Chapter 13: Life in the Ocean

Energy: the capacity to do work. Living matter cannot function without it. (Fig 13.1)

Laws of Thermodynamics:
First Law: Energy cannot be created or destroyed, it can only be changed from one form to another.

Second Law: Disorder inevitably tends to increase in the universe as time passes.
Entropy is a measure of this disorder.

>Whenever energy is transformed from one state to another, there will be a loss of energy through heat.

>Living things use energy in a sophisticated way.

The main source of energy is the Sun. Light energy is transformed into chemical energy and finally into heat as organisms temporarily forestall the disorderly fate decreed by the Second Law.

<u>CONVERTING ENERGY TO FOOD</u>
Producers: critters with chlorophyll trap sun energy and change it into chemical energy.

That chemical energy is used to make food, which is either used by the Producer or eaten by the Consumer.
(Fig. 13.2)
Photosynthesis $6CO_2 + 6H_20 \text{ ------> } C_6H_{12}O_6 + 6O_2$

The stored energy is released when food such as glucose is used by the organisms.

A few critters use Chemosynthesis, where there is no sunlight available.

Primary Productivity (Fig. 13.3): The synthesis of organic materials from inorganic substances by photosynthesis or chemosynthesis.

.Expressed in $gC/m^2/yr$ (grams of C per square meter of ocean)

Organic Material: Glucose, and the source is CO_2

>Phytoplankton produce between 90-96% of oceanic carbs.

>Seaweeds from 2-5%, Chemos 2-5%

Ocean Productivity: 75-150$gC/m^2/yr$ (Figure 13.3)

Biomass: mass of living critters

>Ocean is lower, but much more efficient (Table 13.1)

Feeding (Trophic) Relationships
Primary Producers are Autotrophic, which means that they make their own food.
Heterotrophs are critters that eat other critters.

Trophic Pyramid – Figure 13.5

(Trophos – one who feeds)
Primary Producers are at the bottom
Primary Consumers (Herbivores) – animals that eat the primary producers
- Followed by Tertian Consumers, than top consumer (Top carnivore)

Mass of consumers becomes smaller as energy flows toward the top of the pyramid.

Just a small piece - whole picture – food web – Figure 13.6

All living things – 23/107
-99% - C, H, O, N Table 13.2

Form compounds:
Carbs, Lipids (fats, waxes, oils), proteins, nucleic acids

Central message of biology – unity – most things on Earth (living) are related through a common evolutionary history. Fig 13.7

Biogeochemical Cycle- natural processes that recycle nutrients in various chemical forms from the non-living environment to living organisms, and then back to the non-living environment

1. Carbon Cycle – largest
   Enters – $C0_2$ via respiration, volcanism, fossil fuel burning, etc.
   $C0_2$ is fixed by plants into organic molecules
   Animal eats: a) Critter can grow – 45%
   b) Respired by critter (used as energy) – 45%
   c) Wasted (Doc – dissolved organic carbon) – 10%

DOC is used by bacteria, eaten by protozoans, which are eaten by zooplankton, which are eaten by fish (microbial loop)

$CaC0_3$ can get locked up in a rock, then uplifted, etc
(Figure 13.8)

2. Nitrogen Cycle
- critical component of proteins, chlorophyll and nucleic acids
  N_2 – dissolved gas DON- dissolved organic nitrogen
  Dissolved inorganics – $N0_3$-, $N0_2$-, NH_4+
  nitrate nitrite ammonium

Table 7.4 – N_2 48% of dissolved gas in seawater
Must be bound with 0_2 of H_2 or fixed into usable chemical forms
- some areas of ocean is N-Limited

N Enters: primarily as $N0_3$ in rivers, rain or are created by Nitro fixers

Assimilated by critters, excreted as (NH4) ammonia and urea

These are oxidized back into nitrate, via nitrite by nitrifying bacteria

In anoxic areas, denitrifying bacteria use nitrate in respiration and convert nitrate back to nitrite and nitrogen gas
Figure 13.9 – Nitrogen Cycle

3. Phosphorus and Silicon
All organisms use Phosphorous to link the parts of nucleic acids, and it is used in molecules that carry energy within the cell.

Calcium Phosphate- used in bones, teeth, some shells

Skeletons – diatoms, radiolarians ($Si0_2$)

P and Si cycles are simple

Enter: As rain or rivers, taken in photic zone by critters, released (P) when organisms Decompose – which is promptly converted to Phosphate (at ocean PH) which is used by Phytoplankton and bacteria

Silica is released back to the water when critters die, used then as ionized form of silicate

<u>Both P, Si cycle in 3 loops</u>

1. Most Rapid – Daily feeding, death and decay of surface organisms
2. Slower Loop- occurs as the bodies of organisms fall below the pycnocline and the P escapes down into deep ocean circulation
3. Largest- Millions- Begins with then P or Si locked up in rocks or shells that become marine sediments

- comes out volcanoes

4. Fe and other Traces
Fe utilized in small amounts in Photosynthesis, Nitro fix, Proteins
Zn, Cu, Mn – in enzymes
Fe scarcity can hurt- settles to bottom

Physical and Biological Factors
Physical factors- aspects of the environment that affect living organisms

1. Light
   - alot reflects
   - Blue goes the deepest and gets absorbed
   - Chlorophyll also absorbs – hence blue –green color
     Figure 13.11

Photic Zone – light penetrates – 100 m (330 ft)
(mid lat) 150 m (500 ft)

Record – 590 m (1935 ft) in the Tropics

Aphotic Zone – dark layer below
Figure 13.12
Euphotic zone – good photosynthesis
(averages 70 m or 230 ft)

Disphotic Zone – not as bright (dis- difficult)

2. Temperature – Figure 13.13

   Metabolic Rates (rate at which energy – releasing reactions proceed within an organism) increases with temperature

   Metabolic rates double with a 10°C (18°F) rise

   Majority of critters – ectothermic - cold blooded
   - Internal T is close to surroundings

   Endothermic- warm blooded – stable higher internal T's

3. Dissolved Nutrients
   Nutrient- compound required for the production of organic matter
   - N,P – essentially fertilizer
   - Can be over utilized

4. Salinity
   - Important to stay constant, and for buoyancy
   - Important for water balance inside cells

5. Dissolved Gases – $C0_2$, 0_2
   Table 13.3
   - Lots of $C0_2$ in sea water
   - Used more near the surface
   - Plankton Blooms – sealed off areas

6. Acid – Base Balance
   - pH=8
   - Tropics – 8.5
   - Colder waters 7.5, 7.0 related to $C0_2$ conversion to carbonic acid

7. Hydrostatic Pressure: Weight of water above you
   - Big changes can harm critters

Biological factors – Biologically generated in the environment

1. Diffusion – dye molecules diffuse: nutrients, gases, liquids

   Osmosis- diffusion of water through a membrane
   - Moves from areas of higher concentration to lower

   Isotonic- little net flow- balanced

   Hypertonic- freshwater in a marine critter

   Hypotonic- water flows out
   Figure 13.15

2. Active Transport
   - From an area of low concentration to high concentration
   - Sugars pumped through a membrane after photosynthesis

3. Surface to Volume Ratio
   Small cells are more efficient – Figure 13.17
   Thus cells grow by dividing; it's more practical

Limiting Factor: limits normal function of critters
>Light

CLASSIFICATION OF STUFF

Classification of the Marine Environment into Zones
1) Pelagic Zone: area of open water
2) Neritic Zone: near shore over the continental shelf
3) Oceanic Zone: beyond the continental shelf

Bottom Classification: Benthic Zone
1) Littoral Zone: intertidal
2) Sublittoral: to the edge of the shelf
3) Bathyal Zone: to the ocean floor
4) Abyssal Floor: flat bottom
5) Hadal Zone: trench area

The Progression of Life: Evolution
>Critters progress according to natural selection
>Variations are created by mutations and adaptation

Linnaeus Classification System
Kingdom>>Phylum>>Class>>Order>>Genus>>Species
Table 13.4