels himself in constant contact with the experience of the kolkhoznik leaders in agriculture, of the Heroes of Socialist Labour; for it is they who have created a standard of agrotechnique that has no equal in the world.

During the controversy over the question of the renovation of varieties by means of intravarietal crossing, a certain "opponent," Professor Vakar, plucked the stamens from the plants growing on small experimental plots and later hastened to publish the announcement that no seed setting had resulted from the "love marriages," from the pollen of different plants. Lysenko hurled himself upon this "opponent" with the passionate rejoinder: "What do we care, Professor Vakar, that in your hands this method produced bad results, when in two thousand kolkhozes, 80 to 90 per cent of castrated flowers produced seeds? That is far more important!"

The science that he champions always has a definite purpose, which is pursued to the utmost; I would like to say: to *white heat*, in order to show the exceptional quality of this science.

In 1947, Lysenko, in an address he delivered at a meeting of Moscow writers, said:

"Your work will be fruitful if you make your analysis from the viewpoint of synthesis. Otherwise, you may analyze a thing for a hundred years and fail to analyze the aspect that is needed."

He spoke of the responsibility scientists bore, and recalled the planting of potato tops. He confessed that he did not easily, not at once, find the "point" on which "to rest" his lever. Yes, a piece of a tuber can serve as a substitute for a whole tuber for planting. But how were the tops to be stored in the winter? He did not know, and could not find the answer for a long time. Had he brushed this question aside and had communicated his new method of planting potatoes to the country without solving this problem, the very first winter would, perhaps, have killed the whole thing.

But the new method had to be communicated to the country.

Numerous experiments were performed.

There is always a risk when undertaking a new job; but it is your duty to undertake new jobs. That is your business. Do it in such a way that even if it fails, "let the failure be yours alone and not that of production!"

In an ardent speech he delivered in a crowded hall at the Moscow Polytechnical Museum he said: "I have not undertaken to re-educate scientists. Don't undertake to teach scientists. The scientist must teach himself, he must go on learning to the very end of his days—I know that myself. . . ."

And he added:

"A scientist must convince himself and not wait until others convince him."

A man who has done a great deal, who has greatly expanded the limits of the ordinary "budget of life," nevertheless feels the pressure of time with exceptional acuteness. "How long, on the average, can a plant breeder work? Usually, he graduates from the institute at the age of thirty. He is allowed some time after graduation to gain practical experience. . . . And so he reaches the age of thirty-five. Well, how many years can he work? Until the age of fifty, or sixty; a few lucky ones go on to eighty or ninety. . . . In other words, it can be said that for real work the plant breeder has fifteen vegetative periods. The plant breeder can plant his field fifteen times. . . ."

This makes you realize that the struggle Academician Bogomolets waged to prolong human life to the age of 150 was not a struggle to achieve a "luxury," but to achieve the span of life that the creative worker in a free human society actually needs!

Lysenko never forgets that the object on which he is working is not a scheme, not an algebraic sign, but a living organism. The formal geneticists want to reduce all living beings to definite characters, and they regard this as proof of the exceptional subtlety of their methods. "Yellow peas, green peas." A character! What are similar characters and different characters? Where a "Mendelist," casting a bored glance at two plants, mutters indifferently: "complete identity!" Michurin and Burbank saw hundreds of divergencies! "There are no two organisms in the world that have any single character absolutely alike."

To Lysenko it is obvious that "the practical work of the sovkhozes and kolkhozes calls for far more subtle methods than the most subtle methods employed by the present-day Morganist school of genetics. The latter are so crude that they cannot be employed in practical work."

The Morganists "count chromosomes, alter chromosomes by means of various influences, then break them into pieces, transfer a piece of chromosome from one end to another, hook a piece of one chromosome on to another. . . ." This is as suitable for the execution of the practical tasks of agriculture "as the work of a lumberjack is for a wood turner's shop."

Lysenko relates the following:

"In Michurin's orchard I saw two mountain ash trees: an ordinary one, and one grown by Michurin. The one bred by Michurin did not seem to be in any way different from the ordinary one. When, however, you taste the fruit of the ordinary one it is sour, but the fruit of the Michurin tree is quite eatable. An enormous difference, a practical difference. . . ." Chromosomes cannot tell you anything about it. "I am convinced that neither today nor in ten years' time will it be possible to distinguish between these two mountain ash trees with the aid of the chromosome apparatus. . . . And yet, the *slightest* difference in the hereditary basis, having nothing in common with breaking chromosomes, with hooking one piece on to another, etc., is very important for practical work, for the people whose duty it is to create new varieties of plant organisms."

The Morganists, comparing the "shirt" of a variety with their variety description cards, sometimes imagine that the variety over which they keep vigilant guard is still before them in its entirety, in complete conformity with Johannsen's theory; but actually, nothing has remained of the variety, its entire, most precious living essence has vanished. And the "guardians" clutch their heads and ask themselves in wonder: "How could we have overlooked this?"

"Learn how to alter the type of metabolism of the living body and you will alter heredity," asserts Lysenko.

This can happen in an entire organism as well as in separate sections of the body (in plants)—with *one* branch, bud, or eye of a potato. Usually, "bud variations" did not affect the offspring. "So you see," commented the Morganists profoundly, "a wide gulf separates this from the mutation of the hereditary substance!"

But there is no gulf. The offspring come, not from these altered parts of the parent body, but from the unaltered parts. If this were not so, the offspring would be altered. It would undergo alteration if the substances produced by the altered section abundantly flowed into the parent organism and thereby compelled an alteration of its metabolism. We already know that it is precisely this course of events that gives rise to grafted hybrids. "The degree of hereditary transmission of alterations depends on the extent to which the substances of the altered section of the body join in the general process which leads to the formation of reproductive sex or vegetative cells."

All the Morganists denounced Lysenko's views as paradoxical and heretical. Actually, these views are closely connected with a great biological tradition—with the views of Darwin, Timiryazev, V. O. Kovalevsky and Michurin, of the coryphaei of Russian soil science Dokuchayev, Kostychev and Williams.

To the deep chagrin of the Freiburg destroyer of mouse-tails, Lysenko asserts that the organism and its environment, the conditions of its life, its development, which take part in its formation, all constitute an integral whole. "Unheard of!" exclaim the Weismannists.

They ought to have addressed this remark to that classic of world physiology, Ivan Mikhailovich Sechenov; because it was he, as far back as 1861, who wrote: "An organism without the external environment which maintains its existence is impossible, therefore, the scientific definition of an organism must include the environment which influences it. . . ."

It is not the Michurin theory but the false Weismann-Mendel-Morgan theory that has no traditions in science.

Why does bourgeois science so frantically deny all the achievements connected with Michurin science?

Lysenko knows that it is far from being only a matter of disagreements among scientists. More than once has he written and spoken about the special place that has fallen to the lot of biology among the other natural sciences in the capitalist world. Biology is the science of life, and man is also a living being. Biology directly concerns human beings—white and coloured, exploiters and exploited. It directly concerns the question of the nature of the living being—the body and the mind, life and death, matter and spirit. Biology takes a direct part in the struggle between materialism and idealism—between human reason and the "black-coated army" of priests and ministers of all religions. Biology, and the deductions of science concerning life, are related not to the indirect, the subsidiary aspects of man's conception of the universe, but to the *fundamental* question of all philosophy, namely—what is primary in the universe, matter (as is proved by materialism), or the spirit (as the idealists claim)?

And those who control the ideological levers in capitalist society, the inspirers and organizers of the political and ideological doping of the masses, cannot permit the free development of biology.

Darwin's theory was put in the prisoner's dock.

Darwin was also a bourgeois scientist—but he lived in a different, the better period of the development of the bourgeoisie. At the present time the Soviet science of life, the most daring and most consistently materialist, is the object of the hatred and enmity of the present-day ideological leaders of those who control the development of science in Washington and New York, in London and Oxford, etc.

The struggle they are waging against Soviet science is a struggle, dictated by fear and hatred, against the invincible ideas of Socialism, against our great people, against our country.

And for this struggle they are mobilizing biology.

Thus, politics invade biology and become interwoven with it.

But does not science in its progress meet with objective criteria which must inevitably compel the rejection of the shell of error and allow truth to triumph?

We know that the criterion of truth is practice; it is a powerful and unquestionable criterion. In technology and military affairs, everything is clear. If a false theory of calculation for wings and fuselage is adopted—the airplane must crash; a badly-designed tank will not budge; a skyscraper wrongly planned will collapse before it reaches the tenth storey.

The real criterion of the truth of the science of life is the living practice of man, the transformer of nature. Who in the capitalist world eagerly waits for, urgently calls for the deductions, the ideas and proposals of science and immediately puts them to a searching test on millions of acres? What farming is like in America we have read about in *Grapes of Wrath*. Theory is divorced from practice. In the capitalist world, biology gropes in the dark, at least to a very large extent; it may reach its goal eventually, but it will take a very long time.

Lysenko quotes Timiryazev: "In 1900, first in Germany and then, louder still, in England, the name of Mendel began to be highly praised and an importance was attached to his work totally out of proportion to its content. Obviously, the cause of this unscientific phenomenon must be sought in circumstances of an unscientific order. . . . In England this reaction arose exclusively on clerical soil. When Bateson's own attack, not only on Darwin, but on the theory of evolution in general, . . . had passed unnoticed, he gleefully clutched at Mendelism. . . . In Germany, the anti-Darwinist movement developed not only on clerical soil; it found even stronger support in an outburst of narrow nationalism, of hatred of everything English and the exaltation of everything German. . . . Whereas the clerical Bateson took special care to clear Mendel of every suspicion of being of Jewish origin (an attitude that only recently had been inconceivable in an educated Englishman), to the German biographer he was exceptionally dear as 'ein Deutscher von echtem Schrot und Korn.'* The future historian will probably note with regret this incursion of the clerical and nationalist element into the most important sphere of human activity, the sole object of which is to reveal the truth and to protect it from unworthy dross."

In an address he delivered at the Academy of Sciences in 1940 Lysenko said that in agrobiology we had no reason to keep in step with Western Europe or America, because we are advancing, and he added: "They have no Michurin theory there, and this is not because they have no scientists of talent. They have had distinguished men there, and have them now; but they have not the conditions that we have for the display and development of talent. They had that genius in biology Burbank, but there is no Burbank theory, although there might have been."

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* A true-blooded German.

Concerning his own future as a Soviet scientist, he speaks in the following terms:

"In our Soviet Union men and women are not born: organisms are born, but men and women are made—tractor drivers, motor drivers, mechanics, academicians, scientists. I was not born a man, I was made a man. And to feel that you are living in such an environment is more than being happy."

He said this at the Second Congress of Kolkhoz Shock Workers in Moscow.

He repeated the same idea in an election speech he delivered when he was standing as a candidate for the Supreme Soviet of the U.S.S.R.

"I am often asked who my parents are. And I usually answer: peasants, since 1929, kolkhozniks. But actually, I have other parents: the Communist Party, the Soviet Government, the kolkhozes. They brought me up and made a real man of me.

"What is vernalization? It would not have existed had there been no kolkhozes and sovkhozes. And had there been no Soviet government, I would certainly not have been engaged in scientific work."

THE VICTOR GENERATION

> But sometimes it is not well-known men of science who lay the new roads for science and technology, but men entirely unknown in the scientific world, plain, practical men, innovators in their field.
>
> J. Stalin
>
> Speech delivered at a reception to higher educational workers in the Kremlin, May 17, 1938

> Science must climb down from its pedestal and speak in the language of the people.
>
> K. Timiryazev

AN EXPERIMENT ON 500,000 HECTARES

In an article in *Izvestia* of December 20, 1939, Lysenko wrote: "Last year, before the session of the Supreme Soviet of the U.S.S.R., Comrade Stalin asked me what was to be done to increase the millet yield in the arid southeastern districts; and he himself explained why the millet yield was so low. He emphasized that little attention had been paid to millet, that it was not sown at the proper time, that the soil was not properly prepared for it, that the crop was not properly tended, it was not sown in wide rows, it was badly harvested and there was a considerable waste of grain. In general, millet was regarded as a low-grade crop. . . ."

Not only the practical agriculturists, but the scientists too were inclined to give millet up as a bad job. Millions of people had known millet for ages—it makes good porridge, and the people in the South use it for their "conder soup." Moreover, its stalks and panicles make excellent fodder for cattle. There is the well-known calculation: 40-50 centners =10-12 centners of pork and fatback. And yet millet was regarded as a low-grade crop!

Professor Tsadé in his book *Plant Growing* wrote: "Millet cannot compete either with the principal grain crops or with maize. . . ." And A. A. Sokolov wrote: "For yield, it [millet] is lowest in the list of grain crops. . . ." "except for buckwheat," he concluded, to show that he was unprejudiced.

Statistics for over thirty years had shown dispassionately that in 50 gubernias barely an average of 6.16 centners per dessiatine had been harvested.

Evidently, this plant had remained in such a wild state that it was completely unaware of the laws that were obligatory for all the inhabitants of Green Land. Some people are of the opinion that it had never heard, for example, even of the vernalization phase. It did not care in what month it was sown—in April, or even in July. And it was useless fertilizing the soil for it. Such, at all events, was the opinion of the researchers at the Anuchinsk and Bezenchuk experimental stations, who had experimented with millet. After putting tons of manure and superphosphates into the ground, they barely managed to squeeze out an extra centner per hectare. It certainly did not pay. . . .

On October 26, 1938, the Party and the Government passed a decision "on measures to ensure stable yields of millet in the arid districts of the southeast of the U.S.S.R." The decision laid it down that preparations be made in 1939 to ensure on an area of 500,000 hectares, a millet crop of not less than an average of 15 centners per hectare.

The Staff-Headquarters of this first battle for millet was the Lenin Academy of Agricultural Sciences of the

Two types of millet panicles

U.S.S.R., and its President, T. D. Lysenko, was the commander-in-chief.

On the battlefield, time is precious. In that very same year, 1938, the Academy's brigades of agrotechnicians, mechanization experts and fertilizer experts went out to the districts concerned. What did they take with them? The knowledge that millet is one of the most drought-hardy crops; and also the knowledge that millet is not the Caliban of the plant world, but rather a feeble, even tender plant; that it could not rely on its own strength, that it was begging and praying that man should understand, support and protect it; and then it would repay the care and attention bestowed upon it a hundredfold.

Later, when the work done was summed up, it was calculated that over three hundred conferences had been held in the districts, attended by 18,000 agronomists and kolkhoz brigade and team leaders. In addition, 20,000 agronomists and team leaders had attended special courses. Two hundred and sixty-five thousand posters and pamphlets on the vernalization of millet, on the method of sowing, cultivating the soil between the rows, and harvesting had been distributed. Nobody had counted the number of lectures and radio speeches that had been delivered, or the number of articles written for the central and all the local newspapers. At the beginning of the sowing, the Academy of Agricultural Sciences had a list of the names of 40,000 kolkhoz team leaders who had pledged themselves to obtain high millet yields.

Came the summer of 1939. We remember the sultry heat of that summer, at the end of which Hitler unleashed the frightful, predatory war in the countries on the western frontiers of the U.S.S.R. In that summer, hot dry winds raged in the Kuibyshev, Saratov, Stalingrad, and Chkalov regions, carrying drought to the land in the southeast, where a gigantic experiment on 500,000 hectares was being performed.

Millet is a great lover of heat. It will perish with cold if planted too early. It asks to be put into the ground when the sun has brought the soil temperature up to 15° C. It had said this distinctly, had shouted about it before, but no attention had been paid to it.

Sowing time had to be chosen with almost mathematical precision; and the sowing had to be completed within two or three days. The tiny seeds must not be planted too deep, and moisture must get to them. They are defenceless; man alone can protect them from weeds.

The scientists agreed on the methods to be adopted. Tens of thousands of agronomists and team leaders, and hundreds of thousands of kolkhozniks, eagerly adopted them and boldly altered and improved them as circumstances dictated. An extraordinary wave of enthusiasm swept over whole regions. Hundreds of thousands of minds, hundreds of thousands of people, working on one task, learned to understand nature so that, being understood, she should be obedient to man. A valuable suggestion made by one was almost immediately taken up in all parts of this vast experimental field. The number of highly-skilled millet growers grew.

The kolkhozniks practised deep autumn ploughing. Before that they took measures to retain moisture for the soil. In the winter they put up fences in the fields to hold the snow, and changed them about after every blizzard. Between the fences they built snow walls. The field in charge of Z. I. Kirilyuk, a team leader at the Kolos Kolkhoz in the Chkalov Region, was covered with a level blanket of snow sixty centimetres thick. The fields were rolled with heavy rollers before and after sowing to prevent the pulverization of the topsoil and the formation of a thin dry crust after rain, and to enable the moisture to reach the upper layer where the seeds were. They sowed vernalized seed. They put in fertilizer in the autumn and later gave the crop "extra feed"; they carted barrels on wheels containing liquid nutritive mixtures between the green rows.

The newspapers in that year wrote about M. F. Abdulla, of the Krupskaya Kolkhoz in Western Kazakhstan, who from an irrigated area harvested 68 centners per hectare; about team leader F. V. Kondratenko of the Pokhod Kolkhoz in the Chkalov Region—she harvested 50 centners per hectare;

about Bezborodov, of the Serp i Molot Kolkhoz in the Stalingrad Region, who, on an area of 70 hectares, harvested almost 31 centners per hectare; and about I. D. Ishchenko, of the Peremoga Kolkhoz in the Kiev Region, who harvested 65 centners per hectare. ". . . It looks as though our land has been rejuvenated," wrote the kolkhozniks in the Derzhavin District, Chkalov Region. ". . . The crop stands 90 centimetres high. The oldest man in the district has never seen a crop like this in the whole of his life. Our district, Ivanteyevka, is the driest in the region. . . . No woods, no ponds, no rivers—nothing. . . . At the end of June the temperature rose to 47°C. But with the aid of our Soviet science we vanquished nature herself and compelled her to submit to us. . . ." This is from a letter by D. G. Sysoyev, of the Krasny Partizan Kolkhoz in the Saratov Region.

The best panicles were picked for seed. It turned out that there was not a variety of millet that could not be improved. That year the kolkhozniks performed a seed-growing job that would have taken five years with the ordinary methods.

AN EXPERIMENT ON 700,000 HECTARES

The battle of 1939 was won. But what did it signify? Only that the victory was a pledge and a guarantee for the future. In 1940 the "experimental field" assumed even greater dimensions. Seven hundred thousand hectares of millet! In the autumn of 1939 the kolkhozniks picked the best panicles for seed for the land that was already being prepared to receive it. . . .

To cut a long story short, in 1940 the average millet yield on 500,000 hectares was 15 centners per hectare, and on 200,000 hectares it was 20 centners per hectare. The task set by the government was fulfilled.

These two years marked a turning point in the entire world history of millet growing. Yes, the crop that had always been a "stopgap," and had always been planted on the expectation that "nothing good would come of it" ("a picture of rural, peasant poverty: millet, drab, sparse, about a foot high, and patchy—you can see the bare, dusty, brown earth through it. . . ." as a writer in the past described a millet field), this crop, in one leap, jumped into the ranks of the highest-yield grain crops. Not one of the others will easily produce a yield of half a hundred centners per hectare, but in 1940, lots and lots of millet fields produced such a yield.

We know, and will never forget *what* frustrated our third peaceful victory in the battle for millet and interrupted the gigantic experiment of 1941.

But what the mass science of the people had achieved during those prewar years was not scattered by the wind, did not decay. The power gained over nature was not dissipated, in spite of the fact that the millions who had fought for and won that power went off to protect their vast, common home, their motherland.

In 1943, kolkhoznik Chaganak Bersiyev, in Kazakhstan, harvested over 200 centners per hectare. This was probably the biggest crop of any grain plant that man has ever harvested in the field.

THE SHPOLIANS

The beginning of this story can be entitled:

"How Kok-Saghyz Led Millet."

Early in May 1946, a meeting took place that was somewhat out of the ordinary. Among those present were F.S. Ruban, Y. S. Hobta and A. F. Fesenko, brigade leaders of the Molotov and Shevchenko kolkhozes in the Pereyaslav-Khmelnitsky District and of the Proletar Kolkhoz in the Cherkassy District respectively—all rubber growers, who in the preceding year, 1945, had, on their one-year plantations, harvested an average of 31 centners of kok-saghyz roots per hectare (the plan provided for 4 centners per hectare). Also present were Yekaterina Chalaya, a young but already famous millet grower, Young Communist Leaguer, and team leader at the Petrovsky Kolkhoz in the Shpola District, and Olga Tovstonog, also a young team leader and Y.C.L.'er. Many other skilled kok-saghyz and millet growers were present.

The weather was dazzling bright and sunny. Light clouds looking as if they had been painted with a fine brush floated high in the sky. The roads were dusty. It was a very dry summer. These skilled agriculturists had gathered to discuss how to help millet to make the "spurt" that kok-saghyz had already made. The people who were working on the youngest crop in the world wanted to give a few useful hints to those working on the oldest.

The point in question was no more nor less than the cluster planting of millet! Using only half the usual quantity of seeds, you plant forty thousand "bouquets" to the hectare; about two thirds of the black, spring field will be left vacant, but in this daring idea lay the secret of victory!

Everything appeared to be as usual in the villages in the Kiev Region, but actually, something new and mighty had entered their lives. It so happened that this imperceptible but decisive change had affected the Shpola District first and most of all.

It stood on the threshold of every house, engaged the thoughts and affected the work and behaviour of every inhabitant. The people from neighbouring villages would stroll around the fields in their spare time, would meet at some boundary post and, puffing at their makhorka cigarettes or blackened pipes, would enter into conversation. They did not talk about anything in particular: a hot day, very close, there would probably be rain—and then they would pass on to their daily work and, kicking the weeds away, would sit down and discuss in detail what this one or that one had done that day.

One evening, a car, enveloped in a thick cloud of dust, came chugging up the hill towards the place where the neighbours were sitting and chatting. In it was the secretary of the District Party Committee. With him was Semko, the district agronomist.

This was a stroke of luck for them; almost half the village was assembled here. Brigade leader Illarion Denisovich Ishchenko was relating how he, in 1939, at the Peremoga Kolkhoz, had harvested 65 centners of millet per hectare—that was the time he went to Moscow, to the All-Union Agricultural Exhibition. . . .

Then Okhrim Grigorievich Zemlyany related his experiences. Before the war he had been a team driver. On his way back from the war he had pictured himself returning to his old humdrum job, and the prospect had not pleased him; he knew and felt that during the past years he had become a different man, more developed, but he thought to himself: "Even if I take a different job it is sure to be something like the old one."

The first few days in the village after his arrival amazed him. All he heard around him was talk about millet. Millet, millet, and not just millet, but something he could not quite understand. They were saying extraordinary things about it. The words in which the people spoke about it seemed to be the same as those he had been familiar with since childhood, but they seemed to have acquired a new meaning which he could not grasp.

When he was in the army he had pictured the village as he had left it; but later he saw what the war had done to the Ukrainian countryside. Marching westward with our victorious regiments he had passed through gutted villages with nothing left but bare stoves and chimneys, and neglected fields overrun with weeds. Many a time he had picked up, or stirred with his foot, the rusty remains of some agricultural implement. Women mourned the loss of brothers, husbands, fathers—the frightful trail of the Hitlerites!

When he arrived home he found the same thing: gutted houses, denuded orchards, scarcely a family that did not mourn some member either killed at the front or tortured to death in the Gestapo. But he found something else that he had not seen or known before, something that had evidently been born while he was away and had become the predominant thing in the life of the countryside. It seemed as though he had left a ship, expecting to find it later where he had left it, or swept back on its course by the waves; but instead, the ship had sailed on, and he had now to catch up with it.

He found the village teeming with active, concentrated, confident and joyously intense life. The talk he heard around him was merely the outward manifestation of that immense and important thing that constituted its substance, in the same way as the part of an iceberg jutting out of the water gives one an inkling of the enormous mass that is floating below the surface.

In his own village, and in all those in the neighbourhood, the sound of axes was heard, and soon, four hundred houses arose out of the ashes and ruins. New schools were built in place of those that had been wrecked. In that first postwar year the ploughed area in the district was equal to that before the war. There was not a kolkhoz that was not caught up by the spirit of socialist emulation that pervaded the whole district to produce a high, Stalin crop. The names of two girl Y.C.L.'ers was on everybody's lips—Olga Tovstonog and Praskovya Onoshko, of the Dvadtsatiletye Oktyabrya Kolkhoz, who had been among the initiators of this emulation.

Okhrim Zemlyany was caught up by the irresistible force of this life.

He had never grown millet and had never had any intention of doing so. But now he asked his grandfather.

"How many centners do you say you get?"

He did his best to make the question sound ironical, but since boyhood, when his grandfather's word was law in the family, he had been accustomed to regard him as a man who with unerring confidence knew what's what.

The old man answered simply:

"About thirty. Maybe some get forty. . . . Do you understand what that means, Okhrim?" he added, nodding his head impressively.

And so Okhrim Grigorievich Zemlyany, team leader at the Lenin Kolkhoz, became a millet grower.

And having put his hand to the job he set about it with a will—as he had learnt to do in the army. In the execution of any assignment there must be perfect order, and so he started keeping a daily record of his work and of observations in the field.

The seed was vernalized. It was not sown in clusters everywhere, but where it was, the plants that sprang up had thicker stems, broader leaves and deeper roots, which sought in the soil for the moisture the plants could not find in the hot, dry air. And that is how millet grew in the fields worked by the teams led by Illarion Ishchenko, Okhrim Zemlyany, Yevgeni Dyadya, Lukeria Koshevaya and hundreds of others.

Zemlyany obtained a crop of 35 centners per hectare. Dyadya's team, on an area of four hectares, obtained an average of 43.6 centners, and the Shpolians as a whole, on a total area of 2,017 hectares, obtained an average of 27 centners per hectare, that is to say, five to six times as much as they used to obtain before, in spite of the fact that the summer that year was drier than any the old folks could remember.

The staff of the *Pravda Ukraini* devoted one of its regular Thursday literary and social evenings to an address on millet by I. D. Kolesnik, of the Lenin Academy of Agricultural Sciences of the U.S.S.R. On the program there was also a performance by a young soloist from the Kiev Opera; a queer combination which surprised nobody, however, for was it not jolly to sing after hearing that the kolkhozniks had harvested 27 centners per hectare in a severe year like this?

. . . The kolkhoz villages of the Shpolians lie hidden in orchards. Fading, straw-yellow autumn, lacking the gold and red of the northern forests, was already creeping over the green. Singing was heard where the apples were being picked, in the front gardens of the cottages, and behind the plough in the fields, which the evil breath of drought had failed to conquer.

A MILLION HECTARES

In that year the Shpolians, of course, had not been the only ones in the Ukraine to grow millet. The kolkhozes in the Kiev Region had harvested on an area of 105,000 hectares an average of 12.1 centners per hectare—not such a bad result for 1946! But the Shpolians were far ahead of the rest, and in his address at the *Pravda Ukraini's* literary and social evening, Kolesnik praised them to the skies. He himself said later:

"I deliberately set out to make the whole of the Ukraine envious of the Shpolians."

And indeed, the victory won by the Shpolians acted like a spur. The word went round the whole of the Ukraine: "We can't allow the Shpolians to shame us like this!"

The year 1947 was ushered in. In February of that year the Plenum of the Central Committee of the Communist Party of the Soviet Union (Bolsheviks) adopted a decision "On Measures for Raising Agriculture in the Postwar Period." One of the points of this decision read as follows: "To oblige the Ministry of Agriculture of the U.S.S.R. and the Ministry of Sovkhozes of the U.S.S.R., in conjunction with the Lenin Academy of Agricultural Sciences of the U.S.S.R., to organize in 1947, on the same lines as in 1939 and 1940, the raising in the kolkhozes and sovkhozes, on an area of one million hectares, of a millet crop amounting to an average of 15 centners per hectare."

Plain and brief. For thirty years the Soviet Government had accustomed us to the idea that things *can be* done in *this* way; the air we breathe, our whole life, teaches us that it can be done. Our people read these terse, businesslike words and in a businesslike way obey them like a battle order. Do we appreciate the unprecedented, the unusual character of this order? Behind it stands what had never existed in the world before: the years we have lived since the October Revolution, the immense scope and struggle of the most daring and mighty scientific concepts, of the people's science, the science accepted and created by the vast masses—the prewar battle for millet. Of course, the freedom from the elements won by the Shpolians, the new power over the land that was won in 1946, were needed to make it possible for the Party's instruction to be written in those simple words.

The plan assigned to the Ukraine 300,000 hectares out of the million laid down for the millet crop; but the Ukrainians, on their own initiative, planted nearly 800,000 hectares.

The Shpolians expected visitors, and they were not mistaken. Not only their neighbours, but millet growers from the Vinnitsa, Poltava and Kirovograd regions came to them to learn the "secret of victory"; and the possessors of this "secret" took the greatest pride in revealing this secret, in letting everybody see the real treasures of the Shpola kolkhozes.

The visitors saw signboards in the fields like the following: "Brigade No. 9. Brigade leader *I. D. Ishchenko.* Area: 21 hectares. Socialist pledge: 45 centners per hectare."

Ishchenko, a famed brigade leader, had, on the recommendation of the District Party Committee, come to lend a hand at the Kalinin Kolkhoz in the Kamenevatsk District; and now, this kolkhoz, which year after year had been unable to get things going right, had jumped into the front ranks.

The visitors also inspected the field in charge of team leader Yekaterina Chalaya.

They read Okhrim Zemlyany's log:

"On the fifth day the millet roots began to germinate.

"On the eighth day the seedlings began to shoot up briskly.

"May 20-25. Raked the ground.

"June 2. Crust formed after rain. . . ."

The Shpola District was now fighting to get 30 centners of millet per hectare on a total area of 2,200 hectares.

. . . In a distant field there is a crowd of people. What is going on there? Perhaps Katya Chalaya, a young Y.C.L.'er and one of the most celebrated girls in the whole of the Kiev Region, has arrived there? She is a welcome guest everywhere. She is invited everywhere, and she tells the people about her team, an ordinary team of ordinary people who have achieved such wonderful results. She not only tells her neighbours about it, but right there in the field shows them how her team works and assures them that they can achieve the same wonderful results if they work in the same way.

Perhaps it is somebody who has arrived from the Regional Centre, or from Moscow, from the Ministry of Agriculture, or from the Academy?

No, it is somebody else, a frequent visitor now, so frequent, in fact, that he is no longer regarded as a guest. It is Nikita Bubnovsky, the secretary of the District Party Committee, himself an agronomist. He walks between the rows, stoops to the ground to look at the root necks, and examines the panicles. Nobody noticed him ride up. The roads were not so dusty that year. And the millet is man high.

Grigori Grigorievich Zemlyany says:

"The people have grown up, got married and their children have married during all the years I have been farming, but I have never seen millet over four feet tall before. . . ."

The kolkhoz crop of 1947 ripened—the millet of the Shpola, Pereyaslav-Khmelnitsky, Korsun-Shevchenko, Kiev, Vinnitsa, Kamenets-Podolsk and Odessa districts and regions. On a total area of over 750,000 hectares they harvested an average of 15 centners per hectare. In the Kiev Region, the average on 200,000 hectares was over 16 centners per hectare. Some kolkhozes (in the Kiev and Kirovograd regions) harvested 30-40 centners per hectare. The newspapers wrote about new expert millet growers: about brigade leader Polishchuk, of the Balta District, Odessa Region

(46 centners); about Drobot of the Babanov District, Kiev Region (45 centners); about team leader Sidorenko of the Cherkassy District (46 centners); about brigade leader Boiko and team leader Solop of that splendid XVII Partsyezd Kolkhoz in the Shpola District, who had harvested an average of 35 centners per hectare on an area of 120 hectares. . . . And about Okhrim Grigorievich Zemlyany, who had brought his crop up to 50 centners per hectare.

The sound of axes was heard in the Ukrainian villages—new houses were being built. The chimneys of brick kilns were smoking. Through the snow-white smoke could be seen the cherry and apple trees in the orchards the kolkhozniks had planted. In the winter the kolkhoz team leaders attended agrotechnical schools. How would you define the innovating and creative work of these people from our villages—mental or manual?

In making preparations for the thirtieth anniversary of the establishment of Soviet rule in our country, the Shpolians invited artists to decorate their villages, and to paint the portraits of the heroes of kolkhoz labour to be hung in a gallery for the admiration of all.

WHAT IS SOCIALIST ROMANTICISM?

That day the newspaper *Pravda* referred to Ivan Danilovich Kolesnik, now a member of the Lenin Academy of Agricultural Sciences of the U.S.S.R., as one of the country's most celebrated agriculturists.

Lysenko, his teacher, said:

"I only suggested the idea of cluster sowing. It was worked out and introduced in agricultural production by Stalin Prize winner I. D. Kolesnik and the kolkhozniks in the Kiev Region."

One of the commanders in the battle for millet in the Ukraine, Ivan Danilovich Kolesnik also took part in promoting the cluster sowing of kok-saghyz and the planting of potato tops for seed; it was for this that he was awarded the Stalin Prize.

He travelled in those local trains which stop every twenty minutes. People leave and enter, then the engine emits a long and piercing whistle, the train gives a lazy jerk and stops, then jerks again, the wooden seats in the carriages are packed, and amidst the heavy tobacco smoke the passengers discuss their kolkhoz or town affairs, and somebody on the upper seat butts in to say that another shop of the huge plant at the Dnieper has been restored. Kolesnik also alights at one of the country stations, where a car, or sometimes a farmer's cart, is waiting for him; sometimes he foots it across the fields, taking long strides, breathing deeply and, from habit, lifting his face and slightly screwing up his eyes.

In those fields lie his life and work.

Just now, in his little room at the Academy in Moscow, he takes out a photo showing a millet field in Poltava, with the millet standing taller than a man; and against the background of this Asiatic weed stands a girl holding a sheaf—and a glow lights up his face.

"Good, eh? Real good, isn't it?"

He mentions the girl's name, patronymic and surname. Who is she? A close acquaintance? A relative, perhaps? No! He has never even met her!

Listen to the way he talks about the kolkhoz peasants. He regards them as his equals—colleagues and collaborators. He does not "sympathize" with their needs, but in a cool, businesslike manner sees to it that they are met, for their interests are his, the interests of the people who are cooperating in a common cause.

During his travels in the Ukraine he met the writer Valentin Ovechkin. They travelled together, each, at first, absorbed in his own thoughts. At about that time Ovechkin was writing an article for *Pravda* in which he adversely criticized something he had seen in several districts: the boosting, year after year, of the same record breaker, while all around there were farms which were not even achieving the average crop yields.

Suddenly, both the writer and the scientist began to talk about the same thing. Kolesnik too was opposed to these perpetual record breakers. In his opinion, the criterion of the "maturity" of a district was a high average yield.

He said:

"What would people think of a factory manager, or director of a state trust, who boasted that he had not dropped below the preceding year's level? You can be quite sure what they would think. But in agriculture you hear some people boasting: 'Not worse than last year.' What are they proud of? The fact that they are marking time? In socialist agriculture there must be the same continuous improvement, the same ascending curve as we have in industry!"

He was of the opinion that to fight for this and facilitate it was the chief feature and main function of the new science, the people', Soviet, Michurin science.

"Was there agrotechnique in the past? There was. But often it was like a body without a head. Agrotechnique without agrobiology."

There is an enemy that he hates and fights with all his might wherever he meets it, namely, conservatism.

"Would you like to hear what the kolkhozniks in the Ukraine have done?" he asks. "I'll put it briefly: They have buried the ancient farming methods! Yes, that's exactly what science should do: change the old farming methods; when it does that it is science."

"What was the cluster planting of kok-saghyz, the first cluster plantings? A fight not only for this rubber-bearing dandelion, but for the new conception of plant biology that would reveal the real strength of plants to man and enable him to use it. It opened a new path in the science of agriculture," he said, unhesitatingly.

With joy he watches the way in which a plant changes its very appearance under new conditions; how millet, which has always been a sprawling plant, stands up straight like a wall in the field.

At one kolkhoz he saw a field overrun with weeds through which one could faintly discern the feeble shoots of millet that had been sown in the ordinary way, by scattering. He felt like a doctor standing at the bedside of a man in his death throes. He decided that the only remedy was to drive a tractor plough through the entire mass, to plough lanes forty centimetres wide, leaving strips of the crop twenty centimetres wide.

It was a very drastic remedy; but his prestige was high among the kolkhozniks. They took his advice and did what he recommended. But as the tractor ploughed through the field there was at first a restrained and then a loud murmur among the kolkhozniks who had gathered to watch the operation. And Kolesnik himself felt a cold shiver run down his back as he watched this mutilation that he had advised. I think he left this kolkhoz earlier than he had intended, hurriedly, without taking leave.

He returned some time later. He had heard something about the results of the operation, but for all that, he was ill at ease. But when he arrived he could scarcely believe his eyes. A solid mass of tall, green stalks with heavy panicles waving in the wind stood before him. The once "feeble" millet had overpowered the weeds on this field, which had been transformed from an ordinary into a "cluster-sown" field!

"What should be our normal yield of millet?" he now asks, and answers the question himself: "I think about 50 centners per hectare."

And here is the most incredible thing—a second harvest in the same summer. In the Ukraine, in 1947, the millet fields were harvested by August 15. The stubble was left; just ordinary reddish-yellow stubble, a little softer than wheat stubble. It was not for nothing that the peasants had left the stubble. Five days passed, and then the incredible happened. The dead came to life. The stubble began to sprout, and it grew so fast that by September 2, the panicles appeared. On this Kolesnik observes in a serious tone:

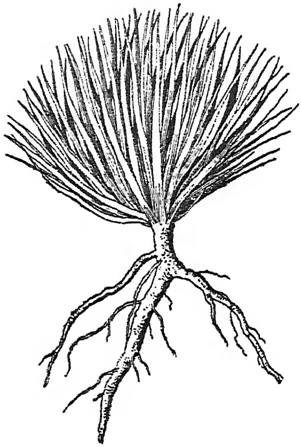
"It is a wise plant, it knows that the morning frost will set in soon."

But as he says this there is a merry twinkle in his eyes.

For the first time in history, perhaps, a second harvest is gathered from one sowing!

What has happened to the plant? What will man do with it tomorrow? Kolesnik was summoned to Moscow. When he arrived he was struck down with influenza, but even when lying sick in bed in his room at the Academy of Agricultural Sciences his thoughts were roaming the wide plains of the Dnieper. He sent a telegram requesting that when the millet was being threshed, 100 panicles from each field be left until his return. He wanted to see the "tomorrow" of this millet with his own eyes!

. . . The sequel to this story about millet brings us back to the old starting-point—the rubber-bearing plants. To kok-saghyz? No, not to kok-saghyz, although, of course, it



Tau-saghyz

is the principal hero and favourite among the rubber growers.

In 1930, a year before the exploring party found this dandelion with the yellow flower in the Tian Shan Mountains at a height of 2,000 metres above sea level, in the Kara Tau Mountains a Kazakh named Dyurbekov showed the botanists another plant they had not seen before. That was tau-saghyz. It is richer than its "younger brother" kok-saghyz; its roots are almost half filled with rubber sap. But it is obstinate and capricious. It rarely allowed itself to be cultivated . . . and in the fields it yielded to its younger brother.

But now, the new weapon for vanquishing nature is tried on tau-saghyz—cluster sowing. Kolesnik is already talking about tau-saghyz plantations in the Ukraine, wonderful plantations, which will have to be planted only once, and will produce sap for tens of years; for such is the mighty power to revive, to sprout again, that is inherent in this plant.

Listening to Kolesnik I say to myself: "Of course, this man is a dreamer; but the dream he is dreaming is of a special kind. He himself is entirely terrestrial; his life, his place of work are entirely among men, whose labour, with thousands of hands, 'shapes' the earth; and he himself is able with his own hands to do all sorts of work in the field." And so, it seems to me that his dream is primarily to inspire people to put his dream into effect. And to get this done with thousands of hands is the happiest dream of his life.

He described cluster sowing as a new path in agriculture, and he went on to talk about the cluster sowing of lucerne, and about that wonderful branched wheat, with its hundredfold yield, which must, and will, also live in the Ukrainian fields!

And I know that the wonderful branched wheat will grow in the Ukrainian fields and produce a hundredfold yield.

In one lecture he delivered, Kolesnik made buckwheat the hero of his story. Yes, buckwheat!

When, it seems only the other day, millet was declared to be the most hopeless of field plants, we remember that the reservation was made: "except buckwheat, perhaps." "Except buckwheat. . . ?" To the people who are today fighting for this new power over the land, this sounded like a challenge; and the challenge has been accepted.

And so, about buckwheat.

Kolesnik did not speak about the low, thin-stemmed, pinkish buckwheat, but about dwarf trees, about "bouquets," like small copses. Concerning the buds on these bushes he said that in the driest weather "they will feel approximately like a man resting under a lime tree on a hot day." And he also said that it would be a good thing to put beehives in the buckwheat fields, because when, as in the ordinary way, the hives are kept away from the fields, "by themselves," the bees get tired out from the long flights.

"Use up fuel," said somebody in the audience.

"That's right!" agreed Kolesnik. "They use up fuel!"

And he went on to say that bees in buckwheat fields do not sting; they are too busy to do that. The white, honey-sweet caps are a metre and sometimes a metre and a half long; the bees, weighted with nectar, do not fly, but crawl along them—and in gathering the pollen they pollinate the buckwheat.

This harmony of life enchants him. *This can be done in every kolkhoz.* And in that small room at the Academy where he was lying sick, he spoke to me about this with bubbling enthusiasm. And while I was musing over the dream which was creating this real living world with the hands of man who had learned the secrets of nature, he suddenly asked me:

"What is socialist romanticism? In the Soviet countryside; in the kolkhoz?"

And he added:

"Would you like to know?"

He took out a notebook, turned the leaves, but, without reading from it, he said in a firm and confident tone, as if he had learned the formula by heart:

"Socialist romanticism is unity of will, from that of the secretary of the Regional Party Committee to the kolkhoz team leader, through the science of the agronomist experimenter."

He paused, shut his eyes, and added:

"Perhaps I haven't expressed the idea quite right, but this I know: we cannot live without it."

Nineteen forty-eight and nineteen forty-nine. The Ukrainian roads wind through golden fields and green orchards and lose themselves amidst vast fields of sunflowers that stretch to the horizon like a heaving, sunlit sea. In these fields and orchards the magnificent and most romantic battle of the whole people with nature is raging on a grander scale than ever. And writers on the history of science will include what is taking place in them among the most important and remarkable events in their annals—man's world-important victory in his ancient dispute with the elements; discoveries, one after another, which mark a turning point, a revolution, in man's conception of what labour and knowledge can procure from the land. Millions of hands are creating this knowledge, acquiring these victories, and in the front ranks of the fighters are Mark Ozerny, Ivan Polovkov, Pencho Penchev from Transcarpathia; Maria Lysenko and Yelena Hobta, the famous Ukrainian women . . . and hundreds of others.

How swiftly these things are happening!

The dream about buckwheat. . . . The kolkhozes in the Dymer District have already obtained, on an area of 2,800 hectares, an average crop of 12 centners per hectare—a *treble* harvest.

Along the roads in the Cherkassy District the maize crop stands like a wall. Forty centners per hectare—this is not the record crop of the advanced growers, it is *the average for the district.*

Sugar-beet fields, kok-saghyz plantations. Something entirely unseen before: nut copses; the first citrus-fruit groves; large-scale rural flower raising, initiated by the kolkhozniks in the Dymer District as a people's enterprise to beautify the earth!

And millet?

Many kolkhozes are now obtaining yields far exceeding those obtained before. The people at the Proletar Kolkhoz in the Kiev Region consider that 50 centners per hectare is their standard yield, Kolesnik tells me.

"That's exactly the figure I mentioned!" he added.

> . . . They have but one book which they call "wisdom." This they read to the people.
> Agriculture is much followed among them.
> . . . They use secret remedies, so that fruit is borne quickly. . . .
>
> Tommaso Campanella, *City of the Sun*, 1602

Watermelons growing near Moscow! We read about this on October 7, 1947. An unprecedented experiment carried to its consummation. And the Ilyich Kolkhoz, in the Kuntsevo District, Moscow Region, reported it to the country.

And not only watermelons; melons and kidney beans too.

Another change had to be made in the map; the line which for ages had marked the "limit of cultivation" of these crops had to be shifted. Green striped watermelons and yellow, fragrant melons with their soft protuberances! They always conjured up in our mind the glaring, midday heat, the smell of warm dust, the billowy white clouds in the blue sky over the crowded, clamorous market place somewhere in the South.

How did they in Kuntsevo, right near Moscow, win this victory?

Its inspirer and direct organizer was the man with whose name all the great victories achieved by our people are associated.

In the spring of 1947, *Stalin* gave the Ilyich Kolkhoz a difficult assignment—to grow watermelons and melons. This kolkhoz had already won fame by its fine crops of vegetables. It is one of the kolkhozes that does not simply take ready-made what agronomic science has to give it, but engages in research itself to find new ways of altering nature.

It took just pride in its new varieties of early-ripening potatoes, which yield 30 tons to the hectare.

And so, this kolkhoz received Stalin's assignment. Nobody had hitherto done anything of the kind, to grow melons in this latitude was something entirely new for agronomic science. An agronomist, E. E. Kuzin, arrived at the kolkhoz to help in the new task. Kuzin was attached to the melon brigade of which E. F. Krutova was in charge.

Both Kuzin, who for many years had specialized in the "northerning" of melon and related crops, and the melon brigade knew perfectly well that the problem would not be solved by simply planting the seeds and waiting to see what would grow. Nature cannot be altered at one stroke. Everything was important: the choice of the plot (a southern slope), the soil, fertilizer for it, warming it with fresh horse dung, well-prepared seedlings, protection from wind, watering, tending.

The watermelons began to ripen in August. The first one to be picked weighed four kilograms. Later, the Ilyich kolkhozniks wrote: "We were convinced that it is possible to grow, near Moscow, melon and related crops which hitherto have been brought here a thousand kilometres from the South."

In 1948, every brigade at the Ilyich Kolkhoz pledged itself to plant watermelons and melons. And a hundred and fifty other kolkhozes in the Moscow Region did the same.

"Agriculture is much followed among them. . . ." These words were written three and a half centuries ago in a noisome cell by a hand that had been mutilated by inhuman torture, the hand of Tommaso Campanella.

The "egg," that is what the brutal jailers jestingly called this prison in Naples in which people rotted alive. And Campanella had been flung into it because he wanted his native land Calabria to be freed from the Spanish yoke, and also because he dreamed of a better form of human society.

He was tortured for twenty hours at a stretch, and once for forty hours. . . .

He was flung into the cell almost a youth and left it, twenty-six years later, an old man.

His name means "bell." "The bell that heralds the morn" (so he called himself) told mankind of a country that did not exist. Buried alive, Campanella wrote about the City of the Sun, the creature of his imagination.

That story was a dream, confused, naive and utopian, perhaps, of mankind's communistic future as Campanella pictured it.

Campanella had never seen agriculture held in high esteem. Nor have the descendants of his fellow countrymen seen it even three and a half centuries later.

We, in the land where real Communism is being built, are the first living witnesses of this.

The husbandman was called "bondman," "serf," "villein," or "villain," which soon began to mean lowborn, base, boorish; and what other contemptible names were given to those whose labour provided the food of all, whose bread everybody ate! The "great unwashed," "rabble," that is what the tillers of the soil were called.

It is hard for us to grasp this now; but this lasted for centuries nearly everywhere, almost in all countries. And it seemed quite natural. To make the absurdity of a world where *this* was possible obvious and self-evident to all, the October Revolution was needed.

And so we are the living witnesses of the high esteem and honour in which the people hold the labour of the husbandman (as well as all other labour that benefits our country). Again I unfold the copy of the newspaper of March 1947 in which is published the list of kolkhozniks who were then awarded the highest honour—the title of Hero of Socialist Labour . . . together with the Order of Lenin and the Gold Sickle and Hammer Medal . . . "for obtaining the highest yields in 1946."

Who were these first glorious heroes of agricultural labour? Praskovya Nikitichna Angelina, or, as the whole country, and as our great leader affectionately called her at the congresses of advanced kolkhozniks in Moscow, Pasha Angelina, tractor brigade leader at the Staro-Byeshevo Machine and Tractor Station, Stalino Region, member of the Supreme Soviet of the U.S.S.R., Stalin Prize winner, and recipient of the Grand Gold Medal at the All-Union Agricultural Exhibition. She is the bearer of two Orders of Lenin, of the Order of the Red Banner of Labour, and of numerous medals. Her parents had been poor peasants, and she herself, at the age of eight, began to work as a farm hand.

The publishers of the reference book, *World Biography*, of Broadway, New York, wanted to include Angelina in the next edition of their book. The editor politely informed her that he was interested in the biographies of leaders of the United Nations . . . the creators of atomic bombs, and other workers in science, art, literature and industry. She was among the "others." In her answer, Praskovya Nikitichna reminded the editor of the "amazing career" of a certain English gentleman she had read about in the boastful and yet snivelling *Britansky Soyuznik* (*British Ally*) published by the British Embassy in Moscow. In its fawning description of this gentleman's carreer it had stated that he had "come from the people," that he had started as a newsvendor, subsequently became a millionaire, is the owner of numerous newspapers and has been elevated to the peerage. The gentleman in question is the notorious Lord Beaverbrook.

And this woman, celebrated in our country, formerly a farm hand and now a tractor driver, heroine of labour and legislator, wrote the following: "Whereas the gentleman I refer to 'rose from the ranks of the people,' 'came from the people,' as was quite rightly stated in that magazine, and became a peer, *I rose with the people*. This is the chief thing."

Anna Denisovna Koshevaya, a kolkhoznik in the Kiev Region, in 1935 obtained the highest yield of sugar beets ever obtained in our country. And in the drought year 1946, the yield of the sugar-beet crop in her kolkhoz, Chervony Gigant, amounted to 526 centners per hectare. In 1944 the yield was 526 centners per hectare, in 1945—527 centners, in 1946—526 centners and in 1947—526 centners, a mathematically even result obtained with unerring confidence, *absolutely* irrespective of weather conditions—this is the most astonishing thing about this.

In the roll of honour there was also the name of Mark Yevstafievich Ozerny, from Dniepropetrovsk, who for several years on end had not harvested less than 100 centners of maize per hectare, and in 1946 harvested 136 centners.

Ivan Nikitich Rakitin, from the Altai, was the first organizer of a high-yield team. For ten years on end the field in which his team worked raised only high-yield crops, and in 1946 he harvested 34 centners per hectare of spring wheat.

Another wheat grower in the Altai, Pyotr Fyodorovich Varivoda, in that same severe year, harvested, on an area of 24 hectares, 35.3 centners of wheat per hectare.

Fyodor Antonovich Boiko, the manager of the famous sovkhoz Gigant, which in that same severe year, 1946, delivered to the state 24,000 tons of grain. . . .

It is scarcely necessary to continue this list, for the most remarkable thing about it is that it is endless. By the time you read this, the newspapers will have published many new lists of Heroes. They contain the names of Siberians and Ukrainians, and Altaians, an dof people who have grown wheat in the Sverdlovsk Region, of kolkhoz team leaders in Georgia, and of cotton growers in Central Asia; people of numerous nationalities have vanquished nature in the South and North, in the mountains and plains, in the ancient taiga and in the steppes of the Yenisei. And all these people will be not "individuals" standing by themselves, in the golden words uttered by Pasha Angelina, they will rise with the people.

No, it is not enough to say that the old and cherished dream has come true in our country. Something bigger than that which was heralded by Campanella's bell has taken place; the morn has broken over the land more brightly and more beautifully than the "herald of the morn" dreamed, or could have dreamed.

For example, not only has the former attitude towards the husbandman's labour vanished in our country, but the husbandman's labour itself has gone. The kolkhoznik is not the husbandman, or peasant, of olden days. The peasant in the old days never did, nor could ever do, the work now being done by our advanced kolkhozniks, the innovators and creators in the field of agriculture. We are not in the least surprised to read that kolkhoznik Ismail Ibrahimov, of the Kaganovich Kolkhoz in Uzbekistan, has taken the degree of Master of Agricultural Sciences. . . .

The Zavety Lenina Kolkhoz in the Kurgan Region. In the winter the temperature drops to 40° C. below zero; fierce winds drive the snow from the fields; the bare ground freezes as hard as iron; in the spring it will thaw slowly, and later it will be scorched by the dry heat of the summer.

One of the members of that kolkhoz is Terenti Semyonovich Maltsev, a member of the Supreme Soviet of the U.S.S.R. and Stalin Prize winner. His name was already famous before the war.

He produced a variety of wheat that grows slowly in the early stage and ripens quickly in the last stage; this wheat outwits the tardy spring and escapes the hot, dry wind of the summer. Maltsev has worked out a whole system of agrotechnique for the trans-Urals.

The daring novelty of his system opens an entirely new chapter in agronomic science.

Maltsev, who had received no education, not even at a village school, has read books on philosophy, and the works of Darwin, Timiryazev, Michurin, Williams and Lysenko. He has a private library of 2,000 volumes.

At his kolkhoz he has four thousand experimental plots, more than many a scientific institute has. On them, of spring wheat alone he is experimenting with over two hundred varieties.

A kolkhoz field has become the experimental field of science.

An ordinary kolkhoznik became the master in this field. He set up a "scientific institute" that was not provided for in the plans of Academies. That is what happened at the Zavety Lenina Kolkhoz.

"You are a real biologist thinker," Academician T. D. Lysenko wrote to him. Maltsev is linked with the celebrated scientist of our country by strong and permanent ties of collaboration and friendship.

At the All-Union Agricultural Exhibition in 1941 Maltsev was awarded the Grand Gold Medal, and in the following year the Government conferred on him the highest decoration—the Order of Lenin. He has been nominated for membership of the Lenin Academy of Agricultural Sciences of the U.S.S.R.

In our country the time has passed when one individual wizard, or magician, could possess mighty power over nature. Thousands of people possess that power today. And submitting to this power, animals and plants cast off their age-long appearance like an old skin and assume the new appearance with which man endows them. Never in all its long history has agriculture known such a rejuvenation of the land by man as has taken place since the socialist, kolkhoz countryside has existed.

Marx and Engels once said that all that man has experienced up till now is merely "prehistory," that the real, great history of mankind will commence when society will no longer be divided into classes and people will be united in one communist family. Then they will possess a science, the might of which we cannot now conceive. Compared with it, the science of the past will appear to be only "prescience."

We are witnessing the dawn of such a science.

A THOUSAND AND THIRTY-FIVE TUBERS

Since we have mentioned the dawn of a science of unprecedented might, we must, of course, tell you about the explorers to whom the future belongs more than to anybody else.

Explorers—what scenes that word conjures up in our minds!

We picture to ourselves vast forests beyond which, in unknown mountains, it is necessary to find the sources of unknown rivers; ships ploughing the lead-coloured waters of the northern seas for the purpose of plotting on the map the outline of a lost, frozen land; men tapping the steep sides of valleys with their geological hammers—and suddenly there is the sparkle of gold-bearing sand, undulating, reddish layers of iron ore are revealed, or oil gushes from the depths of a drill hole.

A man is sitting motionless in a room, his eye glued to a telescope through which he sees a gigantic, unknown world: the deep shadows of sharp-peaked mountains fall on a plain that seems to have been flooded with grey, molten glass. The astronomer draws the map of this lunar wilderness. He has been on that distant luminary without moving a step from that room in the tower of the observatory.

And the engineer designers, from whose drawings new and mighty machines are born!

And the chemists, who feel at home among queer-shaped test tubes and long-spouted retorts filled with seething liquids and gases that look like clouds of yellow smoke!

Try to find in any jungle or pampas you like—in the mangrove beds in India, in the savannas of America, in the marsh thickets in New Guinea, wherever you like on the globe—a hen of the kind I have in mind that lays an egg every day; this Michurin apple, the size of a small melon; or this pig, which is a living pork and lard factory! You will not find them, because there are none there, and they never existed in nature until men-creators, transformers of nature, animal breeders, created them.

As I am writing these lines I recall the most remarkable competition that ever took place in the world. It was held in the last prewar years—about three years before the war.

The Academy of Sciences of the U.S.S.R. and the Central Committee of the Young Communist League opened a competition among the young scientists of the country to show which of them had filled most "blank spaces" in our knowledge of the world; which of them had made the most profound and most important discoveries, most valuable for our country and for the whole of mankind.

A competition of young scientists! No country, except our great country, could organize a competition like that.

We constantly read of competitions, organized somewhere in Philadelphia or Baltimore, for smokers, and the first prize is awarded to the fellow who, not sparing his lungs, manages to smoke simultaneously five cigarettes as well as a cigar stuck in his nose; of a "hands and knees race" having taken place in Salt Lake City or in Buffalo; or of a "sitting on a bough" match in Indianapolis, and of a "youngest mother-in-law" competition in Cincinnati. But a competition among young scientists? Never!

In 1948 a scientific debate took place in the Brussels University on the subject of "Should the Flames of Hell Be Taken Literally or Figuratively?"

Reading about this, you rub your eyes and wonder: "1948? Is it not a misprint?"

It is exactly like the debates that used to be held in the hoary past, about 700 years ago, in the universities of the Middle Ages. There were about half a dozen such universities throughout the whole world. People travelled on mules and in lumbering coaches to hear the disputes between the eminent scholars. Of these, too, there were about a score and a half; senile old men in the garb of monastic orders and wearing flat or high conic caps to distinguish them from the ignorant and unenlightened. On meeting, these ancients went for each other hammer and tongs. Nobody understood a word they said; they spoke an outlandish Latin, which must have made Cicero turn in his grave.

What stirred their blood, long cooled by years of pious vigils, to such heat?

Oh, the questions at issue were of vital importance, like the one discussed in Brussels about the flames of hell! What interpretation from the standpoint of the Catholic Church is to be given to the opinion about God and nature expressed by an Arab whom they mistakenly named Averroes, who, in his turn, had interpreted the opinion of the Greek Aristotle? And: how can there be a Devil, since the Scriptures say that God is almighty and, therefore, should have been able to destroy the Devil?

After shattering each other's arguments in the language of Plautus and Petronius, the score or so of ancient scholars went their diverse ways on their mules and in their coaches, but life around them went on as if there had been no disputes about God and the Devil.

The only difference between these disputes and the debate held in Brussels in 1948 was that the disputants at the latter returned to their homes in tramcars and motor cars, bought prosaic tickets and travelled by train, or flew home in aeroplanes.

The result of the competition among young Soviet scientists was announced at a meeting of the Presidium of the Academy of Sciences of the U.S.S.R. by V. L. Komarov, late president of the Academy. No less than eight thousand young scientists had responded to the appeal of the Academy and of the Central Committee of the Young Communist League. A whole army division of scientific researchers! Scarcely any of them had reached the age of thirty; some were only eighteen or twenty.

One of them still attended secondary school; but while studying grammar, the Punic Wars and geometry, he went through a university course of higher mathematics. Many of his classmates no doubt regarded mathematics as a dull subject, but if he were asked he would say that it was the most fascinating subject in the world.

Another was a first-year university student, but the most celebrated astronomers discussed his astronomical discoveries.

A third . . . but it is impossible to enumerate all these splendid youths.

This was the result the jury announced.

A hundred and twenty-nine of the works submitted were such as to deserve for their authors the degree of Master of Science. Concerning sixty-three of them, the jury stated that they were "quite normal treatises for the degree of Doctor of Science." Thirty others were even superior to treatises for the D. Sc. degree: had they been submitted for this degree, they would no doubt have caused a sensation in university circles and would have served as subjects for discussion at scientific societies and in scientific magazines.

Three of them the jury did not classify, or rather, put in a special class as standing far above the level of the rest. They were works of a kind that start new trends in science.

They were works on mathematics by Kantorovich from Leningrad, and Sobolev and Pontryagin from Moscow. The latter, though blind, is now a celebrated mathematician. To be blind and yet devote one's life to mathematics, a sphere in which it would seem to be impossible to take a single step without chalk, a blackboard, paper and pencil!

The judges were right in putting the works of these three young researchers in a special class. All three are now celebrated scientists. S. L. Sobolev is a member of the Academy of Sciences; L. S. Pontryagin is a corresponding member, and Kantorovich is a professor.

What infinite talent our people must possess to be able, at the first call, to send a whole army division of young people to the outposts of science!

Recalling this prewar competition, one cannot help reflecting on the joy of research; whoever engages in it and knows the joy of learning new things about the world around us will never abandon it.

But in addition to the prize winners at this competition, we want to speak about those who, even younger than these competitors, were the runners-up of these young scientists.

We learned the name of one of these very young ones at the time we read about the above-mentioned competition. It is Mikhail Solomakha, and he himself, no doubt, first realized that he was a naturalist researcher in those, for him, trying and anxious days of the summer of 1936. He was then a pupil in the sixth grade at School 109 in Kharkov; and some plants he had growing on an experimental plot had wilted and looked as though they had been eaten by rust.

He had grown these plants from the seeds of a wheat-couch-grass hybrid that had been sent him in a small box by the Saratov Plant-Breeding Station. They were peculiar plants, with narrow leaves, strangely resembling both wheat and the weed, but he knew them inside out, as it were; and it was with joy that he had watched them gaining strength day after day and more and more boldly pushing up from the black-earth of the experimental plot. But now they were wilted and drooping.

It would have been an easy thing to water the plot to revive them; but that would have spoiled the experiment. These hybrids were supposed to be extraordinarily tenacious and immune to all hardships, including drought!

Mikhail was aware that his plants were going through the test, only this test dragged on for weeks, and he was only a sixth-grade schoolboy. Boyishly, he prayed for rain, and at night he strained his ears in the hope of catching the sound of rainwater running down the rainpipes.

But he did not water the plot!

During that summer, Mikhail became a maturer lad; the plot and the feeble but infinitely complex life of the plants that grew on it ceased to be a mere schoolboy's hobby.

With that perseverance, without which it is impossible to be a naturalist researcher, he brought his hybrids to fruition and gathered seeds from them.

In the following year he received five hundred grains of a perennial wheat from the producer of this variety—A. I. Derzhavin. This variety suffered from a severe defect—fragile ear.

Mikhail's team—he had a team of schoolmates to help him—planted the seeds and tended the crop, but delayed the harvesting for two weeks after the wheat had ripened. Of two thousand ears, two did not break. Their grains were collected separately.

This was one method of eliminating the fragile ear defect, the method of selection. Mikhail tried another method—hybridization. He pollinated a hundred and fifty of the flowers of Derzhavin's wheat with the pollen of different wheat varieties. . . .

A year after that, this schoolchildren's team received an assignment from no less a person than Lysenko—to produce, by means of training and selection, a variety of winter wheat for the kolkhoz fields of the Ukraine.

The young naturalists developed into researchers. . . .

"There is no science more fascinating than the science of agronomic biology," said Lysenko to Solomakha when the latter visited him one day. "Read Timiryazev. Learn from Michurin. Bear this in mind: to do a big thing, you must be able to do a small one. Do a small thing, it will grow big."

The autumn 1939 session of the Lenin Academy of Agricultural Sciences of the U.S.S.R. was indeed an extraordinary one. When the chairman called for the next paper to be read, three schoolchildren stepped on to the platform, one behind the other, two boys and a girl!

One of the boys, Gleb Derzhavin, related how he and his schoolmate (he pointed to the other boy, Vanya Kuznetsov) had worked on the vegetative hybridization of eight varieties of potatoes.

. . . Strong, stout potato stems with a violet tinge grow out of the earth in pots. The operation is performed with a razor. The day must be carefully chosen, and the hand must not tremble. The skill of a surgeon is needed to make the incision in the living body so as not to kill, but to create life.

A top, cut to a wedge (only two strokes of the razor), is inserted into the slit of the incised plant. In this care must be taken that the "epidermis" (the skin) of the cutting fits exactly the "epidermis" of the stem, otherwise the ducts and the layers of rapidly-dividing cambium cells, the most important living tissue in the stem, will not fit each other; and the two organisms will not merge, will not become one.

Then the wound is bandaged.

Now patience is needed. An unseen struggle between the lives of two united bodies is raging prior to their becoming one life; a struggle between two varietal properties.

What will the offspring be? New tubers under the "dual" plant?

The adult scientists—bold innovators—were bearing the brunt of the dispute as to whether vegetative hybridization was possible at all; but these young researchers were already working on it. Derzhavin and Kuznetsov had accepted asexual hybridization as a ready-made instrument, and in grave but simple terms he told the academicians what vegetative hybrids they had obtained by the mode of operation just described above.

The girl, Tonya Kozlova, had set herself the task of compelling a planted tuber to use its vital strength to the utmost. And it turned out that this strength is immense; nobody had imagined how great it is.

A tuber is cut into two halves and planted in earth contained in a box. Sprouts emerge from the eyes. Don't touch them; let them gain a little strength! Soon each has grown four to five centimetres. Now they can stand on their own feet. Tonya cuts and transplants them, and other sprouts emerge in their place. These too are cut and transplanted; but the tuber keeps sending up new and new sprouts.

That is how Tonya squeezed every drop of vital strength out of the tuber.

One tuber produced 250 sprouts, and only then was it exhausted.

The 250 sprouts grew into 250 potato plants. This was not a simple thing to achieve. It was necessary to put the box with the seedlings now in the light and now in the shade, to water them in proper time, to loosen the earth, bank up the plants, give them "extra nourishment" in the way of fertilizer, etc. It was necessary to catch every throb of life of the young plant, to hold its life entirely in your hands. This was not achieved at one stroke, not in the first year. But when it was achieved, this was the result: 1,035 tubers under 250 big, but subdued plants.

A thousand and thirty-five out of one! The figure seemed fantastic even to highly-experienced experts. To plant a whole potato patch with one potato is no joke!

The most wonderful thing about these juvenile researches and discoveries was that neither Kozlova, nor Derzhavin, nor Kuznetsov was an exceptional child.

In my high-school days, long, long ago, when, with the aid of paper darts and clandestinely read Darwin, we repulsed our teacher "Saucepan's" "miracles" and "mysteries," a great transformer of nature was at work in Russia, but we did not know him, we had not even heard his name: Michurin. For most city children, nature remained a beautiful stranger. She flourished in her magic profusion somewhere far away, beyond the low hills where the sun set amidst a lurid glare. To tell the truth, my schoolmates had a very nebulous idea about nature's profusion, and the love they bore her, though rapturous, was bookish.

Today, however, schoolchildren, young naturalists, meet and are in correspondence with academicians, with the foremost scientists in the country.

And they commence their work by participating in that great, general transformation of the living world that is taking place throughout our country.

They approach the living organism on which they are experimenting, conscious of their power over it, of their right to this power, and of the usefulness of the work they have undertaken. When you see young naturalists working at biological stations, the strange but amusing thought arises in your mind that some are "breaking in" the potato, say, in the same way as a spirited horse is broken in until it becomes quite quiet and obedient, and answers the slightest touch of the reins; others are learning to employ and combine different influences for the purpose of bringing out all the vital strength in the tuber, in the seed, and are tirelessly striving to learn to control the organism with the same infallibility as that with which a linotype operator controls his keyboard.

The naturalist has torn down from his work the "veil of mystery," which never helped, but, to tell the truth, always hindered him, and the joy of creatively penetrating the mystery of life has not in the least diminished.

That is precisely how man, the master of nature, should work, seek, and acquire this mighty knowledge. At the present time our children are being trained in these habits in their earliest years; and that is very important, because for a long time a man looks at the world as he had been taught to do in his childhood and youth. A man's knowledge grows, but it is very difficult to "acquire new eyes."

The present young naturalists will grow up to be scientists possessing skilful hands, keen eyes and an uncluttered mind. What previous generations had to fight hard to obtain is as free as the air for them. They will step over much of the discord engendered by armchair science, and will march on and really vanquish the living organism.

They are fighting their first battles with nature without arguing about the main thing, but simply knowing it—knowing that there are in the world not millions of copies of one and the same organism, but millions of organisms, and that the scientist must not yield to the "lesson of heredity," but control it.

Already splendid vanquishers of nature have sprung up from among the recent young naturalists. For example, young naturalist Fil Teterev entered into correspondence with Michurin, and later the great transformer of the soil invited the schoolboy to visit him, had a long talk with him, gave him a daring Michurin assignment, which to the ears of the Mendelist plant breeders of that time sounded "impossible." "I will not live long enough to do it myself, Fil," he said. And Filipp Kuzmich Teterev carried out the behest of his great teacher. It was he, the Leningrad botanist and pomologist, who, crossing a cherry with an Ussuri birdcherry which can stand a temperature of 50° C. below zero, produced a cherry which grew fruit in clusters. He also crossed a cherry with an almond and obtained cherries with almond stones; and he planted these cherry-almonds near Leningrad!

The young naturalists' rally in August 1948 will certainly not be forgotten for a long time. It marked the consummation of an all-Union competition that was started eighteen months before by the schoolchildren of Choboti, in the Moscow Region; and it was held in the town from which the new power over the soil had marched out into the world, and which now bears the name of the creator of that power—Michurinsk. And it so happened that the young naturalists of Michurinsk won the Young Communist League Challenge Banner.

This rally revealed an amazing fact: there are five million young naturalists in the Soviet Union. This is no joke, it is no longer a "children's hobby." And nobody thought it strange that a delegation of these young people was later received by Comrade I. A. Vlasov, the Chairman of the Presidium of the Supreme Soviet of the R.S.F.S.R., in the presence of the secretary of the Central Committee of the Young Communist League.

"Make our motherland a flourishing garden," preached Michurin; and today, gardens and orchards are being planted all over our vast country. In his talk with the young naturalists' delegation, Comrade Vlasov stressed the enormous importance for the state of the development of horticulture.

The school readers in the old days used to refer to plants as "our green friends," but this was not taken any more seriously than other copybook maxims. Filth rotted in the yards of shopkeepers and merchants; the sun seemed to be suspended in suffocating dust above the cobblestoned roads; and grey as dust were the leaves in the garden of some country railway station with the bushes all broken and mutilated. With what anger Gorky wrote about the wretched appearance of these towns of the Okurovs.

Today, the words "our green friends" are full of meaning for us. The central newspapers have come out "in defence of our friend." Our cities are no longer "stony deserts." Verdure means repose, beauty and health. Not striplings, but mature trees are planted, and at once our streets are converted into shady avenues. In the spaces between the houses, right next to the road where the stream of traffic is rushing by, gardens, glorious in a riot of colour, meet the eye. How many threatening signs had to be put up before: "plucking flowers prohibited," "breaking trees prohibited," "liable to a penalty," etc. Today, the people, the masses, regard the verdant decoration of our cities as public property and protect it accordingly.

We can confidently say that in no other country has tree planting assumed such wide dimensions, and in no other country is such state importance attached to friendship with nature as in ours.

At their rally, the young naturalists reported that in the Ukraine they had planted 5,000,000 trees; in the Yaroslavl Region 42 nurseries had been laid out with 100,000 seedlings; near Arkhangelsk apples have been grown in no way inferior to those grown in Alma-Ata; in Uzbekistan they were picking strawberries twice a year; the young naturalists from Choboti, the initiators of the competition, had laid out gardens all round their school, and the young trees they had planted were now growing in the neighbouring kolkhoz villages and along the country roads. Baskets of fruit from the Urals were exhibited, new varieties produced by young but skilful hands; Michurin grapes, which the young naturalists from Georgia tasted and pronounced: "quite as good as ours"; and Ukrainian peaches—these were exhibited by a delegate from Kirovograd.

These are real, big things, and happy is the young generation which started them in its early years, and will be able to see the consummation of this great and immense common task—the conversion of our vast country into a flourishing garden.

GREEN LAND IS ALTERING ITS FRONTIERS

GRAIN GROWS IN HIBINI

There has been nothing more immutable than the frontiers of Green Land. They were protected by Haberlandt's tables.

Oats need a total of 1,940 degrees of heat to be able to ripen; barley needs 1,600 degrees; peas—2,100; root crops—2,500. This law was inexorable, and all prayers for clemency were hopeless.

But an agronomist from Leningrad travelled to Hibini, in the Kola Peninsula, where the total temperature during the vegetative period amounts to only 1,135 degrees.

Of course, this young Estonian had learned all that the books could tell him about this distant, dreary wilderness. The temperature was above zero only ninety days in the year; but at soil level the temperature was above zero barely 55-60 days. This he knew by heart. Deeply impressed in his mind was a thick, red line, which he pictured as a fat, self-satisfied, prosperous burgher triumphantly pointing to Haberlandt's tables; the line that checked the advance of cereals to the Far North. The absolute temperature limit!

But for all that he went.

What prompted him?

It is always important, and interesting, to trace a great idea to its source.

We said that this agronomist was young, but he already had immense experience in life.

Johann Eichfeld was an Estonian peasant. The childhood of this village boy ended in 1905. His elder brother had been taking part in the revolutionary movement. His whole family fell under suspicion. The tsar's punitive forces raided the village. His home was broken up. Johann left Estonia. The life of the homeless youth was a hard one. The eyes of the police followed him everywhere. He slaved as a minor telegraph clerk for a miserable salary until he was compelled to don the soldier's uniform in 1914.

In 1917, he, for the first time, filled his lungs with free air that had been cleared by the revolutionary storm. He went to Petrograd as a soldiers' deputy, and his whole life changed. The revolution had opened for him the path to knowledge, of which he had always ardently dreamed.

He graduated from the Petrograd Agricultural Institute.

What had drawn him to agriculture? The simple explanation would be, of course: he was the son of a peasant. But there was a deeper reason for it.

The Estonian barons had rented marshland to their peasants. Before the latter could plant grain they had first to clear the land, drain and manure it; in short, to convert a quagmire into good, fertile soil. By their patient, tireless toil, the peasants performed this miracle, but it was the landlords who enjoyed the fruits of this labour. Still, the peasants sowed grain on this man-created soil and not only compelled the former bog to yield grain, but even beautified it; beautiful gardens sprang up around their cottages. The impression that one gains on visiting an Estonian village is that these cottages are buried in flowers. And nobody, not the village urchins, nor a casual passer-by, would think of wantonly plucking a flower, or breaking a lilac twig.

Eichfeld knew this not from hearsay; it had been part of the life of generations of his forebears, of his family, and of the surroundings in which he himself had grown up. This scene was linked in his mind with his earliest consciousness of his relation to nature; but before this could mature into a definite world outlook he had to experience much more than he had done when he left his village to go out into the world: the hardships of his youth; his mournful reflections on the fate of his brother who had been sentenced to death; the reading of many enlightening and daring books which told of a life for the millions different from that which had been their lot for centuries; and the breathing of the free air of the great country in which the millions had already begun to build the new life.

The fact that the world outlook that he acquired became all-absorbing and imperatively moulded his entire existence is a specific feature of his personal character.

It was unjust that man should be doomed to live on a black and barren bog.

The bog must not be allowed to triumph over man.

I am trying to find another word with which to designate the idea and sensation that so powerfully possessed him. Is it hatred? Indignation? Perhaps it is simply *refusal to recognize* the disorder that reigns on earth, combined with confidence in the almighty power of human labour, which is destined to transform the earth and beautify it.

In 1920, Eichfeld accompanied the geologist, Professor P. A. Borisov, on an expedition to Karelia. Scarcely a third of the land here bore crops, and poor crops at that. Two thirds, encumbered with boulders and yellow with bog moss, remained uncultivated. Wretched little villages hid furtively among the moraines.

Hunger stalked the land in that severe year. The Soviet Republic was engaged in a fierce struggle against the foreign interventionists on the fronts of the Civil War. Through the towns and villages, across the weed-grown fields, through the silent shops of factories, and along the railways over which slowly crept rare and overcrowded trains, wandered a terrible visitor whose name is now forgotten—ruin.

But the Man in the Kremlin, while leading the country in its life and death struggle, was calmly and deliberately working out plans of gigantic scope and power. An English imaginative writer who boasted of his ability to peer into the future and was famous throughout the world for this, visited Moscow a year later and was amazed by these plans. He left Lenin's office with a mocking smile on his lips and murmuring: "dreamer." H. G. Wells saw nothing then but "Russia in the shadows."

It was the air of great prevision and of the accomplishment of the impossible, of the future that will become the present, that the finest people of that time, the generation of our fathers, breathed.

And this air was also breathed by the humble student, still wearing his soldier's greatcoat, Eichfeld.

In Karelia, Eichfeld became convinced that it was possible to leave the ridges and go down into the lowlands and make the ink-black and ash-grey soil fertile. *Here* it was quite possible to do this. He knew it!

And then what?

He thought of the immense stretches of land that still lay waste in our country, had lain waste for ages.

Land which man had never dared undertake to cultivate.

Sandy desert—68,000,000 hectares. Tundras—300, 000,000 hectares. The prerevolutionary textbooks had dispassionately stated that a third of the area of our country was in the permafrost zone.

The Far North! A vast expanse bordered by the line of the Arctic Circle, stretching from the Finnish frontier to the Pacific Ocean. In Siberia it touches the 60th latitude. In the Far East it goes down even to the 50th.

One must realize what this means. Ten million square kilometres. It means that these northern regions account for forty-eight per cent of the area of our country. Once having grasped this fact, Eichfeld could never forget it.

He loved books—those repositories of human experience and reason. He zealously sought for and studied everything that appertained to the history of the North. The people of ancient Novgorod imported grain from Moscow, for none grew in their distant, northern "Five Provinces." Karamzin, the celebrated historian and novelist, wrote about the North as "nature's coffin."

But the traders and fishermen who, three hundred years ago, in their single-mast fishing boats, sailed to Grumant* and to Mangasea, to the mouth of the river Ob, and two hundred years ago gave the world Lomonosov, yes, simple, Russian fishermen, proved that it is possible to live and work in the Arctic.

"Mine was not a fantastic idea even from the beginning," said Eichfeld later.

He recalled the famous Arctic explorer Sibiryakov and Dr. Fyodorov from the Solovetski Islands—ardent advocates of settlement in the North—who had firmly asserted that it is possible to settle on the coast of the Arctic Sea. These

* Spitsbergen.

men, and others like them, would have achieved much more than they did had they not been faced with the brick wall of indifference erected by the government departments in St. Petersburg, and had not the local officials strangled with red tape the timid attempts the tsarist government did make to "infuse life" into the North. The all-powerful satraps feared that they would lose their privileges if the legend about the severity of the North being insurmountable were exploded.

Sidorov, an Arkhangelsk merchant, petitioned for support of the northern fisheries, but he received an answer from General Zinoviev, the tutor of the last of the tsars, couched in the following brief, aristocratically-blunt terms: "In view of the fact that the permanent ice in the North makes the growing of grain impossible and that no other occupation is possible there; in my opinion, and in the opinion of my friends, the people in the North ought to be withdrawn into the interior of the country; but you, on the contrary, talk about some sort of a Gulf Stream, which cannot be in the North. Only a madman can suggest an idea like that."

The Gulf Stream was regarded as an impossible thing, and it was quite logical that when, during the First World War, it was found necessary to seek for an ice-free port on the Murmansk coast, the rulers of the type of this General Zinoviev called in the Archimandrite of the Solovetski Monastery as an advisor. . . .

History swept them on to the garbage heap. . . .

The Petrograd Institute of Plant Industry approved of Eichfeld's idea of experimenting in Arctic agriculture in Hibini, but the Institute was then short of funds.

Eichfeld started out with 200 rubles in his pocket and also a doctor's certificate to the effect that the climate of the North was dangerous to his health, for it was found that this champion of Arctic agriculture showed a disposition towards tuberculosis.

He, however, was convinced that Hibini would be the finest health resort for him.

Among the papers he took with him was one containing the following excerpts.

"Fertility is by no means such a natural property of the soil as might be imagined; it is closely connected with present-day social relationships."

"It is the business of the materialist, i.e., of the Communist, to revolutionize the existing world, practically, to turn it against things as he finds them and to change them."

"With the development of the natural sciences and agronomy, the fertility of the soil changes too, because the means with which it becomes possible to turn the elements of the soil to immediate use undergo change."

He also wrote down what these great ideas of the founders of Marxism meant to him: "The transformation of society and nature by man is the profoundest philosophical poetry of our socialist era." "Man is the smith who fashions nature." And very briefly, with youthful rapture, he wrote about his country and his times which had started this new era: "A century in five years."

When he alighted from the train the following scene met his eyes: dreary thickets of stunted trees looking as if they had been scorched. Low, rolling hills. Tall, steep mountains, precipitous, as though they had been sliced.

The ground squelched under his top-booted feet. He stooped to examine it. He knew from the textbooks that microbiologists calculated that here even the omnipresent bacteria amounted to only 200 million to the hectare. . . . Or perhaps less? In the central zone of the country they ran into thousands of millions. Only now did he realize what this lifeless, dull-coloured crust—here a slimy black, there bluish, and in another place a sandy yellow—was. It was *not* soil.

Somewhere, hundreds of kilometres to the south, ran the northern limit of agriculture; as if in another world, on another planet. Here "it looked as though the mighty Fenno-scandia Glacier had only just left this place, leaving the smooth tops of the mountain tundras and huge heaps of boulders, pebbles and sand. . ." is the way he described his impressions later.

In the lake, however, the bottom was distinctly visible through the placid water, and a frail boat seemed to be suspended in a shining vacuum. The day did not wane, and a wonderful, soft, crystal-clear refulgence lit up the primordial chaos of rock and sand. The outlines of all objects stood out clear and distinct, like print, and were visible to the eye to the very end of the Earth. And when you shouted, your voice seemed to float in the light air far, far away, for scores of kilometres perhaps, to the most distant parts. . . .

The inexpressible charm of the Arctic captivated the heart of the new arrival—the charm, which, as those who have been there know, enchants a man, and makes many devoted to the North for the rest of their lives.

Eichfeld saw people, many people, sick with scurvy. In the spring nearly a third of the sparse population is afflicted with this disease.

The employees of the Murmansk Railway lived in freight cars; they had covered the roofs with earth and grew vegetables on them. "The gardens of Semiramis," commented Eichfeld with a sad smile.

A plan matured in his head. The North was not lacking in everything. Its character was not all negative. In respect to one of the most important factors of life it was richer than any other place on Earth—an abundance of continuous light all through the summer. . . . The mistake made in the previous timid attempts to grow plants in the North was that "they took for granted" soil that was *not* soil! But Eichfeld knew that soil could be made, and here *must* be made.

On his own back he lugged from the railway station the manure he had ordered somewhere far in the South. He lugged these baskets of manure a distance of several kilometres and emptied them on ground on which, at a depth of a hundred, and in places eighty centimetres, the permafrost, permanent frozen soil, began.

During the white nights Eichfeld did not sleep: with gun in hand he watched for rabbits near his experimental plot. Not a sound disturbed the infinite stillness. No rabbits appeared, but he did see the green shoots creeping upwards out of the ground as if being pushed up by an invisible force. He really did imagine that he could actually see them grow.

In the beginning of August came a snap of early-morning frost. He had not expected it. With his fingers he tried to straighten the darkened, crumpled, wilted leaves. He could not save many of the plants. Only a part survived.

How proudly, with head erect, he carried cabbages, or an armful of root crops, showing them to everybody. "Do you see, *they have grown*! You *can* grow stuff here!"

He had no doubt whatever about his success. He plunged into new experiments.

One day he read an article in a Moscow newspaper that had arrived, an article signed by someone named Zatsepin. It was a witty and bitingly sarcastic article. The author admitted that it was possible to grow one head of cabbage in the Arctic if one spent one's whole life on it; but was it worth it?

Far away from this crystal light, from the scurvy-stricken people who had fearlessly come here to fight nature, far from the cabbages grown for the first time in history on soil that man himself had made, Zatsepin's wit sounded convincing; especially to some of those who were responsible for providing Eichfeld with his meagre funds. He received an order to pack up and return home.

But now that he was *convinced* of success, it was more difficult than ever to turn him from his course. His friends were of the opinion that this Estonian peasant had the obstinate "forehead of Paracelsus."

He went home to fight, to argue his case until he was hoarse and prove that he was right.

He found ever new arguments in support of what he was doing. How many people would be living in the Soviet Arctic within the next few years? A million and a half, or two million at least, is that not so? For two million it will be necessary to transport vegetables and milk alone to the amount of 1,200,000 tons. These will contain a million tons of water. Fancy transporting water with incredible difficulty and precaution to the Far North!

Soon, Eichfeld returned to Hibini.

In the winter, armed with a geologist's hammer, he, accompanied by two others, climbed to the summit of Mount Rasvumchorra. This small party had received an assignment from Kirov to obtain and bring back a ton and a half of the "rock of fertility"—apatite. In the summer, Eichfeld conducted his experiments on a wider scale. In 1926, three years after he had obtained his first crop in Hibini, at 67°44′ north latitude, marsh-draining operations were commenced. Eichfeld knew better than anybody else how this should be done. He could not restrain himself from writing: "This work is one of the most fascinating pages in the history of the development of the Far North."

He lived in a rough log cabin. But now, every summer saw what had never been seen here before: grass growing as tall as a man; enormous, four-pound heads of cauliflower—it looked as though some power was pushing the plants up from the earth.

Came the turning point in the hoary history of the North.

Kirov met new year 1930 amidst the snows of the Kola Peninsula. Wild, steep mountains reared to the sky, but the man who gazed at their blurred outline through the blizzard and gloom of the endless night uttered the following fearless and weighty words: "There is no soil which, in skilful hands, under Soviet government, cannot be turned to the benefit of mankind"

In the lifeless wilderness, on the shore of Lake Vudyarv, where only reindeer teams used to leave their trail, the town of Hibinogorsk, now Kirovsk, sprang up. Beyond Lake Imandra the town of Monchegorsk arose.

Only a few years before, in 1925, the first discovery of Hibini apatite was made; it became one of the greatest geological discoveries in the world—amazing, unique mineral wealth, containing fifty-eight chemical elements, in the confined area of Hibini!

The 1930's were the years of the transformation of the Arctic.

Fiery strips shot out into the darkness from the unslumbering shops of factories, works and mines on the Kola Peninsula: there nepheline, copper and nickel were mined and refined; it became the largest centre of the phosphate industry in the world. The coal fields of Pechora were dubbed "the

Northern Donbas." Towns and industrial settlements sprang up in distant Taimyr, in Yakutia, in the cold zone, in the Valley of Kolyma, which hitherto had been scarcely known by name. And the children of Igarka wrote letters to Maxim Gorky in Moscow.

There were more inhabitants in any one of these towns than in the whole of ancient Novgorod at the height of its glory.

The life that now seethed in the Arctic called for immense supplies of food. The number of people who had arrived there, and particularly of those who were expected to arrive, really ran into millions. They had to be fed. The cost of transporting food amounted to an average of 500 rubles per ton, and to many places it was difficult to transport.

The Bolshevik Party took the matter of Arctic agriculture into its hands.

ARCTIC AGRICULTURE

The soil was created in the following way.

To podzol, sandy, and sandy-loam soils were added abundant supplies of organic fertilizers. For several years running compost was carried to irony-sandy soil, for it was found that mineral fertilizer was not enough. And the immense proportion of 100 tons of compost per hectare was considered normal here.

Of course, before this it was necessary to clear the ground of heaps of stones—the traces of the ancient glacier.

Machines broke up the lifeless earth crust and, for the first time, air and life penetrated it; it began to breathe, and invisible myriads of soil-creators—bacteria—inhabited it.

There was an advantage in the drained marshes in that they did not need manure.

In 1932, a chain of experimental stations was set up in the Far North, stretching from Murmansk to Kamchatka.

Eichfeld remained in Hibini.

It would be no easy matter to enumerate all the crops that it was found possible to grow in the Arctic in spite of the gloomy forecasts of all the Cassandras and vulgar wits. Potatoes—Snezhinka, Asia, and Vermont varieties. Oats barley, and even wheat. Work was started on breeding local varieties. One of them was called Umptek, which in the language of the Saamis means "twice inaccessible tundra."

Small-fruit bushes were planted. Peas were grown. Thick beds of green lettuce, fennel, and parsley. Crops of swedes, turnips, radish, beetroot, carrots and onions were harvested.

It was then that the splendid qualities of an old friend of man's were thoroughly appreciated, namely: kohlrabi. Formerly, acquaintance with it had been slight. As a remedy for scurvy, it was found to be one and a half times more effective than the universally accepted standard remedy—lemon. This was a wonderful botanical discovery, for kohlrabi can be cultivated almost everywhere in the North!

The behaviour of many of the settlers from the South was surprising.

Eichfeld witnessed a regular revolt in the plant world. Swedes and radish usually bloom in the second year, but here they bloomed in the first summer. Barley simply "broke loose"; it threw out purple, double-row ears. "It is going mad," wrote Eichfeld in his notebook. Biennials became annuals, and winter crops changed into spring crops.

And on top of all was this unexpected, unforeseen, wonderful power that was pushing the plants up from the earth!

Spinach, for example, throwing out long, thin shoots covered with blossoms, had no time to ornament itself with the luscious leaves for the sake of which it is cultivated!

But on his own piece of bogland, Eichfeld, as a rule, harvested crops which he himself described as fabulous: three hundred centners of root crops, or potatoes and cabbage, per hectare. And of timothy grass for hay, he mowed 70 centners per hectare!

These were the gifts of the North.

Here, potatoes are totally unaware of the scourge that afflicted their fellows in other places—late blight.

Africans, Americans and Asiatics grew splendidly here, and the more southern their origin the better they thrived; this fact particularly astonished those who for the first time became acquainted with agricultural affairs in Hibini. Barley and oats ripened quicker than near Leningrad; in nine weeks Algerians outstripped many a native northerner. Some Indian cereals felt more at home in Hibini than in the Kuban.

It was those who came from mountainous districts that thrived best.

It was a flood of facts that could not be fitted into any preconceived schemes.

It was now perfectly obvious to Eichfeld that Haberlandt's tables—that lifeless enumeration of the "eternal properties" of plants—may indeed be good for the latitudes of Germany, where they were drawn up, but only for those latitudes.

At the time those tables were drawn up, the "centres of origin" theory was in fashion. According to this theory, the diversity of original varieties in mountainous regions is explained by the fact that these regions were the centres of their origin and, therefore, the greatest "concentration" occurred of the genes that came into being in these very same places. But Eichfeld, who had witnessed the outbreaks and revolts of his barley and radishes, believed that even for mountainous regions the explanation is much more simple—diversity of conditions.

He saw how the seeds he planted in the Arctic changed into spring varieties. He himself, creating unprecedented Arctic varieties one after another, selected pairs for crossing and, training each of these pairs for different conditions, enhanced their hereditary potentialities.

Here it was necessary either to alter nature, or yield and admit defeat. It was not the table of "properties," nor the "concentration of genes" theory that helped Eichfeld. Only *one* theory lit up his path—that of the great naturalist Michurin.

In those years Eichfeld learned of another researcher, who was working in the south of the country, and in whose hands Michurin science worked wonders. He developed this science, and Eichfeld eagerly watched the harmonious and remarkable system of ideas that this researcher was building up. This man was Lysenko. From the South, Lysenko sent the pioneer in Arctic agriculture a request to test under Arctic conditions the varieties of cereals in the world collection of the All-Union Institute of Plant Industry in Leningrad. In response to this request, Eichfeld planted on his experimental plots in Hibini thousands of varieties of wheat, oats and barley. This was the northern test for these cereals, proceeding simultaneously with the tests in the fields of the Ukraine, Azerbaijan, the Caucasus and Kazakhstan.

Thus began the collaboration between the two scientist innovators, although separated by thousands of kilometres.

The land must be beautified. And so, on his very first arrival in the North, this son of an Estonian peasant began to cultivate not only what might seem to be strictly necessary, but also garden flowers: asters, stock, sweet peas, mignonette, night violets, lobelias and flox. He tended them with care and anxiety, and it was with joy that he recorded in his notebook: "The decoratives are thriving splendidly."

Year after year the varieties increased in number. He entered in his notebook the dates of the blooming of the peonies, tulips, dahlias, irises and pansies. His lodgings and the premises of the Arctic Research Station were filled with the langorous fragrance of heaps of flowers. When he gazed from his window at the gorgeous carpet that was spreading in this Arctic region his heart was filled with pride and exaltedly poetic phrases came to his mind: "bright Sicilian snapdragon," "orange-coloured nasturtium adorning the tombs of the ancient Incas."

The Arctic Research Station, the most northern in the country, seemed to be buried in flowers. Eichfeld learned with pleasure that his station was the most flower-bedecked in the country.

But Eichfeld said in that humorous tone that was peculiarly his own: "The model of an automobile is not the solution of the transport problem."

. . . All this was mere experiment, an approach to the real task.

The first farm to be organized was the state farm named "Industria." "An emerald patch," wrote Eichfeld, admiring its fields.

At this farm rye grew in the open field, and so did cabbage, cauliflower, carrots, swedes and turnips. The fields, which expanded from 90 to 305 hectares, were the scene of the ordinary, busy, complex agricultural operations. It had over four thousand hotbed frames, and its hothouses occupied over four thousand square metres; here fresh vegetables ripened. There was sufficient hay to meet all the requirements of the cattle. The manager said: "We will soon be the best sovkhoz in the Leningrad Region." (At that time this area was part of the Leningrad Region.)

In 1930, a botanical garden was opened in Kirovsk, the only Arctic botanical garden in the world. Chrysanthemums and roses bloomed next to strawberry beds and currant bushes in the same latitude in the cold zone.

The fame of this incredible Arctic agriculture spread throughout the world. Dr. Alberts arrived and saw the "emerald patch" with his own eyes.

"This is a revelation!" he exclaimed rather theatrically, but he was sincerely amazed. He came from Alaska—from Jack London's Alaska. There he was considered to be the director of an agricultural experimental organization. But the population of Alaska had diminished considerably. When the "gold rush" was over, the population of a million and a half square kilometres was no more than that of the young town of Hibini. The once-famous wealth of fur animals is exhausted; even reindeer are now extinct there. A severe economic crisis affected the country. There were seven experimental stations in the region which, truth to tell, were engaged in simple experiments, conducted in a haphazard way "to see what would come of it." During the crisis all seven stations were shut down one after another.

"A revelation!" repeated Dr. Alberts, the "general without an army."

In 1935 there were only three cases of scurvy in Hibini.

Centres of agriculture had already arisen along the whole immense front of our Far North. On the banks of the Igarka and Kolyma, haystacks could be seen; salad made from fresh tomatoes was as delicious here as in Kiev; the muffled rumble of the pack ice in the Arctic Ocean was heard in the deathly silence of the night in the hothouses on Dixon Island, where, with the aid of artificial light, the cells of supple stems, those tireless spinners, performed their mysterious, joyous, everlasting work, spinning the threads of life; and in March, the Soviet miners in Spitsbergen treated the Norwegian governor to spring onions.

What only a quarter of a century before had been but a dream—Arctic agriculture—had become a factor of everyday life. Just before the war, in Naryan-Mar, potatoes yielded 300 centners to the hectare; cabbage over 500 centners to the hectare. In Salehard, 28 kilograms of tomatoes were gathered from every square metre of hothouse space—twice the amount taken from hothouses in the Leningrad Region. The Noril Sovkhoz sprang up in the wooded tundra. Arctic kolkhozes appeared: the Vperyod Kolkhoz near Mezen and the Krasnaya Zvezda Kolkhoz at Ust-Tsilm; kolkhoz rye and wheat were already ripening in Kamchatka. Statisticians have calculated that in 1939 the following was produced per head of the population of the whole of the Far North: 74 kilograms of potatoes, 23 kilograms of vegetables, 59 kilograms of cereals. Stockbreeders have noted that the Pechora and Yakut cows yield 1,200 to 5,000 litres of milk per annum.

Such were the first victories in one of the greatest and most noble battles man has fought with nature; in the battle which man, during his thousands of years of existence on Earth, dared to undertake only today, only in our country, where the Bolshevik Party—the Party of Lenin and Stalin—is leading the people.

Then the war broke out. . . .

But the people, led by the Party, led by Stalin, are quickly healing the wounds inflicted by the frightful war.

Immediately after the war a new offensive was launched against the tundra, against the marsh and the stone-hard, frozen soil of the Arctic.

We have heard of the crops harvested by the old and new sovkhozes and kolkhozes at Mezen, Pechora, in the Turukhansk District, in Vorkuta, Chukotka, Kamchatka and Sakhalin. Two hundred and three hundred centners of potatoes per hectare is an ordinary thing. In many cases four hundred centners are harvested. Potatoes are the chief crop. Potatoes, vegetables, and milk. As for cereals, it is easier to transport them to the North.

In the dreary tundra, amidst the rust-coloured mosses and stunted and charred woods, near the new towns, mines and Arctic industrial giants, on the diabase and granites of the bleak islands in the Arctic Ocean, the number of emerald patches is growing. They are multiplying, and later, now here and now there, they will merge.

An entire special institute, the functions of which would have seemed fantastic to our forefathers, and even to us a quarter of a century ago, is now operating in Leningrad—the Institute of Arctic Agriculture.

* * *

The director of the world-famous All-Union Institute of Plant Industry, the member of the Lenin Academy of Agricultural Sciences of the U.S.S.R., and of the Academy of Sciences of the Estonian Soviet Socialist Republic Johann Eichfeld, Stalin Prize winner and Chevalier of the Order of Lenin and Order of the Red Banner of Labour, is in his study.

It is winter. On the broad inside window sill are ranged pots of plants and flowers—a small hothouse.

Among the books on his desk is Kurbatov's *Gardens and Parks*. I also see photographs of the sculptures in the Park of Culture and Rest on the Kirov Islands in Leningrad.

The man sitting at the desk loves this city, his city, the most beautiful city in the world, perhaps. He is speaking about the further improvement of its suburbs. This is essential, and the time for it has matured, he says. He intends to send a memorandum on the subject to the proper quarters. The suburbs of old St. Petersburg were a gloomy contrast to the masterpieces of architecture of Zakharov and Voronikhin, to the ensembles of Rossi and Quarenghi. This contrast is disappearing in the magnificent new districts of Leningrad—it must disappear everywhere. And how the approaches to the great city would change if the roads were lined with trees! Yes, fifty kilometres from the city, the traveller must already feel that he is entering a great and beautiful city in a transformed land. . . .

This man, past middle age, is still dreaming, as he dreamed in his youth, of beautifying the earth, and is working for this.

He can look back to the past without any misgivings. The victory of Arctic agriculture, the possibility of which had been fiercely disputed not only by the Zatsepins, but also by many of the worshippers of Haberlandt's tables, was a glaringly obvious victory over the science of those tables, over the science of inexorable heredity. It was the victory of Soviet, agrobiological, Michurin science.

Biologists were engaged in heated dispute on the question of intraspecific struggle. I asked Eichfeld to give me his opinion about it. He sat silent and motionless for a little while and then he said:

"I only want to remind you about forests. How did forests come into being? If a lone tree grows so well, why are there so few lone trees?"

He stopped speaking. His hand mechanically stretched towards his spectacles lying on the desk.

Catching his thought I quoted a line from the once-famous poem by A. F. Merzlyakov "Through Valleys Smooth":

Oh, even a tree finds it dull alone to grow. . . .

"Of course," commented Eichfeld. "Pines can spread only in masses. Where there is fir, or birch, there are no pines. We see, therefore, that forests can exist only because . . . forests exist."

This aphorism, characteristic of the man who carefully weighs his thoughts before uttering them, as if examining them from all sides, clearly showed whose side he is on.

He opened a book, one that he, evidently, was constantly consulting, for its margins were heavily annotated and numerous passages were underscored. Holding the book in his hand he said:

"One must not mark time in science. Not on anything, not on any theory—like the theory of intraspecific struggle. Ossification means death for the researcher."

He put on his spectacles and read the following:

"Content is impossible without form, but the point is that a given form, since it lags behind its content, never *fully* corresponds to this content; and so the new content is 'obliged' to clothe itself for a time in the old form, and this causes a conflict between them."

These words, the utterance of a genius, sum up the dialectics of the development of the science that casts aside the old, that seeks the new, and pushes ever forward. They are the words of Stalin, written in his *Anarchism or Socialism?*, on page 37.

The window looks out upon a wide square and the dark-red façade of a palace in which several agricultural institutes are housed. In front of the palace, under the road, the Moika River flows unseen. On the other side of the square tower the huge, black columns of St. Isaac's Cathedral, and in the middle, a dwarf compared with these columns, stands an equestrian statue of Nicholas I, a bronze figure with an eagle on his casque, moustaches arrogantly curled upwards, sitting unnaturally straight in the saddle and causing the horse to rear to make it look like the other horse behind the cathedral—that of the Bronze Horseman, mounted on a rough-hewn rock pedestal, with arm outstretched towards the Neva. . . .[2]

This is the scene outside the window. What about the interior? . . . It is doubtful whether another place could be found in the whole of the vast city of Leningrad resembling the few rooms on the lower floor of this building, from which the Blue Bridge across the Moika and the dark-red façade of the palace can be seen!

Outwardly, there is nothing imposing about the place. The spacious rooms are filled with stacks of shelves rising from floor to ceiling, along the walls and across the floors. If anything, the place looks like a library. But on the shelves are hundreds and thousands of small boxes. And so it is in room after room—deep and high run straight rows of strangely similar boxes. No, it is not a library. It is more like an arsenal in which some unknown weapons are stored. The endlessness of all these rows and their geometrical correctness is overwhelming.

The place is as silent as a cathedral. The noises of the street fail to penetrate it. In speaking, one involuntarily lowers one's voice—not only not to disturb the people who are working amidst the silence. . . .

Here, in these boxes, in these rooms on the lower floor of the spacious premises of the All-Union Institute of Plant Industry in Herzen Street, is kept one of the greatest treasures on Earth.

This is the Institute's world collection of seeds.

This collection was started a long time ago, in 1905, by Russian agronomists and botanists. They had scarcely any funds to start with, but these enthusiasts did more than seemed possible. They succeeded in getting together a good, "university" collection of seeds. The real beginning of this collection, however, unexampled in the history of science, should be dated 1917. The Soviet Republic, which had only just come into being, approved of a grandiose plan, which it deemed of exceptional importance: to investigate the plant resources of the world, to collect the seeds of everything that is and can be cultivated on Earth. Science was given an opportunity that it had never enjoyed in any other country.

An expedition of Leningrad botanists visited sixty-five countries. They reached places that no explorer had reached before. On steep rocks, on red clay, and on the fertile silt of yellow, lazily-flowing rivers, they examined the ears of cereals which, as it were, bore the impress of the level of culture of the people who grew them. In Central Asia, on the high plateaus where the black windstorms sweep the traveller from his feet and compel the droves of wild horses to gallop headlong for cover, the scientists squeezed grains out of thin ears that clung so tightly to their seeds that they had to be threshed with grindstones. And in the lowlands, under a clear sky, they found wheat so tender that the grain scattered if the harvesting was delayed in the slightest degree. The inhabitants of humid sea coasts baked excellent bread in their low ovens, but after threshing their corn they carelessly threw the chaff away; the ears were awned, prickly, and the cattle would not eat it. . . .

The expedition came back with scores of discoveries. Only now did man really know his old friends in the plant world. It turned out that even wheat was a stranger. Up to 1917, of the wheat race, the race from which man has created thousands of varieties, only five species were known. By 1935, Soviet researchers had already described fifteen, and today twenty-five species of wheat are known. Two thirds of the species of the most ancient crop on Earth have been discovered in the shortest interval of time by Soviet scientists!

In the Cordilleras, in Mexico, Peru and Chile our botanists discovered sixteen species of potatoes hitherto unknown to science—sixteen relatives of the potato that had had the good fortune to cross the ocean that separates the New World from the Old! These sixteen new species of potatoes were found in wild thickets and in the tiny fields of the Indians; they had cultivated them together with the potato we know, having no inkling that they were planting, banking and digging up tubers about which the learned botanists of the world had never heard.

In 1941, only a month before the outbreak of the war, an expedition of the All-Union Institute of Plant Industry was working in Lithuania and Western Byelorussia. This expedition was led by M. M. Yakubtsiner, the author of numerous books, a man of short stature, fond of a joke, and a high expert on wheat.

That is how the collection grew.

And for the first time in history man was able to survey as a whole what is drily referred to as "the resources of the plant world."

Shelves rising to the ceiling, packets of seeds and herbs in boxes. It is with a strange feeling that you read on the labels: Abyssinia, Afghanistan, Alaska, Algiers, Arabia, Argentina, Australia, Austria, Cairo, Czechoslovakia, Chile, China, Columbia, England, Eritrea, Japan, Kashgar, Korea, Kurdistan, . . . Malta, Manchuria, Mauritania, . . . Scotland, Switzerland, Yugoslavia.

This is what man has taken from nature, and what he himself has created for her during the ten thousand years of his labour—all that by which people live, all the two thousand million people on the globe!

At the end of the 20's, and particularly during the 30's, Soviet geological expeditions changed all previous conceptions of the wealth contained in the bowels of the earth. We learned that there are thirty-five times more coal in Kuzbas than the geologists of tsarist Russia had calculated. That as regards iron ore deposits, we are the richest country in the world. That scores of recently discovered fields of most valuable minerals are waiting for the miners' picks and drills. That beneath the surface of the earth stretch vast oil regions, the like of which does not exist in any other country. . . .

The change in the conception of "reserves" was not less radical in botany than in geology.

A calculation was made of the actual agricultural wealth of our country—an ancient land of agriculture. The first map of the abundant varieties was drawn—from Brest to Vladivostok. A study was made of the cultivated varieties, of the semiwild varieties, man's casual tributaries, and of the wild varieties, which man had hitherto ignored. The dandelion with its viscous sap growing on the desert highlands; the branched wheat of Transcaucasia, half weed and half vegetable, and what since ancient times has been sown in oases in the desert and in taiga clearings, where cereals with thin, sparse grains were unafraid of fierce winter—like forest animals in their white fur coats. Pomologists explored the densely-wooded Caucasian valleys where wild apple, wild pear and plum grew in profusion. Botanists explored the virgin forests of the Maritime and Amur regions in the Far East. Long ago the Cossacks who accompanied Poyarkov[3] and Khabarov[4] had dubbed these forests "Gardens of Eden"; and in our times that seeker for the unknown, V. K. Arseniev, and his inseparable companion Dersu Uzala,[5] wandered through them, gun in hand; and from there the companions travelled to the distant town of Michurinsk to perform unprecedented crossings—Far Eastern apricots with almonds; Ussuri pears with liana actinidia.

The chief and most important in the collection, however, are, of course, the bread grains. Cereals. They account for half of all the specimens in the collection. And first place among the cereals is held by wheat. Of wheat alone there are 38,000 specimens!

What, compared with this, are the Swiss herbs collected by dynasties of De Candolles, by all the De Candolle dynasties?

But there is another wonderful and unexampled feature about the world collection of the All-Union Institute of Plant Industry. It is not merely a lifeless copy of the plant world of gardens and fields. It is a world in itself. It is alive!

The parcel post carries packets from the Institute to all parts of the country. Seeds from all parts of the world are planted in the Ukraine, in the Arctic, under the scorching sun in Kazakhstan, and on the experimental plots of the Institute's vast network of experimental stations and bases. Supple shoots springing out of black soil, tubelike stems, branches rocked by the wind, pollen in the heated air, creatures of life constantly re-creating themselves—that is what the collection is! On these thousands of experimental plots the living properties of all the thousands of varieties in the world were "read" for the first time in the history of agrobotany. The theory of phasic development helped to do this. Vernalization, this new power over the plant organism, made it possible unerringly to grow in our country arrivals from every part of the globe.

The number of seed packets sent out every year runs into tens of thousands. The collection is part and parcel of the seething life on the fields of our country.

The plant breeder inspects his experimental plots. He seeks, finds, pollinates and crosses. The plot is a practical participant in his experiments.

And the confident, amazing victories achieved by our plant breeders are due in no small degree to the existence—to the life—of this world collection.

. . . And in those silent rooms in Leningrad the greatest experts on crop plants in the world are working. Fruit and vegetable experts who have no equals. The highest experts on legumes. People who can tell you more about oil-bearing and fibre plants, about root crops, or barley and rye, than anybody else in the world. The names of these people are famous. Every one of them possesses inventor's patents. That means that every one of them has created a new plant that is being widely cultivated in the country. During the war and the first postwar years the Institute produced a hundred and seventy new varieties, and in 1949 the number will reach two hundred.

Yevdokia Fyodorovna Palmova sits bending over her desk. Her hair is white, she is nearly seventy. But with her old, but skilful hands she deftly opens the packets before her, separates the seeds, examines them on every side, compares them, counts them and catalogues them. Her life has been a life of labour—here in this room, and in the experimental fields—a life of zealous and seemingly inconspicuous labour. She performed her work just as zealously and inconspicuously during the siege of the city by Hitler's hordes—her shoulders are just a little more rounded, and her hair grew white.

And now she bends over her desk, hour after hour, continuing her work without a moment's interruption. She may be examining the seeds of the most ancient varieties or those of varieties that do not yet exist, that are only just coming into being. Packets, precise movements of the hands from which the tiniest necessary seed never escapes, a magnifying glass near at hand, a moment's reflection, and an entry in the catalogue. . . .

It is almost incredible that she, a plant breeder, would want to leave her place of work and take an ordinary vacation in the South, in the summer, that is, in the "vegetation period." But if this almost inconceivable event did occur, Yevdokia Fyodorovna would see through the carriage window vast fields of waving corn stretching as far as the eye can reach. In those fields there would be the wheats Melanopus 69 and Gordeiform 189—the two most widespread hard wheats in the world; and also the soft Erythrospermum 841. Those are her wheats! They are of her creation; constantly rejuvenated, constantly young, the beautiful adornment of millions of hectares—they are the fruit of her labour. See how widely her life has left its impress upon the whole land!

. . . Here, in these rooms on the ground floor, you get the peculiar feeling that you have risen to an immense height from which you obtain a view of the whole Earth; and you get a clear picture of what Russian agriculture, our agricultural science, our grain, has meant, and means now, for the whole Earth.

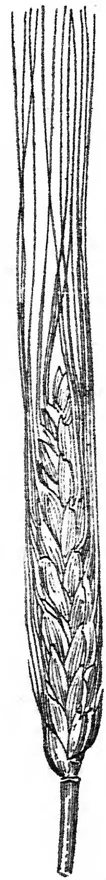
M. M. Yakubtsiner, the wheat expert, tells us about it, and in the course of his narrative he points to the shelves and says: "Here we have all the wheat varieties in the world. You only have to put your hand out and take them down."

Hard wheat—gives a record yield. Every grain in its close-packed ears is one fourth larger and heavier than the grains of soft wheats. The quality of the proteins contained in the grains of hard wheat is amazing. They make excellent flour, and the bread from it is exceptionally delicious. Ten per cent of the world's wheat area is taken up with hard wheat. And its best varieties came from our country!

All the vitreous wheat grown in the United States and Canada originated from varieties grown in the Ukraine and the Crimea.

Our Ukrainka is the world wheat champion.

America has borrowed many kinds of crops from us, Kubanka and Arnautka are just the famous wheat varieties of the southern parts of our country. The most widespread winter wheat in America, Turkey, originates from a Ukrainian wheat; and the next most widespread, Kanred, comes from our Krymka. The major and most well-known Canadian variety, Marquis, is a descendant of West-Ukrainian wheats.



An ear of Arnautka wheat (two-thirds natural size)

The wheat varieties Garnet, Huron, Prelude, and Preston would not have existed had it not been for the Leningrad varieties Ladoga and Onega.

The grain created by the brains and hands of our people has proved to be the best in the world. It is with pride that one loudly repeats this—it is the purest thing; the bread, the food, the life of mankind!

And what about our contribution to world agricultural science? How is that to be measured?

In the science of classifying and biologically describing cultivated plants, all that was done in the past, here and in other countries, has been so immeasurably exceeded that it is true to say that it has been created anew in the U.S.S.R. The theory of the initial material, of utilizing the wealth of varieties is the honour and glory of our science.

Knowing this, it is with complex feelings that you gaze at these stacks of shelves, boxes, index cards and catalogues—at this world collection, the instrument of so many wonderful discoveries and bloodless victories in man's great work.

Suddenly you ask yourself: "How is this? This precious collection is housed in the city which not so long ago had gone through a terrible siege, which had been fiercely battered by aircraft and artillery, where the walls of buildings had borne not only the century-old signs showing where the water reached in 1824, during the flood that we all know about from the description given in Pushkin's splendid poem "The Bronze Horseman," but also the warnings: "Citizens, this side of the street is most dangerous under enemy artillery fire." By what miracle was this wonderful collection—20,000 kilograms of grain—saved during the siege when people were dying of hunger?

It is even more amazing than the saving of the art treasures of the Hermitage.

"*They*," meaning our enemies, "were already convinced that our collection was lost. Read this," said Yakubtsiner, in the low voice in which one speaks about something inexpressibly mean and one feels ashamed of the man who had committed it. I read the following:

"I had not the time to discover what had happened to the remarkable programme of work on the evolution and genetics of crop plants. . . . (except that some of the seed-collections left at Leningrad were eaten during the siege)."

Just like that, in passing, in brackets: "some were eaten." I suppose we ought to be grateful to Dr. Julian Huxley, leading British biologist and grandson of Thomas Huxley, Darwin's friend and assistant, "the watchdog of Darwinism," as he called himself,—we ought to be grateful, I say, that this Dr. Julian Huxley spared at least part of the collection and did not say that the whole had been eaten.

"Eaten by whom?" I enquired.

"By us, the guardians of the collection, he wants to say," answered Yakubtsiner in the same low voice.

Huxley is well known. He is a distinguished evolutionist and works in the same field as his famous grandfather had done; but how little in common there is between the two! Development? Progress? Only recently, in the year of the great Battle of Stalingrad, grandson Huxley gave utterance to the following cold verdict: Evolution can be pictured as a series of branches ending in a blind alley. . . . What would old Huxley, the fearless "watchdog," have said to this?

Julian Huxley is not inquisitive. He came to the Soviet Union for the postwar anniversary celebrations of the Academy of Sciences and stayed here two weeks. He could have learned absolutely everything he wished to know—everything about the field of science in which he is engaged. For what other purpose does a scientist visit the scientists of another country? But he "had not the time" to discover what had happened to the program of work on evolution and genetics which he himself describes as remarkable. And he, a biologist, was not even interested in the pride of world science—the collection of the All-Union Institute of Plant Industry. Why, then, this casually uttered assertion: "except that some . . . were eaten"? Why this casually uttered calumny?

Perhaps it was prompted by his general conception of the human race?

The Director-General of the UNESCO (i.e., Sir Julian Huxley) has no high opinion of the human race. Probably, on his Albion Isle, among his friends, colleagues, parliamentary orators and prim lady philanthropists, he has not had the good fortune to meet with anything to contradict his opinion. At all events, he has arrived at the conclusion that it is necessary to put a stop to the present method of propagating human beings. How can a matter like this be left to the discretion of such creatures? They must be bred like Borsoi wolfhounds, race horses, or double tulips! This is the only way of salvation. Only in this way will it be possible to obtain genuine castes and to endow at least some of them with altruistic and collectivist qualities.

Castes! Alas, even in present-day India the stern caste system is threatened.

Professor Huxley is in a pessimistic mood.

He argues as follows:

Scientists create and guard a priceless collection.

The scientists are starving. What will the scientists do?

Naturally, the scientists will eat the priceless collection.

Such is the inexorable logic of Dr. Huxley, a logic capable of gladdening the heart of Lévy-Bruhl himself, that most zealous collector of examples of "primitive thinking."

Julian Huxley's article, "Evolutionary Biology and Related Subjects," was published in the magazine *Nature*, 1945, Vol. 156, No. 3957, pp. 254-56.

Almost immediately after this article, in the same volume of this academically unbiased magazine *Nature*, in No. 3969, on page 622, this slander is repeated: " . . . when Leningrad came to be besieged, the residue of the collections was eaten. . . ." No details. Just the bald statement, and a false one, to make people think that the Bolsheviks had, vandal-like, destroyed this unique collection.

"Harland and Darlington" are the names at the bottom of this latter article. Harland is the geneticist who in Peru had regenerated a variety of cotton by a method worked out by Soviet Michurin scientists and forgot to mention whose method it is. Darlington is the geneticist who, knowing in what way the fields of the chief agricultural dominion of the British Empire—Canada—are indebted to our cereals, and the orchards of Canada to the Michurin varieties, had the brazenness to say that Michurin . . . had obtained his varieties in Canada, and that Lysenko ("an obscure assistant at an agricultural research station in the Ukraine") had "probably heard about vernalization from German sources," that in his researches Timiryazev . . . followed William Ockham, the English schoolman of the fourteenth century! . . .

That great lover of life, Maxim Gorky, who had unshakable confidence in man and in his work on Earth, wrote: "Man—there is a proud ring about that word." But he also knew: "That which is born to creep cannot fly."

Creepers do not understand the lofty flight of the human mind—creativeness—and hate it. With what malicious glee they try to deprecate, to slander it! Nothing new has been discovered. Everything was known to William Ockham in the fourteenth century!

And they hate particularly the country where the freest and most humane creativeness has become a law of life. Michurin alone created hundreds of new plants and achieved the proudest victory over nature? No, "it is easier to assume that he obtained his best plants from Canada and the United States." And it is still easier to assume that the simplest instrument of self-observation—a mirror—would bring S. D. Darlington, F.R.S., to agree with Huxley's opinion of the human race and to approve of the man-breeding theory.

Such is the yardstick with which they wanted to measure the conduct of the Leningrad scientists. They poured calumny on the still fresh graves of those who perished while guarding the priceless collection to the very last grain. With what indignation the London magazine was read in Leningrad!

But the lie was too obvious.

Shortly afterwards *Nature* published a correction. A few lines, unsigned, to the effect that, apropos of a statement made in a previous issue, it appeared that no part of the collection had been eaten, that many of the assistants at the institute were killed, or died of starvation, while guarding the collection. . . . A slight correction. Sorry, we were mistaken. . . .

If these few lines are not noticed by all those who had read the two articles containing the falsehood—what does it matter?

UNDYING HEROISM

Now this is what happened in Leningrad.

The last train to dash through from Moscow to the besieged city carried a detachment of naval forces. With this train came a representative of the Lenin Academy of Agricultural Sciences of the U.S.S.R., Professor I. I. Prezent, now a member of the Academy.

No more trains arrived in Leningrad after that.

It is easy to understand what, at that time, August 1941, every single railway car that could be despatched from Leningrad meant. But as soon as the hope arose that another train, just one more, would succeed in getting through, the last perhaps, cars were assigned from it for the All-Union Institute of Plant Industry and its collections.

The train started off, but soon stopped again and the passengers were informed that they could go home as it was not certain when the train could leave. Eichfeld got out of the freight car in which he was riding; he had refused the privilege of travelling in a passenger car. The Institute's property had been loaded in open railway trucks, which had been dubbed "wherries." The men took turns in guarding these wherries. The train never got further than Rybatskoye, a station only a few kilometres from Leningrad.

The nights were already dark and the cold set in early. The enemy was fighting his way to Tikhvin. Famine started in the besieged enormous city. Incendiary bombs rained on the roof of the Institute. On hearing the "alert" the laboratory assistants and Doctors of Science dashed up the steep stairs to the attic to save the building.

More and more people arrived to stay at the Institute, among them the staff of the Institute's station at Pushkin, outside of Leningrad. Yevdokia Palmova left the Pushkin station only in a summer frock, but carrying bags containing specimens of her experimental crops. A. Y. Kameras lugged on his shoulders sacks containing specimens of the potato collection.

The staff of the Institute of Plant Industry and that of the All-Union Institute for the Protection of Plants, which occupied the same building, lived together.

The massive, brick building was as icy as a cellar. The scientists, their fingers stiff with cold, opened the packets containing the seeds from the world collection in order to divide the specimens in duplicate packets.

Likhvonen, the manager of the Supplies Department, on receiving his plate of "soup"—water with several leaves and roots floating in it—would pour it into a can and carefully carry it to the Petrograd Side,* where his family lived. He walked there and back, and returned almost bent double.

One day he failed to return.

Some of the bomb craters in the streets were filled with water from damaged water mains. The local inhabitants scooped the water out of them with buckets. Later the water froze.

At the end of 1941, E. F. Arnold, a bookkeeper who had worked at the Institute for thirty years, lost her ration cards. When she arrived at the office that morning she looked half dead.

"What's the matter?" Eichfeld asked her. The woman sobbed. "Well, tell me, what's happened?"

At last the woman told him of her misfortune.

"Lost your ration cards?" said Eichfeld. "That's not much to worry about. I will get you other cards." He got up, his carefully pressed clothes hanging on him like a sack. "Calm yourself, we'll soon put that right."

He did get her other cards—his own, and left himself only the permit to the House of Scientists on the Neva Embankment, where scientists were served Lilliputian portions of a fatless meal which they called "dinner."

The track across Lake Ladoga, the "road of life," as it was subsequently called, had not yet been laid. The only communication with the "mainland" was by air; and every aeroplane had to meet a thousand urgent demands with every perilous flight.

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* A district of Leningrad, a good distance from the Institute. — *Tr.*

Nevertheless, two aeroplanes were placed at the Institute's disposal for the purpose of taking out the most precious specimens. Eichfeld was on the point of exhaustion. His face, always carefully shaved, was like that of a corpse. His assistants tried almost forcibly to get him to board a departing aeroplane, but he absolutely refused to go.

On December 25, Professor Bukasov, the famous potato expert, K. M. Mynbayev, a specialist in rubber-bearing plants, and V. A. Korolyova-Pavlova, an assistant, left, accompanying an assortment of the collection.

A word which two months before only medical men had known became a household word in Leningrad—dystrophy. It meant frightful weakness and cold sweat at the slightest unusual exertion, and arms and legs as heavy as lead; hollow cheeks and temples; then a swelling body and face. Exhausting diarrhea; a feverish glint in seemingly enormous eyes, but most often dimmed by a dull film. A person would begin to speak and then stop as if lost in reflection. . . .

A heavy blow to the Institute was the death of Dmitri Sergeyevich Ivanov, the rice specialist. His enormous figure had seemed always to fill every room he entered. It was difficult to picture the force that could have driven life out of that big, powerful, cheerful body with the light, springy step.

Perhaps this bereavement was felt most heavily because it was the first.

In the Oil-Bearing Crops Department there was a scientific worker named Alexander Gavrilovich Shchukin. A quiet, inconspicuous person. He was in charge of stocks of arachis full of proteins and oil, and of flax and sunflower seeds. They ran into scores and scores of pounds. Scores of pounds of fats worth their weight in gold entirely in his charge. But he withered away, calm, polite and obliging as ever. He died of starvation, not even suspecting that there was a name for his conduct—heroism.

An incendiary bomb struck the house wherein lived Alexander Yakovlevich Maliboga, a scientific assistant in the Agrometeorological Department. The house was burnt out, and Maliboga perished in the flames.

Professor Yevgeni Vladimirovich Wolfe, famous expert on plant geography, was passing Maltsev Market when he was struck by a shell splinter and was killed.

Professor Georgi Karlovich Kreyer, director of the Medicinal Plants Department, and Georgi Vladimirovich Heinz, manager of the library, a bibliographist and inventor of a new system of scientific cataloguing, died of starvation. The latter, only six months before, had received books, magazines and scientific works from hundreds of scientific institutes and societies in all parts of the world in exchange for the literature of the All-Union Institute of Plant Industry.

At night the stony silence of the streets was suddenly disturbed by the roar of artillery, growing in volume and dying down again. The beam of a searchlight, a second and a third, would scour the sky and the terrific rattle of a nearby antiaircraft gun would break out like the unloading of a ton of bricks. . . .

The crunch of footsteps in the snow—a passing naval patrol. . . .

The moon peeps out and millions of cold diamonds glisten on the ground, on the telegraph wires, and on the snowy raiment of the trees.

One night two scientists from the Institute were plodding home. It was terrifically cold. The trams and trolleybuses were stranded in fluffy snowdrifts and snow was piled on their roofs like huge pillows.

One of the scientists said:

"I think all us Leningraders will be given medals. Like the crew of the *Chelyuskin*. What do you think?"

The other wanted to answer. He removed the handkerchief that protected his mouth and exhaled a cloud of vapour, but then he staggered from weakness. After recovering a little, he said jokingly:

"Why not? Look, that's the tram I always used to ride on. Doesn't it look like an icebound ship?"

These people did not whine and snivel, they went on with their work; and when things were hardest they joked and laughed.

Vera Andreyevna Fyedorova, an assistant in the Introductions Department, was working at her desk at the Institute when she fell face forward. She never raised her head again.

Serafima Arsenievna Shchavinskaya, a tomato specialist, and agronomist Mikhail Andreyevich Shcheglov died of starvation.

Samuel Abramovich Egiz, Doctor of Biological Sciences, director of the Tobacco Department, died.

By this time one of the most amazing and glorious deeds of the war was accomplished: the track across Lake Ladoga to the hero city was laid; but nobody in the city knew as yet how it was going to work. At the Institute the rumour spread that it will be necessary to walk 170 kilometres across the ice. "Like Sedov walking to the North Pole."

The evacuation of the staff of the Institute and of the world collection which they had saved was fixed for the middle of January. They were to be among the first party of civilians to leave Leningrad; and they were given a privilege that was incredible under the conditions then prevailing in the city: they were given three days' provisions.

Professor I. I. Prezent, the representative of the Lenin Academy of Agricultural Sciences of the U.S.S.R., issued an order defining what each member of the staff was to take on the journey: so many kilograms of personal baggage. Sleighs were obligatory. No pillows or blankets, there would be no room for them. Instead, the staff were advised to make themselves overalls padded with down and feathers from quilts and pillows. When these overalls were worn, the feathers protruded through the cloth and the wearers presented a strange sight. Yakubtsiner dubbed this outlandish clothing "chanticleer costumes."

The train left on January 17 and took a long time to creep to the lake. The fifty kilometres seemed as long as the distance to the moon.

At last the steel road ended. Then came the ice.

Before dawn, on January 22, a "caravan" of motor trucks started on its journey to the "mainland" and vanished in the gloom of wintry Ladoga.

But some of those who left Leningrad did not make the journey across the ice; they died in the overcrowded freight cars: G. A. Rubtsov, the greatest pear specialist in the world; the child of T. Y. Zarubailo (he himself was in the army); the wife of P. N. Bogushevsky, and he did not long survive her.

Yakubtsiner was taken from the train at Zvanka; they thought he was dead. For three months he lay at the Volkhov Hydroelectric Power Station and another three months in hospital in Yaroslavl.

. . . And when the last truck raced off across the ice and the last farewell call "We'll meet again!" reached the shore, I. I. Prezent, Doctor of Biological Sciences, dragged himself back into the freight car. Reclining on the seat and fitfully dozing, he saw the hoarfrost glistening in the corners of the dilapidated car. The train crawled back to Leningrad to take the second party of the Institute staff and the second part of the collection.

The departure was expected any day, but the representative of the Lenin Academy of Sciences of the U.S.S.R. was unable to leave his flat in Zhelyabov Street. Often he was in a state of delirium. One day G. N. Reuter, the secretary of the Party organization at the Institute and captain of the Anti-Aircraft Defence team, came hurrying in with the announcement:

"A train is leaving!"

"Very good. . . . I'll be ready soon. . ." answered Prezent feebly.

It took him six hours to get to the Smolny, the Party headquarters, and even now he does not remember how he managed to crawl those few kilometres. When he became clearly conscious of his surroundings he found himself in the office of the secretary of the City Party Committee with a doctor at his side, and they were pouring something hot down his throat.

"We will reserve some cars for you without fail," said the secretary.

The second party left on February 2. Eichfeld went with it. Of the collection, including the part despatched by aircraft, eight tons were evacuated, only the most irreplaceable, the core of the collection. The rest remained and had to be guarded.

The following stayed behind: N. R. Ivanov, our greatest bean expert; Reuter; V. S. Lekhnovich, Candidate of Sciences; senior scientific assistant O. A. Voskresenskaya; R. Y. Kardon, a splendid apple expert; junior scientific assistants P. N. Petrova and E. S. Kilp; laboratory assistant N. K. Katkova; the Director's representative K. A. Panteleyeva; the superintendent of the building M. S. Belyayeva; janitor A. P. Andreyeva, and members of the auxiliary staff M. Biryukova, E. Golenishcheva, A. Lebedeva and A. Romanova.

Winter, the fierce winter of 1941-42, refused to make way for spring. In the building near Blue Bridge, people with ashen-grey faces and swollen, bleeding fingers, went into the rooms where the cases and boxes were kept, in groups of three, as if entering the strongroom of a bank. That was the arrangement they had made among themselves. Nobody was to enter the rooms alone. Stern Kardon opened the doors with the heavy keys; an icy blast blew from the gloom, causing the flame of the small kerosene lamp to flicker.

Swarms of rats scampered away; in the gloom they looked enormous, black and gaunt. They had cunningly opened some of the metal boxes and had pushed them to the floor. They leapt from the shelves, scarcely afraid of the people. And the people got down on their hands and knees, swept up the seeds, put them back in the boxes, replaced them on the shelves and boarded them up. The rats increased in number; evidently, by ways known only to themselves, they came from other yards in Herzen Street, from houses on Prospect Mayorova, Gogol Street, Krasnaya Street, and even from the Embankment—drawn to the place where tons of grain were stored. Day after day, month after month, in the gloom (the windows had been boarded up long ago), these starving, exhausted people waged a bitter struggle against swarms of fierce and hungry siege rats.

The people triumphed. They vanquished the cold, the hunger and the rats—in the same heroic way as their comrades, the soldiers on the Leningrad front (among whom were volunteers from the Institute) beat off all the furious attacks of Hitler's hordes upon Leningrad.

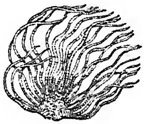
At last, the Soviet Army, guided by its great leader, with a mighty blow shattered the hostile ring around the city.

The war ended. The Victor Army occupied Berlin.

The priceless world collection was brought back to the City of Lenin, to the building near Blue Bridge. It had been saved to a grain—the part that was evacuated and the part that had remained.

But the names of those who sacrificed their lives, and of those who were ready to do so, to save one of the greatest treasures of science so that it may continue to serve for the happiness of millions, must not be forgotten.

LIVING EARTH



A GIANT

A mighty face, as if cast in metal; large, distinctly Russian features. A high, open forehead. A long, broad, parted beard. A firm, steady gaze.

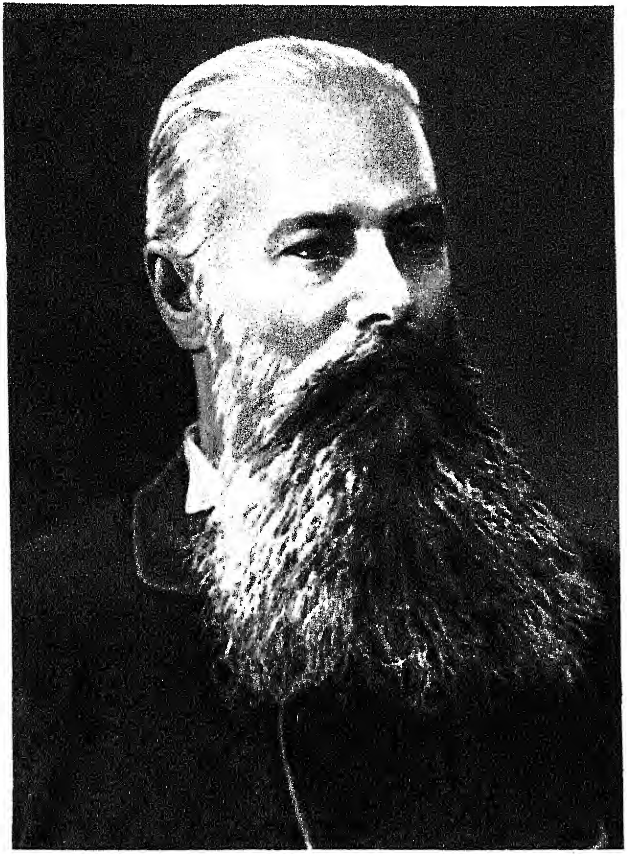
He looked a commander of men.

He wrote in a clear, firm hand, as straight as a ruled line. There was no need to be a handwriting expert to be able to say, after a glance at a page he had written, that it was indeed the hand of a giant, strong and of integral character, who never equivocated, had nothing to hide, a stranger to flabby vacillation, and, evidently, knew what he had to do and where to go.

A man like that could live to be a hundred, and seemed strong enough to move mountains!

We are speaking of Vasili Vasilievich Dokuchayev, the giant in Russian and world science, with whose name we, in the present generation, have long associated the term—*great*.

Like the great physiologist Ivan Petrovich Pavlov, Dokuchayev was the son of a village priest. He was born on February 17, 1846, in the village of Milyukovo, Sychev Uyezd, Smolensk Gubernia, and when he reached school age he was sent to a seminary. It was almost the same type of



VASILI VASILIEVICH DOKUCHAYEV

seminary that Gogol described when, in relating the extraordinary adventures of the philosopher Khoma Brut,[6] he wrote that the latter "had nothing in his pockets except some strong, coarse-cut tobacco," and it was certainly of the type described by Pomyalovsky,[7] where all the pupils were known only by nicknames, where they played the cruelest pranks upon each other, where the juniors were frightfully bullied by the seniors, and where the tutors tried in vain to knock theology and Latin into their pupils' heads by means of the liberal use of the birch.

The pupils at the seminary that Dokuchayev attended were allowed to go home for the Christmas holidays. Those who lived within twenty or thirty miles "footed it," but those who lived at a great distance from the school clubbed together to hire a cart to take them part of the way and finished the journey on foot. "A journey equal to an Arctic expedition," commented Dokuchayev's first biographer at the beginning of this century.

It was easier when they went home for the summer vacation. They tramped through fields and woods, heard the birds sing and whistled to them. Kindly villagers put them up for the night in the threshing barn, or in the hayloft, gave them a hot meal, and in the morning put a chunk of fresh-baked rye bread into their knapsacks.

At home Dokuchayev found friends awaiting him—the lads of the village, with whom he went fishing, bird catching and berry picking; and when the crop ripened he helped with the harvesting.

He finished school, his boyhood days were over. What was he to do next? His father wanted him to go to divinity college.

"Yours will be a better career than mine," he said. "You will receive an urban parish, and if my dream comes true. . . ."

He did not say what his dream was, but before his son could answer he raised his forefinger and said impressively:

"Your grace, Father Vasili. . . ."

And he said it in a tone as if he were uttering something for which he had himself been longing in vain, for his name too was Vasili.

Young Vasili was sent to a divinity college in St. Petersburg. What happened there was very different from what his father had expected, but it could have been foretold by anybody who had taken the trouble to study the things that interested young Dokuchayev, with his clear, precise mind, strong character and aversion for sentimentality, mysticism and grandiloquent oratory.

After a short stay at the divinity college he decided that this was not the place for him. He applied for entry to the St. Petersburg University.

This was not an easy thing for an ex-seminary student. One had to have splendid abilities and a passionate desire for knowledge, and proof that one possessed that knowledge. When had he found the time to acquire it? Theology and physics and mathematics are as wide apart as the poles! But he passed his examinations and was accepted. He took up the natural sciences.

His student life was not easy either. He was borne down by sheer, downright poverty. Recalling those days, he, with his characteristic broad humour, which he preserved to the end of his life, described them in one brief, vivid sentence:

"I did not know the use of stockings then!"

When he was asked what he had been taught at the divinity college he answered bluntly, in a deep, grave voice:

"Funnyletics!"

He applied this term not only to homiletics, i.e., the art of preaching, but to all the "sciences" taught at the divinity college.

In 1870 he decided to take his summer practical studies in his native village. The only thing of interest there was the little river Kachnya. His choice surprised his fellow students. Why the Kachnya? They dreamed, if not of the canyons of Colorado, then at least of the peaks of Ai-Petri in the Crimea, of the Kungur caves, the lofty Pamirs, or the volcanoes of Kamchatka. Only those parts of the Earth seemed interesting to them where it was seen in its gigantic nakedness, and where the vestiges of its agonizing birth pangs were visible. The ordinary face of the Earth, a thousand Kachnyas, all as like as drops of water, had no attractions for them! But this sturdy country lad, Dokuchayev, was of the opinion that the Kachnya was interesting precisely because there were thousands of rivers like it, because the land, for millions of square miles, was like that in his native village, because it abounded in green forests, grew the food that people lived on, and which, if dug, gave access to endless layers of rich, black soil. And what really surprised Dokuchayev was that science knew more about the glaciers of Greenland and the geysers of New Zealand than about this vast land that surrounds us, and which people call by the sacred name of Mother.

And so he went to study the Kachnya. He took for his companion a fellow villager, Andrei Piun. On basic questions, the Milyukovo peasant and the St. Petersburg university student understood each other perfectly.

In 1871, Dokuchayev read a paper at a meeting of the St. Petersburg Naturalists' Society "On Alluvial Formations Along the River Kachnya." This was his first scientific work.

In spite of the hardships of poverty he was forced to endure, he finished his university course brilliantly. He found strength for everything. Indeed, it seemed as though it had not yet been tapped, that it was seething in that giant body demanding work. But where was that work?

At that time three "regular" roads were open for geologists who graduated from the natural sciences department of the university: mineralogy—the science about the minerals found in the earth's crust; petrology—the science about the mineral and chemical composition of rocks; and geology. None of these had any attraction for Dokuchayev. Paleontologists regarded him as "one of their own" after the sensational find he made when still a student: the skeleton of a mammoth, on the banks of his native Kachnya, where, according to the authorities of that time, it could not possibly have been; and it made all these authorities devote their attention to this small Smolensk river! Their attempts to induce him to join their circle were fruitless, however. When the mammoth was mentioned in his presence, his face assumed a naive and surprised expression, and with a merry twinkle in his eye he would enquire in his deep, bass voice:

"Do you mean that antediluvian cow?"

His supercilious tone was no doubt affected, for after all said and done, he regarded the mammoth also as one of the products of the "earth's convulsions," something like an Arizona crater. . . .

The only thing that interested him, and entirely absorbed him, was the vast, ordinary surface of the earth with which man's life is so closely bound: alluviums, ravines, rivers and the soil, the soil! What he wanted to interest himself in, and regarded as most important for the millions, was a science that did not yet exist ; did not yet exist not only in Russia, but "just imagine, nor in Paris, nor at Oxford, nor in Berlin, nor in Jena!"—so he was assured. And the meaning behind this assurance was that not only did no such science exist, but it simply could not exist.

The soil? From what aspect did this thin layer of the earth's crust interest him? How it originated? But the geologists could have told him all he wanted to know about that, if only, of course, they could spare the time to tear themselves away from the much more complex and important problems of the folds of the Devonian sandstone and of the Triassic marls. What secrets are there in these uninteresting deposits, which arose under our eyes, today, or yesterday, at all events, in the very alluvial epoch in which we are living? They do not contain a single important fossil. Deposits which are only one minute old by the clock by which the history of the Earth is measured!

Or the composition of the soil? On the whole, it is very uniform. The mineralogists would want not more than two or three pages of their textbooks to describe it all. And besides, there is agrochemistry—Liebig. . . .

And listening to this, Dokuchayev wondered why a thing that was so clear to Andrei Piun, could not be made clear to clever and intelligent researchers who knew so much and were sincerely devoted to science, namely, that there is a fundamental difference between soil and barren rock, and that this difference lies in the most important thing about them.

"I understand you," a grey-haired crystalographer, or a specialist in dolomites, would say to him. "I understand you perfectly. The ploughable stratum is of immense importance in the life of man, and in the life of our country in particular. But, young man," and here the voice of the speaker would acquire a metallic ring, "you must not confuse economic necessity with logical necessity. What is subordinate solely to science cannot be deflected by any of our earthly needs. The ploughable stratum is only one of the rocks, one of thousands, of tens of thousands, and there are no grounds for singling it out in principle from the rest. Remember this. Alexander Humboldt travelled over half the world and became convinced that soils, like all the rocks, are scattered in disorder over the whole globe. They are governed not by geography, but by geological arbitrary rule. The lava of Hecla is the same as the lava of Vesuvius. The vegetable grower in Gomel will find in the Canary Islands the same kind of soil as that in which he plants his cucumbers. Whoever wants to be a priest in the Temple of Truth must be able to resist the most enchanting mirages."

Dokuchayev would have preferred simpler language than this highfaluting talk about temples and truth; and he was not so sure that he wanted to be a "priest."

He began to wonder whether the years he had spent at the university had not been wasted, and whether he should start all over again and study to be a physician, or a surgeon. Doctoring was a perfectly plain and useful business, no pseudo philosophizing, and work that was obviously needed. . . .

Later he applied for a post as a schoolteacher in Moscow.

This period of doubt did not last long. Dokuchayev had strength enough not only to start life all over again, but to hew for himself a path in science.

He was encouraged by A. A. Inostrantsev, the famous geologist, who realized that the young man's head was filled not only with mirages.

"The future will show what value there is in what you say," he said. "You must prove by deeds the truth of what you believe in. The first thing to do is to set to work."

Dokuchayev received the post of curator of the university geological museum. A quiet life, pottering about with the exhibits on the shelves, verifying the labels, probably early short sight, respected old age gradually creeping over you, accompanied by signs of crankiness, a growling tone of voice and old-fashioned clothes. "To finger a piece of junk and cry out—Eurika!" said Dokuchayev ironically, contemplating the prospect. No, that was not the program of life he had mapped out for himself.

He travelled about Russia, the Russia of peasant fields and bright birch woods, of oak forests and gloomy thickets through which the northern rivers slowly flowed. He climbed the Finnish granite rocks, the brothers of the one on which the steed of the Bronze Horseman in Petrograd was prancing.

He travelled on a commission for the Naturalists' Society—of the Geological and Mineralogical Department of which he was appointed secretary in 1874.

His life now bubbled with seething activity and he proved of what untiring, intense and diverse work he was capable. He studied rivers, their deposits and the windings of their valleys; and everywhere he closely observed, examined and studied the soil and collected specimens. How infinitely diverse the different soils are to the observant eye! The colour of ash, chestnut, red, dull yellow, whitish; black soils, a lifeless, muddy blackness; and other black soils, alive, rich and thick, a fertile blackness.

Uniformity? Monotony? People thought like that because they had cast only a brief contemptuous glance at this rainbow of colour.

Gradually, Dokuchayev began to see clearly what before he had been convinced of merely by intuition. Now he would have found the arguments he needed if he again heard about Alexander Humboldt, and about soils being the by-product of the conflict between Vulcan, Neptune and Aeolus, the god of the winds! Alexander Humboldt! The man who had lived nearly a hundred years, the man who was grandiloquently called the "Aristotle of the nineteenth century," whose voyage to Orinoco was hailed as the "second discovery of America," to whom was flatteringly ascribed the actual creation of scientific geography, the man who had written so much about landscapes had *not seen* the sum and substance of the latter—the soil. He knew that the living world was not a chance excretion on our planet; the forests of Casiquiare had taught him that. But he had separated the living from the nonliving world. He thought as follows: leaving aside the dracaena of Africa and the mosses of Lapland, we will see no difference between the home of the giraffe and that of the Arctic fox; for how is it possible to distinguish between one skeleton and another if the flesh is absent from the bones? The sand of the Zambezi may also be found on the shores of the White Sea. Humboldt's "landscapes" appeared in a sort of vacuum, as if suspended over the earth, on which alone everything lives and grows. A fine "scientific geography, indeed!" Two planets—one alive and the other lifeless. Humboldt could never conceive them as one.

Actually, there is only one.

For his Master of Science degree, Dokuchayev submitted, in 1878, a treatise on "The Mode of Formation of the River Valleys of European Russia." In it he clearly formulated the ideas that had arisen in his mind in his student days. He was no longer a youth developing strange and vague ideas. The rumour spread through the university that the curator of the geological museum, just returned from his long expeditions with boxes full of collections, was really creating a new science. The hall in which he read his treatise was crammed to the utmost, and the debate that followed was a triumph for the young scientist.

But this treatise was only an "introduction." Two years before he had been present at a lecture on "Agronomic Journeys in Some of the Gubernias of the Central Chernozem Belt of Russia." These journeys had been made by Alexander Vasilievich Sovietov, a fifty-year-old, even-tempered, broad-faced man with a broad, brown beard already streaked with grey—the first Russian Doctor of Agriculture. His treatise "On Systems of Agriculture" that he had submitted for his scientific degree had caused a sensation, for he then entered into debate with *none other* than Mendeleyev.

At that time Dokuchayev had been completely engrossed in the work of drawing a soil map of European Russia, and this work, conducted for the first time in history according to this scientific method, brought him further refutation of the "soil disorder" theory.

He went to hear Sovietov's treatise, and listened to it with rapt attention.

The chernozems (black soils), Russia's pride, are the most amazing of soils: crumbly in some places, as soft as butter in others, with a colour so unusual, so different from that of all other soils in the world, that it seems to be the very colour of the fertility that fills them—what are the Russian chernozems?

Dokuchayev realized that he now had work before him for many years to come—to study and learn the secret of the chernozems—the great wealth of our country; with and through them to ascertain and reveal the general laws that govern the earth crust of the globe.

He could expect little help from books, although he could not complain of a dearth of them; this unusual "black earth" had long attracted the attention of scientists and had stimulated the imagination, imagination more than anything.

Pallas, in the eighteenth century, was the first to surmise that chernozem is the silt of an ancient sea. At one time it was saline. Sixty or seventy years later the Englishman Murchison more definitely expressed the opinion that it was silt from the Glacial Sea. He called attention to the map of the prealluvial period and claimed that it was obvious that the arm of the glacier on the Middle Volga had reached into the sea bay. "Salt silt that became saltless! There is no sense in this," hotly retorted Wangenheim von Kwalen. "It is simply that the glacier brought the peat down from the northern bogs and spread it over the present plains."

"Just so!" exclaimed Eichfeld, eagerly clutching at the idea. "Peat! That's it, peat! But why look for ancient bogs only in the North? True, feather grass, and the bluebells that now delight the hearts of poets, did not grow on the edge of the glacier where the steppes spread now. It was precisely the black marshes that stretched here." "Like those among which the gates of Hades of the ancient Greeks stood open, is that it?" enquired Professor Stuckenberg sarcastically. "I have my doubts about the marshes, but at all events, note this: the soil we are discussing is formed of fresh-water deposits. What have salt and the sea to do with it?"

The German Orth, who journeyed through Russia, briefly defined chernozem as "marly, humous, loamy soil." Schmidt of Derpt assumed that since chernozem was rock, there could be no secret about it. What are these famous soils of the Ukraine? "The product of the grinding up and erosion of the upper stratum of the Dnieper granite heights!"

There was a small group of scientists who threw doubt upon all these extravagant conjectures about the origin of chernozem. Güldenstädt, Gueaux, Eversmann, and particularly Ruprecht, were of the opinion that chernozem was "humus," i.e., decayed matter left by dead organic life. It was the opinion of these latter scientists that Dokuchayev carefully studied.

He became convinced, however, that these were conjectures rather than opinions backed by proof; they lacked unquestionable facts, and consequently, very opposite conclusions could easily be drawn. The more so that, groping in the dark, the propounders of this theory of the organic origin of chernozem sometimes wandered into very strange theoretical lanes.

Ruprecht drew a distinction between chernozem that was formed on the spot and chernozem that "infiltrated" (goodness knows where from!); and he talked about some kind of ancient chernozem "continents."

Dokuchayev did not know that the first to approach the solution of the chernozem riddle was that man of clear and sober mind, Lomonosov. "Thus, there can be no doubt that chernozem is not original and not primordial matter, but came from the decay of animal and plant bodies in the course of time. . . ." This is a passage from *First Principles of Metallurgy*, written in 1742-43, nearly half a century before Güldenstädt.

The one obvious conclusion that Dokuchayev drew from his zealous studies was that facts were few.

And so he drew up a "program of research on chernozem."

Of course, A. V. Sovietov, and two others, took part in drawing up this program: A. I. Khodnev and M. N. Bogdanov. The participation of a zoologist and an explorer seems surprising; but Bogdanov was one of the galaxy of old and splendid Russian naturalists who were not only keen researchers in their special narrow fields, but also philosophers of the natural sciences; they took an ardent part in public affairs, they were poets in their work. Bogdanov's books, *Scenes From the Life of Nature in Russia* and *Village Parasites*, are as alive today as they were three-quarters of a century ago, and they have been read by several generations of juveniles and youths. There are few more poetic stories about our fields and forests, about simple nature in the central zone of Russia, and about the birds and gardens in an ordinary Russian town—a town on the Volga, Simbirsk, Bogdanov's birthplace; and the stories were written at about the time when Vladimir Ilyich Lenin was born there.

What Dokuchayev did during the next few years was no less than the rediscovery of a vast area of land on which millions had lived and toiled for a thousand years and more; it was the discovery of chernozem. Dokuchayev did not simply theorize on the basis of a score or so of facts. He explored and described this area, showed the "where, what, when and how," in the same way as a geographer describes a newly-discovered country. For the districts and provinces of the chernozem "country" and its "islands," he, for the first time, traced the "isohumus" lines, in the same way as meteorologists trace the "isotherms" of localities with the same mean temperature, and "isobars" showing the same mean barometer pressure.

He carefully traced the borders of the chernozem area—those broken lines beyond which lie the "grey forest lands" of the North, and, in the South, adjoining the "chocolate" soils of the steppes of the Black Sea coast. The "chestnut and brown" lands.

He studied the "hilly" chernozem, the slanting, utterly black layers of chernozem on the hillsides, the heavy layers of brown chernozem of the valleys, in some places as much as seven feet thick; the Belgorod sandy chernozem, the brackish chernozem in the Kharkov and Poltava regions; the skeleton and coarse chernozem from the South Urals; the ashy, wind-blown chernozem of the soft hillock and soil "dunes" near Berdyansk. . . .

In the steppes rise ancient burial mounds—kurgans—Scythian and Batu. They are covered with a thin layer of black soil. How long did it take for this layer to accumulate? Dokuchayev clambered over the boulders of which the ancient walls of the Staroladoga fortress were built to measure the thickness of the soil that covers them. *Five inches*. Grass, and even bushes, grow here. The fortress was built in 1116. It took 770 years for this layer to accumulate.

As a geologist, an investigator of soils, he carefully inspected those ancient traces of the work of man's hands, the ancient human habitations on earth.

He found and described the encampments of the Stone Age. He collected specimens of primitive weapons. Later, in 1889, at the Eighth Congress of Russian Naturalists and Physicians, he read a paper on prehistoric man of the Oka dunes.

Dokuchayev's services to archaeology are highly valued to this day, but his discoveries in this field have been eclipsed by his other great and major discoveries.

At last he finished his "encyclopedia" on the geography, chemistry and history of chernozem. Yes, on its evolution, its genesis! After all, what is soil?

Soil is a special natural body, or rather, an entire, independent category of bodies. Soils differ distinctly from rock. They have their own definite laws of development, and it is by these laws that they must be recognized; there is also order in the distribution of soils.

The factors which by their joint operation form soils are—organic life (primarily plants and the lower organisms), climate, topography, and height in relation to sea level. Dokuchayev added that it was, of course, necessary to know the original "maternal rock" and the "age" (soil and geological) of the country.

What about chernozem?

It was formed from the accumulation of decayed, steppe-grass plant material. The "maternal rocks" here were loess, chalk, clays and eroded granites. . . . What to many people seemed a paradox is the fundamental fact here: far from creating chernozem, the forests, with their vast masses of decaying plant material, checked its formation wherever they invaded the steppe.

Dokuchayev proved with classical clarity and fullness that the decay of plants in the forests cannot produce chernozem, but only other "grey" soils, much poorer in humus; and he proved this not by general argument, but by figures, weights and measurements, which, as a famous saying has it, is "knowledge of nature."

The chernozem region is confined within its borders by complex natural conditions; the hot, dry steppes of the extreme South, which have little life, collect too little humus. No humus is formed in the humid cold of the North; there, a heavy, lifeless mass of peat is formed. The northern border of the chernozem coincides, in general, with the isotherm July, 20° C. above zero.

In 1883, Dokuchayev wrote for his Doctor of Science degree a treatise on "Russian Chernozem," which marked a complete rupture with the generally accepted views on soil, which had originated chiefly from the German geological school, and opened for science a new world of facts and phenomena. His "sponsors" at the St. Petersburg University were A. A. Inostrantsev and D. I. Mendeleyev. They acted as the official opponents in the debate on the treatise. Mendeleyev was regarded as the terror of candidates for scientific degrees; but on this occasion, this slightly stooping, powerfully-built man with overhanging eyebrows and leonine head—a man so unlike others that a sharp line seemed to separate him from all those around him—was quite unrecognizable. According to the reminiscences of contemporaries, in the debate on Dokuchayev's treatise the great chemist and versatile naturalist was "profuse in his praise."

It was obvious that a new science had come into being. And, also running counter to tradition, it was given not a Graeco-Latin, but a Russian name: pochvovedeniye—soil science.

The proverb has it: "a lone man on the battlefield is not a warrior." As we have seen, Dokuchayev was not a "lone" man; he had taken up and immensely developed what the agronomist Sovietov had striven for. The zoologist Bogdanov had helped him to prepare for his researches. Mendeleyev, the chemist, had made agronomical experiments (near Simbirsk, in 1867, the year in which Sovietov received the degree of Doctor of Agriculture, the first degree of this category to be issued), and in these experiments the twenty-four-year-old botanist Timiryazev had taken part.

Dokuchayev's epoch-making work rose on the crest of this wave.

At that time another splendid scientist was investigating chernozem—Pavel Andreyevich Kostychev, who was almost of the same age as Dokuchayev. Kostychev's book, *The Soils of the Chernozem Region of Russia—Their Origin, Composition and Properties*, appeared in 1885. The Kostychevs, we will mention in passing, constitute a Russian botanical "dynasty." The son, Sergei Pavlovich, became a member of the Academy of Sciences and, in our Soviet times, has written books on the most complex and mysterious processes of the physiology of plants that are fundamental works for world science.

In the times we are speaking about, Russian science regarded it as a matter of pride and honour to study the soil treasures of their country, to "solve the riddle" of chernozem.

The debate on Dokuchayev's treatise lasted four hours. The Dean of the Faculty, N. A. Menshutkin, the famous chemist, solemnly proclaimed Dokuchayev "Doctor of Geognosis and Mineralogy."

. . . On winter mornings Professor Dokuchayev appeared at the university when the twilight still hovered over the half-deserted Embankment and the wind blew fiercely over the bridges across the icebound Neva. His powerful figure, whose calm and even step no gusts of wind however fierce could disturb, could be seen from a distance. In the cloakroom he unhurriedly removed his fur-lined coat and enormous fur cap. And as this giant strode down the endless corridor of the St. Petersburg University, formerly the building of Peter the First's "Twelve Collegiums," he seemed to many to radiate cold. People were overawed by the indomitable force that he pervaded, and they respectfully stepped aside to make way for him. He mounted the rostrum in the lecture hall and began his lecture. He was not distinguished for his eloquence, he refrained from oratorical flights; but strange to relate, the silence in the hall was so tense that you could hear a pin drop. It was the force of conviction that thrilled and held his listeners. His style in lecturing was said to be like that of Mendeleyev.

Those who formed a judgment about Dokuchayev without having heard him in the lecture hall, actually knew nothing about the real Dokuchayev!

Rarely has anybody been able so irresistibly to attract young hearts and souls and to train really devoted pupils so well as this burly man, outwardly stern, and even harsh.

Dokuchayev had long noticed at his lectures a thin, evidently sickly, weak-chested youth with close-cropped hair and wearing spectacles. The youth differed from the lecturer in everything, except, perhaps that he had attended a seminary, only in Arkhangelsk. Dokuchayev always saw him sitting in the front row, evidently in order to be as near as possible to the lecturer, so as not to miss a word.

"What do you intend to do?" Dokuchayev asked the youth when the latter had finished the university course.

"I am thinking of preparing for a professorship," answered the youth.

"Would you like to work with me?" enquired Dokuchayev.

Two rugged flushes broke out on the youth's pale cheeks as he eagerly grasped his teacher's proffered hand.

And so Nikolai Mikhailovich Sibirtsev became Dokuchayev's lifelong assistant and friend.

There was another important and beautiful feature about Dokuchayev's character: he never suppressed the individuality of his pupils. Sibirtsev himself quickly developed into a splendid researcher, about whom, only in recent years, the late Academician Williams made the following comment: "The theory that soil is a separate category of natural bodies arose in Russia as a result of the creative efforts of three Russian scientists—V. V. Dokuchayev, P. A. Kostychev and N. M. Sibirtsev."

Dokuchayev forthwith enlisted young Nikolai Sibirtsev's cooperation in the new and very important work upon which he was engaged. This was in 1882, when Dokuchayev was still only a lecturer; a whole year passed before he submitted his treatise "Russian Chernozem" for his Doctor of Science degree.

What was this new work?

As we know, Dokuchayev's idea was that soil arises and develops as a result of the complex interaction of a number of factors, "causes." Hence, it must be studied by the complex method, by the combined efforts of a number of specialists, so as to take in all these complex processes. This complex method was in itself one of Dokuchayev's important discoveries. It could not be employed by a scientist working alone; only a body of scientists could cope with researches of this kind. This led straight to the formation of a school of scientists, bound by common interests and friendship.

The year 1882 saw the beginning of the first of Dokuchayev's complex expeditions that became famous in the history of science. The Nizhni-Novgorod Zemstvo Administration requested that a commission be sent to inspect and assess the land of the Nizhni-Novgorod Gubernia (for taxation purposes, the Administration was not interested in anything else). This could have been done thoroughly and honestly, and then a book could have been published at the Administration's expense, a book with tables of figures and a few observations about the alarming spread of ravines in this wooded-steppe region, about the open-field system, the poverty prevailing in the villages, and about the Makarev Fair; and also regrets that the methods employed by "enlightened farmers" were spreading very slowly in the gubernia.

But Dokuchayev did not set about the task in this way. What did he do? His biographer tells us that "here, his extraordinary talent as an organizer revealed itself to the full." He enlisted the services of some of his students for the work. Among them were: P. A. Zemyatchensky, A. N. Krasnov, F. Y. Levinson-Lessing, N. M. Sibirtsev and A. R. Ferkhmin. All of them subsequently became famous scientists.

It was during the Nizhni-Novgorod Expedition of 1882-86 that the Russian school of soil science, the first in the world, arose.

They slept in peasants' huts. In them the St. Petersburg professor felt quite at home; he recalled his Kachnya expeditions with Andrei Piun. In the mansions of the gentry, however, the investigators met with frowns, and efforts were made to get them out of the house as quickly as possible. Plain, blunt Dokuchayev subjected one of these "enlightened farmers," in whom some of the Nizhni-Novgorod Zemstvo people had placed high hopes, to a regular interrogation. That gentleman hum'd and ha'd and growled:

"You are only stirring up the peasants. You collect samples of the soil in bags and take them away, and the peasants think that the government is investigating with the intention of giving them all the land."

The result of this expedition was a report that took up fourteen volumes. It was not only the most detailed imaginable description of that part of the surface of the globe known as the Nizhni-Novgorod Gubernia, but the construction of a regular science of the soil, the consummation of the ideas expressed in the treatise "Russian Chernozem." Chernozem took its place in the "rainbow of soils" that had once astonished Dokuchayev. Those fourteen volumes revealed and explained what the geographers had only noted, and what the geologists had not been able to explain: the formation of hills and ravines, of the topography, of the very face of the country as we see it around us.

Dokuchayev was aware of the value of the work that had been done; but this was only the introduction to a thorough study of the land of Russia, to our country's "self-realization." As Dokuchayev conceived it, it was but the bricks for the foundation of a work of urgent importance for Russia.

Then commenced those years of persevering but fruitless efforts on the part of Dokuchayev to secure the establishment in St. Petersburg of a Soil Committee to serve as the headquarters of this work.

Meanwhile, Dokuchayev's "collection of Russian soils" travelled to Paris, to the World Exhibition under the Eiffel Tower, where it was awarded a gold medal. In that same year, 1889, the collector himself made a short journey abroad—Paris, Berlin, Vienna. . . . Soon after his return he found himself up to his neck in work. He was the chief organizer of the Eighth Congress of Russian Naturalists and Physicians. He was now forty-three years of age, and his name was placed on a par with those of Mendeleyev, Timiryazev, Inostrantsev and the brothers Kovalevsky. His vigour seemed to be inexhaustible. He was the secretary of the St. Petersburg Naturalists' Society, a member of the Geological Committee, and, jointly with Sovietov, edited the *Materials for a Study of Russian Soils*. Another Dokuchayev complex expedition set out for the Poltava Gubernia, the work of which resulted in the compilation of sixteen volumes of materials, and, as he had done in Nizhni-Novgorod, Dokuchayev established a natural history museum in Poltava.

One other student of Dokuchayev's joined the Poltava expedition—Vladimir Ivanovich Vernadsky, who became a great scientist and founder of geochemistry. . . .

Although Dokuchayev subsequently precised and amended his "genetic classification of soils," the general picture of the distribution and arrangement of the soils of the great Russian plain was already clear in his mind.

The region of northern pine forests, meadows and sour grasses. Hummocks, ice ridges and hollows—the "moraine landscape." A vast region of "light grey soils."

South of this region lie the wooded steppes: the undulating hills, the silvery rivers winding through green valleys and birch woods, so familiar and dear to the millions of inhabitants of Central Russia. The blue flax flowers; the rye and oats on the "grey wooded" lands. . . .

We already know that they border the north of the steppe chernozem, and that to the south a broad belt of them passes into the chestnut soils of the arid fescue-grass steppe.

The summer is still hotter, the sun still higher, the earth more parched and covered with sparse wormwood. Whirlwinds blow up the yellow sand, the withering breath of the adjacent desert . . . this is the fifth soil zone—the region of brown, saline soils.

Five zones—five main types. Each has its own variant of supesok (sandy loam) and suglin (clayey soil).

But in addition to these, there are the bogs—land which is formed when access of air is difficult. There are alluviums, formed by water and by wind.

True, Dokuchayev revised the picture later, but the regular order of the soils was already included in a bold sketch that combined in one whole—climate, landscape, life and earth.

What was lacking in this picture? Man, who cultivates and re-creates the earth. That gap was to be filled by the scientists who came later, in our Soviet times, who developed soil science to unprecedented dimensions; and among those scientists are Dokuchayev's pupils. But in 1886, when Dokuchayev's classification of soils was published, it was not merely a summary of discoveries; it was already a magnificent program of action for science, and primarily for Russian science.

Nobody realized this more clearly than Dokuchayev himself. For fifteen years he continued his efforts to secure the establishment of a Soil Committee, the permanent headquarters for Russian soil science. After all, only a *beginning* had been made in the study of the soil of Russia!

His superhuman energy did achieve something.

An Agricultural Institute was established in Novaya Alexandria, in the Lublin Gubernia. Another was established in Moscow. Not much for the whole of Russia! And even then the authorities wanted to close the one in Novaya Alexandria—it was an out-of-the-way, poverty-stricken place; it had no professors, no scientific appliances, and scarcely any students.

Dokuchayev went to the government commission in charge of the Institute and demanded that the order to close it be suspended, and that he be given the opportunity to do something about it.

His demand was conceded; he secured the suspension of the order almost by force.

He thoroughly revised the Institute's curriculum and made it unlike anything of its kind in the world. He took this curriculum to Novaya Alexandria and a neglected house with two wings, resembling a country mansion, met his gaze. The place was almost deserted; a handful of third-year students were, not attending to, but dozing over their studies. "Oh, there is plenty of work to do here. . ." he said to himself.

He reorganized everything. It would be more true to say that he built up the Institute anew. He "simply seethed," say those who were there. The days were too short for him; he worked nights. He seemed not to know what weariness is. His rejuvenated voice boomed through the corridors and classrooms. His step became light and springy. One morning, after a sleepless night spent over urgent papers and telegrams, he laughed out loud and exclaimed:

"It's good to be alive, oh so good!"

It looked as though he had thrown twenty years off his shoulders.

Here a chair of soil science was instituted, the first in the world. Who was to be put in charge of it? His nearest pupil, of course—Sibirtsev. He had never lost touch with him. Sibirtsev was his senior assistant in a new expedition that was "testing" the forest and water regime in the steppes, but his permanent place of residence was Nizhni-Novgorod, where he was the curator of the natural history museum, which Dokuchayev had founded.

When the first professor of soil science in the world arrived in Poland he walked with a stoop, coughed, kept putting his hand to his chest and every now and again adjusted his thin-rimmed spectacles through which he peered shortsightedly, and smiled apologetically.

"The same old Nikolai Mikhailovich," said Dokuchayev, shaking his head. Then he frowned and boomed: "It's great, isn't it? *Our own chair!* We got it at last! You'll soon grow young again. Together, we'll make things hum! It's jollier when there's two at the campfire—isn't that what your Volga folks say?"

During those years of Dokuchayev's administration of the Novaya Alexandria Agricultural Institute—1892-95—there seemed nothing that this giant of a man lacked the strength to do. He continued his duties as a professor in St. Petersburg. He was chief of a special expedition organized by the Forestry Department. He was the head of a commission for the "physico-geographical, natural-historic, agricultural, hygienic and veterinary inspection of St. Petersburg and its environs."

He even dreamed of publishing a newspaper—a big newspaper for "the Russian public," "for all honest people in Russia."

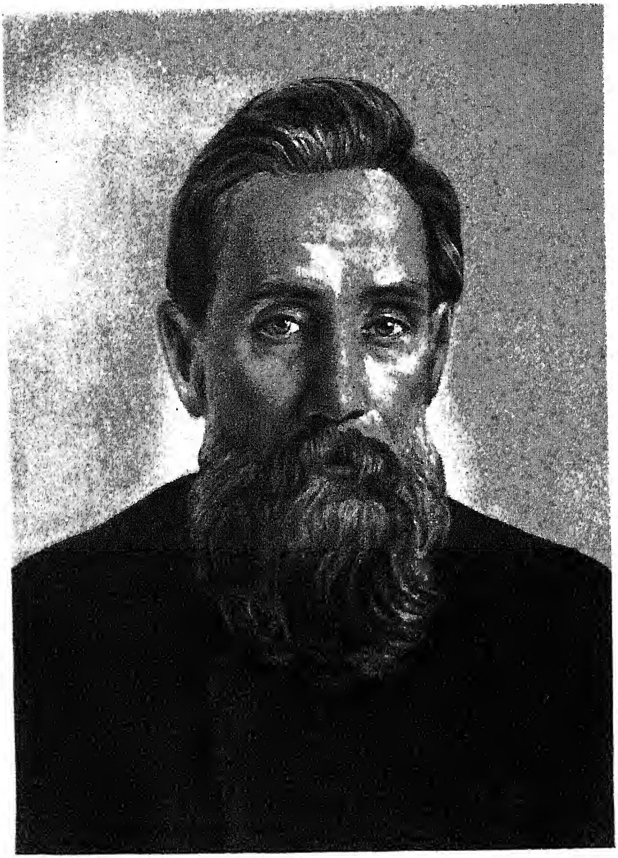
He was at the apex of his career. He was happy. His collection of soils had been crowned with new laurels across the ocean—at the great Columbus Exhibition, held in Chicago, in commemoration of the four hundredth anniversary of the discovery of America. The American newspapers wrote: "Who would have thought that it was possible at the end of the nineteenth century to discover a new continent in our knowledge of nature?"

Dokuchayev's mind was filled with new projects. He made active preparations for the All-Russian Exhibition that was to be held in Nizhni-Novgorod in 1896, where there was to be a soil stand next to Timiryazev's greenhouse

The Novaya Alexandria Institute, *his* Institute, was by common consent regarded as one of the best colleges in Russia. It had a staff of professors and all the students it could take—not only Russians, but also Poles and Jews, for Dokuchayev had succeeded in getting the doors of the Institute opened for all. The lecture hall buzzed with excitement when Sibirtsev lectured. How the students loved this "muzhik from Arkhangelsk," *his* Sibirtsev! But he is not as mild as he looks He is already arguing with his teacher. He wants too much of his own way. Let him. We'll see who gets the best of the argument. But he's got pluck. He wants to write a textbook on soil science. Good! The teacher never got down to doing it. It will be the first textbook on the new science.

Dokuchayev was happy, happier, perhaps, than ever before in his life.

Meanwhile, the clouds of disaster were gathering. The Warden of the Warsaw Educational Area was a certain "important person" whom Dokuchayev's first biographer



PAVEL ANDREYEVICH KOSTYCHEV

one of his devoted pupils, designated by the initial "A"; he did not, at that time, 1903, dare mention this person's name. And we, now, think it inappropriate to mention this scoundrel's name alongside that of Dokuchayev, the pride of Russian science.

This "important person," who might have walked out of the pages of one of Gogol's stories, patriarchally regarded the educational establishments in the area of which he was in charge as his private domain. Poor as the Novaya Alexandria Institute was, he had an excellent apartment fitted out for himself in one of the wings, where he spent the summer at the Institute's expense; and at Christmas time, he graciously accepted a whole pig's carcase and any number of eggs from the Institute's farm.

Dokuchayev put a stop to the ceremonial presentation of pork and eggs, and he reconverted the apartment into classrooms.

Of course, no mention of this was made in the reports to the Ministry of Education from the Warsaw Educational Area,—oh, no! God forbid!—but a close watch began to be kept over Dokuchayev's educational reforms. Suddenly, everything came to a dead stop. Somebody had "put the brakes on."

Dokuchayev hastened to Warsaw to find out what had happened. The warden seemed surprised at his arrival.

"Oh, it is you!" he said. "Well, it is a good thing you have come. I must tell you my dear . . . er, er, . . . professor . . . that I am displeased with you."

Dokuchayev could barely restrain himself. He felt overcome by a wave of fierce hatred for this man with the leisurely, drawling, velvety, baritone voice. This emotion did not escape the eye of the "important person."

"So it is war?" he enquired, raising his eyebrows. Dokuchayev, on leaving the room, noticed with surprise that his hands were trembling.

The warden was haughty, energetic and meticulous. Dokuchayev was stern and masterful; it was not in his character to cringe and be diplomatic. The net around him was woven out of trifles with ruthless and inexorable bureaucratic skill. Every defensive move he made only entangled him still more. The despicable campaign against the great scientist was waged with unrelaxing vigour and with infinite art. Dokuchayev wrote to St. Petersburg, to those who, year after year, were holding up his plan for the establishment of a Soil Committee, but he got no reply. He felt like a hunted animal. He looked round with fierce but hopeless despair. There was no way out.

He could stand it no longer.

He resigned from the Institute that he had created, and which had no equal in the world. The giant's spirit was broken. His biographer notes that at the age of forty-nine, this powerful man was put out of action.

He had not acquired that inherent firmness, that point of support, which Timiryazev always unerringly found under all circumstances.

On top of all came his personal misfortunes. His health broke down. His wife, Anna Yegorovna, whom he loved dearly, was dying of cancer. . . .

Long ago, in his student days, not seeing any outlet for his mighty energy, he had taken to drink, in the endeavour, as it were, to vanquish the unharnessed strength that possessed him.

And now, too, finding himself at a deadlock, his will gave way. He failed to see that those who had cast him aside represented neither Russia, nor Russian science; that it was not they who were associated with Russia's brighter future that was already drawing near. He did not know the real Russia, which Timiryazev knew so well—and it was this knowledge that served as Timiryazev's rock of support when things went hard with him.

Dokuchayev could not remain inactive. He travelled in Bessarabia, the Trans-Caspian and the Caucasus and studied the vertical soil strata that he had foretold and discovered. In St. Petersburg he organized a private school of agriculture. He delivered public lectures on "The Principal Laws of Present-Day Soil Science, the Discovery of Which Is Due Exclusively to the Efforts of Russian Scientists."

He dreamed of forming a Society for the Propagation in Russia of Agricultural Knowledge and Skill. He sat down to write a book about the chief thing in his science, about the *new* principle it propounded: the interrelation between living and dead nature. He began to draft a "General Soil Map of Russia"; it was finished by his pupils Sibirtsev, Tanfiliev and Ferkhmin.

But to those who were intimate with Dokuchayev, all this seemed but "the desperate efforts of a drowning man."

Five years passed.

Spade, drill and hammer—the emblems of the soil scientist—carved on the slab of labradorite under which rested the remains of Sibirtsev who had been laid low by tuberculosis. But Dokuchayev lived; he lived another three years, combating a steadily encroaching nervous disease. His last letter was like a cry of despair: "How good is God's world, how hard it is to leave it!"

Vasili Vasilievich Dokuchayev died in St. Petersburg on October 26, 1903.

He loved nature, but it was not gorgeous, exotic landscapes that charmed him. The simple beauty of nature in the central zone of Russia filled his heart with joy. He would stand long gazing at a bend of a river ("for hours," writes his pupil P. V. Ototsky, the first editor of the magazine *Pochvovedeniye*). He often recalled the Ukraine, the period of his Poltava expedition—early morning, the slanting rays of the sun in the still-sleeping leaves of the poplars, and the cries of the leleki, as he, in Ukrainian, called the stork.

He loved Korolenko and Chekhov. On reading *The Steppe*, he said:

"If only I could describe scenes that way!"

Like many of the intellectuals of that time, he had only a faint idea of the social conditions around him, and so, to his dying day he failed to understand why the misfortune had befallen him in 1895.

Outwardly, he was stern, "dry and businesslike." In his relations with people, public and even private, with his students and pupils, he tried to guide himself by the rule: "People must be judged by how much they have done in life, and how." He took Peter the First as his model and example:

"Now Peter the Great—he worked for the common good. We must learn! . . ."

He divided people into two categories: the "useful" and the "useless." The latter did not exist for him. The newspaper that he dreamed of publishing was to have been a champion of the "common good."

He regarded honesty and diligence as the remedy for all the evils Russia then suffered from. His own experience in life might have taught him that *this alone* was far from enough. . . .

Dokuchayev's complex method of research branched out into new sciences: geobotany, of which G. I. Tanfiliev was the most prominent representative—the study of vegetation in connection with its "environment," i.e., the soil on which the researcher finds it; and our celebrated school of geochemistry, headed by its founder, Academician V. I. Vernadsky.

The geologists of Dokuchayev's time could much more easily explain the origin of the Pamirs than the origin of mounds, hillocks and gullies. Dokuchayev explained the laws of development of the customary and general features of the topography of the land, and then, geomorphology, the science of the formation of the earth, made rapid progress.

Geologists of the olden days regarded soil as an unimportant detail of the earth's crust; but it was found that the conclusions drawn from Dokuchayev's theory of the soil were of exceptional importance for the geologists themselves, for their science, because soil "is the mirror of the local climate; the climate of the present time and, particularly, of times long passed."

The old science of geography was entirely transformed and developed. Dokuchayev endowed the central core of this science—the theory of the landscape—with a new meaning. His horizontal and vertical zones are far more concrete, clearer, and of richer content than the former ideas about climatic zones.

Appealing to Russian agronomists, Dokuchayev said: "Stop this what is often almost slavish obedience to German rules and textbooks, which have been compiled for different natural conditions, for different people, and for a different social-economic order."

And by his work and ingenuity he showed how this was to be done.

World soil science became firmly established after Dokuchayev. It was established by the Russian school of soil scientists. Referring to the work of this school, and of his own work in particular, Dokuchayev said that it was the discovery of a fourth kingdom in nature; and it is no accident that the Russian terms "podzol," "solonets" and "chernozem" can be heard in the lecture halls of universities and institutes in all countries, wherever the soil is studied.

A PLANET'S "ILIAD"

Timiryazev was delivering a public lecture at the Polytechnical Museum. From the brilliantly-lit platform he looked up at the rows of seats towering up into the vast hall like the inside of a crater. In an even voice, in slow, measured phrases, he spoke of the invincibility of life. "If, somewhere in the ocean, a rock rises from the waves; if a fragment of the rock breaks off and exposes a fresh, rugged surface; if a boulder that has lain under the earth for ages is exposed, always and everywhere, on the bare, barren surface"—life appears. Lichens appear and "decompose, loosen the rock, and convert it into fertile soil." "They fear neither winter cold nor summer heat. . . ." Ground to a white powder, they, the pioneers of life, revive at the first touch of a drop of rain. They will find refuge even on the smooth surface of a piece of glass—look at some derelict, long uninhabited house with remnants of glass in the half-ruined, moss-covered window frames. . . .

Life is omnipresent; life is invincible! Timiryazev's grand conception of the cosmic role played by plants came into being. What is the area of the Earth, of the whole of the Earth? Five hundred and ten million square kilometres. But the Earth has another surface, the area of which runs into several thousand million square kilometres.

This is the surface of the green leaves on the land, and of the film of sea weeds in the ocean. It is a cloak that envelopes the whole Earth, presented to the rays of the sun and blocking their way. Caught in this green net, the rays are transformed into chemical energy. What colossal and inexhaustible energy is masterfully harnessed by the living plant world and compelled to work on Earth! This energy can be measured. The energy of the rays caught and "fixed" by the plant world is calculated at 162,000 billions of calories per annum. This is twenty-five times as much as the energy of all the coal used by men, and almost three and a half times as much as the total energy of running water. If we picture to ourselves the amount of work performed by this energy and multiply it by what is scarcely imaginable, the thousands of millions of years that life has existed on Earth, it will be easy to understand that the Earth must have been altered by it. . . .

Years passed.

A Soviet scientist, Academician V. I. Vernadsky, by a series of remarkable researches, established the theory of the biosphere. *The Biosphere*—such was the title of his book that was published in 1926. Many of those who read this little book, written with poetic and solemn simplicity, thought it was infinitely profound; it seemed to them that it contained a whole world, with continents and oceans. If it were necessary to choose from the immense literature on science only a score or so of the books that have marked turning points in the development of human knowledge, the little book bearing the title *The Biosphere* would certainly be included among them.

The living integument of the Earth—side by side with the rock, water and air integument. . . . No, it is not true to say side by side. The Earth is an *all-living* thing. We cannot get away from life as long as we remain on our planet.

You will find its impress on every inch of the earth's surface. The whole of it is transformed, re-created by life: the air we breathe, the land we walk on, and even water, falling as rain, and eroding the limestone, flowing slowly through quiet valleys and wearing away rocks in the ocean.

How totally unlike our present planet the Earth would be if it were without life. What would it be like? Perhaps it would be a huge replica of the Moon, with this difference, however, that, in rolling through universal space, it would carry with it a shroud of poisonous and suffocating gases.

Life alone has made the Earth habitable for us, and for everything else that lives on it today!

This circle of ideas was a great discovery. It was the exceptional idea of Russian science. In the West, the most celebrated scientists were still repeating the cheap, seemingly profound wisdom of the nineteenth century: "Life is accidental mould on the globe. . . ." "Like the mould on cheese," said others, gloomily extending the metaphor.

After the work performed by Russian scientists it became evident that relationships almost unknown before had been discovered, relationships that affected the most important thing on our planet, without which it is impossible to understand either life or the Earth.

It is impossible to "take away" life from the Earth and leave the Earth "by itself"; it is impossible to obliterate life from the two thousand million years of the Earth's history without obliterating the history itself.

Here is the figure that illustrates how completely the Earth is impregnated with life: in every hectare of soil there are no less than three thousand billions of microorganisms: 3×10^{15}!

Around us we see meadows and woods, reeds by the riverside and beyond, cornfields: the face of the Earth is the face of life. And these myriads of living bodies possess almost incredible energy. A single, tiny, invisible coccus, if not prevented from propagating, could in the course of thirty-six hours form a film that would cover all continents. In thirty-six hours this tiny living sphere would reproduce enough of its kind to cover the Earth! Even if this is only a possibility, even though we know that, in reality, a number of causes retard the multiplication of living beings, this, after all, is, in truth, a most extraordinary chemical process! Vernadsky spoke of the "geochemical energy of life."

As for the power possessed by lichens, we have just read what Timiryazev said about it.

Nothing in nonliving nature can destroy pure clay—kaolin; neither water, nor oxygen, nor carbon dioxide. It begins to "yield" only in a blast furnace.

Fungi do destroy kaolin.

But this is not simple destruction; it is transformation, creation.

Life so alters environment that the latter can become the home of a new life. Wherever the breath of life touches the crude rock it infuses a creative power into it; wherever life passes, it leaves a life-creating trail.

The green and flowering Earth, great producer of life, is itself the creature of life. A mother who bears children and is in her turn borne by them!

The scientific work of the man about whom I will speak in a moment flowed in the stream of these discoveries. Can it be said that his work was the crown of these discoveries? At all events, he added features to them that could become possible only in Soviet science, the science of the Stalin epoch. "The Earth and life"—this is the order in which decisive discoveries had been made. But this order was still too general. From it a special link had to be taken: "the Earth and man." Not man in the abstract, but man who labours on the Earth, social man.

The Earth, the soil, had already been studied. It was now necessary to examine human social labour as a participant in the moulding of the face of the Earth, its properties, chief among them its fertility, the "generative power" of the soil. A term until recently unknown to soil scientists—"cultivated soil"—must now become the pivot of the theory of soil development.

At this time Soviet geologists and geochemists began to speak of a great dividing line in the history of the Earth. The last, "purely natural" geological era, the Cenozoic, had to be considered closed and the opening of a new era, the human, quite different from all the preceding ones, had to be recognized. The author of the theory of the biosphere proclaimed this.

The book by the scientific researcher we are now discussing made it possible to understand what this meant more precisely. It did not merely "note a fact"; it proceeded from the experience of socialist society, of socialist labour. Its whole purpose was to teach man how to take the creation of the life-bearing Earth, the life of the soil, the biography of our planet, entirely into his own hands.

This book, one of the most remarkable in the history of science, was a handbook on man's cosmic role in nature's affairs.

It was dedicated to the memory of Vasili Vasilievich Dokuchayev and Pavel Andreyevich Kostychev.

In the preface to the first edition, the author wrote that it was an attempt to "provide a technical basis for the organizational principles of agricultural production in the Union of Soviet Socialist Republics."

In his preface to the fourth edition (the last during his lifetime), written in 1938, he characterized the contents of his book as an investigation "of the conditions for a continuous and unlimited increase in the yields of agricultural crops." He pointed to the achievements of the innovators in agronomics, the Stakhanovites of agriculture, in our country, and said that, in working on his book, he had "tried to find the best means of carrying out the tasks set us by our great teacher, leader and inspirer of new victories, Joseph Vissarionovich Stalin, and his closest colleague and friend, Vyacheslav Mikhailovich Molotov."

This book is *Soil Science* by the late Academician Williams.

Vasili Robertovich Williams died in 1939. Those who have seen him personally, or have seen the innumerable portraits of him, know the man with the large, stern features, imposing, bald skull, prominent, almost unwrinkled forehead, the loose lower lip characteristic of the aged, and fleshy nose, wearing Chekhov pince-nez. And there is something eaglelike in the shortsighted eyes behind those glasses.

It is not an ordinary face. It puts you in mind of the sculptures in the Roman Hall at the Hermitage in Leningrad. It is a face you cannot help noticing, and one that at once impresses itself upon your memory.

Before me lies a photograph of Williams in conversation with a group of kolkhozniks from the Altai, famous for the high yields they obtain. Here is another that shows him in the act of signing a socialist emulation pledge. And here is one in which, his head slightly inclined, and screwing up his eyes, he is confidently holding a tiny graded glass in his large, capable hand, measuring off some chemicals for the purpose of analyzing the acids of humus.

He usually wore a white blouse with an open collar; a tie discommoded him. On his breast are the membership badge of the Supreme Soviet of the U.S.S.R., the Order of Lenin, and two Orders of the Red Banner of Labour.

At the time this photograph was taken the "Chief Agronomist of the Soviet Union" was over seventy, but it would be difficult to apply the term "very aged" to him.

There was one feature about him that surprised his assistants and even roused their indignation: he would never take a vacation, or go to a rest home. His assistants may have been right in regarding him as cranky, but he simply could not tolerate even the thought of "interrupting" the ideal arrangement of his "working time" by which he ruled his life. He could not conceive of existence without a clear and definite plan, order and punctilious accuracy. He had supreme contempt for slipshodness, no matter what romantic air it might assume, and he never forgave absent-mindedness and forgetfulness.

He rose at six. At eight o'clock he was in his laboratory. At eight prompt, not a minute earlier, or later.

Until ten o'clock he engaged in chemical research. Everybody remembers those hours of deathly silence. At ten, his swing-chair would make a half-turn and bring him out of the isolation of the laboratory desk into association with people, newspapers, magazines and all the "topics of the day."

Lunch and dinner at definite hours. Definite hours for work in the museum, preparation for lectures and work on manuscripts.

Definite hours, strictly adhered to, for receiving people who came to him as a member of the Supreme Soviet.

Often, his workday ended at midnight.

He was convinced that methodical order greatly increases the amount of work that can be done in the course of the day; and he insisted on methodical order in thinking. "The main thing," he reiterated, "is to teach people how to think, to familiarize them with the system of thought on the given subject, to train them to systematize acquired knowledge, to group this knowledge, to appraise its relative value. . . ."

The creator of the cultivated soil theory attached great value to the cultivation of all labour. His assistants recall the refined technical equipment he used in his laboratory work. "The subtlest of special instruments, the rarest of chemical retorts of his own design, automatic washing devices, rubber caps for washing soil from bowls, syringes borrowed from dentists, brushes borrowed from artists, knives borrowed from confectioners, hammers, hooks, and so on and so forth. . . ."

This was also the negation of half-hearted work; is not primitiveness the sister of slipshodness?

In response to the greetings he received on the fiftieth anniversary of his scientific and public activities, Williams said:

"I hope to live to the day when the kolkhoz hectare will yield fifty centners of wheat."

He lived to see the hectares cultivated by kolkhoznik Yefremov and his followers yield as much as seventy and a hundred centners each.

Russel, an English soil scientist, once asked him in amazement:

"Have you discovered the elixir of youth?"

"I have lived through three revolutions," answered Williams. "I not only lived through them, but took an active part in them. That, evidently, is my elixir of youth."

Towards the end of his life, at the age of seventy-six, he wrote a letter to Comrade Stalin, saying:

"I don't seem to get old. The consciousness that I am in the ranks of Lenin's great Party, that I am working under its guidance, and yours, my dear Joseph Vissarionovich, and that I have the good fortune to be taking a direct part in the building of classless socialist society, the first, unprecedented in the history of mankind—this consciousness rejuvenates me, and inspires me in my daily practical and scientific work. . . ."

For half a century he lived at the Petrovsky, now the Timiryazev Academy of Agriculture; but he knew the land not only in theory, and not only from experimental plots.

He was born in Moscow on October 10, 1863. His father was a railway engineer, one of the builders of the St. Petersburg-Moscow Railway; his mother was a peasant woman. Cruel poverty pursued the Williams family. The father died and the mother and children were left almost without means. While continuing his studies at high school and later at the agricultural academy, Williams was obliged to find work to help to support the family. He studied hard, notwithstanding the fact that he had every day to walk from Ostozhenka Street to Petrovka, where the agricultural academy is situated—a matter of ten kilometres. Like Timiryazev, Dokuchayev, Pavlov and many other Russian scientists before him, he fought his way along the road to science.

He graduated from the "Petrovka Academy," where later he lived and worked.

He started his travels early on receiving a travelling scholarship to study in the biological and agronomic laboratories in Europe.

It was Williams who, in 1894, organized the five Russian agricultural stands at the Columbia Exhibition in Chicago, at which Dokuchayev's collection of soils was exhibited.

He walked through the fields and vineyards of Provence and over the dunes and heaths of North Germany; he visited California and the Great Lakes; he studied the Canadian granary, Saskachewan, where the ploughed prairie is planted with wheat.

He travelled through the Black-Earth Belt of Russia, explored the sources of the Volga, the Oka, the Syzran and Krasivaya Mech described by Turgenev. He helped to lay the first tea plantation in Chakva, near Batumi, and it was he who organized the famous sewage farms at Lublino, near Moscow.

He travelled through Siberia.

In the end there arose in his mind's eye the picture of the life of the Earth—the same, from the Poles to the Equator; a single soil-forming process.

He then gave his concrete definition of soil—"the friable upper layer of the globe's land surface, capable of producing plant crops."

This is not a statement of how the soil came into being; it, as it were, takes the bull by the horns and states at once what the function and purpose of the soil are. The definition looks not back, but ahead.

Williams regarded soil science as the synthesis of the natural sciences; but all the processes in "the fourth kingdom of nature" are special processes.

The chemistry of the soil (a chemistry of amazing richness and intensity!) is not the ordinary chemistry of any of the mineral rocks. "The entire chemistry of the soil is nothing more than the function of its organic matter. . . ." "When unskilful tilling breaks up the structure of the soil, when its stock of water is inadequate to ensure even the smallest crop, when, unable to find the necessary conditions, life expires in it, do we not introduce organic matter—manure—into it? No. We introduce manure only in order to revive in the lifeless soil the biological processes that were checked by imperfect methods of tilling that failed to answer the purpose; the processes without which no movement of matter is possible."

Williams found in fertile soil a real "colloidal environment." As is known, the living matter of organisms is in a "colloidal state."

He explained what this state signifies for the soil: "An extraordinary development of the inner surface"—an enormous inherent capacity of the pinch of earth that you can take up between your fingers; "the development of a new capacity—the capacity to absorb. . . ."

A mighty rock, an exposed ridge, towers out of the Earth. Time passes. In the daytime it is scorched by the sun; at night it cools. It is covered with a fine network of fissures. And in the hours when night passes into day and day into night, strange rustling or singing sounds rise from its stony breast.

The wind beats against the rock. Storms lash it with prickly dust and convert it into something like the honeycomb of bees. Rain washes away the crumbling parts of its once monolithic body. In cold winter nights the water in its crevices freezes. The crags are split as if with a wedge.

And so, limb by limb, the giant is broken up, ground up by time. The stony ridge of the Earth is transformed into a heap of marl. . . .

And whenever marl appears on the surface—in the wrinkles of rock, from under shifting sand, or under melting and retreating glaciers—life starts its work in the marl—it creates soil.

Its first layer is as thin as thin can be. It is the result of the work of bacteria. The scientist, not forgetting that hand in hand with his science of the great world goes its sister poetry, calls this layer—"the sunburn of the desert."

The light of life has awakened in the lifeless wilderness, beckoning, calling to the wayfarers of the living world.

The first to appear is an alga. Williams knows its name. A small, black alga—"*dermatocaulon juvenalis.*" It spreads. The "sunburn" is no longer visible under its thick, black cover.

Then come the lichens.

The lichen tundra begins to develop.

This is the Earth's youngest soil zone.

Where is this zone? In the North?

Williams, however, found fossil remains of tundra lichens in the boulders brought to Moscow from Central Asia.

Hence, this is not only a zone, but a *stage*. All the zones passed through this stage.

One must accustom oneself to this amazing conclusion: "The soil zones and types of soils that are distinguished in soil science are only static moments in a colossally long and extended dynamic process."

It seemed as though we had hitherto been looking at separate photographs—but then the figures moved, came together, were filled with living blood, and what had formerly been a drab, flat background has become a seething, sparkling, ringing world. It revealed itself to us—and we saw mountains slowly rising to the clouds like polypae and monstrous, winged creatures flying over the giant forests; after millions of years had passed, only a black wilderness remained where the forests had been, like the scene of a huge conflagration. More ages pass—and we see a bird with strange feathers like scales, heavily flapping its short, stumpy wings, flying over a sparkling river that is running between violet banks; an ancient layer of coal is already lying deep down beneath layers of earth. . . . Another page in the planet's book of life turns. The river has gone; we see only a gorgeously coloured, fragrantly smelling grass carpet stretching as far as the eye can reach. The wind touches the grass and disturbs the honey-sweet fragrance, and a drove of swift animals in striped fur coats disappears in the distance as if something had frightened them. The soil is black and rich, it does not crumble, the imprint of small hoofs is distinctly visible on it. . . .

The earth and life are inseparable.

But we must go back to the beginning, to the starting point.

Before us lies only the primordial soil: the lichenous tundra. Century after century, millenium after millenium—nothing but tundra. The rust-coloured thallous, the pillowy moss, the slender "rhizoids," die out. . . . And gradually—like the hoard in a mizer's chest—organic matter accumulates. Cloudberries begin to grow in the tundra, and creeping dwarf-willows begin to spread. They, too, add their mite to the hoard and, at last, the chest is full.

But for all that, the free-growing grasses of many kinds cannot bloom green here. Only the gloomy forest, the conqueror of the tundra, can make use of the treasures of the mizer's hoard. What is taking place under the close-packed canopy? Motionless columns pierce the gloom; century-old, dark, rugged, moss-covered giants. The earth at their feet is bare and damp. Sparse ferns, the needlelike spikes of horse-tails, a "lifeless carpet" of brown conifer needles, rotting among a mass of sticky leaves, and wood touched by the finger of decay. And also "felty" mushroom spawn. . . .

Here the "fungous" process of propagation of organic matter takes place. Crenic acid, one of the acids formed by the decomposition of vegetable matter, accumulates; it is the acid of the fungous process.

A grey, heavy soil forms under the forest carpet: podzol. It is a dull, lifeless soil; even air fails to penetrate it when it is sogged with water. But in its depths the bacteria that do not breathe air are at work—the anaerobes. They slowly dissolve the oxide of iron and the salts of crenic acid. A reddish earth appears under the podzol, and still lower down—the grey gley soil.

Years pass. The rugged giants die out. The green canopy opens. The seed year of the forest is ushered in: dense growth of seedlings spring out of the earth. With them grass appears for the first time. The seedlings grow. The forest now has two storeys. Soon it will cruelly vanquish the grass. Everything will be as it was before.

But something has changed. Seed years became more frequent. Frequent visitors! And on every visit the waving seedlings are accompanied by the merry rustle of grass. These newcomers, this united army of pigmies which daringly attacks giants, is it really vanquishable?

In many places, thousands of places, the giants can no longer cope with the pigmies. It is a battle between yesterday and tomorrow. The earth is no longer the domain of the primordial forest. The Gothic architecture of mammoth trees, the feudal castle of the cedars are now *things of the past.*

The *turf* period of soil formation has now set in. This is one of the most important periods on Earth. Not forests, but meadowland. The meadowland remains green until the winter, until the water in the soil freezes. In the spring, when the earth is saturated with water the anaerobic bacteria—the bacteria which exist without air—set to work. Organic matter keeps on accumulating. It is moisture-absorbing; water finds it more difficult to reach the deep strata. The forest—where it has still survived—is now doomed. The grasses—blue grass, timothy grass, fescue, willow herb, the legumes with their remarkable property of absorbing nitrogen and enriching the soil with it—these are the masters of the meadowlands.

And here, for the first time, the soil acquires that exceptionally important property without which there can be no "real" soil: it acquires *structure*. It becomes "crumbly" and yet *firm*. If the soil did not possess this property, man would not have known agriculture.

What is this firmness? Is not yellowish-red, lifeless clay firm? Put some in water, said Williams; it will dissolve into a small cloud. It possesses *cohesion*, but no firmness whatever.

At the time we are speaking of, however, the fate of the still poor soil that is being formed under the turf in the senile forest hangs in the balance; it is at the crossroad. What is to become of it? Will it become real soil, or . . . ?

Let us picture to ourselves this continuous accumulation in it of organic remains. We know that it is matter that absorbs moisture like a sponge. At last it absorbs too much; it becomes oversaturated.

The soil is sealed up. Air reaches only the thin upper layer. Beneath it is a pool. The inhabitants of the meadowland now change. All the plants that have roots of any depth make way for those that grow on the surface: quaking grass, vanilla grass and vetchling. . . . There are no loose-tillering grasses; there are only the compact shrubbery of the waterlogged meadowland. The earth is soggy. The cores of these shrubs have died out long ago. They stand saturated with stagnant water. Mounds arise and grow. There is almost no drainage. Again the inhabitants change. Soft, turfy mosses, bushes and small, crooked trees bearing small berries, club mosses, sedge and black water—before us is a bog.

Williams was fully aware that the conclusion he drew sounded paradoxical. "The cause of the formation of bogs is the shortage of ash elements in the food of the plants; the presence of water in a bog is simply due to the great water-absorbing capacity of organic matter. This conclusion is the opposite of the very old view . . . that the formation of a bog is the result of the accumulation of water. Here we have a combination of cause and effect. . . ."

If, however, we accustom ourselves to this system of ideas and deductions, we will find that it is the most natural, harmonious and intelligible one. Things and phenomena of the external world that had seemed fortuitous, and each of which had called for a special explanation, will now, with logical necessity, follow from the general process; the most unexpected facts will fall into their places. Rivers with their specific features, the shape of their valleys, their flood plains, the ground water, clays and shifting sand; a papyrus marsh somewhere in Uganda; the bright aspen groves; young woods; the light soil of pine woods; the "infusoria" earth that gardeners prize so much—we recognize in all this the inevitable result of this or that definite phase or divarication of a single process, the "natural manifestations" of the turf period of soil formation.

But is not climate the final and all-deciding factor in the plant world? Williams even looked at this deduction sceptically. He knew what changes trees introduce into the climate of the tundra; and he knew that a desert is made not by the desert climate, but by the degeneration of the plant covering, the degeneration of the soil; it is the desert that makes the desert climate! It used to be asserted that the "chernozem zone" arose only in the area of "eternal steppes," of the eternal "steppe climate." But chernozem is found from

Yakutsk to India; and in North America. It stretches longitudinally for thousands of kilometres from north to south, through different climates.

What interested Williams far more than climate zones was the age of the soil. When was a given area at zero point in soil formation, from which the counting of "soil time" can be started?

This question may seem almost superfluous. Did not soil begin to form everywhere approximately at the same time from the moment the first plants appeared on land, somewhere in the Silurian or the Devonian period?

A superficial and hasty answer!

The sea advanced and retreated. The waves swept over the land and laid bare its bed. Lava poured over the land. Such was the complicated process, with numerous interruptions and resumptions, of soil formation!

But it is not these ancient ebbs and flows that interest us now. They do not determine the "starting point."

Only quite recently, counting by the clock of geology, in the epoch immediately preceding the present one, a huge glacier covered nearly the whole area of what is now Russia. This glacier retreated slowly, over a period of thousands of years. The places first to be cleared were those where the sun was hottest. The ice armour in the North was the last to melt. Greenland is still covered with a thick coat of continental ice. There, the glacial period has not yet ended, and the traveller who visits this island, the largest in the world, is actually making a journey into time.

In some places the bared soil retained something of its preglacial age; but for the most part it was lifeless, mineral, "subbed" morain: silicates, clays, crushed quartz, loams and chalk. . . .

Here, time started anew. . . .

In the South, it not only started earlier than in the North; it also passed quicker. Here we must on no account forget about climate; where it is warmer, all the organic processes always take place faster. And so before us we have "zones": tundra, wooded tundra, taiga, wooded steppe and steppe chernozem. The borders of this zone are extremely intricate; they are not determined by isotherms, by lines of equal temperatures. Dokuchayev knew that very well—all these zones are of different age, they are all in motion, and their motion is of different velocity.

In the turf period of soil formation that great treasure chernozem appeared. Mountain chernozem, valley chernozem, and the chernozem of the hill slopes that Dokuchayev investigated. In the East and Southeast were the rich, clayey chernozems of the meadowlands, with "birch groves" scattered here and there. This is the famous "birch steppe." A typical example of this is Baraba, or the Baraba Steppe, in southwestern Siberia, on the watershed between the rivers Ob and Irtish.

In the South, "soil time" passed faster than in the North. And so, sooner or later, where bogs stretched for kilometres, they were no longer to be seen. They died out.

Their mossy "patches" were covered with clear bright water. Later, the "patches" merged. In places the bogs dried up, in others blue steppe lakes were formed.

Year after year the spring sweeps over the spaces with increasing turbulence and gullies are left where the flood waters flowed. In the summer the rivers dry up, leaving chains of pools, the former "still waters." Later, a dry ravine is formed in their place, and into it run the higher dry gullies.

The turf period ends. The *steppe* period is ushered in.

There is much less water, but neither forest nor meadowland is flooded more than steppeland.

Why is this?

One thing at least is evident: a turning point has been reached in the development of the soil covering. The zenith is reached with chernozems; beyond them comes a decline.

Williams pictured this turning point to himself in the following way.

Chernozem has an ideal crumble structure. Through the crumbs the rain penetrates deeply into the soil; no matter how much rain falls, chernozem absorbs it all. The crumbs absorb the water by capillarity when it percolates through the spaces between them, and somewhere in the depths it feeds the ground water—that is why the level of rivers never sinks very low.

Chernozem soil provides plants with everything they need; there is no soil more fertile.

Meadowland, however, keeps piling up organic matter until the limit is reached where every addition of humus does not improve but worsens the soil. At this stage bogs can no longer form; bogs may be formed in the prechernozem phase as a "legacy" for podzol.

Now we get the following: all the spaces between the crumbs are filled with humus. The crumbs are glued together; what is called "structure" disappears; the earth no longer absorbs water, the suction becomes slower and slower. Scarcely thirty per cent of thaw or rain water enters the soil; seventy per cent of it flows away.

The flowing water washes away the most valuable part of the soil—the fertile top soil. The land is scarred with ravines. The meagre stock of water in the soil scarcely suffices until the middle of the summer. The steppe is already dry long before the cold weather sets in. Then follows drought, although the rainfall, perhaps, is no less than it was here when the meadowland remained wet and green until the frost came. The ground water becomes exhausted. The rivers dry up. Many of them have disappeared without leaving a trace.

The meadow grasses have now been entirely displaced by steppe grass. They grow much less thickly; the earth becomes visible between the stalks; the silver plumes of feather grass wave over the land.

In the summer the grass withers. Aerobic bacteria—those that breathe air, of which there is plenty in the dry soil, quickly decompose the remains of the grass.

The soil becomes poor in humus.

It cannot recover its structure.

The entire climate of the steppe is changed.

Patches of the steppe become salty, and these salt patches stand out bold and white, barely covered with dwarf wormwood and brittle, articulate, reddish salt-marsh grass.

It is not difficult to picture the transition to the last soil-formation period—the desert period, when the last change takes place to the desert plant community, to the desert landscape and desert climate.

Trees appear again and again even after the ancient forests have perished. White birch, rustling aspen, the leafy woods in which Yaroslav the Wise, Prince of Kiev, went hunting. . . . The desert too has its desert forests. There is no end to the tree forms on Earth. But these new trees are less massive, less rugged, more flexible in the struggle with the grasses; in appearance, character and purpose they are entirely different from the trees in the ancient forests—the taiga. And different again are the tropical jungles, interlaced with liana, teeming with life, with their special, characteristic soils—red soils. Whoever has visited Batumi, in Ajaria, the most tropical part of our country, has, perhaps, seen the "crimson soil" on the heavily wooded mountain slopes. Whoever has been in the Transcarpathians has no doubt seen the brown soil in the tall beech forests.

All these are "divarications" of the soil-formation process, and since the main and general features of this great natural process have been described there is no need for us to discuss them in greater detail here.

The chief and general features of this great natural process have passed before us.

But of the five hundred and ten million square kilometres of the Earth's surface, land, which we have been discussing in these pages, accounts for only a hundred and fortynine million.

What is taking place in the world's ocean, the first cradle of life, and its greatest repository?

Williams discussed this too. The investigator enlarged the field of his investigations.

He showed us the close connection that exists between the continents and the vast blue spaces over which wave after wave rolls silently, only to break up in pearly surf upon its shores.

Land and water, cut off from each other by this roaring line, "enemies" confronting each other, but equally containing life—are they not one and the same? What are the wide spaces of the ocean?

Soil, answered Williams. *Also soil!* They bear all the symptoms of soil. They are fertile; like land, they are the objects of human labour—does not man conduct husbandry in natural and artificial water basins?

More than that. "Strictly speaking, if a wider view is taken of the subject, the universal bearer of fertility is water, the hydrosphere, the ocean." What would the land be without water?

Whence does the ocean take its fertility? We already know: fertility—the ability to generate life—is always itself the result of the work of life. This is as true for the Earth's "water integument" as it is for its "rock integument." "The cause of the ocean's fertility is that it is inhabited by living organisms. . . ."

What do we know about the water of the ancient seas, about primordial water? At all events, we know that it was lifeless. We would no more recognize in it the water that is familiar to us than we would the kindly earth in the lifeless rocks of the desert.

It was something like the distilled water of the apothecaries. In the course of the millions of years of its existence life saturated it with oxygen and carbon dioxide, endowed it with the ability to dissolve numerous substances of the Earth's surface and enriched it with salts. Here, too, a process of soil formation took place. And, of course, it had its periods. The "forms of life" in the sea changed more than once.

Williams included these amazing changes in his investigations. They were due also to the changes that took place on land, to the nature of the dissolved substances that chiefly flowed into the sea from the land.

He traced "the profound dialectical interconnection between the two vehicles of the one, general, qualitative property of fertility—between Soil and Ocean." He told about the flow of silicic acid and about the relatively meagre life that existed at that time; about the siliceous armour of the microscopic radiolaria, about the diatomic algae, about cartilaginous fishes without real bones, about the trilobites resembling enormous wood lice, their shells containing chitin, as do the insects of the present day.

Millions of years passed. New soils arose on the land. Bacteria fixed nitrogen. Nitric acid, the strongest of solvents, appeared, and the formation of soil was extremely accelerated.

At that time plant life flourished in profusion thanks to the abundance of new nutritious substances. Their roots took nitrates from the chemical compounds of the soil, which included nitrogen. The roots also dissolved calcium nitrate salts. For the first time in the history of the Earth, the particles of calcium, separated and oxydized by the oxygen in the air, combined with carbon dioxide. That is how carbonate of lime appeared, and this marked a "geological era."

Water carried lime into the ocean. "By a spurt like an explosion," said Williams, new types of aquatic creatures were able to develop in place of the old: gigantic crustaceans, like the one that is used as a font in the Cathedral of Notre Dame in Paris; it was a world of osseous fish and colossal lizards.

The ocean itself "became the regulator of the carbon dioxide content of the atmosphere," and the atmosphere acquired a new property, namely, of containing a constant amount of carbon dioxide.

The carbon dioxide permeated the waters on land—the rain and dew—and these waters became mighty solvents: the chemical corrosion of marl proceeded at a rapid rate and again everything on the continents, and later in the seas, began to change.

It is a grand picture that the investigator has unfolded for us. It seems as though the innermost secrets of our planet have been revealed to us for the first time, and we see how the seas and continents stretched forth their hands to each other, and how the entire Earth became transformed into one vast house. The course of the colossal process of life creation revealed itself to us, and Williams explained it in solemn terms marked by italics: "*A single process, embracing both Land and Ocean.*"

There are few scientific theories in the history of the natural sciences equal to this in grandeur, daring, potency and breadth of world outlook.

THE HUMAN ERA

When men still hunted or went to war with arrows and spears and cultivated their fields with mattocks, they knew nothing about all this, and even had not the slightest inkling of it. Nevertheless, already at that time men vigorously intervened in nature's affairs. Nature ceased to stand alone: Nature was combined with men; the soil ceased to be the product of Earth and Life; since then there have been Earth, Life and Man.

True, for a long time man only gropingly intervened in the affairs of the blind giantess—Nature.

There are two meanings in the phrase "the human era": the meaning that accompanied man's past work on Earth for a good ten thousand years, and the meaning that arises today, under our eyes, in our country—a meaning that looks to the future.

It was this second proud meaning that served as the main object of Williams' investigations.

But before we discuss this most important aspect of Williams' work, we must cast a glance backward; for unless we understand the first meaning, we will not understand the second.

Many old folks still remember the year in which people were forced particularly to ponder over the significance of man's work on Earth.

This was the year 1891. It is still known as the "famine year." It is by this name that it has gone into history.

Famine was a frequent visitor in the countryside in the old days. In some places the peasants lived in constant starvation. This raised no comment; it was a common thing. Bread baked from flour mixed with ground pigweed seed was considered not so bad. "The trouble is not that there is pigweed in the rye," they used to say. It was only when disaster spread to province after province, or became nationwide, that the saying went round: "There is no worse disaster than when there is neither rye nor pigweed. . . ."

Such a disaster occurred rather frequently—almost every five years, when you come to count.

Famine visited not only the Russian countryside. The Irish famine in 1847 carried away a million victims. There have been famines in Germany and in England. As for the Eastern countries, it is needless to speak of them. In India, tens of millions suffer from famine year after year, and during the famine of 1869-70, Bengal lost a third of her population. During the drought in Persia in 1870-72, one fourth of the population perished.

During the reign of Nicholas I (1825-55) famine occurred in Russia as many as ten times; there was famine in Smolensk in the 1860's, in Samara in 1872, in the Lower Volga in 1880, in South Ukraine and in the central provinces in 1885.

The gates were flung wide open for famine by the dire poverty of the peasants, by the open field system, by the primitive cultivation of the soil, which was not ploughed, but scratched with primitive wooden ploughs. Even in the years when the harvest was considered good the crop barely sufficed until the next harvest. The peasants had no stocks, and if the next harvest happened to be a poor one, the peasants starved. The barns of the local landlords were crammed with grain that was actually going bad; in the provinces, only a few hours' railway journey from the affected area, there was plenty of grain, but the authorities were incapable of rendering the famine-stricken districts any assistance; they relied mostly on private charity. The consequence was that the famine-affected farms were unable to prepare for the following spring; no crop was gathered the following autumn, and in this way the number of "decaying villages" increased on the rich chernozem of Russia.

This is what happened in "ordinary" famine years. The year 1891, however, was an extraordinary famine year. Famine affected twenty-nine gubernias. Nobody remembered a disaster of such dimensions. It was aggravated by the recurrence of drought and crop failure, though of smaller dimensions, in 1892.

Priests walked round the parched and cracked fields carrying holy banners, but all their prayers for rain were in vain. The sun scorched the bare heads of mothers carrying infants in their arms; it was dazzlingly reflected on the frames of the icons; dust filled the mouths of the people as they discordantly chanted their prayers to heaven for rain. Repin's famous painting *Church Procession in the Kursk Gubernia* carries us back to that distant time, which is unfamiliar and unintelligible to us today. . . .

Progressive people in Russia took the sufferings of the people greatly to heart.

The activity displayed by Leo Tolstoy during the famine year is well known.

A quarter of a century before this disastrous year, when Tolstoy, then still young, was working on his book *War* *and Peace,* famine was threatening the countryside in the central provinces, and Tolstoy wrote to the poet Fet the following anxious and stirring lines: ". . . the general course of affairs, i.e., the impending national famine disaster, is tormenting me more and more every day. . . . On our table we have red radishes, yellow butter, nicely-baked soft bread on a clean tablecloth, the garden is green, our young ladies in muslin frocks are glad of the heat and shade; but out there the wicked devil famine is doing his work, covering the fields with pigweed, causing the dry earth to crack, chafing the calloused heels of the muzhiks and their women, splitting the hoofs of the cattle, and shaking and stirring all the people up so that we, sitting in the shade of lime trees in muslin frocks and with yellow butter in ornamental dishes, are likely to see trouble."

In 1891, however, the disaster was beyond all previous dimensions and, putting all other work aside, Tolstoy devoted all his efforts to the organizing of relief for the famine-stricken countryside. He travelled through the rural districts of the Tula, Oryol and Ryazan gubernias, opening relief kitchens, collecting funds, registering the famine-stricken families, obtaining grain and distributing it among these families. He issued a public appeal, and he wrote articles for the newspapers in which he blamed the tsarist-landlord system for the disaster. Commenting on one such article entitled "Why the Russian Peasants Are Starving," the *Moskovskiye Vedomosti* wrote that it was "open propaganda for the overthrow of the social and economic system that exists all over the world. . . ."

Gleb Uspensky[8] also worked on "famine relief," and in Nizhni-Novgorod Vladimir Galaktionovich Korolenko[9] was the "living centre" of this relief work.

Russian science mobilized itself for the purpose of combating the disaster. The questions arose:

What is drought? What is it due to? Is it really invincible? What must be done now?

Timiryazev delivered lectures, wrote a pamphlet entitled *Plants Combat Drought*, and translated a book by the German agrochemist Wagner, *The Principles of Rational Fertilization*.

In the minds of all persistently arose the question:

What has happened to our steppes? What has become of their former gigantic power of procreation? Why are the best and most valuable chernozem regions becoming devastated?

Everybody vividly recalled Gogol's famous description of the steppe at the time of Taras Bulba:

"The farther they penetrated the steppe, the more beautiful it became. Then all the South, all that region which now constitutes New Russia, even as far as the Black Sea, was a green, virgin wilderness. No plough had ever passed over the immeasurable waves of wild growth; horses alone, hidden in it as in a forest, trod it down. Nothing in nature could be finer. The whole surface resembled a golden-green ocean, upon which were sprinkled millions of different flowers. Through the tall, slender stems of the grass peeped light-blue, dark-blue, and lilac star-thistles; the yellow broom thrust up its pyramidal head; the parasol-shaped white flower of the false flax shimmered on high. A wheatear, brought God knows whence, was filling out to ripening. Amongst the roots of this luxuriant vegetation ran partridges with outstretched necks. The air was filled with the notes of a thousand different birds. On high hovered the hawks, their wings outspread, and their eyes fixed intently on the grass. The cries of a flock of wild ducks, ascending from one side, were echoed from God knows what distant lake.

From the grass arose with measured sweep a gull, and skimmed wantonly through blue waves of air. And now she has vanished on high, and appears only as a black dot: now she has turned her wings, and shines in the sunlight. Oh, steppes, how beautiful you are!"

Was it ever like this? Yes. Russian researchers knew that this was not only Gogol's fantasy. Middendorf, Beketov, Krasnov, Korzhinsky and Tanfiliev re-created the picture of the former grassy ocean with its spreading dog rose, prickly, flower-bedecked tea-plant (*Lycium barbarum*)—kinsman of the yellow acacia, *Prunus nana*—kinsman of the almond and steppe cherry.

Only recently the procreative power of the steppes had seemed inexhaustible. . . . In 1850, at the London Exhibition, the Arnautka was exhibited as a freak of nature. This was a heavy-eared wheat that grew near Kerch. All the time it had grown it had not had a single drop of rain. There had been a drought—there had always been droughts—but at that time the soil provided the fields not only with food, but also with drink.

A. V. Sovietov mentioned the Kerch Arnautka in the treatise he submitted for his Doctor of Science degree. Already at that time, in the 1860's, he noted with anxiety the disappearance of the "strength of the soil."

Red cereals, hard spring wheats, lost their vitreousness; their nitrogen content diminished. Nearly everywhere, they were being displaced by soft cereals, by soft wheats. These, in turn, were displaced by grey cereals—winter rye, oats and tiny Ryazan and Tambov millet. "What had become of 'pink Orenburg' and 'red' millet?" asked Sovietov.

In the period of disaster another splendid Russian agronomist, A. A. Izmailsky, wrote a book entitled *How Our Steppes Dried Up*. It contained the following passage:

"The steppes—our ordinary steppes . . . receive too little shade from their sparse vegetation . . . the rays of the sun heat the soil without any hindrance, and the wind, meeting with no obstacles on this almost bare surface, freely carries away the few drops of rain that manage temporarily to hide in the top soil."

What a glaring contrast to the steppe in Taras Bulba's time! Izmailsky uttered the warning:

"If we continue carelessly to watch the progressive change in the surface of our steppes, and the consequent progressive drying up of the steppe soil, there can be scarcely any doubt that in the relatively near future our steppes will be reduced to a barren desert."

He wrote this warning in italics. *Desert!* A frightful word.

What was the cause of this terrible evil?

The general answer to this question was already obvious to Russian scientists.

The causes were the inefficient farming of the aristocratic landowners; the greed of the city merchants who, after piling up fortunes, "settled on the land" in order to squeeze all they possibly could out of it; and also the three- and two-field system of peasant farming on tiny plots of land.

But scientific thought must find an exact biological explanation of the harmfulness of inefficient, wasteful and primitive methods of farming. It must explain what has actually happened to the soil when we say that it has deteriorated.

The explanation that had predominated in science for a number of decades was the crude one given by the German agronomic school headed by the celebrated Justus von Liebig. It was thrown up in Dokuchayev's face when he was a student. This school asserted that when harvesting the crop we take something from the soil. Had not the plants that we harvest built up their bodies out of the substances of the soil? There are no magic purses in which money never diminishes. What is spent must be replaced. Liebig's innumerable pupils saw three ways of doing this. The first was the ancient one that was known in antiquity when the fallow land system was practised—a plot is cultivated to the utmost limit, until it is completely exhausted, and then it is abandoned; it is allowed to "lie in fallow," i. e., to rest. The second way was crop rotation: different plants have different requirements. If the crop is changed on a given plot, the soil is rested to some extent. To encourage crop rotation, red trousers and blue coats were introduced in the French army. This created a demand for red and blue dyes, and the farmers grew madder and woad from which these dyes were made. In Germany, the troops were fed on pea sausage. This created a demand for peas. When it was discovered that legumes possessed the amazing property of enriching the soil with nitrogen, the scientists divided all field plants into two categories: those which exhausted the soil, and those which improved it.

The third way of reviving the fertility of the soil was to restore to it what had been taken from it. Liebig himself became a trustee of the Olendorf "special fertilizers" factory at which fertilizers were manufactured for wheat, for potatoes and for beetroots, according to most precise prescriptions, calculated to restore to the soil the substances which the given crop robs it of.

In spite of flawless calculations, however, the soil refused to give a crop certificate to the effect that it had received *complete* compensation for what it had given. On the fields treated with the Olendorf products, the "manures," which had been too lavishly applied, even began to leach, and the "special fertilizers" factory closed down.

Then, recalling the times of Julius Caesar, they recommended the sideral system of manuring. Sideral means "star." Timiryazev saw no sense in this term. The sideral system was simply the system of using green manure. The Romans employed it, believing that the celestial luminaries exercised a mysterious influence upon plants. By planting rye, mustard, or Alexandrian clover after wheat and beans and ploughing them into the ground in the autumn, the Romans thought that they were manuring the ground by the influence of the stars. Leaving astrology aside, there was, of course, some sense in this green manure; but this, too, failed to bring about the *complete* restoration of fertility.

It seemed clear to Liebig that the natural rest the land receives while in fallow is due to a physical-chemical process, to weathering, which reduces the mineral mass of the soil to a state in which it can serve as nutriment for plants. Exhausted land is simply land that no longer possesses this ready-made food. The land itself, this mass, has remained. Give it a rest, and after that it will provide food enough. The idea arose of accelerating the weathering process, and the "Liebigites" advised a method of ploughing that had never been practised before, namely, not to turn the soil, but to stand the layers almost on end, so that the wind could blow all round them. Clever English engineers even designed a plough which turned up narrow strips.

Alas! The field with the furrow ridges standing on end lost their fertility more rapidly than ever.

As regards the crop-rotation system, for its time it was an unquestionable achievement of agronomic thought. The extensive introduction of this system did indeed lead to increased crops. It must be said, however, that this system appeared long before Liebig; and its appearance was in no way connected with any of Liebig's theories.

In Russia, the "crop-rotation" system was employed by progressive farmers as early as the beginning of the nineteenth century. D. M. Poltoratsky, in Avchurin, Kaluga Gubernia, which afterwards became famous, employed the new system on six hundred hectares. To the surprise of his contemporaries, he sowed grass. I. I. Samarin, in the Yaroslavl Gubernia, introduced a "four-field" system of rotation on his farm.

The "crop rotators" V. G. Orlov and D. P. Shelekhov can also be mentioned. And also the peasant vegetable growers in the Yaroslavl Gubernia, who as early as the eighteenth century alternated sweet peas and fragrant grasses with beans and chicory.

Apparently, clover was brought to England from the Vologda Region, and from England it was taken to Germany.

When the "classical" English and German crop rotations were being worked out, they strictly excluded the planting of the same crop on a given plot even for two years running. The inventors of these systems argued that the demands upon the soil must be changed every year, so that this or that "property" of the soil may rest. And so the "rational farmers" planted in continuous rotation root crops, clover, spring crops and winter crops. Bare fallow was completely eliminated. It was a constant race, spurred on by fear lest they remain on the same spot even for one extra year. Liebig's arithmetic assured them that if this race were kept up, the total "fatigue" of the soil would be fully compensated by the total "rest."

Grain crops take a great deal of phosphorus from the soil; after harvesting their wheat, rye or barley, the farmers planted legumes, and after that industrial crops. According to Liebig, these crops take from the soil chiefly lime and potassium. The phosphorus accumulates, and the legumes make a "gift" of nitrogen to the fields.

The arithmetic was flawless, but for all that, the curve of fertility, which jumped upwards on the introduction of the crop-rotation system, in the end began to drop, although not so much, of course, as under the three-field system.

The agrochemists were of the opinion that this drop ran counter to common sense, but this was poor consolation!

After all said and done, the crop-rotation system was an important improvement, of course, and it was natural that progressive farmers strove to introduce it. The Russian agronomists did not, however, copy the "English system," they amended it very considerably. For example, they were of the opinion that it was wrong to eliminate fallow. A. V. Sovietov expressed himself strongly in favour of fallow. A. N. Engelhardt, agrochemist and Narodnik publicist, wrote in his "Letters From the Countryside": "We must create our own Russian agronomic science." He wrote these letters in the Smolensk Gubernia, to which he had been deported by the authorities, and they were published in the progressive magazine *Otechestvenniye Zapiski*, edited by Saltykov-Shchedrin and Nekrasov.

Thus, Russian scientific thought long ago threw doubt on the agrochemical schemes of Liebig and his English admirers and followers. It is not surprising that it was Russian science that was destined to strike the mortal blow at the entire Liebig theory.

The "rational fertilizers" were to have fully restored the fertility of the soil. They were, of course, useful, and increased the diminishing crop; but they did not fully restore fertility.

Evidently, there was some truth in the crop-rotation system, but it was an approximate truth, only part of the truth.

Ploughing "on end" did not help the soil to "rest."

But land in fallow did rest.

All this had to be studied and unravelled.

The decisive experiment was conducted by Pavel Andreyevich Kostychev.

Kostychev took a plot that had just come out of fallow and another plot that had been exhausted and was about to be put into fallow. It seemed evident that the soil of the first plot should contain an abundance of nutriment, while the stock of nutriment in the second should be utterly exhausted. Liebig had taken this for granted.

Kostychev made a careful analysis of samples of both soils. Then he took another "pair" of soils, and after that a third, a fourth and a fifth. . . . He resorted to all sorts of chemical devices. He took tests of the soils of the same field and of two neighbouring fields: the experiment was to be made in the purest form—they were exactly the same kind of soils, except that one sample was "exhausted," while the other had "rested." Kostychev tested the amazing, incredible results he obtained scores of times.

He did this because they were incredible.

In the exhausted soils he found even more nutritious substances (precisely in the form in which they are assimilated by plants) than in the fallow, rested, soils in which, if wheat or rye were planted, they would rise up like a wall!

Obviously this meant the collapse of the Liebig theory. But what was to take its place? After all, what is fertility?

Kostychev found one difference between fertile and unfertile soil—a difference in their physical state, in their "structure." It will be more true to say that fertile soil *possesses* structure. "It is granular," said the researcher, trying to find a word for it. Unfertile soil can be compared with badly-baked dough that had "gone flat." When this soil is wet, you cannot drag the cartwheels out of the heavy, sticky mud; when dry, it turns into dust. It is *wrecked* soil, in contrast to virgin, or unbroken, soil. Perhaps the Russian people call virgin soil "tselina"* not only because it has never been ploughed?

While in fallow, wrecked soil "builds itself up" again—this is what its "resting" really amounts to!

Thus, end of nineteenth-century science was not helpless when faced with the grim question:

"What is the cause of the disaster that has befallen the chernozem heart of Russia?"

At that time a very important answer to the problem of the "famine year" was given by the leader of the Russian soil scientists Vasili Vasilievich Dokuchayev. His book (the entire proceeds from the sale of which were to go for famine relief) was entitled *Our Steppes in the Past and Present*. The great scientist was then at the zenith of his mental powers, at the beginning of his Novaya Alexandria period.

Summing up the situation, Dokuchayev said: We have explained the cause of drought, but can we combat it? Is there a force that can vanquish the invincible elements?

There is!—he answered. That force is science. It can vanquish drought and restore to the steppes the fertility it possessed as described by Gogol. It can do it . . . if it is allowed to enter the fight without being tied hand and foot.

"The sturdiest body, even that of a Hercules," he wrote,

* "Tselina," literally "whole soil."—*Tr.*

"cannot repeatedly withstand such disastrous fortuities as have fallen to the lot of Russia at the present time. The most energetic and resolute measures must be taken without fail to restore the heart of our agricultural body."

He proposed a nationwide plan and, considering the conditions that prevailed in Russia in the reactionary reign of Alexander III, it was truly amazing for its daring.

The rivers must be regulated. The big ones—the Volga, Don, Dniester, Kama and Oka—and the small ones. Regulate their course, straighten them when necessary, remove shallows and rapids, afforestate the desert areas, build reservoirs and dam rivers.

The formation of ravines must be checked. Steep slopes must not be ploughed, but planted with trees and bushes—let them be converted into orchards and woods.

The entire water system in the open steppes and watersheds must be reconstructed. Not isolated, but a whole system of ponds must be dug. Plant shelter belts for the protection of fields; and in sand-dune areas, and on all uncultivated land, plant whole forests; artesian wells must be dug.

A proper ratio must be established between the areas of ploughed land, grassland, forest and water, and having secured it, to keep strictly to it.

The soil must be cultivated in such a way as to make the best use of its moisture and to avoid destroying the soil. The crops for planting must be properly chosen, and a crop rotation suitable for the given locality must be introduced.

But which of these five splendid "musts" could be carried out in that dark period? The first three were totally out of the question. Concerning the last two Dokuchayev himself wrote that "nor can they be carried out immediately."

He knew that his science was tied hand and foot. Could he resign himself to this?

And so he started an experiment that was as conspicuous for its daring as was his whole scheme.

He decided to put his proposals into effect on a small scale, in order to demonstrate what his science *could* do!

With incredible strain and effort he succeeded.

He started the experiment, scarcely expecting to see its results. Trees grow slowly. . . . But what did that matter? Future generations would see them!

Dokuchayev's experiment, started in 1892, is continuing to this day. It is assuming wider and wider dimensions—a living connection between us and the scientist who passed away almost half a century ago.

He set up a chain of "stations," one of which was the most important. Its location was carefully chosen in the Voronezh Gubernia, the centre of numerous droughts, including that most frightful drought of 1891. A few years after this drought, investigators of agriculture described this area in the following terms: "The forests have thinned out and are of smaller area, the rivers have run low and in places have entirely vanished, the shifting sands have invaded the fields, the hayfields and pastures, the fields have slipped into the ravines and in place of what was once good ploughed land there are gullies, pools, ravines and even yawning chasms; the land is exhausted, its productivity has diminished; in short, the area of bad land has increased, the landscape has been disfigured, natural wealth has been exhausted and the natural conditions have deteriorated. At the same time, scarcity, poverty and dire need have entered the lives of the inhabitants. . . ."

In the Talov District, on the watershed between the Volga and the Don, lies what is known as the Kamennaya, or Stony, Steppe. Its very name is indicative of its exceptional barrenness.

On this land, scarred by ravines, frozen by winter's icy blasts and bare to the scorching sun of summer, Dokuchayev set to work. He explored the deep-lying ground waters. He dug ponds. He planted tree belts 32 and in some places 60 metres wide. The slopes of the ravines, hills and the watershed became covered with foliage.

Henceforth, field cultivation was to be conducted according to the strict requirements of scientific agronomics.

Thus, the Kamennaya Steppe Experimental Station, with an area of 10,000 hectares of land and 1,000 hectares of woodland, came into being on the great Russian plain.

Years passed. The striplings grew.

Decades passed. Dokuchayev's shelter belts cast broad shadows on the plain.

Vasili Robertovich Williams worked out a new system of agriculture. He spoke of man acquiring a power over nature such as he had never possessed before.

Williams called this system the travopolye system.

He included Dokuchayev and Kostychev among its inventors.

He began where Kostychev had left off.

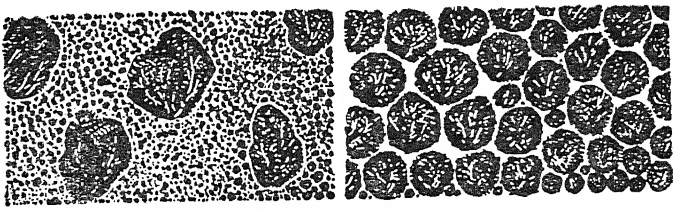
Kostychev had pointed to the importance of soil structure. He had studied the way structure was restored in "resting" land and had already suggested the idea of planting mixtures of grasses and legumes, the restorers of soil structure.

Williams regarded soil structure as the pivot, the key position of the entire science of fertility.

A contemporary of and participant in man's greatest intervention into the affairs of nature, Williams was well aware that, practically, there was now no land that man could not put his hand to. Virgin soil? Feather-grass covered steppes? These too had been ploughed, although, perhaps, our generation does not remember when this had been. "Virgin soil" is only a conventional term.

There is no contrast between virgin and ploughed soil; but there is a contrast between soil that has structure and soil that has lost it.

What, precisely, gives soil its structure? The millions of "crumbs" in the soil, each of a size ranging from that of



Soil structure
Left: structural soil. Right: structureless soil

a pea to that of a hazel nut. Tiny, moist islands. What can drought do to them? It can only dry their minute upper surfaces; and this helps them more securely to retain the moisture concealed within them. There is no direct communication, no capillaries between the crumb islands. . . . The moisture in each crumb is held as in a tiny vessel.

But supposing the crumbs are destroyed, reduced to dust. Capillary passages now permeate the entire soil. The moisture flows along them very slowly. The first drops of rain, on penetrating the soil, enter the capillaries and block the path of the other raindrops. Take a very fine, glass, capillary tube; when a single drop of liquid enters it, it remains stuck and will not allow another drop to enter. If a wick becomes saturated, it ceases to absorb more moisture. This is what happens in structureless soil.

As soon as the rain stops, evaporation begins to suck the meagre stock of moisture from such soil. The moisture cannot hide even in the depths, for even from there capillary suction will draw it through the entire thickness of the soil to the ever-thirsty surface; this soil is like a wick. In the winter it is choked up with icicles. In the spring the thaw water rushes noisily over it and cuts ravines. . . .

People did not know what to do with such land, with this inexorably spreading desert. They saw that there was no water, so they decided that the land must be irrigated and were delighted with the short-lived green film that arose on the edges of their canals. Often they had no inkling that irrigation is a good thing when combined with skilful cultivation of the land, when it is given the important and complex tending that it needs. When that is done, irrigation does indeed become a powerful means of reviving the land.

Where that was not known—for example, in the once flourishing oases in the Orient—people treated the land that was dying of thirst with a poisonous medicine. Together with evaporating moisture, constant capillary suction drew salts from the depths, and day after day, month after month and year after year, these salts settled on the surface; and the soil, which had been watered with clear, fresh water, became salt; it became spotted with white and coloured fluffy scales.

Williams' line of reasoning was as vivid as—one would like to say—as a blueprint. He conceived the soil as an engineer conceives the machine he is designing.

Reading the pages written by Williams, I recalled the lifeless earth that I saw in my boyhood. Like the older people among whom I grew up, I did not realize that I was seeing something that ought not to have been. The people in the village where I grew up thought, or rather, did not think, but took it for granted, as they took the wind, night, the dawn and winter's snow, that this was ordinary land and that there was no other kind.

The grass and steppe flowers quickly passed away. At harvest time the steppe became brick red with a touch of grey from wormwood, stretching to the horizon. The couch grass was already fading, the field mice burrowed in the stubble. There were many snakes; lazily, with a feeble, angry hiss, they would wriggle out of one's way and, contracting their bodies, which looked like streaks of black oil, they would creep into the deep, crisscross cracks in the sun-baked earth, so wide that I, a ten-year-old lad, could insert my hand into them.

Then the windy season came. The wind blew persistently for weeks on end, not even dying down at night. Its mournful whining constantly rang in one's ears. The sea assumed a dull leaden colour, and rows of leaden scales seemed to run over its ruffled surface away from the shore—the wind blew from the north, from the land. Over the steppe a dark cloud rose up like a reddish-yellow curtain with smoky edges; it spread and shut out half the sky. This was a dust cloud that constantly hung over the land. In the distance black dots became visible; they grew rapidly and rolled and rolled over the bare steppe, sometimes three and four together. These were withered bushes torn up by the roots. Dry masses about three feet tall, they raced across the steppe. . . .

Neither the children nor the adults realized that what they saw was land killed by unskilful and primitive tilling, trampled down by the stupid practice of grazing cattle on the harvested fields for the sake of the manure.

Many years later I roamed across the sands of the Kara-Kum desert with a researcher from the Repetekskaya Sandy

Desert Experimental Station. The scene before me was exactly as I had pictured it from travellers' stories and from books. A boundless ocean of burning sand. Many times before that I had been surprised on meeting in the Kara-Kum blue shoots of saxaul. But this was a real desert, the desert of my imagination. A vast circle of almost unbearable yellowness. The surface seemed ruffled by countless, smooth sand hills, indistinguishable from each other. The sound of one's voice was deadened by them—one could not hear a shout from a nearby hill, and it was enough to step a little distance away from one's companions for a dreadful feeling to overcome one: everything around was all alike, it was impossible to tell where the road lay or from which direction one had come. It was easier to get lost in this vast open space than in a dense forest.

We climbed a sand hill and my companion said in a voice that seemed to me to be unnaturally loud:

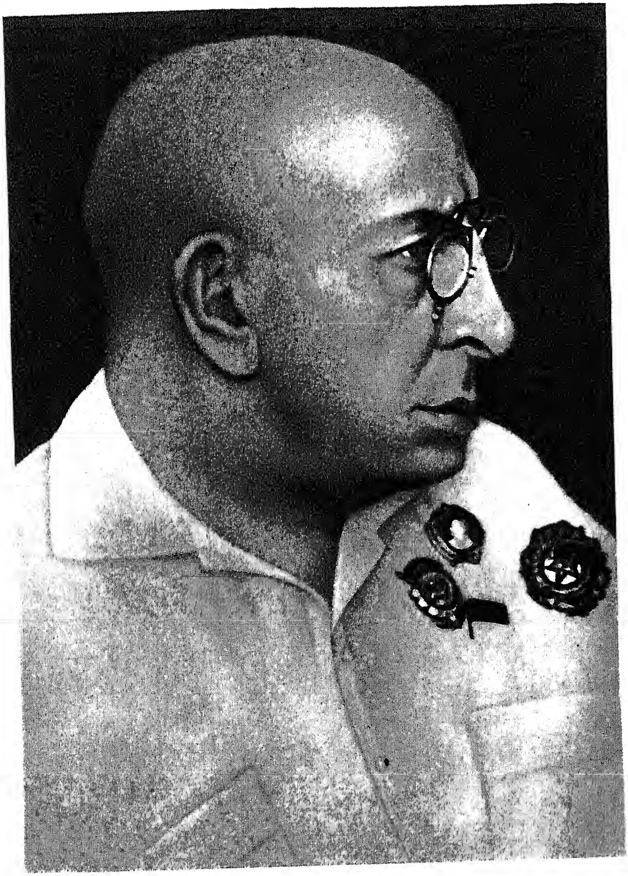
"Lifeless land. Look at it. Do you think this is desert? The desert is also alive. Land becomes lifeless when it is killed! The vegetation was trampled down, the saxaul was cut down, the sands shifted and piled up, and this is the result. . . ."

And so twice—during the aptly called "black storms" of my boyhood, and here in this yellow circle, I saw lifeless land.

Is it lifeless forever?

Since ancient times a simple prescription for its resurrection has been known, a prescription mentioned many times in these pages, namely, *fallow*. In other words: let the land rest.

And so, step by step, Williams traced what takes place in fallow land. He analyzed, took apart, the hidden operations that take place in fallow land in the same way as a



VASILI ROBERTOVICH WILLIAMS

mechanic takes a machine apart to lubricate all the parts before starting the machine again.

During the first year of rest the rodlike roots of the tall, profusely-grown weeds compress the soil. When they have withered, the field will be studded with hollow, conical cavities. Next year there will be no weeds; the field will have been converted into couch-grass land. This grass will remain for seven and even ten years. The soil will be covered with springy turf. Around the network of couch grass rhizomes a crumbly soil is formed, as yet, coarse-grained. Then the couch grass gives way to the thin-stalk plants: timothy grass, brome grass and cereals.

This thin-stalk fallow lasts ten to fifteen years. During this period the crumbs grow finer and more numerous. The legumes accumulate nitrogen. Fescue grass, cereals growing in low, compact clumps, take the place of the thin stalks and in their turn give way to feather grass. The soil is now firm. It is rich in everything plants need. But it took twenty years to reach that state. Can man afford to wait so long? He ploughs up the fallow land before this.

Time, however, must be subordinated to man's will. Having obtained an exact blueprint of fallow in operation, he can, and must, compel it to operate faster and better.

Williams' directions are most detailed.

Proper cultivation of the soil will take the place of the slow, blind efforts of the weed and couch-grass rhizomes. The work of the wild thin-stalk plants will be done by the planting of the loose-tillered cereals which are akin to them. The task will be completed by the planting of cereal and legume mixtures.

This is not simply the copying of nature.

In nature, the peak of fertility is achieved by the turfing process. After reaching the peak, nature pushes the soil, which she herself has created, downwards, to the steppe, the desert.

People thought that inefficient cultivation of the soil destroyed fertility, and this, of course, is true. It was also asserted that in harvesting the crop we take the nutritive substances from the soil. This, too, in a way, is true. But even the complete restoration of what was taken did not entirely mend matters. People had no inkling of the fundamental cause, namely, that all our annual field plants—grains, industrial crops, fodder, root crops and potatoes—all belong to the steppe formation; and in the soil beneath them an inexorable *steppe* process takes place. To change it to the turfing process, the steppe must be converted into meadowland. The problem is thus precise and clear; and Williams, with mathematical precision, arrived at the solution—the travopolye system.* This is a system with the aid of which man changes the development of the soil by planting grassland plants—perennial loose-tillered grasses and cereal-legumes.

In Williams' books, in which the most inspired poetry about nature is combined with most carefully calculated, almost pedantic, one would like to say masterfully strict instructions, we read that soil is irreplaceable, and that it can be constantly improved.

In the human era, the wonderful era of man that has been opened in our country, soil must be created of a fertility that nature has never known. For this *man's soil,* Williams introduced the term "cultivated soil."

This is not a figment of the imagination. Such soil exists. It was on such soil that the famous kolkhoz team leader Yefremov and his followers grew their splendid crops.

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* Travopolye—literally, grassfield.—*Tr.*

In describing the travopolye system, Williams enumerated its component elements: what should and what should not be done.

This system, the system creating cultivated soil, is not merely a system of grass-crop rotation; it means transforming and reconstructing the soil! Here are the constituent elements, the inseparable links of the whole chain.

Dokuchayev shelter belts; afforestation of watersheds, ravines and gullies, tree belts round reservoirs; afforestation of desert land.

Regular field-crop rotation.

Ploughing; cultivation of the soil; agrotechnique.

Fertilizers—provision of additional organic and mineral nutriment for plants.

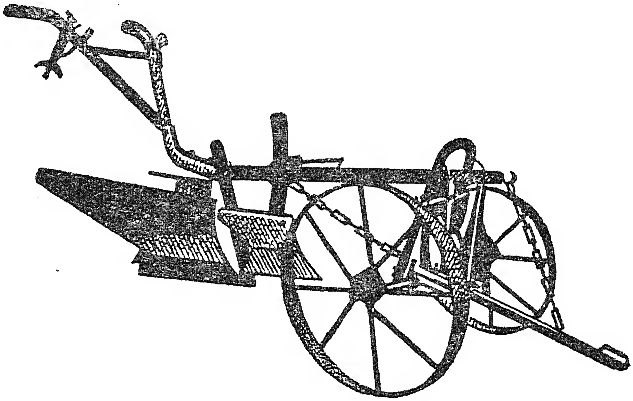
Seed selection—the planting of high-yield seed of varieties especially raised for and adapted to the given locality.

Lastly, water—irrigation, mobilization of available moisture, ponds and reservoirs to form a silvery chain across the fields. . . .

Grass-crop rotation can and must be arranged in different ways according to circumstances. In the grain regions, grass must, of course, be followed by wheat, and before all others, by the splendid "whole" hard wheat; in the flax-growing regions—long fibre flax; in Central Asia—cotton. The kolkhozes already have rotations of seven, eight and nine crops, and room is found on their fields for hard wheat, for soft wheat, for potatoes, etc.

Yes, the cultivation of the soil is of exceptional importance, but it must not be cultivated in the old-fashioned way. The object is to create a cultivated soil such as has never existed before, and therefore, it must be *tilled in a cultivated way*.

Uninformed people may say—and for decades even certain agronomists used to say: "As long as the plough is a good one, what does it matter whether the ploughshare is adjusted to this or that 'system'? Scores of 'systems' have followed one after another since ploughs began to be made in factories. . . ."



Plough with skim coulter

True, no less than two thousand types of ploughs have been put on the market by capitalist firms, each having some novel variation for the purpose of attracting buyers; but there is nothing scientific about them; to help the farmer is not their object.

Williams, however, insisted on one particular "system" in which the competing private manufacturers were not in the least interested, namely, that all ploughs must without fail be fitted with skim coulters.

Why?

Because field soil has two layers. The structure of the upper layer has already been disturbed. It is disturbed by the people working in the field with horses and machines, big streams of water, and by the aerobe bacteria which quickly decompose the humus. In the past, shallow ploughing was practised, and this pulverized the soil still more.

The skim coulter is fitted in front of the ploughshare like a small plough. It cuts and turns the upper layer at the bottom of the furrow left by the plough at the last ploughing. The main ploughshare firmly ploughs in this upper layer and covers it with a thick layer of lower soil. The skim coulter cuts a shallow furrow, but this is forthwith covered by a deep furrow. The result is that the fertile soil is brought to the top and the unfertile layer is sent to the bottom to "rest," so that its fertility may be restored. And with it are buried the upturned weed roots. There they will rot; they will not grow again.

Deep ploughing has long been practised in our country. After the Plenum of the Central Committee of the Party passed its historic decision of February 1947, 20- to 22-centimetre ploughing became the law, and from 1949 onwards, all ploughing will be done with ploughs having skim-coulter attachments. . . .

Within the next few years, in conformity with Stalin's great plan, the most potent method of transforming the soil ever invented by man—the travopolye system—will be employed in all kolkhozes and sovkhozes, on a boundless area of millions of square kilometres.

Our socialist fields are not waiting for favours from Nature. They, in the words of Michurin, are wresting them from her.

Golden cornfields are the most valuable things in agriculture, but they do not constitute the whole of agriculture.

Formerly, tree growers were little concerned with fields. Farmers would merely take a look at "commercial orchards" and perhaps plant two or three apple trees near their houses.

What is one whole was broken up into parts, each knowing nothing, and caring nothing, about the other.

But Dokuchayev already urged that woodland and orchard and field and grassland should constitute one harmonious whole.

Williams introduced the industrial term "shop."

Agricultural shop; plant-breeding shop; livestock shop—such is agriculture!

All are needed, all must supplement each other; the absence of any one of them will prevent the work from being conducted as it should be.

Long ago, Darwin formulated a simple and beautiful law: the greater the diversity of life, the greater is the sum total of life that the earth can sustain in every one of its parts.

Woodland protects the fields. On watersheds trees alone can create a stable water regime—and here harvests will cease to "jump up and down," will cease to be "fortuitous."

Fields and grassland will provide food for livestock. In addition to field- and vegetable-crop rotation, there will be fodder-crop rotation. Livestock will provide manure for the soil. And the man-created soil will sustain such a sum total of life, will provide such an amount of sustenance for the plants and animals that serve man as neither the virgin soil of the steppes that Gogol described, nor the cornfields of our grandfathers and fathers could ever sustain.

LAND OF THE FUTURE

. . . I came home one evening and switched on the radio. Somebody was delivering a lecture of some kind, and as I had not heard the beginning I did not listen very attentively. Suddenly, a couple of sentences made me prick up my ears. I listened closely now, afraid to miss a word. But the more I listened the less I understood. The transmission was being delivered from a place, the whereabouts of which I could not determine. As I listened I became conscious of a queer feeling that the fine, ringing voice of the speaker was coming not from the present, but from the future. I heard a wonderful story, told in a now slyly-humorous and now artlessly-naive tone, almost in the manner of ancient authors, about a land of the future that evidently spread out around the speaker.

". . . What can be done with the realm of the marmot. The place, open to the four winds, seemed to be carpeted with felt. If a traveller were to walk over this felt carpet only one shadow would be thrown, the shadow of the traveller. We suppose that the traveller carried his drinking water with him, in a flask, or soldier's water bottle. The narrow, deep wells looked like boreholes, and they were so rare that they were especially marked on the map. Birds of passage, on meeting this land, rose higher in their flight.

"This land flourished for about three months, and after bringing forth sparse oats, ankle high, a litter of red foxes, and some bushes called camel's thorn, it withered like an old dame, conscious of having made a great effort; it became covered with angry wrinkles, and for a long time was frozen as hard as stone by winter's frost.

"A hard, stinted, and yet extravagant existence!

"And so, we changed the climate. It was necessary also to change the landscape to one that contrasted less with the natural requirements of human eyes.

"Among us were some who favoured the wide and open spaces of the steppes and others who loved woodland. It seemed wise to satisfy both. We decided to live in the woods, while at the same time remaining in the steppe.

"The physical-geographical and climatic features that had predominated in the past had been a rather irrational combination of mutually contradictory elements. It cost no little effort to introduce some order into this.

"When it had been ascertained that from 35 to 40 per cent of the ordinary velocity of the air was adequate for all purposes, strong winds, not to speak of storms, were stopped. The winter freezing of the soil was reduced by three fourths. Evaporation was reduced two thirds. At the same time the moisture in the air had to be increased.

"Of course, the need arose for a new soil. The old soil, with its felt carpet and borehole wells dug into the depths of the earth, ridiculously ran counter to all conceptions of what the place of man's existence on earth might be.

"We raised the ground water to the surface. We put a stop to the wasteful flowing away of three fourths of the rainfall. We compelled the snow to melt slowly and evenly, so that the land could absorb the whole of the thaw water.

"Our land can be compared to a chain of discs in emerald frames. On these discs we have restored the ancient fertility of the steppe. We are able to create artificial virgin soil on any plot of land in a matter of two or three years. In laboratories this artificial virgin soil is compared with natural virgin soil preserved in reservations, and it is found that it consists of firm crumbs amounting to 81 per cent, and humus amounting to 9.8 per cent, whereas natural virgin soil consists of crumbs 83 per cent and humus 9.9 per cent.

"You know that present-day city builders have more to think about than the architects of the past. They have to consider not only the façades of buildings and the composition of streets and public squares, but also the bird's-eye view of a city. A new angle of view has been added—the air.

"We, too, have to pay attention to this angle of view.

"Birds and aircraft passengers see carpets down below, now a golden yellow, now crimson bespattered, olive-coloured fields, ornamented spaces of opalescent brilliance, dark velvet with silvery ribbons and blue patches of lakes. One day two venerable professors of esthetics who visited us ardently tried to prove to us that we had been prompted by the desire to create, simultaneously with the new soil, a new system of esthetics, a new sense of beauty. We made no attempt to disabuse the minds of our guests, for, after all, we do believe that a charming landscape is by no means a minor thing. For us, however, beauty is not an end in itself. We think that the more man frees the creative forces of the soil and compels them to work, the more beautiful will the land become. Beauty is the companion of creative life.

"On leaving his white cottage hidden in a beautiful garden, a man will walk with a singing heart past fragrant, pearly fields bordered by eternal woods, and the cry of the swan will gladden his heart. He will turn off the road and find himself in the depths of an orchard, among purple plums, and apple and pear trees weighted with fruit. Standing on the edge of a mirrorlike lake, he will not guess that he is standing on the edge of an old ravine that had formerly corroded the land.

"We must now speak about the emerald frame of the discs, about the eternal woods that border our fields.

"It had been calculated that the influence of these woods is felt in the field for a distance of 600 metres. This was taken into account when the diameter of the discs was determined. We made efforts to give the frame a light and airy form. It is not a dense forest standing like a wall; it is rather like a feathery cloud. The crowns of the straight trees rise twenty-five metres high. White acacias, poplars, oak and pointed-leaved maples grow side by side with aspens, wild olives, yellow acacias and spindle trees. Orioles whistle in the branches; umbrellalike mushrooms peep out of the greensward. It is like a natural wood, only more picturesque. It does not need much tending—only the pruning of the bad and the superfluous.

"There was some controversy about the most suitable width for these borders of the fields. Some were of the opinion that it was sufficient to plant avenues. Others would have been satisfied with ordinary fences and condescendingly agreed to their being painted a frog green. This controversy, very heated at one time, seems ridiculous to us now; it is obvious to us that not fences but tree belts are needed, and we plant them in such a way that they may retain their forest nature amidst the steppe, so that the steppe should not swallow them.

"After becoming the masters of the land we did not limit ourselves to changing the climate generally. We are creating the local climates and landscapes that we need. On our fields we have a northern and a southern crop rotation.

"I have spoken at length about the flora of our country, but have said little about its fauna. The latter is abundant and diverse. Livestock raisers and hunters are quite pleased with it. The land, our fields and our animals, need each other. According to our calculations, every twenty-five hectares of bare fallow needs a herd of a hundred cattle. On our livestock farms and prairie grasslands there are many hundreds of cat——"

Suddenly, my radio set began to splutter and the transmission was interrupted. I searched the ether, but in vain. I caught snatches of song and speeches in different languages, and of music from Chaikovsky's ballet *The Nutcracker*. I was ready to give up the quest in despair when, on turning the knob, I again heard the resonant voice on a quite unexpected wave:

". . . creation of new plants. The mistake that many plant breeders in the past made was that, while thinking about their crossings, they paid little attention to the place in which these crossings were made. They pictured organisms as existing in an abstract, conventional environment, which did not concern them, the plant breeders, in the least. It was incorporeal, like the ether of the old physicists. But plant breeding is not conducted in a vacuum. A real field of activity for our plant breeders was opened when we restored the fertility of the soil. We are now able to breed and grow cereals with grains of exceptional size, accumulate the tender stalk property of meadow grasses, and endow plants with frost hardiness. In the latter case, we take hybrids resulting from the intravarietal crossing of winter wheats and during the win——"

Again the transmission was interrupted in the middle of a word and I was unable to learn precisely what method was employed in the land of the future to develop and fix the property of winter hardiness in plants. And I was unable to catch again the wave on which the unknown lecturer was speaking.

What was it I heard? Where was that land?

In an ordinary room, in a Moscow flat, where on the wall, between a timetable of lectures at the Institute and a map of our country marked with circles indicating new construction jobs, a clock ticked in measured rhythm, and the humdrum noises of the street came in through the window, the utter improbability of my fancy—a transmission from the future—soon became obvious. Are not time machines the figment of the imaginations of those who wish to escape from the present?

Something more extraordinary than a time machine—the fantasy of an English imaginative writer—had really entered my room. The land of the future was at the same time the land of today.

This could be only in one country.

In what part of the country, of my country, did this land lie?

Perhaps it was a transmission from the Dokuchayev Institute of Agriculture of the Central Black-Earth Belt, from the famous Kamennaya Steppe? The layout of the fields there, bordered by emerald shelter belts, its grasslands, parks and blue lakes, fitted well with the description I had heard. The grim name Kamennaya (Stony) Steppe was a useful reminder of what had been in the past; and the contrast between that and what exists now is the measure of the work of human hands.

History sometimes records striking experiments.

In 1946, our country was again afflicted by a frightful drought. It began at the end of March in Moldavia, moved on to the Ukraine, spread to the central regions of the country and reached the Volga.

Again the Kamennaya Steppe proved to be the area in which the drought most cruelly parched the land, its very epicentre. For seventy days the soil did not receive a single drop of rain. This drought was more frightful than that of 1891.

But I read the following: "Nevertheless, although the crop in many of the surrounding kolkhozes had completely withered, our agricultural crops, on large areas between the shelter belts which had lain in fallow and had been subjected to the influence of perennial grasses, amounted to the following (centners per hectare): winter wheat 16.52; winter rye 14.97; spring wheat 10.62; oats 15.75; millet 16.43; peas 8.2; lentils 9.5; vetchling 10.6; kidney beans 8.8; sunflower seeds 21.2; perennial grasses (green mass) 88.2; Soudan grass for hay 117.0; fodder beets 188.0."*

This crop, harvested in a severe year, far exceeded not only the crops harvested in the central Russian regions even in good years, but also that harvested in the fields of the Kamennaya Steppe itself fifteen years previously. And those fields, and the crop harvested in them, had also been out of the ordinary.

What had those fields lacked at that time?

The travopolye system was introduced in the Kamennaya Steppe in the period of 1934-38, under Williams' personal supervision. At that time, too, on the instructions of Lysenko, Michurin science became the basis of the entire work of plant breeding and seed growing.

The ideas of Dokuchayev, Kostychev, Williams, Michurin and Lysenko merged in a single stream, in a single science of how to become master of the land. The result is that the curve of the crop-yield chart swung upwards; it is continuing to rise, and for grain has now reached an average of 20-25 centners per hectare.

But perhaps what I had heard was the story of the kolkhoz fields served by the Deminsk Travopolye Machine and Tractor Station in the Novoannensk District, Stalingrad Region, with their nine- and ten-field crop rotation, shelter belts and, in all fourteen kolkhozes, a more than threefold increase in yield? Of the famous Hero MTS (many members

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* V. S. Dmitriyev, *Crop Rotation and the System of Agriculture*, Gosplanizdat, Moscow 1947, p. 51.

of the staff are Heroes of Socialist Labour), the birthplace of dispatcher control of agricultural labour, with radio communication between the dispatcher and all twenty-five tractor brigades?

Or perhaps it was about the Stalin Kolkhoz in the Kuban, where a thousand grains gathered in a zone a hundred metres from the shelter belt proved to be eight and a half grams heavier than any thousand grains gathered in the open field, and where 27 centners per hectare were harvested from these protected fields in a drought year?

Or the Comintern and Pyatiletka kolkhozes in the Mikhailovsky District, Zaporozhye Region, and the Voroshilov Kolkhoz in the Byelozersky District, Kherzon Region, where the "Dokuchayev-Williams complex" and the Michurin science of controlling living forms have merged in a single scientific system, which is transforming the land and is increasing man's power over it? Perhaps the voice reached me from the Salsk Steppes? From the famous Salsk Steppes with their reddish, parched, undulating dreary spaces, such as they were only yesterday? There, too, the rustle of tall trees is already heard, and under the protection of these 2,600 hectares of kolkhoz shelter belts, in the severe year of 1946, grain crops yielded 13, 14, 15 and even 18 centners per hectare, and the kolkhozniks gather the heavy, choice grains that ripen on the very edge of these "woods" for seed. . . .

Or did these tidings come from what only recently had been the desert near Astrakhan, where there had been no other shadow except that cast by the traveller, but where now trees are rustling, silvery water is flowing, and white villages stand among green-garlanded fields stretching into the distance? . . . But is it possible to enumerate all the parts, islands, and even extensive areas, of the land of the future? They are multiplying, spreading and merging under our very eyes. According to the grandiose Stalin plan, the greatest that man has ever undertaken in the matter of reorganizing our planet, in the course of sixteen years the face of the earth will be changed on gigantic areas equal to nearly three times the area of France, five times the area of England, and four times the area of Italy. Nature will be changed, the climate will be altered, and that most terrible and seemingly irresistible scourge—drought—will be destroyed, utterly abolished, so that mankind will forget what it was. Actually, by 1965, in the life of one generation, a huge new continent will have been created, with different natural features and natural laws, with an unprecedented landscape, with its own pattern of waters and land, forests and fields, inhabited by a new fauna and flora. The great, joyous continent of abundance. . . .

We may say, simply state the fact, that the promulgation on October 24, 1948, of the decision of the Party and the Government entitled: "A Plan for Planting Shelter Belts, Introducing Travopolye Crop Rotation and Digging Ponds and Reservoirs for the Purpose of Ensuring High and Stable Crop Yields in the Steppe and Wooded-Steppe Districts of the European Part of the U.S.S.R.," was one of the greatest events in human history. Nobody has anywhere, ever before, dared to undertake anything like this on even a fraction of this scale. Recall the books you have read by writers like Jules Verne and H. G. Wells, the flights of fancy of imaginative minds—all—even flights of fancy!—pale into insignificance compared with *this*!

This is not fancy, however, but actual reality—and we are all participants in it.

CREATIVE LIFE

LAND OF TWILIGHT

A farmer's work proceeds in Cycles, as the shuttling year returns on its own track.

The Bucolics and Georgics of Virgil

So it was—so it will be.

Ancient proverb

You can put any amount of work into the land, you can manure it, employ every method and means of cultivating it—after every new effort the land will yield a diminishing quantity of produce, a declining curve of productivity.

Thünen's notorious "law of diminishing returns"

Dust over the roads of America. Dust over the asphalted, goudron, patent-surface speedways of America, over the straight-as-an-arrow highways and old macadam roads.

The land spread out in festive raiment when Fenimore Cooper's "pathfinders" roamed over it; but it was treated pitilessly, by them and by their descendants. It will last for ages, they said. The raiment became faded and worn.

Here, the most ruthless and rapacious method of farming is ruining the soil. Already, more than half of the total cultivatable area of the United States has been ruined. Many of the actual deserts that exist there today were not there at the time when the author of *Life on the Mississippi,* Mark Twain, was young.

Salt marshes, like gigantic sores, have eaten into the "Wheat Belt". . . .

Here is what Stuart Chase, a well-known American economist, says: "The three billion tons of solid material washed out of the fields and pastures of America every year by water erosion contains forty million tons of phosphorus, potassium and nitrogen . . . the greater part of it super-soil, richer than that of the Nile. . . . One sixth of the country is gone, going or beginning to go. . . . Dust . . . strangles men and animals with dust pneumonia. . . . Dust is more terrible than flood. . . . The great dust storms of recent years are not a chance phenomenon, but the culmination of a long tragic process."

Appalling figures—three billion, forty million. . . . Rain is washing away and salting, wind is blowing away and scattering the prairie, where the immigrant Irish captain, Main Reed, once captured Indian wigwams, and where he rapturously told some dark-eyed señorita on a hacienda in Texas the thrilling story of his conquests.

Crop rotation? The farmer must work as hard as he can today to raise wheat and corn, for tomorrow there will be a crisis and they will not be needed. And the farm itself may not be needed. In that case, the farmer will pack his few belongings on a Ford, and off he will go along the dusty roads—it does not matter where, to the orange plantations in California or to an atomic bomb factory—in search of a place where a pair of good, strong hands are wanted.

What talk can there be of crop rotation, let alone the travopolye system, when the inevitable result of the domination of the agricultural monopolies is crop specialization carried to the utmost limit, to monoculture; the system under which one particular crop is planted on millions of acres, year after year, until the soil is ruined and the land is converted into a desert? The three-field system of the ancient Russian countryside was the acme of rational farming compared with this ruthless killing of the soil.

The country which has flooded the two hemispheres with its Jeeps, Dodges, Studebakers and Packards, has not so very many tractors in its fields. It does not pay the farmers to use them; and it happens that, somewhere in the West, an up-to-date combine harvester is hauled by a team of horses. But the heaviest tractor, and even a tank, damages the soil much less than do horses' hoofs; and a caterpillar tractor does only one fifth of the damage. It is "lighter" in its going than a man's feet. A team of horses crushes, tramples out and wipes out the soil.

Under this system of farming, even machines cause damage. A harvester combine, glistening in its coat of pink varnish, goes rattling over a field. What does it reap? It leaves stubble almost knee high. It leaves the straw standing, and it throws the part it has reaped, together with the threshed ears, back on to the field. Why construct machines that will reap near the root? It is simpler, easier and quicker to reap only the ears. The main thing is to get the crop in as quickly as possible; "time is money." Nobody needs the straw; and nobody cares about the morrow. But all the weeds have remained; their seeds have been scattered all over the field. What does it matter? Who can say whether this field will be mine tomorrow? Let the one who gets it worry about that!

There are no fields in the world more weed-befouled than those in the United States.

Nearly every year new designs of ploughs appear on the market. Superior to all others, the manufacturers assure the farmers. Beautiful finish. All previous makes spoilt your fields, this one improves them. And it is cheap. Buy no other!

But the soil continues to deteriorate. This is so glaringly evident that one of the commissions the United States government vainly appoints from time to time decided to examine at least the ploughs the farmers were using. This commission consisted of agronomists, engineers and even mathematicians. They were horrified: every newly-advertised plough revealed a blend of ignorance and downright deception. To attract buyers by novelties, the manufacturers eliminated from the old designs of ploughs necessary and useful features. Nobody will buy a worthless motorcar; but who can understand the true properties of a plough that is boosted by unscrupulous advertising? This commission, like the previous ones, just washed its hands of the whole affair. Its report shared the fate of all other reports of this kind—it was buried in the files. Tomorrow, the farmers will again read about a new plough that is superior to all others; and this superior plough—beware of imitations!—will ruin and pulverize the soil still more, will sow the fields with weeds in still greater abundance. Skim coulters? The money-making directors of the firms that make ploughs would undoubtedly say if they were asked about them:

"Our ordinary customers would not even understand what a plough with a skim-coulter attachment is. Nobody would buy it. There is no demand for it."

And it is true. Such a plough would simply not go through the high stubble left by the wasteful combine harvester. The skim coulter would get cluttered up and the plough would slip at the very first step.

. . . There are, of course, in the countries where the soil is aging, hard-working scientists, toiling diligently in the laboratories of Cambridge and Los Angeles, New York and Edinburgh. But what are they looking forward to? What great idea do they hope to present the world? Their efforts will meet with the same fate as that which befell the report of the agronomists, engineers and mathematicians who investigated the American ploughs.

In that world, a man and his ideas do not count for much. The geneticist Harland, who has already been mentioned in this book, is flesh and blood of this world. But one day, Harland dared to do something that was exclusively his private affair—so he had heard and read in his schooldays—he married a "coloured" woman. The "people of his world" apply the term "coloured" to the greater part of mankind, believing, for some reason, that their own skin is colourless, and taking great pride in it. Well, the universities were closed against Harland and he found himself in Lima, in Peru.

The plant breeder Carleton was called "the man who fed America." His wheats—incidentally, borrowed from Russia—performed a triumphal march through Kansas, Nebraska, Texas, Montana, Oklahoma—through the entire country, in fact. But his own career, as described by Paul de Kruif, was a sad one. Speculators made tens of millions of dollars by deals in wheat which would not have existed had it not been for Carleton; but he continued to receive only his modest salary as an official of the Department of Agriculture. Nobody mentioned the services he had rendered. Who says that it is possible to make money by feeding the millions? Business is done in an entirely different way!

Carleton's family grew. Hardship pursued him. One of his daughters fell very sick, and then another. His son was sick too and only a serious operation could save him. There is no country where need of medical treatment is such a misfortune as it is in America, a worse misfortune, perhaps, than the ailment that needs treatment. The right to health is a privilege only of the rich. Doctor's visits, or a place in a hospital, cost lots of money. Carleton fell into debt. His house was sold by auction. He borrowed 4,000 dollars from a grain dealer. The Republicans were in power then; the grain dealer was regarded as belonging to the opposition. An official of the Department of Agriculture receives money from an opponent of the government! Carleton was fired. He was reduced to beggary. He could not find work in his own country. He went to Panama and from there to Honduras. He passionately longed for his native plains, but he was not destined to see them again. He died in 1925. He was only a little over fifty.

"A friend in need is a friend indeed." The rule of the capitalist world, however, is: "When a man is down, kick him!"

What can science do in that world? For whom does the plant breeder raise his varieties? Fat years are followed by lean. Years of crisis, when locomotives are fueled with golden grain. Cabinet ministers sit up nights with wrinkled brows devising monstrous schemes for destroying crops; and the common people for whom the plant breeder is striving—the tillers of the soil, grain farmers and vegetable growers—will be fined for violating these schemes by growing too much food for the starving people.

As in ancient times: fat years, lean years. As in ancient times: man's impotence in face of the elements.

And the diligent scientists plod on, each in his narrow, special field, not daring to raise his eyes to look round. They are not sure of anything. They dare not think out the ideas of their own science to their logical conclusion. *Man's impotence in face of the elements*. All the wonderful instruments now available fail to drive away their timidity. They have forgotten what their grandfathers knew. Evolution? Birth and death? Transformation of nature? What is there to say about these?

Take books. There are lots of them. Books written by researchers who feel the ground shaking under their feet, by people who are bewildered and dismayed. The dense gloom of the grave seems to enfold the glazed pages of these books. Here are some more books. In them, reason, science, research, freedom are openly anathematized. Insane racialism is extracted from test tubes filled with Drosophila flies. The creation of a new variety of maize is regarded as the prototype of man-breeding. With the aid of the Petri dishes of the microbiologists, and of the electron microscopes of the virus specialists, preparations are being made to conduct frightful bacteriological warfare. And the possibility is being cynically discussed of turning to this vile purpose the discovery of the "substances of life" in botany, the growth substances—whether it is possible to sprinkle the fields of "enemy countries" with strong concentrations of these substances that will kill the crops. "This ought to be no less effective than the atomic bomb."

Books on theoretical biology, on the living world. You can hardly believe your eyes when you read: only individual species and forms within the limits of closely-related groups of forms could arise in the natural way; and these groups are islands, separated by "gulfs without bridges," and they could have come into being only by an act of creation, by divine action. Where and when was this written? Perhaps in that year 1735, and in that printery in Leyden, where Linnaeus' *System of Nature* was printed? No. It was printed at the Yale University, in New Haven, Connecticut, in 1940; and the author of these ideas is Richard Goldschmidt, one of the most prominent of the formal geneticists, who long ago wrote the well-known popular book on biology with the queer, unappetizing title *Ascarida* (ascarides are intestinal worms), formerly a German and now an American scientist.

Who would think that *The Origin of Species* came out eighty-one years ago?

Is Goldschmidt the only one who expounds such ideas? No. He only repeated, almost word for word, what the aged German classificator Kleinschmidt had revealed to the world, evidently as the secret of his life, ten years before. The Englishman Davis, however, claims priority in enunciating these ideas. True, he concedes that there has been some evolution, but this does not prevent a "creative force" from being the arbiter of the fate of the world; and this "creative force" had revealed its chief secrets to him. It had whispered into his ear that it had husbanded its strength, that it had not been its intention to create things out of nothing as was believed by its stupid, excessively naive worshippers, the out-and-out opponents of evolution. Why should it create things out of nothing when raw materials like eggs and embryos were available? It breathed on the egg of a dinosaur and out popped a bird, like a cuckoo out of a finch's nest!

Davis defended evolution in opposition to the ornithologist Douglas Dewar; to be logical, however, he should have recognized him as his authority, for it was Sir Douglas who had never observed natural transitions even between families. And the paleontologist Dyke swore on his honour that however deeply he had dug into the earth, himself wielding spade and geological hammer until he got corns on his hands, he had everywhere found remains of exactly the same types of animals and plants as existed on Earth today. The same types with no "bridges" between the different types; and they had no common roots. To doubt that would mean throwing doubt on the genuineness of Dyke's university degree.

It must be difficult indeed for young persons who have been brought up in an entirely different atmosphere, educated in Soviet schools and colleges, and even for anybody living in our country where human reason and science are held in such high esteem, to understand what *all this* means. How is *this* possible? they will ask themselves.

Does this mean "serving truth"? It is the mortal struggle that idealism is waging against materialism; the struggle that the "science" that serves to enslave people is waging against the science that serves to unite people, that serves to increase man's power over nature for the benefit of the people.

L. Dunn, the co-author of the textbook *Principles of Genetics* by Sinnot and Dunn, in an article he wrote explaining the ABC of Morganism, says that it cannot possibly be supposed that the germ cells obtain their properties from other cells of the organism; that the Mendelist theory of heredity and the theory that the direct influences of environment or training are inherited cannot be equally true. Then he goes on to speak about Soviet Michurin science and about Lysenko, and one can almost hear his voice quivering with anger as he says that Lysenko's aim is different not only from that of the geneticists, but of all scientists in general, since he is striving not so much to explain the processes of nature as to control them in the most direct way. . . .

Now the secret is out! He could not have been more frank. He dots all the i's and crosses all the t's.

What is the object of the biology that the Dunns preach?

This, too, is clear, only too clear. To prove the existence of some kind of a "scute" gene among the Drosophila flies and to vindicate the obscurantism of the Goldschmidts. This is the theoretical aspect. It also has a practical object: the geneticist laboratories have undertaken the task of preserving "eugenics," the "science" of improving the "human race," bequeathed by Galton. We hear hymns of praise to parson Malthus, who has long rotted in his grave. Birth must be restricted; restrict birth at all costs! . . . This is demanded by the test tubes filled with Drosophila flies, and by the shades of Weismann, Mendel and Morgan. Among whom must birth be restricted?

"We have in mind Negroes," answer the priests of the "pure" science of biology. "But still more important are the peoples of India. . . . And of Indonesia. . . ." Think of the millions of rebels fighting for a People's Republic in Java! This is what is filling the hearts of the geneticists with dismay!

Dismay and craven fear. And what about Malay, Viet-Nam, and that giant China? Vain are the appeals to the spirit of Malthus. . . .

"But for the Slavonic countries, birth control is absolutely essential. . . ."

This is how they blurt out their innermost thoughts. "With all the authority of the science of genetics" they literally repeat all the ravings of the late Nazi führer. "Urgent measures must be taken!" they cry hysterically. Measures, what measures? Letting himself go, the English general Fawcett, Darlington's compatriot, threatens that if these "measures" are not taken, he will appeal to the ancient trinity—war, disease and famine.

. . . Academic impartiality, dispassionate, matter-of-fact essays, treatises, researches and papers—scores, hundreds and thousands of books, magazines and symposiums in nearly all languages, a veritable Egyptian pyramid of literature, the mere catalogue of which would take up whole volumes. Flies, snapdragon, mice, and flies again, flies, flies, flies, formulas of segregation, discussion of the crossing of longs with the shorts, yellows with greens, ruby eyes with ivory eyes, brother with sister, sister with father, and father with granddaughter. Most intricate drawings and charts of chromosomes containing thousands of genes. . . . Thus, on the land of expiring fertility, on the land of *that world,* sterile formal genetics, the successor of Weismann's "germ substance" and of Mendel's sweet-pea experiments, has grown into a monstrous phantom hovering threateningly over human reason and scientific conscience.

IN THE LAND OF LIFE

> There is no limit to the growth of crop yields.
>
> V. R. Williams, *Soil Science*

> To ensure a considerable increase in crop yield . . . to take measures to secure the most rapid introduction in production of the achievements of agricultural science, to regard this work as a most important condition for raising agriculture to a higher level.
>
> Decision of the Plenum of the Central Committee of the C.P.S.U.(B.), February 1947

A man casts a master's eye over the map of the world from the Carpathians to the Kuril Islands, from the icy regions of the North Pole to the sun-scorched plains of Afghanistan.

We deem it quite simple and natural that we are living on land of *increasing fertility*. On what other land should man live, build and think of the morrow?

Nevertheless, this is, perhaps, the first time in history that millions have been imbued with this confidence. The difference between the new world outlook this has created and all previous ones is far sharper than the difference between man's world outlook in antiquity and in the Middle Ages, between the world outlook of the Chinese in the Confucian epoch and that of the foppish graduates of English colleges, between that of the hunters and agriculturists in the Land of the Incas and that of the modern Yankees.

What previous human society possessed firm knowledge that the coming day will be still more generous than the passing day, that the land can, and must, be improved without limit?

Only children, perhaps, in previous societies, had been endowed with some conception of *such* a world; but grown-ups would listen to them and say with a sad and condescending smile: "The golden dreams of youth. You will know better when you grow older." It was as if life harboured a gloomy and shameful secret which had to be kept hidden as long as possible.

For a time it was kept from the child. It merrily ran to the doorpost which bore the mark the loving hand of its mother had made the year before. "How you have grown!" Life is growth, the world is growth; the mark that is made today—how far it will have been left behind next year!

But "real life" came soon, too soon for millions of children. It was a life of "descending curves." It grew downwards. Filled with fear and anxiety, people looked longingly back to the past. When men invented myths they, everywhere, invented the story of a Golden Age that was said to have existed in the distant past and had gone, never to return. The saying: "The good old times" has been current for a thousand years. Good times *may* return, but God knows when. After we have gone, "in a hundred thousand years' time," as one of Chekhov's heroes used to muse. In the "age of steam and electricity" science began to clothe the "descending curve" philosophy in figures and formulas. At the end of the last century, for example, certain physicists gravely prophesied the universe's "death from cold." This was elevated to a principle in connection with the second principle of thermodynamics, the theory of increasing entropy—the depreciation and dissipation of energy. Timiryazev was one of the first who, from the very outset, denounced the absurdity of such prophesies. "The sun will be extinguished" was the scare raised in popular books on astronomy. The newspapers, out for sensation, published statements like: "In a hundred years' time all oil resources will be exhausted." "In five hundred years' time there will be no coal." The "limits theory" was invented—an infinite number of all sorts of "absolute limits" for all spheres of human activity. "Diminishing returns" was proclaimed a "law". . . .

This web of lies that shaded man's eyes and made the world look gloomy has now been swept aside.

We are the citizens of a growing world.

The work of changing the Earth that is going on in our country has already reached geological, *cosmic* (to use the terms of Timiryazev and Vernadsky) dimensions. The astronomers on Mars or Venus (if there are astronomers there) cannot help seeing it.

If there were astronomers on those planets they would see a change in the shade of certain parts of the Earth's disc. In the bare steppes, trees are being planted; more than half a million hectares of shelter belts will be a component part of the steppe landscape of the future.

In conformity with the great plan that is being carried out in our country, between 1949 and 1965, 5,709,000 hectares of new shelter belts will be planted. This means that in the course of fifteen or sixteen years, trees will be planted which, if grouped in one area, would make a forest a hundred kilometres wide and stretching from Moscow to Kursk.

The astronomers on our neighbour planet would see the yellow patches replaced by the green line of the new Vakhsh

Valley, new inland seas, bright velvet lines of new canals, and of rivers turned in their courses.

The gigantic Mingechaur Dam is being erected and life will flourish in the steppes of Azerbaijan. The Golodnaya (Hungry) Steppe will disappear. The first canal has already crossed the Salsk Steppe. There, a total of three million hectares of land will be irrigated. The trans-Volga region is awakening to life, and the transformed Volga-Aktubinsk flood plain, a land of fabulous abundance, will stretch from Stalingrad to the estuary of the great river. Already there is talk of the Fertile Valley, a new "Nile Valley" that will lie across the map of Europe.

The "emerald patches" of Arctic agriculture that now dot the Arctic regions. At one time this was "nature's coffin." In the extreme south of our country there was another lifeless space—the yellow patch formed by the Kara-Kum and Kzyl-Kum deserts. Turkmenia was once called the "Desert Republic." Now we read of the great battle that is being waged against the sands. The Great Ferghana Canal has already been constructed. Not far from ancient Samarkand the Uzbek Sea is arising. The Great Kara-Kum Canal will carry the waters of the Amu-Darya River to the largest desert in the world.

Along the irrigation canals and gutters that have already been constructed in Turkmenia, tree belts are being planted on a total length of 3,000 kilometres.

There are fields of waving corn on the Pamirs, the "roof of the world," and, as in Hibini, the nature of plants there has changed in a strange and peculiar way; the stalks of oats and barley are as sweet as sugar.

While in the Southeast life is already awakening on what was the most lifeless land in the world, land that had died from thirst, another new granary is being created in the

West, on swamped land. This is in the Polesye, millions of hectares of wild country with patches of black mud and swarms of mosquitoes and gnats in the dense forests described by Turgenev and Kuprin. But this waterlogged land is saturated with nitrogen; and whatever else it may suffer from, it knows not drought. And when it comes to life it will grow stable and abundant crops. . . .

Simultaneously with the Polesye problem, another problem is being grappled with, namely, the proper distribution of woodland in Byelorussia. The upper reaches of many of the rivers of the Dnieper Basin run through Byelorussia, and if their sources are surrounded with the necessary woodland, drought will vanish from the Ukraine.

One undertaking in this work of reorganizing our country, if not the greatest, is certainly one of the most astonishing, namely, the removal of the curse from Colchis. Here, according to the Greek myth, came the Argonauts in quest of the Golden Fleece. It is not for metallic gold, however, that this region is famous, but for that blessed fertility about which it is said: "If you thrust a stick in the ground it will flower." Formerly, the place had been a foggy, fever-stricken, quaky marsh. Wretched hovels stood on the sparse dry patches, and frogs croaked in the streets of Poti. . . .

All this is changed now. In conformity with Stalin's instructions, thousands of hectares have been drained. The fabulous fertility of the region is now under human control. Eucalyptus trees line white, arrow-straight roads. Magic trees, which can almost be seen to grow. Their roots dry the soil—it is not for nothing that they are called "pump trees," and their smell, reminiscent of lemons, drives away mosquitoes, the carriers of malaria.

Soil is being resurrected. Our mighty fertilizer industry provides millions of tons of nitrate, phosphorus and potassium. The soil over immense areas is mixed with peat, lime and gypsum. Peat, too, is an organic humus; it contains a great deal of nitrogen. Lime is used chiefly on sour, podzol soil; it neutralizes excessive acidity of the soil and improves its structure. Gypsum is used on salt land; and in Kirghizia, for example, formerly barren soil, after being treated with gypsum, becomes suitable for an exacting crop like sugar beet.

It has been proved in our country that it is possible to vanquish that terrible scourge which many people in the past regarded—and many people abroad still regard—as unavoidable, namely, *erosion* of the earth's surface. Yes, it is possible to prevent the destruction of the soil, to prevent the formation of gullies and ravines, and the washing and blowing away of the top soil. We had to vanquish not only "natural" erosion. The trail of the fighting in our Great Patriotic War, where the foot of the invading enemy trod, was marked by devastated fields, by the twisted scrap of splendid agricultural machines; the earth was scarred and pitted with trenches, dugouts and bomb and shell craters, and the fertile topsoil was buried under the lifeless subsoil clay. "To bring the Stalingrad environs into a state fit for ploughing, over 700,000 cubic metres of earth have to be shifted! In the Moscow Region the war destroyed over 10,000 hectares of farmland." *

"War erosion," was a term unknown in the history of agronomics. This war erosion (to which the fields of the U.S.A. and Canada, for example, were not subjected), also had to be combated.

We know that the mechanization of agriculture is not

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* N. Mikhailov, *Across the Map of the U.S.S.R.*, Moscow 1950, p. 192.

only a powerful means of easing and accelerating man's work on the land, but also a means for creating cultivated soil. Already before the war our country was ahead of all others in degree of mechanization of agriculture; and the damage the war caused in this sphere was terrific. This too is something they have not to cope with across the Atlantic. It is not an easy matter to make good this damage; it calls for great exertion of effort and determination on the part of the people.

Our fields will receive more machines than they had before the war. Our country will not only remain ahead of all others in the mechanization of agriculture, but will run far further forward in this respect. In conformity with the historic decision of the February 1947 Plenum of the Central Committee of the C.P.S.U.(B.), in 1947 and 1948 our industry was to provide the rural districts with 100,000 tractors and the rate of output was to increase after that. During the whole five-year period our agriculture will be supplied with 325,000 tractors, and these will be more powerful and more perfect than those that operated in the fields before the war. In addition, they will receive self-propelled harvester combines. The Stalinets-6 is being put into the field. This new harvester combine had to be specially designed to harvest the tremendous crops our advanced kolkhozes are raising, for the old type of harvesters were found unsuitable for them. Incidentally, it may be said that none of the American harvester combines would be able to cope with even what we regard as an average kolkhoz crop.

Our country produces the largest crops in the world.

At the beginning of the war, the crop area in our country was nearly fifty per cent larger than before the revolution; and the main crop was not rye as it was in the old days, but wheat, which spread far out of the southern steppes, out of the chernozem belt, to the north, the wooded regions, to the east, beyond the Urals into Siberia, and to the south-east into Kazakhstan.

The rising curve on the crop field chart is an amazing, a visible index of the increasing fertility of the soil; and this did not take place in the course of ages, nor even of decades, but under our eyes, year after year.

In the period of the Second Five-Year Plan the average crop yield increased 21.3 per cent over that in the period of the First Five-Year Plan—winter wheat increased 26.7 per cent and spring wheat 31.1 per cent. If we compare the last three prewar years, which were by no means favourable (we remember the icy springs and the scorching summers), with not an ordinary prewar year, but with 1913, which was a record year for tsarist Russia, we will see a spurt from an average of 6.9 centners of wheat per hectare (1913) to 10.57 (1938-40). During the same quarter of a century the average yield in the United States dropped from 9.8 centners per hectare to 8.9. In Canada, the average yield per hectare is barely 68 per cent of previous wheat crop yields. We are speaking of the most precious crop—wheat, but we distinctly see the same two curves, like two diverging roads, in respect to other grains: the rising curve of increasing fertility in the U.S.S.R., and the declining curve in the two biggest granaries in the capitalist world—the United States and Canada.

It looks as though practice in those countries is in harmony with the theory that prophesied the exhaustion of the procreative power of the soil. . . .

Already in 1937, our country was ahead of all countries in the production of wheat, barley, oats, potatoes and of many other crops.

Before the war our fields produced 45 per cent of the world's wheat crop, although the wheat area in our country was only a little over one fourth of the world's total wheat area. This alone is indicative of the tremendous increase in the wheat yield per hectare compared with the world average wheat yield.

The grain crop per head of the population in our country amounted to 4.5 centners; in the United States, it was only 1.9 centners, in France 1.8 centners, in Germany 1.5 centners.

This is not merely being "ahead of all countries"; it shows overwhelming superiority; it is a striking qualitative difference. It already gives us an idea of how we in our country will proceed towards the realization of mankind's age-long dream—Communism, the motto of which will be ". . . to each according to his needs. . . ."

Repeated attempts have been made to calculate the highest yield the land is capable of producing. Wilcox, an American, calculated that the limit of wheat is 110.5 centners per hectare. A yield of 92 centners per hectare, once obtained in Italy, was regarded as the "world record." This was mentioned in the textbooks, and was remembered for a long time. Both the "record" and the "limit" shared the fate of the "limits theory." Kolkhoznik Matsenko of the Yampolsky District, Vinnitsa Region, obtained on the experimental field of the village laboratory a wheat crop of nearly 112 centners per hectare.

As has been already mentioned in this book, in 1943, Chaganak Bersiyev, a kolkhoznik in Aktyubinsk, a monument to whom now stands in his village, obtained a millet crop yield of over 200 centners per hectare. This was the largest grain-crop yield ever obtained by man.

It is reported that a new theoretical limit for wheat has been worked out, namely, 150 centners per hectare. We will not attach too much credence to this. Remember what

Williams said: "There is no limit to the growth of crop yields."

The truth of this statement is proved by the achievements of agriculture in our country. It is no accident that the record for crop yields not only for some, but for *all* the principal crops, is held by our country—the U.S.S.R.

The Sugar-Beet Research Institute in Belgium regarded as an unbeaten record a yield of 810 centners of sugar beets per hectare that was obtained somewhere in Western Europe in 1888 (how ancient!); and a smaller yield of 760 centners per hectare was registered in 1933. Soon after this was officially registered in Brussels, at the other end of Europe, in our country, Maria Demchenko started the "five-hundred-centner movement." Five hundred centners of sugar beet per hectare was only the starting point for our Soviet sugar-beet growers. Already in 1936, several score of kolkhoz teams in the Ukraine reported that they had obtained yields of over 1,000 centners per hectare. Later, team leader Otorbayeva, in Kirghizia, obtained a crop of 1,320 centners per hectare. This was exceeded by Semyon Utepbergenov, of the Lenin Kolkhoz in Kazakhstan; he reported a yield of 1,410 centners per hectare!

In the Orient, rice has been grown for thousands of years. It is the "staple" crop there. In our country, rice is a young and by no means a "leading" crop. In spite of the thousands of years that this crop has been cultivated, neither in China, Japan nor India, nor in Italy and Spain, where rice is also grown, has the rice yield ever exceeded 30-40 centners per hectare. Fifty centners per hectare is a record. The highest known yield did not exceed 90 centners per hectare. In 1936-39, the kolkhozniks in the south of the Ukraine already obtained rice crops ranging from 50 to 75 centners per hectare, those in the Krasnodar Territory obtained as much as 107 centners, and in Kazakhstan 128 centners per hectare. In 1946, Ibrai Zhakhayev, a kolkhoznik in the Kzyl-Orda Region, a Stalin Prize winner, obtained 160 centners per hectare. Is this the limit? No! At the time you will be reading this book you will hear of new victories achieved by Soviet rice growers. In the opinion of our experts, rice is one of the most fertile of the grain crops.

Incidentally, it shares this virtue with maize. We know that maize is the principal crop not somewhere in the backward countries of the Orient, but in the United States. There, great efforts are being made to increase the yield of this crop. New varieties are being raised. Recently they have been planting hybrid seeds obtained from crossing different "lines" and higher yields have been obtained.

Nevertheless, the American fields have never witnessed such a spurt in maize yield as was achieved in the Ukraine in 1948. Abroad, a maize yield of 100 centners per hectare is unknown. In the Caucasus, before the war, yields of 130 and even of 165 centners per hectare were obtained. As the reader already knows, Mark Yevstafievich Ozerny, Hero of Socialist Labour, in the severe drought year of 1946, obtained in the Dniepropetrovsk Region a yield of 136 centners per hectare on four kolkhoz hectares. In 1948 he beat this achievement; he obtained an unprecedented yield of over 205 centners of maize per hectare.

In 1927, a farmer in the United States obtained, on two hectares, a cotton yield of 46.6 centners per hectare, nine times the average yield for the country. This farmer was awarded a prize and his achievement was boosted as a "miracle." Two or three years later, however, farmers in America were paid bonuses to destroy the cotton crop. In our country, in Uzbekistan, before the war, 50 centners and over per hectare were gathered from thousands of hectares, and on hundreds of hectares 100 centners per hectare were obtained. In 1938, the whole world learned of the victory achieved by team leader Aliyeva, in Azerbaijan, who obtained 151 centners of cotton per hectare.

A yield of a ton of long-staple flax per hectare seemed incredible; but we already know of four tons per hectare obtained by Y. Saukh, in the Yemilchinsk District, Zhitomir Region.

One must ponder over what all this means. It is not "just another record," not merely "an increase in yield"; a revolution in agriculture has taken place under our very eyes!

This could not have taken place without a revolution in the science of agriculture.

Our scientists are creating a Soviet science of agriculture, the most potent and advanced in the world. Its special, unexampled potency, however, lies in the fact that it is being built up not only by professional scientists, great as the part they play in it may be, but also by the masses of the advanced kolkhozniks, working in cooperation with our scientists. In his book *Plant Breeding*, which was awarded a Stalin Prize, Academician I. V. Yakushkin writes: "We already have grounds for speaking of a Stakhanov system of agrotechnique, of the creative efforts of the masses of the people in the sphere of agriculture."

The advanced agriculturists, the Heroes of Socialist Labour, have succeeded in getting wheat to grow on their fields as densely as only flax used formerly to grow, namely, 2,000-2,400 stalks to the square metre. And flax on their fields now grows 3,000 stalks to the square metre. Picture to yourselves this bristling wall which, it would seem, even a field mouse could not penetrate!

The Stakhanovites have devised numerous methods of providing the crops with "extra nutriment" while they are growing. When, in a dry year, the sugar-beet fields were gasping with thirst and water was scarce, the beet growers resorted to the subsoil irrigation of the roots, so that not a single drop of moisture should be wasted.

The Stakhanovites know how, when and with what implements to loosen the soil so as to "feed" the soil and the growing tissues with air; how to distribute the plants in the fields so as to enable them to get the utmost benefit of light. Seeds are now being "fed" with light at the end of the vernalizing period; this has increased the yield of spring wheat by one tenth.

A new method of cultivation is being introduced for many kinds of crops—the planting of seedlings, and this has caused a further spurt in yield.

Can heat in the fields be regulated? It appears that man is capable of doing this to some degree. It is possible, by cultivation, to change the heat regime of the soil; the soil can be warmed with a layer of straw, peat or dung. This is not simply a blanket; the manure undergoes slow decomposition and generates heat. In this process carbon dioxide is formed, which, as we know, is the "raw material" for that wonderful process of photosynthesis that takes place in green plants. The result is that the fields are manured with an unprecedented gaseous fertilizer! Academician I. V. Yakushkin is convinced that during the next few years highly expert socialist crop growers will display exceptional interest in the "feeding of plants with carbon dioxide." And this veteran plant breeder adds: "It is the duty of the science of agriculture to undertake the speediest solution of this problem."

What is exceptionally important in all this work of the Stakhanovites of agriculture, the builders of the new, people's science of soil fertility, is that *the yields on their fields are increasing faster than the increase of expenditure of labour.*

This completely and most strikingly refutes the notorious theory of "diminishing returns," which, as the reader knows, tried to elevate to a "law" that, in agriculture, every additional expenditure of labour produces a smaller return until, at last, the weary husbandman becomes convinced that the sole reward for his labour is just one additional grain. The experience of our advanced kolkhozniks proves the very opposite.

Another exceptionally important thing has taken place in agriculture in our country: the record yields obtained are not the achievements of individuals; there is a steady increase in the total yield throughout the country; higher levels are reached year after year over the whole of the vast area of our kolkhoz fields.

The term "guaranteed harvests" has come into use. It was coined in the decision of the February 1947 Plenum of the Central Committee of the Bolshevik Party and in the orders of the Government. Fields with guaranteed harvests! This is something unheard of before. For thousands of years the husbandman believed that his crops would flourish "if God so willed," or "if the weather is favourable," or "if there is rain,"—which, after all, are the same thing.

The whole of our science of agriculture, all the efforts of our advanced agriculturists, nay more, our kolkhoz system, are striving to achieve guaranteed harvests.

For the purpose of creating areas with such guaranteed harvests a great and also unprecedented work has been undertaken, namely, to introduce irrigated agriculture in the ancient granary, the agricultural heart of our country: in the central black-earth regions, in the Ukraine, in the Volga region, in North Caucasus, in the Crimea, in Western Siberia and in those parts of Kazakhstan where hitherto grain has been grown without irrigation. By the end of the postwar five-year plan period the irrigated areas in all these regions will amount to many hundreds of thousands of hectares. How everything will change on these ancient fields—the growth of grain, and the very nature of agricultural labour! Even the landscape with which we are familiar since childhood will become different.

When you pick up this book the first guaranteed harvests will have ripened and been reaped. It goes without saying that they will not be equal everywhere. Here too, the Stakhanovites of agriculture will lead the way for all the kolkhozniks. It was not for nothing that the term "advanced" came into being and has become current among us. Things have reached the stage now when it is not the record as such that is important, as is the case in the statistics of the Brussels research institute and of other institutes abroad; a record is important when it serves as a lesson for all kolkhozniks. We expect the kolkhoz that achieves a record to act as the leader of all the other kolkhozes. The "record" district must show other districts how it achieved its record.

This is what the Shpolians did in the Kiev Region: In the spring of 1948, the highly-skilled crop growers in the Kamenets-Podolsk Region met together, and as a mark of appreciation of the decision of the Presidium of the Supreme Soviet of the U.S.S.R. to confer the title of Hero of Socialist Labour upon the advanced agriculturists of the Ukraine, they resolved that each of them should communicate to his neighbouring kolkhoz the methods he employed. Accordingly, the Lenin Kolkhoz, for example, drew up precise and concrete measures, a manual on progressive agriculture in fact, for the benefit of the neighbouring kolkhoz, showing how to obtain average yields of grain crops of not less than 22 centners and sugar beets of not less than 400 centners per hectare.

The famous Altai team leader, Mikhail Yefremov, is now specially engaged in communicating his great skill to the younger generation of kolkhozniks.

Is not this a wonderful thing? Ponder over what it means.

The American farmer who received a prize in those days when they still gave prizes for big crops in America, was no doubt a very good fellow, diligent, intelligent, and knew his job. But when several newspapers boosted him and described his achievement as a "miracle" (only to forget about him next day), we can picture to ourselves how he posed in front of the newspaper cameramen, crossing his legs and exposing all his teeth in a dazzling smile, as much as to say: "Alone I did it—gaze at me!"

The portraits of our heroes are also published in the newspapers. They become celebrities, truly known to all the people, and are treated with honour and respect. But what a difference! Every one of them is conscious of the fact that he is a leader only in so far as he gets others to follow him. He is proud of having brought others up to his own level, and is eager to go further forward and lead the others again.

Not only does every Hero of Socialist Labour know this about himself, he also knows that this is exactly what the people expect of him.

When the results of our socialist emulation are summed up the judges take into account not only what each outstanding individual has achieved himself, but also to what extent he has taught his methods to others, to what extent he has led others.

This marks the birth of a new human consciousness. This is a victory much harder to achieve than victory over the land, over nature; it is victory over what had seemed to be the eternal "alone I did it—gaze at me" state of mind.

A HISTORIC SESSION

The events that took place in the conference hall at the Ministry of Agriculture of the U.S.S.R. during that week from July 31 to August 7, 1948, will remain an eternal landmark in the history of science.

There, the session was held of the Lenin Academy of Agricultural Sciences of the U.S.S.R., an ordinary session, as the newspapers reported at the time of its opening. But it was by no means an ordinary session; it was one of historic importance.

The membership of the Academy had greatly changed. It had been augmented by numerous researchers who are working on new lines, creating knowledge that is transforming nature, agrobiologists, plant breeders and soil scientists, famous for their discoveries, for their books, and for the new varieties of plants and breeds of animals they had raised. They were Michurin scientists.

Hundreds of guests were present at the session: scientists engaged in allied branches of science, biologists of all specialities, scientific research workers from the Academy of Sciences, universities and institutes, philosophers, writers, agriculturists and agronomists from distant parts of the country.

The vast hall was so crowded that people stood close-packed even in the aisles, but when the chairman opened the proceedings and T. D. Lysenko, the President of the Academy, rose to deliver his address, solemn silence reigned.

His address, entitled "The Situation in Biological Science," had been approved by the Central Committee of the Party, and is now known all over the country.

Lysenko spoke about the ideological struggle that had been raging in the arena of biology throughout its history, and he summed up the results of this struggle.

He made a detailed and circumstantial analysis of Mendelism-Morganism, traced it to its sources, showed its inseverable connection with the Weismannist idea that the "heredity substance" is unknowable; he exposed the seemingly profound "mathematical" scholastics of the chromosome theory of heredity and the chaos and chance which the Morganists put in place of law in nature—he exposed the entire reactionary, idealistic and metaphysical essence of Mendelism-Morganism and revealed its utter practical sterility.

In the glaring light of this clear, precise and profound analysis formal genetics looked like a corpse. There were still some Morganist professors who delivered lectures and bred flies, but it became obvious to everybody that life had cast their theory aside and had passed on, having settled the question about it once and for all; that it was not a matter of entering into controversy with them, but of removing the corpse from the great path of development of genuine, free, creative science.

Lysenko spoke about this science, about Soviet, Michurin agrobiological science. This science takes the best of what was contained in former materialistic, evolutionary biology. The "Neo-Darwinists"-Weismannists had made a bogey of the whole of Lamarck's theory, but, said Lysenko in his address, "the well-known Lamarckian propositions, which recognize the active role of external conditions in the formation of the living body and the inheritance of acquired characters, unlike the metaphysics of Neo-Darwinism (or Weismannism), are by no means fallacious. On the contrary, they are quite true and scientific. . . ."

"We, the representatives of the Soviet Michurin trend, contend that inheritance of characters acquired by plants and animals in the process of their development is possible and necessary."

Michurin science proceeds from Darwinism, but Darwinism freed from its defects, purged of the errors of Darwin himself, of its Malthusian "appendages." Soviet, creative Darwinism is Darwinism raised to a new stage and enriched, transformed by the theories of Michurin and Williams. "The foundations of Soviet agrobiological science were laid by Michurin and Williams," said Lysenko. Our Michurin science marks a new stage in the entire science of biology, the highest point ever reached by man's knowledge of living nature.

Two worlds—two ideologies. Two fundamentally different aims of science.

In 1944, Erwin Schrödinger, the most well-known theorist on quantum mechanics, published a book in England entitled *What Is Life?* It caused quite a sensation and went through several editions. What did this veteran expert on atoms and electrons, who at a venerable age started out on a stormy voyage across the, to him, unexplored ocean of phenomena into the world of living beings, take as his compass? He chose formal genetics, the "gospel" according to Mendel and Morgan! The whole of this "sensational" book on the nature of life is nothing but a rehash of "Sinnot and Dunn," with coloured illustrations, already familiar to readers of the works of the Morganists, showing the chromosomes in the salivary glands of Drosophila flies, in the pollen of the school botany-lesson plant tradescantia. But Schrödinger concludes his book with an epilogue in which he philosophizes, draws conclusions and—"to the discomfiture of our Morganists"—observes Lysenko—reveals the real background of Morganist genetics. Talk about crossing overs and recessive allels, and about Doctor Darlington's work on chromosomes turns out to be ". . . the closest a biologist can get to proving God and immortality at one stroke"! . . .

This could not be put plainer. A gulf separates it from Soviet science.

The Michurin biologist is a creator who re-creates the world around man for the benefit of the people. He knows that *"a scientific handling of practical problems is the surest way to a deeper knowledge of the laws of development of living nature."* And this knowledge is not contemplative, but active. It gives man a power over nature such as only recently people dared not even dream of.

That is why "Soviet biologists hold," said Lysenko, "that the Michurin principles are the only scientific principles. . . . The future belongs to Michurin."

A burst of applause greeted this statement.

Michurin science! It came into being under the eyes of the present generation of the Soviet people. The theories of Timiryazev and Michurin on the development of organisms and on controlling them merged with the theories of Dokuchayev, Kostychev and Williams on soils, fertility and the travopolye system to form a single science. To these names must be added another, that of Lysenko. The merging of the two streams of our natural sciences was accomplished by his work, by his solution of the extremely important problems of socialist agriculture. He himself has not said this; it was said by the members of the Academy S. F. Demidov and P. P. Lobanov. And the Saratov scientist S. I. Isayev characterized the role played by the President of the Academy in the following expressive words:

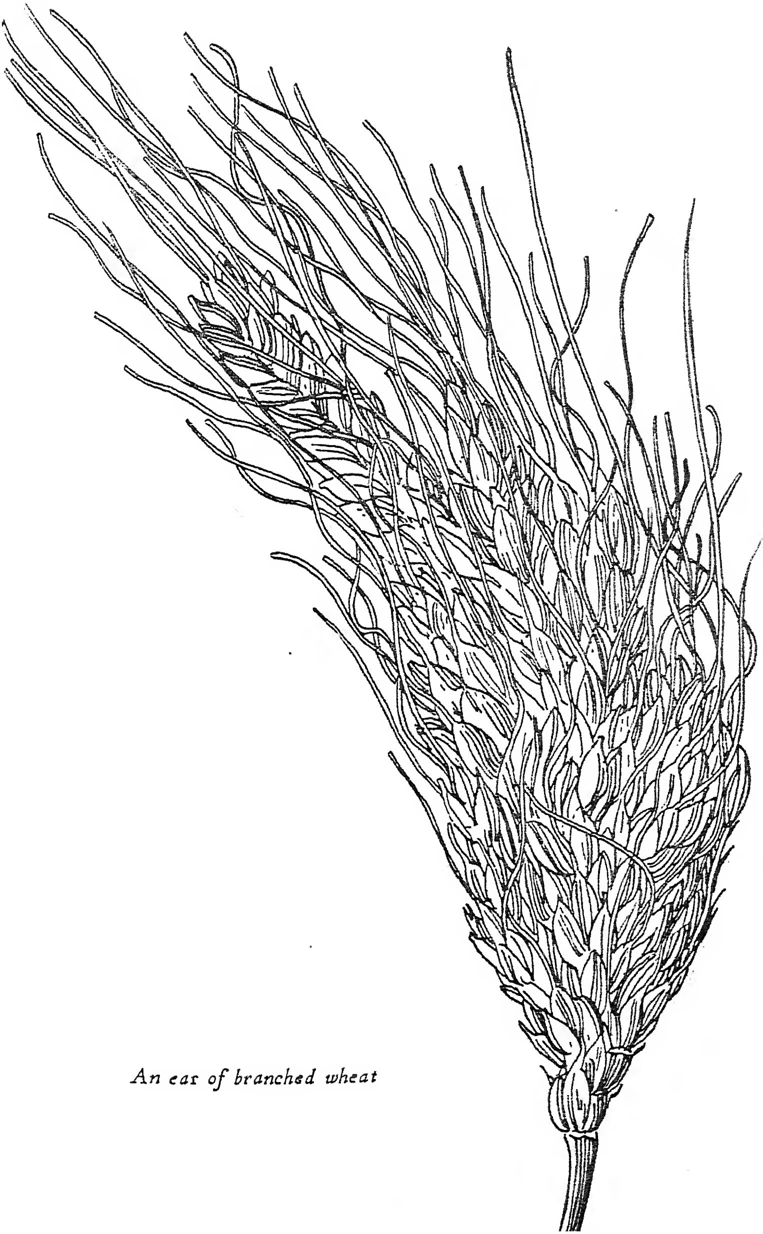
"When Michurin passed away, Lysenko caught up the Michurin banner in biological science."

The session opened on Saturday. On Sunday the delegates visited Gorki Leninskiye, near Moscow, where the Academy's experimental base is situated. There they saw standing wheat unknown to agriculturists, wheat with clusters of branched ears on each stalk. Each ear contained five grams of grains; a small package of them is enough to produce a harvest six bags full; this means 100, or perhaps, 150 centners per hectare. Nearby flows the river Pakhra, and next to it stands the white house in which Lenin died.

In compliance with Stalin's instructions, T. D. Lysenko is working on this wheat in conjunction with Academicians A. A. Avakian and D. A. Dolgushin. The time is not far distant, however, when this wheat will be growing not merely on experimental fields, but on kolkhoz fields; and then there will not be a region in the industrial heart of our country, in the latitude of Moscow, that will not be able to grow all the wheat it requires; and a fivefold increase in the fertility of the fields will mark one of the greatest revolutions in the history of agriculture.

The session was resumed on Monday. At one of the sittings, G. P. Vysokos, the director of the Siberian Scientific Research Institute of Grain Husbandry, spoke of a whole series of spring wheats which had been transformed into winter wheats; and he also stated that when planted in stubble, the not very winter-hardy Ukrainka and Novokrymka wheats withstood the Siberian frost, and that spring crops, when planted in stubble, were never afflicted by that cruel disease loose smut. He demonstrated sheaves of Siberian wheat with yields ranging from 16 to 32 centners per hectare!

V. S. Dmitriyev, Chief of the Agricultural Planning Administration of the State Planning Commission of the U.S.S.R., informed the session that the seemingly insurmountable difficulties connected with the cultivation of alfalfa in the southern regions are overcome by Lysenko's system of summer planting in clean fallow, and that the great task of afforestating the steppes will be greatly accelerated by the adoption of Lysenko's system of tree growing, namely, cluster planting.



An ear of branched wheat

The clusters of seedlings will beat off the young forest's most dangerous enemy—grass. The most difficult and costly part of the work of afforestation—tending the young shoots—will become almost unnecessary; and in three or five years the woods will already be serving their purpose. Shelter belts, grass sowing. . . . Lysenko's proposals are helping to "pull up" these very important links in the travopolye system. In Lysenko's opinion, the merging of the theories of Dokuchayev and Williams with those of Michurin is not a mental, theoretical deduction, but a practical one; for theory without practice is useless, and with practice the potency of one theory reveals all the potency of the other.

Yes, the Michurinists had certainly very important things to show at the session.

At one time there was only one Michurin orchard, in Michurinsk. Today there are tens of thousands of Michurin orchards throughout our country. They are flourishing in the Urals, they have stretched across the "Stone Belt." There was not a single fruit tree in the Minusinsk District; today there are orchards in every kolkhoz in that district, covering a total area of 1,700 hectares. Orchards in Novosibirsk, in Biisk, in Gorno-Altaisk; Michurin apple and cherry trees are growing in the mining villages in the Kuznetsk Basin. Grapes are growing near Moscow. Incredible things are happening in the kolkhoz fields in the Ukraine: not a mere increase, but an upward leap in the maize yield of 20-25 centners per hectare, in one year alone, 1948! And kok-saghyz, and millet. . . .

And the cherries near Leningrad, more delicious than those grown in the South! The ultra-early variety of potatoes now grown in Hibini, which ripens with such rapidity that it has proved to be a boon for the South, where *two crops* of it are gathered in one year! The Gribov melons grown near Moscow, the fruit of which begins to form after the very first leaf. The Michurin Station in Sochi has raised a citrus which flowers in the first year. Academician P. P. Lukyanenko remarked at the session that "it would be of great practical advantage to have winter varieties of rice," and he spoke of this as an early possibility.

All this was only what the Michurinists had already achieved and were working on at that time.

"In actual life itself, in the practice of millions, the Michurin trend in biology has been weighed and tested and confirmed, and has earned the esteem of the masses," passionately declared A. V. Mikhalevich, one of the speakers at the session, in a speech that was listened to with rapt attention.

The spirit of Michurin was reflected in everything that was said at the session about the victories achieved by Soviet advanced science. The words he had uttered in his lifetime rang out in the hall with tremendous force:

"I see that the system of collective farming, by means of which the Communist Party is inaugurating the great work of renovating the land, will lead labouring humanity to real dominance over the forces of nature.

"The great future of our entire natural science is in the collective farms and state farms."

And also this other statement of the great renovator of the land:

"Partisanship in philosophy is the chief orientating factor. . . . Only on the basis of the teachings of Marx, Engels, Lenin and Stalin can science be fully reconstructed. . . . Man is part of nature, but he must not merely outwardly contemplate this nature. . . . The philosophy of dialectical materialism is an instrument for changing this objective world; it teaches how to influence this nature and to change it; but the proletariat alone is capable of consistently and actively influencing and changing nature—this is what the teachings of Marx, Engels, Lenin and Stalin—those unexcelled titanic minds—tell us."

Every Michurinist applies these splendid words directly to himself and to his work, to the struggle he is waging against the advocates of pseudoscientific formal genetics, the offspring of slavish subservience to Western ideological biology, of cosmopolitan worshipping of the idol "world science."

What did the others, the Morganists, have to show at the session?

It had long been evident that their views were alien to the spirit of Soviet science, but nobody had "persecuted" them, nobody had "turned them away from the threshold." On the contrary. For many years they had dominated scientific circles and, thanks to their numerical superiority, had dictated their views to the rest. Well, what did they have to show? What did they bring in proof of the power and usefulness of their knowledge?

By a tremendous exertion of all its strength the country had borne the hardships of the war, had achieved a tremendous victory over the most frightful enemy it had met in the course of its history, and was then engaged in the tremendous task of rehabilitation, was marching towards new victories, marching towards Communism—but the chief theoretician among our Morganists, N. P. Dubinin, Corresponding Member of the Academy of Sciences, was taken up with research into the influence exercised by the German invasion . . . upon the structure of the chromosome in the Drosophila fly! The hardships suffered by the poor Drosophila moved him very deeply. "The Drosophila population found itself under such severe conditions of existence. . . ."

Academician I. I. Schmalhausen, in an extensive monograph "on the factors of evolutions" (in which he had not found it necessary to mention Michurin, the man who put evolution into practice), had arrived at the conclusion, strictly in conformity with the genetics of Johannsen and Morgan, that "the formation of breeds of domesticated animals and of varieties of cultivated plants" is proceeding in a descending curve. According to Schmalhausen, the first plant breeders, at the "dawn of time," had only utilized, discovered the chaotic "reserves of mutations" which had accumulated long, long ago, when the present "breeds" and "varieties" were still in a wild state. These "reserves" are now exhausted, he claimed. Evolution is now moving more and more slowly and with greater and greater difficulty. In short, "to be able to produce a new variety, you must already possess one," as Jordan once stated.

Referring to this "theory" advanced by Academician Schmalhausen, Lysenko said:

"It is an insult to progressive science to assert—in face of these facts and subsequent achievements of followers of Michurin's teaching—that strictly directed selection must progressively decline."

And Mikhalevich, in his speech at the session, advised Academician Schmalhausen to visit the Kiev Region for the elucidation of scientific truth, and to ask the people there, the kolkhozniks, whether the "reserves of variability" are diminishing or, on the contrary, increasing, and whether there is any sense in talking about "subsiding variety formation."

He mentioned the kolkhoz brigade leader Batyushinsky, the famous millet grower Okhrim Zemlyany, Heroes of Socialist Labour Yelena Hobta and Polovkov and said:

"They have definite opinions on many questions which you, formal geneticists, regard as subjects of academic controversy!"

If we could assume that in their lamentations over "descending curves" the Morganist theoreticians had in mind not the Michurinist, but the Morganist practical workers, they would, indeed, be absolutely right.

They had nothing to show at the session. They tried to prove their case by referring to varieties produced by plant breeders, for example, varieties produced by A. P. Shekhurdin, who raised that splendid wheat Lutescens 062, and it made one blush to hear this, for it was perfectly obvious that the method of breeding these varieties—the old, old method of selection—has no relation whatever to Mendelism-Morganism.

Yes, the ranks of the Morganists had greatly thinned. And what had become of their former boastfulness? They no longer pranced proudly with open visors. They vowed that they too were Michurinists, naively pretending that their hearers had forgotten that only a few years before they had superciliously spurned Michurin. Academician Schmalhausen assured the assembly that he had not rightly expressed himself in his books. J. A Rapoport claimed that formal genetics were on the threshold of great discoveries. His hearers remembered that, with envious constancy, genetics had been in that expectant state for no less than a quarter of a century.

Professor A. R. Zhebrak, who several years ago wrote an article for an American magazine in which he cast aspersion upon Soviet advanced science and upon Lysenko, for which reprehensible action he was strongly censured by public opinion in our country, showed the audience some shrivelled bunches of wheat reaped two years previously and invited it to guess what kind of wheat it was. He admitted that the wheat he demonstrated was of little use, but he promised some time in the future to breed a wheat that nobody had ever seen before.

Summing up all the speeches of this type, the newspaper *Pravda* quite rightly described the Morganists as barren fig trees.

The Morganists had felt very comfortable under the protection of Academician V. S. Nemchinov, then director of the Timiryazev Agricultural Academy whose speciality was statistics. The session called upon V. S. Nemchinov to say what he now thought of the Morganists' work, of their theories. He answered:

"I do consider that the chromosome theory of heredity has become part of the gold fund of human knowledge, and I continue to hold that view."

Amidst the laughter of the entire assembly, Lysenko, in winding up the debate, made the following comment on this "view."

"Unable to reveal the laws of living nature, the Morganists have to resort to the theory of probability, and, since they fail to grasp the concrete content of biological processes, they reduce biological science to mere statistics. . . . Probably that is also the reason why Academician Nemchinov has told us here that, as a statistician, he found that he could easily understand the chromosome theory of heredity."

At the session "the wolves appeared in sheep's clothing," but they were not as innocent as they tried to appear. As Professor N. I. Noujdin rightly remarked:

"Actually, there is no scientific discussion, the discussion ended long ago. Still less is there constructive controversy that promotes science." There is an open struggle by coteries of formal geneticists against the progressive Michurin theory, and this struggle is assuming the most unseemly forms. This must be stopped quickly, because it is hindering our work, is hindering us in training cadres, retarding the development of genetics and selection, and consequently, is causing immense harm to theory and practice.

Scores of examples were quoted at the session of the enormous harm and damage, inestimable in money, that was being caused by this vicious struggle. People spoke of it with pain and anger.

For instance, P. F. Plesetsky, the director of the Ukrainian Institute of Fruit Growing, spoke of two periods in the work of his institute. The first was the Morganist period, when the entire institute did nothing.

Stockbreeders speak with pride of the late M. F. Ivanov—he died in 1935—a splendid Soviet scientist who raised new types of animals, including the valuable breed of Askania fine-fleece sheep. He employed genuine Michurin methods.

At the session E. M. Chekmenev, Deputy Minister of Sovkhozes of the U.S.S.R., spoke of the efforts the Morganists-Mendelists had made to hush up the work Ivanov was doing. "When it became no longer possible to hush up its significance, they tried to discredit it. They attributed it to 'blind chance,' or to his 'exceptional intuition'. . . ." They succeeded in getting their way then, and the valuable flock of Askania sheep was registered not as an independent homebred breed, but as a type of the foreign-bred Rambouillet breed.

They claimed that Ivanov had simply imported merino sheep from America and obtained his "Askania-Rambouillet" from them. In this way they tried to conceal from Soviet stockbreeders the creative methods employed by that genius M. F. Ivanov.

While hushing up Ivanov's methods, the Morganists practised their own, but what were the results? For fifteen years, the Morganist J. L. Glembotsky, working at the Kotovsky Sovkhoz, in the Stalingrad Region, strove to "improve" the flock according to methods proposed by the well-known Morganist theoretician, Professor Serebrovsky. Comrade E. M. Chekmenev quoted the following figures: in 1933, the average weight of ewes was 49 kilograms; in 1947 it was 48.7 kilograms. In 1934 the average weight of fleece was 3.1 kilograms; in 1947 it was 3.2 kilograms.

The Michurinist K. D. Filyansky, working at the Bolshevik Sovkhoz, in a much shorter period obtained fleeces of 6 kilograms. S. I. Shteiman, working on Michurin lines on his famous "Karavayevo herd" bred an entirely new type of cow; and he brought about this radical transformation under the eyes of a single human generation. Poslushnitsa II, one of the cows in this herd, yields 16,000 litres of milk a year. The udders of the Karavayevo cows weigh on the average 15 to 18 kilograms, and those of the best weigh from 22 to 25 kilograms! They are from 1.5 to 1.85 metres in circumference.

The weight of an ordinary cow's udder is 1 to 1.5 kilograms.

All the organs of the Karavayevo cows—heart, liver, lungs, spleen—are different from those of other cows. Respiration is faster, blood pressure higher, and even body temperature, which seemed unchangeable in mammals, has been raised a whole degree. These facts were quoted by V. A. Shaumyan, director of the State Kostroma Cattle-Breeding Station, which raised the famous Kostroma breed of cattle.

All these years, the Morganists failed to raise a single new breed of cattle.

Is not this comparison between the results of the work of Michurin science and of the Morganists' "science" astounding?

Academician M. A. Olshansky related at the session that ten years ago, a certain scientific commission sat to discuss the subject of "Control of the Segregation of Hybrids." Just as the discussion opened, a prominent Morganist demonstratively got up and walked out.

The Michurinists are now controlling the segregation of hybrids. "In pure lines, selection is impotent," but the training of specimens of these "pure lines" under different conditions makes them hereditarily different, and the Michurinists have produced quite a number of new, excellent and diverse varieties out of the former pure lines. Michurin fruit growers have shown that by controlling the concentration of cellular sap, it is possible to control the formation of either of growth buds or of fruit buds on trees.

Take even the Drosophila fly—the chief defender of the citadel of Morganism—is it not also a living thing? Well, the Michurin geneticists have shown by experiments—as a sideline to Michurin science, it is true, but a very effective one—that here, too, the Morganists have not a leg to stand on. In its development, the Drosophila fly obeys all the real—not Weismannist—laws of life; its heredity can be altered by training, by the influence of environment, and it transmits acquired characters to its offspring.

Our well-known biochemists N. M. Sisakian and B. A. Rubin informed the session how the objective methods of biochemistry irrefutably indicate changes in the very chemistry of the organism when their conditions of existence have changed, thus furnishing additional proof of the flawless truth of the principles of Michurin science from a new aspect.

Academician I. F. Vasilenko also spoke at the session. He is a specialist in machine building. What had he to tell this assembly?

He said that the Soviet science of agricultural machine building was the most advanced in the world. This science was founded by Academician V. P. Goryachkin, and its specific feature is that it is based not only on technical calculations, but also on agrobiology.

Soviet designers have turned out hundreds of amazing machines. Some of them seem to be endowed with the finest sense of touch, even hearing and sight. One of them finds in a heap of grain the barely discernible seeds of weeds. Another sucks the cotton from the cotton bolls. The third seeks out unopened cotton bolls. A fourth plants seedlings, levels the ground around them and waters them. Machines destroy caterpillars, check the invasion of locusts, plant trees and potatoes, hoe sugar beets, weed, hoe and carefully loosen the soil around tender shoots. A multitude of these clever mechanical craftsmen! And what human inventiveness lies in their powerful hands, and in the flexible joints of their hundreds of nimble fingers!

The Soviet science of agricultural machine building has produced the most perfect plough and a harvester combine that reaps near the root and does not scatter weed seed over the field. This science, which has designed hundreds of "ingenious" machines, has solved the problem of the complete mechanization of harvesting and autumn fallow ploughing ("as Academician Williams insisted on," explained Comrade Vasilenko). Extensive tests have already been made of the "complex" method of combine harvesting and autumn fallow ploughing. Only on the basis of the Michurin theory of the development of plants and animals could the Soviet science of agricultural machine building achieve these astonishing successes.

After speaking about the mechanization of perennial grass growing, which, as is known, is an important component of the travopolye system, and of haymowers that drive to and from the fields almost at the speed of a motorcar, Academician Vasilenko quoted the following example.

Milking machines have existed for a long time. How were these machines designed abroad? To squeeze the milk from the cow's udder, the teats must be compressed and released, so they designed two-stroke machines. The cows often fell sick as a result of the operation of these machines, but nobody could explain why. The designers insisted that it was not due to the machines.

The Soviet, Michurin machine designers approached the matter in a different way. They worked in collaboration with nature. They studied the way a calf sucks its mother's milk and found that it did so not in two, but in three actions—compression, release, and inhalation. The calf draws its breath, the teat rests, and in that instant the blood circulation is restored. Our milking machines are now designed on the three-stroke principle. They hold first place among all the milking machines in the world. Cows "don't notice" the milking when done with these machines.

When the session was at its height, it was learned that thousands of kolkhozes in Siberia had expressed the wish to sow in stubble. At the other end of the country, in the Ukraine, an event less conspicuous but no less remarkable occurred: a hundred tractor drivers in the Sitskovetsky District had acquired Williams' book, and one of them, Dmitri Palchenko, wrote: "Every time I read this book I felt as if a bandage was being removed from my eyes. When I began to employ stubble-ploughing and then ploughing with skim coulters, it seemed to me as if V. R. Williams had lit up in my mind powerful headlights of knowledge, which gave me the ability to see into the bowels of the earth I was cultivating—that great storehouse of big harvests. . . . If they send me to a collective farm without skim coulters, I will buy them out of my own pocket, but I will not plough without them."

The question as to which science the people accepted and which they rejected was perfectly clear.

A. V. Mikhalevich, assistant editor of *Pravda Ukraini*, said in the course of his speech: "Science exists for the purpose of improving the lives of the people," and an outburst of applause greeted these words.

So irresistible was the force of all these facts, of the unanimity of the participants in the session, of all those in the hall, so obvious was the utter bankruptcy of Morganism-Mendelism, that the quondam adherents of Morganism—P. M. Zhukovsky, I. M. Polyakov and S. I. Alikhanian—went on to the platform and stated that they renounced their views.

It is difficult to imagine that there is an honest Soviet scientist today who does not realize the objective significance and ultimate goal of the reactionary, thoroughly idealistic theory of formal genetics that had been imported into our country by the servile worshippers of things foreign.

Lysenko summed up the debate. He did not have to speak long. Only a few questions had to be cleared up. The only thing the Morganists had been able to boast about was their experiments in so-called artificial polyploids. In the language of Morganism, polyploids are organisms with a multiple set of chromosomes. Employing, according to their custom, drastic methods of influencing the organism, poisoning it with colchicine, the Morganists crippled the segregating cells in such a way that the chromosomes in them segregated, multiplied, whereas the cell itself could not divide. The result was a polyploid. The Morganists asserted that this was of great economic importance, and that in this way they had already produced varieties of buckwheat, kok-saghyz and other plants. It transpired, however, that entire laboratories, after spending long years soaking seeds in colchicine, had produced multitudes of polyploids, but not a single variety; that most of the "varieties" they had produced suffered from a "slight" defect: they did not produce seeds; that good polyploid varieties were indeed known in agriculture, but there were no fewer excellent varieties that were not polyploids—in short, that with artificial polyploids varieties do not jump out of their own accord like tickets from a slot machine. No, this method is by no means a magic wand. Lysenko said:

"We recognize the action of the conditions of life upon the living body. Why then should we refuse to recognize the action of such potent factors as X-rays or a strong poison like colchicine, etc.? We do not deny the action of the so-called mutagenic substances. But we insist that such action, which penetrates into the organism not in the course of its development, not through the process of assimilation and dissimilation, can only rarely and only *fortuitously* lead to results useful for agriculture. It is not the road of systematic selection, not the road of progressive science."

Chance, "luck," reign in the theory and practice of formal genetics.

Science which fails to give practice a clear perspective, power of orientation and confidence in the achievement of practical aims does not deserve the name of science.

In its very spirit, Michurin science is inseparable from practice.

This is its chief feature, its essence and fundamental character. It enters, intervenes, in the very depth of life, and devotes all its mighty power to the execution of its commands, to the solution of enormous economic problems; and from it acquires new strength, learns the practical, creative path to a profounder and more effective knowledge of the laws of nature. Unity of theory and practice, which transforms the whole of science—the dream of the great scientists of the past—is here achieved.

The President of the Academy said: "Progressive biological science owes it to the geniuses of mankind, *Lenin* and *Stalin*, that *the teaching of I. V. Michurin has been added to the treasure house of our knowledge, has become part of the gold fund of our science.*"

He concluded his speech with a tribute to the Michurin science, the science of the transformation of living nature for the benefit of the Soviet people, with a tribute to the Party of Lenin and Stalin which revealed Michurin to the world and created in our country all the conditions for the efflorescence of advanced, materialist science.

And when he uttered his final words: *"Glory to the great friend and protagonist of science, our leader and teacher, Comrade Stalin!"* the thousand or so people who filled that vast hall rose like one man and stood for a long time clapping, the sound of applause, now rising and now subsiding, only to break out with renewed vigour.

In that same month, August 1948, the Presidium of the Academy of Sciences of the U.S.S.R., at a three-day enlarged session, discussed the results of the session of the Lenin Academy of Agricultural Sciences of the U.S.S.R.; and the supreme scientific body in our country arrived at the conclusion that the development of Michurin science must become the pivot of all the natural sciences.

As a result, the work of our universities, of the vast network of scientific institutes, research laboratories and plant-breeding stations that stretches over our country, was quickly reorganized. An unprecedented wave of enthusiasm swept through the ranks of our agrobiologists, soil scientists, agronomists, zootechnicians, academicians and advanced kolkhozniks. The great festival that had been spoken about at the session appeared to have arrived. . . . Never had life made such demands upon the scientist, and never had the demands of life so enthused the scientist. A whirlwind of gigantic activity, of noble tasks, blew into the recently closed and stuffy rooms where yesterday the Mendelists had engaged in their pettyfogging scholastics. The fields are waiting! The livestock farms are demanding! —this became the supreme law. Vast perspectives opened up before every scientific worker who went out to meet the voice of Nature; minor problems ceased to exist. Wonderful tidings arrived from Gorki Leninskiye, near Moscow, from the fields of the Ukraine from which the 1948 crop had been harvested, from the orchards of Siberia where abundant crops of heavy, delicious fruit were being picked on the edge of the taiga, from the stockbreeding farms in Uzbekistan with their beauty and pride—the renovated flocks of karakul sheep.

Not a small group of scientists, but the entire country was promoting Michurin science, the science of man's power over the land and of the transformation of the land for the benefit of the people.

It was a revolution in science.

EXPLANATORY NOTES

[1] *Zaporozhskaya Sech*—the encampment of the Ukrainian Cossacks founded in the sixteenth century beyond the Dnieper Porogi, or Rapids, the refuge of peasants who had fled from serf oppression. Women were not allowed in the encampment. They lived in settlements outside of it. p. 255

[2] *The Bronze Horseman*—the equestrian statue of Peter I in Leningrad. It is mounted on a rough-hewn granite rock. p. 386

[3] *Poyarkov, Vasili*—chief of a military expedition sent to the Amur region of the Far East in 1643. The expedition obtained new, authentic information about the River Amur and about the people inhabiting the region. p. 390

[4] *Khabarov, Yerofei Pavlovich*—explorer and conqueror of the Amur region, in the middle of the seventeenth century. The city of Khabarovsk is named after him. p. 390

[5] *Dersu Uzala*—hunter and explorer, participated in the expedition of the famous Russian explorer of the Ussuriisk region, V. K. Arseniev. p. 390

[6] *Khoma Brut*—a character in Gogol's novel *The Witches*. p.409

[7] This refers to *Ocherki Bursy* (*Sketches of Seminary Life*) by N. G. Pomyalovsky (1835-63), an outstanding representative of Russian democratic literature of the 1860's. p. 409

[8] *G. N. Uspensky* (1843-1903)—Russian writer of the revolutionary democratic trend who, in a number of his sketches, depicted the life of the urban poor, the minor government officials and the peasantry.
p. 464

[9] *V. G. Korolenko* (1853-1931)—outstanding Russian writer and public figure. His works gave a vivid and truthful picture of conditions in Russia and breathed hatred toward the tyranny of the autocracy.
p. 464

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