Botany

en.wikibooks.org

December 27, 2013

Contents

Note: current version of this book can be found at ***http://en.wikibooks.org/wiki/Botany***`http://`

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2.1 Introduction to the Botany Study Guide

This *Study Guide to the Science of Botany* is a textbook at ***Wikibooks*** shelved at the Wikibooks:biology bookshelf[2] and intended to establish a course of study in the subject of Botany, utilizing articles provided in ***Wikipedia***[3], with links to other relevant web sites and other Wikibooks as appropriate. In some cases, portions of the text from *Wikipedia* articles have been used to materially develop introductory text within the Guide.

For the new user, it need be pointed out that *Wikipedia* differs from a standard encyclopedia in two important respects: 1) it is a **hypertext** document, and 2) it is open and editable, and therefore **constantly changing**. For the student following this or any guide through *Wikipedia* to cover a specific subject, it is recommended that each article (page) be read first in its entirety, before any hyperlinks are followed to other topics or explanations. It is too easy, otherwise, to simply become lost in a maze of links, and miss the main thrust of an article presented as an assignment from the Guide. Because *Wikipedia* is constantly changing (and, it is believed, improving) the quality of each article encountered will be variable. Some articles are well written and go to adequate depth, whereas others, lacking a proponent, are shallow and incomplete. Short or sloppy looking articles may contain questionable facts. These short-comings should diminish with time, but can be a problem for the student.

One clear advantage to using this Guide linked to a hypertext like *Wikipedia* is the "circular redundancy with serendipity" factor that arises when an article is read and its hyperlinks followed; this factor can be a powerful learning tool. The persistent reader is subjected to a fairly high degree of repetitive reading, often presenting slightly differing perspectives on the same general topic, with the result that learning comes from redundancy and seeing difficult concepts presented in more than one way. At the same time, some hyperlinks lead down less relevant paths, bringing new and unanticipated knowledge. If, as a student, you are truly interested in mastering the subject of botany, you must be prepared to read beyond the basic assignments; in some cases, beyond Wikipedia to explore other, "outside" web sites.

It seems likely that the typical user of the *Study Guide to the Science of Botany* is not necessarily an active student taking a course in botany at the high school (AP) or college

1 http://en.wikibooks.org/wiki/Botany
2 http://en.wikibooks.org/wiki/biology%20bookshelf
3 http://www.Wikipedia.org/

level, but a person with a strong interest in plants---an amateur naturalist or a gardener. Therefore the guide must incorporate both the basic biological and physiological aspects of plants as well as extensive taxonomy-based coverage of the diversity of plants and related organisms. The amount of material now available on the web covering the latter subject is becoming nothing short of phenomenal. In effect, one now has access to much of the world's plant diversity, with photographs and descriptions, in many cases from web sites maintained by specialists. One goal of the guide is to provide a systematics-based approach to capturing this kind of information, hopefully giving the student a strong background in plant systematics. The importance of this approach is not that everyone should become a taxonomist---or become more familiar with plant taxonomy, a specialized field of botanical science with a relatively narrow following---but that appreciation for (and understanding of) species diversity is most critical at this time in our earth's history marked by accelerated species extinctions and destruction of native ecosystems by both human population expansion and man-induced spread of non-native species.

The *Study Guide to the Science of Botany* includes two other "parallel" documents intended to enhance the usefulness of the Guide. These could also be used separately or independently as source documents for a beginning course in Botany. They are the *Discussion* pages and the *Laboratory Exercise* pages. Both are explained in detail in the next Section titled *How to use this Guide*[4].

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4 Chapter 3 on page 7

5 http://en.wikibooks.org/wiki/Category%3ABotany

3 How to use

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How to Use the *Botany Study Guide*

The purpose of the *Study Guide to the Science of Botany* is to weave - out of the information on Life Science and especially Botany contained in *Wikipedia* - a course of study for the student or layman. It is anticipated that this course will be either supplemental to instruction being received at a school or college, or will be self-directed. In either case, the Guide is not a novel and should not be approached as one. A smooth flow of dialogue is simply not possible and should not be anticipated. The Guide may be closer to the sometimes disjointed notes generated by a student from a lecture or careful reading of a detailed textbook.

Within each subsection of a Chapter, introductory text is followed by one or more "reading assignments" of the form:

- Read Botany[2] (Links need not be pursued at this time)

Following (that is *clicking* on) the link (to *Wikipedia* "Botany" in this case) will open an article intended to provide the details of the Chapter subsection. Recommended articles should be read from top to bottom, and then re-read following some or all of the links embedded in the article to other articles for expanded elucidation or to clarify terms; that is, in most cases, completion of an "assignment" (recommended article) includes at least some or all articles linked to the first. Obviously, it cannot be the case that all links are followed to articles, whose links are then followed to articles, and so on until no new material is encountered. It is likely there would be no quick end to such a pursuit. The amount of time spent wandering beyond the original article is partly a personal matter of how much the reader is getting out of the foray than anything else. Realize it is certainly possible to wander well off the subject at hand. As in the example above, notes are provided with assignments giving some direction for pursuing links. An instruction NOT to follow links simply means the additional material will be encountered later in the course of instruction, and going beyond the assigned article may provide too much detail for a beginning student. The following example:

- Read Science[3] (The following links are included:)
  - Scientific Method[4]
  - Philosophy of Science[5]

1 http://en.wikibooks.org/wiki/Botany
2 http://en.wikipedia.org/wiki/Botany
3 http://en.wikipedia.org/wiki/Science
4 http://en.wikipedia.org/wiki/Scientific%20method
5 http://en.wikipedia.org/wiki/Philosophy%20of%20science

specifies that two other links ARE part of the assignment. Other links encountered may be followed to expand your knowledge or, as always, to aid in understanding of technical terms encountered. Hyperlinks included with the text in the Guide are there simply for convenience, usually to topics somewhat peripheral to the main one. In all cases, finding your way back to the Guide may become tricky, but we have to leave this up to you to establish, beyond pointing out that your browser's *Back* button is intended for this purpose.

3.1 Discussion Questions

At the end of each subsection are posted one to several questions. In general, you will get more out of these questions if you write out your answer on a piece of paper. You may wish to accomplish this on the re-read, allowing each question to guide your quest for an answer. A discussion page for each chapter provides answers to the questions posed. However, the questions are intended to be thought-provoking, and may not have a single straight-forward answer. Answers on the discussion pages are also necessarily much longer than would be expected of any one student; it is expected that each student answer will fit somewhere within the broad discussion presented.

3.2 Laboratory Exercises

A natural sciences course laboratory unit is supposed to provide hands-on experience in exploring topics raised in the text and lecture units. The best that a website can give towards this goal is a manual that is liberally provided with pictures and diagrams. The student must provide the "hands on" from the neighboring natural world. Fortunately, in botany, this is much easier to accomplish than in almost any other field of science. Both the outdoors, the local market, and (if available) a botanical garden can be sources of materials for study. Indeed, we may teach the structure of a *pome* using an apple in the hope that the student will end up with a pear.

In using any of the Laboratory Exercises, it is always best to read through the entire module before actually doing anything. Resist the temptation to view the material as an instruction manual to be followed in a specific order. For one thing it is difficult to write a module that covers, at each step, all that the student should know before proceeding on to the next step. The value of any exercise will be significantly enhanced if you have a pretty good idea where it is going in advance.

3.3 General Navigation

The *Study Guide* is divided into Sections and Chapters which define the subject material of each module. At the bottom of each text page (main text of a module), is a short version of the Table of Contents, allowing the reader to jump between chapters within a Section. Here is an example of the "Wiki Contents Table" for Section I:

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Note that at the beginning of each module, links are provided to both the previous chapter and the succeeding chapter, as well as to the main Table of Contents. Links to units associated with a module, as for example to a Laboratory Exercise, appear near the end of the module

3.4 Final Note

As a final note[6], read the next Section and consider how you might make a contribution to the Guide.

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Botany[9] ---- Both this Guide and all articles in *Wikipedia* are free content[10] that can be added to or edited by anyone. It is an opportunity for the user of these documents to contribute information, or even state given information more clearly, simply by editing a page. As a student with a textbook and a lecturer (teacher), you may find yourself in possession of useful facts, another point of view on existing facts, or a report you prepared of exceptional quality. Any of these can be added to an appropriate page in this Guide or the *Wikipedia*. However, this caution is strongly advised: *Do not place into the Guide any text or pictures taken verbatim (or close to verbatim) from a text book, web site, or other copyrighted source without permission of the copyright holder.* In general, this means, anything you submit should be your own work.

To learn how to edit or contribute material to this textbook, first read the introduction at: *How to Edit*[11].

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Chapter 1. Introduction to Botany

3.5 Botany as a Science

Botany is the branch of **biology** concerned with the scientific study of plants. Traditionally, botanists studied all organisms that were not generally regarded as animal. However, advances in our knowledge about the myriad forms of life, especially microbes (viruses and bacteria), have led to spinning off from Botany the specialized field called **Microbiology**.

6 Chapter 3.4 on page 9
7 http://en.wikibooks.org/wiki/Category%3ABotany
8 http://en.wikibooks.org/wiki/Category%3ABotany
9 http://en.wikibooks.org/wiki/Botany
10 http://en.wikipedia.org/wiki/free_content
11 http://en.wikipedia.org/wiki/Wikipedia%3Aintroduction
12 http://en.wikibooks.org/wiki/Category%3ABotany
13 http://en.wikibooks.org/wiki/Botany%23Detailed%20contents
14 Chapter 3.9 on page 13

Still, the microbes are usually covered in introductory Botany courses, although their status as neither animal nor plant is firmly established.

Plants are living entities, and material presented within *Biology* will have relevance here, most particularly at the cellular and subcellular levels of organization (Chapter 2). Both plants and animals deal with the same problems of maintaining life on planet Earth --- their approaches seem quite different, but the end result is the same: continued existence in an organized state, as part of a universe whose tendency is towards greater disorganization. Back on Earth, however, it is a fact that microbes, plants, and animals comprise a very interdependent system. We divide them apart, because our minds work best that way. We categorize and learn common features or properties of the categories. This approach is neither right nor wrong, but is clearly efficient for our minds. Nonetheless, it is desirable to regularly step back and realize that the boundaries between categories are often just constructs, and exceptions to our categories usually abound.

It was alluded to in the opening definition that Botany is a **science**. Just what makes Botany, or anything else a science? It is important to acquire a grasp of the fundamentals of science itself to fully appreciate both how botanical knowledge was gained as well as how it can be used. It is usually quickly disinteresting to acquire facts simply for the sake of knowing. Humans do not just appreciate mountains *because they are there*, they climb them because they are there!

3.6 Living Systems

Biology is defined as the study of life, and Botany is that discipline within Biology concerned with the study of living organisms called **plants** and with certain other living things that are not plants (but are not animals either).

3.6.1 Defining 'Plant'

Like many words in common usage that apply to biological entities or concepts, the term ***plant*** is more difficult to define than might be at first obvious. Although botanists describe a **Kingdom Plantae**, the boundaries defining members of Plantae are more inclusive than our common concept of a "plant". We are tempted to regard *plant* as meaning a multicellular, eukaryotic organism that generally does not have sensory organs or voluntary motion and has, when complete, a root, stem, and leaves. However, botanically only vascular plants have a root, stem, and leaves, and even some vascular plants, such as certain carnivorous plants and duckweed, fall afoul of that definition. But to be fair, the vascular plants are the plants we tend to encounter every day and that most people would readily regard as "plants".

A more significant point of departure between Plantae and plants occurs among the seaweeds. Technically, only a relatively minor group of seaweeds (the chlorophytes or green algae) are members of the Kingdom Plantae. The majority of seaweeds, like the kelps (very large brown algae from the Order Laminariales), despite a superficial appearance of such, lack true stems, leaves, roots, and any kind of vascular systems as found in higher plants. Thus, the kelps are not Plantae; but are they plants? Certainly if we regard the green algae

as plants, it is difficult to exclude the more prominent red and brown algae of our coastal waters.

Another, much broader definition for *plant* is that it refers to any organism that is ***photoautotrophic***---produces its own food from raw inorganic materials and sunlight. This is not an unreasonable definition, and is one that focuses on the role plants typically play in an ecosystem. However, there are photoautotrophs among the **Prokaryotes**, specifically photoautotrophic bacteria and cyanophytes. The latter are sometimes called (for good reasons) blue-green algae. Then there arises the problem that many people would consider that a mushroom is a plant; a mushroom is the fruiting body of a fungus (Kingdom Fungi) and not *photoautotrophic* at all, but *saprophytic*. However, there are more than a few species of flowering plants, fungi, and bacteria that are not autotrophic, but *parasitic*.

We cannot hope to offer a firm answer. The list of characteristics that separate the Plantae from the other biological kingdoms provides at least a technical definition, but realize it is only a technical definition. The problem this lack of precision or agreement in the definition of "plant" presents is one of understanding statements, often encountered in *Wikipedia* (and other) articles, of the sort: *...xylem is one of the two transport tissues of plants*. In general it cannot be assumed this means all plants, algae through flowering plants. It very probably does not include fungi or bacteria. Indeed, it is usually safest to assume the discussion is about vascular plants (essentially the ferns, conifers, flowering plants, and a few others; see discussion below on "General Terminology") unless stated differently (e.g., *...in vascular and non-vascular plants this is*such and such).

3.6.2 Plants as Organisms

The distinction between life and non-life is not as easily made as you might think. There exist intracellular "parasites" that are progressively less alive in terms of being metabolically active:

3.7 Plants and their Uses

There can be no disputing the fundamental significance of plants to the ecology of our planet. Photosynthetic plants utilize energy arriving from the sun to create complex organic molecules from inorganic substances, and by this process contribute oxygen to the atmosphere. Advanced animal life is very much dependent upon this source of oxygen, as well as the organic molecules that form the basis of nearly every food web on the planet. However, humans utilize plants in many ways, especially as sources of pleasure, food, and material for shelter, clothing, and more. Consider here the role plants play in our everyday lives and in our economy.

3.8 Introduction to Plant Classification

At the beginning of this chapter it was suggested that each of us categorizes information we encounter on a daily basis. Our minds seem to want to find relationships between facts and

observations, to erect mental bins in which to place new items with previous "facts". This natural human process is the basis for prejudice, in as much as "facts" categorized together can become strongly associated. But these are personal constructs. In order for scientists of many races, speaking many languages, and coming from all manner of backgrounds and experiences to work productively together to solve common problems, the objects with which they work must be classified within a universally accepted framework.

The classification of living things is called **systematics**, or **taxonomy**, and ideally should reflect the evolutionary history (phylogeny) of the different organisms.

Taxonomy arranges organisms in groups called **taxa**, while systematics seeks clues to their relationships. The dominant system of *Scientific Classification* is called **Linnaean taxonomy**, and includes classification ranks as well as an organism naming convention called **binomial nomenclature**.

Traditionally, all living things were divided into five kingdoms:

Monera[15] --- Protista[16] --- Fungi[17] --- Plantae[18] --- Animalia[19]

However, this five-kingdom system has been replaced by Carl Woese's three-domain system, which focuses on phylogenic roots and comparison of DNA structures. The older approach utilized visual observation as the basis of classification. The three domains reflect whether cells have nuclei (**eukaryotic**) or not (**prokaryotic**), as well as differences in cell membranes and cell walls.

Archaea[20] --- Eubacteria[21] --- Eukaryota[22]

Recall (and review as necessary) how these groupings relate to the sequence of events in the evolutionary history of life as summarized in Timeline of Evolution[23]. You will return to the subject of Scientific Classification to consider in much more detail the groups of organisms studied in Botany, beginning with Chapter 7. First, however, we shall turn our attention to the structure and function of cells and eventually to gain an understanding of plant structure (*plant anatomy*) and function (*plant physiology*).

3.8.1 General Terminology

In Section II of this text we will delve much deeper into "plant" systematics. But you should be aware of some general terms related to classificatory schemes that are used regularly in discussing plants. You have probably encountered these terms many times, although may not be aware of their exact definitions. For example, much of the material in Section I of this textbook is biased towards **flowering plants**. That is, much of the descriptive material here as well as at Wikipedia refers specifically to these. Flowering plants are

15 http://en.wikipedia.org/wiki/Monera
16 http://en.wikipedia.org/wiki/Protist
17 http://en.wikipedia.org/wiki/Fungi
18 http://en.wikipedia.org/wiki/Plantae
19 http://en.wikipedia.org/wiki/Animal
20 http://en.wikipedia.org/wiki/Archaea
21 http://en.wikipedia.org/wiki/Eubacteria
22 http://en.wikipedia.org/wiki/Eukaryota
23 http://en.wikipedia.org/wiki/Timeline%20of%20evolution

angiosperms; plants that have flowers and produce seeds, and comprise the majority of the plants we would normally encounter in say a nursery if not on the street, field, or empty lot. **Seed-bearing plants** include both the angiosperms and the gymnosperms, the latter now treated as a modern group called **conifers**. The conifers are also common plants, especially in higher latitudes, but bear cones instead of flowers. Both conifers and flowering plants develop vascular tissues internally that conduct fluids (especially water) throughout the plant. Included in the **vascular plants** are ferns. Ferns have vascular tissue, but reproduce by spores. They do not produce seeds and do not bear flowers.

3.9 See Also

- *Discussion*[24] *of this chapter*

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Chapter 2. Plant Cells

3.10 Introduction

Figure 1 A loupe (left) and a hand-lens (right) - tools used by botanists in the field

A **cell** is a very basic structure of all living systems, consisting of **protoplasm** within a containing **cell membrane**. Only entities such as viruses---literally on the boundary between non-living chemicals and living systems---lack cells or basic cell structure. All plants, including very simple plants called *algae*, and all animals are made up of cells,

24 http://en.wikibooks.org/wiki/Botany%2FIntroduction%20discussion
25 http://en.wikibooks.org/wiki/Botany%23Detailed_Contents
26 Chapter 3.4 on page 9
27 Chapter 3.13 on page 16

and these are organized in various ways to create structure and function in an organism. Biologists recognize two basic types of cells: **prokaryotic** and **eukaryotic**. *Prokaryotic cells* are structurally more simple. They are found only in single-celled and some simple, multicellular organisms (all bacteria and some algae, which all belong to Bacteria and Archaea domains). *Eukaryotic cells* are found in most algae, all higher plants, fungi, and animals (Eukarya domain). Thus, differences between these two cell types are critical to how an organism is classified, and an important consideration in the evolutionary sequence of life on the planet Earth.

3.11 Plant Cell Structure

Nearly all cells are too small to be seen with the unaided eye. As always there are some exceptions, but generally magnification is required to detect a cellular structure. In plants, a good hand-lens or loupe (see photo at right) will sometimes suffice, but in working with cells or observing how cells are organized to form tissues and structures, a high power **microscope**[28] is used.

- Read about Cells[29] ~ You may wish to follow some or all links to "Main articles" as these provide detail that may interest you; or you might return to explore further should questions arise later in the course.
- Read Plant cells[30] and, at minimum, articles at the following links (but ignore, for now, the topic of Plant Cell Types):
  - Cell Wall[31]
  - Protoplasm and cytoplasm[32]
  - Vacuole[33]
  - Ergastic substances[34]
  - Plastids[35]
  - Chloroplasts[36]

Also note that the textbook, *Cell Biology*[37], is available at *WikiBooks* and can be used as a more detailed reference. You should read the Introductory Chapter[38] (all subsections) at this time.

`Questions`:

1. *Can you think of reasons why*macroscopic*organisms are multicellular?* (Macroscopic means large, in the sense of "not microscopic")

28 `http://en.wikipedia.org/wiki/Microscope`
29 `http://en.wikipedia.org/wiki/Cell%20%28biology%29`
30 `http://en.wikipedia.org/wiki/Plant_cell`
31 `http://en.wikipedia.org/wiki/Cell_wall`
32 `http://en.wikipedia.org/wiki/Protoplasm`
33 `http://en.wikipedia.org/wiki/Vacuole`
34 `http://en.wikipedia.org/wiki/Ergastic%20substances`
35 `http://en.wikipedia.org/wiki/Plastid`
36 `http://en.wikipedia.org/wiki/Chloroplast`
37 `http://en.wikibooks.org/wiki/Cell%20Biology`
38 `http://en.wikibooks.org/wiki/Cell%20Biology%2FIntroduction`

3.12 Basic Cell Function

You should, by now, have a general appreciation for the complexity of cellular structure. Improvements in microscopy, especially development of the Electron microscope[39], have revealed that cells are not merely membranous sacks containing fluid of gel-like consistency. The degree of organization of the **cytoplasm** into **organelles** and their **membranes** should have you convinced that much (perhaps most) of what is really going on around you on this planet is occurring at a scale that is simply inaccessible to your eyes. And while you cannot be expected to directly observe chemical reactions at a molecular scale, contemplate that you cannot, even with powerful optics, directly observe most of the structure where these reactions are somehow controlled to produce outcomes favorable to life---indeed, are life. Hopefully, as you acquire knowledge and become a biologist---a botanist---you will learn to recognize the relevant phenomena by their macroscopic expressions (that which you can readily observe with the unaided eye).

To appreciate basic cell function, it is necessary to first list the processes or outcomes that cells must accomplish to further existence. More specialized functions will be discussed under plant cell structure, as our interest must eventually focus on plants. For now, recall that in your reading you have already encountered these several basic abilities of cells:

- **Metabolism** involves taking in of raw material to use in building cell components and breaking down of other molecules to provide energy for various growth processes; byproducts may be released.
- **Protein biosynthesis** by transcription of DNA to RNA and then translation to protein, used in growth or released for use elsewhere by the organism.
- **Reproduction** by cell division.

Now explore each in turn. Think initially of a single-celled organism with no special abilities, only a "will" to stay alive and perpetuate itself. Remember, the environment will not be kind. The cell must grow and reproduce to counter the tendency of outside forces to breakdown molecular structure and destroy life. Then consider the situation where a cell is part of a multicellular organism, and may be performing more limited and specialized functions.

- Read Cell metabolism[40] (Follow links and read at least these articles):
  - Metabolic pathway[41] (Links need not be followed)
  - Cell respiration[42] (Follows all links)
- Read Protein biosynthesis[43] (Follow links as necessary to understand process and terminology; Also included is:)
  - Gene expression[44]
- Read Cell reproduction[45] (The following links are included:)

39 http://en.wikipedia.org/wiki/Electron_microscope
40 http://en.wikipedia.org/wiki/Cell_metabolism
41 http://en.wikipedia.org/wiki/Metabolic%20pathway
42 http://en.wikipedia.org/wiki/Cellular%20respiration
43 http://en.wikipedia.org/wiki/Protein_biosynthesis
44 http://en.wikipedia.org/wiki/Gene_expression
45 http://en.wikipedia.org/wiki/Cell_division

- Mitosis[46]
- Cell cycle[47]

`Questions`:

1. *Have you been able to discern a relationship between genes and basic cell function? If so, is this also a basic cell function, and where do we list it?*

3.13 Plant Cell Specializations

We will learn about the cells of algae and other organisms (e.g., bacteria and fungi) traditionally covered within Botany in later chapters on those organisms (Chapters 5 - 7). Here, we concentrate on the cells of plants.

The simplest type of plant cell is called a **parenchyma cell** and most of the basic metabolic and reproductive processes of the plant occur in these cells. A term for *parenchyma* cells with chloroplasts, is **chlorenchyma cells**. Other plant cell types that we shall be considering are:

- **Collenchyma** ˜ living cells with thickened walls for increased support
- **Sclerenchyma** ˜ lignified dead cells forming fibers for increased support
- **Epidermal** ˜ surface covering
- **Cork**
- **Xylem tracheid** ˜ single long (up to 1 mm) thin cells for transporting water and support
- **Xylem vessel** ˜ cells form individual elements in an even longer (up to 1 meter in extreme cases) tube for transporting water
- **Meristematic cells** ˜ growth

- Read Parenchyma cell[48]

Laboratory Exercises[49] for Chapter 2 >>

Discussion of questions[50] for Chapter 2 >>>

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46 `http://en.wikipedia.org/wiki/Mitosis`
47 `http://en.wikipedia.org/wiki/Cell_cycle`
48 `http://en.wikipedia.org/wiki/Parenchyma`
49 `http://en.wikibooks.org/wiki/Botany%2FMicroscopy_laboratory`
50 `http://en.wikibooks.org/wiki/Botany%2FPlant_cells_discussion`
51 `http://en.wikibooks.org/wiki/Category%3ABotany`
52 `http://en.wikibooks.org/wiki/Botany%23Detailed_Contents`
53 Chapter 3.9 on page 13
54 Chapter 3.15.1 on page 17

Chapter 3. Plant Tissues

3.14 Introduction

3.15 Plant Tissues

Most plant cells are specialized to a greater or lesser degree, and arranged together in **tissues**. A plant tissue can be simple or complex depending upon whether it is composed of one or more than one type of cell. The simplest tissue found in plants is called **parenchyma**. The cells are not very specialized, more or less rounded or angular where packed together, and thin-walled. A type of parenchyma called **chlorenchyma** because the cells contain chloroplasts forms tissue (usually in the leaves) responsible for most of the photosynthesis occurring in the plant. Note that in simple tissues at least (tissues comprised mostly of one cell type), the tissue name follows from the cell type. However, tissues may also have unique anatomical names related to where in the plant they occur.

3.15.1 Meristems

The growth of a plant requires a source of undifferentiated cells located in places where growth is needed and can be initiated to further the body plan (in comparison to animals, plants are rather open in this regard). Some enlargement in size is always possible by elongation or enlargement of existing cells, or by existing cells simply dividing. But differentiation of one cell type into another is only possible if the initial cell (mother cell) is not very specialized. Tissues comprised of cells that remain undifferentiated and supply, by their divisions, cells to form new tissues and organs, are called **meristems**. Meristem tissue occurs in places that allow for a very orderly pattern of growth.

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Chapter 4. Plant Vegetative Organs

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55 http://en.wikibooks.org/wiki/Category%3ABotany
56 http://en.wikibooks.org/wiki/Botany%23Contents
57 Chapter 3.13 on page 16
58 Chapter 3.19 on page 20

Figure 2 Myriophyllum aquaticum

The parrot's feather, an aquatic plant (Myriophyllum aquaticum)
Click to enlarge[59] picture

3.16 Introduction

As was noted in the previous chapter[60], most plant cells are specialized to a greater or lesser degree, and arranged together in **tissues**. A tissue can be *simple* or *complex* depending upon whether it is composed of one or more than one type of cell. Tissues are further arranged or combined into **organs** that carry out life functions of the organism. Plant organs include the **leaf**, **stem**, **root**, and **reproductive structures**. The first three are sometimes called the *vegetative organs* and are the subject of exploration in this chapter. Reproductive organs will be covered in Chapter 5[61].

The relationships of the organs within a plant body to each other remains an unsettled subject within plant morphology. The fundamental question is whether these are truly different structures, or just modifications of one basic structure (Eames, 1936; Esau, 1965).

59 `http://en.wikibooks.org/wiki/Media%3AParrotfeather.jpg`
60 Chapter 3.13 on page 16
61 Chapter 3.19 on page 20

The plant body is an integrated, functional unit, so the division of a plant into organs is largely conceptual, providing a convenient way of approaching plant form and function. A boundary between stem and leaf is particularly difficult to make, so botanists sometimes use the word **shoot** to refer to the stem and its appendages (Esau, 1965).

3.17 The Leaf

The plant leaf is an organ whose shape promotes efficient gathering of light for photosynthesis, but the form of the leaf must also be balanced against the fact that most of the loss of water a plant might suffer is going to occur at its leaves. Leaves are extremely variable in details of size, shape, and adornments like hairs.

Although the leaves of most plants carry out the same very basic functions, there is nonetheless an amazing variety of leaf sizes, shapes, margin types, forms of attachment, ornamentation (hairs), and even color. Examine the Leaves (forms)[62] page to learn the extensive terminology used to describe this variation. Consider that there are functional reasons for the modifications from a "basic" type.

3.18 The Stem

The stem arises during development of the embryo as part of the *hypocotyl-root axis*, at the upper end of which are one or more cotyledons and the shoot primordium.

- Read: Stem[63]

3.19 The Root

The root is the (typically) underground part of the plant axis specialized for both anchoring the plant and absorbing water and minerals.

- Read: Root[64] (Follow any links for terms you do not understand and to gain a complete picture of root structural variation)

  Be sure to read about and understand the meaning of each (at a minimum) of the following terms: **adventitious roots**, **endodermis**, **epidermis**, **gravitropism**, **root cap**, **root hair**, **stele**, **taproot**.

Most of the material you have read discusses the root organ as found in the angiosperms (flowering plants). However, among the vascular plants, only Psilotales lack such an organ, having instead rhizomes that bear hair-like absorbing structures called **rhizoids** (Eames, 1936 in Esau, 1965).

62 http://en.wikibooks.org/wiki/Botany%2FLeaves%20%28forms%29
63 http://en.wikipedia.org/wiki/Plant_stem
64 http://en.wikipedia.org/wiki/Root

Questions:

```
4-1. At this point the conceptual differences between cell types, tissues,
organs,
     and organisms may be somewhat confusing. Using the leaf as an example,
describe
     this structure in a way that considers the cell types, tissues, and organs
for
     that part of the leaf where photosynthesis is concentrated.
```

<Big>Laboratory Exercises[65] for Chapter 4 >>

Discussion of questions[66] for Chapter 4 >>>

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Chapter 5. Plant Reproduction

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66 http://en.wikibooks.org/wiki/Botany%2FPlant_structure_discussion
67 http://en.wikibooks.org/wiki/Category%3ABotany
68 http://en.wikibooks.org/wiki/Botany%23Contents
69 Chapter 3.15.1 on page 17
70 http://en.wikibooks.org/wiki/Botany%2FPlant_morphology

Figure 3 Noni (*Morinda citrifolia*) flowers and fruit. Note stages of progressive maturation shown from a cluster of flowers to an accessory fruit.

3.20 Vegetative Reproduction

Vegetative reproduction is a type of **asexual reproduction**---other terms that apply are *vegetative propagation, clonal growth*, or *vegetative multiplication*. Vegetative **growth** is enlargement of the individual plant; vegetative reproduction is any process that results in new plant "individuals" without production of seeds (see *The Seed* below) or spores. It is both a natural process in many, many species as well as one utilized or encouraged by horticulturists and farmers to obtain quantities of economically valuable plants. In this respect, it is a form of cloning that has been carried out by humankind for thousands of years and by "plants" for hundreds of millions of years.

- Read Vegetative Reproduction[71] (Follow all links)

71 http://en.wikipedia.org/wiki/Vegetative_reproduction

3.21 Sexual Reproduction

3.21.1 The Flower

The **flower** is the reproductive organ of plants classified as *angiosperms*---that is, the flowering plants comprising the **Division Magnoliophyta**. All plants have the means and corresponding structures for reproducing sexually, and these other cases will be explored in later chapters. However, because **flowering plants** are the most conspicuous plants in almost all terrestrial environments, we justifiably devote this chapter to the flowering plants alone. You will learn how other plant groups (and non-plant groups, such as fungi) reproduce sexually in Section II of the *The Guide*.

The basic function of a flower is to produce **seeds** through **sexual reproduction**. Seeds are the next generation, and serve as the primary method in most plants by which individuals of the species are dispersed across the landscape. Actual dispersal is, in most species, a function of the **fruit**: structural parts that typically surround the seed. But the seed contains the germ of life of the next generation.

- Read Plant sexuality[72] (Follow links you find interesting, concentrating on acquiring a grasp of the terminology)
- Read The Flower[73] (Follow links you find interesting, but at minimum read each of the following articles)
  - Read calyx[74] - the sepals
  - Read corolla[75] - the petals
  - Read androecium[76] - the stamens
  - Read gynoecium[77] - the pistil(s)

  Be sure to read about and understand the meaning of each of the following terms: **androecium**, **anthesis**, **calyx**, **carpel**, **corolla**, **gynoecium**, **inferior ovary**, **nectary**, **perigynous**, **petal**, **pistil**, **pollen**, **sepal**, **stamen**, **superior ovary**, **syncarpous**.
- Read Inflorescence[78]

  Be sure to read about and understand the meaning of each of the following terms: **bract**, **inflorescence**, **panicle**, **raceme**, **spadix**, **spikelet**.

Questions:

```
5-1. Do you think the flower structure is in any way responsible for the
considerable
     success of flowering plants in populating the earth?
```

72 http://en.wikipedia.org/wiki/Plant%20sexuality
73 http://en.wikipedia.org/wiki/Flower
74 http://en.wikipedia.org/wiki/Sepal
75 http://en.wikipedia.org/wiki/Petal
76 http://en.wikipedia.org/wiki/Stamen
77 http://en.wikipedia.org/wiki/Carpel
78 http://en.wikipedia.org/wiki/Inflorescence

3.21.2 The Seed and Germination

the primary purpose of the seed is one of preserving the continuity of life---starting a new generation in a new physical location. For large plants (shrubs and trees), this can be especially important because successful germination and growth close to the parent may be difficult or impossible; the established plant monopolizes light and water resources in its immediate vicinity. Seeds can also serve the function of overwintering or surviving harsh conditions. The entire generation---every individual---may die in the Fall or the dry season. In many annual species, only the seed exists during unfavorable dry or cold conditions.

- The Seed[79] (Follow all links on anatomy and function)
  - Read Germination[80]

needed here an explanation of clonal reproduction of plants... through genets, rhizomes or whatever. I am not a botanist, please, if you are, explain this.

3.21.3 The Fruit

The fruit is the actual agent of dispersal in most flowering plants.

- The Fruit[81]

Laboratory Exercises (flowers)[82] for Chapter 5 >>

Laboratory Exercises (seeds)[83] for Chapter 5 >>

Discussion of questions[84] for Chapter 5 >>

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79 http://en.wikipedia.org/wiki/Seed
80 http://en.wikipedia.org/wiki/Germination
81 http://en.wikipedia.org/wiki/Fruit
82 Chapter 3.21.3 on page 23
83 Chapter 3.22.1 on page 29
84 http://en.wikibooks.org/wiki/Botany%2FPlant_reproduction_discussion
85 http://en.wikibooks.org/wiki/Category%3ABotany

3.22 Chapter 5. Plant Reproduction Laboratory ˜ Flowers

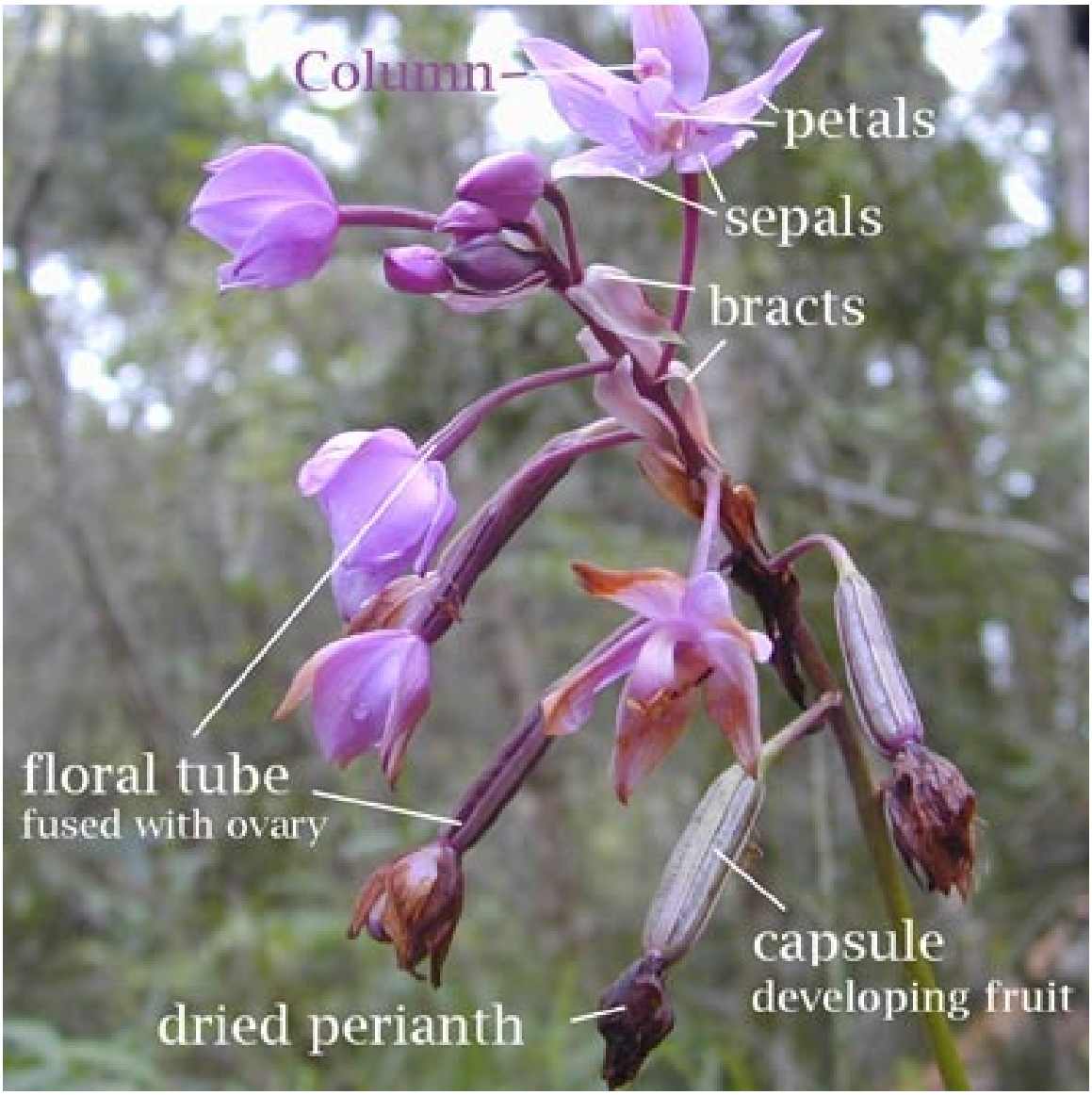

Figure 4 Spathoglottis plicata

*Infloresence of the orchid,*Spathoglottis plicata*(enlarge to examine*[86]*).*

3.22.1 An orchid flower

This first laboratory exercise for Chapter 4 deals with the flowers of a ground orchid from Southeast Asia. The photograph on the right demonstrates the descriptive terminology that can be applied to this species. You may wish to read about orchids[87] to place this

86 http://en.wikibooks.org/wiki/media%3AOrchid_lab.jpg
87 http://en.wikipedia.org/wiki/Orchidaceae

plant taxonomically and better understand unusual aspects of the structure of this flower. In reading the description below, be sure you understand how or why each bolded word applies to this specimen. Also, observe that the flowering-through-fruiting sequence is well demonstrated in the photograph because each flower is in a slightly different phase of its life cycle from bud to fruit.

Spathoglottis plicata Blume --- The flowers of this orchid are carried on an erect **raceme** growing out of the pseudobulb, each flower subtended by a green to purplish **bract** that becomes strongly **reflexed** with age. The purple **sepals** and **petals** are similar and **spreading**, elliptic to elliptic-ovate; the **labellum** is in three distinct parts: the lateral lobes narrow and erect, the middle lobe horizontal and cleft or 2-lobed. Lying above the latter is the narrowly **clavate column**. The **inferior ovary** in *Spathoglottis* develops into a cylindrical **capsule** (fruit) as the **perianth** withers.

4-1. Review the photograph of the inflorescence of the orchid. *Which one of these statements is true*:

a) this inflorescence demonstrates *determinate* growth

b) this inflorescence could as well be called a *spike*

c) the uppermost flower shows *anthesis*.

d) there are five petals, therefore this is a dicot.

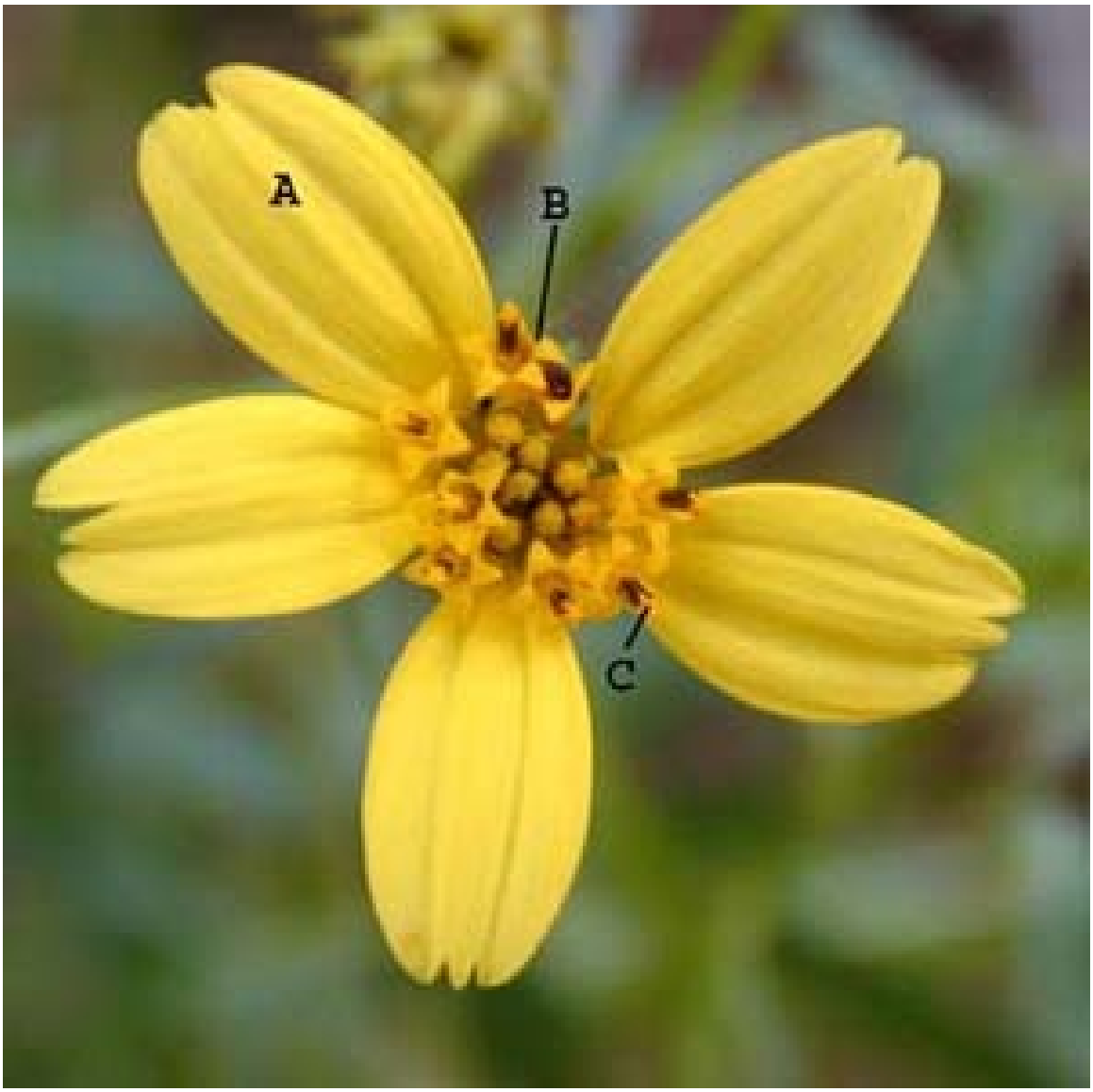

Figure 5 PHOTOGRAPH 1

Photograph 1: Bidens torta*(Examine*[88]*)*

Following are a series of photographs of flowers from various plants. *Note that by clicking on the word* "Examine" *in each title, you can enlarge the particular photograph for closer examination.* Read each question and the offered answers carefully. All parts of answer choice must be correct for that choice to be correct.

4-2. *The structure at* ***B****is*:

a) leaf

b) corolla

88 `http://en.wikibooks.org/wiki/Media%3AFlowerLab3.jpg`

c) ligule

d) sepal

e) petiole

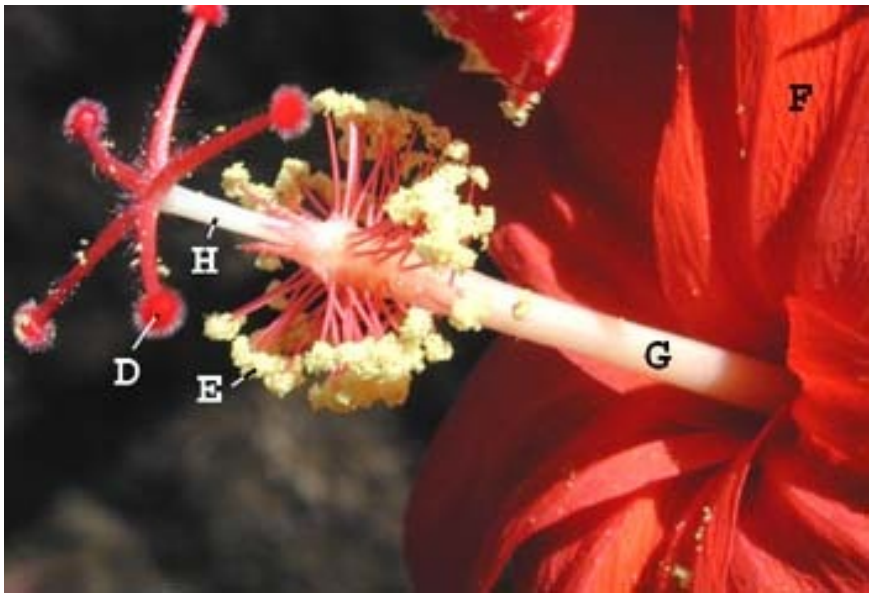

Figure 6 PHOTOGRAPH 2

Photograph 2. Hibiscus (Examine[89])

4-3. *Although the flowers in these three photographs appear very different, the following parts or floral structures are essentially the same*:

a) AA and F

b) BB and C

c) G and H

d) F and B

e) D and BB

4-4. *Which statement of the following applies to the structure indicated at* ***E***:

a) Pollen grains have landed on this pistil

b) Androecium of a monoecious plant

c) This is a spathe

d) E is an anther releasing pollen

e) This flower head is on a dioecious plant

89 http://en.wikibooks.org/wiki/Media%3AFlowerLab1.jpg

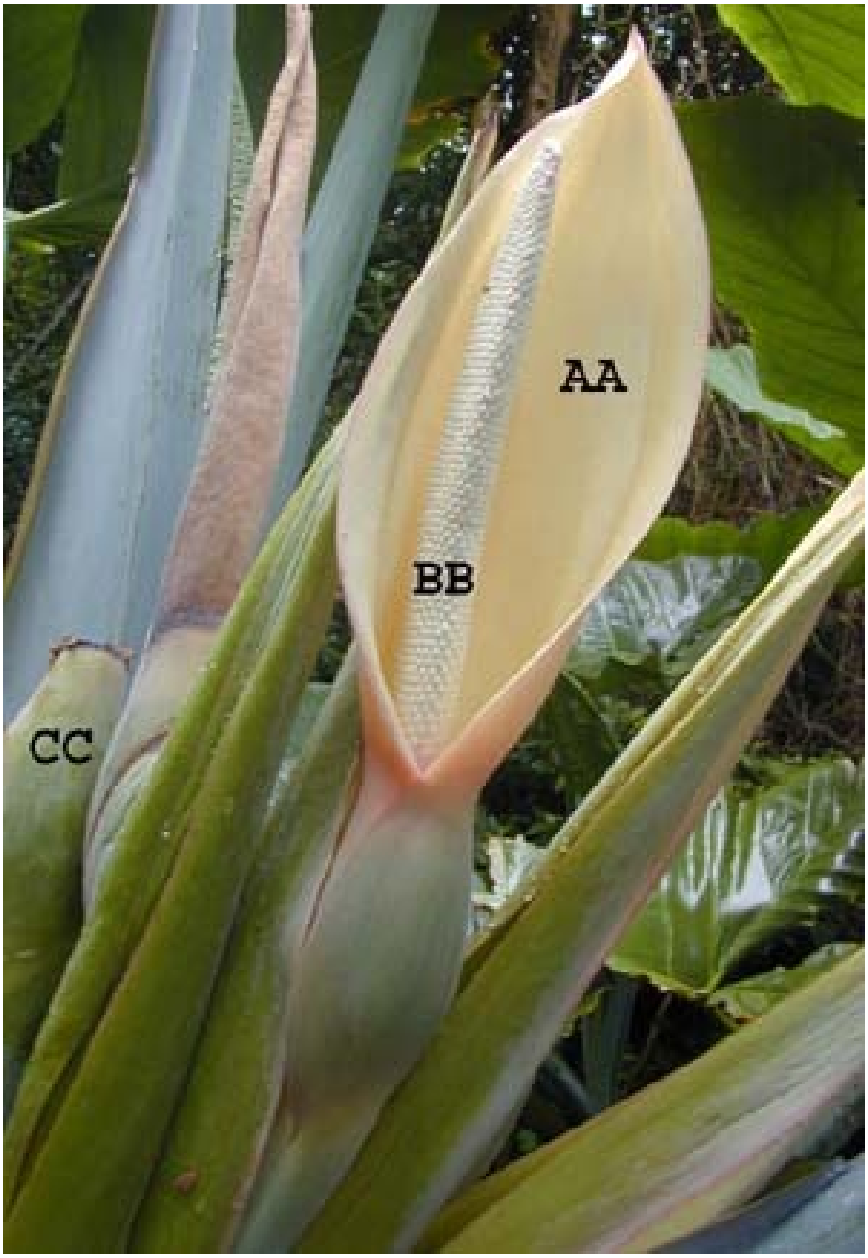

Figure 7 PHOTOGRAPH 3

*Photograph 3.*Xanthosoma *or 'Ape (Examine*[90]*)*

<< Return to Chapter 5[91] ---- Answers to Chapter 4 Laboratory Questions:

4-1 ˜ c (this flower alone is capable of pollination)

4-2 ˜ b (A flower head with tubular disk corollas)

4-3 ˜ d (both **F** and **B** indicate petals of their respective flowers)

90 http://en.wikibooks.org/wiki/Media%3AArum%20flower.jpg
91 Chapter 3.19 on page 20

4-4 ˜ d (the androecium is supported on a tubular structure (**G**) that surrounds the pistil (**H**)

Category:Botany[92]

3.23 Chapter 5. Plant Reproduction Laboratory ˜ Seeds

3.24 A monocot seedling

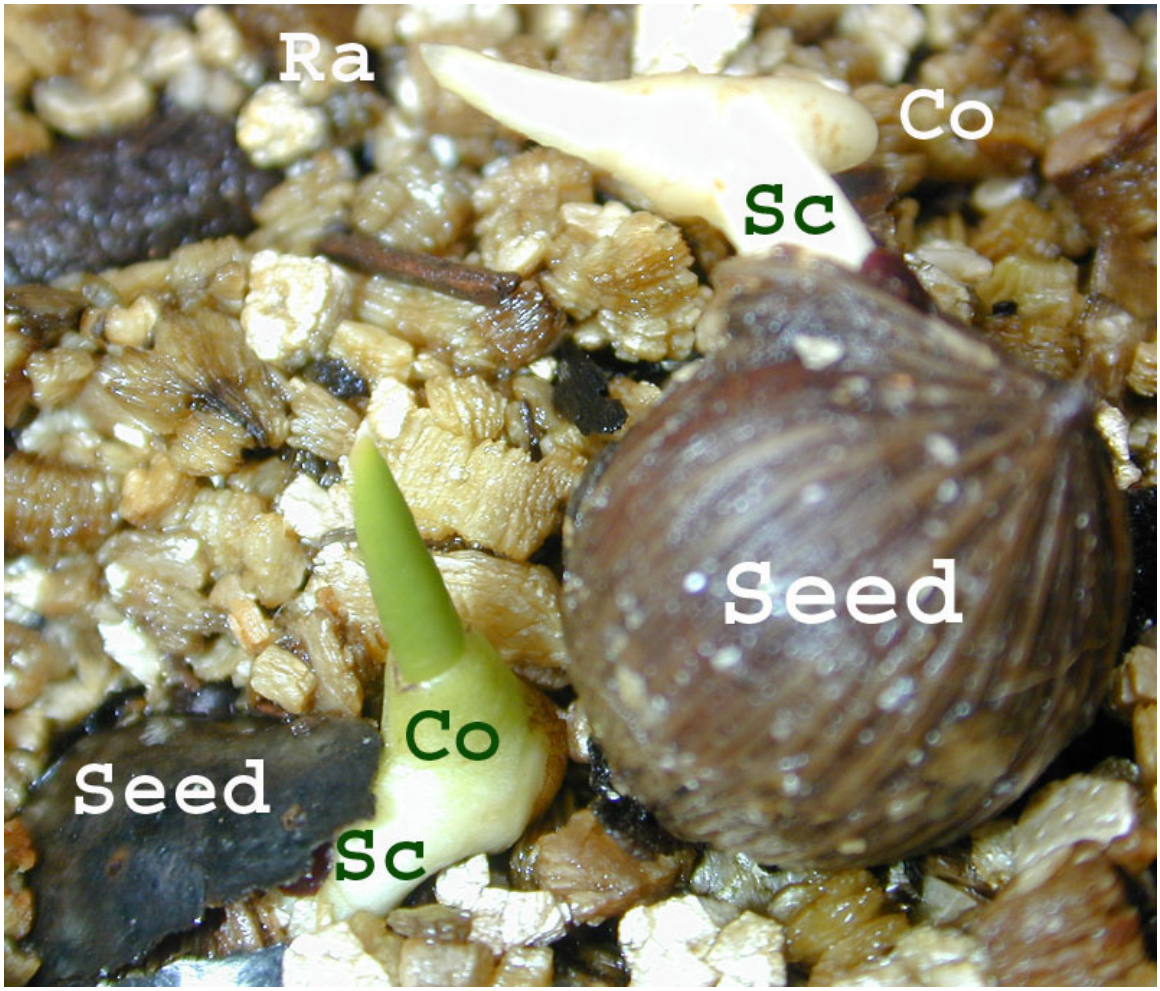

Figure 8 Pritchardia remota

The photograph at the right shows two germinating seeds. These are seeds of the fan palm, *Pritchardia remota*, a species found naturally only on (endemic to) the remote island of Nihoa in the Hawaiian islands. The seed on the left is in the proper orientation in the planting medium (only a part of the fruit coat covering the seed is visible), while the one on

92 http://en.wikibooks.org/wiki/Category%3ABotany

the right (in a slightly earlier stage) has been laid on the surface in order to better reveal development of the root. The following structures are labeled:

co - *coleoptile* or shoot pole of plant axis; essentially a cap within which the plumule (first leaf) is developing, to eventually project through as in the seedling on the left.

ra - *radicle*; primordial root or root pole of axis (note tiny root cap), buried in the medium in the seedling on the left.

sc - *scuttelum*; that part of the cotyledon that remains inside the seed to absorb food stored in an endosperm.

(enlarge to examine[93]).

<< Return to Chapter 5[94] ----

Category:Botany[95]

93 http://en.wikibooks.org/wiki/media%3AMonocot_seedling.jpg
94 Chapter 3.19 on page 20
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