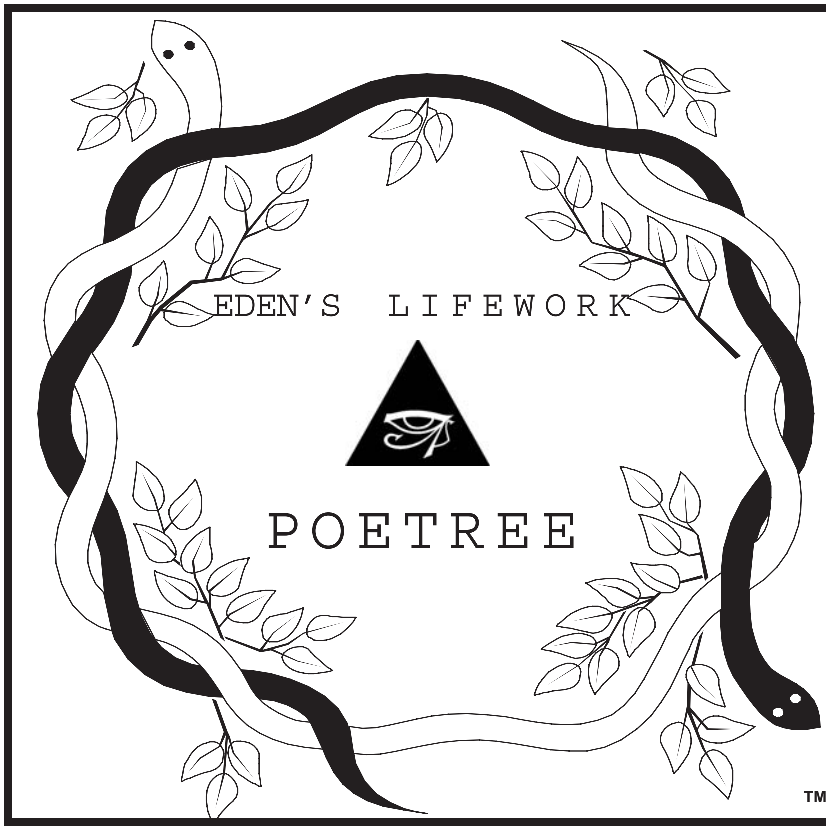
GRASS ECOLOGY/ECONOMY.

Isaiah realized that *"all flesh is grass",* that human consciousness is *self-aware bread*. Jesus brought to humanity the consciousness of divine awareness in grass/flesh. Flesh is grass transubstantiated. *Life's transubstantial incorporation of grass—divinity's exchange medium—grows the mystery of the labyrinth's greening*. Wheat is word transubstantiated. Bread is word transubstantiated. And, as Jesus is the Bread of Truth, so are we called to be. We are bread born from and cast upon the water—broadcast word "right as grain", eventhough green as grass. Soul and body's sustaining growth is not possible except communally empowered by nourishment; body/soul's empowering food is *graintruth continuity* energized in essential soul/substance relativity.

Natural spirituality is wavefield empowerment—cosmic thermodynamism distributed in wavefield consciousness overlapping molecular complexities. Conscious wavefield complexity is driven internally and externally; internally by electron wave-energy, and externally by the electromagnetic wave-stimulation of impacting photons. Elemental "sexual" ambiguity grounds in the tension energy of the positive atomic nucleus and the negative electrons. Electrical ambivalence (positive/negative potential) is the motor-energy (cosmic) driving all Earthlife transformations.

The empowering food of body, which is at the same time the empowering food of soul, is basic glucose, whose glycosidic linkages *transubstantially* provide structural energy/substance from which vital edifications arise and diversify. The "house" that God built for The People is *The House of Bread*, the edification of Divine Providence in natural providence.

Soul and body, we are "bread", communal edifications of *bread*. As transubstances of bread we are necessarily "agents of bread"—conscionable "doers" whose lifework is the provisioning of bread—the caretaking of soul/body. In bread-provisioning, in grainkeeping, we *brother-keep, we sustain community*. Jesus' words over bread at his last supper, "This is my body", are spoken with an insight of cosmic consciousness intended to enlighten our own *transubstantial* sense of communal connection. This *priesthood*, the provisioning of material/spiritual eucharist, conscionably and mutually obliges man and woman alike. *We are obliged to empower each other in universal priesthood, not to deny others their conscionable birth-calling*.



TENTH BOOK

THE HOUSE OF BREAD

"Eucharistic Continuity"

SYLVESTER L STEFFEN
MONICA R STEFFEN

EDEN'S LIFEWORK POETREE
A RECONCILIATION OF SCIENCE & RELIGION

NOVOGENESIS
PROCESS COSMOLOGY
The **Quantum-Faith** Trilogy

METAGENESIS
PROCESS METAPHYSICS
The **Quantum-Hope** Trilogy

THEOGENESIS
PROCESS THEOLOGY
The **Quantum-Love** Trilogy

THE HOUSE OF BREAD
ESSENTIAL EUCHARIST
The **Quantum Continuity**

THE GENESIS OF REASON-BASED RELIGION

HARVESTALL

THE MEANING OF THE MARK

The *Grain Guardian* trademark personifies the *enigmatic sphinx*—Egypt's ancient face (associated with the wisdom of biblical Joseph). He dreamed of years of abundance followed by years of famine, and he commanded that granaries be built in times of plenty against the years of want. When the grain failed and the nations were ravaged, word of Egypt's Grain Guardian spread, and people traveled from different parts of the world to purchase grain for their daily bread.

The true Grain Guardian knows that the problems of keeping grain are as old as grain itself, while grain's wise keeping is a need as new as the need for daily bread. The exploitive production of grain without its wise preservation wastes life and the Earth's resources; the present American practice of energy intensive agriculture degrades grain, hemorrhages agricultural economics and cheats the American farmer and the global community of sustaining necessities. The cultural practice of mindlessly exploiting Earth's ecology is a *culture of death* that sustains neither local nor global economies, nor life itself. If global life is to remain sustainable, local communities must conscionably culture the sustainable, bioregionally compatible, necessities of life, and not exploit them to death.

And *after* words? Poetic Justice!

"Sustainable vitality" is Earth's most active complexity equilibrating interactive, intensional forces. Vitality is the sustaining balance of supply/demand—Nature's equilibrating economy that generates the ecologic internet and provides for its interdependent membership. The human body, for example, is a communal unity of untold billions of symbiotic organisms contributing to the intensional equilibrium of physiological processing. Human beings are just one of very many intensional networks within Earth-life's continuity of networks. Network disintegration occurs when critical masses of network complexes spin out-of-control and ravage the bigger networks from which they derive. "Cybernetic sense" is conscious restraint that conscionably sustains network continuity. "Success" is preserving equilibrium in life's network; "failure" is losing it. Success is vitality, failure is destroyed vitality. Salvation—health—sanity is conscionable continuity. Our generation is witness to the unparalleled proliferation of network disintegrations, catastrophes of global proportions, unconscionable, humanly induced interventions that trash essential continuity.

The human predicament is that ignorance trashes cybernetic sense while arrogance crashes it—is it possible for these devastating forces to be restrained? When websites overload network resources to the point of breaking down their *ecologic generators*, the essential resources of "Eden's Middletree" are themselves terminally at risk. Cultures that put terminal demands on network sources are "cultures of death". In the *culture of death*, we Westerners are the worst ever because our tools are the most powerful ever and our ignorance and arrogance are culturally absolutized, professionalized and idolized.

Global resources/sources are being imploded by explosive consumer demands. The image that comes to mind—of this Earth-life catastrophe now happening—is of Earth as an animal carcass crawling with unaware maggots. When the carcass is totally consumed, the maggots are gone with it.

This spectre, of Earthlife's networks collapsing, raises the inevitable question: *"how far is the global human population from the ultimate predicament of its own self-consumption?"*

A Continuing Work-in-progress

Steffen, Sylvester Lawrence, 1933-
Eden's Lifework Poetree:
a Reconciliation of Science and Religion, the Trilogies
Novogenesis, Metagenesis, Theogenesis,
and "The House of Bread".
Sylvester L Steffen.
Tenth Book, The House of Bread, Eucharistic Continuity
Co-Author Monica R. Steffen
ISBN: 0-9633664-1-6-10
Graphics and design by Monica R Steffen
Editing by Monica and Leticia L Steffen
Computer text by Monica, Leticia and Rebecca M Steffen

Library of Congress Catalog Card Number: 99-96709

Curriculum Field:
1. Education 2. Interdisciplinary studies 3. Philosophy
4. Poetry 5. Political Science 6. Religion 7. Science
8. Social studies

WORD UNlimited
54355 E Bobcat Lane
Strasburg, CO 80316
e-mail: wordunlimited@usa.net

Printed in the United States of America

Printed by
G&R PUBLISHING COMPANY
507 Industrial Street
Waverly, IA 50677

FORWARD TO THE PAST

The option to field-shell corn that became available some forty years ago has, for many farmers, brought with it the end to the corn crib—a *natural*, cost effective method for keeping corn. In the corn crib, the natural interaction between corn seeds and the atmosphere allowed for the *natural curing* and drying of freshly picked corn on the cob. But with the elimination of the corncob, twice as many corn kernels were compacted into the same space normally occupied—and the natural "wick" which facilitates moisture removal was eliminated. This presents a big problem for the corngrain since the doubled concentration of kernels in the same storage space does not allow for necessary exchanges between the grain and atmospheric air. Concentrated in this way, new corngrain quickly heats up and spoils. This new problem forced the grain industry to look for quick solutions.

Agricultural Engineers determined that the fast drying of grain with ventilation fans and kiln heaters was an acceptable solution; the damage caused to corn was casually assumed to be tolerable compared to the "benefits". However, user experience has, in the forty ensuing years, documented serious and costly disadvantages: major investments in short-lived, hazardous, labor-intensive drying and handling equipment; escalating costs for liquid propane gas; explosive dust; crumbly and light-weight grain that lacks palatability and nutrition.

Clearly, some subtle value which is *natural* to earcorn drying is being lost when corn is intensively heat dried. In 1908, the Russian scientist Vasiliev hinted at this value when he expressed his dismay that "seed ripening" had been so little studied; to him it was clear that at a fundamental level, *seed ripening* deals "essentially with the synthesis of organic substances."[†]

What is an important economic value to the corn grower/user is what natural seed ripening contributes nutritionally and weight-wise to live corn seeds.

This booklet is written especially for sustainably-minded farmers. It intends to give back to them the option that was theirs with earcorn handling, and in the sense that it accomplishes that, it accomplishes a "*forward" move to the past*. With a working knowledge of seed science, the farmer can make sound management decisions in the grain handling options available to him. *Grain-life is again an option the farmer can choose—even with field-shelling*.

† H.S. McKee, "Structure and Synthesis of Protoplasm," Growth and Differentiation in Plants: A Monograph of the American Society of Plant Physiologists, Ed. W.E. Loomis, Iowa State College Press, Ames, Iowa, 1953, p. 328.

It is time for the United States Department of Agriculture to take seriously the "seed friendly" and the farmer friendly management of stored corn, and to become an advocate for naturally sustainable economies in the public interest, and not for energy-consumptive and pollutive agriculture.

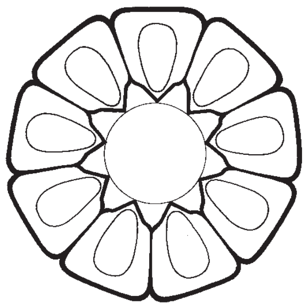
The scientific documentation of "*grain ecology*" and "*grain economy*" is now a matter of formal record. This "pioneer" grain science of Sylvester L. Steffen teaches "after-ripening" and "ever-normal" corn keeping; it is specified in multiple patent disclosures which have been validated not only by on-farm usage but also by challenges in U.S. Federal Courts of law in Minnesota and Indiana, and in Iowa District Courts, Linn and Jones Counties. (U.S. Patent Nos: 3,408,747; 4,045,878; 4,045,880; 4,053,991; 4,077,134; 4,148,147; 4,175,418; 4,247,989; 4,256,029; and 4,800,653. Canadian Patents: 1,086,052 and 1,090,562.)

Water and Grain Weight. Research data involving blended samples of white and yellow corn (10% and 18% moistures, respectively) show actual increases in the dry weight of the corn over an extended time in storage. As the differential moistures between the seeds gradually approached an equilibrium, the 18% moisture yellow corn showed significant gains in "dry matter", by weight, even as moisture from it equilibrated with the drier 10% white corn. In the dry sample (10% moisture), a significant loss of dry matter occurred, presumably because of increased oxygen uptake and increased respiration; however, at the end of the storage period, even the drier white corn shows recovery from the initial losses of dry weight. (see Figure 2, p. 40.)

Water components are recycled variably in countless carbohydrate, protein and fatty acid linkages; the *after-ripening process* is contingent upon chemical access to the internal "reservoir" of water that serves as a resource in the linking process. Flexible access to reserves of seed moisture allows for biochemical consolidation that "synthesizes" seed chemistry with the release of H and OH, and for biochemical dissolutions that "hydrolyze" chemical bonds by adding H and OH. Flexible access to internalized seed moisture (avoiding the uptake of oxygen) that facilitates water-component reusage within carbohydrates, proteins and fatty acids, may result in actual increases of marketable weight—*a phenomenon that is the very opposite of the "shrink" caused by exposures of corn to heated air drying*.

Public Accountability. This cumulus of research suggests that the science of seed *after-ripening* needs to be investigated for its specific public interest values (energy conservation and grain value enhancement) and for its applicability to on-the-farm management of stored grain. That this value has not been researched is clearly stated in the November 17, 1981, letter from the United States Department of Agriculture to Sylvester L. Steffen. "...I don't have any data that would either support or negate your claims regarding an increase in dry matter during storage of corn when moisture content is 15-20% and temperature about 40^{o}F." This official acknowledgement is signed by Larry M. Seitz, Research Chemist for the North Central Region's Science and Education Administration at the U.S. Grain Marketing Research Laboratory in Manhattan, Kansas, the United States Department of Agriculture.

In a real sense, however, it already has been researched and documented over a period of more than two decades in the practices of farmers who have experienced the comparative economics of the hot-air drying and the CHILLCURING of shelled corn.



I. CORN ECOLOGY.

"Ecology" is the home environment where all Life joins in communication. It is the Living Network into which we are born and upon which we depend. We share this uncommon home with all Life in common. There is peace in this shared existence when we individually recognize our place and when we preserve the harmony that provides for all cohabiting life. In this "home", corn shares an important place with us.

"Corn" is a metaphor for the Holy Other that gives being to our very self. Corn is the "grass" of Isaiah; it is more than a metaphor; it is the Sacrament of Provident Reality for all land life—the Eucharist of our own *being, doing and having*.

This writing is more than a practical discourse on the values and management of Living Grain; it is a dialogue with our personal conscience that seeks to raise our own personal sense of religion and to give our individual lives a more fulfilled sense of direction—a more sustainable accommodation. Such fulfilled personal outcome gains greater "grace" for all.

Figure 2

WEIGHT CHANGES IN BLENDED CORN
(10% + 18% Blended Moisture Contents)

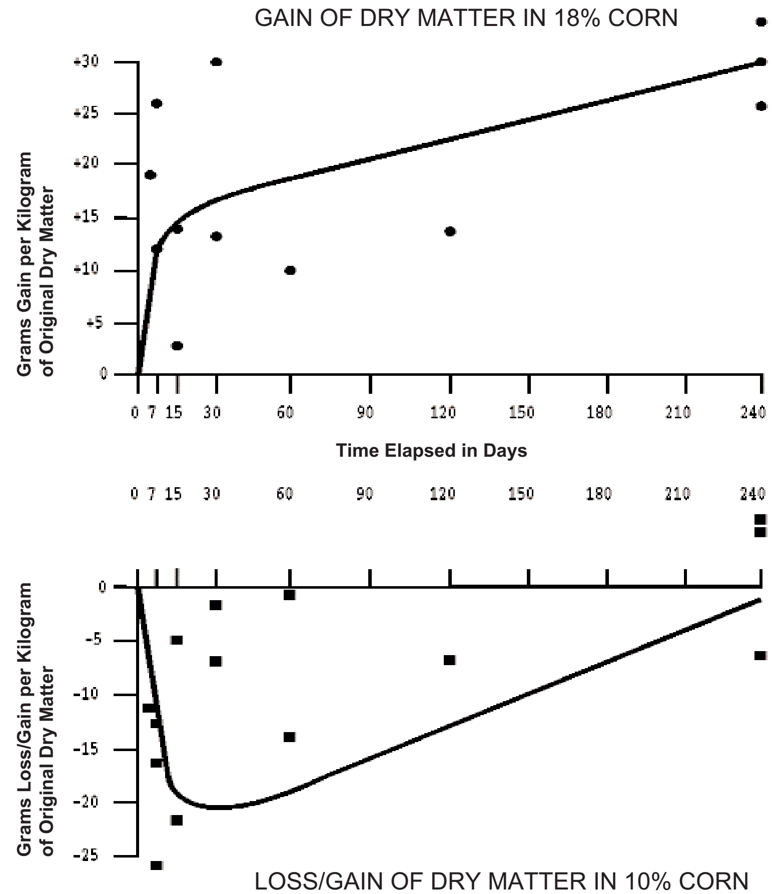
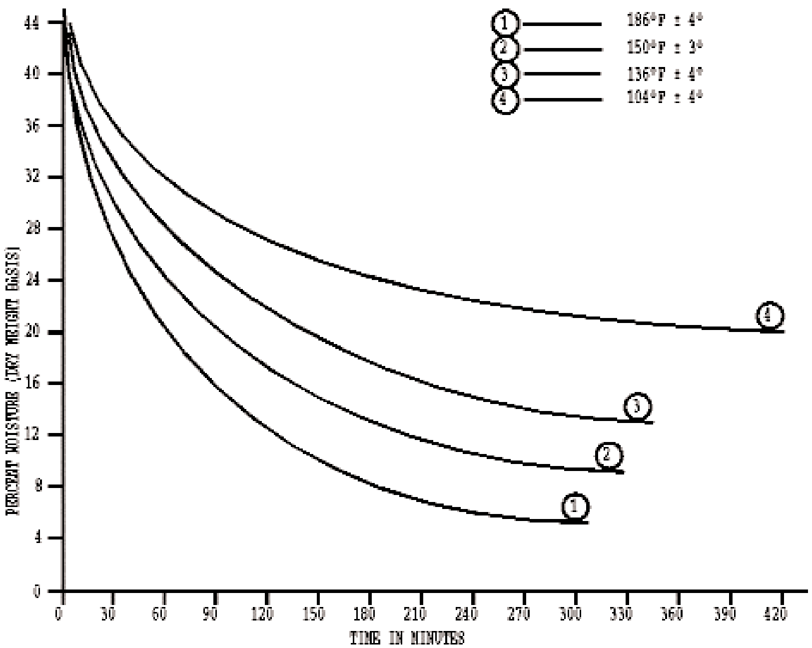


Figure 1 **DRYING CURVES**



Drying rates of shelled corn at four temperature levels.

Germination tests show that there is <u>cumulative</u> <u>damage</u> to corn seeds from exposure to heat: the more immature the corn, the greater the damage; the longer the exposure to heat, the greater the damage. "Damage" is measured by losses in germination and in seedling vigor, and by seedling abnormalities.

Table 5 **GERMINATION RATES**
(as affected by Drying Temperatures and Corn Maturity)

Drying Temps.	32% Corn	27% Corn	22% Corn
$104^{o}F$	75%	82%	92%
$140^{o}F$	28%	39%	80%
$160^{o}F$	1%	5%	39%
$185^{o}F$	0%	0%	0%

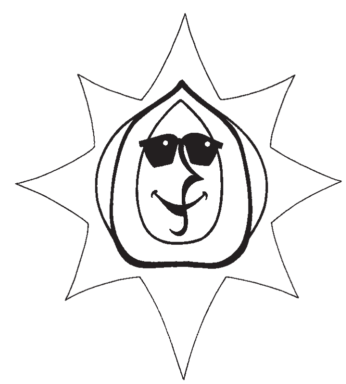
RADIANT ENERGY.

Solar Radiation. Light itself is a stream of particles (photons) whose quantum of energy is defined by its *particular* wavelength. The "substance" of light is real and ever active in the networks of air, water and soil that collaboratively assemble the stuff of Life; human life is part and parcel of Earthlife's intertwined networks.

The Universe's coherent sense of physical order is inherent in the laws that predispose subatomic particles (quanta) to their electrical agencies as the *inductive "motors"* that drive atoms and molecules.

The *self-motivated* symmetries of universal substances (particulate quanta) occur through attractive and repulsive accommodations. Elemental atoms are formed by the forces of cosmic dialectics. The nucleus of the atom carries a positive *centripetal* potential, while the electrons in the *nuclear skies* carry negative *centrifugal* potentials; their purposeful exchange is life's language of structural logic.

The solar flux of photoelectric energy vitalizes the Earth and cocoons our privileged orb with diversifying networks. The golden sun is and will always be Earthlife's singular source of sustainable, revitalizing energy. If we humans conduct ourselves in ways consistent with preserving the global network of sunshine-structured life, we may recover the conscionable awareness that *Sun Power is the original and only sustaining lifesource of global ecologics and economics.*



As individuals and as communities of individuals, we human beings become fulfilled, both physically and spiritually, when we self-accommodate within Life's sustainable networks. Because we are in fact *a network within The Network*, we have the frightening ability to trash and crash The Network, but also the vitalizing ability to strengthen and amplify its diverse "waves" and ways.

Grain Power Is Sun Power. Particulate quanta flow from the sun in waves of radiant energy. Life on earth is complexly diversified because of the unique ability of system networks to capture the sun's radiant substance. This trapping of photoelectric substance is the original and only sustainable method of harnessing nuclear energy. The seed, a life-incorporated storage battery, is simply stored Sun Power—the food of life's network web—the "transubstance" of flesh. Conscious of this natural value, humans have from times immemorial recognized the unified religious/secular value of cereal grain seeds in the commerce of life, the "eucharistic sacrament" of communal sustainability—creation's living connection to its Creator.

The destiny of the live plant is directed toward the *purpose* of producing seeds, and the destiny of seeds toward the *purpose* of producing the live plant. In this cyclical strategy of Nature, energy and matter return to renewed usages, over and over again. In addition to reusing Nature's structured symmetries, living matter is augmented by the green-cell "theft" of solar substances (photons). By this acquisition, the substance and diversification of life on Earth are driven to expand.

The seamless blanket of life which covers Earth, that is, ocean life, soil life and airborne life, seeks to proliferate and diversify in a sustainably interdependent manner. The common denominator in life's diversified, sustainable network is the sharing of solar energy. Sensible practices that are "true to life" are only possible with a working knowledge of the mechanisms and processes essential to sustainable living; such knowledge enables the intentional corroboration of "agriculture" with Nature. Sustainable agriculture is the foundation of a sustainable society. True agriculture is "sacrament" working intentionally.

Our purpose here is to come to a better scientific understanding of the living commerce in corn seeds so we may consciously work with the "providence" of life. Einstein's equation $E=mc^2$ speaks directly to the economy of living energy, to the substantive effects of sunlight, and specifically, to the photoelectric *syntropy* that produces living reserves of stored food energy against *entropy*. Life's critical defense against entropy is the seed. Without the seed there is no diversified life, no photoelectric reserve by which to diversify and sustain life.

The Molecular Microcosm. The way in which Sun Power is captured is incredibly clever. It is accomplished in the microcosmic world of atoms and molecules (linked clusters of atoms). Each atom has a nucleus which is at the center of its micro “planetary system”. Traveling in orbitals (skies) around the nucleus are electrons whose energetic momenta accelerate when exposed to the stimulation of harmonic electromagnetic radiation. The number of electrons circling the nucleus varies with the type of atom.

Atoms join to become molecules when the electrical imbalances between them are accommodated by electron exchange. The

Research data on corn dried at high temperatures show evidence of "water fractioning"; the more immature the grain, the greater the compromise of seed chemistry. As corn of different maturities (moisture contents of 32%, 27% and 22%) were dried at different high temperatures (185°F, 160°F, 140°F and 104°F), samples of corn were monitored periodically for purposes of establishing drying-rate curves and for purposes of projecting the estimated drying times required to bring samples of grain to desired final moisture contents. Samples were collected based on "projections" of the extrapolated moisture contents after specified times of exposure. After samples were taken they were put in storage, and after some weeks the "actual" moisture contents of the samples were determined. Two "final" moisture contents were obtained; one was the "projected" moisture content, and the other was the "actual" moisture content. The discrepancies in moisture contents between the *projected* and the *actual* moistures followed a pattern which suggests biochemical interference with seed moisture. Although a pattern has emerged, further research is called for.

Table 4 **MEAN DEVIATIONS OF "ACTUAL" MOISTURE PERCENTAGES FROM THE "PROJECTED"**

	32% Corn	27% Corn	22% Corn
185°F	-1.40%	-1.00%	-0.28%
160°F	+3.25%	+2.13%	+1.60%
140°F	+1.93%	+2.03%	+1.18%
104°F	+3.87%	+1.63%	+0.75%

Negative numbers: the *actual* moisture is less than the "projected"
Positive numbers: the *actual* moisture is greater than the "projected"

What is suggested here is that the seeds exert a "chemical grip" on water that will not be compromised unless seed chemistry has been violated by high heat. This *chemical grip* is further illustrated in the "Drying Curves" (see Figure 1, p. 39) which show that increased heat can speed the forced removal of water, especially at higher moisture contents; but as the moisture content is reduced, the extraction of water becomes increasingly difficult.

SCIENTIFIC BASES.
The technology of the HARVESTALL CHILLCURING$_{TM}$ process is based on the research findings of Sylvester L. Steffen. This original research included studies on drying corn of different maturities in storage, using natural air and using small additions of heat above natural air temperatures. Other research included studies of the effects of high-heat drying (at four temperatures) on corn grain of different maturities. Samples of corn were kept in refrigerated storage and used in making *germination* and *emergence* assays.†

Dormancy Index. Indication of a *dormancy index* is suggested in the six-month and eighteen-month germination/emergence tests conducted on samples of corn obtained from the original research. (See Table 3, "Germination/Emergence Rates" below.) The germination of corn seeds stored at 18% moisture content and 40^{o}F was essentially the same after six months in storage as it was after 18 months in storage. The apparent difference is in the *emergence rates* of the seedlings. Emerged sprouts were counted after five days and again after seven days germinating; the count of emerged seedlings after seven days represents the *germination percentage*, while the five-day count (calculated as a percent of the total percentage of germination) is the *emergence percentage*. *The consistently higher emergence percentages in the seeds stored for 18-months is a strong indicator that some important biochemical changes occurred within the seeds during the prolonged storage time.*

Table 3.

GERMINATION/EMERGENCE RATES
(as affected by Time, Temperature and Moisture)

	6-Months Storage at 40^{o}F		18-Months Storage at 40^{o}F	
Storage Moistures	% Total Germination (7 days)	Emergence (5 days) % of Germination	% Total Germination (7 days)	Emergence (5 days) % of Germination
12-14%	75%	47%	75%	93%
14-16%	70%	56%	73%	86%
16-18%	74%	59%	71%	88%
18-24%	42%	33%	13%	53%
Above 24%	17%	0%	0%	0%

†Sylvester Lawrence Steffen, "Effects of Drying Method on Germination of Corn," Diss., Iowa State University of Science and Technology at Ames, May 1960. University Library.

molecular transformations that occur when electrons are shared or surrendered create subtle new potentials in the electrical fields of the new molecules. Pathways involved in the exchange of electrons are subject to qualifications by the subatomic components in the nucleus and in the electrons. When atoms are clustered in a particular molecular configuration, they manifest (as a unit) a specific "vibrational frequency" which qualifies the interactive potential of the molecules and atoms in the cluster. This *vibrational frequency* attenuates compatible wavelength frequencies from within the electromagnetic spectrum of the sun's radiation. This capacity for *attenuating* (trapping) compatible solar radiation is called an “harmonic” response.

The energy state of a molecule, i.e., its life-potential, increases by virtue of its harmonic attenuation of solar radiation. For example, water vapor is in a more highly excited energy state than liquid water. The continuous exposure of molecules to specific wavelengths of radiation may so excite them as to cause them to disassociate from some molecules and to associate with others.

The most abundant, common materials used by living systems are carbon dioxide (CO_2) and water (H_2O). Both are triatomic molecules, that is, they are composed of three atoms. Their triatomic structures make them uniquely responsive to solar energy at like or nearly alike vibrational frequencies within the infrared spectrum. When H_2O and CO_2 are excited by infrared radiation, they become primed for cyclical usage in living systems. These atoms and molecules become the energy stores and the structural substances of living systems.

Living systems have the ability to use the vibrational energy of molecules as well as their structural components. Living systems are in perpetual states of transformation. Life is a transitional complexity of cyclical events involving purposeful molecular arrangements that provide for food acquisition and utilization. By some incredible economy, living systems can restructure raw substances as they use the energy contained in them and capitalize on these materials not only for structuring and restructuring their own systems but for storing these energies for later use—all of which happens at the atomic/molecular level.

Life itself is a highly complexified expression of wave-field energies that are subtly disposed in organized matter, whether in the molecule of a human body or the seeds of plants. The cellular ribbons of DNA and RNA dispose cell substances to the autotrophic work of life's spiral ascent. The genetic library of DNA ribbons (structured in every cell) transmits natural codes of workable relationships which have been perfected over the eons. DNA is an open "*computer chip"* that enables nature/nurture to adapt purposeful accommodations to the natural and nurtural contexts of the times.

The continuum of universal transformations, characterized by *purposeful redundancies* in atoms and molecules and enabled by water, light and the natural laws of continuity inherent in DNA, confirms the connectedness and unity of life.

Water and the *Quantum* Agency. The natural laws of living relationships are indelibly written with water. The openness of life is a credit to water's transparency. The *providence* of life (in the accessing of food-energy) is the doing of water, which is both agent and catalyst in cell-dynamics.

Life's origins were enabled by special sets of circumstances in which structural substances and energies were transformed by electron exchange. Life began in the medium of water and totally depends on water.

Hydrogen is present in water in vast quantities, but the recovery of hydrogen atoms and their electrons from water requires a large amount of energy. Photosynthetic autotrophs (organisms that produce their own light-made food) have devised an elegantly organized system of pigments (chloroplasts) which facilitate the capture of the sun's light energy. They use the sun's radiant energy to raise electrons to excited states and then trap them in such a way that a portion of their energies is extracted in a usable form before the electrons return to their grounded states. What is essentially a light-induced separation of electrical charges is sufficiently energetic to split water into hydrogen and oxygen gases. It is also sufficient to generate ATP (an ester derivative that biochemically supplies the necessary energy for cellular processes) which is required, along with oxygen, to bind the carbon and oxygen of CO_2 into biologically useful compounds with higher reserves of *free energy potential*.

Photons are the energy agents that are intercepted in the chloroplasts of green plant cells and are used in the assembly of *elemental* carbohydrates (CH_2O) which are the basic food and structural materials of diversified life. Chloroplasts possess *light potential* responsiveness to photon activation, and therefore, have the electrical ability to mediate the chemical interactivity of water and carbon in the seed. Photons may be operative in the visible as well as in the invisible electromagnetic spectra. In plant seed development, including "after-ripening", the contribution of photons is *molecularly substantive*.

Corn DRYPOINT$_{TM}$ Based on Evaporative Cooling.

DRY-BULB TEMP.	5°F TEMP. DROP		10°F TEMP. DROP		15°F TEMP. DROP	
AMBIENT AIR (°F)	RELATIVE HUMIDITY (%)	CORN MOISTURE (%)	RELATIVE HUMIDITY (%)	CORN MOISTURE (%)	RELATIVE HUMIDITY (%)	CORN MOISTURE (%)
25	60	15.1				
30	63	15.1				
35	65	15.0				
40	67	15.0	22	---		
45	69	14.9	35	---		
50	70	14.7	40	10.6		
55	71	14.6	45	11.0		
60	72	14.4	49	11.4	28	---
65	73	14.2	53	11.5	33	---
70	74	14.0	55	11.4	36	---
75	75	13.9	58	11.3	40	9.8
80	76	13.7	60	11.3	43	9.7
85	77	13.7	62	11.2	45	9.7
90					47	9.6
95					50	9.5

Table 2.

Corn DRYPOINT$_{TM}$ Based on Seasonal Normals.

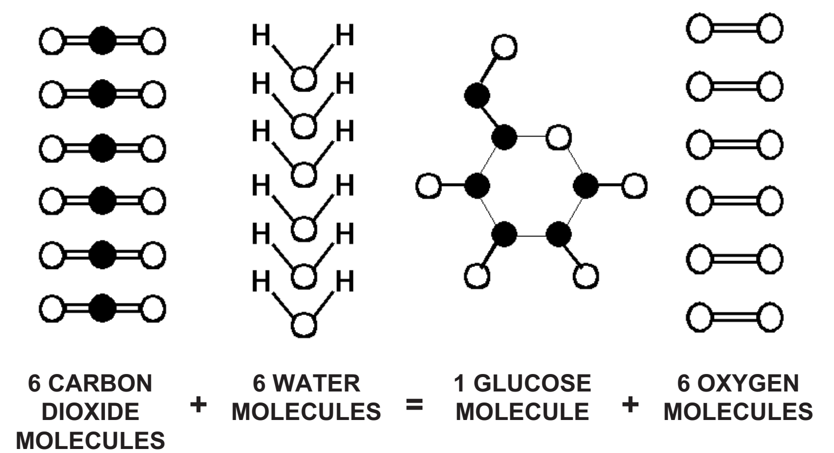
Month	Seasonal Air Temperature (°F)	Seasonal Air Relative Humidity (%)	Equilibrium* Corn Moisture (%)
September	55	60	13.0
October	45	70	15.1
November	40	75	16.6
December	30	80	18.7
January	20	80	19.6
February	35	80	18.2
March	50	80	16.9
April	50	70	14.7
May	55	60	13.0
June	70	60	12.0
July	70	50	10.9
August	70	60	12.0

***Deviations are subject to seed and seasonal variables.**

Table 1.

Photosynthesis. Water (H_2O) and carbon dioxide (CO_2) are molecules that are found in the air; together they are the raw materials of photosynthesis. Reduced to their essential elements, *water and carbon dioxide are the food materials of all life, the original substance of life*. During the process of photosynthesis, carbon, hydrogen and oxygen are rearranged into carbohydrate molecules from the original CO_2 and H_2O, which is accompanied by the release of oxygen (O_2) into the atmosphere. *Photosynthesis essentially generates two vital results:* it splits water and carbon dioxide which enables the use of their components in the manufacture of glucose (glycosidic molecules), and it releases O_2 into the atmosphere.

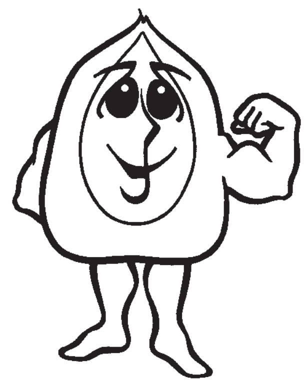
The process of photosynthesis occurs in two stages: the *light reactions* and the *dark reactions*. The hydrogen necessary for reduction in the synthesis of glucose comes from NADPH (nicotinamide adenine dinucleotide phosphate). This carrier molecule along with ATP (adenosine triphosphate) provide the free energy needed to synthesize glucose. During the *light reactions*, the chlorophylls, enzymes and cytochromes in the chloroplasts of plant cells trap light energy to manufacture NADPH and ATP. These accumulate during exposure to sunlight. In the *dark reactions*, they interact with carbon dioxide to produce the glucose molecules that power the growth and differentiation of the plant. These are the original substances that form the seed.



$$n(CO_2) + n(H_2O) \xrightarrow{\text{radiant energy}} n(CH_2O) + n(O_2)$$

This is where life's continuity and all food begin, where the edification of living networks begins. All life depends upon this process for energy and structure. Humans victimize themselves when they trash this network reality. There is no substitute source for human life!

THE CORN KERNEL.

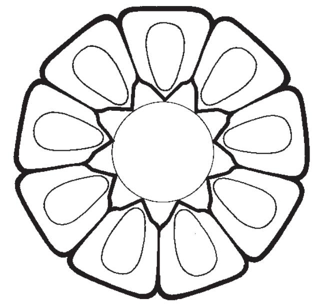


Farmers need to understand grain so they can manage it in a biologically sustainable way, which is to say, in a least cost way that sustains the greatest utility in their grain. Every kernel of grain is a living seed. If the kernel is dead, then that grain is already decomposing and losing usefulness. Proper management of living grain requires an understanding of ***seed life*** so as to secure seeds biologically and bring them to full value.

Seed water is essential to seed maturation just as it is essential in the production and germination of the seed itself. Biochemical changes occur in the cell chemistry of the seeds only within the catalytic medium of cell water. As the chemical ingredients of the cells consolidate through seed-controlled enzymatic processes, water components are released for repetitive usages; excess water in its free state is eventually released from the seed. Respiration occurring within seeds also releases water, heat, and carbon dioxide, all of which play an important role in seed chemistry and seed preservation.

The maturing ("after-ripening") of stored food reserves in grain occurs over a period of time following the death of the mother plant; the "after-ripening" of grain is essentially the "synthesis of organic substances"†. The purposeful destiny of the synthesized organic substances in seeds is to structure the materials and energies used in the growth, differentiation and maintenance of the seed embryo in its becoming a new plant. Beyond its usefulness to the embryo, the whole seed is an essential food source upon which all other animals, including humans, depend.

† H.S. McKee, "Structure and Synthesis of Protoplasm," Growth and Differentiation in Plants: A Monograph of the American Society of Plant Physiologists, Ed. W.E. Loomis, Iowa State College Press, Ames, Iowa, 1953, p. 328.



III. APPENDIX.

Soil, air, light and rain make it right with grain. The power and process of grain comes from the continuity of natural laws. Natural vitality is the *divine grace* of Earth's living internet. The energetic means that make grain are the same that make grain useful. Grain is a molecular complex of naturally ordered bondings which participate in nature's transformational webbing of biochemical connections.

The natural script of grain's genetic coding is a revelation of provident Nature. Water's true-scripting of grain is a light scripture that belongs to all life. In obeying Nature's scripting, humans get it right with Nature, with God. The research data presented here in the appended Tables and Figures give some sense of the scripted, natural continuity inherent in corn.

Fueling the Future. Clues to accessing renewable fuel for the future may be discerned in nature's way of fueling living "machines", that is, in operating within the *cybernetic* constraints of network life. Certainly, the common quest of every living creature is for the energy required to live a self-fulfilling life. It is the work of agriculture to facilitate the global community in accomplishing this objective, not just for today, but for the future. In order to be successful, the global community and the individuals composing it must recognize that *as a group*, *as individuals,* all are interdependent, and each has equal right to the natural necessities required to accomplish individual self-fulfillment. With equal magnanimity, the sun shines on all; no one individual or group has claim to greater "chosenism" under the sun nor to greater entitlement to possess the goods of the Earth. It is for each of us to strive each day with greater resolve "to see the light", and to enable each other to participate in the *natural grace* of religious/secular *eucharist*.

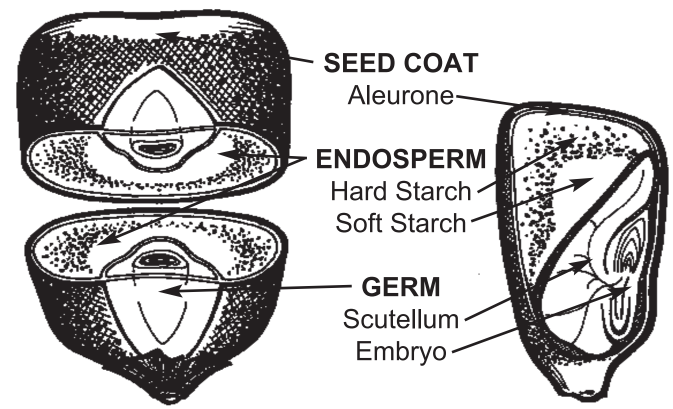
It is never too late to set priorities straight. The Earth produces that man may live. To exploit Earth beyond the sustainable capacity of network life and beyond personal justification is not tolerable, for the need of Earth's produce is not just for today but for the many tomorrows of future life.

More than ever, the cultivation of network life must be done with a sense of knowledge and obligation. The moral compulsion to be honest with science, not just in the discovery of new knowledge, *but in the application of science for the common well-being*, rests heavily on the shoulders of academia and on publicly elected officials who yet seem more ready to serve the patronizing appetites of corporate profiteering than the common interest. This observation is not meant to blame but to inspire, for none of us is free from the tendency to put self-interest ahead of the interests of others.

Today nothing less than a transformation of cultural attitude is needed, namely, *that true self-interest begins and is fulfilled in the knowledge and culture of "other" interest—of common interest*. Nothing less than this kind of altruism is needed to assure that there is enough energy for all "under the sun". When we choose individually to advantage one another equitably such an assurance may be enjoyed by all.

The biochemical processes occurring within the seed are particularly responsive to temperature. A 10^{o}F decrease in temperature increases the amount of time required for a chemical reaction to occur; conversely, a 10^{o}F increase in temperature accelerates a chemical reaction and may reduce by one-half the time required; which is to say that the cooling of grain dramatically slows down the release of moisture from the seed and therefore, reduces the ventilation requirements. This fact explains the principle that *"the release of moisture by the seed is more a factor of temperature than of relative humidity."*

These processes may be better understood with a clearer understanding of the seed's structure and its internal workings.



BODY PARTS.
The ***germ*** contains the *embryo* and a structure analogous to the placenta, the *scutellum*. The scutellum attaches to the ***endosperm***, the food supply for the germ, which makes up the bulk of the kernel. The germ and endosperm are covered by the ***seed coat***, the skin which secures the seed against the hazards of weather and invasions by microorganisms.

The Germ. The embryo is a living, breathing, consuming organism that attaches to the scutellum, the digestive organ which nourishes the embryo. The scutellum is instrumental in regulating "dormancy", a condition responsive to temperature and moisture. During dormancy, respiration is reduced to minimal levels by limiting the embryo's access to oxygen and glucose, thus conserving the food reserves stored in the endosperm.

Because the embryo is the only part of the corn kernel that contains *eucaryotic cells* (cells that have a true nucleus with genetic coding), it is the only part of the kernel that has mitochondria, the organelles which contain the enzymes and the necessary mechanisms for regulating cell metabolism. These mechanisms and the functions dependent on them, are not found in the cells of the endosperm.

Energy is available to the embryo in the form of simple sugars (glucose). The scutellum's capacity to hold a reserve of sugar is limited, but stable environmental conditions contribute to insuring that the maximum quantity of food is conserved within the endosperm in the form of complex carbohydrates. The simpler sugars are less stable and are therefore more easily consumed and/or converted into other usable forms.

The natural laws of seed conservation control the availability of food to the embryo and are driven by seasonal and diurnal cycles. During deepest dormancy, the least amount of food is used and vital energy is conserved.

The Endosperm. This food supply warehouse is the seed's own energy-storing battery. Macromolecules, such as carbohydrates, proteins and other glycosidic (sugar derived) complexes are housed here, ready and waiting to be processed as the seed's needs require. Energy as well as structural materials are stored for use by the embryo or other consuming organisms. These complexes are put into the seed by the original photosynthetic processes and by the processes of *synthesis* which occur during the ripening and after-ripening period. In these synthetic processes, moisture is released as the seed's carbohydrates and proteins condense down into more stable configurations.

The endosperm of corn seeds is highly involved in after-ripening. It is largely composed of starch complexes interlaced with plastids that give corn its characteristic yellow pigmentation. These plastids, like all plastids, possess their own genetic material although they are without mitochondria and nuclear DNA. Unlike the germ which develops from the fertilized ovary, the endosperm develops from unfertilized ovarian tissue and does not undergo cell division because it lacks nuclear DNA; thus, the plastids are agents that facilitate seed chemistry transformations in the endosperm.

Endosperm tissue is generally short-lived in the development of most seeds, but this is not the case with corn seeds. In corn (grass-seeds), it becomes a valuable reservoir in which an abundance of photosynthesized food is accumulated. In fact, the endosperm, especially in corn seeds, becomes the visibly dominating structure of the seed.

WORKING "WITH THE GRAIN"

Nature does things with uncanny ease if obstacles aren't put in her way. When they are, all kinds of unexpected things begin to happen. Misinformation about values in grain and misdirection in the management of grain are sources of self-inflicted grief, waste and expense that are communal losses. If one wishes to preserve the values in grain by curing and drying with naturally provided seasonal conditions, one must operate within the tolerances granted by the natural agencies at work in and upon the grain. This is precisely what HARVESTALL CHILLCURING$_{TM}$ does. Although the grain is stored in a man-made environment, that environment is controlled so as to best utilize nature's economies. *This is working "with the grain" and with the free economics of natural, atmospheric air. The meaning of "sustainable agriculture" is exemplified in this approach to grain-care, for by it, the science of nature's sustaining providence is humanly authenticated. <u>Nothing less than this kind of social discipline can secure a sustainable future for farmers, for nations, for humankind</u>.*

Whether or not a CHILLCURING$_{TM}$ System will in fact perform up to its user-friendly capabilities depends entirely on how the system is managed. Effective management practices are premised on knowledge: knowledge of grain and how grain cures *naturally*, and knowledge of environmental conditions and how they affect grain in its storage environment. Because these understandings are of critical economic importance to the individual farmer and to the world, true Grain Guardians recognize their obligation to educate farmers and the general public in the science of grain ecology and economy.

HARVESTALL, the marketer of CHILLCURING, recognizes its ongoing obligation to refine equipment and to simplify grain-care so that the operation of the system and the risks to grain are less critically dependent upon the day to day decisions of the operator.

This is where the application of programmable, solid-state electronics can be helpful. As understandings are acquired and electronic tools are refined, they may be joined so as to improve economies and facilitate management. Technological tools are available today which are capable of integrating certain variables into a logic that may be somewhat independent of hands-on judgment. Nevertheless, there can be no substitute for "farmer savvy" in dealing with the unpredictabilities of Nature when it comes to managing stored grain.

Honest marketers of corn drying and storage structures need to be "*responsive to farmers' needs*", that is, knowledgeable of "*true values"* in grain that come from after-ripening.

DORMANCY.

Temperature and moisture are interdependent factors that affect seed dormancy. A sustainable environment is maintained in the grain by periodic ventilation which purges the accumulations of free-moisture and free-heat that are slowly released by respiration and that accumulate under influences of atmospheric conditions. *Based on corn storage studies of grain temperature/moisture, an operable dormancy index identifies corn seed stability as "18/40", that is, when seed moisture content is 18% and the storage temperature is 40^{o}F.*† (See Table 3, p. 37.)

The exchange of moisture and gases (oxygen and carbon dioxide) that occurs between the seed and its environment influences the biochemical stability of the seed. Moisture in the seed may contribute to dormancy. As the seed "breathes", it uses oxygen and gives off carbon dioxide; as less oxygen becomes available to the seed's cell system, the concentration of carbon dioxide in the seed moisture may build up and may retard respiration; this CO_2 in the seed moisture may eventually be accessed for other biochemical uses. Still, a minimal amount of respiratory activity is needed to support the embryo during this dormant period. Exposing the seed to increased temperatures and moistures causes accelerated metabolic responses within the germ in preparation for germination, which increases the embryo's need for sugar.

The seed coat plays a critical role in seed dormancy. It has been shown that some freshly harvested cereal grains remain dormant even when moist, so long as the seed coat remains intact. The seed coat may accomplish this by sealing out fresh water and oxygen while sealing in residual seed moisture and carbon dioxide. Rapid drying shrinks and breaks the outer seed membrane, allowing oxygen, carbon dioxide and water to move in and out of the seed unrestricted. This may activate the embryo (and micro-organisms) by promoting accelerated respiratory activities and the oxidation of seed sugars.

The gradual elimination of seed moisture occurs naturally and slowly when the temperature is cold. By allowing the seed to release moisture at its own natural pace, it is possible to insure the integrity of the seed chemistry/structure, promote dormancy and maximize the "added value" of after-ripening.

†Sylvester Lawrence Steffen, "Effects of Drying Method on Germination of Corn," Diss., Iowa State University of Science and Technology at Ames, May 1960, p. 75. University Library.

Its content is of enormous economic value to human commerce because of the photosynthetic provisions warehoused in it. Historically, the fuel that drives the diverse, vital economies, including human, comes primarily from the seed endosperm; whether from seeds of maize, wheat, rice, rye, oats, or amaranth, soy beans, etc., these are essentially the *transubstantial "bread"* of living commerce, of *religious eucharist*.

.

The Seed Coat. The purpose of the skin is to protect. The seed coat functions as an enclosure that protects the germ and its food supply and regulates the seed's interaction with the atmospheric environment. The endosperm is enclosed by surface cells (aleurone) in which the seed proteins accumulate. The protein accumulations in the aleurone cells consolidate interdependently with the outward movement of moisture from endosperm starch. The seed coat's inner surface is also in contact with these aleurone cells. The inner skin-cells function as a moisture-exchanging buffer between the aleurone cells and the atmospheric air. The seed coat prevents desiccation of the seed and allows the processes of maturation to continue while dissipating the released seed moisture into the atmosphere.

BODY CHEMISTRY.

Chemical Synthesis. The chemistry of life is the chemistry of water and carbon dioxide. Carbon (C), hydrogen (H) and oxygen (O) are the basic construction materials of all biochemistry. Water is not only the provider of hydrogen and oxygen atoms to the alchemy of life, but is the biological medium of all cell function and is the energetic environment which enables the chemistry of life.

When the seed has matured and no longer needs the plant water for translocating materials from the plant to the seed, excess water can begin to be evacuated. The elimination of water occurs at the point where the kernel attaches to the cob; it is through this conduit (wick) that moisture first entered the developing seed and through which it is also released. Unless grain allows for the evacuation of excess water, the ingredients of the seed would be exposed to biodegradation.

When the glycosidic materials (sugars) are no longer produced photosynthetically by the parent corn plant, the processes that stabilize the seed's chemistry begin in earnest. The movement of water may now reverse its direction, i.e., the excess water, in its free state, may begin to exit from the seed. This stage of maturity is indicated by the formation of the *hilar cap*, a dark membrane at the seed's tip. The individual seed now functions as an independent organism—a living system in its own right.

The new organism's first major task is to consolidate its accumulated food materials. The build-up of stored energy in the seed (carbohydrates, proteins and lipids) may be likened to "charging the battery", for energy potential is stored and stabilized in these macromolecules. More than 85% of the seed is food stored in large molecules. These macromolecules are the result of a long succession of glycosidic linkages that synthesize long, stable carbon-based molecular chains.

The process of "chain linking" is catalysed by the elimination of water components, that is, the hydroxyl (OH) and hydrogen (H) radicals. At each new linkage in the chain, a molecule of water is released for reuse and may eventually, after many transformational usages, be cycled out of the linked food system.

Chemical Hydrolysis. The embryo cannot use the complex chemical compounds as a food source until they are “digested” through the process of *hydrolysis*. Hydrolysis is the conversion of stored starch to sugars, the conversion of stored protein to simpler proteins, and the conversion of fats to fatty acids. This process involves the loosening of chemical bonds through the addition of water. The more complex the original compound, the more water molecules need to be restructured into it in order to bring the macromolecule to simpler, more usable chemical states.

Hydrolysis is the reverse of synthesis. Just as a molecule of water (HOH) is given off at each linkage site in the consolidation of complexified molecules, so a molecule of water is restructured back into the larger molecules to reconstitute their molecularly less complex constituents. To do this, the OH and the H radicals must return to where they came out. To facilitate this process, a certain amount of water must be accessible to the seed for restructuring back into the kernel's chemistry.

Whenever a molecule of water is put back into the seed’s carbohydrate system, the "dry" matter of the kernel is increased by the molecular weight of the hydrogen and oxygen molecules that are reintroduced into the macromolecules. These reintroduced components of water are no longer water. And providing that these new products are not immediately consumed, the marketable "dry weight" of the grain is actually increased.

Generally, the conditions for germination are the conditions

When the ventilation fans are not running, wind-induced ventilation on the surface of the grain helps to keep the grain cool by removing heat from the attic space under the roof and at the grain's surface. This also helps to draw air up through the column of stored grain. Naturally induced ventilation is beneficial to sound corn keeping and to reduced fan ventilation.

Cycled (Programmable) Ventilation. The practice of nonstop, single-speed ventilation is an energy-wasteful practice. The release and movement of free moisture from the seed to the storage environment slows down as the seed matures and when it is kept cool. To repeat: when grain is CHILLCURED, less ventilation is required because cooling slows down the seeds' chemical activities and water release.

Interrupted ventilation allows the seeds time to release moisture so that drying may be more effective when ventilation is resumed. With managed ventilation, the stored corn itself can become an "active" reservoir of solar heat. When the sun shines the air naturally contains a more than adequate supply of heat for drying; as ventilation continues, the dried grain will rise to the daytime temperature. Toward the end of the day, after the grain has been charged with the day's solar heat, ventilation may be discontinued. Then, in the following early morning hours, ventilation can again be resumed; the air will pick up the stored solar heat in the grain and use it to dry the upper layers of wet corn. Such a pattern of cycling can be repeated on a daily basis and modified over time as the grain moisture content and weather conditions allow, improving whole-bin drying and electrical conservation.

Weather fronts may set up conditions that make the air behave as a "water pump", that is, cause the removal of greater than usual amounts of water from the grain/air. For example, when a cool weather front passes through and the atmospheric temperatures begin to drop, larger amounts of moisture (and heat) will be released from the warmer grain as it is ventilated. [*If, however, the air temperature drops below freezing, care should be taken not to freeze the corn. Moist grain should not be allowed to set for long periods of time without ventilation, particularly if grain temperatures drop below freezing, because frost may accumulate in the airspaces. Extremes between the grain temperature and the atmospheric temperature should be avoided*.]

A simple timing device can be used for periodic, pre-programmed ventilation. Multiple, smaller horsepower fans allow for variable-rate ventilation. The strategic ventilation of stored grain affords very significant economies.

GRAIN/AIR RELATIONSHIPS
Depths • Volumes • Pressures

Cfm/bu	SP	Cfm/bu	SP	Cfm/bu	SP	Grain depth to the eaves.
				1.4	8.2"	21'
		0.8	2.6"	1.8	7.9"	18'
1.4	3.5"	1.0	2.2"	2.3	7.4"	15'
1.9	3.0"	1.3	1.8"	3.1	6.8"	12'
2.7	2.6"	1.7	1.4"	4.6	6.0"	9'
4.4	2.0"	2.7	1.0"	7.7	4.9"	6'
9.7	1.0"	5.5	0.6"	17.6	2.9"	3'

Vane-Axial 3450 rpm	Centrifugal 1750 rpm	Centrifugal 3450 rpm	
1 HP/1000 BUSHELS	1 HP/1000 BUSHELS	2 HP/1000 BUSHELS	
Bin dia 33'	Bin dia 30'	Bin dia 27'	*Three examples of bins holding each approximately 10,000 Bushels.*
Grn dpth 15'	Grn dpth 18'	Grn dpth 21'	

The above figure illustrates the performances of fan options. The actual performance may vary with the fan make. Obtain a **certified performance rating** for your particular fan from the manufacturer.

be used. *As a rule of thumb, in a given storage system, a four-fold increase of fan horsepower is required to double the volume of air, that is, 4xHP = 2xCfm/bu.* Optimally, it is desirable to get as much air flow as possible with the least expenditure of electrical power. Since the HARVESTALL CHILLCURING system generally operates at static pressures (SP) under 3.5 inches (water column displacement), vane axial fans are the most economical. Since the volume of air flow through the grain is a critical variable, the successful operation of the system depends greatly upon the engineering of the ventilation, that is, upon having the right fan for the application. All components of the system must function compatibly in order to maintain proper ventilation.

under which hydrolysis occurs; these conditions generally provide also for an increased uptake of oxygen and increased respiration. In the seed, however, it may be possible to have hydrolysis occur even while dormancy restrains respiration. Under controlled storage conditions, hydrolysis may allow for higher levels of available food and increased weight in grain. This may come about through the utilization of *residual* seed moisture as the stored starch and stored protein convert to simpler sugars and proteins. It is important to recognize that hydrogen and oxygen (OH and H radicals) are real and important contributors to grain weight and should not be forced out of the kernel's chemistry.

GLYCOSIDIC COMPLEXES.

Carbohydrates. Carbohydrates constitute the most abundant fuel source available to living plant systems; sugars and starch comprise the primary food components, and cellulose, the primary structural component.

Glucose is the basic plant and animal food that is produced by green plants and stored in seeds. Simple sugars are converted into polysaccharides (complex glycosidic chains) and ultimately into long-branched starch chains in the mature kernel. Glycosidic linkages occur with the release of water from the sites where the glucose rings are joined. The site of linkage is critical in determining whether a particular chain of glucose molecules becomes part of the stored food (starch) or part of the structure (cellulose).

Starch molecules are chemically inclined to assume a stable configuration by way of condensation that endures for as long as environmental conditions allow. Greater chemical complexity generally means greater stability.

Lipids. The term “lipid” refers to substances such as fats, fatty acids and esters. Like starch, true fats are reserve fuel materials in seeds. In cereal grains, fats are located primarily in the germ; during germination, fats are mobilized to fuel the developing embryo. The accumulation of fat in seeds takes place during the development of storage tissue; this formation occurs in the seed itself with the conversion of sugars to fat.

Before a polysaccharide (a complex sugar) is converted to starch, it may undergo selective processes which convert it into a fatty acid. Fatty acid molecules are generally composed of carboxyl acids (COOH) and long hydrocarbon (CH) tails.

Fat molecules are made up of fatty acid chains and alcohol radicals. They are produced by the process of *esterification,* whereby three fatty acid molecules chemically react with glycerol to form an *ester*. An ester is generally composed of an acid and an alcohol radical. Again, this is a reaction involving condensation, i.e., water is released as a by-product of the chaining process.

The fact that fats and carbohydrates share common chemical origins and linkage sites explains why sugars can be produced from fats. The by-products of these biochemical processes, including CO_2 and the radicals of water, may be recycled in the production and maintenance of food stores and structures within the living system. Plants do not produce "waste". The by-products of one reaction become the raw materials for another reaction.

The fat content of the endosperm is considered to be generally negligible; however, in view of the close relationship that exists between fats and carbohydrates and the versatility of enzymes to catalyze and restructure molecules into glycosidic linkages, the fat potential of the endosperm may yet be underestimated.

Proteins. Proteins are often referred to as the "building blocks" of life. Many of the physical, chemical and biological properties of living materials are derived from proteins. Enzymes constitute much of the protein within cells; their function is to mediate the metabolic processes of living cells. Specialized proteins in the cell nucleus are the major constituents of chromosomes whose function is to determine the reproductive and genetic characteristics of the particular, living organism. Proteins in mitochondria participate in the energy metabolism of glucose.

The synthesis of proteins is initiated in the plant's root cells where elemental nitrogen is transformed into simple amino acids. During the development of the seed, these simple amino acids undergo condensation through the release and reuse of water radicals (similar to the process involved in the production of polysaccharides) and are transformed into long-chained polymers. This process of polymerization is a highly specific and apparently invariant process involving a complex series of enzyme-catalyzed reactions by which peptide bonds unite chains of amino acids and release water. Protein complexes are even more heat-sensitive than carbohydrates.

Enzymes. At this point, it is useful to explain the roles of *enzymes*. Enzymes are the protein complexes which catalyze cell metabolism. Their function is to initiate, accelerate and participate in the metabolic processes that *synthesize* raw materials into more complex structures by the removal of water, and that *hydrolyze* the break down of com-

the grain mass so as to remove the released seed moisture and heat from the storage environment.

VENTILATION.

Grain/Air Relationships. Seasonal temperatures/humidities are somewhat predictable and so are the effects of these seasonal factors on the removal of seed moisture. The chemical release of water from the seed is a factor mainly of seed temperature. This release of water is accompanied by the release of heat. As freed moisture builds up, so does the heat. The amount of ventilation required to remove moisture and heat from the stored grain mass is determined by the rate at which grain releases moisture; this is a function of the volume of grain and its maturity. Rightly engineered ventilation is critical. Evaporative cooling contributes to ventilation economies. This fact of physics/biology explains the great economic benefits of CHILLCURING, as a process for drying the grain, as well as for preserving superior quality in grain.

An appropriately sized storage system should be able to accommodate 25% corn at about 3/4 of the storage capacity. This helps to prevent delays in harvest even under less favorable harvest conditions. Spreading the harvest over a ten-day period of time greatly adds to the efficiency of the system's performance. If very immature corn persists through Fall, an even longer period of harvesting might be recommended; and if adverse conditions continue, it may be acceptable to fill the bin during Winter, while maintaining essentially non-stop ventilation of the grain, though not necessarily using the full fan(s) ventilation capacity.

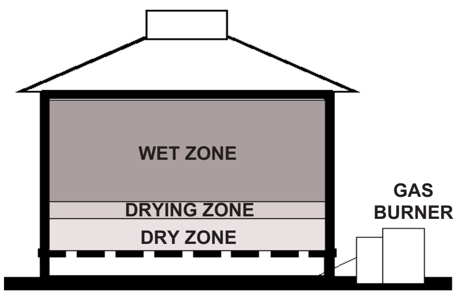
Adequate (but not excessive!) air flow needs to be provided to grain for its proper care and maintenance. The more mature the grain is when harvested, the greater are the management economies and the better the market qualities of the grain. Compaction, condensation and damaged grain are factors which may adversely affect the volume and the distribution of air. Such conditions tend to increase static pressures (which increase power consumption) and decrease air flow, thereby, putting the grain at risk. Preserving the physical integrity of the seeds at harvest cannot be overemphasized; harvesting corn with moistures under 25% greatly reduces harvest injury. Once the seeds have been stabilized (chilled), ventilation requirements may actually be quite minimal, so long as the seeds are not fractured and so long as temperature contrasts do not cause moisture to accumulate in the air spaces around the grain.

The depth of the grain column offers resistance to air movement; therefore, fans with the ability to overcome this resistance must

The plenum (dry-bulb) temperature and the exhaust-air (wet-bulb) temperature readings give direct indications of seed moisture throughout the course of ventilation. Selective control of wet-bulb depressions during drying can provide selective control of the final grain moisture content within naturally occurring limits.

Circadian Rhythms. The natural rhythm of day following night has, over time, come to be biochemically essential in the cyclical stages of all living organisms. The recurrence of this rhythm qualifies "the wheel of life". This is also true in the life of the grain seed. Knowledge of cyclically dependent biochemical responses is helpful in making management decisions that best preserve and access biological (market) values in live grain. In the management of stored corn grain, natural cycles are related to the seasonal and circadian (day/night) fluctuations of atmospheric temperature and relative humidity.

These cyclical fluctuations are induced by light and darkness which impact the molecular harmonics of the seed and the air. Temperature fluctuations benefit grain by allowing the effects of cooling and moisture removal to take place in the upper regions of the grain column. The temperature differences from the daytime highs to the nightime lows are useful fluctuations which facilitate "whole bin drying" and bring grain moistures to a more uniform content from top to bottom. "Whole bin ventilation" minimizes the zonal layers of overly dry, drying and undried grain.



GRAIN MOISTURE IN HEATED-AIR DRYING SYSTEMS

The use of flame-heat in bin-drying corn typically creates stratified zones of uneven moistures in the grain column, i.e., a ***dry zone*** at the bottom of the grain column, a ***drying zone*** immediately above the *dry zone*, and a ***wet zone*** above the *drying zone*. Grain in the *wet zone* is most susceptible to mold, respiration and spoilage because of its constant exposure to warm, saturated air over long periods of time; grain in the *dry zone* is particularly subject to cracking and crumbling, especially when stirred.

The stability of stored corn seeds depends on the proper management of fluctuations in atmospheric temperature and moisture so that seed dormancy is maintained. This is accomplished by ventilating

plex structures into simpler, more usable forms by the addition of water to their chemistry.

Enzymes are the “doers” in living systems. The efficient operation of living systems depends on the ability of enzymes to carry out their functions in all phases of cellular activity. They enable systems to draw upon external sources of energy; they speed up chemical reactions which would otherwise proceed more slowly; they can reverse the normal direction of a reaction; and they determine which activities will happen and which ones will not. They are responsive to specific conditions in the organism and engage in their tasks as the need arises. When shortcuts to action are needed, they find them. They keep the biochemical surpluses and deficits in balance. When energy is needed, they tap into the larger macromolecules of stored food to get it. In effect, they are the governing agents that control and regulate the goings-on of living systems.

To supply cells with glucose, e.g., the seed's embryo, a great many enzymes are involved. Some may function to produce glucose from carbohydrates; some may to produce fats from proteins. When the levels of glucose increase to excess, different enzymes may be activated. The triggering mechanism that activates enzymes may, for example, be the concentration of glucose itself. As the levels of glucose decrease, the cells may activate these enzymes and cause monosaccharides to be metabolized.

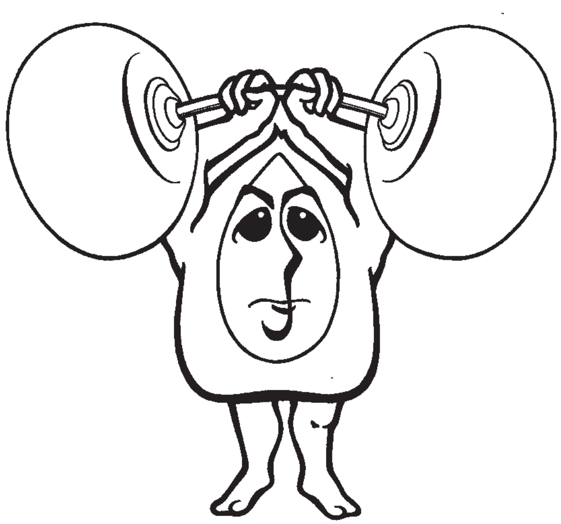
By engaging or disengaging specific genes, the living cell controls the kinds and quantities of enzymes needed. This control is critical to the proper functioning of the organism. Since most cells “burn” large quantities of glucose, enzymes that break down glucose and enzymes that obtain glucose from larger, more complex molecules may out of necessity be present simultaneously.

The burning of "fuel” (glucose) occurs in the mitochondria of cells. The mitochondrion is a microscopic organelle with threadlike structures containing enzymes which function in respiration and other energy-consuming biochemical cycles.

Living systems are composed of specialized cells within the organism. For example, in the cornseed, the embryo cells are different from the endosperm cells. These specialized cells perform specialized functions, and consequently, they possess dramatically different enzymes able to engage very specific tasks. The functions of specialized cells are determined by their specific chromosomal structuring. For example, the scutellum is a food-digestion and storage organ that connects the embryo (and feeds) to the endosperm. Controlled levels of glucose are maintained in the scutellum to provide for the metabolic needs of the embryo. If the embryo is exposed to circumstances that accelerate its respiration and deplete its sugar reserves, enzymes may be activated in the scutellum to restore reserves to needed levels.

Accessible moisture must be present for glucose to be extracted (hydrolyzed) from polysaccharides. The hygroscopic nature of seeds, i.e., their ability to absorb moisture from the atmosphere and lose moisture to it, may explain in part the ability of seeds to become dormant for many years, that is, to use very sparingly their stored food reserves and dip into them only as needed for the embryo's survival.

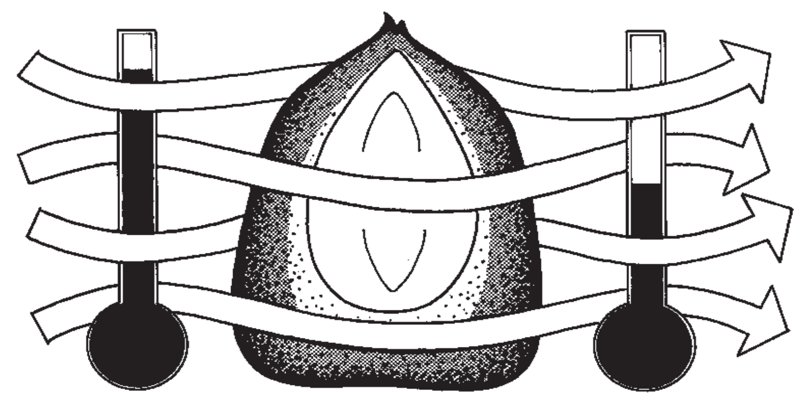
All seeds must be able to adapt to short-term changes. A substantial change in the concentration of a certain enzyme may result from a change in the environment, i.e., a change in temperature, humidity, etc. Enzymes are sometimes needed in vast amounts and at other times in lesser amounts. For example, the germinating seed engages more kinds and greater quantities of enzymes than the dormant seed.



Increases in seed temperature accelerate seed activity. Temperature increases in grain for purposes of forced moisture removal are stressful to the grain and contribute to deterioration and shrinkage (weight loss). Healthy, unstressed grain retains its maximum value and weight. Moisture should be removed from the grain only as required to maintain its stability. <u>Drying grain more than that is a waste of grain weight, energy and money</u>.

Temperature Differential. When water evaporates from a surface, it causes that surface to cool; the chilled temperature of evaporative cooling is called the "wet-bulb" temperature. The evaporation of moisture from grain also causes the grain to cool to the wet-bulb temperature. A reading of the dry-bulb and wet-bulb temperatures indicates the relative humidity as well as the equilibrium moisture to which the grain can come at those prevailing conditions.

Freshly harvested grain has a relatively high moisture content. When the grain is ventilated, its *free moisture* evaporates and the grain is chilled to the prevailing wet-bulb temperature. The heat-loss from "evaporative cooling" is measured as the ***temperature differential*** between the *dry-bulb* (ambient air temperature) and the *wet-bulb* (bin exhaust-air temperature); the temperature differential serves as an indicator of the grain "drypoint" (the equilibrium grain moisture at a specific temperature and relative humidity).(See Table 2, p.36.)



DRY-BULB **WET-BULB**

The temperature differential is greatest immediately after harvest when the grain is wettest. As grain moisture approaches equilibrium with air-moisture, the difference between the dry-bulb and wet-bulb temperatures decreases; when grain-moisture reaches equilibrium with air-moisture, there is no temperature differential because no evaporation is taking place. Continuous monitoring of the differential temperatures provides a reliable indication of grain moisture equilibrium, thus providing sure knowledge and peace of mind regarding the progress of drying and the grain's safe-keeping. The Corn DRY-POINT$_{TM}$ Table on p. 35, shows seasonal normals of dry-bulb and wet-bulb temperatures, a useful management tool for drying corn.

SYSTEMS' ENGINEERING.

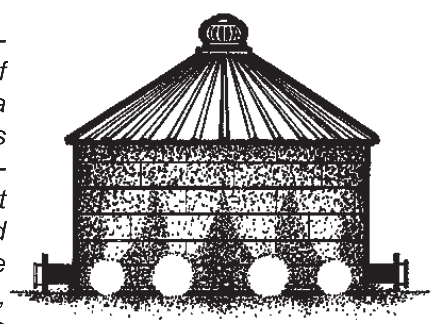
While most conventional grain drying systems use *temperature-rise* as their measure and control of grain drying, the pioneer process patent†, marketed by Harvestall Industries under license, teaches biologically sustainable drying, not by the additions of heat to raise the temperature of the drying air, but, *by the removal of heat from the drying air and by the evaporative cooling of the grain to temperatures below atmospheric (dry bulb) temperatures*.

NATURAL ECONOMIES.

TEMPERATURE.

Infrared Sunshine. Infrared energy from the sun warms everything; it is the energy of life. The wave energy of infrared is what gives warmth to corn, water, etc., by harmonic attenuation. When water is cold, it is ice; as the water molecules are exposed to infrared radiation, they become more excited. The water changes from solid to liquid, from liquid to vapor, and with prolonged exposure to specific wavelengths at sufficient intensities, even the vapor molecules may catalytically disassociate.

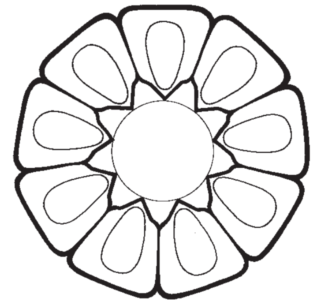
Even under adverse seasonal conditions, sufficient radiant energy (solar heat) is available to bring seed moistures to safe levels. Solar heat is absorbed and collected by atmospheric air. GRAIN CHILLCURING$_{TM}$ is a “solar technology” which utilizes this natural resource by drawing in large volumes of atmospheric air and passing it through the grain. The grain itself is an effective collector of solar energy which is naturally used in seed processes.



Supplemental Infrared.

In addition to deactivating airborne mold spores, the use of infrared GRAINLAMPS^{TM} as a supplement when the sun is not shining, raises the ventilation air temperatures by about 1^{o}F. Electrical motor heat and fan blade friction also increase the air temperature. In all, these factors approximate the normally available free heat provided by atmospheric air under seasonally favorable drying conditions.

†U.S. Patent #4,800,653: "Method and Apparatus for Controlling the Drying and Cooling of Field-Harvested Seeds in Storage," January 31, 1989. S. Steffen



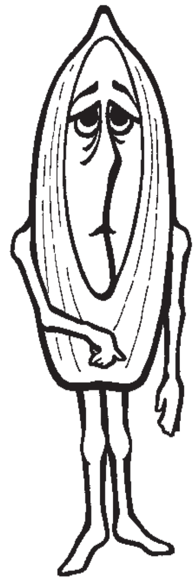
II. CORN ECONOMY.

In the common "home" of the living, Nature has apportioned the orderly means by which all are bound interdependently, sustainably. Because humans possess a greater consciousness of the intimate workings of this network interdependency, they can choose either to exploit this Sacred Order for disproportionate self-advantage or to accommodate personal self-advantage to the proportional economy that extends Nature's distributive harmonies to All Other.

When we conscientiously conform our personal *being, doing and having* to the cybernetic economy of Natural Providence, we provide a sustainable future also for our own kind.

The "culture of Life"—agriculture—is an obligation belonging to all human beings. Metaphor and Reality, "Corn economy" is the conscionable act of "breaking Bread" in a *sustainably providential* manner. In our care and use of Living Grain, we may learn to become more aware of how to care for Earth's network life and for our own communal and personal selves.

THE BODY AT RISK.



Kernel moisture must be appreciated for its resource value to the living seed. Seeing moisture only as a threat to be eliminated by all means and at any cost is a *life-threatening* error. This prejudice against water has given rise to much wasted energy as a result of gas-heat drying, and much wasted grain because of the damage that kiln-heat inflicts on the seed.

The forced removal of water from the seed (drying with heat) deprives it of a resource necessary for its biochemical processes to occur. There are other injurious effects that occur as a consequence of exposure to heat: the denaturing of protein, the destruction of cell walls, and general structural breakdown. The excessive removal of moisture and later reabsorption may cause increased respiration (mold) and the further depletion of the carbohydrate reserves in the grain.

The use of heat to dry grain forces water to be prematurely removed from the seed before its chemistry can be stabilized; and it may even "crack" the chemistry as well as the physical integrity of the kernel. The premature removal of water causes weight losses; damage to seed chemistry from heat exposure may disable the seed by preventing normal hydrolysis. This may lead to the loss of oils and fatty acids; proteins may become denatured; denatured proteins are unreactive and unavailable to sustain the viability of the kernel.

Heat is even more devastating to immature grain than it is to mature grain. In the economy of grain, the importance of preserving the structural and chemical integrity of the seed cannot be overemphasized. **Economic losses happen with:**

Accelerated Respiration. The breakdown and consumption of stored foods are accelerated, as is the production of heat, water and carbon dioxide when respiration is activated. The result is a burned-out, light weight grain seed.

Chemical Denaturation. Seed exposure to high-heat causes chemical *denaturation*. Carbohydrate/protein denaturation is a one-way breach. The more immature (wetter) corn seeds are, the more subject they are to chemical breaches. Denaturation involves an irreversible

and 40°F is at no greater risk of spoilage than corn at 14% moisture and 60°F. *The temperature of the corn is as much a factor in corn keeping as its moisture content*. In fact, if high heat was used to force the corn to dry down to 14% in October, it may be more susceptible to spoilage in February than 18% non-heat dried corn. Grain moisture content alone is only partly responsible for securing grain quality. *The objective of least cost management is to hold the grain at the highest allowable moistures compatible with prevailing seasonal temperatures so as to preserve the greatest seed quality.* Managing these relationships helps to conserve energy, both in terms of the external energy applied to maintain a stable storage environment as well as the internal energy potentials stored in the seeds.

"RE-STORATION": The Dormancy Stage.

Within eight months of harvest, stored corn is generally either sold or used up, but this may not always be true. Some may wish to carry grain over for an additional year or more. It is certainly within the realm of possibility to preserve grain value over extended periods of time and perhaps to a certain extent even to affect some enhancement of grain value.

During this stage of storage, even less ventilation is required than in the previous two stages; but again, grain must get air when it needs it, or it will suffer spoilage.

As it has been shown, certain benefits can be achieved in grain through the process of hydrolysis, i.e., increasing the content of "dry matter" by restructuring water molecule radicals back into the seeds' chemistry. Knowledge of the factors which permit controlled hydrolysis to occur makes possible a discipline which may facilitate its occurrence without uptakes of external moisture which accelerate respiration; the re-use of internal seed moisture may sustain and improve the quality of carbohydrates and proteins during prolonged storage. For example, the protein potential of corn may be largely unappreciated simply because it has yet to be discovered how corn protein can be converted by *naturally occurring* hydrolysis into its derivative proteins. Controlling the storage environment by *holding grain at seasonally low temperatures* *and at correspondingly safe moisture levels*, (see Corn DRYPOINT$_{TM}$ Tables in Appendix, pp. 35-36) may allow just such processes of hydrolysis to occur.

the pace of chemical restructuring and moisture release may be decelerated. Cooler temperatures do not allow chemical changes to take place as rapidly as do warmer temperatures—which slows down the kernel's release of free moisture. "Curing" (the process of after-ripening) allows the seed to use moisture at its own pace. Generally, field-shelled corn is not biochemically mature at harvest; once it reaches a temperature/moisture equilibrium with the prevailing atmospheric and environmental conditions it becomes stabilized. Over time the seeds continue to release respiratory heat and moisture which may accumulate and create conditions that promote spoilage. Ventilation helps to reduce the risk of spoilage under these conditions.

Grain is the most perishable immediately following harvest. Protecting seeds from harvest injury is of critical importance; harvest damage to seeds is a primary initiator of spoilage. Quickly removing the heat from the seeds by ventilation (evaporative cooling) immediately following harvest is also critically important for the long-term keeping of corn grain.

"CHILL-AERATION": The After-Ripening Stage.
Once the grain is cured, its activities are greatly diminished and only periodic ventilation is required. Although the ventilation requirements are greatly reduced, ventilation is still important, for the slow accumulation of respiratory by-products continues as does condensation due to seasonally contrasting air temperatures. When grain needs air, air must be provided, or it will spoil just as surely as it will during the "Chill-Curing" phase.

The surface grain (along the bin wall and at the top of the grain column) is exposed to dramatic fluctuations of temperature; these temperature fluctuations may vary greatly from the grain temperature. Extreme contrasts in temperature can be very hazardous to the safe keeping of grain, for they may cause convection currents within the grain mass and may cause moisture to migrate; this moisture may condense at the surface center of the grain column and activate molds, resulting in hot grain. The cardinal rule of good grain management is: **avoid temperature extremes!** This can only be accomplished by selective ventilation.

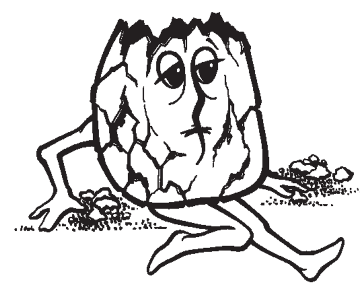
For winter storage, grain temperatures should be maintained within a range of 30°-40°F; for summer storage, 50°-60°F. Remember, cooler grain better tolerates higher levels of moisture, and this ultimately favors better grain and better grain keeping.

Mistaken notions exist as to the *safe* moisture content for stored grain. Contrary to conventional wisdom, corn at 18% moisture

compromise (breakdown) of biochemical bonds—the most active of which are the bonds that link the radical components of water (H-OH). The forced chemical disconnection of water components from the carbohydrate/protein chemistry may directly account for the loss of chemical solubility as well as the loss of substantial grain weight, known to the farmer as "grain shrink". *This weight loss is a direct loss to the farmer who gets paid for the **scaled weight** of his grain*.

Denatured Protein. Amino acids are simple proteins which deteriorate easily. Temperature increases can irreversibly change the chemical structure of these proteins and diminish their usability. Seed enzymes, too, are protein compounds that are readily subject to heat-provoked denaturing. When enzymes degrade, they lose their ability to perform their specialized functions.

Crumbling Structures. When cells are parched dry, they crack and crumble just as parched land does. When this happens, grain integrity is destroyed. *Kernel ingredients crack up and become dangerous, highly explosive dust.*



The protective function of the skin is destroyed when it is desiccated and loses its integrity. *Living grain integrity is secured only when grain is saved from physical and chemical degrading*.

Sick and Sour Grain. Ever present mold, bacteria, etc., (in and on grain) become active when heat and moisture are left to stagnate in the air spaces around stored grain. As molds become active, they spread their infestation and invade the seed, especially at sites where the integrity of the seed coat have been compromised by bruising and breakage.

When the spread of mold becomes visible, it becomes very obvious that the grain is perilously sick. As the infestation progresses, death ensues and seed sugars begin to ferment and produce the characteristic "sour" smell that accompanies the production of alcohol from grain.

But none of this needs to happen. Grain can easily and economically be preserved in a sound, sweet and healthy state—in a perfectly live condition—if nature is given a chance. Seed-sensitive management begins at harvest, with care to avoid inflicting unnecessary damage to the seeds. Ignorance of the value and the sensitivity of live grainseeds leads to mismanagement and to costly losses.

"EVER-NORMAL" CORN KEEPING.

Grain has a storied past sequenced in its genetic memory. Grain's genetic heritage suffers the whims of humans who at times ignorantly trash it when they could intelligently preserve the encoded potentials composing each and every grain seed. In the practice of grain keeping, we would be well advised to accommodate our conduct to the biologically encoded imperatives which naturally enhance the food worth of cereal grains.

The *curing* of grain is an invariant, biological process as certain as the coming and going of the seasons. The inherent mechanisms behind the evolution of cereal grains have caused them to accommodate to the circumstances of their environment in a way that enables them to produce self-sustaining, viable seeds. Human interference with grains' genetic mechanisms, e.g., hybridizing for artificial and mechanical advantage, has caused much frustration for grain producers. Tampering with natural, seasonal and bioregional constraints introduces artificial complexities. For example, producers who select high-yield hybrids are well advised to plant varieties of corn that are able to reach maturity within the time period allotted by their zonal growing season; this is important in order to produce mature corn (under 25% moisture) which is ready for harvesting at the end of the growing season. The field-shelling of wet corn (moisture content above 25%) should be avoided because the as yet soft seeds are easily bruised and crushed. This damage sets the stage for multi-faceted spoilage in the handling and storing of the grain.

The ventilation of the grain after harvest needs to be adequate in order to stabilize the grain in its storage environment. The immediate ventilation and chilling of freshly harvested grain to the wet-bulb temperatures (by evaporative cooling) affords many benefits to the grain:

1. free moisture is removed from the storage environment
2. seed respiration is slowed down
3. mold spores are prevented from becoming active
4. risks of biochemical degradation are diminished.

Almost every farmer knows something about drying grain. Indeed much study and research have been done to find ways to remove water from grain, usually with very little consideration given to how the "quality" of the grain is affected, specifically, seed-life. The prevailing assumption seems to be that although Mother Nature can be trusted to produce the grain seeds, she can't be trusted to dry them. And so man's schemes have been applied to dry grain prematurely, and Mother Nature has been largely ignored and slighted for her technique of doing it.

It is not only a true assumption but also a self-evident fact that Mother Nature also safely dries corn. If this were not true, annual grasses would not exist, for their survival within the context of their environment (prevailing, seasonal temperatures, relative humidities, etc.) is dependent on the successful production and preservation of live seeds.

A highly sophisticated, natural accommodation exists between atmospheric air and living seeds which allows seeds to ripen and dry down when exposed to natural, open air. When grain is removed from its natural, open-air environment, it cannot cure as it normally would. Placed in a new and artificial environment, hostile forces may soon come into play, and the grain may spoil unless conditions allow it to ripen and naturally dry-down. It is the fresh, sun-drenched open air that provides all that is needed to cure and dry corn seeds. Natural dry-down and after-ripening occur in stages which have different ventilation requirements.

Stages of Storage. The after-ripening management of corn grain in storage may be divided into three stages:

1. "CHILL-CURING": The Post-Harvest Stage
2. "CHILL-AERATION": The After-Ripening Stage
3. "RE-STORATION": The Dormancy Stage

"CHILL-CURING": The Post-Harvest Stage.

"Curing" is the process of chemical consolidation and the release of moisture by freshly harvested corn. The water that is processed within the kernel during curing moves toward the seed's surface, i.e., toward the seed coat which directs it out of the seed. The more immature the corn is at harvest, the earlier and more rapidly the moisture is released, which increases the need for ventilation.

The restructuring of seed chemistry is conditioned by genetics and environment; air temperature and relative humidity are the most influential environmental factors. By reducing the seed temperatures,