General Biology

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1 Getting Started

7 Cell structure

7.1 What is a cell?

The word cell comes from the Latin word "cella", meaning "small room", and it was first coined by a microscopist observing the structure of cork. The cell is the basic unit of all living things, and all organisms are composed of one or more cells. Cells are so basic and critical to the study of life, in fact, that they are often referred to as "the building blocks of life". Organisms - bacteria, amoebae and yeasts, for example - may consist of as few as one cell, while a typical human body contains about a trillion cells.

According to *Cell Theory,* first proposed by Schleiden and Schwann in 1839, all life consists of cells. The theory also states that all cells come from previously living cells, all vital functions (chemical reactions) of organisms are carried out inside of cells, and that cells contain necessary hereditary information to carry out necessary functions and replicate themselves.

All cells contain:

- Lipid bilayer boundary (plasma membrane[1])
- Cytoplasm[2]
- DNA[3] (hereditary information)
- Ribosomes[4] for protein synthesis

Eukaryotic cells also contain:

- At least one nucleus[5]
- Mitochondria[6] for cell respiration and energy

Cells may also contain:

- Lysosomes[7]
- Peroxisomes[8]
- Vacuoles[9]
- Cell walls[10]

1 http://en.wikipedia.org/wiki/plasma%20membrane
2 http://en.wikipedia.org/wiki/Cytoplasm
3 http://en.wikipedia.org/wiki/DNA
4 http://en.wikipedia.org/wiki/Ribosome
5 http://en.wikipedia.org/wiki/Cell%20Nucleus
6 http://en.wikipedia.org/wiki/Mitochondrion
7 http://en.wikipedia.org/wiki/Lysosome
8 http://en.wikipedia.org/wiki/Peroxisome
9 http://en.wikipedia.org/wiki/Vacuole
10 http://en.wikipedia.org/wiki/Cell%20Wall

Gradient

Physical difference between two regions of space, in such a way that the molecules tend to move in response to the gradients.

Diffusion

Movement of the molecules in a fluid, from the regions of high concentration to those of low concentration.

Passive transport

Movement of substances in a membrane that doesn't need to use energy.

Simple diffusion

Diffusion of water, gases or molecules across the membrane.

Facilitated diffusion

Diffusion of molecules across the membranes with the participation of proteins.

Osmosis

Diffusion of the water across a membrane with differential permeability.

Transport that needs energy

Movement of substances across a membrane generally in opposition to a gradient of concentration with the requirement of energy.

Active transport

Movement of small molecules using energy (ATP).

Endocytosis

Movement of big particles towards the interior of the cell using energy. The cells enclose particles or liquids.

Pinocytosis

(Literally cell drinking) Form in which the cell introduces liquids.

Phagocytosis

Way of eating of the cells. It feeds in this case of big particles or entire microorganisms.

Pseudopods

False feet (the amoeba).

Exocitosis

Movement of materials out of the cell with the use of energy. It throws waste material.

Isotonic

The cytoplasm fluid of the interior of the cells is the same that the outer.

Hypertonic solution

8.2 Chromatin

Chromosomes consist of chromatin[11]. This is made up of strings of DNA, which typically measure centimeters in length if stretched out. This DNA is wound around a histone[12] core and organized into nucleosome[13]s.

The chromatin[14] must be uncoiled for gene expression[15] and replication[16]. Chromosome micrograph

8.3 Endoplasmic reticulum

The endoplasmic reticulum[17] is a cellular organelle[18] made up of a series of extended folded intracellular membranes. It is continuous with the nuclear membane.

There are two main types of endoplasmic reticulum:

- RER: rough endoplasmic reticulum (site of protein synthesis[19]) associated with ribosomes
- SER: smooth endoplasmic reticulum (site of lipid synthesis[20])

8.3.1 Rough Endoplasmic Reticulum

Proteins are directed to the RER by a **signal sequence** of a growing polypeptide[21]s on the ribosome. This is recognised by a signal recognition particle which brings the ribosome/polypeptide complex to a channel on the RER called a translocon. At the translocon, the signal sequence and ribosome/polypeptide complex interact with the translocon to open it. The signal sequence becomes attached to the translocon. The ribosome can continue to translate the polypeptide into the lumen of the RER. As synthesis continues, 2 processes can happen.

1. If the protein is destined to become a membrane bound protein then the protein synthesis will continue until termination. The ribosome can then dissociate, allowing protein folding within the RER lumen to occur and continuation to the golgi apparatus for processing of the polypeptide.
2. If the protein is destined for storage for later secretion after stimulation or for continuous secretion then a protease-enzyme which cuts proteins at the peptide bond-can cut the signal sequence from the growing polypeptide. Continuation to the golgi etc. can then occur.

11 http://en.wikipedia.org/wiki/chromatin
12 http://en.wikipedia.org/wiki/histone
13 http://en.wikipedia.org/wiki/nucleosome
14 http://en.wikipedia.org/wiki/chromatin
15 http://en.wikipedia.org/wiki/gene%20expression
16 http://en.wikipedia.org/wiki/replication
17 http://en.wikipedia.org/wiki/endoplasmic%20reticulum
18 http://en.wikipedia.org/wiki/organelle
19 http://en.wikipedia.org/wiki/protein%20synthesis
20 http://en.wikipedia.org/wiki/lipid%20synthesis
21 http://en.wikipedia.org/wiki/polypeptide

Cilia and flagella are threads of microtubules that extend from the exterior of cells and used to move single celled organisms as well as move substances away from the surface of the cell. motor proteins-move, wave motion

9 Membranes

9.1 Biological membranes

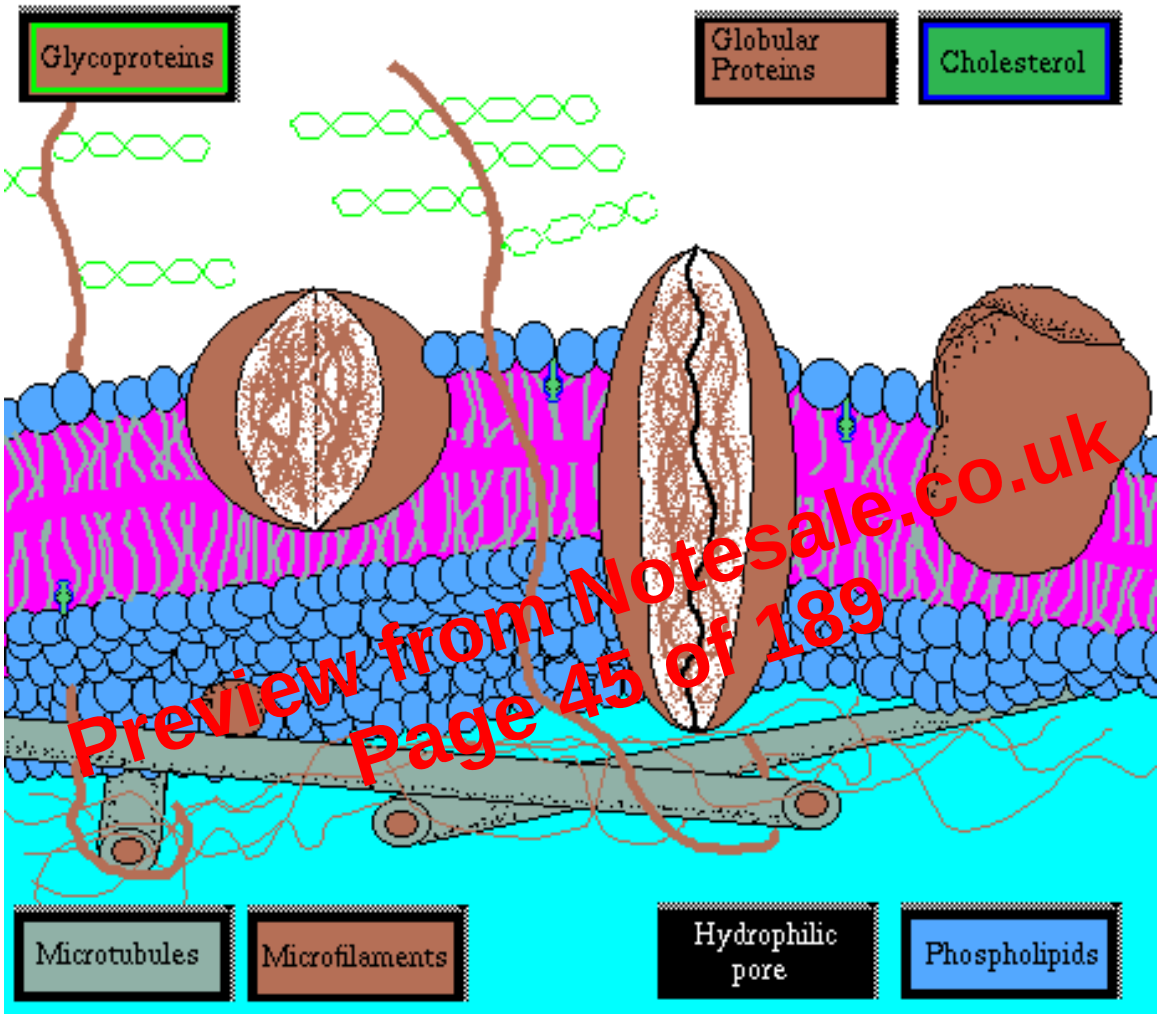

Figure 5 Plasma membrane bilayer

Biological membranes surround cells and serve to keep the insides separated from the outsides. They are formed of phospholipid bilayer[1]s, which by definition are a double layer of fatty acid[2] molecules (mostly phospholipid[3]s, lipids containing lots of phosphorus).

Proteins[4] serve very important functions in cellular membranes. They are **active transports** in and out of the cell, acting as gatekeepers. They relay **signals** in and out of the cell. Proteins are the **site of many enzymatic reactions** in the cell, and play a role in **regulation of cellular processes.**

9.2 Phospholipid

Phospholipid bilayer

- basis of biological membranes and cellular organisms
- contains a charged, hydrophilic (attracted to water) head and two hydrophobic (repelled by water) hydrocarbon tails
- In presence of water, phospholipids form bilayer
  - maximize hydrogen bonds between water
  - creates barrier to passage of materials
  - fluid mosaic model shows horizontal (common) and "flip-flop" (rare) movement of phospholipids

9.3 Fluid mosaic model

- Current model of membrane
- Phospholipid bilayer
  - Phospholipids
- Move freely in lipid layer, but rarely switch layers
- Different phospholipids in each layer in different organelles
  - Glycolipids
  - Sterols (cholesterol in animals)
- Transmembrane proteins "float" in fluid lipid bilayer
  - also called intrinsic, integral proteins
- Exterior (extrinsic, peripheral) proteins

9.4 Membrane proteins

- Transport channels
- Enzymes
- Cell surface receptors

1 http://en.wikibooks.org/wiki/lipid%20bilayer
2 http://en.wikibooks.org/wiki/Fatty%20acid
3 http://en.wikibooks.org/wiki/phospholipid
4 http://en.wikibooks.org/wiki/Proteins

- Cell surface identity markers
- Cell adhesion proteins
- Attachments to cytoskeleton

Integral membrane proteins

- Anchoring to membrane
  - Protein has attached phosphatidylinositol (GPI) linkage, anchors protein in outer layer (no picture)
  - Protein has one or more hydrophobic transmembrane domains
- -helix
- -sheet

Channel protein Transport across membranes *** Diffusion**

- - From higher concentration to lower concentration
  - Membranes are selectively permeable
- Ions diffuse through membrane channels
  - Selective
  - Movement determined by diffusion and voltage differences
- **Facilitated diffusion**
  - Carrier protein, physically binds transported molecule
- **Osmosis**
- Diffusion of water down concentration gradient
- In cell: various solutes (amino acids, ions, sugars, etc.)
  - interact with water, e.g., hydration shells
- Water moves through aquaporin channels into cell
- Depends upon the concentration of all solutes in solution
  - Hyperosmotic solution: higher concentration of solutes
  - Hypoosmotic solution: lower concentration of solutes
  - Isoosmotic solution: solute concentrations equal
- Water moves from hypoosmotic solution to hyperosmotic solution

Osmotic pressure **Bulk transport**

- Endocytosis: energy requiring
  - Phagocytosis
- Solid material, typically food
  - Pinocytosis
- Primarily liquid

**** Receptor-mediated endocytosis**

- Pits on cell surface coated with clathrin and receptors
- Bind specific proteins
- Exocytosis
  - Discharge of materials from vesicle at cell surface

- Sulfur bacteria
  - SO_4 reduced to H_2S
  - Formation of H_2S set stage for evolution of photosynthesis (H_2S as electron donor before H_2O)
  - About 2.7 by, based on ratio of 32S/34S, where only biological processes produce 32S enrichment

12.5 Glycolysis overview

Glycolysis accounting

- Oxidation
  - Two electrons (one proton) are transferred from each G3P to NAD^+ forming NADH

2NADH

- Substrate level phosphorylation
  - G3P to pyruvate forms 2 ATP molecules

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4 ATP (from 2 G3P)
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–2 ATP (priming)

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2 ATP (net gain)
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Summary: The net input of glycolysis is 2 ATP molecules which are used to split one glucose molecule. The net yield of this step is 2 ATP and 2 pyruvate.

12.6 Regeneration of NAD^+

- Reduction of NAD^+ to NADH can deplete NAD^+ supply; it must be regenerated
- Two pathways, coupled to fate of pyruvate
  - With oxygen: enter electron transport chain, forming water (and ATP)
  - Without oxygen: fermentation
- lactate
- ethanol

12.7 Alcohol fermentation

12.8 Lactate formation

Either lactic acid[1] or alcohol can be formed as a result of anaerobic respiration in cells.

1 http://en.wikipedia.org/wiki/Lactate

13.2 "Dark" reactions

- ATP drives endergonic reactions
- NADPH provides hydrogens for reduction of CO_2 to carbohydrate (C-H bonds)
- Occur in the stroma
- First step in carbon fixation

13.2.1 The Detailed Dark Reactions

What the Dark Reactions Do:

The dark reactions build sugar from carbon dioxide gas (CO2), water (H2O), and energy from ATP molecules that were charged up during the light reactions. The dark reactions occur in the stroma of a chloroplast. Dark reactions usually occur in the light, but they don't have to. They'll occur in the dark until the chloroplast's supply of ATP runs out (usually about 30 seconds).

The Calvin Cycle:

The Calvin Cycle is the fancy name for the metabolic pathway that builds sugar. This means that it involves a whole lot of chemical reactions, and it uses a lot of different enzymes to catalyze the reactions.

Carbon dioxide gas is stable, therefore the bonds that hold the carbon and oxygen atoms are strong. Therefore it takes a lot of energy to break the bonds and separate the carbon atoms from the oxygen atoms. The energy needed to do this comes from ATP molecules.

When inorganic carbon (like from CO2) is being added to an organic molecule (such as sugar), this is called carbon fixation.

It takes 2 complete turns of the Calvin Cycle to make a glucose molecule.

Some portions of this text is based on notes very generously donated by Paul Doerder, Ph.D., of the Cleveland State University. The detailed portions are not provided by Dr. Doerder.

How cells divide

13.3 Prokaryote cell division

- Binary fission
  - Doubling of cell contents, including DNA
  - Fission to divide contents
- Segregation of replicated genomes by growth of membrane between attachment points
- Partitioning of cytoplasmic components
- Escherichia coli
  - Capable of cell division every 20 minutes under optimal conditions (DNA in continuous state of replication)
  - Model organism of bacterial cell division

- Sometimes membrane bound, requiring cell-cell contact with receptor
- E.g., upon wound, platelets release PDGF which stimulates fibroblasts to enter cell cycle (exit G0), to heal wound

13.16 Cancer

- Unregulated cell proliferation
- Cancer cells have numerous abnormalities
  - >46 chromosomes
  - Mutations in proto-oncogenes
- Encode proteins stimulating the cell cycle
- May be regulated by phosphorylation
- Often over expressed in cancer cells
  - Mutations in tumor-suppressor genes
- Encode proteins inhibiting the cell cycle
  - Often bind to products of proto-oncogenes
- May be regulated by phosphorylation

13.17 Mutations and cancer

This text is based on notes very generously donated by Paul Doerder, Ph.D., of the Cleveland State University.

- Transposition
- Chromosomal rearrangement
- Mutagenic agents
- Raw material for evolutionary change

20.9 Point mutation

- Ionizing radiation
  - UV light induces thymine dimers
- Reparable
- Error during DNA synthesis
- Movement of transposons
  - McClintock
- Chemical mutagens
- May alter
  - Properties of promoter, enhancer
  - Amino acid sequence of polypeptide

20.10 Acquisition of genetic variability

- Mutation
- Sex (fusion of genomes)
- Recombination
  - Crossing over
- Reciprocal (may result in gene conversion)
- Unequal (gives rise to gene families)
  - Independent segregation
- Transposition by transposons
- Conjugation in bacteria
  - One way transfer from donor to recipient

20.11 Eukaryote genome

- Thousands of transposons
- Millions of transposon derived elements
  - LINES, SINES
- Above may constitute largest portion of genome
- Pseudogenes
- Tandem clusters (rRNA genes; nucleolus)
- Multigene families
- Single-copy genes (one copy per 1n)

  - Also used for DNA fingerprinting and RFLP analysis
- cDNA construction
  - Reverse transcription from mRNA template

21.6 RFLP(restriction fragment length polymorphism) analysis

- Basis of DNA fingerprinting using SNP - single nucleotide polymorphisms and repeats of DNA sequence
- Many uses
  - Criminal cases using multiple probes
  - Parentage
  - Species identification
  - Gene evolution
  - Species evolution

21.7 Sanger DNA sequencing

- Uses dideoxynucleotides (ddNTP), a template strand, DNA polymerase 1 (Also known as Kornberg enzymes) and dNTPs
  - Missing 3'-OH for nulceopjilic attack for elongation
  - DNA synthesis stops after one is incorporated into DNA fragment
  - ratio of ddNTP to dNTP determines likelihood of termination
- Manual method with 32P-labeled ddATP and 4 test tubes - ddATP, ddCTP, ddGTP, ddTTP
- Automated method using ddNTPs labeled with fluorescent dyes in capillary tube
  - Often done commercially

21.8 Automated sequencing

Typical machine

- - 2 hour sequencing run
  - 600-1000 bases per sample
  - multiple samples
- Up to 500,000 bases per day (12 hr)
- Data processed by computer
- In big labs, sequencing reactions also are automated

21.9 Genome projects

- Determine entire nucleotide sequence of genome

Answers to Viruses Practice Questions[1]

For Eubacteria, please visit General Biology/Classification of Living Things/Eubacteria[2].

22.5 Archaea

- Proposed as separate group from (eu)bacteria by Carl Woese
  - based on structure and metabolic pathways
  - inhabit extreme environments
  - unique branched lipids in membrane
- Share traits with both eukaryotes and eubacteria, e.g., RNA polymerase, introns
- Biochemically diverse
- Economically important
  - Taq polymerase used in PCR

22.5.1 Types

- Methanogens
- Halophiles
- Thermophiles

Underground bacteria

- Metabolism
  - built around inorganic energy sources
- e.g., basalt reacts with H_2O to make hydrogen which is catalytically combined with CO_2 to form carbohydrate (akin to photosynthesis)
- may result in deposit of minerals
- Unresolved problems
  - Did bacteria move downward from surface or did they first evolve there, protected from harsh surface conditions?
  - Could bacteria be ejected into space in rocks?

22.6 Prokaryote evolution

- Tentative, subject to change
- Derived largely from molecular systematics (rRNA sequences)
- Note: most bacteria can't be cultured, thus hard to study! (Studied by PCR of water/soil samples)

1 http://en.wikibooks.org/wiki/%2FAnswers

2 http://en.wikibooks.org/wiki/General%20Biology%2FClassification%20of%20Living%20Things%2FEubacteria

22.12.2 Myxomycotes (Plasmodial slime moulds)

Myxomycoties are visible to the naked eye as tiny slug-like organisms which creep over decayed and dead matter. This streaming blob containing many nuclei is called a **plasmodium**.

22.12.3 Acrasiomycotes (Cellular slime moulds) and its reproductive cycle

Acrasiomycotes exist as individual amoeboid cells with one nucleus each. When in unfavourable conditions, each acrasiomycete cell gathers together to form a **pseudoplasmodium**.

Reproductive Cycle:

1. One acrasiomycete cell joins with others to form a pseudoplasmodium.
2. The pseudoplasmodium shrinks and forms a smaller plasmodium.
3. The plasmodium migrates to a suitable environment.
4. The plasmodium develops a sporangia, where original parental nuclei has divided by meiosis into haploid spores to be germinated.
5. When favourable conditions arise, the spores germinate and are carried away by animals or the wind.
6. Cycle repeats.

22.13 Protists Practice Questions

1. Which of the following adjectives describe the major food source of protozoa?

a) chemoautotrophic

b) photoheterotrophic

c) chemoheterotrophic

d) heterotrophic

e) A, C, D

f) C, D

2. The protozoan *Giardia lamblia* can inhabit a human body's intestinal tract and cause gastroenteritis.

a) Give the abbreviated binomial name of this protozoan.

b) Would the relationship between this protozoan and human being be mutualistic, commensalistic, or parasitic?

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plant
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23.12 Sporophyte/gametophyte

23.13 Megasporangium (nucellus)

- Key to seed development
- Nucellus: solid, fleshy, surrounded by integuments derived from sporophyte (seed coat)
- Entire structure called ovule
- Flower may have many ovules

23.14 Pollen

- Develop from microspores, become male gametophyte
- Protected by sporopellenin
- In most plants, sperm lack flagella (loss)
- Many mechanisms to transport pollen
  - wind
  - insects, birds,

23.15 Gymnosperms

- "naked seed"
  - ovule not fully enclosed by sporophyte at time of pollination
- Conifers, cycads, gnetophytes, Ginkgo
- Small, inconspicuous plants to giants like sequoia
- Conifers: to carry cones fv
  - male cones, Female conesvv
  - evergreen

23.16 Pine life cycle

23.17 Other Coniferophyta

- Cycadophyta: cycads
  - tropical, subtropical
  - flagellated sperm
- Gnetophyta
  - e.g., Ephedra, Mormon Tea
- Ginkgophyta: Ginkgo

- only one surviving species
- diocious (separate % and &trees)

23.18 Other gymnosperms

23.19 Angiosperms

- Flowering plants, Anthophyta
  - monocots- single seed leaf (grasses, lilies, etc.)
  - dicots- two seed leaves (roses, pulses, maples)
- More specialized xylem (water transport)
  - vessel elements
  - fiber cells
- Fossils date to 130 my
- Animal (e.g., insect) coevolution

23.19.1 Monocots vs dicots

23.20 Earliest angiosperm

- What is earliest angiosperm?
- Recent analysis of nucleotide and amino acid sequences suggests that Amborella, a tropical plant found only on the island of New Caledonia, is closest relative to flowering plants

23.21 Angiosperm flower

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23.22 Angiosperm life cycle

This text is based on notes very generously donated by Paul Doerder, Ph.D., of the Cleveland State University.

23.23 Introduction

Although you may not recognise fungi, they are just as prevalent as plants and animals. Their spores are in the air which we breathe, fungi allow us to make bread, and mushrooms (a type of fungi) are eaten by us. A few types of fungi are unicellular. For example, yeasts live as individual oval or cylindrical cells. However, the majority of fungi live are multicellular. Their bodies are composed of **hyphae**, a network of fine filaments. In a mushroom, the

- ***Echinodermata*** — 7000 — echinoderms (figures)
- Chaetognatha — 100 — arrow worms (figures)
- Hemichordata — 85 — acorn worms
- ***Chordata*** — 50,000 — chordates (figures)

23.31 Phylum Porifera

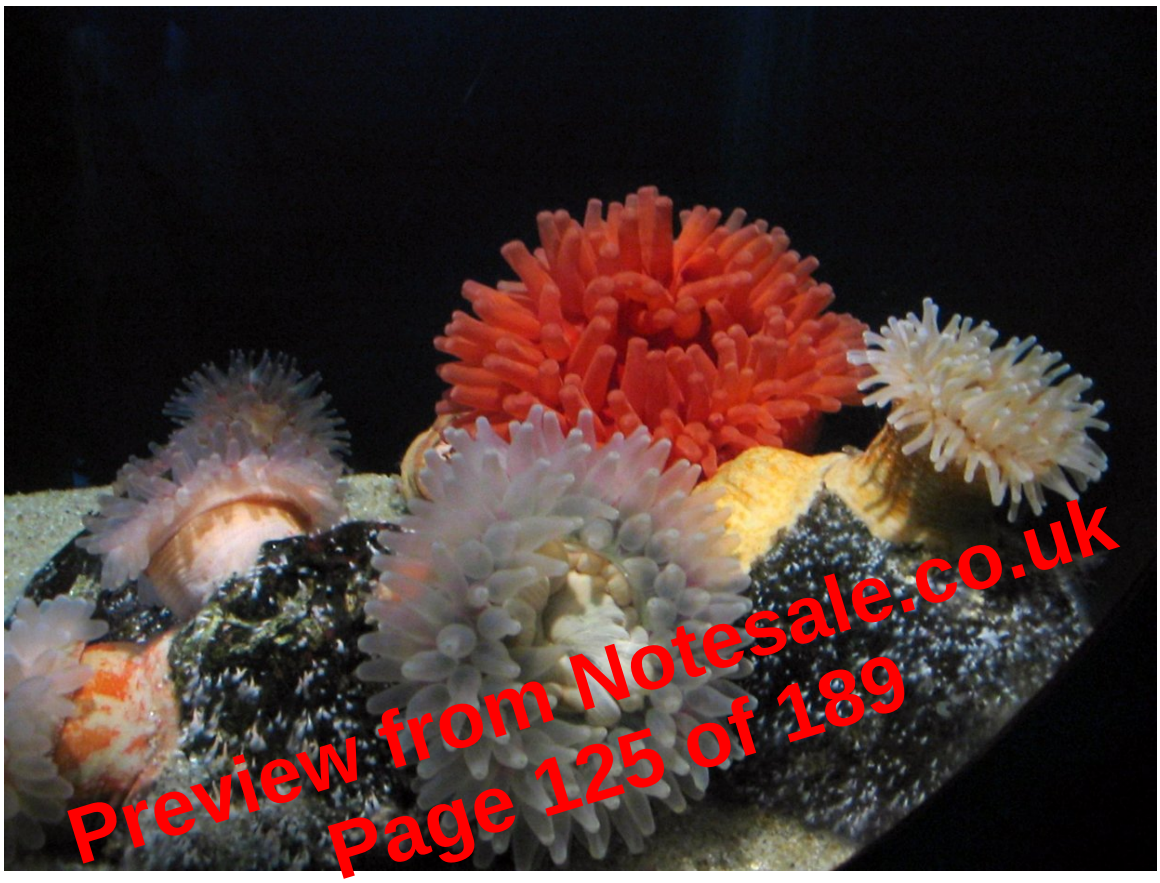

Figure 6 Sponges

Name means "pore-bearing".

This phylum consists of the sponges. The number of species is estimated to be between 5,000 and 10,000. All are aquatic and almost all are marine.

Animals in this phyla have no true tissues, which means, for example, that they have no nervous system or sense organs. Although sponges are multicellular, they are described as being essentially at a cellular level of organization. They are sessile as adults, but have a free swimming larva.

Their bodies are porous. They are filter feeders; water flows in through many small openings, and out through fewer, large openings. They have inner and outer cell layers, and a variable middle layer. The middle layer often is gelatinous with spiny skeletal elements (called spicules) of silica or calcium carbonate, and fibres made of spongin (a form of collagen).

Choanocytes are flagellated cells lining the inside of the body that generate a current, and trap and phagocytize food particles.

Their cells remain totipotent, or developmentally flexible: they can become any type of cell at any point in the sponge's development. This allows for the great regenerative power sponges have.

Sponges are an ancient group, with fossils from the early Cambrian (ca. 540 mya) and possibly from the Precambrian. Sponges often are abundant in reef ecosystems. They somehow are protected from predators (spicules? bad taste?).

Many organisms are commensals of sponges, living inside them. Some sponges harbor endosymbiotic cyanobacteria or algae (dinoflagellates, a.k.a. "zooxanthellae").

23.32 Phylum Cnidaria

See text pages 886 - 889.

Name comes from the Greek knide- meaning "nettle".

This phylum They have one opening, which serves as both mouth and anus. The body wall has an outer ectoderm, an inner endoderm, and a variable undifferentiated middle layer called mesoglea or mesenchyme that may be jelly-like. The mesoglea is **NOT** considered to be true mesoderm and so the Cnidaria are described as diploblastic. Tentacles usually extend from the body wall around the mouth/anus.

- The uniramians (centipedes, millipedes, insects) have one pair of antennae and unbranched (uniramous) appendages.
- The crustaceans (crabs, shrimp, lobsters, barnacles and many others) have two pairs of antennae and branched (biramous) appendages.

Major Classes Include

- Class Arachnida (mites, scorpions, spiders, ticks)
- Class Diplopoda (millipedes)
- Class Chilopoda (centipedes)
- Class Insecta (insects)
- Class Crustacea (crabs, crayfish, lobsters, shrimp)

23.38 Phylum Mollusca

See text pages 900 - 905.

Name means "soft".

This phylum consists of snails, slugs, bivalves, chitons, squids, octopus, and many others. About 110,000 species

All molluscs have a similar body plan:

- A muscular foot, usually used for movement.
- A visceral mass, containing most of the internal organs.
- A mantle, a fold of tissue that drapes over the visceral mass and secretes the shell, if present.
- Most have a radula, or a rasping organ to scrape food.

Molluscs are bilaterally symmetrical, or secondarily asymmetrical. They are coelomates, but the coelom generally has been greatly reduced; the main body cavity is a hemocoel. Development is typically protostomous. The gut is complete with marked regional specialization. Large, complex, metanephridia (excretion).

Many molluscan life cycles include a trochophore larva. This stage also is characteristic of annelids.

There are several major classes of molluscs:

- Class Polyplacophora (chitons)
- Class Gastropoda (snails, slugs, nudibranchs)
- Class Bivalvia (clams, mussels, scallops, oysters)
- Class Cephalopoda (squids, octopuses, chambered nautiluses)

23.39 Phylum Echinodermata

Name means "spiny skin"

This phylum consists of sea stars, brittle stars, sea urchins, and sea cucumbers.

from epithelium. Below this is **dermis**, thicker and with blood vessels.

Two specialized epithelia:

- **pseudostratified**
- **transitional**

Pseudostratified epithelia

lines the trachea (where it is ciliated)and the male urethra (where it is non ciliated), looks stratified but not.

Transitional epithelia

found only in bladder and urinary system. As it stretches it appears to go from 6 to 3 cell layers deep.

Glandular epithelia

(**gland**: group of cells that excretes something.. mostly derived from **epithelium**. Glands are classified into **endocrine** and **exocrine** by where they excrete.

Endocrine glands

secrete hormones into the **blood** without use of ducts.

Exocrine glands

secrete onto the **body surface** or into a **cavity**, thru a **duct**. Exocrine substances include sweat, mucous, oil, and saliva. An exocrine gland is the **liver**, which secretes bile.

Sarcomere: Thick and thin filaments interspersed in ordered grid.

Sliding filament theory: thick and thin filaments move past each other in opposite direction, shortening length. Longer muscles contract more rapidly than short ones (see cell bio for details).

Myosin molecule: two polypeptides twisted together with two globular heads at end.

Myosin filament: many slender myosin molecules together.

Actin filament: chain of actin single, **tropomyosin** strands with repeated **globular troponin**, and with **actin**. All play role in muscle contraction. Myocin heads have sites that bind to actin. Actin filaments have many regular sites that can bind to myosin.

Troponin has **four site**s:

1. one to bind **myosin**
2. one for **actin**
3. one for **tropomyocin**
4. one for **calcium ions**

Nerve signal reaches muscle, triggers release of chemical signal called neurotransmitter, that diffuses across cell membrane (**sarcolimic reticulum**) and binds to receptors in it. Receptor is **acetylcholine**, ACH. When there is enough nerve signal, the message travels through t-line to sarcoplasmic reticulum to release calcium ions.

Lacking calcium, **tropomyosin** is blocked. In calcium+ myosin binding sites exposed and heads bind to **actin** molecules, delivering force to move **fibers** in relation to each other. Myocin head then interacts with **ATP** to get "recocked", if myosin still exposed then it fires again and results in further muscle contration. If there is no further nerve signal, **sarcoplasmic reticulum** sequesters Ca+ ions again and no recocking occurs.

Quirari (or curare): known from movies, used in South America, blocks **acetylcholine receptors** in cell and causes skeletal paralysis. Victim dies of asphyxiation because he can't breathe.

Duchenne's muscular dystrophy: degeneration of **sarcolema**, plasma membrane of muscle cell unable to release signal and quickly atrophies.

Fast and **slow twitch fibers**: vertebrate muscle fiber. Terms relative within one group of animals. Differences related to differences in **enervation**, type of **myocin**, and **actin activation**.

Two parts of force generated by muscle: 1. **active** component 2. **elastic** component (energy stored in muscle when stretched by gravity or another force. Stored in muscle elastic tissue around tendons. Especially important in **limb oscillation**, like running, or trunk twisting, like fish swimming. Up to 90% of stored elastic energy can be recovered.)

nerve, uses**acetylcholine** to signal. Hyperpolarizes membrane to inhibit heart contraction. (Autonomic nervous system: two parts working in contra to control from both sides.) Dominant effect here is **inhibitory**. If we cut Vagus nerve, heart rate promptly rises about 25 bpm.

Vasa recta: capillaries that surround the Loop of Henle.

Glomerulus: main filter of the **nephron**, located within the **Bowman's capsule**

Kidney properties and processes important to its function

1. **Active transport of solutes** from one fluid to another against a concentration gradient, Na^+ actively transported out of filtrate by cells of the thick ascending loop of Henley into the interstitial fluid

2. **Passive movement of solutes** and water from one fluid to another(down a concentration gradient), movement of water and NaCl out of descending loop of Henley into interstitial fluid.

3. **Differential permeability of cells** in different regions of the nephron to movement of water and solutes, ascending thick look is impermeable to water, descending portion is permeable to water

4. **Hormonal control of that permeability**, antidiuretic hormone(ADH) increases permeability of collecting due to water, resulting in reduced volume of filtrate and thus more concentrated urine.

5. **Increasing solute concentration in the interstitial fluid of the kidney** from the cortex to the deepest medulla, maintained by a countercurrent multiplier mechanism

The majority of the modules making up this book are based on notes very generously donated by Paul Doerder, Ph.D.[21] and Ralph Gibson, Ph.D.[22] both currently of the Cleveland State University[23].

The book was initiated by Karl Wick[24], who donated many of his own class notes for other modules, and who is fleshing out the outline format of Dr. Doerder's notes into text.

34.1 Users

Alsocal[25]

Darren Hess[26] MD/PhD recent grad, enjoys teaching, hopes to help work up the Nervous System Tissue section.

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