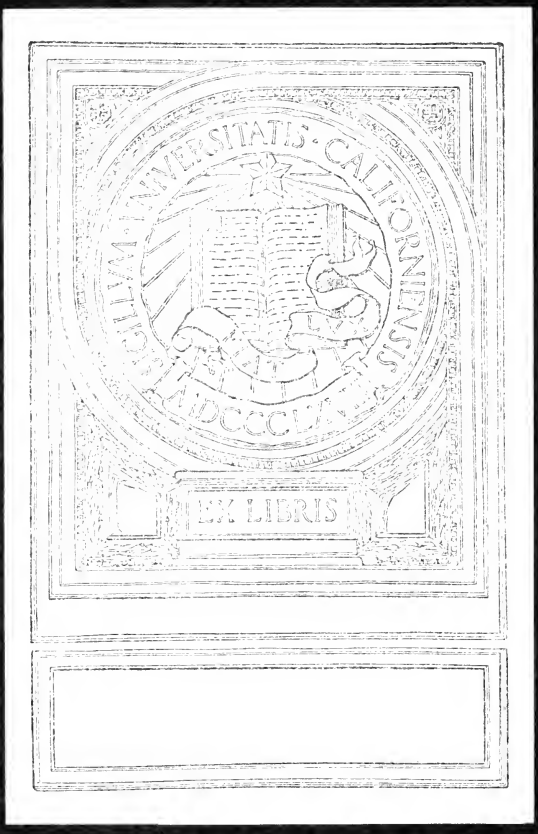
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BULLETIN

OF THE

UNIVERSITY OF CALIFORNIA

SYNOPSIS OF A COURSE OF LECTURES

ON THE

Origin, Composition, and Functions of Soils, and their bearing on Agriculture.

Delivered at the University of California, during the first Term, 1874-5.

PROF. EUG. W. HILGARD.

Definition of "Soil":

Different meaning as referred to different plants.

Judging of Soils by the natural growth.

Different forms of trees, etc., on different soils, and errors resulting from their neglect.

Exceeding complication of considerations in judging of the value and nature of soils, involving a very varied knowledge and careful judgment, or long and costly experimenting.

Hence necessity for scientific examination on the spot, and mechanical and chemical analysis of soils; to serve as guides for practice, or practical tests.

Necessity for coöperation between farmers and scientists, to prevent endless mistakes and expense.

Experimental Stations.

University Press, Berkeley

Origin of Soils.

Mechanical and chemical disintegration of rocks.

Mineral composition of important crystaline rocks.
Chief rock-forming minerals.
Quartz, the Feldspars, Mica, Hornblende, Augite, Talc (Serpentine.)
Calcareous Spar or Calcite, Dolomite, Gypsum, Apatite.
Decomposition of these by atmospheric agencies; Water, Carbonic Acid, Oxygen, Ammonia.
Quartz—soluble and insoluble forms.
Feldspars—formation of clays and carbonates.
Hornblende and *Augite*—formation of ferruginous clays, loams, carbonates.
Mica—difficult to decompose.

Sedimentary rocks—Sandstones, shales, limestones, how formed; their composition.
Character of soils derived from these several rocks.
Feldspar the source of potash.
Apatite that of phosphates.

Decomposition greatly accelerated by pulverization,
Effects of frost on rocks,
Mechanical Attrition.

Mechanical processes active in soil formation.

Action of flowing water.
Action of water charged with sand and gravel.
Action of glacier ice.

Composition of Soils.

General Soil Ingredients are

Unaltered Rock-powder.
Altered Rock-powder.
Clay.
Vegetable matter.

According to the proportion of these they may be classed as

LIGHT SOILS		HEAVY SOILS	
Sandy,	Humous.	Clayey,	Siliceous.

Definition of these terms.

Great diversity of sub-classification, adapted to local circumstances, and locally very important.

DETERMINATION OF CHARACTER OF SOILS.

Observation in the Field—Derivation, Position, Depth, Substratum, Natural growth, Climate.

Experience in cultivation.

Taking of fair specimens—difficulty—precautions.

Examination of subsoils best adapted to general purposes.

PHYSICAL PROPERTIES of soils—quite as important as chemical composition.

"Lightness"—"Heaviness"—Porosity—Absorption of aqueous Vapor—Waterholding power—Capillary coefficient—Color—Specific gravity.

Difficulty and tediousness of direct determination of these.

Mechanical analysis as a substitute, sufficient for practical purposes.

Elutriation. Subsidence method—faults.

Hydraulic method.

Apparatus of Noebel—Fresenius—Mueller—Schoene.

Mixed character of sediments, and inconstancy of results. Causes—"Flocculation."

Preliminary preparation—Boiling—removal of gravel and clay prior to washing.

The *Churn Elutriator* or *Soil-washer*—Construction—Precautions in use.

Character and nomenclature of sediments.

Direct determination of Clay by precipitation.

Action of common Salt. Lime.

Influence in formation of bars at river mouths.

Importance of Flocculation—Effects of tillage—"Woolly" condition—Tamping of clays.

Molecular properties of sediments—absorptive coefficients—mechanical resistance.

Estimation of tillability of soils; influence of sediments on "lightness" and "heaviness;" clay not the only factor of "heaviness."

Influence of Flocculation.

Porosity *vs.* Resistance to tillage.

Absorbing power of Soils.

Not in direct ratio to clay. Examples.

Influence of Sediments—of Ferric Oxide—of Humus.

"*Humus.*" Its origin, and influence on the physical properties of Soils.

Summary of functions of physical soil ingredients,

CHEMICAL COMPOSITION, AND ANALYSIS OF SOILS.

Elements concerned in formation of Soils.

Whence derived.

Nutritive and inert Soil ingredients.

Ash ingredients of Plants; derived from Soil; Carbon from Air, Nitrogen from both.

A priori view of Soil analysis—Composition of crops.

Fallacies. Distinction between available and unavailable portion of nutritive soil ingredients.

Difficulties, and attempts to overcome them.

Causes of failure—rejection of soil analysis.

Professor Johnson's arguments.

Discussion of objections. What soil analysis may fairly claim to do for practice, in application to virgin soils.

To identify and distinguish soils, thus making past experience available in new regions.

To determine their prominent characteristics, both physical and chemical.

To show abundance, scarcity or absence of important soil ingredients, thus indicating the general adaptation, permanent value, and cheapest mode of improvement, or maintenance of fertility.

Always provided, that systematic observation on the spot, of all circumstances influencing cultivation, and comparative examination of soils of similar origin, be kept in view. Mere columns of figures of little use.

Taking of Specimens—details.

Methods of chemical analysis; elements to be determined.

Choice of solvents. General Analysis—Details.

Determination of Phosphoric Acid.

Determination of "Humus" and Nitrogen.

FUNCTIONS OF THE SEVERAL CHEMICAL SOIL INGREDIENTS, AND THEIR CONDITION IN THE SOIL.

Outlines of Vegetable Physiology.

Experiments on growth of plants in soils devoid of organic matter; in solutions.

Object of the course mainly the consideration of the

indispensable soil ingredients, their distribution, functions and sources of supply.

Distribution of Ash ingredients in Horse Chestnut, Beet, Cereals, etc.

Amount and character of ashes in old and young leaves, stems, wood, etc.

Metallic Elements.

Potash. Percentage contained in soils. Examples. How contained. Feldspar—Zeolitic compounds. Mechanical absorption. Liebig's experiments.

Laws of surface absorption. Composition of drain waters.

Root crops especially exhaustive of Potash.

Potash manures in general.

Soda. Inferior in importance to Potash.

Small amount in soils—easily washed out, yet rarely needs to be supplied.

Salty soils—Salt plants.

Sodium salts used in agriculture.

Other Alkalies in minimum quantities.

Lime. Amount usually present in soils. Relation to Potash. Nutritive as well as stimulant.

Largely present in *stems*.

General importance as a soil ingredient, both physical and chemical.

Effects on mechanical condition of Soil.

"Flocculation."

Renders soils loose, pervious, tillable—"warms" them.

Chemical Effects of Lime—"fallowing" action.

Effects on organic decay, and formation of "humus."

How present—carbonate, sulphate, phosphate, humate.

Natural characteristics of calcareous soils—their growth, color, thriftiness. Examples.

Importance of a supply of lime to Agriculture.

Magnesia. Like lime, important *stem* ingredient.

Rarely deficient in soils—seldom needs to be supplied. Partially replaces lime.

Percentage in Soils. Numerical relation to potash. How present in soils.

Copiously carried off in drain waters. Soluble magnesium salts injurious to vegetation.

Alumina. Not a true ash ingredient, though often found in ashes.

Origin of clays. Varieties. Kaolin. Pipe-Clay. "Soapstone." Brick Loam.

Tints imparted to clays by Iron—changes by oxidation and reduction.

By Manganese—by Carbon—how recognized.

Recapitulation of the properties of clay as a soil ingredient.

Iron. Widely diffused, omnipresent, Nutritive as well as mechanically important. Tonic.

Hygroscopic efficacy of ferric oxide; chemical inertness.

Proto salts poisonous. Reduction of ferric oxide by vegetable matters. Yellow mud and blue mud.

Bottom lands—blue subsoils—"rusting" soils.

Iron in surface soils and subsoils.

White or "Crawfishy" soils—Black pebble or bog ore subsoils. Deterioration of soil thereby: causes.

Chalybeate Springs. Formation of Ferruginous sandstone.

Manganese. Vicarious of Iron. Less important.

Copper. In very minute quantities, in wheat, potashes, etc.

Non-metallics.

Silicon. Silica predominant ingredient of soils.

Sand and silicates.

Apparently unessential to plants but very largely absorbed by grasses, pines, etc. "Lodging" of grain.

Silica in drain waters—Acid soils—Action of lime.

Sulphur. Sulphates omnipresent. Small percentage in soils. Often deficient.

Cheaply supplied by gypsum. Sulphates in drain water.

Effects of fermentation on sulphates. Iron pyrites, etc. Remedies.

Phosphorus. Phosphates of highest importance to nutrition of plants and animals.

Derivation of soil phosphates. Small percentage—relation to Potash.

Accumulation in seeds. Small-seeded plants on soils poor in phosphates.

Their deficiency a common cause of sterility.

Must be currently restored to cultivated soils.

Effect of bone-dust on old pastures.

Chlorine. Present in all soils and plant ashes.

Correlative with Sodium. Rarely deficient.

Fluorine. Very generally present in small quantities. Most largely in bones.

Iodine. Common, in traces.

Carbon. Ultimately derived from air: directly in part from soil. Formation of humus by decay of vegetable matter. (Physical effects of humus on soils—see above).

Chemical effects on soil ingredients.

Action of Crenic and Apocrenic acids.

Oxidation of humus. Production of carbonic acid, the universal solvent.

Direct absorption of soluble vegetable matter.

Hydrogen. Absorbed by plants in shape of water.

Nitrogen. Highly important nutritive and constituent ingredient. Flesh-former.

Free nitrogen of air not assimilable.

Ammonia and nitric acid of atmosphere—absorbed by soil. Inadequate for crops.

Nitrogen in soil. How contained? Small percentage and largely unavailable.

Connection with humus—Nitrification accompanying oxidations, evaporation etc.

Ozonization. Formation of Hydrogen Peroxide.

Possible agency of microscopic plants in soil.

Necessity for artificial supply of Nitrogen for crops. Nitrogen Theory *versus* "Mineral" Theory.

General effects of nitrogenous manures on plants.

EXHAUSTION OF SOILS.

Recapitulation:

"All plant ingredients must be simultaneously present in sufficient quantities. Absence of *one* renders *all* inert."

"Supplying that *one* deficient ingredient enormously profitable."

"Excess of *any* lies inert in the soil as dead capital."

Hence the necessity for

Rotation of Crops.

Causes of necessity for rotation. Abstraction of different ingredients in unequal degrees by different crops.

Different depth of roots—fibrous and tap roots.

Examples.

Rotation utilizes soil resources best. Makes interest ac-

crue on the *whole* soil capital. Should be the guidin principle in all cases.

Order of rotation can be determined by analysis of crops

MODIFICATION OF SOILS BY ARTIFICIAL MEANS.

1. *By mechanical operations.*

Tillage secures looseness, easy penetration of roots, cir culation of air, soil-gases and water.

How nature tills—mulching, frost, wetting and drying.

Artificial condition of culture; overriding of natural ad aptations of soils and localities. Hence necessity fo tillage, preparation and cultivation.

Importance of depth of soil for equalization of extreme and safety of crops.

Depth of soil equivalent to cultivating larger areas, bu with less labor and greater safety of crops.

In shallow soils, crops are at the mercy of seasons.

Heavy soils need thorough tillage most.

Deep tillage—sub-soiling.

Chemical and physical differences between soil and sub soil.

Stirring versus turning up—conditions under which eithe may be useful or injurious.

Treatment of subsoiled lands, for maintenance of profit able productiveness.

Subsoiling not a preventive of exhaustion.

Drainage—Underdraining.

"Relieves wet soils:" but does a great deal more—use ful in all soils.

General plan of underdrains. Various methods, til drains, log-drains, brush-drains, etc.

Mode of action, difficulties and remedies.

Action of underdrains on clay soils. Analogy to subsoil ing; protection against drouth by deepening of soil.

Drained lands can be tilled at all times; are less cold; less liable to surface washing.

Advantages to public health.

2. *By addition of Material—(a.) "Mechanical Manures."*

Not often profitable by themselves—should be combined with other objects.

Management of natural drainage to effect desirable changes.