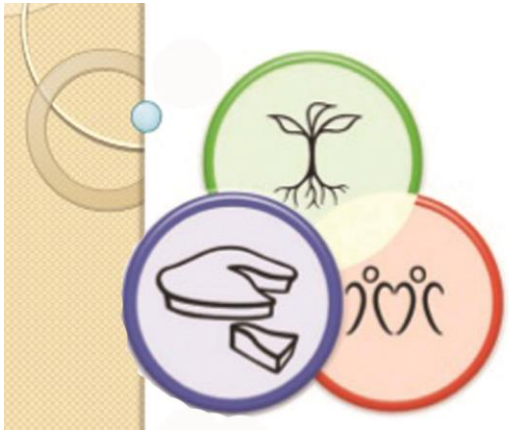
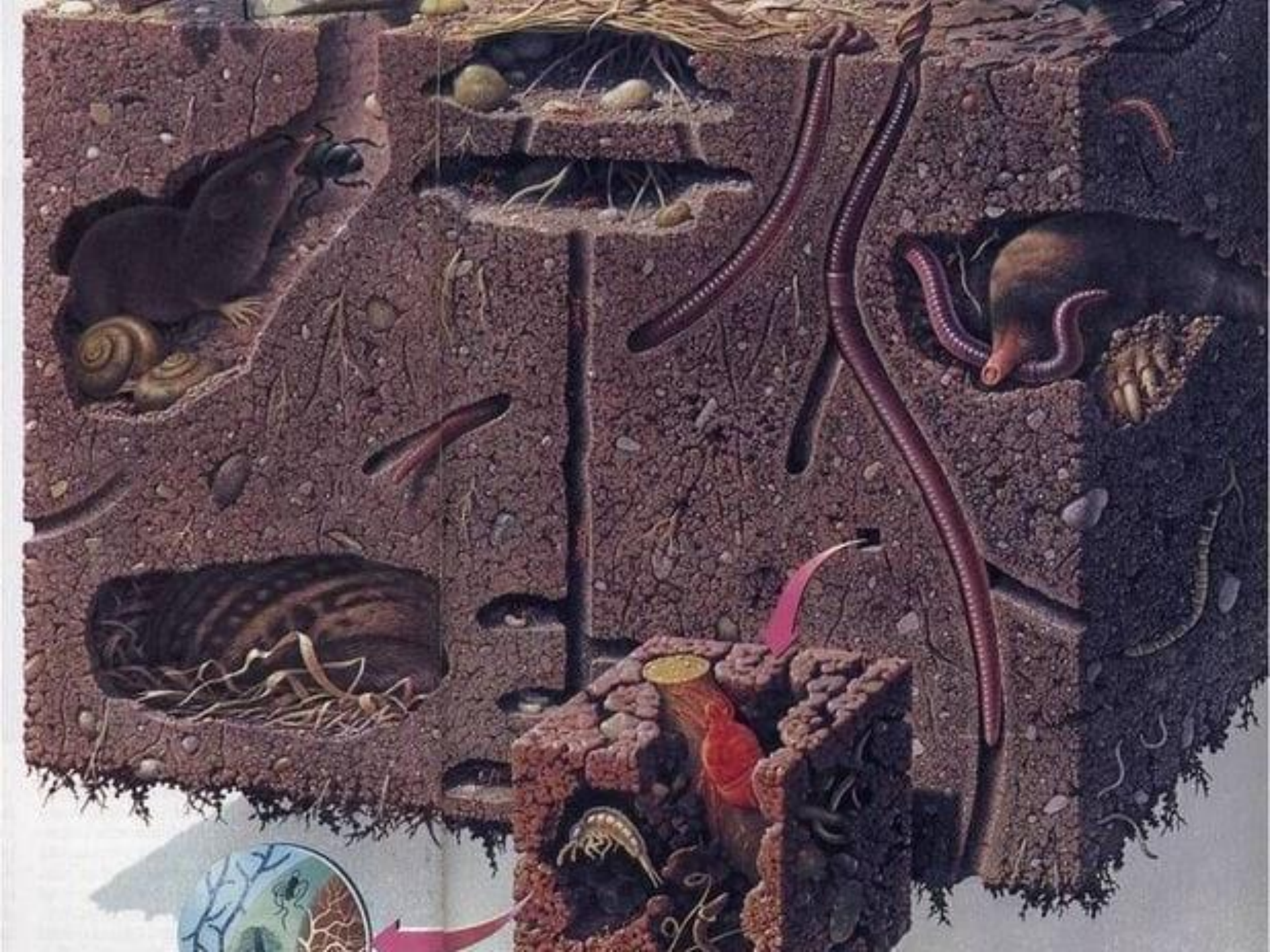
Soil

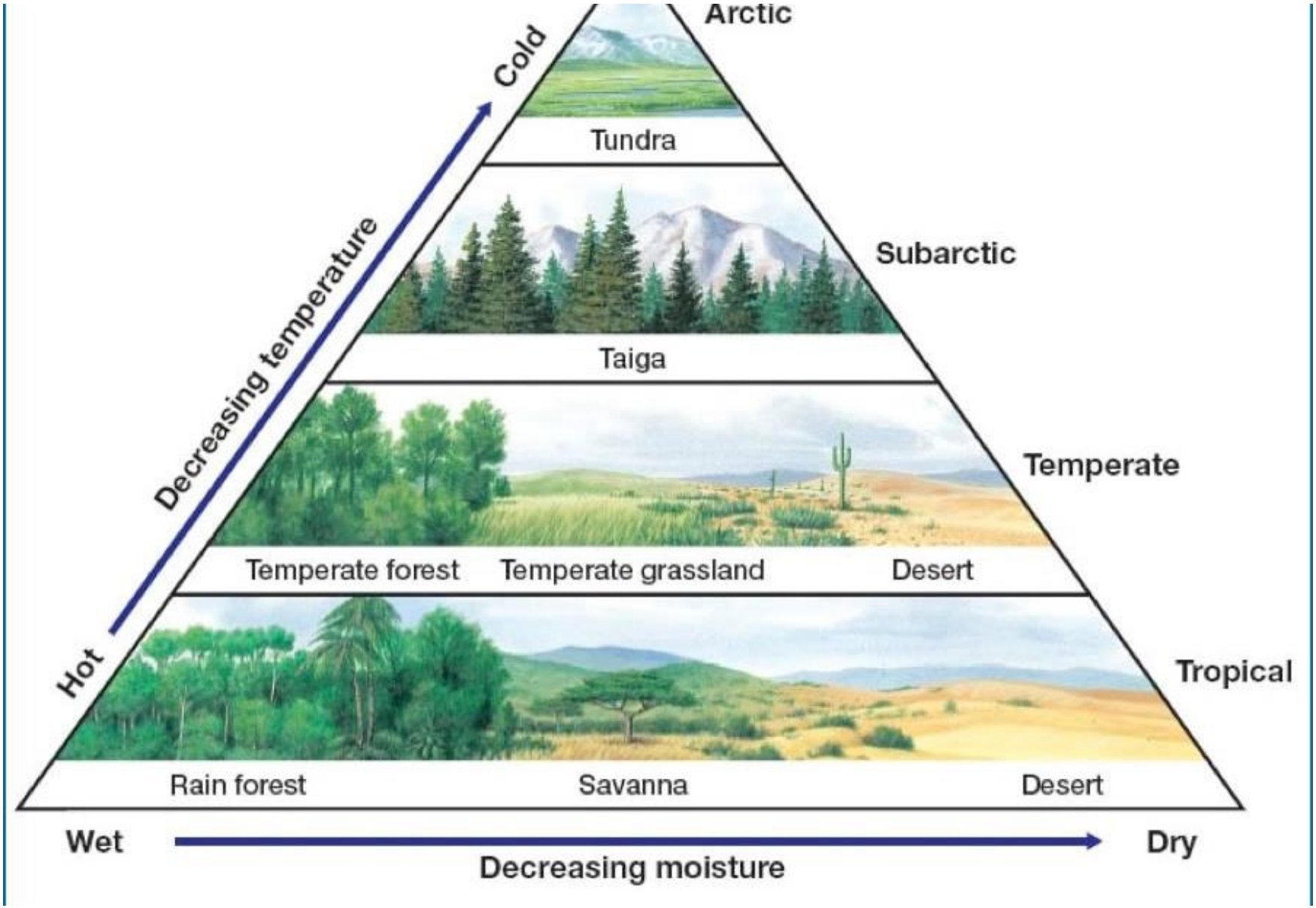
an introduction from a permaculture perspective

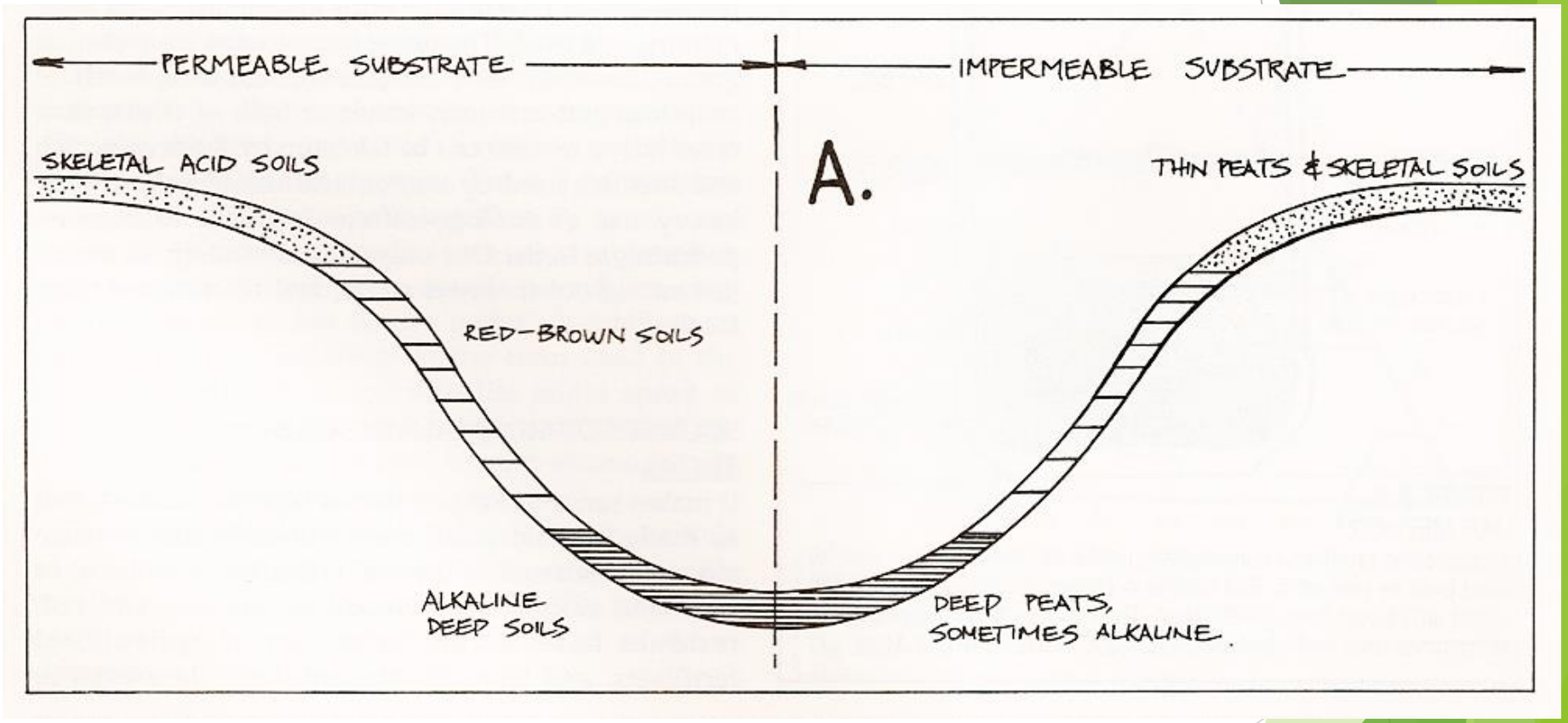


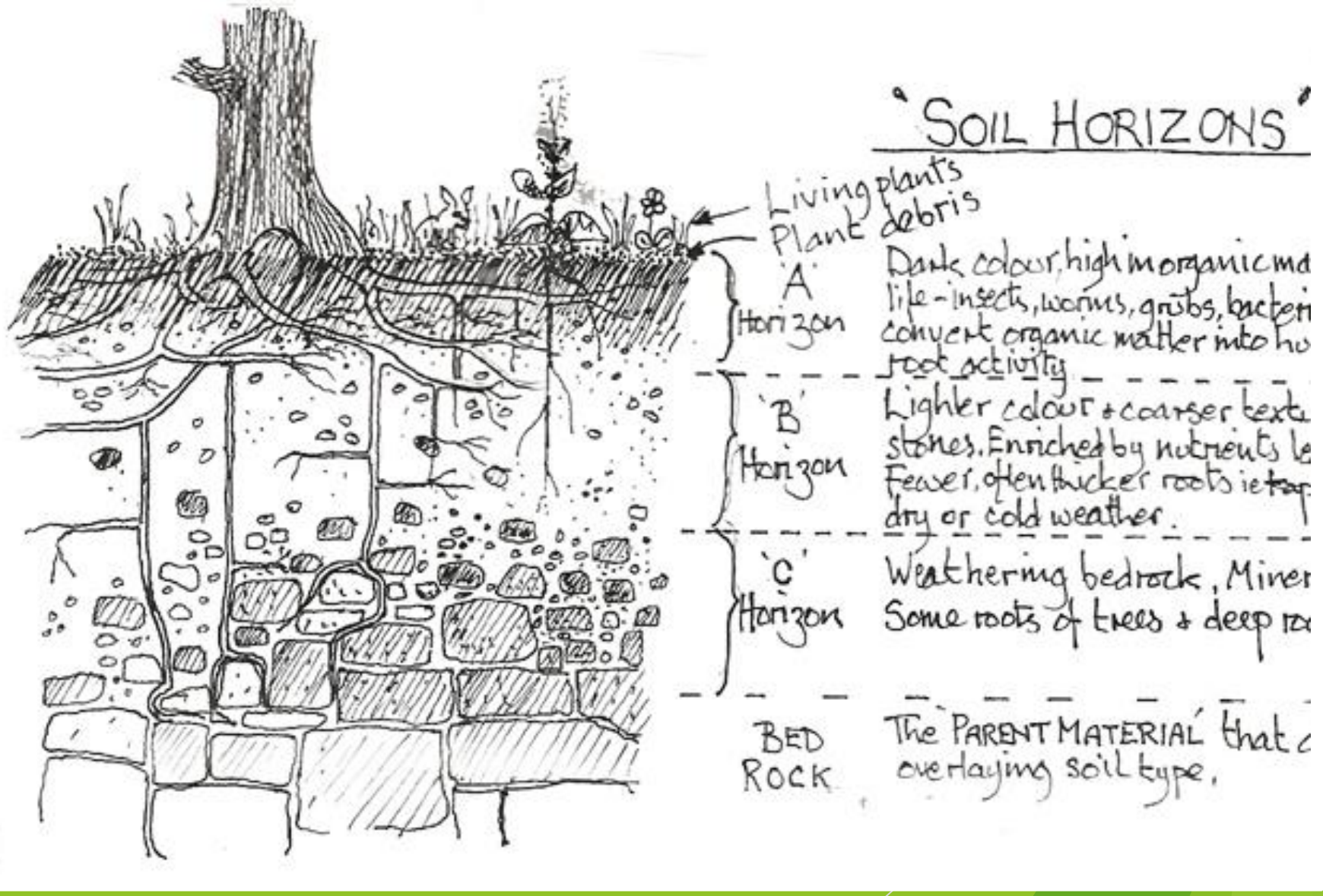
What is permaculture?

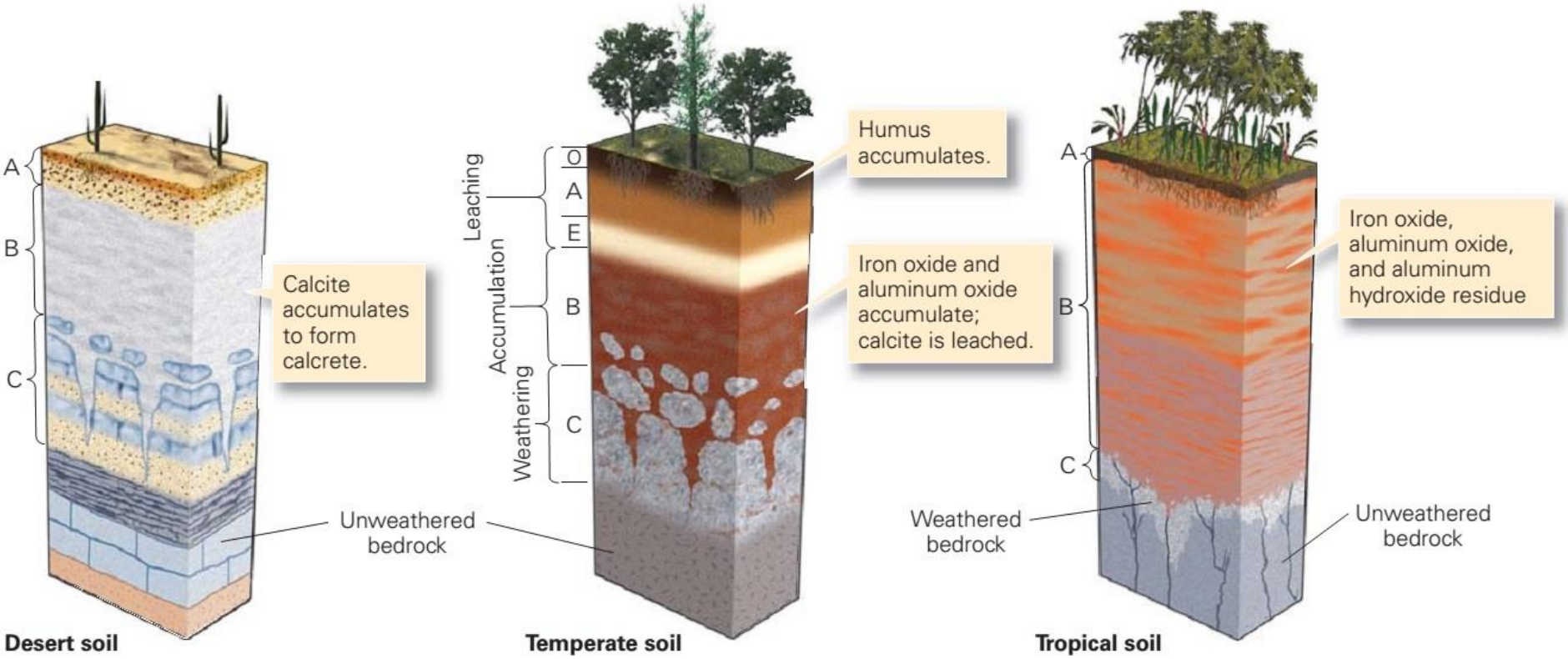
Permaculture is a creative design process based on whole-systems thinking that uses ethics and design principles. It guides us to **mimic the patterns and relationships we can find in nature** and can be applied to all aspects of human habitation, from agriculture to ecological building, from appropriate technology to education and even economics.




Arctic
Cold
Tundra
Subarctic
Decreasing temperature
Taiga
Temperate
Temperate forest
Temperate grassland
Desert
Hot
Tropical
Rain forest
Savanna
Desert
Wet
Dry
Decreasing moisture


PERMEABLE SUBSTRATE
IMPERMEABLE SUBSTRATE
A.
SKELETAL ACID SOILS
RED-BROWN SOILS
ALKALINE DEEP SOILS
THIN PEATS & SKELETAL SOILS
DEEP PEATS, SOMETIMES ALKALINE.

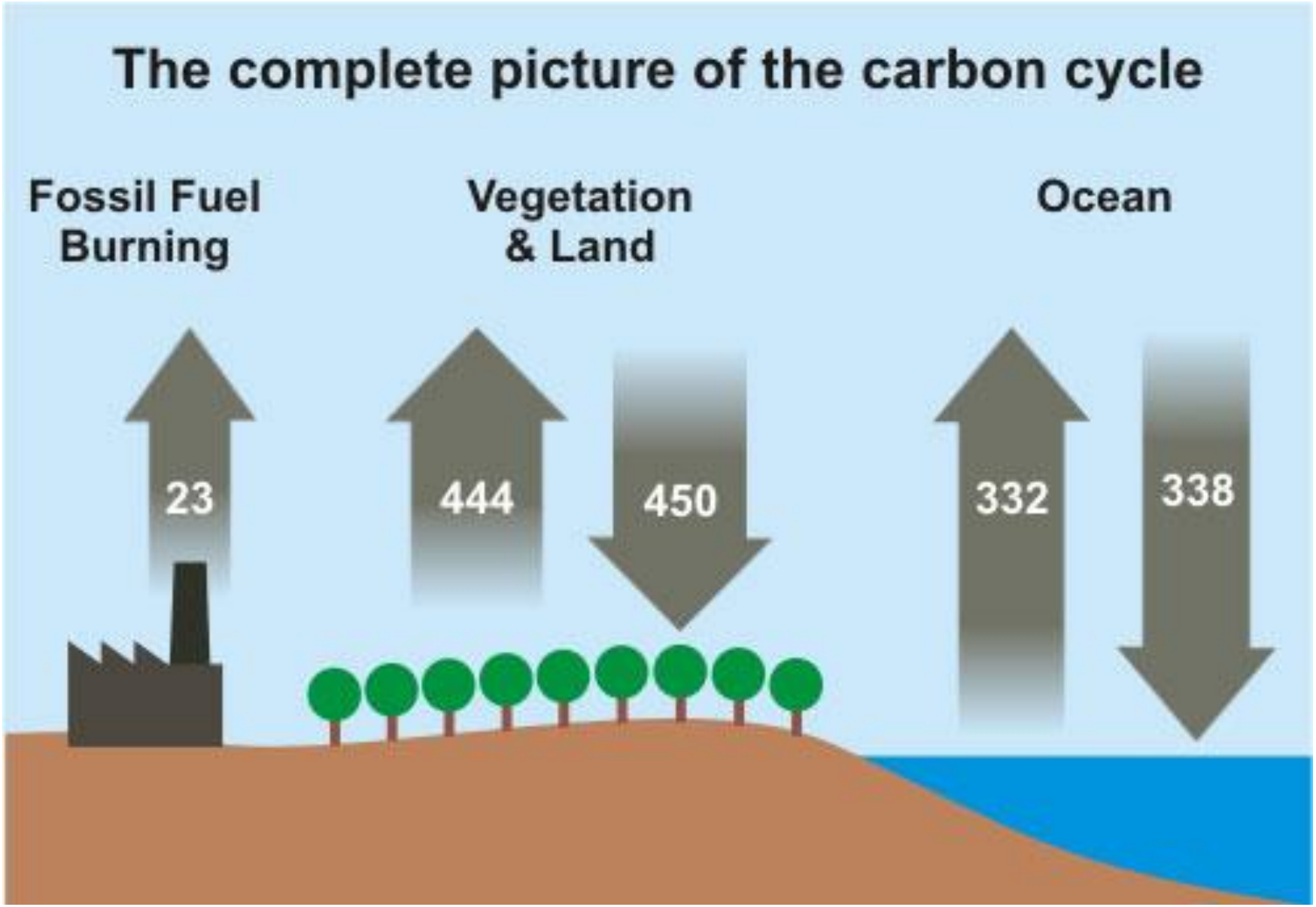

SOIL HORIZONS
Living plants
Plant debris
A Horizon
Dark colour, high in organic ma
life - insects, worms, grubs, bacter
convert organic matter into hu
root activity
B Horizon
Lighter colour & coarser texta
stones. Enriched by nutrients le
Fewer, often thicker roots ie trap
dry or cold weather.
C Horizon
Weathering bedrock, Miner
Some roots of trees & deep ro
BED ROCK
The PARENT MATERIAL that c
overlaying soil type.

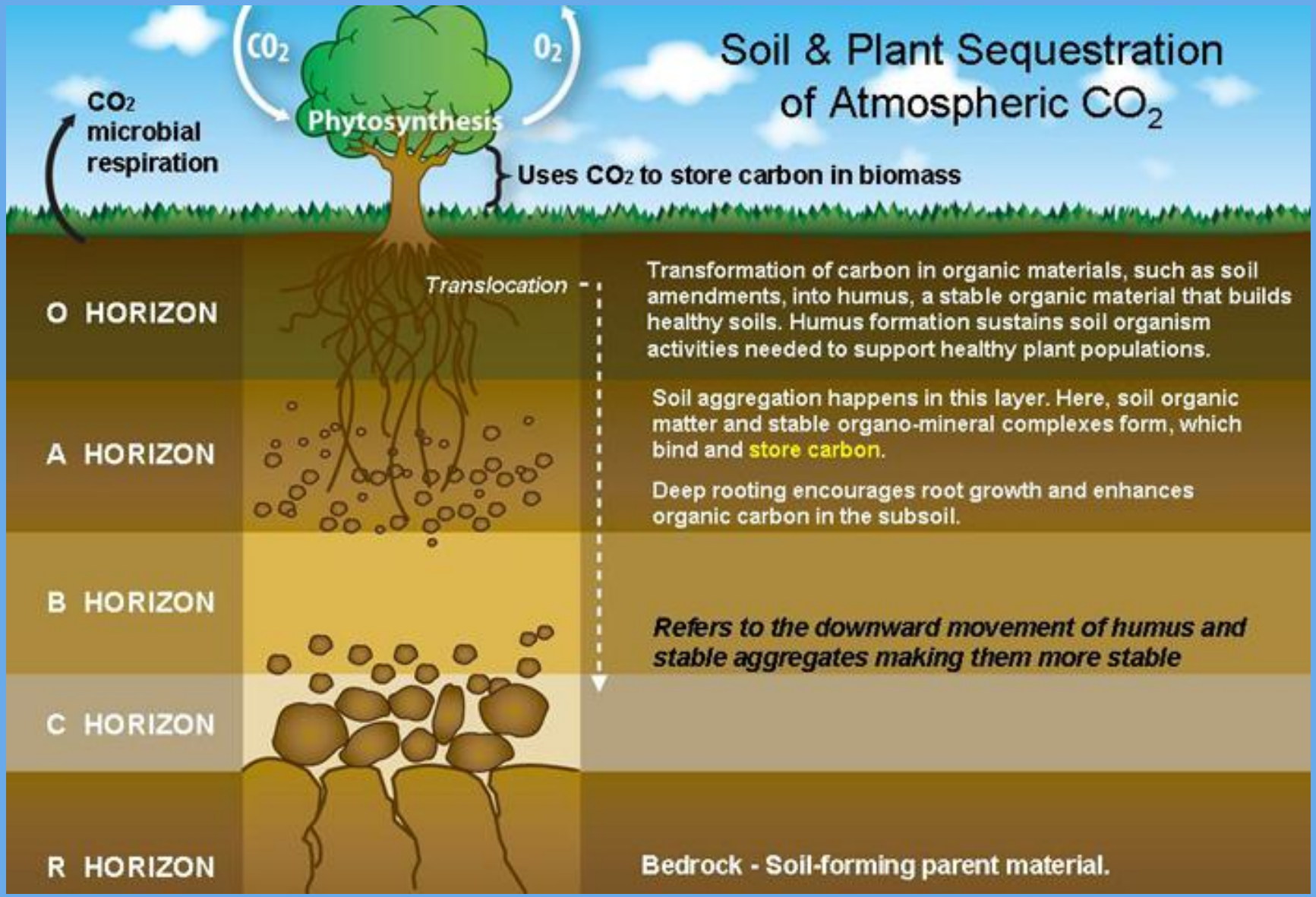


(a) Aridisol forms in deserts. Rainfall is so low that no O-horizon forms, and soluble minerals accumulate in the B-horizon.

(b) Alfisol forms in temperate climates. An O-horizon forms, and less-soluble materials accumulate in the B-horizon.

(c) Oxisol forms in tropical climates where percolating rainwater leaches all soluble minerals, leaving only iron- and aluminum-rich residues.


The complete picture of the carbon cycle
Fossil Fuel Burning
Vegetation & Land
Ocean
23
444
450
332
338


Soil & Plant Sequestration of Atmospheric CO_2
CO_2
O_2
Phytosynthesis
CO_2 microbial respiration
Uses CO_2 to store carbon in biomass
Translocation
O HORIZON
Transformation of carbon in organic materials, such as soil amendments, into humus, a stable organic material that builds healthy soils. Humus formation sustains soil organism activities needed to support healthy plant populations.
A HORIZON
Soil aggregation happens in this layer. Here, soil organic matter and stable organo-mineral complexes form, which bind and store carbon.
Deep rooting encourages root growth and enhances organic carbon in the subsoil.
B HORIZON
Refers to the downward movement of humus and stable aggregates making them more stable
C HORIZON
R HORIZON
Bedrock - Soil-forming parent material.

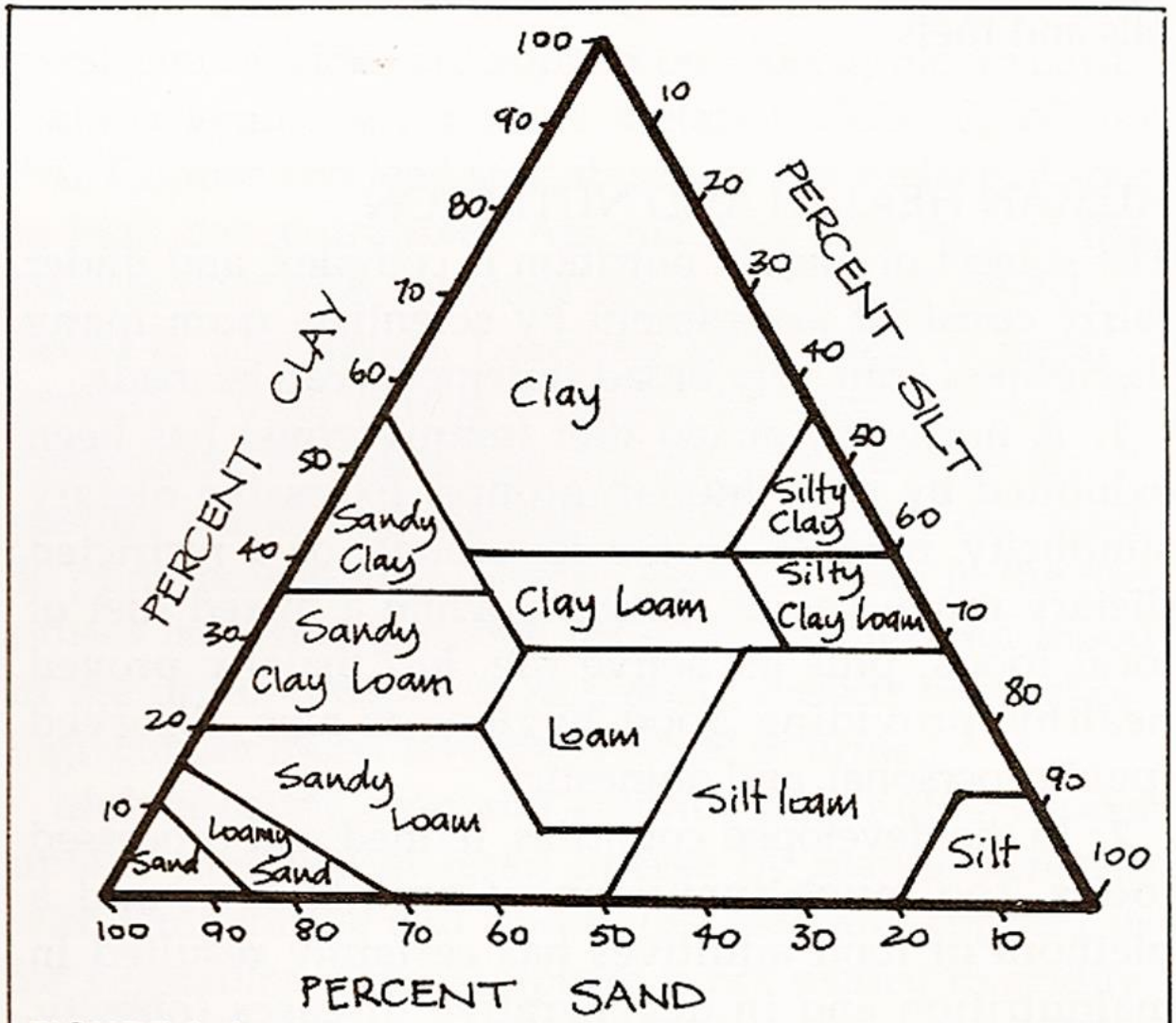


FIGURE 8.1
SOIL PROCESSES.
The USDA classification of soil types by particle size.

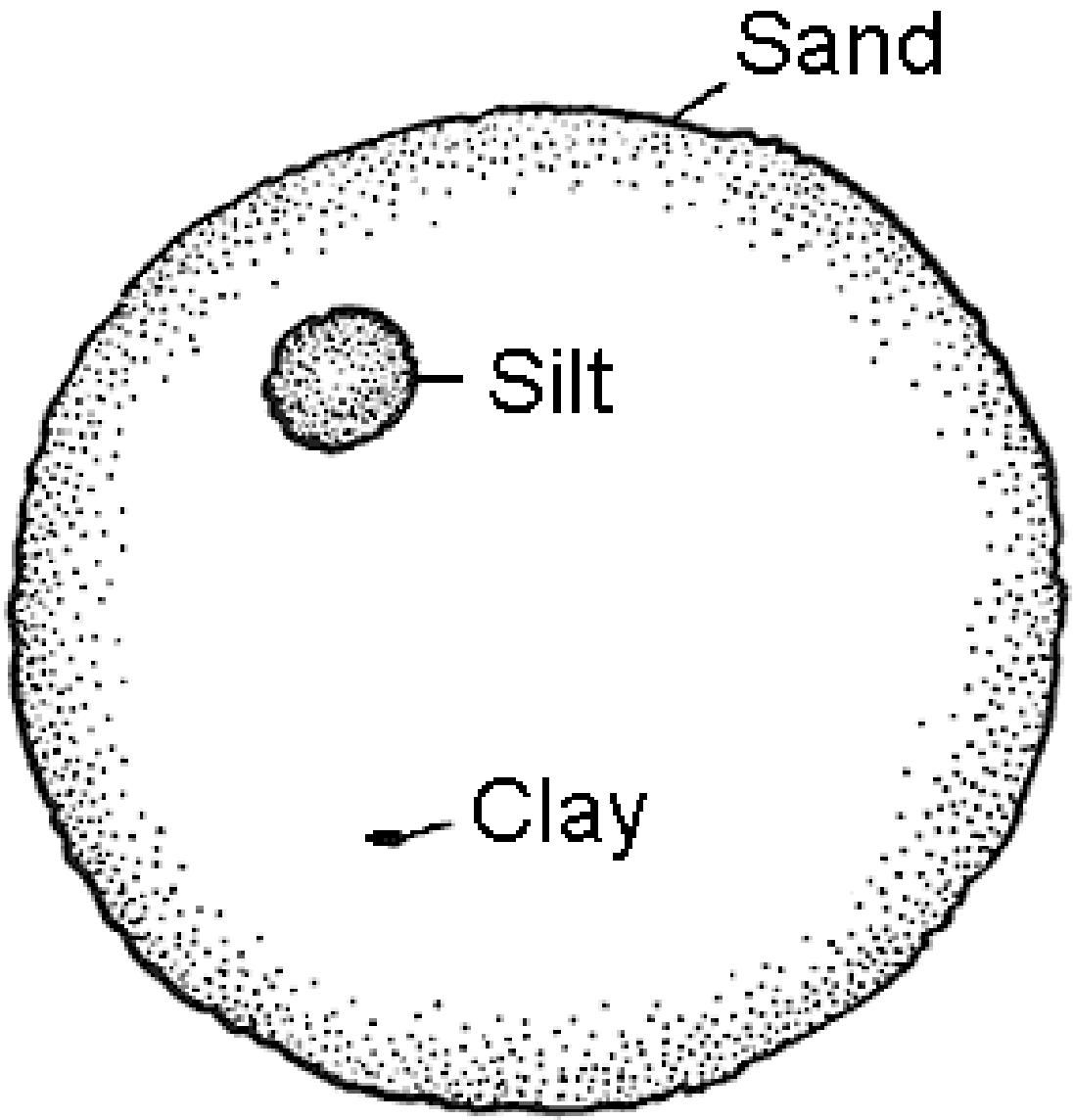

Sand
Silt
Clay

TABLE 8.6
RECOMMENDED SCALE OF SOIL PARTICLE SIZES (mm).
[After McDonald *et al*]

Fine clay	< 0.002
Clay particles	0.002
Silt	0.002 - 0.02
SAND	**0.02 - 2.0**
fine	0.02 - 0.2
coarse	0.2 - 2
GRAVEL	**2 - 60**
Fine	2 - 6
Medium	6 - 20
Coarse	20 - 60
COBBLES	60 - 200
STONES	200 - 600
BOULDERS	>600

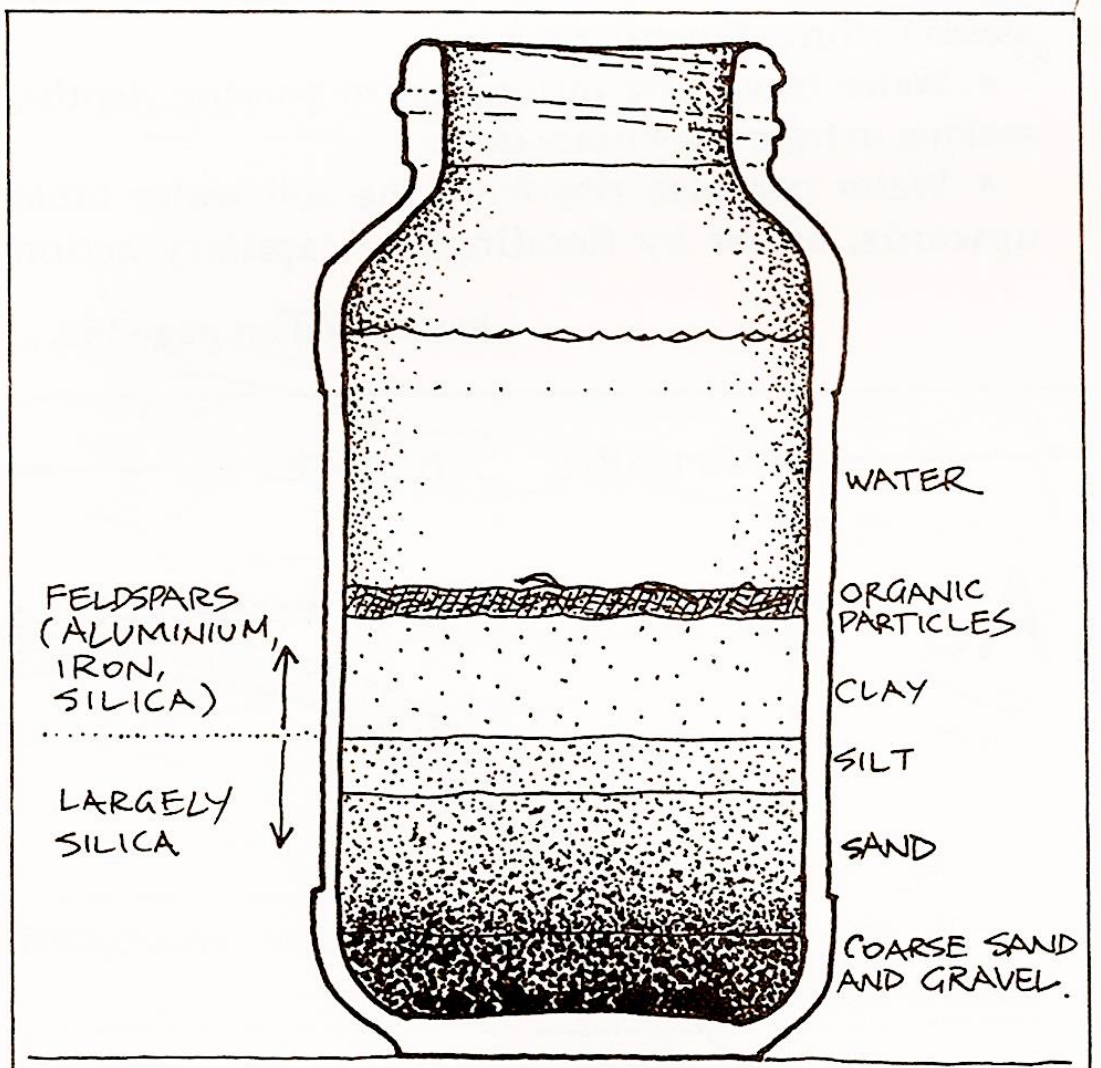
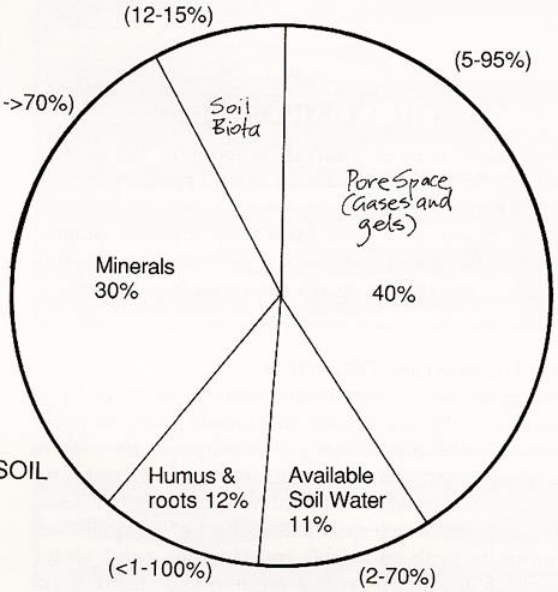
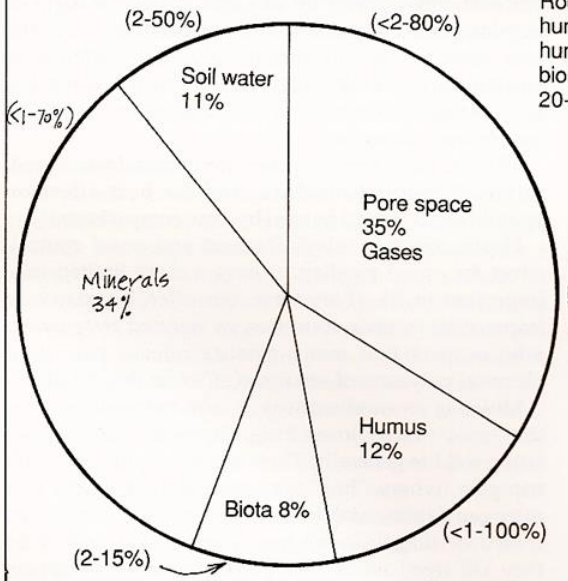


FIGURE 8.2
JAR METHOD
of assessing crude soil composition; useful for classification, uses for mud brick or pisé work. Soil sample is shaken in water and allowed to stand until layers form (1–20 days). The volume of each fraction determines uses and a texture classification (see **FIGURE 8.1**).

TABLE 8.6
PIECHART OF TOTAL VOLUME COMPONENTS OF AN "AVERAGE" SOIL.

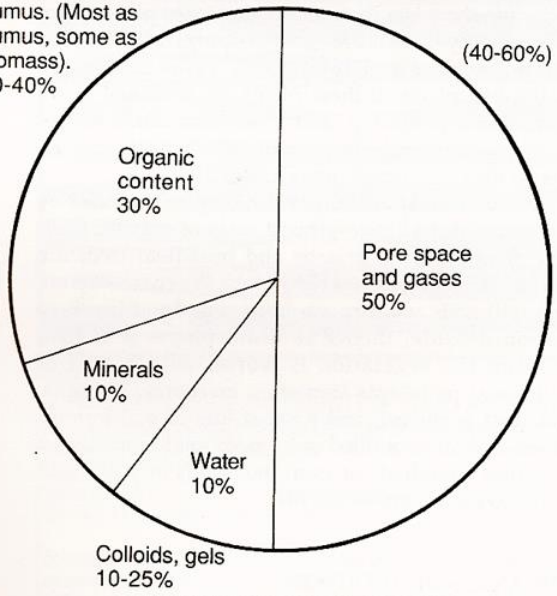


COMPOSITION OF AN AVERAGE SOIL



THE COMPOSITION OF A GARDEN LOAM WITH MULCH AND A RICH SOIL BIOTA. (A range of proportions from wet peats to compact mineral soils is given in brackets).

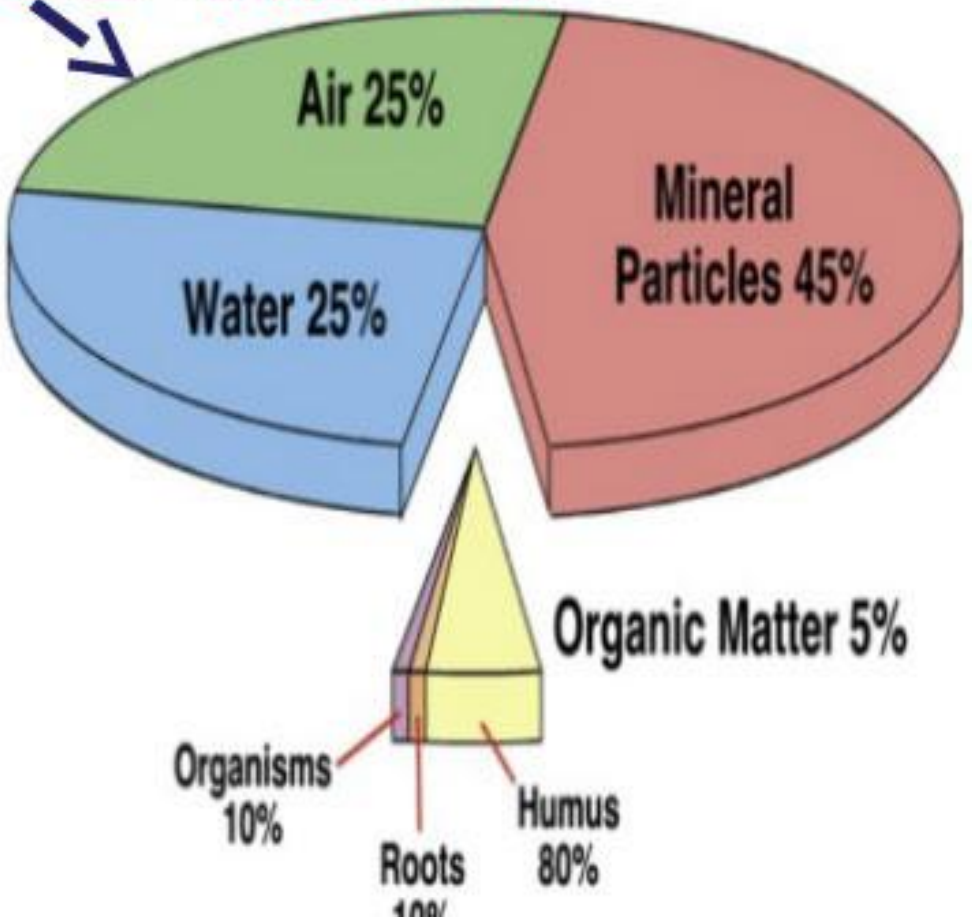
Roots, animals, humus. (Most as humus, some as biomass). 20-40%

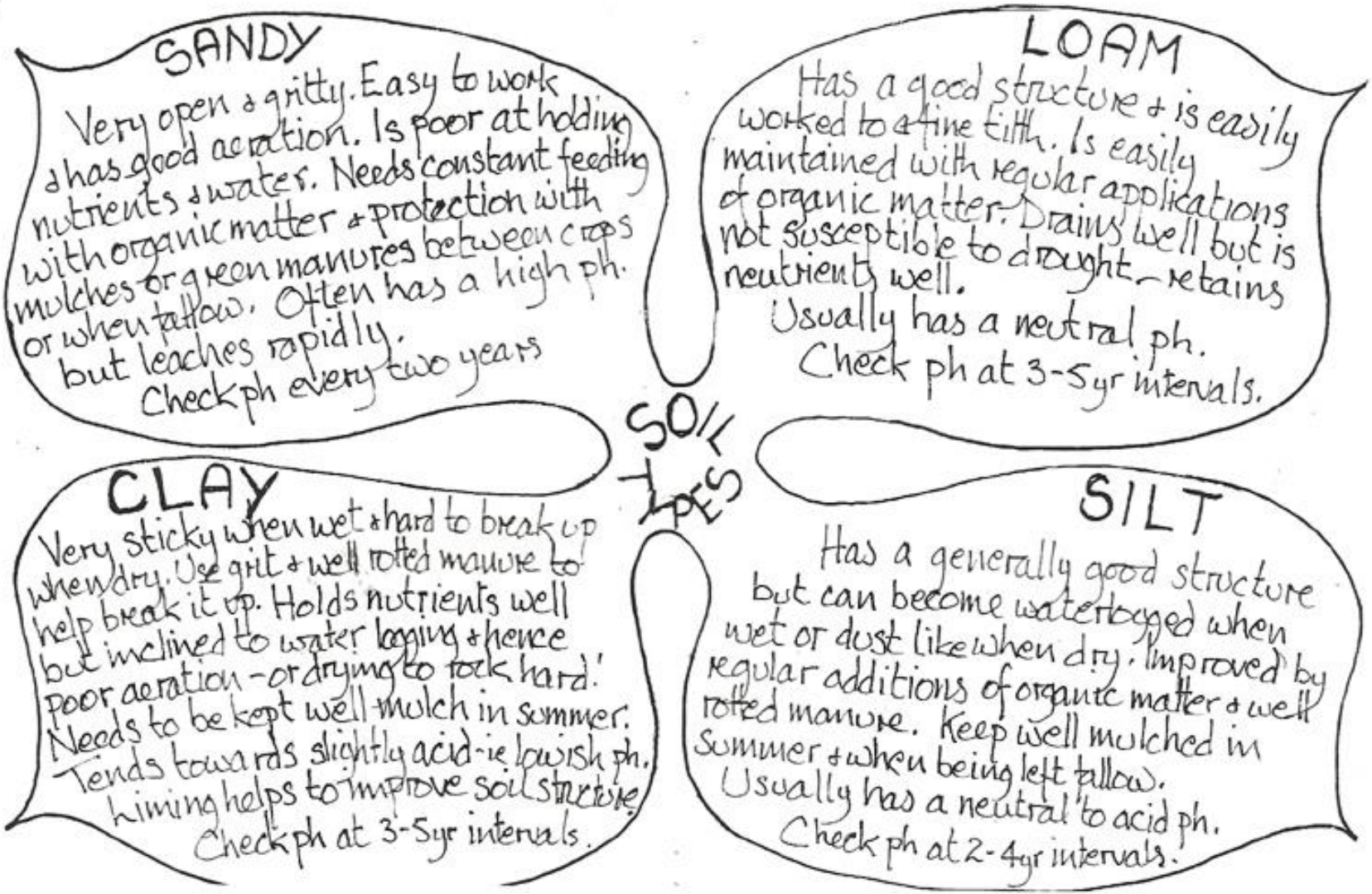


ESTIMATED TOPSOIL VOLUME

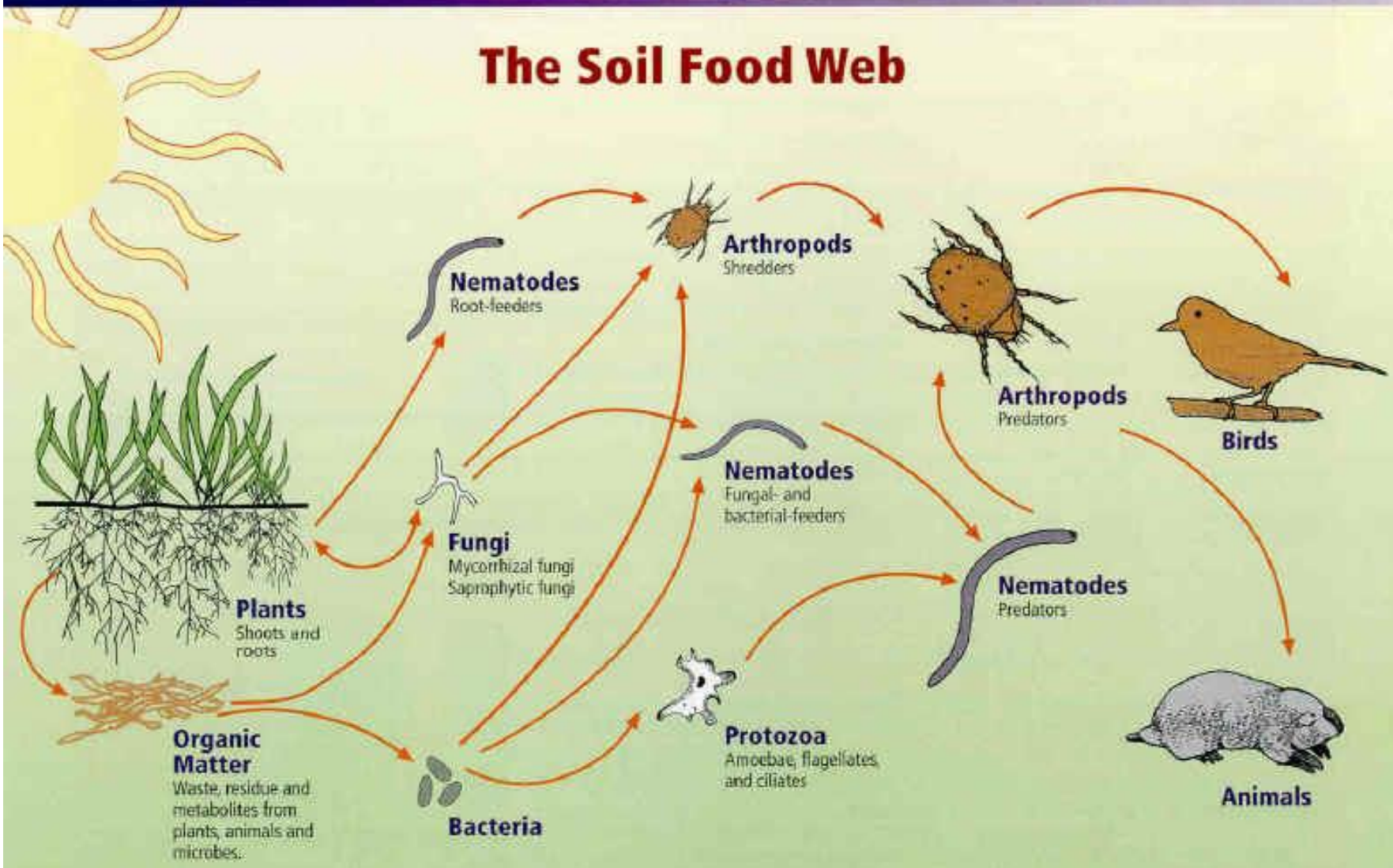
What Is Soil Made Of?

Start Here (Copy on chart)




SOIL TYPES
SANDY
Very open & gritty. Easy to work & has good aeration. Is poor at holding nutrients & water. Needs constant feeding with organic matter & protection with mulches or green manures between crops or when fallow. Often has a high ph. but leaches rapidly.
Check ph every two years
LOAM
Has a good structure & is easily worked to a fine filth. Is easily maintained with regular applications of organic matter. Drains well but is not susceptible to drought - retains nutrients well.
Usually has a neutral ph.
Check ph at 3-5yr intervals.
CLAY
Very sticky when wet & hard to break up when dry. Use grit & well rotted manure to help break it up. Holds nutrients well but inclined to water logging & hence poor aeration - or drying to rock hard!
Needs to be kept well mulch in summer.
Tends towards slightly acid - ie lowish ph.
Liming helps to improve soil structure
Check ph at 3-5yr intervals.
SILT
Has a generally good structure but can become waterlogged when wet or dust like when dry. Improved by regular additions of organic matter & well rotted manure. Keep well mulched in summer & when being left fallow.
Usually has a neutral to acid ph.
Check ph at 2-4yr intervals.

The Soil Food Web



First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

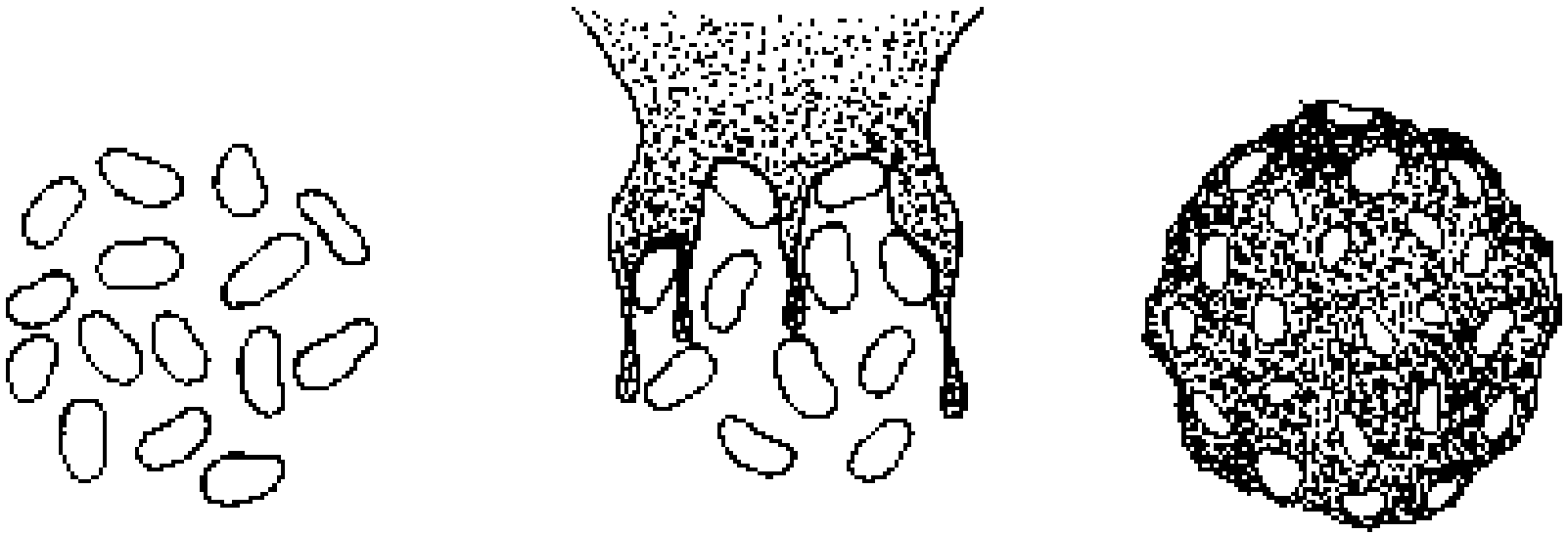
Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

MICROBIAL AND FUNGAL

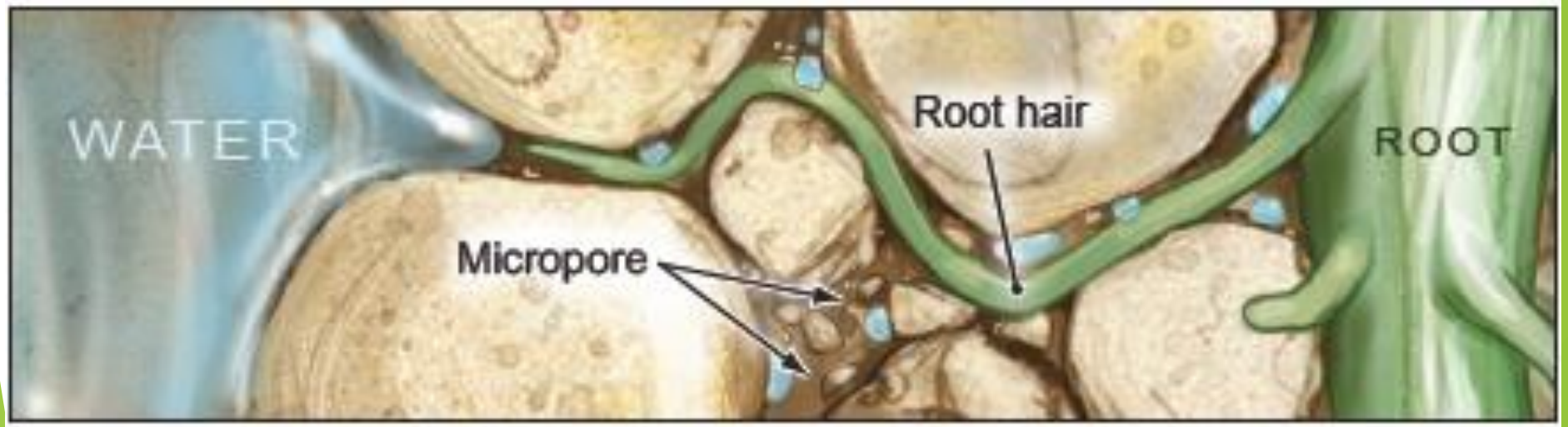
BYPRODUCTS GLUE

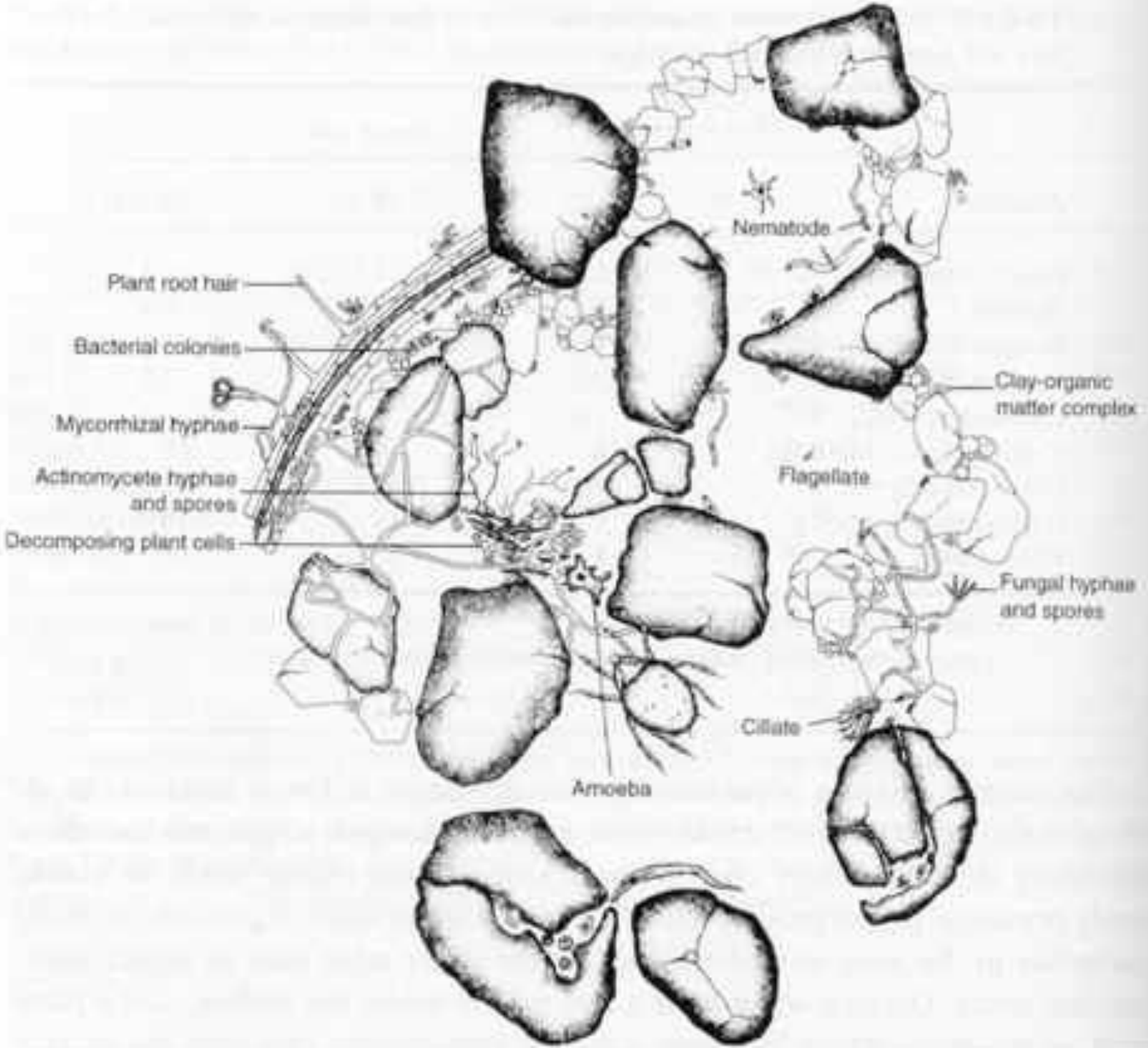
THE PARTICLES TOGETHER



DISPERSED STATE

AGGREGATED STATE


WATER
Root hair
ROOT
Micropore


Nematode
Plant root hair
Bacterial colonies
Clay-organic matter complex
Mycorrhizal hyphae
Actinomycete hyphae and spores
Flagellate
Decomposing plant cells
Fungal hyphae and spores
Ciliate
Amoeba

Earthworms

- There are 3 main **types of earthworms**; the **compost worm**,
- the **earth-worker worm,** and the
- **root-dwelling worm.**

Worm types

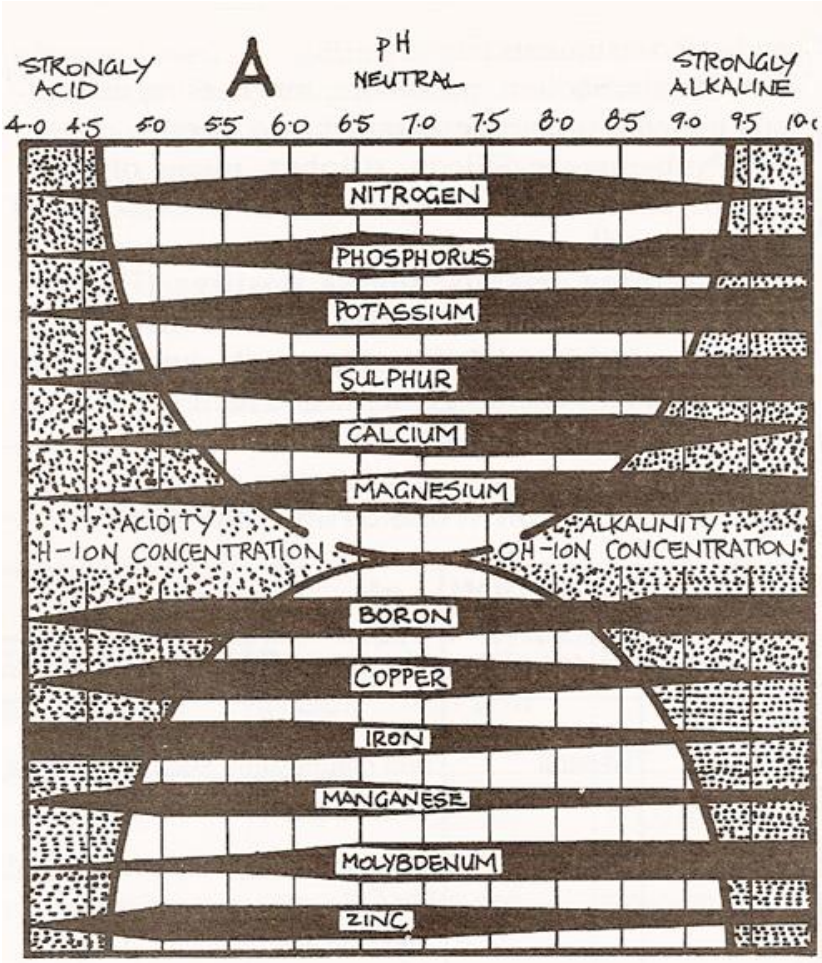
Anecic, vertical feeders, live in soil

Compost: live in surface and organic matter, eat bacteria and protozoa

Endogenic, horizontal feeders

Root dwelling worms


LOW
MEDIUM
HIGH



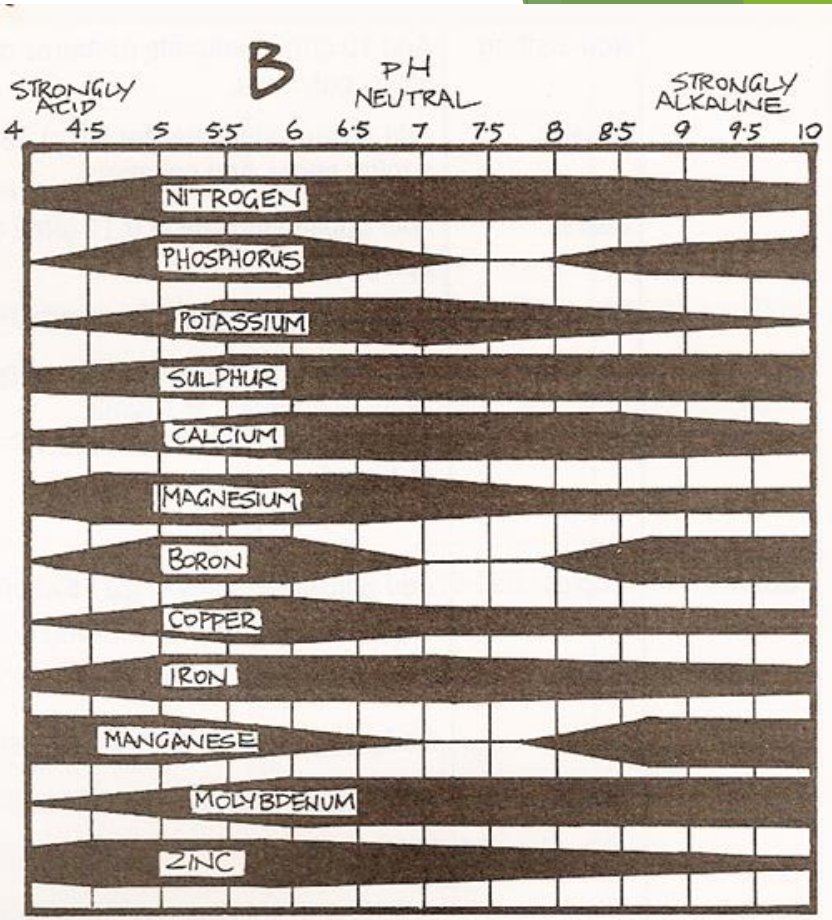
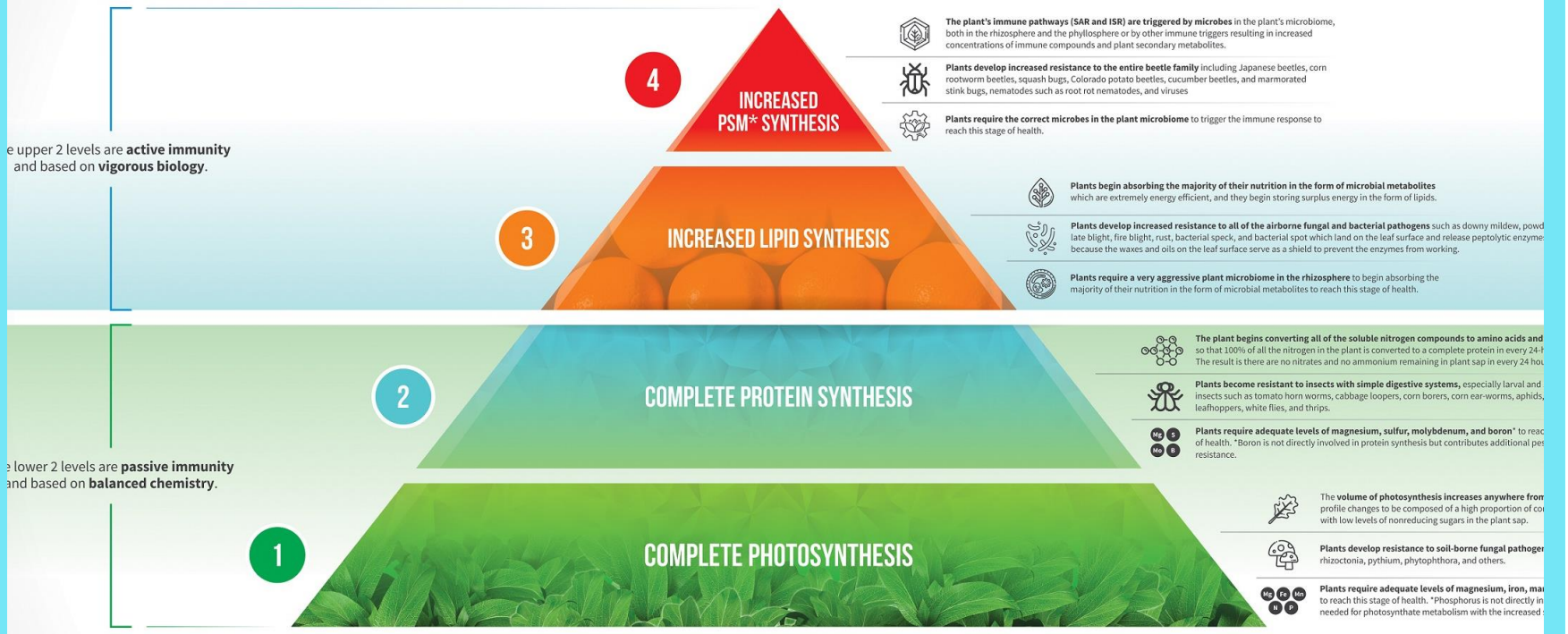


FIGURE 8.4
INFLUENCE OF pH ON AVAILABILITY OF PLANT NUTRIENTS

A In inorganic (mineral) soils. The widest parts of the black areas indicate maximum availability of each element. The curves represent pH values.
[After Nelson, L. B., (Ed.), *Changing patterns of fertiliser use,* Soil Science America, Madison, WI (1968)].

B In organic soils. The widest parts of the black areas indicate maximum availability of each element.
[After Lucas, R. E., amd J. F. Davis, "Relationships between pH values of organic sols and availability of 12 plant nutrients", *Soil Science*, 92:17-182 (1961)]

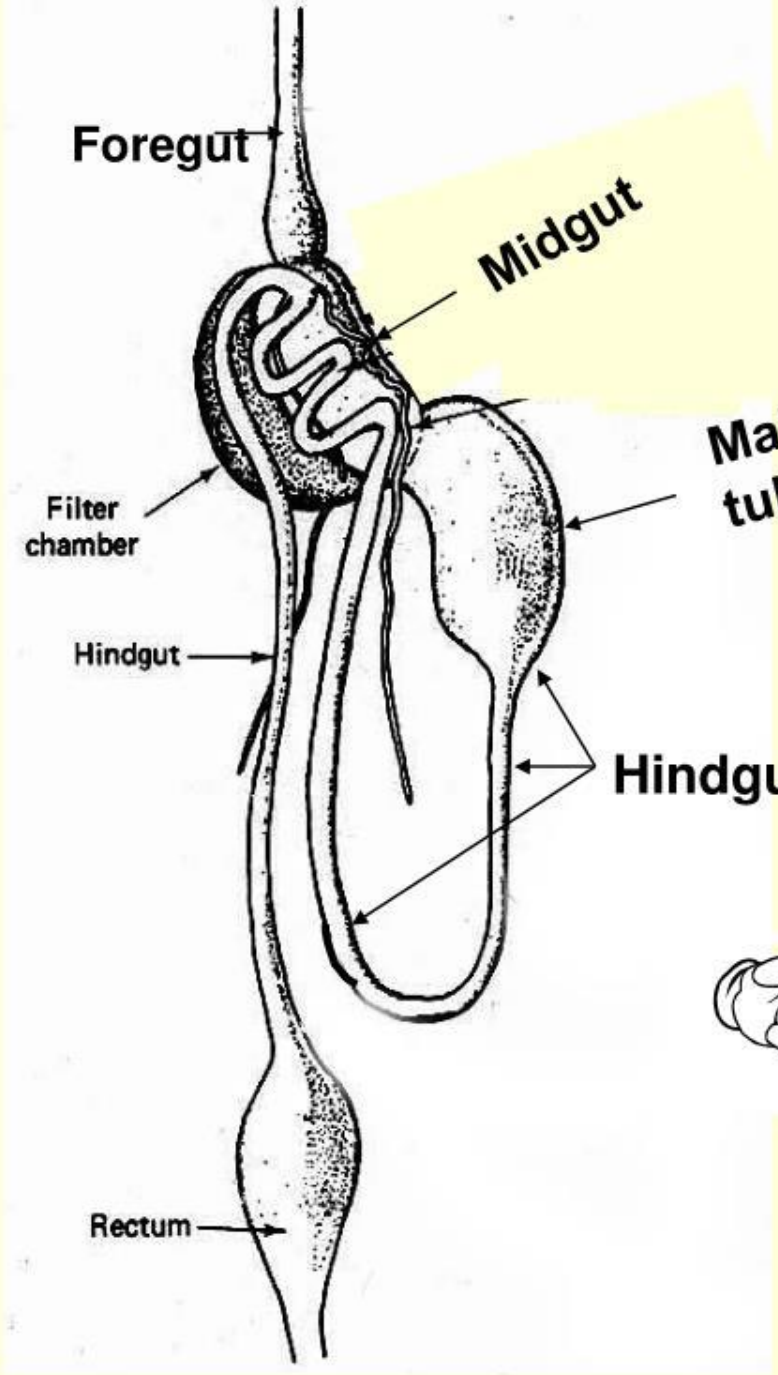
PLANT HEALTH PYRAMID



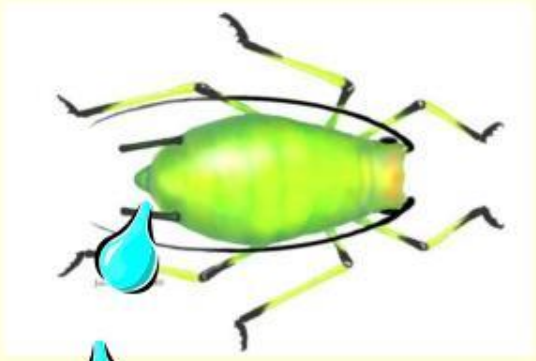
"Healthy plants can become completely resistant to diseases and insects."

- John Kempf -

AdvancingEcoAg.

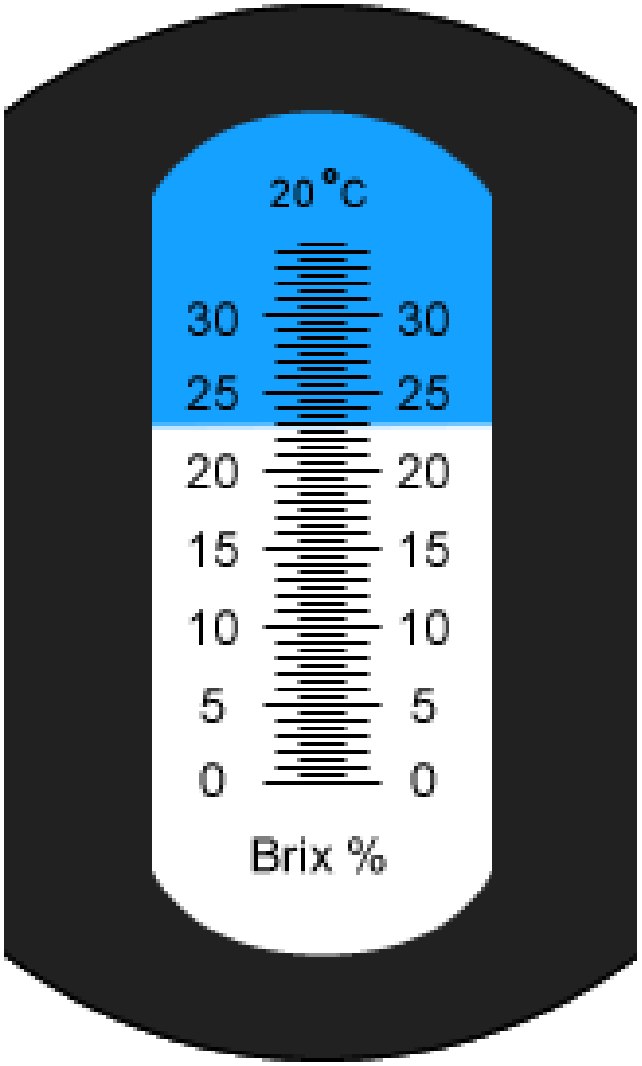


Filter chamber of aphids and other homopterans



Honey dew


ATC


20°C
30
25
20
15
10
5
0
Brix %

Refractive Index of Crop Juices -- Calibrated In % Sucrose Or ºBrix

	Poor	Average	Good	Excellent
FRUITS				
Apples	6	10	14	18
Avocados	4	6	8	10
Bananas	8	10	12	14
Blueberries	8	12	14	18
Cantaloupe	8	12	14	16
Casaba	8	10	12	14
Cherries	6	8	14	16
Coconut	8	10	12	14
Grapes	8	12	16	20
Grapefruit	6	10	14	18
Honeydew	8	10	12	14
Kumquat	4	6	8	10
Lemons	4	6	8	12
Limes	4	6	10	12
Mangos	4	6	10	14
Oranges	6	10	16	20
Papayas	6	10	18	22
Peaches	6	10	14	18
Pears	6	10	12	14
Pineapple	12	14	20	22
Raisins	60	70	75	80
Raspberries	6	8	12	14
Strawberries	6	8	12	14
Tomatoes	4	6	8	12
Watermelons	8	12	14	16
GRASSES				
Alfalfa	4	8	16	22
Grains	6	10	14	18
Sorghum	6	10	22	30

	Poor	Average	Good	Excellent
VEGETABLES				
Asparagus	2	4	6	8
Beets	6	8	10	12
Bell Peppers	4	6	8	12
Broccoli	6	8	10	12
Cabbage	6	8	10	12
Carrots	4	6	12	18
Cauliflower	4	6	8	10
Celery	4	6	10	12
Corn Stalks	4	8	14	20
Corn (Young)	6	10	18	24
Cow Peas	4	6	10	12
Cucumbers	4	6	8	12
Endives	4	6	8	10
English Peas	8	10	12	14
Escarole	4	6	8	10
Field Peas	4	6	10	12
Garlic, Cured	28	32	36	40
Green Beans	4	6	8	10
Hot Peppers	4	6	8	10
Kale	8	10	12	16
Kohlrabi	6	8	10	12
Lettuce	4	6	8	10
Onions	4	6	8	10
Parsley	4	6	8	10
Peanuts	4	6	8	10
Potatoes	3	5	7	8
Potatoes, Sweet	6	8	10	14
Romaine	4	6	8	10
Rutabagas	4	6	10	12
Squash	6	8	12	14
Sweet Corn	6	10	18	24
Turnips	4	6	8	10

Within a given species of plant, the crop with the higher refractive index will have a higher sugar content, higher mineral content, higher protein content and a greater specific gravity or density. This adds up to a sweeter tasting, more minerally nutritious food with lower nitrate and


cUltivate




SUE'S
SEED SAVING
PLOT