THESIS

ECOLOGY NOTES

COLD SPRINGS HARBOR

MISS DANA

JULY, 1900

Ecology.

Introductory Lecture, July 5, 1900.

Plant ecology is really the science of plant house-keeping or the study of the relations of plants or plant organs to their environments. Parts of plants, individual plants, and groups of plants have distinct relations to their environment.

Morphology of plants tries to answer the question "what?"

Physiology, the question "how?"

Ecology, the question "why?"

Ecology presupposes elasticity in the plant organism. Plants and their organs are adapted to, or working towards, adaptation to their environment. All things in nature have a meaning. We have a right to the question why. Plants may become less adapted to environment if the latter is changing. Rudimentary organs are less common in plants than in animals.

Variations may be looked for along three lines.

1. In different species. Finding intermediate links.
2. In separate individuals of the same species.
3. In the same individual.

The theory of multiple hypothesis calls for every possible explanation that will account for the phenomenon and then finding as many phenomena as possible which will not accord with the theory. The remaining theories will form a working hypothesis.

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Lecture 2, July 6, 1900.

Plant Functions.

Normal plants if there are such ; typical plants, a better name. Plant function includes nutrition, conduction, photosynthesis conduction, storage, respiration, digestion, transpiration, secretion and excretion, and movement.

1. Nutritive function. The five most important substances absorbed are O, CO_2, H_2O, organic and inorganic substances ; the first two are taken in through the stomates, the others by the root-hairs from the soil. Exceptions are found in submerged and desert plants. The former take theirs in from the H_2O through the skin, the latter from the air.

2. Conduction of raw material. O and CO_2 are in the leaves where they can be used. The others must be carried through the tubes.

3. Photo-synthesis. Carbon assimilation is a better term. $CO_2 + H_2O = CH_2O + O_2$ or and oxygen. CH_2O is a carbohydrate. Proteids introduce a new element N. Some N may pass through the stomata but not much.

4. Conduction to place of use. Xylem cells carry water. Sieve tubes of ploem carry the proteids. Sugar can be more easily carried since it passes through any part by osmosis. Starch can only be carried as starch in the milky juice of plants as in Euphoebia. The cross section of a pumpkin shows sieve tubes with a viscous fluid. The development of the flower is complex, since

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the unmanafactured material must be carried to the leaves and after being changed, must be taken to the flower.

5. Storage. Perennial plants show storage to the best advantage. Magnay is an extreme example. Proteids are stored up in seeds, and carbohydrates in almost all parts of the plant. Storage of water is greatest in succulent plants and very common in all plants, especially those which grow in the desert.

6. Digestion is hardly important to be classed under a distinct head since it is confined to carnivorous plants.

7. Respiration is one sort of oxidation. The external manifestation is just the reverse of protosyntax. The latter throws off O while respiration gives off CO_2.

8. Transpiration or the giving off H_2O, is of great importance ; it is evaporation and is modified by the plant. Warming attributes most things to it. It was formerly supposed that all the water was raised by the roots, but this view is thought now to be incorrect.

9. Secretion and Excretion. By excretion O is given off in photosyntax, H_2O by transpiration. All secretions and excretions are not necessarily given off through glands.

Plants have organs of secretion less fully developed than animals, yet their organs meet their needs since plants take in less unnecessary materials than animals, and consequently have less waste.

Examples of excretion are tannin, resins, gums and oils. Its function determines the nature of a gland. A secretion is a product which has some use in the plant organism. Some secretions

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are excretions. Glands may be external or internal. Dots on orange rind and spots on mint are external glands.

9. Movement. Lower plants like Algae have much movement. higher plants movement is confined to the leaves.

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Lecture 3, July 7.

Light.

The influence of light on vegetation is one of the most important factors in plant life. Light is absolutely necessary to all green plants, indirectly to all life. If things are parasites or saprophytes, they are indiresctly dependent.

Chlorophyll depends on light. Plants kept in the dark do not develop it and even lose what they had, as in the bleaching of celery.

Growth independent of sunlight is the result of stored-up food. A potato will grow in a dark cellar. Fungi have been found growing in caves on bits of tallow, droppings from the miners' candles. Plant gwowth is influenced not only by intensity but also by duration of light. Oats will ripen more quickly in some northern sections than in those lying further south. The reason for this is supposed to be partly the continued periods of light in the northern regions..

Other colors, expecially in autumn, are associated with sunlight. This coloring is usually found on the upper side of the leaf or on the under side if that has been exposed to the direct sunlight.

The opening and closing of flowers is also influenced by the light. Other factors also help to produce this effect. Too much light injures the chlorophyll.

Plant forms are greatly influenced by the intensity and duration

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of light. Trees of some species will have different shapes when standing alone or in forests.

Many plants may be divided into heliophilous (sun-loving) and heliophobous (shade-loving) as most forest trees. If we arrange forest trees according to their need of light, we would probably have an arrangement like the following :-
larch, birch, aspen, pine, linden, oak, beech. If a beech-nut can sprout in a beech forest while an oak cannot, the final stage of our forests will be beech forests.

All plants do not come under these divisions. Poison ivy has a wide range. A plant which adapts itself to a large habitat is plastic in its habits.

Heat.

Heat is one of the most important ecological factors, more important than light because of the great differences of heat distribution on the earth's surface. All plants have a certain heat range, from a maximum to minimum temperature. Neither of these is best adapted to the life-work of the plants. They develop best in temperature between called the optimum. This varies for different plants and for different functions in the same plants.

Heat influences chlorophyll-building, assimilation, respiration, transpiration, roof-activity, development of leaves and blossoms, growth, and movement. Variations below the minimum or above the maximum are not necessarily fatal to plants, most of which can endure a greater variation below than above.

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Many plants have become slowly adapted to a wider heat range. Most of our cereals are natives of a semi-tropical regions. Corn is becoming adapted to more northerly sections. No part of the earth's surface is entirely destitute of plant life solely because of absence of heat. In polar region plants carry on life and reproduction during sunless periods at a temperature ranging from 18° to 0°. 22 plants out of 27 carry on the work of reproduction at that temperature.

Many plants must acquire means for protection against extremes and sudden changes in temperature. The latter are more injurious than low temperatures, and sudden thawing is detrimental to plant organs. Plants on eastern exposure often suffer from night frosts since they are reached by the early rays of the sun.

Protection against low temperature.

1. Peculiarities in characteristics of protoplasm.

2. Changes in characteristics of cell contents. Many contain substances resembling resin. Ex. Snow Algae. One plant endured, unprotected, a temperature -46°.

3. Amount of Moisture. Much moisture predisposes to little endurance of low temperature. Young twigs suffer most from cold. In polar regions such twigs freeze stiff at night without injury probably owing to peculiarities of protoplasm. Dry seeds can endure many years in Artic regions.

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Air.

Winds have great influence on plant forms, and on their distribution. This is best shown when the winds blow over great, unbroken stretches of land, or where the force is broken by mountains, hills or forests. The influence of the wind can be seen in regions which have a loose, sandy structure.

Air gives freedom of movement which is so necessary to all plants. Plants cannot have have too much air yet may be injured by some of its constituents. For example, lichens do not usually grow in cities. Smoke is injurious to pines. There is danger in having too little air. Unfavorable conditions for plants ~~are~~ on high mountains are caused by the rarity of the air. In swamps and pools there is danger of too little O. There the interchange of gases is restricted and consequently there is not enough ~~a~~ O.

Too much wind brings a two-fold danger: first it may tear and break the plant structure, but the greatwr danger lies in causing excessive transpiration. Vegetation has been killed in a single day by a terrific rain storm. Excessive transpiration going beyond power to absorb moisture on account of cold causes low, woody, branching structures. Ex., forests on mountains, tundras, lichens and mosses of northern regions. The proof that this is caused by dryness and not cold is that in dry, hot countries, plants asume the same forms. Wind causes the baking of the soil and consequent dryness.

Leaves and branches are often less developed on the windward

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side, occasionally on that side only, branches and leaves springing from the root, have a chance to develop. Wind often causes mechanical injury to parts.

In Jutland looking towards the windward side the east appears like a forest, the windward side like a heath. In beech forests, where light wind can enter the surface, vegetation is different from that of the danser portions.

In northern regions snow protects against transpiration. Snow lies thickest in hollows and quiet places, hence vegetation is different there.

Uses of wind.

1. Renewal of oxygen.

2. Fertilization of plants and forest trees, some depending entirely on wind.

3. The small amount of moisture is probably the reason why the mosses and lichens can endure such low temperatures.

4. Woody structures are well adapted to low temperatures. Most small plants of Arctic regions contain many wood fibres. Semi-tropical plants when brought to our region, do not receive heat enough to develop their woody structure. Hence their tips die and trees of this class become only shrubs with us. Woods in Siberia endure a minimum temperature -60°. (larch forests.)

Hair covering. Hairs are cells filled mostly with air, and containing little moisture.

Minor protection. 1. Young plants and leaves have many minor protections. In cold regions many plants are covered with a felt-like or wooly substance.

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2. Old withered leaves cling to plants and protect buds, just as man protects tender plants with straw, etc. Such protection does not exclude intense cold but makes it less sudden in its approach. The danger from heat is not so much the burni ng of the tissue but the danger of excessive transpiration. The danger from cold is not so much the danger from freezing but the impossibility of the roots to supply the moisture lost by transpiration.

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Lecture 4, July 9.

Water.

Water is one of the necessary elements for plant life. Plant structure and cell sap both contain much water. Quantitatively not qualitatively there is a third factor in which water is the most important factor, that is in supplying the water lost by transpiration. The transpiration current is the principal means of supplying plants with food and water. The old theory was that food material was carried along like leaves on sticks in water. The present theory is that each substance obeys its own law and acts according to the law of osmosis peculiar to itself. This makes each substance active instead of passive. In water plants there is no definite current carrying water from part to part. Probably there is no transpiration in water plants.

Water is intermediate between soil and air. Soil is most stable, air, the least. Air is most transparent, soil least and water intermediate. For plant structure a certain amount of stability is necessary. Transparency is essential to leaf work. Water alone is best fitted to support plant life.

Dangers of water relations.

This danger has only been recently explained.

1. Plants can take up water more rapidly than they can give it out. The power which forces water from root to stem is called root pressure. Plants may take up so much water that transpiration

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cannot keep up with root pressure. Then the air spaces become injected, and plant work cannot be carried out.

2. The second danger is that of freezing. Plants best adapted to cold are those which dry up during the winter, as Algae. The drying up prevents freezing, hence many trees can live in cold regions.

Too little water.

This is the greatest danger in plant life.

1. Water is not a more important factor ecologically than food or light, but a more variable one since many plants are exposed to conditions varying from moisture to drought.

2. It is not the absolute amount of water which determines whether a plant may live in a certain habitat or not. If a pond contained water for eleven months and dried up during one month, its vegetation would be determined by the one month of drought.

Xerophytes are plants that have adapted themselves to dry conditions. Xerophytes may grow in the water, yet have all the characteristics of desert plants. According to Warming Xerophytes are plants adapted to dry conditions only. Schimper regards them as plants protected against excessive transpiration.

Groups of climatic Xerophytes.

1. Plants of the desert are Xerophytes in their highest and best state.

2. Mountain plants.

3. Arctic plants.

4. Plants of beach and sand dune.

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There are dangers of transpiration due to other in fluences besides climate. Plants may he adapted to dry conditions during part of the year and wet conditions during the remainder. Such plants, according to Schimper, are called <u>tropophytes</u>.

Hydrophytes are plants which grow in wet soil.

Mesophytes are plants which are adapted to intermediate conditions of moisture. Schimper's tropophytes do not correspond to Warming's mesophytes.

Water currents are like air currents in many ways. They favor fertilization and distribution of seeds. Water currents bring about a renewal of air food. O is not replaced in stagnant water and the water becomes charged with the acids of decay. Vegetation over stagnant water will show different characteristics from that over running water. Water moving rapidly may cause mechanical injury to the plant structure, but too strong a current is not as dangerous as stagnant water.

<u>Effects of falling water</u>.

1. Falling water is the best cleanser of vegetation.
2. Rainfall supplies water in upper soil layers.
3. Dew is a very important ecological factor.
4. Influence of snow according to Warming and Schimper since it prevents excessive evaporation.

<u>Soil.</u>

Soil in its relation to plants is composed not only of soil particles but also of large amounts of water and air. Soil is the

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source of many of the foods, for example the nitrates and salts, and is also the source of organic humis. Soil is the best medium to keep plants stable and is also the best protection for plant life and best for vegetative reproduction. The danger of too little food supply is not so great as that of too little water.

Animals.

The relation between two life forms acting together is called Symbiosis, and is sometimes defined as a relation which is mutually beneficial. Now the term includes all relations between plants and animals. Insect and bird pollination are classed as symbiosis. The relation of the pitcher-plant to animals is another example ; dead animals producing food for plants ; destructive work of animals influence of plants on plants ; relations of parasitism as shown in the dodder. The relation of mutualism is beneficial symbiosis, as oak and ivy ; Algae and fungus and lichens ; nitrogen tubercles on clovers ; epiphytes and lianas. A broader example is where a shade plant is absolutely dependent upon the shade of another plant. A still broader symbiosis is a plant society in which the individual members react upon one another. Another kind is the growth of one kind of trees in soil where trees of other genera grew formerly ; as oaks succeeded by beech forests or vice versa.

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Lecture 5, July 16, 1900.

Leaves.

Functions of leaves.

1. What is a leaf ? Something borne on a stem. Meaning of form, size, arrangement, and direction of leaves.

1. Admission of light is one function. Leaf so placed that the admission of light is easy. (Photosynthesis) Hence direction is involved in this particular. Perpendicular to the incident rays gives most light. Shape of leaf also involved.

Best condition for obtaining light would be for each chlorophyll cell in favorable relation to the light rays.

2. Admission of CO_2. Same truths hold good with regard to admission to CO_2, but CO_2 is admitted on all sides.

3. Admission of O. Probably connected with that of CO_2. This is a universal factor, common to all plants.

4. Emission of O.

5. Emission of CO_2.

6. Emission of H_2O. (Transpiration.)

Very important. Favorable light conditions would be favorable also for transpiration. Large blades favor it. Transpiration in most plants comes from under side as a means of protection. Transpiration not a universal process except in aerial parts of plants and probably in subterranean parts if soil is dry.

7. Emission of liquid water from so-called water structure.

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(Guttation). Drops found in morning upon corn and grass blades.

8. Supply of food material. If small leaf does not reach its full development.

9. Nature of conduction. Much the same as food supply but especially applies to water supply. Is conduction even ?

10. Protection. This is negative.

a. From exposure to sunlight.

b. Protection from excessive transpiration.

c. Protection from mechanical injury.

A banana leaf exposed to wind would be torn to pieces.

d. Protection from animals.

11. Storage.

a. Water storage in sand and spit plants.

b. Air storage in submerged plants.

c. Storage of starch foods less important.

12. Absorption of water as in plants of desert regions or in mosses. Also hairs, as in chickweed. Also absorption of inorganic food materials.

13. Absorption of organic foods, as in the carnivorous plants.

14. Irrigation. Leaves which catch drippings from other leaves. Spiral arrangement and certain petioles seem to favor this idea.

15. Secretion.

16. Reproduction, only important in lower forms as in ferns.

17. Protection of other organs, as by the scale leaves.

18. Mechanical necessity, or leaf direction, as gravity in lower leaves, pointing downward.

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19. Heredity.

The grass and sedge form, (elongation, verticality, narrowness) typical of a marsh plant.

Algae.

Red Algae grow lowermost, green next, and brown nearest shore. Water lily shows red on lower surface. Question of color. Fucus a xerophytic plant, resembling salt marsh plants.

Meaning of leaf form.

Surface, expanse, and shape.

Best examples of expanded leaf in floating leaves, (water lily), shade plants (Impatiens), and submerged marine plants. Many also grow in sunlight, as rosette plants, and many trees, sycamore, linden, and catalpa.

Reduced expansion, compound and grass forms. Ecologically locust is a small-leaved form.

Submerged forms, examples as deeper Algae, grasses, desert plants, willows, pines, locust or divided leaves, shade plants as mosses. Arctic plants. Ferns.

The expanded leaf is more favorable to the individual, the compound to the plant as a whole. The divided leaf is the best where there is great need for economy.

In the shade leaves tend to grow larger. In the linden, leaves in the shade are larger and thinner than those in the sun but both sweem to have about the same amount of chlorophyll. Those at the top have need of less transpiration, hence another

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reason for the reduced surface. It is almost universal that the shade form of a plant is larger than the sun form, as poison ivy. Kerner's theory does not account for this. As you go up the plant the need is for protection, as you go down, for light.

- Why is the grass form so successful ? The verticality allows a greater number of leaves, horizontal position is best for the individual. Verticality and reduction represent the best type of adaptation to light.

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Lecture 6, July 17, 1900.

Kerner's Light Theory. Light.

Light an aerial factor in the development of leaves. No green leaves found except in air or water. Scales found in soil. Green leaves called commonly foliage. Red leaves also, since green is masked by red.

A third type is the floral leaf. Stems are also often green and do same work as leaves. Sometimes leaves are absent and stems act as leaves. Most stems of herbacious plants are green.

Chlorophyll depends upon light.

Form of leaves.

Greater surface in proportion to volume, the greater the possibility of Protosynthesis. A spherical form has smallest surface. All gradations between greatness of bulk and smallness of volume and the opposite. A large thin leaf the best type.

A stem must have a large volume to its surface, since it must support the leaves. The less mechanical work a leaf has to do, the fewer organs it must develop.

1. Leaves are plastic. Variations in size and shape under different conditions. Power of adaptation to environment.

2. Leaf direction. Perpendicularity to rays of greater intensity. Position of leaf on tree and movement of the sun. Also variation of the position of sun during different seasons. Absolute horizontally best for leaves at Equator--varies as we come further north.

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Verticality.

If a leaf faces north and south, the south side would receive light all through the day. The east and south facing as in the compass plant. This receives light morning and evening but not at noon.

A perfect compass plant--Sylvium. This shows an ideal condition for prairie plants. A single leaf receives the most light when it is perpendicular to rays of greatest intensity. Since stems are usually vertical, this is another advantage of leaves over stems with regard to protosynthesis.

Direction of leaf also plastic. Heliotropism--tendency of a plant to face or turn away from the sun. Stems turn directly toward the light. Although diffused light seems best, trees grow toward the intense light. This is not true in sand spit or desert plants where leaves are positively heliotropic.

Structure of leaf.

Palisade cells, on upper with most chlorophyll.

Spongy tissue, on lower with less chlorophyll.

In weak light, upper side most effective, in strong light lower. Chlor. bodies change their position with respect to sun. Lab. ex. with prickly lettuce. Cottonwood since leaves move, has same structure on both sides of leaf.

Effect of light on color.

Light or dark green probably dependent on physical properties. Shade leaves have darker color, but are so thin that the chlor. shows better. The sun leaves have more chlor. but it is masked by ha

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In general density of arrangement is dependent on size and shape of leaves. The larger the leaves the fewer number, the smaller the leaves the greater number.

Kerner says number and size of leaves are related to phyllotaxy, but Dr. Cowles considers this not absolutely true. That the arrangement of leaves on the tree is dependent upon widely different causes. The mint family.

In Maple this difficulty may be gotten over by the length of petiole and its twisting. The question of number of rows is comparatively unimportant with regard to that of light. When plants have many vertical ~~leaves~~ rows of large leaves, the petiole may get shorter, the leaves smaller toward the top, and wide space between leaves.

In most plants there is a tendency toward the "mosaic arrangement". This reaches its highest development when shape of leaves are modified to fit into each other. Hackberry, begonia, etc. Another case of mosaic arrangement is fitting angular leaves into each other, as Ivy. Still another fitting smaller into larger leaves.

Reading in Atkinson, Chapters X.and XI., pages 13-58.

Field lesson, July 16, 1900.

Petioles. As a rule monocotyls and gymnosperms have no petioles. Dicotyls and ferns have. Exceptions goldenrods and asters. General shape of the petiole flattened, or grooved ; rounded only in a few, such as the cucumber and squash. Petioles are more apt to be colored than leaf blades. In cottonwood the petiole is flattened vertically giving the opportunity for free movement.

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Desmodium shows pulvinus or thickenings at base of petioles. This is a common feature of all Liquimnosae.

Stipules.

Two classes.

1. Green persistent, usually larger.

2. Non-green, deciduous, usually smaller.

Wanting in many plants.

Leaves growing under poor conditions take the form of the leaves on the upper side of the normal plant, provided the plants show variations in shape of leaves. Ex. Peppergrass.

Plants.

Collinsonia Canadensis. Horse-Balm.

Desmodium nudiflorum. Tick-trefoil.

Sanicula Marylandica. Black Snakeroot.

Actaea alba. White Baneberry.

Asclepias incarnata. Swamp Milkweed.

Circaea Lutetiana. Enchanter's Nightshade.

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Lecture 7, July 18, 1900.

Light (continued).

Water plants with regard to influence of light.

2 great types of leaves.

1. Floating as water-lily.
2. Submerged.

Leaves of water plants are in position to receive sufficient light. Many water plants have two kinds of leaves, floating and submerged. Ex. show that such plants can change the ~~plant~~ kind of leaf under different conditions.

Proserpinaca very plastic, shows first dissected, then entire, then dissected, then entire under different conditions. In water plants other influences besides light seem to affect the leaves. Finely-dissected leaves the type the general type of submerged leaves, since that form allows the light to sift through to a great depth.

Rosette plants.

Not so common here. Dandelion, Sedum. This form cannot be explained by light relation ; yet, though plant as a whole avoids light, each leaf is so placed that it may receive some light.

Tree rosette as tree fern, yuccas, palms, etc. Here leaves seem to come under the same conditions as in the true rosette.

Compound leaves.

Compound and finely-divided leaves Kerner considers an

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adaptation for more light. Other things also affect such leaves. Theoretically leaves should be more compound above but the reverse is usually true.

Plants may be cone-shaped as mullein with broad leaves, and the inverted cone with dissected leaves as Ambrosia. This is Kerner's view but it is not adjustable to facts. The shape of a ~~plant~~ leaf does not determine the shape of a plant, but the surroundings generally decide it. The elm becomes cone-shaped when grown in the forest, but in the open is the reverse.

Kerner's theory of light does not explain leaves wholly. As to form the leaf is somewhat influenced by light but more so by other factors. As to size, horizontally and vertically, light has very little to do with it. As to position and arrangement, Kerner's view is much more important.

Admission of CO_2.

What is influence of CO_2 on leaf shape and arrangement ? CO_2 is necessary in large quantities. Conditions favorable to admission of light are alos favorable to admission of CO_2 ; but light only enters from one side while CO_2 comes in from all sides.

Warming thinks that since CO_2 is so plentiful there is no necessity for special modifications to admit it. From recent experiments it has been proved that CO_2 is more plentiful in lower leaves hence CO_2 may influence the shape.

Admission of O.

No question as to quantity except in water-plants especially in

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Ithaca, N. Y., ...*190*.., stagnant water. Here small quantities of O is present and animals obtain most. From study of water plants it has been shown that large spaces for air always exist. Need for O therefore modifies water-leaf.

Emission of CO and O.

Unlikely that these factors influence shapes and forms at all.

Transpiration.

One of the greatest factors, greatest in size and one of the greatest in form. Transpiration mainly determines difference between size of leaves in shade and sun. Extremes. Impations. Large thin entire leaf and Saticormia where leaves have been lost entirely.

Linden shows this, since leaves are larger near base, and thinner, smaller and thicker above. This can best be explained by transpiration conditions. Need for protection from excessive transpiration changes plants from horizontality to verticality as seen in the desert types. Succulent plants explained best by this factor. Rosette plants can also be explained as to those in cold regions, but desert plants not so easy.

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Lecture 8, July 19, 1900.

Transpiration (continued).

Peat bog plants.

Plants with a pronounced Xerophytic structure.

Shimper says the nature of the peat_bog leaf is caused by difficulty of plant to obtain proper nourishment, as water free from acids. Hence even for a plant growing in the water, this kind of water is essential.

Stahl of Jena, one of the greatest ecologists of the day. Paper on Sleep Movements, dealing with compound leaves. Old meaning of motile leaf was supposed to be the protection against cold. (Darwin.). Stahl shows that warmer climate, greater movement. His view is that closing at night is to further transpiration. An expanded leaf would collect dew, while a vertical leaf would shed it. Another point would be the position of the stomata.

The Legume family is better adapted to its environment than other families because it can work at day by protosynthesis, while at night it can collect materials for food. Other plants must do both at once. The Legume family is best adapted by its stomata and motility to favor transpiration in early morning and late afternoon Stahl also thinks that the petiole of the poplar is an adaptation along this line.

The reason that a plant seems to try for a greater transpiration is that the greater the current, the greater amount of salts carried.

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This was old physiological view. Now it is thought that each substance is carried into the plant independently. Still Stahl's idea is true so far as plants are able to use up the salts carried by the water.

Meaning of leaf teeth.

Veins go up into the point of the tooth. Hydrothode. A raised surface gives greater opportûnity for evaporation. Hence the importance of the pyramid-shaped tooth of the leaf. The tooth is a safety-valve to permit passage of water ------

7. Gutation.

The hydrothode or water pore is the usual form in most plants. Xerophytic or sun forms have no hyfrothodes usually, but they are common in shade plants. Root pressure goes on, but transpiration often ceases at night. Transpiration is giving off gaseous water through air spaces. Gutation is giving off liquid water through veins. Hence gutation seems most important factor in deciding margin of leaf.

8. Supply of food material.

Very important factor. Wächter published paper on leaves of water plants. He found that arrowhead leaved varied considerably in going from margin out into the lake, from full normal leaf to a petiole. It might be explained by difference in light or difference in current, but Wächter found it dependent entirely upon richness or poverty of the food supply.

Alao cases where largest leaves are lowest. It may be because

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these leaves receive best supply of food. If CO_2 is more abundant near the ground then lower leaves would receive most.

9. Nature of conduct ion.

Embryonic leaf largely veins, only matured leaves filled up. Conductive tissues must be developed before chlor. tissues. Eight and nine determine size of leaf or upon amount of food material.

10. Protection from exposure.

Light, heat and drought. Only another way of expressing transpiration.

11. Protection from mechanical injury.

Either due to wind or water currents. Direction of a leaf, plastic ordinarily, is greatly modified by wind or water. Ex. common weed and pond weed, also Algae.

Kerner suggests this plasticity also explains compounf leaves, as in banana leaf which has been torn by the wind.

12. Protection from animals.

Old view not so much accepted now. Did thistle develop spines as protection against animals or did the spinous originally serve as a protection ?

13. Storage---of air and water.

Large leaves and petioles often come from having large storage cells. Storage of food materials also modified leaves sometimes, as those of a lily or onion bulb.

14. Absorption of H_2O.

Ex. leaves of mosses and water plants ; also seen in hairs developed

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on desert plants. Cup plant in west, with perfohate leaves in which water collects and is absorbed by special glands.

15. Absorption of organized food materials.

Utricularia, Droscera, Sarracenia.

16. Irrigation.

It is necessary for leaves to get rid of water which falls upon them. Kerner says there is a relation between dripping-points of leaves and the water-supply to the roots. Spiral arrangement of some plants also favors irrigation, hence it seems to partially explain phyllotaxy.

17. Secretion.

Glands can scarcely be said to modify shape of leaves.

18. Reproduction

Does not usually modify leaves except in case of ferns.

19. Protection of other organs.

Scale leaves protecting buds. In Viburnum scale leaves in winter become green in spring and develop chlor.

20. Flotation.

Air spaces may also be developed for purposes of buoyancy.

21. Mechanical necessity.

A last resort except

22. Heredity.

Something due to past environment. Ex. Asparagus, Alao may explain the phyllotaxy of leaves. Venation as well. Those things which are least variable are most apt to be due to heredity. Variation

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seems to come from difference in environments. But unvaried forms must have been caused once by definite conditions. Forms which are variable do become fixed in time and when plasticity is once lost, it is lost forever.

Reading--Coulter--Dhap. IV.--Shoots. p. 53-88.

Field Work July 18, 1900.

To study development of leaf teeth, use Viburnum, Red Oak, Chestnut, Circaea, Sycamore.

Examples of climbing plants.

Polygamum scandens, Bindweed.

Ampelopsis quinquefolia, Woodbine.

Cuscuta, Dodder. Smilax.

Apios tuberosa, Hog peanut.

Rhus toncoden, Poison ivy.

Amphicarpaea monoica, Hog-peanut.

Climb by tendrils, stems, petioles, suckers, adventitious roots, holdfasts.

Lee Cut-grass, a half-climber, backward hooks on the leaves. Autumn coloration may be defined as the color of a dying leaf. In such cases the color is usually stronger in the upper side of the leaf, seemingly associated with light.

Disease will also cause coloration in plants, as rust in the dandelion.

Field Work July 19, 1900.

Roots and other absorbing organs.

Roots are generally fibrous.

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1. Because by this form greater varieties of soil can be reached.

2. Because such forms pass more easily around obstacles.

The mechanical functions are as holdfasts and for purposes of absorption. The reason for general downward direction is undoubtedly force of gravity. This geotropism may be the result of heredity. Originally the roots may have assumed this position in its search for food and the habit may have become fixed. Exceptions are common. as aerial roots in ivy ; water hyacinth, etc.

Cypress knees, supposed to be the result of growing in stagnant water for purposes of aeration. Here another force works against geotropism.

Study of Leucobrym.

Cells connected by pores. Three layers, with chlor. in the central one. Air cells on surface guarding chlor. cells within. If placed in water, epidermis becomes transparent and leaves appear green. Can be grown for several years without developing rhizoids. Leaves absorb water as in Sphagnum.

Prof. Barnes of Chicago University believes that mosses absorb water entirely through leaves, not at all through stems. Dr. Cowles believes conduction through leaves more important than through stem but not entirely the way. Mosses if placed in water become wet immediately, showing the absorption. Lichens absorb water eagerly. Probably take in also some mineral food from the substratum since they decay rocks.

Asclepias incarnata growing in the water showed roots containing chlor.

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This is not uncommon with plants with aerial rootlets or in water-plants. It might be possible under special conditions to modify the structure of roots in this respect. If roots of water-plants contain chlor. it might be of advantage to the plant, since all the work can go on near the same spot. This would save a tremendous amount of expenditure of energy.

Monotropa uniflora.

Probably a degenerate form, since it bears scales and is one of the Ericaceae. It is not a saprophyte, since it lives by means of a fungus at its roots, mycorhiza or root-fungus, a plant which gets its food partly by other plants, partly from soil, is called a pymbiotic parasite.

Duckweeds.

Spirodela, Many roots.

Lemna, One root.

Wolffia, No roots.

Botanists regard duckweed as a reduced type of calla. Bladderwort is also a reduced type having lost its roots. Beech trees have no root-hairs. Live as do many other trees, partly by the root-fungi. Same fungi cause nodules on Lequiminosae.

Cladoma, Reindeer lichens.

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Field Work July 20, 1900.

Life History of a Growing Beach Vegetation.

Beach vegetation is usually Xerophytic. The beach may be divided into zones, lower beach, middle, upper, and mature or fossil beach.

The lower beach was characterized by the entire absence of plant life. Plants are unable to adapt themselves to such variations as growth on this xone would expose them. Plants may grow in water or upon land since they need a certain stability. The beach shows a certain gradation in the plant life though no strict line of demarcation can be drawn between the different zones.

Next to the zone of the lower beach is that of annual plants. During certain seasons of the year the water rises more than at others. Therefore plants which obtain a foothold there, must be able to complete their life work within a short time. The zone of annuals along L.I. Sound corresponds to the same zone along Lake Michigan. Every species found in Chicago except the bug-seed, is duplicated here.

Plants in Zone of Annuals.

1. Cakile Americana, Sea-rocket.
2. Xanthium, Cockleburr.
3. chenipodium album, Lamb's Quarters.
4. Polygonium convolvulus, Bindweed.
5. Oenothera, Evening Primrose.
6. Salsola kali, Saltwort.

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7. Solidago sempervirens, Goldenrod.

8. Atriplex hastata, Orache.

9. Euphorbia polygonifolia, Spurge.

10. Lathyrus maritimus, Sand Pea.

11. Strophostyles Angulosa.

Cakile, Salsola, Euphorbia and Xanthium were the dominant forms on this beach. The plants of this beach are the most xerophyte. Though near the water they are too far removed to be reached by it, and are exposed to stronger winds which tend to dry the soil which containing little decaying vegetation cannot hold much moisture. These plants receive little shade from other plants.

Salsola has reduced, succulent leaves and thin epidermis. Many plants of this region have no hairs. Xanthium was the only exception to this rule found there.

Cakile has succulent stems and leaves but the leaves are not much reduced, yet this plant is always found in exposed conditions, being one of the first plants found on a beach. Euphorbia is characterized by folding leaves, a milky juice and spreading habit.

The upper beach is always free from wave action.. It is usually a young region where perennials begin to replace annuals. It may be called the Zone of Perennials.

Plants of Zone of Perennials.

1. Xanthium, Cockle-bur.

2. Amorphila, Sand reed.

3. Lathyrus maritimus, Sand pea.

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4. Salsola kali, Saltwort.

and 7, 3, 1, 5, 9, of the list of annual plants ; besides

10. Rhus toxicodendron, Poison ivy.
11. Helianthus, Sunflower.
12. Arenaria peploides
13. Atriplex hastata, orache.

The third plant zone is exposed to less xerophytic conditions.

Plants of third zone.

1. Amophila, Sand reed.
2. Prunus maritima, Beach plum.
3. Asclepias cornuta, Milkweed.
4. Rumex acetocella, Sheep sorrel.
5. Lenaria vulgaris, Butter-and-Eggs.
6. Verbascum thapsus, Mullen.
7. Myrica cerifera, Bay berry.
8. Artemesia candata, Wormwood.
9. Chrysopsis falcata, Golden aster.
10. Artemesus stelleriana, Dusty Miller.

besides 10, 7, 5, of first list and 10 of the second.

Lathyrus shows sleep movements, its leaves assuming lateral position during the day, thus preventing transpiration. Ammophila has a strongly xerophytic leaf having the power of folding. It has also a long, linear, migrating stem.

Beaches are of two kinds, xerophytic and hydrophytic. In the former there is a zone without plants, in the latter, plants extend to the water's edge.

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Many attempts have been made to explain why the zone of annuals is so similar along all beaches. One extreme theory is that the striking similarity of ocean and lake beaches was caused by the former salt condition of Lake Michigan. Plants grew under salt conditions and remained after these conditions disappeared.

Warming's view is that a halophyte is essentially a xerophyte. Salicornia herbacea is the only one which will not grow away from salt water.

Geographical distribution of coast forms.

1. Those that grow anywhere.

    cheniopodium album, Lambs' quarters.

    Oenothera, Evening Primrose.

    Asparagus,

    Juniperus Virginiana, Red Cedar.

2. World-wide coast ferns.

    Cakile. Salsola. Lathyrus. Ammorphila.

The first grows along the Atlantic Ocean, the others, in the northern hemisphere.

Typical Dune Plants.

Artemesia stellariana----Eastern Asia, Massachusetts, and Long Island.

Great Lakes and Atlantic.

Cakile. Salsola. Ammophila. Xanthium. Euphorbia. Atriplex. Artemesia candata. Hudsonia tomentosa. Myrica cerifera.

Not found on the Lakes.

Solidago sempervirens, N.Y. to Va.
Chrysopsis falcata, N.J. to Cape Cod. Prunus maritimus, N.B. to Va.
Artemesia stellariana, L.I. to Mass.

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Lecture IX. Summary.

(With regard to what has developed leaves.).

Internal anatomy. Highest type of chloroplasts formed in highest plants. Nature seems to have been experimenting in the Algae.

Leaf-form. Lowest form--unicellular, first--Protoccoccus. Then filamentose, then expanded type. Natural order of evolution. A plant to become multicellular must become filamentous, expanded, or show evolution of an internal atmosphere. Adaptation of form to external environment in lower forms; in higher also accommodation must be made to the internal atmosphere as wellas outward surroundings.

Direction of growth.

Lowest plant more or less horizontal ; in higher liverworts we have the approach to verticality in stem. Evidence from Paleontology, especially may be worked out witht he conifers. A perfect series can be made out between cordates leaf and the needle upon one side and the ginkgo on the other.

A leaf is a mean between extremes ; the result of forces acting in opposite ways, light and food supply against need for protection. Ulva an ideal of what a leaf should be if developed from a condition of light alone.

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Leaf form including shape and cross section due mainly to light and need for protection but also to a necessity for plasticity as in compound leaves, the best examples of which are found in the water. Size in contrast to form seems to be largely a matter of food supply. Sometimes form may also be modified by food-supply. In determining direction and arrangement the light relations come in.

Leaf color.

Certain rays are absorbed and certain colors reflected. Green commonest color in plant as to leaves ; due to chlor. which works only in sunlight, though plastids are present. Decolorization of green leaves due to blanching in the darkness ; to disease ; Exper. show iron is necessary to presence of chlor. Chlorosis a and Etiolation or bleaching, both diseases. Partial covering of plants as by sand dunes produces decoloration above. In bullrush zones of color were shown.

In spring, leaf grows so rapidly that development of chlor. is not apt to keep up with the growth of the leaf, hence the brilliant color of fresh spring foliage. White and yellow colors come from disease ; the color being due to the degeneracy of the plants. White and yellow are purely pathiological conditions.

Explanation of green color.

One theory is that the green color has no ecological meaning, the other that it has. It may have been evolved by the evolution of nature. More rays absorbed at the ends of spectrum than in the middle. At the red end there is the greatest amount of proto-

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synthesis taking place, especially at the yellow band. Heat is also most developed at this end while light is best developed at the violet end. Hence green is an intermediate color it may be the color of chlor. since it absorbs the other rays such as the red and blue. Cyanophyceae--blue-green Algae--live best in warm atmospheres.

<u>Significance of Reds</u>.

Sometimes green does not develop a great enough amount of heat, so red leaves may be developed in the spring. Stahl and King have experimented on red leaves of maple and beech. Greater heat given off by red leaves. Hence it has been thought that the red of leaves is developed. Often on the lower side of shade leaves and water leaves for the conservation of heat. Many plants which live over winter as mints have red color on lower surface.

<u>Autumn Coloration</u>.

Caused by introduction of new substance. Anthocyan, if acid it is , if not acid . This substance is a result of breaking up of the chlorophyll. Kerner considers the leaf continues to do it's work, a short time after the red color is found.

Objections to Kerner's theory.

1. It appears to contradict itself.
2. Amount of temperature change, very small.

Observational Objects.

1. Spring leaves generally red.
2. Leaves may turn red whenever their work is done.

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3. Another objection is that tropical plants show the most color.

Overton published an article upon coloration in plants. His theory is that the amount of sugar in a plant depends on the amount of red color. Spring and fall, times of the conduction of sugar. A third view is that color, especially green color, has no ecological meaning.

Read--Coulter--Chapter V.--Roots, also Discussion of Xerophytes--p. 193. Warming--p. 177--on.

Laboratory Outline.

Absorption.

Root-hairs, typical structure in any plant.

Rhizoids in mosses and liverworts.

Leucohryium and Sphagnum.

Hair on Chickweed or Stellaria.

Parasitic absorption in Cuscuta.

Mycorhiza of Alder.

Legume tubercle.

Monotropa uniflora.

Asclepias roots.

Lichen.

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Lecture 10, JUly 23, 1900.

Stems.

One of the most important features is the direction. Another, shape ; still another, branching. Color of stems an additional factor.

Evolution of stems.

In the lowest Algae we find no stems. Even higher forms as Ulva have no true stems, but in Fucus we have a true stem, since in the center the cells are closer together giving stiffness. In Algae of the Pacific coast large stems are often found.

Fungi develop no leaves, but perfect stems as do also liverworts. Mosses show a real stem with definite roots below and definite leaves above. Going up from the mosses, the stemless form is the exception.

The erect stem is found in a great majority of plants, and was first developed in the mosses. Kerner calls the stem an indirect adaptation to light, but other factors also influence it. In fungi the light relation is insignificant. Another theory is that carrying a plant above the ground favors reproduction, spores or pollen being carried by insects or wind.

Kerner's theory with regard to stem is that elongation of internodes farmss the development of leaves. In a forest trees are apt to crowd upward towards the light. Palms do not branch but bear all leaves on the erect stem. The greater the branching the greater the chance for leaf display. The petiole further relates the leaf to the light. Tree ferns and Monocotyledons have no

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petioles or branches. While in Dicotyledons there is great ability for branching and leaf display, the stem gives nothing to the plant but mechanical support. In some plants it may be better not to have so great a chance for leaf display since it requires so strong a mechanical support. This necessitates a large supply of food.

The stems of fungi may be connected with reproduction, and sporophytes in mosses, with the same thing. In most of the rosette type, the chief use of the stem is probably for purposes of reproduction and it may also have influenced the long stem of the mullein. The same principle is true though perhaps in a less degree in trees, since many trees are anemophilous.

The cylindrical stem is most common, then the square, and lastly the triangular. Sometimes we find the flat stem. The cylindrical is probably the strongest. Round and square stems can best bear the weight of their branches. Shape of stem may be influenced by wind which if prevailing may elongate the diameter of the stem in direction of the wind changing a cylindrical stem to an elliptical one. Tree stems need mechanical support and trees usually have rounded stems. Where there is little need for protection a square stem may answer better than a round one since it requires less strengthening tissue. Square and triangular stems have more surface in proportion to volume, hence can do more chlorophyll work.

Coccoloba, an extreme xerophyte, is the best example of a flattened stem. It has lost its leaves and the flat stem does the leaf work. Round stems have less surface, hence less transpiration.

Color of <u>Stems</u>.

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Most herbaceous stems are green. Red is found moreoften in stems and petioles than in leaves. Kerner explains the red stem as the red leaf ; that the red is a protection for the withdrawal of protoplasm. The bark of older trees, usually dark probably because cells are dead. Exception, the birch. There colors are probably due to presence of waste products.

<u>Field Work   July 24, 1900</u>.

<u>List of trees on east slope</u>.

Quercus primus	Chestnut Oak.	Quercus coccinea	Scarlet Oak.
Quercus rubra	Red Oak.	Quercus alba	White Oak.

Acer rubrum   Red Maple.

Castinea satina Americana Chestnut.

Fagus ferringinea Beech.

Carya alba   Shell bark Hickory.

Betula lenta   Sweet Birch.

Prunus serotina   Wild black cherry.

Prunus cerasus   Cultivated cherry.

Robinia pseudocassia Locust.

Nyssa multiflora   Sour-gum.

<u>List of Shrubs</u>.

Cornus Florida   Dogwood.

Clethra alnifolia   Pepperbush.

Gaylussachia resinosa Huckleberry.

Vaccineum stamineum   Blueberry.

Vaccineum corymbroseum Swamp Blueberry.

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Vaccineum Pennsylvanicum	Dwarf Blueberry.
Amelanchior Canadensis	Service-berry.
Rhus toxicodendron	Poison Ivy.
Viburnum dentatum	Maple-leaved. Viburn um
Vibernum acerifolium	
Hamamelis Virginica	Witch Hazel.
Lindera benzom	Spice bush.
Kalmia latifolia	Locust.
Ampelopsis quinquefolia	Virginia Creeper.
Vitis aestivalis	Summer Grape.
Myrica cerifera	Bay berry.

Laurel is usually found on treeless slopes. If found in forests, it probably dates back to a time when the land was treeless.

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Field Work. July 25, 1900.

Cooper's Bluff.

The bluff was a steep, sandy slope extending down to a flat beach. It was a Kame, part of the terminal moraine which the glacier left upon its withdrawal from Long Island. The situation was different from that at Lloyd's Neck. Here the shore was being gradually washed away, there it was being built up, hence the vegetation showed considerable differences. At Cooper's Bluff older formsof vegetation were found close to the shore. As the waves washed out the beach, the cliff became undercut and land-slides frequently occurred, bringing the higher forms nearer to the shore, while at Lloyd's Neck, the vegetation appeared to be going backward.

There seemed to be four zones.

1. The Beach Zone, from the beginning of vegetation to the slope. Here we found :

Strophostyles angulosa	
Atriplex hastatum	Orache.
Salsola Kali	Saltwort.
Chenopodium album	Lamb's Quarters.
Polygonatum convolvulus	Black Bindweed.
Ammophila arundinacea	Sea Sand Reed.

This locality was poorer in its flora than Lloyd's Neck. There were as many species but fewer plants because of the encroachments of the sandslides and waves.

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In one place was an old tree trunk filled with soil and here under more sheltered conditions we found :

Euphorbia, a Rumex, Bidens, Sea-rocket, and others.

II. Cliff Zone.

Here were really three regions, showing some differences in the flora ; the bluff proper where were found :

Trifolium arvense	Blue toadflax.
Linaria Canadensis	Rabbitsfoot clover.
Achillea Millefolium	Common Yarrow.
Rumex acetosella	Sheep Sorrel.
Oenothera	Primrose.
Erechtites hieracifolia	Fireweed.
Rhus Toxicodendron	Poison Ivy.
Erigeron Canadensis	Horse-weed. Butter-weed.
Chenopodium album	Lamb's Quarters.
Polygonum Convolvulus	Bindweed.

2. The landslide flora where many plants growing naturally at the summit had been brought down on the slope. Among these were :

Alnus	Alder.
Betula lenta	Birch.
Salix	Willow.
Amelanchior	Service-berry.
Rhus toxicodendron	Poison Ivy.
Poa compressa	Grass.
Myrica cerifera	Bayberry.

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Rubrus occidentalis	Black Raspberry.
Agiostis	Bent-grass.
Lactuca	Lettuce.
Achillea millefolium	Yarrow.
Ampelopsis quinquefolia	Virginia Creeper.
Solidago.	
Vaccinium Pa.	
Viburnum dentatum	
Prunus	Cherry.
Hypericum perfoliatum	St. Johnswort.
Taraxacum officinale	Dandelion.
Cornus florida	Dogwood.

3. The oasis flora where the presence of little springs produces a growth of mosses and liverworts.

III. The Margin Zone.

Here were found most of the land-slide forms.

IV. The forest region beyond the margin.

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Lecture 11, July 26, 1900.

1. Erect Stems. 2. Lianas.

The philosophy of stems is really the philosophy of Ecology. The stem largely decides the character of the plant. All climbing plants are called leaves. Great variety of means of climbing ; tendrils, roots, thorns, petioles, stems, etc.

Lianas most developed in rich tropical forests, also found in our own region growing upon trees. Warming and Kerner regard the liana as a unique and economical method of getting at the light. Large expanse of foliage with little mechanical support. As forms become independent they have greater difficulty in living ; hence the liana has not so good a chance as the tree upon which it grows. Chief danger is death of the host plant, also the liana may be torn away by the wind. Stems show compensation.

3. <u>Epiphytes</u>.

Attempt to meet same conditions as the lianas. Here we have few, except lichens. In Florida there is the long moss. Another theory is that it is the result of a struggle for life in a crowded forest. Mere existence is only possible when away from the crowded ground.

4. <u>Creeping stem</u>.

Example of two types--clover and raspberry. First creeps along the ground and roots at the nodes. The second has a walking habit, as has also the camtosoris rhizophyllium. Great meaning of this form of stem is reproduction ; to increase the area of the plant. Vegetative reproduction. Also the migration to a new field where food

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Prostrate stem.

Not related to creeping stems since they do not root at the nodes, hence no vegetative propagation or migration. Protection the common theory which seems true in Arctic plants. A second theory is that of insufficient food supply. A third which seems more plausible is that of mechanical necessity.

6. Rhizome.

No essential difference between rhizome and creeper except that one is aerial, the other subterranean.

Three types of propagation.

1. Linear type, unbranched. A migrating form. Puncus balticus, example.

2. Radial type, as clover, forming a mat, center hollow. Fairy ring, often found in fungus growth. Most common type and best one.

3. Circular type. Migration in a circle, found in some orchids.

7. Bulb and tuber type. This represents the deepest form of stems. Protection one great factor ; another, need for storage. This type notoriously conspicuous in desert plants. A reason for such forms is shortness of growing season and great length of unfavorable conditions. Shade conditions also favorable to bulbs.

8. Rosette type, one kind the permanent rosette; the other, the winter rosette. First, xerophytic in habit, desert plants. Need for protection, very important factor in rosette form. In the temporary rosette shows exposure to alternating conditions. Ex. Mullein and Oenothera.

9. Multicipital or Stem--Base--Complex. Reduction of stem to a

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point, Vewain, also dandelion. A series of stems on one stalk. Ecologically it differs little from rosette stem. Increase of stems but not of plants.

10.Floating types which vary.

11.Thallus--no true stem. Stem and leaf are one and are flat, as Marchantia and duckweed. In Algae the stem and leaf have not been differentiated, but the duckweed cannot be so explained. Two theories; one, that water habitat is more favorable for plants hence the plants lose all different parts, the other, that the parts are lost from poverty since the water form is less favorable. Latter view seems to be more sensible from experiments which have been made.

Uses of stems.

1. Display of foliage and flowers.

2. Vegetative reproduction.

Vertical stems favor light relations.

Horizontal stems favor reproduction.

3. Protection best favored by the stem working downward.

4. Mechanical support.

5. Conduction. The 4th and 5th incidental to the 1st.

6. Leaf work.

7. Storage.

Conflict between 1st, 2d, and 3d causing the different kinds of stem.

Moss shows first two types, in the protonema and gametophore.

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Laboratory Work.

Protection.

Thick stem--Cedar and Laurel.

Hairs--Mullein, Artemesia.

Colors.--Physical conditions.

(Degenerations of chloroplasts.).

Flowers--Red and yellow leaves.

Glands.

Mint, St. Johnswort. (depressed)

Rose calyx (stalk gland).

Hydathodes.

Any leaf teeth.

Leaf Movement. (stomata).

Tubercles.

Mycorhiza.

Orchid roots. { Habenaria
Goodyearia }

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Lecture 12, July 27, 1900.

Roots.

1. Absorption.

a. Soil plants.

More-uniform in structure than stems or leaves.

Ordinary roots much branched, ends smaller than those of stems being the root-hairs. Chief function of root-hairs is absorption of water and salts in water ; hence root is not organ of absorption but of display. Osmosis governs the absorption of different substances, the root-hairs having the power of selective absorption, hence plants have really an advantage over animals. Two functions of roots are display and conduction.

Why is there difference in size between root-hair and leaf ?

1. It is capillary to enable it to penetrate the soil.
2. It can come into more intimate contact with the soil particles, every cell coming in touch.
3. It has greater amount of surface in a given volume, than any other form could have.

Liverworts have no true roots, but rhizoids, which are like root-hairs in function but like the root in tropisms. In mosses they are more highly developed but a great gap between rhizoids of mosses and roots of ferns.

In a few land Algae like Botrydium, we find rhizoids developed.

b. Water Plants.

If Indian corn is grown in water, root-hairs are lost, but many

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water plants as eel-grass, contain them.

Reason for many root-hairs, the increase of absorbent surface.

Meaning of reduction--Two theories.
1. Food obtaining so easy that organs disappear.
2. Conditions so hard that the plant is unable to develop all its organs.

The food is so scattered through the water that it is difficult especially in stagnant water, for the plant to obtain what it needs.

Why are so many water plants so similar ? Because of similarity of environment. Water plants show gradual decrease of root organs and use of leaves as absorbent organs, hence leaves take on a root-like, finely divided form.

c. Saprophytism.

Plants which obtain their food from decaying organic matter. Many fungi are saprophytes, but few among the higher plants. All plants seem to enjoy some decaying organic matter, hence most plants are saprophytes in part where they have an opportunity. Autophyte--a plant absolutely independent.

d. Parasitism.

Plants which live on living parts of other plants. Intimate r relations of parasite and host. Rafflesia--no leaves, no stem, but a root system, like fungal threads and immense flowers. Found in W. I. Some plants are both saprophyte and parasite. Associated with this feature, we have carnivorous plants.

e. Mutualism.---where two organisms are of benefit, each to the other. Ex. tubercles of Leguminosae. Mycorhiza in Beech, Birch, Alder, and many of Heath family. These are nitrogen gatherers.

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f. Lichens.

A lichen is a plant complex, made up of Algae and Fungi. Three things to be considered.

1. Relation of whole to what it is attached. If on a tree it must be an epiphyte or saprophyte. Both theories held, but neither proved absolutely.

2. Relation of Alga to Fungus.

3. Relation of Fungus to Alga.

(a) Anatomy--old view--that Alga and Fungus were derived from same source. This disproved. Experiments have been made by which lichens have beenmade, showing the two plants absolutely independent.

(b) Mutualism--2d view.

(c) Parasitism.

Fungus must be benefited. As to the Alga, it is an open question. An equal case seems to be able to be made out both for parasitism and mutualism. Lichens are xerophytes, but Algae and Fungi are largely hydrophytes. This seems a proof on the side of mutualism.

Soredia--a means of reproduction, composed of a few hyphae of Fungi and a few Alga cells which is not unlike a gemma--given off by the lichens.

(d) Helotism

Half way between the two--Warming.

2. Holdfast Organs.

Roots are decidedly holdfast organs, also rhizoids and root-hairs. Tamaracks have not a good opportunity for vertical root development,

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hence are easily blown over. Roots also are contractile as in bulbs. Climbing roots.

3. Mechanical support.

Banyan--Indian corn--prop roots.

4. Storage.

Turnip--Beet.

5. Leaf work.

As chlorophyll develops in roots of water plants as in water plants and epiphytes.

6. Aeration.

Cypress swamps.

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Reproduction.

A. Vegetative.

Most primitive and most important kind of reproduction ecologically. Many Algae depend entirely upon this. In liverworts and mosses we find gemmae ; also almost any part of thallus or plant. Protonema of mosses very wonderful since a great clump may grow from a protonema which is produced by a single spore--in ferns many plants from a single spore. In higher plants as Elodea. One individual plant was taken to Europe, either a pistillate or staminate, and now all the rivers of northern Europe contain it. Water-hyacinth in St. John's River, Florida, Duckweed.

B. Specialized reproductive organs.

A sexual spores in Algae, Mosses and Liverworts and Ferns. Flower and Seed. A flower is a collection of organs modified for purposes of reproduction. Pistils and stamens, real reproductive organs. To prevent self-fertilization, we have

1. Proterandry and proterogyny.
2. Imperfect flowers.
3. Stigma above stamens.
4. Pollen impotent on its own pistil.

Cleistogamous flowers--violet. It may be the flower has become too specialized for insect fertilization. In Cruciferae many cases of self-pollination are found. Willows---insect-pollinated.

Poplars---wind-pollinated.

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Meaning of floral envelopes.

Why is a calyx ?

1. Protection of bud.

2. Protosynthesis. Useful for manufacturing materials for local needs.

3. Protection of seeds.

Potentilla Canadensis, an example of all three. Kooders found in many tropical flowers, hydathodes in the calyx.

Why is a corolla ?

Darwin, Cubbeck, Miller, and others believed the corolla was for the attraction of insects. Plateau published experiments in which he proved that insects were color blind, hence the petals do not attract insects at all. War waged at present time between the two factions, though Plateau's theory seems to be not very tenable but the question still remains open.

Seeds and Fruits.

Nearly every wing of seed is green at first, hence Prof. Lloyd thinks that it does the work of protosynthesis.

Protection.

A. During Growth Period.

B. During Rest Period.

C. During   Period.

For growth hairs which are usually stiff, rigid, and dead. Position of hairs often explained conditions. Direction of growth in hairs.. Why are hairs so usually stiff ? A vertical hair is

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best protection against animals, horizontal against transpiration. Hairs generally found on shade and water plants. Kerner suggests that these hairs serve to keep water out in wet times. Glands as in rose-petals. Kerner suggests sticky hairs prevent insects and ants climbing up stem, or another theory that they give help in their moving up and down.

Lothelier--on spines. From examples he says drouth produces spines, but dryness, none. Also they have been developed by different conditionsf food and nourishmant.

2. Waxy coat or bloom.

Regarded as having a protective function.

3. Thick skin,

Clearly a protective function. Such plants found most plentifully in Arctic and Alpine regions, also in places of annual rains. Hairy forms found chiefly in desert regions. Thick-skinned leaf more transparent than hairy.

4. Succulent leaf.

Most extreme of all types. Have very thin skins. Some will hold their water for several months even near fires.

5. Lessened leaf surface.

6. Vertical position.

7. Leaf movement.

8. Poisons.

Modern view is away from protection--Case of Nettle--here sting is undoubtedly for purposes of protection.

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Many plants seem to have no protection but grow in positions where they can be away from danger ; others seem to grow utterly unprotected.

2. Protection during transition.

Buds--by scales, hairs and position in bud. At this time (transition) we find also greatest development of color.. Leaf movements. Development of seedlings. Seedcoats, movements, bendings of stems, scales, hairs, etc.

3. Protection during rest period.

This is highest development. Crisis in life a tree, usually the season of winter. Duckweed--large cells or air spaces which serve not only for storage of air but also for purposes of buoyancy. In fall a bud comes out without the cells and falls to the bottom where it remains during the cold season.

Annuals.. Perennials. On land have various ways of protection. Rosette form during period of rest and erect stem during period of vegetation. Corns, bulbs, tubers, rhizoids. Trees themselves with deciduous leaves. Evergreens.

Why is a tree ?

Question of erectness--a necessity of light.

Question of woody stem--duration and economy.

No form better adapted to extreme xerophytic conditions than a certain modification of the tree type, the barrel-shaped tree with immense development of storage tissue. Yuccas on our western deserts.

First trees were Pteridophytes and Gymnosperms.

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Ancient trees.

Lepidodendrons---like Cycopodiums.

Calamites---like Equisetiums.

Ferns proper.

Gymnosperms.

The first two are distinctly xerophytic in structure, hence the question whether the original trees grew in deserts or tropical wet regions.

Deciduous versus evergreen.

Drouth and cold, alternating with moisture and heat produce deciduous trees. Uniformity of conditions produce the evergreen. Exception to this evergreens which increase towards the north. One reason is advantage of being ready for work at all times without beginning again. Power to resist sudden changes as summer frosts.

Sclerophyll or hard-leaved type, as laurel or holly.

Needle-leaved or northern types.

Soft-leaved or southern types.

The first is fitted to resist unfavorable conditions, as cold and rain together and drouth and heat ; hence this type of plant is largely developed in Mediterranean region, in California, along the Gulf coast, etc. This leaf a kind of half-way condition.

Light. Vegetative Reproduction. Protection.

Tree, deciduous tree.
Tree, evergreen---needle, tropical, hard-leaved. Lianas. Rhizome, Bulb, Rosette, Annual.

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Lecture 14, August 1, 1900.

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Long Island.

Long Island. 120 miles long and from 10-20 miles wide. Two distinct parts. Northern, hilly, southern flat. Hills begin at Bay Ridge, extend to Roslyn, N.E., then east to Sag Harbor and thence to Montauk Point. Valleys extending across harbor from the bays ; fewer streams than valleys on north shore. 30 valleys have been counted. On the south shore valleys probably remnants of old glacial streams. No lakes or rivers on the island, but many springs due to fact that upper soil is sand and gravel preventing surface drainage and under layer of clay. Hence drainage of Long Island is like that of a limestone region. Few ponds, but many swamps. One lake, Ronkonkonia--3 miles. Many indentations on north shore, irregular coast-line made more irregular by post-glacial action as at Lloyd's Point.

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Historical Geology.

1. Archaean.--Crystalline--found on western part of Long Island--Astoria and Hell Gate and Long Island City. In Brooklyn such rocks have been struck by Artesian wells. Chiefly gneiss and granite. These rocks have no influence on flora.

2. The Paleozoic and early Mesozoic unrepresented until we come to the Tertiary and Cretaceous represented by the clays underneath the drift. In the south the soil is entirely so. Yellow sands and gravels. age unknown. Merrill's theory that these deposits represent an earlier glacial epoch. Whenever this gravel is in contact with drift, it is always below it and always above known tertiary deposits. The present cofastal plain of Long Island was once much more extended, out to the hundred fathom line. Buried rivers in this vicinity, as Hudson. At close of cretaceous period, probably Long Island was continuous with New York. New Jersey and Mass. separated from Conn. by a fresh water stream.

Soil probably glacial on north side and boundary absolutely distinct between hills on north from plain on south. Hills average 250 ft. in height. Highesr hill, Harbor Hill, near Roslyn, 391.ft. A second moraine on north coast gives its shape to the coast. Between these two moraines is a plain, well-marked. Terminal moraine stops on a southern slope--this positive proof of glacial advance. South slope probably was an overwash from the glacier.

Glacial clay or till, best deposits in Brooklyn. Sands and gravels in Kames, in other parts. Also boulders of gneiss and granites.

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Theory of these Hills.

Kame theory. Merrill's theory--fold ed strata always in association with bays, hence he concludes that the glacier scoured out the ~~hills~~ bays and pushed up the hills at the sides.

Evidence against this theory.

In post-glacial times, we find the most important modifications upon our flora. Wearing away of east end and deposition along the south shore, besides local changes which form the important relations in ecological study.

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Lecture 15, August 2, 1900.

Physiographic Ecology of Long Island.

3 phases.

1. Plants, organs, and their ecological relations.

2. Plant societies and their ecological relations(locally).

3. Climatic ecology or geographic botany. (Phytogeography).

Western prairies explained by climatic differences.

Edaphic as (local in character) opposed to climatic. Such factors as have to do with zonal distribution, springs, slopes, etc.

Ecology used since 1895 when it was introduced by Warming. Three distinct phases given above. Physiographic ecology deals with relations of plants societies to their local environments. Two distinct units in such a study.

1. Topographic form, merely a stage in development of a region.

2. Plant society an assemblage of plants in a common habitat. Also a stage in the development of a region from the plant's standpoint.

Physiographic Ecology has no histiry, since this may be termed the prehistoric time. Begins really with Warming when he published in 1895. Greatest work since then that of Schimper, in 1899. Other papers have been published.

Edaphic Factors.

1. Water. Water level always modifies flora of a region.

hydrophytic soil 80%.

xerophytic soil 10 %

mesophytic, between the two.

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Importance of water from its variability and uncertainty. One of great causes for difference in water is difference in soil. Another, evaporation ; others, openness of soil and slope. Soil water is an edaphic factor.

2. Light.

Sunlight both edaphic and climatic. Zones of the earth divided because of light being distributed differently. In a forest difference comes from the influence of light as an edaphic factor. Succession of forest trees ; first aspens, and white birches ; then pines, then oaks and lastly beeches. Such succession found in Michigan caused very largely by difference in light. First are light-loving trees and they grade down to those which can grow in shade. Other influences of light. Suggestions in water plants, as different colored Algae.

3. Heat--most important climatic factor from north to south. Of comparatively little importance as an edaphic factor. Difference in temperature of soils. (A) Slope. (B) Amount of water. Do not look for early spring flowers in a swamp. It is too cold and wet.

4. Air. One of the most important factors, but not ecologically because of its evenness. Movements often radically change the flora of the region. Importance of air in the water. In stagnant water plants have been unable to get proper gaseous food through the ordinary channels, hence they seem to adopt extraordinary methods like the Utricularia.

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5. Soil.

Schimper considers soil most important factor but he includes everything under the term soil which is contained in it, as water, etc. Soil ecologically is that in which a plant can grow. Soil is divided mechanically into

1. Solid rock.

Difference in flora in this case depends upon character of rock. Different types of lichens grow on granite, limestone, etc. Lichens a real rock plant, mosses grow more in crevices. Shaly rocks decay so rapidly that lichens find it difficult to grow on them. Sandstone varies. Granite allows much growth of lichens since the feldspar in it erodes more rapidly than the other elements and gives foothold for the spores.

2. Residual soil.

Not found in glaciated regions, hence not found in Long Island.

3. Secondary soils.

Soils which begin as residual soils but are transported to other places. Example--Fire Island. All the soil secondary, probably came from Montauk Point and before that from N. E. Such soils represent erosion of rocks ages ago, either by water action, wind action or glacial action. Deposits strictly due to glaciation are usually unstratified. Those due to water stratified and coarse. Those due to wind fine and stratified ~~and~~ or unstratified. Bulk of Long Island deposits may be ascribed to waters which came from melting ice.

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Secondary Soils.

(a) Sand including gravel. Sand is almost the opposite of clay. It is porous, but its food value is poor because of ite make-up. Sand is made up of particles of almost insoluble minerals as quartz. Water percolates through it so rapidly it has almost no cohesion and no water capacity. It heats and cools with greater rapidity than other soil, hence it is most xerophytic of soils.

(b) Clay. Heterogeneous soil. Most northern clays represent pulverized rock left by glacier, Chief element $Al_2(Si\ O_4)_3$. Clay may or may not be rich in food stuffs, according to its origin. It consists of more soluble materials and retains them. Smaller the particles, less the porosity. A swamp is never found on a sand hill but often on a clay.

(c) Humis---a soil derived from decay of organic matter where there is not complete oxidation. Better than sand or clay chemically and also because it contains soluble avids. Plants require a certain amount of inorganic substances. Presence or absence of water largely determines presence of humis. Three kinds of humis : mould, peat, schlaum. Schlaum is entirely formed below the water. Organic mud.

Color of soil depends largely upon the amount of oxidation. Blacker and finer humis, better the soil, as in a forest. Underground animals add greatly to the value of soil, as earthworms and bacteria. Peat is charavteristic of a northern climate from coolness and moisture Recent studies show that physiographic youth of region also determines the formation of peat. Best explained by absence of oxidation and

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drainage. Few bacteria in swamps. Too acid to raise many plants.

Forests--evergreen, tropical forests highest development of plant kingdom. Richer the forest, greater the humis. Accumulative effects in a forest. C. and N. are gradually increasing in a forest soil.

(d) Mixed soil as loam--either humis or a mixture of two or three elements known as mixed soils.

(e) Calcareous soils.--marls of N.J. coral soils of Bermuda.

(f) Salty soils. Salt seems to produce a xerophytic form of plants.

Chemistry vs. Physics of Soils.

Which has more effect upon flora of the region ? Abrupt changes in flora from one stratum to next.

One theory, the chemical conditions of the soil. Unger. Thurman, on the contrary, held the view that the kind of soil decides the flora, whether it is dry or porous, etc. Warming accepts the physical theory in most cases ; but excepts halophytes or marsh plants. Schimper inclines to the chemical view. Dr. Cowles considers the chemical view the better.

Nägeli called attention to struggle for existence ; that chestnut grows in sandy places not because it likes it best but because the beech crowds it out by occupying better places.

Another factor is the physiographic age of region. The true theory is probably that of a mixture of all four.

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Field Work. July 27, 1900.

Spit Vegetation.

Drawing.

Regions 1 and 2 represent the xerophytic side of the beach ; 3, 4, and 5 the hydrophytic area. Under the water was eel-grass in great quantities. From the water's edge to high tide was no vegetation owing to the instability of conditions. Region 1 might be called the zone of annuals since it was covered with water part of the year. The perennials would be those which had grown this year.

Plants in Region 1.

1. Salsola Kali Saltwort.
2. Chenopodium album Lamb's Quarters.
3. Cakile Americana Sea-rocket.
4. Polygonium Convolvulus Black Bindweed.
5. Xanthium Cockle-bur.
6. Atriplex hastata Orache.
7. Ammorphila Sand-reed.
8. Oenothera Primrose.
9. Strophostyles angulosa
10. Rhus toxicodendron Poison Ivy.
11. Solidago sempervirens Goldenrod.

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12. Bidens frondosa   Beggar-ticks.

13. Stromonium (Datina)   Stinkweed.

14. Panicum sanguinale

15. Taraxacum   Dandelion.

16. Ambrosia   Ragweed.

The most typical forms are Salsola, Cakile, and Xanthium. Number of individuals of each species were small.

Region II was characterized by biennials.

1. Ammorphila arundinacea.

2. Salsola.

3. Xanthium.

4. Cakile.

5. Panicum sanguinale.

6. Solidago sempervirens.

7. Erigeron Canadensis.   Horse-weed.

8. Marrubrium vulgaris   Horehound.

9. Asparagus.

10. Linaria vulgaris.

11. Achillea Millefolium   Yarrow.

12. Lathyrus maritimus   Beach pea.

13. Nepeta cataria   Catnip.

14. Ampelopsis.

15. Plantago lanceolata.

17. Sweda linearis   Sea-blite.

18. Atriplex.

19. Oenothera.

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20. Bidens. 21. Chenopodium. 22. Lactuca Lettuce.

23. Mollugo verticillata Carpet-weed.

24. Ailanthus glandulosus. 25. Rhus. 26. Malva rotundifolia.

This zone might be called the Ammorphila zone since that plant predominates. The nexr most prominent plants were Solidago, Rhus, and Salicornia.

Plants of Region III.

Cakile Americana.

Solidago sempervirens

Ambrosia artemisiaefolia

Oenothera

Sueda

Salsola.

Atriplex.

This region was narrow extending from the edge of the summit to the winter tide mark. Cakile predominated and there was a good deal of Sueda and Salsola.

Plants of Region IV.

This might be called the Spartina juincea region since that plant occupied the largest space. With it was

Statice (var.) Caroliniana. Salsola Kali. Atriplex. Sueda linearis

Region V.

This zone was completely covered at high tide and showed a growth of Spartina polystachya.

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Swamp Vegetation Fresh Water.

1. Goodyera pubescens Rattlesnake Plantain.

2. Habenaria tridentata

3. Botrychium dissecta

4. Botrychium ternata

5. Osmunda cinnamomea

6. Osmunda regalis

7. Pteris aquilina

8. Woodwardia augustifolia

9. Onoclea sensibilis

10. Dicksomia punctilobia

11. Aspidium Thelypteris

12. Vaccinium corymbosum Tall swamp bluberry.

13. Carpinus Water beech.

Betula lenta Sweet birch.

15. Viburnum dentatum

16. Nyssa sylvatica Sour gum.

17. Rubrus hispidus Evergreen blackberry.

18. Viola blanda

19. Viola prunufolia

20. Chrysosplemin Americanum Golden Saxifrage.

21. Impatiens ulva

22. Alnus incana

23. Kalmia latifolia

24. Elodes campanulata Marsh St. Johnswort.

25. Acer rubrum.

26. Smilax rotundifolia.

27. Andromeda ligustrina.

28. Arisaema triphyllum.

29. Symplocarpus foetidus.

30. Hamamelis Virginiana.

31. Drosera rotundifolia.

32. Rosa Carolina.

33. Clethra almifolia.

34. Polygonium Convolvulus.

35. Polygonium arifolium.

Polygonium sagistatum.

37. Medeola Virginica.

38. Tridentalis Americana   Chickweed, Wintergreen.

39. Rhododendron viscosa   Azalea (False Honeysuckle).

40. Vitis Labrusca   Northern fox-grape.

41. Rhus venenata

42. Hydrocotyle Americana   Water pennywort.

43. Pyrola rotundifolia.

August 3, 1900.

Ocean Beach at Fire Island.

On the south shore the land is being slowly built up. Dunes have been formed, but owing to the variable character of the winds the dunes do not attain the height of those near Lake Michigan. Several zones may be distinguished.

I. The Ocean Beach Zone.

II. First Row of Dunes.

III. Inner Dunes. { a. Ammophila region.
b. Hudsonia region. }

IV. Swamps in the Dunes.

V. Low Dunes on the Bay Shore.

VI. Beach Zone on the Bay Shore.

No vegetation on the ocean beach owing to the disastrous effects of strong surf and high winds. The shape of the first dunes is like this (drawing), not the usual dune shape since the dune has received a cliff-like aspect from the vigorous wave action. The direction of the wind being variable the dunes as a whole are not moving, though there is more or less shifting of the sand. This sand was purple in some places and was mixed with garnet particles as well as magnetite.

II. First Dune Region.

Ammophila.

Lathyrus maritimus. Cakile Americana. Oenothera biennis.

Solidago sempervirens. Euphorbia polygonifolia.

The inner dunes were the highest on Fire Island, and most nearly approach moving dunes. They showed two characteristic zones of vegetation ; first the Ammophila zone where that plant was found in exposed situations where the life struggle is most severe. Second the Hudsonia zone. In this Hudsonia grew in more protected places, especially on the north side of the dunes. Other plants of the Hudsonia zone were :

1.Lechia maritima Pinweed.

2. Carex straminea

3. Cyperus Grayii.

III. Plants of the Swamp Regions growing in depressions.

1. Discopleura capillacea Boneset.

2. Eupatiorum perfoliatum

3. Lycopodium.

4. Sabbatia stellaris

5. Spartina juncea.

6. Potentilla anserina.

7. Panicum dichotomum.

8. Viola lanceolata.

9. Polygonum acre. Water Smartweed.

10. Erechtites hieracifolia Fireweed.

11. Solidago tenufolia

12. Oenothera fructicosa (var. humifosa).

13. Polygola verticellata.

14. Spiranthes praecox.

15. Hibiscus Moschentos Rose-Mallow.

16. Pluchea camphorata Camphor-plant.

17. Kalmia angustifolia

18. Vaccinium macrocarpon Large Cranberry.

19. Iris.

20. Iva frutescens.

These depressions scattered among the dunes are undrained swamps. They are probably remnants of the sea which being cut off, formed lakes and finally became fresh water marshes.

V. and VI. Low Dunes and Beach on the Bay Side.

Here the flora was essentially like that of the sand spit, xerophytic in character.

1. Cakile Americana.

2. Salsola Kali.

3. Xanthium Cockle-bur.

4. Atriplex arenaria Orache.

5. Euphorbia polygonifolia.

6. A few Ammophila plants.

7. Amaranthus pumilis Pigweed.

8. Arenaria peploides Sandwort.

The future of Fire Island seems to be occupied by forests. The following seedlings were found :
Pinus rigida. Betula populifolia. Populus tremuloides. Myrica cerifera. Juniperus Virginiana.

Plants found in Marsh at Babylon.

Eloides campanulata   Marsh St. Johnswort.

Habenaria blephariglottis   White fringed-orchid.

Lecture 17, August 8, 1900.

Classification of Plant Societies.

Drude's Handbook of Plant Geography, 1890, purely geographical. Engler and Drude : Vegetation der Erde, to be in a hundred volumes only a few having now been published.

In 1895 Warming--Danish--published "Plantes amfund." In this the classification based on the water conditions of the soil.

In 1898--Schimper--uses as his principal classification, in dividing the world, heat. Torrid, temperates, Arctic, Mountain and Water. Warming's is a classification in the small, Schimper's in the large. The latter divides each of his zones as forest, grassland and deserts, which are determined by climatic causes. Peat bogs, dunes, etc. are determined by edaphic causes.

Nilsson and other Scandinaviarian writers are working along ecological lines. Graebner in 1898 published a pamphlet which classified according to chemical food stuffs of the soil. In attempting to place the flora of North America according to Warming's classification, a difficulty is found in peat bogs. The real trouble of Warming's plan is that he bases all upon one factor, water.

Dr. Cowles' Theory of Classification.

1. That nature is dynamic not stactic.

2. That the presence of plants depends upon the topographical conditions of the place, almost entirely. As a region gets older, the topography has more and more to do with the flora, and the geology, less and less.

3. Topography depends on dynamics, not statics.

4. That plant societies are made what they are largely by past influences, since the vegetation lage behind the topography. Result of accumulative effects.

The vegetation of any district is a complex resultant of past and present. Accumulative effect of environment shown by the increase of humus. Each plant society by its own existence prepares the way for its own downfall and its replacement by something else. Hence there must be definite suvecession of plants. A genetic classification such as this is based on relations. Peat bogs and heaths are genetically connected.

Topographic Changes.

Two great agencies at work in a region, denudation and deposition. Effect of such processes, since highest hills most eroded and highest valleys less filled up, is planation. A hill necessarily must be xerophytic and a walley hydrophytic ; hence as planation increases, the ultimate end of all plant societies over inland areas where climate is favorable, seems to be to reduce all to mesophytes.

Crustal movements also have to do with this classification.
Atkinson's p. 374-423. Coulter's Plant Relations.

Stream Vegetation August 8, 1900.

Vegetation along a flowing stream changes very much from various causes. Chief among these is the drainage whether the stream flows rapidly or slowly. Another is difference in the depth flora which sometimes grows to the very edge of the water and still anoyher the difference in temperature.

First Region.

From the spring where the stream flows more rapidly. Around the source we found a quantity of Sagina procumbens which always grows best in a cool, shady place.

Sagina procumbens. Lycopus Virginicus. Eupatorum purpureum, Joe-Pye weed. Eupatorum perfoliatum, Boneset. Viola cucullata (with cleistagomous flowers). Impatiens fulva. Alnus. Symplocarpus foetidus. Chrysosplenium, Golden Saxifrage.

Second Region.

Where the stream began to slow up.

1. Sphagnum. 2. Rubrus hispidus. 3. Viburnum. 4. Apios tuberosa. 5. Polygonum arifolium, Halbert-leaved Tear-thumb. 6. Polygonium sagittatum, Arrow-leaved Tear-thumb. 7. Osmunda. 8. Glyceria nervata, grass(fowl meadow). 9. Epilobium coloratum. 10. Carex intumescens, sedge. 11. Scutellaria laterifolia, Mad-dog Skullcap. 12. Chelone glabra. 13. Galium trifidum, var., latifolium, Small Bedstraw. 14. Viola blanda. 15. Eloides campanulata.

Third Region.

Where the stream flowed through open meadows.

1. Pilea pumila. 2. Polygonum Hydropiper, Water-pepper. 3. Onoclea sensibilis. 4. Carex. 5. Scirpius. 6. Lycopus seminatus. 7. Ludwigia alternifolia, Seed-box. 8. Mentha viridis, Spearmint. 9. Mentha piperita, Peppermint. 10. Asplenium Filix-foemina. 11. Hypericum nudicante, Orange-grass, Pineweed. 12. Houstonia. 13. Polygonum Pennsylvanicum. 14. Vernonia.

Along the wood road grew AnAphalis margaritacea, Pearly everlasting. In the stream was Myricophyllum tenellum.

Lecture 18, August 9, 1900.

I. Progressive Series {Youth to maturity. Poverty to wealth.

A. Towards water level Xerophytic to Mesophytic.

1. Hills {a. Chemical and Physical Nature. b. Direction of Slope.

Crustal movements may have the same or opposite effects as physiographic factors. An upward crustal movement in a swamp will have the same effect as the physiographic. A country-s development may be traced from youth to maturity, as well as from poverty to wealth, a condition due to the accumulation of ~~we~~ humis.

The Flora at the start on a hill or mountains must be xerophytic. Erosion is always tending to wear a hill down to level, rounding the edges first. The slope being different, by drainage changes, the rocks are worn into finer materials, and as plants die, humis accumulates. Changes in shape bring about different conditions for plant life. The principal changes will be

1. Less exposure. 2. More water. 3. Finer soil.
4. Accumulation of humis.

From these differences vegetation will soon change from xerophy- to mesophytic. In digging through a hill we find the water level, no sudden change, but the amount of water in the soil gradually increases as we pass downward.

Hills (a) Chemical and Physical Factors.

1. Sand and gravel. (Kames--glacial).

With regard to the nature of the soil Kames are the same as sand

dunes, except the particles are larger, and the development of vegetation is probably the same. Kame flora probably originated in glacial times. If a Kame could be denuded we would find the same succession of flora as that on a beach. On a sand hill there is a long period between youth and maturity because sand does not readily retain water and humis accumulation is slow. A clay hill is just the opposite, and also erodes more rapidly. On the hills in this region chestnut oaks and chestnuts are now the most dominant trees. Pinus rigidus was probably the first, followed by Quercus nigre and Castanea the first of which was replaced by Robinia.

It is difficult to determine what the future will be. Beeches and maples are xerophytic and are found to some extent at foot of the hills. They represent a later stage than the chestnut.

3. Rock Hills.

Lichens are the first plants found on rock hills. Granites are best adapted to lichen growth since the different constituents decay unequally giving rise to crevices which allow the plants to gain a foothold. Limestone and sandstone are less well adapted owing to their rapid disintegration. Lichens are followed by crevice plants especially mosses and some of the pinks.

B. Direction of Slope.

The sun is such an important factor that in spite of the direction of prevailing wonds, the north slope is always the moistest. Moisture and wind are most important factors in determining the slope of a hill.

C. Altitude.

(a) Absolute altitude is height above the sea level.

(b) Relative altitude is height above the surrounding country. The first has a strong effect and gives rise to distinct zones. It shows especially over great heights while relative height effects smaller areas which differ slightly in altitude. In three hills of 200, 400 and 800, the vegetation will be about the same, being exposed to about the same conditions unless protected by other hills.

In a hill in the latitude of N.Y. the most xerophytic plants will generally grow on the upper parts of the north and south slopes. The north slope is xerophytic because there is less heat and an increased exposure to colder winds, while on the south the same conditions prevail, the soil being drier on account of the greater amount of heat. East and west slopes will be more mesophytic.

In the latitude of Georgia the south slope will be the hottest and driest making it most xerophytic ; while the lower north slope will be most mesophytic owing to the greater amount of moisture, the latitude being such that the least supply on the north side will be sufficient to produce a mesophytic flora.

In the forests of Canada, a xerophytic forest is usually due to the absence of heat and not to the absence of moisture. Hence in this case the most xerophytic portion of a hill will be the upper part of the north slope, since that region is most exposed to the cold. The lower part of the south slope will probably be mesophytic, due to the increased heat.

D. Environment.

1. If a hill is surrounded by other hills, a mesophytic flora may often be produced. A hill protected by higher hills may have a mesophytic flora to the top.

In a V-shaped valley the flora will probably be mesophytic being protected from excessive heat, wind and cold. While the slope tends to make the soil dry, this will be counteracted by the absence of strong light. When erosion changes a V-shaped valley to a U-shaped one, one side will have a mesophytic flora, the other side protecting it just as hills surrounding it may protect another hill. Two factors tend to produce a mesophytic flora on hills.

1. The physiographic changes of the hills.
2. The accumulation of humis.

This is beautifully shown in the White Mountains where we have a mesophytic flora before a base level is reached. On the other hand, on the seashore or desert, we may have base level without a mesophytic flora.

II. A hill exposed to ocean action must remain xerophytic as long as the ocean remains, so will have a xerophytic flora in a mesophytic climate. There may be a mesophytic flora if the ocean has encroached on the land bringing areas formerly removed from water action to the coast. In order to have a mesophytic forest, there must be a great amount of atmospheric moisture.

Lecture 19, August 11, 1900.

2. Xerophytic Beach.

Found commonly along exposed shores ; least marked in harbors.

Ex. Fire Island.

1. A case where beach is encroaching upon the shore.

a. Below low tide complete submergence, flora not xerophytic.

On a protected beach, flora is

b. Below high tide. Alternation of submergence and dry land. Here we find xerophytic plants forms of Algae.

c. Lower beach from high tide line to that of highest summer storms. During most of year conditions excessively xerophytic, preventing water forms, while the occasional submergence prevents xerophytic types, so this is a desert zone. In very wet seasons and in spring Algae sometimes grows here.

d. Middle beach from limit of summer to limit of winter storms. This is quiescent in summer, hence Annuals can grow there. Salsola, Cakile, Xanthium, etc.

e. Upper beach or fossil beach, above line of storms, so-called since it once was a beach. Here perennials may grow. Ammophila, Lathyrus, etc.

f. Dunes. A wind-blown structure while beach is wave-produced. Dune sand more uniform and finer than beach sand. Heavier elements. not blown up to form dunes as seen in the garnetiferous and magnitite sands on the beach at Fire Island.

Beach conditions extreme in every respect ; on dunes, same conditions, and also those of denudation and burial. Ammophila indirectly one of the most commercial plants in the world being a sand-binder. When a dune gets very large, the conditions become very bad for Ammophila and the plant dying, the wind has full power over the sand hill. After Ammophila comes the <u>shrub zone</u>, Prunus maritanus, Myrica cerifera, Rhus toxicendendron.

<u>Tree Zone</u> follows the shrub. Juniperus Virginiana; then pines and oaks. Quercus nigre seems almost as resistant as the pine. A characteristic undergrowth accompanies each kind of tree. Humis is being increased. Xerophytic beach easily told from desert stretch while on hydrophytic beach the vegetation presents an unbroken series.

Why is this difference ?

1. Difference from exposure (seen on Spit).
2. Difference in Slope, that of xerophytic being more rapid than hydrophytic.
3. Hydrophytic beach more common where springs enter.

Exposure the predominant factor. Shingle or gravel beaches xerophytic since there is little chance for accumulation of humis.

B. <u>Away from water level.</u>

1. Drained swamps or rivers.
2. Undrained swamps or kettle holes.
3. Hydrophytic shores or salt marsh.

I. Rivers.

Two elements   a. Changes in climate and altitude.
                b. Influence of physiography on the river/flora.

In a typical river there are four stages-------Miss. River.

1. The ravine stage.

2. The U-shaped valley.

3. The Foof plain.

4. The Crescentic lakes or Ox-bows.

Flora in all regions very different. The beginning of a river is retregressive. If a river eats back in a wooded country, we should find a ravine flora replacing the forest.

Development of flood plains.

Great area of rich soil deposited by the river in its constructive stage. In the destructive stage, the flora will retrogress ; in the constructive, the progressive stage.

Lagoons or undrained swamps.