Chapter 1- Light and Life

Light has 2 important functions on Earth

1) Source of all energy that sustains all life
2) Provides organisms with important info about the physical world

Light: the portion of the electromagnetic spectrum that humans can detect with their eyes.
-spans the wavelengths from 400 nm(blue) to 700nm(red)
-wavelengths outside this range are called uv/infrared radiation
-light behaves as a stream of energy particles called photons
-the amount of energy in a photon is related to its wavelength
-blue light = (shorter wavelength) =photons with higher energy
10^{21} photons hit each square meter of earth every second on a sunny day.

1.1b light interacts with matter
-light has no mass but can interact and change matter
-when photons hit an object they can be
a) reflected off the object
b) transmitted through the object
c) absorbed by the object
Pigment: molecule that absorbs photons of light
-Individual photons differ in the wavelengths they can absorb
-all pigments have a region where carbon atoms are convalently bonded with alternating single and double bonds. This is called conjugated system.

Examples: chlorophyll a-photosynthesis
Retinal-vision
Indigo-dye jeans to blue

1.1c Why Chlorophyll is Green
-absorption of light occurs when the energy of a photon is transferred to an electron of the pigment molecule.
-the color of a pigment is determined by the wavelengths of light it cannot absorb.
Cholorphyll a can absorb red and blue photons but reflects green photons

1.2 Light as a Source of Energy
-light energy is used to synthesize NADPH and ATP, which are used to convert carbon dioxide into carbohydrates.
-Sun plants capture energy from the sun and store it in the chemical bonds of sugars and other food molecules plants,animals and fungi release the energy stored in the chemical bonds of food molecules and use it as fuel.
-all life depends on capturing energy from the sun and converting it into a form that living organisms can use.

1.3 Light as a source of information

1.3a Rhodopsin

- the basic light sensing-system found almost universally in all organisms is the photoreceptor
-the most common photoreceptor in nature is rhodopsin.
-used for an eyespot in some species (not only basis in vision)
-Rhodopsin consists of a protein (opsin) which binds a pigment molecule (retinal)

1.3b-sensing light without eyes

- eye spot of C.reingardtii contains photoreceptors that allow it to sense light direction and intensity.
-Phototaxis- locomotion towards light
-Positive phototaxis-towards light
-Negative phototaxis-away from light
-Phytochrome: senses the light environment and is critical for photomorphogensis, the normal development processes activated when seedlings are exposed to light.
-phytochrome becomes active when the plant is exposed to wavelengths of red light.

1.3c-the eye

Eye: the organ animals use to sense light
-the process of vision not only requires an eye but it also requires a brain or at least a simple nervous system that interprets signals sent from the eye.
- eye and brain are thought to have co-evolved.
-simplest eye is the ocellus (100 photoreceptor cells lining a cup or pit)
Planaria- have an ocellus eye, they position themselves so that the amount of light falling on the two ocelli Is equal and fades as they swim away from the source of the light and towards darker areas.
- Compound eye: common in arthropods (insects)
- contains hundreds-thousands of ommatidia units fitted closely together
-the brain receives a mosaic image of the world
-even the slightest motion is detected by compound eyes
Camera Eye: single lenses
- light enters through a transparent cornea, lens concentrates the light, the retina records the image.
READ OVER THE EYE EVOLUTION DIAGRAM
- eye spot--□ euglena
-eye cup□ planaria
-pinhole eye □nautilus
-primitive lens□ box jellyfish

1.3d evoulution of the eye

- 2000 small improvements over time would gradually yield a camera type eye in less than half a million years.
-500 years ago fossils show animals with primitive eyes

1.4- Light can Damage Biological Molecules
- organisms use light because it is the most dominant form of electromagnetic radiation reaching Earth's surface
- light contains the right amount of energy, needed for life, shorter wavelengths have enough energy to destroy the chemical bonds life is made from
-it would oxidize the molecule producing ions.
- longer wavelengths would not have enough energy to excite the electrons needed

1.4a- Damage by Light: Direct Effects
- photosystem ii is constantly being damaged by light, but repair of damaged photosystems developed early during the evolution of life.

1.4b Damage by Light: Indirect Effects
- because of its high energy, UV radiation can randomly ionize the atoms in a range of molecules.
- DNA and UV radiation can form a dimer (when two neighboring bases that make up DNA covalently link)
- dimers can change the shape of the double helix structure of DNA and prevent its replication and hinder gene expression.
- dimers can cause genetic mutations that are dangerous
-to avoid sunlight animals may shield their skin (fur)
-humans rely on melanin as an important protective mechanism
-melanin is a pigment that absorbs UV radiation
- humans synthesize melanin in skin cells called melanocytes
- melanin in skin prevents DNA damage that is linked to the development of skin cancer
- Humans require some UV radiation to synthesize vitamin D

1.5 Role of Light in Ecology and Behaviour
- differences in the intensity and spectral composition of the light coincide with organism adaptations to the specific light environment of particular habitats.
- for many animals it helps attract members of the same species while making them potentially less visible to predators.

1.5a Using Light to tell time: Circadian Rhythms
-biological clock is set by external light environments but can run a long time without any input from outside the organism
-biological events will still occur even when organism is placed outta light and into darkness
- in photosynthetic organisms, many proteins needed for photosynthesis are synthesized before dawn
- this allows photosynthesis to occur at maximum efficiency during the daylight
- in many organisms, DNA replication only occurs at night
-in animals the suprachiasmatic nucleus control circadian rhythms
- regulates the secretion of melatonin (controls our sleep-wake cycle)
- jet lag interferes with normal circadian cycling
-timing of flowering and dormancy is due to circadian rhythms
- hibernating and migration….

1.5c Using colour as signals
- animals use bright colours to signal that they are distasteful, armed or dangerous
- monarch butterflies-colour to show bad taste
-bees and wasps- colour to warn other animals
-the colour of flowers is to attract pollinators

1.5d Light in Aquatic Habitats
-no light penetration below 150 m
- below 30m light is monochromatic (blue wavelengths)
- fish living in shallow marine waters tend to come in many colours
-fish living in deeper water tends to be black backs and silver under bodies

1.5e Ecological Light Pollution
- the presence of natural light disrupts orientation in nocturnal animals otherwise accustomed to operating in the dark (eg frogs and salamanders)
-100-1000 birds die every year when migrating when they collide with lightened buildings and towers
- some animals benefit from lights such as bats, because insects are attracted to the light

1.6 Life in the Dark
-bioluminescence: organisms such as fish squid, some types of bacteria that produce their own light
-used to attract prey, attract a mate or to communicate

Chapter 2

2.1b, 2.3a, 2.3d, 2.4, 2.5

2.1b The fundamental Unit of life is the cell
- Cell Theory
1) All organisms are composed of one or more cells
- prokaryotes-one cell
-eukaryotes-multi-celled
2) The cell is the smallest unit that has the properties of life
- if cells are broken open, the property of life is lost, no longer grow/reproduce
3) Cells arise only from the growth and division of preexisting cells
- although DNA and RNA contain reproductive information, new cells can only arise from pre-existing cells

2.3a The origin of the Information System
- all organisms contain DNA
- DNA is a large, double-stranded, helical molecule
- DNA functions similarly in all organisms, the information in DNA is copied onto molecules of a related substance RNA, which then directs the production of protein molecules
-enzymes are required to catalyze the replication of DNA, the transcription of DNA into RNA and the translation of RNA into protein
- DNA had the ability to directs its own replication so offspring receive the same basic molecular instructions as their parents have
-changes in DNA are what contribute to evolutionary change over generations

2.3d The Development Of Energy-Harnessing Reaction Pathways
- oxidation-reduction reactions were probably amount the first energy releasing reactions of the primitive cells
- in our cells we, oxidize food molecules and use some of the liberated energy to reduce other molecules
-ATP become established as the coupling agent that links energy-releasing reactions to those requiring energy

2.4 Early Life
2.4a Earliest evidence of Life
-fossilized evidence of stromatolites-3.5 billion years ago
- nonfossil evidence of cyanobacteria shows that life may have existed 3.9 billion years ago

2.4b Could life have come to earth from space
-Panspermia is the name of the hypothesis that suggests life on earth has extraterrestrial origin
- 1) life arouse quickly after the formation of the Earth, Earth fromed 4.6 billion years ago and we have chemical evidence for life 3.9 billion years ago, since Earth had to cool down this is a very little time spam for life to evolve
2) life is far more resilient than previously thought and could possibly survive for years in space

2.4c Prokaryotes have properties common to all cells

- two domains of life: bacteria and archea
- lack a nucleus
-contain a plasma membrane which seperates the external environment from the cytoplasm of the cell
-the cytoplasm contains the cytosol which is mostly water,salts, and various organic molecules and organelles
- plasma membrane contains protein complexes that form electron transport chains
- in photosynthetic prokaryotes-plasma membrane is the site of photosynthetic electron transport chains
-DNA is organized into chromosomes
- DNA is found in the nucleoid

2.4d Prokaryotes Display Remarkable Diversity
- 10 times smaller than a typical eukaryotic cell
- less internal membrane organization compared to eukaryotic cell
- display metabolic flexibility, ability to use a variety of substances as energy and carbon sources and synthesize almost all of their required organic molecules from simple inorganic raw materials.
-biochemically more versatile than eukaryotes

2.4e Oxygenic Photosynthesis and the rise of atmospheric oxygen
-earliest prokaryotic cells relied on anaerobic metabolism
-earliest forms of photosynthesis used compounds such as H_2S which could easily be oxidized by the energy trapped by the sun
- cyanobacteria started to harness the electrons from water
- this released protons, electrons as well as resulted in the formation of oxygen which was released
- after millions of years, oxygen slowly accumulated in the atmosphere
-oxygenic photosynthesis- organisms that rely on the oxidation of water
- the rise of oxygen let to the evolution of prokaryotic cells which are able to undergo aerobic respiration
- aerobic respiration: energy is extracted from food molecules, with oxygen acting as the final electron acceptor
- this was a key factor that led to the development of eukaryotic cells

2.5 Eukaryotic Cells
- characteristics that distinguish them from prokaryotes
1) the separation of DNA and cytoplasm by a nuclear envelope
2) the presence in the cytoplasm of membrane-bound compartments with specialized functions
3) highly specialized motor proteins that move cells and internal cell parts

2.5a The Endomembrane System Is Derived from the Plasma Membrane
- eukaryotic cells are characterized by an endomembrane system
- divide the cell into functional and structural compartments called organelles
- major membrane components include the nuclear envelope, ER and golgi complex

- members of the endomembrane system are connection directly in the physical sense or indirectly by vesicles
- vesicles: small membrane bound compartments that transfer substances between parts of the system
- nuclear envelope controls the movement of both proteins and RNA molecules into and out of the nucleus
- ER and golgi complex functions= synthesis and modification of proteins, their transport into membrane or to the outside of the cell, synthesis of lipids and detoxification of harmful compounds

1) ER: an extensive interconnected network of membrane channels and vesicles
- each vesicle is formed by a single membrane that surronds an enclosed space called the lumen of the ER
-two forms, rough and smooth ER
- Rough ER: many ribosomes on its outer surface.
-protein synthesis on the rough ER are for the plasma membrane for release outside the cell
- after being synthesized, proteins enter the lumen where they fold into their final form
- the proteins are then delivered to the cell surface within vesicles that pinch of the ER and move to join with the golgi complex
Smooth ER: synthesis of lipids that become part of the cell membranes

2) Golgi Complex: a stack of flattened membranous sacs and it usually located between the rough ER and the plasma membrane
- receives proteins that were transported by vesicles from the rough ER
-further chemical modifications occur here
- the modified proteins are then sorted into other vesicles that pinch off from the margins of the Golgi sacs on the side of the complex that faces the plasma membrane
- the Golgi complex regulated the movement of several types of proteins
- exocytosis: proteins secreted from the cell are transported to the plasma membrane, and release their contents to the exterior
-endocytosis: brings molecule into the cell from the exterior

2.5b- The Theory of Endosymbiosis Suggests that Mitochondira and Chloroplasts Evolved from Ingested Prokaryotes
- another characteristic of eukaryotic cells is the presence of energy-transducing organelles: the chloroplasts and the mitochondrion.
-theory of endosymbiosis: prokaryotic ancestors of modern mitochondria and chloroplasts were engulfed by larger prokaryotic cells, forming a relationship called symbiosis, slowly over time the host cell and endosymbionts became inseparable parts of the same organism
- thought to be caused by the rise in oxygen in the atmosphere

2.5c Several Lines Evidence Support the Theory of Endosymbiosis
1) Morphology- the form or shape of both mitochondria and chloroplasts is similar to prokaryotic cells.
Mitochondria- aerobic prokaryotes
Chloroplasts- cyanobacteria

2) Reproduction- chloroplast and mitochondria are derived only from preexisting mitochondria or choloplasts. Divide by binary fission.
3) Genetic Information- both mitochondria and chloroplasts contain their own DNA
4) Transciption and Translation- chloroplast and mitochondria contain transcription and translation machinery.
5) Electron transport- chloroplast and mitochondria can generate energy in the form of ATP

2.5d The cytoskeleton Supports and Moves Cell Structures
- cytoskeleton: maintains characteristic shape and internal organization of the cell
- is an interconnected system of protein fivers and tubes that extend throughout the cytoplasm.
- reinforces the plasma membrane and functions in movement both of structures within the cell and of the cell as a whole
- animal cytoskeleton contains: microtubules, intermediate filaments and microfilaments
-microtubules: microscopic hollow tubes
- intermediate filaments- are fibers that occur singly, in parallel bundles and in interlinked networks either alone or in combination with microtubules, microfilaments or both
-microfilaments are thin fibers that consist of two rows of protein subunits would around each other in a long spiral.
-eukaryotic cell movements are generated by

Chapter 3

3.1 Biodiversity

-the number of species of organisms
-accurate number of species such as mammals, birds and flowering plants
-inaccurate number of species of microscopic organisms
- one way to group organisms is to consider how they obtain carbon
- most plants are autotrophs: synthesize organic carbon molecules using inorganic molecules
-all animals are heterotrophs: obtain carbon from organic molecules
-organisms are also divided according to the source of their energy they use to drive biological activites
- chemotrophs: obtain energy by oxidizing inorganic or organic substances
-phototrophs: obtain energy from light

3.2 Selection
-selection occurs when some force of phenomenon affects the survival of individual organisms
- eg. When there is a bacteria outbreak in an hospital, only the resistant bacteria will survive
-they will reproduce to and the offspring will be resistant as well
- the key factors behind selection are a selective force (pressure) and the capacity for explosive population growth.
- selection is a major force responsible for evolution and biodiversity.

3.2c-climbing plants reaching for the light
- vines find support that often has biomass and reproductive output that matches or exceeds that of the trees on which they grow
- climbing plants grow quickly depending on the reduced biomass of supporting structure they achieve a higher leaf biomass and outcompete other plants when it comes to reaching for the sun

3.3 Evolution
- a gradual change in the characteristics of a population of organisms over time, can be the result of selection
- all organisms today descended from a common ancestor (explains why all organisms share features) eg. using ATP
-Darwins theory of evolution
1) individual organisms in a population vary in many heritable traits
2) any population can produce many more offspring than the environment allows, competition for resources allows only some to survive
3) some individuals have traits that give them an advantage in their local environment, these organisms are more likely to survive
4) organisms pass on favorable traits to their offspring
-genetic mutation contributes to evolution

Hypothesis:
-early stages of an idea or model
Theory
-hypothesis widely accepted by the scientific community via rigorous experimentation and re-testing with the same results.

Species
-organism with high level of genetic similarity

Chapter 5-Membranes and Transport

5.1-An overview of the Structure of Membranes

- development of plasma membrane was a key to evolution
- acts as a selectively permeable barrier and allows for the uptake of key nutrients and elimination of waste products while maintaining a protected environment in which metabolic processes can occur
- development of internal membrane allowed for compartmentalization of processes and increased complexity (ex. nuclear membrane)

5.1a- The fluid Mosaic Model of Membranes

- The fluid mosaic model proposes that membranes are not rigid with molecules locked into place but consists of fluid lipid molecules in which proteins are embossed and float freely
- the lipid molecules of membranes exist in a double layer (bilayer) that is less than 10nm thick
-lipid molecules of the bilyar vibrate, flex back and fourth, spin around their long axis, move sideways and exchange places within the same bilayer half
- rarely a lipid molecule flip-flops between the two layers
- lipid molecules in the membrane are highly dynamic as exchanging places occurs millions of times a second
-mosaic= membrane contains a wide assortment of different proteins, each have a specific function
- proteins move more slowly in the fluid environment because they are larger than lipid molecules
- small number of membrane proteins anchor cytoskeleton filaments to the membrane and do not move
- a number of lipid and protein components of some membranes have carbohydrate groups linked to them, forming glycolipids and glycoproteins
- the relative proportions of lipids and proteins depends on type of membrane
- Examples: inner mitochondrial (76% protein / 24% lipid), plasma membrane (49% / 51%) and myelin membrane (18% / 82%)
-another characteristic is one half of the bilayer is different than the other half (membrane asymmetry), reflects differences in the functions of both sides
-hormones and growth factors bind to receptor proteins which are found only on the external surface of the plasma membrane.
- their binding triggers changes to distinctly different protein components found on the inner surface of the membrane, which lead to signal transduction within the cell

5.1b- Experimental Evidence in Support of the Fluid Mosaic Model

- 2 major pieces of evidence
    1) Membranes are fluid
    - A study carried out in 1970, human cell and mouse cells were tagged with dye, the cells were fused together, within minutes the two proteins started to mix, in less than an hour the two colors had completely intermixed on the fused cell
    - Based on this, the membrane bilayer seems to be as fluid as a light machine oil
    2) Membrane Asymmetry
    - Block of cells is rapidly frozen by dipping it in a liquid nitrogen (-196 degrees C), the block is fractured by a microscopically sharp knife edge. Electron microscope shows that