Welcome to *Ecology 101*

Premise of course:

Ecosystems approach

a. Physical attributes
b. Energy flow
c. Productivity

Readings:

Required:

The Diversity of Life, Edward O. Wilson

Sand County Almanac, Aldo Leopold

Ecology: A Bridge Between Science and Society, Eugene P. Odum

Recommended:

Science Times

Science

Nature

Grading

1. Midterm: 50%

2. Final: 50%

Examination format:

Multiple choice, true/false, short answer, essay

Schedule:

September
- Introduction
- Basic Principles I - Evolution of Ecosystems
- Basic Principles II – Species and the Niche Concept
- *Basic Principles III – Energy Flow and Trophic Levels* `
- Biogeochemical Cycles I

October
- Biogeochemical Cycles II
- Rivers

MIDTERM EXAMINATION
- Lakes
- Estuaries and Wetlands

November
- The Oceans
- Coral Reefs
- Rain forests

December
- Hardwood and Boreal Forests

FINAL EXAMINATION

Websites:

Required:

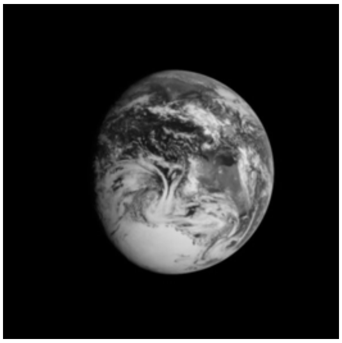
www.http://ci.columbia.edu/ci/eseminars/1111s_detail.html
www.http://streamecology.org
www.http://IES.org (Institute for Ecosystems Study)

Recommended:

www.medicalecology.org

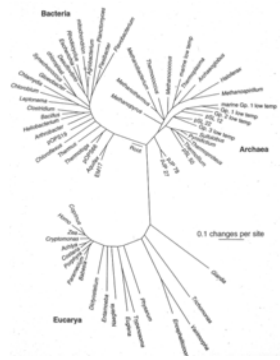
www.http://NASA.gov
, then go to Earthwatch
www.http://NOAA.gov

Is That All There Is?

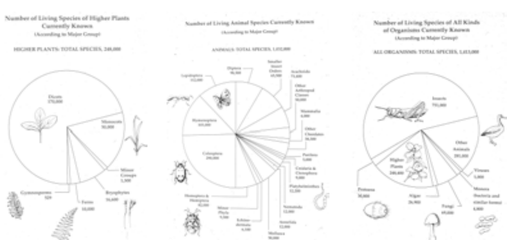


"Right now we can only guess that the correct answer for the total number of species worldwide lies between 2 and 100 million"

Life on Earth

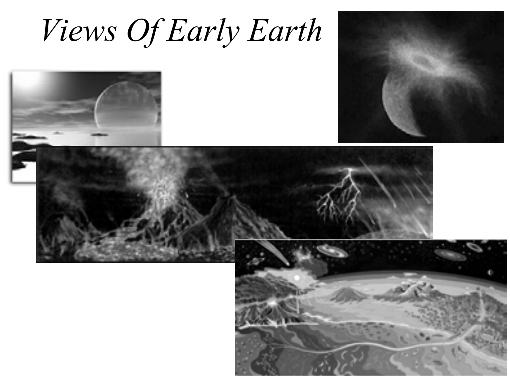


The Diversity Of Life



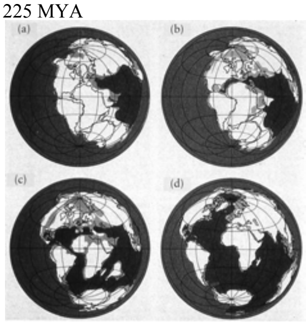
from: *The Diversity Of Life*, E.O. Wilson

Views Of Early Earth



"*Drifting Apart*"

225 MYA



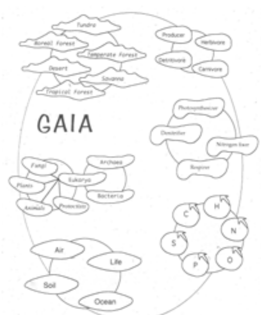
Now

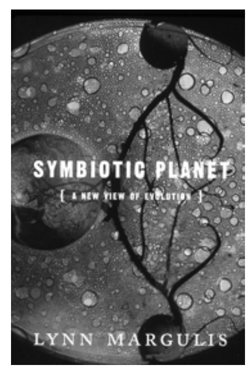
Still Drifting After All These Years

Life Without The Sun's Help

Extremophiles Rule!

GAIA Hypothesis





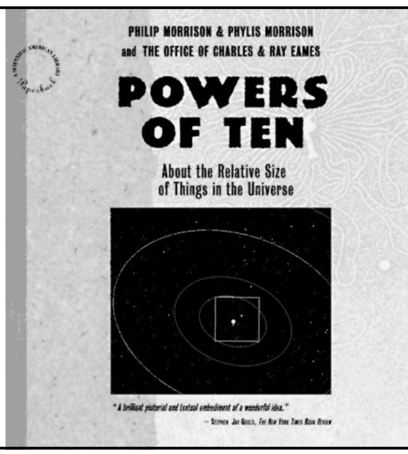
Some General Ecological Principles

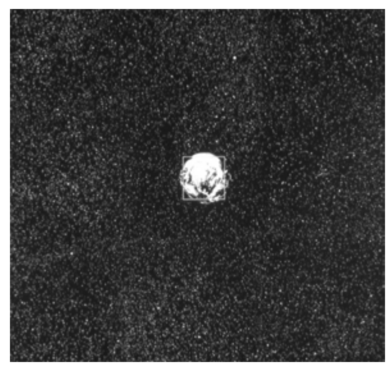
Ecosystem Ecology

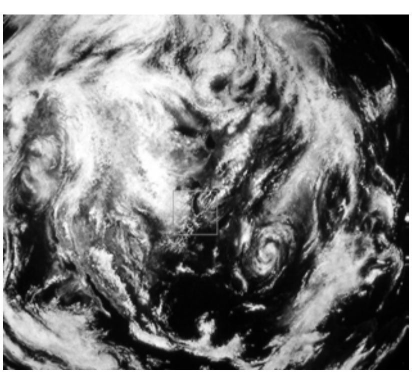
Describing Ecosystems

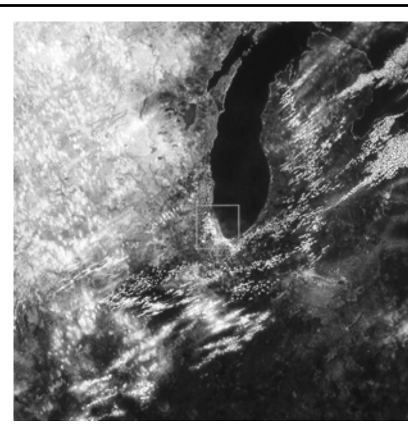
1. Identify a definable geographic region (e.g. grassland prairie)
2. Identify all plants and animals within that region (i.e., the biodiversity index)
3. Study how these disparate groups form associations of food chains and food webs (i.e. form ecosystems).
4. Study the flow of energy through these associations (i.e., measure productivity)

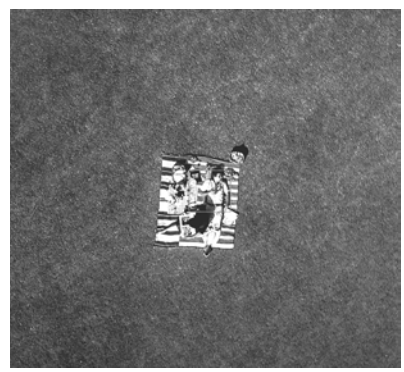
Levels of Complexity



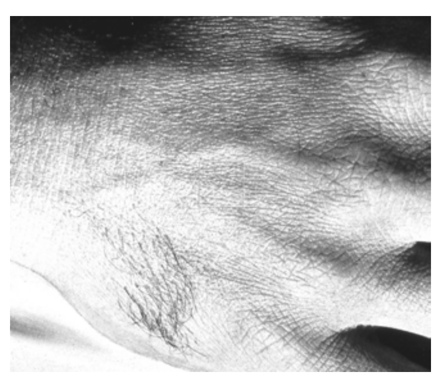


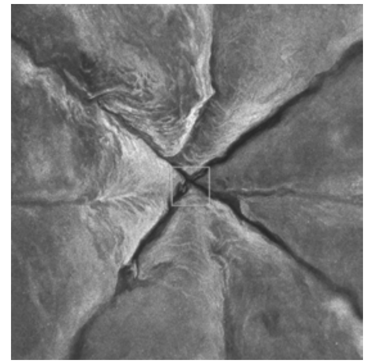


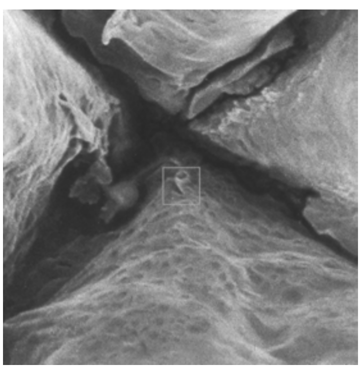




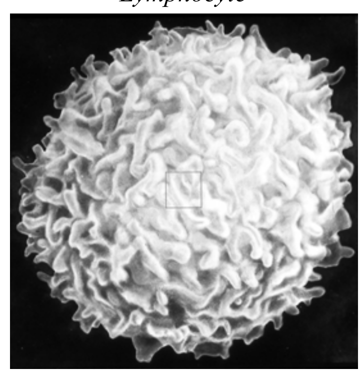
Why is this man sleeping?



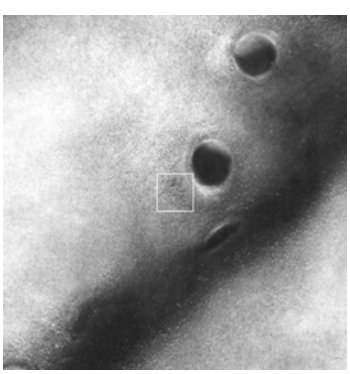




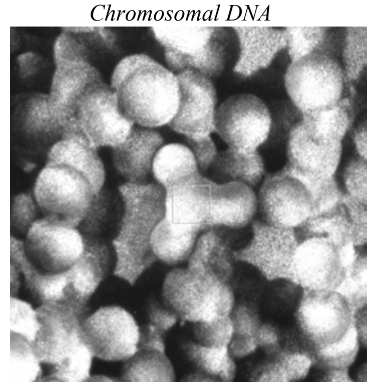
Lymphocyte



Nuclear Envelope

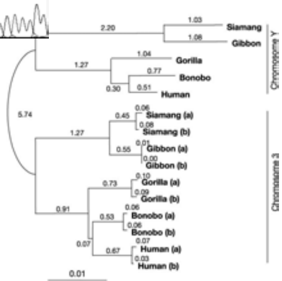


Chromosomal DNA



We have come a long way in just 20 years

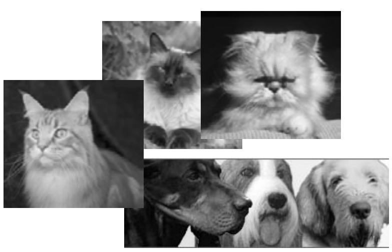
THE UNIVERSITY OF MICHIGAN
DNA Sequencing Core



*What Is A Species?**

* Variations on a theme. One snail species, many varieties

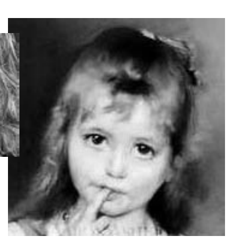
How Many Species of Dogs And Cats Are There?



One!

Two Species Or One?

Neandertal



Modern Human

Study: Human DNA Neanderthal-Free
By Jennifer Viegas, Discovery News

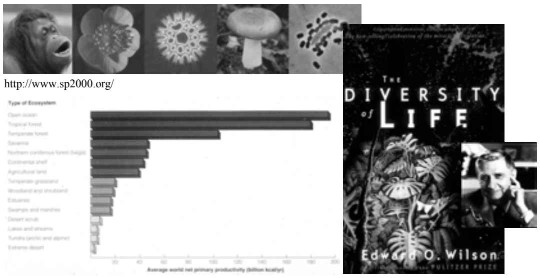
Cro-Magnon vs. Neanderthal

May 12, 2003 — Neanderthals did not contribute to the gene pool of modern humans, according to a recent study that compared the DNA of two ancient Cro-Magnons with that of four Neanderthals.

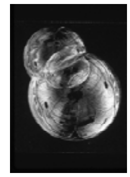
While Neanderthals and early humans coexisted in Europe for a few thousand years 40,000 years ago, the findings suggest they did not interbreed, an action that would have made Neanderthals a direct ancestor of modern humans.

The study also supports the "Out of Africa" theory. According to this view, modern humans evolved in East Africa and then spread into Europe and Asia through the Middle East.

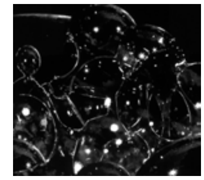
Speciation Drives the System



*The Concept Of Niche**



The Three Body Problem



The N^{th} Body Problem

"No two species can occupy the same niche."

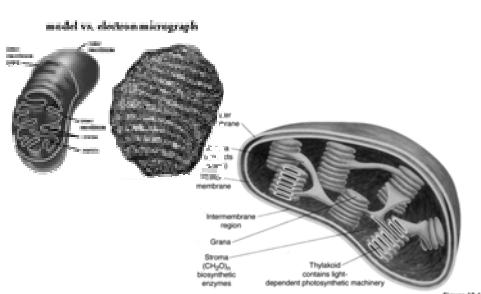
* as developed by G. Evelyn Hutchinson

SPATIAL CONCEPT OF NICHE

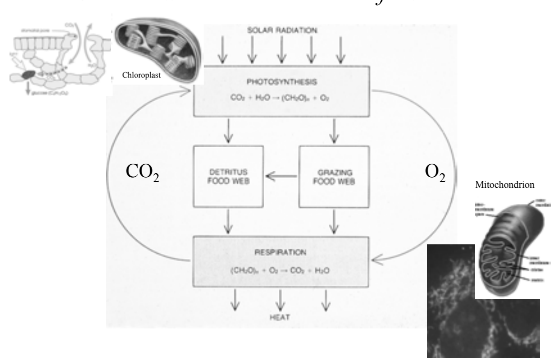
- G.E. HUTCHINSON (1957), A YALE SCHOLAR: "THE NICHE IS AN ABSTRACTLY INHABITED HYPERVOLUME"
- CONCEPT OF DIMENSIONALITY OF CONTROL FACTORS
- FUNDAMENTAL VS. REALIZED NICHE

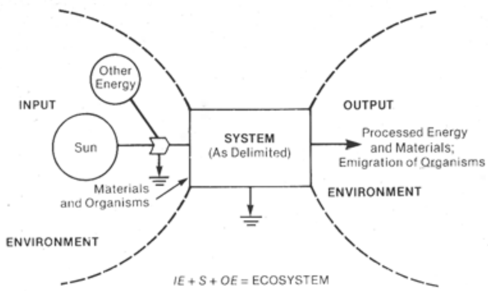
There Can Be No Ecosystems Without Plant-Animal Interactions

It Takes Two To Tango

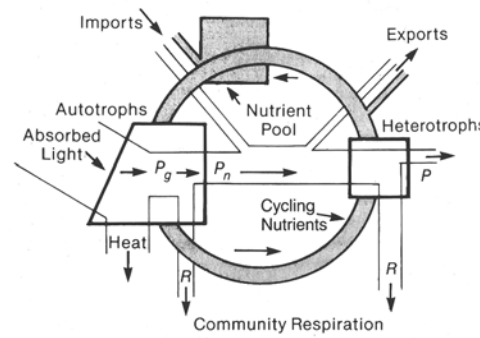


General Scheme For Most Life On Earth



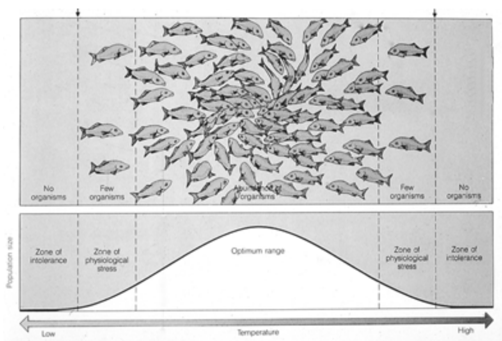


from Odum, *Fundamentals of Ecology* Saunders Pubs. 1971



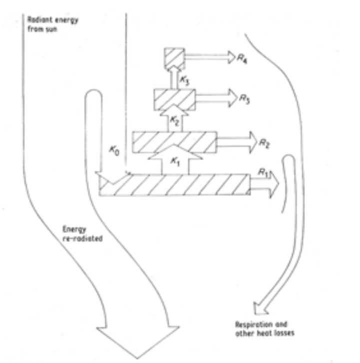
from Odum, *Fundamentals of Ecology* Saunders, Pubs.1971

Tolerance Limits



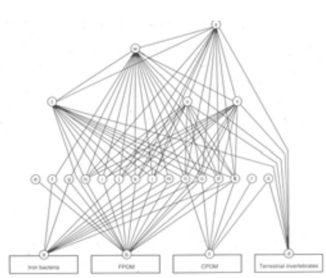
from Miller, *Living In The Environment* Thompson, Pub.

Trophic Levels And Energy Flow

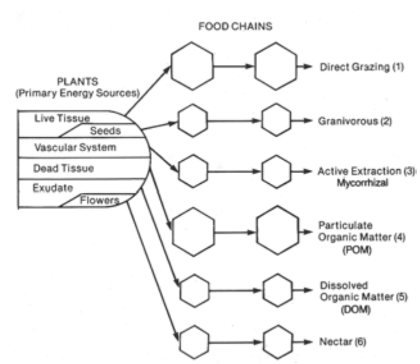


From Odum, *Fundamentals of Ecology*, Saunders Pubs.1971

Trophic Relationships



Nature Abhors A Vacuum



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The Galapagos Islands

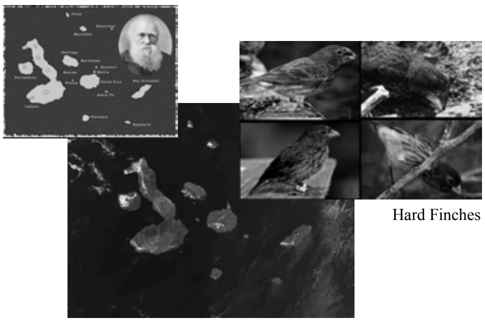
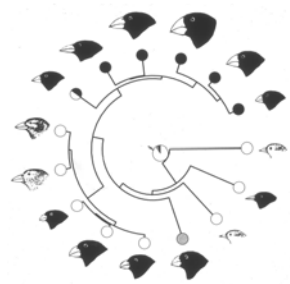


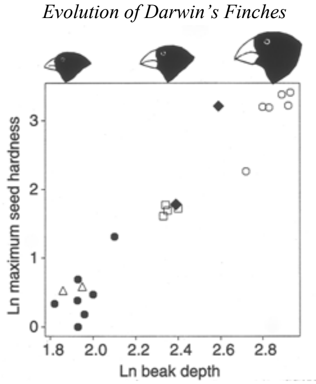
Photo: NASA

Learn more: http://www.talkorigins.org/faqs/wells/finches.html

Genetic Relationships Among Darwin's Finches
Beak Size and Shape

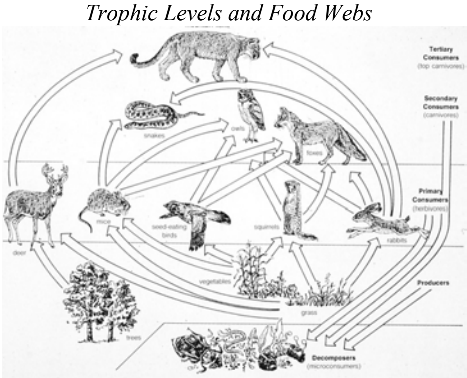


Evolution of Darwin's Finches



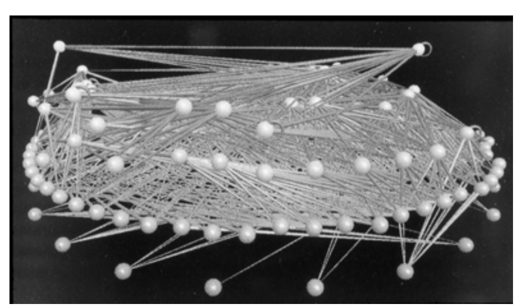
An Early Food Web

Trophic Levels and Food Webs



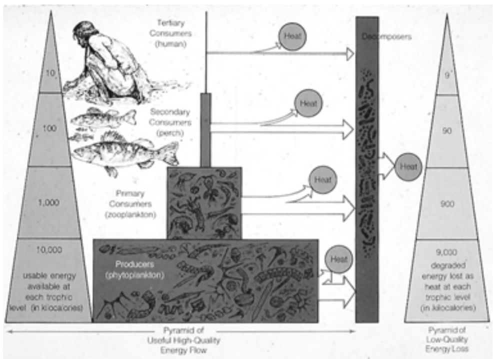
from Miller, *Living In The Environment* Thompson, Pub.

Trophic Levels and Food Webs:
The Complexity of Interactions



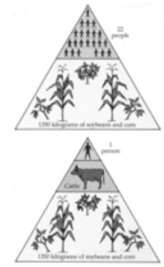
Science Magazine

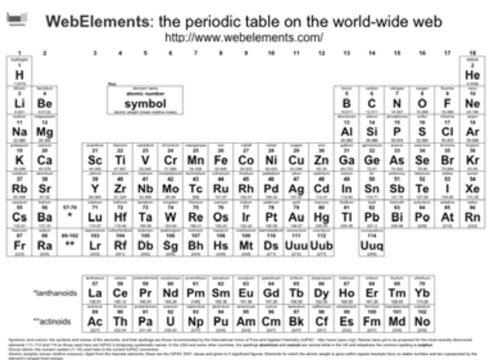
Food Pyramid



from Miller, *Living In The Environment*, Thompson, Pub.

Food Pyramids

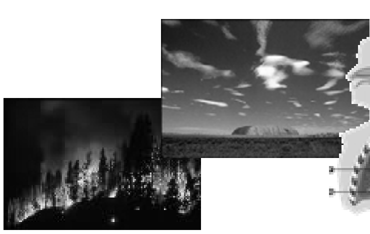


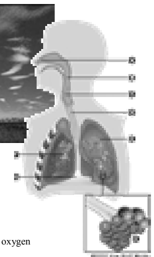


Biogeochemical Cycles:

Oxygen
Carbon
Sulfur
Nitrogen
Phosphorous
Calcium

Oxygen Cycle





Brazil's forests produce 40% of the earth's atmospheric oxygen

Oxygen Cycle

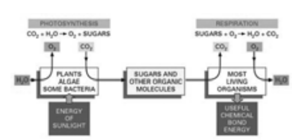
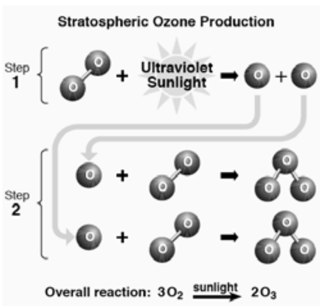
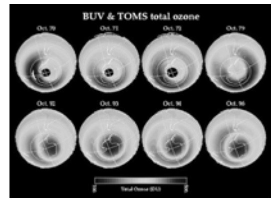


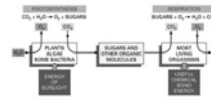
Image obtained from http://www.accessexcellence.com/AB/GG/photo_Resp.html

Oxygen Cycle



Oxygen Cycle





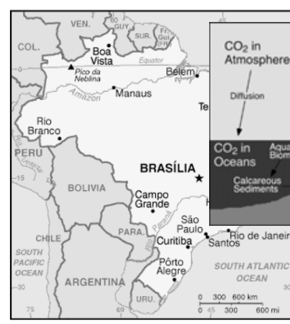
www.nasa.gov

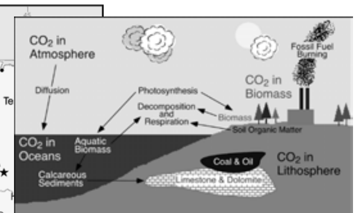
Depletion of ozone leads to ecosystem health risks

Carbon Cycle

Temperate rainforests store vast amounts of carbon, both above and below ground.

Carbon Cycle





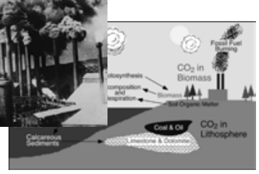
Brazil's rainforests re-cycle carbon faster than any other ecosystem.

Carbon Cycle

Carbon sink

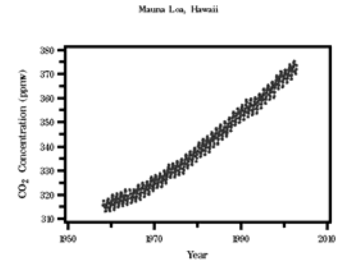
vrs

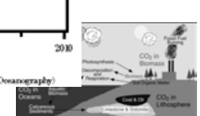
Carbon stink



Today, the earth's atmosphere is accumulating CO_2 faster that it can be sequestered.

Carbon Cycle

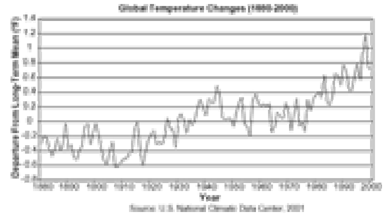




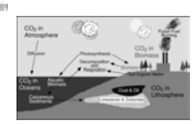
Carbon Sinks:

1. Marine viruses and phytoplankton
2. Forests
3. Coral reefs

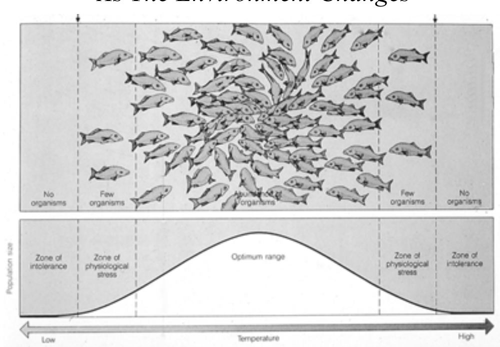
Carbon Cycle



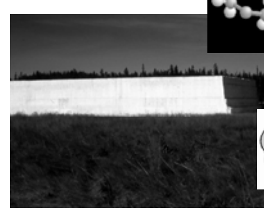
The earth's "core" temperature is rising

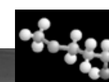


Nature Is "Re-shuffling" The Deck As The Environment Changes

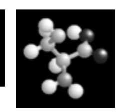


Sulfur Cycle

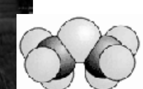




Methionine



Cystiene



Dimethyl sulfide

Sulfur Cycle

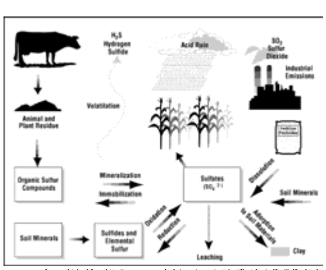
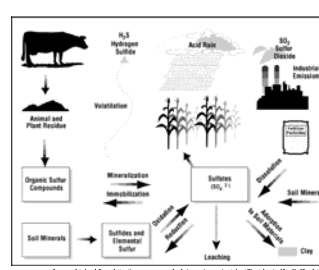


Image obtained from http://www.agnr.umd.edu/users/agron/nutrient/Factshee/sulfur/Sulfur.html

Sulfur Cycle



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Sulfur Cycle

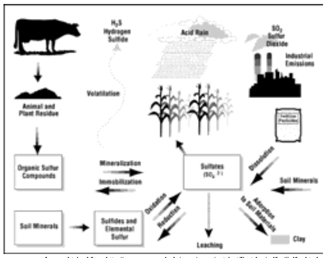
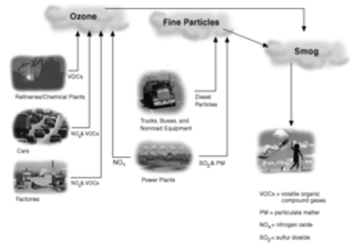
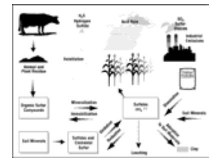


Image obtained from http://www.agnr.umd.edu/users/agron/nutrient/Factshee/sulfur/Sulfur.html

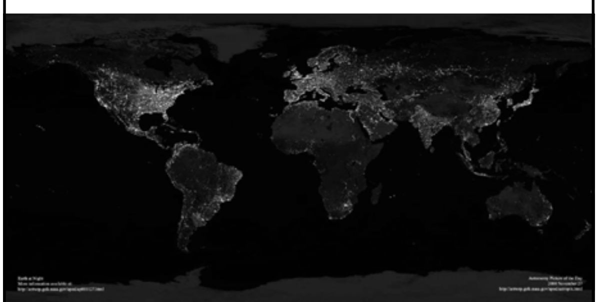
Sulfur Cycle





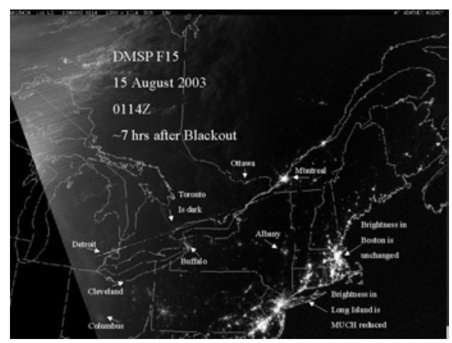
Courtesy: EPA

The Earth At Night



Most energy generating systems that utilize fossil fuels put significant amounts of SO_2 into the atmosphere.

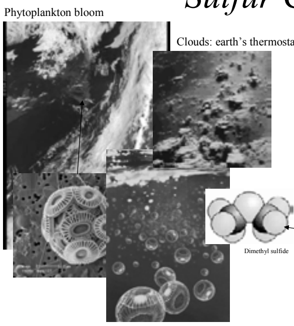
"What the…. "



Sulfur Cycle

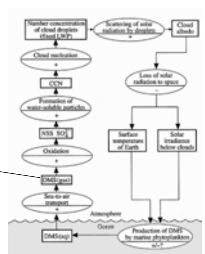
Phytoplankton bloom

Clouds: earth's thermostat



Dimethyl sulfide

Coccolithic phytoplankton



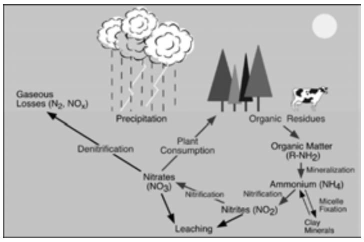
Cloud Formation

www.puffythecloud.org

Luke Howard

http://www.inclouds.com/

Nitrogen Cycle

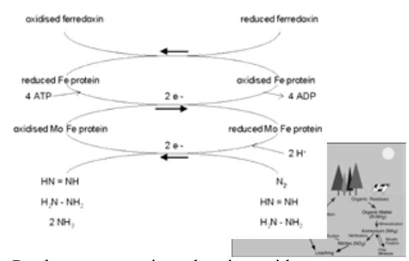


*Nitrogen Cycle**

*what is wrong with this picture?

Corn is not a legume

Nitrogen Cycle

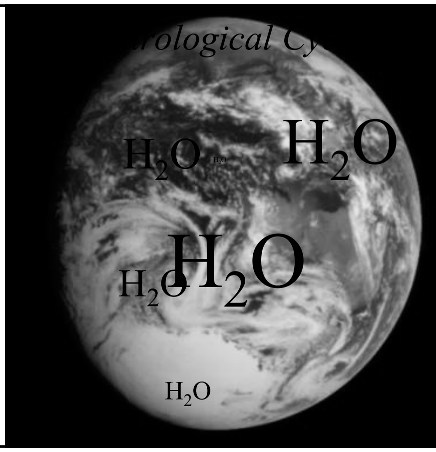


Products: ammonia and amino acids

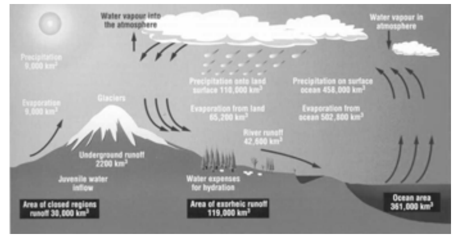
What is wrong with this picture?

Courtesy *NASA*

No clouds

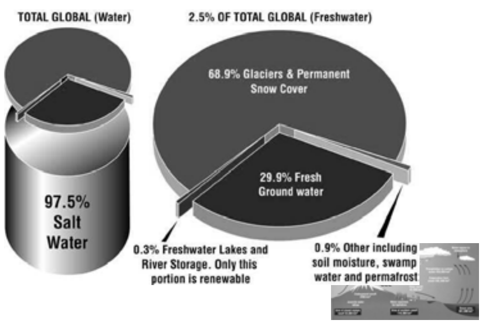


Hydrological Cycle

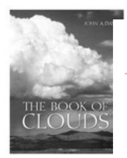


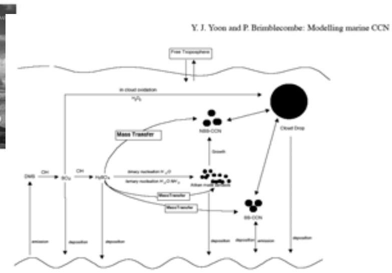
Courtesy: UNESCO

Hydrological Cycle

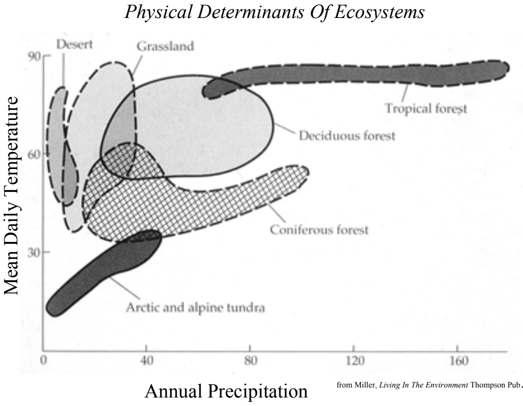


Hydrological Cycle



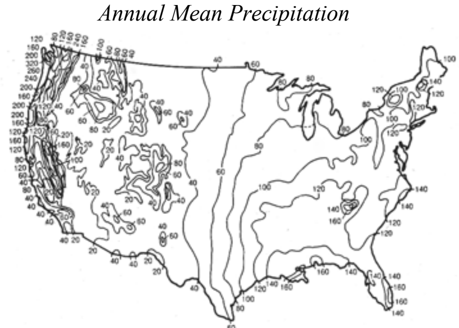


Physical Determinants Of Ecosystems



from Miller, *Living In The Environment* Thompson Pub.

Annual Mean Precipitation



Ecozones

Courtesy *NASA*

River Ecology

Lotic Ecosystems

Limnology, The Science Of Lakes

Limnology, The Science Of Lakes

Courtesy *NASA*

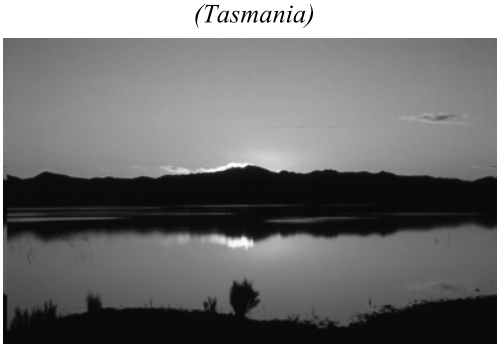
Distribution Of Large Lakes

Lake Louise, Alberta, Canada

New Zealand Lake

Pedder Lake, Australia

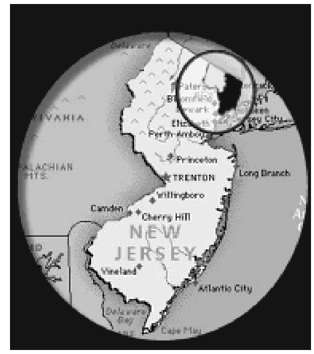
(Tasmania)



Quake Lake, Montana

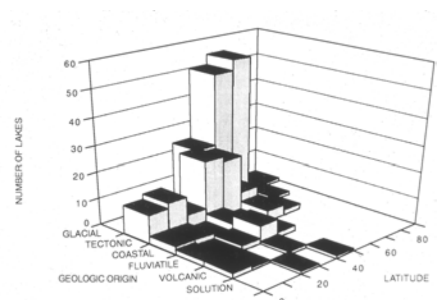
New York City Drinks Lake Water

So Does Northern New Jersey



Lentic Ecosystems

Classification Of Large Lakes



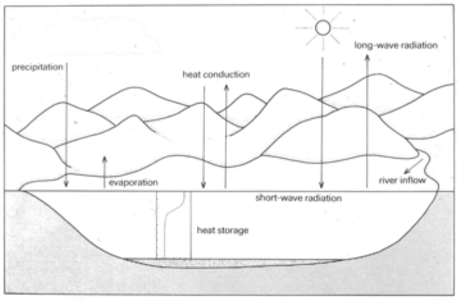
Frequency of occurrence of large lakes by area

Range in area (km²)	Total number	Total area (km²)	Mean area (km²)
500– 1,000	113	76,330	675
1,000– 2,000	63	84,643	1,343
2,000– 3,000	21	50,192	2,390
3,000– 4,000	9	30,907	3,434
4,000– 5,000	13	58,543	4,503
5,000– 10,000	15	102,768	6,851
10,000– 50,000	5	291,478	22,421
50,000–100,000	1	331,910	66,382
<100,000	1	374,000	374,000
Total	253	1,400,771	

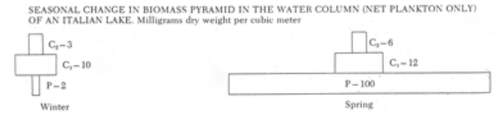
Factors Affecting The Trophic Status Of lakes

Interrelationships of the main factors affecting the trophic status of a lake

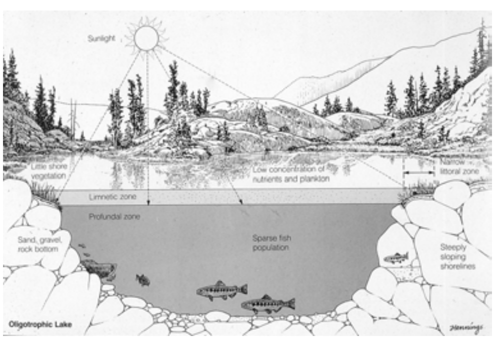
Energy Considerations



Food Pyramids

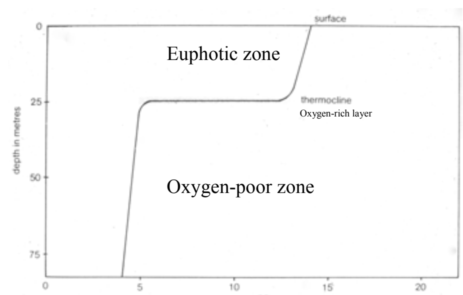


Oligotrophic lakes

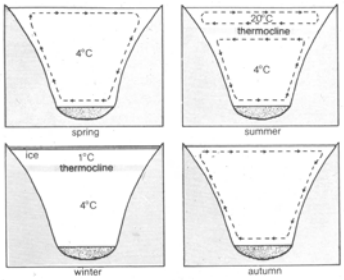


From: Miller, *Living In The Environment*

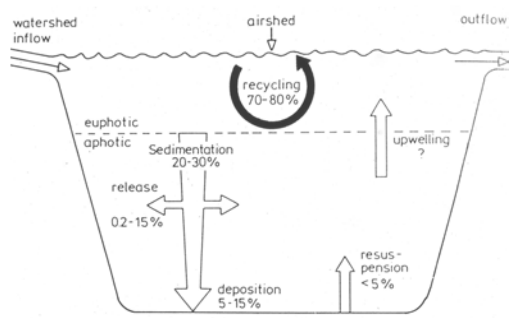
Temperature Profile, Summer



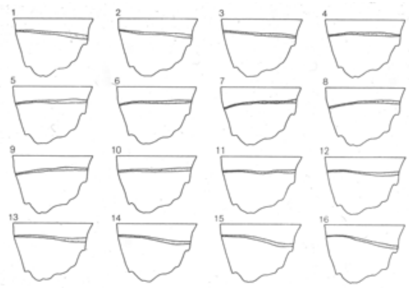
Temperature Profiles Throughout The Seasons In An Oligotrophic Lake



Circulation Patterns



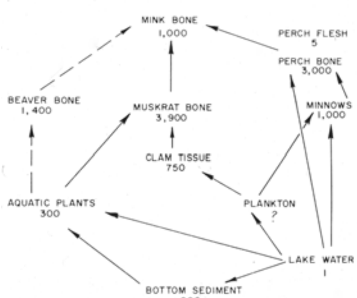
Thermal Profiles Of An Oligotrophic Lake Over A 12 Hour Period



Energy Flow In An Oligothrophic Lake

Energy flow in Loch Leven, Scotland.

Accumulation Of Strontium ^{90} In A Lake



Langmuir Circulation

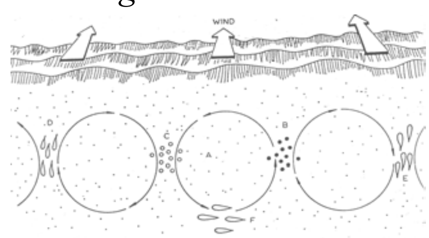
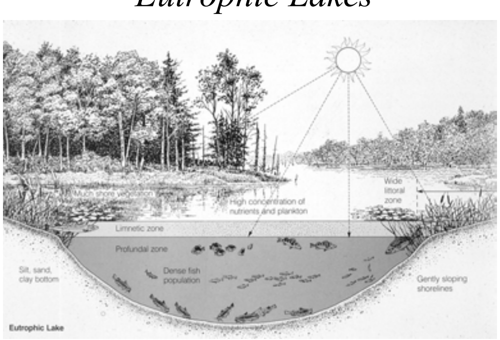


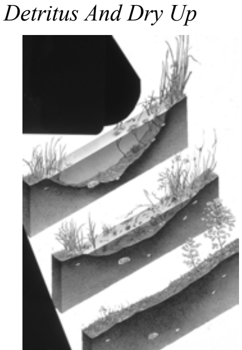
Figure 3.18 Langmuir circulation and plankton distribution: A, randomly distributed neutrally buoyant particles; B, sinking particles aggregated in upwelling zone; C, floating particles concentrated in downwelling zone; D, E, and F, zooplankton aggregation positions determined by the velocity field in the cell. Redrawn from Stavn (1971) by Ledbetter (1979).

Eutrophic Lakes



From:Miller, *Living In The Environment*

All Lake Undergo Eutrophication And Eventually Fill In With Detritus And Dry Up



Pitcher Plant Bog

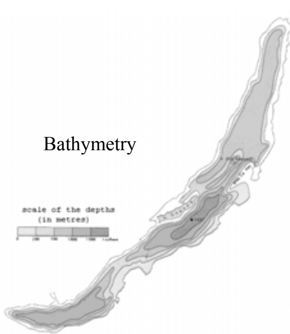
Unusual Lakes

Lake Baikal From Space

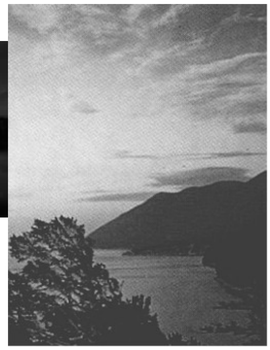
Courtesy *NASA*

Lake Baikal From Space

Lake Baikal, Siberia



Lake Baikal, Siberia



Living Lakes

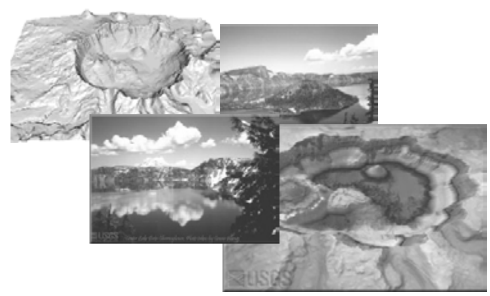
http://www.livinglakes.org/baikal/

Lake Baikal, Siberia

Lake Baikal, Siberia

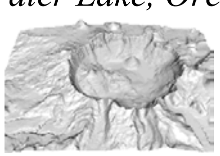
Baikal has more endemics than any other lake in the world. Its great age--more than 25 million years--also sets it apart from any other freshwater lake as a living laboratory of evolution. During its life, 30 species of sculpins (above) have evolved. In comparison, 10,000-year-old Lake Superior has but four species.

Crater Lake, Oregon



http://craterlake.wr.usgs.gov/bathymetry.html

Crater Lake, Oregon

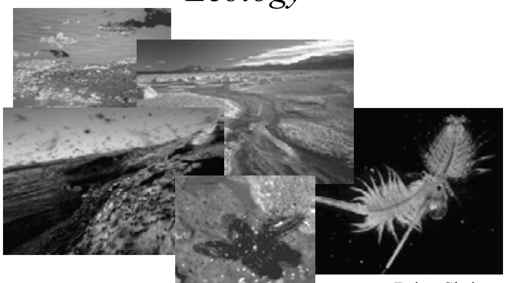


Biological studies include the discovery of bacterial colonies associated with hydrothermal fluids. These yellow-orange mats consist of thousands of *Gallionella* and *Leptothrix* bacteria. Golden-colored bacteria were found surrounding Llao's Bath. A thick band of moss, *Drepanocladus aduncus*, encircles the lake at depths from 26-140 m (85-460 ft). It hangs like icicles on vertical cliffs and forms thick, lush fields on the gentler slopes around Wizard Island. A fascinating discovery is the animals living in the deepest basin of Crater Lake (589 m, or 1,932 ft). These animals which withstand such high water pressure include flatworms, nematodes, earthworms, copepods, ostracods, and the midge fly *Heterotrissocladius*.

Mono Lake, California

Mono Lake, California: Ecology

Birds feeding on shrimp and flies



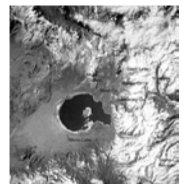
Alkali Flies

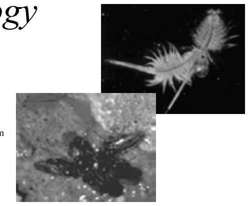
Brine Shrimp

Mono Lake, California: Ecology

Pluvial lake (no outlet)
Carbonates ($CaCO_3$), chlorides, sulfates
pH - 9.8
Salinity - 70-90g/L

Desulfonatronum thiadismutans - alkali-loving bacterium
Spirochaeta americana - haloalkaliphilic anaerobe
Bacillus arsenicoselenatis - arsenate-loving benthic bacterium

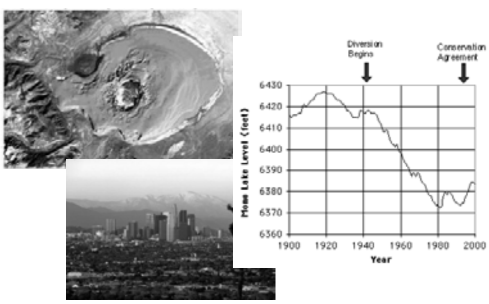




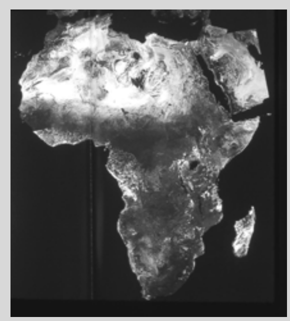
Halophilic green algae:
Nannochloris sp. dominates

Primary productivity: 340-540g $C/m^2/yr$

Mono Lake, California: Remediation



Tropical Lakes Of Africa



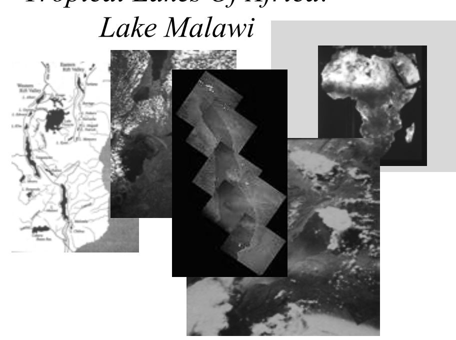
Tropical Lakes Of Africa: Lake Nakuru

Surface area [km2] 40
Volume [km3] 0.092
Maximum depth [m] 2.8
Mean depth [m] 2.3
Water level Unregulated
Length of shoreline [km] 27
Catchment area [km2]1,800** Including the lake area.

World Lakes Database

http://www.ilec.or.jp/database/afr/afr-07.html

Tropical Lakes Of Africa: Lake Malawi

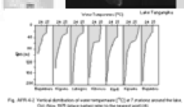


Tropical Lakes Of Africa: Lake Tanganyika

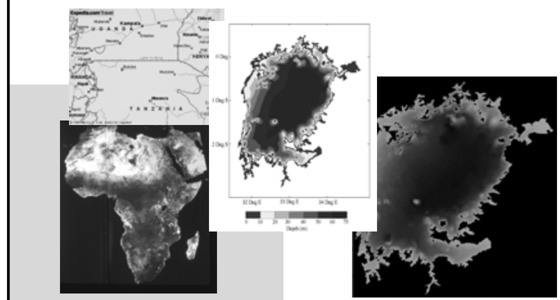
Surface area [km2] 32,000
Volume [km3] 17,800
Maximum depth [m] 1,471
Mean depth [m] 572
Water level - Unregulated
Length of shoreline [km] 1,900
Catchment area [km2] 263,000

PRIMARY PRODUCTION RATE [mg C m-2 day-1](l, 4)

April-May	600
October-November	1,400
Annual	1,000



Lake Victoria, East Africa



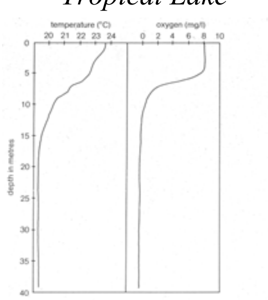
Tropical Lakes Of New York City

Cichlids Unlimited

Some Attributes Of Three African Lakes

Lake	World Rank in Size	Area km² (miles²)	Depth m (feet)	Clarity m (feet)	Age in Years	Cichlid Species
Tanganyika	7th	34,000 (13,100)	1,470 (4,823)	22 (72)	6 million	300
Malawi	9th	31,600 (12,200)	700 (2,310)	17 (56)	1–2 million	500
Victoria	3rd	68,600 (26,500)	95 (305)	1–8 (3–25)	12,400	400

Temperature And Oxygen Profiles Of A Tropical Lake

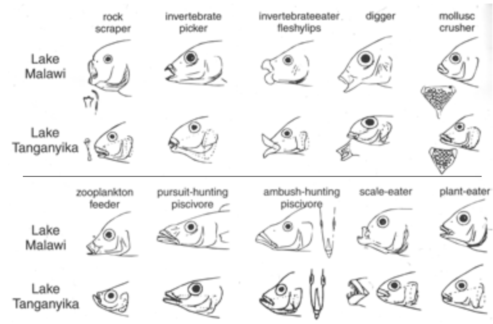


Vertical profiles for temperature and oxygen in a stratified lake – Lake Bunyonyi in Uganda (after Denny, 1972)

Lakes Malawi And Tanganyika: Speciation Of Cichlids

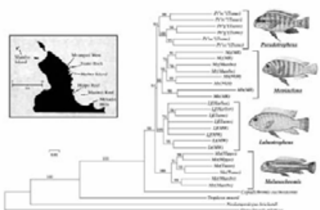
Speciation of Cichlids

*Speciation Of Cichlids**



*Parallel Trophic Evolution

Phylogenetics Of Lake Malawi Cichlids



http://tilapia.unh.edu/wwwPages/malawi/Phylogenetics.html

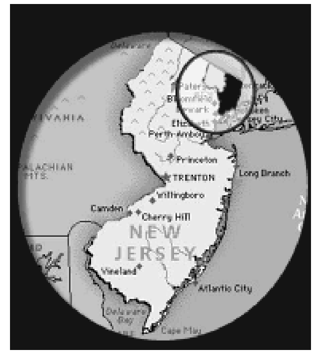
Lake Victoria Has Cichlids, Too

That Is Until Someone Stocked It With Nile Perch!

Nile Perch And Foe

New York City Drinks Lake Water

So Does Northern New Jersey



*Two Approaches To Watershed Management**

New York City

Northern New Jersey

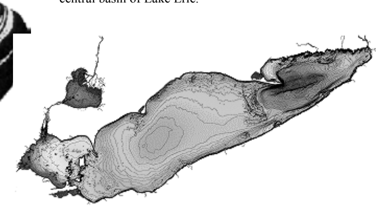
*Which water would you rather drink?

Beavers Alter The Landscape
In favor Of Wetlands

Most Significant Cause Of Pollution
World-wide: Agricultural Runoff

Zebra Mussels and Lake Erie

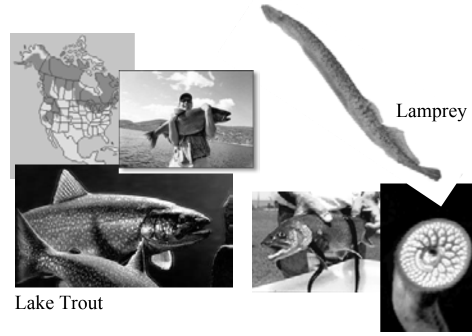
Lake Erie dead zone may be due to zebra mussels
September 2003
U.S. Water News Online
Researchers think zebra mussels may be causing a low-oxygen ``dead zone" in the central basin of Lake Erie.



St. Lawrence Seaway

The seaway was officially opened on June 26th 1959 and cost 470 million US dollars

Host, Predators, And Parasites

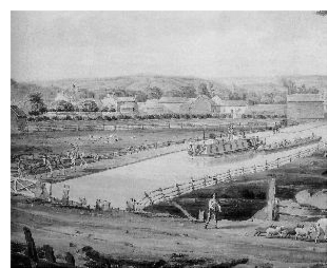


Lamprey Eel

Lake Trout

Lake Trout With Wounds Inflicted By Lamprey Eels

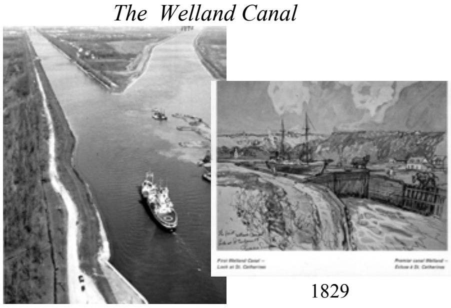
How The Lamprey Eel Got Into The Great Lakes



The Erie Canal, circa 1825

How The Lamprey Eel Gained Entrance Into The Great Lakes:

The Welland Canal



1829

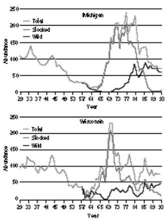
Today

Controlling Lamprey Populations

1. Lampricides - TMF (3-trifluoromethy-4-nitrophenol)
2. Adult lamprey trapping

The Lamprey Eel And Lake Trout:

Remediation (of sorts)



Lake Trout in the Great Lakes

by
Michael J. Hansen
National Biological Service
James W. Peck
Michigan Department of Natural Resources

Lake trout (*Salvelinus namaycush*) populations in the Great Lakes collapsed catastrophically during the 1940's and 1950's because of excessive predation by the sea lamprey (*Petromyzon marinus*) and exploitation by fisheries.

http://biology.usgs.gov/s+t/noframe/m2130.htm