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4

DIATOMS (FRESH WATER & MARINE) 75,500.+

OVERLAPPING CELL WALLS (PILL BOX)

(DIATOMACEOUS EARTH) (LOMPOC, CALIFORNIA) +10 sq. miles
FOSSILS 3000. FT. THICK.

USES:
FILTERS < BACTERIA, SUGAR
FIRE BRICKS - INSULATE
ABRASIVES - POLISHES (TOOTH PASTE)
DYNAMITE - (ABSORBS NITROGLYC.) TNT

✓ ALL THESE FORMS CONSTITUTE PART OF THE PLANKTON USED AS CHIEF FOOD SUPPLY BY HIGHER ANIMALS OF SEA incl. whales).

PETROLEUM DEPOSITS
CORAL REEFS

HIGH IN VITAMINS A, D.

SUMMARY OF ALGAE:

HETEROGENEOUS GROUP WITH MANY PIGMENTS .

UNICELLULAR & MULTICELLULAR FORMS — COLONIAL

ASEXUAL & SEXUAL REPRODUCTION WELL DEV.

✓ EVOLUTIONARY IMPORT. TRENDS { ISOGAMY
HETEROGAMY
OOGAMY

WHY ARE ALGAE MOSTLY SMALL ? WHY ONLY FEW LARGE PLANTS IN SEA

1. NO CONDUCTING TISSUE
2. NO PLACE TO BECOME ANCHORED. (EXCEPT NEAR SHORE)
3. PROBLEM OF LIGHT ABSORPTION
4. CURRENTS TIDES WINDS — PLANKTON
5. INCREASED PRESSURES AT GREATER DEPHTHS (ABSORPTION DIFFICULT)

BACTERIA & FUNGI CONVENTIONALLY PLACED IN THALLOPHYTA

BOTH LACK CHLOROPHYLL ... OTHERWISE DISTINCT.

IMPLICATIONS OF NO CHLOROPHYLL : PARASITES OR SAPROPHYTES.
(FEW ARE PHOTOSYNTHETIC
FEW " CHEMOSYNTHETIC)

BACTERIA

ANIMAL & PLANT PATHOGENS ... DECAY (N CYCLE) ... ANTIBIOTICS ...

G.F. LEEDALE. TAXON 23: 261-270. 1974.

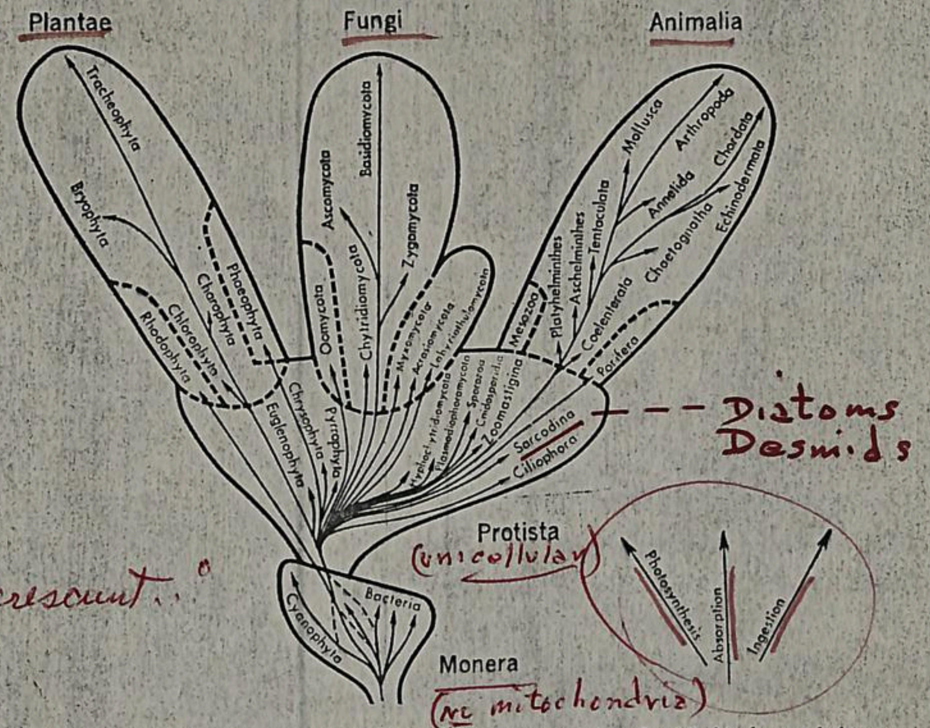

Fig. 3. Whittaker's five-kingdom evolutionary scheme; reproduced with kind permission from *Science* 163: 150-160. 1969 (fig. 3 R. H. Whittaker). Copyright 1969 by the American Association for the Advancement of Science.

strong affinities with Phaeophyta (Plantae) and Oomycota (Fungi) and no obvious affinities with Ciliophora or Sporozoa.

Secondly, higher kingdoms in both schemes are polyphyletic (on present ideas) to a degree that is profoundly disturbing to the ideal of a natural classification. Drawing the protistan line at the unicell/multicell boundary forces Whittaker to include Rhodophyta and Phaeophyta in Plantae with the green plants; Oomycota, Myxomycota, Acrasiomycota and Labyrinthulomycota with the "true" Fungi; and Mesozoa and Porifera with the Metazoa in Animalia. As Whittaker himself says, his three kingdoms of higher organisms appear less as kingdoms than as alliances of separate multicellular groups.

The main question for our discussion is, then, does a scheme like that of Copeland or Whittaker represent the best broad classification we can make at present, despite its acknowledged limitations, or are there sensible (better) alternatives?

Margulis (1973) has recently suggested a modification of Whittaker's system (Fig. 4). This removes phyla from Plantae, Fungi and Animalia into the upper reaches of the Protista, leaving the three kingdoms of higher organisms arguably monophyletic. It does, of course, increase the heterogeneity of the Protista and objections to that kingdom on those grounds. It is, in effect, a partial return to Copeland's scheme with the main exception of

BACTERIA

ALGAE

VIRUS
- Common Cold
- Smallpox – Jenner 1796
- Yellow fever – 22 mμ
- Polio – 12 mμ
- Psittacosis
- Influenza

Tobacco mosaic 30 mμ

Rickettsiae
- Typhus (fleas)
- Spotted (ticks)
- Tsutsugamushi (mites)

1979

JANUARY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

FEBRUARY

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

MARCH

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18	19	20	21	22	23	24
25	26	27	28	29	30	31

APRIL

4

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22	23	24	25	26	27	28
29	30					

MAY

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20	21	22	23	24	25	26
27	28	29	30	31		

JUNE

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24	25	26	27	28	29	30

JULY

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29	30	31				

AUGUST

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26	27	28	29	30	31	

SEPTEMBER

11

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23	24	25	26	27	28	29
30						

OCTOBER

14

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21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER

13

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18	19	20	21	22	23	24
25	26	27	28	29	30	

DECEMBER

2 EXAM

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9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Table 23–2 *Evolution of Animals: Major Physical and Biological Events in Geologic Time*

Millions of years ago	Era	Period	Epoch	Life forms	Climates and major physical events
	CENOZOIC	Quaternary	Recent Pleistocene	Age of man. Planetary spread of *Homo sapiens;* extinction of many large mammals, including woolly mammoths. Deserts on large scale.	Fluctuating cold to mild. Four glacial advances and retreats (Ice Age); uplift of Sierra Nevada.
…-7		Tertiary	Pliocene	Large carnivores. First known appearance of man-apes.	Cooler. Continued uplift and mountain building, with widespread extinction of many species.
…-26			Miocene	Whales, apes, grazing animals. Spread of grasslands as forests contract.	Moderate uplift of Rockies.
…-38			Oligocene	Large, browsing mammals. Apes appear.	Rise of Alps and Himalayas. Lands generally low. Volcanoes in Rockies area.
…-53			Eocene	Primitive horses, tiny camels, modern and giant types of birds.	Mild to very tropical. Many lakes in western North America.
65			Paleocene	First known primitive primates and carnivores.	Mild to cool. Wide, shallow continental seas largely disappear.
…-136	MESOZOIC	Cretaceous		Age of reptiles, extinction of dinosaurs. Marsupials, insectivores. Angiosperms become abundant.	Lands low and extensive. Last widespread oceans. Elevation of Rockies cuts off rain.
…-195		Jurassic		Dinosaurs' zenith. Flying reptiles, small mammals. Birds appear.	Mild. Continents low. Large areas in Europe covered by seas. Mountains rise from Alaska to Mexico.
230		Triassic		First dinosaurs. Primitive mammals appear. Forests of gymnosperms and ferns.	Continents mountainous. Large areas arid. Eruptions in eastern North America. Appalachians uplifted and broken into basins.
…-280	PALEOZOIC	Permian		Reptiles evolve. Orgin of conifers and possible origin of angiosperms; earlier forest types wane.	Extensive glaciation in Southern Hemisphere. Appalachians formed by end of Paleozoic; most of seas drain from continent.
…-345		Carboniferous Pennsylvanian Mississippian		Age of amphibians. First reptiles. Variety of insects. Sharks abundant. Forests, ferns, gymnosperms, and horsetails.	Warm. Lands low, covered by shallow seas or great coal swamps. Mountain building in eastern U.S., Texas, Colorado. Moist, equable climate, conditions like those in temperate or subtropical zones, little seasonal variation, root patterns indicate water plentiful.
…-395		Devonian		Age of fish. Amphibians appear. Shellfish abundant. Lungfish. Rise of land plants. Extinction of primitive vascular plants. Origin of modern subclasses of vascular plants.	Europe mountainous with arid basins. Mountains and volcanoes in eastern U.S. and Canada. Rest of North America low and flat. Sea covers most of land.
…-440		Silurian		First terrestrial plants. Rise of fish and reef-building corals. Shell-forming sea animals abundant. Modern groups of algae and fungi.	Mild. Continents generally flat. Mountain building in Europe. Again flooded.
…-500		Ordovician		First fish. Invertebrates dominant.	Mild. Shallow seas, continents low; sea covers U.S. Limestone deposits; microscopic plant life thriving.
600		Cambrian		Age of marine invertebrates. Shell animals.	Mild. Extensive seas. Seas spill over continents.
	PRECAMBRIAN			Earliest known fossils.	Dry and cold to warm and moist. Planet cools. Formation of Earth's crust. Extensive mountain building. Shallow seas.

ERA	YEARS AGO	PERIOD		EPOCH	CHARACTERIZED BY
Archeozoic	5,000,000,000-1,500,000,000				earth's crust formed; unicellular organisms; earliest known life
Proterozoic	1,500,000,000-600,000,000				bacteria, algae, and fungi; primitive multicellular organisms
Paleozoic	600,000,000-500,000,000	Cambrian		WALES	marine invertebrates
	500,000,000-440,000,000	Ordovician			conodonts, ostracods, algae, and seaweeds
	440,000,000-400,000,000	Silurian			air-breathing animals
	400,000,000-350,000,000	Devonian			dominance of fishes; advent of amphibians and ammonites
	350,000,000-300,000,000	Mississippian	Carboniferous		increase of land areas; primitive ammonites; development of winged insects
	300,000,000-270,000,000	Pennsylvanian	Carboniferous		warm climates; swampy lands; development of large reptiles and insects
	270,000,000-220,000,000	Permian			many reptiles
Mesozoic	220,000,000-180,000,000	Triassic			volcanic activity; marine reptiles, dinosaurs
	180,000,000-135,000,000	Jurassic			dinosaurs, conifers
	135,000,000-70,000,000	Cretaceous			extinction of giant reptiles; advent of modern insects; flowering plants
Cenozoic	70,000,000-60,000,000	Paleogene	Tertiary	Paleocene	advent of birds, mammals
	60,000,000-40,000,000	Paleogene	Tertiary	Eocene	presence of modern mammals
	40,000,000-25,000,000	Paleogene	Tertiary	Oligocene	saber-toothed cats
	25,000,000-10,000,000	Neocene	Tertiary	Miocene	grazing mammals
	10,000,000-1,000,000	Neocene	Tertiary	Pliocene	growth of mountains; increase in size and numbers of mammals; gradual cooling of climate
	1,000,000-10,000	Quaternary		Pleistocene	widespread glacial ice
	10,000-present	Quaternary		Recent	development of man

But da Vinci correctly interpreted fossils! in fossil shells

FOSSILS

L. fodio = dig

J. BERINGER - 1726

(2) "LITHOGRAPHIA WÜRZBURGENSIS"

J. SCHEUCHZER

"HOMO DILUVII TESTIS"

(1) 1726

= witness

Leonardo da Vinci

(3) 1452 - 1519

PAN/GAEA

all earth

N. LAURASIA

SOUTH GONDWANA

N. AMER. ASIA	$\pm 200 \times 10^{6}$ yrs ↓ $\pm 140 \times 10^{6}$ yrs	S. AMER AFRICA INDIA & AUSTRALIA

[PHOSPHATE DETERGENTS] Phenoxyherbicide 2-X-1979
NOVA

TPP trichlorophenol

* 2-4-5-T - carcinogenic } use in Vietnam } 24-T + 24D
Agent Orange incl. DIOXIN - broad leaf plants die within 1 week.
44×10⁶ lb. birth defects

1962 - Rachel Carson

1978 - use by loggers in N.W. USA - Oregon.
Gymnosperms survive - Firs.
Foresters argue that without pesticides a profitable wood industry would be impossible. But human health hazards are great. Dow Chemical Co. disagrees. But 22 ppt in monkeys is toxic. Persistence of DIOXIN in environment, but degradation (in part) takes place with time - and ? in sunlight. "2-4-5-T is about as toxic as aspirin" But effect in humans (other mammals?) is additive.
EPA (Envir. Prot. Agency) found that women aborted in areas where 2-4-5-T was sprayed. Industry generally argues that pesticides involve a risk, but constantly underrate their use. However, Vietnam Veterans exposed to DIOXIN 10 yrs ago are showing symptoms now {skin cancer, kidney, spleen defects birth defects} — 2-4-5-T may become inserted into DNA!

Sperm count 30% lower than 1969 in US population; contaminated with PCB!! US beef has PCB!! ±13% ...

1949 accident in Chemical Plant - MONSANTO

* 1969 recommendation to ban pesticides causing birth defects

NOVA
Baxford
Boston
2-X-1979

PCB - 1960's Work on Peregrine Falcon in Baja Calif.:
Based on Benzene Rings (bi-phenyl) Used 1st in electrical industry [Poly chlorinated Biphenyl] Monsanto began manufacturing PCB in the 30's — as toxic, carcinogenic.
→ Kyushu, Japan accident - mixed with rice
Dr. James Allen, U. Wisconsin - Long Island, NY - Tern abnormalities.
[±10 PPM probably found in humans today!]

Niagara Falls contaminated by PCB!

1972 - Hudson River Fish contamination by PCB.

* 1979 - PCB banned after ± 40 yrs of use! [MONSANTO]
Not biodegradable

Toxic Substance Control Act - 1976 i.e. TOSCA
PCB dumped along highway in N. Carolina!

LOVE CANAL, NY partly evacuated because of PCB. Hooker Chem. Co.

Table 22-2 *Comparative Summary of Characteristics in the Six Major Phyla of Eukaryotic Algae*

PHYLUM	NUMBER OF SPECIES	PHOTOSYNTHETIC PIGMENTS	FOOD RESERVE	FLAGELLA	CELL WALL COMPONENT	REMARKS
Euglenophyta (euglenoids)	800	Chlorophyll *a* and *b*, carotenoids	Paramylum and fats	1, 2, or 3 per cell, apical	No cell wall	All unicellular, most freshwater; sexual reproduction unknown
Chrysophyta (golden-brown algae and diatoms)	6,000–10,000	Chlorophyll *a*, and often *c*, carotenoids, including fucoxanthin	Leucosin and oils	1 or 2, apical, equal or unequal	Pectic compounds with siliceous material	Most marine
Pyrrophyta (dinoflagellates)	1,100	Chlorophyll *a* and *c*, carotenoids	Starch and oils	2, lateral	Cellulose	Marine and freshwater; sexual reproduction rare
Chlorophyta (green algae)	7,000	Chlorophyll *a* and *b*, carotenoids	Starch	Usually 2 per cell, identical	Cellulose	Mostly freshwater, but some marine
Phaeophyta (brown algae)	1,500	Chlorophyll *a* and *c*, carotenoids, including fucoxanthin	Laminarin and fats	2, lateral, in reproductive cells only	Cellulose and algin	Almost all marine, flourish in cold ocean waters
Rhodophyta (red algae)	4,000	Chlorophyll *a*, carotenoids, phycobilins, chlorophyll *d* in some	Floridean starch	None	Cellulose, pectic materials common, xylan in *Porphyra*	Mostly marine but some freshwater; complex sexual cycle; many species

The phyla of algae differ from one another widely in the nature of their flagella (when present) and in their biochemical characteristics, especially with respect to differences in pigmentation, nature of reserve food, and cell wall components (Table 22-2). The names of some phyla are derived from the colors of the predominant accessory pigments, which mask the bright green of the chlorophylls. A wide variety of carotenoids is found in the algae. The xanthophylls are yellowish-brown carotenoids; the xanthophyll fucoxanthin gives the brown algae their characteristic color and name. It is also found in the golden-brown algae and diatoms (phylum Chrysophyta). The red algae (Rhodophyta) owe their colors to several kinds of phycobilins, accessory pigments that, unlike the carotenoids, are water-soluble. In the green algae the color of the chlorophylls is usually not masked by accessory pigments. The diversity of pigments present in the chloroplasts of the various phyla of algae suggests that (1) various types of oxygen-producing prokaryotes were in existence prior to the development of eukaryotic cells, and (2) the various phyla of algae may have evolved as a result of the establishment of symbiotic relationships with different photosynthetic prokaryotes, which then evolved into modern chloroplasts.

Seaweeds & Their Uses. V. J. Chapman. 1950
(589.3C)

The Useful Algae

(Sci Amer. Dec. 1952)
F. J. Weiss

Great diversity — Microscopic to gigantic (ie Greens to Kelps)

Absence of organs of higher plants (lvs. Stems - Roots)

(*) ± 10X more photosynthesis in sea than on land.

Diatoms & Dinoflagellates most numerous in sea.

But: Sargasso Sea — North Atlantic ±250,000 sq. miles of Brown Algae

Algae — Grass of the Sea : ie Food chains

Plankton: Algae → Protozoans → Crustaceans → Herring (most abundant ocean fish) → cod tuna (other carnivorous fish)

Other habitats of Algae : Ubiquitous | Rock, hot springs (>160°F), ice-snow, lake bottoms, caves, in Protozoa, in animal intestines, lichens

Biblical reference in Exodus : Manna for Israelites was prob. Nostoc — Heb. MAN HU = "what is it"?

Israelites ordered to harvest Manna in AM — Hot sun melts gelatinous env.!

Still found in Calif. deserts & eaten in China & Pakistan

Nostoc fixes N

Pyrrophyta – Dinophyta & Bioluminesc. ✓

Diatoms & TNT – Nobel 1866 ✓

Coral Reefs & Red Algae • ✓

Algal Pigments & Chlorophyll ✓

SARGASSO SEA • ✓

food chains ✓ etc

ALGA (L.) = "SEAWEED"

ECOLOGY OF OCEANS

IXTOC I VI-'79 OIL SPILLS etc → "ARGO MERCHANT" - XII-1976 ±6×10⁶ GALS. OIL NANTUCKET

PLANKTON < PHYTO — PHOTOSYNTH. / ZOO —

JASON & ARGONAUTS STOLE "golden fleece" of Colchis — EL DORADO legend

fucoxanthin

HISTORY - GEOLOGY

FORMATION OF CONTINENTS

PANGAEA < LAURASIA (NORTH) → NORTH AMER. EURASIA
GONDWANA (SOUTH) → S. AMER, AFRICA, INDIA, AUSTRALIA, ANTARCTICA

* CONTINENTAL DRIFT

±200,000,000 YRS AGO TO ±40×10⁶

DINOFLAGELLATES

TNT

Diatoms — Unicellular ±10,000 sp.

CYANOPHYTA

MONERA PROTISTA

Euglenophyta
Chrysophyta — L. chrysos: golden 6000 — silicon
Pyrrophyta
Phaeophyta — Laminarin ±1000.
Chlorophyta — Starch ± 7000
Rhodophora — Floridean starch phycoerythrin ±4000
Bryophyta — Mosses - Liverworts
Tracheophyta < Ferns, Gymnosperms, Angiosperms
chlorophyll - carotene - xanthophyll
Blue green algae — Cyanophyta — Phycocyanin — Prokaryotes — Monera — fix N_2 — Nostoc
Bacteria

I

Chrysophyta — LOMPOC

DIATOMACEOUS EARTH

FORAMINIFERA (SARCODINA) i.e. Protozoa — CHALK (DOVER)

Gr. II (Fire) (red pigments)

Pyrrophyta [Dinoflagellates]

bioluminescence

"red tides" (toxins)

Phytoplankton — Gr. drifting

Zooplankton

Manna — EXODUS 16. ¿ MAN HU ?

TNT

1866 NOBEL DYNAMITE + guncotton

FOOD CHAINS

PLANKTON
↓
CRUSTACEA
↓
FISH
↓
MAN

etc

Fucoxanthin — brown
Algin — brown
Agar — red
Iridophycin (red) - red
Tracheophyta — conducting
kelps

Phycobilins
Phycoerythrin

± 15,000.

SPECIAL

ALGAE SEPARATED ON BASIS OF PIGMENTS CONTAINED: (ALL HAVE: CHLOROPHYL, CAROTENE, XANTHOPHYLL)

BLUE*GREEN .....PHYCOCYANIN (1500 sp.)
GREEN .... (6000 sp)

BROWN .... FUCOXANTHIN (1,000 sp)

RED ..... PHYCOERYTHRIN (2,500.)

DIATOMS ... YELLOW*BROWN (5,500)
(CHRYSOPHYTA)

INDIVIDUAL GROUPS:

BLUE*GREEN (MOSTLY FRESH WATER) — CYANOPHYTA

UNICELLULAR OR COLONIAL

NO CHLOROPLASTS (DIFFUSED PIGMENTS) PHYCOCYANIN

OSCILLATORIA

NO ORGANIZED NUCLEUS (CHROMATIN MATERIAL)

ASEXUAL REPRODUCTION ONLY (FISSION)

GLYCOGEN FOOD RESERVE(FOUND IN HIGHER ANIMALS)

SOME FIX N (SOME BACTERIA TOO)

BIBLICAL MANNA IS NOSTOC OF DESERTS. ± SIZE OF A BEAN.

GREEN (FRESH WATER MOSTLY) 6,000. — CHLOROPHYTA

DISTINCT NUCLEI — FOOD SOURCE: CHLORELLA

CHLOROPLASTS — Unicellular

SEXUAL & ASEXUAL REPRODUCTION (EVOLUTION OF SEX: ULOTHRIX, OEDOGONIUM SPIROGYRA VOLVOX
ISOGAMETES
ANISOGAMETES
OOGAMETES

STARCH RESERVE FOOD

BROWN (ALMOST ALL MARINE) 1000. — PHAEOPHYTA — stored food Laminarin — GIANT KELPS

LARGEST OF ALGAE (MACROCYSTIS several hundred feet) (SARGASSUM SEA) ± 250,000 sq. miles

LIVE IN COLD WATERS — HOLDFAST, STIPE, BLADE — POSTELSIA

AIR BLADDERS (FLOATING)

USES: KELPMEAL (STOCK FEED), IODINE, FERTILIZERS, ALGIN — ICE CREAM (STABILIZER), COSMETICS (EMULSIFY), JELLY & JAM (GELLING AGENT), Beer

RED 2,500. — RHODOPHYTA

THALLI GREATLY BRANCHING

WARMER WATERS (AGAR*AGAR)

COMPLEX SEXUAL REPRODUCTION

NO MOTILE SEX CELLS. } analogy with Angiosperms

CORAL ISLANDS.

FLORIDEAN STARCH

SOME WAYS IN WHICH ALGAE ARE OF IMPORTANCE TO MAN

I. GREEN ALGAE (chlorophyll not masked by other pigments)
1. Foundations of food chains for animals in water.
2. Add humus to top soil of cultivated land.
3. Contribute oxygen to air by photosynthesis.

II. DIATOMS (abundance of carotinoids give cells a golden color)
1. Constitute an important part of the floating organisms known as plankton, which makes up a major portion of food available to marine animals.
2. Edible oils for human consumption, containing vitamins A and D.
3. Filtering agent for the clarification of sugar syrups, cleaning solvents, mouth washes, medical sera.*
4. Insulation against heat and sound.*
5. Mild abrasive agent in silver polish and tooth paste.*
6. Water-proofing and strengthening of concrete and Portland cement
7. Ceramic glazing materials.*
8. Emulsifier for paints.*

* Fossil material, called diatomaceous earth, used for these.

III. RED ALGAE (phycoerythrin, a red pigment, masks the chlorophyll)
Three important substances are obtained from red algae: agar, iridophycin, and carrageenin. Some of their uses are the following:

1. AGAR: Microbiological culture media.
   Roughage in feeds.
   Gel in fruit cakes, sherbets, ices, jelly candies, frozen desserts, and meringues.
   Gel in canned meats.
   Base for greaseless creams (cosmetics) to stabilize emulsions.
2. IRIDOPHYCIN: Used in stabilizing chocolate fibers in chocolate milk.
3. CARRAGEENIN: Pharmaceutical emulsifier.
   Stabilizer for ice creams, ices, and sherbets.

IV. BROWN ALGAE (fucoxanthin, a brown pigment, masks the chlorophyll)
The following products are obtained from various brown algae:
1. Kelpmeal for feeding stock.
2. Edible kelp for human consumption, called "kombu".
3. Potash.
4. Iodine.
5. Acetone (by fermentation of carbohydrates)
6. Fertilizer.

Algin is a substance derived from various brown algae. The following list gives some uses for this substance.

7. In food industries, for stabilizing ice creams, ices, and sherbets.
8. Gelling agent in milk desserts, jellies, and puddings.
9. Emulsifier in cosmetics.
10. Material for dental impressions.

Note: The red and brown algae, as well as the green algae, provide food and oxygen for animals in water.

ANAEROBIC | AEROBIC | RESPIRATION | at all times | all cells.

$C_{40}H_{56}$ - CAROTENE

$C_{40}H_{56}O_2$ - XANTHOPHYLL -

rare metal

Tantalum - Ta

Promethium - Pm

rare earth

93 Neptunium - Np

94 Plutonium - Pu

NP → U 238

92 Uranium U

Pasteur

---

cellulose

Hyphochytriales
Lagenidiales
Saprolegniales
Leptomitales
Peronosporales

chitin

Chytridiales
Blastocladiales
Monoblepharidales
Hyphochytriales
Mucorales
Entomophthorales
Endomycetales (yeasts)
Moniliales
Smuts - Polypores - Agarics

[The Fungi Vol. 1]

Chlorophyll
CAROTENE
XANTHOPHYLL

PHYCOCYANIN
PHYCOERYTHRIN

PHYCOLOGY

FOSSILS
PRECAMBRIAN

NO CHLOROPLASTS
NO CELLULOSE
± 250 spp

ASEXUAL Repr.

EUGLENOPHYTA
PROTOZOA

Blooms

RED SEA
TRICHODESMIUM

±10,000 spp

fucoxanthin

RED TIDES
GONYAULAX
TOXINS
FISH KILL

±1000 spp

PYRROPHYTA

intermediate bet.
PRO / EUKARYOTES
?
(ATYPICAL MITOSIS)

ALGAE – PROKARYOTES – EXODUS 16

MONERA
N₂ FIXING
B-G – CYANOPHYTA – MANNA – NOSTOC?
BACTERIA
PROTISTA – EUKAR.

CHRYSOPHYTA – DIATOMS
"GOLDEN" – oils – NO STARCH
SILICON WALLS
PHYTOPLANKTON
FUCOXANTHIN
NO CELLULOSE

PYRROPHYTA – DINOFLAGELLATES
"Fire" – CELLULOSE + – NOCTILUCA
STARCH + oils – (luminescent) marine

CHLORO – ±7000 – PLANTAE

PHAEO – KELP ±1000 SEAWEEDS – CHLORELLA (food)

RHODO – ± 4000

MARINE vs FRESH H_2O

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"Red Tides" – PYRRO-
Noctiluca – Fish Kill

AGAR
Coral – CARRAGEENIN

Floridean Starch

Yeast – FUNGI
REPROD. PATTERNS
wood rotters
Oomycetes
Zygo
saprobe – Asco
parasite – Basidio
pathogen – Deutro
Mycelium

Isogam
Anisogam
Oogam

ALGAE
Negative char.
Root, stem, leaf –
Conducting tissue –
Diversity (size, ecology, reproduct.) etc

Floridean starch
*Chlorella – combat KWASHIORKOR
Diatoms*
*Kelp – Laminarin
phytoplankton
bioluminescent
chloroplasts {B-G –}
*Sargasso Sea – Irish moss
*Agar – ($CaCO_3$) Coral – Carrageenin – Chondrus
| Isogamy – oogamy |
(flagella) →

es

1866 – d. 1896
A. NOBEL – Swede.
Nitroglycerine [Sobrero]
HNO_3 + H_2SO_4 + Glyc. } Explosive
CRIMEAN WAR [1853-56]
VOLTA 1745 + Diatomaceous earth + NH_4NO_3
DYNAMITE (stabilized)
Opening of West U.S. – 1866 – BAKU Oil – Peace + War
ROENTGEN 1901 X-Rays (1895)
± $\$10^6$ NOBEL PRIZE FUND – SWED. ACAD. Sci

"SEA WEEDS"

CORAL

Points to be covered: 19-IX-'79

PROKARYOTES < heart-beat, 5 KINGD

MONERA

EU

PL, AN. FUNGI

MONO - DI

POLYSACCHARIDE

CHLOROPHYLL HONMG

CHLOROPLAST < GRANA, THYLAKOID

Photons (Gr = Pouch)

SPECTRUM PHOTOSYNTH.

red blue short - long wave length

(λ λ λ)

AUTOTROPH

HETERO

STARCH

PHOTONS

+ CAROTENE XANTHOPHYLL

I

5-KINGDOM

MONERA

B-G Bacteria

PROKARYOTE vs EU [no organized nucleus]

II PROTISTA

PROTOZOA

ALGAE

Diatoms etc.

PLANT vs ANIMAL

CHLOROPHYLL

CELLULOSE

MERISTEM

PHOTOSYNTH. (PL.) III

vs

INGESTION (AN.) IV

vs

ABSORPTION (FUNGI) V

EUKARYOTES

CONTINENTAL DRIFT

PANGAEA — CONTINENTS

LAURASIA

CHLORELLA → GREEN ALGAE | SEX.

FLORIDIAN STARCH

KELPS — LAMINARIN

IODINE

IRISH MOSS

CARRAGEENIN

RHODOPHYTA — NO MOTILE CELLS IN SEX REPROD.

SARGASSO SEA — MACROCYSTIS, SARGASSUM

ALGAE

LITHOTHAMNION

CORAL ISLANDS

FORAMINIFERA — SARCODINA

CHALK CLIFFS

ASEXUAL VS SEXUAL REPROD.

Chlorella as Food

(Sci. Amer. Oct. 1953)
H.W. Milner

World food supply critical in many areas.

a) Poor economy
b) Crop failures — esp. more Protein needed
c) Famines etc.

Attempt to get greater yield & more economically – less waste
i.e. a maximum of CHO, Fats, Protein & minimum of waste.

Chlorella under controlled conditions promises good results.

Analysis: ± 50% Protein | Possible to produce ± 40 TONS DRY / YR. / ACRE
± 7% Fat
Vitamins +

Method of Growth: Hydroponics – Studies in Tokyo – Texas – Mass.

High concentration of CO_2 needed (± 5%) >
Nitrates supplied

Thin Polyethylene Tubing w. algae + H_2O. CO_2 & Air pumped through.

160 ft. long, few inches deep

Chlorella harvested in centrifuge } Pilot plant → ± 16 tons/acre

Taste? – to be improved.

Importance of Algae:

1) Concentrate K and I from sea water - were 1st major sources of these.

2) Lime-secreting RED Algae - Form Coral Reefs
accumulate minerals (Ca, K, Fe, S, Cu, Mg. etc)

3) Fertilizers (Help maintain soil fertility.)
ie natural land flora
↓ Kelps esp. (Seaweeds) Coastal areas of Asia

4) Food for Livestock (Norway - Sheep
Scotland - Cattle & Sheep
Ireland - Potato fertilizer

5) Human Food

± 100 spp. of seaweed eaten in China, Japan, Philippine, Hawaii, Burma, etc

Southern Chile use Durvillea antarctica (Br. alg.)
ie COCHAYUYO (Inca) - Sea Cabbage

Irish Moss - Chondrus crispus - gelatinous green alga used in puddings.
(CARRAGEEN) (RED ALGA)

Algin - from Browns (emulsifier etc. in ice cream)

Agar - from Reds (Bacteriology etc)

SOME WAYS IN WHICH ALGAE ARE OF IMPORTANCE TO MAN

I. GREEN ALGAE (Chlorophyll not masked by other pigments)
1. Foundations of food chains for animals in water.
2. Add humus to top soil of cultivated land.
3. Contribute oxygen to air by photosynthesis.

II. DIATOMS (Abundance of carotinoids give cells a golden color)
1. Constitute an important part of the floating organisms known as plankton, which makes up a major portion of food available to marine animals.
2. Edible oils for human consumption, containing vitamins A and D
3. Filtering agent for the clarification of sugar syrups, cleaning solvents, mouth washes, medical sera.*
4. Insulation against heat and sound.*
5. Mild abrasive agent in silver polish and tooth paste.*
6. Water-proofing and strengthening of concrete and Portland cement.*
7. Ceramic glazing materials.*
8. Emulsifier for paints.---gives flat finish for wall paint, also.*

* Fossil material, called diatomaceous earth, used for these.

III. RED ALGAE (phycoerythrin, a red pigment, masks the chlorophyll)

Three important substances are obtained from red algae: agar, iridophycin, and carrageenin. Some of their uses are the following:

1. AGAR: Microbiological culture media.
   Roughage in feeds.
   Gel in fruit cakes, sherbets, ices, jelly candies, frozen desserts, and meringues.
   Gel in canned meats.
   Base for greaseless creams (cosmetics) to stabilize emulsions.
2. IRIDOPHYCIN: Used in stabilizing chocolate fibers in chocolate milk.
3. CARRAGEENIN: Pharmaceutical emulsifier.
   Stabilizer for ice creams, ices, and sherbets.

IV. BROWN ALGAE (fucoxanthin, a brown pigment, masks the chlorophyll)

The following products are obtained from various brown algae:
1. Kelpmeal for feeding stock.
2. Edible kelp for human consumption, called "kombu".
3. Potash.
4. Iodine.
5. Acetone (by fermentation of carbohydrates)
6. Fertilizer.

Algin is a substance derived from various brown algae. The following list gives some uses for this substance.

7. In food industries, for stabilizing ice creams, ices, and sherbets.
8. Gelling agent in milk desserts, jellies, and puddings.
9. Emulsifier in cosmetics.
10. Material for dental impressions.

Note: The red and brown algae, as well as the green algae, provide food and oxygen for animals in water.

XXIX. ALGAE (Pondscums and Seaweeds). Assigned Reading: Text, Chapter 47, pp. 606-613.

A. Characteristics. Algae vary in size from small, one-celled species to the large massive kelps. They live in fresh or salt water or moist places.

B. Pigmentation. Algae contain the green pigment chlorophyll, necessary for the manufacture of sugar from water and carbon dioxide in light. Hence algae are independent plants, not parasitic or saprophytic like bacteria and fungi. Some classes of algae also contain blue, brown, red, or yellow pigments in addition to chlorophyll.

C. Economic importance.

1. Water pollution, bad odors and taste from algal oils and decay. Dense algal growths (water bloom) often smother fish, especially where raw sewage is emptied into lakes and rivers.

2. Algae serve as food for man and aquatic animals and are rich in vitamins. (Dulse, Irish moss as foods). Potash, iodine, agar, algin, and fertilizer are obtained from algae. Sicileous cell walls of diatoms are used for filters, fire brick, metal polishes, scouring powders and soaps. Algin is an important viscous colloid used in dentistry.

3. Phytoplankton: food for aquatic animals. High in vitamins A and D. About 10,000 pounds of plankton are produced per acre of ocean per year.

Thallophytes' characteristics >

1. Unicellular sex organs (usually). When multicellular, gamete not surrounded by sterile cells.

2. Sporangia unicellular

3. Zygotes never develop into multicellular embryos while still in ♀ sex organs.

BLUE-GR. [Cyanophyta] [I 1400 species]

1. Non-filamentous
2. Phycocyanin.
3. No organized nucleus.
4. No plastids (pigment in "outer layer") — Polytomella (no chlorophyll)
5. Absence of flagellated reproductive bodies.
6. No sexual reproduction.
7. Glycogen reserve.
8. Gelatinous envelope } H_2O retaining protector / Buoyancy } "survival value".

Pseudovacuoles (gas?) } Buoyancy / defence vs intense illumination. ?

Complementary chromatic adaptation (color of light-accumulating part of cell complementary to color of light in which plant is growing. — called Gaidukov phenomenon)

1. Chroococcales — unicellular — colonial — Ex. Gloeocapsa

2. Chamaesiphonales — solitary or colonial — epiphytes —

3. Hormogonales — filamentous

Trichome — each unit or filament constituting a hormogone

a) Homocysteae — without heterocysts:

Oscillatoriaceae — Oscillatoria, Phormidium, Lyngbya

Hormogone — A fragment of a filament.

b. Heterocysteae — with heterocysts:

Nostocaceae
Scytonemataceae
Stigonemataceae
Rivulariaceae

POSTELSIA ("SEA PALM")
(RUPRECHT 1852)

2

① LIFE CYCLE: ZOOSPORES → ♂ ♀ GAMETOPHYTES.
EGGS DISCHARGED FROM OOGONIA BUT REMAIN ATTACHED
FERTILIZATION OCCURS (SPERM NOT OBSERVED) → ZYGOTE → SPOROPHYTE.

② GAMETOPHYTE: ♀ GAMETOPHYTE OF FEW CELLS ± 25 µ. ie MICROSCOPIC.
♂ " " " " " ± 10 µ.

③ GROWTH BY INTERCALARY MERISTEM LOCATED BETWEEN STIPE AND BLADE.

④ DISTRIBUTION — PACIFIC COAST — FROM VANCOUVER ISLAND TO SAN LUIS OBISPO.
ON ROCKY SHORES EXPOSED TO VIOLENCE OF WAVE ACTION.

⑤ AFFINITIES — MOST CLOSELY RELATED TO NEREOCYSTIS, BUT LACKS PNEUMATOCYST.

⑥ SPOROPHYTE: ANNUAL, SMALL HOLDFAST OF BRANCHING HAPTERES — MODIFIED RHIZOIDS — STIPE ERECT (40-60 cm HIGH), CYLINDRICAL, HOLLOW, TAPERING FROM BASE TO APEX. APEX SHORT, RADIALLY BRANCHED.
BLADE SPLIT LONGITUDINALLY (SPLIT BEGINS AT JUNCTURE OF BLADE AND STIPE) FORMING A "LEAFY" CROWN.
BLADE NARROWLY LINEAR, DENTATE MARGIN.
DEEP, PARALLEL GROOVES ON BOTH SIDES OF BLADE
SPORANGIA IN LINEAR SORI LINING GROOVES.
SPORANGIA UNILOCULAR ONLY.

⑦ TAXONOMY: CYCLOSPOREAE
LAMINARIALES
LESSONIACEAE
POSTELSIA
palmaeformis RUPRECHT

FROM: SETCHELL & GARDNER 1925
FRITSCH — 1945

GREEN

Chlorophyta ± 5700 species

① Same pigments as vascular plants { Chlorophyll a β, Carotin, Xanthophyll }
② Motile reproductive cells with anterior flagella (2) (usually).
③ Unicellular sex organs.
④ Cell wall of cellulose + pectin (as in higher plants)
⑤ Starch the reserve.
⑥ No apical cells (Except Charales) → CHARA, → NITELLA }
⑦ Sexual reproduction : { isogamous – similar morphology; anisogamous – heterogamous – both motile; oogamous – " – "egg" sessile.

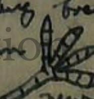
Chlorophyceae — unicellular – multicellular.
no apical cells
sex organs not surrounded by sterile cells after fertilization

Charophyceae → multicellular
apical cell growth
sex organs borne in sterile cellular envelope

BROWN

Phaeophyta ± 900 species

① Fucoxanthin α β + other pigments } chlorophyll α β, Carotin, xanthophyll
② Multicellular.
③ Motile reproductive cells } 2 ‡ lateral flagella 
④ Algin in outer wall.
Cellulose inner ".
⑤ Cell division animal-like } wall forms from outside in.
⑥ Plant body macroscopic.
⑦ Growth by ⓐ intercalary meristems,
ⓑ trichothallic
ⓒ apical meristem
⑩ All oogamous (Fucales).

Asexual reproduction → Fragmentation ↓ Sargassum
→ Propagulae – Vegetative reprod. by vertical division of apical cell forming a radiating branch which breaks away from main thallus  develops into a new thallus.

(11) Reserve food: { laminarin / mannitol

Plurilocular sporangium → 2N thallus → neutral zoospores (sporangia) (neutral spore) → 2N Thallus.
Plurilocular sporangium → N thallus → neutral spore

~~Unilocular sporangium → N thallus (gametophyte)~~

Diploid thallus (2 N) → unilocular sporangium.

Oogonia & antheridia of Fucales borne on 2 N plant ∴ homologous with unilocular sporangia.

Differentiation of gametophyte and sporophyte only possible by culturing.

A – If plant bears only unilocular sporangia ∴ a sporophyte (2N)

B If plant bears only plurilocular sporangia it may be a gametophyte with gametangia.

(or)

a sporophyte with neutral sporangia.

Plethysmothallus – dwarf stage with either neutral or unilocular sporangia.

Fucales have a 1-celled haploid spore!

Isogeneratae – alternation of ~ similar generation } Ectocarpus, Sphacelaria
Heterogeneratae – " " dissimilar " } → Laminaria, Costaria, Lessonia, Macrocystis
Cyclosporeae – No alternation. (

{ Conceptacles / receptacles

Fucus
Sargassum
Ascophyllum
Pelvetia

RED Rhodophyceae ± 2500 sp.

(K)

1. Non flagellated gametes
2. Carpogonium (♀)
3. Trichogyne
4. Phycoerythrin + others.
5. Some "coral formers" (Lithothamnion)
6. Floridean starch stored.

Spore types

1. neutral → from vegetative cells – never in sporangia
2. monospore – singly in sporangia.
3. Tetraspore – in sporangia on 2N plants → meiosis → N spores
4. parasporès – in sporangia on 2N plants → 2N spores
5. carpospores – formed directly or indirectly from zygote in carpogonium

Sex Organs

♂ organ a spermatangium with 1 non-motile spermatium.

♀ " " 1-celled carpogonium, elongated into trichogyne.

Bangioideae – thallus growth intercalary
direct division of zygote → carpospore

✓ Floridae – thallus growth terminal
carpospores form indirectly from zygote.

SCHEELE, KARL (Swedish) — CITRIC, MALIC ACIDS

1771 – 1772 "fire air" O_2 from HgO_2

[not published until 1777!]

PHLOGISTON

PRIESTLY, JOSEPH

1774 – $HgO_2 \rightarrow O_2$ ↑

"dephlogistigated air" — phlogiston → = Gr. inflammable

LAVOISIER, Antoine

2 gases in "air" (14 JUL 1777)

1779 – Oxygen — acid | produce

MAY 8, 1794 – guillotine

Text – P. 144

C-cycle etc

greenhouse effect

P. 827

raise temp. of atmosphere

absorption of infra-red rays

P. 826 – Solar constant

1.94 cal./sq. cm/min

(heat [illegible] → [illegible])

See: Martin, G.W. 1932. Bot. Gaz. 93(4): 421-435. Systematic position of Slime Molds.

SEE: INGOLD, C.T. FUNGI. IN VISTAS IN BOTANY. ED. W.B. TURRILL. PERGAMON PRESS. 1959. 348-386.

MYCOLOGY

(see Forest Pathology Notes)

General Orientation:

SEE: GWM. ARE FUNGI PLANTS? MYCOLOGIA 47: 779-792. 1955.

Chlorophyllous vs achlorophyll. groups. ie algal groups separated from other "lower" forms.

See: Handbuch für Pilzfreunde. Michael, E. & B. Hennig. Fischer Verlag. 1960. 2v. (Register of contemporary Mycologists in Vol. 2)

chlorophyll + { algae
bacteria } "Thallophyta"
*fungi
acrasiales — "cellular slime molds" asexual
labyrinthulales
plasmodiophorales
myxomycetes — "True slime molds" sexual
rickettsieae
virales
pleuropneumonia
ACTINOMYCETALES MYXOBACTERIALES
Ray Fungi

most of these highly diversified forms placed in "Thallophyta". This requires some explanation; justification; definiti

Briefly characterize each of these;

Are they plants or animals or neither? etc. where do the Fungi belong & what is their relationship to the other groups?

Fungi defined by GWM in N.Amer.Flora 1. 1949. (Myxomycetes)

See: Duddington, C.L., The Friendly Fungi, 1957. (mostly eelworms) Dactylella, Arthrobotrys, Harposporium (sticky spores)

Ideas on phylogeny: (fungi)

a. Polyphyletic (from green, red algae
b. Monophyletic (" filamentous algae — ie VAUCHERIA → PHYCOS
c. Protozoan (" colorless flagellate

Fungi not conventional "plants"; use of the terms: saprobic and assimilative phase (for vegatative).

Myxomycetes:

Life cycle:

spore (N) → swarm cell → myxamoeba (sin flagell.
(heterokont) ANTERIOR
pairing (plus, minus); → zygote (young plasmodium (coenocyte)
fruiting body (R.D. before spore formation)

2 Subclasses: Exosporeae; Ceratiomyxales; Ceratiomyxaceae; Ceratiomyxa

Endosporeae (Myxogastres): spores pallid: Liciales; no capillitium
Trichiales; dense "
spores dark: Stemonitales; lime +, -
Physarales " +

INTERNATIONAL SYMPOSIUM ON ORIGIN OF LIFE. MOSCOW, 1957. OPARIN, CHAIRMAN

CHORDATA ↑ PROTOZOA ← ORIGINS ? → ALGAE ("THALLOPHYTA") ↑ SPERMATOPHYTA

CHONSPMG PROTOPLASM ACHLOROPHYLLOUS FLAGELLATE → FUNGI

404 BE OCT 26 9AM

Talmme quote Fries as follows: "Mycology is one of those despised and neglected studies which bring the pursuer neither money nor glory." (See: Mycologia 26: 20 1934. C.L. Shear.) Pres. Add.

A. SOME DISEASES OF PLANTS CAUSED BY FUNGI

1. Soft rot of sweet potato due to Rhizopus.
2. Corn smut showing enlarged kernels, stem tissues and anthers filled with spores. Ustilago Zea
3. White pine blister rust showing Canker of pine stem. Cronartium ribicola.
4. Oranges attacked by blue mold.
5. Blackstem Rust of Wheat. (Riker mount.)
6. Ergot of rye (Riker mount).
7. Cedar-apple rust (Riker mount).
8. Onion smut (Riker mount).
9. Wood rots (Specimens).

B. HUMAN AND ANIMAL DISEASES CAUSED BY FUNGI. Coccidiomycosis

1. Athletes Foot. Organism: various species of Trichophyton.
2. Ringworm Diseases of skin, face (Barber's itch) and scalp. Organisms; various species of Microsporium, Trichophyton.
3. Favus of the Scalp. Organism: Trichophyton schoenleini.
4. Blastomycosis. Organism: Blastomyces dermatitidis.
5. Dermatophytosis. Organism: Trichophyton mentagrophytes.
6. Sporotrichosis. Organism: Sporotrichum schenckii.
7. Maduromycosis.
8. Actinomycosis or Lumpy Jaw. Organisms: Various species of Actinomyces and Nocardia.

C. MISCELLANEOUS FUNGI OF ECONOMIC IMPORTANCE

1. Blue cheese (Roquefort style) showing growth of penicillim.
2. Penicillium (Petri dish culture) from which the antibiotic penicillin is produced.
3. Streptomyces (Petri dish culture) from which the antibiotic streptomycin is produced.
4. Deadly Amanita -- a poisonous mushroom.
5. Puffball; note mycelium at base.
6. Cloth rotted by fungi and test showing strength of textiles.

TRUFFLES - edible AGARICALES

Myxomycetes } Liceales, Trichiales } bright spores
Keys } Stemonitales, Physarales } Dark spores

Life-cycle heterokont flagella.

EUMYCOTA

Chytridiomycetes

Oomycetes { gametangia ≠ oospores

Chytridiales .... ISOGAMY PLANOGAMETES
Blastocladiales } Post. uniflagell. zoospores, HETEROGAMY
Monoblepharidales .... OOGAMY (unique)

Plasmodiophorales Ant. biflagell.
Saprolegniales
Lagenidiales } Post [illegible]
Leptomitales
Peronosporales { Pythiaceae, Peronosporaceae, Albuginaceae

Zygomycetes { gametangia = zygospores
Mucorales } Endogenous vs Exogenous spores
Philophora sporangiola
Entomophthorales

Heterothallism

(Keys for genera.)

DIVISION - KING - FUNGI
SUBDIV
CLASS = MYCOTA - MYCOTINA
ORDER MYCETES SUBCLASS
FAM. - MYCETIDAE
| TRIBE (ü OOMYCETIDAE)
GENUS ZYGOMYCETIDAE
| SECTION
| SERIES
✓ SPECIES
VARIETY
FORM

INT. CODE BOT. NOM. 1956

ART. 16

(PARIS 1954)

ENGL, FR, GERM } OFFICIAL LANG.
DISS. SPAN. } UNOFFICIAL TRANSL.

Ascomycetes
Hemiascae } Taphrinales, Endomycetales
Euascae Plectascales (Plectas- [illegible]
(Capitate) : 120 Eurotiales - I [illegible]
: 100 Myriangiales - [illegible]
(no) monascal locule
true : [illegible]
peri- : Microthyriales - dimidiate
thecia : 700 (Thyriothecium)
locules 700 Dothideales - locules | [illegible]
Hemisphaeriales - dark
800
Erysiphales .. cleistothecia
Pyreno 800 Hypocreales = bright stroma
1500 Laboulbeniales - parasites etc
4500 Sphaeriales - typical
100 Hysteriales ... hysterothecium
250 Phacidiales
Discos 1400 Helotiales ... inoperculate
500 Pezizales - operculate
140 Tuberales .. hypogeous

DIV.- EUMYCOTA
SBDIV.- EUMYCOTINA
CL. - ASCOMYCETES
SBCL.- HEMIASCOMYCETIDAE
SBCL. - EUASCOMYCETIDAE
ORD. - PROTOMYCETALES
ORD. - ENDOMYCETALES
ORD. - TAPHRINALES
ORD. EUROTIALES } PLECTO -
MYRIANGIALES
DOTHIDIALES
MICROTHYRIALES
MELIOLALES
ERYSIPHALES
HYPOCREALES } PYRENO -
LABOULBENIALES
SPHAERIALES
HYSTERIALES
PHACIDIALES
HELOTIALES } DISCO -
~~PEZIZALES~~
TUBERALES

Ascomycetes REVIEW
Hemiascae } no ascocarps
Endomycetales .... yeasts
Taphrinales, ...
Euascae } ascus formation, ascogonia, antheridium, trichogyne
Eurotiales - mazaedium
Myriangiales } ... monascal locules
Dothideales - } plurascal locules
Microthyriales - dimidiate
Meliolales
Erysiphales
Hypocreales
Laboulbeniales
Sphaeriales } PYRENOMYCETES (perithecia)
Hysteriales
Phacidiales
Helotiales
Pezizales } DISCOMYCETES (apothecia)
Tuberales.

CALICIALES
PYRENULALES
GRAPHIDIALES
LECANORALES

See: Cantino, E.C. 1950. Quart. Rev. Biol. 25: 269-277. Nutrition & Phylogeny in the water molds.

Nutritional Evolution. (Lwoff, A. .... Paris)

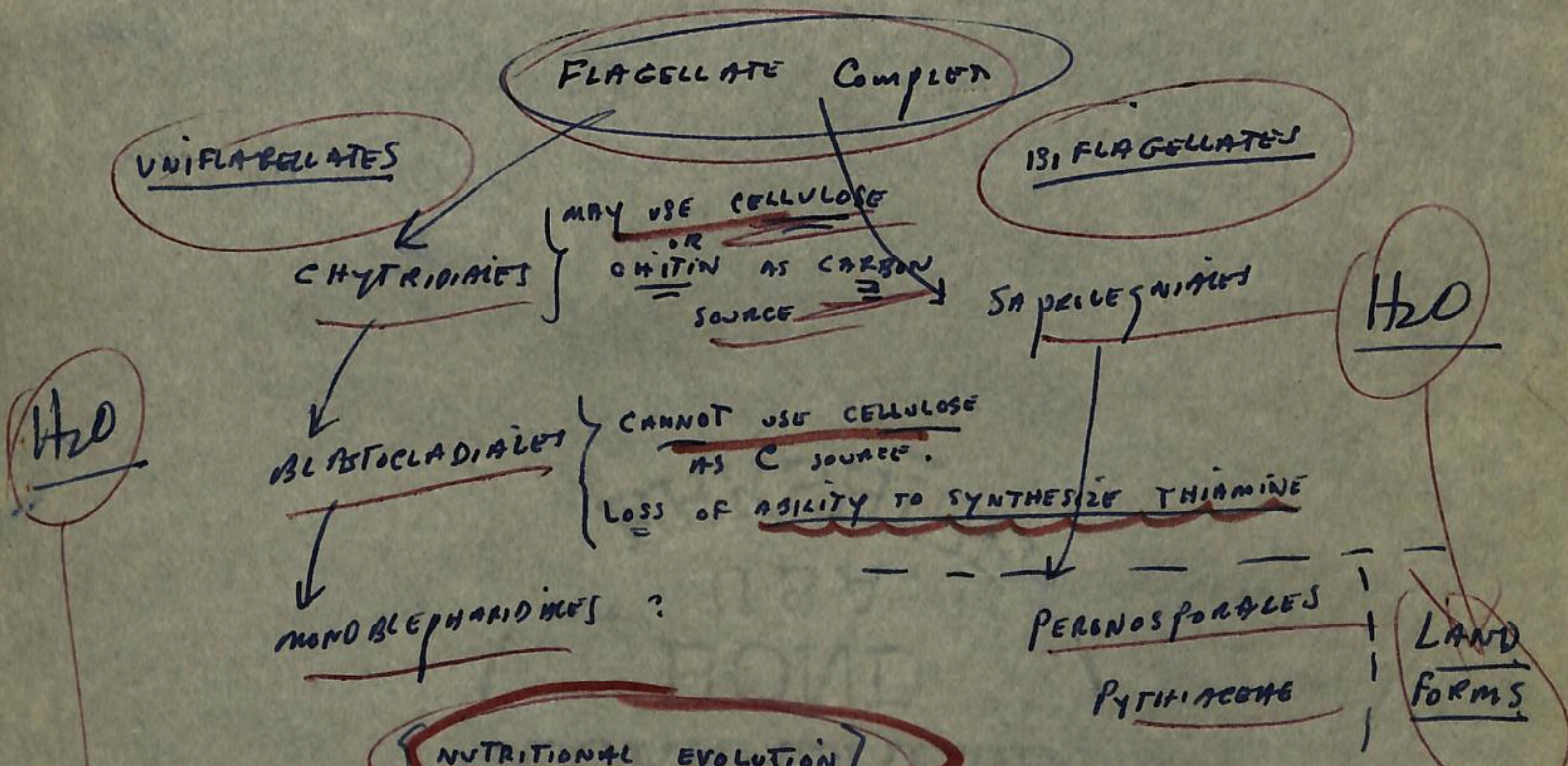
1) Autotrophs able to SYNTHESIZE vitamins etc.

2) Heterotrophs not able "

ie loss of capacity to synthesize means greater dependence on environment; greater specialization. (as in PARASITES)

BUT: Chytrids utilize inorganic N,S to make proteins } METABOLISM COMPLEX

Blastocl. can't use " N,S.; must have amino acids. } M. SIMPLER



A GRADUAL LOSS OF ABILITY TO SYNTHESIZE → GREATER DEPENDENCE ON ENVIRONMENT.

But correlate with morphological complexity.

∴ SPECIALIZATION IN NUTRITIONAL NEEDS FOUND IN HIGHLY EVOLVED GROUPS.

LAND

2b Rusts, Smuts evolved from saprophic forms.

EM Studies [Fine Structure]

Fungal Cell Components

• Plastids absent

Nuclei with double membrane & pores.
(lipoprotein)

• Nuclear membrane remains intact in mitosis
unlike conventional plants & animals

Centrioles, when present (some sporangia &
zoospores) as in animal cells.

Mitochondria ubiquitous; Ribosomes also
(Respiration)

• Fungal cells generally smaller than plant/animal

Endoplasmic Reticulum (ER) [Protein synthesis]
with surface Ribosomes

Golgi, Dictyosomes – function unknown.

Lomasomes – bet. plasma membrane &
cell wall. — also in algae, higher pl.

• Glycogen storage polysaccharide as in animals.
Starch in plants

• Septa – Plate with pore in Phycos - Ascos - Deuter.
Dolipore in Basidios

Beginnings of Bacteriology
(chronology) Topley and Wilson

1745 Needham publishes memoir on spontaneous generation. (Ireland)

1749 Buffon supports these views.

1769 Spallanzani opposes Needham; showed that flasks containing fluid if heated long enough remained sterile.

1854 Schroeder and Dusch used cotton wool plugs to keep flasks sterile.

1860 Pasteur begins his contributions. Attacks question of spon. gen. finally disproves it by experiment; his greatest single contrib. to advance of science. Among others: invest. distrib. of micro org. in air; boiling milk under pressure at 110°C. preserved it; particles filtered thru cotton-wool introduced into sterile media(Fluid)gave rise to varios living microorg.

1871 - Cohn observed bacterial spores; resistance to heat.

1876 Pasteur-Bastian controversy: alk. urine after boiling not always sterile.(due to growth of spores). Pasteur introducd heating to 120°C. under pressure to sterilize, fluids; also dry heat at 170°C. for glassware.

1882 - Tyndal "Final blow to spon. gen."

Pasteur recognized import of using suitable media.

Researches in fermentation, pebrine anthrax, chicken cholera, rabies.

Introduced idea of virulence and attenuation (with anthrax).

Attenuated culture same as vaccine Pasteur's concept.

1876 Koch on the scene.(1843-1910) Memoir on Anthrax first publication.

1877 Methods for fixing, staining bacteria. Use of aniline dyes(Weigert's methods in histology)

*1881 Koch introduces solid media; makes poss isolationn of pure culture from single colonies.

---

paper on tuberculosis bacillus.
red cholera vibrio.

describes leprosy bacillus.
" gonococcus.
isolates bacillus of fowl choler
observes typhoid bacillus.
describes staph.
scovers tubercle bacillus.
en isolates strep of erysipelas.
r isolates diphtheria bacillus
ribed by Klebsin1883)
isolates typhoid bacillus.
er isolates bacillus of swine-
elas.
scovers bacillus of hemorrhagic
emia in cattle.
and Smith discover bacillus of
olera.
ler observes tetanus bacillus in

el isolates pneumococcus.
sch " colon bacillus.
er " swine plague bacillus.
lbaum discovers meningococcus.
" malta fever bacillus.
er's bacillus.
describes strep of equine strangles.
to cultivates tetanus bacillus.
and Nuttall describe anaerobic
s now called Clos. welchii.
to and Yersin independently find
bacillus.
isolates bacillus of fowl typhoid.
engem describes Cl. botulinum as
of a kind of food poisoning.
bacillus of bovine abortion.
s dysentery bacillus.

1898 Nocard and Roux describe organism of pleuro-pneumonia in cattle.

1898 Loeffler and Frosch find foot-and-mouth disease a virus ultramicroscopic and passing a porcelain filter; opens new field.

1882 Koch's paper on tuberculosis bacillus.
1883 Discovered cholera vibrio.

1874 Hansen describes leprosy bacillus.
1879 Neisser " gonococcus.
1880 Pasteur isolates bacillus of fowl chole
1880 Eberth observes typhoid bacillus.
1881 Ogston describes staph.
1882 Koch discovers tubercle bacillus.
1883 Fehleisen isolates strep of erysipelas.
1884 Loeffler isolates diphtheria bacillus (described by Klebsin1883)
1884 Gaffky isolates typhoid bacillus.
1885 Loeffler isolates bacillus of swine-erysipelas.
1885 Kitt discovers bacillus of hemorrhagic septicemia in cattle.
1885 Salmon and Smith discover bacillus of hog cholera.
1885 Nicolaier observes tetanus bacillus in soil.
1886 Fraenkel isolates pneumococcus.
1886 Escherisch " colon bacillus.
1886 Loeffler " swine plague bacillus.
1887 Weichselbaum discovers meningococcus.
1887 Bruce " malta fever bacillus.
1888 Gaertner's bacillus.
1888 Schutz describes strep of equine strangl-les.
1889 Kitasato cultivates tetanus bacillus.
1892 Welch and Nuttall describe anaerobic bacillus now called Clos. welchii.
1894 Kitasato and Yersin independently find plague bacillus.
1895 Moore isolates bacillus of fowl typhoid.
1896 vanErmengem describes Cl. botulinum as cause of a kind of food poisoning.
1897 Bang's bacillus of bovine abortion.
1898 Shiga's dysentery bacillus.
1898 Nocard and Roux describe organism of pleuro-pneumonia in cattle.
1898 Loeffler and Frosch find foot-and-mouth disease a virus ultramicroscopic and passing a porcelain filter; opens new field.

Fungi } Heterotrophic Eucaryotes (GR. nourishment) [Procaryotes – no mitochondria]
Organic decomposition
Pathogens
Wood / litter rotters
Food spoilage
Antibiotics etc

I Myxomycota
II Eumycota
- Oomycetes (isogamy, heterogamy, oogamy) } "Phycomycete" (RHIZOPUS, MUCOR)
- Zygomycetes
- Asco – CYTTARIA – TRUFFLES, MORELS
- Deutero – (Imperfects) – PENICILLIUM ROQUEFORTI, P. CAMEMBERTI
- Basidio –

"Cup fungi" – nazi? quality

Paté de foie gras – Périgord – T. melanosporum

Solanum tuberosum
} Phytophthora infestans
Potato Blight (Late)
1845–50 Famine in Ireland

Grape Mildew – Plasmopara viticola
1882 France (Pierre Millardet, Prof. Bot. Bordeaux)
CuSO4 + Lime → Bordeaux Mixture
Cu toxic to spores

1885 Champagne
Chablis
Bourgogne (Burgundy)
Sauternes
Bordeaux
Médoc
: TOKAJI : JEREZ

Fungus | Green Pl.
NO
- Root, Stem, Leaf
- Seeds
- Chlorophyll
- Light
- Food Absorbed
Cellulose + Chitin → Cellulose
Glycogen

Fungus Display

{ Bacchus
VITIS ✓
VITICULTURE ✓

PENICILLIUM 1929 FLEMING

Phylloxera – root aphid (leaf)
American VITIS resistant to Phylloxera & P. viticola – introduced to France c 1865 (50)

Saccharomyces ellipsoideus
S. cerevisiae

$C_6H_{12}O_6$ + YEAST → Bread, Wine, Alcohol
↓ ZYMASE
$C_2H_5OH + CO_2$

(PL) Autophytic – (ANIM) Ingest – (FUNG) Absorption

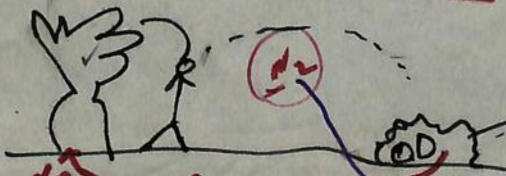
Mycology – Gr. Mykes = mushroom
Phy –
Bey – ✻ (L. beside)

PARASITE vs SAPROBE (Gr. rotten) – PATHOGEN (Gr. suffering)

GLYCOGEN
CHITIN
HIGHER / LOWER FUNGI

Spore → Hypha (Gr. web) → Mycelium → 2N Fr. → R.D. → Spore - - - →

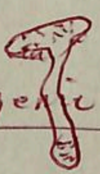
Sexuality / Asexual
Centres



ORGANIC DEBRIS } DEATH & DECAY
NO_3 ← NO_2 ← NH_3 ; NO_2 → NO_3 (RHIZOBIUM) (legumes)

BASIDIO –
- Fairy Rings (Shakespeare – Midsummer Night's Dream)
- Hallucinogenic (Lewis Carroll's "Alice") [A. caesarea. Claudius 54]
↓ etc
- Huck Finn (Mark Twain) "Them rotten chunks called fox-fire ..." glow in a dark place
Luminescence
- Poe – Fall of House of Usher. Merulius lacrymans

"FOX FIRE" — luminescent
Clitocybe illudens
HUCK FINN
(HALLOWEEN)
FAIRY RINGS
WOODEN SHIPS etc.
DRY ROT — Serpula lacrymans
[HOUSE OF USHER
POE
ALICE — Hallucinogenic



L. CARROLL
POISONOUS vs EDIBLE MUSHROOMS] MYTH v. REALITY
AMANITA VERNA VIROSA etc
CAESAREA
AGARICUS bisporus etc.

Sheep's milk
CHEESE
roquefortii
camembertii
COTTON
CANE
RICE

ASPERGILLUS
{ASPERGILLUM
ASPERSORIUM } Brush for dispensing HOLY H2O.
BLUE CHEESE roq. cam.
PENICILLIUM — FLEMING 1929 P. notatum
PENICILLUS } Artist's brush
P. ROQUEFORTII etc.
{ALTERNARIA
FUSARIUM
etc. } PLANT PATH. — COTTON CANE RICE etc.
→ TRICHOPHYTON } ATH. FOOT
puccinia Ustilago
BASIDIOS — RUST SMUT
POISONOUS/EDIBLE USTILAGO maydis
FAIRY RINGS
LUMINESCENT — CLITOCYBE illud.
HUCK FINN
POE'S HOUSE OF USHER } wood rotters etc
ALICE & CATERPILLAR

GODS (goddesses) OF AGRICULTURE
{ ISIS — EGYPT
DEMETER — GREECE
CERES — ROME
QUETZALCOATL — MEXICO

SAVAGRY
BARBARISM
CIVILIZATION

Folklore
silver coin
etc.

wild plants
Cultivation
Hunters
Fishermen etc
"CIVILIZATIONS"

ECONOMIC BOTANY vs Ethnobotany historical intro.
i. Plants useful to man.
Indigenous to America
Zea mays — MAIZE — CORN → dift meaning abroad etc.
PHASEOLUS vulgaris spp. — BEANS
CUCURBITA spp — SQUASH
SOLANUM tuberosum — POTATO etc
LYCOPERSICUM esculentum — TOMATO
NICOTIANA rustica — TOBACCO
• CHILI — CAPSICUM spp.
MANIHOT ESCULENTA "CASSAVA" "YUCCA"
THEOBROMA CACAO
etc DATURA etc

[SOYBEAN ASIAN]
GLYCINE max

[Ethnobotany] — [mycology]

Historical — Ancient man — Present

Ethnopharmacology / Psychopharmacology

Culture
early discovery
by man

[Gr. breath — spirit]
Psychedelic [Gr. manifest]

[Medicine Man → Shamanism

CURANDERO(A)
etc.
(Turkic)
ASIA USSR

Animism
L. animus = spirit soul

L. spiritus = breath
immortality

sensory perception
hallucinations
[L. wander in mind]
{ SORCERER — L. fate
NECROMANCY — Gr. dead

divination — prophesy

* [time/space perception — distortion]

nutmeg — Myristica — MALASIA

cacti — Lophophora
Trichocereus

Psilocybe
Panaeolus
Stropharia
Amanita muscaria

*

AVAILABILITY
Local
MYRISTICA — NUTMEG
IPOMOEA V. — MORNING GLORY
PSILOCYBE SPP.

Hallucination = L. wandering of mind
Psyche — Gr. Personification of
soul as beautiful girl loved
by Eros (= Cupid — Roman).

Psychedelic = Intensified sensory
perception w. hallucinations
visual — auditory etc

Pol 1809 — House of Usher — not Pathogenic fungus.
Merulius lachrymans
SERPULA
Poisonous vs edible mush.
distinguish ?

Myxomycetes — no mycelium

Rea…
Sym…
Ama…
Lactari…
Lenten…
Agari…

Agaricus bisporus — ± 200 × 10⁶ lb/yr.
Volvariella volvacea — Padi Straw
Lentinus edodes — Shiitake
Tuber melanosporum — Truffle — ± 100,000 lb/yr. France
Lactarius salmonicolor
Morchella esculenta spp.
Auricularia fuscosuccinea
Cantharellus cibarius
Amanita caesarea
etc
Penicillium roquefortii
P. camembertii

F…

(LICHENS)

FUNGI — 1845 — 89 / 89 / 90

OOMYCETES — 1845 — LAND — etc.
ZYGO — EVOLUTION
ASCO — YEAST, CYTTARIA, etc.
BASIDIO — AGARIC, BOLETE, POLYPORE, etc.
IMP — PENICILLIUM, ASPERGILLUS, etc.

USES — EXAMPLES — N₂ CYCLE, DECAY, "ROTS"
PARASITE
PATHOGEN
SAPROBE
SYMBIONT

TWAIN
POE
CARROLL

Blue cheese — Penicillium *
Rusts —
Poisonous vs Non poisonous fungi
Aspergillus spp. — + Aspergillus — Miso < Soybeans, wheat, rice
Shoyu — Aspergillus + yeast < Soybeans, rice
Tempeh — + Rhizopus < soybeans only

Agaricus bisporus
Amanita sp. — caesarea
Lactarius spp. — deliciosus
Morchella
Volvariella volvacea — Padi Straw
Lentinus edodes — Shiitake
Auricularia fuscosuccinea

Ascomycete — Pyreno = stone of fr.
— Disco — Cup fungi

PLANTS / ANIMALS / FUNGI : PROTISTA : MONERA

BACTERIA
B-G. ALGAE

MYCOTA

(HYPHA MYCELIUM

[CHITIN / CELLULOSE]
GLYCOGEN

(*) N^2 → NO_2 → NO_3 [Rhizobium sp (Legumes)]

NH_3 → NO_2

AMMONIFICATION
NITRIFICATION
N^2 FIXATION

PASTEUR 1857

YEAST — Bread - wine | Biblical ref.

ANAEROBIC RESP.

$C_6H_{12}O_6$ —zym.→ $C_2H_5OH + CO_2$

I. POTATO BLIGHT
PHYTOPHTHORA INFESTANS
1845-50 Ireland

OOMYCETE

II. GRAPE MILDEW
PLASMOPARA VITICOLA
MILLARDET 1885
$CuSO_4$ + Lime
WINES
Bordeaux mix.
JEREZ etc

ALEX FLEMING 1929
PENICILLIN
"ANTIBIOTIC"
[1945 NOBEL]

FAIRY RINGS (SHAKESPEARE)

ALICE & CATERPILLAR
Hallucinogenic
1865
PSILOCYBE

POE'S House of Usher
MERULIUS SP.

RUSTS - SMUTS etc.

Luminescent Fungi Clitocybe illudens
Huck Finn - "them rotten chunks called fox fire" - -

"criteria"

Poisonous vs Edible

Truffles — $350 lb. (1980) etc.
myths

A. bisporus
A. verna etc.
A. caesarea
A. muscaria
"Fly Agaric"
etc.

A. HUXLEY - ISLAND (1962)

MOKSHA etc.

[POISONOUS vs EDIBLE]

Glycine soja

Oriental Foods w. Fungus Fermentations

"peanut butter" texture — II — MISO — Soybeans – 2 parts; wheat – 1 "; Rice – 1 "

fermented w. Aspergillus oryzae

+30 days → paste like peanut butter

SOLID

Cheese texture — III — ✓ — TEMPEH — (cheesy texture) Soybeans only cooked

inoculate: Rhizopus oligosporus

+24 hrs.

...inkle

" holy water

of Mass

soybeans + rice/wheat

LIQUID — I — ✓ — SHOYU – liquid : SOY SAUCE — + H_2O

" + H_2O

→ amino acids

SUFU

Aspergillus soyae + wheat + Yeast

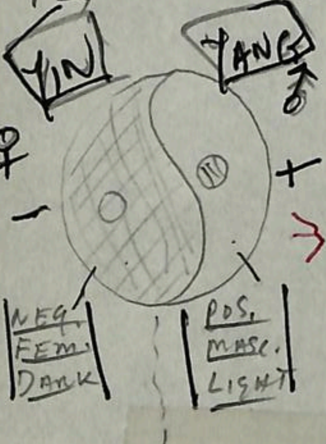
aging for 1 yr or more

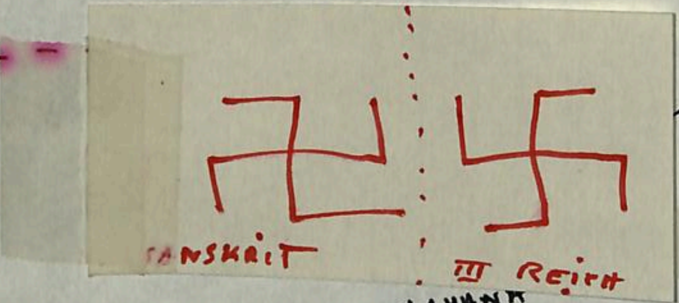
THEORIES of DISEASE

GR. MYTHOLOGY (I)

- PROMETHEUS
- PANDORA (1st woman!)
- DEMONIC POSSESSION (II) (BABYLONIA)
- ASTROLOGY (III) — [ZODIAC 12 signs etc]

YIN — YANG





BACTERIA

"Bluestocking" LEEUWENHOEK — 1683

Lady Mary Wortley Motagu d. 1762.

LADY MARY 1717

1802 — Brit. Royalty inoculated "VACCINATION" 10,000 Pnd. Prize

MUHAMMED d. 632 AD

BUDDHA d. 480 BC

* HIPPOCRATES [460-360 BC] OATH

CADUCEUS — Gr. staff of Mercury, god's messenger

TMV

BEIJERINCK — 1898

STANLEY — 1935

CHAMBERLAND/PASTEUR FILTERS

CRYSTALS → NUCLEOPROTEINS → DNA *

1946 NOBEL *

HAVANA

LAZEAR d. 1900 PANAMA

W. REED (Virginia) 1901 VIRUS * — self-exper.

N.O. EPIDEMIC 1905

VACCINE

AEDES

JAUNDICE

YELLOW FEVER

MALARIA

Wm. GORGAS (ALABAMA) 1904 PANAMA — 1914 CANAL — MOSQUITO CONTROL

insect transmission

* LAVERAN 1880 — PLASMODIUM v. — 1907 NOBEL

1907 NOBEL — Fr. in Algeria (1st Protozoan) (NOT BACTERIA)

ROSS 1897 (Eng.) — 1902 NOBEL *

ATABRINE etc. ← ANOPHELES

QUININE — CINCHONA (PERU BARK) JESUIT'S "

(KINA — QUECHUA)

HISTORY! PASTEUR SHOWED: MICROORGANISMS ± 1865 → DECAY

METRIC SYSTEM METER = ± 39" = 3.28'

% 5

1876 - STAINING (WEIGERT)

1882 - SOLID MEDIA

MAN'S LIFESPAN >

BACTERIA SMALLEST OF ORGANISMS .. (FEW MU) μ

LEEUWENHOEK (1632-1723) 1683

DEMONOLOGY VS SCIENTIFIC OUTLOOK RE: DISEASE

MORPHOLOGY.....

μ = .001 mm

$m\mu = 10^{-6}$ mm

$\text{Å} = 10^{-7}$ mm

SHAPE
FLAGELLA
CAPSULES
PIGMENTS

COCCI
BACILLI
SPIRILLI
FILAMENTOUS

PIGMENTS
GRAM ±
ACID-GAS
H_2S
SUGARS
MOTILITY
SPORES
CAPSULES
AEROBIC - ANAEROBIC
HAEMOLYSIS ±

GROWTH ON SOLID (AGAR) OR FLUID (BEEF BROTH etc.) MEDIA.

(DULL, SHINY, SMOOTH, WRINKLED, FLAT, HEAPED UP, SPREADING)

MULTIPLY (ASEXUALLY) AT RAPID RATE : GEOMETRIC RATIO: IE SINGLE CELL DIVIDING FOR 24 HRS ... 2000. TONS etc.

PHYSIOLOGICAL DISTINCTIONS: ie SUGAR FERMENTATIONS

AEROBIC vs ANAEROBIC

PATHOGENICITY

IMPORTANCE TO MAN: (SCAVANGERS OF EARTH) "DUST TO DUST"

DISEASES: T.B. PNEUMONIA LEPROSY TYPHOID plague
STREP. DYSENTERY DIPHTHERIA

(ANIMALS: SHEEP ANTHRAX TB CATTLE) BIRDS
PLANTS

✓ Brucellosis
✓ Cholera
✓ Meningitis
✓ Anthrax
etc. · Boils

FOOD SPOILAGE: MILK MEAT VEGETABLES etc.

FOOD POISONINGS

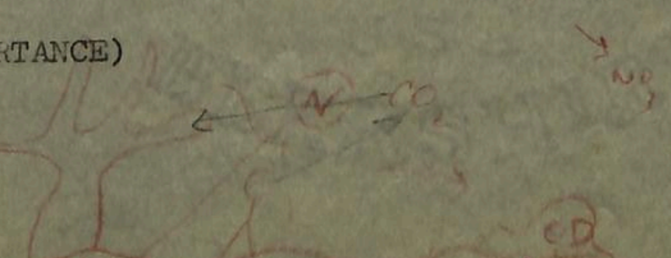
PASTEURIZATION : ± 150°F = 65°C } ± 30 MIN.
± 185°F = 85°C } 3 MIN. : FLASH

DECOMPOSITION OF ORGANIC MATTER (RETURNED TO SOIL)

N CYCLE: AMMONIFICATION
NH_3 → NITRIFICATION
NO_2 N*FIXING
DENITRYFYING

(IMPORTANCE)

VIRUS DISEASES
PLANTS / ANIM.
TMV
POLIO
COMMON COLD



Legumes { N_2 Fixation / Rhizobium

NITRIFICATION NO_3 ← NO_2 ← NH_3 (Bacteria / B.G. ALGAE)

Antibiotics (mostly from Fungi)

Define:

Penicillin - 1929 A. Fleming etc.

How bacteria enter body. (& viruses)

1) Trauma
   a) Tetanus & other anaerobes
   Clostridium tetani & botulinum

2) Respiratory tract
   a) Pneumonia, TB, Diphtheria, Leprosy
   Diplococcus Mycobacterium Corynebacterium Pasteurella

Colds, Measles, Small Pox, Ch. Pox, Polio, Yellow Fever

3) Intestinal infections
   a) Cholera, Dysentery (Salmonella / Shigella) Typhoid
   Vibrio
   Amer. Veterinarian 1914

4) Contact
   a) Syphilis, Gonorrhea
   Treponema - Neisseria g.

Insect Transmission — Yellow Fever, Malaria

Sanitation

Aedes = without taste Gr.
Anopheles sp. = harmful Gr.
Plasmodium vivax et spp.

Gorgas 1904 Panama

Lazear d. 1900 — self exper.

Walter Reed 1901 — VIRUS

New Orleans epidemic 1905

1st human disease attributed to a virus

Animal excreta
↓
Feces → Fingers → Flies → Food

MÜLLER - SWISS DDT 1939 - insecticide 1943 Typhus in Naples Louse	ROSS - ENG. 1897 - confirmed 1902 - Nobel	LAVERAN - FRANCE 1880 - Plasmodium in 1907 - NOBEL	ALGERIA TROP. MED. mosquitoes

EXORCISM ?

SALEM, MASS. – 1692

witches

"trial" & execution

JEANNE D'ARC – 1431

SAVONAROLA – 1498
BRUNO – 1600

HUMORAL THEORY

HIPPOCRATES OATH

YIN YANG

Blood – Phlegm
Y. Bile – Bl. Bile

4 ELEMENTS – Air etc
4 QUALITIES – Dry – etc
cold

1

[Bacteria & Disease] – [Plant & Animal incl. Bact. Phage]

Ancient Theories of Disease: Mystery – Superstition – Prejudice etc. – Fear

Epidemics

(1) [DEMONIC] – ie [PANDORA'S Box] all gifts

GREEK PANTHEON [ZEUS]

Mythology

∵ PROMETHEUS stole fire from [JUPITER] (ZEUS) →

• PANDORA sent to punish Prometheus by releasing from box all plagues which afflict mankind (only Hope remained) } analogy with "EVE"

(2) [BABYLONIANS] – Disease ∵ the work of [demons] which swarmed in earth air water.

[ANIMISM]

DEMONIC POSSESSION – Demon entered body causing disease or other abnormal manifestations, had to be chased away. – ∴ Tortures used etc.

[ghost = G. geist = spirit]

(3) [ASTROLOGY] – Position of stars determine fate etc.

> . | ie EXORCISM – SALEM → 1692 MASS – | JEANNE D'ARC 1431 etc. SAVONAROLA – 1498 BRUNO – 1600 man's

Mysticism – Symbolism – Patriarchal – Papal

Prevalent throughout Middle Ages. Witches boiled instead of water. Today!

magen DAVID = shield of DAVID, ± 1000 BC

etc.

[Buddha, Gautama [d. ± 480 BC]]

Yin-Yang – [BOT]: [Hippocrates (460–370 BC)] of Cos not Chios (moth.) 400

NAZI – Sanskrit (it is well) good luck

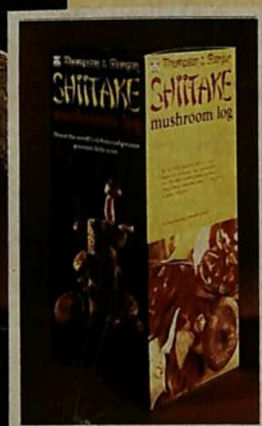
[Theory of Humors] – Phlegm (Phlegmatic) – Blood – Yellow Bile – Black Bile complementary to 4 elements – earth – air – fire – water. (

Islam = aslama = to surrender – & 4 qualities – Dry – moist – Hot – Cold (

Muhammad – Prophet 570–632 – Equilibrium more important. [China: YIN & its YANG] Symmetry

Grow delicious gourmet mushrooms at home.

Mushrooms have long been considered a gourmet delicacy, and now you can grow one of the rarer and more costly variety in your kitchen, on your coffee table or in your garage . . . at a fraction the cost.



Through a horticultural breakthrough Shii-take mushroom spores are impregnated into an artificial "log" of compressed wood chips and grain starch. In a year the log will produce from 2-8 pounds of mushrooms.

A superior variety mushroom with a distinctive flavor, the Shii-take is high in essential minerals, yet low in calories. *Sorry, not available for shipment after May 31.*

No. 9296. . . . $17.00

Your first crop of mushrooms will appear in just 4 weeks. Includes log, plastic incubator, stand and recipes.

Gr. = USELESS

♀ Anopheles spp. → Plasmodium spp. } malaria

Aëdes sp → virus } yellow fever

Gr. = distasteful — L. = POISON

MALARIA

- Alphonse LAVERAN – 1880 (Fr.) (ALGERIA) discovered Plasmodium in Man (1907 NOBEL)
- ROSS – in India – 1897 – (Eng.) Plasmodium in ♀ Anopheles (1902 NOBEL)

QUININE – Peru

ATABRINE

YELLOW FEVER — SP.-AMER WAR 1898

- Wm REED – HAVANA 1901 – (Amer.) mosquito transmitted virus cause. 1905 NEW ORLEANS epidemic
- LAZEAR – 1900: self exper. with Aedes. died 1900
- Wm. GORGAS – 1904 mosquito control

* Panama Canal open 1914.

IWANOWSKI 1892

- BEIJERINCK – 1898 (Dutch)

TMV

VIRUS = poison [L.]

Yellow fever

Smallpox – Chicken – Cow pox

Mumps

Polio

Influenza – Colds

STANLEY – 1935 – crystal virus *

"filterable virus"

[diatomaceous earth filter]

"CHAMBERLAND / PASTEUR"

1905 – N.O. yellow fever

Quinine – malaria – Peru

COIN "TEST" for POISONOUS MUSHROOMS

SEMMELWEISS 1847

"Childbed Fever"

melanosporum

KOCH'S POSTULATES

VIENNA BUDAPEST

use CARBOLIC ACID

d. 1865 - Accidental contamination from gut.

LISTER 1867 PASTEUR 1865

IMMUNIZATION

Ed. JENNER 1798

SMALLPOX VIRUS
COWPOX

VACCINATION [L. VACCA]

POLIO SALK 1955 - killed virus
SABIN 1960 - LIVE VIRUS

PASTEUR 1865 - ABIOGEN.

KOCH 1876 * & GERM THEORY
B. anthracis cattle.

1881 - SHEEP ANTHRAX

CONTROLS | INOC. with ~~ATTENUATED~~ KILLED BACT.

"GERM THEORY" of DISEASE
PASTEUR

PATHOGENS

STREP TYPHOID, ~~[illegible]~~ PNEUMONIA - PLAGUE - PASTEURELLA PESTIS

MYCOBACTERIUM tb (KOCH 1882) TB
M. leprae (HANSEN) disease (LEPROSY)
TREPONEMA PALLIDUM → SYPHILIS
NEISSERIA GONORRHEA
PASTEURELLA PESTIS — PLAGUE — 1665 LONDON - DEFOE
BACILLUS ANTHRACIS — ANTHRAX
VIBRIO CHOLERA —
~~DIPLOCOCCUS PNEUMONIAE~~

VIRUSES (filterable) etc. — 1898 - BEIJERINCK (Dutch)
TMV
1935 - STANLEY (Amer.)
CRYSTALLIZED

DIATOMS etc.

PETRI - 1887

I – III

Vectors of "Plague" – Louse, Rat, Man

Sleeping Sickness – Tse Tse Fly, man

1905 NOBEL

t.b.

1876 – Anthrax
1881 – Cholera
1882 – T.B.

KOCH'S POSTULATES

animal experimentation

KOCH – 1882 + POSTULATES
1) Organism identified in all cases
2) ISOLATE pure culture (in vitro)
3) INOCULATE → + symptoms, etc
4) REISOLATE pure culture

JENNER – 1798
SEMMELWEISS – 1847
LISTER – 1867 – antiseptics
PASTEUR – 1865
ANTHRAX – 1881
RABIES – 1885

1865 – PASTEUR – ABIOGENESIS – GERM THEORY – 1881 – SHEEP ANTHRAX; 1885 – RABIES

1882 + KOCH'S (T.B.) – POSTULATES

~~1865~~ *1847 – SEMMELWEISS < BUDAPEST, VIENNA } CHILD BED FEVER → LISTER – PASTEUR

IMMUNIZATION – VACCINE

1) ATTENUATED CUL. (LIVING) = SMALLPOX, RABIES – cow pox
2) KILLED CUL – TYPHOID – CHOLERA
3) ANTITOXIN = TETANUS – DIPHTHERIA

*1798 JENNER – SMALLPOX VACCINATION – LADY MARY 1717 TURK

LIVE – SABIN 1960 – POLIO; SALK 1955 POLIO

ANTIGEN – ANTIBODY

SABIN 1960, SALK 1955 – POLIO VACCINES

Q → Archimedes (± d. 212 BC) ± 225 B.C. – ERATOSTHENES contemporary

"HUNCH" INTUITION

Eureka!

✓ specific gravity – ratio of densities

✓ lever

[body buoyed up by force = weight of body displaced]

(Bathtub) etc.

Bacteriology

Robt. Koch: [1843–1910]

b. Göttingen. 1876: Bacillus anthracis in cattle. (= cause) Aetiology

1882 – T.B. bacillus discovered. } BCG vaccine (oral), Tuberculins

Vallery-Radot – Devonshire

* Louis Pasteur [1822–1895] Fr.

× 1848 – Chemistry of crystals — Dextro-Levorotation in Polarized light.

(*) 1864 – Spontaneous generation

1865 – Silkworm disease

(*) 1865 – Germ Theory of Disease

SYPHILIS (Fracastoro – Poet – ±1550) [YAWS]
(shepherd) in
Treponema pallidum – Schaudinn 1905

1881 – Sheep anthrax — sheep inoculated with attenuated (heated) bacteria → immunity
Cattle
Bacillus anthracis — Control group of sheep died.

INFLUENZA, Measles, Mumps — VIRUS

Dog, Bat

(*) 1885 – Rabies virus — Attenuated (LIVE) virus prepared from rabbit spinal cords. — Negri bodies
Joe Meister d. 1940 — Nazi occupation Paris
[July 6]

POLIO VIRUS
1955 SALK – DEAD VIRUS
1960 SABIN – LIVE (ORAL)

1888 – Pasteur Institute

Gram, Hans Christian [1853–1938]
Danish
1884 – Gram +, –

Joseph Lister [1827–1912] Eng.

1867 – Carbolic acid (phenol) used 1st as antiseptic in amputations – to eliminate infections.

[Neisser]
1879 – Diplococcus gonorrhoeae
1905 – T. pallidum [Schaudinn]

√ S. Kitasato [1856–1931]

Student of Koch

1894 – Pasteurella pestis isolated — Bubonic Plague

1874 – HANSEN
LEPROSY
M. leprae
skin, nervous syst.

MODERN APPROACH

Ignaz Semmelweiss – d. 1865
1847 – wash hands! – childbed fever (Pathogenic)
Vienna
Budapest

ETIOLOGY

PURE CULTURE TECHNIQUE

1) Discovery of microorganisms

a) Leeuwenhoek etc. – 1683

2) Control of microorganisms

a) Methods of isolation, growth, etc.

Pasteur, Koch

R. KOCH – 1876 – ANTHRAX
1882 – T.B. – POSTULATES
1881 – CHOLERA

Liquid, Solid media

1887 – Julius Petri

1881 – Vibrio cholerae

1882 finds TB bacillus

Koch's Postulates 1882

1) organism present in all diseased cases.
2) Isolate & grow in pure culture
3) Inoculation into susceptible host → +
4) Reisolation in pure culture → dis.

Immunity & Disease < Active / Passive (Tetanus antitoxin)

1798 Edward Jenner (d. 1823) – Active, acquired immunity

milkmaids

1) Smallpox – Cowpox, ie Vacca (L.)

VACCINATION

1802 – entirely legal – formerly inoculated

vaccine (attenuated or killed organism to → immunity) ie (PASTEUR)

Vaccination vs Smallpox practiced by CHINESE long ago. ie Smallpox scabs ground up & used as snuff! also Turks!

2) Pasteur – Rabies vaccine 1885 – JOE MEISTER

"shots" 10000 POUND PRIZE

Methods of Immunization

1717 L. Mary Montague spread use of smallpox vaccine in Eng.

1) Attenuated Cultures

a) Smallpox virus (vaccine)

b) Rabies : POLIO – SABIN

Latin Rabies = madness

2) Killed Cultures (Heat – chemicals – Freezing)

a) Typhoid (vaccine)

b) Cholera

SALK POLIO

VIRUS – 1892 – IWANOWSKI

1935 – STANLEY – TMV

3) Antitoxin – Antiserum (Horse)

a) Diphtheria – Tetanus – Passive immunity

Diphtheria = skin

Clostridium tetani – KLOSTER = SPINDLE

SALK & POLIO

SABIN – live oral vaccine

194 NOT

MYXOMYCOTA
DIV. EUMYCOTA
SUBD. EUMYCOTINA
CL.

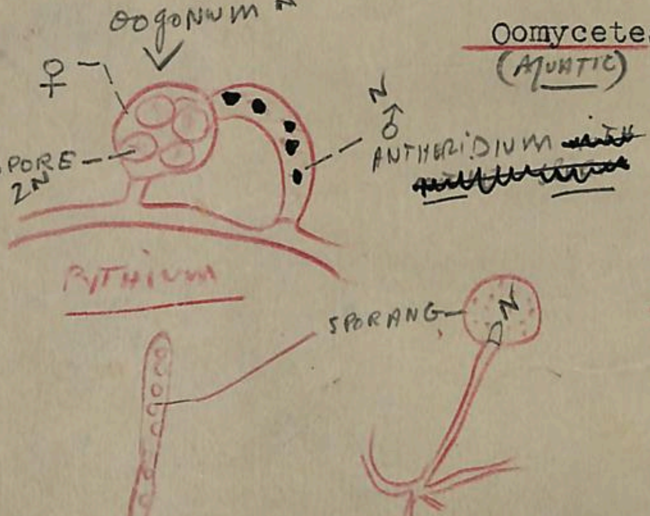
C. M. CHRISTENSON. 1951. THE MOLDS & MAN.

Survey of Fungus groups:

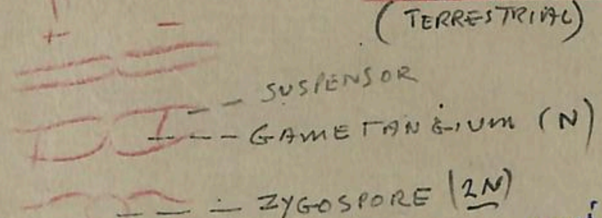
± 5000. PHYCOMYCETES: ("algal fungi") tubular coenocytes; fructificatio small(compared w. other groups); asex. reprod. by zoospores(oomyce sex. reprod. by oospore, zygospo re

a) ZOOSPORE UNIFLAGELLATE
b) " BI "

Oomycetes: (AQUATIC) in sex. reprod. male, female gametangia diffe fertilization tubes (excpt Monoblepharis), oospheres(female gamete) unite w. zoospore to produce zygote (oospore w. a wall); asex. reprod; sporangiospores, (more or less permanent structures); & conidia (more or less evanescent structures ie produced on phialids or directly on hyphae



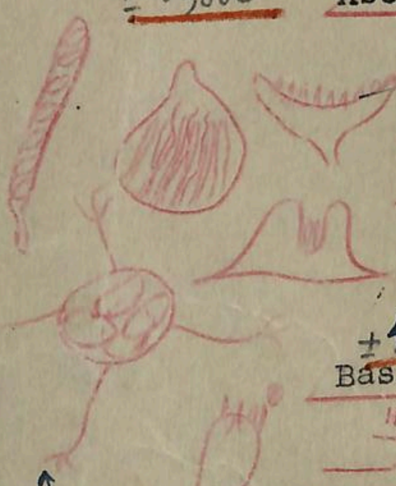
Zygomycetes: (TERRESTRIAL) male, female gametangia alike morphologic Zygospores the result of sexual reprod. no fertilization tubes or motile gametes gametangia unite directly.



HEMI-
EU-

± 35,000 Ascomycetes: sex. stage ends in ascus; spores formed by free cell formation; spores endogenous;

Pyrenomycetes: perithecia, cleistothecia, hysterothecia.
(ASCOCARP fruiting body)
Discomycetes: apothecia
vegatative hyphae uni-nucleate, septate.
Ascus types.



RUST, SMUT, GASTEROS.

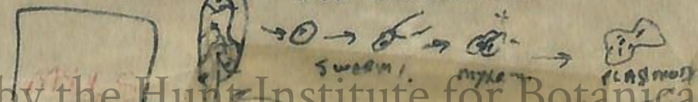
(Basidoicarp)

± 10,000 Basidiomycetes: sex. stage ends in basidium.; spores exogenou vegatative hyphae dicaryon; clamp connectons. septate.

HETERO, HOMO.

± 15,000 Fungi imperfecti: (DEUTEROMYCETES) no sexual phase ; only conidia produced; hyphae septate or non-septate.

Lichens: mostly ascomycetous fungi in mutualism w. algae. few basidios.



produce microscopic, multinucleate masses of delicately netted transparent protoplasm (aphanoplasmodia). Individual aphanoplasmodia can differentiate into clusters of stalked cylindrical fruiting bodies or can form strands of multiple cysts when unfavorable conditions arise (Fig. 1).

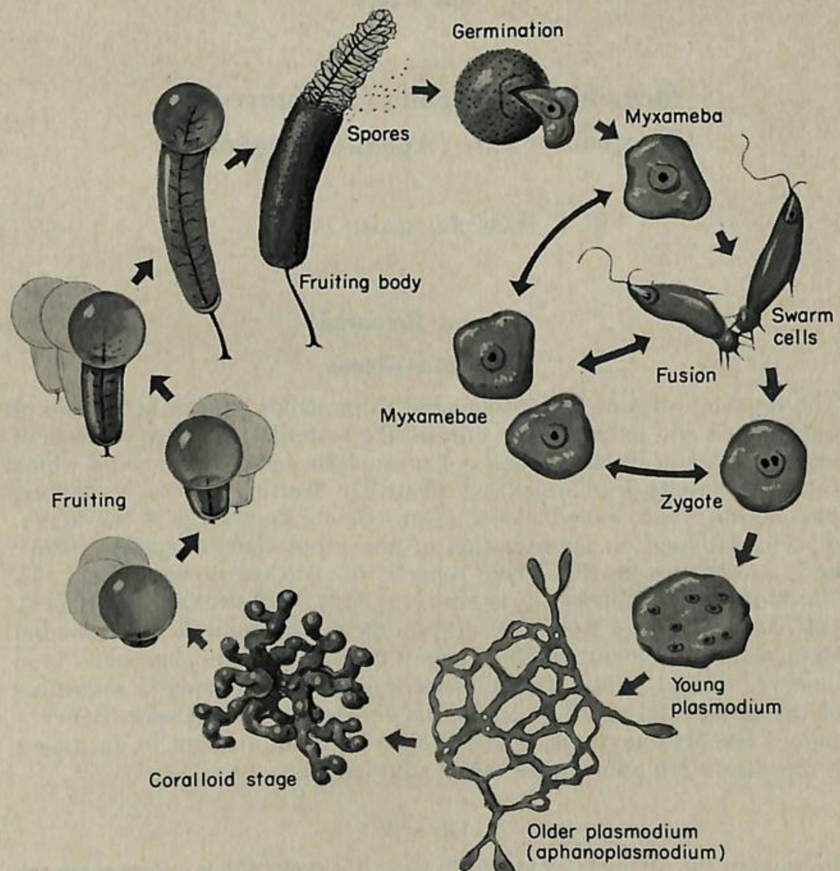
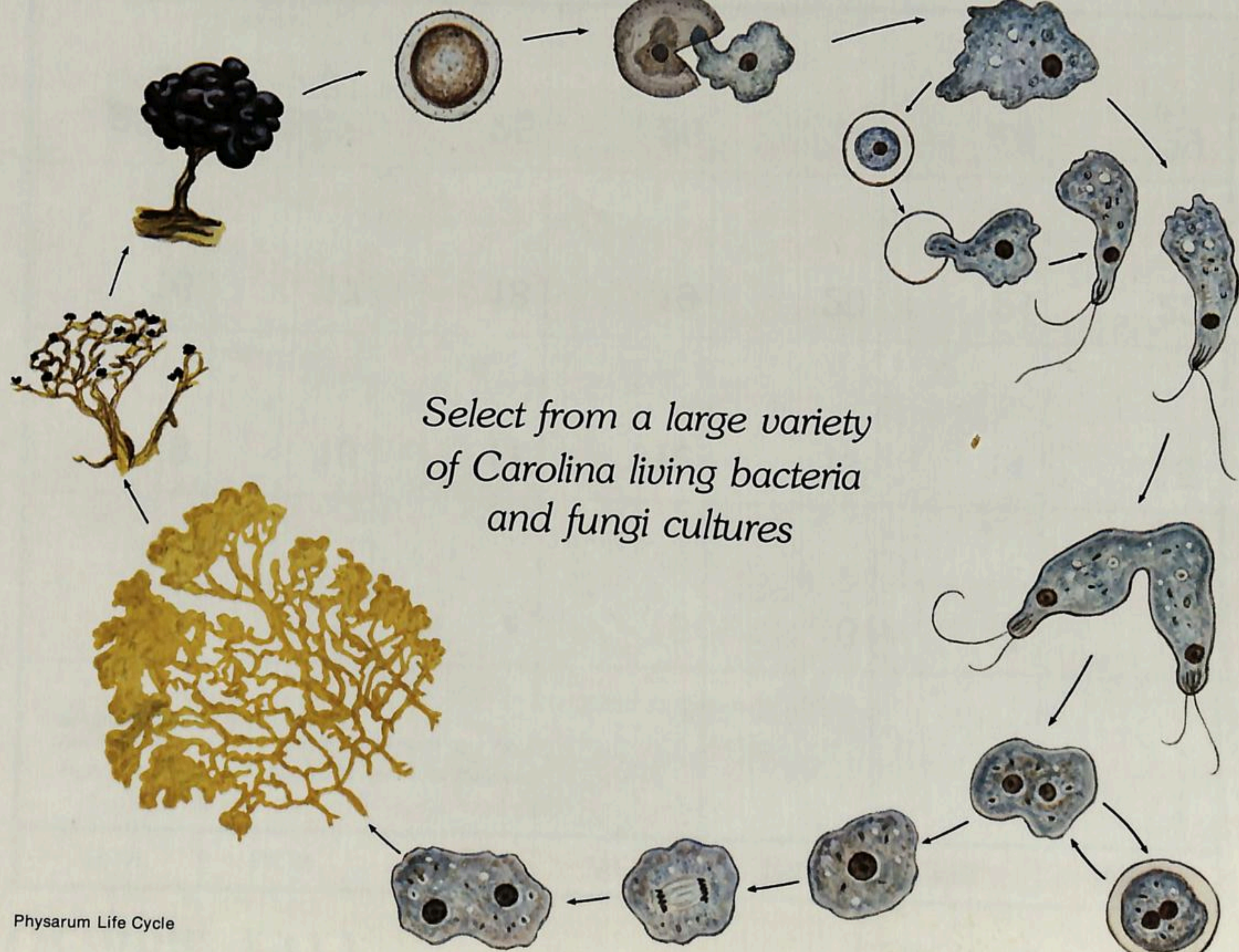


Fig. 1. Life history diagram of *S. flavogenita*

Plasmodial types

Until recently it was thought difficult to distinguish between plasmodia of myxomycetes. Today through the studies of various workers we recognize three general types of myxomycete plasmodia: the



Physarum Life Cycle

TAXONOMY [Taxis + nomus
order law !]

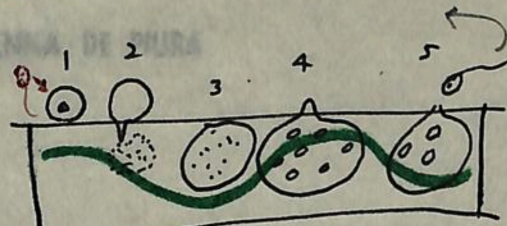
"Taxonomy is not a science, but an art, for its triumphs result not from experiment, but from disciplined imagination guided by intuition." Dennis 1960.

"Taxonomy is the mother and father of all microbiological research. It is as important to know what a fungus is as what it does. ... Taxonomy is deadly monotony and few care to engage in it. The taxonomist is poorly paid during his lifetime and achieves no glory. His heirs can only afford for him an unmarked gravestone after he dies."
C.L.Porter in Developments in industrial microbiology. v.1, p.267. 1960. PLENUM PRESS, N.Y. $6.-

Tulasne quotes Fries: "Mycology is one of those despised and neglected studies that bring the pursuer neither money nor glory."

Types of Chytrid Development — Sparrow 58. (part)

I Olpidium Type:



} Algal filament

1. Zoospore encysted
2. Penetration tube into host (dissolution of wall)
3. Thallus enlarging
4. Mature sporangium (gametangium?) — papilla (in inoperculate)
5. Discharge of zoospores

II Chytridium type: Sporangia dev. externally; only penetration tube produced.

Chytridiales
Blastocladiales
Monoblepharidales

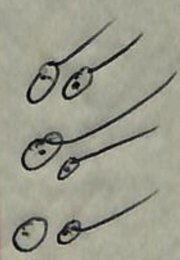
(Uni) flagellate

↓

Saprolegniales
↓
Peronosporales

(Bi) flagellate

Chitridiales — isogamy
Blastocladiales — anisogamy
Monoblepharidales — oogamy











Photos by Joseph T. Collins and George R. Pisani

The ASC Information Center has been designed to help solve problems as rapidly and completely as possible. You'll find the Center invaluable in two ways: as an indirect **access** to the information contained in hundreds of collections throughout the nation and as a quick **referral** to biologists of specific expertise. Each biologist offers one or more of a myrid of services, including . . .

Evaluating reports, plans or environmental impact statements

Identifying, collecting and preserving specimens

General information about plants or animals

Access to collections or library materials

Arranging a specimen repository

Environmental Surveys

Teaching or training

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You may decide, however, that your situation calls for a list of biologists or facilities who have already been informed of your needs, and have expressed a desire to offer their services to you. If so, then you will be interested in the **Total Program.** Under this plan, ASC personnel contact each person included on the Fundamental Program list. You will receive a roster of those biologists who are ready to perform the services you need. If time is of great value to your organization, the Total Program is essential.

The Fundamental Program and the Total Program are money-saving and time-saving conveniences you can't afford to ignore. Both programs are in full operation and ready to help you. Questions? Call Rebecca Pyles, Information Specialist, at . . . **(913) 864-4867**

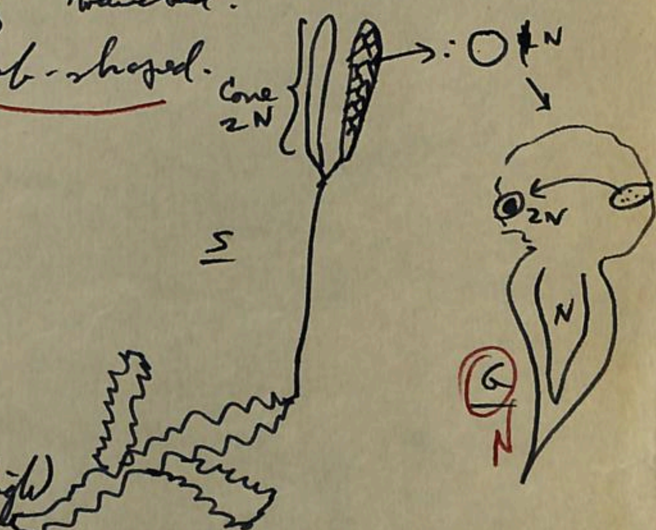
Phyla - cont'd: **Pteridophyta**: } Tracheophyta — Club Mosses, Horse Tails, Ferns } Vascular tissue (xylem - phloem); Sporophyte predominant. Gametophyte reduced; True lvs. stem, root.

Club Mosses (Lycopsida) (Lycopodium, Selaginella) Carboniferous forms

Selaginella → highest development — approaches seed plant.

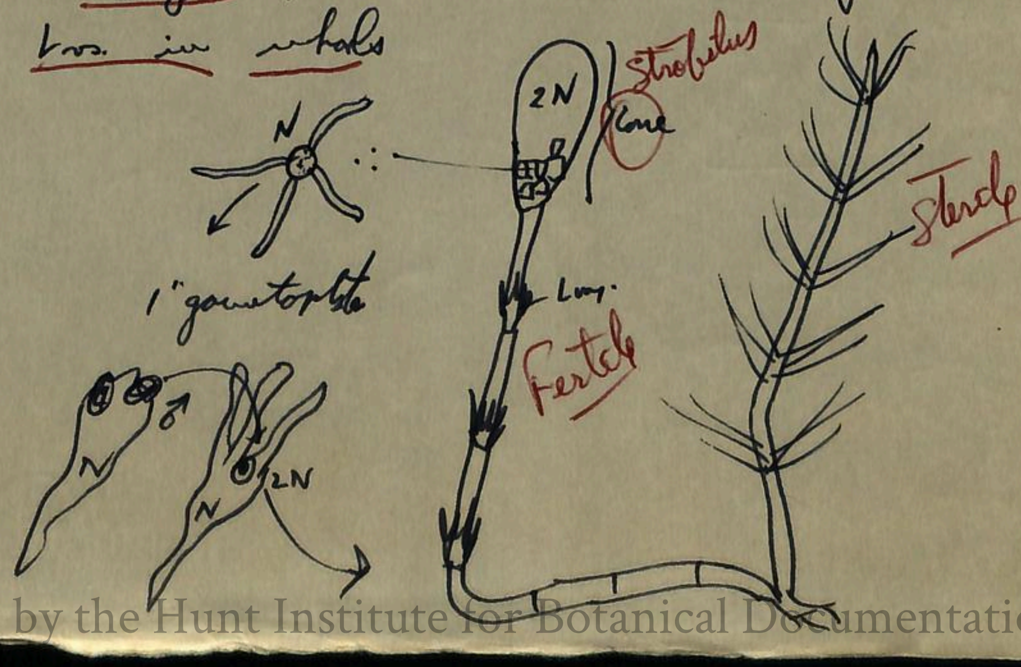
Characters:
- Lvs. spirally arranged.
- Leaf has 1 vascular bundle.
- Gametophyte <1 inch long, no chlorophyll
- Roots & stems dichotomously branched.
- ~~Reproductive~~ Sporophyte club-shaped.

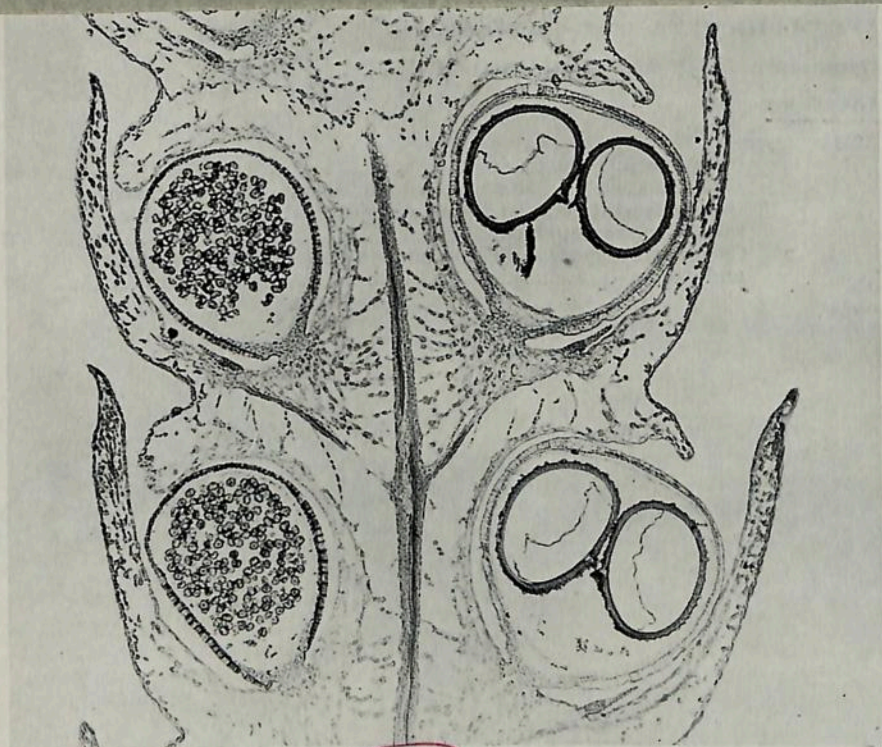
- Homosporous
- Heterosporous } Selaginella



Horsetails (Sphenopsida) Equisetum (Reaches 4' high)

Characters:
- Stems jointed, hollow, + silica (∴ scouring rushes)
- Lvs. in whorls





29-28 ab **Selaginella** strobilus l.s., showing both microsporange and megasporange attached. (40X)

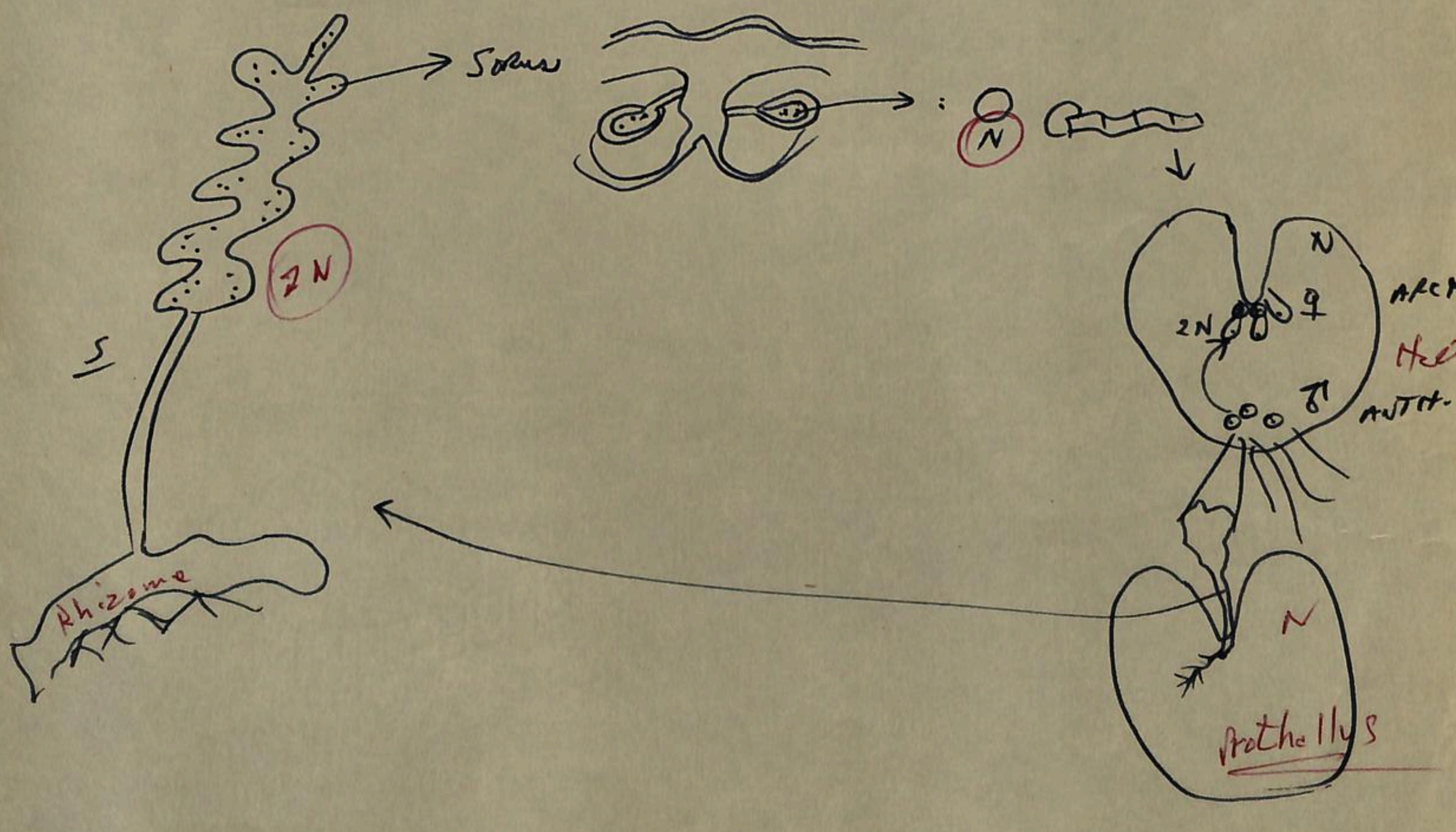
HETEROSPORY

Ferns ± 5,000 sp.

Characters:
- Lvs. large
- Swimming sperm
- Gametophytes independent
- Sporophytes ..
- No seeds. (Spores)
- Some tropical ferns - 40-50' high. ?
- Some ferns adapted to H_2O

Vascular tissue

Life Cycle of Fern



II. DIFFERENCES BETWEEN HIGHER PLANTS AND ANIMALS. Assigned Reading: Text, Chapter I.

A. Photosynthesis: Green plants are entirely independent, making own food. They do not need locomotion but require light, water, and CO_2.

B. Essential or primary amino acids needed for proteins by plant and animal are synthesized only by plants.

C. Lack of nervous system results in correlation of parts by hormones, vitamins and enzymes as chemical regulators. Reactions are slow when compared to resulting from a nervous system. Vitamins function as regulators of respiration and in the correlation of plant parts.

D. As plants need circulation of sap but have no heart to act as pump, they depend on high osmotic pressure for transport of body fluids in vascular (circulatory) tissues. High O.P. leads to a need for cell walls to prevent rupture. Circulation has no red corpuscles, and hence lacks respiratory function of blood.

E. Plant cells, in contrast to those of animals, are surrounded with inelastic walls of cellulose, making cells fairly rigid. Immobility of plants (lack of locomotion) is largely a result of cell walls which often become woody (lignified) or corky when mature.

F. Plants lack an excretory system and must re-utilize or detoxicate their waste products. Many such products are of economic use.

G. Plants possess persistent terminal and lateral meristems, and potentially unlimited growth. Plants do not mature as an entity, retaining considerable embryonic tissue.

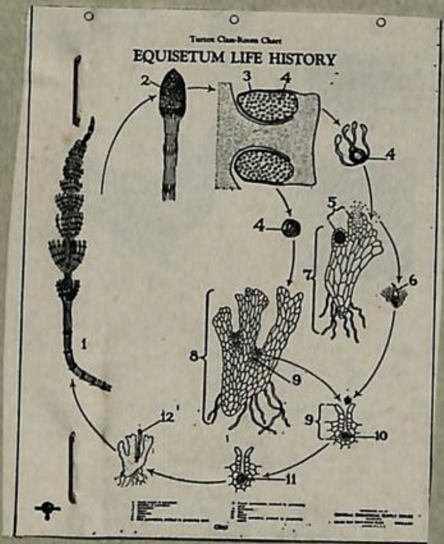
H. Animals and green plants have a reciprocal relationship in nature, largely in oxygen (O_2) and carbon-dioxide (CO_2) exchange.

III. SEED PLANTS (SPERMATOPHYTES) compromise two sub-divisions:

A. Gymnosperms: Conifers, needle-leaved, evergreen, cones, all trees. Name implies "naked seed" due to lack of fruit (ovary). No colored flower parts, no petals or sepals, wind pollinated.

HORSETAILS (EQUISETUM) SPHENOPSIDA HOMOSPOROUS

CHARACTERS: STEMS JOINTED , HOLLOW, WITH SILICA (SCOURING RUSH)
LVS. IN WHORLS.



FERNS PTEROPSIDA

CHARACTERS: LVS LARGE.

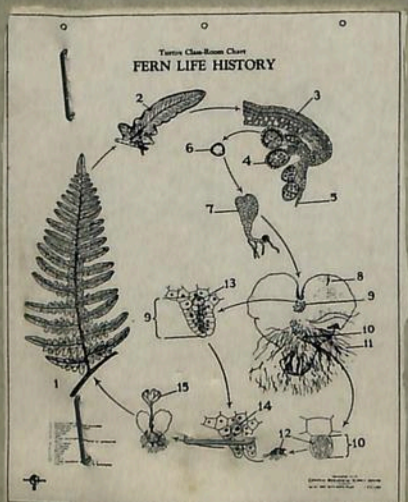
INCREASE IN SIZE OF SPOROPHYTE (2N)

NO SEEDS (SPORES)

GAMETOPHYTE & SPOROPHYTE INDEPENDENT.

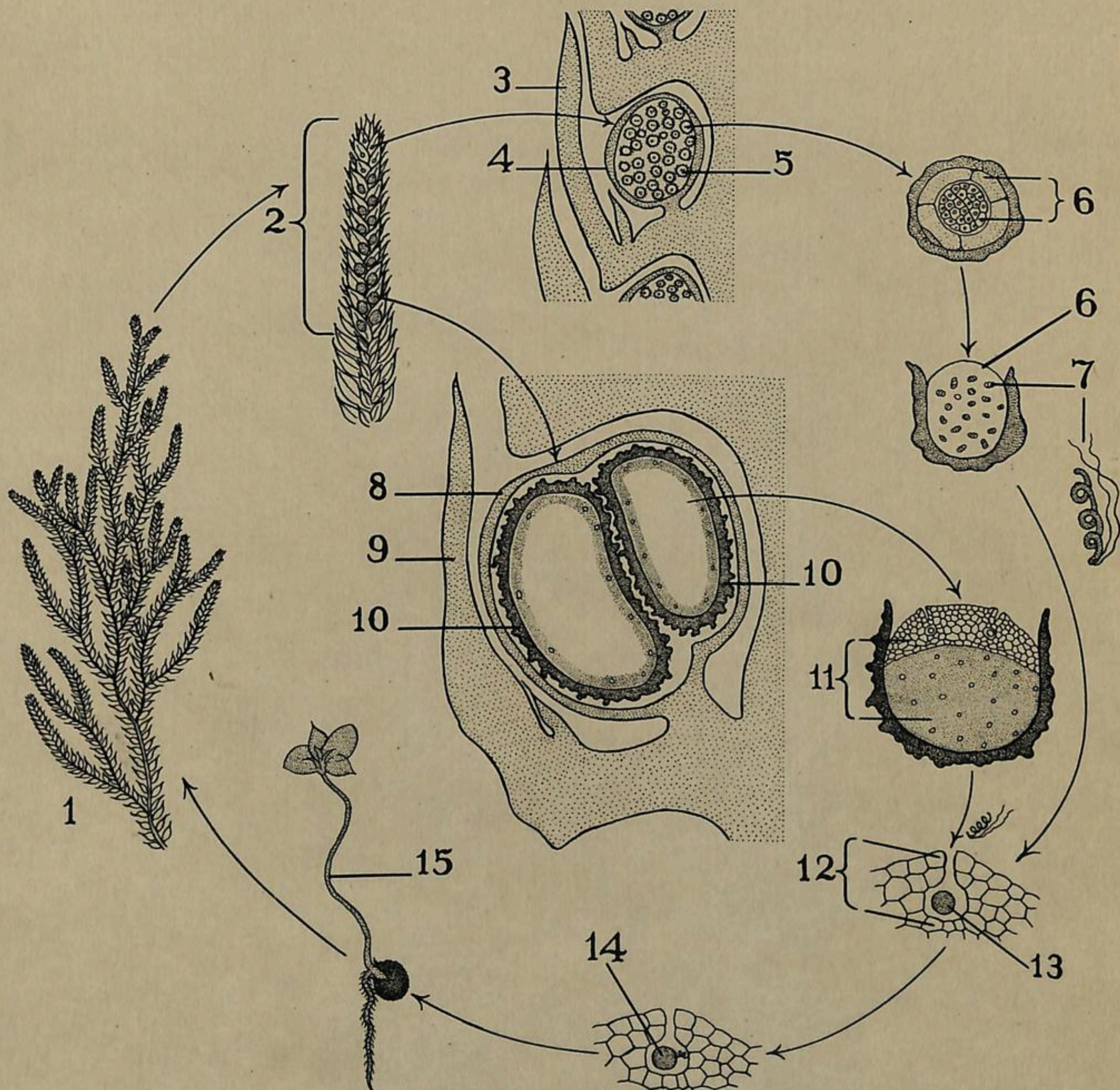
(SOME TROPICAL FORMS 40-50 ft. HIGH.)

LIFE CYCLE



[SORUS [Gr. Heap]
(w. sporangia)

TURTOX KEY CARD
for
Selaginella Life History



1. Portion of plant (sporophyte)
2. Strobilus
3. Microsporophyll
4. Microsporangium
5. Microspore
6. Antheridium (male gametophyte), produced by germinating microspore
7. Sperm
8. Megasporangium
9. Megasporophyll
10. Megaspore, with developing female gametophyte
11. Female gametophyte, produced by germinating megaspore
12. Archegonium
13. Egg
14. Zygote
15. Young sporophyte, produced by germinating zygote

Subject No. 21.1

Div. — Tracheophyta = Vascular Plants

(-opsida = appearance Gr.)

SUBDIV. Psilopsida — Most primitive land plants. (gametophyte mycorrhizal)
(Gr. Naked - Slender)

Psilophytales - Fossil genera only — No Roots, No Leaves (alga-like), Rhizome, Primitive vascular tissue
ie Rhynia
Hornea
Asteroxylon

Psilotaceae - Modern Plants. Ancestors above
Simplest living Tracheophytes — Psilotum (Scaly lvs.), Tmesipteris (Broad lves.)

Lycopsida — Club-Mosses - Ground Pines
Gr. (wolf)

Fossils:
Lepidodendrales - Fossils only. (Giant club-mosses) — Lepidodendron, Sigillaria (see below) (trees)

Modern:
Lycopodiales - Lycopodium — Homosporous (Mycorrhizal gametophyte)
Selago - small juniper L.
Selaginellales - Selaginella (Little club-mosses) — Heterospory (approach to seed)
Isoetales - Q Isoetes (Quillworts)

Sphenopsida - Horsetails
(Sphen - wedge G.)
Equisetales - Fossil and Modern genera — Calamites
Equus - horse L.
Equisetum - Jointed stems
Small lvs. in whorls
Homosporous

THE DIVISION TRACHEOPHYTA

Plant body is the chief structure of the diplophase (sporophytic generation). Plants with specialized conducting cells found in the complex tissues xylem and phloem. Have archegonia --- except in angiosperms, in which embryo sac has developed.

Often called vascular plants.

A. Subdivision PSILOPSIDA: Leaves usually absent; if present, small and simple. Roots absent. Sporangia terminal on stems or branches.
   Order 1: Psilophytales - Ancient and simple vascular plants. All extinct. Examples: Rhynia, Horneophyton, Psilophyton, Asteroxylon.
   Order 2: Psilotales - Two living genera: Psilotum and Tmesipteris.

B. Subdivision LYCOPSIDA: Leaves simple, usually small, irregularly or spirally arranged (never whorled). Stems not jointed, as in horsetails. Sporangia borne singly in the axils of the fertile leaves (sporophylls). Sporophylls commonly reduced and grouped in terminal cones called strobili. Leaf gaps absent.

   Order 1: Lepiodendrales - The giant clubmosses, known only as fossils. In the genus Lepiodendron, 300 species have been named. In the genus Sigillaria, 400 species are known.
   Order 2: Lycopodiales - The big clubmosses. There were several hundred species; 180 species in the genus Lycopodium are still living.
   Order 3: Selaginales - The little clubmosses. There are 700 species in the genus Selaginella living today.
   Order 4: Isoetales - The quillworts. 64 species are known in the genus Isoetes. These are living species.

C. Subdivision SPHENOPSIDA. Leaves small and simple, arranged in whorls. Stems jointed. Several sporangia on modified sporophylls, arranged in strobili (cones). Leaf gaps absent. Known mostly as fossils
   Order 1: Sphenophylum - All extinct. Over 100 species described by paleobotanists.
   Order 2: Equisetales - The horsetails. 25 species in the genus Equisetum are living today.
   Order 3: Calamitales - All extinct. 300 Species have been described by paleobotanists.

D. Subdivision PTEROPSIDA. Leaves usually large and complex. Sporangia on sporophylls, called megasporophylls (with megaspores, which grow into female gametophyte) and microsporophylls (with microspores, which grow into the male gametophyte) in the heterosporous species. Many ferns have remained homosporous in evolution, despite the fact that the vegetative organs are well developed.
Class 1: FILICINEAE - Present day ferns. Sporangia numerous, on lower surface of sporophylls. Mostly homosporous. Fertilization by swimming sperms. 9000 species described in the literature.
Class 2: GYMNOSPERMAE - Seeds naked; pollen (young male gametophyte) deposited on or near the ovules.
   Order 1: Pteridospermae - The seed ferns. All extinct.
   Order 2: Bennettitales - Ancient tree ferns. All extinct.
   Order 3: Cycadales - The cycads. Many extinct species. There are 90 living species in several genera. Examples: Xamia, Cycas, Dioon. Sperms are motile. Regarded as the most primitive seed-bearing plants living today.
   Order 4: Early conifers. All extinct. Tall slender trees with simple leaves.
   Order 5: Ginkgoales - One living species Ginkgo biloba, the

"maiden-hair tree". Several extinct species, including some that grew on the North American continent.

Order 6: Coniferales - 550 species. Leaves mostly needle-like; evergreen, except for some cypresses and a few others. Male and female strobili (cones). Seeds on surface of scales (megasporophylls) of female cone. Sperms non-motile, conveyed to egg by pollen tube.

Order 7: Gnetales - There are 70 living species in the genera Gnetum, Welwitchia, and Ephedra.

Class 3: ANGIOSPERMAE. The flowering plants. Seeds enclosed by modified sporophylls called carpels. These carpels become the fruit. Leaves typically broad or long. Pollen deposited on stigma. Non-motile sperms transferred to the embryo sac (reduced female gametophyte) in center of ovule by a pollen tube.

Subclass 1: DICOTYLEDONAE -- 200,000 species. The dominant land plants.

Subclass 2: MONOCOTYLEDONAE. -- 50,000 species. Contain most important food producing cultivated plants, the cereals, sugar cane, and food palms (oil palms and date palms).

Table 21–4 *Vascular Plants: Phylum Tracheophyta*

		No. of species	Leaves	Gametophytes	Sperm	Seed
	Subphylum Lycophytina (Club mosses)	1,000	Microphylls, in spirals	Independent	Biflagellate	Not present in modern f
	Subphylum Sphenophytina (Horsetails)	12	Scalelike, in whorls	Independent	Multiflagellate	Not present
	Subphylum Pterophytina	More than 260,000	Megaphylls	Small, usually microscopic	Flagellated in some	Present in most forms
	Class Filicinae (Ferns)	11,000	Megaphylls	Independent	Flagellated	Not present in modern fo
Gymnosperms	Class Coniferinae	550	Megaphylls, often reduced to needles or scales	Dependent, reduced	Not flagellated, carried in pollen tubes	Present, naked seed
	Class Cycadinae	100	Megaphylls, large and fanlike	Dependent, reduced	Flagellated but carried in pollen tubes	Present, naked seed
	Class Ginkgoidae	1	Megaphylls, fanlike	Dependent, reduced	Flagellated but carried in pollen tubes	Present, naked seed
	Class Gnetinae	70	Megaphylls, often scalelike	Dependent, reduced	Not flagellated, carried in pollen tubes	Present, naked seed
	Class Angiospermae (Flowering plants)	About 250,000	Megaphylls	Greatly reduced	Not flagellated, carried in pollen tubes	Present, enclosed in mature ovary (fruit)

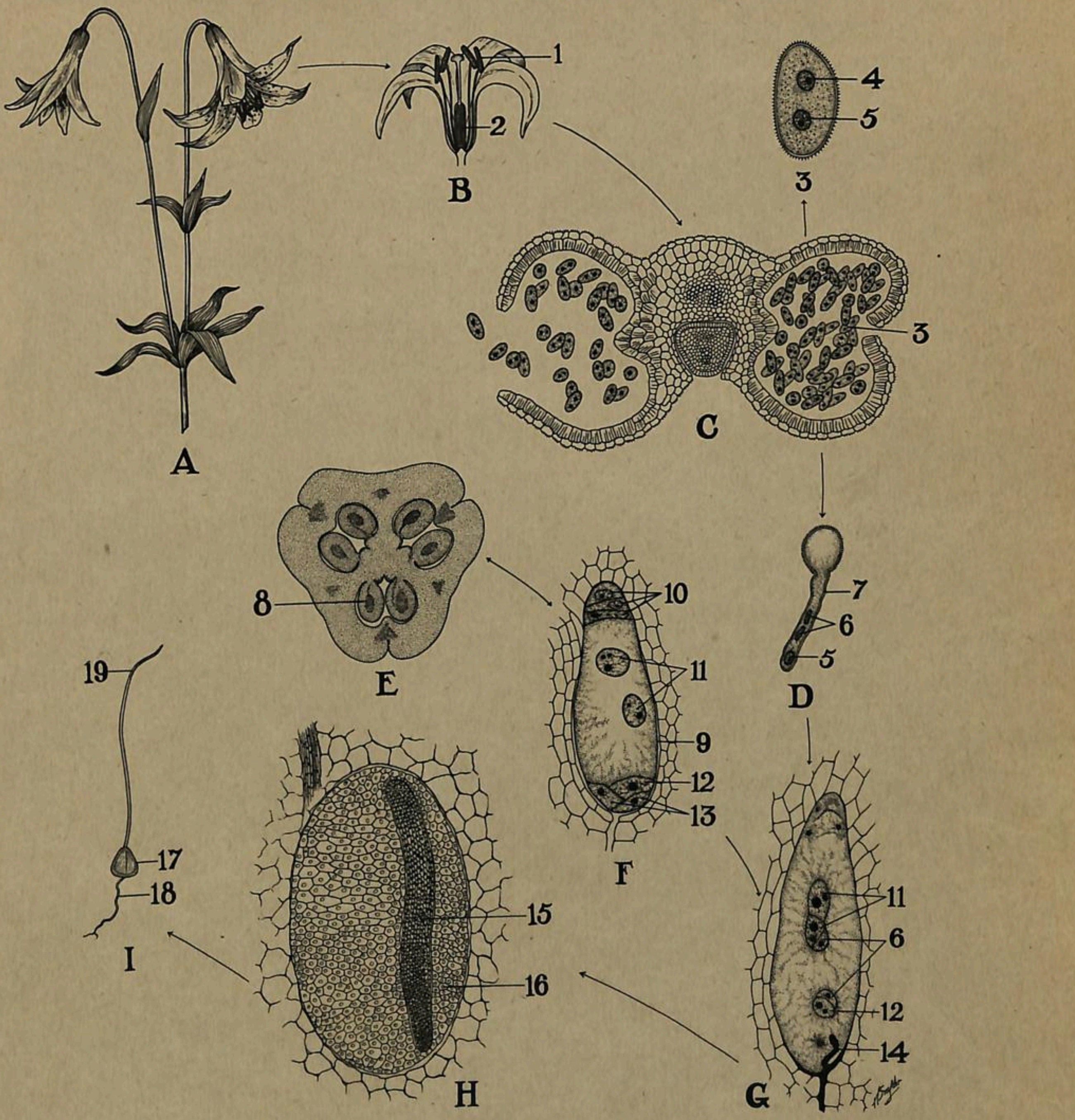
Class Filicinae: Ferns

Ferns are vascular plants that are generally distinguishable from most oth plants by their large feathery leaves that, in most species, unroll from base to during growth. The sporangia are on the undersurface of the leaves or, som times, on specialized leaves. Such spore-bearing leaves are called *sporophy* As we shall see, the carpels and stamens of flowers are also sporophylls.

According to the fossil record, ferns first appeared almost 400 million yea ago, and they have remained relatively abundant until the present time. Most the 11,000 living species in this class are found in tropical regions, but so occur in temperate and even arid portions of the globe. Because they ha flagellated sperm and need free water for fertilization, those species grow in arid regions must, like the bryophytes, exploit the seasonal occurrence water for sexual reproduction.

Ferns have anatomically simple stems compared with those of gymn sperms and angiosperms, and these stems are often reduced to a creep for

Lily Life History



A. Habit of plant
B. Longitudinal section of flower
C. Cross section of anther
D. Germinating pollen grain
E. Cross section of ovary
F. Section of ovule—8 nucleate stage
G. Section of ovule, double-fertilization stage
H. Section showing embryo
I. Seedling (habit)

1. Anther
2. Ovary
3. Pollen grain
4. Generative nucleus
5. Tube nucleus
6. Sperm nuclei
7. Pollen tube
8. Ovule
9. Embryo sac
10. Antipodal cells
11. Polar nuclei
12. Egg nucleus
13. Synergids
14. Remains of pollen tube
15. Embryo
16. Endosperm
17. Seed
18. Root
19. Leaf

TURTOX PRODUCTS

Subject No. 6K701 22.5

ADVANCE OF BRYOPHYTA OVER ALGAE ..... (LAND vs WATER ENVIRON.)

MULTICELLULAR SEX ORGANS (JACKET CELLS FOR PROTECTION)

GAMETANGIA EMBEDDED IN THALLUS.

ACCESSORY ENVELOPES.

SURROUNDING "LEAVES".

PARAPHYSES (AGAINST DRYING OUT)

HEPATICS	ANTHOCEROS	MOSSES
PROTONEMA RUDIMENTARY	THALLOID GAMETOPHYTE with SINGLE PYRENOID & CHLOROPLAST IN EACH CELL.	PROTONEMA FILAMENTOUS, LEAFY (ie TWO*PHASE GAMETOPH.
DORSO*VENTRAL FLATTENING: THALLOID OR LEAFY	STOMATA IN SPOROPHYTE.	GREATER DIFFERENTIATION (STEM & LEAF; also COSTA IN MANY).
LEAF WITHOUT COSTA	BASAL MERISTEM.	CAPSULE WITH PERISTO OFTEN.
LVS. OFTEN LOBED OR TIPS DIVIDED.	ARCH. & ANTHERID. SUNK IN THALLUS.	CALYPTRA.
CAPSULE WITHOUT PERISTOME	COLUMELLA.	Stomata

ALGAE

Pro

BRYOPHYTA ← EMBRYOPHYTA

small land plants

LYCOPHYTINA
CLUB MOSS

TRACEOPHYTA
xylem - wood
phloem - bark

SPHENO -
HORSETAILS

PTERO -

FERNS

sporophyte
Gameto -

GYMNOSPERMS
CONIFERS
CYCADS

archegonia
antheridia

ANGIO ← MONOCOTS
DICOTS

N, 2N, N

Flower

CAMBIUM

MONOECIOUS VS DI -

ALTERNATION OF GENERATIONS

*GAMETANGIUM

• JENNER - 1796 / '98

milkmaids { SMALLPOX (VIRUS) / COWPOX

• SEMMELWEISS - 1847

→ • LISTER - 1867

CARBOLIC ACID = PHENOL

• PASTEUR - ① 1865 GERM THEORY

ABIOGENESIS 1864

② 1881 - ANTHRAX sheep

③ 1885 - RABIES J. Meister 1940

1) LEEUWENHOEK - 1683

2) JENNER - 1798

COWPOX / SMALLPOX

1802 - Brit. Royal Fam. VACCINATED

LADY MARY 1717

• KOCH - POSTULATES:

1876 - ANTHRAX

1881 - CHOLERA

1882 - TB

• SALK - 1955 (dead vacc.)

POLIO -

• SABIN - 1960 (live)

VACCINES

in DISEASE CONTROL

BEIJERINCK - 1898

TMV

STANLEY - 1935

CRYSTALS

Spermatophyta

1) Gymnosperm ... "naked seed"; wind pollinated; cones. Tracheids

2) Angiosperm ... "covered seed"; insect, water pollinated; flowers. Vessels.

   a) Monocotyledon ... stem, leaf, flower characteristics — 3's

   b) Dicotyledon ... " " " — 4's

Metagenesis in flowering plant

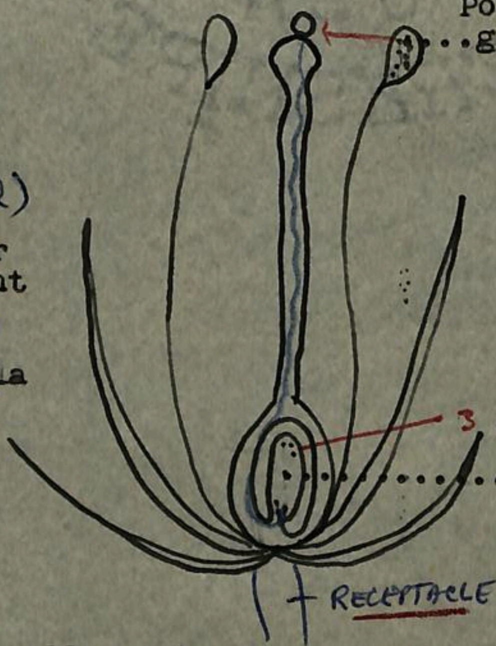
STAMINATE VS PISTILLATE FLS.

PERFECT VS IMPERFECT

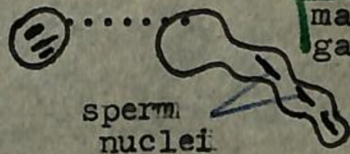
MICROSPORANGIUM

COMPLETE VS INC.

- Pistil — stigma, style, ovary (megasporophyll)
- Stamen — anther, filament (microsporophyll)
- Petals — corolla
- Sepals — calyx



Pollen grain



male gametophyte

sperm nuclei ..tube nucleus

SELF VS CROSS POLLINATION.
> GRASSES

H_2O, WIND, INSECTS, BIRDS, MAN.

megasporangium ... Ovule with 8 nuclei — 3 ANTIPODAL, 2 POLAR, 2 SYNERGIDS, 1 EGG

female gametophyte

[2 Polar + 1 sperm → ENDOSPERM 3N (double fertilization)]

Growth of pollen tube down pistil tissues; disposition of nuclei of pollen tube; fertilization (double); zygote, embryo, sporophyte. endospermm nucleus. SEED Fruit — MATURE OVARY + ACCESSORY STRUCTURES. ie APPLE, PEAR — RECEPTACLE ENLARGED

Reduction in size of gametophytes (microscopic); increase in size of sporophyte.

1) SIMPLE → SINGLE PISTIL (APPLE) POME

2) AGGREGATE → α PISTILS FROM 1 FLOWER (STRAWBERRY, BLACK—)

3) MULTIPLE → α OVARIES .. α FLS (MULBERRY, PINEAPPLE, FIG)

{ SEEDLESS FRUITS / PARTHENOCARPY (NAVEL ORANGE, GRAPE, BANANA, PINEAPPLE

GYMNOSPERMS	ANGIOSPERMS < MONOCOT / DICOT
OVULE NAKED	OVULE ENCLOSED IN OVARY
POLLEN FALLS DIRECTLY ON OVULE	POLLEN ON STIGMA (FLOWER)
WIND POLLINATED	OTHER AGENCIES (ANIMALS WATER)
CONES	FLOWERS, FRUITS
ARCHEGONIA	NO ARCHEGONIA
ALL WOODY (TRACHEIDS)	WOODY & HERBACEOUS (TRACHEAE)
RESIN DUCTS	NONE
"EVERGREEN"	"DECIDUOUS"
MANY FREE NUCLEI IN GAMETOPHYTE	TYPICALLY 8 NUCLEI
ENDOSPERM HAPLOID	TRIPLOID (DOUBLE FERTILIZ.)
MANY COTYLEDONS	ONE OR TWO
CLOSED BUNDLES (NO CAMBIUM)	CAMBIUM IN MOST
NO COMPANION CELLS	PRESENT
LVS. NEEDLE SHAPED OFTEN	LVS. MOSTLY BROAD

METAGENESIS

ALT. OF GEN

MOSS — SPOROPHYTE 2N

FERN — ↓

±10,000 — GAMETOPHYTE N

VASCULAR PLANTS { TRACHEOPHYTA

FERNS

LYCOPODS ← CLUB MOSS, HORSE TAIL

GYMNOSP. ("EVER GREENS") NO ROOT, STEM, LEAF

ANGIOSP.

ALGAE

BRYOPH

CONIFERS — ABIES

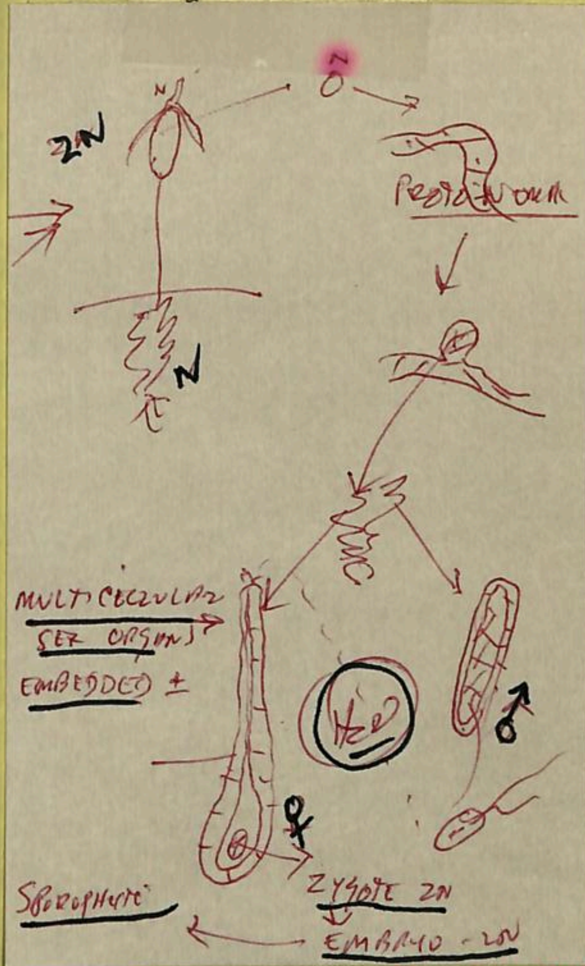
CYCADS — PINE, FIR, SPRUCE

CYPRESS → TAXODIUM

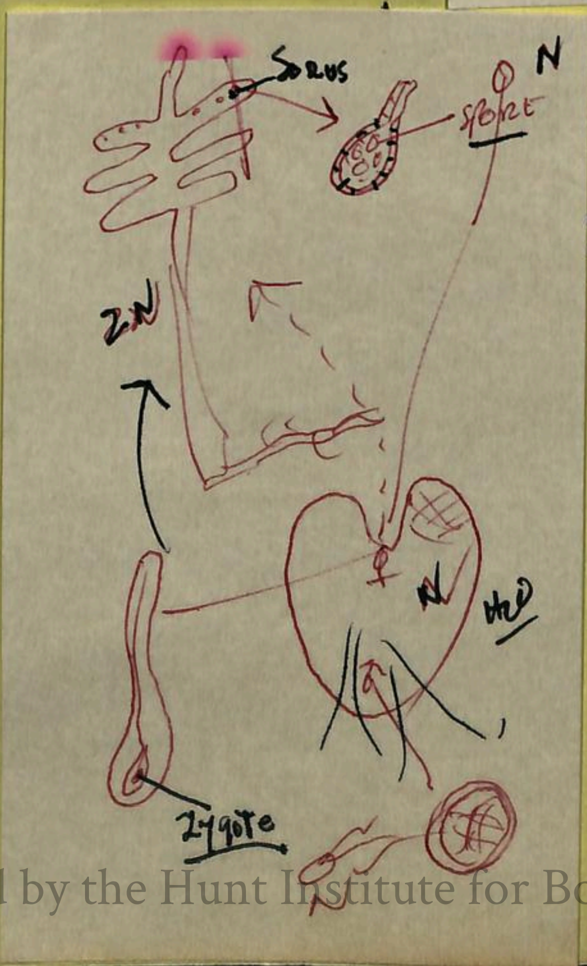
SPRUCE → PICEA

HEMLOCK → TSUGA

±500



gametophyte reduction



— EMBRYOPHYTA —

Phylum — TRACHEOPHYTA

Subphylum — LYCOPHYTINA (Gr. wolf) — CLUB MOSS

SPHENO (Gr. wedge) — HORSE TAILS, EQUISETUM

PTEROPHYTINA (Gr. wing) — FERNS

SEED — GYMNOSPERM → Ginkgo, Cycads, Conifers

FLOWER — ANGIO → MONOCOTS (orchids, grasses, Palms, Lily), DICOTS (Legumes, Rosaceae, Common trees, etc.)

3's vs 4-5's

leaf venation

1 vs 2 cotyledons

± CAMBIUM

SPERMATOPHYTA (CIRCA 200,000.)

SEED PLANTS ..

GYMNOSPERMS ..(NAKED SEED) (500 spp.) — CONES

CYCADS

CONIFERS } CONES NEEDLES TRACHEIDS "EVERGREEN"

ANGIOSPERMS (COVERED SEED)(FLOWERS)

MONOCOTS } GRAINS → ORCHID } flower parts in 3's 6's

DICOTS } flower parts in 4's & 5's

GYMNOSPERMS: ("EVERGREEN")

ALL WOODY (TRACHEIDS) (MOSTLY TREES)

ACTIVE XXXMM CAMBIUM

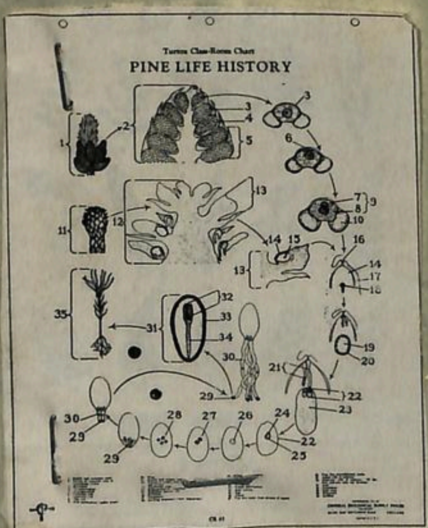
WIND POLLINATION

NO FRUITS

REDUCTION OF

SEED NAKED

PINE LIF



Pteropsida — Ferns — Living & Fossil
(Pteris — Wing Gr.)
Tree Ferns (40 ft.) ± Tropical

Large lvs
Leaf gaps (breaks in vascular syst. to lvs.)
Diversified Stele

Class: ① Filicineae

Mostly Homosporous (all "common" genera)
Some Heterosporous (H_2O Ferns)

Fern Cycle — Metagenesis Ⓝ / (2N)
Sporophyte — Gametophyte

— all heterosporous

Class: ② Gymnospermae — "Naked Seeds"

± 1000 spp.

Cycadales — Thick unbranched stem; Large, Fern-Like lvs; Little xylem - Large Cortex

Ginkgoales — "Living Fossil" (Mesozoic); Simple Lvs — dichotomously branched

Coniferales — Dominant Gymnosperm today; "Evergreens" (Sequoia, Pinus, Taxus etc.)

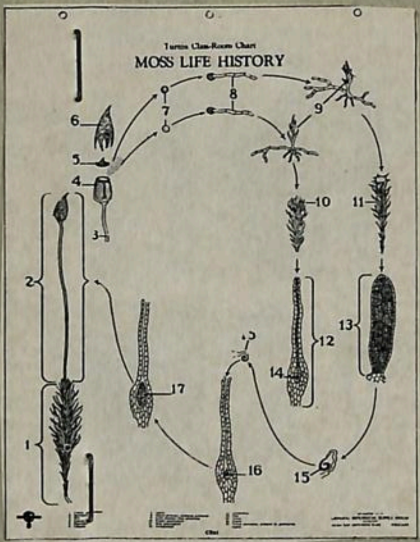
Class: ③ Angiospermae — "Covered Seeds" — Flowering Plants

Dicotyledoneae ± 150,000 — 2 COTYL.; RING OF VASCULAR TISSUE + CAMBIUM; NETTED VEINS IN LEAF; FLORAL PTS 4–5
Ex. LEGUMINOSEAE, ROSACEAE, ERICACEAE

Monocotyledoneae ± 30,000 — 1 COTYL.; SCATTERED VASC. TISS. — NO CAMBIUM; PARALLEL VEINS; FLORAL 3s.
Ex. GRAMINEAE, PALMACEAE, LILIACEAE

(1 - 15)

LIFE CYCLE MOSS .



✓ EMBRYOPHYTA [Gr. swelling]
✓ X-CELLED SEX ORGANS

MONOECIOUS or DI

PEAT

METAGENIC CYCLE

SPOROPHYTE DEPENDENT.

N ⇄ 2N

PTERIDOPHYTA (5000.)

THESE & REMAINING PLANTS TO BE DISCUSSED ARE TRACHEOPHYTA (XYL.& PHL.)
SPOROPHYTE PREDOMINANT GENERATION. GAMETOPHYTE REDUCED.
TRUE LVS. STEMS ROOTS.

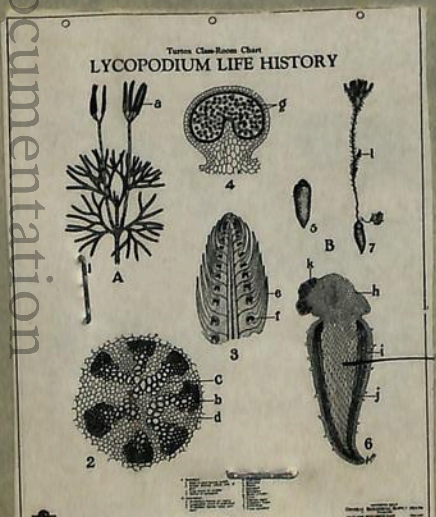
3 MAJOR GROUPS INCLUDED: CLUB MOSSES (LYCOPSIDA)
HORSETAILS (SPHENOPSIDA... EQUISETUM)
FERNS

HOMOSPOROUS STROBILI

CHARACTERISTICS: CLUB MOSSES: (LYCOPODIUM SELAGINELLA) → HETEROSPOROUS → CLOSE TO SEED.

BUT: NO SEED COAT, NO DORMANT P.

LVS SPIRALLY ARRANGED
LEAF WITH ONE VASCULAR BUNDLE
GAMETOPHYTE SMALL (INCH) NO CHLOROPHYLL
ROOTS STEMS DICHOTOMOUSLY BRANCHED
SPOROPHYTE CLUB*SHAPED.



→ GAMETOPHYTE (N) < ANTHERIDIA → SPERM (N) / ARCHEGONIA → EGG (N) > ZYGOTE (2N) → SPOROPHYTE (2N) → R.D. → SPORES → GAMETOPHYTE

NO VASCULAR TISSUE

Phyta cont'd →

Bryophyta:

- Produce an embryo ✓
- Multicellular sex organs
- Heterogamous reproduction (oogamy)

No true root, stem, leaf.

[Advanced over Algae: i.e. sex organs > protection]

{Liverworts} mostly flat-ribbon-like thalli (dorso-ventral)
{Mosses} Erect habit mostly

* Metagenesis: gametophyte stage predominant. [Trend established – thru Land Plants]

Importance to Man:

Few direct uses: ext. Peat as fuel – largely unexploited (Sphagnum)

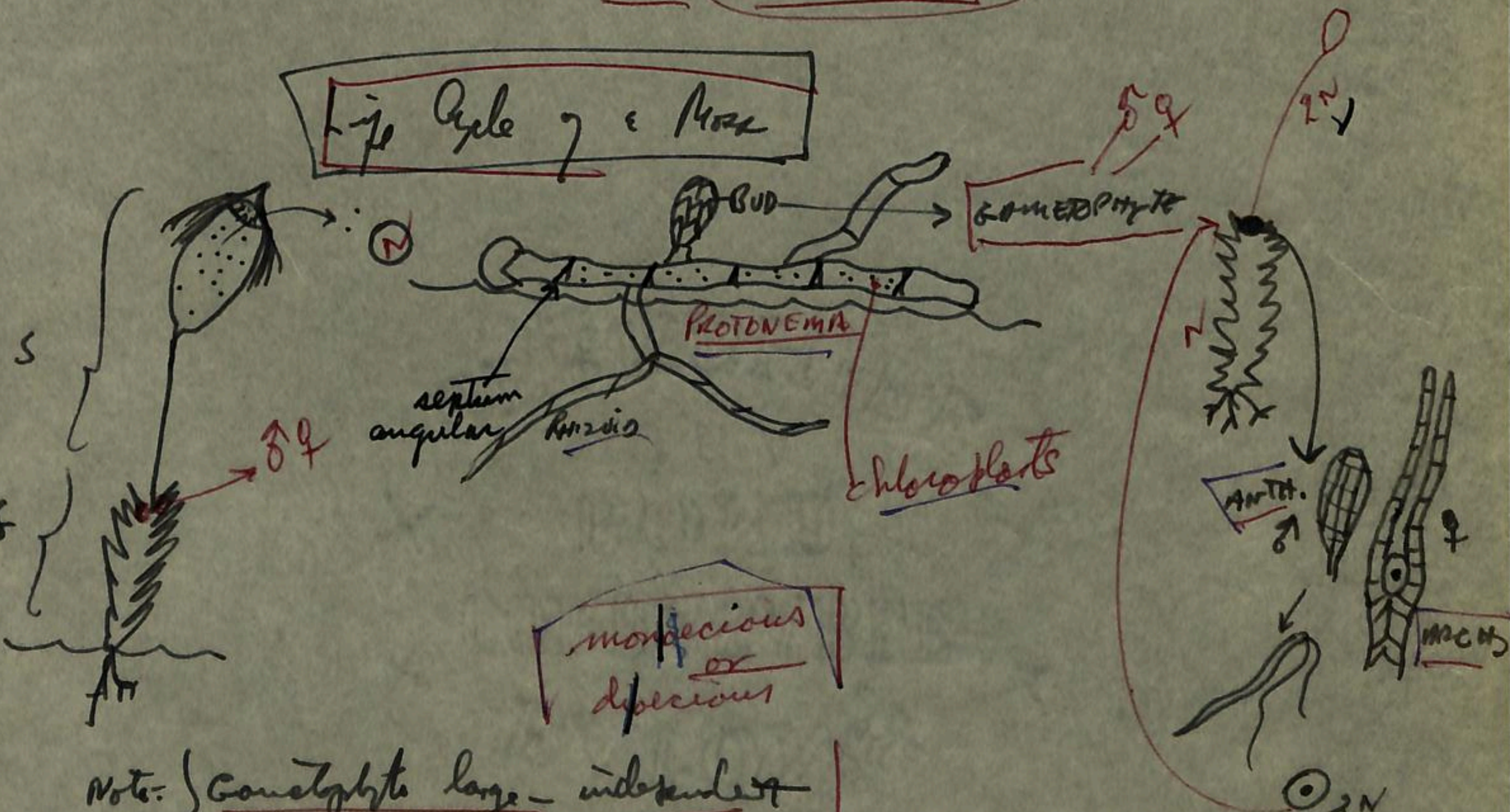
✓ Surgical dressings in early wars (high absorptive properties)

✓ Packing material

Many rock inhabitants – ~~most~~ build soils

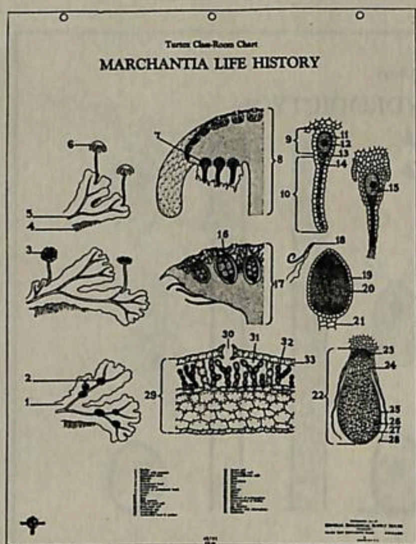
Prevent soil erosion

Life Cycle of a Moss

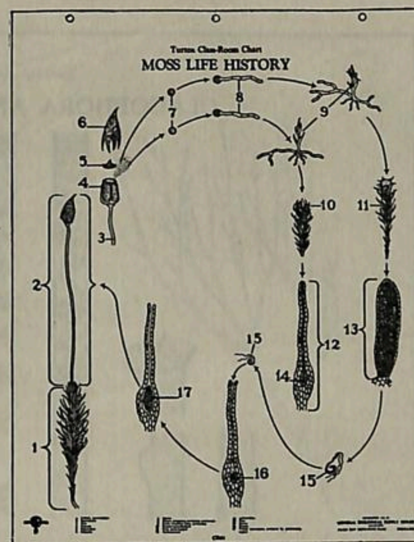


Note: {Gametophyte large – independent
{Sporophyte small – dependent

⊙ 2N
↓
Sporophyte



CR60



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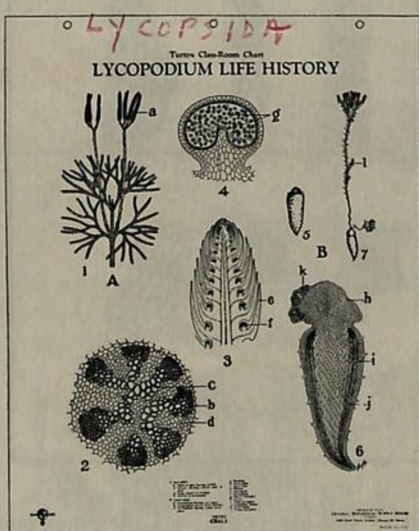

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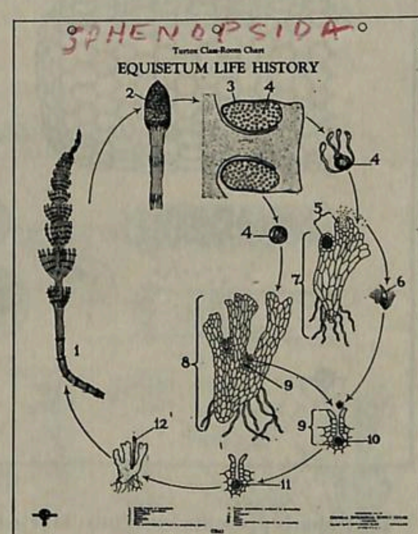


CR63

CR50.05 **Blue-Green Algae.** Structure and detail of Oscillatoria, Gloeocapsa, Nostoc and Gleotrichia. Nine drawings.

CR50.12 **Volvocales.** Drawings of principal representatives.

CR50.1 **Volvox.** Nine drawings of stages in life cycle.

CR51 **Spirogyra.** Vegetative cell and three stages in conjugation. Four drawings.

CR51.01 **Cladophora and Hydrodictyon.** Detailed drawings in stages in life cycle.

CR52 **Ulothrix.** Ten drawings of all stages in the life cycle.

CR53 **Oedogonium.** Life cycle. Fourteen drawings

CR53.2 **Desmids.** Drawings of fifteen types.

CR54 **Vaucheria.** Life cycle. Nine drawings.

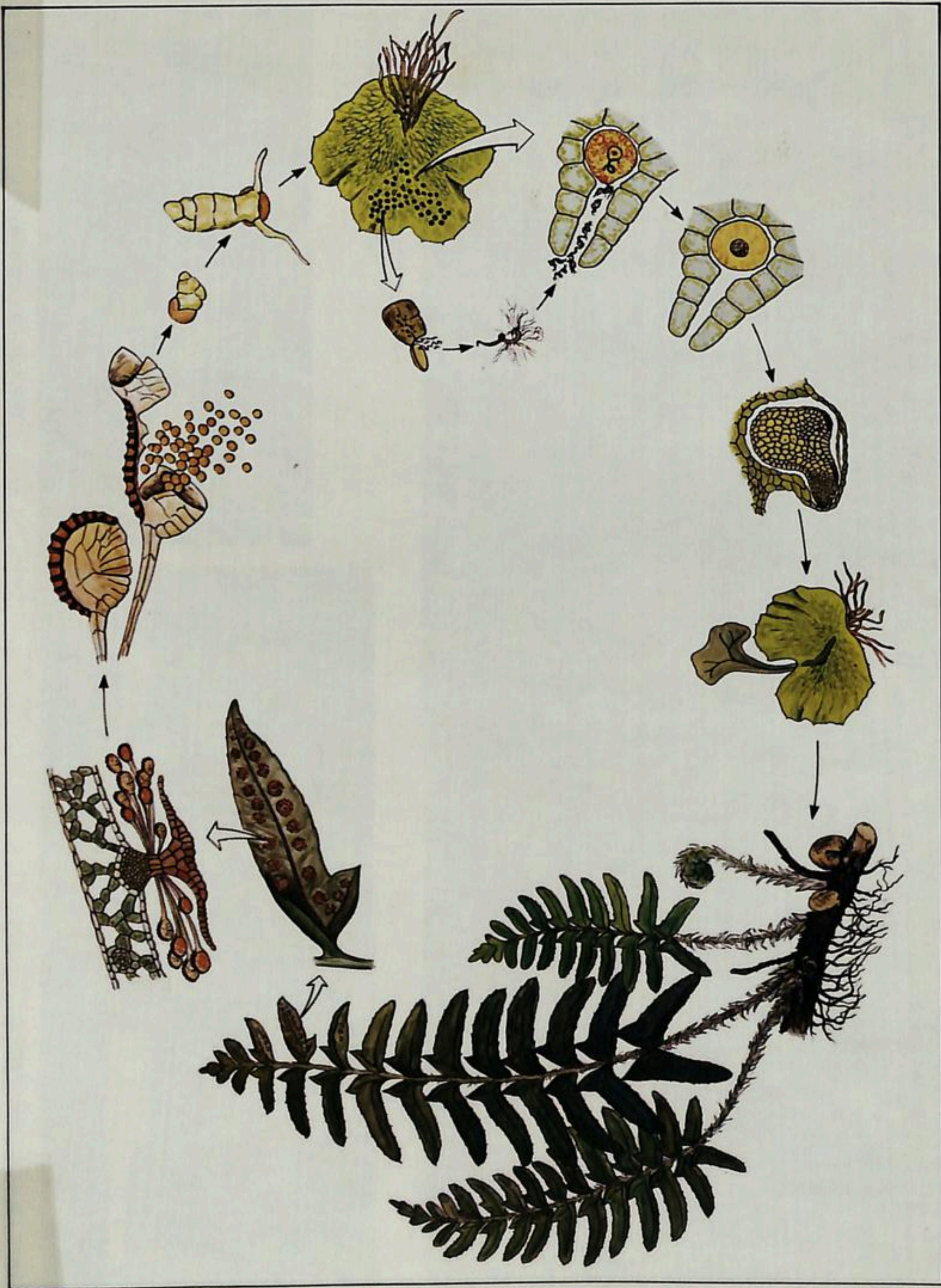
CR54.1 **Chara.** Ten drawings of structure, and life cycle.

CR55 **Ectocarpus.** Eight drawings of structure, and life cycle.

CR56 **Fucus.** Ten drawings of structure and life cycle.

CR56.1 **Diatoms.** Sixteen drawings illustrating twelve of the most important forms.

Prices for Turtox Class-Room Charts are shown on page 314.



Fern Life Cycle

Ginkgo — "Maidenhair tree" — i.e. leaves like *Adiantum*

China native — descendant of Mesozoic.

Resembles Conifers most.

Leaves bilobed, dichotomously branched veins.

Trees either staminate or ovulate.

Development generally as in Cycads.

♂ gametophyte } Pollen grain w. motile sperm.

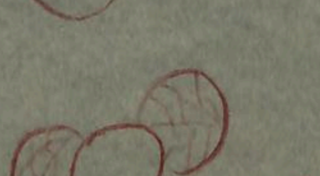
♀ gametophyte } Ovule w. archegonia } → Seed w. fleshy outer integument.

"Cone-bearers" but not all. Conifers ± 400 spp.

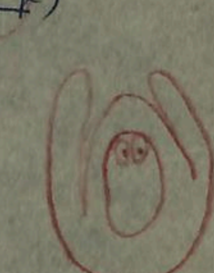
Pine, Hemlock, Yew, Spruce, Fir

Among tallest of Trees: Sequoia, Pseudotsuga. Monoecious mostly i.e. both cones on same tree

Staminate Cone (Small)
↓
Microsporophylls
↓
2 Microsporangia
↓
Microspores (N) (Pollen grains) ⇛ Fertilization ——→



Ovulate Cone (Large)
↓
Megasporophyll
↓
2 Megasporangia
↓
Ovules (N) — Archegonia w. Egg (N)
↓
Seed (Embryo (2N) + Endosperm (N) + Coat (N))



1st Sister Lectures: T.Th.S. 8-9 AM 10-11 — First Semester: Dec.9 - Jan. 24.

BIOLOGICAL SCIENCES — 2nd "

#2

Justification for study of BOTANY:

omit

1. SOURCE OF FOOD SUPPLY FOR ALL ANIMALS. (CLOTHING, HOUSING, MEDICINE etc.) — all ENERGY
2. ONLY AUTOTROPHIC ORGANISMS: (SOME BACTERIA).
3. Cultural considerations.
4. PROFESSIONAL TRAINING. (AGRIC., TEACHING, FORESTRY , ANTIBIOTICS etc)

Gr. Logos = DISCOURSE

BRANCHES OF BOTANY:

TAXONOMY (Gr. = arrangement / Gr. nomos = LAW)
MORPHOLOGY (Gr. = form)
ECOLOGY (Gr. oikos = house)
CYTOLOGY (Gr. = hollow place)
PATHOLOGY (Gr. = suffering)
PHYSIOLOGY (Gr. = nature or constitution)
PALEONTOLOGY (Gr. = old)
GENETICS
AGRONOMY (Gr. = field)
POMOLOGY

BRIEF SURVEY OF PHYLA:

NUMERICALLY .... THALLOPHYTA (ALGAE) .. 30,000

FUNGI ... 100,000.

BACTERIA ... 5,000.

BRYOPHYTA ... 25,000. (MOSSES LIVERWORTS)

PTERIDOPHYTA .... 5,000. (FERNS, CLUB*MOSS,

SPERMATOPHYTA .... 200,000. (SEED PL)

TOTAL .. 355,000.

(compare with ANIMALS: about 1 MILLION).

(850,000. insects.)

1960

- COLEOPTERA: 276,000
- LEPIDOPTERA: 112,000
- HYMENOPTERA: 103,000
- ORTHOPTERA: 22,000

CHARACTERISTICS OF THE PHYLA: (ARRANGED PHYLOGENETICALLY) ?

THALLOPHYTA: (Negative characters:)

ALGAE
BACTERIA
FUNGI

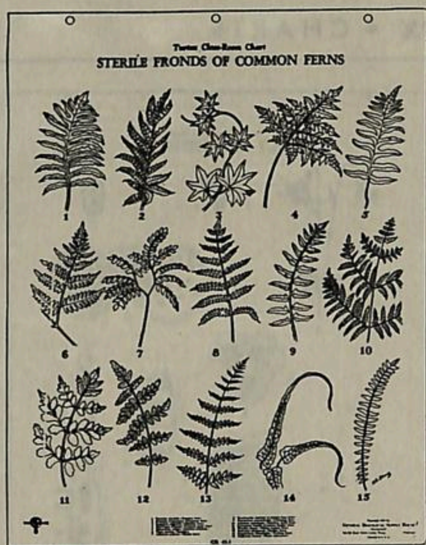
LACK TRUE LEAVES, STEMS, ROOTS.

LACK EMBRYOS. (or without protective structures)

(positive characters)

SEX ORGANS UNICELLULAR (no protecting envelopes)

CHIEFLY AQUATIC (some in soil, bark of trees etc)



CR63.1

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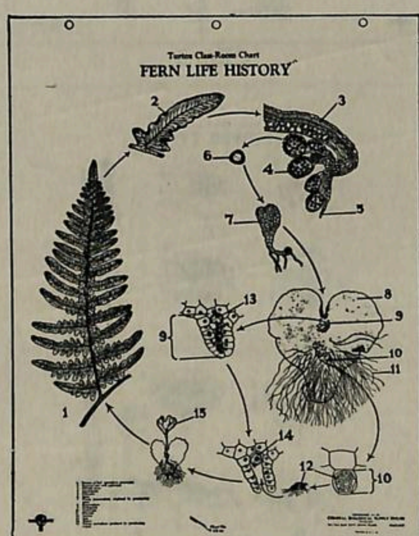
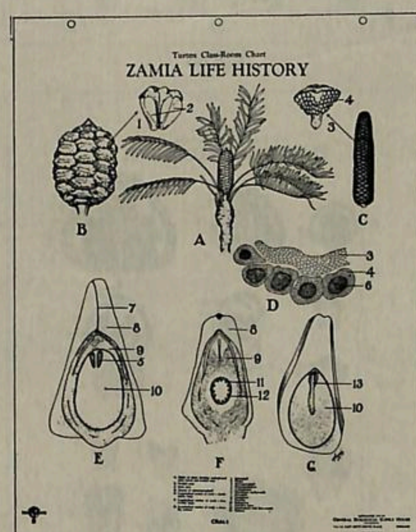


CR64



CR64.1

CR57 Polysiphonia. Eight drawings of structure and life cycle.

CR58 Rhizopus (Bread Mold). Nine drawings of structure and life cycle.

CR58.01 Slime Molds or Myxomycetes. Enlarged habit sketches of six species.

CR58.02 Yeast. A series of 16 drawings of various types of yeast.

CR58.1 Saprolegnia. Habit and reproduction. Four drawings.

CR58.2 Lichens. Details of Physica and habit sketches of four types.

CR58.3 Peziza. Habit sketch and details of spore formation.

CR58.4 Powdery Mildews. Seven of the most generally studied forms.

CR58.5 Penicillium and Aspergillus. Details of structure and development. Eight drawings.

CR58.6 Dutch Elm Disease. Details of organism, carrier and damage. Eleven drawings.

CR59 Puccinia (Wheat Rust). All details of the life cycle. Eight drawings.

CR59.1 Mushroom. Life cycle of Coprinus and details of structure and spore formation. Four drawings.

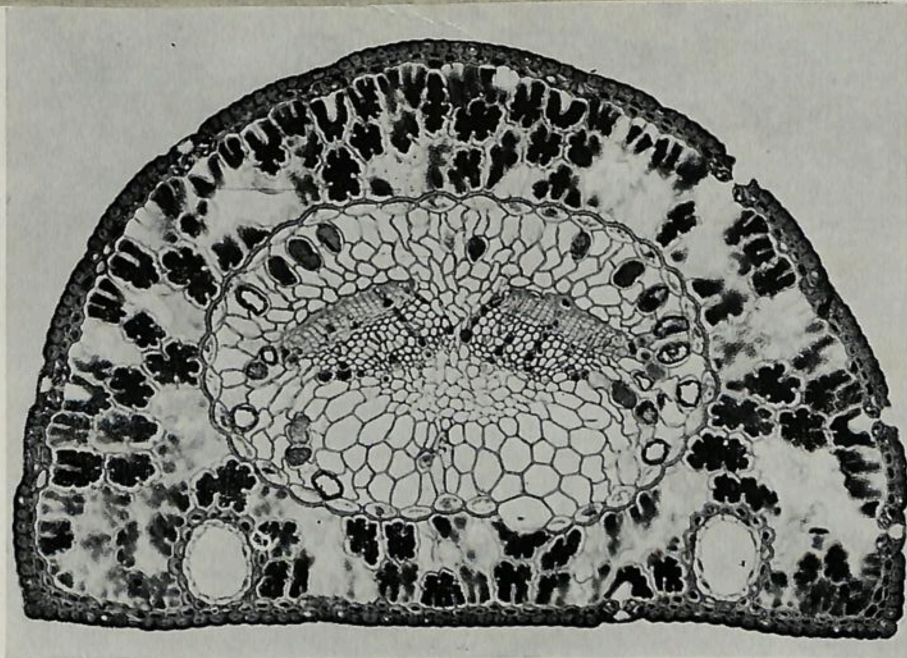
CR59.2 Common Fleshy Fungi. Drawings of nine types, including Amanita, earthstar, puffball, etc.

CR59.3 Morchella. Life cycle and details of structure and spore formation.

CR59.4 Common Woody Fungi. Sixteen drawings.

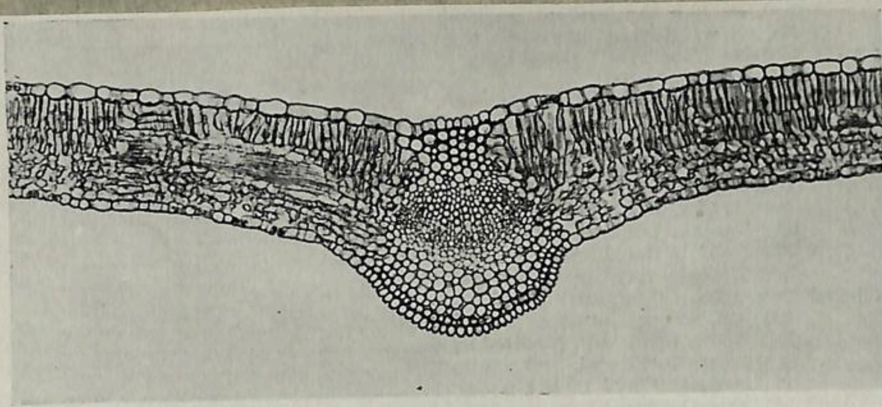
Set CR-971 Algae. A survey and identification set of 13 Turtox Class-Room Charts of more than 18 fresh-water and marine algae....................................$12.60

Set of CR-976 Fungi. Set of 14 Turtox Class-Room Charts of more than 20 fungi. 13.60



35-44 c2 **Pinus resinosa** leaf, a 2-needle type. (20X)

BL



50-586 b **Syringa leaf x.s.** (100X)

48

50-402 **Nerium** (Oleander) leaf x.s., showing a group of sunken stomates. (200X)

44

TRANSPIRATION (cont'd.)

LOSS OF WATER IN VAPOR FORM FROM PLANTS. (HAZARD)

(zb. SINGLE CORN PLNT MAY? LOSE ½ GAL. WATER/ DAY DURING GROWING SEASON.)

LOSS IS MOSTLY THRU STOMATA (90%).

FACTORS INVOLVED:

- TEMP. (HIGHER THE GREATER LOSS)
- LIGHT (GREATER IN BRIGHT LIGHT .. STOMATA OPEN)
- WIND (HIGH VELOCITY GREATER)
- HUMIDITY (HIGH HUM. SMALLER LOSS)
- SOIL (VARIOUS FACTORS)

BUT: RISE OF SAP PARTLY DUE TO "TRANSPIRATION STREAM".

COOLING EFFECT ON LEAVES (HIGH TEMP. MAY DAMAGE LVS.)

EXCESSIVE WATER LOSS → WILTING .... DEATH

ABOUT 10% WATER TAKEN UP BY ROOTS USED IN PHOTOSYNTHESIS.

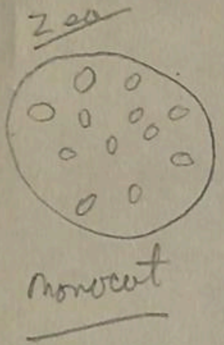
WATER LOSS THRU GUTTATION (LIQUIS WATER THRU HYDATHODES)

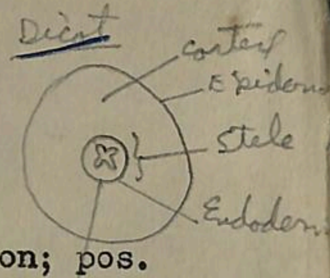
ADAPTATIONS OF PLANT TO PREVENT EXCESSIVE LOSS:

- CUTIN
- SUBERIN
- SUNKEN STOMATA
- DECREASE LF. SURF.

Rise of H_2O

1) Root Pressure
2) Transpiration
3) H_2O Cohesion
4) Capillarity $h = \frac{2T}{r d g}$

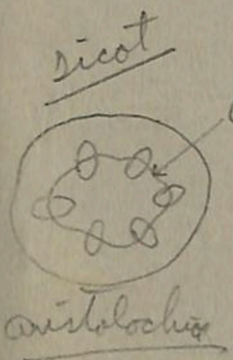


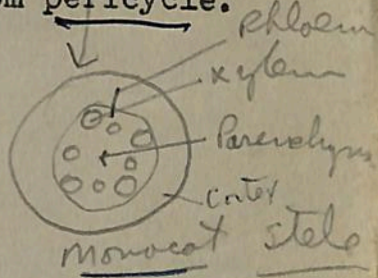


MORPHOLOGY .... STEMS .. ROOTS

STEM	ROOT
Grow upward from soil	Downward orientation; pos. geotropism.
Nodes, internodes.	not present.
Branches arise externally from buds on surface.	Branches arise from pericycle.
Bud scales protect growing tips.	Root cap.
Appendages are lvs, flrs.	root hairs.
From hypocotyl of embryo.	From radicle of embryo.

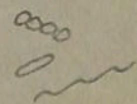
chlorophyll +





Divisions "Thallophyta"

est: Bacteria } Morphological types.



Viruses } Living substrate
ultramicroscopic
active in high dilution
Specificity
Intracellular inclusions (animal disease

Polio
Yellow Fever
Warts
Mumps
Measles
Small Pox
Colds
Herpes

2º Rabies
Negri bodies

Parasitism

Autotroph vs Heterotroph

Effect on host: 1) Compete for food.
2) Produce toxins in host;
3) Stimulate growth of galls, tumors,
4) Penetrate host cells → necrosis

VIII. STEMS OF ECONOMIC IMPORTANCE AND THEIR USES. (Hill: Economic Botany, 1937).

1. Bamboo (Bambusa). . . . . . Structural uses, young shoots used as food
2. Benzoin (Styrax benzoin) . . . . .Expectorant from gum benzoin
3. Camphor (Cinnamomum Camphora). . . . . .Gum camphor from wood
4. Chicle (Achras sapota) (SAPODILLA). . . . . Dried latex for chewing gum
5. Cinnamon (Cinnamomum zelylanicum). . . . . Spice from bark

Mexico / Honduras — ZAPOTE FRUIT

6. Cork Oak (Quercus suber) . . . . .Cork from bark
7. Drug Cascara Sagrada (Rhamnus Purshiana) . . . .Bark used as cathartic
8. Drug Quassia (Picrasma excelsa). . . . Bitter vermifuge (worm remedy)
9. Ephedrine (Ephedra sinica) . . . Ephedrine alkaloid used as astringent
10. Flax (Linum usitattissimum). . . . . Fiber for linen

11. Ginger (Zingiber officinale) . . . . Spice from rhizome
12. Guaiac (Guaiacum). . . . . Resin used for rheumatism
13. Hemp (Cannabis sativa) . . . . Hemp fibers for rope and twine
14. Logwood (Haematoxylon) . . . . Histological stain & dye
15. May Apple (Podophyllum peltatum) . . . Purgative from resin in rhizome

16. Oak (Quercus species). . . . . Oak bark, tannins, lumber
17. Olibanum (Commiphora Myrrha) Myrrh & frankincense
18. Orris "Root" or rhizome. . . . . Starch for face powder, cosmetics
19. Papyrus (Cyperus Papyrus). . . ."Bulrush" of antiquity, earliest known source of paper fiber, whence name "paper"
20. Pine (Pinus palustris and other species). . Pine tar from bark, timber

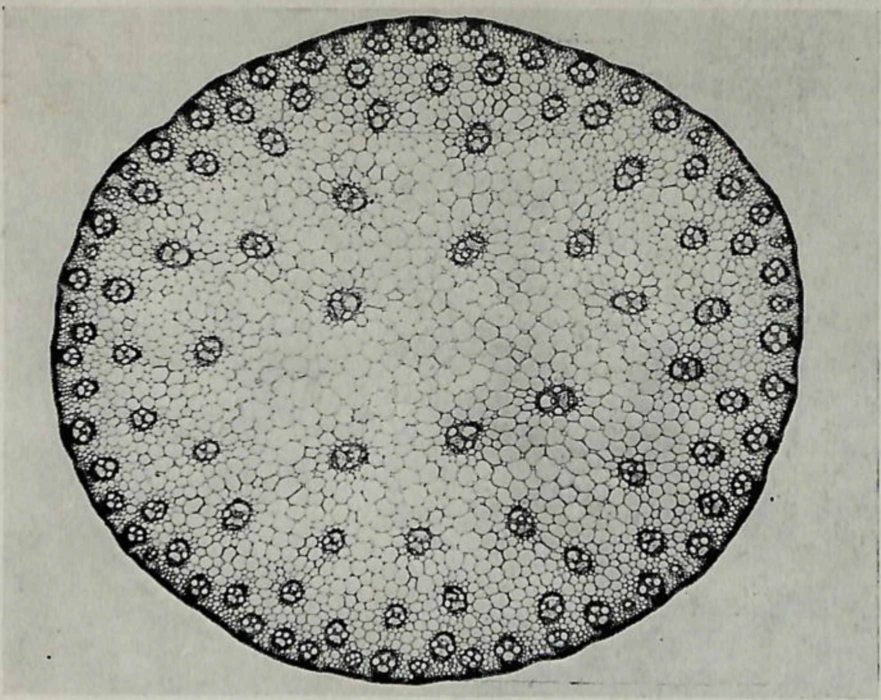
1638 Peru → Java

21. Potato (Solanum tuberosum) . . . . Tuber for food
22. Quinine (Cinchona) Calisaya. . . . . . .Alkaloid from bark for malaria
23. Rattan (Calamus species) . . . . . . Split stems for Wicker furniture
24. Red Cedar (Juniperus virginiana) . . . . Pencils, fenceposts
25. Rubber tree (Hevea brasiliensis) . . . . Rubber latex

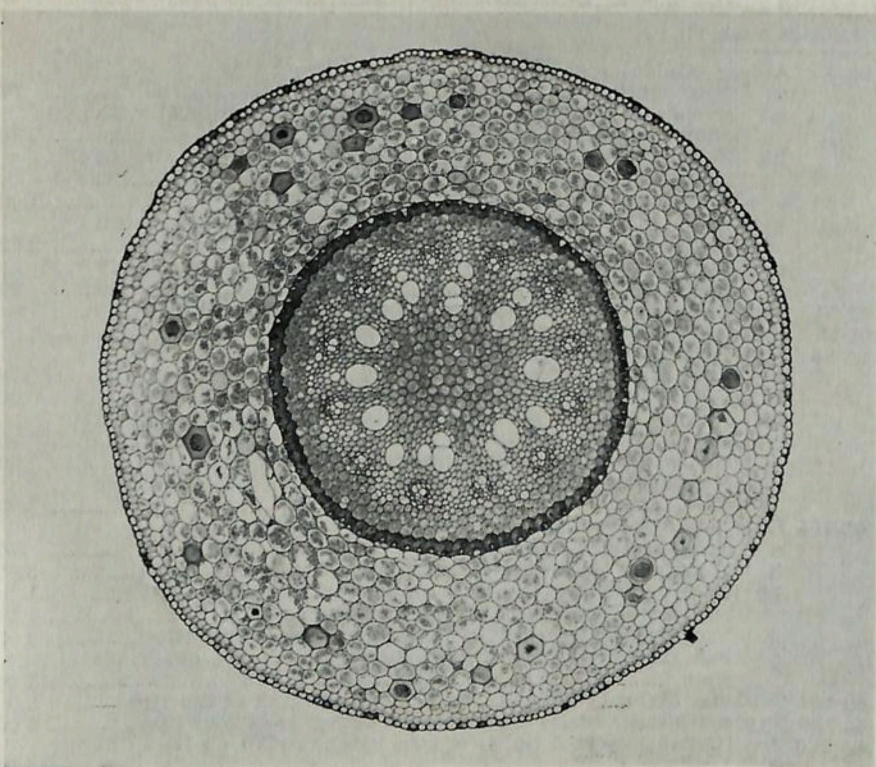
26. Sago Palm (Metroxylon Sagu). . . . . Stem for food starch
27. Slippery Elm (Ulmus fulva) . . . . Mucilage from bark
28. Sugar Can (Saccharum officinalis). . . . . Mollasses & sugar
29. Taro, Dasheen (Caulocasia species) . . . Edible corns, rich in starch
30. Walnut (Juglans nigra) . . . . Cabinet wood, tannins from bark

31. White Pine (Pinus Strobus.Naval Stores (Tar, resin, turpentine), wood
32. Willow (Salix) . . . . Wicker ware, crates, cheap lumber
33. Willow (Salix alba). . . . . Glucoside salicin, a drug
34. Wood Fern (Dryopteris Filix-Mas) . . . . . . Worm remedy or vermifuge
35. Cellulose Plastics: Celluloid (nitrates), Rayon & Photofilm (acetatec), Lacquers (ethyl cellulose), Cellophane (viscose or regnerated cellulose).

BL

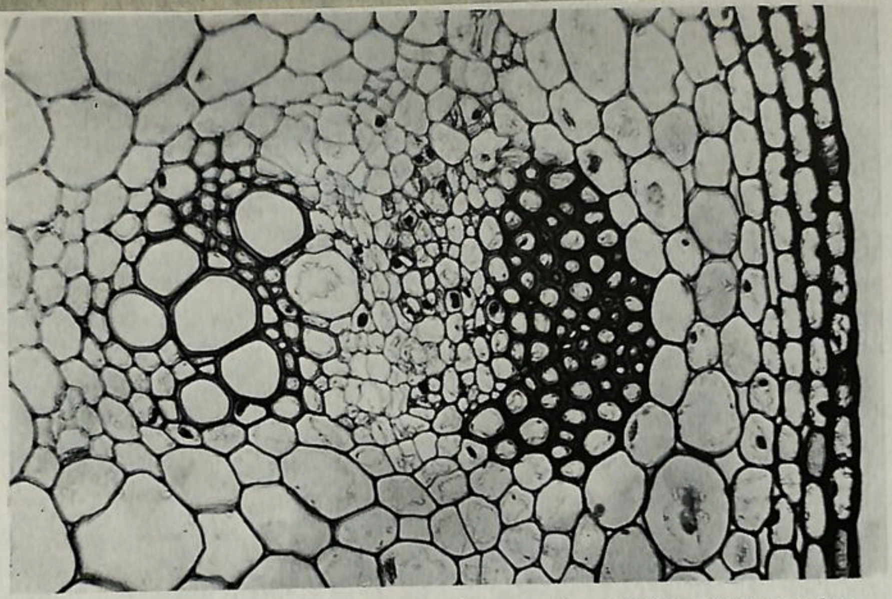


74-180 ao Zea (Corn) stem x.s., a solid Monocot stem. (25X)



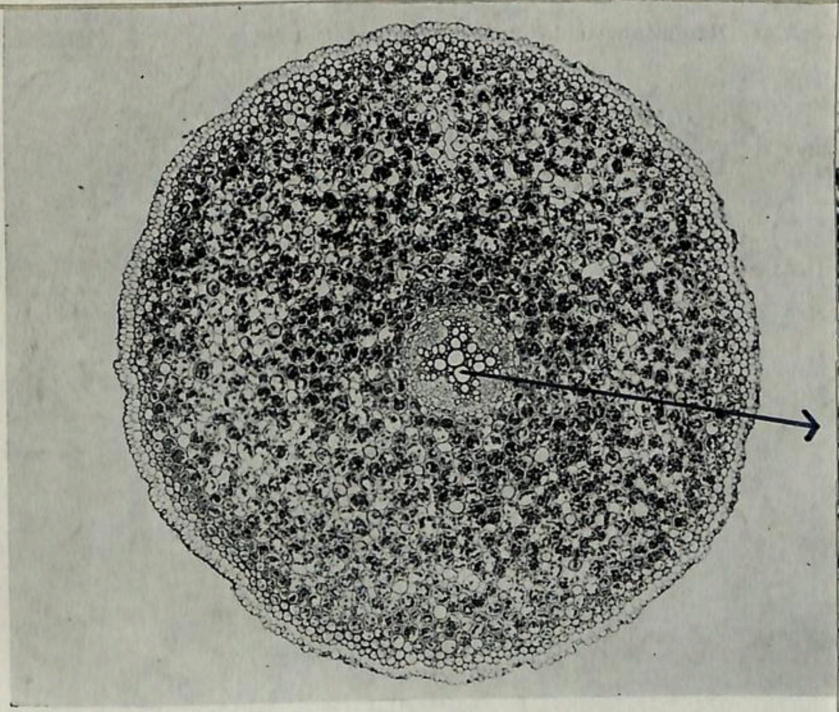
67-152 Smilax root x.s., showing thickened endodermis. (65X)

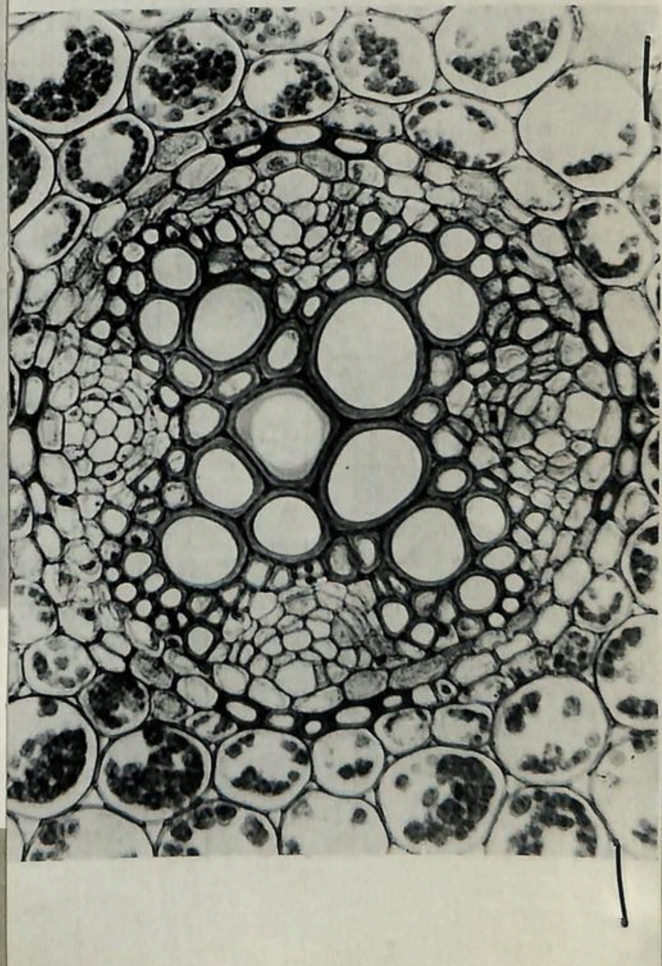
Bc



49-284 a **Helianthus stem x.s.**, showing an enlarged view of a vascular bundle. (230X)

39





42-508 c4 **Ranunculus older root x.s.**, at low magnification. (40X)

36

1-15

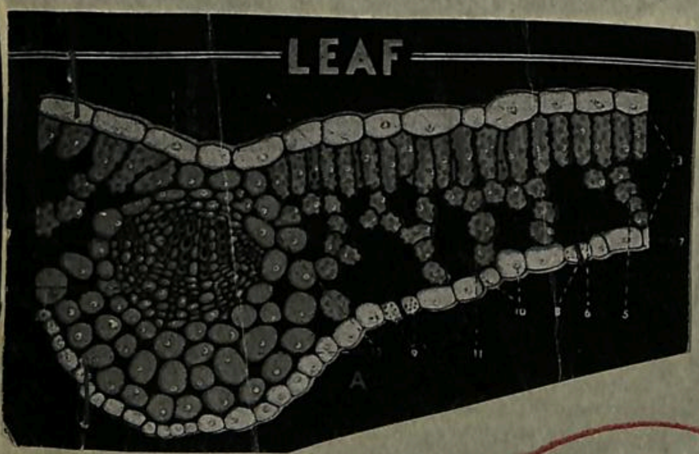
LEAF

FUNCTIONS: PHOTOSYNTHESIS } IN RELATION TO VASCULAR SYSTEM.
TRANSPIRATION ✓

ABSCISSION LAYER

ORIGIN FROM SEED:

STRUCTURE: STOMATA. (2 X 10^6 on LOWER SURFACE OF SUNFLOWER LF.) — OPEN IN DAY, CLOSE AT NIGHT.



WATER LILY: 460/sq. mm UPPER ONLY.

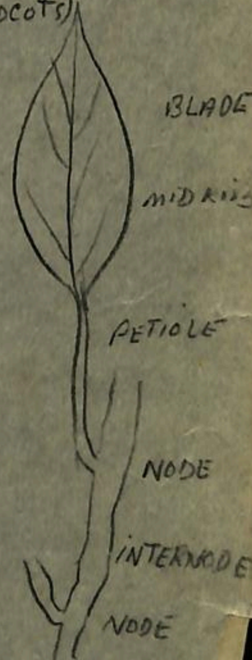
COMMON PEA: { 100 UPPER / 200 LOWER

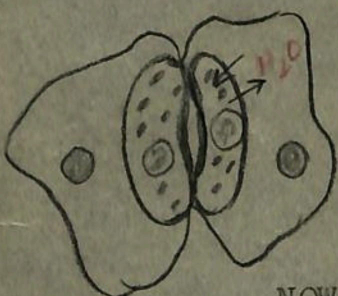
VENATION } PARALLEL – GRASSES – (MONOCOTS) / NETTED (DICOTS)

SIMPLE } MAPLE, OAK, BANANA

COMPOUND } PECAN / ACACIA / LOCUST

VEINS





TURGOR CHANGES IN GUARD CELLS → OPENING & CLOSING.

STARCH ⇄ SUGAR

1-15

NOW CONTINUE WITH PHYLA:

BRYOPHYTA . LIVERWORTS . . DORSO*VENTRAL FLA
MOSSES . ERECT.

ALL PLANTS ABOVE THALLOPHYTES PRODUCE AN EMBRYO.

ADVANCES OVER ALGAE:

- MULTICELLULAR SEX ORGANS
- LAND PLANTS CHIEFLY (AMPHIBIOUS)
- SPOROPHYTE PARTIALLY INDEPENDENT.

STRESS REPRODUCTION

IMPORTANCE TO MAN:

- PEAT (FUEL) (SURGICAL DRESSINGS)(PACKING MAT
- PREVENTION OF SOIL EROSION
- BUILDING OF SOILS

TRANSPIRATION

CUTICULAR & STOMATAL CHIEFLY; but: from any plant surface.

ie Loss of water vapor from plant.

RATE differs with environment & peculiar adaptimmation of plant.

ie

Distribution of plants depends upon ability to RETAIN WATER.

zb.

HYDROPHYTES
MESOPHYTES
XEROPHYTES

SOME FACTORS: WIND
HUMIDITY
HEAT
SOIL

CHIEF FUNCTIONS :

1) COOLING EFFECT on hot days.

2) TRANSPIRATION PULL } RISE OF SAP, + ROOT PRESSURE + H_2O COHESION

BUT:

always a DANGER OF EXCESSIVE WATER LOSS.

ROLE OF STOMATES: open & close independent of actual need of plant

✓ OPEN IN DAYLIGHT:(HIGH SUGAR CONTENT IN GUARD CELLS CAUSES WATER TO DIFFUSE IN: CELLS THEREFORE TURGID & STOMA OPEN)

✓ CLOSE AT NIGHT: (SUGAR TO STARCH, & WATER DIFFUSES OUT: CELLS LOSE TURGOR & STOMA CLOSE.)

RATE OF TRANSPIRATION:

12 foot CACTUS may lose:		.02 quarts/day
small APPLE TREE	" :	10-20 "
DATE PALM in OASIS	:	400-500 " !

WILTING caused by too RAPID LOSS OF WATER (faster than intake)

$$h = \frac{2T}{rdg}$$

CAPILLARITY
T = Surface Tension
r = Radius of Tube
d = Density of Fluid
g = Gravity

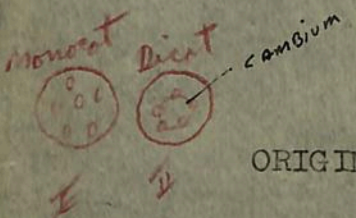
EDIBLE ROOTS: RADISH SWEET POTATO TURNIP BEET CARROT

RISE OF H_2O IN XYLEM: MYER & ANDERSON, CH. 15.

ROOT PRESSURE: ± 2 ATMOS.
H_2O COHESION: UP TO ± 300 ATMOS.
± 30-50 ATMOS. NEEDED FOR H_2O TO RISE ± 400'
TRANSPIRATION

STEM

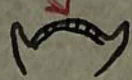
FUNCTIONS: CONDUCTION SUPPORT
FOOD STORAGE



HERBACEOUS VS WOODY (PERENNIALS)
ANNUAL
BIENNIAL — CARROT, BEET

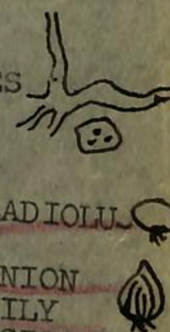
ORIGIN FROM SEED:

BUDS HAVE DOME*SHAPED MERISTEMS WHICH GIVE RISE TO LEAVES.

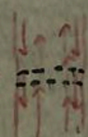


SPECIALIZED STEMS: FERNS, GRASSES

vegetative reproduction:
- RHIZOME. HORIZONTAL UNDERGROUND STEM ... NODES & INTERNODES
- TUBER . STORAGE STEMS . "EYES" ARE BUDS (IRISH POTATO)
- CORM. SHORT THICK RHIZOME (BROADER THAN LONG).. CROCUS GLADIOLUS
- BULB. ENLARGED BUD WITH MANY LEAVES (LONGER THAN BROAD) ONION LILY NARCISSUS TULIP

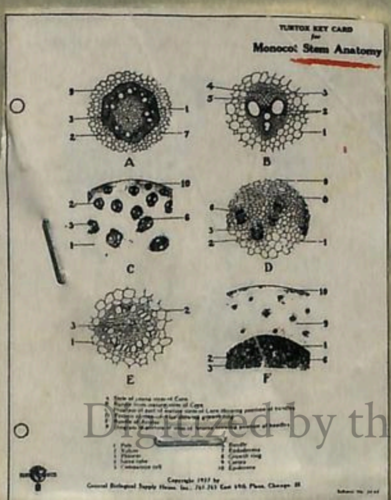


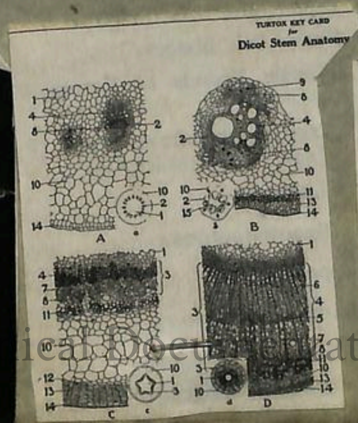
GIRDLING

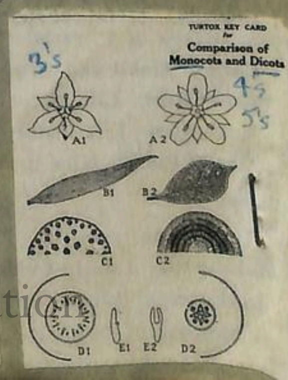


SAPWOOD
HEARTWOOD

HISTOLOGY: MONOCOT VS DICOT . FVB — XYLEM, CAMBIUM, PHLOEM — ANNUAL RINGS
HERB. VS WOODY.







JAN. 13

JUST AS CELLS WITH A SIMILAR FUNCTION MAKE UP A TISSUE

AGGREGATION OF TISSUES MAKE AN ORGAN. → SYSTEM

ORGANS OF HIGHER PLANTS: ROOT STEM LEAF

ROOT

FUNCTIONS: ABSORPTION } ROOT HAIR ZONE } SEVERAL HUNDRED / sq. mm.
K, Ca, Mg, Fe, P, S, N } ESSENTIAL

ANCHORAGE

CONDUCTION

FOOD STORAGE

{ MONOCOT / DICOT

ORIGIN FROM SEED:

... PLUMULE

...... HYPOCOTYL

.... RADICLE

.... COTYLEDON

SEE: TRANSEAU, SAMPSON, TIFFANY: P. 313
WINTER RYE 4 MO. GROWTH

GROSS MORPHOLOGY: FIBROUS ROOTS: GRASSES. { CANE, BAMBOO, CORN
MANY BRANCHES ± = SIZE
(DIFFUSE)

HAUSTORIA (DODDER)

TAP ROOTS: TURNIP, CARROT, RADISH, BEET, BEAN — PROMINENT ROOT
(FLESHY) → STORAGE

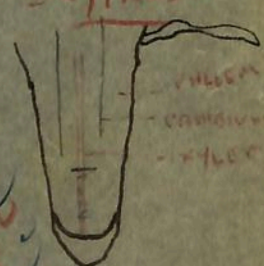
AERIAL — ORCHIDS

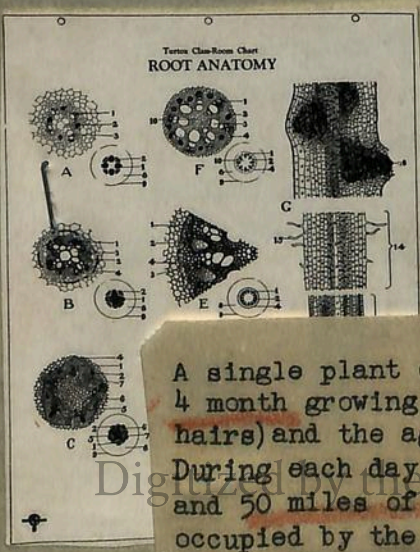
"KNEES" — CYPRESS

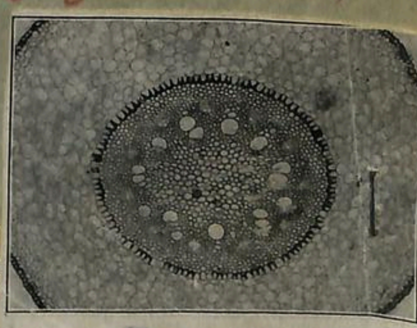
HISTOLOGY:

EPIDERMIS
CORTEX
ENDODERMIS
PERICYCLE
XYLEM
PHLOEM

ZONES: CAP
MERISTEM
ELONGATION
ROOT HAIRS
MATURE → WOODY







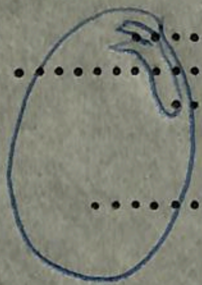
37.242 Smilax Root, prominent endodermis covers vascular cylinder. Vascular bundle is typical of monocot roots.

A single plant of Winter Rye growing in 2 cu. ft. of soil in 4 month growing season and 4321 sq. ft. of surface (roots plus hairs) and the aggregate length of all hairs was 6000 miles. During each day of growth, there were formed 3 miles of new and 50 miles of root hairs, all confined to the 2 cu. ft. of occupied by the root system. — State Univ. Iowa

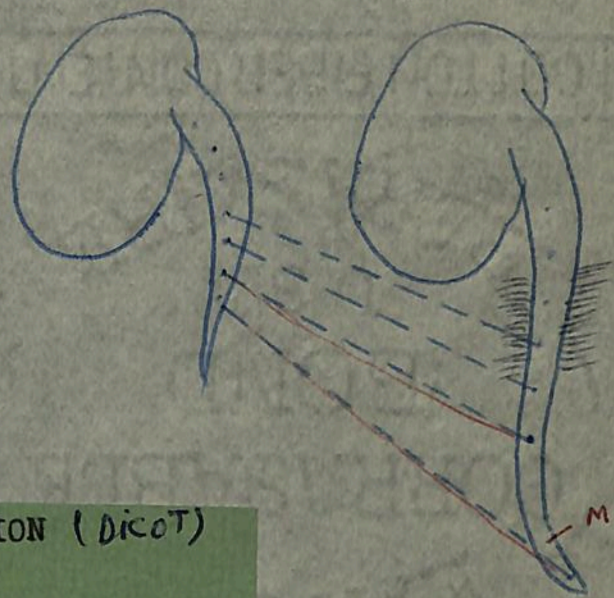
ROOTS

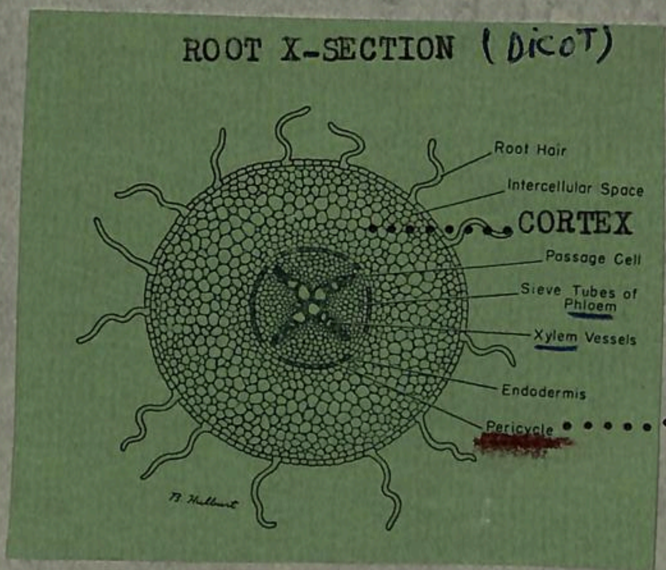
PRIMARY ROOT ORIGIN FROM EMBRYO .

SHOWING MERISTEMATIC REGION (±24hrs.growth)



EMBRYO ....PLUMULE = LEAF
...HYPOCOTYL= STEM
...RADICLE = ROOT
..........COTYLEDON





........2ndary roots originate

STELE MADE UP OF: XYLEM PHLOEM PERICYCLE ie CENTRAL CYLINDER

METABOLISM

DIGESTION: CONVERSION OF INSOLUBLE FOODS INTO SOLUBLE FORM

(BY HYDROLYSIS ENZYMES)

STARCH → SUGAR

> INTRACELLULAR IN PLANTS (NO SPECIAL ORGANS)

(SOME ANIMALS TOO ... AMOEBA)

CHIEF AGENTS IN DIGESTIVE PROCESS (PLANTS & ANIMALS) ARE ENZYMES (CATALYSTS).

PROPERTIES OF ENZYMES:

- NOT USED UP IN PROCESS } CATALYTIC
- SPECIFIC IN ACTION
- HEAT SENSITIVE
- COLLOIDAL
- NAMED FOR SUBSTRATE ACTED UPON
  - (MALTASE ...MALT SUGAR TO GRAPE S.
  - SUCRASE .. SUCROSE TO GLUCOSE.
  - PROTEINASE .. PROT. TO "AMINOS"

ROLE OF OSMOSIS

all Heterosporous — **Gymnosperms** — Cycad / Ginkgo (Maidenhair Tree) "Living Fossil" / Conifer

About 1000 spp. today — Dominant in Mesozoic

1. "Seed Ferns" of Paleozoic, most primitive Gymnosperms
2. All woody — mostly trees — few shrubs.
3. Naked Seeds

Cycads

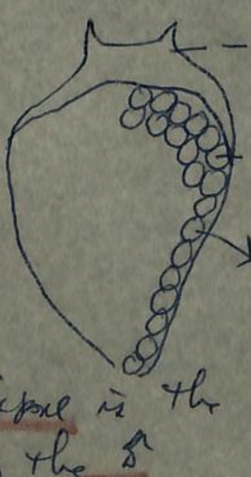
Sporophyte — Typically unbranched stem with crown of fern-like leaves. Largest grow to ± 60 ft. (Macrozamia hopei of Australia). Trunk made up of armor of leaf bases. Age of Dioon edule estimated from number of leaf bases. ie average of 10 leaves/yr. — Some 1000 yrs old or more!

♂ Cone (Strobilus)

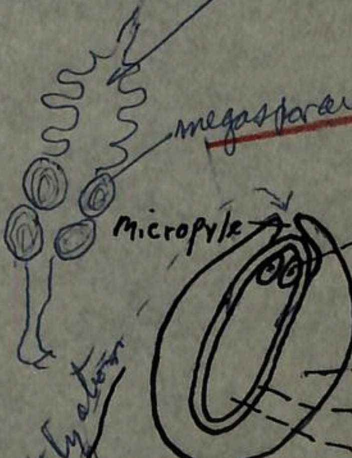
Compact, with microsporophylls arranged spirally. — (look ± like "corn on the cob")

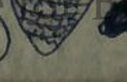
♀ Cone

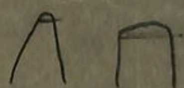
Compact or leafy (Cycas) + bearing megasporophylls

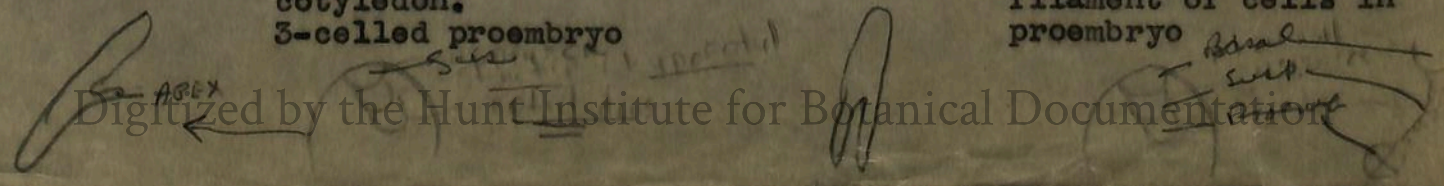


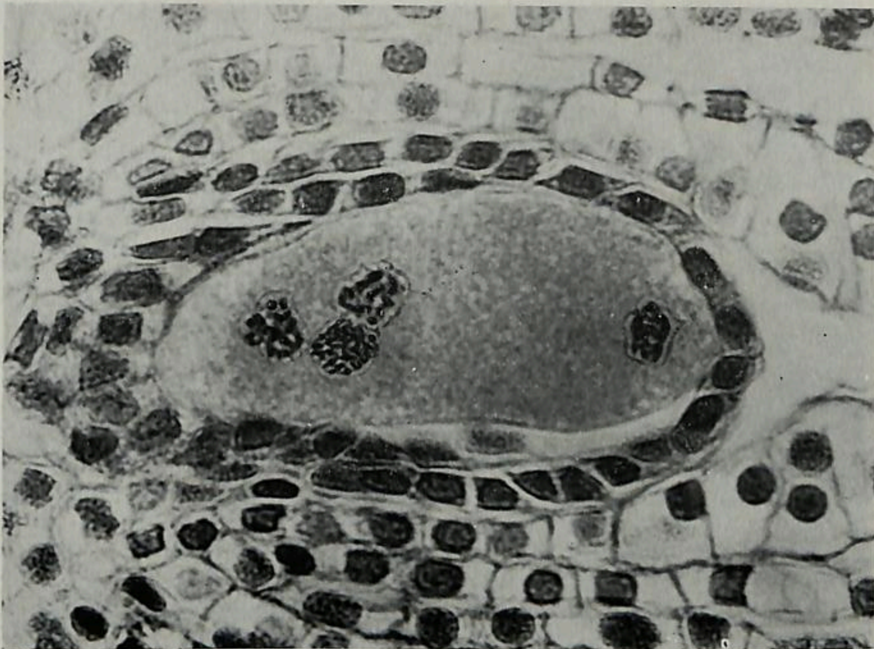
mature microspore is the first cell of the ♂ gametophyte (N)



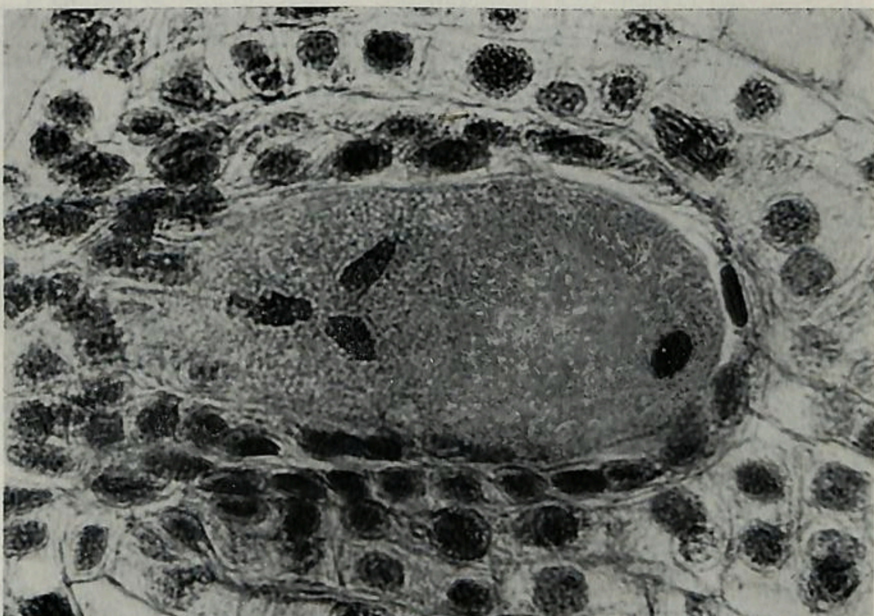


	MONOCOTS	DICOTS
1.	Single layer of tunica	Larger number of tunica layers
2.	Calyptrogen - root cap of independent origin (distal part root apex)	root cap - terminal portion of root tip.
3.	root apex - 3 groups of initials: distal - root cap median - periblem and dermatogen inner - plerome → vascular tissue (Histogen Theory)	root apex - 3 groups of initials distal - cap and dermatogen median - periblem inner - plerome
4.	vessels infrequent in stem and leaves	vessels - typical secondary wood
5.	Scattered vasc. bundles in stem	stem a siphonostele
6.	endodermis more common in root	
7.	Primary tissue only	Primary and secondary tissue
8.	All cells of procamb. strand becomes vascular tissue.	procambium becomes xylem, phloem with remaining cambium.
9.	Secondary growth - rare; formation of a cylinder of new bundles embedded in tissue of less specialized nature. Cambium layer developes from meristematic parenchyma of pericycle or innermost cortex cells.	Secondary growth by persistant cambium.
10.	Epidermis only; if ruptured cortex becomes cutinized.	Epidermis sloughed off; periderm forms.
11.	Pith in roots.	Pith typically absent in roots.
12.	12-20 radial points of primary xylem in roots.	relatively few primary xylem points in root.
13.	Persistant epidermis on roots	hypodermis protective layer of roots.
14.	Endodermis lacking in stem. ?	Endodermis present in stem
15.	Evolution of vessels - appear first in roots.	Evol. of vessels - appear first in secondary xylem of stem and root at same time.
16.	Apex elongated cone-shaped 	Apex relatively flat dome
17.	Embryo - one terminal cotyledon stem apex at one side of cotyledon. 3-celled proembryo	embryo - 2 terminal cotyledons stem apex terminal filament of cells in proembryo





82-104 g **Lilium** embryo sac, showing a somewhat later migration stage than that shown in the preceding figure.



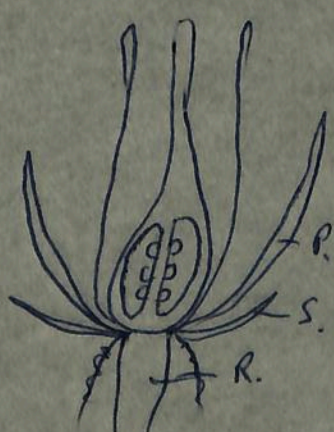
82-104 g **Lilium** embryo sac, showing stage just before fusion of the three chalazal megaspores.

Hypogynous flowers { Stamens, Petals, Sepals } attached to receptacle below ovary
Buttercup
Lily & Legumes
∴ Ovary is Superior

Perigynous flowers } Floral tube bears Stamen, Petal, Sepal, attached to Receptacle } ∴ Ovary Superior
Cherry

Epigynous fl. } Floral tube united to ovary wall, so Stamen, Sepal, Petal seem attached to Top of Ovary } ∴ Ovary Inferior
Apple
Fuchsia
Squash

Dicot: Floral parts in 5's
Monocot: in 3's



Superior Ovary
2 carpels

Locule with ovules

Inferior Ovary

FRUITS

1. Simple - single pistil / 1 flower

Apple
Pear

2. Aggregate - ∝ pistils / 1 flower

Strawberry
Black -

3. Multiple - ∝ pistils (ovary ?) / ∝ flowers

Pineapple
Mulberry
Fig

BEFORE DISCUSSING REMAINING PHYLA, } Introduction: is the way in which plants are organized — compare animals. (cell, Tissue, organ etc.)

REVIEW FUNDAMENTAL TISSUE TYPES. (5)

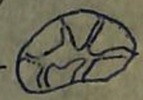
[Gr. divided]

1. MERISTEM: (GR. = DIVISIBLE) CHIEF FUNCTION GROWTH (UNLIMITED)".
   TIPS OF STEMS & ROOTS. (TERMINAL)
   CAMBIUM. } → SECONDARY TISSUES. LATERAL GROWTH.
   CELLS ISODIAMETRIC , VACUOLES SMALL OR LACKING.
   IN ACTIVE DIVIDING STATE.

2. EPIDERMAL: PROTECTION FROM EVAPORATION. (MODIFIED PARENCHYMA)
   LACKS CHLOROPHYLL (Usually)
   CUTINIZED OR SUBERINIZED.
   GUARD CELLS (WITH CHLOR.) OPEN & CLOSE etc.

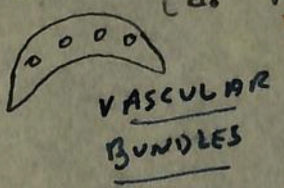
3. PARENCHYMA: MOST COMMON TYPE } ± 14-SIDED ACCESSORY TO OTHERS.(STORE WATER .... PITH)
   THIN*WALLED CELLS
   LARGE VACUOLES
   ± ISODIAMETRIC
   FOOD STORAGE, FOOD SYNTHESIS } FUNCTION

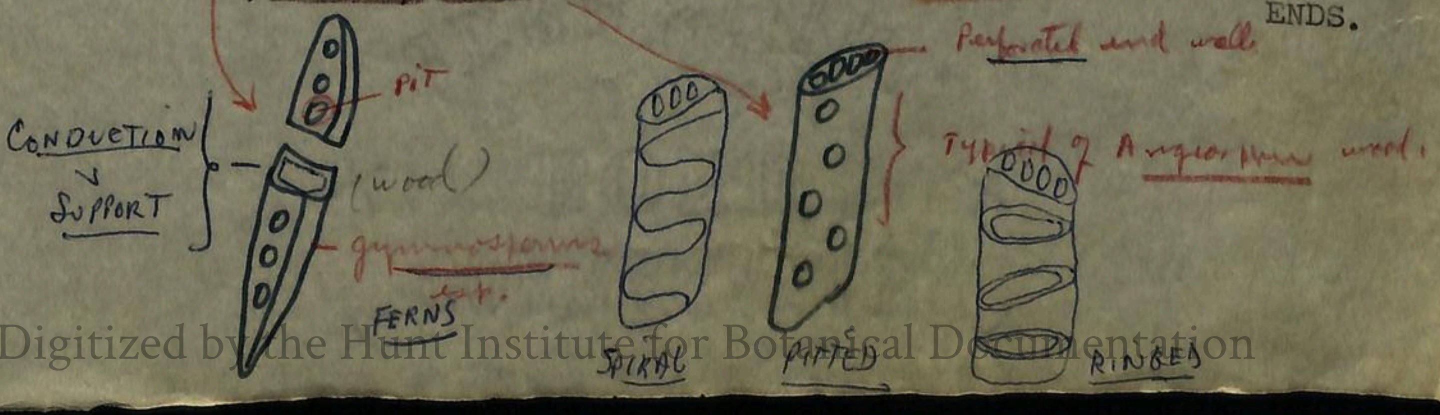
✓ { 4. SCLERENCHYMA: [GR. Hard] SUPPORTING FUNCTION. (CORK) (FIBERS .. ROPE PAPER (STONE FRUITS)
   THICK*WALLED (LIGNIFIED)
   a.) STONE CELLS (2D GRIT IN PEARS) — VERY THICK-WALLED, VARIABLE SHAPE } –



CELERY

{ 5. VASCULAR: system continuous thru plant. CONDUCTION. PHLOEM TAKES FOOD DOWN TO ROOTS. XYLEM CARRIES WATER UP TO LEAVES.
   { XYLEM & PHLOEM (BARK) → SIEVE TUBE — LONG, THIN-WALLED CELLS w. PERFORATED ENDS & LARGE VACUOLE; COMPANION CELL – SMALL; DENSE CYTOPL.
   TRACHEIDS (dead cells)
   (VESSELS) TRACHEAE) END TO END: MANY FEET LONG: PERFORATED ENDS.





ANGIOSPERMS

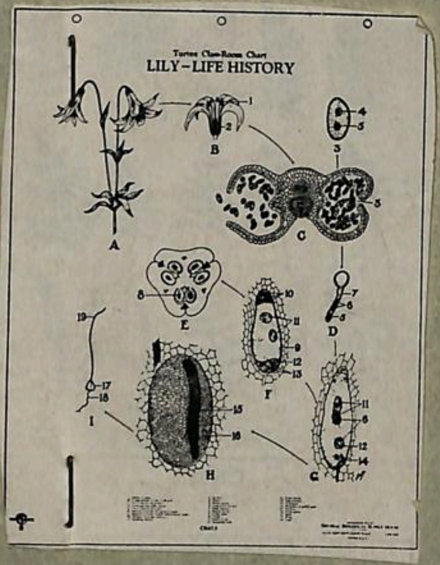
SEED ENCLOSED IN FRUIT (OVARY)

NO ANTHERIDIA OR ARCHEGONIA

FURTHER REDUCTION OF GAMETOPHYTE

1-16-54

FLOWER REPRODUCTION



GYMNOSPERM & ANGIOSPERM CONTRASTED:

GYMNOSPERM		ANGIOSPERM
CONES	....	FLOWERS
SEED EXPOSED (SCALES)	.....	ENCLOSED IN OVARY
WIND POLLINATION	...	INSECT WATER BIRDS
NO VESSELS IN WOOD (TRACHEIDS) ONLY	......	VESSELS (TRACHEAE) + TRACHEIDS

Berry — Single fleshy fruit

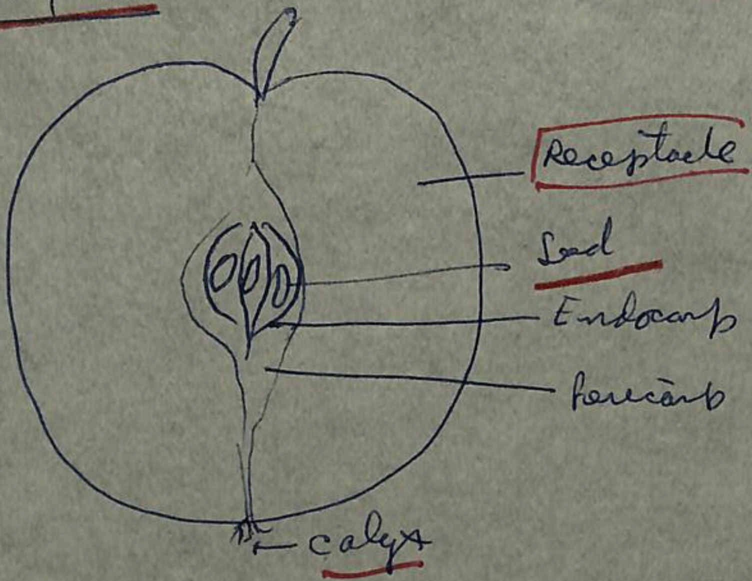
Pericarp fleshy

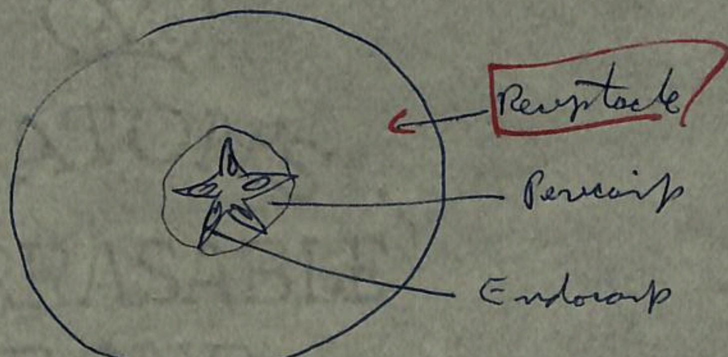
- Grape
- Tomato
- Cranberry
- Gooseberry

Fruits
- Dry
  - Dehiscent — Legumes
  - Indehiscent — Grains
    - Corn
    - wheat
    - oats
- Fleshy
  1) Simple — Single Pistil
     - Apple
     - Pear
  2) Aggregate — ∞ Pistils of 1 Flower
     - Strawberry
     - Black "
  3) Multiple — ∞ Pistils (ovaries) of ∞ Flowers
     - Pineapple
     - Mulberry

Pome Fruit } Apple, Pear, Quince — Rosaceae; Inf. Ovary; Compound Pistil

Simple, Fleshy Fr.



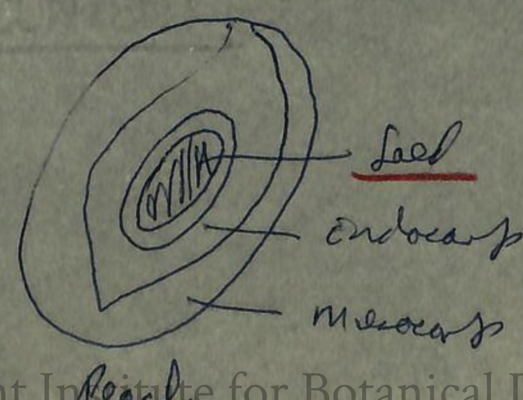


Drupe = Stone Fruit (endocarp) from Superior Ovaries

Almond
Apricot
Olive

Fleshy Fruit

Peach
Plum
Cherry



Peach

CHEMICAL ELEMENTS NECESSARY TO PLANTS

1. Carbon
2. Hydrogen
3. Oxygen

$$6CO_2 + 6H_2O \xrightarrow[\text{Energy from light}]{} C_6H_{12}O_6 + 6O_2$$

THE ROLE OF THE MINERAL IONS

4. Nitrogen (NH_4^{-}, NO_2^{-}, NO_3^{-})-- needed for synthesis of <u>amino</u> <u>acids</u>, the building blocks of proteins.

5. Phosphorus (PO_4^{---}) -- Affects rate of cell division and rate of cellulose formation in cell wall; incorporated in certain plant proteins and involved in the action of certain enzymes.

6. Calcium (Ca^{++}) -- important constituent of middle lamella; permeability of membrane is affected by presence and absence of calcium ion; unites with certain organic acids, such as oxalic acid, to prevent harmful accumulations.

7. Potassium (K^{+}) -- helps regulate certain physiological processes; may function in sugar formation; affects permeability of plasma membrane-- (not found in any organic substance).

8. Sulfur (S^{--}, SO_4^{--}) -- part of two amino acids; is thought to play a role in respiration as part of an enzyme.

9. Magnesium (Mg^{++}) -- is a part of the chlorophyll molecule.

10. Iron (Fe^{++}) -- necessary for chlorophyll formation, even though it does not become a part of the molecule-- seems to act as a catalyst; also, it seems to play a part in some respiratory processes

(Elements 4 through 10 are needed in large amounts

11. Boron ($B_4O_7^{--}$, BO_3^{---})
12. Copper (Cu^{++})
13. Manganese (Mn^{+++})
14. Zinc (Zn^{++})

Roles are not very clear; deficiencies cause disease, so may be associated with enzyme systems. They are needed only in small quantities, and are called "trace elements".

15. Molybdenum
16. Sodium
17. Silicon
18. Chlorine

Elements found in plants about which practically nothing is known.

Prepared Microscope Slides of Commercially Valuable Woods for Wood Technology and Wood Anatomy

We prepare two series of wood preparations. These are slides showing wood sections cut in three planes and slides of macerated wood tissue.

Each of our 3-section wood slides bears the customary cross, radial and tangential sections necessary for the critical study of the wood represented. The sections are stained with iron-alum haematoxylin and safranin. Where celloidin embedding results in an improved slide, this technique is used; otherwise sections are cut without a matrix.

Slides of macerated wood are of value in the study of wood anatomy since the wood elements are shown as complete units and can be studied as such. Thus, these slides have a unique function and serve as a valuable adjunct to our 3-section wood preparations.

CONIFERS NATIVE TO NORTH AMERICA

W-1	**Abies balsamea** (Eastern Balsam Fir).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-4	**Abies lasiocarpa** (Western Balsam Fir).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-7	**Chamaecyparis Lawsoniana** (Port Orford Cedar).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-8	**Chamaecyparis nootkatensis** (Alaskan Cedar).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-9	**Chamaecyparis thyoides** (White Cedar).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-15	**Juniperus virginiana** (Red Cedar).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-17	**Larix laricina** (Larch).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-19	**Larix occidentalis** (Tamarack).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-22	**Libocedrus decurrens** (Incense Cedar).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-25	**Picea Engelmannii** (Engelmann Spruce).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-27	**Picea mariana** (Black Spruce).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60
W-31	**Picea sitchensis** (Sitka Spruce).	
	w 3-section wood slides.	1.25
	m Whole mount of macerated wood.	.60

PREFACE

Genetics, the study of heredity, is of great antiquity. It dates back to the work of the primitive agriculturalists who thousands of years ago in the ancient centers of civilization domesticated the various plants and animals we use to this day. Paradoxically, modern genetics is one of the most youthful of the major biological sciences. It originated with the rediscovery in 1900 of a scientific article originally published in 1866 by a young Augustinian monk named Gregor Mendel. This paper described a hypothesis which originated from a bold piece of abstract thinking combined with elegant experimentation. Mendel's experimental analysis (which will be outlined further on in this text) constitutes one of the very greatest achievements in pure science, and a vast array of theoretical and practical consequences followed.

We now know that the genetic machinery of living things generally consists of units called genes. Genes are immense when compared to most biologically important molecules, but even so they are too small to be seen with the light microscope. It appears that many genes exert their influence in living systems by controlling steps in chains of biochemical reactions through the production of organic catalysts called enzymes. Genes have the ability to reproduce themselves; that is they can gather from their immediate environment many smaller molecules and can combine these to form replicas of themselves. Furthermore, a gene molecule can undergo a physical or chemical change termed a mutation, and the mutated gene often will reproduce its new pattern just as faithfully as it previously copied the original pattern.

Only living things are able to reproduce and to evolve. These abilities are in the final analysis bound to the ability of their genes to replicate their original and their mutated patterns. Since the science of genetics boils down to the study of genes and their operations, genetics becomes the most basic of all biological sciences, and its study often can give insight into the most fundamental biological problems: the origin of life, the origin of cellular

GENETICS

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Illustrated by E. JOHN PFIFFNER

STAFF ARTIST · CHICAGO NATURAL HISTORY MUSEUM

New York · OXFORD UNIVERSITY PRESS · 1962

Chapter **4**

Some Favorite Organisms of Geneticists

In Chapters 1 and 2 some of the tools currently available for study of cells were described and mention was made of what cytological studies tell us about the components of cells. You now know what the various nuclear and cytoplasmic organelles look like, what they are made of, and how they behave in the resting cell. In Chapter 3 the dynamic changes that somatic and sexual cells undergo in order to reproduce themselves were outlined. In this chapter a description will be given of seven organisms which have provided vast amounts of useful information concerning the operation of the genetic machinery. These species are themselves some of the favorite biological tools manipulated by geneticists.

Drosophila melanogaster

From the standpoint of genetics *Drosophila melanogaster* is the best known of all organisms and the one most commonly used in an elementary genetics laboratory. Because of this latter fact a more detailed description of this species will be given than for the others. A catalogue of the advantages of the fruit fly follows: (1) The fly is small, anatomically complex, readily handled, and breeds prolifically in the laboratory. (2) Conditions for culturing *Drosophila* are simple, cheap, and readily controlled (see Appendix D). Flies can be raised by the hundreds in half-pint milk bottles or by the tens of thousands in population cages. (3) The life cycle is short. (4) Many mutants have been described, and this information is readily available. (5) The number of chromosomes is small. (6) The chromosomes of the salivary gland cells of the mature larva are gigantic and show a characteristic banding. The homologous chromosomes pair in most somatic tissues, including the salivary gland. As will be elucidated later this behavior makes possible the identification of chromosomal rearrangements and the mapping of deficiencies and, as a result, the cytological localization of genes. (7) Homologous chromosomes do not undergo crossing over in the germ cells of the male. This greatly simplifies the genetic procedures employed. (8) A satisfactory, but complex synthetic medium has been developed for the aseptic growth of *Drosophila* by J. H. Sang and others. (9) An encyclopedic body of information is readily available for this species, from which the worker can proceed to still unexplored areas of research. (10) Collections of hereditary variations exist, and stocks of various mutants are readily available to all workers in the field. (11) A yearly bulletin (*Drosophila Information Service*) is published which lists all publications concerning *Drosophila* that year, the stock lists of the major laboratories, the addresses of all *Drosophila* workers, descriptions of new mutants and genetic techniques, research and teaching notes. As a result *Drosophila* workers can keep abreast of the work going on throughout the world.

Life cycle of Drosophila melanogaster

The fruit fly undergoes complete metamorphosis. The stages of its life cycle are: the egg, larva, pupa, and adult. At 25°C development may be subdivided as follows: embryonic stage, one day; first instar[1] larva, one day; second instar, one day; third instar, two days; pupa, four days; total, nine days. At room temperature the total developmental time is about two weeks.

PRE-ADULT STAGES. The egg is about 0.19 × 0.50 mm. (weight 1×10^{-5} gm.). Immediately following entrance of the sperm the meiotic divisions are completed, and the egg nucleus is formed. The other nuclei form polar nuclei which degenerate. The sperm nucleus and egg nucleus fuse to form a zygote nucleus which proceeds to undergo mitotic divisions.

Embryonic development results in the formation of a white, segmented, wormlike creature, the larva or maggot. The larvae feed constantly and burrow through the food, leaving numerous channels and furrows. The larval organs are shown in Figure 4–1. The salivary glands of larval *Drosophila* produce digestive juice and also a secretion which is used to glue the insect to the substratum when it undergoes puparium formation. The polytene chromosomes in nuclei of cells of these glands in the third instar larva have been previously described.

[1] instars: the periods between molts (i.e. a first instar larva undergoes molt 1 and is transformed into a larger, second instar larva).

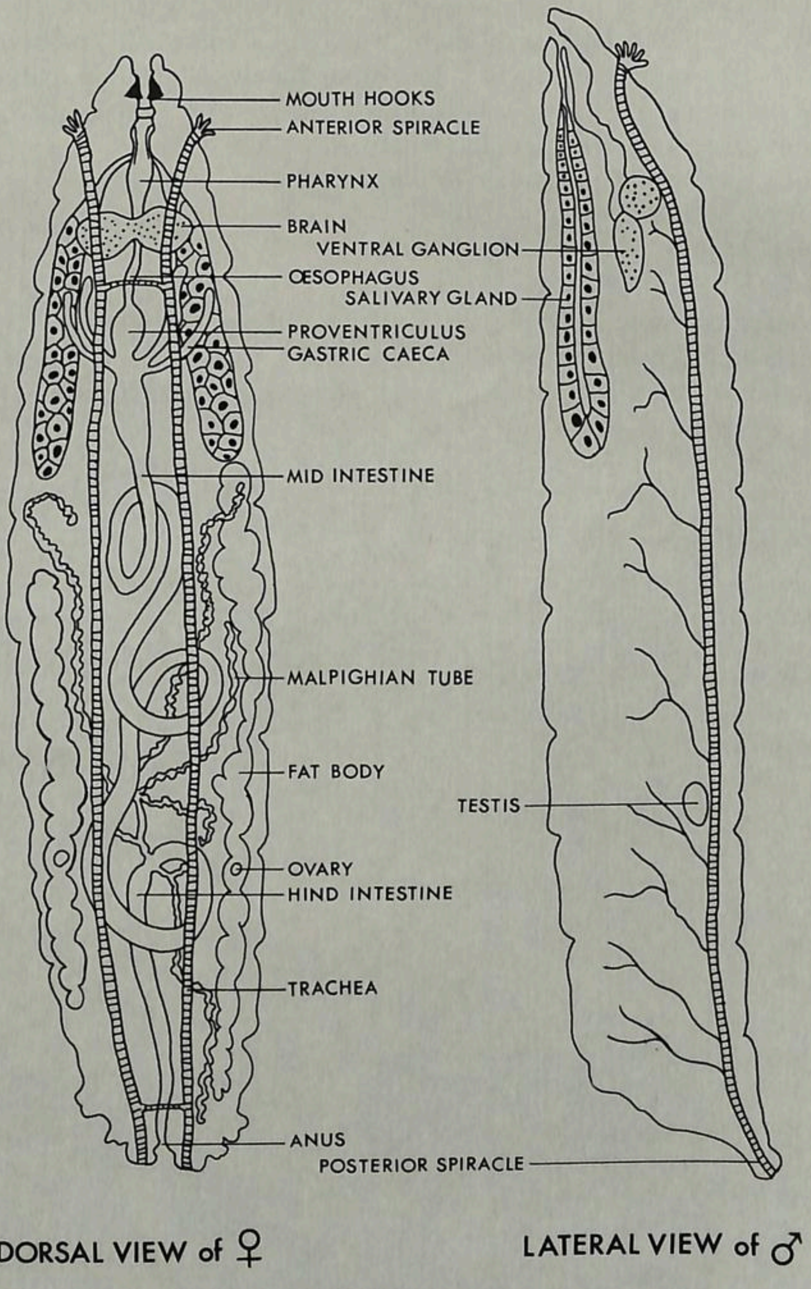
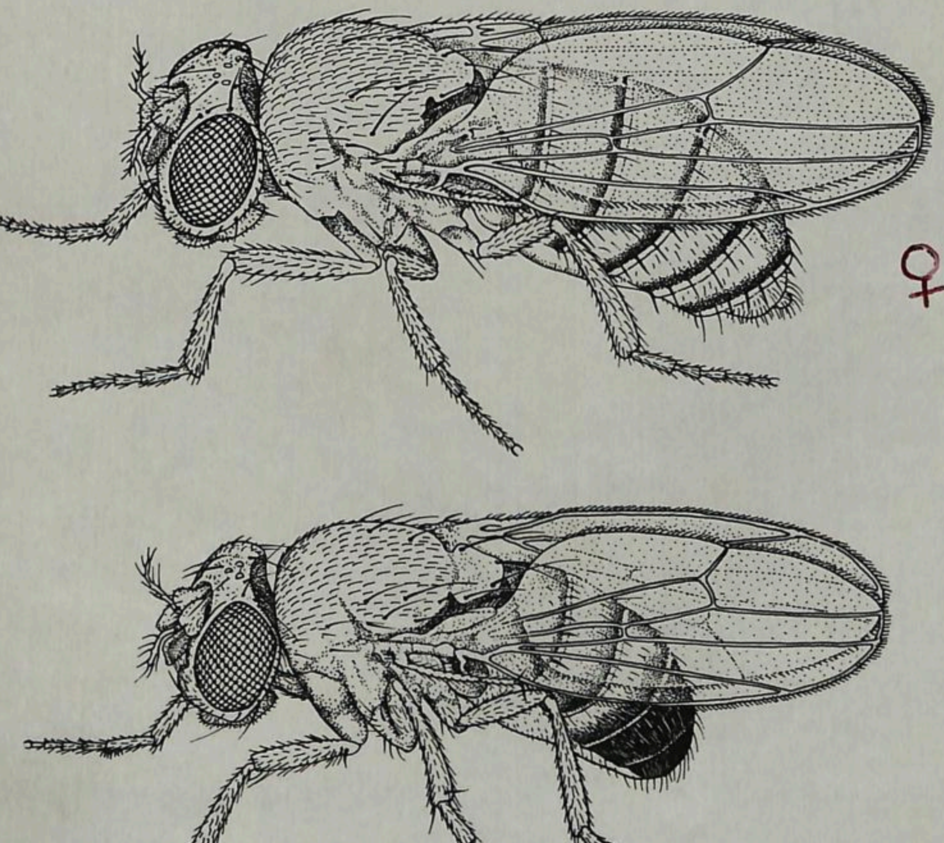


Figure 4–1 A diagrammatic illustration of some of the organ systems of the third instar larva of *Drosophila melanogaster*. The ventral ganglion is not shown in the female and the fat body and alimentary canal of the male are not shown.

When the larvae are preparing to pupate, they creep from the culture medium and glue themselves to some relatively dry surface. *Drosophila* pupate within the last larval skin, which is at first soft and white but slowly hardens and darkens in color. Immediately following pupation most larval tissues undergo histolysis and are destroyed by phagocytes. More or less simultaneously embryonic structures called imaginal discs grow to produce sections of the adult organism (which is fitted together like a mosaic).

THE ADULT. Adult flies are 2–3 mm. long. Females weigh about 1.5 mg. when mature; males 0.8 mg. (see Fig. 4–2 and front endpaper). The compound eyes are each composed of about 740 *ommatidia* (facets) in the male and about 780 in the female. Three single eyes (the *ocelli*) are arranged in



A

B

Figure 4–2 (A) Adult female and (B) adult male of Drosophila melanogaster. (Redrawn after H. J. Muller, The Harvey Lectures *43*: 169.)

the nuclei of the two synergids and the egg. The latter is fertilized by the remaining sperm nucleus to form the diploid embryo (N). The synergids later degenerate.

The development of the kernel takes about 50 days from double fertilization to maturity. During this period a 1400-fold increase in volume takes place. The ear (B) may have as many as 1000 kernels, each of which represents an independent fertilization. The kernel (C) consists of the relatively small diploid embryo, the triploid endosperm, and a tough diploid outer covering of maternal origin, the *pericarp*. At the apical end of the kernel one can often observe the scar marking the original point of attachment of the silk. The surface cells of the endosperm contain aleurone grains and oil. The remaining cells contain starch. The embryo has a central axis terminated by a primary root on the basal end and a stem at the apical end. The scutellum or first leaf serves to digest and absorb the endosperm during the growth of the embryo and seedling.

The adult corn plant which grows from the seedling is rather large, generally averaging 7 feet in height. The plant takes about four months to mature.

Zea mays is the plant for which the most genetic information is available. It is a species of great economic importance, for the world crop is worth hundreds of millions of dollars annually. The species is completely dependent upon man for its propagation, since under natural conditions its seeds would not be dispersed.

Neurospora crassa

This fungus grows as a ground pad composed of filaments or *hyphae* which are tangled together to form a mass called the *mycelium*. The hyphae branch and fuse. Since there are perforations in the hyphal cross walls, the mycelial cytoplasm is continuous. Hyphal cells are multinucleate and each nucleus is haploid. Under certain conditions hyphal fusions may occur between different strains of *Neurospora*. This process (*heterocaryon* formation) results in a hyphal cell which contains nuclei of different genetic constitutions in the same cytoplasm.

The organism can be propagated through transfers of fragments of the mycelium. Aerial hyphae constrict to produce asexual haploid spores which are of two types: oval macroconidia, which are multinucleate, and smaller, spherical uninucleate microconidia. When asexual spores are incubated upon fresh medium they will germinate and form a new mycelium. The organism will grow upon a minimal medium containing sucrose, ammonium tartrate, ammonium nitrate, potassium dihydrogen phosphate, magnesium sulfate, sodium and calcium chloride, biotin, and small quantities of trace

Zea mays

Corn is a member of the grass family (the Gramineae) and is *monoecious,* that is, it bears male and female flowers on the same plant. The staminate (male) flowers are borne in the tassels which terminate the stems; whereas the pistillate (female) flowers are borne in the ears which are formed at the base of the upper branches. In plants it is conventional to refer to the haploid stage as the *gametophyte* and the diploid phase as the *sporophyte.* The maize plant is the sporophyte, and each cell nucleus contains 20 chromosomes.

The life cycle of maize is shown in the back endpaper. Meiosis occurs in the *microsporocytes* (microspore mother cell, D of back endpaper) in the tassels; and occurs in the *megasporocyte* (megaspore mother cell, I) in each of the ovules in the ear. During microsporogenesis, meiosis (E-F) results in four haploid microspores. Within each microspore a mitotic duplication yields two nuclei one of which duplicates mitotically in its turn. Since cytokinesis does not occur, each microspore is transformed into a pollen grain containing three haploid nuclei (G). The average tassel produces about 25,000,000 such pollen grains.

The corn ear can be thought of as a fused group of inflorescences each bearing a double row of flowers. Since each flower will eventually produce a kernel, the kernels will be arranged in double rows extending the length of the ear. The style of each flower develops into a silk while within the pistil a single ovule is differentiated. It is within the ovule that a megaspore mother cell is formed. The nuclear events occuring within the megaspore mother cell are shown in J through L of back endpaper. During megasporogenesis, meiosis results in four haploid nuclei of which three degenerate. Then follow three consecutive, synchronous, mitotic divisions with the result that the female gametophyte (or embryo sac) so formed contains eight haploid nuclei (M).

When a pollen grain (or male gametophyte) lands on a silk it germinates (H) and sends out a pollen tube which grows down the silk to the embryo sac. The tube contains the three haploid nuclei, one of which functions as the tube or vegetative nucleus, while the other two sickle-shaped, sperm nuclei participate in the double fertilization which follows. In the embryo sac two of the eight nuclei move toward the center of the embryo sac and remain in contact. These identical polar nuclei are later fertilized by one of the sperm nuclei and a triploid fusion nucleus is produced which gives rise to the endosperm of the kernel. The cluster of three apically arranged nuclei divide until a group of 20 to 40 antipodal cells are formed. These later degenerate. The remaining cluster of three basal nuclei forms a triangular pattern on top of the head. The thorax is composed of three fused segments: the prothorax (bearing the first pair of legs), the mesothorax (bearing the second pair of legs and the wings), and the metathorax (bearing the third pair of legs and the trisegmented *halteres*). The wing has a characteristic pattern of five longitudinal veins and two crossveins. Large bristles and small hairs grow in a definite pattern over the body. The external genitalia of the two sexes are strikingly different. Males have (on the foreleg only) a *sex comb* consisting of a row of bristles arranged like the teeth of a comb, whereas females lack this organ.

The internal reproductive system of the female is shown in Figure 4–3. Each of the two ovaries is comprised of a group of egg tubes (ovarioles). In the distal portion of the ovariole is located the germarium, which contains follicular cells, oogonia, and nests containing compact groups of 16 cells which arise as the result of four consecutive, synchronous divisions of an oogonium. Proximal to the germarium are four to eight egg chambers (depending on the age of the adult fly), each larger than the preceding one.

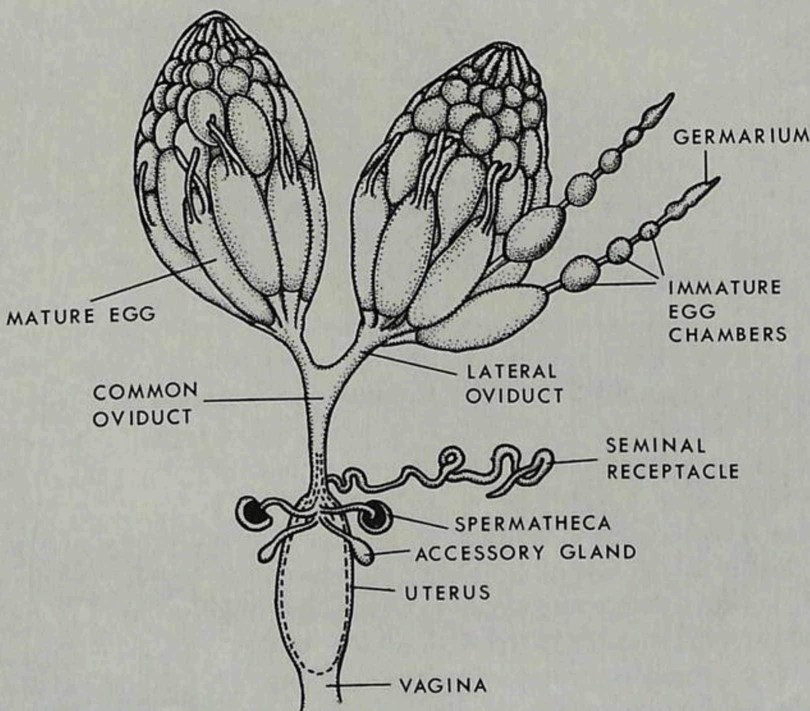


Figure 4–3 The reproductive system of a female *Drosophila melanogaster*. Two ovarioles have been pulled loose from the right ovary. The uterus contains a mature egg (shown as a dashed outline). Sperm stored in the seminal receptacle and spermathecae enter the egg before it leaves the uterus. (After A. Miller)

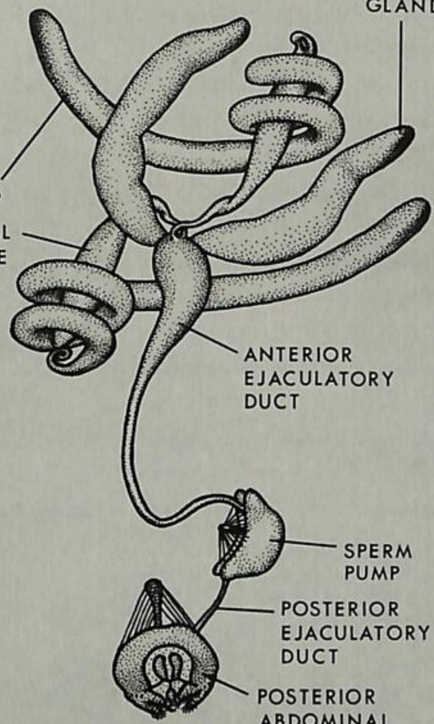


Figure 4–4 The reproductive system of a male *Drosophila melanogaster*. (After A. Miller)

Each consists of 15 *nurse cells,* the oocyte, and an envelope of follicle cells. The nurse cells nourish the oocyte, which grows until it increases in volume by over 100,000 times. Eventually the nurse cells degenerate, leaving the fully grown primary oocyte (the "mature" egg). Crossing over presumably occurs in the germarium in the 16-cell nests which are not as yet surrounded by follicle cells.

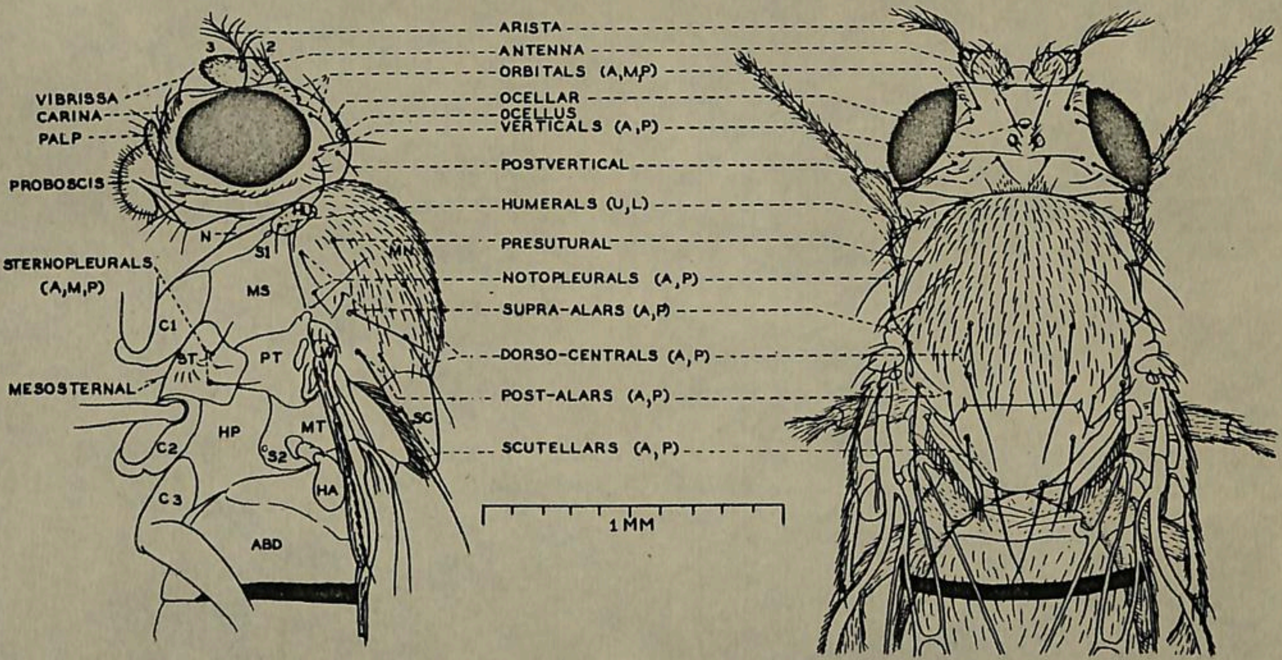
In the male (see Fig. 4–4) each of the two testes is a tube with the basal half helically coiled. The mature testis contains germ cells in various stages of maturation, but spermatozoa and spermatids are most common. Spermatogonia are limited to the extreme tip of the testis.

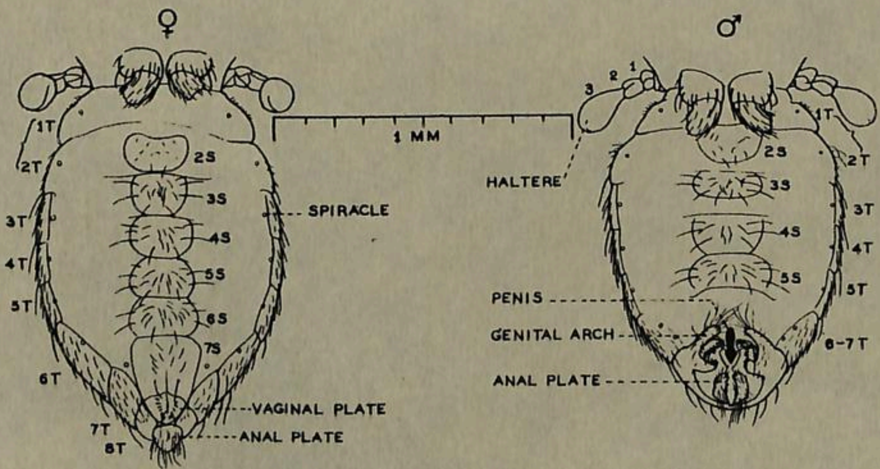
Mating generally occurs during the first day of adult life, and females start ovipositing during the second day. During its ten-week lifetime a fertilized female can produce 3000 eggs (about 30 times her own weight). Generally 95 per cent of the eggs laid hatch. Under optimal conditions a geneticist can breed a maximum of 30 generations yearly.

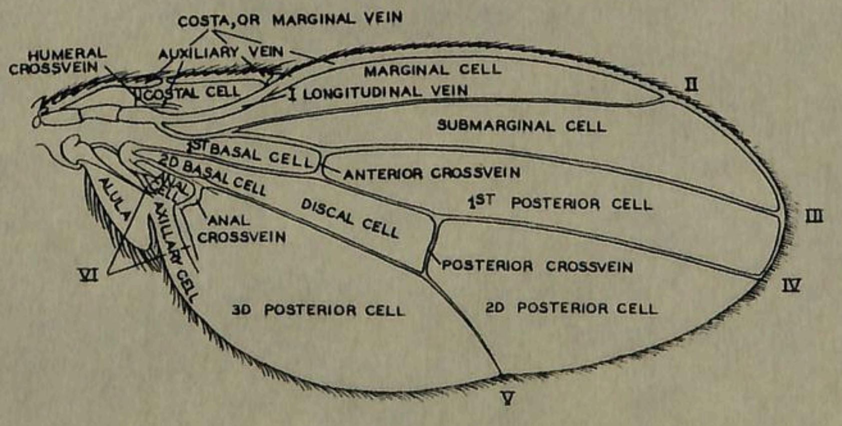
D. I. S. WORK SHEET NO. 1

EXTERNAL STRUCTURE OF DROSOPHILA

(C. B. BRIDGES)







LEGEND:-

A - - - ANTERIOR
ABD - ABDOMEN
C1, C2, C3 - COXAE
HA - - HALTERE
HP - - HYPOPLEURA
HU - - HUMERUS
L - - - LOWER
M - - - MIDDLE
MN - - MESONOTUM
MS - - MESOPLEURA
MT - - METANOTUM
N - - - NECK
P - - - POSTERIOR
PT - - PTEROPLEURA
S - - - STERNITE
S1, S2 - THORACIC SPIRACLES
SC - - SCUTELLUM
ST - - STERNOPLEURA
T - - - TERGITE
U - - - UPPER
W - - - WING

MITOSIS

Events of Metaphase

I. Split chromsomes occupy position at equatorial plane

A. Achromatic figure apparent

B. "Tractile" fibers forming (from chromosomes); kinetochore face the poles

II. Each chromatid contains paired coiled chromonemata.

Events of Anaphase

I. Chromatids separate beginning at point of fiber attachment; chromosomes move toward poles assuming U and J-shaped as they move - chromosome shape depends upon the point of "tractile" fiber attachment

II. Chromonemata uncoiling.

III. Chromosomes occupy position at opposite poles of cell

IV. Spindle apparent between chromosome groups; "tractile" fibers disappearing

V. Chromosomes clump at poles; coils of chromonemata contract.

Events of Telophase

I. Beginning of cell plate in central part of spindle.

A. Thickenings appear on spindle fibers and apparently fuse, forming the beginning of a cell plate

B. Phragmoplast becomes progressively wider at equatorial plane - cell plate extends to periphery of cell.

C. Spindle disappears, persisting longest at periphery of cell plate

D. Cell plate forms primary cell wall.

II. Chromosome clumps become less compact

A. Chromonemata first uncoil and then become closely associated forming a "spireme"

B. Matrix losing stainability - eventually disappearing

III. Simultaneous appea ance of membrane, nucleolus (i), and karyolymph - nucleus enlarging; chromonemata rearranging into reticulum and chromatin

IV. Cell wall completely developed to form two daughter cells

A. The Nucleus, a highly specialized organ consisting of:

1. Nuclear membrane, lying against the cytoplasm;
2. Reticulum, composed chiefly of chromonemata of chromosomes;
3. Karyolymph, or nuclear sap;
4. Nucleolus or nucleoli; and
5. Occasional ergastic matter.

B. The Cytosome, the extra-nuclear region comprising:

6. Cytoplasm, with differentiated
7. Membranes at its outer surface (plasma membrane) and bounding the sap vacuole (tonoplast);
8. Plastids, characteristic of plants, with a special role in the elaboration and storage of carbohydrates (chiefly);
9. Golgi material, or "Golgi zone", characteristic of animals, and concerned in the elaboration of secretions; regarded by some workers as ergastic;
10. Centrosomes, present in animals and some lower plants; and
11. Ergastic substances, non-protoplasmic constituents comprising
    a. Chondriosomes, small masses of a substance reacting as phospholipide and albumin, produced and used by the protoplast; regarded by many as cytoplasmic organs;
    b. Vacuolar materials, in particular the cell sap of plants;
    c. Other ergastic substances, chiefly reserves and by-products.

C. The Cell Wall of plants, mainly ergastic in nature, but possibly incorporating protoplasm; or
The Intercellular Substance of Animals.

* * * * * * *

Because of their prominence in the literature, the partial classifications employed by P.A. and P. Dangeard, Guilliermond, and Meyer for plant cells are presented here.

Dangeard (1923,1929,1931):
1. The nucleome, the nucleus or nuclei.
2. The vacuome, comprising all vacuoles.
3. The plastidome, comprising all the plastids.
4. The cytome, or assemblage of cytosomes (plant chondriosomes).
5. The ergastome, including the oily or osmiophilic bodies called liposomes by Faure-Fremiet.

Guilliermond (1919 et seq.):
1. The chondriome, comparable to that of animal cells and comprising chondriosomes of two kinds:
    a. Ordinary ones common to plants and animals;
    b. Active ones forming plastids in green plants
2. The vacuome, or vacuole system.
3. The lipoid granulations, which are ergastic.
(4. The nucleus.)

Meyer (1896,1920):
1. The nucleus.
2. The cytoplasm.
3. The plastids.
4. Ergastic substance.

The Physical & Chemical Basis of Inheritance

G. W. Beadle
(C.I.T. Pasadena, Cal.)

The Condon Lectures
University of Oregon Press
(Eugene, Ore.) 1957. $1.—
47 pp.

Genes < Replicate / Mutate

Crossing Over — **Linkage**

All genes in 1 Chromosome = a linkage group.
= N Chromos. number.

Exchange of segments between homologous chromosomes.

Genes must occur in linear order if crossing over is to be explained.

Example: 3 genes A, B, C lie in the same chromosome and experiment shows that crossing over betw. A & B occurs 5% of the time & bet. B & C 3% of the time

Then % crossing over bet. A & C will be either 2% or 8%.

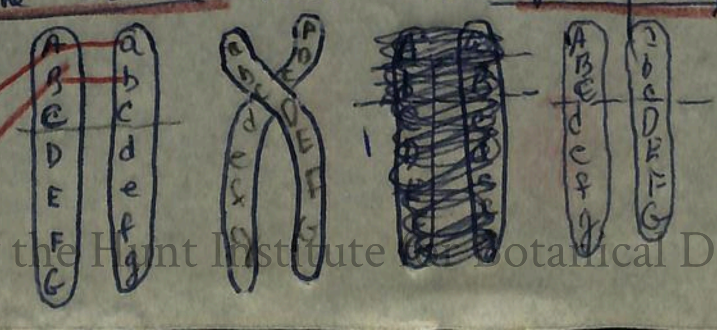
8%: A —5%— B —3%— C

(OR)

5%: A —2%— C —3%— B

The greater the distance between gene loci, the greater the chance that exchange of segments will occur bet. them.

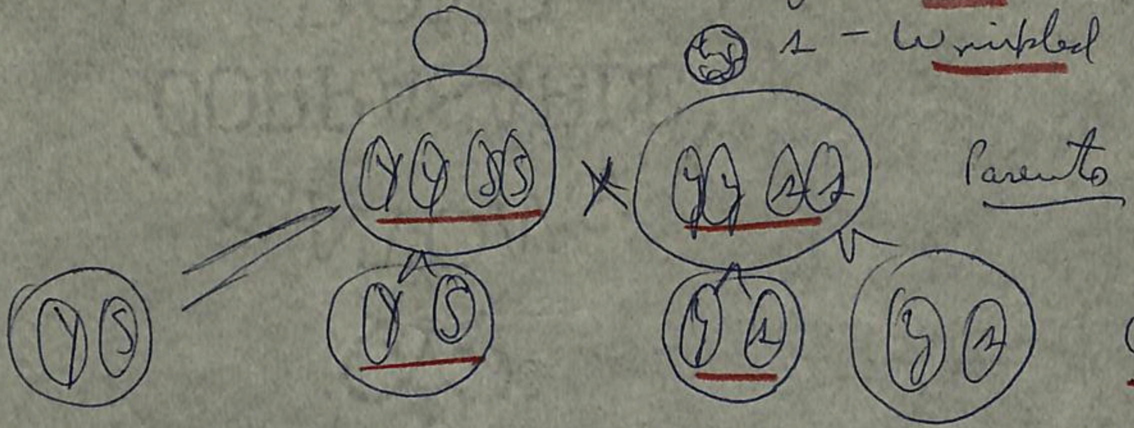
Allelomorphs
A a
B b

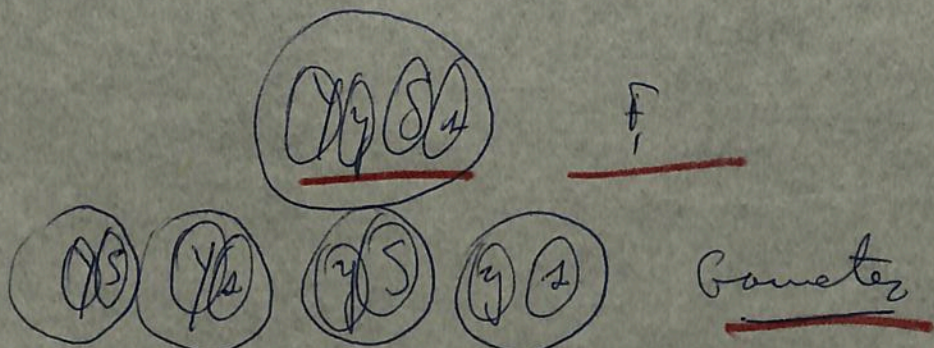


Dihybrid

Y – Yellow
y – Green
S – Smooth
s – Wrinkled
} Pea Seeds

2 factors
∴ 2 pr. chrom.
∴ 2 gene diff.





♀ \ ♂	YS	Ys	yS	ys
YS				
Ys				
yS				
ys				

9 : 3 : 3 : 1
YS Ys yS ys

IN MAN — BROWN EYES vs BLUE

BB × bb
Brown Blue

Bb F_1

BB Bb bb Bb } 3:1 F_2

TT × tt
Tt

PTC TASTERS vs NONTASTERS

3 : 1

TT, Tt, Tt } 3
tt } 1

Phenylthiocarbamide

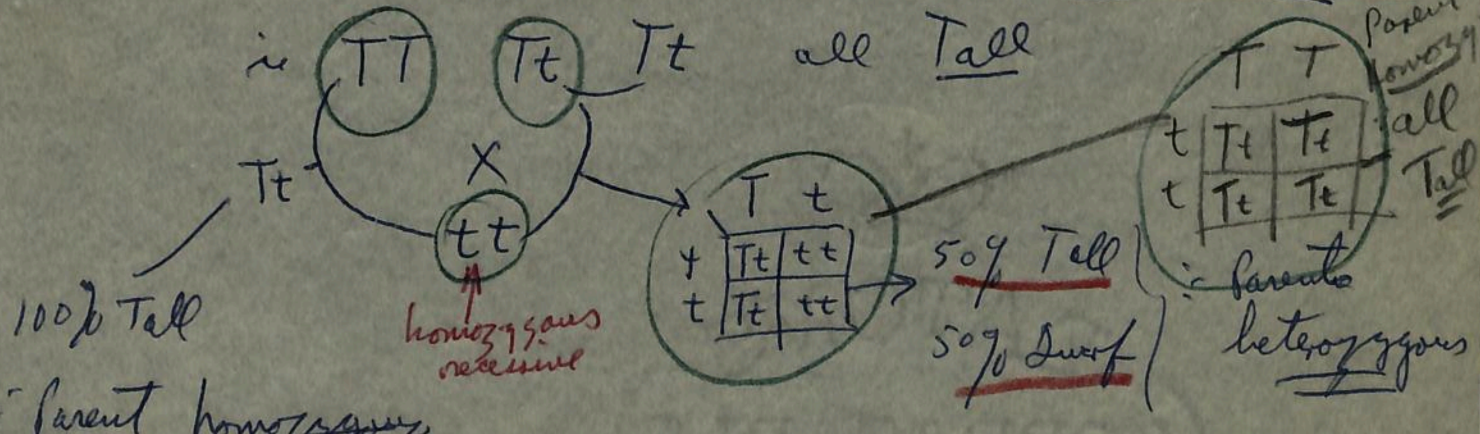
Mendel's 1st Law: Law of Segregation or Purity of Gametes

i.e. Genes occur in pairs.
In gamete formation, each gene separates or segregates from the other member of the pair and enters a different gamete.

∴ Each gamete has only 1 kind of gene.

Back-Cross or Test Cross

To determine homo or heterozygosity of F_2 individuals.
Cross all similar phenotypes with homozygous recessive.



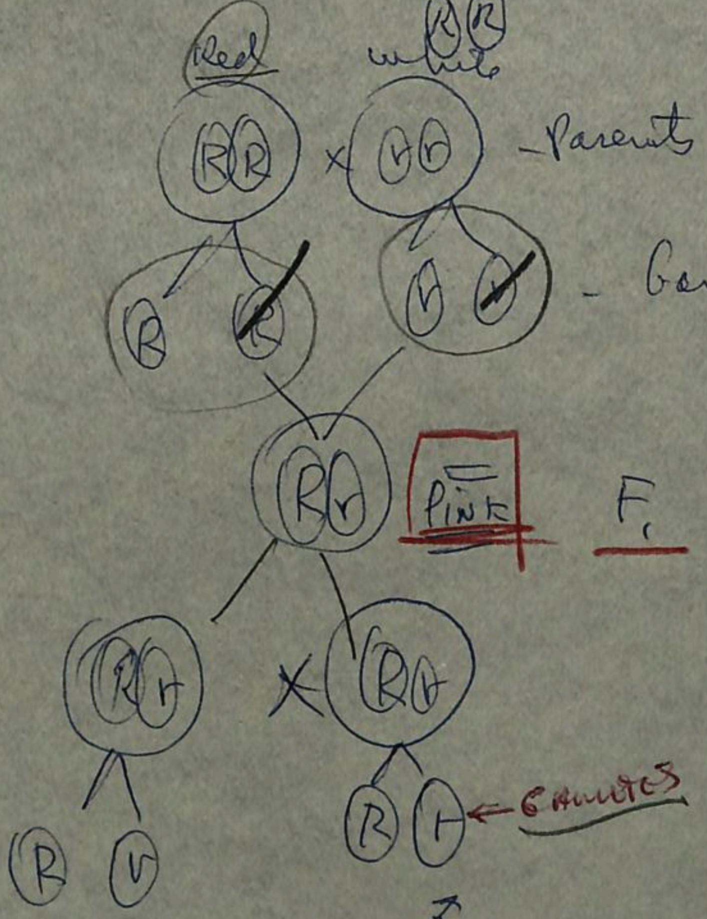
∴ Parent homozygous

Important application in Plant & Animal Breeding
i.e. Progeny selection based on genotypes. e.g. { Resistant seed
High milk production
" egg "

Incomplete Dominance

Four-O'clock (Mirabilis) Red-fl. × White-fl.

RR rr



Monohybrid → 2 kinds of gametes only

♀ \ ♂	R	r
R	RR	Rr
r	Rr	rr

F_2

1 : 2 : 1 Genotypes

FORMULA: 2^n n = No. of hetero-zygous pairs of alleles on different pairs of chromosomes.

- Monohybrid – 2^1
- Di – 2^2
- Tri – 2^3

∴ MAN – 2^{23} → 17^6 GAMETE KINDS

1831 - BROWN - NUCLEUS
1827 - Brownian movement
(SCOTCH)

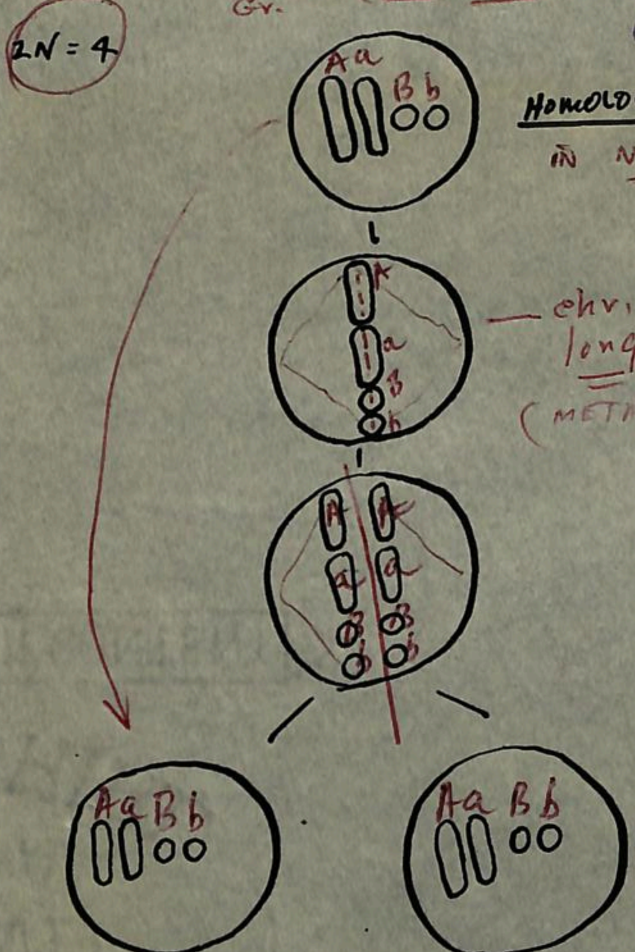
MITOSIS { 1882 - FLEMMING (UNIV. KIEL)
(THREAD)
Gr.

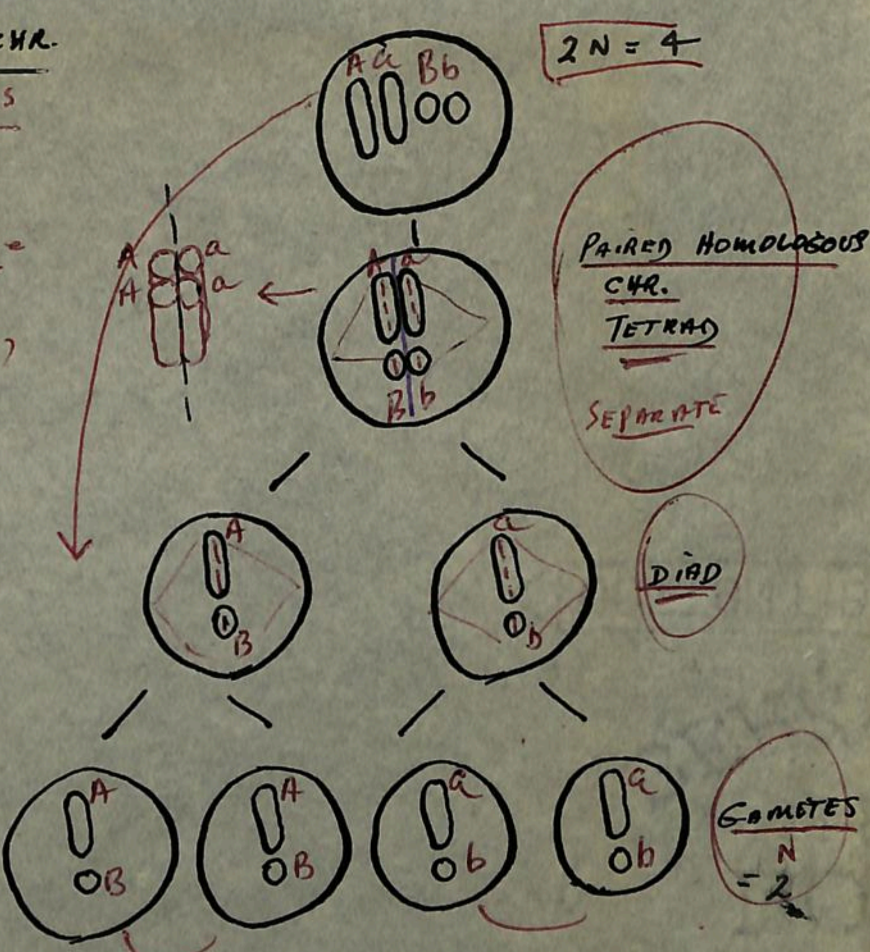
cell dyes
↓
Chromatin 1879
↓
Chromosomes
(WALDEYER 1888)

M. J. SCHLEIDEN - 1838 - CELL THEORY, PLANTS
T. SCHWANN - 1839 - " " ANIMALS

MEIOSIS { 1892 - BOVERI → GERMAN
(= Reduction)
Gr.

* { spermatogenesis
oogenesis





FERTILIZATION ♂ + ♀ → 2N

SCHLEIDEN 1838 - SCHWANN 1839

STRASBURGER - 1884 { PROPHASE → ANAPHASE
[1822-1884]

G. MENDEL - 1865 - VERSUCHE ÜBER PFLANZENHYBRIDEN [BRÜNN]
Paper to NÄGELI who didn't understand it!

[Mendel read Darwin but not the reverse]

Bearing on Darwin's Natural Selection
Mendel's discovery of INDEPENDENT INHERITANCE of UNIT CHARACTERS (GENES)
STRONGLY SUPPORTS ACCUMULATION OF FAVORABLE GENES
BY NATURAL SELECTION.

[Ch. R.
1) DARWIN 1809-1882
Feb. 12 (Lincoln?)]

R = RED
r = WHITE

T = TALL
t = SHORT } (PLANT)

Y = YELLOW
y = GREEN } (SEED)

(TTYY) × (tt yy)

(TY) (ty) } GAMETES

(Tt Yy) F_1

TY Ty tY ty } F_1 gametes (4 KINDS)

	TY	Ty	tY	ty
TY	TTYY	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttYY	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

Tall yellow = 9
Tall green = 3 } 12
Short yellow = 3
Short green = 1 } 4

PHENOTYPES
9:3:3:1

12 Tall
4 Short } 3:1

12 Yellow
4 green } 3:1

(TYR) × (tyr)

TYr
Tyr
tyr
tYR
tYr
TyR
~~ty~~
tyR

The Newton of the World of Living Things

CHARLES DARWIN: Evolution by Natural Selection. By Gavin de Beer. 290 pp. Illustrated. New York: Doubleday & Co. $4.95.

By LEONARD ENGEL

WITHOUT reservation or qualification, I salute the new biography of Charles Darwin by the eminent British biologist Sir Gavin de Beer. In fewer than 300 pages of well-written prose, Sir Gavin not only sets out a fitting personal portrait of the gentle Englishman who was the Newton of the world of living things. He tells us clearly what Darwin did that was so important and that has made Darwin one of the giants of human history. And he explains with care how Darwin did it. In the biography of a scientist, whatever else the author may wish to supply, what is most wanted is a proper explanation and assessment of the scientist's work. For Darwin and his work, the de Beer book does an exemplary job.

Darwin's name is, of course, inseparably connected with the theory of evolution. As architect of the theory, Darwin carried through two great tasks. The first was providing the factual evidence for evolution: gathering the mass of data showing that species are not immutable and that one species does indeed evolve into another. The second was the establishment of natural selection as the driving force behind evolution: species change because nature favors the survival and multiplication of individuals with superior adaption to their environment.

Mr. Engel is the editor of a recent edition of Darwin's "Voyage of the Beagle."

In the century since publication of "The Origin of Species," an immense literature has grown up around Darwin and his work. Unfortunately, much of this literature (and especially some of the most recent) manages to muddy the water and belittle both Darwin and his achievement. For example, there are many volumes devoted to Darwin's predecessors and contemporaries who also advanced evolutionary ideas but who generally did nothing beyond stating them in very crude form. The collective effect of these books is to imply that Darwin really did little that was new or significant. In other recent volumes, the famous chronic illness that plagued Darwin from the time of his return from the voyage of the Beagle to the end of his life is treated as psychosomatic, with the inevitable—and unpleasant—implication that he was merely a self-indulgent hypochondriac.

ALL this is badly in need of just such a corrective as the de Beer book now supplies. The author begins with an account of biology in the years before the celebrated voyage that was to start Darwin on the road to "The Origin of Species." This was the round-the-world cruise of H.M.S. Beagle, one of a number of vessels assigned by the British Navy in the early part of the 19th century to survey the far corners of the globe.

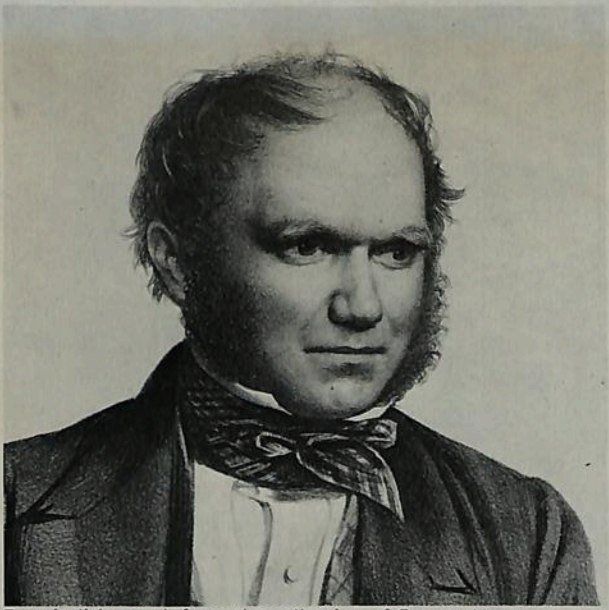
Young Darwin (he was not yet 23 when the Beagle sailed from Plymouth in 1831) was the ship's naturalist, and never was there a harder working or sharper-eyed naturalist. Wherever he went—in South America, across the Pacific, through the Indian Ocean—he puzzled out the geology, observed the fossils, studied the plants and animals, noted similarities and differences in the living forms of different places and different geological ages—and gradually came to the realization that life must change, must evolve.

Darwin was finally convinced of the mutability of life by 1837, the year after his return from the Beagle. Another 22 years passed, though, before the appearance of the "Origin." The delay (which nearly cost Darwin his priority as Alfred Russel Wallace meanwhile also hit upon evolution by natural selection, though Wallace did not gather the evidence for it that Darwin did) can be attributed to two circumstances. One was the sheer volume of work Darwin had to do, not only upon the problem of evolution, but upon other biological researches he had undertaken. The other was his illness.

As de Beer points out, recent research in tropical medicine makes it likely that Darwin suffered not from a psychosomatic illness, but from Chagas's disease, a singularly unpleasant chronic ailment once widespread in South America. Chagas's disease was not identified until well after Darwin's death. However, his symptoms matched those of Chagas's disease, detail for detail; and he was repeatedly bitten by the principal insect carrier of the disease during a trip through the Andes.

What is certain is that Darwin had to overcome a painful, debilitating illness as well as other obstacles to make his contribution to biology. And what a contribution de Beer shows Darwin to have made! Today, a century later, evolution by natural selection remains our key to understanding the ceaselessly changing drama of life.

Charles Darwin, c.1880.


Darwin lithograph from the collection of Garrett Hardin


David M. Phillips, The Population Council

Modes of Speciation

Michael White, Australian National University

The well-known evolutionary biologist Michael White presents a unique synthesis of the processes that enable new species to originate. Unlike previous books on speciation, which deal exclusively with plants or concentrate on phyletic evolution, this book is the first *general* treatment of genetic and geographic models of speciation in both animals and plants. White assesses the mounting evidence for the critical role of chromosomal rearrangements and attacks the orthodox view that all speciation is allopatric.

A *comprehensive* bibliography, drawn from the literature in a variety of languages, will be of interest to both advanced students and research workers.

Publication date: Spring 1978

CONTENTS:

3a

C. Darwin's Background

FEB. 12 (1809 – 82) ← LINCOLN!
(Shrewsbury)

From an illustrious family – his grandfather Erasmus wrote on evolution.

Darwin's father first considered a career in medicine & the Ministry. At Cambridge (undistinguished) he met Rev. John Henslow teacher of Botany. Henslow encouraged Darwin to study Geology & after doing so, Darwin received offer of position of Naturalist on the Beagle. (Dec. 27 1831 – Oct. 6 36)

Beagle a 238 ton vessel set sail for trip around world in 1831 under Capt. FitzRoy.

Voyage of the Beagle. Published 1839.

- Madeira } Is.
- Canary }
- Bahia Brazil
- Rio
- Montevideo
- B.A.
- Patagonia → Falklands
- Tierra del Fuego → Cape Horn
- Chile
- Peru
- Galapagos
- Australia
- Cape Good Hope

Rev. T. R. Malthus (1766-1834)
Essay on Population 1798

read by Darwin in 1838

Read Excerpts from Voyage

Trypanosoma Cruzi

Darwin probably contracted Chagas Disease in S. Am. He was an invalid after return from Beagle voyage.

John Scopes — "Monkey Trial" [1925]
Dayton, Tenn

5

3. MECHANISM OF EVOLUTION. The fact or organic evolution is unquestioned, but there is not complete agreement as to how it comes about.

a. Neo-darwinism is the most generally accepted explanation för evolutionary change.

1. Mutations provide inheritable random variations in the individuals of a species.

2. Overproduction gives more individuals than can survive to maturity.

3. Each individual competes with others in a continual struggle for existence against the forces of the environment. Malthus 1798

* 4. There is survival of the fittest individuals who are best adapted to the environment. Core of natural selection theory

5. The fitness is transmitted by genetic inheritance to the next generation.

6. This continuing natural selection of fit variations by the elimination of unfit individuals, gives rise to new species.

7. Isolation, whether physical or physiological, accelerates the formation of new species by reducing competition and permitting more variations to survive.

b. History of Evolution Theories. The ancient Greek philosophers formulated concepts of organic evolution. Empedocles (495-435 B.C.) founded the idea of gradual development of kinds of organisms and Aristotle emphasized that the order was from simple to complex.

St. Augustine (353-430 A.D.) interpreted Genesis as the imparting to matter of the power to evolve.

* C. Linnaeus (1707-1778) [1753 — Sp. Plantarum]

Buffon (1707-1788), a great naturalist, believed in the modification of species. Cuvier (1769-1832) — catastrophism

* Lamarck (1744-1829) developed the first modern theory of evolution. He thought that organisms felt the need for new structures to meet the demands of the environment and gradually developed them. Those parts used regularly developed more, and parts not used degenerated. Such acquired characteristics were supposed to be inherited by succeeding generations. While logical, this theory is invalid because genetic mutations are random and for the most part not useful. Furthermore, environmentally acquired characteristics are not transmitted through the germplasm. Lamarck's important service was in dislodging the idea of fixity of species and replacing it with the concept of organic evolution.

* Charles Darwin (1809-1882) made the greatest contribution to the present concept of evolution. Starting in 1831 on a five-year world exploring trip with the British ship, the Beagle, he collected the evidence which he organized and published twenty-two years later in 1859 in the book, "The Origin of Species by Means of Natural Selection."

GEOLOGIC TIMETABLE

Eras Periods	Millions of Years Ago	Forms of Life
Cenozoic Quaternary Tertiary	65	Mammals predominate; rise of birds modern kinds of plants and animals; spread of grasses; appearance of primates; dominance of man.
Mesozoic Cretaceous Jurassic Triassic	200	Late Mesozoic: Extinction of dinosaurs; toothed birds; first flowering plants. Early Mesozoic: Dinosaurs dominant; first mammals; modern insects; cycads and conifers.
Paleozoic Permian Carboniferous Devonian Silurian Ordovician Cambrian	500	Late Paleozoic: Amphibians dominant; first reptiles; winged insects; coal-forming forests of seed ferns, horsetails, club mosses; rise of conifers. Middle Paleozoic: First land plants; rise of fishes and amphibians; air-breathing insects. Early Paleozoic: trilobites; brachiopods; first fishes; marine plants.
Proterozoic	1000	Algae; protozoa; sponges; worms.
Archeozoic	2000	Indications of beginnings of life; no fossils.
Azoic	3000	Origin of earth; formation of earth's crust; no life.

curriculum fosters "rampant illiteracy." "Students are getting diplomas for warming their seats and not striking the teacher."

Political Tactics

The textbook watchers use a variety of political tactics to translate their concerns into administrative decisions; they adjust these tactics according to the educational policy-making structure in different states and to their own access to power within that structure. Where policy decisions concerning textbooks are made by centralized school boards and statewide textbook commissions, these administrative organizations become the target for political pressure. Elsewhere, efforts are directed toward local school boards, and if administrative action seems unlikely to yield change, textbook watchers go to the courts and sometimes to the streets.

SCOPES { CLARENCE DARROW – DEFENSE / WM. J. BRYAN

In State Legislatures

The repeal of Tennessee's "monkey laws" in 1967 reflected more a change in the alignment of voting districts than a change in attitudes. Antievolution sentiments persisted; in some areas teachers attempting to teach evolution have been reprimanded or dismissed. According to a public opinion poll in September 1972, three quarters of the high school students in Dayton, Tennessee, still believed in creation: "Darwinian evolution breeds corruption, lust, immorality, greed and such acts of criminal depravity as drug addiction, war, and atrocious acts of genocide."[20] And in 1973, less than six years after repealing its antievolution legislation, the Tennessee General Assembly passed a new statute requiring that

> Any biology textbook used for teaching in the public schools which expresses an opinion of, or relates to a theory about origins or creation of man and his world shall be prohibited from being used as a textbook in such system unless it specifically states that it is a theory as to the origin and creation of man and his world and is not represented to be scientific fact. Any textbook so used in the public education system which expresses an opinion or relates to a theory or theories shall give in the same textbook and under the same subject commensurate attention to, and an equal amount of emphasis on, the origins and creation of man and his world as the same is recorded in other theories including, but not limited to, the Genesis account in the Bible.[21]

This law, essentially declaring the Bible a reference book for biology, passed the Tennessee House of Representatives by a vote of 69 to 15, and the Senate by 28 to 1.

The National Association of Biology Teachers (NABT) challenged the constitutionality of the legislation, contending in a federal district court that it interfered with free speech, free exercise of religion, and freedom of the press as guaranteed by the First and Fourteenth Amendments.[22] One month later, unknown to the NABT, an organization called America United for the Separation of Church and State, Inc., filed a similar suit in a state chancery court in Nashville. As a result, the district court abstained from considering NABT's suit until the constitutional issues were resolved by the state court. NABT attorney Frederic LeClercq then appealed to the United States Supreme Court, both on the jurisdictional issues and on whether the Tennessee act violated constitutional amendments. The Supreme Court refused to accept the case, but finally on April 10, 1975, a court of appeals in Tennessee overruled the equal time legislation, claiming that it showed

> a clearly defined preferential position for the Biblical version of creation as opposed to any account of the development of man based on scientific research and reasoning. For a state to seek to enforce such preference by law is to seek to accomplish the very establishment of religion which the First Amendment to the Constitution of the United States squarely forbids.[23]

This decision was an important precedent, for similar bills had been introduced in the state legislatures of Georgia, Kentucky, Arizona, Michigan, and Washington.[24] Most of these efforts failed, for state legislatures, even if sympathetic in substance, were reluctant to intervene in educational policy making, and textbook critics turned to schoolboards and textbook commissions in their attempts to influence the selection of course materials.

In School Boards and Commissions

In twenty-two states, including Texas and California, there are cen-

NELKIN, DOROTHY. SCIENCE TEXTBOOK CONTROVERSIES & THE POLITICS OF EQUAL TIME. MIT PRESS. 1977 174 pp.

Paleobotany ① (Paleontology)

Fossil history of Plant World – Sequence of plant forms determined from age of rock.

Most fossil in Sedimentary Rock – formed under H_2O by slow deposition of sand, mud, clay which harden into rock under pressure & chemical transformations.

L. fodio = dig → Fossils

∴ Fossil record fragmentary: only harder parts of plants or animals preserved; ie after decay of soft parts, only a print may remain (e.g. Leaf prints in rock)

① Impressions = Molds = Casts

② Petrifactions { Replacement particle by particle of organic part by mineral deposits. ie Petrified forests – (Arizona) – Conifers. More valuable because internal structure also preserved –

③ { Preservation of entire specimen or part, intact (ie insects in amber) or coal (carbonized wood)

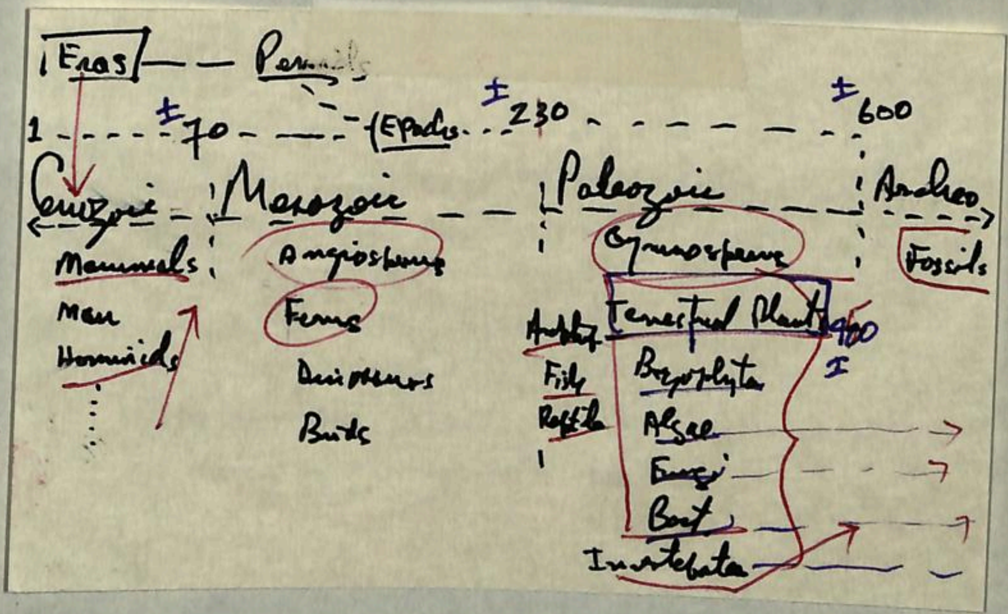
Fossils preserved in Rock Strata from earliest times, reflects history of life on earth.

Azoic

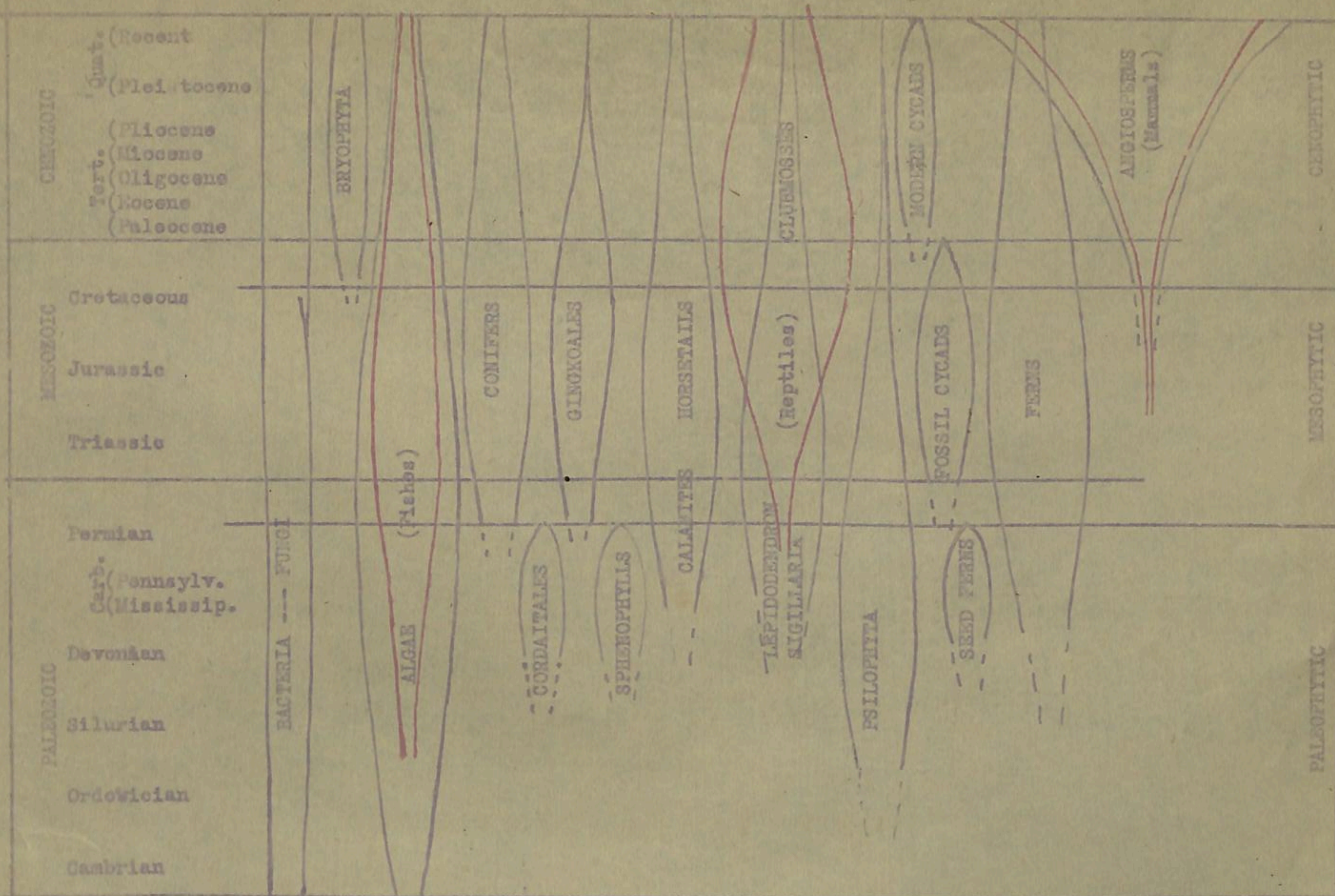
zoe = life

(Geological Time Scale)

Eras				Period	
Archeozoic	= Beginning	— ± 3000	? Marine Algal	Cambrian	– Marine Algae
Proterozoic	= Early	— ± 1500		505 – Ordovic.	— 1st Land Plants ± 425 × 10^6 yrs.
Paleozoic	= Ancient	— ± 580	× 10^6 yrs	425 – Sil.	—
Mesozoic	= Middle	— ± 225		375 – Dev.	— Gymnosperms Forests
Cenozoic	= Recent	— ± 70		325 – Miss.	— Lycopods + Horsetails } Forests
				275 – Penn.	— Seed Ferns – Mosses
				240 – Perm.	— Decline of Lycopods
				= Carboniferous	



Review position of Gymnosperms
Angio —



PRECAMBRIAN: Believed greatly to exceed time from beginning of Cambrian to present. Order of 1,500,000,000 years.

Outlines in red and group names in parentheses indicate important animal groups

Wales. He described, among other things, a simple vascular plant of the *Rhynia* type. Both vascular tissue and cutinized, trilete spores found in situ demonstrated conclusively that *Cooksonia* was a vascular plant. At that time the Downtonian was considered to be a boundary deposit of either Late Silurian or Early Devonian age. It seemed to me to have the oldest vascular plant flora.

In 1962 Obrhel found a similar plant in Czechoslovakia in beds (Pridoli) that were, and still are, held to be uppermost Silurian in age. So Obrhel's plant appeared to be somewhat older. Ishchenko (1969) has reported *Cooksonia* in the Skala beds in Podolia, and I have a note in press on a *Cooksonia* from the Bertie formation (Cayugan Series) in New York. As a result of a series of international conferences on the Silurian-Devonian boundary, the appearance of certain invertebrates (especially graptolites, conodonts, and ostracodes) has been designated as the end of Silurian and start of Devonian deposition. This decision makes the four deposits equivalent in age—all Upper Silurian. I mean the Downtonian in Wales, the Pridoli in Czechoslovakia, the Skala in Podolia, and the Cayugan Series (Bertie limestone) in New York. Thus the oldest currently acceptable vascular plant, *Cooksonia,* is found at three or four widely spaced geographic localities. The time of appearance of this fossil is speculative, but I'll say in round numbers 400 million years ago, five million before the start of Devonian deposition.

Further, there is a report by Petrosian, which I've not seen, of the discovery of a *Zosterophyllum* in the Skala beds of Podolia. If this proves acceptable, then the two groups

TABLE 1. Times of first appearance of dispersed spores that may have come from vascular plants and of groups of plants proven to be vascular. (Spores from Richardson and Lister, 1969; dates from Harland *et al.,* 1964.)

PERIOD	BEGAN MILLIONS OF YEARS AGO	STAGE	VASCULAR PLANTS	
MISSISSIPPIAN	345	Tournaisian		
	353	Famennian		
	359	Frasnian		
		Givetian		
	370	Eifelian		
DEVONIAN	374	Emsian	*Rhynia*-type *Zosterophyllum*-type trimerophyte-type lycopod-type fan-leaved type barinophytes	progymnosperms sphenophytes cladoxylaleans sciadophytes
	390	Siegenian	*Rhynia*-type *Zosterophyllum*-type trimerophyte-type (*Psilophyton*) lycopod-type	fan-leaved types barinophytes sciadophytes
	395	Gedinnian	*Rhynia*-type *Zosterophyllum*-type	
	405	Downtonian (Pridoli) (Skala) (Cayugan)	*Rhynia*-type *Zosterophyllum*-type and 8 genera, 24 spp. of spores	
SILURIAN	415	Ludlovian	6 genera, 15 spp. of same	
	425	Wenlockian	4 genera, 8 spp. of same	
	435	Llandoverian	1 genus of dispersed, supposed vascular, plant spores	

Rhynia-type and *Zosterophyllum*-type appeared almost simultaneously in the fossil record, that is in the youngest stage of Silurian time.

One hopes that palynologists working with isolated spores in the same strata might lend support to this macrofossil evidence. I am happy to report that in general they do. There is abundant documentation of the appearance of a few spores in Early Silurian time and a steady increase in number of species and in their morphological variation through Devonian time. Homospory comes first, heterospory follows, and, in Late Devonian as Pettitt and Beck have now demonstrated, the first seed appears. There is only one flaw in this story. That is ignorance whether the appearance of an apparent vascular plant spore in late Early Silurian means we must seek actively for macrofossils older than the present *Cooksonia,* or it means that cutinized spores produced in quartets evolved earlier than other characteristics of vascular plants. Right now this ignorance only emphasizes the tentative nature of our conclusions and that our students will surely depart from our conclusions as new data accumulate.

The second question concerns attempts to put these new data into a phylogenetic series. So I offer you a tentative chart which makes only a few major points. First, there were some groups that started and ended with no obvious descendants (sciadophytes, barinophytes, fan-shaped leaves). Then there seem to have been two productive groups, the *Rhynia*-type and the *Zosterophyllum*-type. This latter I speculate gave rise to both lycopods and giant lepidodendrids. Lycopods have persisted. The *Rhynia*-type gave rise to trimerophytes represented by *Psilophyton,* and from these most vascular plants have somehow arisen. There is no time for further detail but this is something at which subsequent workers can shoot.

on the low-lying, terrestrial portion of the Devonian delta that was forming in eastern New York, and that parts of the plants fell into small ponds where they were compressed into the lenses which are now exposed occasionally by major earth-moving projects.

Somewhat later than Vanuxem and Hall, and in Lower rather than Upper Devonian strata, Sir James W. Dawson, then Principal of McGill University, embarked in summer 1858 on a momentous trip to the tip of the Gaspé Peninsula. Dawson had learned about Gaspé plants from Sir William E. Logan, founder and first Director of Geological Survey of Canada. Logan had observed fossil plants during mapping expeditions in 1843 and had told Dawson about them. Dawson's first trip, 15 years later, was successful, and within a year a paper appeared in the Quarterly Journal of the Geological Society of London describing a new plant, *Psilophyton princeps.* Either ships were faster in those days or editors were!

As an aside, perhaps I should point out that Dawson was a good example of the versatility of paleobotanists. As Principal of McGill he was a successful money-raiser and innovator. In the latter direction he not only built science at McGill into a position of leadership, he taught botany, zoology, geology, and chemistry, founded an engineering college, and a college for women.

So in 1859, the same year Darwin's *Origin of Species* appeared, Dawson published *Psilophyton princeps,* a slender, dichotomizing, spiny plant with supposed lateral fructifications and rhizome. He considered it a possible relative of living *Psilotum.* In 1871 Dawson established a variety, *P. princeps* var. *ornatum,* for another Gaspé plant supposed to bear paired terminal sporangia, stout spines, and scalariform tracheids.

The vicissitudes of these two taxa constitute a long and intriguing story, too long for presentation here. Suffice it to say that the various organs of *Psilophyton* were not found in organic attachment, and as Hueber and I reported in 1967 there were two different genera involved. First is the true *P. princeps* for which we selected a type specimen. Second was the variety *ornatum* which has yet to be placed in a new genus. The first had paired terminal sporangia that split longitudinally during dehiscence and had centrarch primary xylem. Hueber described this plant in greater detail in 1968. The second organism bore lateral sporangia whose dehiscence was distal and was supplied by an exarch xylem srtand.

For the first group I proposed in 1968 the name Trimerophytina, a group I consider advanced in many characters over the simpler *Rhynia*-type.

For the second type I have suggested the group name Zosterophyllophytina, and my slides illustrative of this type are a selection taken from several members of the group including the *ornatum* type of *Psilophyton* and the *Crenaticaulis* described recently by Davis and me.

And now to dispell the myth that paleobotanists are interested only in anatomy, a statement I've read in *Science* within the year, let's change the subject to another group of people and set of data.

While the more recent of the above events were going on, stratigraphic paleontologists and geochronologists were actively building a more precise chronology and correlation of Devonian strata (Table 1). I illustrate seven subdivisions of the Devonian Period which spanned some 50 million years, and four subdivisions of Silurian. Both time of commencement and the duration of each are given. Were the time available we could examine as well the numerous lesser units into which each of these has been subdivided. All of this subdividing is easier to do in marine deposits containing an abundance of invertebrates but remarkable strides have been made in correlating with them the contemporaneous fresh-water, or continental, strata in which accumulations of plants are much denser. The point is that we are beginning to get the kind of chronological data Wieland regarded as essential to a good phylogeny. An important ingredient for this project is close cooperation among paleobotanists, stratigraphers, paleontologists, and palynologists. This, in fact, is beginning to take place through the medium of international conferences on boundary problems, e.g., the boundary between Silurian and Devonian Periods. But it demands that all learn to speak one another's jargon!

The increased precision in geochronology has produced many changes, some of which make the paleobotanical data far more sensible than they were before. Two examples are the *Baragwanathia* flora in Australia and the Rhynie chert flora in Scotland. The former is now regarded as late Lower Devonian rather than Silurian, the latter as late Lower Devonian rather than Middle Devonian. Additionally, widespread interest in biogeochemistry, especially of Precambrian strata, led to the discovery of algae in these ancient rocks and of apparent eucaryotic green algae in rocks deposited nearly one billion years ago. I refer, of course, to such compounds as amino acids, fatty acids, alkanes, and pristanes isolated from rocks and presumed to be degradation products of organisms and to the studies of such men as Barghoorn and Schopf.

It was this kind of new knowledge that led me to start arranging early vascular plants chronologically.

Two groups, the *Rhynia-* and *Zosterophyllum*-types, seem to occur in Late Silurian.

Two groups, the *Rhynia-* and *Zosterophyllum*-types, lived in earliest Devonian (Gedinnian) time. By Siegenian there were four major groups, the first two plus lycopods and trimerophytes (*Psilophyton*), and three lesser groups, the barinophytes, sciadophytes, and fan-leaved types.

In Emsian time three more groups appeared, cladoxylaleans, sphenophytes, and the first of the progymnosperms (*Protopteridium*-like forms).

Thus ten groups of vascular plants evolved during late Silurian and early Devonian time. The time span involved was under 35 million years. There is no need to continue into Middle and Upper Devonian because the number of kinds of vascular plants continues to increase in progressively younger strata, a continuation of the trend started earlier.

Next you may ask what is the present status of the earliest demonstrable vascular plant and has any effort been made to summarize the current status of the phylogeny of vascular plants?

Lang in 1937 wrote an outstandingly good and analytical paper on the flora of the Downtonian deposits in

The future: I think I've already demonstrated how easily current hypotheses can be shown erroneous or, sometimes, supported but here are a few ideal examples.

1. *Protopteridium* is shown in many textbooks as the first plant to bear a fern frond. Bonamo, working with *Tetraxylopteris,* demonstrated that this is probably a fertile branch system.

2. I was taught not to waste time on Devonian strata in western North America because they were all marine. Dorf first demonstrated the fallacy of this by finding and describing a flora at Beartooth Butte in Wyoming. Now several good deposits are known.

3. Intensive collecting and improved technical ability can add greatly to the precision of our knowledge. Examples:

a. Matten and I described *Triloboxylon* as a new taxon perhaps related to progymnosperms but lacking secondary wood. Scheckler has now demonstrated its affinity to progymnosperms.

b. For some years we have worried about strange variations in the anatomy and morphology of *Tetraxylopteris.* Scheckler can now resolve these problems if he erects a new taxon which will permit him to segregate out the various characteristics.

c. Pyrite is difficult to prepare well for anatomical study. In fact one used to throw it away as worthless. Here are a few samples of good technique—parenchyma in primary xylem in transverse and longitudinal views, alternating bands of sclerenchyma and parenchyma in outer cortex, a variety of protoxylem and metaxylem cells in longitudinal section. All the illustrations are from Scheckler's preparations.

4. Yes, I visualize the day when we'll know many Devonian plants as plants rather than as isolated organs, when we'll be able to speak intelligently about habitats and associations, when we'll know the length of time that was required to evolve new species, and the algae from which vascular plants did evolve. I think we'll learn whether the origin of vascular tissue was related to the origin of metabolic pathways for the manufacture of lignin (perhaps in the Silurian). I think we'll know much more about the possible role of O_2 concentration in the atmos-

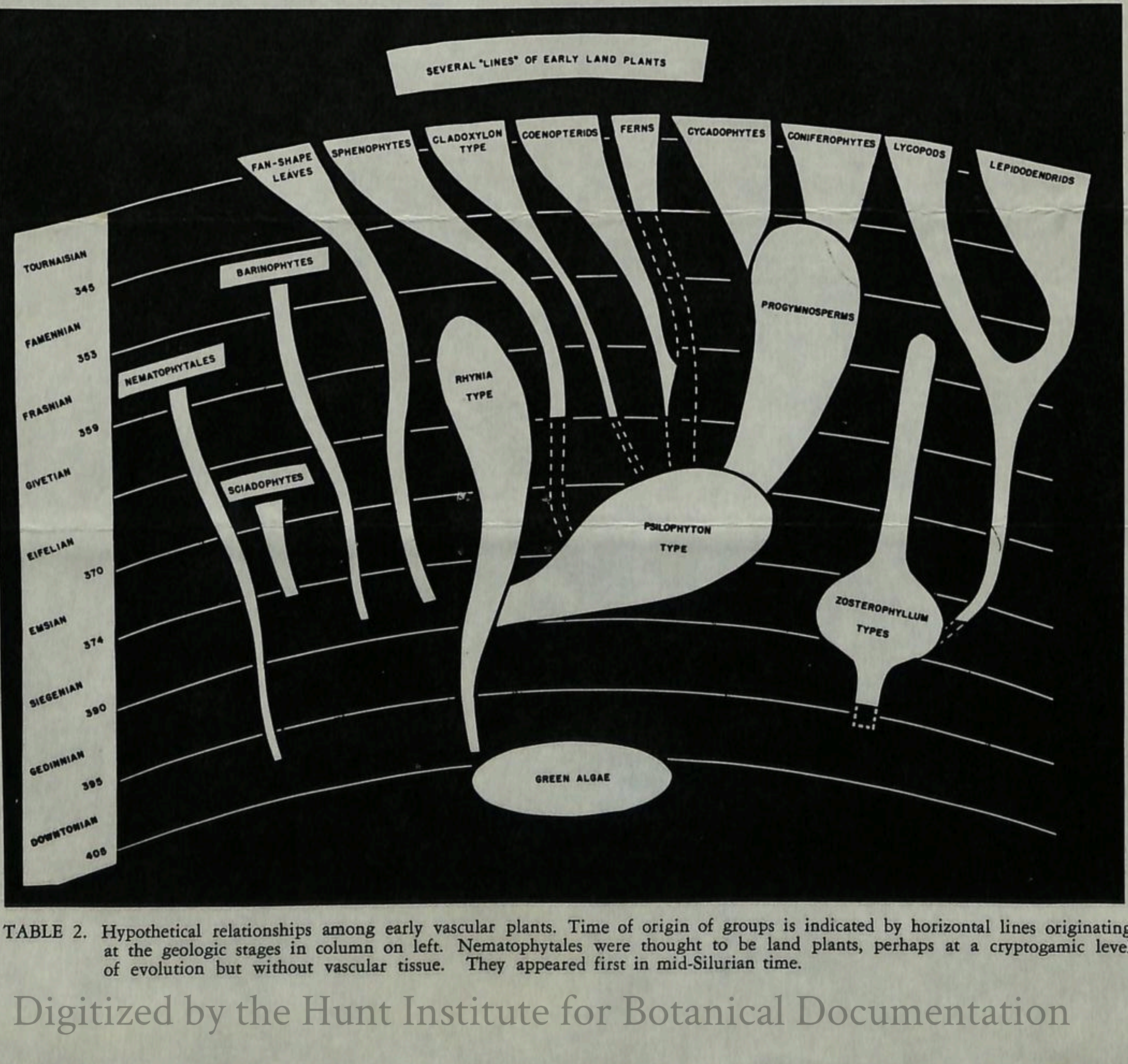


TABLE 2. Hypothetical relationships among early vascular plants. Time of origin of groups is indicated by horizontal lines originating at the geologic stages in column on left. Nematophytales were thought to be land plants, perhaps at a cryptogamic level of evolution but without vascular tissue. They appeared first in mid-Silurian time.

phere, its role in the formation of ozone, and their role in shielding Earth's surface from lethal ultra-violet radiation, thus permitting the occupation of dry land. And of course I'll be watching for confirmation of my wildest statement, actually a primitive attempt at precision, that all the phylogenetically important innovations among vascular plants are found during the 50-million-year adaptive radiation of land plants that occurred in the Devonian Period. Ted Delevoryas has picked me up on this one and allowed as how all the evolution after Devonian time was just "frosting on the cake."

In lieu of the illustrations that accompanied this talk, a few citations in which they may be found are given below. In the same list are sources of some of the remarks made in the text.

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Botany in the Academic Jungle

Sydney S. Greenfield
Rutgers University at Newark, New Jersey

The changing status of botany in American education and the tendency to de-emphasize plant science in certain institutions have been of long-standing concern to botanists. In 1952, a special committee of the Botanical Society of America reported the results of a comprehensive survey of the status of botany in 745 colleges and universities (1). This study showed that although there were many botany departments with well-developed botanical curricula, there were a great many more biology departments in which botany was de-emphasized or completely neglected. The principal causes of botany being de-emphasized, i.e., biology departments dominated by, or exclusively staffed by zoologists with little or no understanding or interest in botany, unbalanced and misleading biology courses, and administrative lack of understanding of the importance of botany, were clearly indicated by this study.

Captain Jacques Cousteau
The Cousteau Society, Inc.
Box 2002, New York, New York 10017

Dear Citizen of the Water Planet,

A shipwrecked sailor was struggling in the water. The shore was near, but his strength was almost spent.

Then suddenly there was a friendly presence in the water, a strong, sleek body that buoyed him up, escorted him to shallow water, saved his life...

This story, or something akin to it, has been told countless times about dolphins and porpoises. When I take it together with what we have learned about these marvelous creatures in the past twenty years, I have to give credence to at least some of these tales.

In fact, dolphins, porpoises and their larger cousins, the great toothed whales, do have a formidable intelligence. We hope some day to understand the subtleties of their brains, which rely heavily on an acoustical perception of the world around them. But the stories of rescued swimmers may find their explanation in a simpler trait, a trait that dolphins share with a majority of us animals, a trait which may be more important than any amount of brain power.

When a dolphin mother gives birth, her baby is expelled underwater. The first act following birth is critical: to lift the freshly-born youngster up to the surface for its first breath. So powerful is this motherly instinct, that other struggling animals have been pushed to the surface instinctively by female dolphins.

How marvelous and beautiful! The instinct to protect the next generation drives some automatic motor response in the dolphin and in many other species. To me this is marvelous because the successful replication of life is what makes our Oasis in Space such a rich biomass, fecund and prolific, forever generating and nursing new organisms.

Surely this blessed miracle of life is the greatest treasure on earth. Yet do we earthlings cherish and guard it? On the contrary. Each month we now pour millions of tons of poisonous waste into the living sea. Many of our lakes, rivers and coastal waters have received their mortal wound. The water is undrinkable. The fish and shell fish, if they exist at all, are inedible.

(over)

K

I do not say this lightly. During the past thirty years my team and I have spent thousands of hours diving in Aqua-Lungs and other underwater devices.

During that time I have observed and studied closely, and with my own eyes I have seen our waters sicken. Certain reefs that teemed with fish only ten years ago are now almost lifeless. The ocean bottom has been raped by trawlers. Priceless wetlands have been destroyed by land fill.

And everywhere are sticky globs of oil, plastic refuse and unseen clouds of poisonous effluents.

Is all now lost? I do not believe it. If I did, I would not be writing to you today.

I passionately believe that the perceptive few who have the opportunity to see the ultimate disaster ahead must band together now to warn the slumbering many. (Is it not always thus?) Such corrective measures as exist must be put into effect immediately. Pioneering research and exploration to help us better understand the sea and its creatures must be undertaken without delay.

To this new crusade I solemnly pledge what years remain to me. I now write to you because your name has been suggested as one who might also wish to join in this supremely important undertaking.

The group to which you are invited is called The Cousteau Society. Its membership will be worldwide, and one of its most important functions will be to give strength and substance to my words when I take our case before governments and other great institutions.

If, instead of speaking simply as Jacques Cousteau I can speak for hundreds or thousands of comrades, how much more closely the world will listen, how much more quickly the world will act!

A second function of The Cousteau Society will be to raise funds through its membership to support the vital exploration and research projects we are even now embarking on. That is why we are seeking annual dues in the amount of $15.00. Any additional sum you may wish to contribute we leave to your own judgment and generosity. Your dues and additional contributions are deductible for Federal Income Tax purposes. Let us return now to the oceans - to our endangered Earth --

Often, when I describe the symptoms of our environmental illness I hear remarks like "they're only fish" or "they're only whales" or "they're only birds."

(more)

I assure you that our destinies are linked with theirs in the most profound and fundamental manner. All life is interconnected and the great life-giving bank is the sea.

If the oceans should die -- by which I mean that all life in the sea would finally cease -- then this would signal the end not only for all marine life, but for all other animals and plants of this earth, including man.

Billions of decaying bodies, large and small, would spread their stench over all the coasts. The expiring sea, scummed with sludge, would have become, in effect, one enormous cesspool. It would cease taking up the CO_2 -- waste product of all animal life -- and would no longer replenish our air with oxygen. The phytoplankton, the vital sea factory for our atmosphere, would be gone.

One cannot predict the exact nature of the catastrophe anymore than one can describe being tossed about in an on-coming cyclone. Beyond a certain early point of disaster almost any scenario would read like a chapter out of Dante:

- enormous climatic changes bringing dramatic alterations in global temperatures,

- melting of the polar ice caps with the water levels of the oceans raising 100 feet or more,

- one third of the world's billions being driven inland only to meet with famine, chaos and disease on an immense scale impossible to imagine.

Would there be a final act with the wretched remnants of the human race packed cheek by jowl on the remaining highlands, bewildered, starving, struggling to survive, trapped and, finally, with CO_2 rising, strangling helplessly in an atmosphere that will no longer support life? One cannot say exactly, but this can be said:

> the death of the oceans means the death of man -- who would gasp out his life on barren hills with what remained of other land animals.

I beg you not to dismiss this possibility as science fiction. The ocean can die, these horrors could happen. And there would be no place to hide.

Earth is the only planet we know of where life can exist. That is because it is that rarest of phenomena, a "water planet." Water is a peculiar and precious substance, with many oddities in its physical and chemical composition. This unique nature of water, operating in a dynamic world water machine powered by the sun and the moon, provided the cradle in which life originated.

(over)

The ocean is life.

Yet again I ask, do we earthlings cherish and guard it? Consider these deadly skirmishes in the enormous assault we have unwittingly mounted against our water planet --

The Poisoned Rivers

A researcher asked a marine biologist if he could supply a map showing which rivers pollute the ocean. The biologist had a simpler way. He said, "Nowadays, any river that flows through a farm, a city or an industrial area is loaded with pollutants."

The Exiled Sea Otters

An ecosystem of classic significance is that of the sea otter, the kelp and the sea urchin. Years ago the charming sea otter was abundant all along the California coast, but now it has been almost wiped out. Reintroduced at great expense in the northern half of California, it is still chased by poachers and hardly survives. So the urchins it used to feed upon gnaw at the roots of the kelp, and what were once fecund marine jungles are now turning into scrubby deserts.

Goodbye Whales, Goodbye Dolphins

The only creatures on earth that have bigger -- and maybe better -- brains than humans are the Cetacea, the toothed whales and the dolphins. Perhaps they could one day tell us something important, but it is unlikely that we will hear it. Because we are coldly, efficiently and economically killing them off. Recently my boat Calypso visited the Antarctic, and in every bay we saw piles of whale bones from the enormous kills of the forties and fifties when whales were all but wiped out. Not all of us wept, but we were all extremely upset.

The Coming Abundance of Pesticides

Every chemical waste of effluent, whether in air, on land, or in water, will eventually end up in the sea. Of all the DDT compounds so far produced over 30% are already in the oceans. We know that eventually all will end up there! (Production of DDT has been stopped in the States. But overall production of untested new pesticides has increased considerably. As always, the producers of pollutants subsidize another research, a counter research, and then, if unsuccessful, a new untested pollutant.)

(more)

"Daddy, What's A Coral Reef?"

All over the world, coral reefs are in bad shape; in Florida, in most Caribbean islands and in Madagascar, we have witnessed a decrease in the vitality of the reefs that has dramatically accelerated during the past ten years - knowing how vulnerable the coral polyps are, the most probable cause is man-made pollution, overfishing and systematic destruction of the reefs by teams of professional divers armed with crowbars to supply souvenir seekers with shells and bleached branches of coral! In its wake came the famous starfish, doing its immemorial job of removing sick and imperfect coral. To save the reefs, divers worked around the clock injecting formaldehyde into the unfortunate echinoderms. But, alas, they were treating symptons, not causes. It is our own vandalism, not the starfish, that may doom the reefs.

A New Look at "The Endless Bounty of The Sea"

Remember when the inexhaustible sea, so-called, was going to feed all the world's new billions? Four years ago I knew that the amount of life in the oceans was dwindling at a terrifying rate. Yet I predicted that the fishing tonnage would continue to rise for a few years because of better equipment methods -- and I was wrong. The tonnage of fish started down in 1971 and has kept going down ever since, in spite of more fishing vessels and better equipment.

I could add thousands more to these examples, and fill a dozen volumes. But I hope these few will convey my distress and concern at what is happening to our oceans, our planet and ourselves.

To do effective battle against such powerful forces of destruction, our Society must be totally independent. No one must say that The Cousteau Society was responsive to pressure of any description. So our strength will not come from government grants, institutional or selfish interests, but from individuals like you and me.

Governments, foundations and corporations, after all, do not have to breathe. We do.

How shall we accomplish our heavy task? We must present the case for our water planet to hundreds of great ones in government and industry. We must continue and dramatically augment unconventional research into the nature and function of the intricate elements of our fragile "water dependent" ecosystem.

(over)

All these things are going to cost money, so I now most earnestly and urgently implore your support.

Because the money you give now may
literally help to save the world.
Save it, not only for ourselves,
but for our children and for their
children.

I am confident that most members of The Society will welcome this unique opportunity to help, and that some will make real sacrifices in order to contribute. To disburse such monies is a solemn responsibility, and we think it is important that Society members know exactly how their money is being spent. Accordingly, financial statements will be sent annually to all contributing members.

The Enrollment Card enclosed invites you to become a Member in The Cousteau Society. The annual dues of The Society are $15.00.

There are benefits, of course: for example, the Log of the Calypso, including beautiful posters and a newsletter which will report Society activities to you throughout the year; polls to obtain your ideas on environmental matters; paperback books, published by The Society, which will be made available to members; and an attractive Society decal which we hope you will display prominently and proudly.

And one thing more...a little wallet card with your name on it... testifying to the world that you were one of the first to stand up for life, for the future, for our water planet.

Faithfully,

JY Cousteau

Jacques-Yves Cousteau

Captain Jacques Cousteau Invites You to Join

THE COUSTEAU SOCIETY, INC. BOX 2002, NEW YORK, N.Y. 10017

☐ I hereby apply for membership in The Cousteau Society, Inc., and enclose my annual dues of $15.00.

☐ I wish to sponsor ____ Gift Membership(s) for the person(s) whose name(s) and address(es) I have printed on the reverse side of card. (Each Gift Membership, $15)

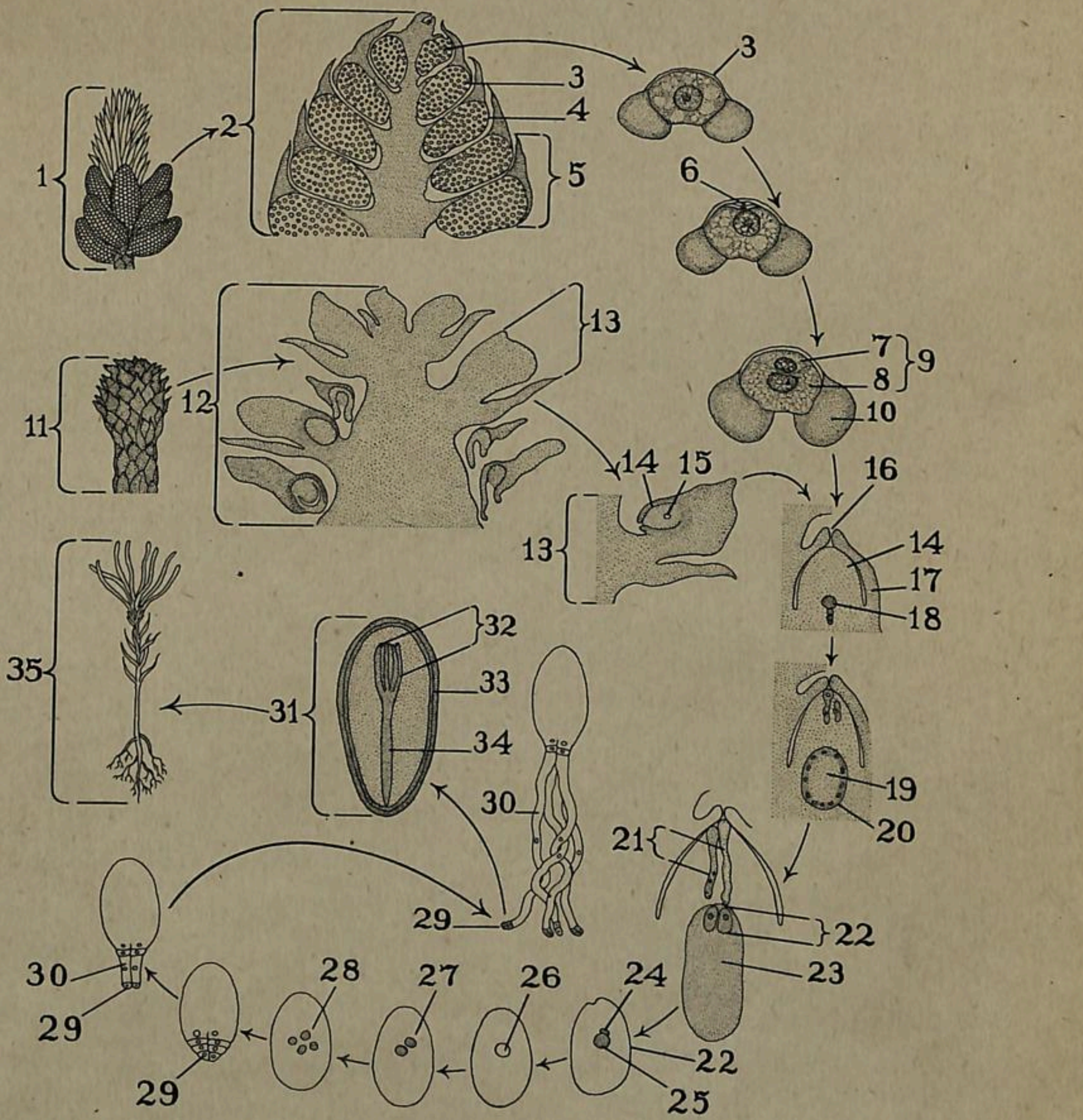
☐ I enclose an extra contribution of: $ ________

☐ Total enclosed for Gift Membership(s): $ ________

The Total Amount of Money Enclosed is: $ ________________________

1. Your name and address will be typed on your membership card exactly as they appear here. If corrections are necessary, please make them on the label itself. 2. Please use reverse side *only* to list the names and addresses of those you wish to receive gift memberships. 3. Dues and contributions are deductible for Federal Income tax purposes to the extent provided by law. 4. Please allow 4 weeks for the delivery of your membership card.

304L
B. LOWY
DEPT OF BOTANY
LOUISIANA ST UNIV
BATON ROUGE, LA 70803



1. Branch with staminate cones
2. Portion of staminate cone in longitudinal section
3. Microspore
4. Microsporangium
5. Microsporophyll
6. Prothallial cells
7. Generative cell
8. Tube cell
9. Male gametophyte (pollen grain)
10. Wing
11. Branch with ovulate cone
12. Portion of ovulate cone in longitudinal section
13. Ovuliferous scale
14. Megasporangium (nucellus)
15. Megaspore mother cell
16. Micropyle
17. Integument
18. Growing megaspore (three degenerate)
19. Female gametophyte, free-nuclear stage
20. Megaspore coat
21. Pollen tubes
22. Archegonia
23. Female gametophyte
24. Male nucleus
25. Egg
26. Zygote
27. Two free nuclei, from division of zygote
28. Four free pro-embryonic nuclei
29. Apical cells of embryos
30. Suspensor cells of embryos. Of the four embryos, only one develops.
31. Seed
32. Cotyledons
33. Seed coats
34. Hypocotyl
35. Seedling

TURTOX PRODUCTS

HOOKE – CELL – 1665 ✓

BROWN – NUCLEUS – 1831 ✓

SCHLEIDEN-SCHWANN – 1838-9 ✓

FLEMMING – MITOSIS – 1882 ✓

BOVERI – MEIOSIS – 1892 ✓

WALDEYER – CHROMOSOME – 1888 ✓
(NAME)

MENDEL – 1865 ✓ – "FACTORS" → GENES → DNA

DARWIN – 1859

MONO – DICOTS ✓ (SEED, LEAF VEINS, etc)

WOOD < TRACHEIDS – GYMNOSP. ✓
TRACHEA – ANGIOSP. ✓

MITOSIS – 1882 – FLEMMING, W.
CHROMOSOME – 1888 – WALDEYER

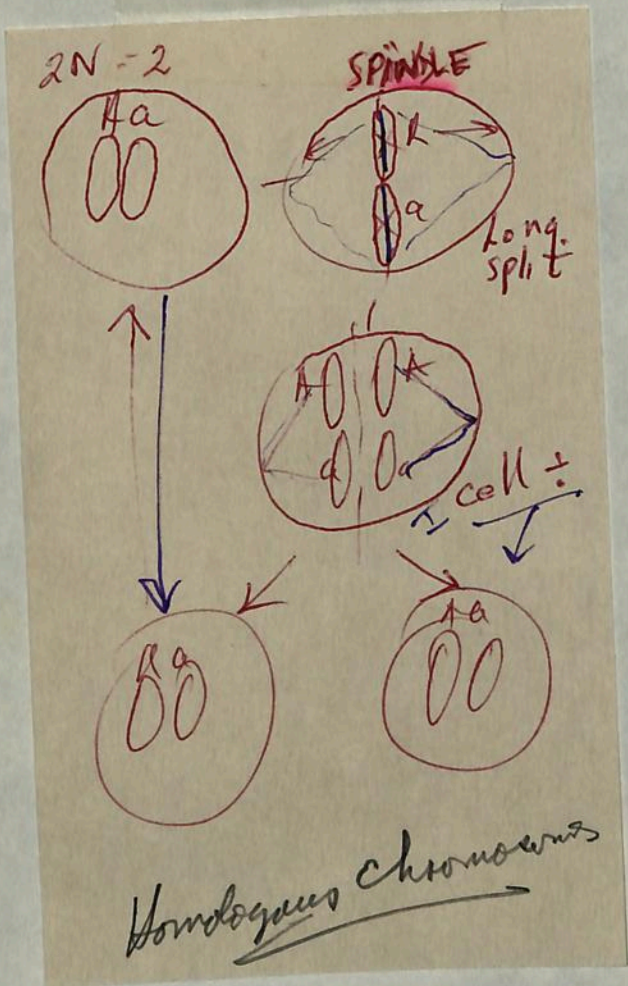
PROPHASE
↓
TELOPHASE
} Ed. 1882 – STRASBURGER

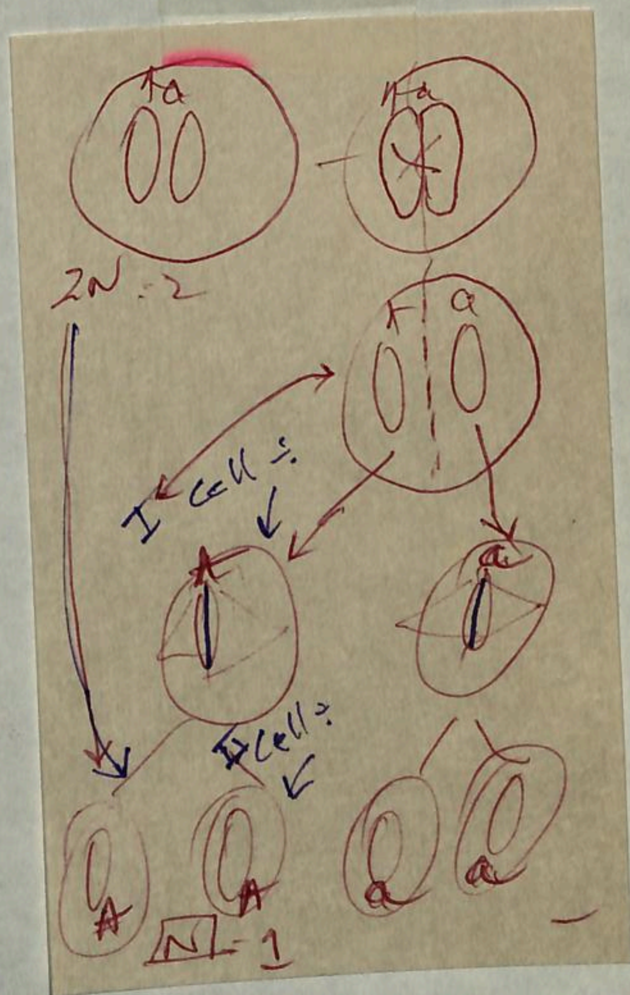
HOOKE – 1665 – CELL
BROWN – 1831 – NUCLEUS

SCHLEIDEN 1838 & SCHWANN 1839 CELL THEORY

Paired, Homologous chromosomes ie 2N
Aa

MEIOSIS – BOVERI 1892





Somatic Cells
MITOSIS
PAIRED HOMOLOGOUS CHROMOSOMES

GAMETOPHYTES &
Gametes ONLY
MEIOSIS

Equational
vs
Reductional ÷

PHENOTYPE
GENO

1866 – G. Mendel
Pisum sativum

- Tall vs Short
- Fl. color
- Fruit shape

HOMOZYG. DOM. × HOMOZYG. REC.

Pisum sativum [L. = Planted]
Dominance
Segregation
Independ. assortment

Monohybrid Cross
- 1 pair chrom.
- 1 – factor difference

Segregation of gametes } 1st Law

♂ Tall × Short ♀ P_1

TT	×	tt

Gametes: T, t

ALL TALL hybrids → Tt — F_1 (2N)

♂ \ ♀	t	t
T	Tt	Tt
T	Tt	Tt

i.e. 100% Tall heterozygous

GAMETES: T, t

♂ \ ♀	T	t
T	TT	Tt
t	Tt	tt

Phenotype = 3:1 (Homo- recessive)

F_2: TT — Homozygous Dom.; Tt, Tt — Hetero – } Tall (3); tt } short (1)

(1:2:1) Genotype

Phenotype — Blue vs Brown eye — Man

Back Cross

♂ \ ♀	T	T
t	Tt	Tt
t	Tt	Tt

100% if Homo

♂ \ ♀	T	t
t	Tt	tt
t	Tt	tt

50% if HETERO

BB × bb
B, b
Bb

	B	b
B	BB	Bb
b	Bb	bb

3:1

1) Each plant has 2 factors influencing each character
2) Only 1 factor passes from parent to offspring | NO BLENDING |
3) Chances of combination of either factor from 1 parent with either factor in other parent are equal
4) Dominant vs Recessive.

TT × tt P_1
Gametes: t, t

	t	t
T	Tt	Tt
T	Tt	Tt

Heterozyg. Dom. — F_1

Tt × Tt F_2

	T	t
T	TT	Tt
t	Tt	tt

3 tall, 1 short — 3:1 — F_2

Backcrosses < tt × TT ; tt × Tt

Phenot... 3 tG : 1 tg

TG, Tg, tG, tg

i.e. 4 KINDS OF GAMETES

TRIHYBRID → 27:9:9:9:3:3:3:1 } 64

Sex Determination

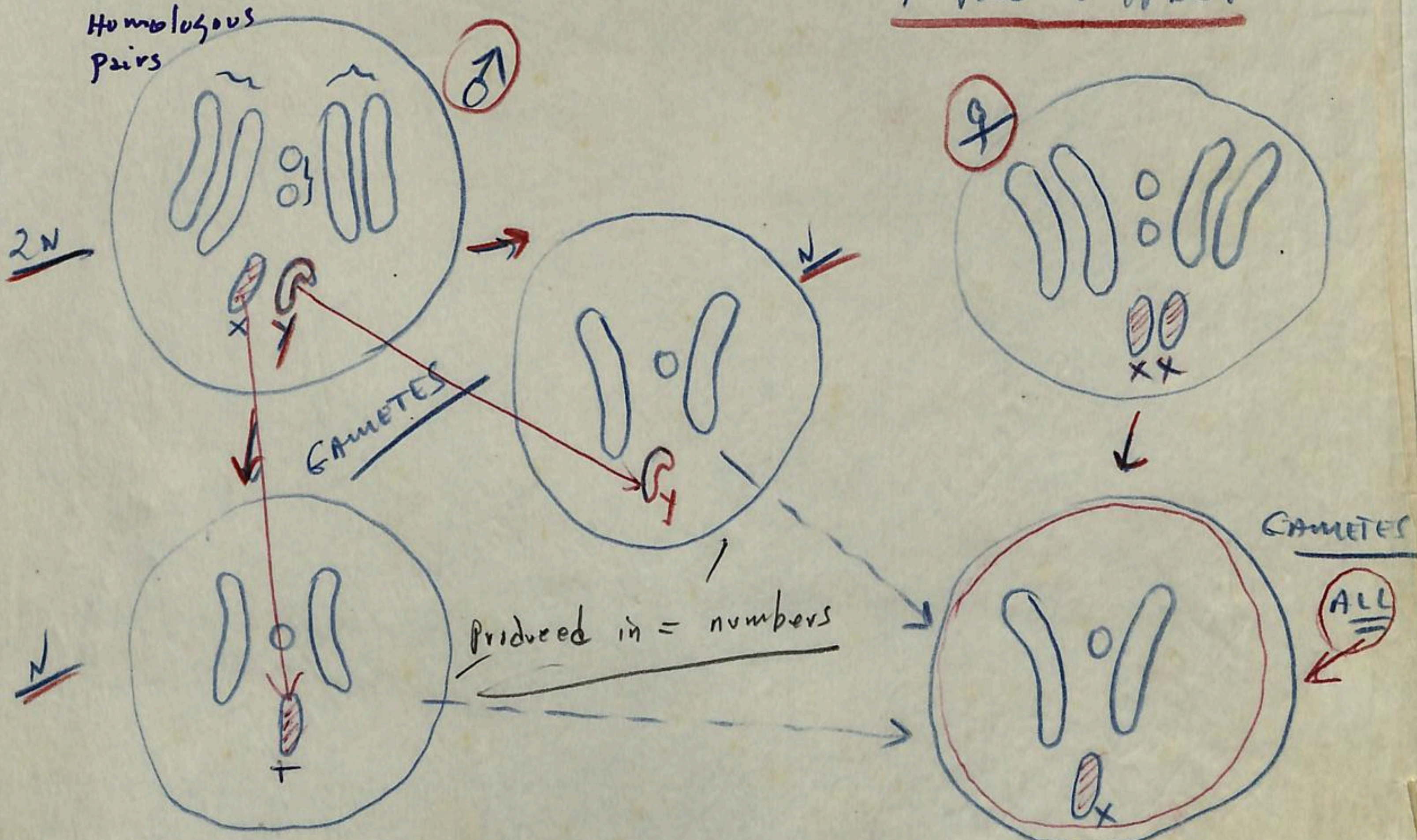
{1906 W.E. CASTLE FIRST USED DROSOPHILA}

[Homo] Drosophila XX = ♀ } i.e. 2N = 8

SEX CHROM. XY = ♂ } 3 exact pairs

1 pair different

MORE



Same principle at work in Man. 2N = 46 (see Beadle p. 71)

i.e. 22 pairs + 1 sex pair

several Birds, some moths ♀ = XY ♂ = XX

Chronica Botanica vol.22

"It is unknown whether plats in nature have root hairs or mycorrhizae or neith; ut there is enough evidence at hand to indicate that mycorhzae predominate over root hairs in the majority of case" A.P.Kelley p. 53. Mycotrophy in plant

... stated their function of root hair to increase surface area for absorption of nutrients.

By 1880, root hair considered as exclusive mechanism in root nutrition.

BUT various exceptions were recorded:

1) Monotropa (Ericaceae) .. no root hairs; fungal assoc. found by Fries in 1832.

2) Orchids (Orchidaceae) .. many epiphytic; no roots. Prilleux 1856 found fungal hyphae in seedlings.

3) Lycopods, Ferns (Lycopodium (Lycopodiae)) .. Treub 1884, ibid. Dangeard 1891 .. hyphae & Tmesipteris; coined: MYCORRHIZOME.

ancient relationship. Psilotales: Psilotum, Tmesipteris. Filicineae: Ophioglossum, Marattia

4) Liverworts (Hepaticae) .. Milde 1851, ibid ; Leitgeb 1874; hyphae in thallus; coined: MYCOTHALLUS

5) Trees .. Theophrastus 300BC fungi & tree roots assoc. 1829 Meger .. ibid with Beech trees. 1841 Tulasne .. tree roots & truffle mycelium.

1885 - Alb. Frank: Pines

6) Ericaceae .. Rayner 1927, claimes obligate mycotrophy; esp. Calluna spp.

"No major group from Thallophytes to Spermatophytes is excepted".

From all these somewhat contradictory data, it can be concluded that the presence of mosaic fungi is not sufficient for diagnosis of dermatomycosis, but that in addition there must be evidence of true mycelial hyphae.

However, the problem of the origin of mosaic fungi does not seem to us to be definitely resolved, for it is possible that the cholesterol deposit occurs in the altered mycelial hyphae. The question needs to be looked into once more.

5. MYCORRHIZAS[1]

Mycorrhizas (μύκης, fungus, and ῥίζα, root) are mycelial hyphae living in association with roots, either on their periphery (ectotrophic mycorrhiza) or in the cells of certain layers of the cortex (endotrophic mycorrhiza).

1. Ectotrophic Mycorrhizas

These are found mainly in forest trees (pine, fir, beech, oak, hornbeam, etc.) but also in some herbaceous plants, e.g. *Monotropa hypopitys*, a plant without chlorophyll, like *Neottia* or broom-rape, but belonging to a neighbouring group, the Ericaceae or heaths.

The absorbing tips of roots of plants with ectotrophic mycorrhizas are covered by a sheath of mycelial hyphae forming a false tissue and giving greater thickness to these rootlets. This sheath bears externally absorbing hyphae which look like hairs, and internally branches which penetrate between the outermost cells of the cortical parenchyma.

The fungi of ectotrophic mycorrhizas appear to belong to the three main groups Phycomycetes, Ascomycetes and Basidiomycetes: they therefore have septate or non-septate hyphae. The difficulty of isolating and studying them has meant that they are still little known.

The role of Basidiomycetes seems to be the best established. The relationship between trees and fungi of this group has been known for a long time, e.g. between larch and *Boletus elegans*, *B. viscidus*, *Hygrophorus lucorum*, *Boletinus cavipes*, *Lactarius porninsis*; between cedar and *Sepultaria sumneriana*; between birch and *Amanita muscaria*, *Lactarius plumbeus*, *L. glycyosmus*, *Tricholoma flavobrunneum*; between beech and *Russula fellea*; between elm and ash and *Morchella*; between poplar and *Tricholoma pessundatum*, *Lactarius controversus*, *Boletus duriusculus*, *Mitrophora hybrida*. Finally, there is a whole flora peculiar to forests of resinous trees[2] (e.g. *Cenococcum graniforme* in *Pinus sylvestris*).

Peyronel (1921) showed, with numerous examples, that the connexion is unequivocal and can be traced between the fructifications of these fungi and trees with mycorrhizas through more or less voluminous, always perceptible, strands (except in the *Lactario-Russula* spp.).

[1] Mycorrhizas are here considered only as a particular type of mycelium. Very interesting details on the question of mycorrhizas can, however, be found in Lutz, L., *Traité de Cryptogamie*, pp. 537–57 (Paris, Masson, 1948), and also in the *Précis de Biologie végétale* by Guillermond and Mangenot, 2nd ed., pp. 503–18 (Paris, Masson, 1946).

[2] Romell, L. G., The ecological problem of mycotropy, *Ecology*, **20**, 1939, (II), 163–7. Maublanc, A., *Ch. comestibles*, p. 20 (1939).

(over)

[XIII, 1–13]

'Trichomycetes'

1. *Enterobryus*. × 200. After Lichwardt, 1954.
   a. *E. elegans* Leidy. Young, short vegetative hypha.
   b. *E. euryuri*. Sporangiospores.
   c. *E. euryuri*. Endoconidia.
   d. *E. euryuri*. Uninucleate spores.

'Dermatophytes'

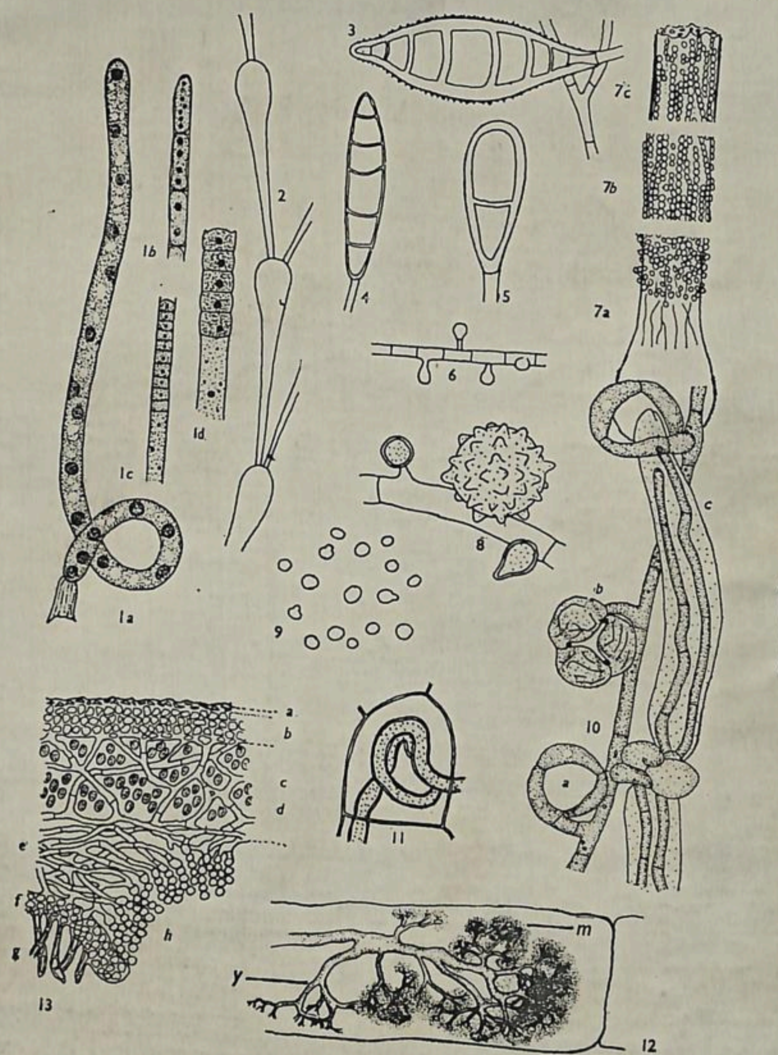
2. *Trichophyton mentagrophytes* (Robin) Blanch. Racquette hypha. × 500.
3. *Microsporum canis* Bodin. Macrocondium. × 500.
4. *Trichophyton mentagrophytes*. Macroconidium. × 500.
5. *Epidermophyton floccosum* (Harz) Langer. Macroconidium. × 500.
6. *Microsporum canis* Bodin. Microconidia (aleuriospores). × 500.
7. a. Part of *Microsporum*-infected human hair. Hyphae growing downwards to form 'Adamson's fringe' in region of keratinization. Arthrospores forming a mosaic on the surface.
   b. Part of *Trichophyton*-infected hair. Ectothrix infection. External spore sheath; arthrospores in chains.
   c. Part of *Trichophyton*-infected hair. Endothrix infection. No external spore sheath.
8. *Histoplasma capsulatum* Darling. Mycelial phase. Chlamydospore. × 500.
9. *Histoplasma capsulatum* Darling. Yeast phase. Budding cells. × 500.
10. *Arthrobotrys dactyloides* Drechs. × 500. After Muller, 1958.
    a. Young ring trap; b. Trap with cells expanded; c. Trapped nematode penetrated by absorptive hyphae.

Mycorrhiza

11. Peloton in *Allium ursinum*. × 500. Drawing by Hawker, 1958.
12. Arbuscules (y, young; m, mature) of *Pythium ultimum* str. in cortical cell of *Endymion non-scripta*. × 500. Drawing by Hawker, 1958.

LICHENES

13. *Sticta damaecornis* Ach. Thallus in section. × 200. After Fink.
    a, Dermis; b, upper cortex; c, algal layer; d, gonidia; e, medullary layer; f, lower cortex; g, rhizoids; h, half a cyphella.



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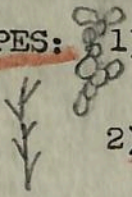
MORPHOLOGY

Characteristic for various sp.

TYPES:  1) Coralloid: freely-branching, like coral; spp. of Birch, Oak

2) Racemose: lateral rootlets branch monopodially on main axis; Spruce other forest trees.

3) Rhizothamnion: thick clusters, like withh's brooms; Casuarina, some Oaks, Pine.

4) Pearl -necklace : begin as racemose; growth intermittent constrictions between. Acer.

Pseudomycorrhizae: thin, lack basal constrictions, darker in color than root.

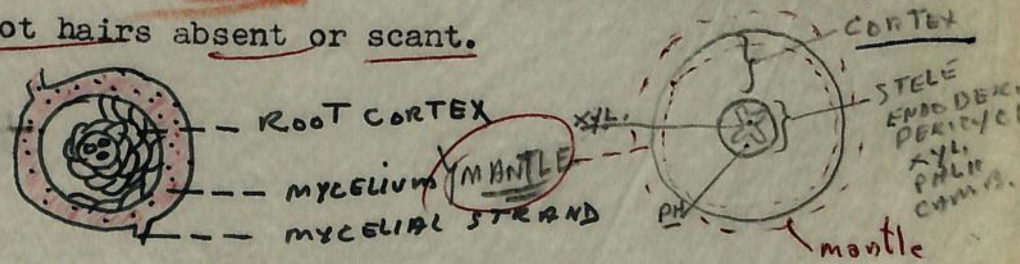
Color of mycorr. influenced by: age & fungal symbiont; shades of yell, red, violet. white, black .

1914 MacDougall offered classification based on color.

1) ECTOTROPHIC: root covered w, many layered mantel of fungus mycelium; penetrate between but not into cortical cells.

Abietineae Root hairs absent or scant.

AMANITA - BETULA



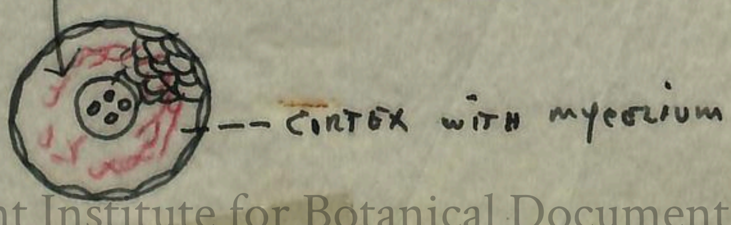
2) ENDOTROPHIC: Mycelium penetrates cortical cells; mantel not formed.

Orchids, Ericaceae (Heaths)

RHIZOCTONIA ?

HARTIG NET: cortical cells become embedded in hyphal network; not? intracellular. esp. Pines.

Stele generally not invaded.



TREE MYCORRHIZA

Melin, Elias 1948 T.B.M.S. 30:92-99. Recent Advances in the study of tree mycorrhiza. (Uppsala, Sweden.)

ECTO & ENDOTROPIC forms common in trees.

Roots attacked become shorter, thicker & branching.

Mycorrhiza of diff. colors depends on symbionts involved;

Hyphae penetrate betwmen cortical root cells; produce mantle around outside of root. (mid. lamella broken down; lignin & cellulose not utilized)

Most of short roots converted into mycorrhiza.

1887, Frank's idea of mutual symbiosis.

Others considered asociation harmful to host.

Recent work shows:

Mycorrhiza beneficial & somrtimes essential to normal growth of trees.

1917, Melin showed experimentally that Pine & Spruce seedlings (Sweden) required mycorrhiza for normal growth.

1921, Melin analyzed roots to isolate fungi of mycorrhiza.

Basidios mostly isolated: Boletus, Amanita, Lactarius, Cortinarius, Russula, Tricholoma, Hydnum & others. also: the Gasteros: Scleroderma, Rhizopogon.

BUT: ALL GROUPS OF FUNGI HAVE BEEN ASSOCIATED W. MYCORRHIZAL HABIT. zb FUSARIUM COMMONLY WITH ORCHIDS.

Mycorr. produced experimentally by A.B.Hatch; in culture, TUBERALES vitamins sometimes required for production of mycorr. (zb in Pine, Boletus variegatus)

Furhher investigation pending study of vitamin needs.

Conditions under which tree mycorr. are formed:

1937. A.B.Hatch found that soils deficient in N, P, K, Ca, (one or more of these) favored dev. of mycorr.

1942. E.Bjorkman reported foll factors affecting myco. formation:

a) Light ie Pine seedlings grown in dark or weak light, no greater than 10% of daylight, produced no mycorr; when light increased to 25% or more of daylight intensity, positive results obtained.

b) N
c) P (either a deficiency OR abundance of these inhibited mycorr. moderate amounts favored mycorr.production.)

Experimental evidence in culture & under natural conditions gave similar results:

ie if (A) N,P, are deficient, then PROTEIN SYNTHESIS INHIBITED; (a SURPLUS of CHO then available to roots which) favor dev. of mycorr. ;

if (B) N,P, are abundant, then PROTEIN SYNTHESIS STIMULATED; (correlated with a deficiency of CHO) which inhibit mycorr. formation.

ie CHO the key in this idea;

BUT: 1944. MacDougall showed that excised Pine Mycorrhiza survived in forest soil .

OTHER FACTORS which may affect mycorr. production:

1) Antibiotic substances in natural soils may be antagonistic to dev. of mycorr.

2) Toxic substances may be produced.

zb Needles shed in Autumn in Swedish forests produced a substance which inhibited prod. of tree mycorr.

ie leaf extracts used experimentally:

low concentration STIMULATED mycorr;

high con. INHIBITED;

1943, Thomas - Phytopath. 33

Endotrophic types:

1) Peloton mycorrhizae: Orchids & Psilotum.

intracellular hyphal coils forminf structure of characteristic morphology, called peloton.

2) Vesicular-Arbuscular:

1939, Butler - TBMS 22: intercommunicating anastomoses form a closed system.

Vesicles are spherical swellings at hyphal tips; Vitis, Gossypium.

Arbuscles: tree-like branching of intracellular hyphal tips.

THEORIES : MYCORRHIZAL RELATIONSHIPS

2 general views:

1) Fungus is parasitic on host.

2) a mutualism bet. host & fungus.

Kelley 1950 reviewed 118 papers:

104 favored mutualism
14 " parasitism

Hartig first important promolgator of parasitic doctrine; but he did no experimental work; however he influenced many other workers.

Fuchs 1911 .. first to experiment w. SYNTHETIC MYCORRHIZAE; found a "limited parasitism", host rendering fungus harmless.

Margou 1921 .. Fungi "indifferent parasites", neither harmful nor useful.

Majority opinion takes non-parasitic view: but no unanimity on mechanism.

CONFLICTING EVIDENCE

Some of these ideas:

1) Mycorrhizae replace root hairs.

1877 Pfeffer .. Roots of Neottia (orchid) have mycelium acting like root hairs.

1902 Marcuse .. Hyphae act as root hairs in most endotrophic forms.

2) Mycophagy: Fungus captured by roots & digested, so obtaining proteins. (N)

3) Nitrogen theory .. Frank 1894. Melin

Fungus supplies organic N to host

4 3) Stahl's theory 1900.

In soils poor in minerals, trees compete w, bacteria, fungi; tree benefited by hyphal assoc.

Other ideas center around utilization of C rather than N .

1926 McLennan . Fungus supplies fats & oils to host; N a negligible factor.

Difficulties w. all theories :

No satisfactory expl. how fungus absorbs & transports nutrients to host.

Reports that root hairs present along w. mycorr. should be regarded skeptically; histological evidence needed to distingu[illegible] hyphae (in form of setae) from root hairs.

SEE: RAYNER, M.C. MYCORRHIZA . 1927 . WHELDON & WESLEY, LTD. LOND[illegible]
(NEW PHYTOLOGIST REPRINT, NO. 15)

ALGAE
FUNGI
LICHENS

PHYLA → SUB.

BRYOPHYTA
EVOLUTIONARY TRENDS
EMBRYOPHYTA
LYCOPHYTINA
SPHENO-
PTERO-

FERNS
GYMNOSPERMS
ANGIO

LICHENS

NOSTOC N_2 Fix

I — STRUCTURE

FUNGUS – ALGA < B-G, G.

few BASIDIOS
ASCO
ISIDIA ASEX.

APOTHECIA
PERI —

Phycobiont
±25% less CHLOROPHYLL
myco

SYMBIOTIC REL.

gel. hyphae | H_2O RETENTION
PHOTOSYNTHESIS etc

II FOLIOSE
FRUTICOSE
CRUSTOSE

SYNTHESIS ATTEMPTS

Rock, Trees, Soil

< ±155°F
Temp. ± −70°C → 70°C

III — PHYSIOLOGY

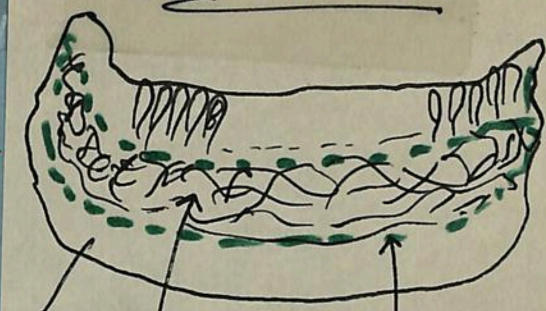
SLOW GROWTH ± 1mm/yr.
± 4000 YRS OLD
SO_2 – CO SENSITIVE — POLLUTION INDICATORS
RESISTANT TO DRYING

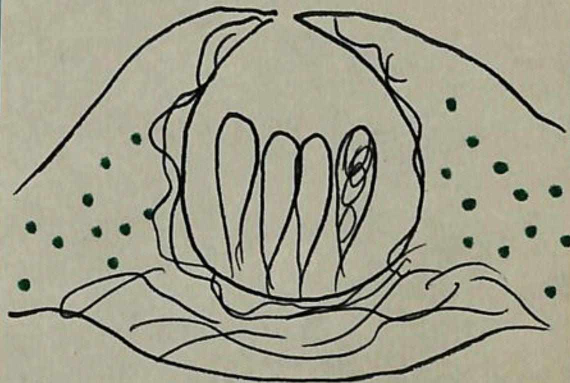
REPRODUCTION

ASEXUAL
FRAGMENTATION
ISIDIA etc
SOREDIA

SEXUAL
APOTHECIA
PERI —

APOTHECIAL FORM





PERITHECIAL FORM

SO_2 ± 100 PPM SENSITIVE

Industrial waste

USES

VS RABIES
LICHEN CANINUS
1753

Doct- Signat.
LOBARIA PULMONARIA

LITMUS

REINDEER MOSS
CLADONIA RANGIFERINA

ICELAND MOSS
CETRARIA ISLANDICA
[EXPECTORANT]

MEDICINAL
USNIC ACID
USNO — VS BURNS in FINLAND
CLADONIA sp.

— STAINED GLASS WINDOWS CORRODED IN EUROPE

THE FUNGI AND THE KINGDOMS

Margulis, Lynn. Department of Biology, Boston University, Boston Massachusetts 02215, U.S.A. and Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125, U.S.A.

The possible phylogenetic relationships between the fungal-like organisms and the ascobasidiomycotes will be discussed in the context of the five kingdom scheme of Whittaker (1969).