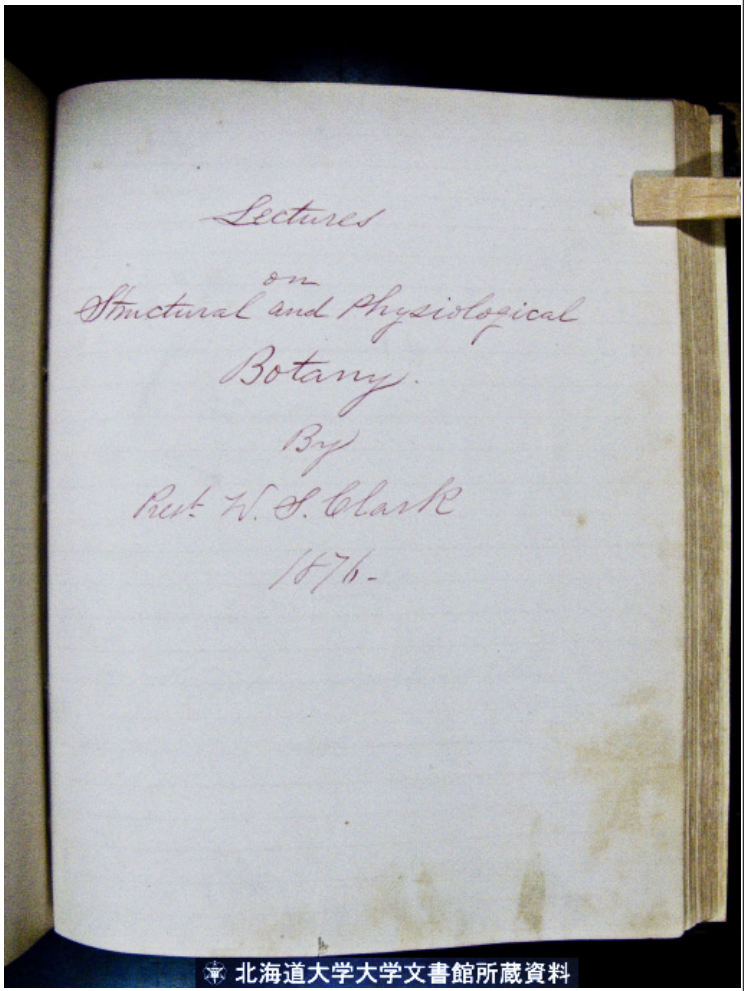


Lectures

on

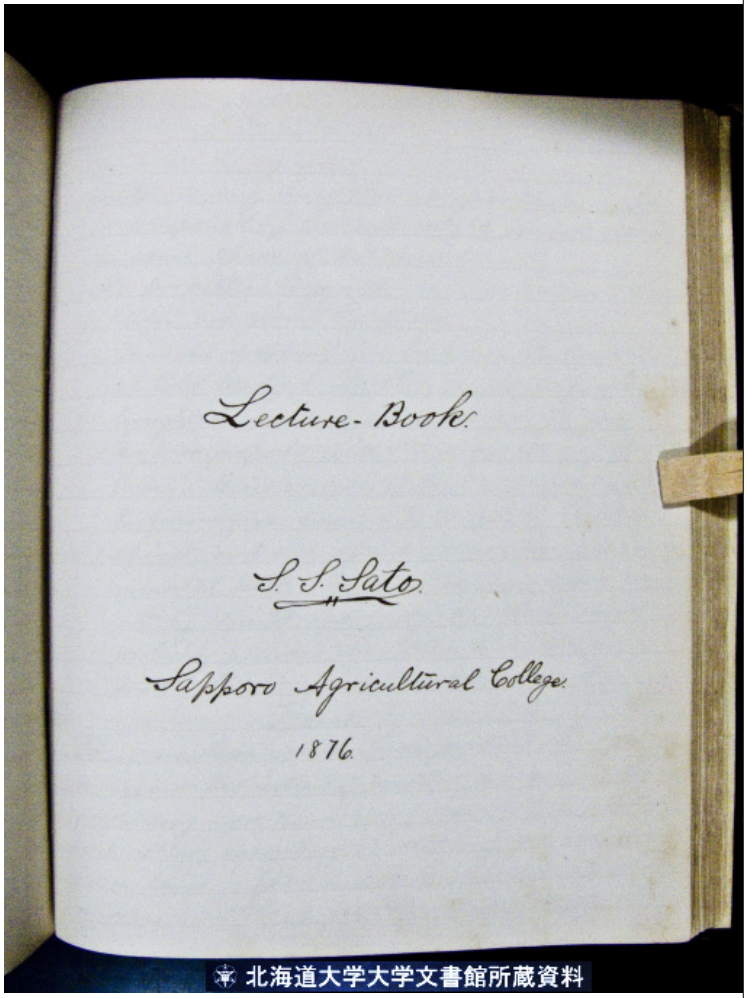
Structural and Physiological

Botany

By

Prof. W. S. Clark

1876.

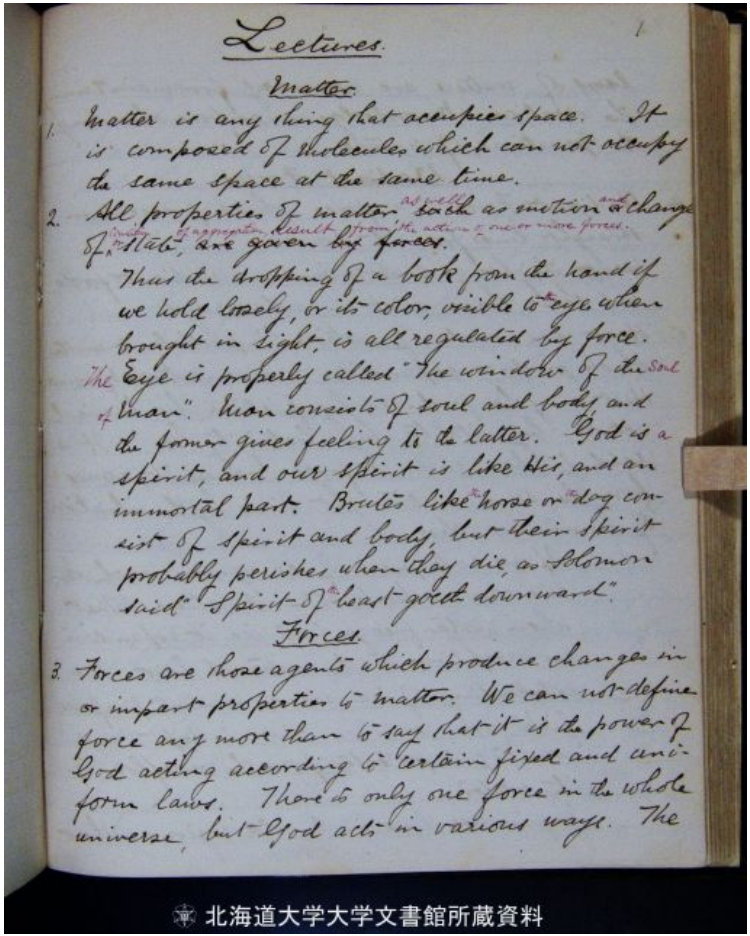


Lecture-Book.

S. S. Sato

Sapporo Agricultural College.

1876.



Lectures.

Matter

1. Matter is any thing that occupies space. It is composed of molecules which can not occupy the same space at the same time.

2. All properties of matter as well as motion and change of condition or state of aggregation result from the action of one or more forces, are given by forces.

Thus the dropping of a book from the hand if we hold loosely, or its color, visible to the eye when brought in sight, is all regulated by force. The Eye is properly called "The window of the Soul of Man". Man consists of soul and body, and the former gives feeling to the latter. God is a spirit, and our spirit is like His, and an immortal part. Brutes like the horse or the dog consist of spirit and body, but their spirit probably perishes when they die, as Solomon said "Spirit of the beast goeth downward".

Forces.

3. Forces are those agents which produce changes in or impart properties to matter. We can not define force any more than to say that it is the power of God acting according to certain fixed and uniform laws. There is only one force in the whole universe, but God acts in various ways. The

Lectures

Matter

1. Matter is any thing that occupies space. It is composed of molecules which can not occupy the same space at the same time.
2. All properties of matter as well as motion and change of condition or state of aggregation, result from the action of one or more forces.

   Thus the dropping of a book from the hand if we hold loosely, or its color, visible to the eye when brought in sight, is all regulated by force. The eye is properly called "the window of the Soul of Man". Man consists of soul and body, and the former gives feeling to the latter. God is a spirit, and our sprit is like His, and an immortal part. Brutes like the horse or the dog consist of spirit and body, but their spirit probably perishes when they die as Solomon said "Spirit of the beast goeth downward."

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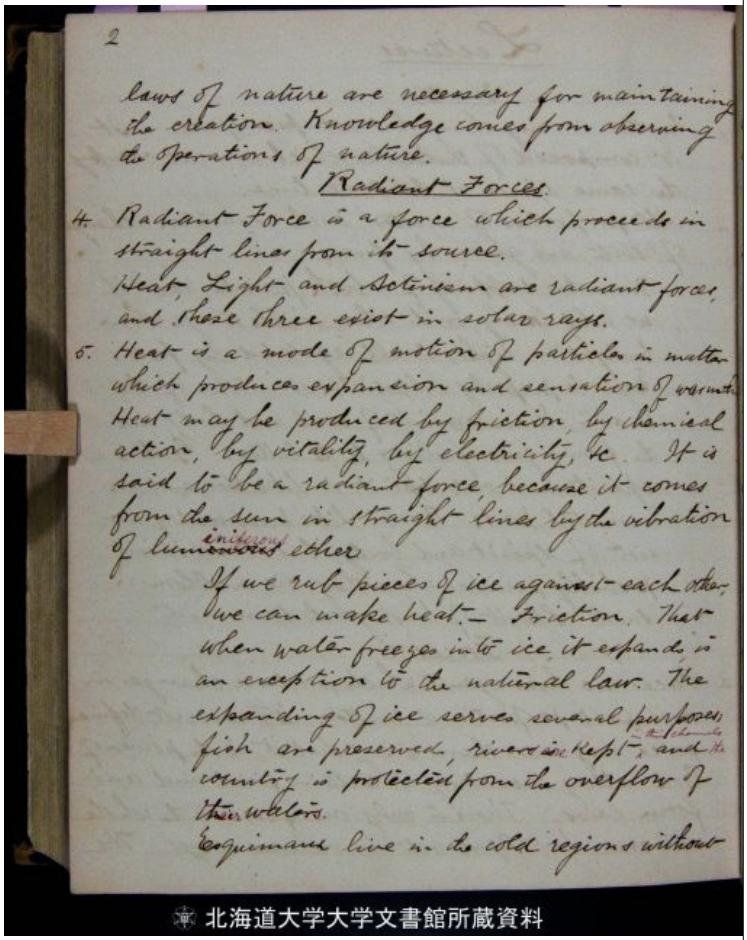
Solomon: 紀元前 10 世紀のイスラエルの王。

Who knoweth the spirit of man that goeth upward, and the spirit of the beast that goeth downward to the earth?

人間の霊は上に昇り、動物の霊は地の下に降ると誰が言えよう。(旧約聖書 コヘレトの言葉 3 章 21 節（新共同訳))



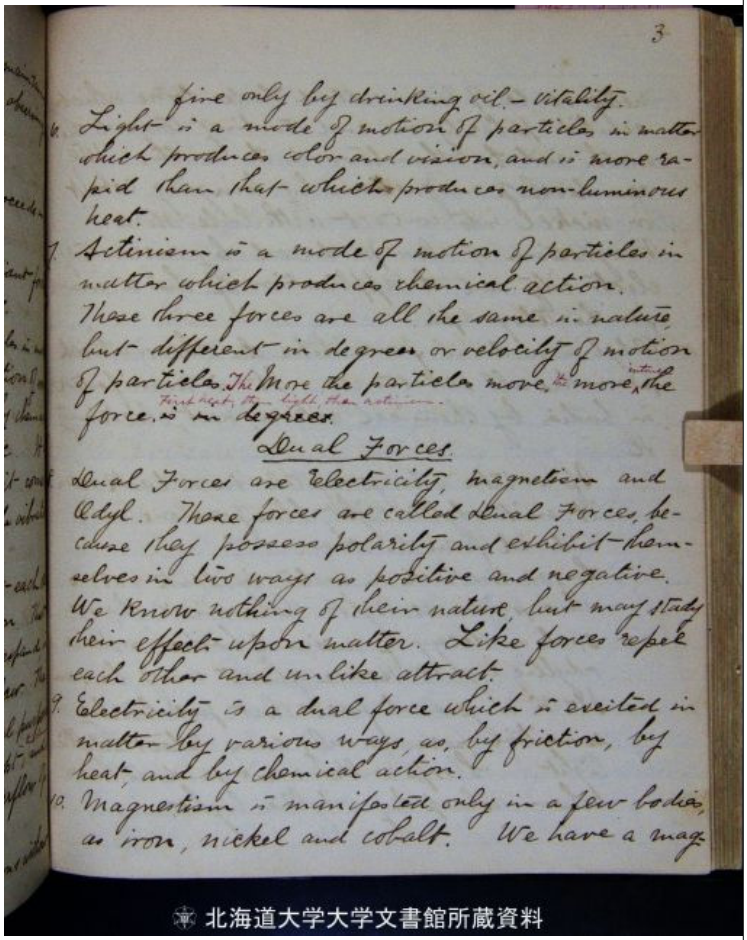
laws of nature are necessary for maintaining the creation. Knowledge comes from observing the operations of nature.

Radiant Forces

4. Radiant Force is a force which proceeds in straight lines from its source.
   Heat, Light and Activism are radiant forces, and these three exist in solar rays.
5. Heat is a mode of motion of particles in matter which produces expansion and sensation of warmth. Heat may be produced by friction, by chemical action, by vitality, by electricity, &c. It is said to be a radiant force because it comes from the sun in straight lines by the vibration of luminiferous ether.
   If we rub pieces of ice against each other, we can make heat. — Friction. That when water freezes into ice, it expands is an exception to the national law. The expanding of ice serves several purposes, fish are preserved, rivers are kept in their channels and the country is protected from the overflow of the waters.
   Esquimaux live in the cold regions without

---

luminiferous: 発光する。
ether: エーテル。光の輻射の仮想的媒体（19 世紀における仮説）。
Esquimaux: Eskimo エスキモー人。
&c: etc



fire only by drinking oil. — vitality.

6. Light is a mode of motion of particles in matter which produces color and vision, and is more rapid than that which produces non-luminous heat.
7. Activism is a mode of motion of particles in matter which produces chemical action.
   These three forces are all the same in nature but different in degrees or velocity of motion of particles. The more the particles move, the more intense the force. First heat, then light, then activism.

Dual Forces

8. Dual Forces are Electricity, Magnetism and Odyl. Those forces are called Dual Forces, because they possess polarity and exhibit themselves in two ways as positive and negative. We know nothing of their nature but may study their effects upon matter. Like forces repel each other and unlike attract.
9. Electricity is a dual force which is excited in matter by various ways, as, by friction, by heat, and by chemical action.
10. Magnetism in manifested only in a few bodies, as iron, nickel and cobalt. We have a magnetic

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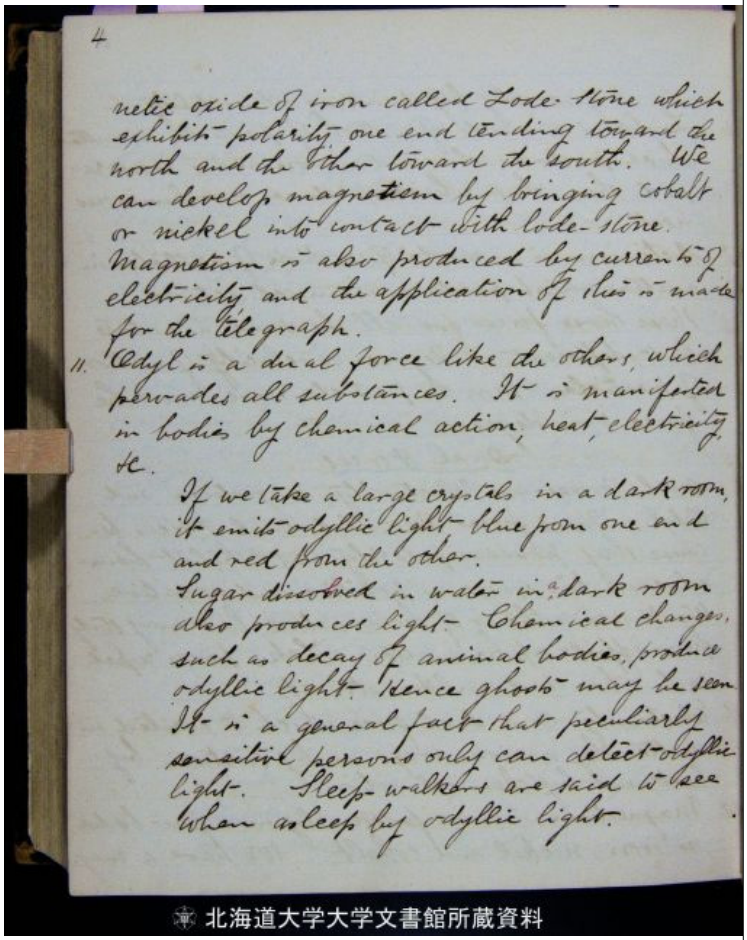
Odyl: Od　オッド。ドイツの化学者 Reichenbach が、化学作用などを説明するためにとなえた仮想的力。



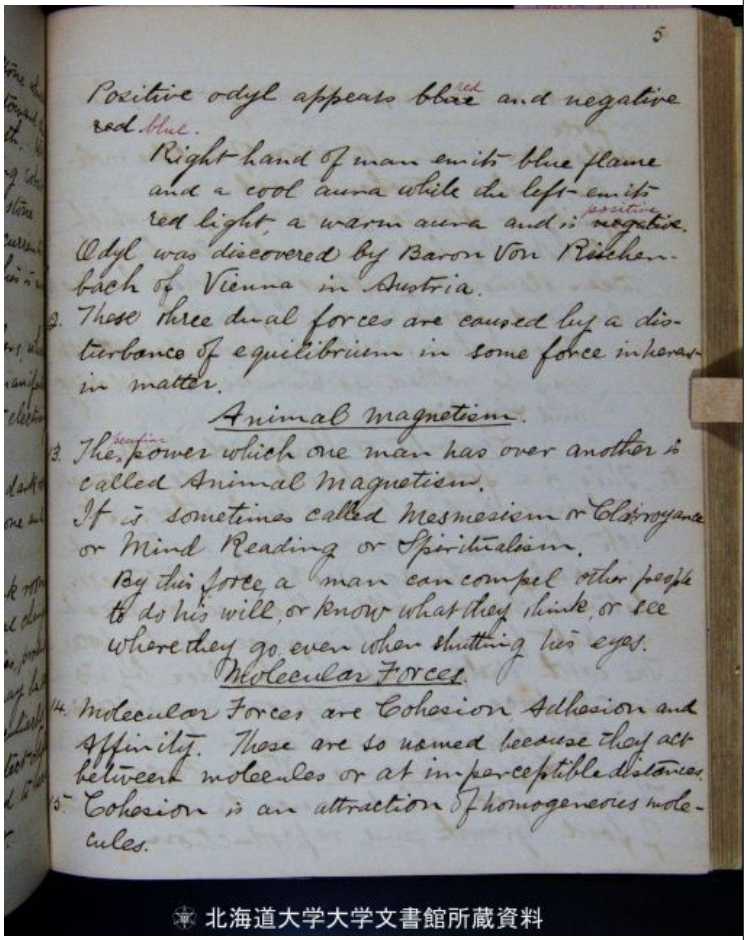
oxide of iron called Lode-Stone which exhibits polarity one end tending toward the north and the other toward the south. We can develop magnetism by bringing cobalt or nickel into contact with lode-stone.

Magnetism is also produced by currents of electricity and the application of this is made for the telegraph.

11. Odyl is a dual force like the others, which pervades all substances. It is manifested in bodies by chemical action, heat, electricity, &c.

If we take a large crystal in a dark room, it emits odyllic light blue from one end and red from the other.

Sugar dissolved in water in a dark room also produces light. Chemical changes, such as decay of animal bodies produce odyllic light. Hence ghosts may be seen. It is a general fact that peculiarly sensitive persons only can detect odyllic light. Sleep-walkers are said to see when asleep by odyllic light.



Positive odyl appears red and negative blue.

Right hand of man emits blue flame and a cool aura while the left emits red light, a warm aura and is positive.

Odyl was discovered by Baron Von Reichenbach of Vienna in Austria.

12. These three dual forces are caused by a disturbance of equilibrium in some force inherent in matter.

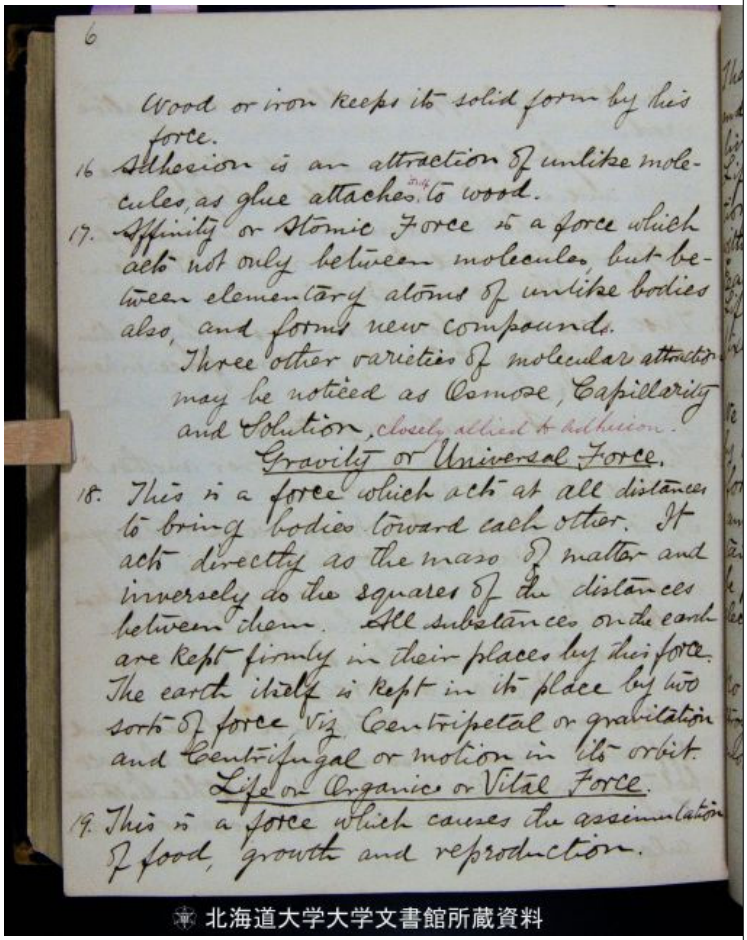
Animal Magnetism

13. The peculiar power which one man has over another is called Animal Magnetism.
    If is sometimes called Mesmerism or Clairvoyance or Mind Reading or Spiritualism.
    By this force a man can compel other people to do his will, or know what they think, or see where they go, even when shutting his eyes.

Molecular Forces

14. Molecular Forces are Cohesion, Adhesion and Affinity. These are so named because they act between molecules or at imperceptible distances.
15. Cohesion is an attraction of homogeneous molecules.

Reichenbach: ライヘンバハ Carl Ludwig von Reichenbach (1780-1869) ドイツの自然科学者。電気･磁気･熱･光の中間にある新しい力を発見したとして，od と命名した。



Wood or iron keeps its solid form by this force.

16. Adhesion is an attraction of unlike molecules as glue attaches itself to wood.
17. Affinity or Atomic Force is a force which acts not only between molecules, but between elementary atoms of unlike bodies also, and forms new compounds.

    Three other varieties of molecular attraction may be noticed as Osmose, Capillarity and Solution, closely allied to Adhesion.

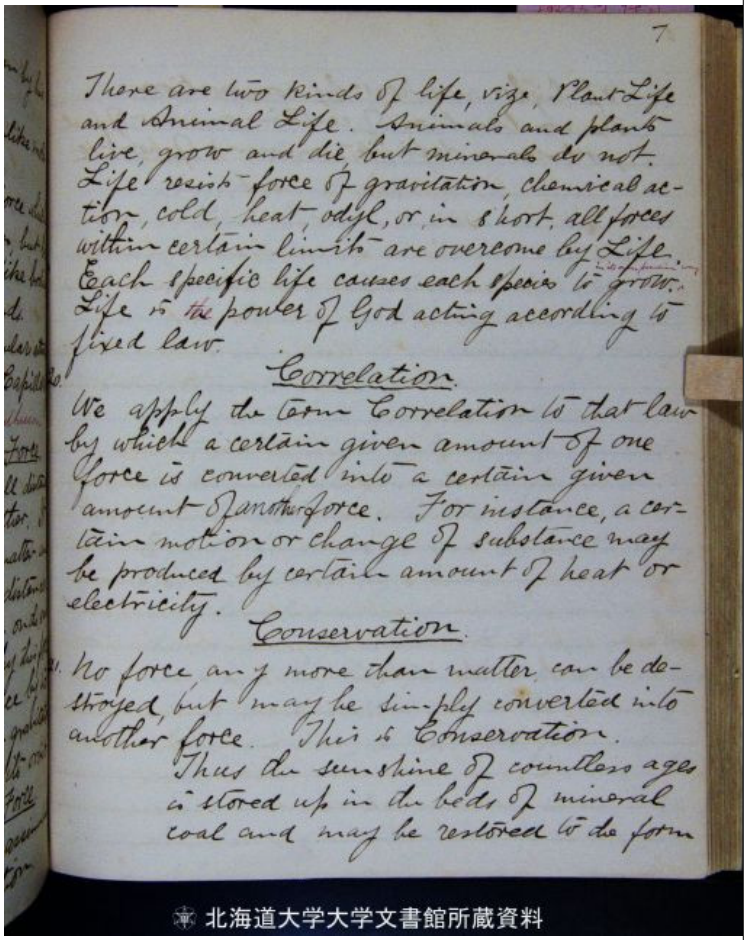
Gravity or Universal Force.

18. This is a force which acts at all distances to bring bodies toward each other. It acts directly as the mass of matter and inversely as the squares of the distances between them. All substances on the earth are kept firmly in their places by this force. The earth itself is kept in its place by two sorts of force, viz. Centripetal or gravitation and Centrifugal or motion in its orbit.

Life or Organic or Vital Force.

19. This is a force which causes the assimilation of food, growth and reproduction.

Osmose: Osmosis 浸透。



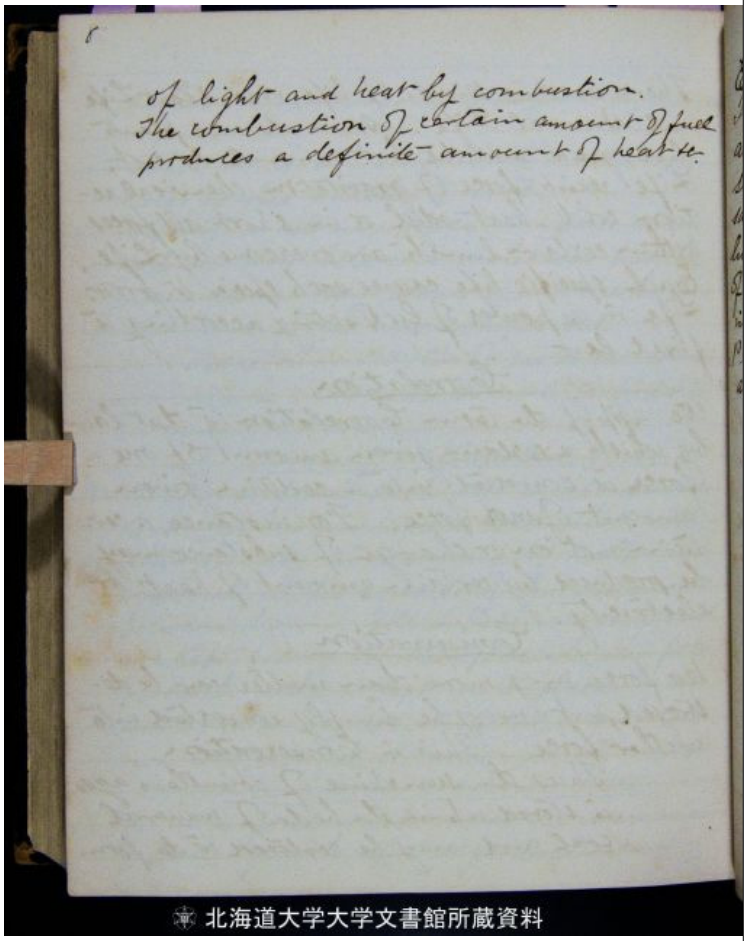
There are two kinds of life, viz, Plant Life and Animal Life. Animals and plants live, grow and die but minerals do not. Life resists force of gravitation, chemical action, cold, heat, odyl, or, in short, all forces within certain limits are overcome by Life. Each specific life causes each species to grow in its own peculiar way. Life is the power of God acting according to fixed law.

Correlation.

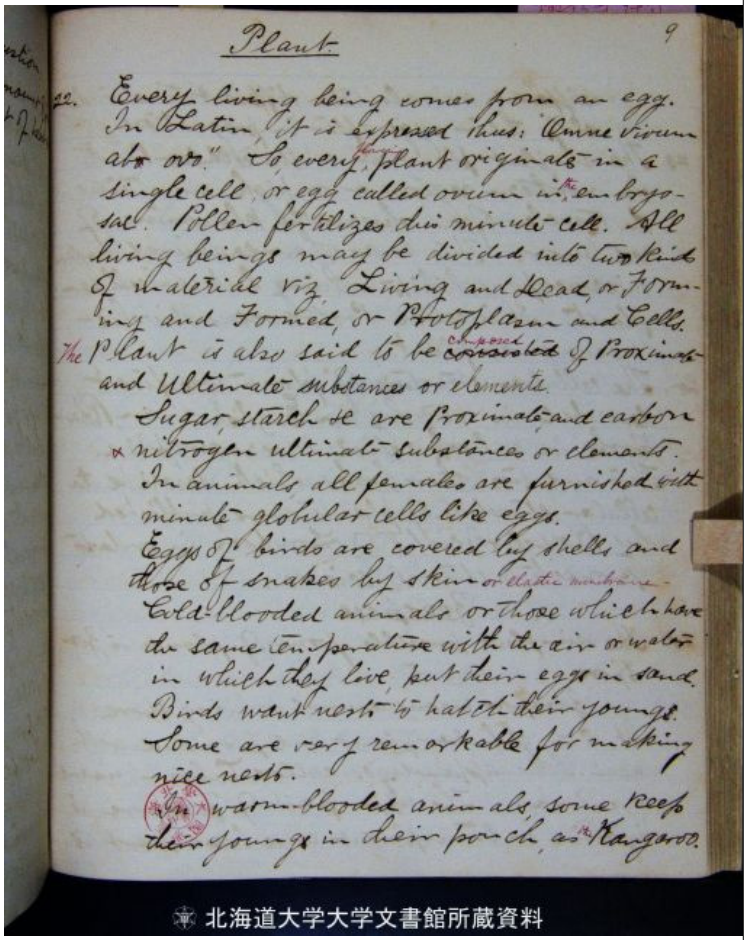
20. We apply the term Correlation to that law by which a certain given amount of one force is converted into a certain given amount of another force. For instance, a certain motion or change of substance may be produced of certain amount of heat or electricity.

Conservation.

21. No force any more than matter can be destroyed, but may be simply converted into another force. This is Conservation.
Thus the sunshine of countless ages is stored up in the beds of mineral coal and may be restored to the form



of light and heat by combustion. The combustion of certain amount of fuel produces a definite amount of heat &c.



Plant.

22. Every living being comes from an egg. In Latin, it is expressed thus: "Omne vivum ab ovo." So every flowering plant originals in a single cell or egg called ovum in the embryo-sac. Pollen fertilizes this minute cell. All living beings may be divided into two kinds of material viz. Living and Dead, or Forming and Formed, or Protoplasm and Cells. The plant is also said to be composed of Proximate and Ultimate substances or elements.

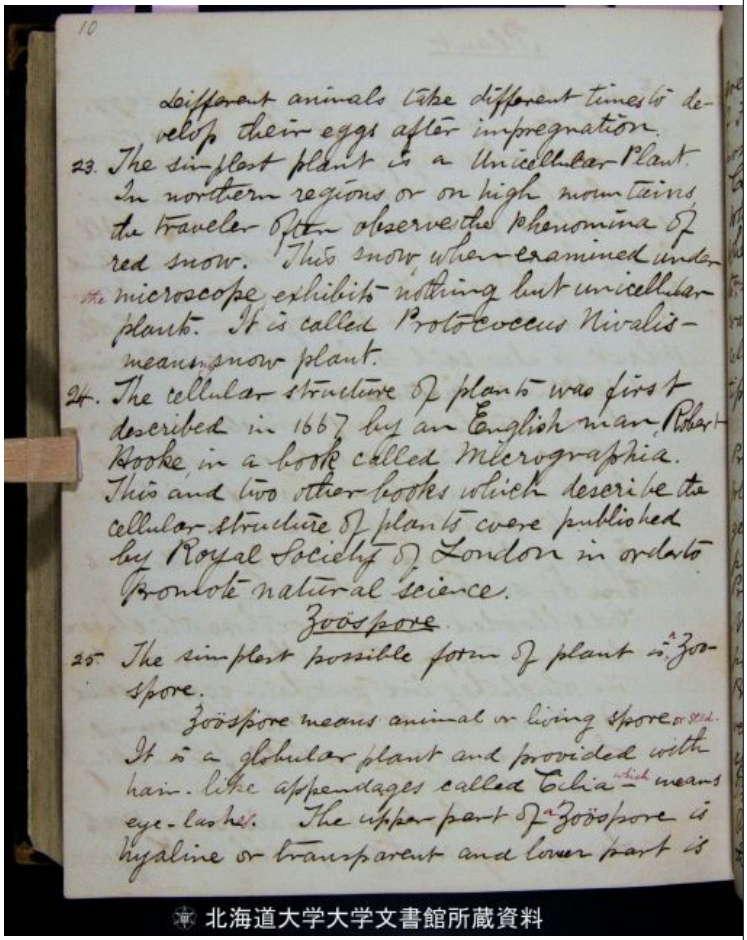
Sugar, starch &c. are proximate and carbon & nitrogen ultimate substances or elements. In animals all females are furnished with minute globular cells like eggs.

Eggs of birds are covered by shells and those of snakes by skin or elastic membrane bold-blooded animals or those which have the same temperature with the air or water in which they live, put their eggs in sand. Birds want nests to hatch their youngs. Some are very remarkable for making nice nests.

In warm-blooded animals, some keep their youngs in their porch, as the Kangaroo.

Omne vivum ab ovo: Omne vivum ex ovo　すべては卵から産まれる（ラテン語）。フランチェスコ・レディ Francesco Redi (1626-1697) が、生命の自然発生説に対し立てた。

pollen: 花粉。



Different animals take different times to develop their eggs after impregnation.

23. The simplest plant is a Unicellular Plant. In northern regions or on high mountains the traveler often observes the phenomena of red snow. This snow when examined under the microscope exhibits nothing but unicellular plants. It is called Protococcus Nivalis — means snow plant.
24. The cellular structure of plants was first described in 1667 by an English man, Robart Hooke, in a book called micrographic. This and two other books which describe the cellular structure of plan is were published by Royal Society of London in order to promote natural science.

<u>Zoöspore.</u>

25. The simplest possible form of plant is Zoöspore. Zoöspore means animal or living spore or seed. It is a globular plant and provided with hair-like appendages called Cilia which means eye-lashes. the upper part of a Zoöspore is hyaline or transparent and lower part is

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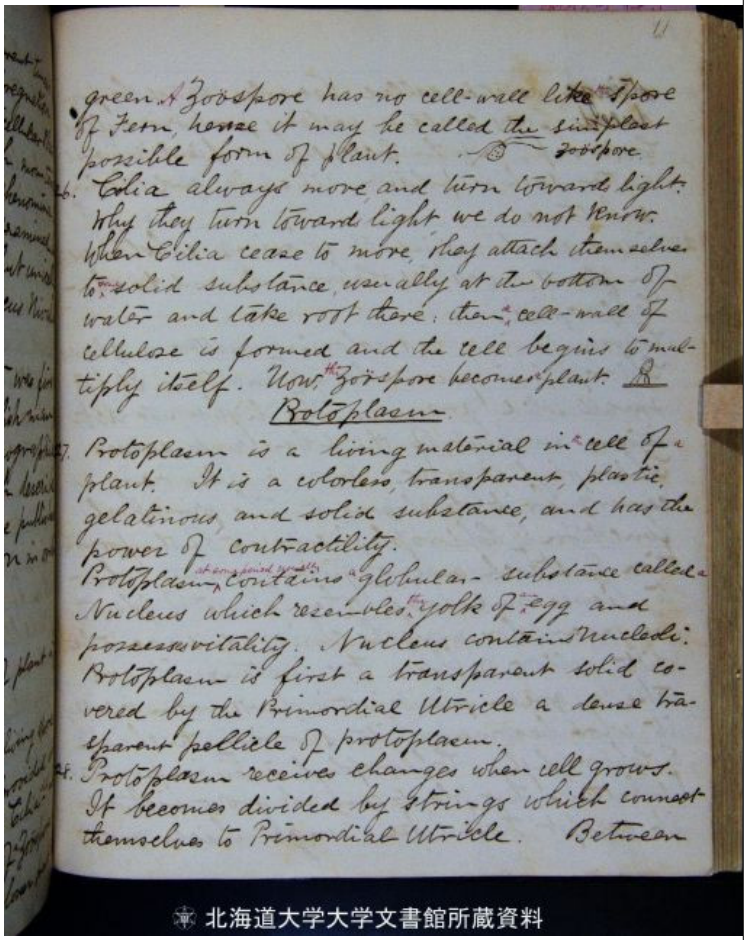
Protococcus Nivalis: 赤雪等の微細な単細胞藻類。
Zoöspore: 精胞子，遊走子。鞭毛で泳ぐ胞子。



green . A Zoöspore has no cell-wall like the spore of Fern, hence it may be called the Simplest possible form of plant.

26. Cilia always move, and turn toward light. Why they turn toward light, we do not know. When Cilia cease to move, they attach themselves to some solid substance, usually at the bottom of water and take root there: then a cell-wall of cellulose is formed and the cell begins to multiply itself. Now, the Zoöspore becomes a plant.

Protoplasm.

27. Protoplasm is a living material in cell of a plant. It is a colorless, transparent, plastic, gelatinous, and solid substance, and has the power of contractility.
Protoplasm at some period usually contains a globular substance called a Nucleus which resembles the yolk of an egg and possesses vitality. Nucleus contains nucleoli. Protoplasm is first a transparent solid covered by the Primordial Utricle a dense transparent pellicle of protoplasm.
28. Protoplasm receives changes when cell grows. It becomes divided by strings which connect themselves to Primordial Utricle. Between

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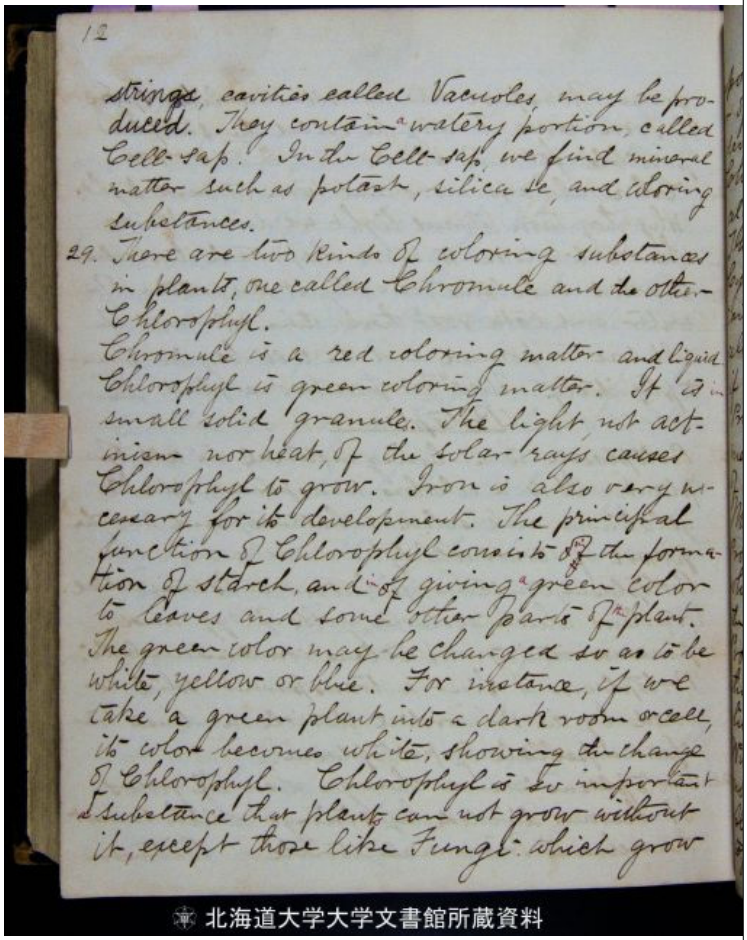
cilia: 繊毛。
protoplasm: 原形質。
utricle: 胞嚢。
pellicle: 薄膜。
primordial: 原生の。



strings, cavities called Vacuoles, may be produced. They contain a watery portion, called Cell-Sap. In the Cell- Sap we find mineral matter such as potash, silica &c, and wearing substances.

29. There are two kinds of coloring substances in plants, one called Chromule and the other Chlorophyl.
Chromule is a red coloring matter and liquid Chlorophyl is green coloring matter. It is in small solid granules. The light not activism not heat, of the solar rays causes Chlorophyl to grow. Iron is also very necessary for its development. The principal function of Chlorophyllons is to the formation of starch, and in giving a green color to leaves and some other parts of the plant. The green color may be changed so as to be white, yellow or blue. For instance, if we take a green plant into a dark room or cell, its color becomes white, showing the change of Chlorophyl. Chlorophyl is so important a substance that plants can not grow without it, except those like Fungi which grow

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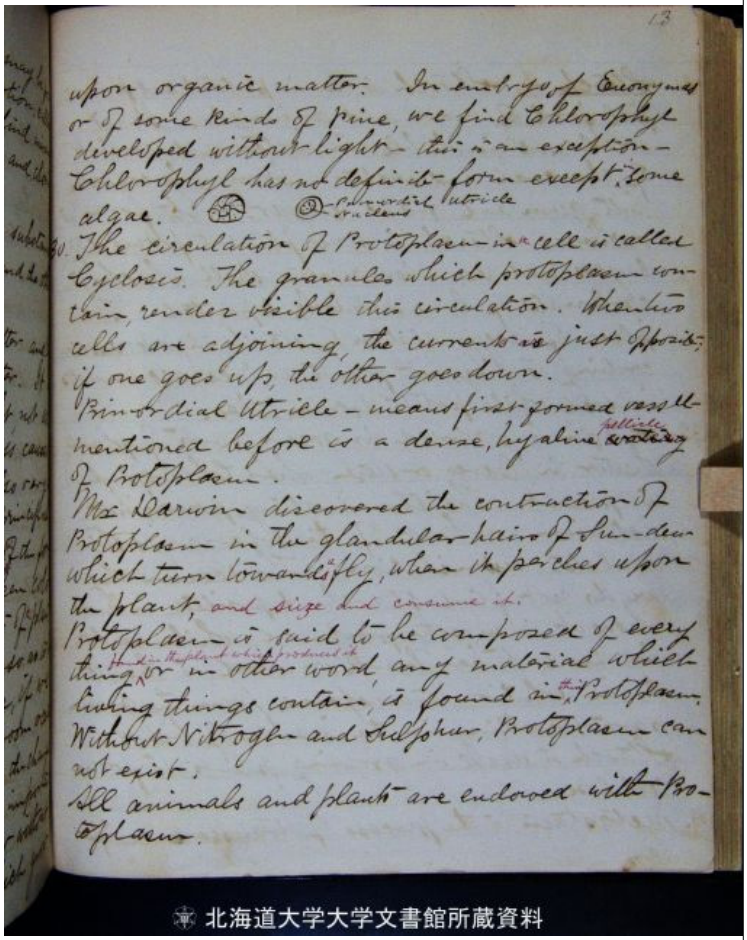
Chromule: 植物の色素，特に花びらの色。
Chlorophyl: 葉緑素。



upon organic matter. In embryo of Euonymus or of some kinds of pine, we find Chlorophyl developed without light — this is an exception. — Chlorophyl has not definite form except in some algae.

30. The circulation of protoplasm in the cell is called Cyclosis. The granules which protoplasm contain, render visible this circulation. When two cells are adjoining, the currents are just opposite; if one goes up, the other goes down.

Primordial Utricle — means first formed vessel mentioned before is a dense, hyaline pellicle of Protoplasm.

Mr. Darwin discovered the contraction of Protoplasm in the glandular hairs of Sun-dew which turn towards a fly, when it perches upon the plant, and seize and consume it.

Protoplasm is said to be composed of every thing found in the plant which produces it in other word, any material which living things contain, is found in thin protoplasm. Without Nitrogen and Sulphur, Protoplasm can not exist.

All animals and plants are endowed with Protoplasm.

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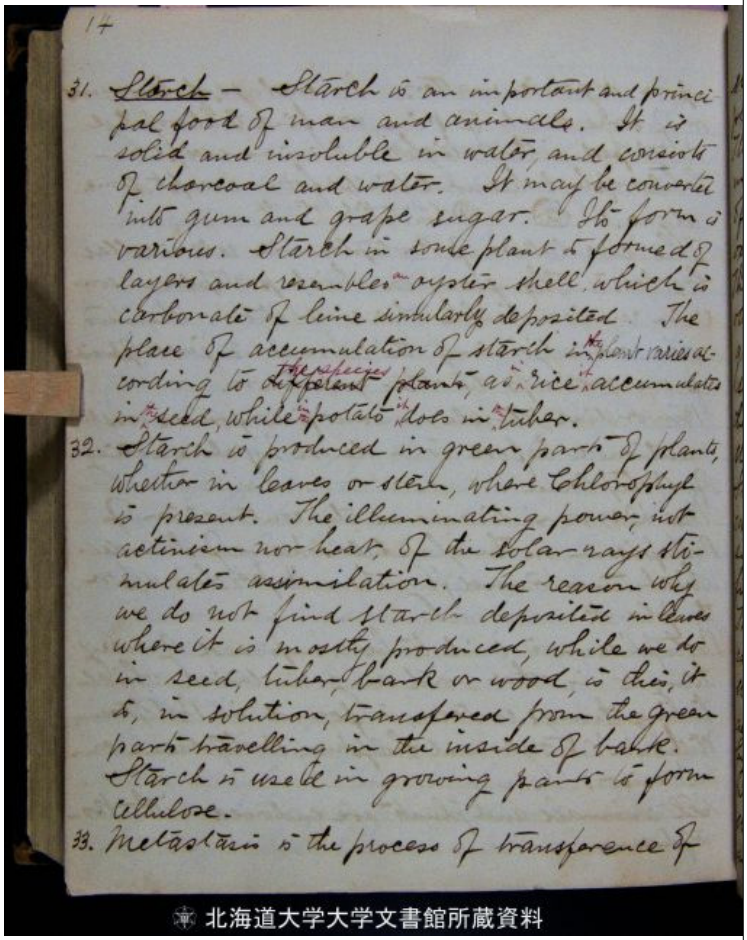
embryo: 胚。
Euonymus: ニシキギ。
algae: 類に属する植物.。
cyclosis: 細胞内での原形質の運動。
Sundew: モウセンゴケ。



31. Starch— Starch is an important and principal food of man and animals. It is solid and insoluble in water and consists of charcoal and water. It may be converted into gum and grape sugar. Its form is various. Starch in some plant is formed of layers and resembles a oyster shell which is carbonate of lime similarly deposited. The place of accumulation of starch in the plant varies according to the species as in rice it accumulates in the seed, while in the potato it does in the tuber.
32. Starch is produced in green parts of plants, whether in leaves or stem, where Chlorophyl is present. The illuminating power, not activism not heat, of the solar rays stimulates assimilation. The reason why we do not find starch deposited in leaves where it is mostly produced, while we do in seed, tuber, bark or wood, is this, it is, in solution, transferred from the green parts traveling in the inside of bare. Starch is used in growing parts to form cellulose.
33. Metastasis is the process of transference of

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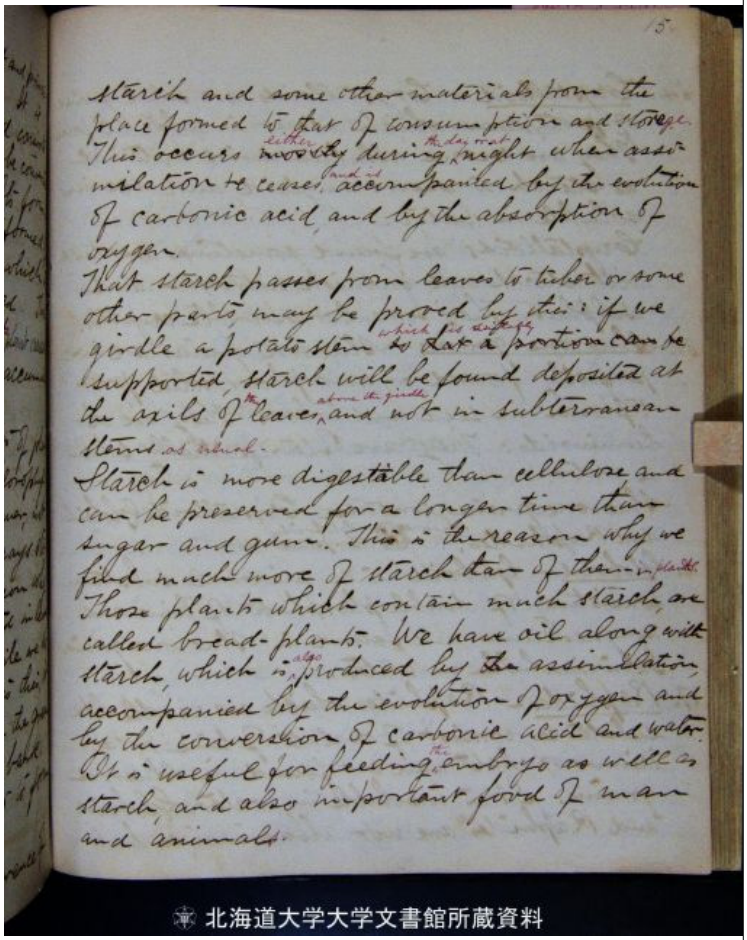
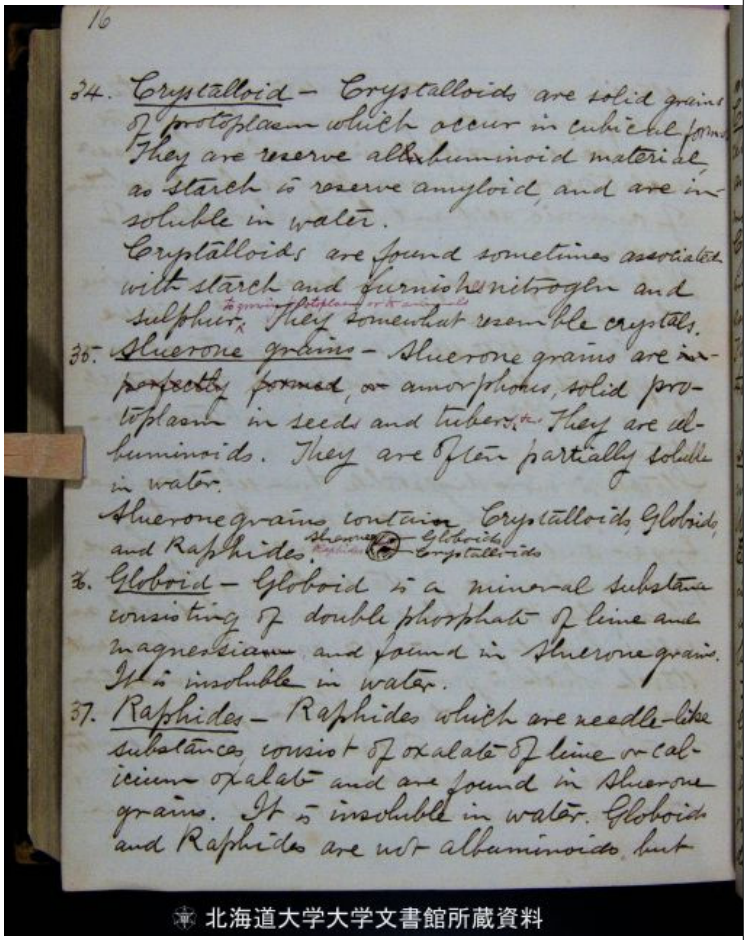
metastasis: 転移。



starch and some other materials from the place formed to that of consumption and storage. This occurs either during the day or at night when assimilation &c ceases, and is accompanied by the evolution of carbonic acid, and by the absorption of oxygen.

That starch passes from leaves to tuber or some other parts, may be proved by this: if we girdle a potato stem which is suitably supported, starch will be found deposited at the axils of the leaves above the girdle and not in subterranean stems as usual.

Starch is more digestible than cellulose and can be preserved for a longer time than sugar and gum. This is the reason why we find much more of starch than of theirs in plants. Those plants which contain much starch are called bread-plants. We have oil along with starch, which is also produced by assimilation, accompanied by the evolution of oxygen and by the conversion of carbonic acid and water. It is useful for feeding the embryo as well as starch, and also important found of man and animals.



34. Crystalloid — Crystalloids are solid grains of protoplasm which occur in cubical forms. They are reserve albuminoid material, as starch is reserve amyloid, and are insoluble in water.
Crystalloids are found sometimes associated with starch and furnish nitrogen and sulphur to growing protoplasm or to animals. They somewhat resemble crystals.

35. Aleurone grains— Aleurone grains are amorphous, solid protoplasm in seeds and tubers &c. They are albuminoids. They are often partially soluble in water.
Aleurone grains contain Crystalloids, Globoids, and Raphides.

36. Globoid— Globoid is a mineral substance consisting of double phosphate of lime and magnesia found in Aleurone grains. It is insoluble in water.

37. Raphides — Raphides which are needle-like substances, consist of oxalate of lime on calcium oxalate and are found in Aleurone grains. It is insoluble in water. Globoids and Raphides are not albuminoids but

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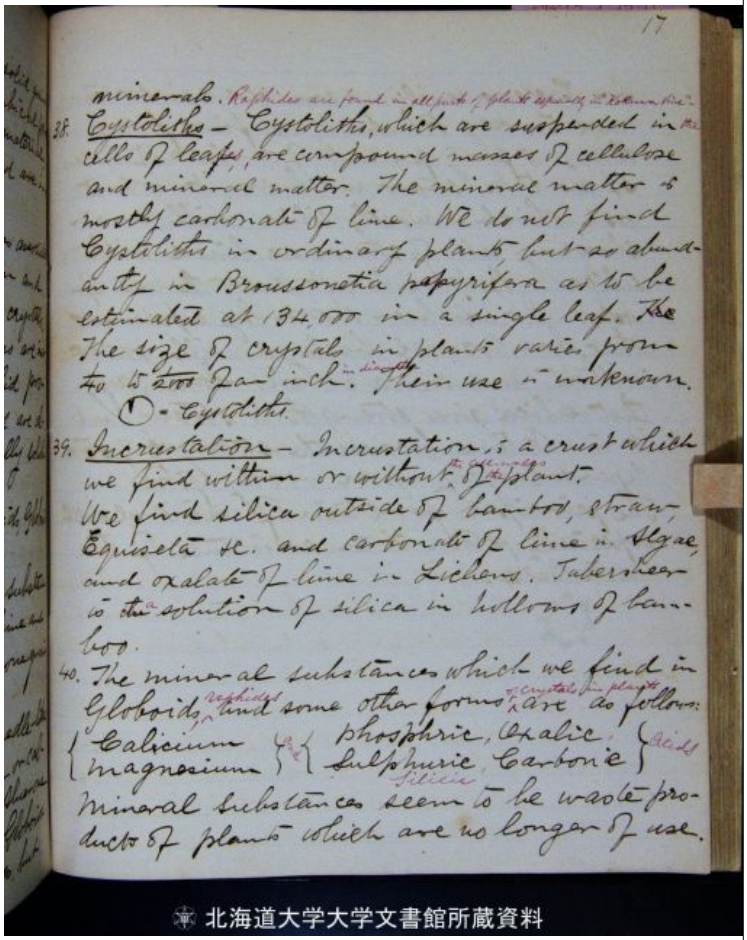
crystalloid: 脂肪種子の結晶体。
albuminoid: アルブミノイド，生体細胞中の蛋白質。
amyloid: アミロイド，澱粉質。
aleurone: アリューロン，粉状蛋白質。
raphides: 束晶。



minerals. Raphides are found in all parts of plants especially in "Kokuwa Vine".

38. Cystoliths— Cystoliths, which are suspended in the cells of leaves, are compound masses of cellulose and mineral matter. The mineral matter is mostly carbonate of lime. We do not find Cystoliths in ordinary plants, but so abundantly in Broussonetia papyrifera as to be estimated at 134,000 in a single leaf.
The size of crystals in plants varies from 1/40 to 1/2000 of an inch in diameter. Their use is unknown.

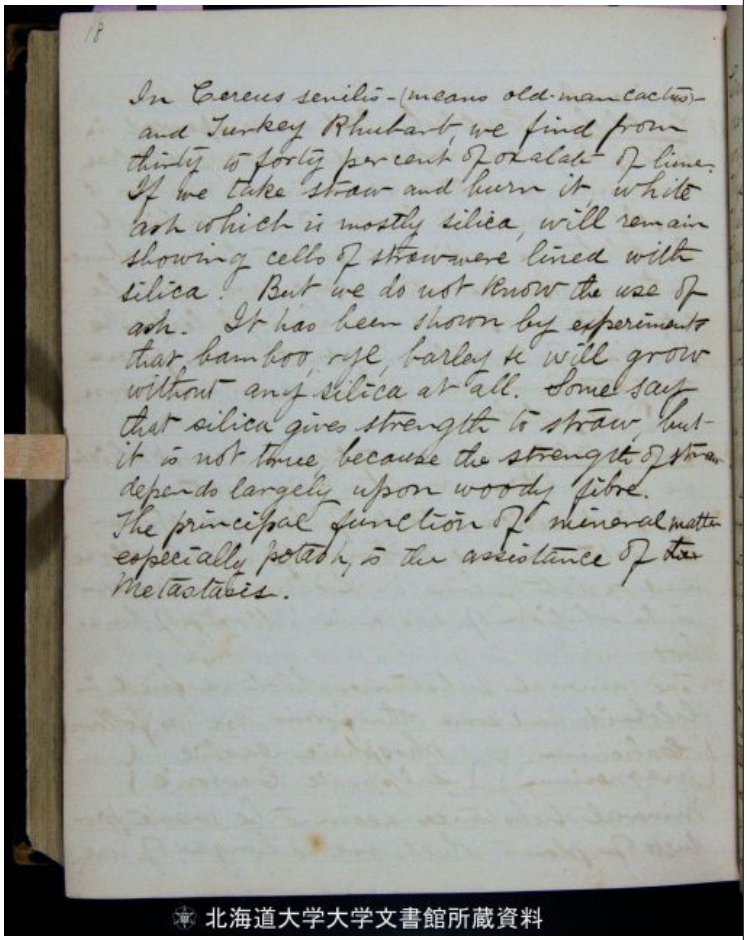
39. Incrustation— Incrustation is a crust which we find within or without the cell-walls of the plant.
We find silica outside of bamboo, straw, Equiseta &c. and carbonate of lime in Algae, and oxalate of lime in Lichens. Tubersheer is a solution of silica in hollows of bamboo.

40. The mineral substances which we find in Globoids, Raphides and some other forms of crystals in plants are as follows:

Calcium	and	Phosphoric Oxalic	Acids
Magnesium		Sulphuric Carbonic	
		Silicic	

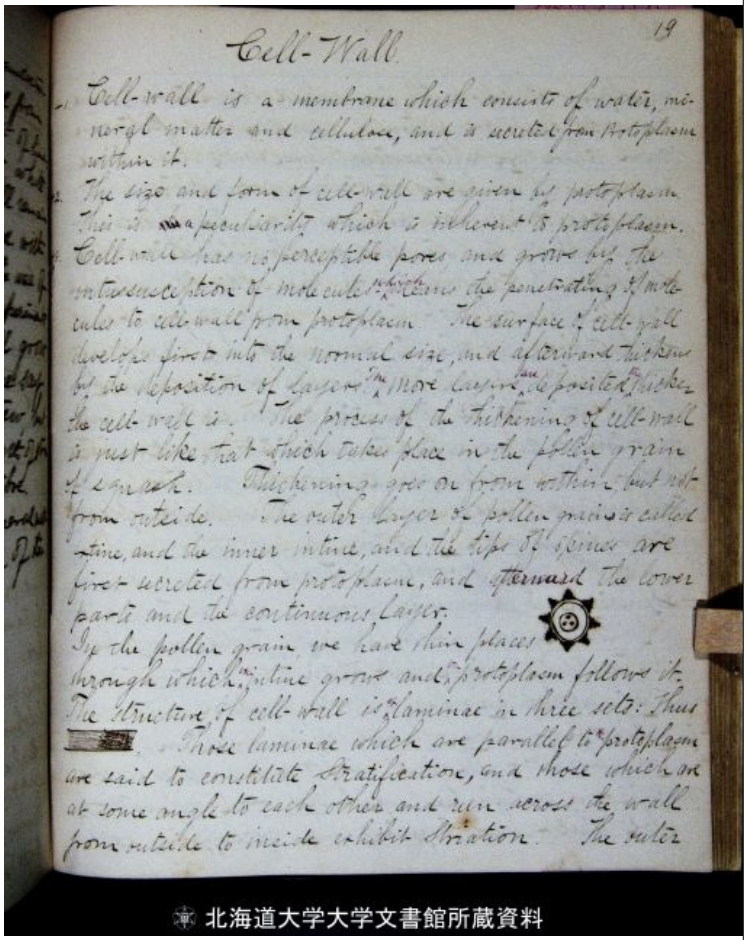
Mineral Substances seem to be waste products of plants which are no longer of use.

Kokuwa vine: コクワ酒。
cystoliths: 鐘乳体，房状体。
Broussonetia Papyrifera: カジノキ。
phosphoric: 燐の。
oxalic: 蓚酸の。
silicic: シリカの。



In Cereus senilis- (means old-man cactus) – and Turkey Rhubart we find from thirty to forty percent of oxalate of lime. If we take straw and burn it white ash which is mostly silica, will remain showing cells of straw were lined with silica. But we do not know the use of ash. It has been shown by experiment that bamboo, rye, barley &c will grow without any silica at all. Some say that silica gives strength to straw but it is not true, because the strength of straw depends largely upon woody fibre.
The principal function of mineral matter especially potash, is the assistance of Metastasis.

Cereus senilis: セレウス属のサボテン。
Rhubart: ダイオウ。
rye: ライ麦。
barley: 大麦。



Cell-Wall

41. Cell-Wall is a membrane which consists of water, mineral matter and cellulose, and is secreted from protoplasm within it.
42. The size and form of cell-wall are given by protoplasm. This is a peculiarity which is inherent to protoplasm.
43. Cell-wall has no perceptible pores and grows by the intussusceptions of molecules, which means the penetrating of molecules to cell-wall from protoplasm. The surface of cell-wall develops first into the normal size, and afterward thickens by the deposition of layers. The more layers are deposited, the thicker the cell-wall is. The process of the thickening of cell-wall is just like that which takes place in the pollen grain of squash. Thickening goes on from within, but not from outside. The outer layer of pollen grains is called extine, and the inner intine, and the tips of spines are first secreted from protoplasm, and afterward the lower parts and the continuous layer.

In the pollen grain we have thin places through which the intine grows and the protoplasm follows it. The structure of cell-wall is of laminae in three sets: Thus. Those laminae which are parallel to the protoplasm are said to constitute Stratification, and those which are at some angle to each other and run across the wall from outside to inside exhibit Striation. The outer

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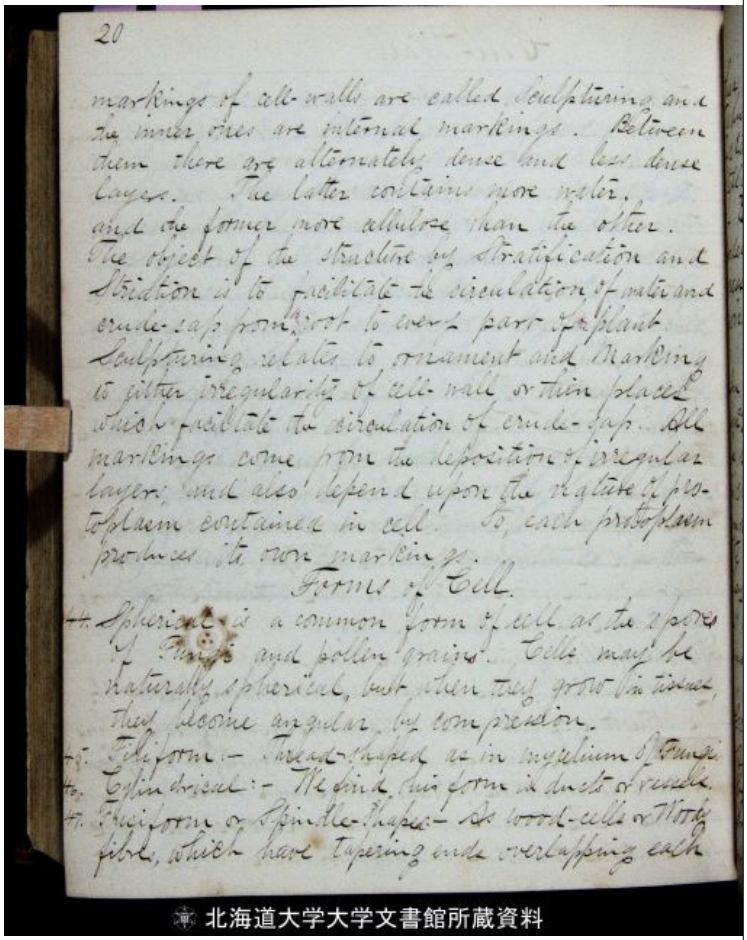
extine,intine: 胞子や花粉の外膜，内膜。
laminae: 葉片，薄幕。



markings of cell-walls are called Sculpturing and the inner ones are internal markings. Between them there are alternately dense and less dense layer. The latter contains more water, and the former more cellulose than the other. The object of the structure by Stratification and Striation is to facilitate the circulation of water and crude-sap from the root to every part of the plant. Sculpturing relates to ornament and marking to either irregularity of cell-wall or thin places which facilitate the circulation of crude-sap. All markings come from the deposition of irregular layer, and also depend upon the nature of protoplasm contained in cell. So each protoplasm produces its own markings.

Forms of Cell.

44. Spherical is a common from of cell as the spores of Fungi and pollen grains. Cells may be naturally spherical, but when they grow in tissues, they become angular by compression.
45. Filiform:- Thread-shaped as in mycelium of Fungi.
46. Cylindrical:- We find this form in ducts or vessels.
47. Fusiform or Spindle-shaped:- As wood-cells or Woody fibres, which have tapering ends overlapping each

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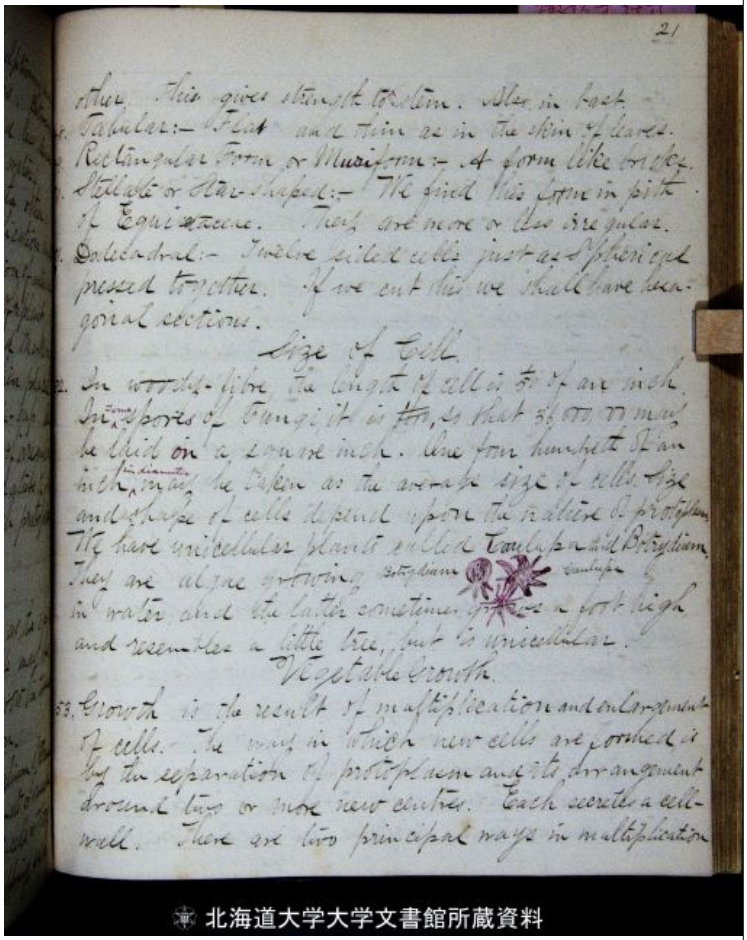
stratification: 層化。
striation: 層紋。
fungi: 菌類。
tissue: 組織。
filiform: 糸状の。
fusiform: 紡錘状の



other. This gives strength the stem.

48. Tabular:—Flat and thin as in the skin of leaves.
49. Rectangular Form or Muriform:—A form like bricks.
50. Stellate or Star-shaped:—We find this form in pith of Equisetaceae. They are more or less irregular.
51. Dodecahedral:—Twelve sided cells just as Spherical pressed together. If we cut this we shall have hexagonal sections.

Size of Cell.

52. In woody-fibre, the length of cell is 1/50 of an inch. In some spores of Fungi, it is 1/6000, so that 36,000,000 must be laid on a square inch. One four hundredth of an inch in diameter may be taken as the average size of cells. Size and shape of cells depend upon the nature of protoplasm. We have unicellular plants called Caulepa and Botrydium. They are algae growing in water and the latter sometimes grows a foot high and resembles a little tree, but is unicellular.

Vegetable Growth.

53. Growth is the result of multiplication and enlargement of cells. The way in which new cells are formed is by the separation of protoplasm and its arrangement around two or more new centers. Each secretes a cell-wall. There are two principal ways in multiplication

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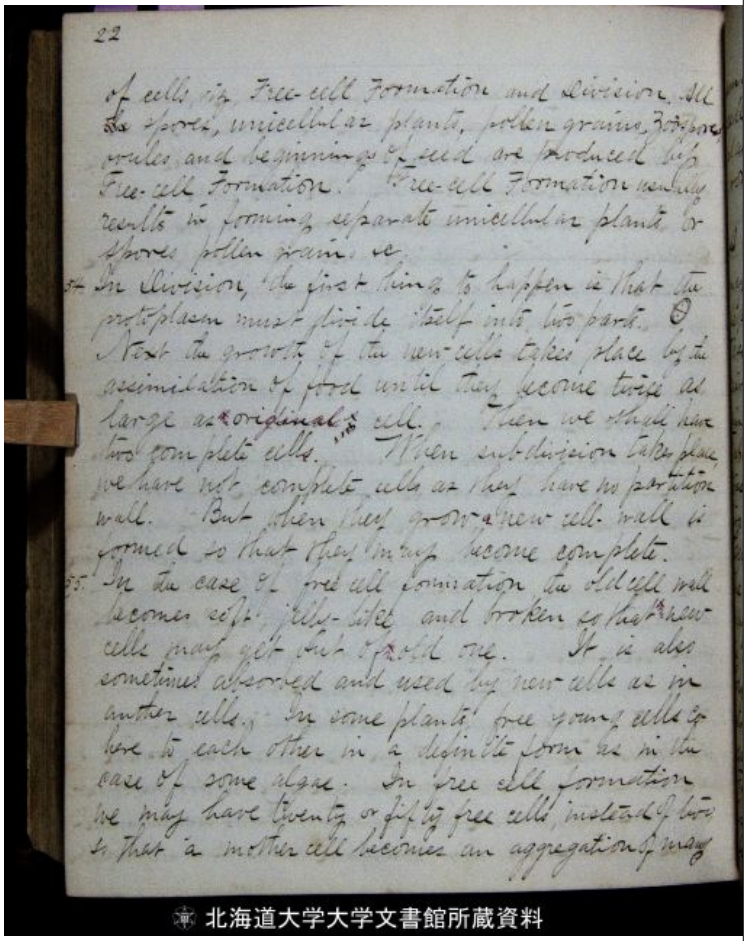
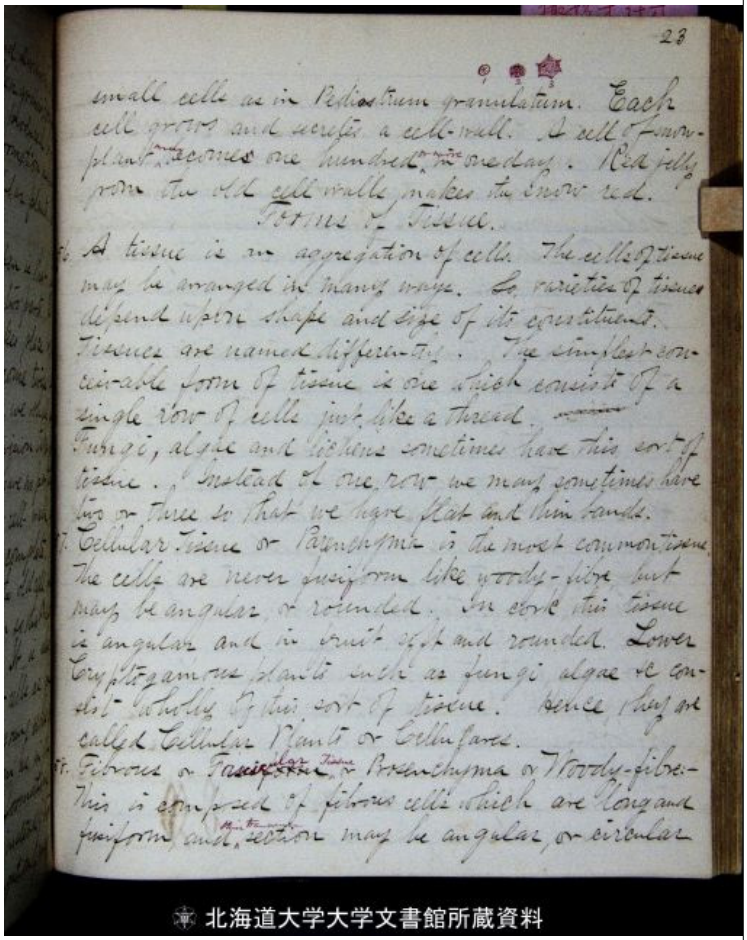
muriform: 石垣状多室の。
equisetaceae: トクサ科。
dodecahedral: 十二面体の。
Caulepa: ヘライワヅタ（？）。
Botrydium: フウセンモ。



of cells, viz, Free-cell Formation and Division. All spores, unicellular plants, pollen grains, Zoöspores, ovules and beginnings of seed are produced by Free-cell Formation. Free-cell Formation usually results in forming separate unicellular plants or spores pollen grains &c.

54. 54. In Division, the first thing to happen is that the protoplasm must divide itself into two parts.
Next the growth of the new cells takes place by the assimilation of food until they become twice as large as original cell. Then we shall have two complete cells. When subdivision takes plane, we have not complete cells as they have no partition wall. But when they grow a new cell-wall is formed so that they may become complete.

55. In the case of free cell formation the old cell wall becomes soft, jelly-like and broken so that the new cells may get that of the old one. It is also sometimes absorbed and used by new cells as in anther cells. In some plants free young cells cohere to each other in a definite form as in the case of some algae. In free cell formation we may have twenty or fifty free cells instead of two so that a mother cell becomes an aggregation of many



small cells as in Pediostrum granulatum. Each cell grows and secretes a cell-wall. A cell of snow-plant may become one hundred or more in one day. Red jelly from the old cell walls makes the snow red.

Forms of Tissue.

56. A tissue is an aggregation of cells. The cells of tissue may be arranged in many ways. So, varieties of tissues depend upon shape and size of its constituents. Tissues are named differently. The simplest conceivable from of tissue is one which consist of a single row of cells just like a thread. Fungi, algae and lichens sometimes have this sort of tissue. Instead of one row we may sometimes have two or three so that we have flat and thin bands.
57. Cellular tissue or Parenchyma is the most common tissue. The cells are never fusiform like woody-fibre but may be angular or rounded. In cork, this tissue is angular and in fruit soft and rounded. Lower Cryptogamous plants such as fungi, algae &c consists wholly of thus sort of tissue. Hence they are called Cellular Plants or Cellulares.
58. Fibrous or Fascicular Tissue or Prosenchyma or Woody-fibre:—This is composed of fibrous cells which are long and fusiform, and thin transverse section may be angular, or circular.

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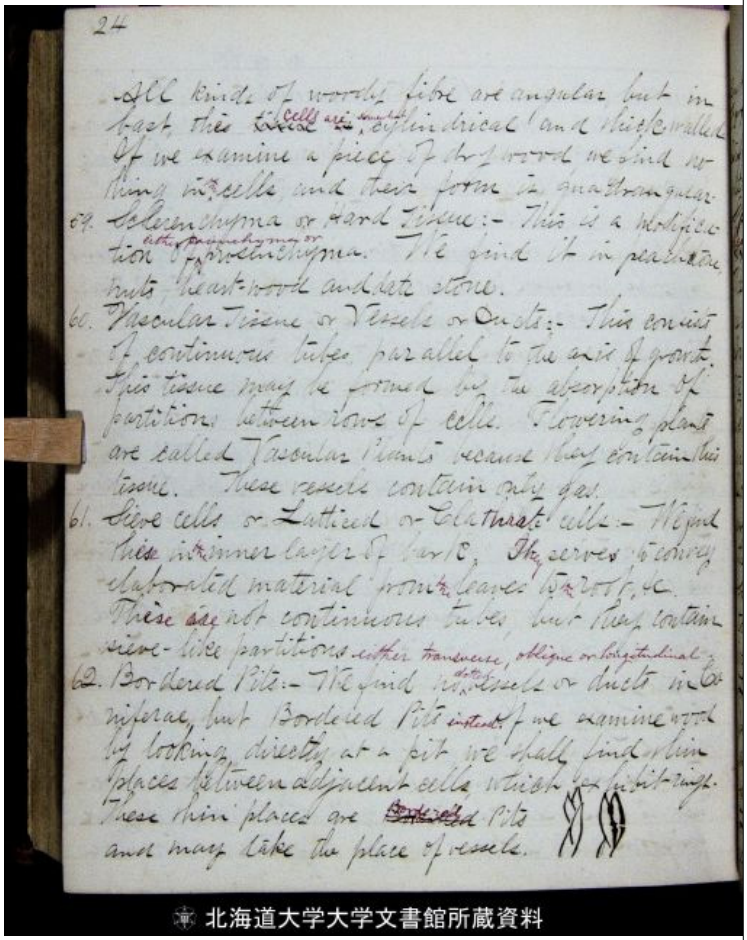
cryptogamous: 隠花植物の。
prosenchyma: 紡錘組織。



All kinds of woody fibre are angular, but in bast, the cells are somewhat cylindrical and thick-walled. If we examine a piece of dry wood we find nothing in the cells and their form is quadrangular.

59. Sclerenchyma or Hard Tissue:- This is a modification of either parenchyma or prosenchyma. We find it in peach-tree nuts, heart-wood and date stone.

60. Vascular Tissue or Vessels or ducts:—This consists of continuous tubes parallel to the axis of growth. This tissue may be formed by the absorption of partition between rows of cells. Flowering plants are called Vascular Plants because they contain this tissue. These vessels contain only gas.

61. Sieve cells or Latticed or Clathrate cells:—We find these in the inner layer of bark. They serve to convey elaborated material from the leaves to the root, &c. These are not continuous tubes but they contain sieve-like partitions either transverse, oblique or longitudinal.

62. Bordered Pits:- We find no dotted vessels or ducts in Coniferae, but Bordered pits instead. If we examine wood by looking directly at a pit we shall find thin places between adjacent cells which exhibit rings. These thin places are Bordered pits and may take the place of vessels.

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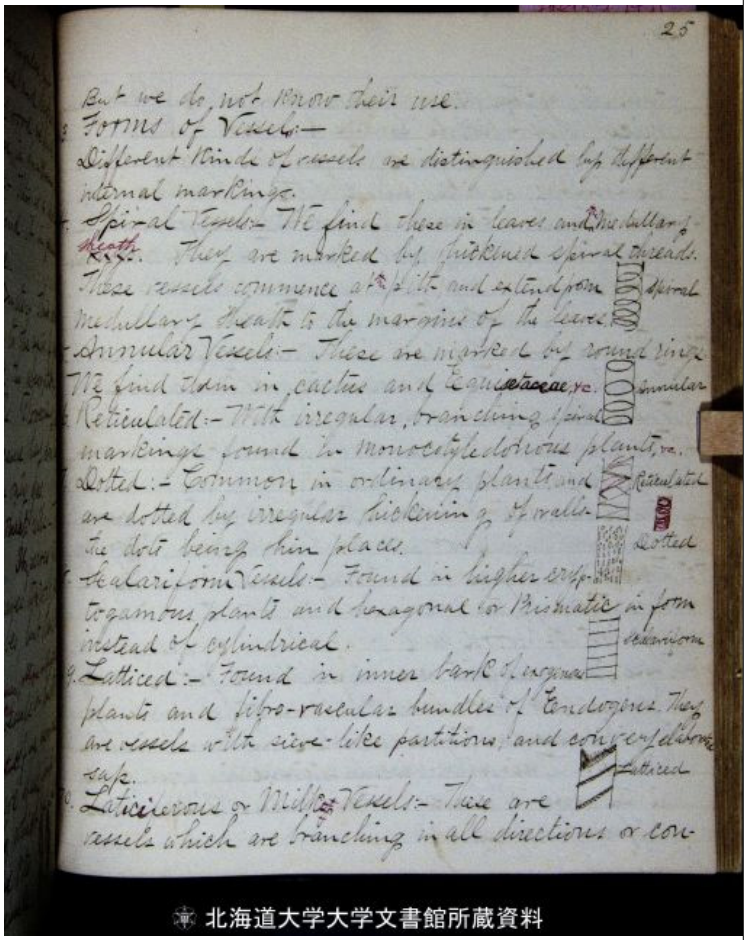
sclerenchyma: 厚膜組織。
clathrate: 網状の。
coniferae: 針葉樹。



But we do not know their use.

63. Forms of Vessels:—
Different kinds of vessels are distinguished by different internal markings.
64. Spiral Vessels:—We find these in leaves and the medullary sheath. They are marked by thickened spiral threads. These vessels commence at the pith and extend from spiral medullary sheath to the margins of the leaves.
65. Annular Vessels:—These are marked by round rings. We find them in cactus and Equisetaceae, &c.
66. Reticulated:- With irregular, branching spiral markings found in monocotyledonous plants, &c.
67. Dotted:- Common in ordinary plants, and are dotted by irregular thickening of walls the dots being him places.
68. Scalariform Vessels:—Found in higher cryptogamons plants and hexagonal or Prismatic in form instead of cylindrical.
69. Latticed:- Found in inner bark of exogenous plants and fibro-vascular bundles of Endogens. They are vessels with sieve-like partitions, and convey elaborated sap.
70. Laticiferous or Milk Vessels:—These are vessels which are branching in all directions or

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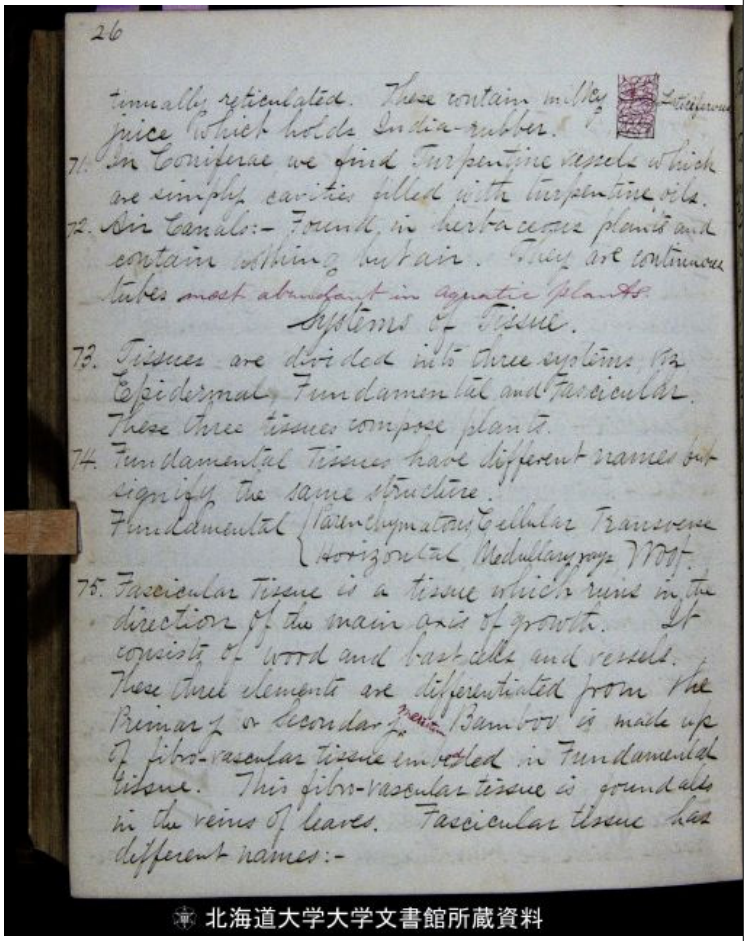
medullary: 髄質の。
sheath: 葉鞘。
reticulate: 網状の。
scalariform: はしご状の。
laticiferous: ラテックス（乳濁液）を出す。



continually reticulated. These contain milky juice which holds India-rubber.

71. In Coniferae, we find Turpentine vessels which are simply cavities filled with turpentine oils.
72. Air Canals:- Found in herbaceous plants and contain nothing but air. They are continuous tubes most abundant in Aquatic plants.

Systems of Tissue.

73. Tissues are divided into three systems viz. Epidermal Fundamental and Fascicular. These three tissues compose plants.
74. Fundamental Tissues have different names but signify the same structure.

Fundamental Parenchymatous, Cellular Transverse
Horizontal, Medullary rays Woof.

75. Fascicular Tissue is a tissue which runs in the direction of the main axis of growth. It consists of wood and bast cells and vessels. These three elements are differentiated from the Primary or Secondary meristem. Bamboo is made up of fibro-vascular tissue embedded in Fundamental tissue. This fibro-vascular tissue is found also in the veins of leaves. Fascicular tissue has different names:—

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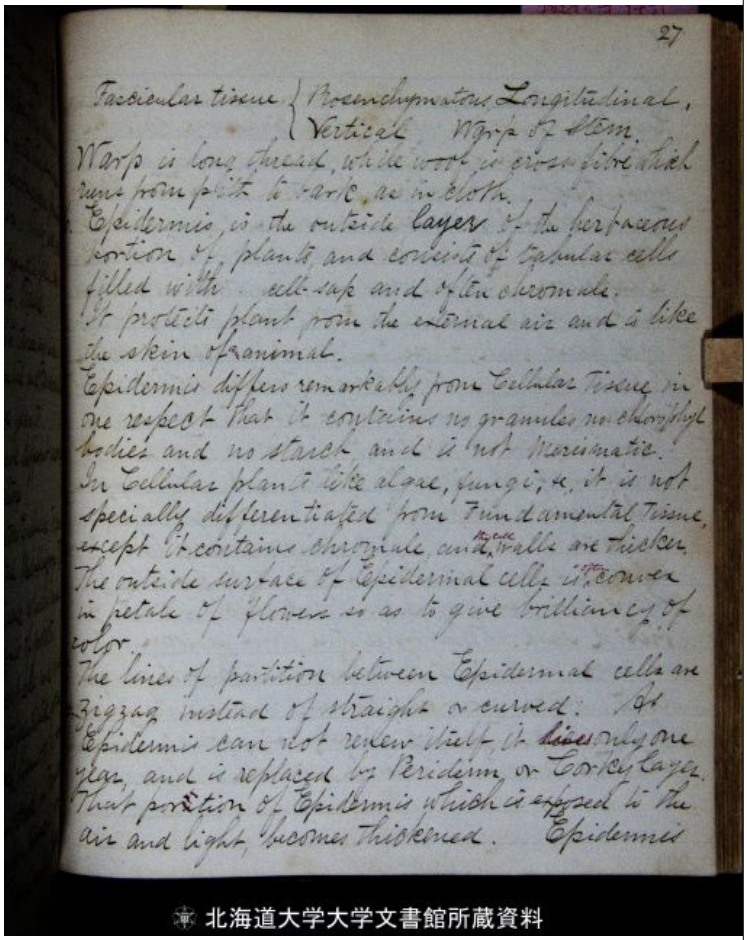
turpentine oil: テレビン(マツ科植物の含油樹脂)油。
parenchymatous: 柔組織の。
meristem: 分裂組織。



Fascicular tissue Prosenchymatous, Longitudinal, Vertical, Warp of Stem.

Warp is long thread, while woof is cross fibre which runs from pith to bark as in cloth.

76. Epidermis is the outside layer of the herbaceous portion of plants and consists of tabular cells filled with cell-sap and often chromule.
It protects plants from the external air and is like the skin of an animal.

77. Epidermis differs remarkably from Cellular Tissue in one respect that it contains no granules, no chlorophyl bodies and no starch, and is not merismatic.
In Cellular plants like algae, fungi, &c, it is not specially differentiated from Fundamental Tissue, except it contains chromule the cell walls are thicker.
The outside surface of Epidermal cells is often convex in petals of flowers so as to give brilliancy of color.

78. The lines of partition between Epidermal cells are often Zigzag instead of straight or curved. As Epidermis can not renew itself, it lives only one year, and is replaced by Periderm or Corky layer. That portion of Epidermis which is exposed in the air and light, becomes thickened. Epidermis

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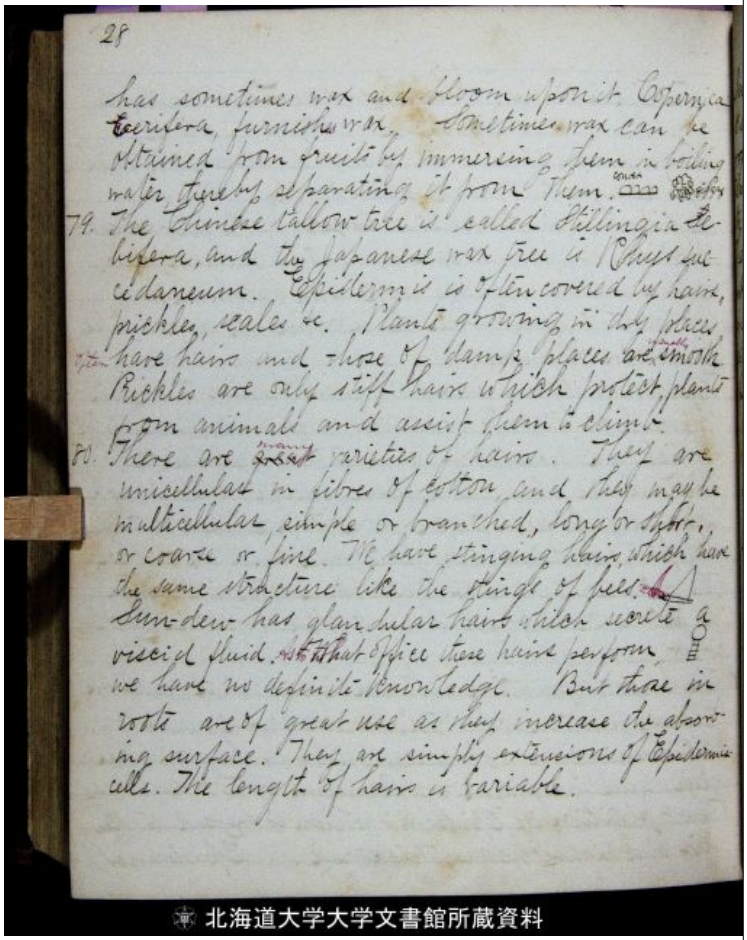
fascicular: 束状の。
epidermis: 表皮。
periderm: 周皮。

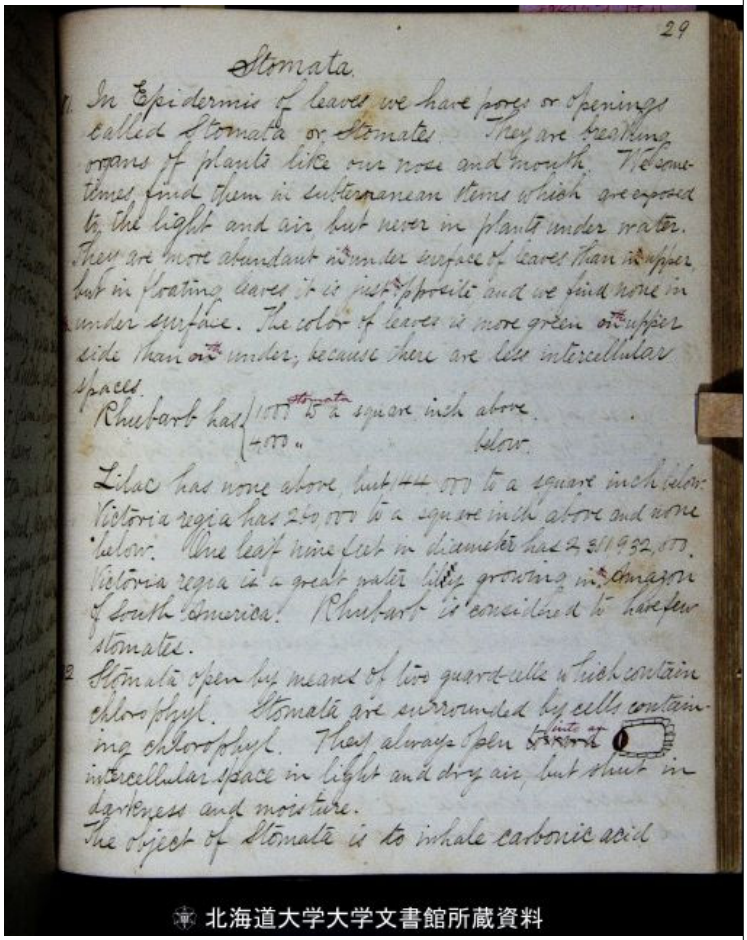


has sometimes wax and bloom upon it. Copernica Cerifera furnishes wax. Sometimes wax can be obtained from fruits by immersing them in boiling mater there by separation it from them.

79. The Chinese tallow tree is called Stillingia sebifera, and the Japanese wax tree is Rhus succedaneum. Epidermis is often covered by hairs, prickles, scales &c. Plants growing in dry places often have hairs and those of damp places are usually smooth. Pickles are only stiff hairs which protect plants from animals and assist them to climb.

80. There are many varieties of hairs. They are unicellular in fibres of cotton and they may be multicellular simple or branched, long or short, or coarse or fine. We have stinging hairs, which have the same structure like the stings of bees.
Sun-dew has glandular hairs which secrete a viscid fluid. As to what office these hairs perform, we have no definite Knowledge. But those in roots are of great use as they increase the absorbing surface. They are simply extensions of Epidermis cells. The length of hairs is variable.

Copernica Cerifera: カルナバ椰子。
Stillingia sebifera: ナンキンハゼ（蝋の木）。
rhus: ウルシ。



Stomata.

81. In Epidermis of leaves we have pores or openings called Stomata or Stomates. They are breaking organs of plants like our nose and mouth. We sometimes find them in subterranean stems which are exposed to the light and air, but never in plants under water. They are more abundant in the under surface of leaves than in upper, but in floating leaves it is just opposite, and we find none in the under surface. The color of leaves is more green on the upper side than on the under; because there are less intercellular spaces.

Rhubarb has 1000 stomata is a square inch above.
4000 〃 below.

Lilac has none above, but 144,000 to a square inch below. Victoria regia has 260,000 to a square inch above and none below. One leaf nine feet in diameter has 2,381,932,000. Victoria regina is a great water lily growing in the Amazon of South America. Rhubarb is considered to have few stomates.

82. Stomata open by means of two guard-cells which contain chlorophyl. Stomata are surrounded by cells containing chlorophyl. They always open into an intercellular space in light and dry air, but shut in darkness and moisture.

The object of Stomata is to inhale carbonic acid

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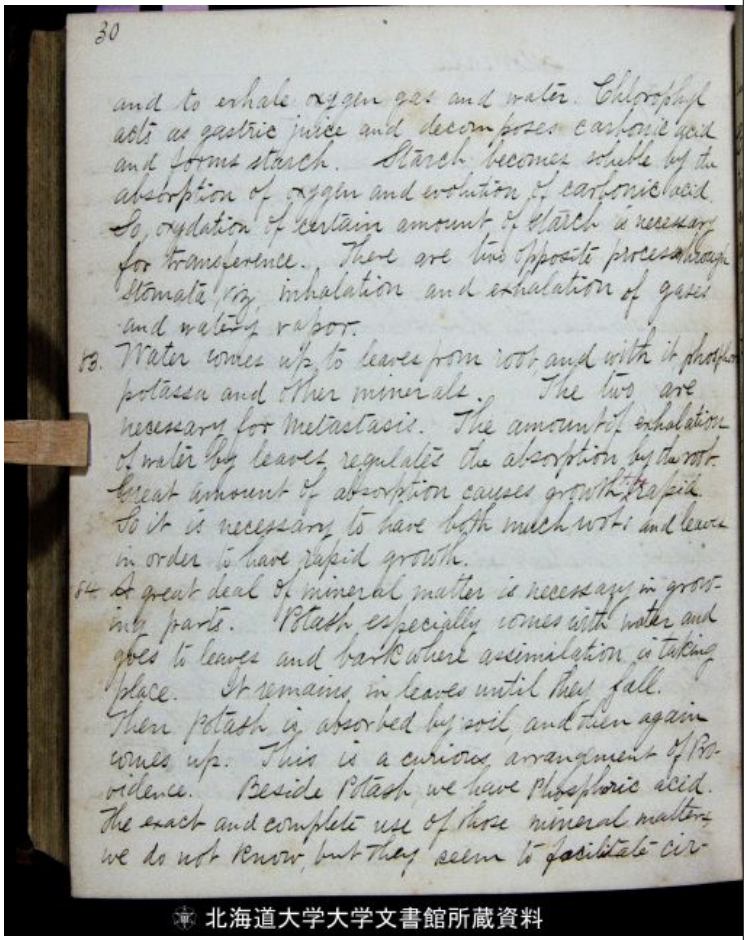
stomata: 気孔。



and to exhale oxygen gas and water. Chlorophyl acts as gastric juice and decomposes carbonic acid and forms starch. Starch becomes soluble by the absorption of oxygen and evolution of carbonic acid. So, oxydation of certain amount of starch is necessary for transference. There are two opposite process through Stomata, viz, inhalation and exhalation of gases and watery vapor.

83. Water comes up to leaves from root, and with it, phosphor potassa and other minerals. The two are necessary for metastasis. The amount of exhalation of water by leaves regulates the absorption by the root. Great amount of absorption causes growth to be rapid. So it is necessary to have both much root and leaves in order to have rapid growth.

84. A great deal of mineral matter is necessary in growing parts. Potash especially comes with water and goes to leaves and baric where assimilation is taking place. It remains in leaves until they fall. Then potash is absorbed by soil, and then again comes up. This is a curious arrangement of providence. Beside potash we have phosphoric acid. The exact and complete use of those mineral matters, we do not know, but they seem to facilitate circulation.

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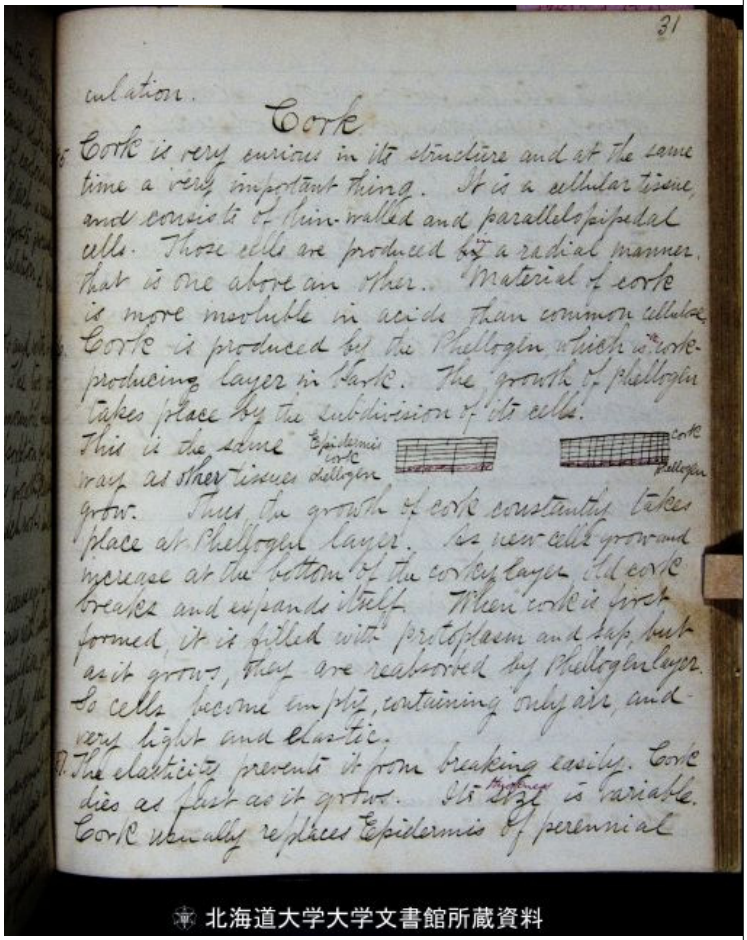
potassa: potash あく、カリ。



Cork.

85. Cork is very curious in its structure and at the same time a very important thing. It is a cellular tissue, and consists of thin-walled and parallelepipedal cells. Those cells are produced in a radial manner, that is one above an other. Material of cork is more insoluble in acids than common cellulose.
86. Cork is produced by the phellogen, which is the cork-producing layer in bark. The growth of phellogen takes place by the subdivision of its cells. This is the same way as other tissues grow. Thus the growth of cork constantly takes place at phellogen layer. As new cells grow and increase at the bottom of the corky layer old cork breaks and expands itself. When cork is first formed, it is filled with protoplasm and sap, but as it grows, they are reabsorbed by phellogen layer. So cells become empty, containing only air, and very light and elastic.
87. The elasticity prevents it from breaking easily. Cork dies as fast as it grows. Its thickness size is variable. Cork usually replaces Epidermis of perennial

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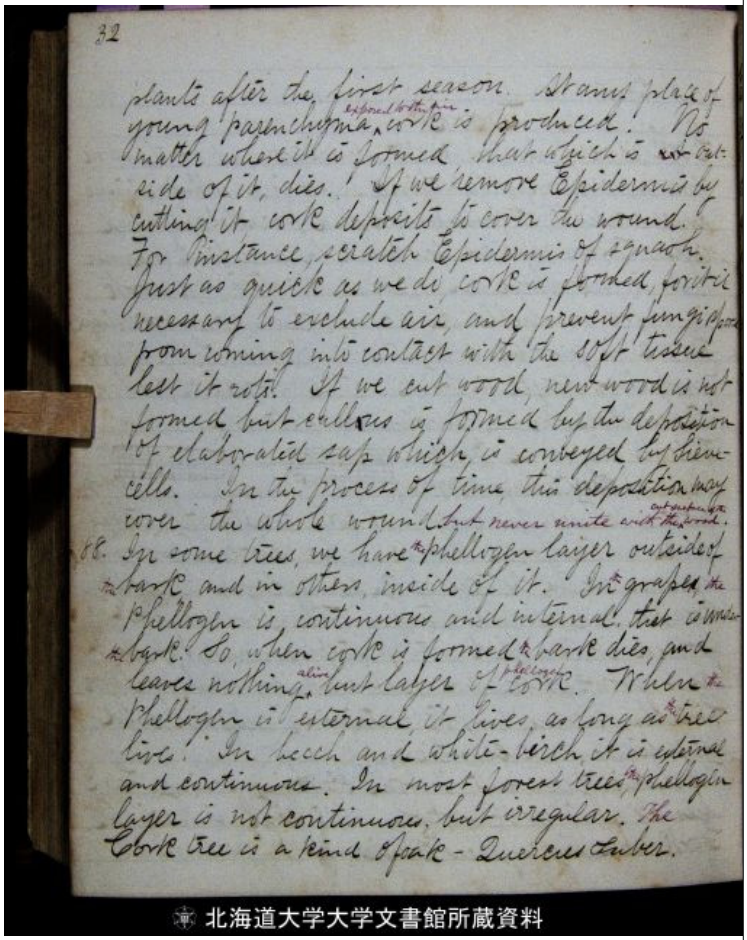
parallelepipedal: 平行六面体の。
phellogen: コルク形成層。



plants after the first season. At any place of young parenchyma exposed to the air cork is produced: No matter where it is formed, that which is outside of it, dies. If we remove Epidermis by cutting it, cork deposits to cover the wound. For instance, scratch Epidermis of squash. Just as quick as we do, cork is formed, for it is necessary to exclude air, and prevent fungi spore from coming into contact with the soft tissue lest it rots. If we cut wood, new wood is not formed, but callus is formed by the deposition of elaborated sap which is conveyed by Sieve-cells. In the process of time, this deposition may cover the whole wound but never unite with the cut surface of the wood.

88. In some trees, we have the phellogen layer outside of the bark and in others, inside of it. In the grapes, the phellogen is continuous and internal, that is under the bark. So, when cork is formed the bark dies, and leaves nothing alive but layer of phellogen cork. When the phellogen is external, it lives as long as the tree lives. In beech and white-birch, it is external and continuous. In most forest trees the phellogen layer is not continuous, but irregular. The Cork tree is a kind of oak - Quercus Suber.

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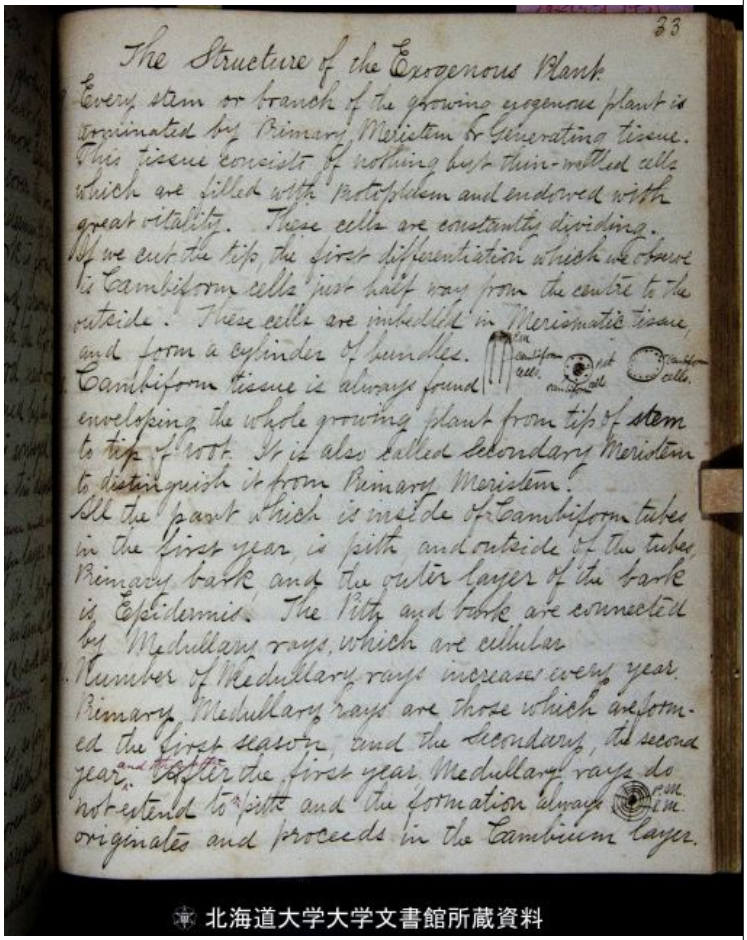
callus: 肉状体。

Quercus suber: コルクガシ（ブナ科）



The Structure of the Exogenous Plant.

Every stem or branch of the growing exogenous plant is terminated by Primary Meristem or Generating tissue. This tissue consists of nothing but thin-walled cells which are filled with protoplasm and endowed with great vitality. These cells are constantly dividing. If we cut the tip, the first differentiation which we observe is Cambiform cells just half way from the centre to the outside. These cells are imbedded in Merismatic tissue, and form a cylinder of bundles. Cambiform tissue is always found enveloping the whole growing plant from tip of stem to tip of root. It is also called Secondary Meristem to distinguish it from Primary Meristem.

All the part which is inside of Cambiform tubes in the first year, is pith and outside of the tubes, Primary bark and the outer layer of the bark is Epidermis. The Pith and bark are connected by Medullary rays, which are cellular.

Number of Medullary rays increases every year. Primary Medullary rays are those which are formed the first season, and the Secondary, the second year and thereafter. After the first year Medullary rays do not extend to pith and the formation always originates and proceeds in the Cambium layer.

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All the part which is inside of the Cambiform tubes in the first year, is pith, and outside of the tubes, Primary bark, and the outer layer of the bark is Epidermis. The pith and bark are connected by Medullary rays, which are cellular.

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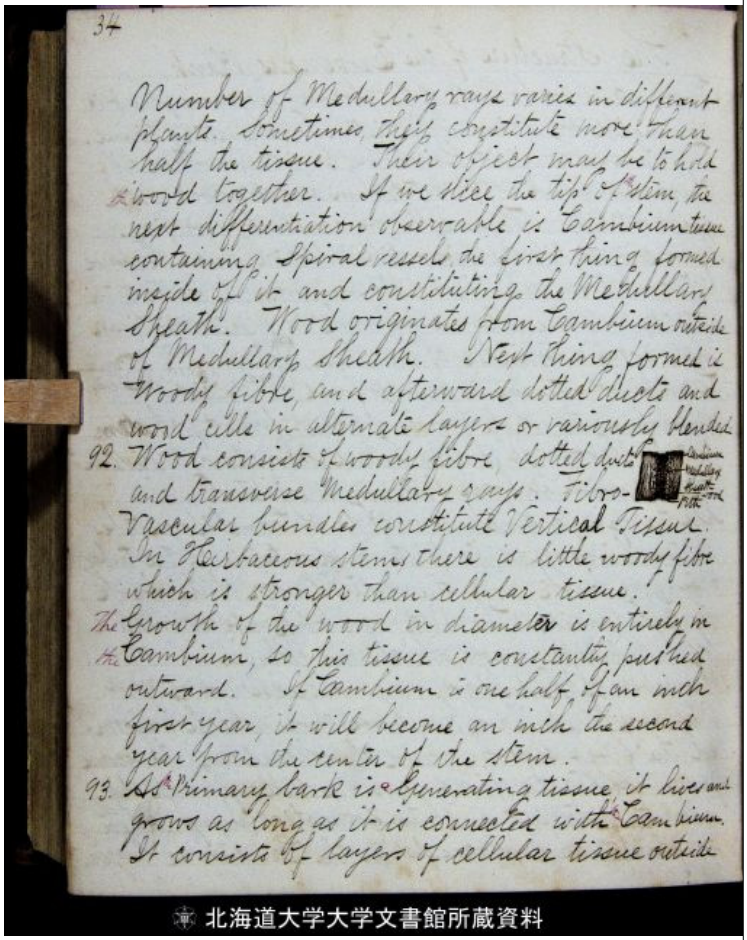
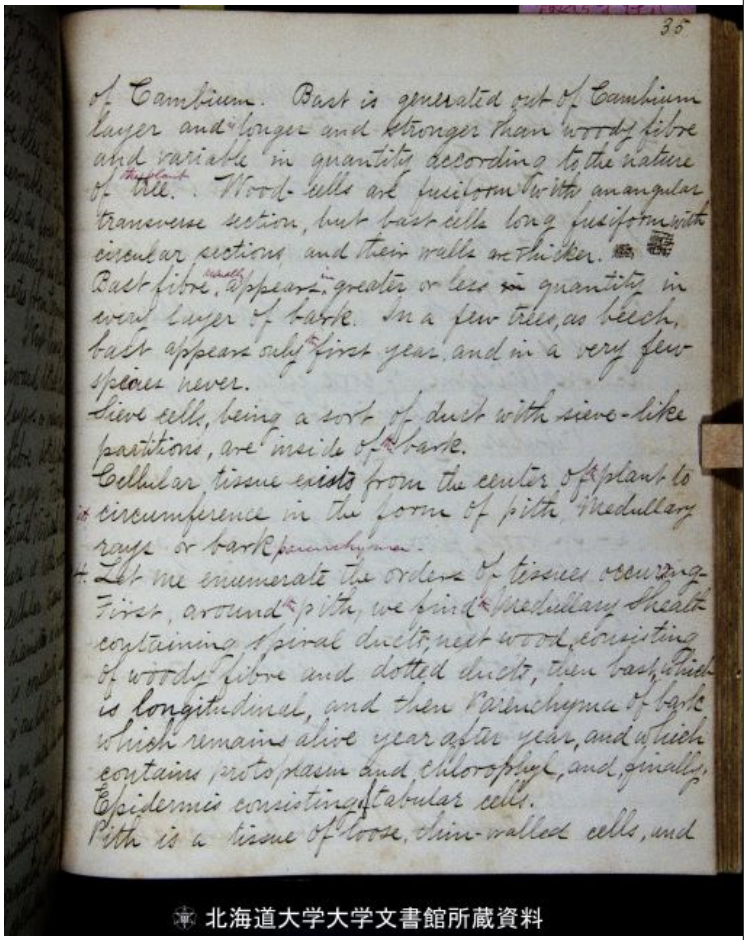
exogenous: 外生植物の。
cambiform: 形成層(cambium)の。elongated。



Number of Medullary rays varies in different plants. Sometimes, they constitute more than half the tissue. Their object may be to hold the wood together. If we slice the tip of the stem, the next differentiation observable is Cambium tissue containing. Spiral vessels, the first thing formed inside of it and constituting the Medullary Sheath. Wood originates from Cambium outside of Medullary Sheath. Next thing formed is woody fibre, and afterward dotted ducts and wood cells in alternate layers or variously blended.

92. Wood consists of woody fibre dotted ducts and transverse Medullary rays. Fibro-Vascular bundles constitute Vertical Tissue. In Herbaceous stems there is little woody fibre which is stronger than cellular tissue. The growth of the wood in diameter is entirely in the Cambium, so this tissue is constantly pushed outward. If Cambium is one half of an inch first year, it will become an inch the second year from the center of the stem.

93. As primary bark is a Generating tissue, it lives and grows as long as it is connected with the Cambium. It consists of layers of cellular tissue outside



of Cambium. Bast is generated out of Cambium layer and is longer and stronger than woody fibre and variable in quantity according to the nature of the plant tree. Wood-cells are fusiform with an angular transverse section, but bass cells long fusiform with circular sections, and their walls are thicker.

Bast fibre usually appears in greater or less quantity in every layer of bark. In a few trees, as beech, bast appears only the first year, and in a very few species never.

Sieve cells, being a sort of duct with sieve-like partitions, are, inside of the bark.

Cellular tissue exists from the center of the plant to its circumference in the form of pith, Medullary rays or bark Parenchyma.

94. Let me enumerate the orders of tissues occurring. First, around the pith, we find the Medullary Sheath containing spiral ducts, next wood, consisting of woody fibre and dotted ducts, then bast, which is longitudinal, and then Parenchyma of bark which remains alive year after year, and which contains protoplasm and chlorophyl, and, finally, Epidermis consisting of tabular cells. Pith is a tissue of loose, thin-walled cells, and

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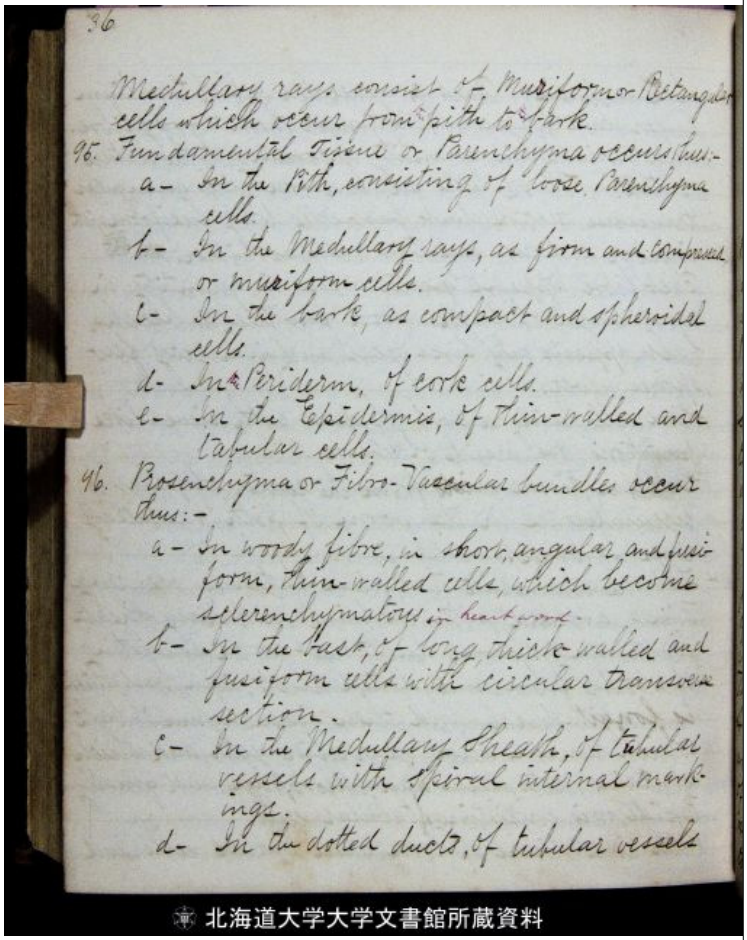
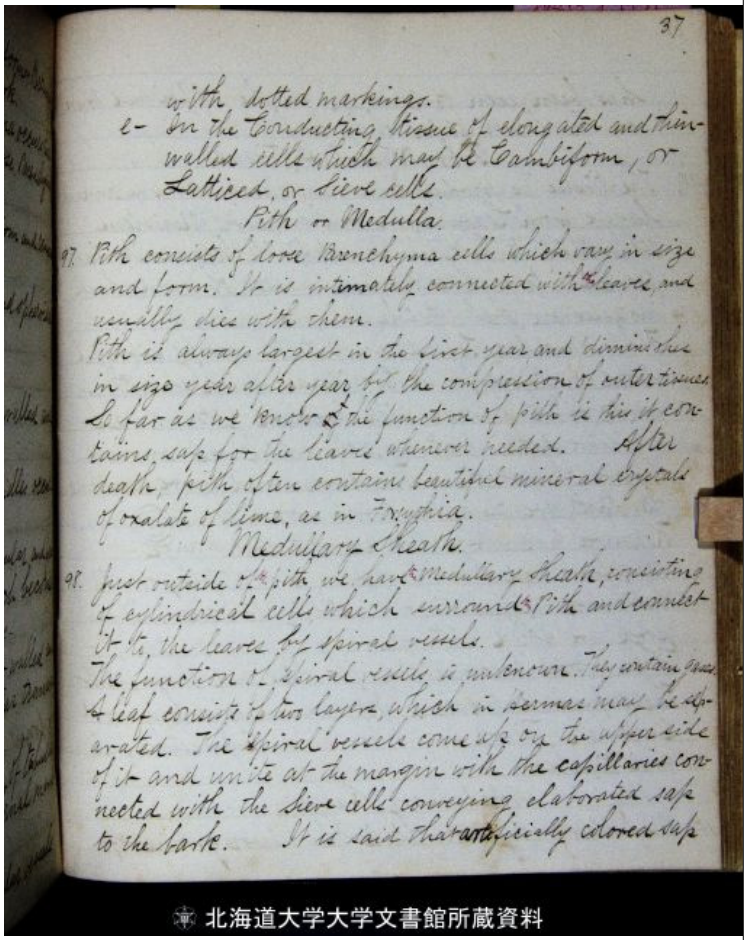
pith: 髄.。



Medullary rays consist of Muriform or Rectangular cells which occur from the pith to the bark.

95. Fundamental Tissue or Parenchyma occurs thus:—
    - a - In the pith, consisting of loose Parenchyma cells.
    - b - In the Medullary rays, as firm and compressed or Muriform cells.
    - c - In the bark, as compact and spheroidal cells.
    - d - In the Periderm, of cork cells.
    - e - In the Epidermis, of thin-walled and tabular cells.

96. Parenchyma or Fibro-Vascular bundles occur thus:—
    - a - In woody fibre, in short, angular and fusiform, thin-walled cells, which become sclerenchymatous in heart wood.
    - b - In the bast, of long thick-walled and fusiform cells with circular transverse section.
    - c - In the Medullary Sheath, of tubular vessels with spiral internal markings.
    - d - In the dotted ducts, of tubular vessels



with dotted markings.

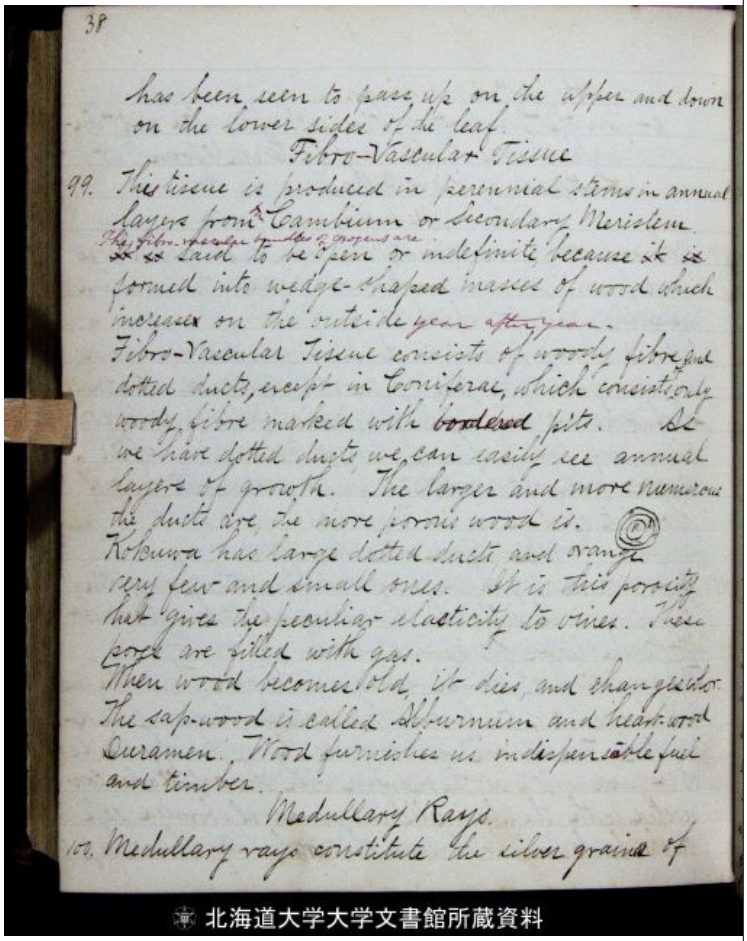
e - In the Conducting tissue of elongated and thin-walled cells which may be Cambiform, or Latticed, or Sieve cells.

Pith or Medulla.

97. Pith consists of loose Parenchyma cells which vary in size and form. It is intimately connected with the leaves, and usually dies with them.
Pith is always largest in the first year and diminishes in size year after year by the compression of outer tissues. So far as we know the function of pith is this it contains sap for the leaves whenever needed. After death, pith often contains beautiful mineral crystals of oxalate of lime, as in Forsythia.

Medullary Sheath.

98. Just outside of the pith we have the medullary Sheath, consisting of cylindrical cells which surround the pith and connect it to the leaves by spiral vessels. The function of spiral vessels is unknown. They contain gases. A leaf consists of two layers, which in Hermas may be separated. The spiral vessels come up on the upper side of it and unite at the margin with the capillaries connected with the Sieve cells conveying elaborated sap to the bark. It is said that artificially colored sap



has been seen to pass up on the upper and down on the lower sides of the leaf.

Fibro-Vascular Tissue.

99. This tissue is produced in perennial stems in annual layers from the Cambium or Secondary Meristem. The fibro-Vascular bundles of exogens are said to be open or indefinite, because formed into wedge-shaped masses of wood which increase on the outside year after year.

Fibro-Vascular Tissue consists of woody fibre and dotted ducts, except in Coniferae, which consists of only woody fibre marked with bordered pits. As we have dotted ducts, we can easily see annual layers of growth. The larger and more numerous the ducts are, the more porous wood is Kokuwa has large dotted ducts and orange very few and small ones. It is this porosity that gives the peculiar elasticity to vines. These pores are filled with gas.

When wood becomes old, it dies, and changes whr. The sap-wood is called Alburnum and heart-wood Duramen. Wood furnishes us indispensable fuel and timber.

Medullary Rays.

100. Medullary rays constitute the silver grain of

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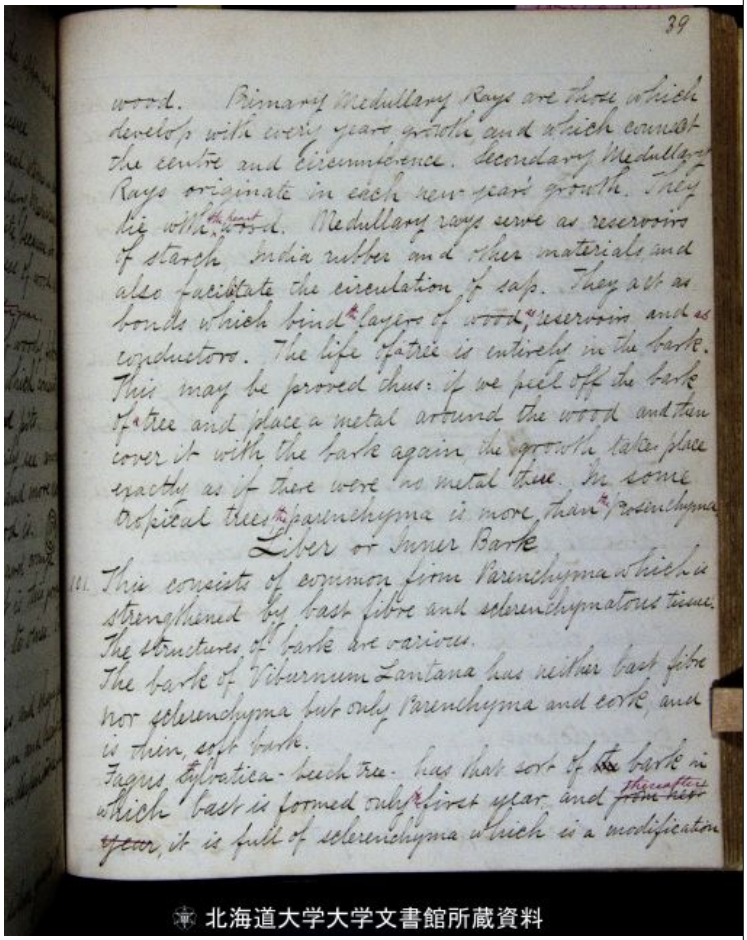
alburnum: 白太.。
duramen: 赤材。



wood. Primary Medullary Rays are those which develop with every years growth and which connect the centre and circumference. Secondary Medullary Rays originate in each new years growth. They die with the heart wood. Medullary rays serve as reservoirs of starch, India rubber and other materials and also facilitate the circulation of sap. They act as bonds which bind the layers of wood, as reservoirs and as conductors. The life of a tree is entirely in the bark. This may be proved thus: if we peel off the bark of a tree and place a metal around the wood and then cover it with the bark again, the growth taken place exactly as if there were no metal these. In some tropical trees, the parenchyma is more than the Prosenchyma.

Liber or Inner Bark.

101. This consists of common firm Parenchyma which is strengthened by bast fibre and sclerenchymatous tissue. The structures of bark are various.
The bark of Viburnum Lantana has neither bast fibre not sclerenchyma but only Parenchyma and cork, and is thin, soft bark.
Fagus sylvatica - beech tree - has that sort of bark in which bast is formed only first year and thereafter, it is full of sclerenchyma which is a modification

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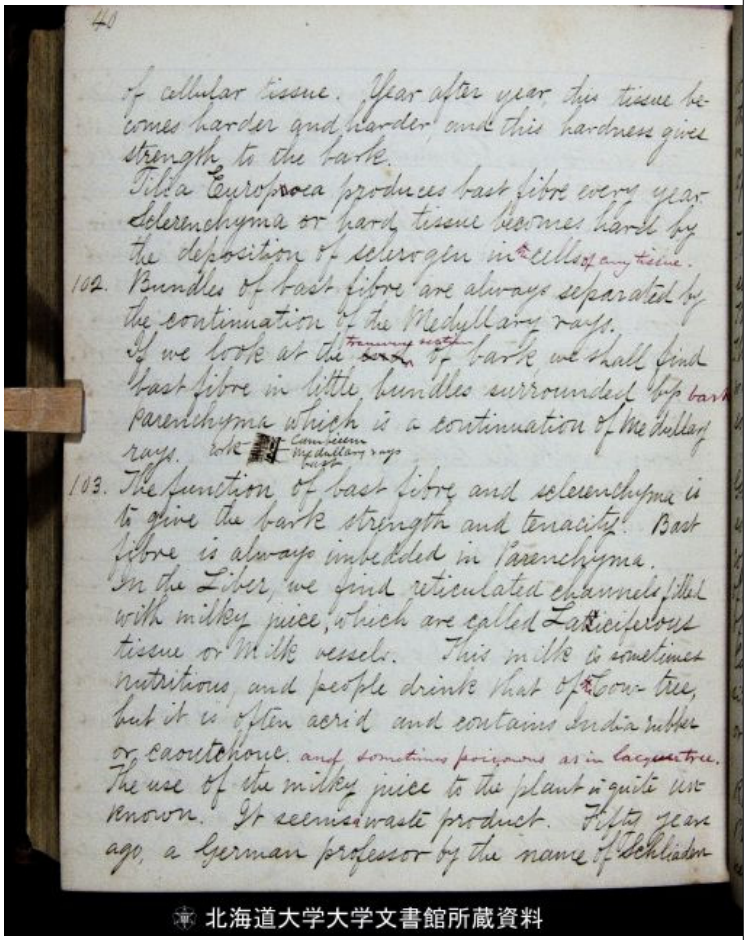
viburnum: ガマズミ属の木。
lantana: ランタナ属の木。



of cellular tissue. Year after year, this tissue becomes harder and harder, and this hardness gives strength to the bark.

Tilia Europea produces bast fibre every year. Sclerenchyma or hard tissue becomes hard by the deposition of sclerogen in the cells of any tissue.

102. Bundles of bast fibre are always separated by the continuation of the Medullary rays.

If we look at the transvers section of bark, we shall find bast fibre in little bundles surrounded by bark parenchyma which is a continuation of Medullary rays.

103. The function of bast fibre and sclerenchyma is to give the bark strength and tenacity. Bast fibre is always imbedded in Parenchyma. In the Liber, we find reticulated channels filled with milky juice, which are called Laticiferous tissue or Milk vessels. This milk is sometimes nutritious, and people drink that of the Cow-tree, but it is often acrid and contains India rubber or caoutchouc and sometimes poisonous as in lacy tree. The use of the milky juice to the plant is quite unknown. It seems a waste product. Fifty years ago, a German professor by the names of Schliaden

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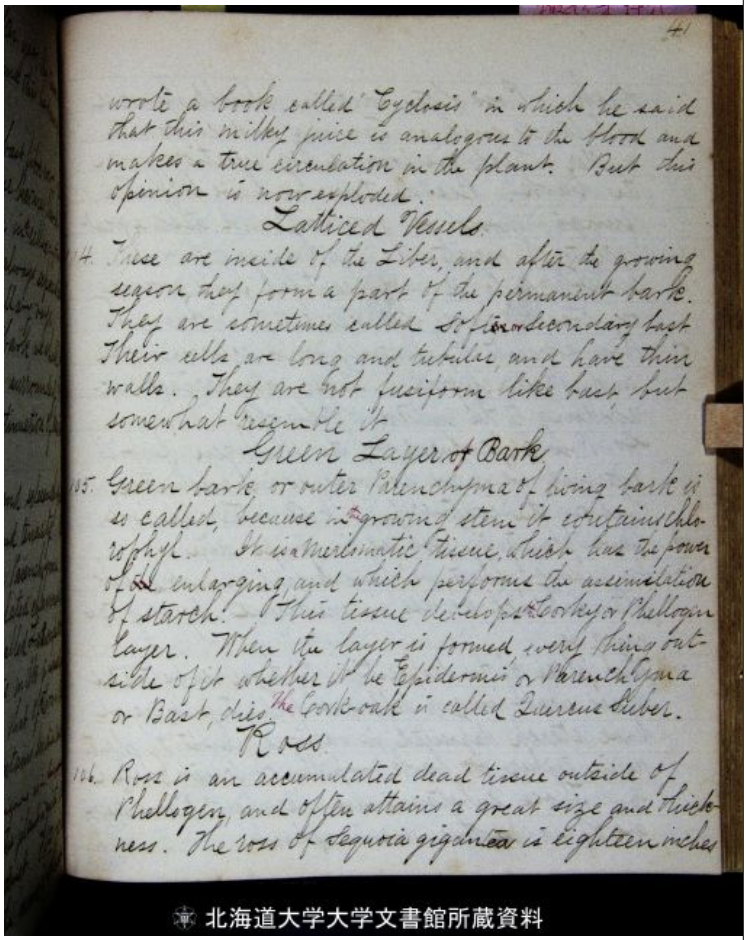
Tilia Europea: ヨーロッパ・シナノキ（？）
sclerogen: 木の細胞を厚くするもの，木質素。
caoutchouc: 天然ゴム。



wrote a book called "Cyclosis" in which he said that this milky juice is analogous to the blood and makes a true circulation in the plant. But this opinion is now exploded.

Latticed Vessels.

104. These are inside of the Liber, and after the growing season, they form a part of the permanent bark. They are sometimes called Soft or Secondary bast. Their cells are long and tubular, and have thin walls. They are not fusiform like bust but somewhat resemble it.

Green Layer of Bark.

105. Green bark or outer Parenchyma of living bark is so called, because in the growing stem it contains chlorophyl. It is a Merismatic tissue, which has the power of enlarging, and which performs the assimilation of starch. This tissue develops the Corky or Phellogen layer. When the layer is formed, every thing outside of it whether it be Epidermis or Parenchyma or Bast, dies. The Cork-oak is called Quercus Suber.

Ross.

106. Ross is an accumulated dead tissue outside of Phellogen, and often attains a great size and thickness. The ross of Sequoia gigantea is eighteen inches

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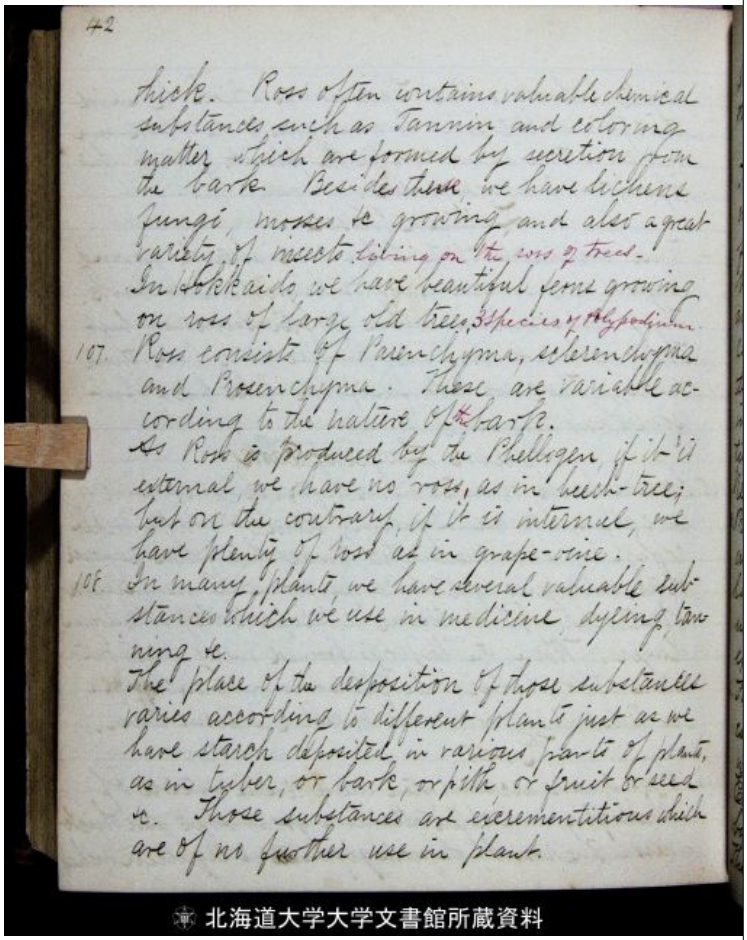
Sequoia: セコイア



thick. Ross often contains valuable chemical substances such as Tannin and coloring matter which are formed by secretion from the bark. Besides these, we have lichens fungi, mosses &c growing, and also a great variety of insects lying on the ross of trees. In Hokkaido, we have beautiful ferns growing on ross of large old trees, 3 species of polypodium.

107. Ross consists of Parenchyma, sclerenchyma and Prosenchyma. These are variable according to the nature of the bark.
As Ross is produced by the Phellogen, if it is external, we have no ross, as in beech-tree; but on the contrary, if it is internal, we have plenty of ross as in grape-vine.

108. In many plants we have several valuable Substances which we use in medicine, dyeing, tanning &c.
The place of the deposition of those substances varies according to different plants just as we have starch deposited in various parts of plants, as in tuber, or bark, or pith, or fruit or seed &c. Those substances are excrementitious which are of no further use in plant.

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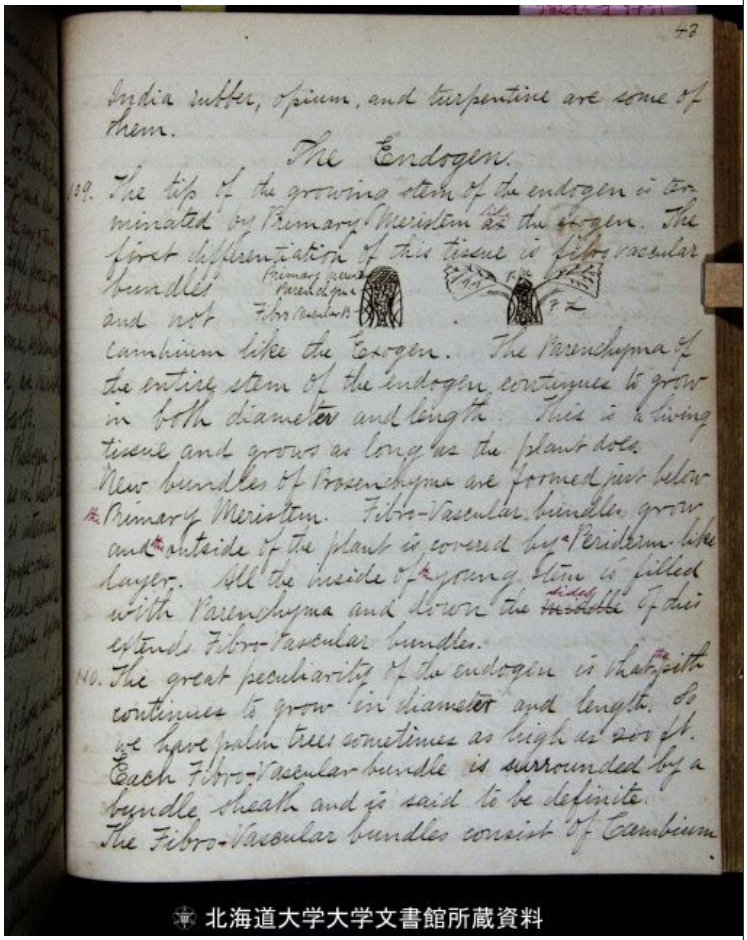
polypodium: シダ植物ポリポディウム

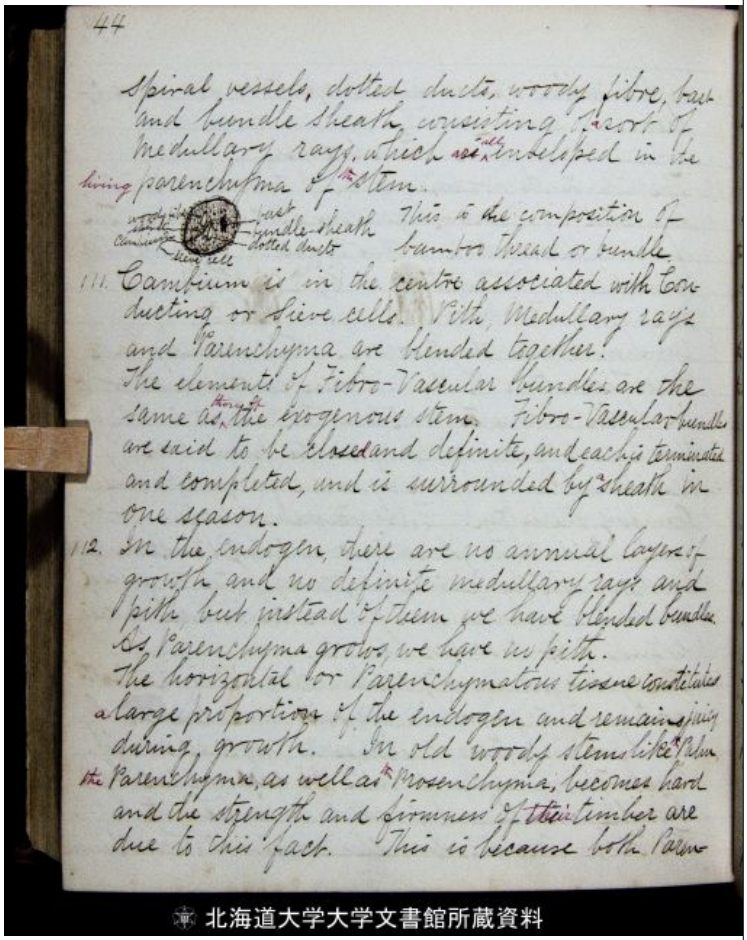


India rubber, opium, and turpentine are some of them.

The Endogen.

109. 109. The tip of the growing stem of the endogen is terminated by Primary Meristem like the exogen. The first differentiation of this tissue is fibre vascular bundles and not cambium like the Exogen. The Parenchyma of the entire stem of the endogen continues to grow in both diameter and length. This is a l living tissue and grows as long as the plant does.
New bundles of Prosenchyma are formed just below the Primary Meristem. Fibro-Vascular bundles grow and the outside of the plant is covered by a Periderm-like layer. All the inside of the young stem is filled with Parenchyma and down the sides of this extends Fibro-Vascular bundles.

110. The great peculiarity of the endogen is that the pith continues to grow in diameter and length. So we have palin trees sometimes as high as 200 ft. Each Fibro-Vascular bundle is surrounded by a bundle sheath and is said to be definite. The Fibro-Vascular bundles consist of Cambium



Spiral vessels, dotted ducts, woody fibre, bast and bundle Sheath consisting of a sort of Medullary rays, which are all enveloped in the living parenchyma of the stem.

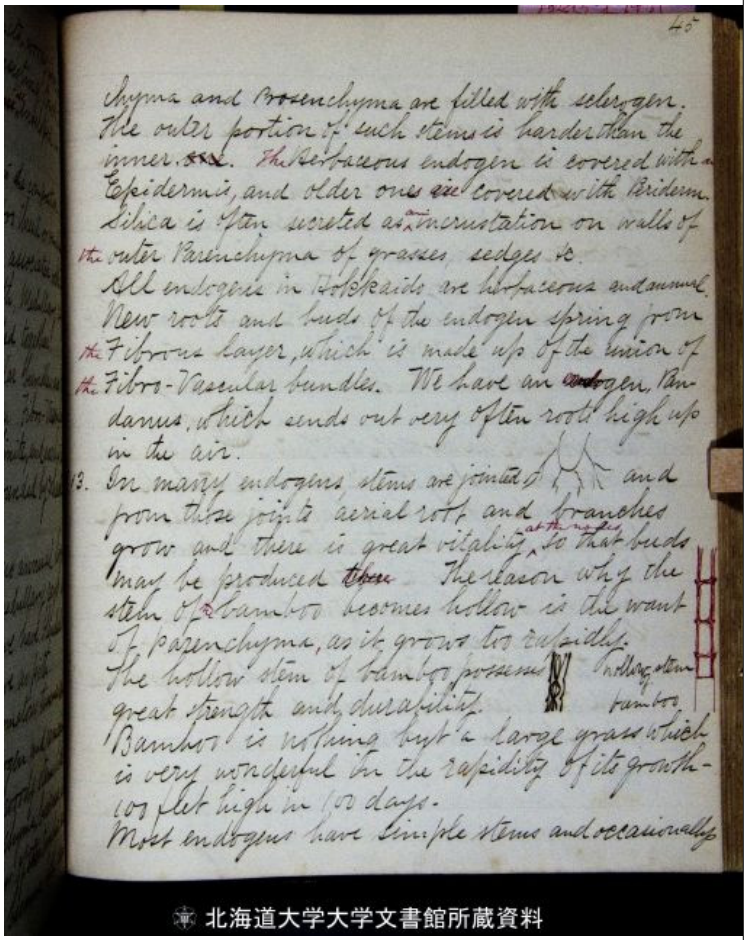
This is the composition of bamboo thread or bundle.

111. Cambium is in the centre associated with Conducting or Sieve cells. Pith, Medullary rays and Parenchyma are blended together.

The elements of Fibro-Vascular bundles are the same as these of the exogenous stem. Fibro-Vascular bundles are said to be closed and definite, and each is terminated and completed, and is surrounded by a sheath in one season.

112. In the endogen, there are no annual layers of growth and no definite medullary rays and pith but instead of them we have blended bundles. As Parenchyma grows, we have no pith.

The horizontal or Parenchymatous tissue constitutes a large proportion of the endogen and remains juicy during growth. In old woody stems like the Palm the Parenchyma, as well as the Prosenchyma, becomes hard and the strength and firmness of their timber are due to this fact. This is because both



Parenchyma and Prosenchyma are filled with sclerogen. The outer portion of such stems is harder than the inner. The Herbaceous endogen is covered with an Epidermis, and older ones are covered with Periderm. Silica is often secreted as an incrustation on walls of the outer Parenchyma of grasses, sedges &c.

All endogens in Hokkaido are herbaceous and annual. New roots and buds of the endogen spring from the Fibrous layer, which is made up of the union of the Fibro-Vascular bundles. We have an endogen, Pandanus, which sends out very often roots high up in the air.

113. 113. In many endogens, stems are jointed and from those joints aerial root and branches grow and there is great vitality at the nodes so that buds may be produced these. The reason why the stem of the bamboo becomes hollow is the want of Parenchyma, as it grows too rapidly.

The hollow stem of bamboo possesses great strength and durability.

Bamboo is nothing but a large grass which is very wonderful in the rapidity of its growth 100 feet high in 100 days.

Most endogens have simple stems and occasionally

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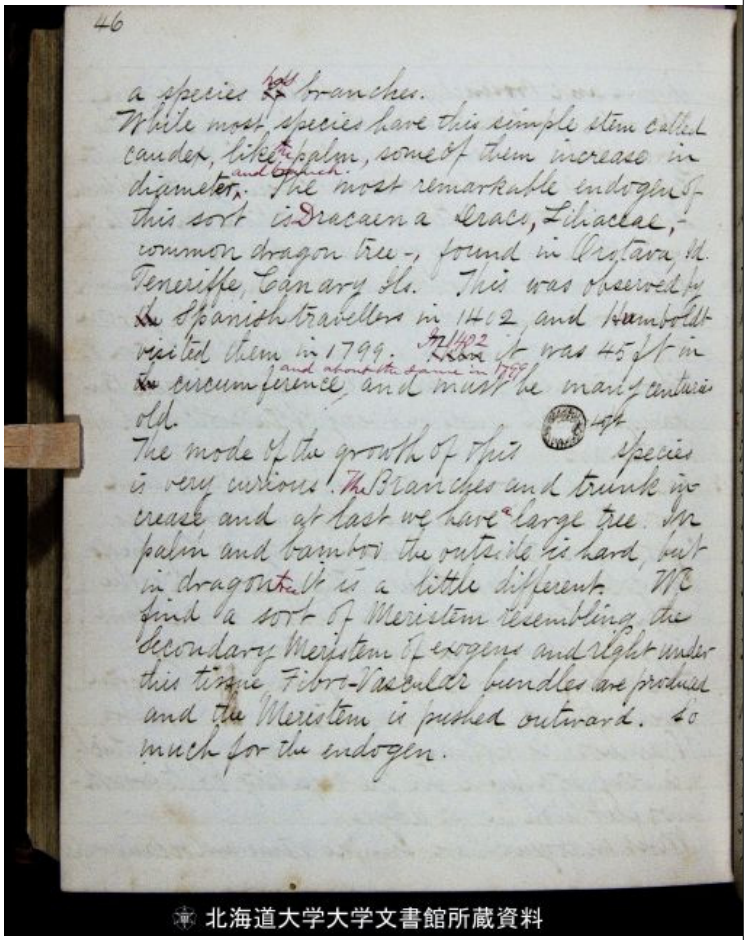
pandanus: タコノキ。



a species has branches.
While most species have this simple stem called caudex, like the palm, some of them increase in diameter and branch. The most remarkable endogen of this soft is Dracaena Draco, Liliaceae, -common dragon tree -, found in Orotava, ld. Teneriffe, Canary &c. This was observed by Spanish travelers in 1402, and Humboldt visited them in 1799. In 1402 it was 45 ft in circumference and about the dome in 1799 and must be many centuries old.
The mode of the growth of this species is very curious. The Branches and trunk increase and at last we have a large tree. In palm and bamboo the outside is hard, but in dragon tree it is a little different. We find a sort of Meristem resembling the Secondary Meristem of exogens and right under this tissue Fibro-Vascular bundles are produced and the Merestem is pushed outward. So much for the endogen.

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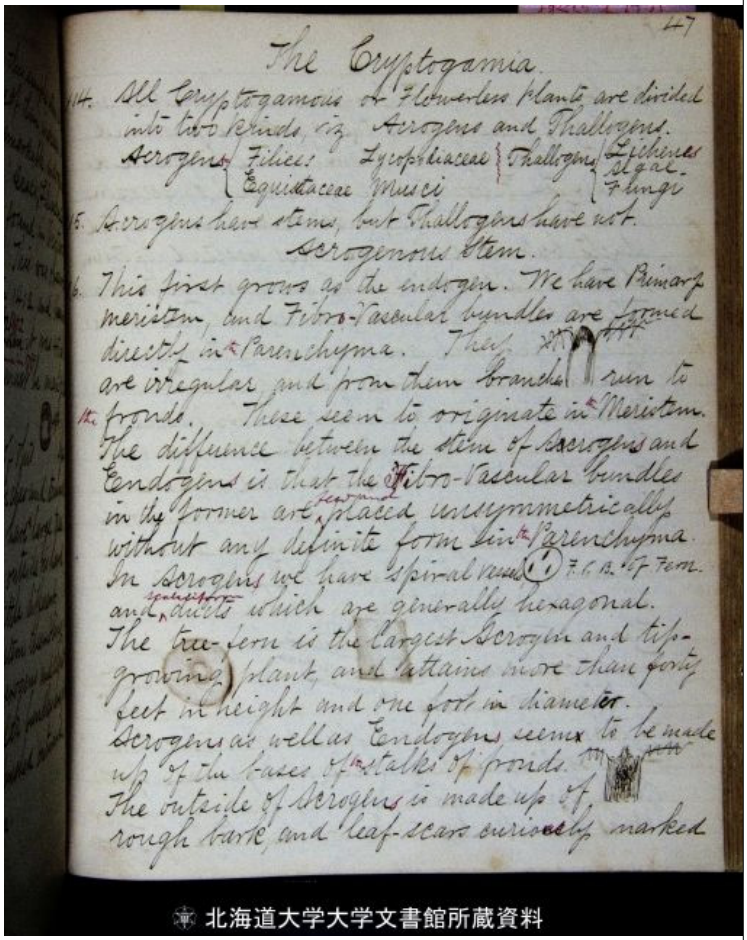
caudex: 植物体の軸部。



The Cryptogamia.

114. All Cryptogamous or Flowerless plants are divided into two kinds, viz., Acrogens and Thallogens.

Acrogens	Filices	Lycopodiaceae	Thallogens	Lichenes
				Algae
	Equisetaceae	Musci		Fungi

115. Acrogens have stems, but Thallogens have not.

Acrogenous Stem.

116. This first grows as the endogen. We have Primary Meristem, and Fibro-Vascular bundles are formed directly in the Parenchyma.
They are irregular and from them branches run to the fronds. These seem to originate in the Meristem. The difference between the stem of Acrogens and Endogens is that the Fibro-Vascular bundles in the former are few and placed unsymmetrically without any definite form in the Parenchyma. In Acrogens we have spiral vessels and scalariform ducts which are generally hexagonal. The tree-fern is the largest Acrogens and tip-growing plant and attains more than forty feet in height and one foot in diameter.
Acrogens as well as Endogen seem to be made up of the bases of the stalks of fronds.
The outside of Acrogens is made up of rough bark, and leaf-scars curiously marked

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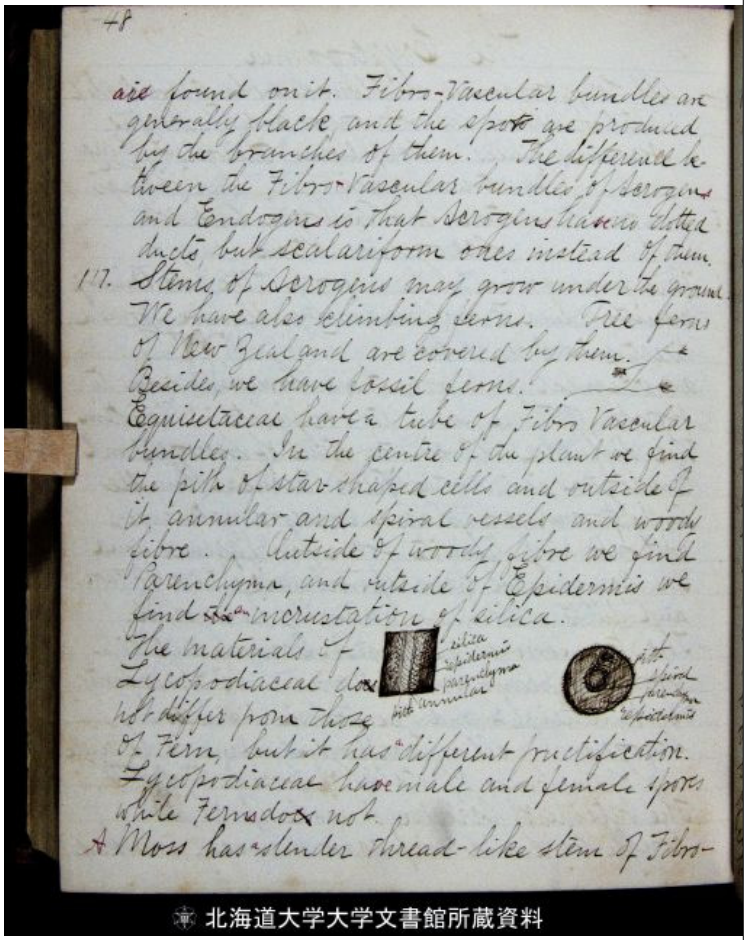
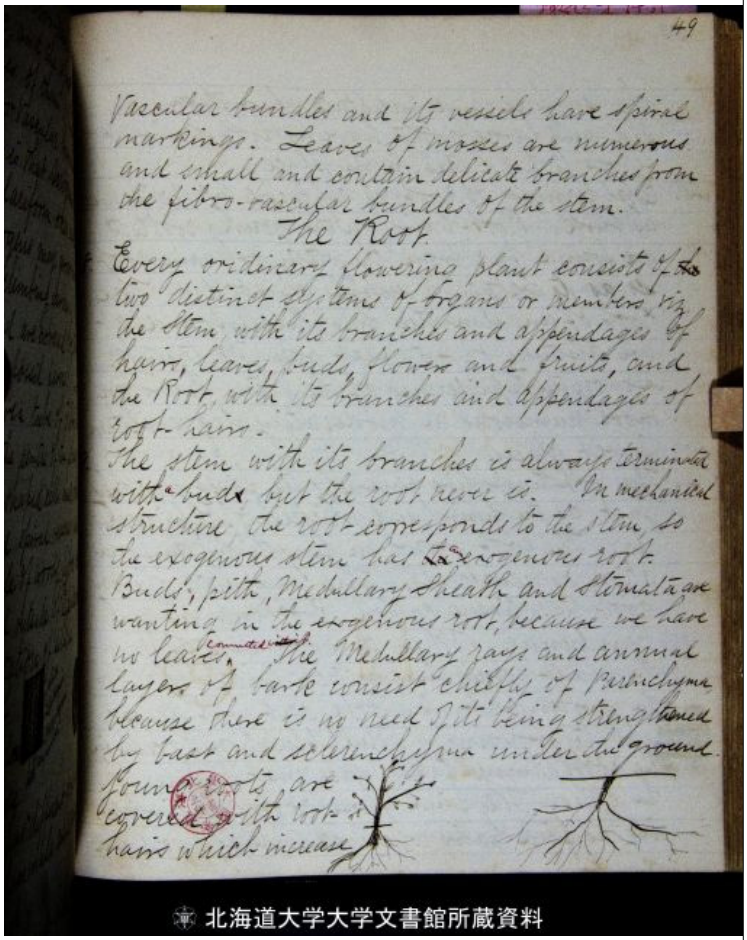
thallogen: 葉状植物。
lichenes: 地衣植物。
musci: コケ。
acrogen: 頂生植物（シダ類，コケ類など）。



are found on it. Fibro-Vascular bundles are generally black and the spurs are produced by the branches of them. The difference between the Fibro-Vascular bundles of Acrogens and Endogens is that Acrogens have no dotted ducts but scalariform ones instead of them.

117. Stems of Acrogens may grow under the ground. We have also climbing ferns. Tree ferns of New Zealand are covered by them. Besides, we have fossil ferns. Equisetaceae have a tube of Fibro Vascular bundles. In the centre of the plant we find the pith of star-shaped cells and outside of it annular and spiral vessels and woody fibre. Outside of woody fibre we find Parenchyma, and outside of Epidermis we find an incrustation of silica.
The materials of Lycopodiaceae do not differ from those of Fern, but it has a different fructification. Lycopodiaceae have male and female spurs while Ferns do not.
A Moss has a slender thread-like stem of Fibro-

Lycopodiaceae: ヒカゲノカズラ科。

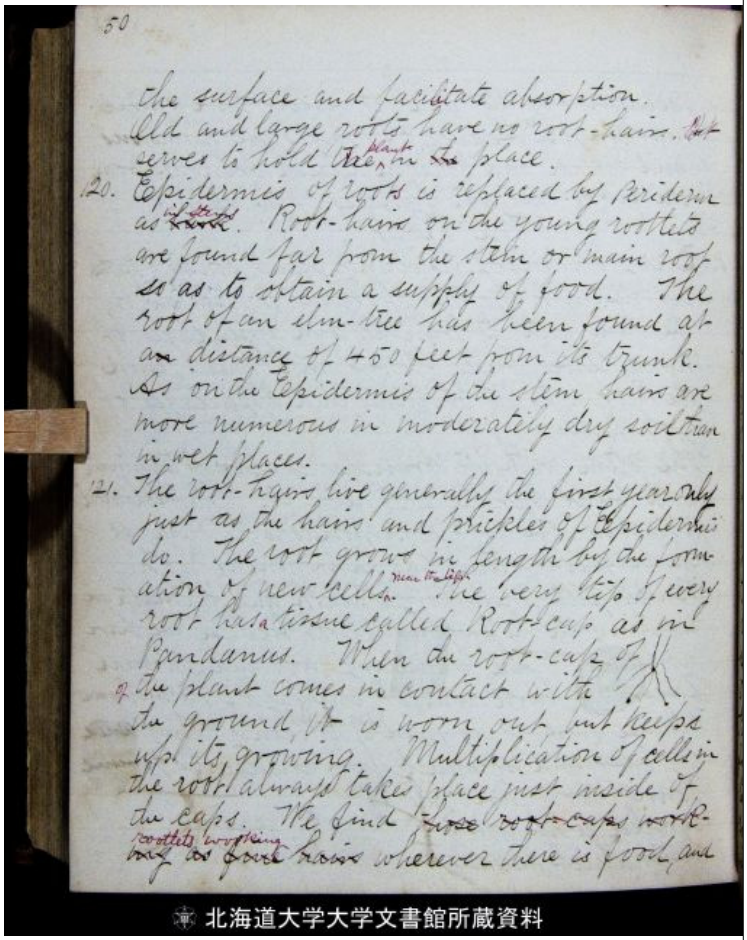


Vascular bundles and its vessels have spiral markings. Leaves of mosses are numerous and small and contain delicate branches from the fibro-vascular bundles of the stem.

The Root.

118. Every ordinary flowering plant consists of two distinct systems of organs or members, viz, the Stem, with its branches and appendages of hairs, leaves, buds, flowers and fruits, and the Root with its branches and appendages of root-hairs.

119. The stem with its branches is always terminated with a bud, but the root never is. In mechanical structure the root corresponds to the stem, so the exogenous stem has an exogenous root. Buds, pith, Medullary Sheath and Stomata are wanting in the exogenous root, because we have no leaves connected. The Medullary rays and annual layers of bark consist chiefly of Parenchyma because there is no need of its being strengthened by bast and sclerenchyma under the ground. Young roots are covered with root-hairs which increase

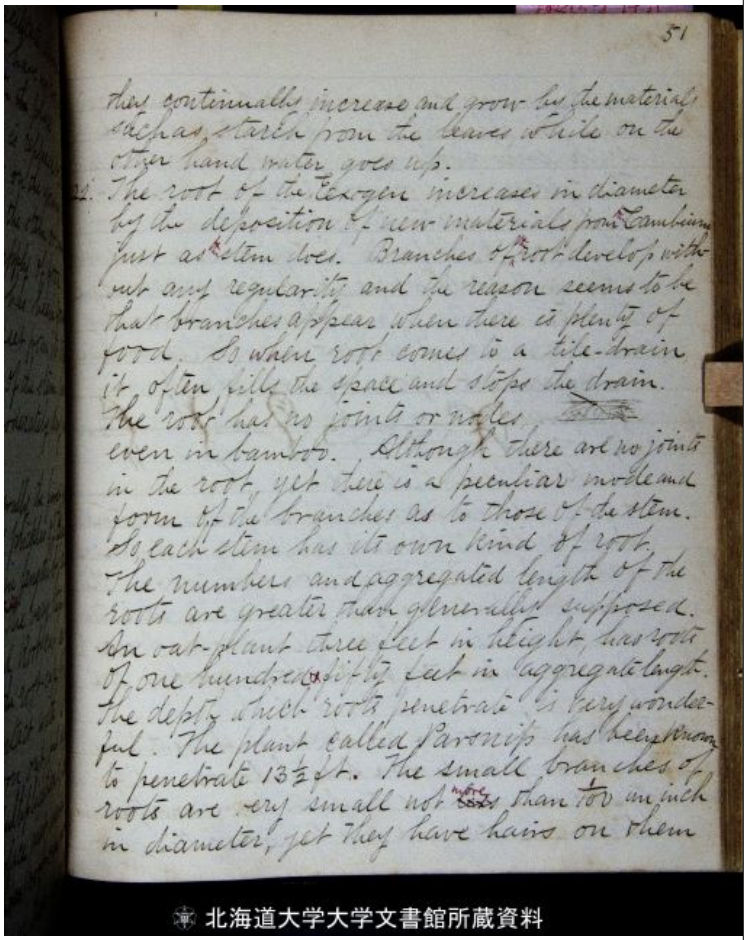


the surface and facilitate absorption. Old and large roots have no root-hairs, &c serves to hold the plants in place.

120. Epidermis of roots is replaced by periderm as in stems. Root-hairs on the young rootlets are found far from the stem or main root so as to obtain a supply of food. The root of an elm-tree has been found at a distance of 450 feet from its trunk. As on the Epidermis of the stem hairs are more numerous in moderately dry soil than in wet places.

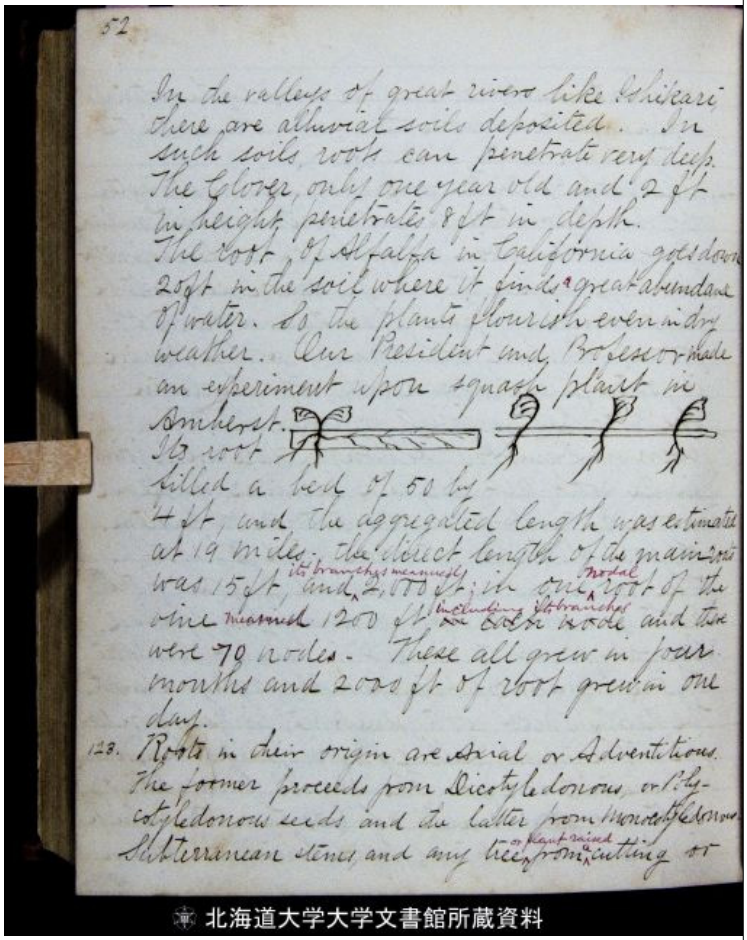
121. The root-hairs live generally the first year only just as the hairs and prickles of Epidermis do. The root grows in length by the formation of new cells near the lip. The very tip of every root has a tissue called Root-cap as in Pandanus.

When the root-cap of the plant comes in contact with the ground, it is worn out, but keeps up its growing. Multiplication of cells in the root always takes place just inside of the caps. We find rootlets working wherever there is food, and



they continually increase and grow by the materials such as starch from the leaves while on the other hand water goes up.

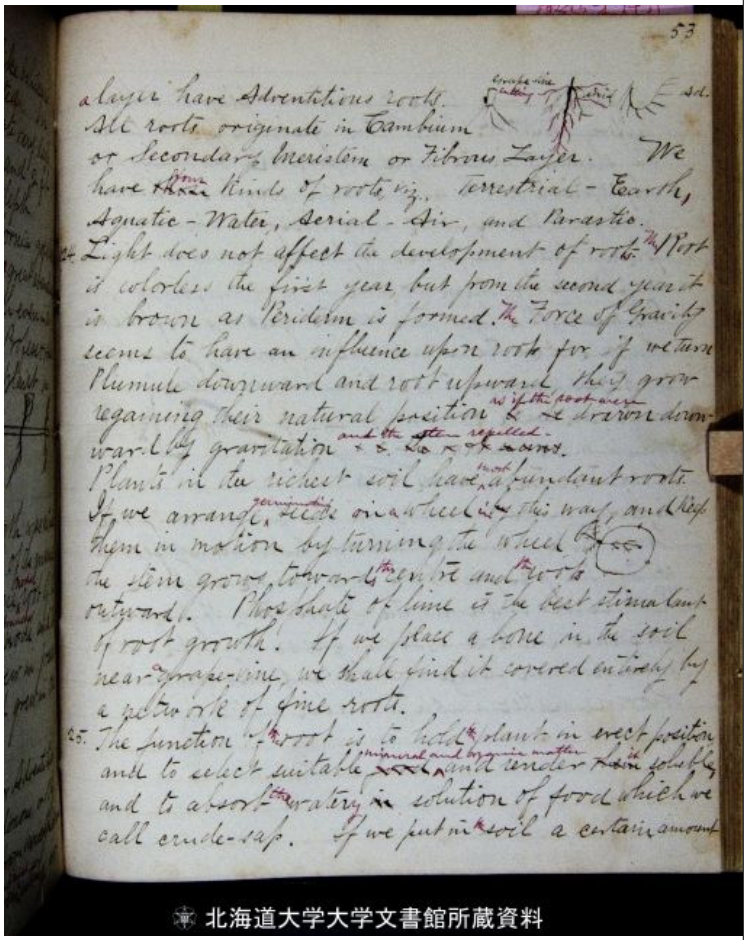
122. The root of the Exogen increases in diameter by the eposition of new-materials from the Cambium just as the stem does. Branches of the root develop without any regularity and the reason seems to be that branches appear when there is plenty of food. So when root comes to a tile-drain it often fills the space and stops the drain. The root has no joints or nodes, even in bamboo. 「図」Although there are no joints in the root, yet there is a peculiar mode and form of the branches as to those of the stem. So, each stem has its own kind of root. The numbers and aggregated length of the roots are greater then generally supposed. An out-plant three feet in height, has roots of one hundred & fifty feet in aggregate length. The depth which roots penetrate is very wonderful. The plant called Parsnip has been known to penetrate 13 1/2 ft. The small branches of roots are very small not more than 1/100 an inch in diameter, yet they have hairs on them.



In the valleys of great rivers like Ishikari, there are alluvial soils deposited. In such soils, roots can penetrate very deep. The Clover, only one year old and 2 ft in height penetrates 8 ft in depth. The root of Alfalfa in California goes down 20 ft in the soil where it finds a great abundance of water. So the plants flourish ever in dry weather. Our president and Professor made an experiment upon squash plant in Amherst.

Its root filled a bed of 50 by 4 ft, and the aggregated length was estimated at 19 miles, the direct length of the main roots was 15 ft, and its branches measured 2,000 ft; in one nodal root of the vine measured 1,200 ft including its branches and there were 70 nodes. These all grew in four months and 2,000 ft of root grew in one day.

123. Roots in their origin are Axial or Adventitious. The former proceeds from Dicotyledonous, or Polycotyledonous seeds , and the latter from Monocotyledon. Subterranean stems, and any tree or plant raised from a cutting or



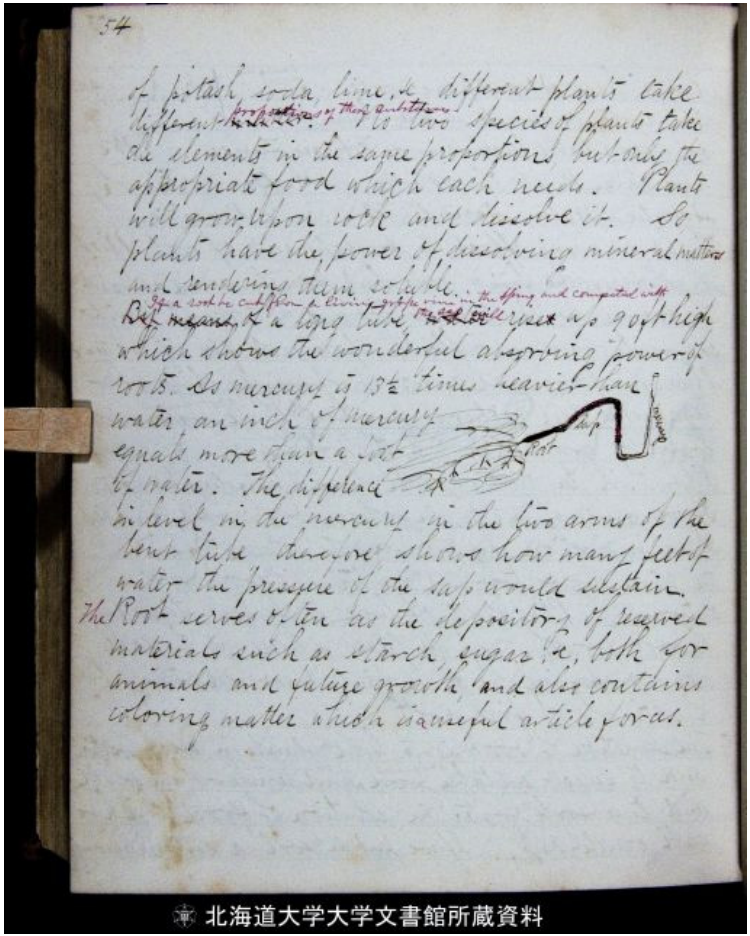
a layer have Adventitious roots. All roots originate in Cambium or Secondary Meristem or Fibrous Layer. We have four kinds of roots viz., Terrestrial-Earth, Aquatic-Water, Aerial-Air, and Parastic.

124. Light does not affect the development of roots. The root is colorless the first year, but from the second year it is brown as Periderm is formed. The Force of Gravity seems to have an influence upon root for, if we turn Plumule downward and root upward, they grow regaining their natural position as if the root is drawn downward by gravitation and the stem repelled.

Plants in the richest soil have most abundant roots. If we arrange germinating seeds on a heel in this way, and keep them in motion by turning the wheel the stem grows towards the centre and the roots outward.

Phosphate of lime is the best stimulant of root growth. If we place a bone in the soil near a grape-vine, we shall find it covered entirely by a network of fine roots.

125. The function of the root is to hold the plant in erect position, and to select suitable mineral and organic matter and render it soluble, and to absorb the watery solution of food which we call crude-sap. If we put in the soil a certain amount



of potash soda lime &c different plants take different proportions of substances. No two species of plants take die elements in the same proportions, but only the appropriate food which each needs. Plants will grow upon rock and dissolve it. So, plants have the power of dissolving mineral matters and rendering them soluble.

If a root be cut from a living grape vine in the spring and connected with a long tube, the sap will rise up 90 ft high which shows the wonderful absorbing power of roots. As mercury is 13 1/2 times heavier than water an inch of mercury equals more than a foot of water.

The difference in level in the mercury in the two arms of the bent tube therefore shows how many feet of water the pressure of the sap would sustain.

The Root serves often as the depository of reserved materials such as starch, sugar, &c, both for animals and future growth, and also contains coloring matter which is a useful article for us.